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KRASOSLOVNI ZBORNIK
XXVI/2
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UVODNIK

Prvič, odkar izhaja zbornik Acta carsologica, smo v enem letu uspeli, ali pa nas je obilica gradiva primorala, kakor pač gledamo na stvar, izdati kar dve številki. In to nista drobna zvezka, pač pa zbornika v običajnem obsegu. Še posebej sem vesel, ker se je to zgodilo ravno letos, ko Inštitut za raziskovanje krasa ZRC SAZU praznuje 50-letnico ustanovitve, kar je skromno prikazano na platnicah z letnicama 1947 - 1997. Letnik 1997 je jubilejni in lahko rečem, da smo 50-letnico proslavili tudi s preko 1000 stranmi obsegajočim letnikom Acta carsologica 1997.

Zato se mi zdi tudi primerno, da je v tej številki malo več poudarka na zgodovini krasoslovja in speleologije. Nedvomno si je v teh 50 letih tudi Inštitut prislužil primerno mesto v tej zgodovini.

Prvi del oziroma sklop tokratne številke obsega prispevke, predstavljene na mednarodnem simpoziju o zgodovini krasoslovja in speleologije, ALCADI '96, ki je bil spomladi 1996 v Postojni. Ni bil posvečen 50-letnici inštituta, pa vendar je vmes več prispevkov, zelo pomembnih za zgodovino našega krasoslovja in speleologije. Naj omenim le prispevek o geodetski izmeri Postojnske jame iz 1891, ko je ob predstavitvi direktor Speleološkega inštituta z Dunaja podaril Inštitutu popoln transkribiran zapisnik - knjigo meritev. Zgodovinski sklop je obenem tudi neke vrste priprava na pomembne obletnice, ki so na vrsti v prihodnjem letu. Takrat bo 250 let, odkar je na našem krasu raziskoval J. A. Nagel. Rezultat njegovega dela je tudi prvi načrt Postojnske jame iz 1748. Istega leta praznuje Postojnska jama 180-letnico odkritja notranjih delov jame. To je tisti dogodek, zaradi katerega je postala Postojnska jama prava turistična jama (1819), zaradi katerega je postala svetovno znana in zaradi katerega je, posredno, tudi Inštitut za raziskovanje krasa lociran prav v Postojni.

Drugi sklop vsebuje gradivo, ki je bilo predstavljeno na mednarodni krasoslovni šoli "Klasični Kras" v Postojni 1996, katere vodilna tema so bila brezna. S šolo je Inštitut pričel na pobudo Slovenske nacionalne komisije za UNESCO, podpira pa jo tudi Slovenska znanstvena fundacija. Letošnja šola je bila že peta po vrsti, kar je tudi, sicer majhen, a pomemben jubilej, saj kaže na to, da se je šola usidrala. Vedno večje število udeležencev pa dokazuje, da jo cenijo tudi v tujini. Pri tem ima določen pomen tudi zbornik Acta carsologica, v katerem objavljamo gradivo s teh šol.

Vendar ne gre za same jubileje, čemur so dokaz "Ostali članki". Tudi za ta del je zanimanje med (bodočimi) avtorji vedno večje. Zelo je razveseljivo, da so med njimi tudi mladi in tudi taki, katerih ime je v stroki že uveljavljeno.

Da je bilo mogoče v enem letu toliko objaviti, gre največ zahvale Ministrstvu za znanost in tehnologijo kot najpomembnejšemu sofinanserju, ne smemo pa pozabiti tudi sponzorjev in neposredne denarne pomoči obeh soizdajateljev.

Urednik

PREFACE

For the first time in the history of editing Acta carsologica we have succeeded, or we have been forced due to lot of material, it depends on point of view, to publish two volumes in one year. And these are not thin issues but both contain normal number of pages. I am specially glad that this happened just in the year, when the Karst Research Institute ZRC SAZU, Postojna celebrates its 50-th anniversary. This is modestly shown on the front cover by the numbers 1947 - 1997. We can say that this year's volume is a jubilee one and Acta carsologica joins to the anniversary by more than 1000 pages.

Therefore it is right that the history of karstology and speleology is emphasized in this volume. The Institute earned in 50 years an appropriate place in this history also. First part of this number of Acta carsologica contains the papers, presented at the International symposium on the history of karst and cave science - ALCADI '96 - which was at Postojna in the spring of 1996. This was not dedicated to the 50th anniversary of the Institute, but there are some very important articles regarding history of our karstology and speleology. Let me mention the paper about the geodetic survey of Postojnska Jama cave from 1891. Together with this paper, the director of Speleological Institute of Vienna submitted to the Institute the complete and transcribed surveying book. The historical part is at the same time a sort of introduction to the forthcoming events of the next year. This is 250 years since J. A. Nagel investigated our karst. The result of his work is also the first plan of Postojnska Jama (1748). In the same year, 1998, Postojnska Jama will celebrate 180 years of discoveries of the inner parts of the cave. This was the reason that Postojnska Jama became a real show cave in 1819, that it became world known and indirectly also the reason that Karst Research Institute is located at Postojna.

The second part of the present Acta carsologica contains papers presented during the International karstological school "Classical Karst" held at Postojna in 1996. The main topic of this school was karst shafts. The Institute started to organise schools by the initiative of the Slovene National Commission for the UNESCO, and this is also supported by the Slovene Scientific Foundation. In this year the fifth school has been organised already. A small but important anniversary, showing that the school is being approved also in the foreign countries, evidenced by the every year bigger number of participants. For the school Acta carsologica is important too as the papers of the schools are printed in it.

But I must not speak of the jubilees only. There are also so called "Other papers". Also for this part the interest among the (future) authors increases every year. I am glad that among them there are young researchers and also recognized authors from the scientific circles.

That we were able to publish that much in one year I must thank the Ministry of Science and Technology as the biggest supporter. But we must not forget the sponsors and financial support of both publishers.

The Editor

PAPERS PRESENTED AT INTERNATIONAL SYMPOSIUM "ALCADI '96" POSTOJNA 1996

PREDAVANJA, PREDSTAVLJENA NA MEDNARODNEM SIMPOZIJU "ALCADI '96" POSTOJNA 1996

The Editorial Board may print only the abstract of those papers which are not suitable for publication in full.

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FRANCESCO TREVISANI

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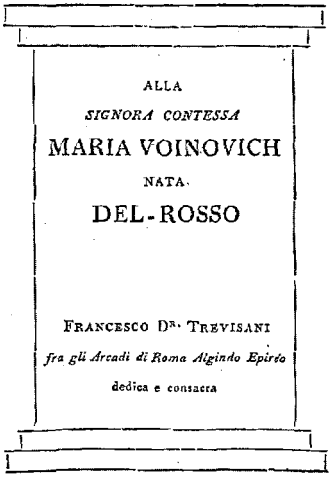
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Qui est ce, qui ose assigner des bornes précises à la NATURE?

J. J. ROUSSEAU.



ALLA

SIGNORA CONTESSA

MARIA VOINOVICH

NATA

DEL-ROSSO

FRANCESCO DR. TREVISANI

fra gli Arcadi di Roma Algindo Epireo

dedica e consacra

Sorgea la notte placida
dalle cimerie mura,
quando coll'ali scossemi
dai sonni miei NATURA;

Pendente tela candida
avea sul braccio bello,
e nella destra morbida
l'animator pennello;

Reggea la manca il docile
plettro,.... così m'apparve....
tutto m'offrì, dicendomi,
canta, dipingi, e sparve.

D'estro novello, e insolito
sento nel sen cribarmi,
lascio le pigre coltrici,
stendo le mani all'armi;

E già la tela candida,
come il pennel la tinge
di tinte vivacissime,
e d'orride si pinge;

— VI —

Già dentro il caldo cerebro,
che un dolce incanto bee,
vengono, vanno, e riedono
l'ardue pittrici idèe.

Scorre il pennello, e scorrono
gli istanti, e mentre sorge
Febo in Oriente, l'anima
compita l'opra scorge,

Cui t'offre umil la cetera,
DONNA GENTIL, che invano
l'Arno richiama, ed invido (*)
mira da se lontano;

Ite, miei carmi,.... i pallidi
timor sgombrate intanto,
è certo, s'ELLA accoglievi,
il mio triönfo, e il vanto.

(*) Fu in *Pisa* ove trasse i suoi Natali la Signora Contessa.

— VII —

AVVISO

DELLO STESSO

AL LETTORE.

Il Sig. Compagnoni *descrisse dottamente alcuni anni innanzi la stessa grotta: veramente dopo la sua bella descrizione è da mal-accorto il presentarne un' altra; e non vi sono, che le circostanze particolari, che possano garantire il secondo, ed il cedere volontario la palma, per potere impunemente delineare, quanto il primo con tutta l' arte dipinse.*



La vezzosa del dì foriera, e madre
dal *talamo di rose* al vecchio amante
s' invola, e lucidissima rimonta
sull'oscuro Orizzonte: i tenebrosi
densi vapori, e gli astri fiammeggianti
fuggono al raggio, che gli insegue, e vince
I sogni placidissimi disgombra,
divino Amico, e lor permetti in pace, (a)
riedere all'ima chiostra, or che risorge
coll'alba il sole, e fa di lei quel, ch'ella
fa della notte, e delle vaghe stelle.
Già sul tuo limitar mordono i freni,
calcitrando il terreno impazienti,
gli ungari corridori, e il bieco auriga
Te d'insereto, e negligente accusa,
che lo scabro martel sugli alti bronzi
frementi ricadendo, annunzia l'ora,
che fissasti al partir: mobile auretta,
che intorno spargi il rombo fragoroso,

— X —

dolcemente all'orrecchio glielo porta,
e lo desta per me, che i sonni suoi
non oso di turbar; . . . : ma s'apre alfine
la muta soglia . . . . i placidi riposi
disgombri alfin, e greca man ti porge
nel boëmo cristal le americane
spume col fresco latte accolte, e miste;
Tu le rifiuti, e dalle pigre piume
sorti d'un salto, al piè adattando il molle
anglico cuojo, ed alle forme inchieste
atiche lane all'Europèo costume. (a)
Già tutto è pronto; e Tu pur anco, vieni,
monta il cocchio ristretto in pria, che l'alto
rettor dei freni ai fervidi cavalli
il conscio segno di partir dispensi.
Ma alfin si parte, e gli agili destieri,
divorando il cammino, arrivan dove
sul verde prato inculto monte s'alza,
che quanto più s'estolle, orrido tanto,
e men fertil divien; ove cred'io,
dell'util Cerer, di Pomona bella
solo a dispetto, vedi pur tallora
o mammola spuntar, o bionda spica,
di cui dai prati in torbido aquilone
trasse sull'ali, e qui depose il seme.
Ma vinto è l'erto dell'informe colle,

— XI —

e l'ampia vetta al guardo offre soàve
ricompensa dell'orrido cammino,
che a manca vedi spumeggiar il salso
immensurabil liquido Orizzonte,
per cui scorrendo mille prore e mille
d'estranio ciel, felicemente onuste
d'utili merci, e peregrine stoffe,
l'aurea Cittade, che all'Adriaco flutto
frena l'orgoglio, fan sì ricca, e bella.
A destra i praticei floriti, e molli,
i culti poggi, i giardinetti ameni
fan sorridere il Ciel di lor bellezza,
u' tanti son palagi, ostelli, case,
tetti, e vigne, che il *guardo ammiratore*
cento villette insiem crede raccolte,
e germogliarle il fertile terreno,
come germoglia le vermene, e i fiori,
talchè dell'Arno tuo, DONNA GENTILE,
i popolati, e fertili contorni
rivedo in lor, di cui così cantava
sul dotto plettro il Ferrarese Omero.
Ma l'utile Ocean, l'ameno colle
agli occhi fura il piè leggero, e pronto
de'fumanti destier, che in monte alpestre
segnan la zampa, ove la mano industre
dal molle sasso trae feconda argilla;

— XII —

nè scuopre più per quanto acuto il guardo
dell'alte antenne, e delle torri eccelse
traccia nel cielo, che dispare, e fugge
del Lombardo Apenino, e de' nevosi
Alpini gioghi la scagliosa fronte.
Or tutto è orror, nè per fuggir più ratto
cessa il terrore, onde NATURA *volle*
i palpiti sospendere del core,
ed arrestare a mezzo il corso il sangue.
Fra rupi alpestri, ed inguai mortagne
ampie fosse ritrovi, ove s'arresta
il limpidetto umor, che larga pioggia
quì provvida dispensa; ad esse corre
sitibondo nel giorno il pastorello
coll'affannato bue, mentre alla notte
l'atre mascelle ancor del sangue lorde
d'incauto agnello, o di men presta lepre
forse viene a lavar il lupo infesto.
presso le fosse limacciose in magro,
ma pur culto terren, che intorno serra
bassa muraglia di rottami, e sassi,
qualche spica biondeggia, ove dimora
d'infausto augurio il turpe augello, e il gufo.
Ma sparve alfin l'orrido scoglio, e sorge
fragrante, e chiaro-ombrifero boschetto,
che offre nel proprio seno ai cittadini, (b)

— XIII —

ed alle oneste donzellette accese
sicuro asilo, che d'intorno investe
la vergin rosa, il vago giglio abbella,
e la quercia ricopre, ove sciogliendo
flebile tenerissimo ussignuolo
dolce canto d'amor, amore inspira.
In due divide la boscaglia retto,
e ben lungo cammin, ove lassiva
la molle erbetta, e i vario-pinti fiori
grato-olezzando guidano le piante
in rustica magion, che a caro prezzo
su rozzo desco al passagger dispensa
scarsa insipida mensa; a Te Tu stesso
niega la soglia, ai mal-accorti aperta;
segui l'orme de' saggi impresse, o Amico,
sopra il destro cammin, che fra spugnosi
rottami, e sassi ammontichiati appena
lascia libero il varco..... Ecco da lunge,
negri tuguri, a cui più negre canne
coprono il tetto .... ti rallegra,.... è presso
la desiata Grotta, ove NATURA
fa in silenzio di Se pompa sì nota.
Videla un giorno disadorna, brutta,
ed orrida così, che in cor le mosse
tema, e pietà, chiamò sua possa allora,
e il tetro orrore d'abbellir risolse;

— XIV —

il forte Veglio apportator degli anni
secco all'opra s'unì; nel cielo alzosse
alto bisbiglio fra i Superni, e v'era
chi oppor volea,.... ma Giove allora (il solo
bilanciatore del comun destino),
agrottando l'austero sopracciglio
fè gli audaci tremar, e l'aureo freno
cauto pria raccogliendo, il guardo volse
indi a mirar l'ardimentosa impresa.
NATURA intanto dai vicini monti
l'acque raccolse, e ne formò torrente,
che sull'erbe spargendosi, e sui fiori,
come verme il terren corrose; o quale
veggiam tallor entro sospesa conca
mezzo, ricolma di minuta sabbia
a goccia, a goccia dal pertuggio angusto
della conca cader il sopra-posto,
ed abbondante liquido elemento, (c)
tal per le vie, che si formò serpendo
fra il docile terren, parte dell'acque
giunse nel vacuo della grotta informe,
ove sul sasso sitibondo, e pregno
d'alcali, e sali nel cader a stilla
a mezzo il corso s'arrestava, e forma
perdendo di liquor; di sale, e sasso
prendea l'aspetto, e la sostanza amara;

— XV —

indi altra stilla ricadendo, e cento,
e mille ancor, come la prima tutte
si trasformaro in solido elemento,
così il marmo di se maggior si fea,
e della grotta s'adornava il tetto.
Altra parte dell'acque in un raccolte
obbedienti alla tendenza prima,
che al centro universal lor diè NATURA,
scese fin nel profondo, u' ferri, e marmi,
e piante, e quanto ivi trovò, converse
in strumenti all'impresa: insinuata
nelle fibre del marmo, e i pori angusti
del dissimil metal, novella forma
al marmo diede, ed al metallo, e solo
degli arbori serbò l'antico aspetto;
forse perchè Le piacque allor formarsi
sotterraneo amenissimo giardino
non visto ancor, che il gran Compagno all'opra
d'ime piriti simili all'erbette
ornò, e di stalatitici fioretti,
cui mentre il guardo uman stupido mira
l'anima cede al lusinghiero incanto,
che fra i mortali non s'arresta solo,
ma sale in cielo a ridestar nei Numi
l'invide fiamme, mentre il Dio tonante

— XVI —

per stupore inarcando il sopracciglio
coll' Artefice immenso si rallegra.
Ferma, auriga i destier: scendiamo, Amico,
ecco l'ima spelonca .... un freddo orrore
serpe per l'ossa in rimirarla .... un' arco
immenso, e cieco allo spettacol vago
l'addito schiude; il rozzo condottiero
ignee scentille accoppia alle recate
faci, e discende ardimentoso innanzi,
poichè il costume, ed il ferrato cuojo,
che il dotto piè gl'investe, lo assicura.
Silenzio impenetrabile, profondo
rende sacra la soglia .... i vasti massi,
la densa oscurità, la strada incerta
fanno orrendo l'albergo, ove di luce
a poco, a poco un raggio vincitore
torna agli oggetti ésistenza, e forma.
Sotto l'arco magnifico, di cui
invan desìo d'investigar ti punge
i cardini robusti, ove s'innalza,
(che il non premuto suol scendendo il vieta)
ampia sala si estende, ove colonne
maëstose s'erigono fuggenti
sostenitrici le sublimi volte,
che fuggono con lor, talchè tu vedi
rinovellata del Roman Teätro

— XVII —

l'involubile scena, e l'ardua forma,
che Berga ancor conserva a Noi perfetta; (d)
illusiön sollecita sen vola
l'inganno a persueder, che all'alma arroca
quelle, che in Lei destan le mobil fibre
dai fidi sensi in lor trasmesse idèe:
di tombe, di velami, addobbi, e freggi,
e fra i pilastri della doppia scena
di statue, di mortai, di Dei l'immago.
Ma per torto cammin sdruscito, e augusto
ci attende il condottiero, il saldo braccio
sostegno offrendo .... io nol rifiuto, e passo.
Deh! che vegg'io?... dove siam giunti?...
è questa
d'Agamenòne la magion sublime,
o de' Titi la Reggia, e de' Neroni?!...
che mai ridir, se attonito rimane
l'occhio, nè val tutte a veder le parti
della sala superba?.... I muri intorno
ricchi son di rabeschi, e di fiorami,
di statue, guglie, candelabri, e tombe
è smaltato il terren; d'armi, di gruppi,
d'archi, d'addobbi ricoperto il cielo.
In due divide la gran sala immenso
macigno gigantesco oltre l'usato,
(somigliante a vastissima colonna)

— XVIII —

diviso ei pur, che parte il suol profondo
al cielo, e parte il ciel rimanda al suolo;
e questa sembra equilibrata in alto
da equin capello, ed ondeggiar, ma invano
smuover la tenteria Sterope, e Bronte;
d'intorno in ispiral giro strumenti,
fiorami, e statue lo scolpiscon tutto,
talchè il vanto con lor, su cui scalpello
segnò de' Daci, e Marcoman le stragi
sacri a Trajano, ed Antonin, contrasta.
L'esperto intanto condottier divide
senz'ordine quà, e là l'aride paglie,
e non visto l'accende .... oh! quale sorge
improvviso spettacolo soäve,
che il vasto immaginar rapisce, e vince!
Gotici vasi, candelàbri Egizj,
arbori, guglie, tripodi, ed orchestre
tutti appàjon distinti: osserva, Amico,
là quella siepe, che ricorda il verno
dellorator degli onor sui, che il padre
dell'erbe Aprile prodigo dispensa.
Vogliti, e mira quell'enorme sasso,
che eminente torreggia, e il sopra-posto
Gotico pedistal, ove furente
l'immagine del Nume arci-tonante
siede impugnando le saette, e i dardi;

— XIX —

stagli il tripode appresso, su di cui
l'ardita guida aride canne accese,
che il furore del Dio fanno più vivo;....
già la vendetta sull'altera fronte
stà pinta; e i lumi, altrove volti, in petto
ti raddopian l'orror, mentre la manca
i fulmini afferrati al *vicin foco*
accende, e insorabile la destra
un ne scieglie, lo impugna, e il corpo tutto
di sterminare, e di vibrarlo è in atto.
Ferma, Giove, che fai?... sospendi l'ira....
Noi t'adoriam prostesi al suol .... ma folle,
ch'io son!... è un sasso senza vita, e moto,
che moto, e vita fantasia gli diède.
Scemano intanto delle poche paglie
le *brillanti faville*, e come manca
dalle fiamme il chiaror, la forma gaja
sfugge pur degli oggetti, e resta solo
qualche traccia di lor, come di luce,
che ammorza, e vince il redivivo orrore.
Di quì si và per tortuöso, ed erto
calle, che guida ad alto scoglio in vetta;
ma pria vedi a sinistra spaventoso
antro profondo, interminal, bujo,
ove son volte le vestiggia, e d'onde
orma impressa non v'è; forse, che il primo

— XX —

della Tracia il Cantor l'avria stampata,
se più severo, ed amoroso meno
serbava il giuro; e non cedeva ai dubbj.
A destra il monte, lacerato il fianco,
offre altra via, che a quella vetta è duce.
Possente, incomprensibile NATURA,
quanto nell'opre tue sei grande, e Dea!...
Più vasta ancor di quante in pria si mostra
reggia, sull'atrio a cui stan due macigni
immensi, e negri a custodir l'ingresso.
Passi fra loro, e lunghe arcate, ed ampie
volte, portici, loggie osservi, e quindi
dupplicate colonne, alti colossi,
armi, trofei, vestiboli con quanto
vasto pensier può immaginare, od arte
dottamente eseguir: sulle pareti
al tulipan vedi la rosa accanto
riprendere il natio niveo splendore,
che tal fu un dì pria, che Ciprigna bella
col suo sangue cangiasse i suoi colori;
e se t'alletta, impunemente puoi
strapparla, Amico, or che la *vigil* spina
cangiò NATURA in sasso innocuo, e rude.

Ma il nostro duce, odo gridar,... venite
Ecco il confine .... malagevol varco

— XXI —

ivi conduce; angusta è l'ardua cima,
e tetra sì, che in sen palpita il core.
Da lungi vedi, come torre eccelsa
dell'imo fondo dell'orrendo abbisso,
che sotto i piè ti si spalanca, alzarse
colossale magnifico cipresso,
a cui cento minor fan serto, e omaggio;
tale solean di Marte in campo un giorno
mille rocche inferior, tratte sul dorso
de' tardissimi punici Elefanti,
alla rocca maggior del Duce sommo
prestar difesa, ed intrecciar corona.
L'arco, ed il ciel, che di cader minaccia,
nè *mai* cadranno per girar *di lustri*,
di coni giganteschi alto-profondi
son ricoperti, a cui la punta acuta
ver l'imo, e all'alto l'ampia base, è volta;
così tallor nel freddo verno osservi
pender da'tetti *diafano splendente*
gruppo di gelo, che il divino raggio
pria *dalla neve in bianco umor disciolse*,
e il notturno rigor, mentre cadea,
cristallizzato in aghi lo converse ....
Se parli; un'eco spaventoso, e basso,
rombando intorno per la cava fossa,
le tue voci ripete, e al cor di porta

— XXII —

nuovo terror; se mai deslo ti pugne
un macigno scagliar nel caos immenso
della vorago interminabil, sorte
tanto orrendo fragor, mentr'ei discende
precipitosamente ruotolando,
che inorridisce l'anima, e rifugge,
mentre l'aere densissimo commosso,
pregno d'*atra mofeta*, e basso puzzo,
il volto offende, e la brillante fiamma
delle facì minaccia: intanto sempre
fragoroso precipita il macigno,
ove sicuro il piede uman non giunge,
che all'occhio indagator NATURA avara,
quì impose, e non a Se confin preciso;
quì imponiamlo noi pur .... benchè deh! quanto,
il veloce pennello trascorrendo,
sul quadro informe dì tracciar commise!
e quanto a pinger resteria!... ma invano
l'estro mi punge di seguir, che il basso
invincibile orror le chiare tinte
oscura, e arresta le pittrici idèe.

— XXIII —

NOTE.

(a) Il compagno di questo viaggio fu il sig. *Nicola Zograffo*, Greco di nazione, che vestiva secondo il costume del nostro paese colle lane del suo.

(b) Egli è amenissimo, ed i signori di Trieste vanno a godere sovente della sua amenità nelle giornate festive.

(c) Si disse *liquido elemento*, come si dirà poco innanzi *solido elemento*, per intendere acqua, e terra; il genio fisico è pregato a compatire, se sol per questa volta si è adoprata una perifrasi, che ricorda i rancidumi, e gli errori dell'antichità; per noi conveniamo coi dogmi novelli, e rinunziamo agli elementi.

(d) Così detta è Vicenza dai monti Berici, che vagamente la circondano; in essa vi è il famoso Teatro Olimpico *sull'architettura degli antichi* Romani.

(e) Queste due famose colonne esistono in Roma; quand'anche fosse spogliata di tutti i suoi sublimi avvanzi d'antichità, basterebbero esse solo per ricompensarne le perdite, ed eternarla; bisogna vederle per esserne convinto.

VILENICA, JAMA CORNIALE IMENOVANA

(prevedla Nadja Adam)

IX[3]

Milina, dneva znanilka, ter mati
iz rožnate zakonske postelje k ljubimcu staremu
odhiti, in se bleščeča zavihti na temno obzorje: temačne
goste izparine, in iskreče se zvezde
pred žarkom bežijo, ki sledi jim, in jih premaga.
Mirne sanje prežene
božji Prijatelj, in jim dovoli v miru, (a)
v globoko se sotesko vrniti, sedaj ko z
zoro ponovno sonce vzide, in z njo opravi tako, kot ona
le-to stori z nočjo in zvezdami nestalnimi.
In že na tvojem pragu uzde brzdajoč,
in s kopiti nepotrpežljivo zemljo udarjajoč,
ogrski tekači, in zlobni kočijaž
Tebe, brezobzirnosti in nemarnosti, obsoja,
da raskavo kladivo na visoke zvonove
drgetajoč udarja in oznanja čas,
ki določil si ga ob odhodu svojem: nestanovitna sapica,
ki naokrog glasno šumenje trosiš,

X

nežno mu ga k ušesu vodi,
in ga za mene, ki njegovega sna ne
upam si motiti, zbudi; .... toda na koncu odpre
se nemi prag .... in mehka mirovanja
dokončno odžene, in grška roka ponudi ti
v češkem kristalu ameriške pene, ujete in pomešane z mlekom svežim;
ti jih zavrneš, in iz lenega puha
odskočiš, nogo navajajoč na mehko
angleško usnje in atiško volno na oblike
zahtevane noše evropske. (a)
In že vse je pripravljeno; tudi Ti, pridi,
povzpni se spredaj na ozek voz, da prevzvišeni
vladar uzd, iskrim konjem
zavestno znak odhoda da.
Končno se potuje, in urni plemeniti konji
naglo pot požirajoč, prispejo tja,
kjer na neobdelanem travniku zelenem, gora kvišku se dviguje,
in bolj ko se tako strašna vzpenja,
manj plodna postaja; kjer mislim jaz,
da samo koristni Cereri, Pomoni lepi
navkljub, vidiš vijolico
celo pognati ali breskev rumeno,
katerih seme je s travnikov nemirni severnik
na krilih prinesel in tukaj ga odložil.
Toda premagana je strmina brezobličnega hriba

XI

kjer široki vrh pogledu sladko nagrado
po strašni poti nudi,
in z leve vidi peniti se slano,
neizmerljivo tekoče obzorje,
po katerem, nebu neznanem, drsi
na tisoče in tisoče ladij, naloženih radostno
s tovorom uporabnim in blagi nenavadnimi,
mesto zlato, ki ob morskem valu Jadrana
brzda svoj ponos, spreminjajoč se v lepo in bogato.
Na desni travniki cvetoči, in mehki,
griči obdelani, vrtiči ljubki,
njih lepota Nebu nasmeh izvablja,
oh, brezštevilni so dvorci, bivališča, hiše,
strehe, in vinogradi, katere občudujoči pogled
vidi kot sto hišic zbranih,
in klije rodovitna zemlja,
kot klijejo poganjki in cvetlice,
tako da tvoj Arno, prijazna gospa,
kraje, in njih plodno okolico,
v njih prepoznavam, o katerih pel je tako
učeni plektronom Homer iz Ferrare.
Toda koristni Ocean, prijetni grič
očem je lahek bil korak, in poln
sopihajočih konjev, ki si v planino
pot utirajo, kjer delovna roka
vlažno kamenje v ilovico spreminja rodovitno;

XII

ne odkrije več, čeprav pogled pazljiv
anten visokih, in stolpe vzvišene
na nebu izginjajočem išče, in zbeži
iz lombardskih Apeninov, in iz zasneženih
Alp grobo lice si podjarmi.
Sedaj vse je groza, niti za urni pobeg
tesnoba ne prestane, kjer Narava hoče
utišati utrip srca,
in zaustaviti obtok krvi.
Med skalami planinskimi, in neenakimi gorami
najdeš brezna široka, kjer zaustavlja se
tekočina čista, in deževje dolgotrajno,
predvidelo je nje shrambo, k njej žejen
tekom dneva z volom sopihajočim,
pastirček hiti, medtem ko ponoči
druge čeljusti, še vedno s krvjo nepazljivega
jagnja ali manj hitrega kunca zamazane,
mogoče pride umit si osovraženi volk.
Poleg blatnih brezen in suhe,
toda vseeno grude rodovitne, ki zapira jo
nizek zid razbitin, in kamenja,

kakšna bledorumena breskev, kjer prebiva
grd ptič zlosrečnik ter čuk.
Končno izgine pečina grozljiva, in pokaže se
dišeč, svetlo senčen gozdič,
ki v svojih nedrjih meščanom, (b)

XIII

in poštenim gospodičnam varno
zatočišče prižge, ki okrog ga oklepa
vrtnica nedolžna, ljubka lilija krasi,
in hrast pokriva, kjer pojoč
tožeči slavček občutljivi
sladko pesem ljubezni, ljubezen navdihuje.
Na pol razdeli goščavo ravna
in dolga pot, kjer spolzka
vlažna tratica, in cvetlice vseh barv
prijetno dišeče vodijo rastlinje
v podeželsko hišo, kjer za drago ceno
na neotesani mizi, popotniku razdele
boren obed plehak; Sebi Ti sam
prestopiti prag prepoveduješ, kateri neprevidnim je odprt,
sledil stopinjam sem vtisnjenim, oh Prijatelj,
nad desno potjo, ki med gobastimi
razvalinami in kamenjem naloženim,
komaj prost dohod dopušča ... In glej, od daleč,
črne bajte, katerim še bolj črno trsje
pokriva streho ... te razvesele, ... in poleg
željene Jame, kjer NARAVA
v tišini delujoč baha se kot se opazi.
Videl sem jo nekega dne brez okrasa, grdo
in tako grozljivo, da v srcu strah je prebudila,
in usmiljenje, poklicala je torej svojo moč
in mračno grozo, da od olepšav jo odreši;

XIV

mogočni čuvaj, leta prinašajoč
s seboj, se s stvaritvijo je združil, v nebo med višave
se je dvignilo glasno šepetanje, in bili so tisti,
ki upreti so se hoteli, toda ... Jupiter takrat (edini
naše skupne usode uravnalec),
obrv strogo je nagubal,
ter predrzne še prestrašil, ko zlato uzdo
pazljivo poprej je zategnil, in pogled zatem
v občudovanje drznega dejanja usmeril.
Narava pa medtem je z bližnjih gora
vode združila, in jih v potok oblikovala,
ki po travi se razlil je, in po cvetlicah,
ki kot črv zemljo je prežrl, oh, koliko
tekočine je takrat v visečo,
z drobno mivko zapolnjeno kotanjo zlil,

in kapljo za kapljo skozi ozko odprtino
iz kotanje v prostor spustil,
in obilica tekočega elementa, (c)
tako po poti, ki ustvarila se je vijoč
prek voljnega terena, del vode
prispel v praznino jame je brezoblične,
kjer na kamen žejen, prepojen
z lužninami, solmi , kapljajoč
v sredino toka se je ustavil, in obliko
izgubil zaradi tekočine ter soli, in kamna
videz ter snov grenka sta postala;

XV

odtlej še ena kaplja je padla, in sto
in tisoč še, tako kot prva vse
so v trden element se spremenile,
tako marmor vse večji je postajal,
ko strop z jamo se je zaljšal.
In druge vode v eno zbrane
poslušne prvotni težnji,
katerih vesoljno središče je NARAVA,
spustile so se vse do globin, železa, marmorjev,
rastlin, in kar tam so našle, izpremenile so
v orodje preoblikovanja: počasi vtisnjena
v vlakna marmorja, in v pore tesne
neenakih kovin, novo obliko
marmorju, kovini so dala, in samo
drevesom prihranila so stari videz,
mogoče, ker takrat všeč bilo jim je oblikovati
podzemni dražestni vrt,
nikoli še viden, katerega veliki Stvaritelj
je na dnu s piriti podobnimi dišavnicam,
okrasil, in kapniškimi cvetlicami,
katerim medtem ko jih presenečeno človeško oko občuduje (opazuje)
duša prepusti se laskavemu čaru,
in ne ustavi se samo med smrtniki,
temveč v nebo se vzdigne prebuditi ponovno pri Numih
plamene zavidanja, medtem ko Bog grmeč

XVI

zaradi začudenja čelo nagrbanči,
se s Stvarnikom razveseli.
Vstavi, jezdec konje: spustimo se, Prijatelj
v globoko jamo .... mrzla groza
se po kosteh ob snidenju ponovnem vije .... obok
neizmerni, slep ob predstavi blodni,
odpre, grob poveljnik
goreče iskre z nosečimi bakljami
združuje, in spušča se smelo naprej,
ker obleka in usnje okovano,

ki nogo izkušeno mu obuva, ga pomirja.
Nedostopna globoka tišina
za svetega prag naredi .... velikanske skale,
gosta tema, negotova pot
gostišče v groznega spreminjajo, kjer luč
malo po malem z zmagovalnim žarkom
vrne stvarem bistvo (obstoj), in obliko.
Pod čudovitim obokom, kateremu
zaman spodbode te želja raziskati
temelje trdne, kjer se vzdiguje,
(ker nestisnjena tla prepovedujejo jim spust)
velika dvorana se razširi, kjer stebri
veličastni dvigujejo se hitro
podpirajoč vzvišene oboke,
ki z njimi bežijo, kar tukaj vidiš
ponovljeno rimskega gledališča

XVII

nespremenljivo sceno, in ostro obliko,
ki jo Berga za nas še popolno hrani; (d)
iluzija nehote zmoto
v prepričanje spodbuja, da duši dodeli
tiste, ki v njej prebude gibljiva vlakna
iz zanesljivih občutkov in vanje ideje zanese
o grobovih, zastorjih, okrasih in frizih,
ter med stebri dvojnosti
kipov, možnarjev, bogov podob.
Toda vzdolž zavite poti, razdrapane ter ozke
nas vodnik pričakuje, trdno roko
v oporo ponuja .... jaz je ne odbijem, in mimo grem .
Oh! Kaj vidim jaz? ... le kam smo prispeli? ...
in ta
Agamemnova prevzvišena palača,
oh, Titov Reggia in Neronov?! ...
kaj reči, če oko osuplo
obstane, so vredni ogleda ostali deli
dvorane sijajne? ... Okrog zidovi
polni so arabesk, cvetja,
kipov, obeliskov, lestencev in grobov
ter tla kot steklo; grbov, skupin,
lokov in okraskov nebo je polno.
Na dela dva deli neizmerno dvorano
skalina velika neobičajna,
(podobna stebru širokem)

XVIII

ki sama je deljena, ker del nje dviguje se iz globin
v nebo, in del nebo pošilja nazaj na dno;
in le-ta na vrhu izgleda uravnovešena
s konjsko grivo, in nihajoč, toda zaman

premakniti jo je skušal Sterop, in Bronte;
okrog pa polžasto zavita glasbila,
cvetlice in kipi popolnoma izklešejo jo,
tako da z njimi bahanje, na dletu katerih
znaki Dacijev, Markomanov pokoli
svetega Trajana, in Antonina, v nasprotju je.
Izkušeno medtem vodnik brez reda
sem ter tja razdeli, slamo suho,
in nevidno prižge ... oh! in vzdigne se
nenadoma predstava mila,
ki brezmejno domišljijo ugrabi, in jo premaga!
Vaze gotske in lestenci egipčanski,
drevesa, konice, trinožniki, in orkestri
vsi se drugačni predstavijo: poglej, Prijatelj,
tjakaj tisto živo mejo, ki spominja na zimsko
defloracijo njegove časti, ki jo April,
oče trav, v izobilju podeljuje.
Obrni se, in poglej tisti kamen gromozanski,
ki prezvišen kvišku kipi, čez njega pa
gotski piedistal je položen, kjer besna
pojava numena strašno grmi
in sedeča, v roki strele in puščice drži;

XIX

tripod je ob njem, na katerega
drzni vodič brezčutne strelice usmeri,
ki bes Boga še bolj okrepijo; ...
že maščevanje na čelu ošabnem
se zariše, in svetila, drugam obrnjena, v prsih
podvojijo ti grozo, medtem ko levica
strele ujete v bližnjem ognju
prižge, in desnica privošči si
eno izbrati, v pest jo stisne, in celo telo
k pokončanju in vihtenju se pripravi.
Ustavi se, Jupiter, kaj počneš? ... jezo umiri ...
Mi, pri tleh živeči, te častimo ... toda nor,
sem jaz! ... to samo kamen je brez življenja, in gibanje,
le kakšno gibanje, ter življenje, mu domišljija je vdihnila.
Medtem pa moč izgubljajo osamljenih slamic
iskre žareče, in kot plamenu
sij primankuje, tako oblike bogate
predmetom bežijo, in ostaja le
kakšna njihova sled, kot od luči,
ki jo uniči ter premaga, na novo oživljena groza.
Tu skozi se gre po vijugasti, strmi
poti, ki vodi nas na vrh do pečine,
poprej pa na levi zloveščc zagledaš
vhod globok, brezkončen, temačen,
kjer obrazi so sledi, in kjer
sledi vtisnjene se ne vidi; mogoče prvi

XX

iz Trakije pevec jo je opeval,
če bolj strog, in manj ljubeč
ohranjal je obljubo, in dvomom ni popuščal.
Na desni gora, razgibano pobočje,
drugo pot ponuja, ki k vrhu tistemu je vodnik.
Mogočna, nerazumljena NARAVA,
kako velika si v dejanjih svojih, o Boginja! ...
Še bolj obsežna kot postavlja se palača
kraljeva, v predverju kolosa dva postavljena (e)
velika in črna, ki vhodu sta čuvaja.
Mimo grem pod dolgimi oboki, lože si ogledam,
dvojne stebre tudi, visoke kipe,
orožje, trofeje, veže in vse kar
bujna domišljija lahko si predstavlja, ali umetnost
učena izpelje: na stenah
vidiš poleg tulipana vrtnico
pridobiti si prvotni čisti sijaj,
ki takšna bila je že dan poprej, kateri Venera prelepa
s krvjo svojo izpremenila ji barve je;
in če mika te, brez kazni
jo utrži; Prijatelj, sedaj ko trn varujoči
Naravo je v nedolžno in surovo skalo zbodel.

Toda voditelja našega, kričati slišim, ... pridite
Tukaj je konec ... težaven prehod

XXI

nas tja popelje; ozek vrh in strm
ter mračen, da, v čigar nedrjih srce bije.
Od daleč vidiš, kot stolp visoko
iz dna globokega in grozljivega brezna,
ki pod nogami odpira se, kvišku iti
čudovito cipreso velikanko,
kateri sto manjših okrog plete venec v poklon;
takšne prinesli so z Marsa nekoč
na polje tisoč manjših kamnov, noseč jih
na hrbtih sloni punski okorni,
da skali največji voditelja prevzvišenega
nudijo obrambo v venec se spletajoč.
Obok in nebo, ki pasti grozita,
a zaradi gibanja zvezd nikoli padla ne bosta,
s svečami velikimi, visoko-globokimi
sta pokrita, katerih ostra ost
se z globino spogleduje. In na vrhu široka ploščad, ki obrnjena
je tako, da v mrzli zimi lesketajočo prozorno družbo ledu,
s strehe visečo, opazuje, kako božji jo žarek
poprej v belo tekočino iz snega raztopi,
in nočni mraz med spuščanjem svojim
v kristalne puščice prelevi ...

Če izpregovoriš, grozljiv odmev, globoko
po jami in breznih zahrumi,
tvoje glasove ponovi ter srce ti zopet

XXII

z grozo napolni; če le kdaj želja te spopade,
v kaos neizmerni se podati,
deležen boš brezna brezkončnega,
trušča mogočnega kateri, ko spuščal se bodeš
naglo kotaleč, napolnil ti z grozo bo dušo,
medtem ko zrak gost in ganljiv,
nasičen s kužnimi hlapi, rahlo zaudarjajoč,
obraz žali, in plamen žareči
bakljam grozi: medtem pa še zmeraj
bučno se spušča skalina,
kjer varno ne prispe človeška noga,
ki očesu raziskujočem NARAVA skopa,
se tukaj vsili, in ne premore meje točne;
kar mi jo začrtajmo ... čeprav, oh!
koliko,
hitri čopič po sliki brezoblični
švigajoč pustil je sledi!
in koliko je še ostalo nenarisano! ... toda zaman
zanos spodbuja me k nadaljevanju, ko globoka
nepremagljiva groza barve svetle
potemni, in slikarju ideje zaustavi.

OPOMBE [4]

(a) Tovariš na tem potovanju je bil g. Niccola Zograffo, Grk po narodnosti, ki se je oblačil po običaju naše dežele, vendar v grška blaga.

(b) Kraj je zelo prijeten, in tržaška gospoda ob prostih dnevih često uživa v njegovi prikupnosti.

(c) Z uporabljeno besedo tekoči element in kasneje uporabljena beseda trdi element, sta mišljena voda in zemlja; genij fizike naj mi oprosti, če sem v tem primeru uporabili opis, ki spominja na staro šaro, in napake antike; kajti strinjam se s sodobnimi dogmami, in se odrekam elementom.

(d) Tako poimenovana je Vicenza po hribovju (Monte Berico), ki jo obkroža in kjer se nahaja znani Teatro Olimpico s staro rimsko arhitekturo.

(e) Ta dva znana stebra obstajata v Rimu; če bi Rim oropali vseh njegovih antičnih zakladov, bi ta dva stebra nadomestila izgubo in ga kljub temu ovekovečila. Človek ju mora videti, da se prepriča.

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[1] *Catalogo deglo incliti ed eruditi ed valorosi pastori e pastorelle arcadi dell'inclita adunanza letteraria di arcadia sonziaca, colonia della insigne arcadia romana.*

[2] *Baronica Voinovich je dejansko živela kar dokazuje oglas v "L'Osservatore Triestino", 15.7.1818.*

[3] *Številka strani navedena po originalu.*

[4] *Opombe kot jih je na koncu pesnitve navedel sam avtor.*

PESEM O VILENICI

Leta 1802 je dr. Francesco Trevisani napisal pesem "La Grotta di Vileniza, detta di Corniale", ki jo je natisnila tiskarna Gasparo Weis v Trstu na 23 straneh knjižice malega formata. V knjižnici Biblioteca Civica v Trstu hranijo le zgoraj omenjeno delo tega avtorja, o njem ne obstajajo biografski podatki, tako da o samem avtorju lahko povemo le tisto kar je možno razbrati iz knjige. Trevisani nam na tretji strani knjige pove, da je med člani Akademije arkadijcev v Rimu bil znan pod imenom Algindo Epireo. Akademije so v Evropi, predvsem pa v Italiji, nastajale od 14. stoletja dalje, zlasti so se razmahnile v času humanizma in renesanse (Accademia della Crusca, dei Lincei, pri nas Accademia Operosorum...). Akademija arkadijcev (Accademia degli Arcadi ali Arcadia) je bila ustanovljena leta 1690 v Rimu kot kulturno zbirališče in torišče literatov in izobražencev ter z namenom, da prečisti književni stil, ki ga je pokvaril italijanski seicento (doba baroka in marinizma). Arkadijci so imeli navado nadeti si grški ali pastoralni psevdonim. Razcvet akademije je trajal do sredine 18. stoletja, nato pa je začel z uveljavljanjem romantike in s svojim poveličevanjem psevdopastoralnosti, erudicije in drobnjakarstva naglo propadati.

Akademija je imela je velik vpliv tudi na našem ozemlju, po več krajih je ustanovila podružnice: Ljubljansko akademijo (Accademia Emonina) leta 1709 in goriško akademijo arkadijcev leta 1780.

Med novicami "L'Osservatore Triestino" iz dne 8. novembra 1802, št.90 omenja slavnostni zbor rimsko-goriško-tržaških arkadijcev ob priliki odkritja doprsnega kipa predsednika njihove akademije. V čast dogodka so arkadijci recitirali več pesmi napisanih prav za to priložnost, vendar na žalost avtorji niso navedeni. Seznam članov goriške podružnice, ki ga hranijo v Archivio Diplomatico e Storico v Trstu zajema le obdobje med leti 1780 - 1791, med njimi pa dr. Trevisani ni omenjen [1].

Trevisani je pesnitev posvetil baronici Mariji Voinovich, rojeni Del Rosso [2], kateri je namenil tudi uvodno pesem v devetih kiticah. Pesnitev je sestavljena iz 351 svobodnih verzov, je neke vrste miselna poezija, ki je po večini patetična in brezosebna. Kot sam Trevisani v neposrednem sporočilu bralcu pravi, nikakor ne more doseči čudoviti Compagnonijev epos (op.p. iz leta 1795), vendar si je zaradi posebnih okoliščin, jamo v obliki pesnitve dovolil opisati tudi sam. Pesnitev na katero me je opozoril dr. Shaw in na čigar pobudo je pravzaprav nastal pričujoči slovenski prevod pesmi, ki opisuje pot skozi podzemlje, ki s svojo lepoto očara, s svojim neizmernim breznom prestraši in vedno znova privlači. V prevodu, ki ne zajema Trevisanijeve uvodne besede ter uvodne pesmi temveč samo osrednjo pesnitev, sem se skušala držati originala pa vendar jezik iz začetka 19. stoletja približati današnjemu bralcu.

Jama Vilenica pri Lokvi je najstarejša turistična jama v Evropi, saj jo obiskujejo turisti že od leta 1633, ko jo je dal takratni lastnik grof Petač v upravo lokavski župniji. Velik sloves in obisk je doživljala v prvi polovici

preteklega stoletja, v Trstu je celo veljalo nenapisano pravilo, da je vljudno vabiti angleške mornariške častnike v njeno podzemlje. Leta 1816 je jamo obiskal cesar Franc I. Sloves Vilenice je začel bledeti z odprtjem Postojnske jame in kasnejšim odkritjem Škocjanskih jam. Jama je nekoč z barvitimi kapniki različnih oblik in prečudovitimi kapniškimi zavesami močno burila domišljijo obiskovalcev in tako navdihnila tudi dr. Trevisanija, da je svoje občudovanje preliv v pesnitev.

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EMILE G. RACOVITZA AND HIS IMPORTANT ROLE IN SPELEOBIOLOGY

VLOGA IN POMEN EMILA G. RACOVITZE V SPELEOBIOLOGIJI

EDE BARABÁS [1]

Izvleček UDK 57:551.44(091):929 Racovitza E.G.
Ede Barabás: Vloga in pomen Emila G. Racovitze v speleobiologiji

Emil G. Racovitza (1868-1947) je poleg prava študiral tudi geologijo in zoologijo. 1904 je obiskal jamo Cueva del Drach (Mallorca) in odkril novo jamsko žival. To je vzpodbudilo njegovo zanimanje za jamsko favno, ki ji je posvetil vse svoje življenje. 1907 je objavil najpomembnejše delo "Essai sur les problèmes biospéologiques". Z R. Jeannelom je ustanovil revijo Biospeologica. Poleg opisov jamskih živali vsebuje opise stotine jam iz Evrope in sveta, kjer so nabirali jamsko živalstvo. 1920 je ustanovil speleološki inštitut v Cluju (Romunija).
Ključne besede: zgodovina speleologije, biospeleologija, speleološki inštitut, Racovitza E. G.

Abstract UDC 57:551.44(091):929 Racovitza E.G.
Ede Barabás: Emile G. Racovitza and his important role in speleobiology

Emile G. Racovitza (1868-1947) qualified in law and studied geology and zoology too. In 1904 he visited Cueva del Drach (Mallorca) and discovered a new cave animal. This aroused his life-long interest in cave fauna. In 1907 he published his most important paper "Essai sur les problèmes biospéologiques". With R. Jeannel he established the journal Biospeologica. It included, among detailed anatomical papers, descriptions of many hundred caves all over Europe and elswhere, in which fauna was collected. In 1920 he founded Institute of Speleology, at Cluj (Rumania).
Key words: history of speleology, biospeleology, speleological institute, Racovitza E. G.

[1] Revärgatan 5, S - 25461 HELSINGBORG, SWEDEN



The portrait of Emil G. Racovita
(from Livre du centenaire Emile G. Racovitza 1868-1968).

Emile G. Racovitza was born on 15 November, 1868 in Iasi and there he studied at the primary school and comprehensive school. When he was nineteen years old he started at the Paris University. There he finished the study of law in 1889 because he wanted to carry out his father's wish. He studied also geology, anthropology and zoology at the same time. It was in 1891 when he finally took the state examination in natural science.

Later, in 1897, he took part of the Antarctis Expedition on the ship "Belgica". Roald Amundsen, who discovered the South Pole few years later, was also between the members of the expedition.

On July 13th 1904 Emile Racovitza was invited by Odon de Buen to the island of Mallorca where he visited the famous cave "Cueva del drach". It was there that he discovered a small, blind animal which they described together under the name of *typhlocirolana moraguesi.*

This aroused his life-long interest in cave fauna and a wide literature search resulted, in 1907, in his most important paper "Essai sur les problèmes biospéologiques". This long and fundamental paper established biospeleology (he called it "biospeology") as a science, emphasized its importance and set out a plan for future work. In a paper, published in Paris few years later, Racovitza's student René Jeannel, stated about the mentioned paper: "Le premier mémoire de se périodique, Essai sur les problèmes biospéologiques par Emile G. Racovitza, est encore aujourd'hui le statut fondamental de la biospéologie".

1900 his old professor named Racovitza "sous-directeur du laboratoire maritime ARAGO" at Banyuls-sur-Mer and "co-directeur de la revue Archives de Zoologie expérimentale et générale". Together with his student and colleague, René Jeannel, he established the journal BIOSPEOLOGICA. It included, among detailed anatomical papers, descriptions of many hundred caves, all over Europe (from Carpathians, Dinaric Mountains, Alps and Pyrenees, that is mainly from France, Spain, Slovenia, Romania) and elsewhere (Africa), in which fauna was collected. They worked together with well known cave fauna specialists as Endre Dudich from Hungary and J. A. Birstein from Moscow. The result of their co-operation were "Biospeologica hungarica" and "Biospeologica sovjetica". Between 1905 and 1929 he published 20 papers on *isopoda* only.

With R. Jeannel he established the journal Biospeologica. It included, among detailed anatomical papers, descriptions of many hundred caves all over Europe and elswhere, in which fauna was collected. In 1920 he founded Institute of Speleology, at Cluj (Rumania). Racovitza and Jeannel are not only the pioneers of biospeleology but also very important regarding the international scientific co-operation. So it is not surprising that UNESCO inscribed his name between the great cultural persons to commemorate in the year 1968.

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VLOGA IN POMEN EMILA G. RACOVITZE V SPELEOBIOLOGIJI

Povzetek

Emil G. Racovitza (1868-1947) je doštudiral pravo na pariški univerzi 1889 in do 1891 dokončal tudi študij geologije in zoologije. 1904 je obiskal jamo Cueva del Drach na Mallorci in odkril novo jamsko žival, ki jo je poimenoval *Typhlocirolana moraguesi*. To je vzpodbudilo njegovo zanimanje za jamsko favno, ki ji je posvetil vse svoje življenje. Resno se je poglobil tudi v literaturo in rezultat tega je njegov najpomembnejši prispevek "Essai sur les problèmes biospéologiques" (1907). S tem obsežnim in temeljnim sestavkom je utemeljil biospeleologijo kot vedo, podčrtal njen pomen in predstavil načrt za bodoče delo. Skupaj s študentom in kasnejšim sodelavcem R. Jeannelom je ustanovil revijo Biospeologica. Poleg anatomskih opisov jamskih živali vsebuje revija opise stotin jam iz Evrope in z vsega sveta, v katerih so nabirali jamsko živalstvo. 1920 je ustanovil speleološki inštitut v Cluju (Transilvanija, Romunija).

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ERWÄHNUNG VON HÖHLEN IN MITTELALTERLICHEN UNGARISCHEN URKUNDEN

JAME V MADŽARSKIH DOKUMENTIH IZ SREDNJEGA VEKA

GYÖRGY DÉNES [1]

Izvleček UDK 551.442(439)"14"

György Dénes: Jame v madžarskih dokumentih iz srednjega veka

V srednjeveških dokumentih so omenjene številne jame. Iskanje dokumentov, interpretacija srednjeveških imen in identifikacija prizora ali jame ni lahka naloga. Prispevek opisuje, kako so našli in identificirali jame v prvih takih štirih srednjeveških dokumentih. Samo ena izmed teh jam ima še danes enako ime, kot v srednjem veku: *Pest-kő* je v dokumentu iz 1391 zapisana kot *Pesthkw.* Avtor podrobneje obravnava še *Öreglyuk* (1340), jamo oziroma grič z jamo *Jászói* (Jasovská) kot "lapis concavus seu perforatus" in jamo *Kőlyuk.*

Ključne besede: zgodovina speleologije, imenoslovje, Srednji vek, Madžarska.

Abstract UDC 551.442(439)"14"

György Dénes: Cave References in Medieval Hungarian Documents

The first written references to caves occur in medieval documents. The finding of the documents, the interpretation of the medieval name, the identification of the scene and cave is not an easy task. The paper describes the finding of four such early cave references in medieval documents. Only one of these caves still has its medieval name; the *Pest-kő* name appears in a document dated in 1391 as *Pesthkw.* The author talks in detail of *Öreglyuk* (1340), of the cave or better of the hill with the cave *Jászói* (Jasovská) as "lapis concavus seu perforatus" and of the cave *Kőlyuk.*

Key words: history of speleology, cave names, Middle ages, Hungary.

[1] Borbely u. 5. II/4, HU - 1132 BUDAPEST, HUNGARY

Höhlen waren für Menschen jeden Zeitalters von großer Bedeutung. Seit der Urzeit können Höhlen einen festen Wohnsitz oder ein gelegentliches Obdach bedeu-tet haben und sind ihnen deshalb immer im Bewußtsein geblieben. Im Mittelalter wählte man als Grenzmarken von Grundstücken oder Herrschaftsbereichen gut bekannten geographische Charakterpunkte, wie etwa Höhlen, einen Höhlenfelsen oder Höhlenberg. Jedem war ein solcher Grenzpunkt ein Begriff, denn er war eindeutig und konnte nicht wie ein Pflock oder Grenzstein, oder wie ein Erd- oder Steinhaufen in betrügerischer Weise verlegt werden.

So stieß ich in zahlreichen mittelalterlichen Urkunden auf die Erwähnung von Höhlen, Höhlenfelsen und Höhlenbergen. Die meisten dieser Nennungen wurden bisher in den Urkunden nicht erkannt, da das in der gegenwärtigen ungarischen Sprache allgemein benützte Wort *barlang* im Mittelalter noch nicht mit der Bedeutung 'Höhle' in Verwendung stand. In den Urkunden wurde damals entweder das zusammengesetzte ungarische Wort *kőlyuk*, das wörtlich übersetzt 'Steinloch' bedeutet, oder das Wort *pest* (lese: pescht) verwendet (DÉNES 1973). Das Wort *pest* ist bulgarisch-slawischen Ursprungs und hat sich bereits vor einem Jahrtausend in der ungarischen Sprache eingebürgert (KNIEZSA 1963; DÉNES 1983). Ein Fels oder Berghang, in dem ein Höhleneingang gähnte, wurde *lyukas-kő* (= durchlöcherter Stein) oder *pest-kő* (= Höhlenfels) oder *pest-hegy* (= Höhlenberg) genannt (KISS 1988).

Aber das Wort *pest* hatte in der mittelalterlichen ungarischen Sprache ebenso zwei Bedeutungen, wie das ihm entsprechende deutsche Wort *Ofen* in einigen süd-deutschen und österreichischen Gegenden, wo es sowohl die Bedeutung 'Backofen' als auch die Bedeutung 'Höhle' hat (DÉNES 1985). Da aber das Wort *pest* in deren Bedeutung 'Backofen' in einem der ungarischen Dialekte, und zwar in dem der in Siebenbürgen lebenden Szeklern heute noch benützt wird, und der Ortsnamen *Mészpest* (= Kalkofen) im ungarischen Sprachgebiet mancherorts vorkommt, erkennt die Mehr-zahl der ungarischen Historiker und Sprachforscher nur die Bedeutung 'Ofen' des Wortes *pest* an, wie in Backofen oder Kalkofen. Die Bedeutung 'Höhle' wird nur ausnahmsweise bei einigen Ortsnamen anerkannt (BÁTKY 1925; HEFTY 1911; MELICH 1938).

Jahrelang sammelte ich die Nennung des Wortes *pest* in mittelalterlichen Urkunden und alten Schriften, und suchte danach die so benannten Orte auf. Es waren dies mehr als dreißig Orte im ganzen historischen ungarischen Sprachgebiet, die im ersten oder zweiten Wortteil ihrer Name die Bezeichnung *pest* trugen. Auf Grund meiner Forschungen konnte ich feststellen, daß das Hauptwort *pest*, wenn es in den Namen von Bergen oder Felsen vorkommt auf jeden Fall 'Höhle' bedeutet (DÉNES 1975b). Wenn man bei Bergen auf den Namen *kőpest* (= Stein-Pest) stößt, ist die Bedeutung nicht 'aus Steinen gebauter Backofen', sondern 'Felsenhöhle'; das Wort *pest-kő* bedeutet somit nicht 'für den Bau eines Backofens geeigneten Stein', sondern 'Höhlenfels'.

Die Bedeutung des Wortes *Pest-hegy* ist 'Höhlenberg'; der Ortsnamen *Pestes* bedeutet 'hohl', sowie 'Hohler-Berg', 'Hohler-Fels' (DÉNES 1978; DÉNES 1995).

Gleiches gilt auch für das ungarische Wort *luk ~ lyuk,* welches 'Loch' oder 'Höhle' bedeutet, wenn es in einem Ortsnamen vorkommt, der einen Berg oder Felsen benennt. Meiner Meinung nach bedeutet der Ortsname *Lukas-kő* 'durch-löcherter Stein' (in lateinisch geschriebenen Urkunden *lapis perforatus* bezeichnet) einen 'Höhlenfelsen' (DÉNES 1973) und nicht, wie ein ungarischer Historiker meint, einen Mühlstein der als Grenzmarke an der Grundgrenze aufgestellt war (SZABÓ 1969. 114).

Als Beispiele für die Erwähnung von Höhlen in den mittelalterlichen Urkunden zitiere ich nunmehr vier Objekte, die ich im Rahmen meiner Forschungen entdeckt habe:

1. Der Ortsname *Pesthkw* der in einer Urkunde von 1391 (OL. Dl. 7699) erwähnt wird bedeutet meiner Meinung nach 'Höhlenfels'. An Ort und Stelle stellte ich fest, daß das der Name des im Gerecse Gebirge westlich von Budapest gelegenen Berges Peskő ist, in seinem Hang öffnet sich auch tatsächlich eine geräumige Höhle.
2. Der Ortsname *Kwpesth* scheint in einer Urkunde aus dem Jahre 1340 auf (CAP. STRIG. Lad. 37. Fasc. 1), er bedeutet meiner Meinung nach 'Felsenhöhle'. An Ort und Stelle stellte ich fest, daß er mit jener Höhle im Gerecse Gebirge identifiziert werden kann, deren Eingang sich zwischen den Gemeinden Bajna und Epöl in einer Bergflanke öffnet. Gegenwärtig ist diese Höhle unter dem Namen *Öreglyuk* (= geräumige Höhle) bekannt.
3. Im Jahre 1331 pachteten die Einwohner der Siedlung Szepsi ein beidem Ufer des Flusses Bódva gelegenes Grundstück von der Jászóer Prämonstratenser Propstei. Ein Grenzpunkt des gepachteten Grundstückes liegt am Bódvaufer — aus der lateinischen Urkunde sei die Umschreibung zitiert: *"unus magnus lapis concavus quasi perforatus"* (GYÖRFFY 1963, 100), was in der deutschen Übersetzung heißt 'ein goßer hohler bzw. durchlöcherter Stein'. Nach dem Text der Urkunde nahm ich an, daß dieser Stein wohl ein durchlöcherter Felsenhügel sein werde. Bei der Begehung dieses in der Urkunde beschriebenen Gebietes wurde meine Vermutung bestätigt. Der angesprochene "große hohle durchlöcherte Stein" ist nämlich nicht anderes als der Berghang mit mehreren Öffnungen der wohlbekannten Jászóer Schauhöhle, Jasovská Jaskiňa.
4. Der Ortsname aus einer königlichen Schenkungsurkunde aus dem Jahre 1266 (OL. Dl. 611) hat zu einem interessanten Ergebnis geführt. Als Grenzpunkt am Ufer des gegenwärtig zur Slowakei gehörenden Flüsschens Turóc (Turec) ist ein gewisser *rupes Munuhpest* erwähnt, der bisher nach der Meinung ungarischer Historiker und Sprachforscher als 'Mönchsfelsen, Mönchsberg, Einsiedlerberg' gedeutet wurde (MELICH 1938; KNIEZSA 1963). Ich war der Meinung, daß die Bedeutung des Ortsnamen *rupes*

Munuhpest in wirklichkeit 'Einsiedlerhöhlen-Fels' oder 'Eremitenhöhlen-Fels' bedeuten kann, obwohl in jener Gegend auch in ausführlicheren Landkarten keine Höhlen eingezeichnet waren. Nachdem ich jedoch diese Lokalität aufgesucht hatte, konnte ich die Grenzpunkte des in Frage stehenden Grundstückes klar identifizieren und dort, wo gemäß der Urkunde der Fels *Munuhpest* stehen soll, fand ich am Ufer des Flüsschens Turóc wirklich einen steilen Kalkstein-Felsen Spuren eines Gesteins-abbaues an der Wand. Die Einwohner der nahe gelegenen Gemeinde Harkács (Gemerská Ves) erzählten, daß es dort früher wirklich eine Höhle gegeben habe, die etwa acht Meter lang mannshoch war. Ende der 50er Jahre, wahrscheinlich 1958, ist diese Höhle jedoch bei Sprengarbeiten zerstört worden. Nachdem ich den Ort wieder aufgesucht hatte, kam ich zu der Ansicht, daß durch die Steinbruchsarbeiten nicht mehr als 3 bis 4 Meter Fels abgebaut worden waren und sich deshalb noch ein Rest der Höhle unter der Blockhalde am Fuß der Felswand befinden müßte. Aus diesem Grunde machte ich den Versuch, den Schutt am Fuß der Wand zu entfernen. Nachdem ich mehrere Stunden hart gearbeitet hatte, gelang es mir die Höhle hinter den Felsblöcken zu finden. Es war, wie vermutet, nur der vorderste Teil beim Gesteinsabbau zerstört worden und ich konnte die ersten fünf Meter aufrecht in die Höhle gehen, dann noch weitere fünfzehn Meter gebückt und kriechend vordringen (DÉNES 1975a). Das Ergebnis meiner Feldforschung bestätigt meine Vermutung, daß das Wort *pest* auch im Namen des Felsen *Munuhpest* 'Höhle' bedeutet. Ich identifizierte dadurch nicht nur den in der Urkunde von 1266 erwähnten Höhlennamen, sondern exhumierte auch die Höhle selbst, die ansonsten durch die vom Gesteinsabbau entstandene Schutthalde endgültig verschüttet geblieben wäre (DÉNES 1995). Meines Wissens diese ist jetzt die erste schriftlich erwähnte Höhle in der Slowakei.

Es hat sich gezeigt, daß die Forschung nach Höhlennamen, die in mittelalterlichen Texten aufscheinen keine vergebliche Mühe ist. Denn durch das Erkennen dieser Höhlennamen und die richtige Deutung, kann der Zeitpunkt der ersten schriftlichen Erwähnung dieser Höhlen um mehrere Jahrhunderte früher angesetzt werden, als man dies früher angenommen hatte. Unsere wissenschafts-geschichtlichen Kenntnisse konnten hiemit wesentlich erweitert werden.

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JAME V MADŽARSKIH DOKUMENTIH IZ SREDNJEGA VEKA

Povzetek

V madžarskih srednjeveških dokumentih so omenjene številne jame. Iskanje dokumentov, interpretacija srednjeveških imen in identifikacija prizora ali jame ni vedno lahka naloga. Prispevek opisuje, kako so našli in identificirali jame v prvih takih štirih srednjeveških dokumentih. Samo ena izmed teh jam ima še danes enako ime, kot v srednjem veku: *Pest-kő* je v dokumentu iz 1391 zapisana kot *Pesthkw* (= jamska stena). Ime jame *Öreglyuk* (= velika, prostorna jama) blizu mesta Bajna je bilo zapisano (1340) kot *Kwpesth* (= skalna jama). Jama *Jászói* (Jasovská jaskyna) - danes znana turistična jama na Slovaškem - oziroma skalnat grič, v katerem je jama, je omenjena v dokumentu iz 1331 kot "lapis concavus seu perforatus" (= votla ali preluknjana skala). Jama *Kőlyuk* (= skalna luknja) ob slovaški reki Turóc (Turec) blizu mesta Harkács (Gemerská Ves) je v dokumentu iz 1266 imenovana *Munuhpest* (= puščavniška jama).

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SPELEOLOGICAL DATA IN "THE DESCRIPTION OF THE LAND OF THE SZÉKELYS" BY BALÁZS ORBÁN

SPELEOLOŠKI PODATKI V "OPISU DEŽELE SZÉKELYS" BALÁZSA ORBÁNA

ISTVÁN DÉNES [1]

Izvleček UDK 551.44(439):929 Balázs O.

István Dénes: Speleološki podatki v "Opisu dežele Székely" Balázsa Orbána

Balázs Orbán, "Veliki Székely", je bil popotnik, pisatelj in politik. 1864 - 1868 je prepotoval pet "széks" (okrožij) dežele Székelys (Transilvanija, Romunija) in 1868 - 1873 objavil v šestih knjigah "Opis dežele Székelys z arheološkega, naravoslovnega in etnografskega vidika". V tem opisu in še v enem kasnejšem omenja preko 50 speleoloških objektov v apnencu in drugih kamninah. Jame opisuje, dodaja svoja geološka in hidrografska zapažanja, omenja arheološke najdbe in pripovedi v zvezi z njimi. Ilustracije v opisu so gravure, vendar narejene po avtorjevih fotografijah, kar ga uvršča med pionirje tamkajšnje fotografije. Tako štejemo Balázsa Orbána med odlične predhodnike raziskovalcev jam v Transilvaniji.

Ključne besede: zgodovina speleologije, Balázs Orbán, Transilvanija, Romunija.

Abstract UDC 551.44(439):929 Balázs O.

István Dénes: Speleological data in "The description of the land of the Székelys" by Balázs Orbán

Balázs Orbán, "The Great Székely" was a traveller, writer and politician. In 1864 - 1868 he travelled through the five "Széks" (districts) of the land of the Székelys (Transylvania, Romania) and in 1868 - 1873 he published "The description of the land of the Székelys from the point of view of archaeology, natural history and folk history" in 6 volumes. In this and in one later description he mentioned over 50 caves in limestone and other rocks. He published cave descriptions, geological and hydrological observations, archaeological findings and the legends connected to the caves. Illustrations in his description are engravings based upon the author's own photographs. So he was between the pioneers of the Transylvania photography.

Key words: history of speleology, Balázs Orbán, Transylvania, Romania.

[1] 4023-BARAOLT, str.1 Decembrie 1918, nr.27., bl.6B., ap.5., jud.Covasna, ROMANIA

Balázs Orbán was a traveller, writer and politician. He travelled through the five "Széks (districts) of the land of the Székelys (Transylvania, Romania), between 1864-1868.

During this journey he made scientific and archival research, took notes and photographs and made sketches. Between 1868-1873 he published "The Description of the Land of the Székelys from the point of wiew of archaeology, natural history and folk history", a work in 6 volumes (Orbán, 1868-1873). Later in 1889 he publised "Torda, the town and its Surroundings". (Orbán, 1889).

In all these works the author mentioned or described 33 caves and 3 potholes in limestone, 2 caves in travertine, 2 caves in andesite, 3 caves in andesite agglomerates and 3 artificial defensive caves in conglomerates. He also described 3 karst springs.

During his activity Transylvanian caves researching had just started. Fridvaldszky, Nedeczky, Benkő and Kleinkauf had just mentioned or briefly described the most famous caves (Dénes, 1992). The first important cave research was made by István Fekete, a surveyor in Udvarhely district. In 1835 he explored the cave of Homoródalmás and made a plan of it. This plan was the first to be made in Transylvania and his work was published in Kolozsvár (Cluj-Napoca) in 1836 (Dénes, 1990). Shortly before Balázs Orbán's research journey, between 1858-1862, Adolf Schmidl explored the caves of Bihar mountains (Dénes, 1992).

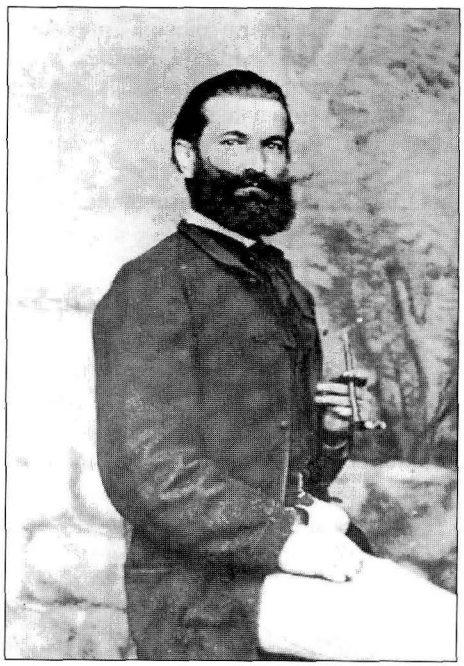


Fig 1: Balázs Orbán (1829 - 1890).

First of all Balázs Orbán's researches were concentrated in the following branches: history and archaeology, folk history and geography. In his geographical description, beside landscape description, demography, economical geography and geology, he showed great interest in cave researching which was scarcely known in Transylvania. He was not an expert in geography but during his travells abroad he learned a lot.

He was an accurate observer. The collected data are accurate, the descriptions are detailed. For all what he saw and experienced he tried to give explanations according to the scientific knowledge of his age. Where he was not to able to manage this, he draw the attention of scientists to that ob-

ject or phenomenon. He published wonderful landscape descriptions, allowing us to learn about the surroundings of the caves, the name of the places, the routes of acces and historical data. He told us about the size of the caves, gave descriptions, geological and hydrologic observations, archaeological findings and the legends connected with the caves.

The cave descriptions are very interesting and he always wrote with great enthusiasm about dripstone formations. The hanging dripstones he called stalactites. Perhaps for the first time in Hungarian speleological literature he used expresions like caving and rope ladder.

Balázs Orbán recognized the importance of photography, a technique which had been just introduced in Transylvania at that time. The photo fixes the reality, but drawings can be inexact. Considering this fact he bought photographic equipment. Taking all this equipment with him, he took a lot of photos and they are important for us for we can see landscapes from last century "Székely Land". We are lucky because a great proportion of these photos has been preserved. The printing technology of that age could not reproduce them, so in his works we see only engravings.

The description of Vargyas-gorge (Cheile Virghisului) and its caves which was near his native land, is detailed; the names of the places, sights and curiosities are presented in romantic style. From his observations he explained the origins of the gorge: the waters of Vargyas river had to struggle to pass through the high limestone mountain. Then we learn about the historical data, the legends of these places and then the description of the Homoródalmás Cave (Pestera Meresti) follows. The explanation of the origins of the cave is wrong. He denies the fact that the waters of the river could create it because it is on a higher level then the waters of the river. He thought that the cave was the result of karst springs work. We also learn about the big bat colony and guano deposits from the cave. To his description he attached the cave plan made by Fekete. As we read this work we learn about the Lócsűr (Hors-Cave), Ugron-lyuk (Ugron-Cave) and Kőcsűr (a natural stone bridge). Already he knew about the sinkhole in

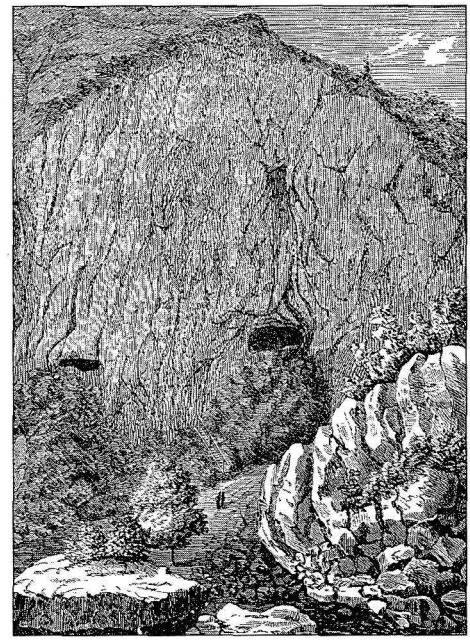


Fig. 2: The entrance of the Homoródalmás Cave.

which the waters were disappearing and about their underground route. The river rises at Vízkelet, a big karst spring wich is situated at the south end of the gorge. Carryng his photographic equipment he took four photos. Two of them represent the entrance of the cave.

He also took three photos in the Olt-pass (Defileul Oltului) from Alsórákos (Racosul de Jos). Here he described three caves of wich the most detailed was the Tolvajos Cave (Robber-Cave). At Olthéviz (Hoghiz) he described a cave in travertine and took a photo of the surroundings of the travertine hill.

In Barcaság (Barca-district, Tara Barsei), he noticed four caves and gave a short description of Ialomita Cave in Bucsecs (Bucegi) mountain.

He explained the functioning of the intermitent karst spring of Fort-yogóhegy (Gespreng berg) in Brassó (Brasov).

He gave a detailed description of three andesite caves full of vulcanic gas at Büdös Hill (Stinking Hill) near Bálványos resort in Háromszék district.

From Csík district he mentioned the pothole on Likas mountain and the ice cave in travertine at Borszék (Borsec) resort.

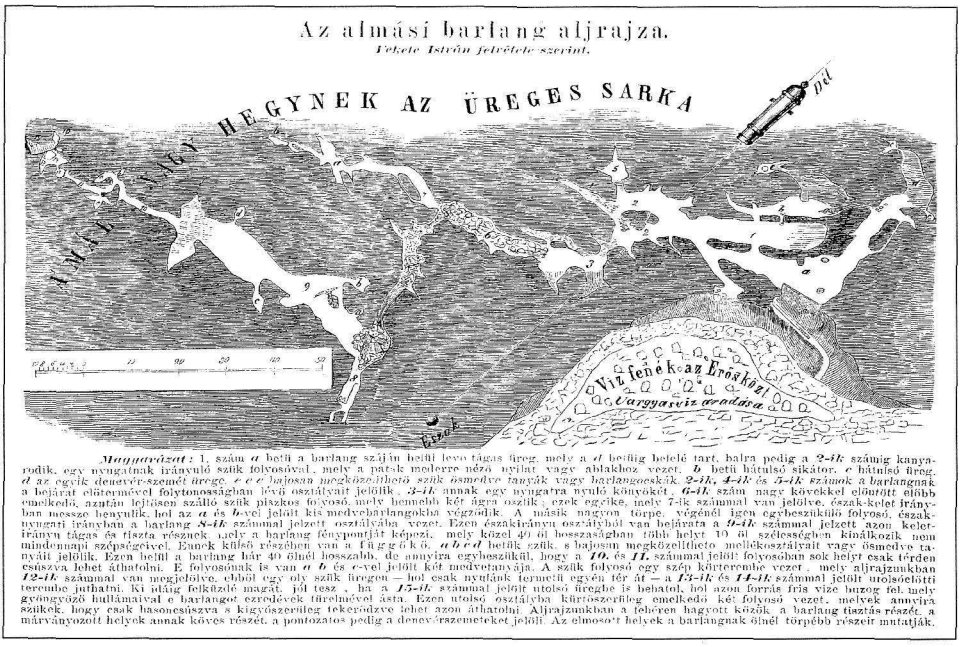
Aranyos district is rich in karstic areas. From this region he described four caves situated at Székelykő mountain at Torockó (Trascau) and seven caves at Kőköz-gorge (Cheile Aiudului). From these descriptions we learn about the position and size of these caves, about the dripstone formations, archaeological finds and historical data. On top of the Gesteg hill he observed a lot of "crater like hollows ordered in lines" which are in fact a line of dolines. He took a photo of the Székelykő mountain, too.



Fig. 4: The entrance of the Homoródalmás Cave (photo by Balázs Orbán).

Among the caves of the Torda-gorge (Cheile Turzii) he described the Balika Caves which were fortified caves. In this part of his work we find the first description of a cave accident. It took place on 13th August 1780 when Kis János a chimney sweeper from Torda (Turda) looking for the "Treasure of Darius" remained stuck in a pothole. The rescuers could not pull him out with ropes and after 7 days of terrible suffering he died.

Orbán also told us about the



Magyarázat: 1. szám *a* betűi a barlang szájún belül levo tágas üreg, mely a *d* betűig belelé tart, balra pedig a *2-ik* számig kanyarodik, egy nyugatnak irányuló szük folyosóval, mely a pat-ak medrére nézo nyilat, vagy ablakhoz vezet. *b* betü hátulsó sikátor. *c* hátulsó üreg. *d az egyik denevér-szemét ürege. e e e* bajosan megközelíthető szük ösmélye tanyák vagy barlangoeskék. *2-ik, 4-ik és 5-ik számok* a barlangnak a bejárat elöterével folytonosságban lévö osztályait jelölik. *3-ik* annak egy nyugatra nyuló könyökét. *6-ik* szám nagy kövekkel elönött elöbb emelkedö, azután lejtösen szálló szük piszkos folyosó, mely hemelob két ágra oszlik, ezek egyike, mely 7-ik számmal van jelölve, észak-kelet irányban messze benyulik, hol az *a és b*-vel jelölt kis medvebarlangokba végzödik. A másik nagyon törpe, végénél igen egybeszükülö folyosó, északnyugotni irányban a barlang *8-ik* számmal jelzett osztályába vezet. Ezen északkiránvu osztályból van bejáratra a *9-ik* számmal jelzett azon kelet-irányu tágas és tiszta részek, mely a barlang fénypontját képezi, mely közel 40 öl hosszaságban több helyt 10 öl szélességben kinálkozik nem mindennapi szépségével. Ennek külső részében van a *f u g g ö k ö. a b c d* betük szük, s bajosan megközelithetto mellékosztályait vagy ösmélye tanyáit jelölik. Ezen belül a barlang bár 40 ölnél hosszabb, de annyira egyhesziikül, hogy a *10.* és *11.* számmal jelölt folyosóban sok helyt csak térden csúszva lehet áthatolni. E folyosónk is van *a b* és *c*-vel jelölt két medvetanyája. A szük folyosó egy szép kürtsrenbe vezet, mely aljrajzunkban *12-ik* számmal van megjelölve, ebböl egy oly szük üregen — hol csak nyulánk termetü egyén tér át — a *13-ik* és *14-ik* számmal jelölt utolsóelötti terembe juthatni. Ki idáig felkuzdé magát, jól tesz, ha a *15-ik* számmal jelölt utolsó üreghe is behatol, hol azon forrás friss vize buzog fel, mely gyöngyözö hullámaival e barlangot ezredévek türelmével ásta. Ezen utolsó osztályba kürtöszerüleg emelkedö két folyosó vezet, melyek annyira szükek, hogy csak hasonesiszva s kigyószerüleg tekeredzve lehet azon átharolni. Aljrajzunkban a jelenen hagyott közök, a barlang tiszta részét, a márványozott helyek annak köves részét, a pontozatos pedig a denevérszemetéket jelölt. Az elmosott helyek a barlangnak ölnél törpébb részét mutatják.

Fig. 3: The plan of the Homoródalmás Cave.



Fig. 5: The Túr Gorge with the entrance of the Malom (Mill) Cave.

caves from the Tur-gorge (Cheile Turului) in which there were prehistoric settlements. He saw the entrances of a lot of caves situated at high level in the rock walls. Also he took a few photos in Torda- and Tur-gorges.

Through his works the author let us know a lot of valuable data about the caves of Transylvania and fixes a situation which we can not find today. By now the dripstone formations and the fortification walls have been destroyed and the archaeological finds have been lost.

Studying all his works we belive that Balázs Orbán was one of the excellent forerunners of cave researching in Transylvania. From 1931 as a memorial by posterity the bigest cave in the Land of the Székelys, the Homoródalmás Cave, was named after the "Great Székely" Balázs Orbán Cave.

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SPELEOLOŠKI PODATKI V "OPISU DEŽELE SZÉKELYS" BALÁZSA ORBÁNA

Povzetek

Balázs Orbán, "Veliki Székely", je bil popotnik, pisatelj in politik. 1864 - 1868 je prepotoval pet "széks" (okrožij) dežele Székelys (Transilvanija, Romunija). Na tem potovanju je preučeval naravo in arhive, zapisoval, fotografiral in skiciral. 1868 - 1873 v šestih knjigah objavil "Opis dežele Székelys z arheološkega, naravoslovnega in etnografskega vidika". Kasneje (1889) je objavil še delo "Torda, mesto in njegova okolica". V teh delih omenja preko 33 jam in 3 brezen v apnencu, 2 jami v lehnjaku, 2 v andezitu, 3 jame v andezitnem konglomeratu in 3 umetne jame obrambne narave v konglomeratu. Vključuje tudi 3 kraške izvire.

Balázs se je osredotočil predvsem na zgodovino in arheologijo, etnografijo in geografijo. Njegovi geografski opisi vsebujejo poleg opisov pokrajine tudi

demografske, ekonomsko-geografske in geološke podatke. Posebno zanimanje je kazal za raziskovanje jam, kar je bilo takrat v Transilvaniji zelo redko. Zbrani podatki so točni in opisi podrobni. Vse, kar je videl in doživel, je želel razložiti ustrezno nivoju znanosti v njegovem času. Njegovi pokrajinski opisi so čudoviti, za nas so posebej pomembni opisi okolice jam, topografska imena, dostopi do jam in zgodovinski podatki o njih. Jame opisuje, dodaja svoja geološka in hidrografska zapažanja, omenja arheološke najdbe in pripovedi v zvezi z jamami.

Balázs Orbán je spoznal pomen fotografije, tehnike, ki je bila v njegovem času ravno vpeljevana v Transilvanijo. Nabavil si je fotografsko opremo in napravil celo vrsto posnetkov dežele Székelys. na srečo je večina njegovih posnetkov ohranjena. Ker takratna tiskarska tehnika ni mogla reproducirati fotografij, ilustrira svoje opise z gravurami. Balázsa Orbána tako štejemo med odlične predhodnike raziskovalcev jam v Transilvaniji.

ACTA CARSOLOGICA	XXVI/2	4	49-54	LJUBLJANA 1997

CONTRIBUTION TO THE KNOWLEDGE ABOUT SPELEOLOGY IN CROATIA

PRISPEVEK K POZNAVANJU SPELEOLOGIJE NA HRVAŠKEM

MLADEN GARAŠIĆ [1]

Izvleček UDK 551.44(497.5)
Mladen Garašić: Prispevek k poznavanju speleologije na Hrvaškem

V prispevku so podatki o speleologih od 1584 dalje ter o speleoloških društvih od 1892, ko je bil ustanovljen "Odbor za uređenje Baračevih spilja". Od tedaj je na Hrvaškem delovalo okoli 50 društev. Ta so nastajala, delovala in iz različnih vzrokov prenehala z delom. Do danes se je okoli 1000 ljudi resno ukvarjalo s speleologijo, kar ni veliko v primerjavi z deželami, ki imajo podoben delež krasa. Toda rezultati speleoloških raziskav (število raziskanih jam, objave, vpetost v mednarodno speleologijo) so pomembni ne le v regionalnem, ampak tudi v širšem merilu.
Ključne besede: zgodovina speleologije, speleološka organizacija, Hrvaška.

Abstract UDC 551.44(497.5)
Mladen Garašić: Contribution to the knowledge about speleology in Croatia

Basic data about speleologists from 1584 are presented, as well as speleological societies since 1892, when Committee for arrangement of Baračeva špilja (Odbor za uređenje Baračevih špilja) near Rakovica was founded. Since then about 50 societies were founded in Croatia. When established, they were active for some time, and many of them stopped the activities for various reasons. Until now data, serious speleological researches were done by thousand people, and it is not much comparing to other countries with such percent of karst. But outcomes of speleological resources (number of researched objects, published papers, presence in speleological world, etc.), are remarkable, not just in regional, but in wide contexts.
Key words: history of speleology, speleological organization, Croatia.

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1. INTRODUCTION

Speleological activity in Croatia started with the first human penetration underground, where shelters or dwelling places were found. Such examples of speleo people remains or paleolithic artifacts exist in the Croatian karst in several places (eg. Vindija Cave in Hrvatsko Zagorje, Hušnjakovo Cave near Krapina, Šandalja Cave near Pula in Istria, Cerovačke Caves in Lika, Bezdanjača pod Vatinovcem Cave in Lika, Veternica Cave near Zagreb, Gromačka Vlaka Cave near Dubrovnik etc.)

2. THE FIRST SCIENTIFIC WORK IN CAVES

The earliest penetrations were due to the needs of man, not his curiosity. In the 16th century started the period of first researches and expeditions. A Croat from Dubrovnik, Nikola Gučetić had in 1584 recorded his observations on meteorological measurements in caves near Dubrovnik and Cavtat. That year is accepted as the beginning of scientific publishing on Croatian caves. Later on researches were made in some caves known in that time (eg. Marin Getaldić made some optical experiments in Betina Cave near Dubrovnik) and some researchers took part in investigating deeper parts of caves or discovering completely unknown ones (in 17th cent J.V. Valvasor described some caves in Trsat, Mt. Učka and Dalmatia), Ivan Lovrić together with Alberto Fortis in 1774 and 1776 explored Gospodska Cave on the Cetina river.

3. THE FIRST SPELEOLOGICAL ORGANIZATIONS

The first society that dealt with cave exploring in Croatia was **Odbor za uređenje Baračeve Špilje** (Committee for Arrangement of Barač Caves) that was founded on **12th of August 1892** near Rakovica in region of the Plitvice lakes. That is considered as the first speleological organization in Croatia and is among the first in the world (after Vienna, Trieste and Postojna).

D. Gorjanović Kramberger and J. Poljak on **31st July 1910** had established a **Committee for Cave Researches (Odbor za istraživanje špilja)** under the Geological Council for the Kingdom of Croatia and Slavonija in Zagreb. That is regarded as the first Croatian scientific society dealing with underground karst phenomena.

4. SPELEOLOGICAL SOCIETY ACTIVITY

During more than hundred years many speleological societies existed in Croatia. Some of them left significant evidences of their activities; others had short existence but were important historic ally.

In tradition of the **Committee for arrangement of Barač Caves** (1892-1896),

and a legitimate successor of the Committee for Cave Researches is the **Croatian Speleological Association (Hrvatsko speleološko društvo)**, established on 2nd April 1954 in Zagreb, and which is republic speleological association and a regular member of UIS (Union Internationale de Speleologie) (Fig. 1).



Fig. 1.- The sign of the Croatian Speleological Association (Hrvatsko speleološko društvo). The first speleological organization in Croatia was founded in year 1892 in Rakovica, near Plitvice lakes.

Here is list of all the speleological organizations which were founded in Croatia before the Second World War (see Fig. 2 for locations):

"Liburnija" in Zadar (1900-1915); **Spiljarski odio** in Velika realka (gymnasium) in Split (1912-1915); **"Runolist"** in Lokve (1923-1935); **"Mosor"** in Split (1926-1935; 1950; 1956-1996); **"Runolist"** in Zagreb (1927-1929); **"Orjen"** in Dubrovnik (1933; 1950; 1986-1989; 1996); **"Prijatelj prirode"** in Zagreb (1936-1940); **"Špiljar"** on Knežija in Zagreb (1941-1944).

After the Second World War there were founded these speleological societies:

"Zagreb-matica" in Zagreb 1949-1988); **"Željezničar"** in Zagreb (1950-1996); **"Rudar"** in Raša (1950-1952); **"Platak"** in Rijeka (1950; 1962-1985); **"Javor"** in Zagreb (1951; 1955-1959); **"Velebit"** in Zagreb (1954-1956; 1960-1996); **"Mosor"** in Dugo Polje (1955-1959), **"Speleološka sekcija Hrvatskog geografskog društva"** in Zagreb (1956-1963; 1991-1996); **"Komisija za speleologiju HPS"** in Zagreb (1956-1996); **"Vladimir Nazor"** in Split (1957), **"Dubovac"** in Karlovac (1957-1963; 1966-1996); **"Mosor"** in Klis (1959/1960); **"Zanatlija"** in Zagreb (1960-1963); **"Paklenica"** in Zadar (1967-1990); **"Velebit"** on the Island of Hvar (1968); **"Speleološki odred izviđača"** in Zagreb (1969); **"Split"** in Split (1970-1978); **"Umberto Girometta / Špiljar"** in Split (1971-1979; 1983-1996); **"Dubovac"** in Vojnić (1970); **"Otočani"** in Novalja, Island of Pag (1974-1990); **"Istra"** in Pazin (1975-1996); **"Japetić"** in Samobor (1975-1996); **"Proteus"** in Poreč (1977-1996); **"OKI"** in Zagreb (1977-1982); **"Biokovo"** in Makarska (1977-1996); **"Sutjeska"** in Zagreb (1978-1986); **"Speleološki odred izviđača"** in Karlovac (1978); **"Ursus Spelaeus"** in Zagreb (1978-1989); **"Svilaja"** in Sinj (1978-1985); **"Vis"** in the Island of Vis (1979-1980); **"Društvo za istraživanja i snimanja krških fenomena- DISKF"** in Zagreb (1980-1996); **"Myotis Myotis"** in Karlovac (1984-1985); **"Pauk"** in Fužine (1986-1996); **"Rovinj"** in Rovinj (1986-1988), **"Buje"** in Buje (1987-1996) **"Kamenar"** in Šibenik (1988-1996); **"Sv. Mihovil"** in Šibenik (1996); **"Jamar"** in Han (1996); **"Karlovac"** in Karlovac (1996).

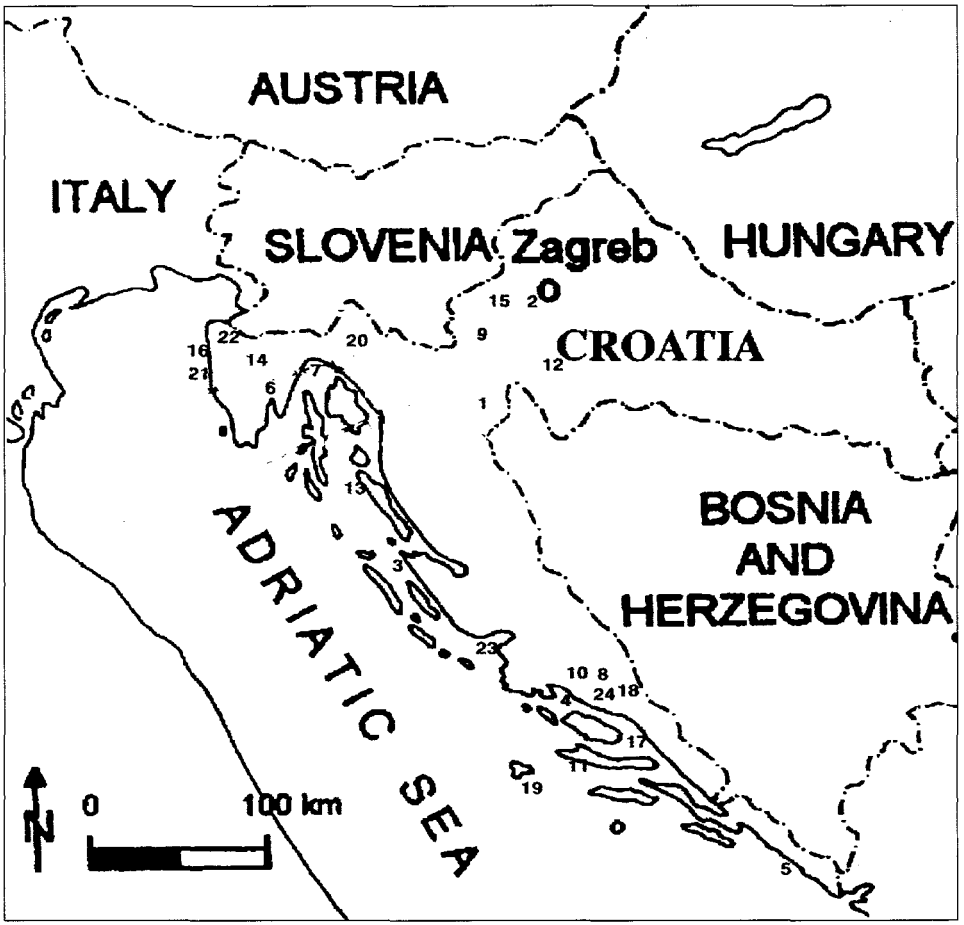


Fig. 2.- Positions of the towns in which were founded speleological organizations in Croatia (1892-1996):
LEGEND: 1- Rakovica; 2- Zagreb; 3- Zadar; 4- Split; 5- Dubrovnik; 6- Raša; 7- Rijeka; 8- Dugo Polje; 9- Karlovac; 10- Klis; 11- Hvar; 12- Vojnić, 13- Novalja; 14- Pazin; 15- Samobor, 16- Poreč; 17- Makarska; 18- Sinj; 19- Vis; 20- Fužine; 21- Rovinj; 22- Buje; 23- Šibenik; 24- Han; 25- Lokve.
Mostly they are situated in regions of Istria, Dalmatia, Gorski kotar and Zagreb region. No one is located in Lika karst region.

It is evident that in Croatia a relatively small number of societies (fifty) existed, but they explored more than 8000 speleological objects in the last hundred years. That is an impressive number considering the number of active speleologists and the area of Croatia.

5. INDIVIDUALS IMPORTANT FOR CROATIAN SPELEOLOGY

Significant contributions for Croatian speleology and karst researches were made also by many individuals (D. Hirc, R. Bujas, U. Girometa, M. Margetić, I. Krajač, F. Baučić, V. Redenšek, V. Horvat, G. Novak, J. Roglić, V. Blašković, S. Smolec, M. Malez and many others).

Altogether there have been over 1300 researchers in Croatian speleology in more than a hundred years, and today there are about 350 active speleologists.

6. CONCLUSION

More than 8000 speleological objects (caves and pits) are known in Croatia today, which is a great number related to the dimensions of karst area and the number of active speleologists. There are 15 tourist caves in Croatia. Speleologists are associated in 23 speleological societies that are active in Croatian territory.

Important are discoveries of endemic underground animals - *Proteus anguinus* in 26 Croatian caves and pits, and unidentified underground species in two pits deeper than 1000 m.

The deepest pit of the Croatian karst is Lukina jama on Velebit, 1392 m deep, and the longest cave system is Đula - Medvedica Cave System near Ogulin, 16,5 km long.

Croatian speleologists are respected in the world and have organized or participated at many international expeditions. Croatia is a member of UIS, International Union of Speleology, which has 60 members. Croatian karst is so-called locus typicus for all karst regions - it is considered as a classic example of karst in the world, where first scientific theories on speleogenesis and karst groundwater flow were born.

There will be more contributions to the history of speleological researches in Croatia due to the work of speleologists from Austria, Hungary, Italy, Slovenia, Czech Republic, Slovakia, France and Germany. ALCADI meetings will play a significant role because more data resources about Croatian speleological karst researches will become available.

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PRISPEVEK K POZNAVANJU SPELEOLOGIJE NA HRVAŠKEM

Povzetek

V prispevku so podani osnovni podatki o delovanju bolj znanih "speleistov" ali speleologov od leta 1584 dalje, kot tudi o speleoloških društvih na Hrvaškem od 1892. leta, ko je bil ustanovljen "Odbor za uređenje Baračevih spilja", pri Rakovici, kot četrto speleološko društvo na svetu. Od tedaj dalje je bilo na Hrvaškem osnovanih okoli 50 speleoloških društev, ki so se vsaka na svoj način ukvarjala s speleološkimi raziskavami. Ta društva so nastajala, delovala in mnoga so iz najrazličnejših vzrokov tudi prenehala z delom. Po razpoložljivih podatkih vemo, da se je do danes nekaj več kot 1000 ljudi resno ukvarjalo s speleologijo, kar je majhno število v primerjavi z drugimi kraškimi področji in glede na delež krasa na Hrvaškem. Vendar so rezultati speleoloških raziskav (število znanih oziroma raziskanih speleoloških objektov, objavljena dela, vpetost v mednarodno speleologijo, itd.) pomembni, lahko bi celo rekel občudovanja vredni in to ne le v regionalnem, ampak tudi v širšem smislu.

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LE RÔLE DES BOTANISTES DANS LES DÉBUTS DE LA SPÉLÉOLOGIE FRANÇAISE

VLOGA BOTANIKOV PRI ZAČETKIH SPELEOLOGIJE V FRANCIJI

CHRISTOPH GAUCHON [1]

Izvleček UDK 58:551.44(44)(091)
Christophe Gauchon: Vloga botanikov pri začetkih speleologije v Franciji

Pogosto je prispevek botanikov k poznavanju podzemeljskega sveta neopažen, običajno omejen le na Tournefortov spust v jamo Antiparos (1700) in njegovo zmotno mišljenje o rasti kapnikov. Vendar so botaniki v 18. in 19. stol. veliko prispevali k odkrivanju in k raziskovanju jam, saj so po terenu nabirali gradivo za herbarije in često iskali jame, da bi pred njimi našli redke rastline. Najboljši primer je Villarjev opis Trou du Glas, glavnega vhoda v jamski splet Dent de Crolles, iz 1786.
Ključne besede: zgodovina speleologije, botaniki, Francija, Alpe, Dent de Crolles, Pireneji.

Abstract UDC 58:551.44(44)(091)
Christophe Gauchon: The contribution of botanists to the development of speleology in France

The contribution of botanists to knowledge of the subterranean world is often undervalued. Sometimes only Tournefort's visit to the Antiparos cave in 1700 is quoted, together with his mistaken views about the vegetative origin of stalactites. But botanists did play a very important part because they systematically practiced field-work to full their herbarium; and they often looked for caves to find scarce plants, unusual elsewhere. The best instance of this contribution is the first description of the main entrance of Dent de Crolles system by Dominique Villars, in 1786.
Key words: history of speleology, botanists, France, Alps, Dent de Crolles, Pyrenées.

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Tantôt encore, un cercle se forme autour d'un alerte vieillard
Qui explore la nature et connaît sa beauté;
La vertu miraculeuse des plantes et leurs formes variées
Sa perspicacité les a dès longtemps scrutées, elle a nommé chaque mousse;
Il pénètre d'un oeil aigu les souterrains abîmes
Et c'est en vain que la terre cherche à lui dérober son or pâle.

Albrecht de HALLER. Les Alpes

La question que l'on peut se poser quant à l'histoire de la spéléologie est de savoir qui allait sous terre, qui explorait et rendait compte de ce que recélaient les cavernes, avant que les spéléologues n'existent? Bien sûr il est aisé d'apporter quelques éléments de réponse: les paléontologues, les archéologues viennent tout d'abord à l'esprit, mais, en France au moins, leurs premières investigations ne remontent pas au-delà de 1826, lorsque furent découverts des ossements d'ours des cavernes dans la grotte d'Osselles (Doubs). On pense ensuite aux physiciens qui dès le XVIème siècle s'intéressèrent aux circulations d'eau souterraines: Palissy, Kircher, Perrault..., puis aux géographes, aux géologues... Mais il est une catégorie de savants que l'on oublie peut-être trop souvent et que l'on ne croirait pas avoir joué ici un rôle bien important, ce sont les botanistes.

Certes, il est au moins une célèbre figure de botaniste qui émerge de l'histoire de la spéléologie, c'est celle de Joseph Pitton de Tournefort, professeur de botanique au jardin des plantes de Paris, dont chacun connaît l'exploration de la grotte d'Antiparos, à la fin de 1700; les observations qu'il fit sur place le conduisirent à se prononcer pour la "végétation des pierres" comme mode de formation des concrétions et à défendre cette opinion jusqu'à sa mort, survenue en 1708. Même si Tournefort n'emporta pas l'adhésion de tous les savants, ses récits de voyage eurent une grande audience, connurent plusieurs éditions et furent même traduits et publiés en Angleterre (Shaw 1992, 244). On a beaucoup raillé Tournefort, et tous n'ont pas compris "la désignation d'un botaniste pour une recherche en minéralogie" (Minvielle 1967, 20). Or, juger sévèrement sur ce seul épisode, c'est méconnaître l'apport des botanistes en général à la découverte du monde souterrain.

Certes, les connaissances des botanistes ne trouvent guère leur utilité dans la compréhension des cavernes, et il n'y a sans doute rien de bon à en garder, mais nous verrons qu'en revanche, leurs façons de travailler les mettaient dans des situations propres à favoriser des découvertes importantes.

I. LA BOTANIQUE AU CENTRE DES SCIENCES NATURELLES:

Il n'est pas innocent que la connaissance des plantes et celle des cavernes soient souvent mises en parallèle, et attribuées aux mêmes hommes. La citation de Haller que nous avons mise en exergue en est une première illustration. Il en est bien d'autres. Bosc par exemple, vantant, en 1797, la diversité

des Grands Causses de l'Aveyron, écrivait ainsi: "Quelle étude plus attrayante que celle de ces plantes, de ces arbustes, de ces simples de toute espèce (...); de ces côteaux (...); de l'intérieur de ces grottes profondes, par lesquelles on semble pénétrer les entrailles de la terre, pour lui dérober les secrets mystérieux de la végétation, ou pour contempler les routes cachées des fontaines et des ruisseaux?" (Bosc 1797, I, 12). Les plantes rares sont autant de secrets, que la nature cache, comme elle cache les cavernes, et qu'il faut chercher et inventorier de la même façon. De plus, l'évocation des plantes médicinales suppose une certaine initiation réservée à un petit nombre, et au secret s'ajoute alors un mystère. A cet égard, l'association entre cavernes et guérisseurs est significative: l'ermite qui séjournait au XVIII^{ème} siècle dans la petite grotte de Loizia (Jura) faisait pousser, juste au-devant, sur un petit terre-plein, du cerfeuil, du cresson et de la valériane (Lequinio 1801, 246-247), et il est probable que l'ermite de la grotte de Saint-Antoine de Galamus (Pyrénées-Orientales) fournissait des plantes abortives aux paysans des alentours (Fabre 1985, 23).

Mais cette parenté entre cavernes et plantes n'existe pas seulement dans les mentalités; au XVIII^{ème} siècle, et dans une moindre mesure au XIX^{ème}, avant que la spéléologie ne se soit constituée en discipline à part entière, les botanistes joueront souvent un rôle de premier plan dans la découverte des grottes. Le rapport entre les deux domaines n'est pourtant pas *a priori* évident, et mérite explication: au siècle des Lumières, la botanique est à la base de toute l'instruction scientifique; Saussure, quand il se rendit pour la première fois dans la vallée de Chamonix, avait surout l'idée d'y herboriser, et ses "Voyages dans les Alpes" abondent de notations botaniques autant que de considérations géologiques.

Les deux disciplines sont d'ailleurs étroitement liées, ne serait-ce que pour reconnaître la flore fossile des gisements houillers; les années d'études du jeune Humboldt sont dominées par une réelle passion pour la botanique (Botting 1988, 16), passion qu'il sut prolonger lorsqu'il entra à l'Académie des Mines de Freiberg; nous y reviendrons.

Un siècle plus tard, Martel comptera parmi ses collaborateurs au moins deux hommes dont la première curiosité avait été pour la botanique: Félix Mazauric, qui dressa la topographie complète de la grotte de Bramabiau avant de s'orienter vers l'archéologie du pays nîmois, avait rédigé à l'âge de 20 ans le récit d'une excursion botanique au Mont-Aigoual; et Joseph Vallot, selon son biographe, était à 16 ans "un passionné de botanique, discipline dans laquelle il s'avérait un véritable spécialiste (et) les herbiers succédaient aux herbiers" (Vivian 1986, 36-37); il publia plus de 20 études de botanique, tout en s'intéressant aux gouffres des Causses, puis se consacra tout entier au Mont-Blanc. De même, Henri Poujol, qui fut le prédecesseur de Martel dans les gorges de la Jonte mais qui refusa ensuite de collaborer avec lui, s'était d'abord fait connaître par des travaux de botanique, avant de procéder à des fouilles archéologiques fructueuses dans les grottes des Causses. La botanique apparaît donc comme une

véritable et indispensable initiation à l'esprit scientifique, quelle que soit la discipline à laquelle on se destine finalement.

En plus des savants, la botanique jouit aussi au XVIII[ème] d'un grand effet de mode et toute personne distinguée qui se pique d'histoire naturelle tient forcément un herbier. En 1770, Jean-Jacques Rousseau herborisa autour de Grenoble, et le secteur du Vercors qu'il arpenta s'appelle, depuis lors, "Désert de Jean-Jacques"; atteint de la maladie de la persécution, il aimait à se retirer dans des endroits tranquilles, et en 1762-63, lors de son séjour à Môtiers-Travers (Jura suisse), il s'était plu à méditer sous le grand porche de la grotte de Môtiers.

II. LES BOTANISTES SUR LE TERRAIN:

Sérieux ou dilettantes, les naturalistes sont donc avant tout des botanistes, mais avec cet avantage formidable sur tous les autres savants que les botanistes, eux, allaient forcément sur le terrain, ne serait-ce que pour remplir leurs herbiers, alors que de nombreux géologues ou géographes ne quittaient guère leurs cabinets de travail. Et quand l'Europe découvrit les grands glaciers de Chamonix et de Grindelwald, les hauts massifs alpins captèrent tous les regards, draînèrent tous les curieux. Les botanistes ne trouvaient guère leur compte dans ces étendues rocailleuses et englacées, et continuèrent à préférer la moyenne montagne, souvent plus isolée et, paradoxalement, plus difficile d'accès. En effet, alors que des touristes par milliers montaient déjà à Chamonix ou au cirque de Gavarnie, beaucoup de massifs moins prestigieux n'étaient desservis par aucune route, ce qui faisait dire à un savant de la fin du XVIII[ème] siècle que "les Pyrénées n'ont paru être ouvertes qu'aux seuls amateurs de la botanique" (Reboul 1788).

Ceux-ci cherchaient à illustrer par leurs trouvailles le principe de l'étagement de la végétation qu'avait, le premier, enoncé Tournefort à la suite de ses observations sur les flancs du mont Ararat (Broc 1991, 174) et arpentaient donc, entre autres, les massifs karstiques des Pyrénées et des Alpes. Le Casque de Lhéris (1595 mètres) au-dessus de Bagnères-de-Bigorre (Hautes-Pyrénées) fut ainsi un haut lieu de la botanique au XVIII[ème] siècle, mentionné par tous les ouvrages de l'époque, et, tout en herborisant, on ne pouvait manquer de remarquer les cavernes qui s'ouvraient sur ses flancs: "Le célèbre Tournefort a parcouru la montagne de Lheyris (à l'automne 1685); comme lui, venez y remplir votre herbier (...) Nous verrons le puits d'Arris, que le vulgaire, ami du merveilleux, croit un abîme incommensurable. Nous visiterons les grottes de la Gourgue et de Coume-Barade" (Joudou 1818, 137). Le peuple ignorant et superstitieux s'oppose donc au savant botaniste, seul qualifié pour observer avec sérénité et méthode les phénomènes de la nature.

De même, dans les Préalpes de Savoie, la grotte des Portes (commune de Doucy) est opposée à la grotte de Banges, fréquentée par les curistes d'Aix-les-Bains: "Cette caverne, moins connue, n'est guère visitée que par les bota-

nistes qui viennent herboriser dans ces hautes régions" (Richard 1839, 109).

Cette pratique systématique du terrain est alors relativement rare, et il semble que tous les savants reconnaissent cette spécificité aux botanistes. Un exemple nous le montre bien, choisi dans les Alpes du Sud: sur le flanc Nord du Mont Ventoux, autour de 1400 mètres d'altitude s'ouvre une caverne aujourd'hui bien connue et longue d'environ 500 mètres: le Trou du Vent. Mentionné depuis longtemps, les descriptions en sont toutefois imprécises, et pourtant le courant d'air qui en sort intrigue. Le géologue Guettard, ayant fait le point des connaissances acquises sur cette caverne, aimerait bien en savoir davantage, et conclut logiquement: "Le Mont Ventoux est fameux en Provence à cause des plantes qu'on y trouve: les botanistes le parcourent souvent; quelques uns d'eux probablement résolvera (sic) cette difficulté & nous décrira ces cavernes, si réellement elles existent" (Guettard 1779, XCVI). Les botanistes se trouvent ainsi en position d'arbitres des problèmes qui ne peuvent trouver leur solution que d'une fréquentation du terain.

III. LES BOTANISTES SOUS TERRE:

Mais ce qui importe le plus pour nous, et qui est la conséquence logique de ce que nous venons d'exposer, c'est que les botanistes seront les premiers à signaler et à décrire toute une série de cavités; en un temps où la spécialisation scientifique n'existe pas encore, certains n'hésiteront pas à pénétrer sous terre et à en ramener des informations intéressantes. La première synthèse sur la Fontaine de Vaucluse, sur son fonctionnement et son bassin d'alimentation, est due à Joseph Guérin, créateur du jardin botanique d'Avignon (1775-1850).

Au cours de ses herborisations dans les Grands Causses, Antoine Gouan fut le premier, à la fin du XVIII^{ème} siècle, à décrire le site de Bramabiau; sa relation est précise et distingue bien l'orifice dans lequel se perd le Bonheur de la résurgence de Bramabiau à proprement parler (Gouan 1796, 196-197). Mais surtout, en 1768, il consacra deux journées à l'exploration de la Baume-Cellier (Monts de Saint-Guilhem, Hérault), élargit avec ses compagnons l'étroiture qui terminait la caverne et découvrit ainsi une nouvelle salle (id. 175-177). Une fois qu'il est entré sous terre, Gouan semble avoir laissé de côté ses préoccupations botaniques et ses investigations sont réellement spéléologiques.

Il n'en est pas de même de Dominique Villars; ce grand botaniste dauphinois de la fin du XVIII^{ème} parcourut pendant des années les montagnes de sa province, du massif des Ecrins jusqu'à la Grande Chartreuse, sans en laisser un coin inexploré. Les grottes l'intéressent pour elles-mêmes sans doute, mais surtout parce qu'il y traque les formes spécifiques de végétation: "Les grottes, les lieux bas marécageux, les aqueducs, les conduits souterrains, les puits, les galeries de mines, les endroits les plus infects qui refusent la vie aux plantes ordinaires, sont couverts de moisissures, de lichen, de biffus, de mousses et d'autres productions analogues. Ces plantes contribuent à la salubrité de l'air" (Villars 1781, 166-167). La lecture de son Histoire des Plantes du Dauphiné, et

surtout de son tome III consacré aux cryptogames, réserve ainsi de nombreuses notations sur les mousses qui croissent "dans les antres, les fentes, à l'entrée des grottes" (*Hypnum crispum*, 893), sur des lichens qui viennent "dans les pierres creuses, les grottes, dans les endroits où l'air circule difficilement et où le soleil ne pénètre presque jamais" (*lichen lutescens*, 1003)... A plusieurs reprises, il cite des espèces qu'il a trouvées à l'entrée de la grotte des Cuves de Sassenage (Vercors) ou dans la grotte de l'Ermitage au Néron (Chartreuse). Mais sa contribution la plus importante tient dans sa description du Trou du Glaz, première mention connue de ce qui deviendra, bien plus tard, le réseau de la Dent de Crolles. Le passage mérite d'être cité *in extenso*:

En 1775, "nous visitâmes la fameuse grotte appelée trou-du-Glaz, c'est à dire trou de la glace, parce qu'elle en conserve souvent toute l'année. La direction de cette grotte est au Nord; sa hauteur est considérable, sa longueur est de plus de 700 pieds, dans un enfoncement régulier & presque horizontal; son élévation est à plus de 3600 pieds au-dessus de la plaine de grenoble; on y trouve des stalactites d'une grosseur énorme et d'une assez belle transparence. La végétation ne se prolonge qu'à 30 à 40 pieds environ, quoique son ouverture ait plus de 20 pieds de diamètre. Les plantes, d'abord légèrement inclinées vers le côté du jour, deviennent de plus en plus penchées et plus minces à mesure qu'on s'enfonce davantage & finissent par être jaunes, étiolées, minces comme des cheveux, insipides, inodores et sans consistance, au moment où cette grotte leur refuse la vie" (1786, XXVI-XXVII). Le témoignage est certes précieux, à la fois sur le plan spéléologique, et sur le plan d'une étude écologique du monde souterrain. A n'en pas douter, Villars est ici un précurseur.

On voit bien par cet exemple que les botanistes ne visitent pas seulement les grottes à l'occasion de leurs excursions en montagne, en plus de leurs travaux sérieux, mais aussi pour y chercher des formes de vie végétale propres à ce milieu. Quelques années seulement après Villars, Humboldt fut animé de la même curiosité, même si elle ne s'appliquait pas aux cavités naturelles : "A l'occasion de ses nombreuses expéditions personnelles dans le sombre labyrinthe des mines de Freiberg, il est complètement fasciné par les mousses et autres plantes qui parviennent à produire une pigmentation verte avec, pour toute lumière, la faible lueur des lampes de mineur. Du coup, il se met à étudier, dans son petit jardin souterrain, l'effet de la lumière sur la croissance des végétaux" (Botting 1988, 21).

Depuis longtemps, la présence de végétaux à l'entrée des grottes avait dû intriguer; dès 1616, Chifflet, médecin de Besançon avait noté à la glacière de la Grâce-Dieu (Doubs) que "les pulmonaires poussent dans cette antre avec la saxifrage" (Chifflet 1616, 97). Mais il semble qu'au début du XIX^{ème} siècle, de telles notations deviennent plus fréquentes. Dans les Pyrénées, par exemple, le grand botaniste Picot de Lapeyrouse relève la présence d'une fougère *Adiantum Capillus Veneris* "sur les rochers humides, dans les cavernes, dans les puits" (Picot 1813, 629).

A la même époque, Monteil explique que le bord du Causse Noir "présente un grand nombre de belles grottes: celles qui sont d'un accès facile servent à renfermer les troupeaux, les autres, où l'on ne pénètre qu'avec peine, offrent des concrétions pierreuses et plusieurs espèces de plantes, telles que le *polipodium*, le *politricum*, le *pinguicula* (qui sert à soigner les gerçures des mamelles des vaches), l'*acrosticum* et l'*adiantum*" (Monteil 1802, 170). On retrouve ici cette prédilection du botaniste pour des grottes d'accès un peu difficile, des grottes qui ne sont pas fréquentées pour les usages quotidiens et qui recèlent des plantes médicinales.

CONCLUSION

Cette inclination des botanistes, ou de certains d'entre eux du moins, pour les cavernes ne concerna certes pas souvent le karst profond, et leur curiosité s'arrêtait en général peu au-delà de la zone de pénombre. Ils se soucièrent rarement de considérations karstologiques ou hydrologiques, mais firent indubitablement faire ses premiers pas à l'écologie souterraine. Et surtout, dans bien des cas, ils ouvrirent la voie: à la suite de Villars, plusieurs auteurs mentionnèrent le trou du Glas, bientôt indispensable à toute description du massif de la Chartreuse; Gouan à la Baume Cellier fut suivi 30 ans après par un autre botaniste, Amelin, qui la fit connaître au grand public. Et il est évident que le travail de défrichement effectué par Poujol fut d'une grande utilité à Martel lorsqu'il vint à son tour explorer les grottes des Causses. Sans exagérer donc cet apport des botanistes, il convenait de leur rendre ici la place qui leur était due, aux côtés des autres pionniers de la spéléologie.

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VLOGA BOTANIKOV PRI ZAČETKIH SPELEOLOGIJE V FRANCIJI

Povzetek

Pogosto je prispevek botanikov k poznavanju podzemeljskega sveta neopažen. Običajno je omejen le na Tournefortov spust v jamo Antiparos (1700) in njegovo zmotno mišljenje, da kapniki rastejo kakor rastline. Vendar so botaniki v 18. in 19. stol., to je v času, preden se je speleologija uveljavila kot veda, veliko prispevali k odkrivanju in često tudi k raziskovanju jam. Od 18. stol. dalje je bila botanika temelj naravoslovne izobrazbe in naravoslovnega znanja. Tako sta Saussure in Humboldt, preden sta se odpravila na potovanji po Alpah oziroma po svetu, študirala botaniko; J. Vallot in F. Mazauric, Martelova tovariša, sta bila predvsem botanika. V drugi polovici 18. stol., ko je Evropa odkrila ledenike Chamonixa in Grindelwalda, so visokogorja pritegnil turiste in znanstvenike, medtem ko so botaniki nadaljevali s pohodi po manj obiskovanih in teže dostopnih predalpskih gorovjih. Zagotovo vemo, da so botaniki v času, ko večina geografov in naravoslovcev ni zapuščala svojih kabinetov, nabirali po terenu gradivo za herbarije.

Znani botanik iz Grenobla, Dominique Villars, je prvi objavil (1786) opis Trou du Glas, glavnega vhoda v jamski splet Dent de Crolles. Klasično Chaixovo delo o škrapljah temelji na seznamu, ki ga je sestavil botanik John Briquet. Na podlagi več primerov iz Alp in s francoskega krasa avtor v tem prispevku pomaga osvetliti vlogo botanikov pri nastajanju znanosti o jamah.

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UNE CAVERNE CLASSIQUE DU VERCORS: LA GROTTE DES CUVES DE SASSENAGE

CUVES DE SASSENAGE, KLASIČNA JAMA V VERCORJU

CHRISTOPH GAUCHON [1]

Izvleček UDK 551.442(44)(091)
Christoph Gauchon: Cuves de Sassenage, klasična jama v Vercorju

Jama Cuves de Sassenage leži v SV vznožju planote Vercors, blizu Grenobla. V jami, dolgi 9 km, se pojavlja voda iz brezna Berger. Tolmuna - "cuves" - v jamskem vhodu sta bila dvakrat opisana v prvi polovici 16. stol. in uvrščena v "Sedem čudes Dofineje". Vsako leto so se okoličani podali do tolmunov, da bi po njih sklepali na letino, globlje v jamo pa do raziskav Faujas de Saint-Fondsa 1781 ni šel nihče. J. Fonné je 1898-1899 izdelal prvi jamski načrt, nadaljevanja jame pa kljub prizadevanjem ni našel.
Ključne besede: zgodovina speleologije, Francija, Vercors, Gouffre Berger, Cuves de Sassenage.

Abstract UDC 551.442(44)(091)
A classic cavern in Vercors, Cuves de Sassenage

The cave of the "Cuves de Sassenage" lies at the foot of Vercors, 5 km far from Grenoble. This more than 9 km long cave is the resurgence of the Gouffre Berger. Twice described in the first half of the XVIth century, the Cuves were two large rockbasins, considered as one of the 7 Wonders of Dauphiné. People scrutinized them each year to know if harvests would be copious but no-one passed beyond, before the first exploration by Faujas de Saint-Fonds in 1781. The first survey of the cave was drawn in 1898-1899 by Joseph Fonné, who could not find any extension in spite of his endeavours.
Key words: history of speleology, France, Vercors, Gouffre Berger, Cuves de Sassenage.

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L'histoire de la grotte des Cuves de Sassenage est tout entière placée sous le signe du paradoxe: "connue depuis toujours", citée par les érudits au moins depuis le XVI[ème] siècle, la grotte ne fut réellement explorée que bien plus tard. Cavité horizontale, elle opposa longtemps aux curieux l'eau froide de ses cascades, le réseau labyrinthique de ses galeries et les silex déchiquetés qui en ornent les parois; ces obstacles, que nous ne percevons plus guère aujourd'hui, retardèrent considérablement la connaissance de cette grotte dont l'exploration fut, pendant des siècles, d'une lenteur désespérante.

Et pourtant, on ne cessa jamais de s'intéresser à cette caverne qui, s'ouvrant au pied du Vercors, à 5 kilomètres de Grenoble, reste accessible en toutes saisons. Au fil des siècles, plusieurs centres d'intérêt se relayèrent, suivant l'évolution des mentalités, et assurèrent aux Cuves de Sassenage une renommée ininterrompue. L'histoire des Cuves, assez proche finalement de celle de beaucoup de cavernes connues de longue date, mérite bien d'être racontée.

I. LE TEMPS DES FABLES

La grotte des Cuves de Sassenage est, à ma connaissance, la cavité naturelle des Alpes françaises la plus anciennement citée: en 1525, dans une biographie du fameux chevalier Bayard, héros dauphinois disparu l'année précédente, Symphorien Champier décrit les "singularités" de sa province, parmi lesquelles "trois tines faites naturellement dans une roche auprès d'un château nommé Sassenage, en la montagne, lesquelles sont grandes à merveilles. Et un certain jour de l'année, ceux du pays vont voir lesdites tines dans le rocher assises, et si l'année doit être stérile, elles sont vides et n'y a comme point d'eau. Si l'année doit être abondante en biens, elles sont pleines d'eau. Et ainsi l'affirment ceux du pays entour." (Champier 1525, 39).

Neuf ans plus tard, un autre érudit dauphinois, Aymar Falcoz donne davantage de détails à propos de ces cuves: "On voit à Sassenage deux fosses que les habitants appellent tines, lesquelles sont dans un rocher et une pierre, et sont d'une grande capacité, dans lesquelles durant toute l'année on ne voit aucune marque d'humidité, et demeurent tout à fait sèches et on ne peut voir d'où l'eau peut sortir ou couler. Si ce n'est un jour de l'année et inévitablement la nuit de l'apparition de notre seigneur qu'on les voit pleines d'eau en abondance, toutefois l'eau n'y abondant toujours d'une égale façon mais l'une ou l'autre fait voir tantôt plus, tantôt moins d'humidité et les habitants de ce lieu tirent des conjectures de ce signe, de la fécondité ou de la stérilité de la terre. L'une de ces fosses dénotant l'abondance ou disette de vin, et l'autre marquant la grande quantité ou peu de blé qu'on cueillera cette année. Or, ce jour étant passé, toute l'eau s'écoule et disparaît merveilleusement sans que personne ne puisse apercevoir comment cela se fait" (Falcoz 1534, LXII-LXIII).

Ces deux textes, peu connus, méritent d'être cités *in extenso*, d'abord en raison de leur ancienneté, mais surtout parce qu'ils fixent pour près de 200 ans la vision dominante des Cuves. Si Champier et Falcoz ont jugé utile d'incorporer la description des Cuves dans le tableau qu'ils dressent de leur province, c'est que les Cuves de Sassenage font partie de ce qu'il sera bientôt convenu d'appeler les "7 Merveilles du Dauphiné": ces "Merveilles" ou "Miracles" sont des sites naturels comme le Mont-Aiguille ou la grotte de La Balme, auxquels l'imagination prêtait quelques vertus surnaturelles. Pendant des siècles, et jusqu'à aujourd'hui, toute description du Dauphiné comportait une évocation de ces Merveilles, et c'est pourquoi l'intérêt pour les Cuves de Sassenage n'a jamais faibli.

Le caractère miraculeux des Cuves tenait donc à cette valeur prophétique qu'on leur prêtait, et à la suite de Falcoz, tous les auteurs postérieurs ont repris la description de la procession qui, le jour de la fête des Rois, montait jusqu'à la grotte. Chacun ajoutait d'ailleurs des éléments propres à renforcer le mystère; en 1656, Salvaing de Boissieu attribue à la fée Mélusine, aïeule légendaire des seigneurs de Sassenage, l'origine de la vertu prédictive de ces deux grandes marmites. A partir de ce moment-là, le souvenir de Mélusine s'attache de façon indélébile aux Cuves de Sassenage, dont la toponymie souterraine va s'orner d'une "table de Mélusine", d'un "lavabo de Mélusine", d'un "labyrinthe de Mélusine", des "oubliettes de Mélusine", et même d'un "vase de nuit de Mélusine", ce qui est un peu irrespectueux!

Le phénomène des Cuves divinatrices est à coup sûr au centre du premier intérêt pour le site, au point que les deux cuves éclipsent la cavité elle-même, dont ne parlent ni Champier, ni Falcoz. Le premier à VOIR véritablement la grotte semble avoir été Nicolas Chorier, grand historien du Dauphiné. Avant même de décrire le miracle des Cuves, il écrit: "Les grottes de Sassenage ne sont pas moins dignes d'être contemplées. L'une est d'une grandeur incroyable, & elle jette de l'horreur dans les ames les plus fermes. En l'autre sont ces cuves si célèbres, & dans la troisième est une table de pierre, que l'on nomme la table de Mélusine" (Chorier 1661, I, 34). Sans doute la description est-elle brève, mais elle nous prouve peut-être que Chorier a pu aller sur place, et personne n'en dira plus jusqu'à la fin du XVIII^{ème} siècle: la première grotte laisse échapper une bruyante cascade, susceptible en effet d'effrayer les visiteurs que Chorier encourage pourtant à venir. La seconde galerie, haute de trois mètres et large d'un, est entièrement occupée au sol par les fameuses bassines que personne n'ose franchir pour s'aventurer au-delà. La troisième est une galerie de peu d'importance, qui s'ouvre en contre-haut du porche principal. Au "miracle des Cuves", Chorier ajoute d'ailleurs une autre merveille, que sont les "pierres ophtalmiques": "Rien ne purifie les yeux ni ne les éclaircit à l'égal de ces pierres" que l'on fait glisser sous la paupière (id., 40). Il est difficile pour nous d'identifier ces pierres, que Chorier semble avoir vues, mais qu'il ne dit pas explicitement avoir trouvé dans les grottes mais "sur la même montagne de Sassenage".

Après quoi la plupart des auteurs piocheront dans le texte de Chorier pour donner du site une relation stéréotypée. Personne n'ose encore remettre en doute le caractère prophétique du lieu, mais certains cherchent à l'expliquer. En effet, Chorier avait provoqué la curiosité de ses lecteurs: "Quel esprit conduit si fidèlement cette eau en ce lieu, pour y être un oracle qui parle sans énigme? Comment l'eau perce-t-elle un rocher si dur? Comment disparaît-elle sitôt? Les savants se sont appliqués souvent à la recherche de la cause de cette merveille, mais leurs doutes en ont augmenté les ténèbres." (id., 39). Piqué au vif, le voyageur J. Dumont proposera une première explication: "Cela pourrait bien être parce qu'elles se remplissent suivant l'abondance des eaux qui descendent des montagnes toujours couvertes de neige pendant l'hiver, & comme vous savez, cette abondance n'est pas indifférente à la fertilité de la Terre. Mais avec cela je serais aisément porté à croire qu'il y aurait bien de l'abus & de la superstition" (Dumont 1699, I, 107). On voit par là que les premières interrogations rationnelles amènent à prendre un certain recul vis-à-vis des croyances ancestrales. Un certain scepticisme s'installe parmi les érudits, et Thomas Corneille écrira dans son Dictionnaire: "Ces Cuves passeraient avec raison pour une des merveilles du Dauphiné, s'il n'y avait rien de fabuleux dans ce qui s'en dit" (Corneille 1708, III, 400). Certes, l'exploration de la cavité elle-même en est toujours au point zéro, mais l'incrédulité qui va gagner tout au long du XVIII[ème] siècle va constituer un nouveau moteur de la curiosité; dès lors il s'agit de venir aux Cuves pour vérifier le bien-fondé de la légende, et souvent pour la battre en brèche.

II. LE TEMPS DE L'INCRÉDULITÉ

Dans les premières années du XVIII[ème] siècle, les Académies parisiennes demandent à leurs corespondants en province de vérifier un certain nombre de faits tenus pour merveilleux: ainsi M. Dieulamant examina successivement la fontaine ardente et la grotte de la Balme, MM de Vaubonnays et Casset rendirent du Mont-Aiguille une relation plus conforme à la réalité; et en avril 1721, M. Lancelot prononça devant l'Académie des Inscriptions et Belles-Lettres un "Discours sur les 7 Merveilles du Dauphiné", tout entier placé sous le signe de l'incrédulité: ici il rabaisse le merveilleux, là il le nie, rien ne résiste à cet esprit cartésien. Des Cuves, il écrit: "C'est une vieille fable que l'adresse maligne de quelques uns des habitants du lieu qui les remplissaient d'eau, a entretenue pendant plusieurs siècles. Il ne s'y en trouve plus à présent, & le miracle a cessé, sitôt qu'il a été examiné avec attention" (Lancelot 1729, 763). Le jugement est sévère, les Sassenageois étant tout simplement accusés de supercherie, bien que l'on ne comprenne pas exactement dans quel but. Heureusement pour les Cuves, Lancelot ajoute: "Ce qu'il y a de curieux à Sassenage, & dont on parle le moins, est une cascade qui est dans une grotte à côté de celle où sont les cuves. La source qui la forme, &

qui sort du creux du rocher, a communication avec un lac qui est à deux lieues de là sur le haut de la montagne de Lans. Cette chute d'eau est reçue dans un grand bassin naturel." (id., 764). Ce texte-là est fondateur car, alors que d'autres Merveilles du Dauphiné une fois désacralisées allaient sombrer dans l'oubli, Lancelot parvient à requalifier l'intérêt du site sassenageois: si les Cuves n'ont rien de remarquable, la grotte non seulement est admirable comme le disait déjà Chorier, mais encore elle pose aux savants un problème autrement plus intéressant, celui de la circulation des eaux à travers les masses calcaires du Vercors. Certes, il n'y a pas de lac à Lans, mais l'idée d'un bassin versant est déjà clairement exposée, et le fonctionnement de la grotte s'en trouve rationnalisé. L'opinion de Lancelot est fréquemment reprise dans les décennies qui suivent, et les Cuves de Sassenage eurent ainsi l'honneur de la grande Encyclopédie de Diderot et d'Alembert (1765, X, 392-393), qui reprirent à leur compte l'explication du pseudo-miracle par la supercherie des Sassenageois.

Mais ces assauts de scepticisme ne faisaient pas progresser la connaissance réelle de la caverne, et il faut attendre pour cela l'intervention d'un nouveau personnage, Faujas de Saint-Fond, Lieutenant-Général de la ville de Montélimar. En 1781, ce magistrat publie une copieuse "Histoire Naturelle du Dauphiné", dans laquelle un chapitre entier est consacré à la "Description des

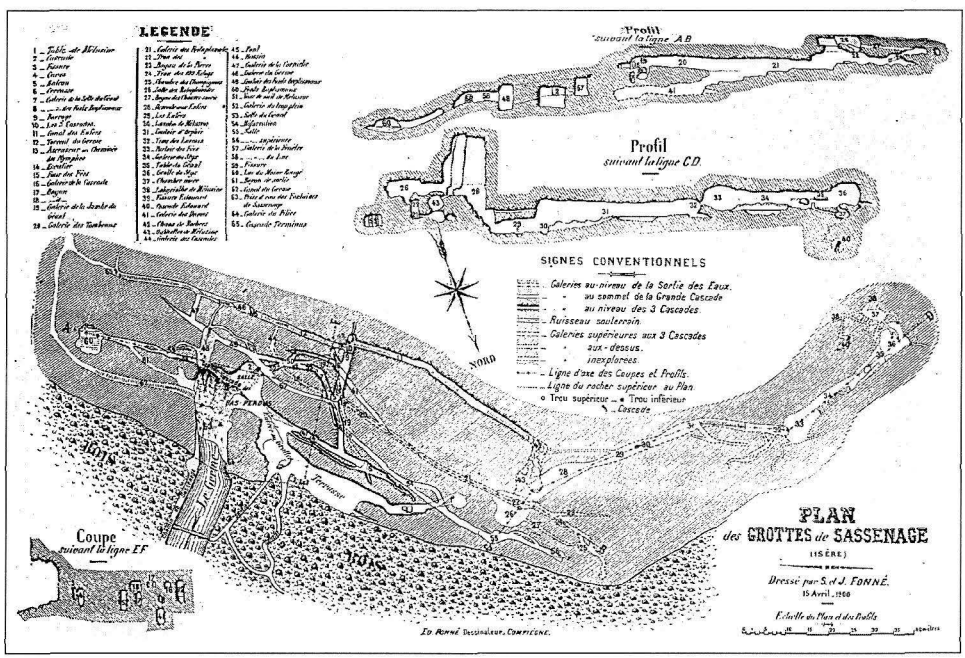


Fig. 1: Plan des Cuves de Sassenage (S. & J. Fonné 1900).

Grottes et des Cuves de Sassénage". Faujas avait lu ce que Chorier avait écrit des Cuves mais n'avait pu admettre "les choses extraordinaires et incroyables qu'il en débitait" (Faujas 1774, 246); il vint donc sur place par deux fois en 1774, puis une fois à nouveau en 1778. Faujas s'est donc livré à une véritable exploration, à une époque où les investigations souterraines connaissent en France une vogue notable.

La description qu'il donne de la caverne est précise; s'il n'en dresse malheureusement pas de plan, il a mesuré la hauteur, la largeur et la longueur des galeries qu'il a parcourues, d'autant plus systématiquement qu'il progresse avec un fil d'Ariane, pour être sûr de ne pas se perdre dans les dédales. Sa description suit les trois grottes qu'avait déjà distinguées Chorier: du côté où sortent les eaux, Faujas s'était heurté en 1774 à des eaux trop abondante, mais son guide l'avait assuré que c'était par là que se trouvaient les pierres ophtalmiques (Faujas 1774, 249). "Pendant l'été 1778 & par un temps de sécheresse", Faujas revint donc aux Cuves et put progresser d'environ 100 pieds "dans un boyau étroit & humide", et fut tout déçu de n'y trouver ni stalactites ni fossiles (Faujas 1781, 277)..., ni pierres ophtalmiques (id., 289).



Fig. 2: Portrait de Faujas de St. Fond (fonds et cliché Bibliothèque Municipale de Grenoble).



Fig. 3: Les Cuves de Sassenage vers 1770 (fonds Bibliothèque Municipale de Pau).

Ses efforts portent donc ensuite sur la galerie où sont les Cuves: ayant d'abord donné les mesures précises de ces deux grandes marmites, il avoue que "l'on imagine difficilement ce qui a pu donner tant de célébrité à deux simples creux ou excavations dans le roc vif" (id., 278). Faujas passe donc au-delà des Cuves, observe quelques bélemnites dans la galerie d'en face, découvre sur sa gauche une galerie qui le ramène jusqu'au cours d'eau souterrain où "l'on est étourdi par le bruit des eaux & fatigué par le vent" (id., 279). Au total, Faujas n'a parcouru ici que 168 pieds, moins de 60 mètres, et il est passé au pied de la "Cheminée des Quatre Vents" sans penser à lever la tête et à chercher au plafond la suite de la cavité.

Enfin, tout comme Chorier, il signale la troisième grotte, celle où l'on remarque la "table de Mélusine". Au total, la longueur de l'ensemble ne dépasse pas les 100 mètres, et c'est bien peu de choses car il y a déjà en France plusieurs grottes connues sur plus d'un kilomètre (Osselles, Arcy, La Balme...). Les observations de Faujas seront connues du monde savant de l'époque, puisque le grand géologue Guettard s'en fera l'écho, et que 30 ans plus tard, l'Encyclopédie méthodique de Géographie physique en reprendra des éléments. L'opiniâtreté de Faujas, son entêtement à vérifier la réalité de ce qui avait été écrit avant lui, les mesures systématiques auxquelles il se livre et qui se substituent dès lors aux dimensions mythiques du lieu, tout cela inscrit bien cette démarche dans le XVIII^{ème} siècle; on retrouve, au même moment, les mêmes attitudes chez les explorateurs de la grotte de La Balme, dans le Nord de l'Isère.

A partir de là, on pourrait penser que tout est dit, et que les Cuves, ayant perdu tout leur mystère, vont cesser d'attirer les curieux. La sensibilité du XIX^{ème} prendra le relais à point nommé: le goût pour le moyen-âge entretient la curiosité pour la légende de Mélusine, et s'y ajoute même la croyance selon laquelle la "table de Mélusine" avait servi à des sacrifices druidiques. D'autre part, le pittoresque du site continue à faire venir les promeneurs qui admirent les jeux de lumière du double porche et s'amusent à s'effrayer du bruit de la cascade. Si l'on en croit Fonné, "tous les dimanches de la belle saison, on voit des centaines de promeneurs (...) s'avancer jusqu'aux grottes" (Fonné 1900, 178).

III. A LA RECHERCHE DE PROLONGEMENTS

Entre 1781 et 1900, il semble que plus personne ne se soit réellement soucié d'étudier les Cuves de Sassenage et de voir s'il serait possible de dépasser le terminus de Faujas. Certaines assertions audacieuses auraient pourtant pu provoquer la curiosité des chercheurs; Pallias n'avait-il pas écrit: "On assure que ces grottes conduisent jusque dans le Royans situé à plus de six lieues de là" (Pallias 1854, 5)? Toutefois, à travers certains ouvrages d'histoire locale ou certains guides touristiques, il semble bien que certains

prolongements étaient déjà connus vers le milieu du XIX^{ème} siècle. Taulier parle ainsi de "vastes souterrains" dont la visite "n'est pas sans dangers, à cause des crevasses qu'il faut franchir, et au fond desquelles on entend mugir les eaux à une assez grande profondeur" (Taulier 1855, 78). On reconnaît là l'allée des Tombeaux, équipée de "deux rails à ornières gravés dans la paroi" (Fonné 1900, 255) pour faciliter le passage en opposition. Sans doute les visiteurs allaient-ils donc au moins jusqu'à la salle des Ratapanades. Un autre guide confirme qu'il s'agit d'une excursion assez éprouvante d'où "les curieux ne sont pas assurés de rapporter de leur expédition toutes les pièces de leur vêtement intactes" (Ferry 1869, 58). Ces quelques notations montrent combien, avant que la spéléologie ne se soit institutionnalisée grâce aux efforts de Martel, l'excursion touristique et l'exploration étaient mêlées, ces guides de promenade étant les seuls témoignages de cette époque.

La deuxième étude sérieuse sur les Cuves de Sassenage attendra donc la toute fin du XIX^{ème} siècle, et l'intervention d'un personnage peu connu et qui se signala pourtant par deux séries d'explorations spéléologiques importantes, d'abord aux Cuves de Sassenage entre 1898 et 1899, puis, après 1900, dans les grottes des Echelles (massif de la Chartreuse): il s'agit de R. Joseph Fonné, aidé le plus souvent de son frère Edouard. Il semble que sa carrière de spéléologue se soit limitée à ces deux groupes de cavités, mais les mémoires qu'il en a laissés sont précieux et accompagnés de plans fort précis. Le plan qu'il dressa des Cuves, qui n'avaient jamais été topographiées, fut d'ailleurs reproduit à plusieurs reprises par Martel, qui remarqua en particulier "le degré de fissuration interne de la montagne" que Fonné s'était efforcé de restituer le plus fidèlement possible (Spelunca Bulletin, 1900, n° 21-22, p. 78). L'intérêt de Fonné pour les Cuves de Sassenage coïncide avec un moment où le propriétaire des lieux, le marquis de Bérenger envisage pour sa grotte de grands aménagements touristiques et industriels. Il est probable que les deux hommes se soient concertés, la plaquette de Bérenger étant illustrée d'un plan qui, quoique signé d'un certain Riboulet, ressemble étrangement à celui de Fonné.

Quoiqu'il en soit, les fréres Fonné vont s'attacher à fouiller aussi complètement que possible les galeries labyrinthiques, et si possible à en découvrir les prolongements. Leurs investigations se font sous la conduite des guides habituels des grottes, qui s'amusent à les perdre sur le chemin du retour, ce qui prouve bien que jusqu'à la salle du Styx qui sera leur terminus, les frères Fonné ne font pas de véritables découvertes. Ils sont toutefois les premiers à décrire toute cette partie de la grotte, et ne se résignent pas à ne pas pouvoir progresser au-delà. Le 6 février 1898, ils s'acharnent donc à trouver un passage dans la salle du Styx, et, en se faufilant à travers les blocs, parviennent à descendre assez pour retrouver le cours d'eau souterrain en amont de sa partie connue : ce sera la "cascade Edouard", atteinte après 5 heures d'efforts. Pas moyen d'aller plus loin, l'eau sortant d'un trou impénétrable.

Mais Fonné n'a pas dit son dernier mot. En 1857, le géologue Lory avaient

expliqué que les eaux ressortant aux Cuves de Sassenage venaient du "large plateau qui s'étend vers le Sud jusqu'au village de Saint-Nizier (Lory 1858, 18), et un écho avait paru au début de 1899 dans Spélunca, signalant l'existence à Saint-Nizier d'un puits: "on prétend qu'il doit communiquer avec les grottes ou cuves de Sassenage" (Spelunca, Bulletin n° 17-20, p.70). Le 12 février 1899, voici donc Fonné à pied d'oeuvre, à plus de 1000 mètres d'altitude; le puits, dans lequel se jette un ruisselet, est encombré de stalactites de glace, mais qu'importe, Fonné et ses trois compagnons descendront chacun à leur tour jusqu'à 35 mètres de profondeur, où ils constateront tous que le puits est irrémédiablement bouché. Là s'arrêteront les recherches de Fonné.

Conclusion: Martel, semble-t-il, n'est jamais venu aux Cuves, mais il en parle à plusieurs reprises. Avant les explorations de Fonné, il supposait que la navigation souterraine pourrait, ici aussi, faire progresser l'exploration (Martel 1894, 416), mais les lieux ne s'y prêtaient vraiment pas. Si, par la suite, il chercha à protéger le site menacé par un projet de captage hydro-électrique, Martel ne cacha pas sa déception quant aux résultats obtenus par Fonné: dans une des comparaisons dont il est coutumier, il dit sa préférence pour les grottes des gorges de la Bourne explorées par Decombaz (1928, 165).

Il est vrai qu'au terme de tous ces efforts, le point ultime atteint dans les Cuves n'est distant de l'entrée que d'environ 160 mètres, et les centaines de mètres de développement acquis dans les labyrinthes ne font pas illusion: les Cuves restent une caverne bien modeste. Le terminus de la salle du Styx ne sera dépassé que le 27 octobre 1947 par Géo Mathieu et Louis Eymas qui, trouvant au sol un passage entre les blocs, allaient donner la clé des découvertes à venir. Fonné, qui n'avait pas épargné sa peine et qui avait minutieusement fouillé ce secteur, était passé tout près du but. Après quoi, Mathieu, Eymas et leurs camarades, au lieu de retourner sur le plateau de Saint-Nizier qui ne leur paraît pas intéressant (Cadoux et al. 1955, 88), investirent le plateau du Sornin où, le 24 mai 1953, ils allaient découvrir le Gouffre Berger. L'aventure ne faisait que commencer!

Même si la jonction avec le gouffre Berger n'a jamais pu être réussie, malgré de nombreuses plongées et escalades, les Cuves de Sassenage sont aujourd'hui connues sur plus de 9 kilomètres de développement, et jusqu'à plus de 400 mètres au-dessus de l'entrée. Les spéléologues grenoblois aiment donc à visiter ce réseau varié et agréable à parcourir, sans toujours penser aux efforts de leurs lointains prédecesseurs.

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CUVES DE SASSENAGE, KLASIČNA JAMA V VERCORJU

Povzetek

Jama Cuves de Sassenage, ki leži v SV vznožju planote Vercors, 5 km od Grenobla, je jamarjem dobro znana in jo pogosto obiskujejo. V jami, dolgi 9 km in v nadm. viš. 408 m (zgornji vhod), se pojavlja voda iz brezna Berger. Prvi del jame je urejen za turistični obisk. Jama je znana že stoletja, vendar je bila v glavnem raziskana šele 1947.

Nekdaj so jamo uvrščali v "Sedem čudes Dofineje", to je med sedem naravnih pojavov, ki so jih v srednjem veku šteli za čudežne. Enkrat letno so se okoličani v procesiji podali do jame in si ogledali tolmuna v živi skali; glede na to, ali sta bila polna vode ali suha, so sklepali na dobro ali slabo letino. Ta dva tolmuna - "cuves" - sta v samem jamskem vhodu in kaže, da globlje v jamo ni šel nihče. Od začetka 16. stol. dalje so številni opisi teh "cuves", toda pred 18. stol. nihče ni opisal jame in njenih rovov.

1781 je Faujas de Saint-Fonds izdal "Naravoslovni opis Dofineje", kjer je poglavje z opisom te jame, takrat preiskane v dolžini 178 čevljev. Do 1898 ni bilo o njej ničesar novega, takrat pa se je J. Fonné ponovno lotil raziskav, opisal labirint rovov in izdelal prvi jamski načrt (1898-1899). To je svojevrsten paradoks: velika jama v več nivojih, znana že zelo dolgo časa, v katero pa ni nihče stopil pred koncem 19. stol.!

ACTA CARSOLOGICA	XXVI/2	7	75-80	LJUBLJANA 1997

INCIDENTI SPELEO D'ALTRI TEMPI - INFORTUNISTICA MINORE SUL CARSO TRIESTINO NEL XIX SECOLO

JAMARSKE NESREČE V PRETEKLOSTI. MANJŠE NEZGODE NA TRŽAŠKEM KRASU V 19. STOLETJU

PINO GUIDI [1]

Izvleček UDK 551.44(450.361)"18"

Pino Guidi: Jamarske nesreče v preteklosti. Manjše nezgode na Tržaškem Krasu v 19. stoletju

Prispevek opisuje tri nesreče, ki so se pripetile v zadnjih dvajsetih letih devetnajstega stoletja jamarjem iz Trsta na Tržaškem Krasu (Škocjanske jame, brezno pri Padričah, Labodnica). Ti so bili člani Abteilung für Grotten Forschung des Section Küstenland des Deutschen und Österreichischen Alpenvereins, Club Alpino dei Sette in Commissione Grotte della Società Alpina delle Giulie.
Ključne besede: zgodovina speleologije, nesreča, Italija, Slovenija, Kras.

Abstract UDC 551.44(450.361)"18"

Pino Guidi: Cave accidents in the past. Smaller mischances in the 19th century on the Trieste Karst

The papers describes three accidents, happened to the cavers from Trieste in the last 20 years of the 19th century on the Trieste Karst (Škocjanske jame caves, pothole near Padriciano, Grotta di Trebiciano cave). The cavers were the members of the "Abteilung für Grotten Forschung des Section Küstenland des Deutschen und Österreichischen Alpenvereins", "Club Alpino dei Sette" and "Commissione Grotte della Società Alpina delle Giulie".
Key words: history of speleology, accident, Italy, Slovenia, Kras.

[1] Commissione Grotte "Eugenio Boegan" - Società Alpina delle Giulie - C.A.I. TRIESTE, ITALIA

PREMESSA

L'esplorazione delle grotte è un'attività che comporta sempre qualche rischio: ci si può far male per colpa propria (avventatezza, uso di materiali scadenti o impropri, inesperienza) o per cause esterne (frane o piene non prevedibili, cedimenti di ripiani ecc.). L'attività speleologica sul Carso triestino nell'altro secolo, che - almeno da quanto emerge dalle ricerche d'archivio tuttora in corso - doveva essere piuttosto intensa[1], non poteva non annoverare anche qualche incidente. A parte quello che ha provocato quattro morti al "Foro della Speranza", da quel giorno chiamato Grotta dei Morti e su cui ha scritto esaurientemente Mario GALLI[2], se ne conoscono parecchi altri, con esito mortale e non. Alcuni dei maggiori sono ricordati nel 2000 Grotte[3], mentre ultimamente si è interessato all'argomento lo storico inglese Trevor R. SHAW[4].

In attesa di poter dare una panoramica per quanto possibile completa dell'infortunistica speleologica (o legata alle grotte) degli ultimi due secoli si presentano qui di seguito tre incidenti che hanno coinvolto i grottisti triestini, episodi a modo loro peculiari di quei tempi pionieristici.

4 MAGGIO 1884 - GROTTA DI SAN CANZIANO

Dal gennaio del 1884 il Grottenabtheilung del D.Ö.A.V., gruppo di esploratori delle grotte della Società Alpina Austro-Tedesca costituito nel settembre dell'anno prima[5], stava conducendo la sistematica esplorazione delle Grotte di San Canziano, esplorazione non più ripresa dopo i tentativi fatti da Adolf Schimdl (insieme all'ingegnere minerario di Idria Ivan Rudolf) nel 1852[6]. Il 4 maggio, durante l'esplorazione del tratto di grotta in cui il Timavo, dopo un percorso sotterraneo di quasi 300 metri, sbocca nella grande Voragine l'imbarcazione che trasportava Giuseppe Marinitsch, quarantenne uomo di punta della squadra, si rovesciava; il malcapitato, trascinato dalla corrente sino all'uscita della caverna, riescì a mettersi in salvo su di uno sperone di roccia dove lo troveranno i soccorritori dodici ore più tardi. Ecco la cronaca dell'episodio come venne narrata il 6 maggio dal *Piccolo corriere del mattino* di Trieste:

"UN INTREPIDO NUOTATORE. Nel pomeriggio di ieri l'altro, alcuni signori facevano un'escursione in battello, nella grotta di S. Canziano, la quale come si sa, è attraversata dal Recca. Ad un tratto il signor Marinitsch, che faceva parte della comitiva, cadde nell'acqua. Trasportato dalla corrente, ben presto gli amici lo perdettero di vista. Egli però nuotava intrepidamente e riuscì a mettersi in salvo.

Il signor Marinitsch stanco e sfinito e tutto molle d'acqua, diede fiato ad un corno che teneva fortunatamente presso di sé. Gli amici intanto lo ceravano disperatamente. Infine, a notte inoltrata, udirono il suono del corno e guidati da quello trassero il compagno a salvamento...". L'avventura finì bene (anche per la

robusta fibra del Marinitsch, che nel 1906 troveremo ancora a San Canziano - sessantenne di ferro - ad esplorare la Galleria del Silenzio), ed oggi quel tratto delle grotte di San Canziano porta il suo nome[7].

Il secondo incidente ricordato in questa breve nota avvenne quattro anni più tardi nel Carso più prossimo a Trieste, ed ebbe quali protagonisti un gruppo di giovanissimi studenti.

MAGGIO 1888 - POZZO PRESSO PADRICIANO,

Una comitiva del Club dei Sette (che però non si chiamava ancora così: il Club sarà formalmente costituito soltanto alcuni anni più tardi) si recò a visitare la prima parte (sino ai pozzi) della Grotta 12; poscia il gruppo andò ad esplorare una vicina grotta che inizia con un pozzo profondo 15 metri (probabilmente la Grotta presso Padriciano, 36 VG). Dalla relazione di Silvio Cavalli[8] leggiamo:

"...ci portammo all'imbocco dell'accennato pozzetto di 15 metri di profondità, distante circa 150 passi, nella direzione di Lipizza, dove lo Chaudoin[9] s'era proposto di scendere.

All'uopo avevamo fatto sulla famosa corda una serie di nodi per facilitare la discesa che seguì senza difficoltà. Raggiunto il fondo, il visitatore si limitò a constatare la direzione apparente che prendevano più rami della grotta, poi si accinse a risalire. dopo cinque metri di salita, lo Chaudoin aveva fatto una sosta su una sporgenza di roccia quando questa cedette e il novello speleologo precipitò con la schiena all'ingiù perdendo i sensi. Il nostro imbarazzo perdurò parecchio, finché lo Chaudoin si riprese e poté rispondere ai nostri appelli. Per facilitare la sua rampicata sostituimmo i nodi con dei lacci e così egli poté uscire quasi incolume, zoppicando solamente un pochino."

Successivamente buona parte dei giovani del Club dei Sette passò all'Alpina[10], vivificando la sua Commissione Grotte. A quei tempi gli speleologi della Società Alpina delle Giulie dedicavano gran parte delle loro energie alla Grotta di Trebiciano, non solo finestra sul Timavo sotterraneo, ma altresì, allora, la più profonda cavità del mondo. E qui, quasi alla fine del secolo, ecco verificarsi un altro incidente rimasto per fortuna senza conseguenze.

12 DICEMBRE 1897 - GROTTA DI TREBICIANO, 17 VG.

Nel corso di una visita alla Grotta di Trebiciano, 17 VG, i grottisti dell'Alpina provenienti dal Club dei Sette ebbero un drammatico contrattempo.

Ecco come racconta il fatto Eugenio Boegan[11] che partecipò all'escursione:

"Con la Commissione Grotte, nelle domeniche e nei giorni festivi, con costanza e pazienza non poca, riprese un rilievo particolareggiato e, per quanto possibile, scrupoloso dell'intera grotta, tanto per l'altimetria, quanto per la planimetria; fece osservazioni termometriche dell'aria a varie profondità, della

temperatura dell'acqua, ecc. quando il giorno 12 decembre 1897, ad una delle nostre solite discese in grotta a circa 200 metri di profondità, successe un incidente che poteva avere serie conseguenze.

La comitiva, composta dai consoci Umberto Sotto Corona, Mario Zey, lo scrivente e un operaio, stava misurando alcuni particolari dei pozzi, quando improvvisamente uno scricchiolio fece comprendere che una impalcatura, che chiudeva trasversalmente il pozzo, cedeva.

Difatti questa dopo pochi secondi crollò tutta intera assieme alle scale sottostanti, trascinando con sé soltanto lo Zey, che, istintivamente afferratosi ad una scala di legno, precipitò con essa perforando altre tre impalcature, fermandosi sopra una quarta e rimanendo illeso miracolosamente!

Venne tosto soccorso dai compagni rimasti al di sopra del sito crollato; gli si calò un fanale e gli venne calata una scala a corda acciocché potesse risalire il tratto del pozzo mancante delle scale di legno, le quali, assieme al legname delle impalcature formavano una catasta aggrovigliata bizzarramente."

Incidente rimasto senza conseguenze, come quelli - la storia si ripete... - annoverati dall'infortunistica speleologica nella Grotta di Trebiciano nel secolo successivo: sempre per colpa delle scale di legno fradice mezza dozzina di speleologi si infortuneranno nella grotta più conosciuta del Carso triestino[12].

NOTE

1) FARONE Egizio, 1994: *Le ricerche sul Timavo sotterraneo in relazione all'approvvigionamento idrico della città di Trieste (1841-1842)* - Atti e Mem. Comm. Grotte "E. Boegan", 31: 95-158; sulle ricerche ed esplorazioni di grotte nel secolo XIX si vedano pure i vari contributi di Egizio FARAONE, MARIO GALLI, Pino Guidi negli "Atti" del Simposio Int. sulla Protostoria della Speleologia, Città di Castello, 1991: 41-111 e Dario MARINI, 1981: *Prima ricerca dell'acqua sotterranea sul Carso* - Alpi Giulie, 75: 60-66
2.) GALLI Mario, 1975*: Documenti inediti e biografie per una "Storia della Speleologia" (Friuli-Venezia giulia). La Grotta dei Morti* - Mondo Sotterraneo, 1974-75: 135-172, Udine 1975
3.) Pur non riportando tutti gli incidenti sicuramente allora conosciuti (nella descrizione delle Grotte di San Canziano, per esempio, non si accenna all'insidente in cui perse la vita Federico Prez) l'opera contiene notizie su una dozzina di infortuni, di cui 7 avvenuti prima del 1900, Cfr. BERTARELLI Luigi Vittorio, BOEGAN Eugenio, 1926: *2000 Grotte, quarant'anni di ricerche [sul Carso??]* T.C.I. ed., Milano 1926: 1-494
4.) SHAW Trevor R., 1994: *Some cave accidentc and rescue before 1894* - ALCADI-94, Zusammenfassung, Symp. zur Geschichte der Speläologie in Raum Alpen, Karpaten und Dinariden, Wien 1994: 25-26. Nel riassunto

l'A. ricorda l'incidente alla Grotta dei Morti (ott. 1866) ed il decesoo (dic. 1891), conseguenza di una pleurite contratta all'Ab. dei Serpenti, di Anton Hanke.

5.) Notizie sui primi anni di vita del Abtheilung für Grottenforschung (o anche Grottenanbtheilung), come pure degli altri due sodalizi più avanti menzionati, si trovano in GUIDI Pino, 1995: *Cenni sull'attività dei Gruppi Grotte a Trieste dal 1871 al 1900*, Atti e Memorie della Commissione Grotte "E. Boegan", 32: 85-127,Trieste 1995.

6.) SCHIMDL Adolf, 1851: *Ueber den unteridischen Lauf der Recca -Sitz.*: 655-682, Wien 1851; GALLI Mario, 1971: *Antonio Hanke e l'esplorazione delle Grotte di San Caziano* - Alpi Giulie, 66-85, Trieste 1971. Su Ivan Rudolf vedi NOVAK Dušan et al., 1988: *Gradivo za slovensko biografijo* - Naše jame 30, suppl.: 1-192, Ljubljana 1988

7.) Galli, 1971, *op. cit.* pag. 78, (da cui è tratto il trafiletto del goirnale) nella seconda parte del lavoro descrive con dovizia di particolari l'inizio delle esplorazioni a San Canziano.

8.) Silvio CAVALLI, 1958: *Come conobbi il mio amico Eugenio Boegan*, pag. 3, dattiloscritto di 38 pagine, datato Trieste ottobre 1958 e conservato nell'archivio della Comm. Grotte "E. Boegan". Il Cavalli (all'epoca Kobau o, talvolta, Cobau) è stato compagno di esplorazioni del Boegan sin dai tempi del "Club dei Sette" e assieme allo stesso redasse nel 1897-98 uno studio sulla Grotta di Trebiciano premiato al concordo indetto dalla Reale Società Geografica Italiana. Il dattiloscritto she ci ha lasciato contiene moltissime notizie sul mondo speleologico giovanile di allora. Quanto all'anno cui il Cavalli riferisce l'incidente è doveroso segnalare che sussiste qualche perplessità: il Club dei Sette, contituto ufficialmente nel 1893, risulterebbe avere iniziato la sua attivita almeno tre anni prima (cioè al massimo nel 1890-1891), per cui la data 1888 parrebbe troppo lontana, oltrettutto quando il Boegan avrebbe avuto soltanto 13 anni.

9.) Ferruccio Chaudion, figlio del comandante dei Vigili del Fuoco di Trieste, CAVALLI, op. cit., pag. 3; descritto come elemento di notevole robustezza e coraggio, nel 1914 - all'avvicinarsi dell'entrata in guerra dell'Italia - diverrà capitano del corpo dei Vigili Fuoco volontari instituito dal Comune di Trieste.

10.) Il "Club dei Sette", prima - in ordine di tempo - società alpinistico-speleologica giovanile triestina, svolse attività (soprattutto speleologica) per almeno quatro anni (1891-1894); per le sue file passarono una sessantina di speleologi. Sciolta nell'estate 1894 dalla polizia in quanto non in regola con la normativa di allora sull'associazionismo, confluì praticamente in toto (uomini, idee, materiali) all'Alpina delle Guilie.

11.) La cavità, sin dalla sua scoperta oggetto di studi da parte del Comune di Trieste, era stata attrezzata con scale fisse di legno, varie volte sostituite in quanto soggette ad un rapido deperimento. La relazione dell'incidente e

riportata alla pag. 21 della monografia sulla cavità (BOEGAN Eugenio, 1909-1910: *La Grotta di Trebiciano* - Alpi Giulie 1909-1910, Tip. Caprin, estr.: 1-68);

12.) Dei molti incidenti registrati nella Grotta di Trebiciano (solo per gli anni '60 gli archivi del Soccorso Speleologico ne riportano cinque: 6.5.1961; 31.8.1961; 8.7.1962; 3.3.1963; 7.4.1968) alcuni erano dovuti al cattivo stato delle scale di legno fiesse, come quelli successi a Marino Vianelo, maggio 1961 (cedimento di due gradini) e ad Arturo Battaglia, tre mesi dopo (cedimento di un gradino). Ambedue gli speleologi si fermeranno sul ripiano posto qualche più sotto, riportando contusioni varie.

JAMARSKE NESREČE V PRETEKLOSTI. MANJŠE NEZGODE NA TRŽAŠKEM KRASU V 19. STOLETJU

Povzetek

Prispevek opisuje tri nesreče, ki so se pripetile v zadnjih dvajsetih letih devetnajstega stoletja jamarjem iz Trsta na Tržaškem Krasu.

Prva se je pripetila članom Abteilung für Grotten Forschung des Section Küstenland des Deutschen und Österreichischen Alpenvereins 4. maja 1884 v Škocjanskih jamah, v delu, ki se imenuje Mariničeva jama. Pri prečkanju Reke je J. Marinitsch padel in tok ga je odnesel, vendar je uspel niže ob vodi splavati na breg.

Maja 1888 se je v brezno pri Padričah (globoko okoli 15 m) spustil članovinec organizacije Club Alpino dei Sette. Pri plezanju iz jame, ob vrvi, se je odkrušila skala in padel je na dno ter se onesvestil. Vendar ni bil resneje poškodovan in je končno sam priplezal iz jame.

12. decembra 1897 je skupina raziskovalcev, članov "Commissione Grotte della Società Alpina delle Giulie" merila značilnosti v vhodnem breznu, ko se je udrl leseni podest in zgrmel v globino. Enega izmed članov je potegnilo zraven. Podrlo je še tri podeste, jamar pa je, kot po čudežu, ostal nepoškodovan.

ACTA CARSOLOGICA	XXVI/2	8	81-85	LJUBLJANA 1997

DER PLAN DER VILENICA VOM 20. APRIL 1818

NAČRT VILENICE DATIRAN "20. APRIL 1818"

HEINZ HOLZMANN [1]

Izvleček UDK 551.442(497.4)"1818"

Heinz Holzmann: Načrt Vilenice datiran "20. april 1818"

Najstarejši načrt Vilenice J. A. Nagla iz 1748 predstavlja le skico tlorisa; drugi, iz Mollovega atlasa (1752) je bolj groteskna slika, kot pa načrt, tretji pa je Vicentinijev načrt v akvarelu iz 1818. Meri 77 x 50 cm in ima sivo osenčen obris ter barvni pogled s strani, s sigo in kapniki. Na sliki so tudi obiskovalci, ki se držijo za ograjo. Na vrhu je šest vrst opisa jamev rokopisu, po vsej širini lista, s podpisom. Najbrž načrt ni bil nikoli javno predstavljen, saj so 1818 odkrili notranje dele Postojnske jame in zanimanje se je usmerilo tja. avtor prispevka je dobil ta načrt pred 10 leti na bolšjem trgu na Dunaju.

Ključne besede: zgodovina speleologije, jamski načrt, Slovenija, Kras, Vilenica, Vicentini.

Abstract UDC 551.442(497.4)"1818"

Heinz Holzmann: The map of Vilenica from 20. April 1818

The oldest map of Vilenica by J.A. Nagel (1748) is only a plan sketch; the second one from the Moll's Atlas (1752) is a rather grotesque painting; and the third one is watercolour by Vicentini from 1818. It measures 77 x 50 cm and shows a grey shaded outline and a coloured side view showing dripstonesan stalagmites. This layout also shows some visitors holding the handrail. At the top a signed six-line handwritten description of the cave covers the full map width. Probably this map was never exhibited publicly because in 1818 the new parts of Postojnska jama were explored and the interest was directed there. The author acquired the map at the Vienna fleamarket 10 years ago.

Key words: history of speleology, cave map, Slovenia, Kras, Vilenica, Vicentini.

[1] Straussengasse 3 a, AT - 1050 WIEN, AUSTRIA

Die Höhle, die wahrscheinlich die älteste Schauhöhle der Welt ist, hat im Laufe der Zeit verschiedene Bezeichnungen gehabt. Von den Landsleuten der Gegend wurde und wird sie als Vilenica bezeichnet, dann als Berggrotte von Triest oder Grotte von Corniale bzw. Höhle von Corjnale oder deutsch Feenhöhle und heute heißt sie Vilenica. Man kann annehmen, daß bereits gegen Ende des 15. Jahrhunderts von Reisenden, Doktoren der Naturwissenschaften und Studenten, von Triest aus, die Höhle besucht wurde. Im 17. Jahrhundert waren es dann die Mannschaften, der Triest anlaufenden Handelsschiffe und besonders die Engländer ließen sich in die Höhle führen.

Der Graf Petazzi (Petač) vom Gute Schwarzenegg (Zavrhek) übertrug das Nutzungsrecht der Höhle 1633 der Kirche von Lokev (Corniale) mit der Auflage ihm die Hälfte der Einnahmen abzuliefern. Laut I. Gams (1973): Slovenska Kraška Terminologija (Ljubljana) 47, besuchte wahrscheinlich Kaiser Leopold I. die Höhle 1660. Aus der Chronik der Pfarre von Lokev ist ersichtlich, daß der Graf Petazzi im Jahre 1709 die Höhle der Pfarre vom Lokev abgetreten hat, um mit einem Teil der Einnahmen die Armen zu unterstützen. Dann muß es aber still um die Höhle geworden sein, denn als 1748 Josef Anton Nagel der Hofmathematikus des Kaisers Franzisko I besuchte schreibt er in seiner Handschrift die in der Österr. Nationalbibliothek liegt.

"Beschreibung deren / Auf allerhöchsten Befehl / Ihro Röm. Kaijl. und Königl. Maijtt. FRANCISCI I untersuchten, in dem Herzogthum Crain befindlichen Seltenheiten der Natur."

Nachdem er über 7 Seiten die Höhle mit all ihren Tropfsteinen beschreibt (einem Grundrißplan (Plan Nr. XII) sowie 3 Bilder fügt er bei), stellt dann am Schluß fest: "Diese von mir zu erst bekannt gemachte Höhle ist ohnstreitig die schönste unter denen die bishero entdeckt worden sind." Und vergleicht weiter die in A. Kirchener (1679): Mundi Subterranei, 3. Auflage (Amsterdamm), beschriebene Höhle auf Antiparos noch die Baumannshöhle in der Grafschaft Stollberg die in "actis eruditorum Lipsiensium" beschrieben und abgebildet ist, noch die von Keyssler so gerühmte Magdalenenhöhle, und ebensowenig die von Valvasor über alle andere erhobene Lueger-Höhle können mit der Corniale in Vergleich gestellt werden. Daher verewigte sich Nagel als Entdecker auf warzigem Tropfstein mit folgender Inschrift:

"Cum N.N. juhus / Augustishimi Imperätoris / Francisci I. hanc et alias / complures cryptas perlustrahset, / in Corniolia Cornialiensem / hanc omnium invenit principem. / Anno 1748 die 18er July".

Nagel hat uns den 1. erhaltenen Plan der Höhle gezeichnet, der aber nur einen sehr einfachen Grundriß darstellt.

Ein weiterer Plan ist uns aus dem sogenannten Mollschen Atlas, 1752 Brünn, eine Handschrift mit 8000 Blättern erhalten. Der Plan und die Beschreibung zeigt, daß hier viel Fantasie mitspielt so ist es ca. 30 km Luftlinie nach Wipach und in der Höhle fließt ein Fluß. Hier liegt wahrscheinlich eine Verwechslung mit der Höhle von St. Kanzian vor, die der Künstler wahrschein-

lich von Einheimischen erzählt bekommen hat. Richtig wird aber bemerkt, daß die Höhle dem Grafen Petazi gehört. Dies läßt schließen, daß dieser Plan wahrscheinlich früher entstanden ist.

Die erste gedruckte Beschreibung erscheint 1795 in Trieste in alt italienischer Sprache und zwar Giuseppe Compagnioni: "La Grotta di Vileniza". Diese bibliophile Rarität wurde auch ins Deutsche vom Autor übersetzt, und liegt uns in einem Privatdruck (1986) vor.

Der Plan von 20. April 1818, der sich im Privatbesitz des Autor befindet, konnte vor 10 Jahren am Wiener Flohmarkt aus dem Nachlaß von dem akademischen Maler E. Fehlinger erstanden werden. Er war im Jahr 1892 warscheinlich in der Höhle und konnte diesen Aquarellplan, 77 x 50 cm, nach Wien mitnehmen. Ein Aquarell von E. Fehlinger, "Die Schmidel-Grotte", in der Höhle von St. Kanzian, 22 x 27 cm, das gleichzeitig mit dem Plan vom Autor gekauft wurde, läßt die Vermutung erhärten. Da 1818 die neuen Teile in der Adelsberger Grotte gefunden wurden und sogleich der Öffentlichkeit zugänglich gemacht wurden, war das Interesse zum Besuch der Vilenica mit einem Schlag vorbei. Da Adelsberg heute in Postojna, an der Eisenbahnlinie Wien - Trieste, liegt, war der Besuch dieser Höhle für das interessierte Publikum weitaus bequemer. So ist anzunehmen, daß dieser Plan nie zur Ausstellung gekommen ist und daher so gut erhalten geblieben ist.

Dieser vom Inspektor des öffentlichen Bauwesens VICENTINI, gezeichnete Plan gliedert sich in drei Abschnitte: Oben ist in sechs Zeilen in Schreibschrift die Höhle beschrieben. Dieser Text wird im nachfolgenden dem Atikel angefügt.

In der Mitte ist ein gestreckter Längenschnitt nur entlang des Führungsweges dargestellt. Es ist die große Tropfsteinsäule im Eingangsbereich, sowie die makanten Stalaktiten und Stalakmitten fein säuberlich gemalt und entlang des Führungsweggeländers stehen insgesamt 8 Besucher. Es ist auch die Höhe der Überdeckung der Höhle, vom Führungsweg bis zur Oberfläche, ca. alle 25 Klafter kotiert und beträgt zwischen 87 Fuß bei der Tropfsteinsäule und 150 Fuß am Ende des Führungsweges. Der Felsenschnitt ist rosa angelegt während die Tropfsteine in Brauntönen gemalt sind. An der Oberfläche ist eine vegetationsarme Karstlandschaft dargestellt.

Die untere Hälfte des Bildes nimmt der Grundriß ein, der in Grauschattierungen in einem grün angelegten Feld gemalt ist. Außer dem Führungswegbereich (180 Klafter) werden noch drei weitere Bereiche C, D und E planlich erfaßt und die Gesamtlänge mit ca 480 Klafter (= 910 Meter) angegeben.

BESCHREIBUNG DER GROTTE VON CORNIALE:

Diese Grotte ist vom Punkt des Einganges A. bis B. in einer horizontalen Länge von 180 Klafter begehbar. Außer den ebenen Flächen steigt man über 330 Stufen hinunter und über 90 hinauf, zusammen 420 Stufen.

Vom Plateau B. bis zum Punkt E. zu dem der Unterzeichnete mühselig vordrang, das heißt in C. D. E. fand er drei schräge Flächen, welche dem Betrachter viele leuchtende Säulen, Katarakte, Drapierungen, Girlanden und wunderschöne Nadeln zeigte. Zwischen denen in der Höhle D., eine hat die Form eines gotischen Kirchturms mit vielen Abschnitten, Kanellierungen und sind nachempfundene Arbeiten der Kunst; und ihr Durchmesser an der Basis ist 16 Fuß. An der Spitze läuft sie zu einem Punkt aus, und hat eine Höhe von ungefähr 90 Fuß. Diese Höhle von runder Form hat einen Durchmesser von 90 Fuß, sie wird getragen von einer großen Zahl von Säulen und der Himmel ist von einer gleichmäßigen ebenen Decke gebildet, in deren Mitte sieht man ein rundes Medaillon von 5 Fuß Durchmesser, umgeben von prismenförmigen Stalaktiten von verschiedener Länge und wunderbarer Großartigkeit.

In der Höhle E. ist der Abstieg sehr beschwerlich, weil es durch eine Passage zwischen zwei eng stehenden Säulen durchgeht, es bieten gleichfalls wunderschöne Ansichten; angrenzend gibt es Zimmerchen von sehr kurioser Form und einen mühselig begehbaren Weg, welcher sehr steil in die Tiefe führt und in welche man ohne Leitern und Seile nicht hineingehen kann.

Vom Horizont des Einganges A. bis B. ist die Tiefe 156 Fuß, im Punkt C 240 Fuß, im Punkt D 350 Fuß und schließlich bis dorthin , wo man vordringen konnte, sind es horizontal ca. 480 Klafter.

Trieste den 20. April 1818

Gezeichnet:Vicentini ausgezeichnet

von seiner Majestät mit dem Kreuz für zivile

Verdienste und Inspektor des öffentlichen Bauwesens

NAČRT VILENICE DATIRAN 20. APRIL 1818

Povzetek

Najstarejša turistična jama tega področja je "Cave of Triest = Grotta di Corniale = Vilenica = Feenhöhle", ki je bila obiskovana že konec 15. stol. Verjetno so vodniki imeli jamske načrte, vendar jih je le nekaj ohranjenih.

Najstarejši načrt Vilenice J. A. Nagla iz 1748 predstavlja le skico tlorisa; drugi, iz Mollovega atlasa (1752), je bolj groteskna slika, kot pa načrt, tretji pa je Vicentinijev načrt v akvarelu iz 1818. Meri 77 x 50 cm in ima sivo osenčen obris ter barvni pogled s strani, s sigo in kapniki. Na sliki so tudi obiskovalci, ki se držijo za ograjo. Na vrhu je šest vrst opisa jame v rokopisu, po vsej širini lista, z avtorjevim podpisom in njegovimi naslovi. Po tem opisu oziroma načrtu je jama globoka ca 480 klafter, to je 910 metrov.

Najbrž načrt ni bil nikoli javno predstavljen, saj so 1818 odkrili notranje dele Postojnske jame in zanimanje se je usmerilo tja. avtor prispevka je dobil ta načrt pred 10 leti na bolšjem trgu na Dunaju.

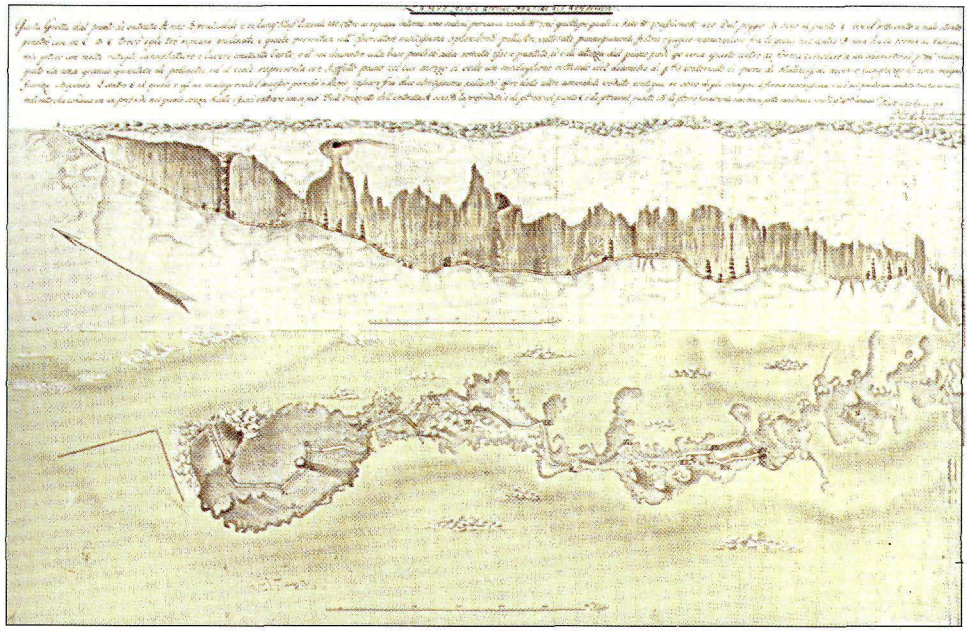


Fig. 1: The plan of the Vilenica cave from 1818.

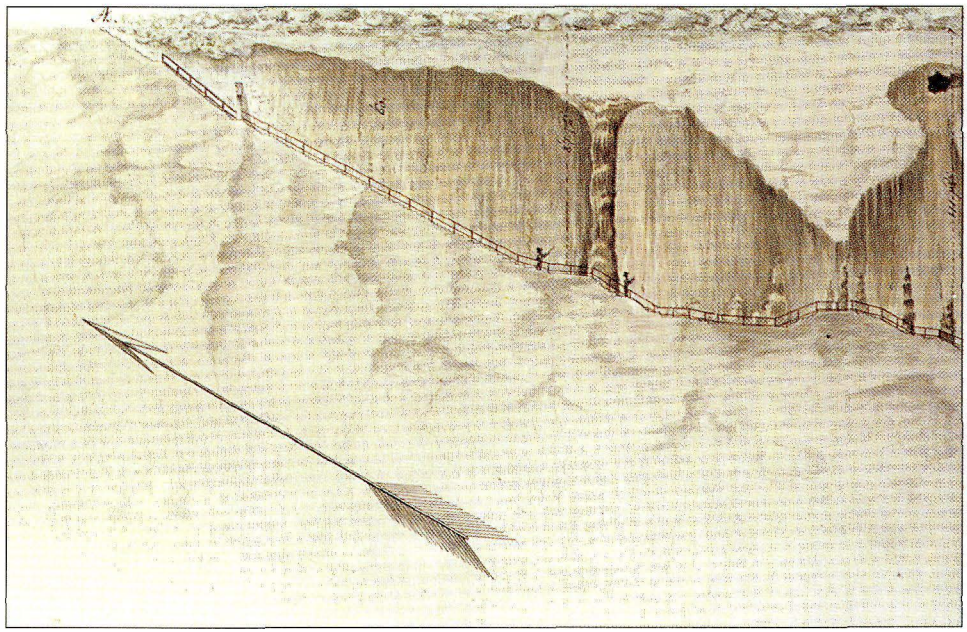


Fig. 2: The plan of the Vilenica cave from 1818, the detail.

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SPELEOLOGISTS ON POSTAGE STAMPS

SPELEOLOGI NA POŠTNIH ZNAMKAH

HEINZ ILMING [1]

Izvleček UDK 551.44:656.835.91
Heinz Ilming: Speleologi na poštnih znamkah

Med znamenitimi osebami, ki jih prikazujejo poštne znamke, jih je tudi več zanimivih za speleologijo. Avtor jih našteje štirinajst in na kratko označi njihov pomen za speleologijo. Vsi so pomembni tudi za dežele v okviru "ALCADI".
Ključne besede: zgodovina speleologije, znameniti speleologi, poštna znamka.

Abstract UDC 551.44:656.835.91
Heinz Ilming: Speleologists on Postage Stamps

Among the postage stamps with portraits of important persons are several that are interesting for speleology. The author enumerate 14 of them and shows their importance for the speleology. They are also important for the "ALCADI" countries.
Key words: history of speleology, important speleologists, postage stamp.

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The author presented pictures of postage stamps bearing portraits of people important in the history of speleology (reproduced from the collection belonging to Mrs. Helga Hartmann, Landesverein für Höhlenkunde in Wien und NÖ).

The earliest person we can connect with speleology is AVICENNA (Abu Sina) born 980 in Buchara, died 1037 during a battle against Hamadan. He was a philosopher, theologian and physician. Being also a scientist he became interested in the origin of dripstones.

Stamp: Poland 1952, Hungary 1987.

GEORG AGRICOLA - Agricola is Latin for "farmer" - the founder of modern metallurgy and mineralogy, was born 1494 in Glachau and died 1555 in Chemnitz where he had been mayor and town-physician. In the consequence of the mining methods of his time he became interested in natural subterraneous cavities and he also published a cave-map in 1646.

Stamp: DDR 1957.

We owe a summary of Karst and Caving, which is of special interest to speleologists, to JOHANN WEICHARD Freiherr von VALVASOR. It is included in his work "Die Ehre des Herzogthums Crain" in 4 volumes, published 1689 in Nürnberg and Laibach. In his work not only caves are included, but also the descriptions of the special hydrological situation of Zirknitzer lake.

Stamp: Yugoslavia 1989.

The Danish scientist NIELS STENSEN searched 1671 in Northern Italy, where he was well known under the name NICOLO STENONE. As a guest of the Count of Castelbarco he visited several already known ice-caves. In the same year he wrote his "Cave-letters", containing descriptions of the ice-caves, sketches of them and reflections about their origin.

Stamp: Denmark 1969.

The Italian naturalist L. SPALLANZANI, 1729 - 1799, realised - early already - that bats do not need their eyes for orientation.

Stamp: Italy 1979.

GEORGES Baron CUVIER, born 1769 (the same year as Napoleon) in Mömpelgard, died in Paris 1832. He was the founder of systematic anatomy - initiated the biggest anatomic collection in Europe - and introduced comparative osteology into palaeontology. His reconstruction of fossil vertebrates are of special importance for speleo-paleontology.

Stamp: Italy 1979.

ALEXANDER Freiherr von HUMBOLDT, born 1769 and died 1859 in Berlin. He is considered the greatest scientist of his time. He contrasts the poetic/speculative tendency of his period with exact experiment. Many research -voyages brought results of an extraordinary synopsis over various fields of knowledge. Speleology owes him the exact descriptions of several caves among them the report about the Guacharo cave and about the birds in it which can locate themselves with sound reflection.

Stamp: Venezuela 1969, DDR 1969.

Of great importance for Belgium and especially for the Grotte de Han is ADOLPHE QUETELET 1796 - 1854. His excellently drawn cave-maps show the progress in research in his time.

Stamp: Belgium 1974.

The scientist HERMAN OTTO lived 1835 to 1914 and is considered the father of Hungarian speleology. Herman's findings of stone-tools caused a discussion about prehistoric man in Hungary and inspired for the foundation of the Hungarian Society of Speleology.

Stamp: Hungary 1954, 1960.

JOVAN CVIJIĆ born 1865 in Loznica, died 1927 in Beograd. Finished his studies with a dissertation on "The Karst". He was the most important geographer who in the course of modern research was able to combine all aspects of geography, as for instance geomorphology, hydrology of karst, ethnography, anthropogeography and also speleology.

Stamp: Yugoslavia 1970.

The important bio-speleologist EMILE RACOVITZA 1868 - 1947 was one of the first to construct a subterranean laboratory for the study of cave animals and who was working on their systematics.

Stamp: Rumania 1958.

CESARE BATISTI born 1875 in Trento is without doubt better known as a politician and a fighter for the independence of his native country - he was sentenced to death by a court martial in 1916 - than as a speleologist. Still, as a geographer he was passionate in describing the mountains of his country and in exploring new caves. As an organiser he was the father of speleology in the country of Trento and a leading person for the speleology in Italy.

Stamp: Italy 1966.

ABBÉ BREUIL (1877 - 1961) and

PIERRE TEILHARD DE CHARDIN (1881 - 1961) are of great importance, having set up the basic perception in the investigation of the history of

early man. BREUIL recognised, against many antagonists, the authenticity and importance of cave wall-painting and became its first expert. His disciple TEILHARD DE CHARDIN, a highly cultivated Jesuit priest, devoted himself to excavations in caves. His finds in the Zhoukoudian cave in China are world famous. In all his works he endeavours to reconcile "Darwin and the Bible".

Stamp: France 1977 and 1981.

GIULIO NATTA 1903-1979, received in 1963 the Nobel prize for Chemistry. This great scientist was also a passionate caver and president of the Gruppo Grotte Milano.

Stamp: Italy 1992.

SPELEOLOGI NA POŠTNIH ZNAMKAH

Povzetek

AVICENNA (Abu Sina) (980-1037), se je zanimal za nastanek kapnikov. (Poljska 1952, Madžarska 1987).

GEORG AGRICOLA (1494-1555), osnovatelj moderne metalurgije in mineralogije, je 1646 objavil jamski načrt. (DDR 1957).

Baron JOHANN WEICHARD VALVASOR je najbolj pomemben zaradi objave "Die Ehre des Herzogthums Crain" v 4 oblikah (1689), kjer je veliko tudi o krasu in jamah. (Jugoslavija 1989).

NIELS STENSEN (NICOLO STENONE) je obiskal ledene jame v Severni Italiji in 1671 objavil "pisma o jamah" z opisi ledenih jam in razglabljanjem o njihovem nastanku. (Danska 1969).

L. SPALLANZANI (1729-1799) je ugotovil, da netopirji za orientacijo ne potrebujejo oči. (Italija 1979).

GEORGES CUVIER (1769-1832), utemeljitelj sistematske anatomije, znan predvsem po rekonstrukcijah fosilnih sesalcev, pomemben za "speleo-paleontologijo". (Italija 1979).

ALEXANDER von HUMBOLDT (1769-1859) je s svojih potovanj opisal več jam, posebej je pomembna jama Guacharo, kjer živijo ptice, ki se orientirajo s pomočjo zvoka. (Venezuela 1969, DDR 1969).

ADOLPHE QUETELET (1796-1854), risar načrtov jame Grotte de Han (Belgija 1974).

OTTO HERMAN, (1835-1914), odkritelj paleolitskih kultur in ustanovitelj Madžarskega speleološkega društva. (Madžarska 1954, 1960).

JOVAN CVIJIĆ, (1865-1927), je objavil disertacijo "Kras" in utemeljil speleologijo kot vedo, ki povezuje razne naravoslovne veje. (Jugoslavija 1970).

EMILE RACOVITZA, (1868-1947), znan po podzemeljskem laboratoriju za preučevanje jamske favne in kot sistematik. (Romunija 1958).

CESARE BATISTI, (1875-1916), geograf in raziskovalec alpskih jam, vodilni med italijanskimi speleologi. (Italija 1966).

ABBÉ BREUIL (1877-1961), raziskovalec prazgodovine človeka in strokovnjak za jamsko umetnost.
PIERRE TEILHARD DE CHARDIN, (1881-1961), učenec A. Breuila in jezuit, odkritelj znane jame Zhoukoudian na Kitajskem, ki je skušal uskladiti Darwina z Biblijo. (Francija 1977 in 1981).

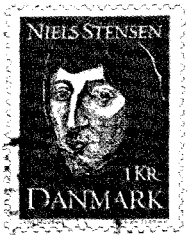
GIULIO NATTA, (1903-1979), Nobelova nagrada za kemijo 1963, navdušen jamar in predsednik Gruppo Grotte Milano. (Italija 1992).


POLSKA


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MAGYAR POSTA




JUGOSLAVIJA 300


NIELS STENSEN
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1799
Italia 170

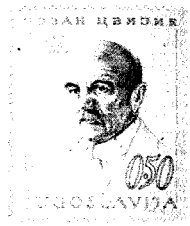

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MAGYAR POSTA


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FRANCE
1879 ABBÉ BREUIL 1961


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GIULIO
NATTA
PREMIO
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1916 FILZI BATTISTI CHIESA SAURO 1966

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CONTRIBUTION TO THE HISTORY OF THE EXPLORATIONS OF THE CAVE VJETRENICA IN ZAVALA TO 1914

PRISPEVEK K ZGODOVINI RAZISKAV VJETRENICE V ZAVALI DO 1914

ANTON KAPEL [1]

Izvleček UDK 551.442(497.6)(091)
Anton Kapel: Prispevek k zgodovini raziskav Vjetrenice v Zavali do 1914

Prispevek navaja najpomembnejše raziskave in avtorje, ki so raziskovali Vjetrenico oziroma objavili opise ali načrte. Prva omemba jame je že iz 15. stol., prve raziskave pa so s konca prejšnjega stoletja (Vavrović), z začetka tega pa so pomembnejši raziskovalci inženirji sarajevske železniške direkcije, K. Absolon in K. Paž.
Ključne besede: zgodovina speleologije, Hercegovina, Vjetrenica.

Abstract UDC 551.442(497.6)(091)
Anton Kapel: Contribution to the history of the explorations of the cave Vjetrenica in Zavala to 1914

The most important explorations of Vjetrenica by those published the results of their work with surveys, are dealt with. Vjetrenica was first mentioned in 15th century. The most important investigators from the end of the 19th century and the beginning of the 20th were Vavrović, the engineers of the Sarajevo's Railway Administration, K. Absolon and K. Paž.
Key words: history of speleology, Herzegovina, Vjetrenica Cave.

[1] Zavod za zaštitu kulturno-historijskog i prirodnog nasljedja BiH, Alekse Šantića 8/III, SARAJEVO, REPUBLIKA BOSNA I HERCEGOVINA

Bosnia and Herzegovina lie in the mountainous heart of the Dinarids, between the Adriatic Sea and the Pannonian plain. The territory covers 51.129 km^2 of which 30 % are karst. It is understandable that in such a large territory there are numerous karst phenomena, the caves being the most important. The karst of Bosnia and Herzegovina has numerous surface and underground phenomena which are seldom found in other lands. One of them is Vjetrenica cave, which is one of the most interesting karst phenomena in Bosnia and Herzegovina. Owing to its flowstone formations, abundance of water, natural beauty and rarity, and to its scientific value as well, it was put in the Register of protected phenomena as the first speleological natural monument under the number 3, under the Cultural and Natural Monuments Protection Act (Kapel 1980).

Vjetrenica cave is situated at Zavala in the SW corner of Popovo Polje, about 15 km from the Adriatic coast. It is a very interesting underground feature and the most impressive one in the Dinaric karst, with regard to its genesis. The cave is very interesting from the hydrogeological, geological, geomorphological, speleological, palaeontological and biological points of view. Because of its flowstone decoration and the wealth of water, Vjetrenica became a show cave in 1964.

Taking into account the fact that Vjetrenica is the biggest and the most complex system in the Popovo Polje region, it is natural that it interested travellers as well as local and foreign scientists long ago. Vjetrenica is over 7,5 km long and thus also the longest cave in Bosnia and Herzegovina. There are many published works about its speleological characteristics, professional and scientific papers, reports, studies, etc.

In the paper Contribution to the knowledge of speleological investigations in Bosnia and Herzegovina by Malez and Lenardić - Fabić (1988), there is a chronological overview of the more important investigations including those of Vjetrenica. The authors suggested that it is necessary to continue the historical investigations of cave data in Bosnia and Herzegovina, so I would like to present a short contribution to the history of Vjetrenica exploration.

The Vjetrenica cave is first mentioned in 15th century, according to M. Vego's (1957) book Places of Bosnia in the Middle Ages, where he stated: "Zavala is mentioned as a village in 1372. It is mentioned again in 1461, when the Vjetrenica cave is mentioned too."

After the Austro-Hungarian occupation of Bosnia and Herzegovina in 1878, the scientific research about the land started too. To achieve this aim the "Zemaljski muzej" (Country Museum) was founded in Sarajevo, the first scientific institution in the country. It began to function by the 1st February 1888 investigating Bosnia and Herzegovina from different aspects. It started its own publication (Glasnik Zemaljskog muzeja) where the results of its investigations were published (Gašparović 1984).

Josip Vavrović, an ex-Austro-Hungarian officer, surveyed and described the

first part of Vjetrenica (1893). He made a good description of the main channel, from the entrance to a point 700 m in. He has drawn a plan of this part of the cave too, at a scale of 1:4000 and a longitudinal section (horizontal scale 1:800 and vertical 1:1000). There are some inaccuracies in his plan but all the same it is much better than the previous one made by H. Mihajlović, which shows only the first 250 m of the cave.

In 1904 the engineers of Sarajevo's Railway Administration succeeded in reaching "Veliko jezero" (the Big lake). They made the plan and longitudinal section of a part of the main channel at a scale 1:1000. The shape of the main channel, up to a distance of 770 m from the entrance, is shown on the plan and the base line only to Veliko Jezero was drawn (Radovanović 1929).

The well-known Czech speleologist Karel Absolon, a curator of the museum of Brno, investigated cave fauna in our caverns. He visited some of them many times, Vjetrenica for example 27 times (Mikšić 1978). In the years 1912 - 1914 he organised three expeditions to Vjetrenica. In the summer 1912, during the first one, they reached "Veliko Jezero" and collected rich underground fauna, which made Vjetrenica well known over the World. In 1913 he and some members of his team reached the top of "Brdo" (the Mountain); while the third expedition was organised with the help of A. Kral in 1914. K. Absolon was the first to enter the channel which starts 600 m from the entrance and leads under the main channel of Vjetrenica (Absolon 1916). In honour of him the channel was called "Absolonov Kanal" (Absolon's Channel) by Radovanović.

Absolon's friend K. Paž, ex-officer of Austro-Hungarian army, brought a big boat into Vjetrenica in 1913 with the help of the army. With the boat they were able to cross "Malo Jezero" (Small Lake) and "Veliko Jezero" thus reaching collapsed limestone blocks beyond (Radovanović 1929).

Finally it is necessary and sad to mention that a lot of written material about Vjetrenica was destroyed during the war in the Republic of Bosnia and Herzegovina (literature in the National and University Library and in the Institute for the protection of cultural-historical and natural heritage of Bosnia and Herzegovina in Sarajevo).

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PRISPEVEK K ZGODOVINI RAZISKAV VJETRENICE V ZAVALI DO 1914

Povzetek

Prispevek navaja najpomembnejše raziskave in avtorje, ki so raziskovali Vjetrenico oziroma objavili opise oziroma načrte.

Prvič je Vjetrenica omenjena že v 15. stol., kot pravi M. Vego v svoji knjigi "Naselja Bosanske srednjovjekovne države" (1957): "Zavala je omenjena 1372 kot vas. Ponovno se omenja 1461, takrat je omenjena tudi jama Vjetrenica."

J. Vavrović (1893), bivši avstro-ogrski oficir, je objavil opis in načrt prvih 700 m glavnega rova Vjetrenice. Tloris je v merilu 1:4000, vzdolžni profil pa ima horizontalno merilo 1:800, vertikalno pa 1:1000. Kljub pomanjkljivostim predstavlja načrt bistveni napredek v primerjavi z načrtom H. Mihajlovića, ki prikazuje le prvih 250 m rova.

1904 so jamo raziskovali inženirji Sarajevske železniške direkcije. Prodrli so do Velikega jezera, napravili načrt v merilu 1:1000 do dolžine 770 m, do Velikega jezera pa so potegnili poligon.

Češki speleolog K. Absolon je obiskal Vjetrenico kar 27 krat in med 1912 - 1914 pripravil vanjo tri odprave. Jama je postala svetovno znana prav zaradi njegovih favnističnih odkritij. Po njem so kasneje imenovali Absolonov kanal, rov, ki poteka pod glavnim rovom.

1913 je Absolonov prijatelj K. Paž s pomočjo vojske spravil v jamo velik čoln. Z njegovo pomočjo so prečkali Malo in Veliko jezero in prodrli do podornih apnenčevih blokov.

Na koncu je treba povedati, da je bilo o Vjetrenici veliko zapisanega gradiva (Narodna i univerzitetska biblioteka BiH, Zavod za zaštitu kulturno-historijskog i prirodnog nasljedja BiH), ki je bilo, žal, uničeno med vojnimi dogodki v Republiki BiH.

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BRIEF ACCOUNT OF THE DEVELOPMENT OF SPELEOLOGY IN SLOVENIA (to 1914)

KRATEK PREGLED RAZVOJA SPELEOLOGIJE NA SLOVENSKEM (do 1914)

ANDREJ KRANJC[1]

Izvleček UDK 551.44(497.4)(091)
Andrej Kranjc: Kratek pregled razvoja speleologije na Slovenskem (do 1914)

Med starejšimi predhodniki speleologov so najpomembnejši Valvasor, Nagel in Hacquet, ter raziskovalci najstarejših turističnih jam (Vilenice, Postojnske in Škocjanskih). V prvi polovici 19. stol. so najpomembnejše speleološke raziskave za iskanje vode za Trst, v drugi polovici pa globokih brezen in velikih vodnih jam na Notranjskem. 1882 ("Slovenski gadje") oziroma 1883 (prve speleološke organizacije v Trstu) pa se prične na Slovenskem čas organiziranega jamarstva.
Ključne besede: zgodovina speleologije, Slovenija.

Abstract UDC 551.44(497.4)(091)
Andrej Kranjc: Brief account of the development of speleology in Slovenia (to 1914)

The most important predecessors in speleology are Valvasor, Nagel and Hacquet, and the explorers of the first show caves (Vilenica, Postojnska jama, Škocjanske jame). In the first half of the 19th century the most important speleological explorations were those intended to find drinking water sources for Triest, and in the second half the explorations of deep potholes and big water caves of Notranjsko. In the years 1882 ("Slovenski gadje") and 1883 the period of organised caving activity began.
Key words: history of speleology, Slovenia.

[1] Karst Research Institute, ZRC SAZU, Titov trg 2, SI - 6230 POSTOJNA, SLOVENIA

On the territory of present-day Slovenia people have known and used caves since Palaeolithic times. The caves were used as shelters, campsites, stores, for water supply (e.g. Podpeška Jama on Dobrepolje) and as sanctuaries. Among them Sveta Jama (The Holy Cave) is maybe the best example. The martyr Saint Socerb (Servulus) lived in the cave and, soon after he died (24th May 284 AD), the cave was visited as a sacred place and an altar was erected in it (Kranjc 1995).

However we cannot speak about "speleological approach" before the Enlightenment. Our first predecessor of Slovene speleology is J. W. Valvasor (1641-1693) who visited, studied, and published about 70 caverns from Kranjska (Carniola). He published the first cave plan of a Slovene cave - Podpeška Jama in 1687 (Fig. 1) - being, according to our knowledge, the second published cave survey in the Western World. A true "speleological project" were Nagel's investigations in 1748. In his manuscript, the first plans of some of our caves (Postojnska Jama, and Željnske Jame near Kočevje) appeared. Although F. A. Steinberg did not take a special interest in caves, his book about Cerkniško Jezero (1758) is very important for the history of Slovene karst and cave science. In the second part of the 18th century the "scientific discovery" of Proteus by Laurenti (1768) gave new aspect to visiting caves. Hacquet, who lived in Kranjska from 1766 to 1786, was the first man who was scientifically interested in karst and caverns. He was aware that karst features are due to a sort of corrosion and that "karst" (he wrote a native expression "krš" or "karoš") is not limited to the Kras region only. It is a pity that he left Kranjska because of ignorant, hypocritical and religious inhabitants. Gruber was the first who understood (and published in 1781) the hydrology of karst in

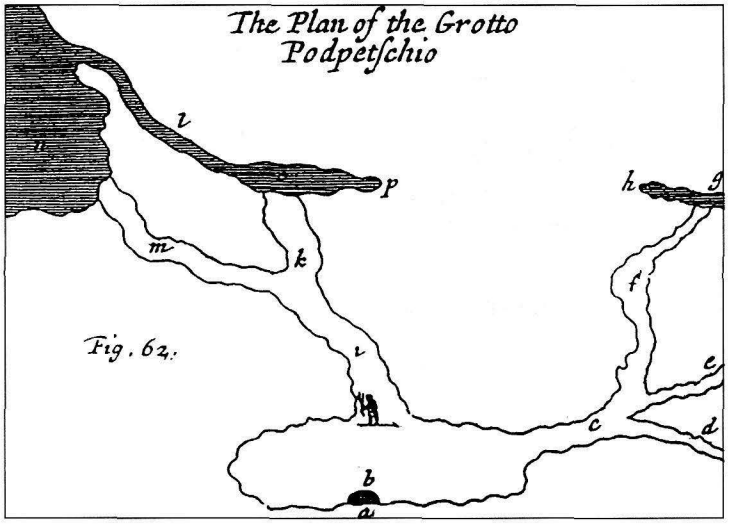


Fig. 1: Valvasor's "Plan of the Grotto Podpetschio" (Podpeška jama), published in Philosophical Transactions in 1687.

Kranjska. He was not specially interested in caves, but he visited quite a lot of them and made possible a much better knowledge about our water caves.

Cave tourism was very important too. It had been practised already in different forms (for example a religious one) for centuries. According to documents Vilenica was a "real" show cave already in 1633. At the end of the 18th century the discovery of *Proteus* in Črna Jama (at that time called Magdalena Grotte) aroused new interest in visiting caverns. Postojnska and Škocjanske Jame caves were officially opened as show caves in 1819. The names such as Luka Čeč and Josip Jeršinovič, Tominc and Mahorčič are closely connected with discoveries and display of these caves.

The first half of the 19th century is marked by investigations for the water supply of Triest; great explorations were carried out in Škocjanske Jame (by J. Svetina in 1839) as well as in deep shafts on Kras by F. Lindner with considerable help of native workers, such as L. Kralj (Jama na Hudem Letu -226 m, Labodnica -329 m). A group of Idrija miners, headed by Arh, formed the "Exploration Commission for Water and Shafts above Triest" (Savnik 1961). Although the exploring technique was such as in mines, we can speak about the great speleological achievements of the period. When they reached the bottom of Labodnica (1841), this pothole kept the world's depth record for nearly 70 years (Shaw 1961).

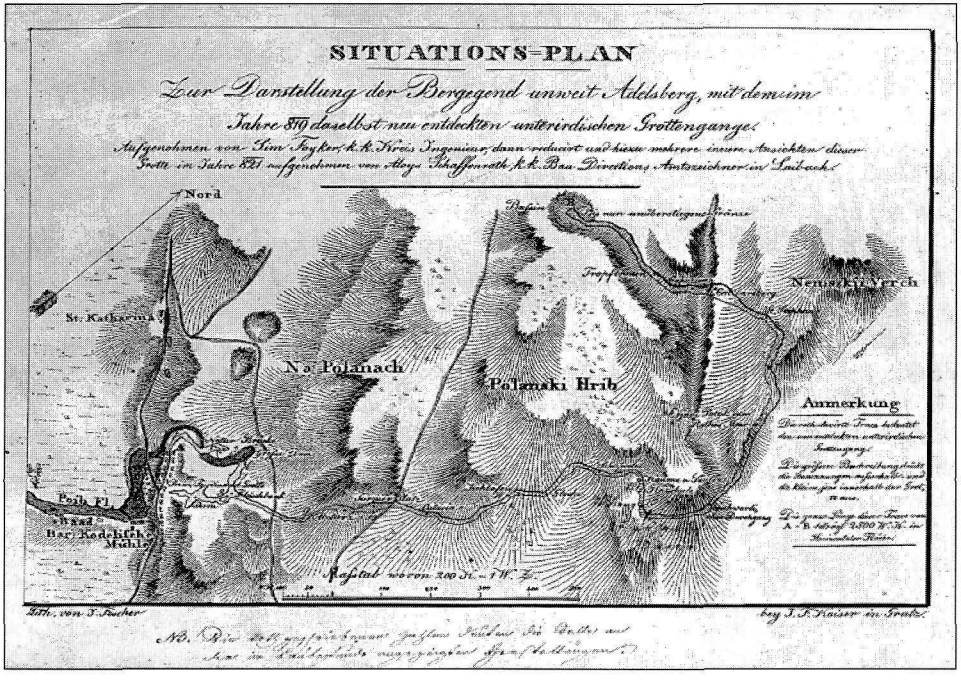


Fig. 2: Schaffenrath's 1821 plan of Postojnska jama from the year 1821.

The first half of 19th century can be considered as the time when real speleology developed in Slovenia, from the technical as well as of the scientific point of view, with important contributions by Slovene speleologists. Besides the above achievements in Labodnica, discoveries in water caves were also very important: J. Cerer's at Križna Jama (1825) (Zörrer 1838), G. Kebe at Velika Karlovica and Zelške Jame (1844) (Kebe 1860) and A. Urbas at Planinska Jama (1847-48) (Urbas 1849). Luka Čeč discovered the inner parts of Postojnska Jama in 1818 and the first plan was made by A. Schaffenrath in 1821 (and the next one by A. Fercher in 1834) (Fig. 2). Among scientific achievements, Hohenwart's paleontological excavations in Postojnska Jama (1830 - 1836) must be mentioned. They were continued by H. Freyer of Ljubljana museum, who explored caves in different parts of present-day Slovenia, including ice-caves on Trnovski gozd and caves in the Alps. Also Hohenwart's guide-book to Postojnska Jama (1830) can be regarded as a speleological monograph. With the discovery of the first cave beetle in Postojnska Jama by L. Čeč, the new study, speleobiology, started.

The second half of the 19th century may be regarded as the classical period of speleology in Kranjska. It began with Schmidl's explorations in the fifties, helped by the cave-surveyor I. Rudolf and Idrija miners. Due to his achievements underground Schmidl is often called "the father of modern speleology" (Shaw 1978), but for Kranjska karst his book "Die Grotten und Höhlen von Adelsberg, Planina und Laas..." (1854) is the most important. Schmidl's description together with additional chapters by other specialists on mineralogy and spelobiology, places the book among the true speleological monographs.

The speleological investigations were carried out mostly in two regions: on the Primorski Kras (Littoral Karst) and in Notranjsko (Inner Carniola). In Notranjska, besides Schmidl's explorations, the explorations of W. Putick must be mentioned. His first big achievement was the descent to the Gradišnica pothole near Logatec in 1886 (Schmidl did not succeed in this) (Putick 1887), later his explorations and flood control works in water caves between the karst poljes of Lož, Cerknica and Planina were a great success (Kranjc 1995a).

Schmidl explored caves in the Primorski Kras too. In a later period the discovery of Divaška Jama (1867) must be mentioned, the explorations of Škocjanske Jame after 1884 (by members of the "Abteilung für Grottenforschung" of the "Section Küstenland d. DÖAV" at Trieste) and the descent into the 200 m deep entrance of Kačna Jama shaft in 1889 (Pazze 1893). F. Kraus was maybe not so important a the field researcher but he was the initiator of the first Austro-Hungarian speleological society, and important for E. A. Martel's visit and explorations of the karst of Primorska in 1893.

Martel's 1893 exploration of Postojnska Jama (the boat descent downstream on underground Pivka river) is a good example how important the caves of Carniola were for the history of speleology (Martel 1894). Court Counsellor von Hauer came from Vienna to Postojna to introduce Putick to Martel and

Kraus. While Martel was exploring down the Pivka river, helped by the Postojna cavers from the speleological club "Anthron" and by the cave guides of Postojnska Jama. Kraus with his team was at the entrance to Postojnska Jama and Putick were awaiting them at the entrance to Magdalena Jama.

The end of the last century is the time when organised speleology was born and karst of Kranjska was soon included: the Verein für Höhlenkunde was founded in 1879 at Vienna, largely due to Kraus' efforts. The Society's sections at Postojna and Planina were foreseen too by Kraus from the beginning. Kraus friends reported about 50 members. But instead, the Anthron society at Postojna was founded in 1889, thus being the first speleological organisation in the territory of today's Slovenia (Kranjc 1988). In the Jama cave near Predjama, is an inscription on the cave wall far away from the entrance: "Slovenski Gadje 21/V 82" (Slovene Vipers) - maybe the predecessor of Anthron. Kraus was also in some way the founder of the Slovene cave register. Before he died he permitted O. Gratzy to publish a part of his cave data, the data of the caves from Carniola (1897). The whole collection he willed to Martel (for the Société de Spéléologie) and after Martel's death, I am sorry to say, all the material was dispersed to collectors in France and elsewhere.

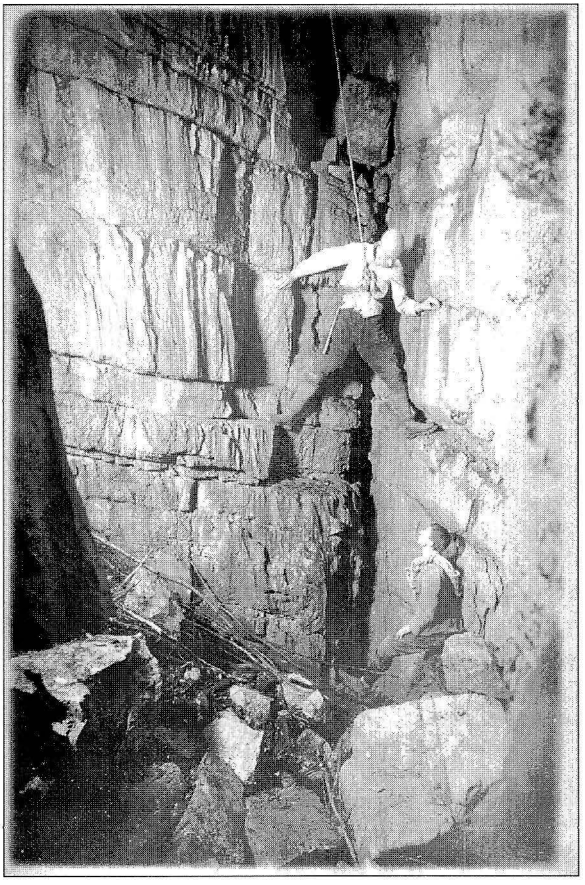


Fig. 3: Caving technique from the beginning of the 20th century (Mačkova jama above Dobrepolje) (Photo B. Brinšek).

But already in 1883 at Triest two speleological organisations had been formed: "Abtheilung für Grottenforschung des Section Küstenland des Deutschen und österreichischen Alpenvereins" and "Commissione Grotte della Società Alpina delle Giulie", both having the karst of Kranjska as a field of their explorations. In 1893 the

"Slovensko planinsko društvo" (Mountaineering Society of Slovenia) was founded and some of its sections (Ajdovščina, Luče, Radovljica, and Trst) immediately started to explore caves too. Before 1900 a caving club existed at Kočevje, probably directly linked with the Vienna's "Verein" but details about it and its work have still to be searched. In 1909 I.A. Perko came to Postojna as the secretary of the Postojnska Jama administration. He tried to make Postojna "the world's speleological centre" by combining tourism (Postojnska Jama), culture (speleological museum) and science (speleological institute). Postojnska Jama became world famous in this period, the speleological institute was founded at Postojna in 1929, and we are still hoping to get the speleological museum.

Perko and Putick are among the fonders of the "Društvo za raziskovanje podzemeljskih jam na Kranjskem" (Society for investigation of underground caverns in Carniola) at Ljubljana in 1910, which marked the beginning of the present-day Speleological Association of Slovenia and thus "the modern times" of speleology in Slovenia. The nucleus of the society was "speleological section" consisting of the members of the mountaineering group "Dren", where specially Brinšek, Cerk, Kunaver and Michler became well-known Slovene caving pioneers (Fig. 3) (Habe & Kranjc 1981).

The First World War did not only bring fundamental changes regarding the territory and national life of Slovenes, but it also marked an important change and a hiatus in speleological activity.

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KRATEK PREGLED RAZVOJA SPELEOLOGIJE NA SLOVENSKEM (DO 1914)

Povzetek

Čeprav so bile jame na današnjem Slovenskem ozemlju znane in obiskovane že od starejše kamene dobe, o speleoloških raziskavah ne moremo govoriti pred Razsvetljenstvom. Med starejšimi predhodniki speleologov je najpomembnejši Valvasor, ki v svojem delu "Slava vojvodine Kranjske..." (1689) omenja okoli 70 jam in je nekatere tudi v resnici raziskoval. Pravi "speleološki projekt" je Naglovo (po cesarskem naročilu) raziskovanje naših jam 1748. Poleg Hacqueta (na Kranjskem je živel 1766-1786), ki je že spoznal, da "kras" ni samo na "Krasu" in da je kras rezultat raztapljanja apnenca (korozije), je treba omeniti še Steinbergovo delo o Cerkniškem jezeru (1758), Laurentijev opis Proteusa (1768) in Gruberjeva (1781) "pisma" o kraški hidrologiji.

Za zgodovino speleologije je tudi zelo pomemben jamski turizem. Tako je bila Vilenica turistična jama že vsaj 1633, Postojnska in Škocjanske jame pa so bile uradno odprte 1819. V zvezi z njihovimi raziskavami omenjam Luko Čeča, Jeršinoviča, Tominca in Mahorčiča.

V prvi polovici 19. stol. so bile najpomembnejše speleološke raziskave namenjene iskanju vode za Trst. Do podzemeljske Reke so skušali prodreti skozi Škocjanske jame (Svetina 1839) in skozi globoka brezna. Pri tem so prodrli 1841 (Lindner) do dna 329 m globoke Labodnice, ki je ostala najgloblje znano brezno na svetu še okoli 70 let. V tem času se je v Sloveniji razvila speleologija tako s tehničnega kot z znanstvenega vidika. Takrat so raziskovali velike jame, kot je Križna (Cerer 1825), Velika Karlovica in Zelške jame (Kebe 1848) ter Planinska jama (Urbas 1847-48). Čeč je odkril notranje dele Postojnske jame (1818) in v njej našel tudi prvi primerek jamske kopne favne (1831); Schaffenrath, Fercher in Hochenwart so merili in izkopavali v Postojnski jami, Freyer pa je raziskoval tudi ledenice in alpske jame. Druga polovica 19. stol. je "klasična doba" speleologije na Slovenskem. Začela se je s Schmidlovimi raziskavami (1850-1854), vrh pa dosegla s Putickovimi odkritji in Martelovim podvigom v Postojnski jami (1893). Izredno zahtevne so bile raziskave Škocjanskih jam (od 1884 dalje) in Kačne jame (od 1889).

Morda bi lahko za začetek organiziranega jamarstva v Sloveniji šteli obisk (1882) "slovenskih gadov" Jame pri Predjami, o čemer sicer ni dosti znanega.

Na vsak način je pa to leto 1883, ko sta bili v Trstu ustanovljeni skupini "Abtheilung für Grottenforschung des Section Küstenland des Deutschen und Österreichischen Alpenvereins" in "Commissione Grotte della Società Alpina delle Giulie". 1889 je bilo v Postojni ustanovljeno prvo pravo slovensko jamarsko društvo "Anthron". 1893 je nastalo Slovensko planinsko društvo, katerega sekcije so se takoj lotile tudi raziskovanja jam. Društvo za raziskovanje podzemeljskih jam na Kranjskem (jedro raziskovalcev so sestavljali Drenovci), ustanovljeno 1910 v Ljubljani, pa je že neposredni predhodnik današnje Jamarske zveze Slovenije.

ACTA CARSOLOGICA	XXVI/2	12	109-117	LJUBLJANA 1997

DANIEL FISCHER UND DIE ANFÄNGE DER SPELÄOLOGIE IN DER SLOWAKEI

DANIEL FISCHER IN PRIČETKI SPELEOLOGIJE NA SLOVAŠKEM

MARCEL LALKOVIČ [1]

Izvleček UDK 551.44(437.6)(091)
Marcel Lalkovič: Daniel Fischer in pričetki speleologije na Slovaškem

Začetki speleologije na Slovaškem segajo v prvo polovico 18. stol. Pri tem je igral pomembno vlogo Matthias Bel in krog njegovih tovarišev. Z vidika zanimanja za jame pa je bil pravo nasprotje M. Belu Daniel Fischer. Poleg medicine, farmacije, fizike in kemije se je Fischer ukvarjal tudi z naravoslovjem. Rojen je bil v Kežmarku 1695, 1713-1716 je študiral v Wittenbergu in umrl v Debrecenu 1764. Jame ga niso zanimale kot objekti, ampak kot kraji in snov, ki mu je omogočala opravljati poizkuse. Preučeval je predvsem rast in obliko kapnikov. Bil je prvi, ki je v okvirih Slovaške in Madžarske pokazal na potrebnost reševanja takih vprašanj.
Ključne besede: zgodovina speleologije, kapnik, Slovaška, Fischer D.

Abstract UDC 551.44(437.6)(091)
Marcel Lalkovič: Daniel Fischer and the beginnings of speleology in Slovakia

Beginnings of speleology in Slovakia go back to the first half of 18th century. M. Bel and circle of his fellows played important role. Opposite pole of M. bel was Daniel Fischer in terms of interest in caves. Beside medicine, pharmacy, physics and chemistry Fischer dealt with natural science history too. He was born in 1695 at Kežmarok, 1713-1716 he studied at Wittenberg and died at Debrecen in 1764. Caves interested him as the objects that enabled him to develop his experiments. He studied the most the growth and the forms of flowstone formations. He was the first in Slovakia and Hungary who showed the interest of such questions.
Key words: history of speleology, flowstone, Slovakia, Fischer D.

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Nach den Erwähnungen über die slowakischen Höhlen in der Literatur im 16. und 17. Jahrhundert begannen in der Slowakei die Anfänge der Speläologie an Anfang des 18. Jahrhunderts zu formieren. Die erste Angaben über die Höhlen publizierte Georg Wehrner, humanistischer Gebildete aus dem Schlesien im Jahr 1549, Pietro Ranzano, der Gesandte des Neapelskönigs am ungarischen königlichen Hofe im Jahr 1558, Johann Paterson Hain, der Arzt im Kesmark (Kežmarok), Leutschau (Levoča) und Preschof (Prešov) im Jahr 1672, und Martin Szentiványi, der slowakische Jesuit und Professor der Universität in Tyrnau (Trnava) im Jahr 1689. Mit dem Verdienst dieselber Gebildeten und mit ihnen Informationen über die Höhlen endstand auch in der Slowakei die Klima, die für die Forschung der Höhlen aus dem naturschaftlichen Interesse sehr günstige war. Die Bedeutungsrolle trugen hier auch Matias Bel und seine Mitarbeiter aus. Zu diesen gehörten auch Georg Buchholtz der Jüngere und Juraj Bohuš.

Slowakischer Polyhistor und Rektor des evangelischen Lyceums in Pressburg (Bratislava) Mathias Bel führte als der erste in der Literatur die breitere Erkenntnisse über in damaliger Zeit bekannte Höhlen der Slowakei an. Er publizierte diese im Werk Hungariae antiquae et novae prodromus aus dem Jahr 1723. Hier widmete er den Höhlen ein ganzes Kapitel. In seinem Werk konzipierte er seine Wissenschaftsbestrebung - Kollektivsbearbeitung der komplexe Monographie über Ungarn. In Einzelbänden dieses Werkes Notitien (4 aus ihnen erschienen in Jahren 1735-1742) beschrieb er dann auch die Mehrheit der bekannten slowakischen Höhlen. Mit seiner Tätigkeit begann Mathias Bel die Epoche des neuen Interesses über die Erkenntnis der slowakischen Höhlen. Mit den Ergebnisse ihrer Arbeit dokumentierten es später nicht nur F.E. Brückmann, oder R. Towson sondern auch andere.

Im Fall Georg Buchholtzs der Jüngere begegneten wir mit dem ersten wirklichen Interesse über die Erkenntis der einigen slowakischen Höhlen. Unter seinem Einfluss in der lateinischen Schule im Paludza in Jahren 1714-1723 interesierte er sich für die Höhlen des Gebiets Liptau. Viele Höhlen forschte, skizierte und beschrieb er. Die Ergebnisse seiner Tätigkeit waren den Unterlagen der Informationen, die M. Bel in seinen Publikationen übergab. Die Bedeutungsrolle hatte auch Juraj Bohuš, der Rektor des Kesmarksgymnasium. Er interesierte sich für die Höhlen des Gebiets Zips.

Der ausdruckvolle Gegenpol von M. Bel, aber nicht nur mit dem Interesse über die Höhlen in der Slowakei, war die Personlichkeit Daniel Fischers (1695-1746). Dieselber gebürtiger Kesmarker und M. Bel gehörten zu den ersten Vorkämpfern der modernen Wissenschaft in der ungarischen Kulturwelt, vor allem aber in der Slowakei. M. Bel mochte ihn für die Zusammenarbeit in seinem heimatskundlichen Projekt erwerben, aber D. Fischer ging in der wischenschaftlichen Forschung mit anderem Weg. Er arbeitete wissenschaftlich in der Medizin, Pharmazie, Physik und Chemie, aber beschäftigte sich auch mit der naturwissenschaftlichen Forschung von Liptau, Zips und Hohe Tatra.

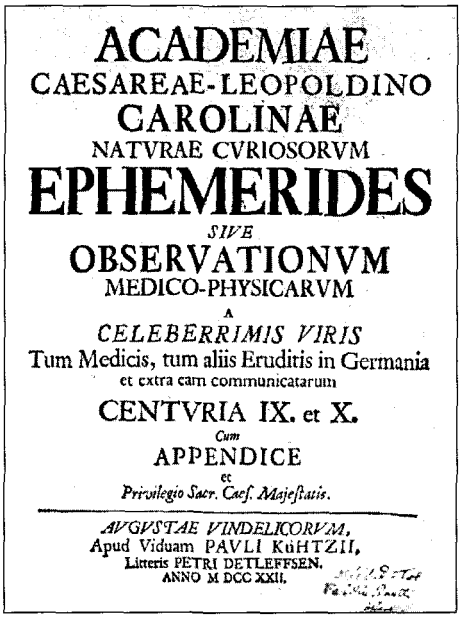
Er wurde am 9. November 1695 im Kesmark (Kežmarok) geboren. Nach den Studien im Kesmarksgymnasium im Jahr 1713 ging es in die medizinischen Fakultät der Universität im Wittenberg studieren weg. Nach dem Gewinn des Lizenziats im Jahr 1716 begann er seine ärzliche Praxis in seinem Geburtsort.

Im Jahr 1718 gewann er auf der Wittenbergsuniversität den Titel Doktor der Medizin. In Jahren 1719-25 wirkte er in der Stadt Liptauer Nikolaus (Liptovský Mikuláš) als Amtarzt des Liptauer Komitats. Von hier ging er im Kesmark (Kežmarok) weg. Hier wurde er Stadtarzt und Amtarzt des Zipsauer Komitats. Zu dieser Zeit war er auch der Leibarzt des Zipsgaugraf Nikolaus Csáky. Er starb im Debrecen im Jahr 1764.

Ähnlich als M. Bel bemühte er sich den Mitarbeiterkreis zu gründen, mit den sein wissenschaftliche Programm realisieren mochte. Er war bewundernswert gebildeter Mensch und orientierte sich sehr gut in der damaligen wissenschaftlichen Literatur. Die Zusammenarbeit mit M. Bel lehnte er strikt ab. Die Problematik der wissenschaftlichen Forschung darstellte nach ihm sehr ansprüchige Rolle und er hielte Bels für ihre Lösung fachtlich nicht zu bereiten. Den Charakter seiner Individualität erfasste auch es, dass er allein das Mehrbandwerk Admiranda Hungariae varia naturae curiosa exhibentia (Verschiedene Besonderheiten der Ungarnnatur) zu schrieben mochte. Diese Ansicht realisierte er aber niemals. Er hatte die Kontakte mit Georg Buchholz der Jüngere und Juraj Bohuš, obwohl sie beide zu grossen Förderern der Belsbestrebungen gehörten. Auch ihnen Grundlagen entwickelte er auch sein Interesse für die Höhlen. Er trat so isoliert deshalb auf, dass er in den Höhlen für etwas anderes interesierte, um was widmeten sich nicht seine Vorgänger und Zeitgenossen.

Wissenschafts-publikationsanfänge von Daniel Fischer hängen mit der Universität von Wittenberg zusammen. Er begann systematisch wissenschaftlich arbeiten, wenn er im Kesmark (Kežmarok) sich siedelnte an. Seine Erkenntnisse sendete er für die Veröffentlichung in Zeitschriften der Academie Leopoldina - Ephemerides und Acta und in der Zeitschrift Sammlung von Natur- und Medizin-Geschichten, die im Wrattislaw erschien. Im Jahr 1719 war er zum Mitglied der gelehrten Gesellschaft Sacri Romani Imperii Academia Caesareo - Leopoldina gewählt.

Daniel Fischers Interesse über die Höhlen hatte gegenüber Mathias Bel ausdruckvolle andere Dimensionen. Er interesierte sich nicht für die Existenz der Höhlen im Kontext der Naturbesonderheiten, oder über die Umschreibung und die Darstellung ihnen Räumen. Die Höhlen nahm er aus die Objekte wahr, mit Vermittlung welchen seine Experimente entwickeln konnte. Die Höhlen boten ihm den Material, der ihre Realisation zu ermöglichten. Das Fischersinteresse über die Höhlen hängt mit dem ersten Zeitabschnitt seiner wissenschafts-fachlichen Tätigkeit zusammen und bindet sich an seiner Aufenthalt im Liptauer Nikolaus (Liptovský Mikuláš). Die dominierende Elemente dieselbes Interesses war die Aktivität von G. Buchloltz der Jüngere in Höhlen



ACADEMIAE
CAESAREAE-LEOPOLDINO
CAROLINAE
NATVRAE CVRIOSORVM
EPHEMERIDES
SIVE
OBSERVATIONVM
MEDICO-PHYSICARVM
A
CELEBERRIMIS VIRIS
Tum Medicis, tum aliis Eruditis in Germania
et extra eam communicatarum
CENTVRIA IX. et X.
Cum
APPENDICE
et
Privilegio Sacr. Caes. Majestatis.

AVGVSTAE VINDELICORVM,
Apud Viduam PAVLI KÜHTZII,
Litteris PETRI DETLEFFSEN.
ANNO M DCC XXII.

des Demänová Tals und von Juraj Bohuš in den Höhlen des Gebiets Zips. Sie beide gehörten zu den Mitarbeiten des Mathias Bels, aber die Informationen und Erkenntnissen zu welchen sie beendigten, bewies Daniel Fischer wesentlich anders.

D. Fischer knüpfte mit Georg Buchloltz der Jüngere die Kontakte schon am Anfang seines Aufenthaltes in Liptauer Nikolaus (Liptovský Mikuláš) an, und diese folgten aus dem Interesse für die naturwissenschaftliche Forschung. Diese Kontakte überdauerten auch nach dem Abgang des Buchholtzs auf einen Post des Rektors des Evangelischen Lyceums im Kesmark (Kežmarok). Mathias Bel war nur der Empfänger der Buchholtzerkenntnisse über die Höhlen, aber D. Fischer war ein Fachmann, der die Antworte auf die Fragen, mit welchen G. Buchholtz der Jüngere bei der Forschung in den Höhlen des Demänová Tals traf, finden mochte. Wir schalten nicht diese Möglichkeit, dass das naturwissenschaftliche Interesse von D. Fischer die wichtige Rolle in der Beziehung mit Georg Buchholtz der Jüngere spielte, von ihm er die Materialien für wissenschaftliches Verfahren erwarb. Sie waren beide die gebürtige Kesmarker und diese Wirklichkeit flusste ihre wechselseitige Beziehung beein und hatte die grosse Rolle auch bei der Formierung des Fischersinteresses für die Höhlen. Mit dem Verdienst von Johann Paterson Hain erschien im Jahr 1672 in der Literatur die Erkenntnisse über die Höhle, die im Zipsen Komitat bei dem Kartäuserkloster neben dem Dorf Helbingsau (Haligovce) fand. Er beschrieb auch die Funde der Drachenknochen. Die Kenntnis der damaligen Fachliteratur flusste die Entscheidung D. Fischers diese Höhle (die heutige Höhle Aksamitka bei dem Dorf Haligovce) zu besuchen beein. Auch er fand in dieser Höhle die Drachenknochen. Wir haben Grunde zu der Annahme, dass es nach dem Jahr 1716 wurde. Es ist sehr schwer vorauszusetzen, dass er mit dieser Höhle während der Gymnasiums- und Universtätsstudien beschäftigte. Es ist sehr regelmäsig, dass er mit der Forschung erst in der Zeit, wann begann er seine ärzliche Praxis in seinem Geburtsort, beschäftigte. Er mochte vor den Gewinn des Titels Doktor der Medizin einige mit Studium die Erwerbungskenntnisse bewiesen. Aus seinen Funden stellte er das ganze Skellet zusammen. Er schenkte es dem Kaiser, für was diente er den Landadel und den Titel des Hofvertrauensmannes Aulae familiaris aus.

Es ist ganz natürlich, dass ihm Georg Buchloltz der Jüngere im Jahr 1719, wenn er die Drachenknochen in Demänová Höhle Beníková fand, ein Teil der Funden für die Bestimmung sandte. Den zweite Teil dieser Sendung waren einige Tropfsteine aus dieser Höhle und gewann er gerade in ihnen die Materie, die ihn sehr zog. Fischer diese Tropfsteine beschrieb und erforschte. Er widmete nicht nur mit der Aussenform, aber er forschte auch ihre chemische Eigenschaften. Er dachte, dass sie die Wasserquellen sind, die aus dem Felsen flossen heraus, und dann wieder auf die felsartige Materie hart geworden. Sie hatten verschiedene und bewundernswerte Formen. Einige aus ihnen hatten die Kegelformen und andere hatten die rauhe Wände. Manche aus ihnen hatten Erbsen- oder Rundformen, eventuell sie aus einigen kleineren und grösseren Kügelchen bestanden. Überwiegende Mehrheit aus ihnen hatte schneeweisse Farbe mit der gelblichen Abstufung.

In seinen Abhandlung ging er von der Disertation des deutschen Wissenschaftlers Martin Gotthard Lerschen über die ausfälltenden und anwachsenden Felsen. Auch der Arzt von Wittenberg Abraham Vater beschäftigte sich mit den Felsenformen. Im chemischen Vorgang setzte er bei der Bildung der Tropfsteinen auch das Vorhandensein von weissen Vitriol, Kochsalz, Schwefel, Salpeter, Weinstein, Erdmasse, Alkohol, Wasser und Luft voraus.

Bis jetzt wissen wir nicht zu beurteilen, inwiefern mit diesem Interesse Daniel Fischers hängten auch seine weitere Besuche in einigen Höhlen des Demänová Tals zusammen. Während der botanischen Forschung in felsenreichen Bergen Ende August 1720 besuchte er mit Georg Bucholtz der Jüngere auch nähere unbekannte Höhle. Im August 1723 wanderte er über das Demänová Tal. Neben der Höhle Fenster (Demänovská jaskyòa Okno) forschten sie zusammen die Höhle Brunner (jaskyòa Studòa) durch, und hier stiegen sie in einer Tiefe von 22 Klafter ab. Wir wissen nicht zu erzählen, ob es nur diese Besuche waren, oder er in die Höhlen oft ging. Die Angaben im Tagesbuch von Georg Buchholtz der Jüngere sind in dieser Richtung sehr kurzgefasst.

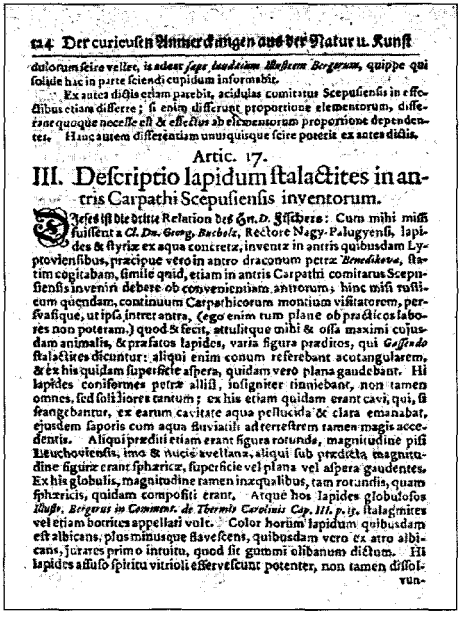
Es ist sehr wahrscheinlich, dass er mit den Höhlen sehr interesierte. Ausser den Höhlen des Demänová Tals, sie lagen in der Nähe von seinem Aufenthaltort, beschäftigte er sich auch mit einigen Höhlen des Gebiets Zips. Georg Buchholtz der Jüngere sendete ihm die Tropfsteinsstücke aus der Drachenhöhle im Benediksfelsen, begann er über es nachzudenken, dass etwas ähnliches auch in den Höhlen der Zipsen Karpathen vorkommen muss. Die Erwähnung dieselbes Charakters skizzierte indirekt auch eventuellen Besuch in diesen Höhlen. In seinem Fall können wir nur sehr schwer voraussetzen, dass der Mensch dieselbes Formats und der grossen Wissenschaftsambitionen auf die Vermittlungsinformationen jemand anderes verlassen konnte. Bei seinen Erwähnungen über die Höhlen der Zipsen Karpathen ist sicher, dass er etwas über die Existenz dieser Höhlen wissen musste. Er dachte nicht nur die Höhle unweit dem Kartäuserkloster. Man kann sagen, dass gerade auf diese Frage wir die

Antwort in der Tätigkeit J. Bohuš finden, er war Fischers Zeitgenosse und Rektor des Gymnasiums im Kesmark. Zur Zeit seines Aufenthalts im Liptauer Nikolaus (Liptovský Mikuláš) beschäftigte sich D. Fischer mit den Höhlen im Gebiet der Belaer Tatra. Hier forschte er eine Höhle über der Stadt Bela (kleine zipsere Stadt unweit der Stadt Kesmark) und das Drachenloch, welches eine halb Meile vom Dorf Morgenröte (Ždiar) entfernt ist. Es ist fast sicher, dass der Bohušaufmerksamkeit auch einige Höhlen in der Nähe der Belianska Höhle (Belianska jaskyòa) nicht entgangen. Wir wissen nicht, inwieweit konnte auch die Belianska Höhle sein. Bei seiner Entdeckung im Jahr 1881 waren an den Wänden ihrer Vorderteilen auch Nammen und Anschriften aus dem Jahr 1718 gefunden.

Daniel Fischer interesierte sich auch im Fall der Höhlen der Zipsen Karpathen für die Tropfsteindekoration. In der Sammlung, die er von dem ständigen Besucher der karpathen Bergen erwarb, beschäftigte er sich in erster Reihe mit den Steinen verschiedenen Formen und nicht mit den Knochen des grossen Tieres, welches aus diesen Höhlen kam her. Diese Steinen nannten Stalaktiten und sie waren pyramidenförmig mit einem spitzen Winkel. Mit dem Schlag an dem Felsen klingten sie. Nach der Zerschlagung floss aus ihnen klares Wasser aus. Es schmeckte nach dem iridischen Flusswasser. Einige hatten rundliche Formen in der Grösse der Erbse oder Nuss, und andere waren die Kügelchen verschiedener Grösse mit glatter oder rauber Oberfläche. Er tat auch mit diesen Felsen die Experimente und erarbeitete sich zu änlichen Erkenntnissen als im Falle der Funden aus der Höhlen des Demänová



SUPPLEMENTUM IV.
Curieuſer und nutzbarer
Anmerckungen
Von
Natur-
und
Kunſt-Geſchichten,
Durch
Eigene Erfahrung und aus vielerley
Correſpondenz geſammlet
von
JOHANNE KANOLD,
Medicinæ Doct. und Practico in Breßlau,
wie auch
der Kayſerl. Leopoldiniſch-Carolinischen Reichs-Academiæ
Naturæ Curioſorum Mitgliede.
Budiſſin,
Verlegts David Richter, 1729.



124 Der curieuſen Anmerckungen aus der Natur u. Kunſt

dulorum ſcire vellet, is adeat ſuge laudatum Illuſtrem Bergerum, quippe qui ſolide hac in parte ſciendi cupidum informabit.

Ex antea dictis etiam patebit, acidulas comitatus Scepuſienſis in effectibus etiam differre; ſi enim differunt proportione elementorum, differunt quoque neceſſe eſt & effectus ob elementorum proportione dependentes. Hanc autem differentiam unusquisque ſcire poterit ex antea dictis.

Artic. 17.

III. Deſcriptio lapidum ſtalactites in antris Carpathi Scepuſienſis inventorum.

Dieſes iſt die dritte Relation des Hn. D. Fiſchers: Cum mihi miſſi fuiſſent a Cl. Dn. Georg. Buchols, Rectore Nagy-Palugyenſi, lapides & ſtyriæ ex aqua concretæ, inventæ in antris quibusdam Lyptovienſibus, præcipue vero in antro draconum petræ Benedikovæ, ſtatim cogitabam, ſimile quid, etiam in antris Carpathi comitatus Scepuſienſis inveniri debere ob convenientiam antrorum; hinc miſi ruſticum quendam, continuum Carpathicorum montium viſitatorem, perſvaſique, ut ipſa intrer antra, (ego enim tum plane ob præticos labores non poteram.) quod & fecit, attulitque mihi & oſſa maximi cujusdam animalis, & præfatos lapides, varia figura præditos, qui Gaſſendo ſtalactites dicuntur: aliqui enim conum referebant acotangularem, & ex his quidam ſuperficie aſpera, quidam vero plana gaudebant. Hi lapides conformes petræ aliiſi, inſigniter tinniebant, non tamen omnes, ſed ſolidiores tantum; ex his etiam quidam erant cavi, qui, ſi frangebantur, ex earum cavitate aqua pellucida & clara emanabat, ejusdem ſaporis cum aqua fluviatili ad terreſtrem tamen magis accedentis. Aliqui præditi etiam erant figura rotunda, magnitudine piſi Leuchovienſis, imo & nucis avellanæ, aliqui ſub prædicta magnitudine figuræ erant ſphæricæ, ſuperficie vel plana vel aſpera gaudentes. Ex his globulis, magnitudine tamen inæqualibus, tam rotundis, quam ſphæricis, quidam compoſiti erant. Atque hos lapides globuloſos Illuſtr. Bergerus in Comment. de Thermis Carolinis Cap. III. p. 15. ſtalagmites vel etiam botrites appellari volt. Color horum lapidum quibusdam eſt albicans, plus minusque flavescens, quibusdam vero ex atro albicans, juxtaque primo intuitu, quod ſit gummi olibanum dictum. Hi lapides affuſo ſpiritu vitrioli effervescunt potenter, non tamen diſſolvun-

Tals. In seiner Abhandlung, die er im Jahr 1729 publizierte, auf der Grunlage des Studium der Literatur, wo zitierte er die Werke von Daniel Hartnaccius, Martin Gotthard Lerschen, Johan Heucber, Athanas Kircher, Matthias Tilinger und anderer Authoren, gelangte zu dieselben Ansichten:

a) Die erwähnte Tropfsteine nennen von Rechts die Slalaktiten - in seiner Auffassung bewiesen die Sinne, dass das abgezogene Wasser der Stein ist, aber sein Ursprung ist nicht bekannt. Ihre Benennung übernahm er von Gassendi und stellte fest, das dieses Wort aus dem griechischen Wort stillo deduzierte ist, und bedeutet es tröpfeln. Dieselbes Ursprungs sind auch die Worte die Säule (das versteifte Wasser hat oft dieselbes Form) und Tropfen, weil das Wasser mit den Tropfen aus der Höhlendecke falle.
b) Die Flüssigkeit mit der Fossilmöglichkeit befindet sich manchmal im Boden - diese Ansicht von Daniel Fischer billigten auch alle Physiker, aber sie stimmten nicht in der Benennung der Flüssigkeit überein. Sie ernannten diese Flüssigkeit der Steinsame oder die gummiartige Flüssigkeit. Für Fischer war nicht wesentlich, wer und wie sie nennt. Er gewann die Übergewicht, dass auch ihr natürliche Charakter zu forschen sollte, aber selbst bei berühmten Authoren fand er keine richtige Erklärung, was diese Flüssigkeit in der Wirklichkeit ist. Auf der Grundlage des Versuchts, der Hamelius im Jahr 1667 publizierte, gelangte er zur Erkenntnis, dass die steinartige Flüssigkeit aus Wasser, Festsalz und Steinspänne (Sand) ist. Ihre Fliessbarkeit bewies das Vorhandensein des Wassers im Inneren einigen Tropfsteinen. Sie musste die gummiartige Form haben, weil sie mit ihrer eigenen Kraft als die Gummi sich verbindeten. In dieser Flüssigkeit befand auch das Festsalz und es bestätigte ihre augenblicke Verdichtung. In beträchlichem Masse setzte sie aus dem Sand zusammen und diese folgte aus destilierter Flüssigkeit, die bei rauh als Sand war.
c) Die Verschiedenheit in der Tropfsteinform hat den Ursprung im verschiedenen Strom der Tropfenflüssigkeit - hier gelangte er zu der Ansicht, dass diese Tropfsteine anderen Charakter haben, als die Tropfsteine, die in dem Innere der Erde aus der steinartigen Flüssigkeit bildeten. Die Tropfsteine in den Höhlen haben die Formen, die mit dem Strom der steinartige Flüssigkeit aus der Decke der Höhle tropft, beienflussten. Diese Form können wir nicht von verschienem Charakter des Salzes, welches diese steinartige Flüssigkeit bildete, ableiten. Anderst hätten sie Oval- oder Kegelformen oder die andere Formen, so in dem Fall der Tropfsteinen aus einer Landschaft Galliae. Nach Meinung von Gasendi schrieb über sie auch kartezienischer Philosopher Antonius le Grand.

Mit Rücksicht darauf mangelhafte Erkenntnisse der Chemie konnte nicht der chemische Aufbau und Genese der Tropfsteinsentstehung verstehen und erklären. Einige Prozesse erklärte er sich sehr mechanisch. Zum Trotz aus dem Ansicht der Slowakei und des damaligen Ungarn mochte er wie der erste

dieses Problem zu lösen. Ausser näher Erkenntnis der Höhlen, oder der Funden der Drachenknochen, identifizierte er auch weiter den Fachkreis des naturkundliche Interesse, welches aus Ihrer Existenz folgte. Mit es beschäftigte sich nicht einmal F.E. Brückmann während der Forschung in der slowakischen Höhlen im Jahr 1724 aber nur später suchte er seine Nachfolgern.

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DANIEL FISCHER IN PRIČETKI SPELEOLOGIJE NA SLOVAŠKEM

Povzetek

Začetki speleologije na Slovaškem segajo v prvo polovico 18. stol. Pri tem sta igrala pomembno vlogo Matthias Bel in krog njegovih tovarišev. Bel je objavil podatke o do takrat znanih jamah.

Z vidika zanimanja za jame je bil Daniel Fischer pravo nasprotje M. Belu. Kulturna zgodovina Madžarske sicer šteje oba za pionirja moderne znanosti, to pa še posebej velja za Slovaško. Poleg medicine, farmacije, fizike in kemije se

je Fischer ukvarjal tudi z naravoslovjem Liptovskega in Spiškega področja. Rojen je bil v Kežmarku 1695, 1713-1716 je študiral v Wittenbergu in dosegel naziv doktorja medicine. Deloval je v Liptovskem Mikulašu in Kežmarku kot zdravnik za Liptovsko in Spiško okrožje. Umrl je v Debrecenu 1764.

Fischer je bil zelo izobražen in je dobro poznal znanstveno literaturo. Vzdrževal je stike z G. Buchholtzem Jr. in J. Bohušem, čeprav sta ta dva podpirala Belova prizadevanja. Tem stikom navkljub se je Fischer zanimal za jame v čisto posebni smeri. Njegovo zanimanje je bilo veliko bolj poglobljeno, tako v primerjavi z njegovimi predhodniki kot sodobniki. Jame ga niso ga zanimale kot objekti, ampak kot kraji in kot snov, ki mu je omogočala opravljati poizkuse.

Fischerjevi stiki z G. Buchholtzem Jr. so izvirali iz skupnega zanimanja za naravoslovne raziskave. Skupaj sta obiskala nekaj jam v Demänovski dolini. 1719 mu je Buchholtz poslal "zmajeve kosti" in kos sige iz Bacikove jame. D. Fischer je to sigo podrobno preiskal in opisal. Poleg oblike je pregledal tudi njene kemijske značilnosti. Enake metode je uporabljal tudi pri preučevanju jam na Spiškem področju. Delal je poizkuse s kamenjem iz tamkajšnjih jam in dobil podobne rezultate.

Na podlagi zapažanj iz 1729 je prišel do sklepa, da izhaja ime za kapnik iz grške besede "stillo", kar pomeni "kapljanje". Preučeval je značilnosti tekočine, iz katere nastajajo kapniki in zaključil, da je ta "tekočina, ki okameni", voda, ki vsebuje pesek. Različne oblike kapnikov naj bi nastajale zaradi različnega načina pritekanja "petrificirne tekočine", ki kaplja z jamskega stropa. Njihovo obliko določa mesto, na katerem nastajajo ali pa ovoj, v katerem nastajajo, ne pa razne prsti, ki jih vsebuje voda. Rast kapnikov pa je odvisna od njihove lastne tekočine.

Glede na stopnjo tedanjega poznavanja kemije Fischer ni mogel pravilno določiti kemijske sestave in nastajanja kapnikov. Nekatere pojave je razlagal preveč mehanistično. Kljub temu pa je bil prvi, ki je v okvirih Slovaške in Madžarske pokazal na potrebnost reševanja tudi takih vprašanj.

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FRIEDRICH SIMONY (1813-1896), HIS CONTRIBUTIONS TO KARST AND CAVE SCIENCE

FRIEDRICH SIMONY (1813-1896) IN NJEGOV PRISPEVEK H KRASOSLOVJU IN SPELEOLOGIJI

KARL MAIS [1]

Izvleček: UDK 551.44:929 Simony F.

Karl Mais: Friedrich Simony (1813-1896) in njegov prispevek h krasoslovju in speleologiji

F. Simony, alpinist, naravoslovec in geograf, se je ukvarjal tudi z glaciologijo in speleologijo, še posebej v pogorju Dachstein. Terensko delo je dopolnjeval z lastnimi risbami, ki jih je kasneje uporabljal kot ilustracije pri objavah in predavanjih. Že 1842 je apneniške planote imenoval "kraška območja". Ukvarjal se je s kraško hidrologijo in morfologijo. Pripomogel je k uveljavitvi dunajskega geografskega inštituta, kjer ga je nasledil A. Penck in kjer je študiral tudi J. Cvijić, in sploh k uveljavitvi speleologije v drugi polovici 19. stol.

Ključne besede: zgodovina speleologije, dunajska geografska šola, Avstrija, Simony F.

Abstract UDC 551.44:929 Simony F.

Karl Mais: Friedrich Simony (1813-1896), his contribution to karst and cave science

F. Simony, an alpinist, naturalist and geographer interested in glaciology and speleology, in particular in the massif of Dachstein. In the field he made the drawings as a scientific documentation and also for the illustrations of lectures and publications. In 1842 he called the alpine limestone plateaus "karstic areas". He studied karst hydrology and morphology. He contributed to the high reputation of the Vienna Geographic Institute, where A. Penck followed him and where J. Cvijić graduated and to the developement of cave science in the second half of the 19th century.

Key words: history of speleology, geographical school of Vienna, Austria, Simony F.

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The beginning

In 1896 Friedrich Simony died in St. Gallen, a place in the Styrian Ennstal, Austria. He was well known as an alpinist, naturalist, geographer and, above all, a scientific explorer of the Dachstein. In this paper we are not going to deal with his main work, the "Region of the Dachstein" (Das Dachsteingebiet), which he was able to complete on the eve of his life as a sort of retrospective view. His work appeared in three numbers between 1889 and 1895. We will look into a very important aspect of his work, i.e. his little known contribution to karst and cave research.

Friedrich Simony's life and work

Simony was born in Bohemia at Hrochuv Tynec (Hrochowtainitz), southeast of Pardubice on November 30th, 1813. He attended Grammar School at Mikulov (Nikolsburg), left school in 1827 and became an apprentice in a pharmacy. As a laboratory assistant he moved from Znojmo (Znaim) to Vienna, where he began his studies in 1833. Having completed his pharmaceutical studies in 1835 he was able to devote himself to natural history, especially in the circle of the "Mining museum" (Montanistisches Museum). In 1840 he joined Franz v. HAUER among others on an excursion to the Gesäuse in the Salzkammergut. In the course of this tour he travelled through the Ausseerland to Hallstatt, ascended the Dachstein plateau as far as the glacier region. He was so fascinated by the area that he studied it throughout his life. He explored the plateau and climbed the peak in summer as well as in winter (first ascent), promoted tourism, made drawings of landscapes, and produced panoramas of the summit region. He conveyed to the world of science the findings from the Hallstatt time, discovered by the pitman J. G. RAMSAUER on the Salzberg at Hallstatt. He drew geological maps, collected rocks, performed systematic depth measurements and measured temperatures in the Salzkammergut lakes, studied glaciers as well as the botany and ecology and many other facts of the area.

With his studies he attracted the attention of the circle of "Friends of Natural Sciences in Vienna" (Freunde der Naturwissenschaften in Wien), which was established in 1846 as a regular meeting around Wilhelm HAIDINGER in the Mining Museum of Vienna. He reported to this society about his field work and thus was able to establish himself in the professional circles of the residential capital Vienna. In 1850, after the foundation of the Geologische Reichsanstalt, SIMONY, as chief geologist, was entrusted with the survey of the Salzkammergut (SIMONY 1850). He was intrested in geology and biological history as well as in general integrative matters of geography. These sciences were of special concern to him, and so he applied himself to promoting them. In 1851 he became professor of geography at the University

of Vienna - a success due to his dedication. From then on he engaged in teaching physical geography and establishing the geographical institute at the University of Vienna. He also played a decisive role in the foundation of the Geographical Society in Vienna (Geographische Gesellschaft in Wien) and the alpine association of Austria (Alpenverein).

In 1885 SIMONY, at 73, introduced his successors into their offices: Albrecht PENCK for physical geography, and W. TOMASCHEK for historical geography. Then he retired. He left to his institute most of his library as well as other material, teaching equipment and posters, which he had constructed himself for his lectures. Further important material from his legacy was given to the Museum of Natural History in Vienna by his son Oskar.

In 1890 SIMONY, at 77, started for his last tour on the Dachstein. After that, with the help of his son Oskar, he devoted himself to the "Dachsteinwerk", which appeared in three parts (numbers) in 1889, 1893 and 1895.

On July 20th, 1896 Friedrich SIMONY died in his 83rd year after "a lingering illness of several months caused by decreptitude" - as it says on his obituary. He was buried in St. Gallen in Styria, where he had mostly lived in his later years and died.

Friedrich SIMONY received numerous distictions due to his success as a teacher and scientist: The title of k.k. Hofrat, privy Councillor of the Imperial and Royal Court, was bestowed on him; he was an honorary member of the Geographic Society of Vienna, of the Austrian Meteorological Society, of the Geographic Society in Berlin and of many other scientific associations. He was a well-known and respected member of Vienna's social circles. In 1877 he received the Grand Medal for Arts and Sciences by crown prince Rudolf and was invited to cooperate in the oeuvre of the crown prince: "The Monarchy in words and pictures" (Das Kronprinzenwerk: Die Monarchie in Wort und Bild).

His private life: Friedrich SIMONY married Amalie KRAKOWITZER from Wels in 1851. On April 23rd, 1852 a son, Oskar, was born, a second son Arthur on Mai 15th, 1854. His daughter, born in 1858, died early.

Friedrich SIMONY's main works

Friedrich SIMONY'S studies and carreer were based on his very own talents and abilities. He was such an outstanding student that he was encouraged and sponsored by his teachers, such as J.F. JAQUIN. His knowledge of botany and geography soon made him an acknowledged "colleague" in the scientific circle of Vienna in the time before March 1848. After having become acquainted with the Dachstein area in 1840 he devoted his studies to the alpine regions. His knowledge of geology enabled him to concentrate on glaciology and related fields. His studies included the observation of water, moraines, sediments as well as suspended sediment transport in water, climate, vegetation and forest development (1876).

The wide range of his interests, the size of his field work and the conveyance of his experience can be seen from his reference list and a catalogue of his graphic works (among others BÖHM 1899, FORSTER 1893, PENCK 1898, recently e.g. GRIMS 1996 and KAINRATH 1993.) The titles of his publications are of general nature and do not easily reveal their contents. In this study SIMONY's earlier reports and publications are used, since they are of great importance for the history of research. Later publication are not dealt with.

Friedrich SIMONY had a remarkable talent for drawing, which he used for the scientific and objective presentation of the landscape. In the field he made sketches and drawings in his diaries, which he could use as illustrations in his lectures and reports. Later on these sketches served as patterns for figures in publications and posters used in speeches and lectures. Documentation was the main concern of his drawing activities, thus he readily included photographic techniques in topographic presentations and used them consequently from 1877 onward.

SIMONY's contribution to karst science and speleology

Friedrich SIMONY was no caver in search of new underground territory, but a natural scientist, who included karst phenomena in his studies. In this paper we present his hardly known contribution to speleology and investigate some topics in detail.

The Koppenbrüller Cave was well known already in the first half of the 19th century. It was mentioned as a rewarding tourist attraction in the guide books (SCHULTES and also SCHADEN 1833). This cave was the only one in the Dachstein area with its entrance at valley level. In this cave SIMONY measured air and water temperatures and watched the variation of the water flow caused by precipitaion and the melting of snow on the Dachstein plateau.

As early as 1842 he used the term "**KARST**" for the alpine limestone massif, noting that the foot of the Dachstein "covers an area of more than 8 square miles / = 460,33 km²/, and its karst like plateau covers a range of 50 to 60 walking hours." He also wrote: "The numerous caves, gorges and crevices inside the mountain, the rugged soil of its plateaus; .. indicate a long lasting fight of the elements .. to which these caves were once subjected." The plateau showed "holes and ridges, which have eaten vertically or slantingly into the rock", giving the whole area "an almost sieve-like aspect". He mentions "the rare appearance of granite foundlings, quartz and crystals on the plateau", indicating "the former presence of a primeval glacier, which might have carried off this rubble from the mountain chain .. of the Hochtauern .. and deposited it .. on the Dachstein." SIMONY characterizes the Dachstein plateau undoubtedly as a karst area, mentioning unnamed Karren, caves and shafts. His view of the crystalline sediments (Augensteine) on the plateau shows that he

assessed their origin much more correctly than it did Eduard SUESS later on, who believed volcanic processes to be responsible.

In a lecture delivered on June 15th, 1846 for the Friends of Natural Sciences he spoke about karst formation in the alpine limestone massifs in particular. He considered the "rolly nature and raggedness of the surfaces of the Dachstein- and Priel-mountains" as a "**type of karst formation**" (HAIDINGER 1847: 55-59). Thus in 1842 and 1846 he used the term **karst** for alpine limestone regions in the modern sense.

Karst springs

Karst springs were of great interest to Friedrich SIMONY. He put down his observations in 1865, characterizing the water flow in the limestone areas from the surface through the "layers, raggedness und hollowing" of the rocks "forcing its way .. deeper and deeper .. until they become formidable water drains" and then surface again in the valley.

As examples SIMONY mentioned (1865) the "Kaiserbrunnen am Wiener Schneeberg", which he regarded as one of the most powerful springs of the Eastern Alps, as well as the "Waldbachursprung", which he called a subterrenean outlet of the "melted snow and ice of the Hallstatt Glacier." He pointed at the seasonal variations of the suspended sediment transport from the glacier region and drew a correlation of the daily variation of the discharge with the differing radiation of the sun on the snow covered plateau. He found out that six hours after the beginning of sunshine the springs started to swell and reached their maximum around 8 or 9 p.m.

Later on, in 1871 (page 26) and 1878 (page 99) he considered the correlation between the Dachstein glaciers and the Waldbachursprung in greater detail: "Although .. there is no doubt that in the bed of the Hallstatt Glacier there exist numerous subterranean outlets, it seems nonetheless.. that most of them flow together .. into one canal, which eventually .. reappears .. at the foot of the Ursprungskogel. Here an icy cold creek appears, the Waldbachursprung .. under a small grove." This clearly formulated subsurface connection between the glacier waters and the Waldbachursprung has been exactly proved today by tracer trials (BAUER 1989). The subterranean passage is not accessable though.

In 1865 (page 189) SIMONY accurately noted the temperatures of the Hirschbrunn springs: Before the snowmelt in spring temperatures were around 5.61°R (=7.00°C), during the snowmelt they lapsed to 4.2°R (=5.25°C), during the summer they varied between 4.2°R (=5.25°C) and 4.6°R (=5.75°C), in autumn between 4.4°R (5,50°C) und 4.5°R (5,62°), whereas they rose in winter up to 5.6°R (7,00°C).

SIMONY focused on the area of the Hirschbrunn-Kessel with its various surfacing springs, comparing temperatures, discharge and water levels, as he

had done at the beginning of his Dachstein research in the Koppenbrüller Cave. He also observed other springs and in the area of the Gosaumühle he found thermal springs not detectable any more. Their temperatures ranged at that time (SIMONY 1865: 190) from 8°R and 17°R (10,00°C and 21,25°C). Furthermore he detected springs below the level of the Hallstatt lake.

He observed that the temperatures of the karst springs did not correspond to the mean annual temperatures at the altitude of their surfacing, which he would have expected. He tried to explain these remarkable deviations with the altitude of the source area. When investigating limestone springs in the area of the upper Traun river he distinguished between "shallow waters of mixed origin" with strong temperature variation and the "real karst waters". He presented a table for the latter (1865: 188), using "Wiener-Fuß" for altitude readings and "Reaumur" far temperatur readings as indices, which have been converted into meters and degree Celcius in the table shown below:

1. (a) Altitude of source (spring) in Vienna Foot	1. (b) Altitude of source (spring) converted in meter	2. Temperatur of springwater in late summer	3. Annual mean temperatur of spring water	4. Annual mean temperture of mountain region
7600 ft	2401 m	1,12°C	—	- 1,50°C
5700 ft	1801 m	2,37°C	—	+ 1,75°C
4500 - 5000 ft	1422 - 1580 m	3,50 - 4,50°C	4,25°C	3,00 - 3,75°C
4000 - 4500 ft	1264 - 1422 m	3,62 - 5,50°C	4,50°C	3,75 - 4,50°C
3500 - 4000 ft	1106 - 1264 m	1,50 - 5,50°C	4,87°C	4,50 - 5,25°C
3000 - 3500 ft	948 - 1106 m	1,75 - 6,25°C	5,12°C	5,25 - 6,00°C
2500 - 3000 ft	790 - 948 m	3,62 - 6,87°C	5,50°C	6,00 - 6,75°C
2000 - 2500 ft	632 - 790 m	5,12 - 7,50°C	6,12°C	6,75 - 7,50°C
1400 - 2000 ft	442 - 632 m	5,37 - 9,62°C	7,25°C	7,50 - 8,50°C

The original descriptions of the columns by SIMONY are the following:

Column 1.: "Altitude of the springs /sources/ in Wiener Fuß" /column 1(a): original footage; column 1(b): converted into meters/.

Column 2.: "Observed spring temperatures in late summer" /notated in half degrees Reaumur, converted into degrees Celsius/.

Column 3.: "Mean annual temperature of all studied springs" /notated in half degrees Reaumur, converted into degrees Celsius/.

Column 4.: "Approximate climatic annual mean of the corresponding altitude" /notated in half degrees Reaumur, converted into degrees Celsius/.

Limestone removal

SIMONY often focused on moraines, rubble and water with suspended sediments in his field work. He called the removal of material and its origin "erosive processes" ("erosierende Kräfte"), summarizing erosion and corrosion in one single term.

He assigned water a special role in the "erosive" ("erosirenden Abtrag") limestone removal, defining it "the omnipresent means of destruction connected with an incessant change of temperature" (1871: 3); in connection with the climate he considered water as "atmospheric erosion". He said that "rain and snow water" served as "chemical solvent, eroding the rocks on the surface." In this way SIMONY expressed and described the origin of karst phenomena: "The whole surrounding area looks as ragged, gnawed at and hollowed as if strong acids had rained on the rocks for centuries." He continues (1871: 5): "The share of atmospheric precipitation in the formation of the terrain must not be underestimated. In any case the latter is being continually 'gnawed off' by the .. corrosion of the surface of the rocks, and .. every crevice rippled by water .. is slowly and continually deepened and enlarged .. to an unmeasurable degree." This limestone removal which was not only mentioned in 1871, is still a prominent topic in modern research!

SIMONY realized that besides the change of temperature of the water there exists another essential influence on the limestone, as he wrote in 1871 (page 10): the carbonic acid, "substantially increasing the effect of atmospheric precipitation, is brought into the system from the air, but is absorbed to a much larger extent from layers of plants and soil. The corrosive power of the water may be increased .. many times .. by carbonic acid." The limestone removal = eroding effect of the biogene carbonic acid from algae and layers of moss was stressed in his later work. In 1869 SIMONY had already written a paper on these "means of destruction in high mountains" and had made it public (1870) in a popular calendar (an almanac with calender and a lot of informativ and educativ items). There are hints to be found in earlier publications.

SIMONY calculated the limestone removal especially for the "Kaiserbrunnen am Schneeberg" (Lower Austria). He said (1871: 43-44) that "25.000 Kubikfuß /= 7.900 m^3/ of solid rock were annually removed by the Kaiserbrunnen as a product of erosion, which corresponds to the volume of a kubicle 29 feet /= 9.16 m/ high". From this he calculated the general surface removal, noting that "in a thousand years a layer of not more than 5/4 Zoll /= 3.29 cm/ would be removed. He tried to compare these rates of removal from the limestone areas with those of the crystalline. He concluded that the surface removal rate by the glaciers was not very substantial. Not a period of a thousand, but hundred thousand years would be required for the big diluvial sediments in the forelands. A remarkable view for that time, which he gained by empirical observation, measurements and calculation.

Karst phenomena, especially karren

Already in his first publications SIMONY gave a realistic presentation of limestone massif morphology in the mountains of Totes Gebirge and Dachstein. He documented the various karst phenomena such as karren, dolines and caves.

He described the phenomenon of karren and made drawings thereof. At first he ascribed the conspicuous formations to the effect of glaciers, he also limited their appearance to the glacier zone. He was of that opinion at the beginning of his research and also later, although he had clearly realized the effect of the water. In 1878 he wrote (on oage 114): "Even if the origin of the karren still seem .. to be doubtful, this question appears to have found .. a sure answer. These strange hollowings are solely the product of the concurrence of melt water from the glaciers and the rubble of the moraines serving as abrasives."

This statement does not correspond with the present state of knowledge and actually differs from SIMONY's other views on karst processes. For, in his above mentioned paper from 1871, he clearly considered the rain- and soil water with its CO_2 to be a driving force for karst processes. However you can see from his drawings that he observed the karren and karren areas correctly and portrayed them in all details. Apparantly he could not correlate the relief of the karren with the effect of the surface removal. In the present it is easier to find different conclusions. His drawings are nonetheless important and correct evidence, such as a sectional drawing of a karren area in his diary, and the drawing Nr.382 from 1844 (Fig. 1).

The caves

Caves are normal phenomena of limestone mountains for SIMONY. Precipitation made its way into the subsoil, as described above, through crevices and "Karrenbrunnen" (karren-pit). Smaller crevices and canals were widenend, and caves developed in the course of time due to subsurface waters, which streamed again through the "canals" to the outer world. Thus he perfectly explained the circle of karst water by the direct connection between sinking surface waters, their subsoil course to the surfacing of the spring.

As to the origin of the caves, SIMONY stated (1871: 11) "that at least a substantial number of them owe their origin their .. continual enlargement .. and also their final collapse to the combined attacks .. of the water." Therefore he must have realized, "that the number of known and accessible caves was infinitely little, .. compared to that of the ones existing. Innumerable caves lie .. inside the mountains ..". Still, about a hundred years later scientists fiercly discussed "caves without entrances" as a "remarkable" phenomenon, although this had been no problem, but a fact in earlier times.

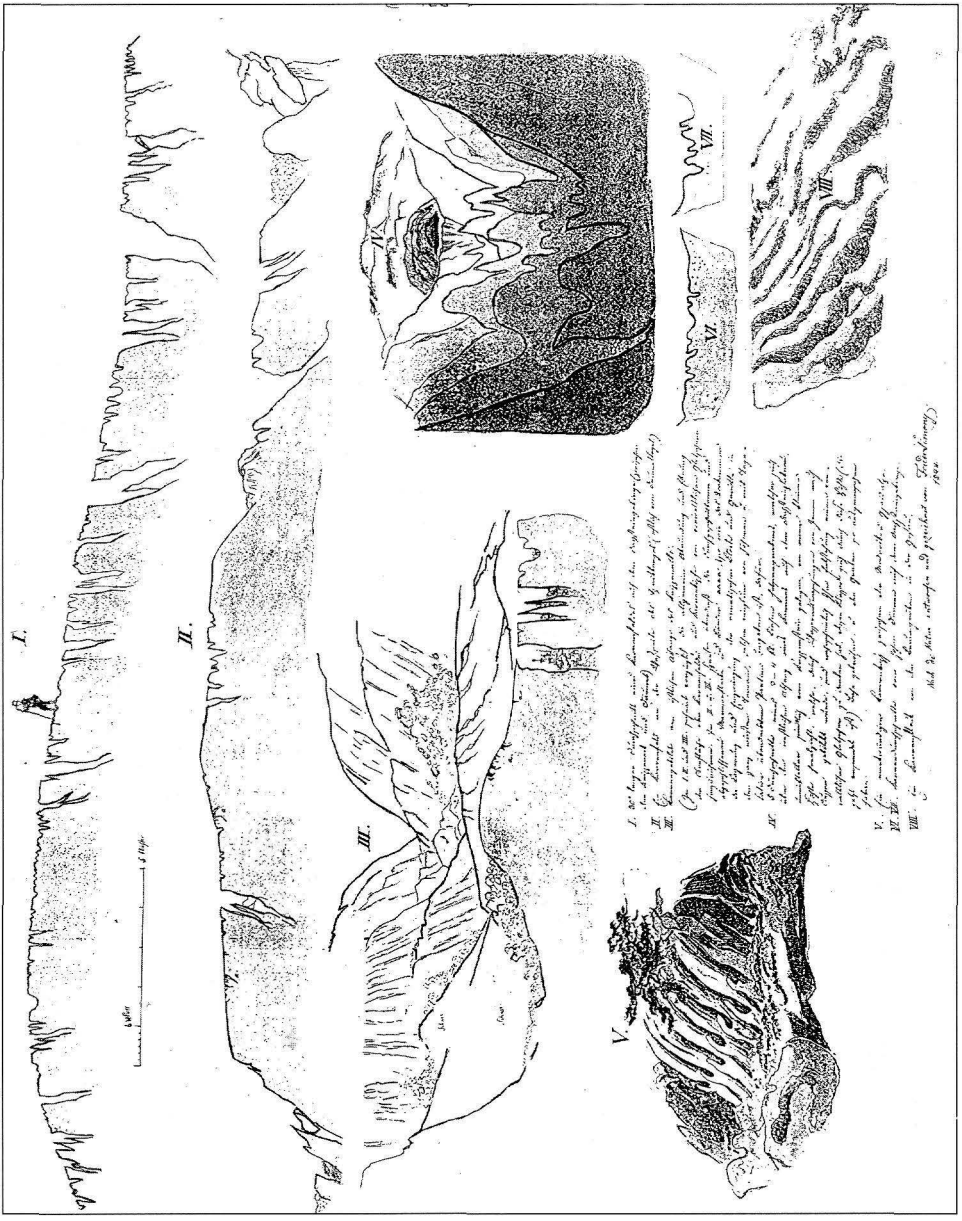


Fig. 1: Karren-Poster by Friedrich SIMONY 1844. Different views of karren in didactic combination with explinanetary legends. See translation on page ***XXX****. Drawing, water coloured, approx. 55x37cm. Archiv des Naturhistorischen Museums Wien: Material SIMONY Blatt Nr. 382.*

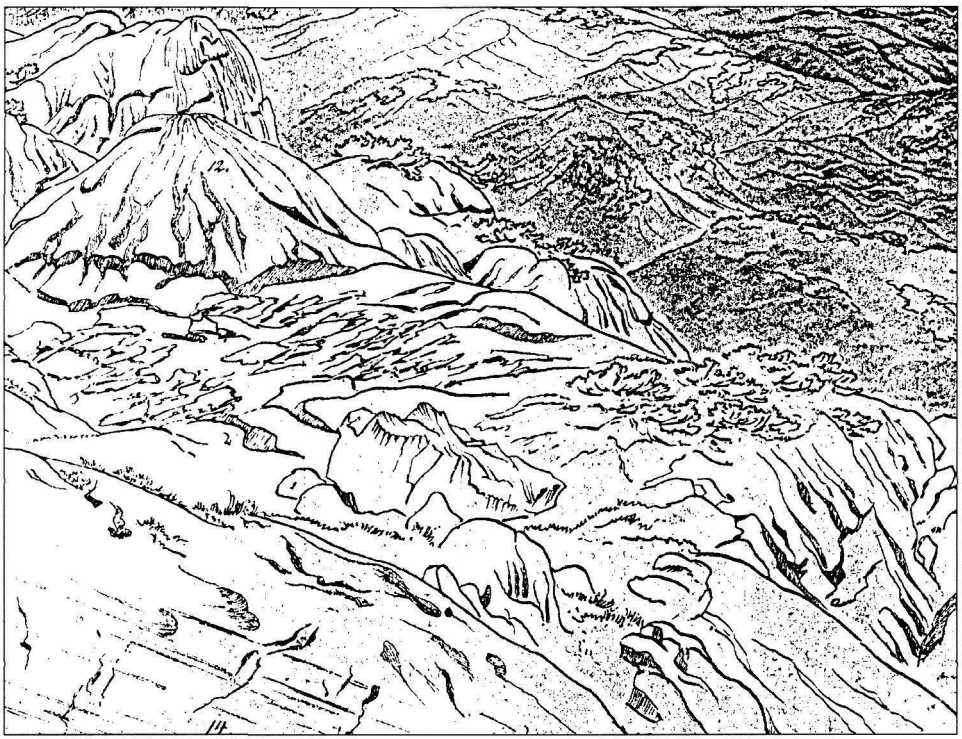


Fig. 2: Presentation of karrenforms: bolder with Firstkarren, "Karrenköpfe" with grooves and subsoilforms. Part of a geater sheet entiteld "Zur Charakteristik von altem Gletscherterrain im Kalk Hochgebirge, Aussicht vom Steige von der Ochsenwieshöhe nach dem Taubenkar (Dachsteinplateau)", made in september 1844. At the side are legends explaining items, with number 12 there are "Karrenköpfe" inscribed. Archiv des Naturhistorischen Museums Wien: Material SIMONY Blatt Nr. 338.

SIMONY named practical examples of the development and collapsing of caves from the Nördliche Kalkalpen. He studied the Almbergloch in the Totes Gebirge and the Thiergartenloch in the Dachstein. He had made drawings already in 1845 (Nr.190) and commented on the development of caves at a meeting of the "Freunde der Naturwissenschaften" (HAIDINGER 1847, GRAF 1979). At that time he had little experience, yet he drew justifiable conclusions on this matter (HAIDINGER 1847: 55-59). He made a distinction between primary and secondary caves, the karst caves belonging to the latter. As to basins, gullies and partly also blind valleys (Sacktäler) he believed them to be formations, which owed "their first appearance to the collapse of large primitive or secondary caves". This opinion can only be agreed to in a few cases.

SIMONY did not consider the caves suitable for tourism, in any case not as shelters for alpinists or hikers. Unfortunately there are no diary notes on the "Gschlösslkirche", which he visited in 1844 and where he found fireplaces as evidence of earlier visits. We are in possession of diaries only from 1847 onward. At the occasion of a later visit he explored the cave more thoroughly and found it apt to be used, to a limited degree, as a shelter for tourists. He wrote (1877: 126 right below): "Although .. our experience generally speaks against the use of caves for touristic purposes, the Gschlösslkirche seems to offer favourable conditions for such usage .. however only if any expensive development is avoided, and only the most necessary equipment should be procured." From this statement we can surmise that SIMONY wanted nature to be changed as little as possible, and not "conquered". Changes should not be noticeable within the cave nor on the outside. This attitude may be regarded as a very first attempt of "soft tourism".

One of SIMONY's studies in caves can be traced from his second diary in 1848 (Nr.1756), containing notes on an excursion to the Loserloch on August 3rd. SIMONY took different temperatures during his ascent, inside the cave

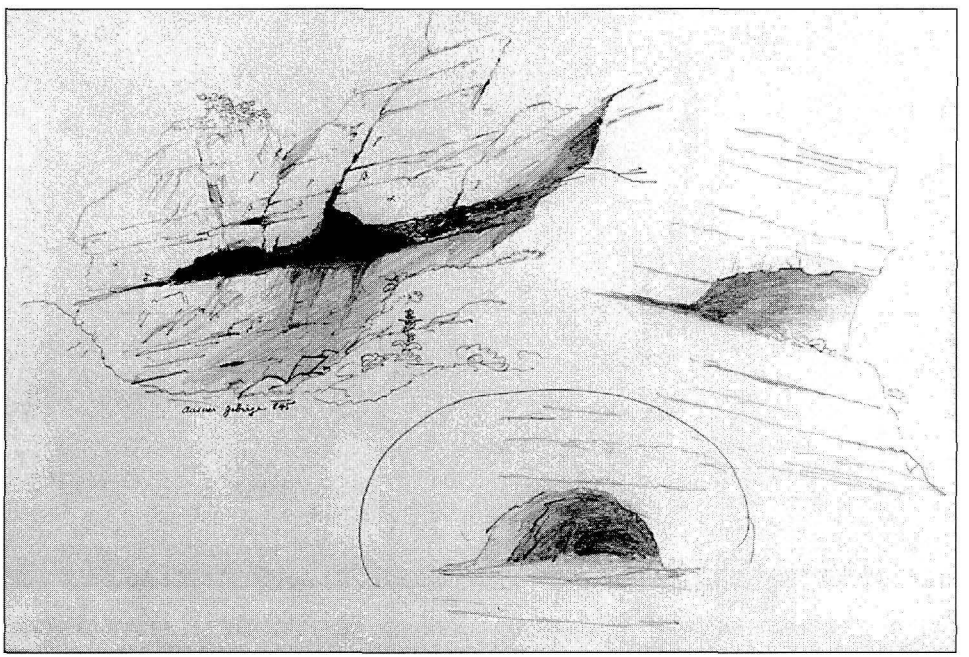


Fig. 3: Drawing according to the speleogenetic questions, "Ausseer Gebirge" = Totes Gebirge, 1845, pencil sketch, approx. 55x37cm; Archiv des Naturhistorischen Museums Wien: Material SIMONY Blatt Nr.190. This sketch is also published by GRAF 1979.

he measured 2.2°R (=2,75°C). He described the chambers of the cave, made a drawing of the entrance area, as well as the way through the cave, producing a horizontal projection as well as a vertical section.



Fig. 4: The great entrance of Almbergloch, Totes Gebirge, Styria. Pencil. "Bleistiftzeichnung nach der Natur von F. SIMONY im Jahre 1845". Archiv des Naturhistorischen Museums Wien: Material SIMONY. This drawing was used on end of the 70ths up to the early 80ths as cover of the local cavers journal "Mitteilungen der Sektion Ausseerland des Landesvereins für Höhlenkunde in Steiermark".

The graphic work

From the rich fund of drawings by Friedrich SIMONY one item (Nr.382) from 1844 is presented here. It is neither a picture nor a drawing, but a poster - in modern sense. This poster on karren in the high mountains is titled "Profiles and Views of the Karren in the Dachstein Area" (*Durchschnitte und Ansichten von Karren aus dem Dachsteingebirge*). It is made on a sheet of drawing paper, size of 39x54 cm, several water coloured sketches are placed together.

Two sections show karren, ravines of different width cut deeply into the limestone layer (I. and II.). Below to the left we find a view through a "Karstgasse" (III.) Various types of karren have developed in horizontal and steep vertical parts of rocks. Below there is a water color drawing of a "Karrenkopf" (V.) with vegetation on top of it, clearly showing karren. The right side of the poster shows five profile sections of a "Karstgasse"(IV) leaning to the entrance of a cave. The section clearly shows the variebility of karren types. Below there are two more profile sections of karren (VI und VII). The text in between runs as follows:

The original text of the poster in translation:

I.: 30° (=Klafter) long section of a karren field (*Karrenfeld*) in the Dachstein mountains (between Krippeneck and Tenneck).

II.: A karren field on the west side of the Speikberg (east of Däumelkogel).

III.: Karren formations (*Karrengebilde*) on the eastern slopes of the Krippeneck. (In I., II. and III. the rounding and flattening of the surface of karren and karren fields (*Karrenfelder und Karrenköpfe*) seems to be a product of ancient glaciers. In II. and III. the sected marble spots and layers point to that as well as the deposition of erratic boulders and gravel in a vast terrain surrounded by higher areas covered with vegetation.

IV.: 5 sections of a 3-4 Klafter deep rock pit running from a small cave through the western slope of a ridge south of Krippenstein. The cave was formed by water erosion probably as a product of ancient glacier water running through the cave (now filled with sand).

V.: A peculiar *Karrenkopf* between Modereck- and Gjaidalpe.

VI., VII.: Karren sections (*Karrendurchschnitte*) on the high Dürren in the Dachstein.

VIII.: A karren spot (*Karrenfleck*) from the Brunngräben in Gosau.

Composed true to nature and painted by F. Simony 1844.

The sheet Nr.382 was composed apparently for didactic reason to show the variety of karren types. In the large section through the karren fields there is a human figure drawn, also a yardstick of 9 Klafter (= 9,48m) length. The backstage presentation of III. and the several profile sections in IV. try to

present the different appearances of karren in a perspective or geometrical way. These combined illustrations were obviously composed for a lecture on this topic. The conspicuous numbering of each drawing on the poster shows the documentary/didactic purpose of the illustration.

Contributions to glacier speleology and other items of karstology

SIMONY was fascinated by the investigation in glacial areas, also he found interest in glacier caves. His observations thereof date back as far as 1840. At the 4th Int.UIS Symposion on glacial caves a special paper is presented.

It must be mentioned that SIMONY compared his earlier drawing with later photos, to assess the dynamic changes of ice and glacier status. For other comparisons he did not use his material. This was done later by the scientists of the Speleological Institute in Vienna. In the karst research program of this institute, especially from 1950 onward, SIMONY's photos were used for comparative studies of plant development in this karstregion. Georg KYRLE (around 1930), as well as Fridtjof BAUER made new photos in these places. Otto CECH analyzed the dyamics of the vegetation with plant-sociological methods (BAUER 1958). Such investigations are still being carried out.

SIMONY's drawings and photos

His drawings, water color paintings and photos are documents of karst and caves that have not yet been given a satisfactory classification. The bibliography set up by BÖHM in 1899 and of late by KAINRATH in 1993 offer a step for beginning. In SIMONY's graphic work several karst regions are presented. It contains the Polauer Berge, the limestone alpine regions of Lower Austria Styria, Upper Austria, Salzburg, than karst massifs like Schneeberg, Rax, Hochschwab, Totes Gebirge, Dachstein, Schafberg, Tennengebirge, Steinernes Meer, Watzmann, as well as the regions of the southern limestone alps in Carinthia and Krain (Slovenia). Besides that we must mention the pseudokarst areas of the Riesengebirge.

The first karst object drawn by SIMONY was the chasm of the Mazocha in Mähren on a water color painting in 1830. Other karstobjects he draw in the early fieldwork in the Totes Gebirge and the Dachstein. Karren and dolines are shown on gearter pictures with a high exactness, also springwater and caveparts like Waldbach, Hirschbrunn, Kessel, Koppenbrüllerhöhle.

The early drawings and graphic works of F. SIMONY still show a little clumsiness, but SIMONY soon reached great perfection. In order to draw the landscape true to nature he used a frame, and only for the sky and the clouds he permitted himself a certain artistic touch. Later on his drawings became more and more precise and less artistic, as SIMONY refrained from painting the sky and artistic manipulations. On his drawings he made captions emphasizing the documentary character of the pictures. With the help of a drawing

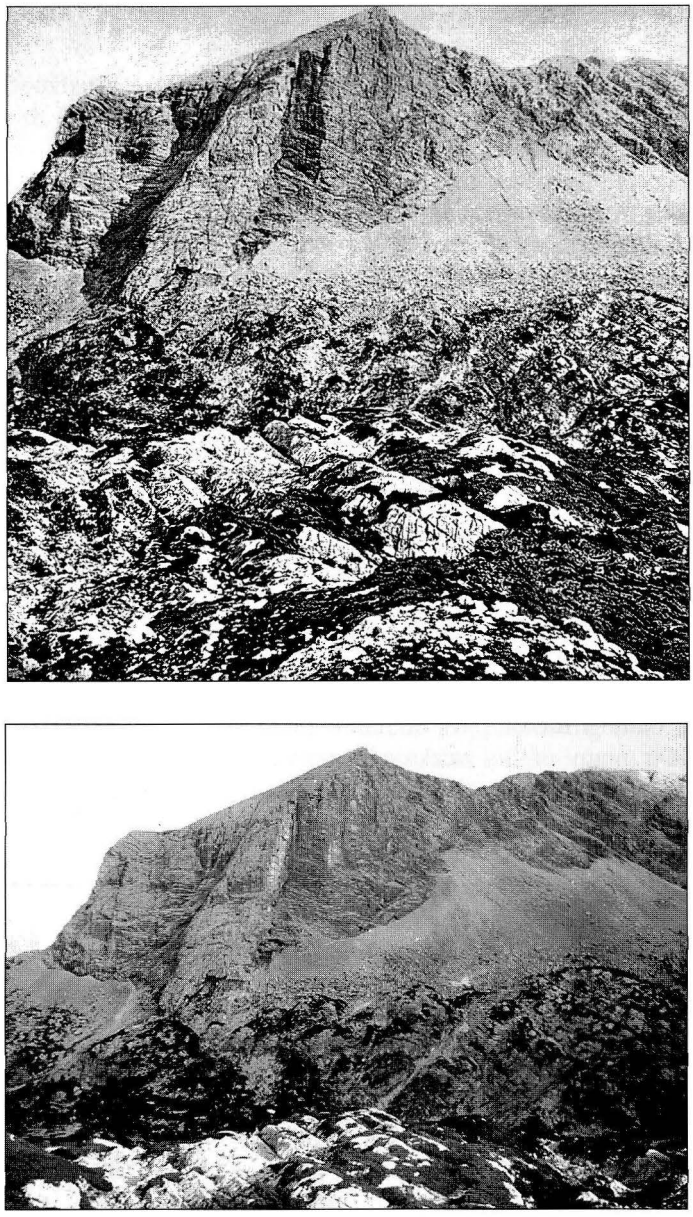


Fig. 5: Taubenkogel, view from Ochsenwieshöhe (1989m), the photograph ***a****: taken by F. SIMONY 1875-08-12 (SIM XXV, SP.J. 35) and* ***b****: by F. BAUER 1955 (SP.J. 481) were used in studies on changes of karst vegetation (O. CECH & F. BAUER).*

aparatus, he had developed himself, and the systematic superelevation of the relief his pictures became purely documentary. This becomes evident when he makes objective pictures from his photos.

Apart from the documentary drawings and photos SIMONY also painted idealizing pictures. On the one hand they were character sketches of landscapes, where he focused on composition and included the portrayal of clouds, on the other hand they were expressive teaching material for his lectures at the university. With his photos he used retouch techniques to stress parts of the pictures that lacked clearness. Thus he emphasized indistinct contours caused by under-exposure or over-exposure, and added suitable skyscapes. He used this kind of picture improvement in his "Dachsteinwerk".

Final remarks

Friedrich SIMONY's speleological works are numerous and were presented in a small scale only. Their high value would favor a closer study of this scientist's achievement. The importance of his research for scientific speleology is only partly known. His publications, drawings and diaries should be studied and presented, as his life's work is practically unknown, but still valuable today.

The results of SIMONY's research had a substantial impact on his colleagues, his students as well as on other contemporaries. His work was reflected in the scientific literature of his time, and its contents became part of common knowledge. Especially the knowledge he conferred in his lectures and speeches was carried on in the educated circles of the 19th century. Therefore references are rarely to be found in contemporary literature. In 1898 Jovan CVIJIC mentioned SIMONY's reports on karren and dolines. Later on, in 1913, BOCK, LAHNER and GAUNERSDORFER refer to him in "Die Höhlen des Dachstein" ("The Caves of the Dachstein"). Recently his work has been recalled to a certain extent. In 1977 SEEMANN gave proper attention to his work of the Dachstein area, and GRAF (1979) to that of the Totes Gebirge. Yet SIMONY's field work is not only important for retrospective, but also for actual research - as introduced and presented by G. KYRLE and Fridtjof BAUER, who compared his pictures with modern ones of the same sites. Today SIMONY's historic material is of great importance for research in the field of speleology. Only a minor part of it has been evaluated so far. In SIMONY's memorial year many of his works will appear accompanying publications and exhibitions. SIMONY's work will be acknowledged to a greater extent, see also the catalogue for the exhibition in the Landesmuseum Linz (SPETA & AUBRECHT 1966, with contributions by Franz GRIMS among others).

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FRIEDRICH SIMONY (1813-1896) IN NJEGOV PRISPEVEK H KRASOSLOVJU IN SPELEOLOGIJI

Povzetek

F. Simony, ob svoji smrti 1896 znan predvsem kot alpinist, naravoslovec in geograf, se je ukvarjal tudi z glaciologijo in speleologijo, še posebej v pogorju Dachstein v avstrijskih Alpah. Terensko delo je dopolnjeval z lastnimi risbami, posnetimi po naravi, ki jih je kasneje uporabljal kot ilustracije pri objavah in predavanjih. Danes je njegovo speleološko delo zelo slabo poznano. Vendar je že 1842 apneniške planote imenoval "kraška območja". Ukvarjal se je s kraško hidrologijo in morfologijo. Tako je preučeval hidrologijo jame Koppenbrüller ter sosednjih kraških izvirov na severnem obrobju Dachsteina, meril je temperature vode in zraka v jamah, preučeval vodni transport trdnega in raztopljenega tovora, intenzivnost korozije tako v kraškem podzemlju kot tudi na površju, itd. Danes lahko ocenjujemo njegovo delo predvsem po njegovih objavah in risbah. S svojim poročanjem v znanstvenih družbah in s svojimi predavanji na univerzi je bistveno pripomogel k uveljavitvi dunajskega geografskega inštituta, kjer ga je nasledil Albrecht Penck, kot profesor fizične geografije, in kjer je končal študije tudi J. Cvijić. F. Simony je bil tisti, ki je v drugi polovici 19. stoletja zelo veliko pripomogel k uveljavitvi in popularizaciji speleologije.

ACTA CARSOLOGICA	XXVI/2	14	139-147	LJUBLJANA 1997

GEODETIC SURVEY OF POSTOJNA CAVES IN 1891 BY J. SCHMID

SCHMIDOVA GEODETSKA IZMERA POSTOJNSKE JAME LETA 1891

KARL MAIS [1]

Izvleček UDK 091:551.44(497.4)"1891"

Karl Mais: Schmidova geodetska izmera Postojnske jame leta 1891 - Prispevek k transkripciji dokumentov, pisanih v gotici, pomembnih za zgodovino speleologije

V zvezi s preučevanjem speleološke dokumentacije sta se Inštitut za raziskovanje krasa (Postojna) in Oddelek za jame in kras dunajskega Naravoslovnega muzeja lotila projekta - transkribiranje nemških rokopisnih dokumentov, pisanih v gotici. Prvi primer je zapis geodetske izmere Postojnske jame iz 1891 J. Schmida iz knjižnice na Dunaju. Trenutno so v transkribiranju dokumenti iz lastnih arhivov (F. Simony, G. Abel), načrtujejo še transkripcijo pisem in dokumentov F. Krausa, A. Silberhuberja, W. Puticka iz arhiva Inštituta za raziskovanje krasa.

Ključne besede: zgodovina speleologije, jamomerstvo, dokumentacija, Avstrija, Slovenija, Postojnska jama, Schmid J.

Abstract UDC 091:551.44(497.4)"1891"

Karl Mais: Geodetic survey of Postojna Caves in 1891 by J. SCHMID - about the transscription of handwritten ("kurrent" - "german script") speleohistoric documents.

For the purpose of speleo-documentation a project was started by the Karst Research Institute (Postojna) and the Department of Karst and Caves of the Museum of Natural History (Vienna) to transcribe documents in German Script into normal. A first transformation was made with geodetic survey record of the Postojna Caves in 1891 ("Berechnung der Adelsberger u. Ottoker Grotten - Vermessung... ausgeführt im Jahre 1891") by J. Schmid, from the cave departement library in Vienna. Now documents from our collections (F. Simony, G. Abel) are transcribed for further investigations. A greater project to transcribe the letters and documents from the archives of the Postojna Karst Research Institut (F. Kraus, A. Silberhuber, W. Putick) is foreseen.

Key words: history of speleology, cave survey, documentation, Austria, Slovenia, Postojnska Jama, Schmid J.

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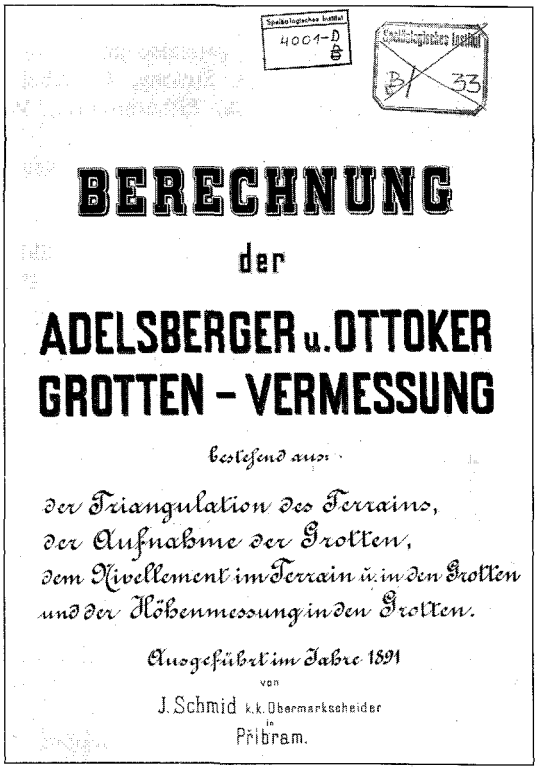
About handwritten data

Handwritten documents do constitute the most important sources for works about the history of speleology. Although it is rather difficult to work with these sources due to "old fashioned" expressions and older hardly legible fonts. Especially young researchers face difficulties when dealing with documents which are written in gothic letters. Naturally for foreign researcher the comprehension of such original documents is even more arduous.

Projects concerning the transcription of historic documents

The Institute for Karst Research of Postojna and the Department of Karst and Caves of the Museum for Natural History Vienna do intend to transcribe and transform the documents concerned into a more comprehensible form in order to ease source research. Hence translation and interpretation will be less challenging.

Josef SCHMID: "Vermessung der Adelsberger Grotten"



Certainly the transcription of the by Josef SCHMID of Pribram penned protocols was a paying subject. These protocols of 1891 were calligraphical transcribed ("mundiert") by Karl KORB in 1892 (Fig. 1).

The protocol was written in a leather bound blank book. The embossed cover carries the title "Vermessung der Adelsberger Grotten 1891". The content of the first page is as follows: "*Berechnung der Adelsberger und Ottoker Grotten - Vermessung bestehend aus: der Triangulation des Terrains, der Aufnahme der Grotten, dem Nivellement im Terrain und in den Grotten und der*

Fig. 1: Title page of the geodetic survey of Postojna caves in 1891 by J. SCHMID (1892: page 1).

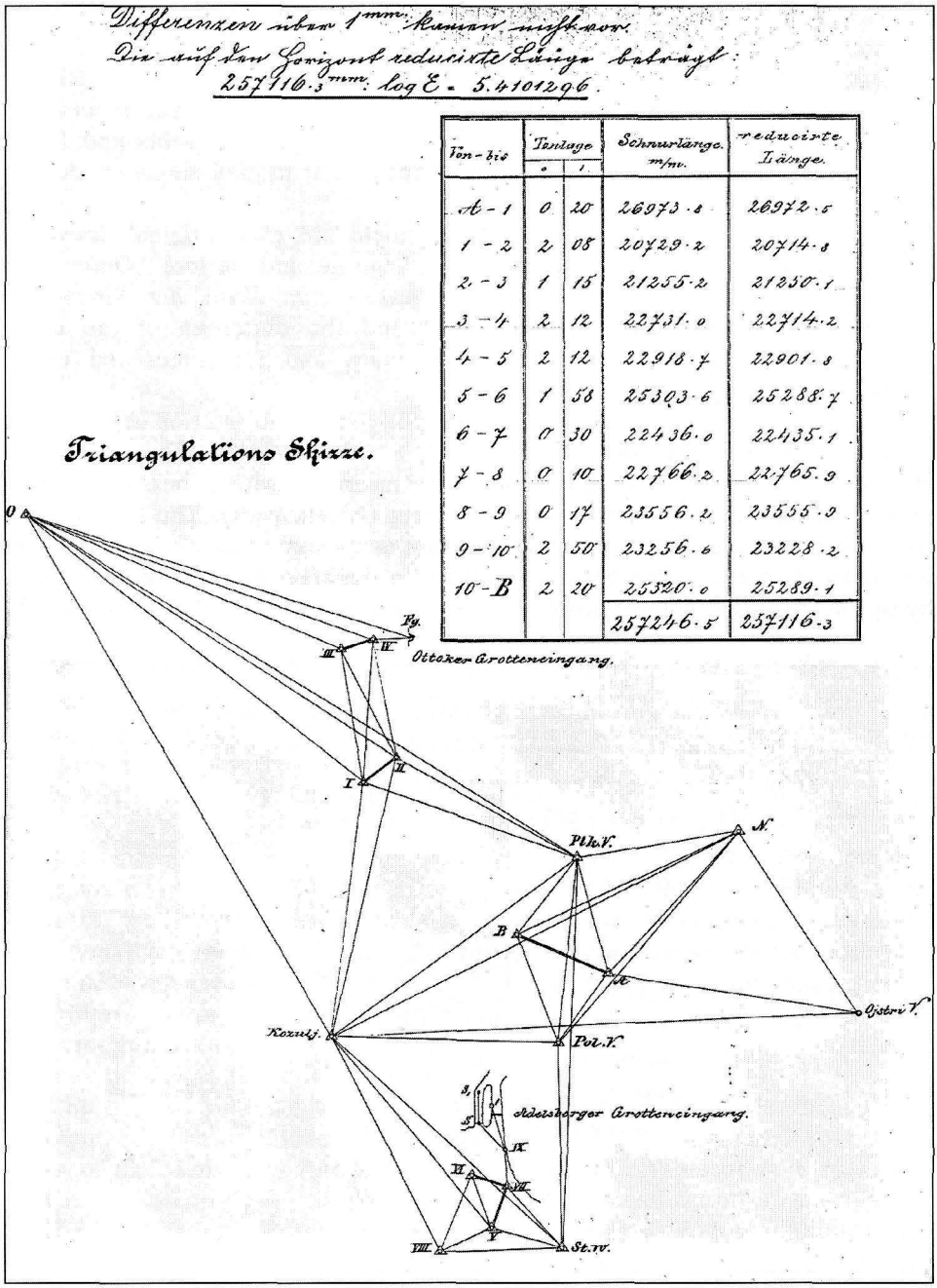


Fig. 2: Triangulation; example for the use of different fonts, of tabular layout and geodetic drawings; (SCHMID 1892: page 8).

Höhenmessung in den Grotten. Ausgeführt im Jahre 1891 von J. SCHMID "k.k. Obermarkscheider in Pribram; mundiert: Karl KORB."

Texts and tables are written in calligraphic fonts. Headings and heightenings are written in Latin fonts and in black ink, normal text in gothic letters and in a dark brown ink. The various tables come in different layouts and fonts, nevertheless, the layout is very clear. The tables are framed single or double line and are red (Fig. 2).

The polygonal sketches of the survey afield are clear original drawings. The points of survey are named in local language and enclose *"Ojstri vrh"*, *"Polane"*, *"Polanski vrh"*, *"Kozulj vrh"*, *"Visuren zum Kreuz der Kirche 'St. Andrä'"*, the church towers of Adelsberg and the entrances of the caves *"Adelsberg"* and *"Ottoker"*. The lines are black and sometimes red or in different colors. See Fig. 3 and 4.

The surveys afield and of the principal polygon in the interior of the caves were done with a smal mining instrument, a *"kleiner Gruben-Theodoliten von Aug. LINGKE et Co."* The side aisles were measured with a bussole. Underground the height was determined by leveling (Nivellement). The survey team used 8 meters long battens. In addition they employed a hot air baloon which was fixed on a band. The baloon which had a diameter of 1 meter was driven by spirit drenched ball of wool. By the latter method heights of up to 33

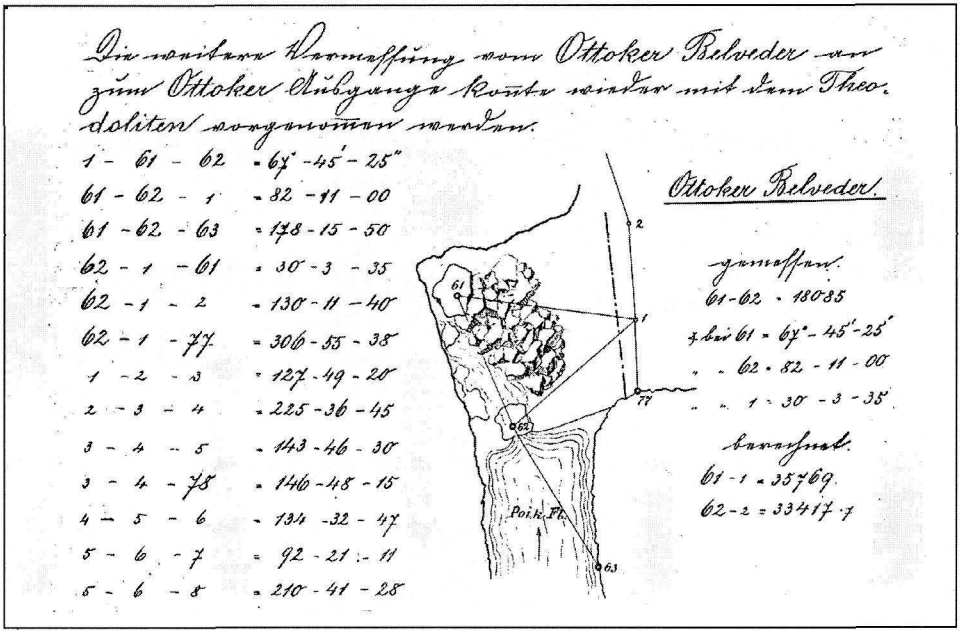


Fig. 3: Measurings in the region of "Ottoker Belvedere"; fonts, tabulations and sketch of the measure point situations (SCHMID 1892: part of page 52).

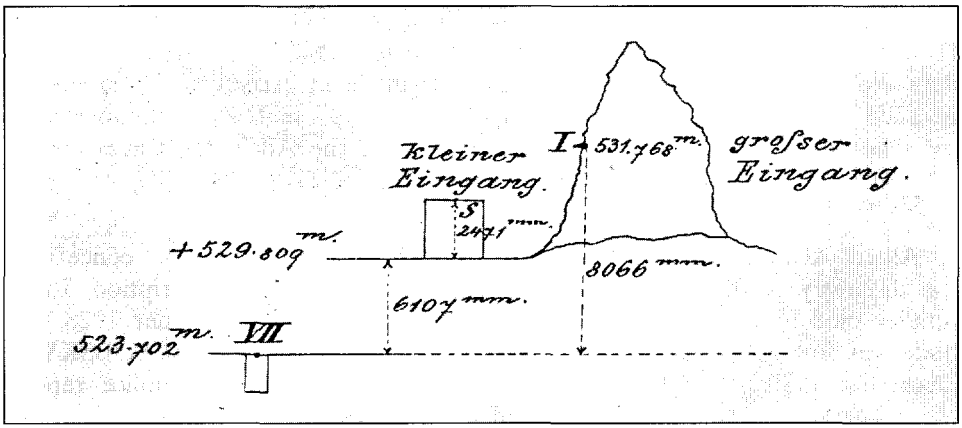


Fig. 4: Sketch of measure points with elevations, Main Entrance of the Postojna Cave; (SCHMID 1892: part of page 81).

meters could be determined, as for instance, the height of the Dome of the Cave of Adelsberg in the river level ("*vom Poik-Niveau*") and on the "*Calvaria Plateau*". The survey lists also give evidence of the then used notations for the various rooms.

When performing the transcription of the protocol it was subsequently paginated to enable the relation of textpassages to pages. Furthermore, the gothic writing was converted to a common printed font and normal writing and headings were converted to a bold font. Table contents were only converted if they had been in gothic writing. Numbers were left unchanged. Tables, drawings were numbered. A "T-" (T=Tabelle) stands for table and a "Z-" (Z=Zeichnung) for the drawings. Below the drawing often the description of polygons can be found as well as two index maps of the triangulation which indicate the cave entrances and drafts of some branches of the grotto. Additional remarks, not in the original text, figure between two slashes (/../).

Further amendments of the protocol have not been made. Orthographic idiosyncrasies were left unchanged. The archaic spelling might confuse some readers (for instance "Tor" was then written as "*Thor*"), but they enables to read or to revert the original text.

The original protocol is stored in the Karst and Cave Department of the Museum for Natural History in Vienna. Most probably it formed part of the stock of the Ministry of Agriculture which then had competencies in speleology and it was a entry gift founding the "Speläologisches Institut" in the 1921. It carries the institute stamp "B-33". Later on, after WW-2 the Speleological Institute was re-established and the library reorganized. The stock of Prof. KYRLE was added to the re-numbered instituts library. Then the number "4001-D" was assigned to the new library list.

According to Andrej KRANJC a sketch of the 1891 survey is stored at the Postojna Institute. Other sketches and drawings of the here presented survey data are not yet ascertained. The big effort made in carrying out the survey, detailed calculations and the makeout of the here presented calculation protocol (sheet) make the official state importance of the Adelsberg Caves clear.

Other documents

Albert AUSOBSKY, a speleologist of Salzburg, left us a report concerning the discovery of the body of Franz RATHSCHÜLER for transcription. Rathschüler died by an accident in the "Frauenmauerhöhle" in Summer 1928. His body was found by the two speleologists Johann GANGL and AUSOBSKY in December 1928. AUSOBSKY's report differs from the official police report, the reporting of the news papers and a report by HOFMANN-MONTANUS (1952) covering the same subject. Albert AUSOBSKY is holder of the original document. A copy of the report is stored with the transcription in the archive of the Department of Karst and Caves - Museum of Natural History Vienna for the purpose of further investigations. According to the will of AUSOBSKY the public does not yet have access to the document, likewise the report is not open for publishing.

Further reports documenting the development of the Salzburg Caving Club are about to be transcribed by its members, as for instance the narrative minutes of the early discoveries in "Bücher der Expeditionen". Thus the younger members will gain interesting insights into the early works of their colleagues. Transcriptions of biographic documents about Walter CZOERNIG could already be used as interesting source for other works (MAIS 1996). The original documents are part of the archive staff "Material Gustave ABEL", stored at the Department of Karst and Caves of the Museum of Natural History Vienna.

Parts of the dairy of Friedrich SIMONY (1813-1896) had been described as they were needed for current research work, e. g. a description of the "Loserhöhle" of 1848; he drew a sketch of the longitudinal section and of the horizontal projection (Fig. 5). The dairies of SIMONY contain several unpublished speleological observations which are subject to a future subscription. The

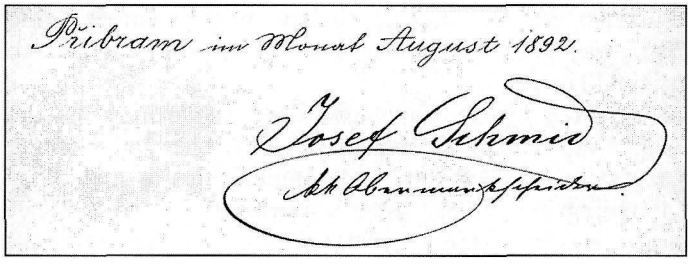

Pribram im Monat August 1892.
Josef Schmid
k.k. Obermarkscheider

Fig. 5: Closing signature: Pribram im Monat August 1892, Josef SCHMID k.k. Obermarkscheider"; (SCHMID 1892: Part of page 102).

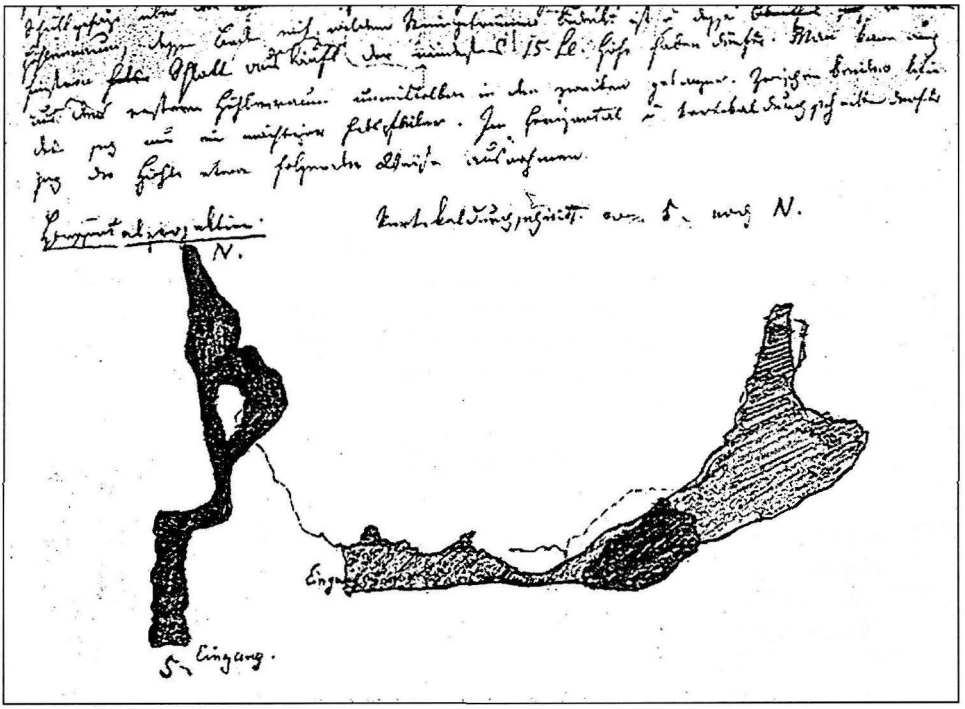


Fig. 6: Map of Loserhöhle in horizontal and vertical projection ("Horizontalprojektion und Vertikaldurchschnitt von S nach N."); F. SIMONY's diary (Nr. 1756) withe the date of 3rd of august 1848, description of Loserhöhle; Original stored in the Department Archive of the Museum of Natural History Vienna.

respective documents are stored in the Archive - Department of the Museum of Natural History, copies of parts with speleological content can be found in the archive of the Karst Department in Vienna.

The transcription of the archive records of the Institute for Karst Research in Postojna constitutes a major projects. It is still in its beginnings. The documents concerned will reveal interesting details with respect to the "Karst-Comités" as the correspondence of F. KRAUS, A. SILBERHUBER, W. PUTICK and others will be examined. Andrej KRANJC presented some of these documents at the ALCADI-94 Symposium in Semriach. Major revealings could not be made. The documents examined so far deal with the field work and frequent financial problems. The examination of these documents will offer a clearer picture of the local research work as it currently available reports do. The original documents are stored in the archive of the Institute for Karst Research in Postojna. Photocopies are kept in the Karst and Cave Department of the Museum in Vienna. The documents will be transcribed and indexed in a data base for easier information retrieval.

CONCLUSION

The Department of Karst and Caves (Vienna) offers interested colleagues the transcription of gothic writings (kurrent od german script) which are in the context with speleology or the biography of speleologists. These writings can be dairies, tourbooks, letters, post cards, biographical notes, etc. Thus we hope to save documents which otherwise would be lost due to their illegibility.

We suggest to store the original document with its owner and to deliver a copy of the original document and its transcription to the archives of official Karst Research Institutes. This would guarantee a competent source research and a save backup of the documents concerned. Archives in question are the respective institutes of Budapest, Postojna and Vienna.

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SIMONY, F.: Tagebücher.- Sammlung Friedrich SIMONY. Department -Archiv of the Museum of Natural History Vienna.1.: Title Page of the geodetic survay of Postojna caves in 1891 by J. SCHMID (1892: page 1).

SCHMIDOVA GEODETSKA IZMERA POSTOJNSKE JAME LETA 1891 - PRISPEVEK K TRANSKRIPCIJI DOKUMENTOV, PISANIH V GOTICI, POMEMBNIH ZA ZGODOVINO SPELEOLOGIJE

Povzetek

Dokumenti, pisani v gotici, četudi v nemščini, često povzročajo težave preučevalcem zgodovine speleologije. Nekatere rokopise oziroma črke je težko brati celo v materinem jeziku. Iz leta v leto je manj ljudi, še posebej mladih, ki znajo brati nemščino, pisano v gotici. V zvezi s preučevanjem speleološke dokumentacije sta se Inštitut za raziskovanje krasa (Postojna) in Oddelek za

jame in kras dunajskega Naravoslovnega muzeja lotila posebnega projekta. Originalni dokumenti, pisani v nemški gotici, bodo transkribirani v "normalno" pisavo in jih bodo lahko preučevali in uporabljali celo taki, ki bolj slabo obvladajo nemščino. Prvi primer takega dokumenta je zapis geodetske izmere Postojnske jame iz 1891 (Berechnung der Adelsberger u. Ottoker Grotten - Vermessung... ausgeführt im Jahre 1891), ki jo je opravil J. Schmid. To natančno geodetsko poročilo kaže tudi na tedanji pomen Postojnske jame. Original hrani oddelek za jame knjižnice na Dunaju.

Trenutno so v transkribiranju, pripravljeni za nova preučevanja, dokumenti iz zasebnih zbirk, kot je npr. rokopisno poročilo A. Ausobskega o odkritju trupla F. Rathschülerja v jami Frauenmauer, dokumenti salzburškega jamarskega društva in dokumenti iz lastnih arhivov (o F. Simonyju, G. Ablu, itd.). Več dela bo potrebnega za transkripcijo pisem in dokumentov F. Krausa, A. Silberhuberja, W. Puticka in drugih, ki so shranjeni v arhivu Inštituta za raziskovanje krasa. To so dokumenti o delu nekdanjega "Kraškega komiteja" na Krasu v 1880tih in 1890tih letih.

Tako so oziroma bodo strokovnjakom za zgodovino speleologije dostopni transkribirani dokumenti, pisani v nemščini in gotici. S tem bo omogočena priprava prispevkov, pomembnih tako za dokumentacijo kot za raziskovanje zgodovine speleologije.

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ABBILDUNGEN DER VETERANI-HÖHLE AUS DEM 17-18. JAHRHUNDERT

UPODOBITVE JAME "VETERANI" IZ 17. IN 18. STOLETJA

KLÁRA PATAY [1]

Izvleček UDK 94(436-89)"16/17"
Klara Patay: Upodobitve jame "Veterani" iz 17. in 18. stoletja

Prispevek govori o zemljevidih in drugih upodobitvah jame Pescabara (Veterani) iz 17. in 18. stol. Jama leži na bregu Donave v bližini Železnih vrat. V času "turških vojn" so bile v bližini hude bitke v letih 1692 in 1788 in zato je cesarska vojska jamo utrdila. Danes je jama pod vodno gladino akumulacijskega jezera.
Ključne besede: zgodovina speleologije, utrjena jama, Romunija, Pescabara (Veterani).

Abstract UDC 94(436-89)"16/17"
Klara Patay: Illustrations of Veterani cave from 17th and 18th century

The article is treating maps and other illustrations of the cave Pescabara (Veterani) from the 17th and 18. centuries. The cave is in the bank of Danube, near Iron gate. In 1692 and 1788, during the "Turkish wars" there were hot battles nearby and therefore the emperor's army fortified the cave. Today the cave is under the water of the accumulation lake.
Key words: history of speleology, fortified cave, Romania, Pescabara (Veterani).

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Die zwei Kaiser - namentlich der deutsch-römische und der türkische - standen während des 16., 17. und 18. Jahrhunderts wiederholt im Kriege. Im Lauf dieser war eine Höhle sogar zweimal der Schauplatz von hoftigen Kämpfen. Das war die Pescabara-Höhle, am linken Ufer der Donau, in der Kazan-Enge, 22 km südwestlich von Orsova.

Den erfolglosen Angriff von Wien im Jahre 1683 folgend bemühte sich das kaiserliche Heer durch langjährigen Feldzügen Ungarn, dessen ein drittel unter türkischen Herrschaft stand, zu befreien. Im Laufe dieser hat 1691 der in Siebenbürgen tätig gewesene, aus Venedig gebürtige General Friedrich Veterani die Gegend des Eisernen Tores besetzt. Da die Donau war für den Türken ein wichtiger Nachschubweg für die strategisch besonders bedeutende Festung Belgrad, hat er die Pescabara-Höhle für ein Stromsperre-Fort bestimmt. Deswegen wurde sie später durch die wiener Heeresleitung Veterani-Höhle benannt. Diese Stelle war für eine Stromsperre besonders geeignet, da die Donau war an dieser Stelle nur 19 m breit, so konnten die stromaufwerts fahrende Schiffe den Kanonen leichten Ziel dienen.

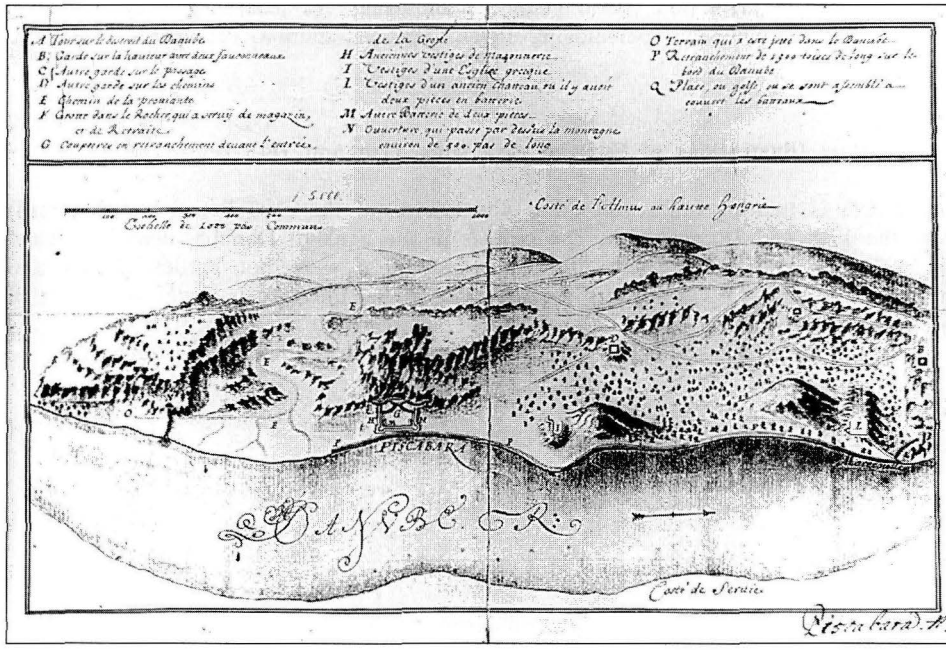


Abb. 1: Die Gegend der Veterani-Höhle. Anonyme Karte, 1692. Kriegsarchiv, Wien, Inv. Nr. H. III. e. 185.

Im folgenden Jahr, das heißt 1692 begannen die Türken einen Gegenangriff. General Veterani stellte für die Stromsperre eine Wache von 300 Mann und 5 Kanonen unter der Kommandatur vom Hauptmann D'Arnan auf. Am 29 März belagerten die Türken die Höhle und den darüberliegenden Berg, doch erfolglos. Ebenso vergeblich blieben die Angriffe am 15. und 27. April. Doch am 2. Mai rückten sie mit vielen Schiffen auf. Die ans Land gestzte türkische Infanterie - 2000 Mann - bestiegen den felsigen Berg - womit d'Arnan hat nicht gerechnet - und besetzten ihn. Die Verteidiger zogen in die Höhle zurück. Die Türken blockierten den Eingang der Höhle, gleichzeitig beschossen sie ihn mit Kanonen vom rechten Flußufer. Dadurch angeregt war D'Arnan gezwungen am Abend unter Bedingung von freiem Abzug zu kapitulieren.[1]

Die Veterani-Höhle wurde im Türkenkrieg Josefs II. erwiedert Schauplatz von Kämpfen. Der Kaiser erklärte als Verbündeter der russischen Zarin Katarina am 9. Februar den Krieg. Bis die Hauptarmee bereitete sich unter der persönlichen Kommandatur des Kaisers in Syrmien für die Belagerung von Belgrad, wurde aus den anderen Truppen eine Kordon von der Adria entlang der Sau, der Donau und den Karpaten bis Moldau aufgestellt. Eine Wachstation dieser bildete die Veterani-Höhle. Sie wurde durch den Major Stein mit einer Division des Bréchainville-Regimentes und zwei Compenien des Wallachisch-illyrisches Grenzregimentes soauch mit Kanonen des 2. Artillerieregimentes (ihre Zahl - 11-17 ist abweichend in den Angabenquellen). Diese wurden teilweise in den Redouten (Schanzen) von dem Eingang der Höhle, teilweise in denen entlang der Donau und teilweise auch am Berg über die Höhle aufgestellt. Das türkische Heer, unter dem Großvezir Pascha Jusuf, welches für die Entsetzung von Belgrad aufrücken sollte, verändernd seinen ursprünglichen Plan, überschritt am 7. August bei Orsova die Donau, drückte die kaiserlichen Truppen von dort und aus der einige km weiter hinten liegende Wachtstation Schupaneck (Jupalnic - Rumänien) zurück und am 10. unternahmen sie mit 36 Tschaiken (Schiffe) einen Angriff gegen die Höhle. Das wurde noch zurückgeschlagen. Doch der während der Nacht mit großer Übermacht - 5000 Man - aufrückende Feind eröffnete am nächsten Tag, das heißt am 11. August eine neue Aktion gegen die am Berge sich befindliche Stellungen. An diesen konnten die Verteidiger schon nicht mehr widerstehen. Nach dem Verlust von 400 Männer zog Major Stein mit dem Rest seiner Division in die Höhle zurück. Inzwischen wurden zwei Röhren der auf den Berg aufgestellten Kanonen eingenagelt und von ihren Lafetten abhebend in die Tiefe hinuntergeworfen.

Während beinahe drei Wochen lang war die Höhle heldmutig verteidigt, doch wegen an Mangel der Besatzung, auf den dritten angebotenen Accord der Türken, übergab sie unter Bedingung von freiem Abzug Major Stein ihnen. Die Offiziere konnten ihre Seitengewähre und Pistolen behalten. Infolge dessen sind die kaiserliche Truppen entlang der Donau bis Belgrad aus ihre

Wachstationen zurückgezogen. Wegen ihre bei der Verteidigung bestätigte Tapferkeit wurde Hauptmann Machowatz aus dem Wallachisch-illyrischen Grenzregiment zu Major, und Artillerie-Leutnant Foitte zu Oberleutnant befördert und auch mit dem Maria-Theresia-Orden ausgezeichnet.[2]

Die Verteidigung der Höhle fand einnen großen Widerhall im Deutschen Kaisertum; schon im nächsten Jahr wurde in Frankfurt und Leipzig ein Büchlein verlegt mit dem Titel "Die Geschichte der Veteranischen Höhle".

Im Zusammenhang mit den beiden Anlässen wurden Karten, Ansichten hergestellt. Von diesen bewahrt die Széchényi Nationalbibliothek in Budapest 3, das Kriegsarchiv in Wien 20 Exemplare. Ausser diesen kennen wir noch eine Abbildung in dem in Wien im Jahre 1790 erschienenen Atlas "Schauplatz des oesterreichisch-russisch türken Krieges".

Unter den in Wien bewahrten Exemplaren steht ein mit den Kämpfen von 1692 in Zusammenhang. Es stellt die Umgebung der Höhle vor, halb ansichtsartig. Die Öffnung der Höhle ist aufgezeichnet, doch noch unter dem Namen Piscabara-Höhle, soauch Schanzen entlang der Donau und vor dem Eingang.[3]

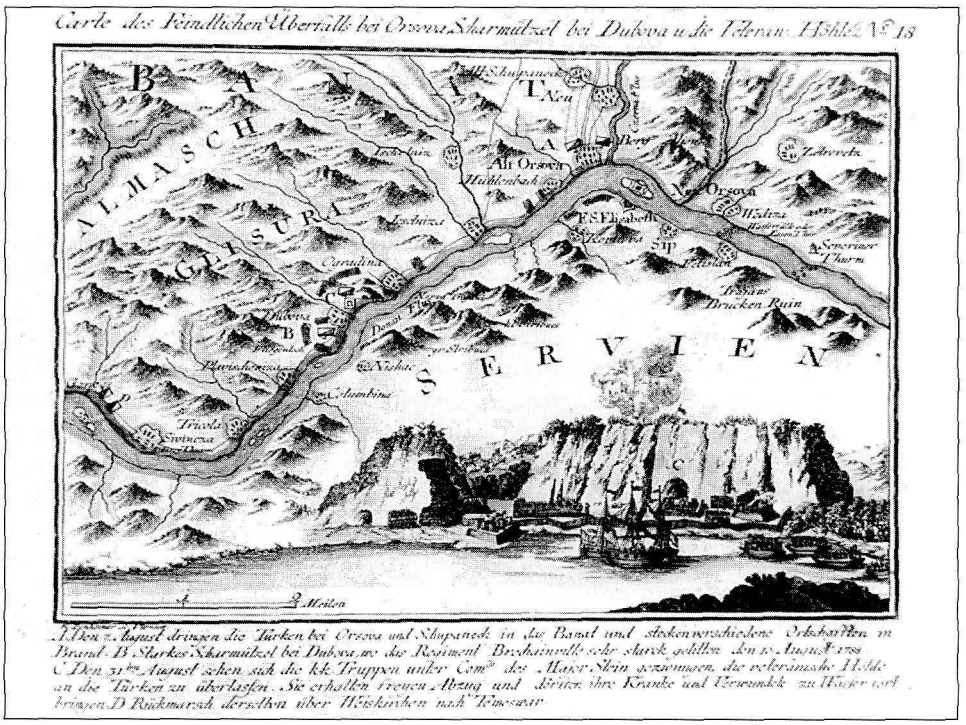


Abb. 2: Karte der Umgebung der Donau zwischen Svinita und Turnu Severin und Ansicht der Veterani-Höhle. Blatt 18. eines anonymen Atlases, Wien 1790, Széchényi Nationalbibliothek, Budapest, Kartensammlung, Inv. Nr. TA 55.

Sämmtliche andere Abbildungen sind mit den Kämpfen von 1788 in Zusammenhang. Eine ist eine Ansicht, die die Umgebung von der Donau aus sehend vorstellt.[4] An einer anderen befinden sich vier Ansichten, von denen zwei bilden den wegen Verteidigingszwecke vermauerten Eingang ab, doch in zwei verschiedenen Formen.[5] Einen Ansicht treffen wir auch an den erwähnten Atlasblatt, neben der Karte von einem längeren Abschnitt der Donau.

An weiteren 19 Blättern finden wir die Karte der näheren Umgebung der Höhle mit den Redouten, Retrenchements (Schanzen) entlang der Donau und am Berg über die Höhle, soauch die Stellungen der kaiserlichen und türkischen Truppen vor und nach der Schlacht vom 11. August.[6]

Von der Höhle selbst - was uns besonders interessiert - finden wir auch Abbildungen, und zwar Grundrisse und Profilschnitte. An zwei Blättern befinden sich diese allein,[7] an neun anderen (von denen aber drei als Duplikate zu betrachten sind)[8] dieselben als Nebenabbildungen der Karten. An diesen ist aber die Höhle in drei Variationen abgebildet.

In den meisten Fällen[9] ist der Grundriß in einer elipsoiden Form gezeichnet, in den ein 4 Klafter und 3 Fuß langer, 2 Klafter breiter und 4 ein halb

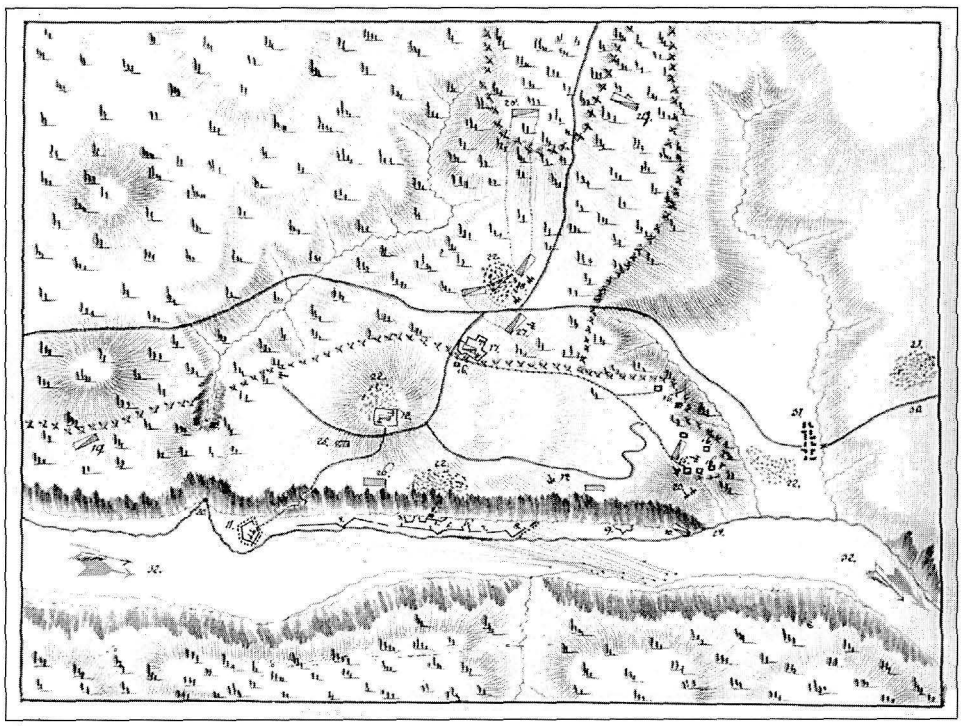


Abb. 3: Die Umgebung der Veterani-Höhle. Anonyme Karte, nach 1789. Széchényi Nationalbibliothek, Budapest, Kartensammlung, Inv. Nr. TK 90.

Fuß hoher Gang führt. Der innere Raum hat eine Ausdehnung in der Richtung des Eingagnges von 12, darauf senkrecht von 16 Klaftern und 3 Füsse. Rechts vom Eingang ist eingezeichnet der Backofen, an der östlichen Wand der Herd, hinten, in der Mittellinie der Brunnen. An der westlichen Seite finden wir eine vermauerte Höhlung; das Pulver-Magazin. Der Boden der Höhle steigt nach hinten; nach der Beschreibung ist er sehr uneben. Im östlichen Profil ist auch ein Loch bezeichnet, woraus das Licht "in die Höhle fällt."[10]

An zwei anderen Blättern ähnelt der Grundirß an einen Rechteck mit abgerundeten Ecken. Die Einteilung des Raumes weicht auch vollständig von den obigen ab. Es befindet sich kein Eintrittsgang und an der westlichen Seite auch keine kleine Höhlung. Doch der große Raum wird durch Mauern geteilt. Die Tür des vermauerten Einganges öffnet in den "Vorkeller". Links von diesem, in einem "Zimmer" finden wir den Herd. Zu diesem schließt sich das "Gewölb", das heißt das Proviantenmagazin. Links hinten befindet sich das weite Pulvermagazin, rechts, direkt hinter dem "Vorkeller" ist der Backofen. Im mittleren Raum, entlang der Wände und in der Mitte sind Pritsche für 250

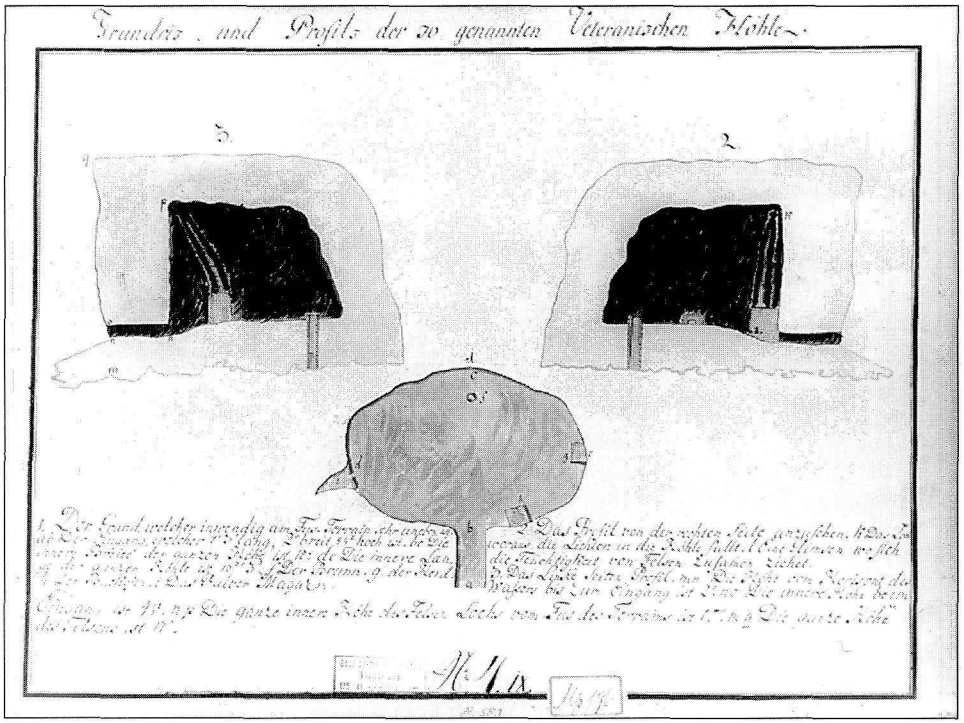


Abb. 4: Grundriß und Profile der Veterani-Höhle. Anonymen Karte, nach 1789. Széchényi Nationalbibliothek, Budapest, Kartensammlung, Inv. Nr. TK 134.

Mann eingezeichnet. Übrigens ist die Höhle für die Beherbergung von 500 Mann geeignet. Auch eine Abweichung vom vorigen Grundriß ist, daß der Brunnen liegt nicht in der Mittellinie. Im Profilschnitt ist der Boden in einem Abschnitt steigend (doch hinten senkend) abgebildet. Die Höhe ist nur ein sechstel der Tiefe, was höchstens 3 und ein halb Klafter bedeuten möchte.[11]

Es gibt auch eine andere Variante dieses Grundrißes. Sie weicht nur damit vom vorigen ab, daß sie ist weniger Rechteckförmig und ihre größte Tiefe befindet sich nicht an der linken, sondern an der rechten Seite, ihr Boden ist völlig glatt und der Plafon senkt gleichmäßig nach hinten.[12]

Es ist nicht bekannt, wann wurden diese Abbildungen gezeichnet; vor oder nach der Schlacht von 1788. Jahreszahl eins ausgenommen[13] - 1805 - befindet sich an keinem; der Name des Zeichners ist auch nur an manchen zu finden. Da an vielen Exemplaren sind die Stellungen der Truppen aufgezeichnet und vom Ablauf der Kämpfe gibt es auch Beschreibungen, sind - mindestens diese - unbedingt nachträglich verfertigt. Doch die Abbildung des Geländes, soauch die Tatsache, daß zur ersten Variante des Grundrißes und Profile sind auch Maße angegeben, läßt darauf hinweisen, daß das Gelände und die Höhle

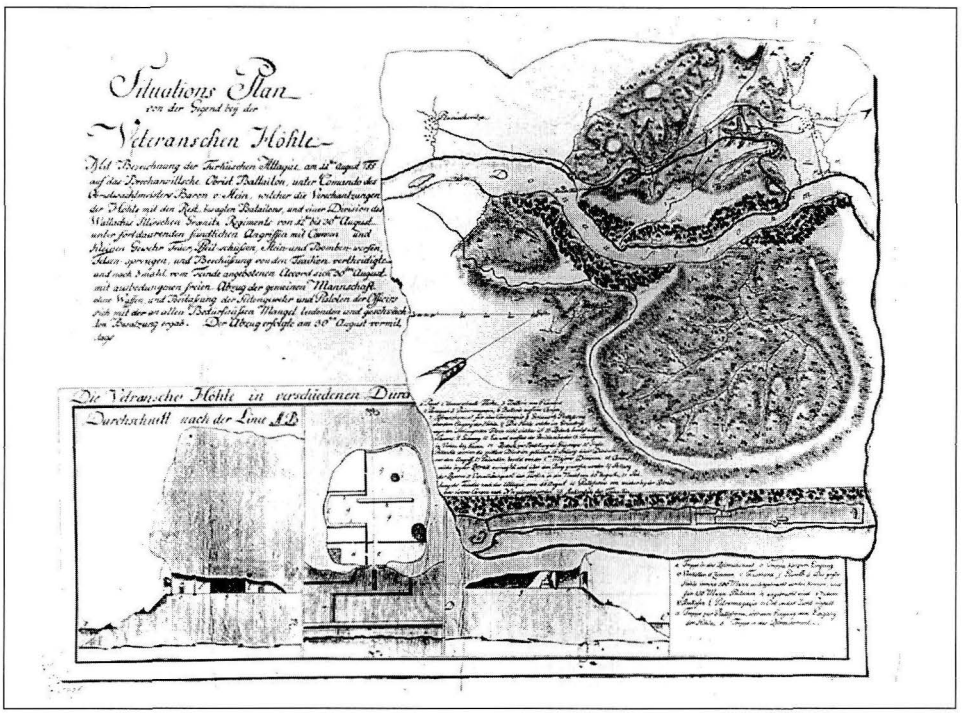


Abb. 5: "Situations Plan von der Gegend bey der Veteranschen-Höhle". Anonyme Karte, nach 1789. Kriegsarchiv, Wien, Inv. Nr. H. III. e. 2953-I.

wurden noch vor der Belagerung aufgemessen und die Zeichnungen wurden aufgrund dieser hergestellt.

Es ist merkwürdig, daß bis die erste Variante bildet die Höhle als von einem einzigen weiten Raum bestehend ab, die zwei anderen schon mit Wänden aufgeteilt. Man könnte vorstellen, daß da die Türken zogen bald vom linken Ufer der Donau zurück, waren diese Abbildungen Pläne für eine neue Ausbildung der Höhle zu ein Fort. Die Ausbreitung des Einganges könnte auch damit in Zusammenhang sein. Vielleicht die Ansichten des vermauerten Einganges[14] dienten auch nur als Pläne. Daß diese später verwirlicht wurden - ist uns augenblicklich nicht bekannt.

Doch entweder wurden die Abbildungen vor, oder nach der Belagerung hergestellt, gehören sie auf jede weise unter den ältesten Höhlenkarten des Karpatenbeckens; die mit den Kämpfen von 1692 in Zusammenhang stehende ist sogar vielleicht die älteste. Doch ob Wände in Innerem der Höhle wirklich errichtet wurden, können wir heute schon nicht entscheiden. Der Eingang der Höhle war nur mit 2 Klafternhöher als der Wasserspiegel zur Zeit der Aufmessung, so ist sie wegen dem Bau des Staudammes am Eisernen Tor unter Wasser gekommen.

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UPODOBITVE JAME "VETERANI" IZ 17. IN 18. STOLETJA

Povzetek

Prispevek govori o zemljevidih in drugih upodobitvah jame Pescabara (Veterani) iz 17. in 18. stol. Jama leži na levem bregu Donave v bližini Železnih vrat (Kazan, 22 km jugozahodno od Orsove). V času "turških vojn" 1692, ko so Turki pripravljali protinapad, je general Veterani v jami namestil 300 mož s petimi topovi. Turki so jih oblegali, dokler se niso predali. 1788, je zopet izbruhnila vojna in cesarskim četam je osebno poveljeval cesar Jožef II. Tudi tokrat je bila jama pomembno stražarsko mesto, varovana s tremi oddelki pehote in artilerijskim regimentom in posebej urejena ter utrjena, vključno s posebej obzidanim skladiščem za smodnik. Turki so jamo oblegali z ladjami in veliko premočjo v četah. Cesarski so se tri tedne branili globlje v jami, 400 jih je padlo, nato pa vdali.

Zaradi teh dogodkov je jama pogosto označena na takratnih zemljevidih in panoramah (iz Budimpešte so znani 3, z Dunaja pa 20 dokumentov) in prikazana z najrazličnejših vidikov, vključno z jamskimi načrti.

Ker je bila jama prvotno le 2 sežnja nad vodo, je danes pod vodno gladino akumulacijskega jezera.

ACTA CARSOLOGICA	XXVI/2	16	159-166	LJUBLJANA 1997

DIE ERGEBNISSE DER ARCHÄOLOGISCHEN HÖHLENFORSCHUNGEN IN UNGARN

REZULTATI ARHEOLOŠKIH RAZISKAV V JAMAH NA MADŽARSKEM

PÁL PATAY [1]

Izvleček UDK 903.3(439)

Pal Patay: Rezultati arheoloških raziskav v jamah na Madžarskem

Na Madžarskem so pričeli z arheološkimi izkopavanji v jamah v 70-tih letih prejšnjega stoletja. Pozitivni rezultati izkopavanj O. Kadiča 1906 v jami Szeleta, so bili vzpodbuda nadaljnjim izkopavanjem, ki niso bila prekinjena niti med I. Svetovno vojno. Najdbam iz mlajšega paleolitika so sledila odkritja neolitika, bakrene in mlajše bronaste dobe. Zelo pomembne so bile raziskave 1932 v jami Subalyuk, kjer so poleg srednjepaleolitskih artefaktov naleteli tudi na kosti neandertalskega človeka. Naloga sedanjih raziskav je odkrivati in raziskovati nove jame ter na novo ovrednotiti starejše najdbe.
Ključne besede: arheologija, speleologija, jamske najdbe, paleolit, neolit, Madžarska.

Abstract UDC 903.3(439)

Pal Patay: The results of archaeological investigation in the caves of Hungary

Archaeological investigations of Hungarian caves began in the seventieth years of the last century. O. Kadič's success in the cave of Szeleta from 1906 was the impulse to continue the investigations which did not stop even between the 1st World War. The remains of the younger Palaeolithic were followed by those of Neolithic, Copper Age and younger Bronze Age. The investigations of the cave Subalyuk in 1932 were specialy important, because besides the artifacts from the middle Paleolithic also the bones of the Neanderthal man were found. The tasks of recent investigations is to find and to explore new caves and to evaluated anew the older findings.
Key words: archaeology, speleology, cave findings, Palaeolithic, Neolithic, Hungary.

[1] Rákóczi út 19, HU - 1088 BUDAPEST, HUNGARY

Die archäologische Höhlenforschungen kamen in Ungarn als Folge den erfolgreichen westeuropäischen in den 70-er Jahren des vorigen Jahrhunderts in Gang. Die ersten Ausgrabungen fanden in den verschiedenen Teilen das dameligen Ungarns statt. Unter ihnen zählen auch diejenige von Zsófia Torma, über denen wir, gemeinsam mit Kinga Székely an der Tagung ALCADI '92 in Budapest ein Referat gaben.[1] Diese Forschungen befanden sich aber im Areal der heutigen Slowakei und Siebenbürgen und nur eine einzige in dem von heutigen Ungarn, namentlich in der Baradla-Höhle von Aggtelek.

Hier führte Baron Jenő Nyáry am 24-26 August 1876, mit 60 Arbeitern eine Ausgrabung. Im Laufe dieser wurden auch 27 Skelette aufgedeckt. Über dieser Forschung gab er schon 16 Tage später, am VIII. Internationalen Anthropologischen und Archäologischen Kongress in Budapest einen Bericht.[2] Die Ausgrabung setzte er noch zweimal fort und 1881 gab er die Ergebnisse in einer Monographie bekannt.[3] Es ist anerkennungswürdig, daß er ließ die Funde durch in der Anthropologie, Zoologie und Botanik hervorragende Fachleute untersuchen, doch infolge seiner genaue Beobachtungen und Angaben entbehrenden Bes hreibungen hat seine Arbeit heutzutag nur noch einen forschungsgeschichtlichen Wert.

Da weder in Aggtelek, noch in anderen Höhlen wurden paläolothische Funde gefunden, bzw. wo - wie es sich nachträglich herausstellte - solche vorkamen (wie z. B. in der Großen Höhle von Oruzsin - Ružin, Slowakei), erkannten die zeitgenossische Geologen den pleistocänen Alter der die Funde liefernden Schicht nicht, sogar sie verneinten während langer Zeit, daß in Ungarn der Nachlaß des diluvialen Menschen zu finden wäre. So - man kann sagen - höhrten die archäologischen Höhlenforschungen auf.

Diese Untätigkeit dauerte bis dan Anfang von unserem Jahrhundert. Es ist merkwürdig, daß ein Freilandsfund gab den Impuls zur Neubeginnung der Höhlenforschungen. Zwei in Miskolc, am Fuß des Bükk-Gebirges gefundene Steinartefakte wurden durch unseren letzten Polihistor, Ottó Herman als diluvial-altrig anerkannt. Mit unverbrüchlicher Ausdauer erreichte er, daß fachmäßige Forschungen wurden in den Höhlen des Bükk-Gebirges begonnen. Die Durch Ottokár Kadić 1907 durchgeführte Ausgrabung in der Szeleta-Höhle führte zu unerwarteten positiven Erfolg. Infolge diesem setzten sich die Arbeiten unter seiner Leitung, später auch unter dieser von Jenő Hillebrand jährlich fort, zu denen sich aber auch andere Forscher, z. B. Tivadar Kormos anschalteten. Sogar der erste Weltkrieg machte diesen Forschungen kein Ende. Das war die Blütezeit der ungarischen archäologischen Höhlenforschung.

Aufgrund der in der Szeleta-Höhle erreichten Ergebnisse dehnten sich die Forschungan überwiegend nur auf die Höhlen des Bükkgebirges aus. In beinahe sämtlichen größeren, oder leicht erreichbaren Höhlen, wie die Balla-, Istállóskő-, Peskő-, Büdöspest-Höhle usw. fanden Ausgrabungen statt. Doch nach einigen Jahren wurden solche auch in den Bergen am Donauknie (z. B. Kiskevély-, Jankovich-Höhle, Felsnische von Pilisszántó) durchgeführt. Obwohl

zahlreiche höhlenführende Gebirge befandesn sich im vorkriegszeitlichen Ungarn, die in der heutigen Slowakei und in Siebengürgen liegenden waren durch den Forschern nur hie und da aufgesucht.

Über die Ergebnisse der Ausgrabungen gaben die Forscher ständig Berichte. Bei der Auswertung der Funde nahmen sie die Resultete der französischen Forschung an und verwendeten auch die Terminologie dieser für die heimischen Funde. Aufgrund dieser meinten sie den Nachlaß des Solutréens, Aurignaciens und Magdaleniens zu erkennen. Doch sie stellten schon fest, daß im Bükk-Gebirge wurde das Hochsolutréen durch ein eigenartiges Protosolutréen vorangegangen.

Im Laufe dieser Forschungen kamen auch Funde aus Holocän-Schichten zum Forschein - im Bükk-Gebirge besonders neolithische - doch im Schatten der Paläolithen legte man weniger Gewicht auf sie.

Wegen der schweren wirtschaftlichen Lage des Landes nach dem ersten Weltkrieg setzten sich die archäologischer. Höhlenforschungen nur in der Mitte der zwanziger Jahren fort. Kadić und Hillebrand suchten vorwiegend die schon bekannten Höhlen mehrmals auf. Zu diesen Arbeiten schaltete sich auch Andor Saád, Arzt in Miskolc, zu.

Unter den neu begonnenen Ausgrabungen war diese der Subalyuk-Höhle im Jahre 1932 von großer Bedeutung. Hier kamen zum ersten Mal ohne Zweifel zum Mousterien gehörige Funde zum Vorschein. Ja sogar Knochenreste einer erwachsenen Frau und eines etwa dreijährigen Kindes des Homo Neandertaliensis kamen aus der oberen Schicht des Mousteriens ans Tageslicht.[4]

Größere Arbeit fand auch 1934-37 unter der Leitung von István Gaál in der Szelim-Höhle statt. Doch nehen diesen besuchten Ottokár Kadić und Mária Mottl im Laufe der dreiziger Jahren mit großer Intensität zahlreiche Höhlen, die aber keine besondere Ergebnisse leisteten.

In den dreiziger Jahren sahen die laitende Forscher - Kadić und Hillebrand - die Zeit ankommend um die Ergebnisse der Forschungen monographisch zusammen zu fassen.[5] Doch ihre chronologische und kulturelle Festlegungen deckten sich nicht in jeden Fällen. Hillebrand hat schon z. B. bemerkt, daß die Entwicklung des heimischen Solutréens ist unabhängig von dem französischen. Unseres "Protosolutréen" geht dem echten französischen Solutréen voran, ist sogar mit dem Aurignacien gleichzeitig. Er hat auch erkannt, daß unseres, bis an der Zeit ins Magdalenien eingereihte Funde sind auch nicht völlig glech mit dem französischen.

Nach dem zweiten Weltkrieg übernahm eine neue Forschergarde - vor allem László Vértes, dann Miklós Gábori, bzw. Vera Gábori-Csánk, in den letzten Jahrzehnten Viola Dobosi - mit großen Fleiß und Begeisterung die Aufgaben der Paläolithforschung, soauch natürlich auch der Höhlenforschung. In zahlreichen, früher noch nicht erforschten Höhlen wurden durch ihnen Ausgrabungen durchgeführt, doch in manchen Fällen suchten sie auch einige, durch die Fachliteratur schon wohlbekannte auf. Von diesen sind die Grabungen der

Lambrecht-, Hillebrand-, Istállóskő-Höhlen und der in der Gemarkung der Stadt Budapest sich befindliche Obere-Remete- (Eremiten-) Höhle die bedeutendsten.

Die Funde der Lambrecht-Höhle kann man auf faunistischem Grund in die zweite Helfte des Riss-Würm Interglacials, nach ihrem Charakter in ein kiesbearbeitendes frühes Mittelpeläolithikum einreihen.[6] An den Wänden der Hillebrand-Höhle, dessen Öffnung war seit dem Neolithikum verstopft, waren Kratzer zu beobachten. Doch nach den vergleichenden Untersuchungen von László Vértes waren es nicht Spuren der Höhlenbären, sondern von Menschen.[7]

In der Istállóskő-Höhle deckte László Vértes eine, bei den vorigen Forschungen noch nicht bekannt gewordene, reiche Knochenwaffen und Geräte liefernde Schicht des Aurignaciens auf.[8] In der Oberen-Remete-Höhle fand Vera Gábori-Csánk in einer, vor dem Höhepunkt der Würm I. Glacialperiode stammende Schicht drei Zähne, und zwar den I_1, I_2 und C von dem rechten Unterkiefer eines Homo Neandertaliensis.[9]

Die neue Forschergarde - vor allem László Vértes - legte die Forschung auf neue Gründe, indem er - neben den typologischen, faunistichen und floristischen Angaben - auch die Ergebnisse verschiedener physikalischer und chemischer Sedimentuntersuchungen der, die Höhle ausfüllenden Schichten, soauch matematisch-statistischer Rechnungen mit Erfolg anwendte. Er hat auch die Ergebnisse der ersten zwanzig Nachkriegsjahren - drei Jahre vor seinem Tod, d. h. 1965 - in einer handbuchartigen Arbeit zusammengefaßt.[10] Hier hat er auch die naturwissenschaftlichen und archäologischen Angaben der einzelnen Höhlen ausführlich und systematisch aufgezählt. Einige zusammenfassende Berichte wurden auch durch Miklós Gábori hergestellt.[11]

In den letzten Jahrzehnten ist die Tätigkeit der Höhlenforscher-Archäologen ziemlich beschränkt geworden, da es gibt schon kaum Höhlen, in denen keine Ausgrabung durchgeführt wurde. So man kann aus den Höhlen keine neue bedeutende Ergebnisse erwarten. Deswegen befassen sich die Forscher einerseits mit der Revision und Neuauswertung der Ergebnisse der alten Ausgrabungen, andererseits legten sie den Schwerpunkt der Paläolithforschung auf die Freiland-Fundstellen über.

Aufgrund der Ergebnisse der Freiland- und der Höhlenforschungen haben unsere Forscher erkannt, daß das Paläolithikum des Karpatenbeckens ist nicht gleich mit dem französischen. Hier kann das Schema folgend zusammengefasst sein:

Unter den Höhlenfunden ist die älteste eine kiesbearbeitende frühmittelpaläolithische Kultur; sie ist am charakteristischesten in der Lambrecht-Höhle representiert.

Das Mousterien kennen wir schon aus mohreren Fundstellen. Sein charakteristischer Fundort ist die Subalyuk-Höhle, mit ihre zwei, sich schart trennende Schichten, derem Material - zumindest laut Zsolt Mester - zeigt keine

genetische Beziehungen zwischen ihnen.[12] Übrigens das Monsterien der Höhlen des Bükk-Gebirges und das Mittelpaläolithikum der Fundstellen von Westungarn weicht teilweise von einander ab.

Der Unterschied der zwei Regionen erscheint auch während dem oberen Paläolithikum. An der östlichen Seite des Bükk-Gebirges (z. B. Szeleta-Höhle) ist sein erster Abschnitt das Szeletien, dessen ältere Phase (früher Protosolutréen benannt) weist mousteroide Züge auf. Deswegen betrachten es manche Forscher noch zum Mittelpaläolithikum gehörig. Es wurde aber erkannt, daß zu selber Zeit lebten in den westlich liegenden Höhéen des selben Gebirges (z. B. Istállóskő-Höhle) Leute des Aurignacien, die aber genetisch und kulturel waren überhaupt nicht mit den Szeletien-Menschen in Beziehung. Die Funde der Donauknie-Berge (z. B. Jankovich-Höhle) die ebenso Bifazial-Spitzen aufweisen, sind doch nicht identisch mit dem Szeletien; sie werden mit den Namen Jankovichien benannt.

Durch den Neuauswertungen wurde auch bekannt, daß die früher als Magdalenien bezeichnete Funde (z. B. Kiskevély-Höhle) stellen eigentlich eine Variante des Gravettiens dar. Es war aber auch zu beobachten, daß dieses Gravettien lebte bis in die Postglacial-Periode (z. B. Felsnische von Pilisszántó). Diese wurde durch László Vértes Pilisszántoien ermannt.

Das Mezolithikum ist in unseren Land besonders ärmlich. Aus Höhlen kam vielleicht nur in der Remete-Höhle eine einzige Obsidian-Klinge zum Vorschein, die nach stratigraphischen Angaben hierher zu reihen ist.

Die Holocän-Ablagerungen der Höhlen lieferten auch in größerer Menge archäologische Funde. Sogar man kann sagen, daß sie durch den Menschen bis den Mittelalter stetig aufgesucht wurden; doch nicht mit gleicher Intensität in jedem Zeitalter. Die Aggteleker Höhle, zu der die Archäologen beinahe in jedem Jahrzehnt zurückkehrten, soauch die Höhlen des Bükk-Gebirges sind reich an neolithischen Funden. Aufgrund dieser gab Ferenc Tompa, der, für diese Gegend charakteristische jungsteinzeitliche Kultur den Namen Bükkar-Kultur. Übrigens deckte er in Aggtelek einen Opferplatz dieser Kultur auf.[13] Ein ähnliches Objekt beobachtete man auch in der Hillebrand-Höhle.[14] Doch in diesen beiden Höhlen waren auch im Boden zahlreiche Pfostenlöcher eingetieft, aus denen die Forscher - so Sándor Gallus, wie József Korek - darauf folgerten, daß die neolithische Bewohner haben sich gegen das abtropfende Wasser durch Errichten von Hütten geschützt.[15]

Währen der Hochkupferzeit waren besonders die Höhlen im Donauknie durch das Volk der Ludanice-Kultur bewohnt.

Ein mittelbronzezeitlicher Gold-, Bronze- und Bernstein-Schmucksachen, bronzenen Beil und Rohmaterial enthältender Varwahrfund kam in der Oberen-Remete-Höhle zum Vorschein.[16]

Die Höhlen des Bükk-Gebirges, soauch diejanige von Aggtelek sind auch reich an Funden der spätbronzezeitlichen Kyjatice-Kultur. In der letzteren fand Ferenc Tompa 1927 einen aus bronzenen Waffen und Schmucksachen zusam-

mengestellten Verwahrfund, ja sogar einen anderen aus goldenen Ringe und Drähte von einem Gesamtgewicht von 140,83 Gramm.[17] Er deckte auch ein gleichzeitiges Skelett auf. Aufgrund dessen ist es glaubhaft, daß die durch Jenő Nyáry ausgegrabene Skelette stammen auch aus der Spätbronzezeit.

Merkwürdigerweise fahlen völkerwanderungszeitliche Funde in den Höhlen. Dementgegen hochmittelalterliche sind schon - doch nicht zahlreich - zu finden. Doch in der Szelim-Höhle deckte István Gaál 102 Skelette auf, die - aufgrund einer Münze und Schmucksachen - aus dem 11-13. Jahrhundert stannen.[18]

Als Sonderbares erwähnen wir, daß Laut den Funden wurde in 15. Jahrhundert in der Legény- (Burschen-) Höhle im Donauknie-Gebirge Falschmünzerei geübt.[19]

Leider es befinden sich in Ungarn relativ wenige Höhlen. Infolge der intensiven Forschungen kann die Zahl der noch umbekannten Höhlen gering sein. Unter den bekannten gibt es vielleicht keine einzige in der keine archäologische Aufschließung durchgeführt wurde. Ja sogar ein Großteil dieser ist schon beinahe fast erschöpft. So gibt es eigentlich für die zukünftige Forschung im Gelände - ausgenommen von Neuentdeckungen in glücklichen Fällen noch intakter Höhlen - nur eingeschränkte Möglichkeiten.

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REZULTATI ARHEOLOŠKIH RAZISKAV V JAMAH NA MADŽARSKEM

Povzetek

Sledeč zgledu raziskav po Zahodni Evropi, so na Madžarskem pričeli izkopavati v jamah v 70-tih letih prejšnjega stoletja. Dolgoročni cilj in želja strokovnjakov, ki so se lotili teh raziskav, je bil dokazati, da je pleistocenski človek živel tudi v karpatskem bazenu. Pozitivni rezultati izkopavanj O. Kadiča 1906 v jami Szeleta, so bili močna vzpodbuda nadaljnjim izkopavanjem, ki niso bila prekinjena niti med I. Svetovno vojno. Najdbam izmlajšega paleolitika so sledila odkritja neolitika, bakrene in mlajše bronaste dobe.

Zelo pomembne so bile raziskave 1932 v jami Subalyuk, kjer so poleg srednjepaleolitskih artefaktov naleteli tudi na kosti neandertalskega človeka.

Ker so bila v najpomembnejših madžarskih jamah izkopavanja opravljena že pred II. Svetovno vojno, je naloga zadnjih desetletij po eni strani odkrivati in raziskovati nove jame, po drugi strani pa na novo ovrednotiti starejše najdbe. Jamske raztiskave naj bi tudi osvetlile bivalno okolje neolitskega človeka.

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A.C. MORLOT, A GEOLOGIST AND A LESS KNOWN RESEARCHER OF KARST PHENOMENA

GEOLOG A.C. MORLOT, MANJ POZNANI RAZISKOVALEC KRAŠKIH POJAVOV

RAJKO PAVLOVEC [1]

Izvleček UDK 551.44:929 Morlot A.C.

Rajko Pavlovec: Geolog A.C. Morlot, manj poznani raziskovalec kraških pojavov

A. C. Morlot (1820 - 1867) je raziskoval Istro in sosednje Zunanje Dinaride. V svojih delih omenja tudi kraške pojave. Skušal je pojasniti njihov nastanek, vendar njegove razlage niso vedno pravilne. Vseeno pa lahko štejemo Morlota za zanimivega raziskovalca krasa, še posebej, če upoštevamo, da je pisal sredi 19. stol.

Ključne besede: geologija, krasoslovje, zgodovina krasoslovja, Slovenija, Kras, Morlot A. C.

Abstract UDC 551.44:929 Morlot A.C.

Rajko Pavlovec: A.C. Morlot, a geologist and a less known researcher of karst phenomena

A. C. Morlot (1820 - 1867) was researching Istria and the neighbouring parts of the External Dinarids in adition to other areas. Besides other geological data he also mentioned karst phenomena in his publications. He tried to establish the origin of various forms, but his explanations were not always correct. However, Morlot can be regarded as an interesting researcher of Karst, especially bearing in mind that he wrote in the middle of the 19th century.

Key words: geology, karstology, history of karstology, Slovenia, Kras, Morlot A. C.

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Adolphe Charles Morlot was born on 22nd March, 1820 in Napoli and died on 10th February, 1867 in Lausanne at the age of only 47. Taking a look at both years we can see that in the year 1995, 175 years have passed since his birth and, in the year 1997, 130 years will have passed since his death. Morlot studied mathematic and and geology in Paris, Freiberg and Bern. In the year 1846 he joined the researching activities of our countries. At that time (1843) "Der geognostisch-montanistische Verein für Innerösterreich, das Land ob der Enns und das Königreich Ilyrien" was founded. Morlot was a busy researcher, especially at fieldwork. This was as well pointed out in the year 1867 by Dr. Franz Hauer, the manager of the geological institute in Vienna. According to his words Morlot was working at the field during the summer, and in the winter he was handling the material; he was hard-working and full of energy.

Morlot's field of research was very wide. He was interested in petrology and ore deposits, and he observed Pleistocene sediments. In the field of regional geology he took part in the geological mapping of East Alps, Styria and Illyria.

ABOUT THE KARST

In 1848 Morlot published his most important work regarding the External Dinarids (1848-a). In the same work he mentioned karst phenomena. In a special publication from the year 1848 Morlot describes the Lobodnica cave (Trebichgrotte; 1848-b). Morlot characterizes the Karst landscape as a limestone region with waste, stony and eroded ground. It would be quite interesting to establish whether Morlot himself created the incorrect explanation of the word karst. He thus presumed that the word derived from the Slovenian word "hrast" (*Quercus*), meaning oak. He wrote that the country was once overgrown with oaks, but there was only a treeless surface in his days. The word karst in fact derives from the word "carra", which means stone (Gams 1974).

Besides, Morlot describes stalactites, whereby all kinds of stalactites and stalagmites are meant. According to his opinion the stalactites in the so called "great caves" appeared in the "younger period" and are growing very slowly at present. According to his deductions the majority of karst phenomena appeared in the Pleistocene, which does not coincide with present opinion.

Although Morlot made a vivid description of karst phenomena it was not he who found that limestone country was full of caves. He stated that limestone countries were so porous that no drop of water could stay there. According to his opinion such a country was similar to a great porous sponge. Morlot mentioned various caves, as for example the caves of Škocjan (Škocjanske jame), Lobodnica (Trebichgrotte), the caves in the neighbourhood of Opčine (Opicina) and Bazovica (Basovizza) near Trieste, the Postojna cave, the Cerknica polje (Cerkniško polje) and others. Morlot spent quite a lot of time on some of them. He seemed to be fascinated by the research activities in

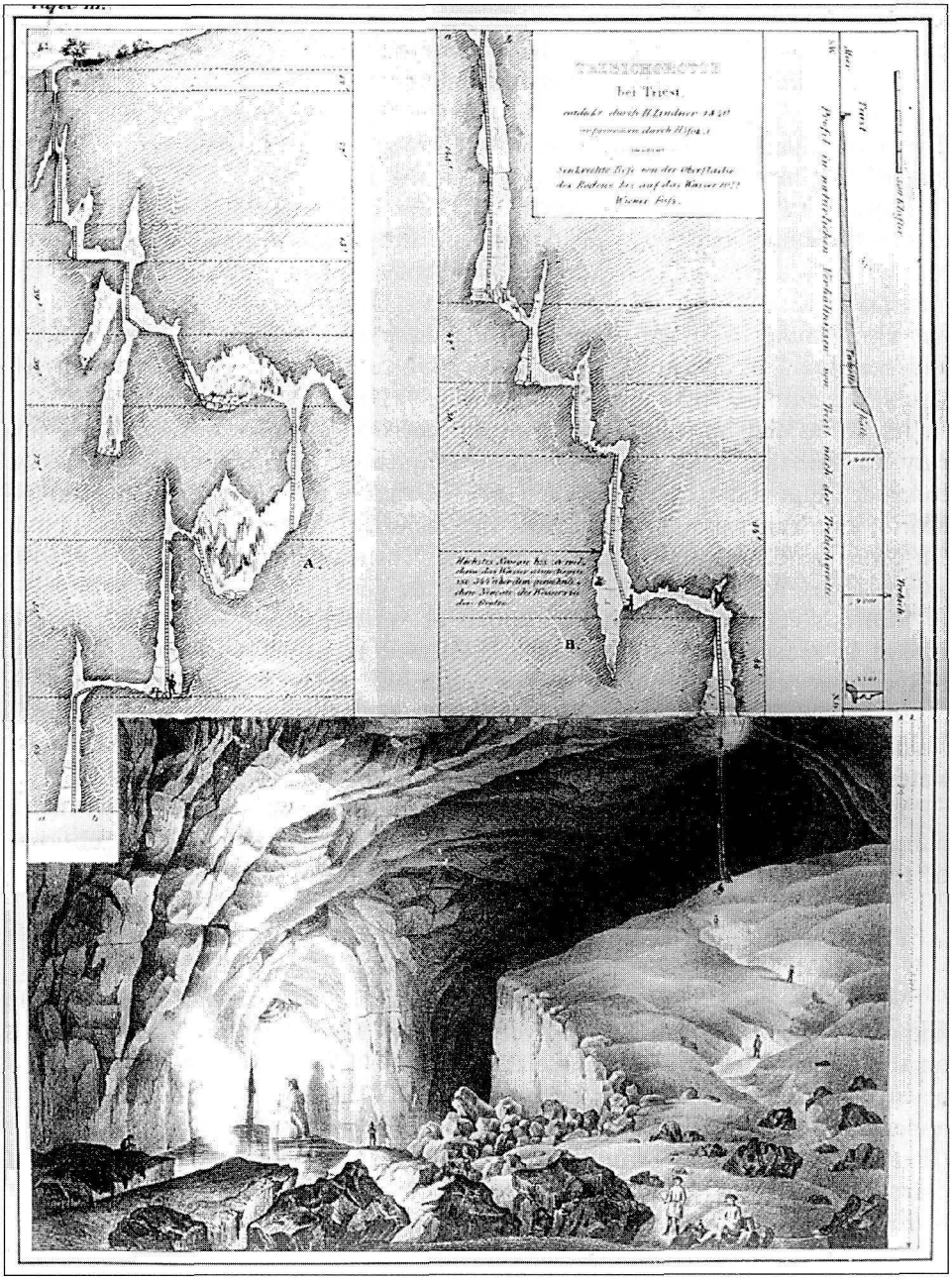


Fig. 1: "Tafel III" of Morlot's work "Über die geologischen Verhältnisse von Istrien mit Berücksichtigung Dalmatiens und der angrenzender Gegenden Croatiens, Unterkrains und des Görzer Kreises" (1848) showing Trebich Grotte (Labodnica).

Lobodnica (Morlot 1848-a, b) which was carefully measured by Sforzi, an engineer from Trieste. The cave was discovered in the year 1840, which is the almost the time when Morlot was researching these places. At that time they were searching for water to supply Trieste. As water rose at some places during the rainy weather and there was a strong current of air flowing through the cracks, they expected to find water in the underground.

Morlot was thinking about karst caves. He observed some of the approximately horizontal ones, that divide and are irregularly shaped. As an example Morlot mentioned the Postojna cave. He knew the Pivka river that vanished into the cave and appears after one hour as Unica in The Planina cave. He was also familiar with the Reka river that disappears into the caves of Škocjan and reappears at Devin (Duino). He explained that the impermeable flysch layers prevent the Reka river from flowing faster into the sea.

As far as the horizontal caves are concerned, Morlot states that they are easy to research and therefore most frequently visited. Hence, we could conclude, that most caves in Karst are of that type. However, according to Morlot one can easily find out how the majority of caves extend into depth. He gives some examples with their depths. Most probably Morlot did not visit all the caves, for many times he states that he got the data "by oral tradition".

Morlot's consideration about inclined or vertical caves, respectively, which should in most cases extend into sack-formed tubes, is very interesting. He belived that mechanical action without chemical processes could not form the caves. According to his explanations the caves are supposed to appear in a similar way as "iron ore deposits" in karst regions, where "acid mineral waters" were present.

Morlot has correctly explained the origin of karst sinkholes, which he named "die Dollinen". He belived that they had appeared due to the subsiding of the roof in the caves.

TERRA ROSSA AND BAUXITE

Morlot speaks about iron oxide that makes the surface red. Therefore he knows the red Istria (Istria rossa) very well and states that the colour depends on the fundamental rocks, because they can always be found on limestone and never on flysch. Consequently he named flysch "Tasello". Morlot compares the appearance of the red weathered soil with the appearance of brown iron oxide (that can be found in form of small grains in clay) and sediments in karst caves, where there is also a clay with brown iron ore. In the vicinity of Karojba in central Istria, Morlot found such formations at the edge of funnel-shaped holes which resemble caves that collapsed. According to Morlot's opinion they were once most probably filled with iron oxide. Bauxite deposits can in fact be found in the karst caves and gulfs near Karojba (Pavlovec 1995).

Already in Morlot's time many people were wondering how the enormous quantities of terra rossa in Dalmatia and Istria appeared. Morlot was obviously amazed at that, otherwise he would not have written this remark.

Sometimes Morlot most probably equated terra rossa or even bauxite with brown iron ore, but his explanation of its origin was not correct. To infer from his treatise, he obviously set his heart upon the explanation of Gressly's, describing similar phenomena in the Jura mountains. Supposedly the rising of mountains created cracks, which mineral waters enlarged into caves. The waters also brought clay and iron solutions.

LOWER AND UPPER KARST LIMESTONE (KARSTKALK)

Morlot introduced the term of lower or older karst limestone where the fossils can very rarely be found. It is light in colour, in most cases white, layered, not bituminous, and sometimes it sounds like glass or metal. On the other hand, Morlot describes fossils in that limestone. It was extracted in Roman quarries near Pula. There were many rudists in it that can also easily be found elsewhere. However, Morlot states that the limestones with the fossils differ from that without them. Most probably he classified the Cretaceous rudist limestones and Cretaceous limestones without rudists among the older karst limestones. There is coal in these beds near Lipica, at Vreme and in other parts. Morlot describes the older karst limestone as being corroded and bare. He did not know its thickness. Yet he stated that the entire Lobodnica cave (Trebichgrotte) is situated within this limestone with a thickness of 300 m.

Morlot called the upper karst limestone also the nummulite limestone. He states that the nummulite formation is spread from the Atlantic Ocean over the Pyrenees, the Alps, Turkey, Asia Minor, and Iran to the Himalayas. The rock forms thick beds, which are mostly compact, light limestone. When struck it smells like bitumen, falls into sharp pieces and very often it "sounds". Its surface is eroded and bare.

In addition to alveolinids and coal, Morlot mentions nummulites as a special characteristic of this limestone. This way we can conclude that Morlot joined all the Paleogene limestones, that is Kozina, miliolids and alveolina-nummulites limestones under the term upper karst limestone.

FOSSILS IN THE CAVES

Morlot did not miss out some of the fossil finds in the caves or karst shafts. He mentioned bone breccias from Roman quarries south from Pula, as well as from some other deposits. It is not quite clear whether Morlot had in mind bone breccias in fact, or whether he was thinking of some other deposits of Pleistocene mammals. He knew some bone breccias from Dalmatia, where they can be found in the cracks or open caves. The cement is red, and the

bones are broken into small pieces. Morlot states that there are mostly cervids with terrestrial and freshwater snails among the fossil finds. There are no marine fossils. Morlot based his statement on the fact that bone breccias have appeared in karst caves.

The almost forgotten data about The Pleistocene mammals from The Postojna cave are very interesting. In the year 1821 (J. Volpi) the finding of *Ursus spelaeus* was described and illustrated with good pictures. He then classified it to the *Palaeotherium* genus, but Morlot referred to it as *Ursus spelaeus*. As the cave bear was found among pieces of stalactites, Morlot inferred that the animal had fallen into the cave and had not been washed in.

CONCLUSION

Adolphe Charles Morlot was not an expressive researcher of karst. However, as a through and meticulous describer of geological and other phenomena, he met karst caves and other karst phenomena. He tried to explain them as much as possible — consistently with the opinions of the middle of the last century. Although Morlot did not make a great contribution to the field of karstology and speleology, he was one of the most interesting researchers during the time of the first serious attempts to get to know karst phenomena in our country.

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GEOLOG A.C. MORLOT, MANJ POZNANI RAZISKOVALEC KRAŠKIH POJAVOV

Povzetek

Adolphe Charles Morlot (Napoli 1820 — Lausanne 1867) je predvsem poznan po raznih področjih geologije, med drugim pleistocena, sedimentologije, petrologije, rudnih ležišč, regionalne geologije, manj na področju krasa. Raziskoval je tudi v Dinaridih, kjer ni šel mimo kraških pojavov.

Izvor besede kras si je Morlot napačno razlagal, češ da pride od hrasta, s katerim je bila poraščena ta pokrajina. Za kapnike je bil prepričan, da jih je večina pa tudi večina drugih kraških pojavov nastala v pleistocenu, danes jih nastaja malo. Morlot omenja vrsto kraških pojavov pri nas, med drugim Postojnsko jamo, Škocjanske jame, Lobodnico, jame v okolici Trsta, Cerkniško jezero in druge.

Morlot govori o horizontalnih jamah, vendar pravi, da so poševne oziroma vertikalne pogostejše. Sklepa tudi na to, da niso nastajale samo na mehanski, ampak tudi na kemični način. Nastanek jam vzporeja z nastankom rjavega železovca. Pri tem misli deloma tudi na jerovico, deloma na boksit, kjer naj bi povsod delovale kisle mineralne vode.

Morlot je uvedel izraza spodnji kraški apnenec, pri čemer misli predvsem na rudistni in druge kredne apnence, ter zgornji kraški apnenec, s čemer združuje paleogenske kozinske, miliolidne in alveolinsko-numulitne apnence. Vsi imajo zakraselo površino.

Morlot omenja kostne breče iz Istre in Dalmacije. Posebno zanimivi so podatki o odlično ohranjeni lobanji jamskega medveda iz Postojnske jame.

A.C. Morlot ni bil izraziti raziskovalec krasa. Kot vesten in dober opisovalec geoloških in drugih pojavov pa se je srečal s kraškimi jamami in drugimi kraškimi fenomeni. Kolikor je bilo mogoče, jih je skušal razložiti, seveda sredini prejšnjega stoletja primerno. Morlot na področju karstologije in speleologije ni prispeval velikega napredka, bil pa je eden zanimivejših raziskovalcev v času prvih resnejših korakov pri spoznavanju kraških pojavov pri nas.

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A HISTORICAL SIGNIFICANCE OF EGON PRETNER FOR BIOLOGY

ZGODOVINSKI POMEN EGONA PRETNERJA ZA BIOLOGIJO

TANJA PIPAN *[1]

Izvleček UDK 57(091):929 Pretner E.
Tanja Pipan: Zgodovinski pomen Egona Pretnerja za biologijo

Egon Pretner (1896-1982), čeprav samouk, je bil v mednarodnem merilu eden najboljših poznavalcev evropskega krasa in živali v kraških jamah, še posebej hroščev. Odkril je nad sto novih živalskih vrst (migetalkarjev, polžev, dvojenog in zlasti hroščev), preko 20 vrst pa se jih imenuje po njem. Obiskal je 1492 jam: 649 na Slovenskem, 773 v drugih deželah Balkana, 70 v drugih evropskih državah. Bil je neutrudljiv terenski delavec, slovenski in celotni balkanski kras, pa tudi kraške predele v sosednji Italiji in Avstriji, je poznal bolje kot kdorkoli. Napisal je nad 70 razprav in člankov v domačih in tujih znanstvenih revijah. Za opravljeno delo je prejel mnoga društvena priznanja in odlikovanja.
Ključne besede: zgodovina speleologije, biospeleologija, *Coleoptera,* Pretner E.

Abstract UDC 57(091):929 Pretner E.
Tanja Pipan: A historical significance of Egon Pretner for biology

On the international scale Egon Pretner (1896-1982), self-taught person, was one of the best authoritis of the European karst and animals in the caves, beetles in particular. He discovered more than hundred new animal species (ciliates, gastropods and arthropods, and notably the beetles), more than 20 species are named after him. He visited 1492 caves: 649 in Slovenia, 773 in other parts of Balkans and 70 in other European countries. He was a tireless expert in the field of knowing better than anybody the Slovene and Balkan karst and also karst regions in neighbouring countries of Italy and Austria. He published more than 70 papers and articles in Slovene and foreign scientific magazines. For his work he gained numerous awards and medals from learned societies.
Key words: history of speleology, biospeleology, *Coleoptera,* Pretner E.

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TO LIGHT UP LIFE IN DARKNESS

It is justified to call Postojnska jama "the cradle of biospeleology". In 1831 the cave guide Luka Čeč discovered on Calvary (Velika Gora) in Postojnska jama the first cave beetle *Leptodirus hochenwarti* (Schmidt 1831). By 1860 researchers discovered in Slovenia almost all the genera and most of the species of cave beetles. The studies of our cave fauna began anew in the beginning of the 20 th century when J. Müller was appointed professor at the grammarschool in Triest. Full of zeal he very systematically explored the caves in the Trieste karst, Istria and the Gorica karst. He educated a lot of entomologists, among others Egon Pretner who attended the grammarschool at this time. During field excursions he met many distinguished European scientists and he preserved these contacts during all the time of his research activity. Among the others they were: Fr. Blasich, O. Chenda, E. Gridelli, Vl. Kodrič, J. Krekich-Strassoldo, Ljudevit and Vladimir Kuščer, C. Lona, C. de Mayer, Carlo and his son Giorgio Ravasini, A. Schatzmayr, H. Springer and St. Gaberščik. E. Pretner also maintained friendly and professional contacts with the following experts: B. Drovenik (Ljubljana), Cl. Besuchet (Geneva), J.



Fig. 1: At the entrance of Jelenca jama (Kras), 13th November 1910. E. Pretner, 14 years old, is in the first plan, pulling the rope (photo Dr. Lennig).

Bole (Ljubljana), P. Brandmayr (Trieste), S. Brelih (Ljubljana), G. Castellini (Firenze), M. Seguin (France), B. Čurčić (Beograd), P. R. Deeleman (Holland), C. D. Deboutteville (France), G. Drioli (Trieste), D. Mihajlović (Valjevo), H. Frank (Laichingen), D. Godard (France), A. Gspan (Ljubljana), B. Hauser (Geneva), R. Husson (France), B. Jalzić (Zagreb), G. Karaman (Titograd), R. Mezzena (Trieste), S. Mikšić (Sarajevo), E. Pichl (Trieste), L. Quaia (Italy), I. Rakovec (Slovenia), F. Anelli (Italy), M. E. Schmidt (Austria), R. Seemann (Austria), J. M. Thiband (France), T. Tischler (Germany), M. Vachon (France).

An interesting story is told by B. Drovenik about cave beetle collecting at Dobrovlje. He was helped by Pretner who was the only one who succeeded in finding several specimens of the species *Anophthalmus erebus erebus* (Kraus), *A. schaumi knirschi* (Winkler) and *Aphaenopodius treulandi cephalotes* (Knirsch) although he used the same method as Drovenik and others. Before the last World War the beetles of Slovene caves were scientifically studied mostly by J. Müller, R. Jeannel and A. Winkler and after the war by E. Pretner. The interest of the Slovene biologists in cavernicolous fauna became very strong after the Second War. The biologists of Ljubljana University organised a series of excursions to the caves of former Yugoslavia and brought back very interesting material. By systematic researches they discovered new species and subspecies and got to know the geographical distribution of cave beetles. According to Pretner it is interesting zoogeographically that in the Dinaric part of Dolenjska the betle's species *Antisphodrus schreibersi* (Küster), and in the mountains between Postojna basin and the Notranjska Reka *Leptodirus* are not found, and that in some caves there live together two species of the genus *Bathyscimorphus* and two species of *Antisphodrus* (*A. cavicola* and *A. schreibersi*). Furthermore, "the centre of Carniola's fauna" is in fact located around Plitvice (Croatia) while almost all the genera described of Slovenia (*Leptodirus, Astagobius, Anophthalmus, Bathyscimorphus, Machaerites and Troglorrhynchus*) extend far to the south over the Slovene-Croatian border. In the years 1934-1938 Wolf's *Animalium Cavernarum Catalogus* was being published with a review of cave fauna, location of finding sites and references for each animal. In this voluminous work the cave fauna of Slovenia is included, studied minutely and in detail, mostly due to Pretner's research work and publications (Pretner 1974b).

Pretner's first published paper is "Neue Hydrophyliden aus dem örtlichen Mittelmeergebiet"; in 1930 two papers were published in Italian and the next year another three. However it was not until his undisturbed professional work in Postojna, that he could dedicate himself entirely to research (mostly to biospeleology and entomology) to such an extent that he became an expert in karst all over Yugoslavia and in particular on the underground fauna. Pretner also knew the karst landscapes elsewhere in Europe, in Italy, Austria, France, Romania, Bulgaria and so on, and he has taken part not only in all speleological congresses in Yugoslavia but also in numerous international congresses

where he usually presented an interesting and fundamental communication. Thus he found at home and abroad a large number of followers (Pirjevec - Rebula 1986).

Pretner's researches in the fauna of Postojnska jama were extremely extensive. He introduced the scientific importance of the Postojna area as a centre of the classical karst. Many are grateful for his professional list of the underground animals that lived, and unfortunately only partially live still in Postojnska jama (Annex 1).

In the years 1970-1975 many reported about cave beetles appearing outside caves. Also in northern Italy and in Yugoslavia they appeared provided that the conditions of low temperature and high humidity were fulfilled. Due to this reason the abundance of beetles in some caves is smaller than under stones and rocks deeply buried in forest soil or higher in the mountains, close to the snow. In a special treatise E. Pretner explained this confusing phenomenon: "Primary habitat of cave beetles is fissures within the karst massif. From these cracks the animals migrate into the caves and thus the caves may be considered as their secondary habitat. To some extent some species may be found below rocks and stones but only in the period from autumn to spring, while they disappear during warmer seasons into cooler and more humid lower layers. Due to microclimate changes from cave to cave some species may be found at the entrance and other, deeper inside. The presence of animals is controlled by local temperature and humidity. Microclimatic conditions define whether the cave beetles are inside or outside the cave" (Pretner 1977a).

The fissures underground are a true living habitat of the underground fauna and from them they come into accessible caves or artificial channels. Abandoned mine passages, catacombs and artificial underground cavities of any kind offer a habitat to the underground fauna and E. Pretner (1979) pointed out that their importance must not be neglected as the fauna is there extremely rich. The underground organisms find much more stable living conditions within the fissures than are provided in large passages of the caves. E. Pretner composed a finding site list of underground coleopterological fauna in artificial caverns of Slovenia, Croatia, Austria, France and Italy (Annex 2).

When E. Pretner retired he deciphered the notes of L. Weirather relating to finding sites of cave beetles and prepared for the Natural Science Museum, Geneva, a 155 page study "Die Verdienste Leon Weiraths um die Biospäleologie, insbesondere Jugoslawiens, sein Höhlenkataster und seine Sammelplätze". L. Weirather was a famous biospeleologist who marked the finding sites of cave beetles by a number in his own cave register and by a false name of a cave or a region where the cave lies. By such a mode he protected himself against the concurrence although he disclosed to his friends, E. Pretner among them, the real name of a cave. The Natural Science Museum bought Weirather's collection of beetles together with all the notes and remarks which E. Pretner that he deciphered and studied from the German shorthand. He also

elaborated the manuscript "Travunia" of K. Absolon about the underground beetles of Bosnia and Hercegovina and succeeded in determining the location and names of almost all the finding sites cited by Absolon (Letopis SAZU 1975; Pretner 1974a).

A CHRONOLOGICAL REVIEW OF EGON PRETNER'S RESEARCH WORK FROM 1949 TO 1979

In 1949 Pretner published a newly discovered finding site of a species *Anophthalmus egonis* J. Müller. This species was then known only from the cave Pesjakov Buden, on the northern Pokljuka slopes; however he later found more than eight different caves containing this species. He discovered a new species *Anophthalmus besnicensis* that lives in Bidovčeva Luknja on the hill called Rovnik near Kranj. Probably he traced the same species in Častitljiva Jama, on the northern slopes of Jelovica. He discovered new finding sites for a species *Anophthalmus erebus* Krauss which is endemitic for Kamnik Alps. At the same time he confirmed the finding site of a species *A. nivalis* G. Müller on Triglav discovered by A. Gspan. He discovered a new species *A. bukoveci* in Turkova Jama, near Logatec. E. Pretner described also the species *A. pubescens* Joseph and its subspecies. All of them live in the caves of Logatec plateau between Ljubljana Moor and Planinsko Polje. During his research work he dealt with the rules of nomenclature and, among others, explained the incorrectness in naming a species *Anophthalmus scopolii* Sturm while correct is Schmidt. In the literature all the coleopterists quoted Sturm as the author of a species *A. scopolii* with the exception only of Sturm himself (Pretner 1949a).



Fig. 2: E. Pretner in the entrance to Gorjanska jama near Bled, 21st May 1939 (photo F. Bar).

A species that E. Pretner discovered in a shaft Covška Prepad near Dobrovlje is called *Aphaobius (Aphaobiella) budnar-lipoglavšek*. He discovered a subspecies *A. (A.) b.-l. mozirjensis* in a small snow cave on Mozirska Planina in the eastern Kamnik Alps. At both finding sites he found also a species *Aphaobius milleri* Schmidt (subsp.). E. Pretner named newly discovered species after a curator of the Natural Science Museum, Ljubljana, Dr. A. Budnar-Lipoglavšek. *Näphaobius (Aphaobiella) tisnicensis* is a newly discovered species that Pretner found in many caves on a mountain Tisnik near Mislinja. This finding site lie on the northeastern border of the area in the Eastern Alps where cavernicolous silfides? live. The distance from it to the cave Covška Prepad, where *A. budnar-lipoglavšeki* was found, is about 18 km towards the south-west. In the hills above these finding sites Pretner did not find any example of the *Aphaobius* genus although in the caves and passages of the area live *Anophthalmus hitleri* Schreib. and *Laemostenus schreibersi* Küst. Pretner described and determined all the properties of silfides; it is important that he did not just cite the names but he described anatomic-morphological, physiological and ecological characteristics. He also composed a simple key for determining the genera of *Aphaobius* filogenetic species. According to Müller *Pretneria* is a subgenus of the genus *Aphaobius;* but Pretner determined *Pretneria* as an independent genus as it ressembles *Orostygia* and *Oryotus* in respect to its habitat and represents an intermediate to these two genera. Pretner also represented the differences between the species *Pretneria latitarsi* G. Müller and *Pretneria saulii* G. Müller. During long years of researches he found out that an important living condition for a genus *Pretneria* is low temperature; this is why it lives only high in the mountains or in ice caves (Pretner 1949b).

Pretner reviewed the genera *Oryotus* L. Miller, *Pretneria* G. Müller, *Astagobius* Reitter and *Leptodirus* Schmidt (*Coleoptera*). He described new finding sites that he discovered and described known species of these genera, many of them new. He also composed a key for determining the species of *Oryotus* L. Miller genus, and keys for subspecies *Astagobius angustatus* and subspecies *Leptodirus hochenwartii* Schmidt. He also collected ecological data on all the three genera (Pretner 1955).

Pretner's researches of the rare genus *Aphaenopsis* confirmed that these organisms are rightly classified into philogenetic series that had baffled the researchers. Based on copulation organs of the male of *Aphaenopsis, Scotoplanetes* and *Adriaphaenops* genera Pretner started to solve the question whether three different genera are concerned or whether there is only one. He assessed the appurtenance to one genus only *Aphaeonopsis* J. Müller and at the same time he investigated the distribution of this Dinaric genus spread in a wide area of the southern Bosnia and Montenegro. Due to confusion within the systematics of genus *Ceutmonocharis* Jeannel, Pretner decided to resolve it and he found a lot of irregularities. He determined to this genus five species and

subspecies: *C. freyeri* L. Müller, *C. netolitzkyi* J. Müller, *C. robici* Ganglbauer, *C. pusillus* Jeannel and *C. Matjasici* n.sp. He elaborated the key to determine these species and subspecies and their distribution (Pretner 1959a, b).

In spring 1959 a team of Karst Research Institute SAZU workers visited Prekonoška Pećina which was considered as the most beautiful cave of Serbia. A team surveyed the cave and prepared suggestions for its touristic display. In the final part of the cave Pretner discovered new blind species of the genus *Duvalius* (Coleoptera) and new genus of a blind arthropod *Serboiulus lucifigus* Strasser; both organisms are true troglobionts (Pretner 1959 c). Since 1963 only three superficial species of this genus were known from Macedonia. They were mostly found below the stones, at the altitude above 2000 m: *D. fodori* Scheibel, *D. peristericus* J. Müller and *D. macedonicus* J. Müller. In 1962 M. Gogala discovered the first true cavernicolous *Duvalius* in Macedonia *D. s. str. gogalai* (Pretner 1963 a).

E. Pretner was enthusiastic about the Montenegro karst, wild and interesting, as he said, and almost untouched from the speleological point of view. He gathered all the known data about previous researches in Montenegro listing explored and published caves, explored but not yet published caves unexplored caves. Due to his better understanding he classified the caves according to mountain massifs around bigger towns. He also noted a name of the cave, if it existed, and if the cave appeared in the literature under some other name he put it down also; he also quoted the author, the year and the name of publication where it was cited. In this way he wished to contribute his part in preparing a register of caves and shafts of Montenegro. Pretner studied the cave fauna in Boka Kotorska and around Titograd and Virpazar in 1933 and he discovered some new species. From 1955 to 1973 he organised shorter or longer biospeleological excursions to Montenegro, except for the years 1960, 1961 and 1964. In the years from 1955 to 1957 the Slovene and Serbian biospeleologists and cavers explored the shafts, caves and swallow-holes on Nikšičko Polje for a planned hydro-power station "Gornja Zeta". They together explored the cave Duboki Do and other caves in Lovćen. In the years 1965-67 Spéléo Club des Ardennes explored underground in Krivošije and Grahovo (Serbia). These explorations were controlled by E. Pretner who also carried out a lot of research excursions together with the family of Dr. P. R. Deeleman. They were good friends and they travelled and cooperated together a lot. In 1969 they explored 16 caves, in 1970 20, in 1971 30 and in 1975 17, altogether 85 speleological objects (Pretner 1961, 1977).

Skakavac is an active cave located in SE Bosnia biologically explored by E. Pretner in 1956. He found two new troglobionts: *Macrochaetosoma drinae* Strasser and a new subspecies of a beetle *Apholeuomus nudus* subsp. *petrovići*. In the sixties he studied the cave fauna in Serbia and composed a list of cavernicoles endemic in Serbia. Besides the discoveries in Prekonoška Pećina he found in Ravnička Jama a new diplopod *Bulgarosomacrucis* Strasser, and in

Mirkina Jama a diplopod *Typhoiulus albanicus* Attems; for the latter it was the northernmost finding site (Pretner 1963 b, c).

In the years 1964 and 1965 E. Pretner, together with J. Bole and S. Červek, succeeded in finding three new finding sites of a cave beetle *Speleodromus pluto* Reitter 1881. Till then it was only known that in the caves of Velebit. Like the genera *Astagobius* and *Pretneria Spleodromus* also lives only in caves with low temperature, i.e. in snow- and ice-caves at high altitudes. The animals walk over the walls and the rocks lying on the floor. Pretner reached these data by careful, long-lasting and patient sampling and contemporaneous measurement of physico-chemical parameters (Pretner 1966).

At the end of 1967 the Laneyrie's *Nouvelle classification des Bathysciinae* was published, based mostly on different internal structures of the male copulative organ. In 1970 Pretner wrote the remarks to the Laneyrie's catalogue which substantially differs from Jeannel's classical classification although the material was not yet studied in detail. The first part of his remarks appears on four typed pages and includes mostly corrections of finding sites, wrongly written names and deficiencies. Typical finding sites of numerous species of the subfam. *Bathysciinae* cited by the authors often differ from those, described in Pretner's list (Catalogus Faunae Iugoslaviae, III/6, Subfam. *Bathysciinae*, 1968). People who gathered the material were mostly foreigners, not understanding the language, and this is why they frequently cited the names of bigger places nearby or the names of the mountains. The gatherers, interested in cave beetle as dealers mostly, intentionally provided insufficient data about the finding sites. Pretner visited numerous caves and again he succeeded for many organisms in finding out the typical finding site and its correct name. He replaced German or Italian names by the original Slavs names. Remarks and completed literature were published on additional 7 typed pages (Pretner 1970 d).

In the huge cave Vrtlina in the southern Velebit Pretner, together with J. Bole and H. Freud, found with surprise that typical representatives of "Carniolian cave fauna" *Leptodirus* and *Astagobius* reach so far to the south. Biospeleological researches in Gorski Kotar, Croatian littoral, in Lika and Velebit indicated that this area, compared to the vicinity, bears the most similarity with the cave fauna of Slovenia, in respect to the genera *Bathysciotes* Jeannel, *Bathyscimorphus* Jeannel, *Parapropus* Ganglbauer, *Astagobius* Reitter, *Leptodirus* Schmidt, *Typlotrechus* J. Müller. From Dalmatia and Bosnia only *Neotrechus* J. Müller and *Duvalius* subgen. *Neoduvalius* J. Müller reach to Slovenia. Post-war researches showed that a line Zagreb - Krk (that had been set up by Jeannel in 1928) as the south-eastern border does not hold, as the cited genera appear also more to the south. E. Pretner (1970 c) described all these genera ecologically and morphologically in detail, sketched them, described the finding sites and noted locus tipicus and added his own thoughts and conclusions based on the years of experience and observation.

Pretner is found also among those who studied the genus *Hydraena*; most of this material he collected in Slovenia, but also in Bosnia and Hercegovina and in Montenegro. He found out that hydraena are not known in some regions or they appear with single specimens only; he assessed that the subgenus *Haenydra* Rey is represented in the area of the former Yugoslavia by 17 species. Among them Pretner found and described 6 endemites living in relatively narrow area: *H. carniolica* sp. n. is known only in Gorenjska, *H. czernohorsky* (J. Müller) from southern Slovenia, Croatian Istria, around Triest and Gorica in Italy, *H. dalmatina* (Ganglbauer) from south Dalmatia and coastal belt of Montenegro, *H. montenegrina* sp.n. from central Montenegro, *H. devincta* Orchymont and *H. muelleri* Pretner from Slovenia and Venetian Slovenia in Italy (Pretner 1970 b).

In 1968 Pretner discovered a new species *Antrosedes longicollis* in the cave Kruščica near Ilidža in Bosnia. When he published the description of this new species he also corrected the name of a species *Blattodromus herculeus* Reitter which is an extreme rarity. He states (1970 a) that the right adjective form is *herculeus* and not *herculaneus*. The species that Pretner found belong to the caves of higher mountains.

He concluded the biospeleological explorations of the Croatian karst by publishing papers (1973, 1977, 1979) in which he provided for each area a short historical review of the explorations in chronological order of discoveries of new species and subspecies. He also described the caves and shafts and cited discovered species of beetles belonging to families *Carabidae*, *Bathysciinae*, *Pselaphidae*, *Scydmaenidae*, *Curulionidae*. In the systematic part he included for each species or subspecies a finding site, divided by areas. A shorter chapter is dedicated to zoogeography.

Egon Pretner was modest and hard-working up to the end, full of new projects that remain our responsibility to complete. We shall hold him in fond remembrance, full of gratitude for everything he has done for Slovene speleology and the young generations that he introduced with love and rich experiences into this marvellous world of the underground.

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ANNEX 1: THE LIST OF POSTOJNSKA JAMA FAUNA BY E. PRETNER

Deblo: SPUŽVE (*SPONGIARIA*)

Spongillidae, species

Deblo: NEČLENARJI (*AMERIA*)

Razred: Vrtinčarji (*Turbellaria*)

Dendrocoelum lacteum O. F. Müller
Dendrocoelum tubuliferum Beauchamp 1919
Fonticola albissima Vejdovsky
Fonticola dalmatina Stanković & Komarek

Razred: Mehkužci (*Mollusca*)

Podrazred: Polži (*Gastropoda*)

Carychium tridentatum Risso
Zospeum spelaeum Rossmässler 1837
Zospeum alpestre rossmässleri Wagner 1912
Oxychilus cellarius O. F. Müller
Frauenfeldia lacheineri Küster
Iglica luxurians Kuščer

Hauffenia subpiscinalis Kuščer
Acroloxus tetensi Kuščer

Deblo: MNOGOČLENARJI (*POLYMERIA*)
Poddeblo: Kolobarniki (*Annelida*)
Razred: Maloščetinci (*Oligochaeta*)
Nais communis Piguet
Tubifex velutinus Grube
Aulodrilus pluriseta Piguet
Eiseniella tetraedra Savigny
Helodrilus constrictus Rosa
Razred: Pijavke (*Hirudinea*)
Herpobdella octoculata Linné
Species
Poddeblo: Členonožci (*Arthropoda*)
Razred: Raki (*Crustacea*)
Nižji raki (*Entomostraca*)
Red: Listonožci (*Phyllopoda*)
Simocephalus vetulus O. F. Müller
Ceriodaphnia affinis Lilljeborg
Bosmina longirostris O. F. Müller
Rhynchotalona rostrata Koch
Pleuroxus laevis Sars
Red: Dvoklopniki (*Ostracoda*)
Cypria ophthalmica Jurine
Cypria pellucida O. F. Müller
Candona candida O. F. Müller
Candona trigonella Klie 1931
Typhlocypris schmeili Müller
Red: Ceponožci (*Copepod)*
Diaptomus spec. ?
Macrocyclops albidus Jurine
Eucyclops macruroides Lilljeborg
Eucyclops serrulatus Fischer
Eucyclops prasinus Fischer
Paracyclops fimbriatus Fischer
Paracyclops fimbriatus f. imminuta Kiefer
Cyclops bisetosus Rehberg
Cyclops charon Kiefer 1931
Cyclops languiodoides f. gotica Kiefer 1931
Cyclops viridis Jurine
Mesocyclops dybowskyi Lande
Paracamptus schmeili Mrázek
Bryocamptus zschokkei Schmeil

Echinocamptus georgevitchi Chappuis
Echinocamptus unicus Kiefer 1931
Echinocamptus dacicus Chappius
Ehinocamptus luenensis Schmeil
Attheyella crassa Sars
Elaphoidella jeanneli Chappuis
Višji raki (*Malacostraca*)
Red: Deseteronožci (*Decapoda*)
Astacaus fluviatilis Fabricius
Troglocaris anophthalmus Kollar
Red: Enakonožci ali prašički (*Isopoda*)
Titanethes albus Schiödte 1848
Androniscus cavernarum tschammeri Strouhal
Asellus aquaticus Linné
Asellus aquaticus cavernicolus Racovitza 1925
Asellus istrianus Stammer
Red: Postranice (*Amphipoda*)
Niphargus stygius Schiödte 1848
Niphargus puteanus spoeckeri Schellenberg 1933
Niphargus kochianus wolfi Schellenberg 1933
Razred: Pajkovci (*Arachnoidea*)
Red: *Palpigrada*
Koenenia austriaca Hansen
Red: Pajki (*Araneidea*)
Stalita taenaria Schiödte 1848
Red: Paščipalci (*Pseudoscorpionidea*)
Neobisium spelaeum Schiödte 1848
Neobisium pusillium Beier 1939
Chtonius cavernarum Ellington
Roncus stussineri Simon
Red: Suhe južine (*Opilionidea*)
Hadziana postumicola Roewer 1935
Nelima aurantiaca Simon
Red: Pršice (*Acarina*)
Asca affinis Oudemans
Ixodes vespertilionis C. L. Koch
Labidostoma lyra Willmann 1932
Eugamasus loricatus Wankel
Veigeia kochi Trägardh
Cyrtolaelaps mucronatus G. & R. Canestrini
Hygrobates longipalpis Hermann
Neumannia limosa C. L. Koch
Arrenurus albator O. F. Müller

Razred: Stonoge (*Myriapoda*)
Podrazred: Strige (*Chilopoda*)
Lithobius stgius Latzel 1880
Podrazred: Kačice (*Diplopoda*)
Acherosoma troglodytes Latzel 1880
Attemisia stygium Latzel 1880
Brachydesmus subterraneus Heller
Gervaisia costata Waga
Razred: Žuželke (*Insecta aut Hexapoda*)
Podrazred: Pražuželke (*Apterygota*)
Hypogastrura purpurascens Lubbock
Hypogastrura sigillata Uzel
Achorutes spelaeus Joseph 1882
Onychiurus armatus Tullberg
Onychiurus boldorii Denis 1938
Onychiurus giganteus Absolon 1901
Onychiurus postumicus Bonet 1931
Onychiurus stachi Denis 1938
Onychiurus stillicidii Schiödte 1848
Anurophorus coecus Joseph (?)
Isotomurus alticolus Carl
Heteromurus nitidus Templeton
Tomocerus niveus Joseph 1882
Oncopodura cavernarum Stach 1934
Sminthurus coecus Joseph 1882 (?)
Plusiocampa erebophila Hamann 1896
Podrazred: Krilate žuželke (*Pterygota*)
Red: Pravokrilci (*Orthoptera*)
Troglophilus cavicola Kollar
Troglophilus neglectus Krauss
Red: Enodnevnice (*Ephemeroidea*)
Baëtis bioculata Linné
Ličinke (*larvae*) spec. ?
Red: Pribrežnice (*Plecoptera*)
Ličinke (*larvae*) spec. ?
Red: Mladoletnice (*Trichoptera*)
Ličinke (*larvae*) spec. ?
Red: Metulji (*Lepidoptera*)
Triphosa dubitata Linné
Scoliopteryx libatrix Linné
Red: Hrošči (*Coleoptera*)
Anophthalmus schmidti Sturm
Anophthalmus hirtus confusus G. Müller 1935

Laemostenus elongatus Dejan
Laemostenus schreibersi Küster 1846
Bathyscimorphus byssinus Schiödte 1848
Bathysciotes khenvenhülleri L. Miller 1852
Aphaobius milleri F. Schmidt (subsp.)
Leptodirus hochenwarti F. Schmidt 1832
Atheta spelaea Erichson
Quedius mesomelinus Marsham
Machaerites ravasinii G. Müller
Red: Dvokrilci (*Diptera*)
Neosciaria vivida f. tenuicornis Lengersdorf 1932
Chironomus viridulus Linné
Triphleba aptina Schiner & Egger 1854
Chiromia oppidana Scopoli
Nycteribia biarticulata Hermann
Nycteribia schmidli Schiner & Egger
Ličinke (*larvae*) fam. *Culicidae*

Deblo: STRUNARJI (*CHORDONIA*)
Poddeblo: Vretenčarji (*Vertebrata*)
Razred: Ribe (*Pisces*)
Phoxinus laevis Linné
Leuciscus spec.
Trutta spec.
Razred: Dvoživke (*Amphibia*)
Proteus anguinus Laurenti
Razred: Sesalci (*Mammalia*)
Rhinolophus hipposideros Bechstein
Rhinolophus ferrum-equinum Schreber
Miniopterus schreibersi Kuhl

ANNEX 2: THE LIST OF COLEOPTEROLOGICAL FAUNA OF ARTIFICAL SPACES BY E. PRETNER

CARABIDAE

Geotrechus saulcy subsp. *metallorum* Jeannel
Rudnik hematitnega železa, Privas (Ardéche)
Aphaenops loubensi Jeannel
Aphaenops cabidochei Coiffait
Hydraphaenops vasconicus subsp. *delicatus* Coiffait
Tunel do dvorane Verna na dnu brezna Aven de Pierre-Saint-Martin in do jame Grotte d Arphidia, Basses Alpes

Speotrechus (s. str.) *mayeti* Abeille
Rudnik hematitnega železa, Privas (Ardéche)
Orotrechus (s. str.) *carinthiacus* Mandl
Rovi na Obirju v višini 900 do 2000 m
Orotrechus (s. str.) *globulipennis* Schaum
Rov pod Plano nad Plužno pri Bovcu
Orotrechus (s. str.) *muellerianus* Schatzmayr
Kaverna pri železniški postaji Prosek (Prosecco) na Krasu
Orotrechus (s. str.)
Rov na vzhodnem rovu Tisnika blizu Hude luknje
Orotrechus (s. str.) *fabianii* Gestro
Podzemeljska kamnoloma Cogolo di Costozza in pri Covolo del Tesoro, Monti Berici
Duvalius (s. str.) *carantii* Sella
Podzemeljski prostori samostana Certosa di Pesio, Alpi Marittime
Duvalius (s. str.) *exaratus* Schaum
Knapovka jama, Paka severno od Velenja (obronki Karavank)
Duvalius (*Euduvalius*) *lucidus* J. Müller
Spilja-rudnik "Minera", Škrip (otok Brač)
Anophthalmus bernhaueri Ganglbauer
Obir: rov nad prevalom Šajda, rovi svinčenih rudnikov "Fladung" in "Seealpe", rov v gorskem hrbtu zahodno od Železne Kaple, približno 600 m visoko
Karavanke v Sloveniji: gornji rov na Počivalu nad kmetijo Počivalnik na južnem pobočju kota 1172 Samuha; gornji in doljnji rov v Podljubelju nad kmetijo Potočnik
Anophthalmus kaufmanii subsp. *weingärtneri* (Winkler)
Rudarski vrt, Sv Jakob na Medvednici nad Zagrebom
Anophthalmus mariae Schatzmayr
Rov pod Valvazorjevo planinsko kočo na Stolu (Karavanke): rudnik "Pri štolnu " pod planino Trento (Julijske Alpe)
Anophthalmus egonis J. Müller
Julijske Alpe: rov nad Rudnim poljem ob stezi za Konjšco planino, rovi "Janez I-III" na Rudnici kota 946 pri Studorju v Bohinju; rov na prevalu med Uskovnico in Ovčarijo; okolica Viševnik planine: rov ob stezi na preval nad Viševnik planino, tretji od zgoraj navzdol, rov pod "Jamo na sedlu"
Anophthalmus ajdovskanus subsp. *fodinae* Mandl
Obir: rov pod Rainerjevim domom na Ojstercu, rovi svinčenega rudnika "Seealpe"
Anophthalmus ajdovskanus subsp. *pretneri* J. Müller
Rov pod Valvazorjevo planinsko kočo na Stolu in rov "Pri knapih" pod stezo na Begunjščici (Karavanke)

Anophthalmus ajdovskanus aff. subsp. *muelleri* Jeannel
Viševnik planina (Julijske Alpe): rov ob stezi od Viševnik planine na preval, tretji od zgoraj navzdol, veliki rov pri mostu v steni nad jamo Zlatico

Anophthalmus ajdovskanus aff. subsp. *santiacus* G. Müller
Italijanska kaverna iz prve svetovne vojne za Gomiščekovim zavetiščem pod vrhom Krna 2245 m visoko (Julijske Alpe)

Anophthalmus ajdovskanus /Ganglbauer/ (subsp. spec.)
Trenta v Julijskih Alpah: rudnik "Pri štolnu" pod planino Trento in rudnik na Srednici pod Vršacem v Zgornji Trenti

Laemosthenes (*A.*) *schreibersi* Küster
Julijske Alpe: kaverna na Lajnerju nad Soriško planino, rovi "Janez I-III" na Rudnici kota 946 pri Studorju v Bohinju, rov ob stezi od Viševnik planine na preval, tretji od zgoraj navzdol; italijanska kaverna iz prve svetovne vojne na južnem pobočju Krna 1600 m visoko, rov pod Planjo nad Plužno pri Bovcu; rudnik na Srednici pod Vršacem v Zgornji Trenti, 1800 m visoko in rudnik "Pri štolnu" pod planino Trento
Karavanke: rovi "Pri knapih" na Begunjščici, nad in pod stezo ter tik ob stezi
Menina planina: Selska luknja pri vasi Selo zahodno od Zgornjega Tuhinja
Pohorje: Rov nad kasarno v Bukovju, Dravograd
Kobansko: rov v Sturmovi grabi, Fala
Škofjeloški hribi: rov Arnežov bavhenk na vznožju Šmarjetne gore pri Kranju

BATHYSCIINAE

Bathysciola (s. str.) *linderi* Abeille
Rudnik galenita, Sainte-Marguerite-Lafigére (Cévennes)

Bathysciola Boldoria (*ghidinii*) F. Lona
Podzemeljski prostori trdnjave v mestu Brescia

Aphaobius heydeni subsp. *robustus* J. Müller
"Štoln" pri Dobravškem mostu pri Kamni gorici (Škofjeloško hribovje)

Aphaobius milleri subsp. *pretneri* J. Müller
Rov pod Valvazorjevo kočo na Stolu in 3 rovi "Pri knapih" na Begunjščici (Karavanke)

Aphaobius milleri subsp. *winkleri* Mandl
Rov pri Uletovega planinskega doma na Peci; rova Kolša in Heller na avstrijskem pobočju Pece ("Petzen") v Karavankah

Aphaobius milleri subsp. *brevicornis* Mandl
Obir v avstrijskih Karavankah: rovi v višini 1400 do 2000 m, rov nad prevalom Šajda in rovi svinčenega rudnika "Seealpe"

Aphaobius milleri /F. Schmidt/ (subsp.)
Karavanke: gornji rov na Počivalu nad kmetijo Počivalnik na južnem pobočju kote 1172 Samuha in dolnji rudniški rov nad kmetijo Potočnik v Podljubelju
Menina planina: Selska luknja pri vasi Selo (Zgornji Tuhinj)
Julijske Alpe: rov ob stezi Viševnik planina-preval, t.j. tretji rov od zgoraj navzdol, rov z navpičnim vhodom levo od steze Viševnik planina-preval, veliki rov pri mostu v steni nad jamo Zlatico; rudnik na Srednici pod Vršačem v Zgornji Trenti in rudnik "Pri štolnu" pod planino Trento

Lotharia angulicollis Mandl
Rov nad prevalom Šajda na južnem pobočju Obirja

Oryotus micklitzi Reitter
Julijske Alpe: rov nad Rudnim poljem na Pokljuki; rov ob stezi od Viševnik planine na preval, t.j. tretji od zgoraj navzdol, rov z navpičnim vhodom levo od steze Viševnik planina-preval, veliki rov pri mostu v steni nad jamo Zlatico pod Viševnik planino, rov ob navedeni stezi na levo, kjer ta ne traverzira več pobočje, ampak krene navzgor proti prevalu

Spelaeobates kraussi J. Müller
Spilja-rudnik "Minera", Škrip (otok Brač)

STAPHYLINIDAE

Lathrobium (*Glyptomerus*) *cavicola* H. Müller
Menina planina: Selska luknja pri vasi Selo (Zgornji Tuhinj)

Phloeocharis (*Scotodytes*) *winkleri* Coiffait
Les Cabesses, rudnik mangana, Rivérenert (Aričge)

CURCULIONIDAE

Troglorhynchus anophthalmus F. Schmidt
Menina planina: Selska luknja pri vasi Selo (Zgornji Tuhinj)

ANNEX 3: SPECIES NAMED AFTER EGON PRETNER

HROŠČI ***Coleoptera***
družina KREŠIČEV, *Carabidae*
Carabus croaticus ***pretneri*** Drovenik-Krätschmer, 1977
Adriaphaenops ***pretneri*** Scheibel, 1935
(Vjetrenica, Zira jama, BIH - endemit)
Neotrechus suturalis ***pretneri*** Scheibel, 1936

(Jama pri Vlaništu, Črna gora - endemit)
Anophthalmus ***egonis*** J. Müller, 1923
(Jame na Pokljuki in Pršivcu, Slovenija - endemit)
Anophthalmus ajdovskanus ***pretneri*** J. Müller, 1913
(Karavanke, Slovenija - endemit)
Anophthalmus micklitzi ***pretneri*** J. Müller, 1913
Anophthalmus milleri ***pretneri*** J. Müller, 1913

družina MRHARČKOV, *Catopiidae, Bathysciinae*
Aphaobius milleri ***pretneri*** J. Müller, 1913
(Stol, Karavanke, Slovenija - endemit)
Pretneria G. Müller, 1931
Pretneria *latitarsis* (G. Müller, 1931)
(Golobja jama, Trnovski gozd, Slovenija - endemit)
Pretneria *saulii* (G. Müller, 1941)
(Snežnice na Kaninu, Slovenija - endemit)
Orostygia ***pretneri*** G. Müller
(Julijska krajina, Italija)
Speonesiotes ***pretneri*** G. Müller, 1934
(pećina Magara, Skadar - endemit)
Leptodirus hochenwarti ***pretneri*** (G. Müller, 1926)
(Jama nad Zosten, Čičarija, Istra)

družina RILČKARJEV, *Curculionidae*
Troglorhynchus ***pretneri*** Solari 1955
(Velika severna Notranjska planota)

PAJKI, ***Aranea***
Troglohyphantes ***pretneri*** Deeleman-Reinhold, 1978
(špela Koruns, gora Prokletije, Črna gora - endemit)
Stalita ***pretneri*** Deeleman-Reinhold, 1971
(Donja Cerovačka pećina, Lika, Hrvaška - endemit)

STONOGE, ***Chilopoda***
Scolopendrellopsis ***pretneri*** Juberthie-Jupeau, 1963

DVOJNONOGE, ***Diplopoda***
Attemisia ***pretneri*** Strasser, 1933
(Križna jama, Lož, Slovenija - endemit)
Acherosoma ***pretneri*** Strasser, 1940
(Medvedja pećina, Lokve, Hrvaška - endemit)
Orobainosoma ***pretneri*** Strasser
Leptoiulus ***pretneri*** *minor* Strasser, 1940

(Menina planina, Savinjske Alpe, Slovenija - endemit)
Brachydesmus inferus ***pretneri*** Verhoeff
Egonopretneria Strasser

RAKI, ***Crustacea***
Spelaeocaris ***pretneri*** Matjašič, 1958
Niphargus aquilex ***pretneri*** Sket, 1959
(Gornja Cerovačka pećina, Hrvaška - endemit)
Monolistra ***pretneri pretneri*** Sket, 1969
(Pećina kod Vrane, Hrvaška - endemit)
Pseudocandona ***pretneri*** Danielopol, 1978

POLŽI, ***Gastropoda***
Zospeum ***pretneri*** Bole, 1961

VRTINČARJI, ***Turbellaria***
Bubalocerus ***pretneri*** Matjašič, 1958

ZGODOVINSKI POMEN EGONA PRETNERJA ZA BIOLOGIJO

Povzetek

Egon Pretner (1896 - 1982) je bil v mednarodnem merilu eden najboljših poznavalcev evropskega krasa in živali v kraških jamah, še posebej hroščev. Največ v tem življenjskem okolju je odkril nad sto novih živalskih vrst in je s tem bistveno prispeval k jamskim katastrom Slovenije in drugih dežel bivše Jugoslavije, saj je bil zanesljivo jamar, ki je obiskal največ jam v Jugoslaviji. Po svojih zapiskih je obiskal 1492 jam: 649 na Slovenskem, 773 v drugih deželah Jugoslavije, 70 v drugih evropskih državah in sestavil je kataster za večino kraških jam v Sloveniji in republikah bivše Jugoslavije. Za opravljeno delo je prejel mnoga društvena priznanja in odlikovanja. Bil je častni predsednik Slovenskega entomološkega društva ter častni član Jugoslovanskega in Francoskega entomološkega društva. Za znanstveno delo je prejel Prešernovo in Jesenkovo nagrado. Ob 80- letnici je bil odlikovan z redom dela z zlatim vencem. Skromen in delaven je ostal do konca, še poln načrtov, ki pa so ostali naša obveza, da jih dokončamo.

Na področju, kjer je dosegel mednarodni sloves, je bil E. Pretner samouk in dolga leta po statusu zgolj amater. Bil je neutrudljiv terenski delavec, slovenski in celotni jugoslovanski kras, pa tudi kraške predele v sosednji Italiji in Avstriji, je poznal bolje kot kdorkoli. Pridobil si je pomembne zasluge na raznih področjih krasoslovja (evidenca jam, geografija krasa, tehnika jamarstva in jamarskega raziskovanja itn.), predvsem pa se je posvečal raziskovanju

življenja v kraškem podzemlju. Tu je odkril številne nove vrste migetalkarjev, polžev, dvojenog in zlasti hroščev. Kot žužkoslovec je posegel tudi na nekatera druga področja, tako je bil na svetu največji specialist za skupino vodnih hroščev *Hydraena*, vendar pa slovi predvsem kot raziskovalec jamskih hroščev. Razvil je izvirne načine za zbiranje tovrstnega študijskega gradiva. Poleg odkrivanja novih vrst je preverjal tudi že publicirane podatke in ustvaril si je celovito sliko o geografski razširjenosti posameznih vrst. Napisal je nad 70 razprav in člankov v domačih in tujih znanstvenih revijah, za sintezo raziskovalnega dela - monografijo o jamskih hroščih Slovenije - pa mu je zmanjkalo časa. Kot velik altruist je E. Pretner zbrano gradivo pogosto prepuščal v obdelavo raznim specialistom, da so tako prvi opisali mnoge živalske vrste, ki jih je sam odkril. Preko 20 vrst pa se le imenuje po njem, kar kaže na veliko spoštovanje in cenjenost s strani biologov. E. Pretner se je med prvimi zavedel ekološke ogroženosti kraških jam in postal je zgoden bojevnik za varstvo narave tudi na tem področju.

ACTA CARSOLOGICA	XXVI/2	19	197-201	LJUBLJANA 1997

A FAIRY PHANTOM DOES AGAPITO'S 1802 BOOK ON VILENICA EXIST?

ALI OBSTOJA AGAPITOVA KNJIGA O VILENICI IZ LETA 1802?

TREVOR R. SHAW [1]

Izvleček UDK 551.44:929 Agapito G.
Trevor R. Shaw: Ali obstoja Agapitova knjiga o Vilenici iz leta 1802?

Avtor sklepa da pogosto omenjene Agapitove knjige o Vilenici "La Grotta di Corgnale" sploh ni. V prispevku je avtorjeva razlaga za to trditev.
Ključne besede: zgodovina speleologije, Slovenija, Kras, Vilenica, Agapito.

Abstract UDC 551.44:929 Agapito G.
Trevor R. Shaw: A fairy phantom - does Agapito's 1802 book on Vilenica exist?

It is concluded that the often-cited La Grotta di Corgnale, by Agapito, does not exist. A possible explanation for the error is suggested.
Key words: history of speleology, Slovenia, Kras, Vilenica, Agapito.

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A very early book about the cave Vilenica has been frequently referred to for nearly a century, but there has been considerable doubt whether it ever existed. This is the supposed La Grotta di Corgnale, written by G. Agapito and published in 1802.

Girolamo Agapito was born in 1783 at Buzet in Istria and educated at Koper (Faraone 1994). Of his several publications, Le Grotte di Adlersberg, di S. Canciano, di Corniale e di S. Servolo..., published in 1823, is the best known.

The earliest reference traced to Agapito's 1802 book occurs in a bibliography of caves in and near the classical Karst, published in Alpi Giulie (Anon. 1897). Here it is listed as "Relazione, della grotta di Corniale, di Girolamo Agapito, in 16°, Trieste, 1802". No part of this entry was printed in italics, as book titles elsewhere in the text were, so "Relazione, della grotta di Corniale" must be a description of its subject and not its actual title, indicating that the book itself had not been seen. The sources of the information in the list include, according to a footnote, "notizie vocali fornitaci gentilmente, de soci e non soci" (verbal information kindly supplied by members and non-members [of the Societa Alpina delle Giulie]).

Later in the same year Boegan (1897b) cited the 1802 book in the same words, "Relazione della grotta di Corniale - Girolamo Agapito", but this time italics have been used so that, by the convention of that article, the description of the book appears as a true title.

When the book is next listed, in a bibliography for the Istrian region (Parona et al. 1923, p. iii), its title has become La grotta di Vileniza detta di Corniale, published at Trieste. A few years later Duemila Grotte (Bertarelli and Boegan 1926) referred to "Agapito, G., La grotta di Corgnale, Trieste, 1802", translating the former name into Italian which is not normal practice in that book. This latest form of the title has continued to be cited to the present day (e. g. Kranjc 1995).

Despite these many statements that the 1802 book by Agapito does exist, there are also many places where it might have been expected to be mentioned but was not. Agapito's own book of 1823 does not refer to it. Boegan (1897a) points out a measurement error in Agapito's 1823 description of the cave, but does not there mention any earlier book by him. Three bibliographies do not include it. The Austrian Literatur-Anzeiger (Anon. 1880) does not contain it, but it has only two entries for the cave anyway. Gratzy (1897) omits the cave from his bibliography altogether. Herak et al. (1976) do not list it, but their references for that period are very sparse. Much more significant is its absence from the careful and comprehensive annotated bibliography of the cave by Faraone (1993).

It is noticeable that none of those who refer to the book quote extracts from it or derive information from it. Nor is the total number of pages or any other physical fact about it given. Even the title is written in three forms in

successive publications. In every case it is only its existence that is mentioned, with no indication that the book itself has been seen.

So, does the book in fact exist? Was it ever written? This author has never met anyone who has seen a copy. The major national libraries and karstological libraries of the world have no copies. Neither the Biblioteca Civica nor any other library in Trieste has any record of the book (dr. Anna Rugliano, pers. comm. 1994).

It may be noted also that in the year of its supposed publication Agapito was only 18 or 19 years of age, and so was unlikely to have written such a book.

If Agapito's 1802 book does not exist, how can so many references to it be explained?


L A

GROTTA DI VILENIZA,

DETTA

DI CORNIALE.

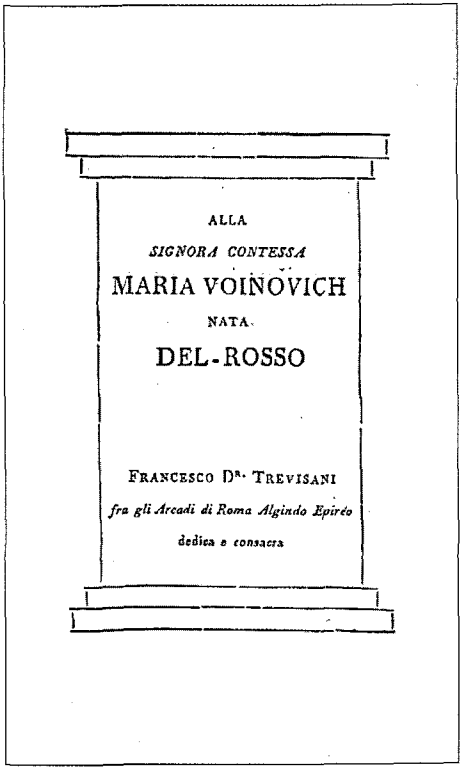
Biblioteca Civica di TRIESTE.

TRIESTE,

PRESSO GASPARO WEIS

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Fig. 1: The title page of Trevisani's book (reproduced by permission of the Biblioteca Civica, Trieste).


ALLA

SIGNORA CONTESSA

MARIA VOINOVICH

NATA

DEL-ROSSO

FRANCESCO D^R. TREVISANI

fra gli Arcadi di Roma Algindo Epiréo

dedica e consacra

Fig. 2: The author's name is given on the dedication page of his book, 'La Grotta di Vileniza, detta di Corniale' (reproduced by permission of the Biblioteca Civica, Trieste).

First of all, another book about the Vilenica cave was published in 1802 - La Grotta di Vileniza, detta di Corniale, a poem by dr. Francesco Trevisani, published in Trieste as a small volume of 23 pages (Figs. 1 and 2). It was cited (with the title abbreviated) in Anon. (1897) and Boegan (1897b). Duemila Grotte (Bertarelli and Boegan 1926) did not include it, but it is listed accurately by Parona et al. (1923, p. cxliv), who also list Agapito's supposed book of the same year under the identical title.

It does seem exceedingly likely, though unprovable, that the person who provided the information for the first entry for the Agapito book (Anon. 1897), was confusing Agapito, as the author of the 1823 book containing a section on Vilenica, with Trevisani's book of 1802. The references then gradually gained respectability and authority. In Boegan's (1897b) article the use of italics provided a quotable title, and Boegan's name in a citation implied reliability. One the book was listed in Parona's bibliography and in the standard reference book Duemila Grotte, its existence became widely accepted.

While non-existence can never be proved, it does seem almost certain that there never has been a Vilenica book of 1802 by Agapito. If so, it is another phantom book of the karst, like Herberstein's De Admirandis Rebus Naturae of the 16th century (Shaw 1994). Perhaps, after all, it was produced by a vila (fairy) of Vilenica.

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ALI OBSTOJA AGAPITOVA KNJIGA O VILENICI IZ LETA 1802?

Povzetek

Že skoraj sto let pogosto citiramo staro knjigo o Vilenici, a že dolgo obstojajo tudi dvomi, da je bila v resnici sploh tiskana. To je domnevna "La Grotta di Corgnale" avtorja G. Agapita, izdana 1802.

Girolamo Agapito je bil rojen 1783 v Buzetu v Istri in se šolal v Kopru. Izmed njegovih del je najbolj znana "Le Grotte di Adlersberg, di S. Canciano, di Corniale e di S. Servolo... ", tiskana 1823.

Prva omemba njegove knjige iz 1802 se pojavi v bibliografiji o jamah klasičnega Krasa in soseščine (Anon 1897), torej 95 let po tem, ko naj bi knjiga izšla. Nekateri podatki, ki jih navaja bibliografija, so izrecno dobljeni od različnih pomočnikov in takrat niso bili preverjeni. Ta navedba iz 1897 je najbrž vir, po katerem je bila knjiga kasneje citirana, vendar pod dvema malce različnima naslovoma, Boeganovim (1897 b) in v bibliografiji Istre (Parona et al. 1923) ter 1926 v Duemila grotte.

Tako je bila Agapitova knjiga iz 1802 sprejeta v strokovno literaturo, čeprav ni nobenih dokazov, da je kdo izmed teh avtorjev knjigo sploh kdaj videl. Tudi z resnim iskanjem po narodnih in regionalnih knjižnicah ni bilo mogoče odkriti niti enega izvoda. Še več, Agapito je bil 1802 star šele 18 ali 19 let, razlog več, da ta knjiga ni bila nikoli napisana. Pač pa je izšla druga knjiga o Vilenici 1802. To je pesnitev dr. Francesca Trevisanija, izdana v Trstu, z omembo avtorjevega imena šele na strani s posvetilom. Na naslovnici ni imena avtorja, v čemer je morda vzrok, da so knjigo nepazljivo pripisali Agapitu, za katerega se je vedelo, da je kasneje pisal o tej jami.

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ŠKADAVNICA CAVE EXPLORED BY ENGLISH TRAVELLERS IN 1737

KAKO STA ANGLEŠKA POPOTNIKA 1737 RAZISKOVALA JAMO ŠKADAVNICO

TREVOR R. SHAW [1]

Izvleček UDK 551.44(497.4)(091)
Trevor R. Shaw: Kako sta angleška popotnika 1737 raziskovala jamo Škadavnico

Majhno jamo Škadavnico sta raziskovala leta 1737 dva angleška potnika, Richard Pococke in Jeremiah Milles. Ta obisk pa je bistveno starejši od kasnejših raziskav te štajerske jame severovzhodno od Ljubljane. Njuni opisi Škadavnice so prvič objavljeni v tem prispevku, z nekaj poročili o krajših potovanjih po Sloveniji, na Cerkniško jezero in o obisku štirih jam iz okolice Postojne.
Klučne besede: Pococke, Milles, speleologija, geologija, zgodovina, biografija, Slovenija, Škadavnica.

Abstract UDC 551.44(497.4)(091)
Trevor R. Shaw: Škadavnica cave explored by English travellers in 1737

The small cave of Skadavnica was explored in 1737 by two English travellers, Richard Pococke and Jeremiah Milles, thus doubling the length of time since the first cave was reported in north-eastern Slovenia east of Ljubljana. Their descriptions of it are printed here for the first time, with some account of the rest of their short tour in Slovenia during which they visited Cerkniško jezero and four caves near Postojna.
Key words: Pococke, Milles, speleology, history, biography, Slovenia, Škadavnica.

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INTRODUCTION

It had been thought that the earliest record of a cave in Slovenian Styria, indeed of any cave in north-eastern Slovenia east of Ljubljana, was a mention of jama Pekel near Šempeter in 1860 (Štorman 1991). Habe et al. (1978) state that it was discovered in that year.

Škadavnica, a small cave about 1,5 km north-west of Vransko and 42 km north-east of Ljubljana (Fig. 1) was thought to have remained unrecorded until 1902, when cave fauna was collected there.

This paper shows that Škadavnica had, in fact, been explored and described by two English travellers, Richard Pococke and Jeremiah Milles, in 1737.

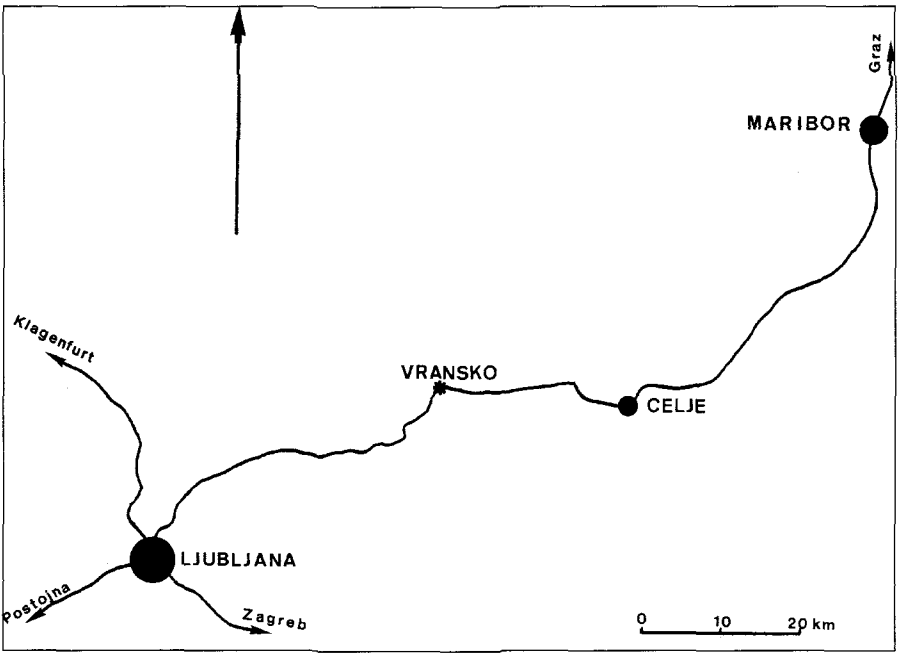


Fig. 1: Map showing location of Vransko.

ŠKADAVNICA TODAY

The name of this cave has been spelled in several ways. 'Škadavnica', as preferred here, is used in the *Krajevni Leksikon Slovenije* (Natek 1976a; b), by Radešček (1993) in his description of the cave, and in the unpublished Kataster folder in the Karst Research Institute at Postojna; it is also the form painted on the rock outside the cave entrance. Naraglav (1977) uses "Ško-

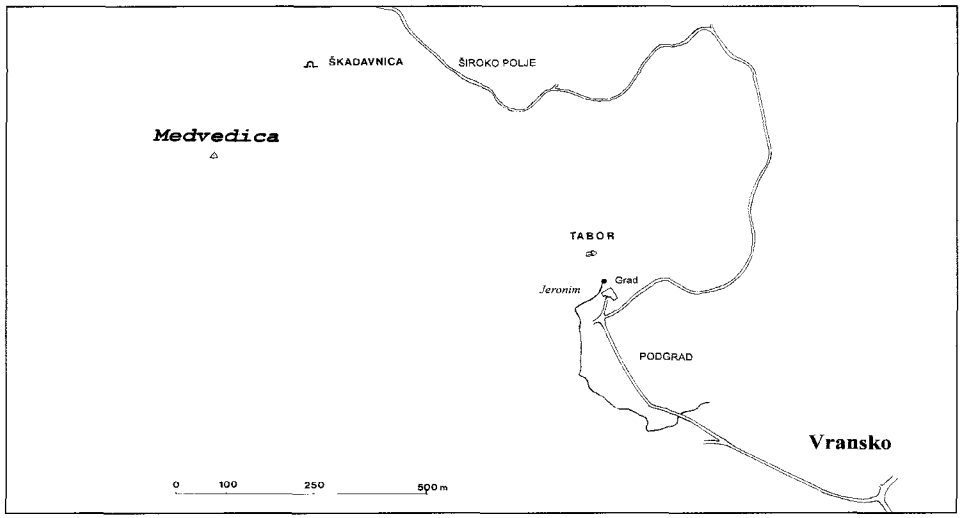


Fig. 2: Škadavnica cave and its surroundings, showing also Podgrajska graščina (described by Pococke as "a Gentlemans house") and the rising at Pogreška jama.

davnica" (which is also given as an alternative in the Kataster and used on the 1973 plan). Kocbek (1926) uses 'Škadovnica' and Radešček (1993) gives this also as an alternative.

The entrance is approximately 1,5 km in a west-north-westerly direction from the church in Vransko. Part way up the north-east slope of the hill Medvedica (Fig. 2), it is best approached by the motorable track from Podgrad, through Široko polje towards Treska. The final 150 m from the track is done on foot through a plantation of conifers which makes the entrance very difficult to locate. The cave is some 700 m west-north-west of Tabor, the prominent white-painted church on the hill top above the buildings at Jeronim, and which is mentioned in the 1737 account.

The 1973 survey (Fig. 3) makes detailed description of the cave unnecessary. The entrance (Fig. 4) is 5 m

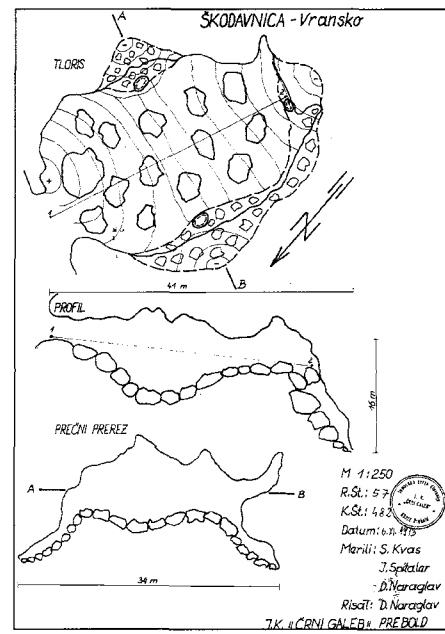


Fig. 3: Survey of Škadavnica cave made in 1973 by members of the Jamarski Klub "Črni galeb" of Prebold, reproduced with their permission.

wide and opens directly in the hillside, with no cliff or other indication of its presence. The main chamber, the only chamber in fact (Fig. 5), is oval in shape and measures 41 m long by 34 m broad at its widest point. It slopes downwards from the entrance and its floor is entirely covered with boulders. There are many holes between and beneath these boulders, three of which are deeper than the rest; the largest of all is at the back of the cave and reaches its deepest point, 16 m below the entrance. A little flowstone remains on the walls near some of these holes. The cave is dry, and daylight penetrates, dimly, even to the back.

Another small cave in the vicinity was also visited in 1737 and so is described here too. Immediately to the south of the church Tabor, at the foot of a steep wooded hillside, is a large house Podgrajska graščina (Fig. 6) together with its block of former stables. The building is now (1996) being restored but, as will be seen, it is much the same as it was 250 years ago. Behind it, close up under the cliff, is the rising of the Podgrajščica (or Pogrešca) stream which emerges from Pogreška jama (Fig. 7). The stream outside the cave is now confined in a concrete channel which may have raised the water level somewhat. The stream entrance is about 1,5 m wide and 1 m high above the water; a dry entrance close by (50 cm x 1,2 m high) leads to the water also.

20th CENTURY HISTORY OF ŠKADAVNICA

The earliest reference to Škadavnica known until now has been that of Penecke (1904), who in 1902 discovered there and in Štabirnica cave the first cave beetles to be found in Štajerska (Slovenian Styria). Naraglav (1977) drew attention to this but did not cite the original paper.

In 1926 Kocbek described Škadavnica briefly, saying that it was 40 m long and 30 m wide, with stalactites. He mentioned also the rising at Pogreška jama, which was said must be long because a draught can be felt at the entrance.

Egon Pretner (1937) visited the Škadavnica cave in July and September 1937, just 200 years after Pococke and Milles, collecting beetles. The hillside around the entrance was overgrown with scrub at that time. His sketch plan and section are reproduced as Fig. 8, and he described the main chamber as 50 m long and 30 m wide. One of the holes in the floor was said to continue for a long way but he did not explore it. Some flowstone was noticed on the right hand side.

Members of the future Jamarski Klub "Črni galeb" of Prebold made their first exploration of the cave on 25 May 1969, Tito's birthday holiday (Vedenik, pers. com., 3 Oct 1995). Some flowstone and dull stalactites on the roof were noticed. The Club returned on 6 November 1973 and made the survey printed here as Fig. 3 (Naraglav & Kvas 1973). A path then led to the entrance, around

which was a more open mixed woodland than today.

Both Škadavnica and Pogreška jama were made more widely known by Natek (1976 a; b) in the *Krajevni Leksikon Slovenije* but this contains no new information.

The latest account of the cave appears in Radešček's (1993) "Guide to the Postman's Cave Route".

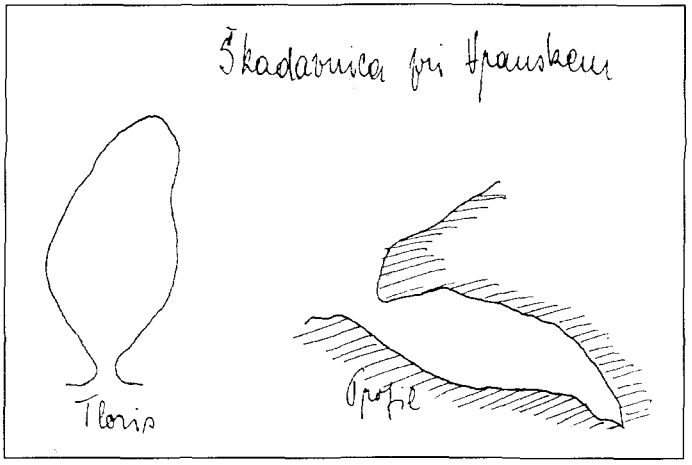


Fig. 8: Sketch plan and section of Škadavnica, made in 1937 by Egon Pretner (from the Cave Kataster of the Karst Research Institute, Postojna. No scale).

POCOCKE

Turning now from the present to the past, an outline is given of the lives of the two men who explored Škadavnica in 1737.

Richard Pococke (Fig. 9) was born at Southampton in England in 1704. He went to Corpus Christi College Oxford in 1720 and graduated BA (Bachelor of Arts) in 1725 and DCL (Doctor of Civil Law) in 1733. Already in 1725 he was appointed Precentor, one of the Canons, at Lismore cathedral in Ireland.

Immediately after gaining his doctorate in 1733 he started on his series of foreign tours, which continued until 1741. These tours, together with those of Milles who accompanied him on some of them, are treated separately below. He was made a Fellow of the Royal Society in the year of his return from his travels, perhaps in recognition of their value. It is probable that he was awarded an honorary LL D

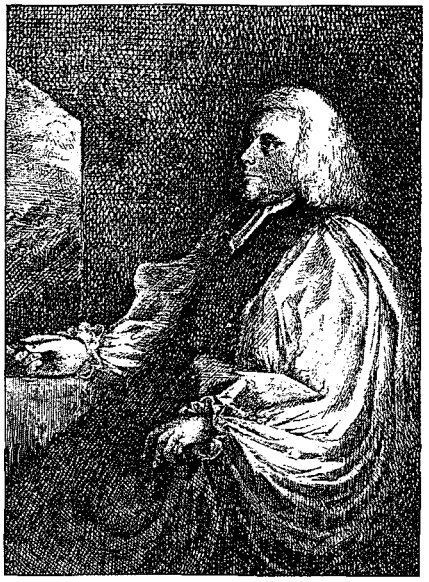


Fig. 9: Richard Pococke in later life (from Pococke 1887). A younger portrait is reproduced in fig. 11.

(Doctorate of Laws) for the same reason, for he uses this degree on the title page of his book in 1743, rather than DCL.

In 1744, when his first series of travels was over and his book written, he was made Precentor of Waterford cathedral. Then in 1756 he became Bishop of Ossory, also in Ireland. In July 1765 he was appointed Bishop of Meath but a few months later he died, on 25 September (Anon. 1765; Kemp 1887; Foster 1891; Wroth 1896).

MILLES

Jeremiah Milles (Fig. 10) was Pococke's cousin. He was born in 1714, probably in Cornwall. In 1729 he entered Corpus Christi College, Oxford, becoming BA in 1733 just before his travels with Pococke, and DD (Doctor of Divinity) in 1747. From 1735 to 1745, as a priest, he was Treasurer of Lismore cathedral and for much of this time he was also Precentor at Waterford. In 1747 he was made Precentor of Exeter cathedral (England), a post he retained until he was appointed Dean there in 1762. Milles was interested in archaeology from an early age, being elected Fellow of the Royal Society in 1742 and becoming president of the Society of Antiquaries in 1768. He died in London on 13 February 1784 (Courtney 1894).

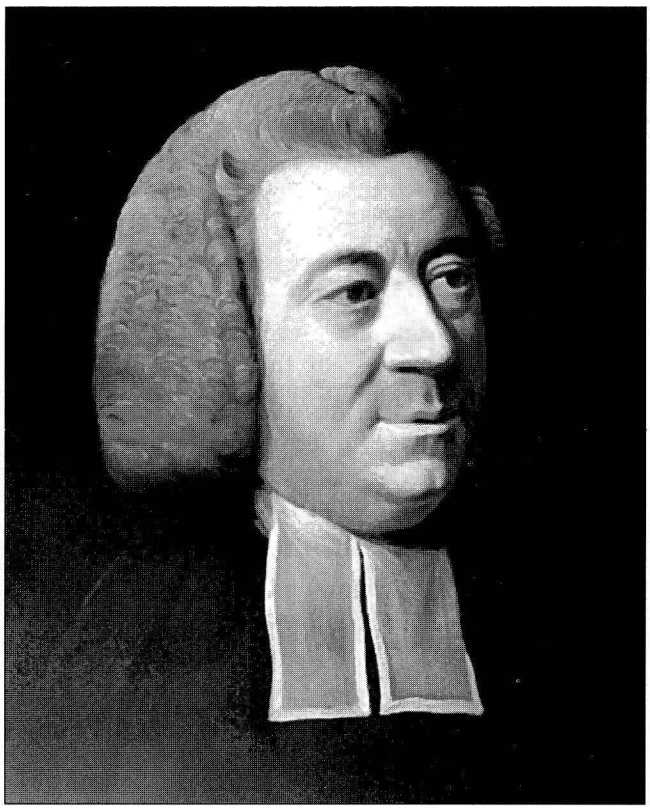


Fig. 10: Jeremiah Milles in later life. An oil painting by Nathaniel Dance, or a later copy of it, in the collection of the the Society of Antiquaries of London and reproduced with their permission. His strange wig was apparently so notorious as to attract a humorous cartoon in The Gentleman's Magazine (Anon. 1782).

THEIR TRAVELS

Before coming to their Slovenia visit of 1737 and their exploration of Škadavnica and other caves there, it is useful to summarize Pococke and Milles's other travels, and to review the extent of their interest in caves elsewhere. In this way the characters and interests of the two men should become apparent.

Their first tour abroad was in France and Italy, from September 1733 to July 1734. Thus they were about 29 and 19 years old respectively when they set out from England. Milles had just left Oxford and Pococke had gained his doctorate in the same year. In the summer of 1735 Milles alone travelled in central and eastern England.

Then came their major tour together which included Slovenia and from which Pococke (1743-45) continued alone to Egypt and the Middle East. They left England on 31 May 1736 and travelled through Belgium, Holland, Germany, Bohemia, Hungary, Austria, Italy, Slovenia and Istria to Italy again. From there Pococke sailed from Livorno for Alexandria on 18 September 1737, and Milles (1737a; 1737b) returned over the Brenner Pass and through Austria, Germany and Belgium to Dunkerque (29 November 1737) and London. Pococke meanwhile landed in Egypt in October and spent the next four years travelling there and in the region which is now Israel, Lebanon and Syria, in Cyprus, Crete and the Greek islands, and then through Turkey, Greece, Italy, Germany, Switzerland, France, Holland and Belgium, reaching London on 10 September 1741. So enthusiastic had Pococke become after travelling in the Middle East that he had his portrait painted in Turkish dress (Fig. 11).

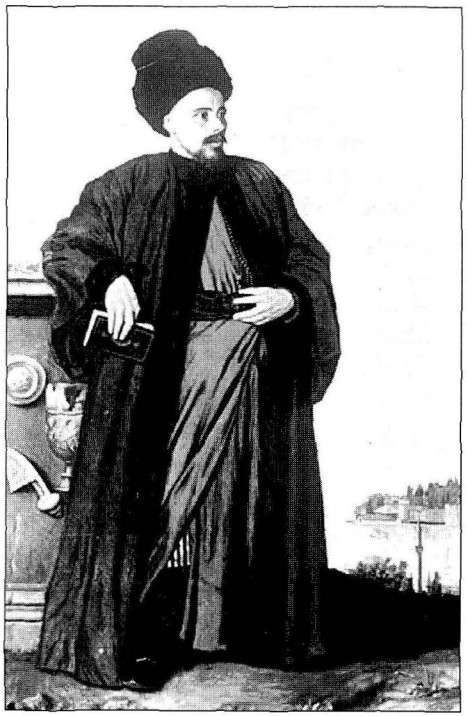


Fig. 11: Richard Pococke in Turkish dress. Probably painted in 1740 when he and the painter were both in Constantinople, it shows him three years older than when he was in Slovenia. An oil painting by Jean-Etienne Liotard in the Musée d'Art et d'Histoire at Geneva and reproduced with their permission.

At the time of these travels, dates were sometimes reckoned by the Old Style (Julian) calendar, and sometimes

by the New Style (Gregorian) calendar used today which was not formally adopted in Great Britain until 1752. In the New Style calendar the same day had a date eleven days žlater' than it did by the Old Style. Pococke and Milles used both forms in their writings but in this paper all have been converted to New Style.

Later in life Pococke (1887; 1888) made several series of tours in the British Isles visiting many parts that were little known and describing them accurately in his diaries. His travels in England were made mainly between 1750 and 1757, with a few later. Irish tours took place in 1749, 1752 and 1758; and he visited Scotland in 1747, 1750 and 1760.

Milles (1735-43), too, explored parts of Great Britain, but less extensively than his cousin. Between 1738 and 1743 he made several tours in southern and western England and in Wales, but there is no record of his going further afield.

THEIR INTEREST IN CAVES

As will be seen shortly, the caves that Pococke and Milles found in Slovenia in 1737 occupied a great deal of their attention. The earlier parts of their European travels seem to have resulted in no such visits and it is likely that they had not, by that stage, seen any of the British caves. Not only had neither of them made any extensive tours in Britain, but they never compared what they saw in Slovenia with caves they had known at home, as travellers so often did. Cadell (1820), for example, likened Vilenica jama with Peak Cavern in Derbyshire; and Pococke (1751) in his later tours compared caves in the north of England with two he had seen previously in the Midlands.

Nevertheless when they passed near the Drachenloch at Mixnitz on 13 June 1737, only a few weeks before arriving in Slovenia, they were sufficiently interested to comment on it and to regret that they were unable to explore it.

In the later stages of his tour Pococke visited several caves and it seems that he made a point of enquiring if there were any to be seen. On 23 June 1738 he went into a cave 29 km south-east of Tripoli in the Lebanon, comparing the stalactites in it with those "in the grots of Carniola". In Crete the following year he explored a small cave on Mount Ida (7 September) and a larger stalactite cave near Hania on 24 September. The ice cave of Grace Dieu near Besançon in France was visited in June 1741.

The very fact that the caves in Slovenia were described in such detail in Pococke's (1743-45) published book is evidence of the interest they held for him, for in this *Description of the East, and some other countries* only about 140 pages out of a total of 886 are devoted to his crossing the whole of mainland Europe, and many parts of his journey are not described at all.

In England Pococke (1750; 1888, p.152-3) went into Wookey Hole in Somerset on 22 October 1750. On 24 and 28 May of the following year

(Pococke 1751 ff.17-19; 1888 p. 192, 196-8) he visited several caves in western Yorkshire - Boreham Cave, Dowkabottom Cave, Weathercote Cave, Jingle Pot, Hurtle Pot, Yordas Cave and Tatham Wife Hole, though of these it was only Boreham and Yordas that he actually entered. Jingle Pot and Yordas he compared with Eldon Hole and Peak Cavern respectively, as if he had seen these previously. He may have done this when he was in Derbyshire in 1743 but his manuscript record of that journey, formerly "in the possession of an Irish gentleman" (Kemp 1887), cannot now be traced.

The Scottish cave of Smoo, a limestone cave on the extreme northern coast of Sutherland, was seen at the end of June 1760 and the then celebrated stalactite cave at Slains in Aberdeenshire a month later (Pococke 1887).

Milles did much less travelling than Pococke after their two European tours together. In England he seems not to have visited the limestone areas of Derbyshire and northern England, and when he was in Somerset his travel diary makes no mention of Wookey Hole. Nevertheless his name is coupled with early records of caves in Devon, the county surrounding his cathedral at Exeter. He accumulated information about Devon with the intention of producing a history and description of it. This was never published but the manuscript materials for it still exist in the Bodleian Library at Oxford. The answers to a series of questionnaires he sent out (Milles c.1750) are supplemented in the draft text written in his own handwriting (Milles c.1760). The latter includes references to caves which Milles himself had explored in Buckfastleigh and the nearby village of Dean Prior.

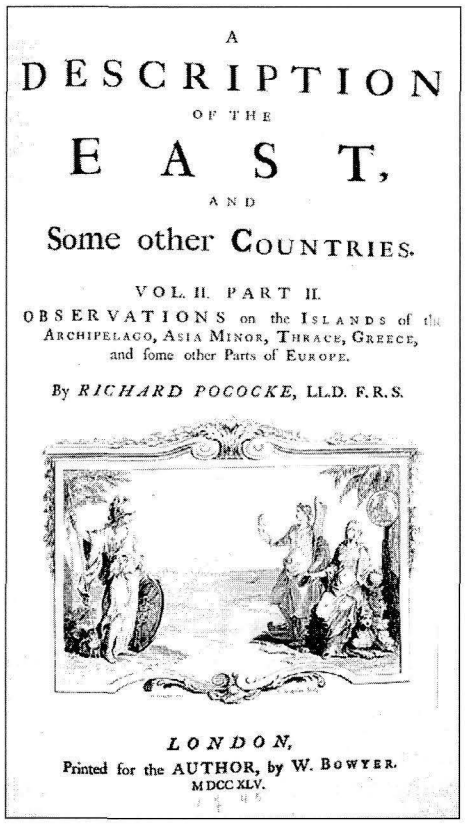
His continuing interest in caves is again shown by two letters he wrote in 1775 and 1776 to George Catcott, commenting on the draft of Catcott's (1792) book on Penpark Hole at Bristol. The letters were printed with the book.

SLOVENIA JULY 1737

The Sources

As with much of the travels made jointly by Pococke and Milles between 1733 and 1737, there are four sources of information on the Slovene part of their tour. These supplement and complement each other, as well as (sometimes) copying one from another.

The most accessible source is Pococke's published book (1743-45) (Fig. 12), most of which is devoted to his travels in Egypt and the Middle East, together with Cyprus, Crete and parts of Greece. Physically it is a large and impressive book, consisting of two folio volumes 42 cm in height and containing almost 900 pages besides maps and illustrations. As already mentioned, it contains a much fuller account of the visit to Slovenia than it does of most of the travelling in mainland Europe, but the dates of particular visits are often not stated in it. The English edition was followed by a German translation (Pococke 1754-55), a French translation (1772-73) and then a Dutch translation


A
DESCRIPTION
OF THE
EAST,
AND
Some other COUNTRIES.

VOL. II. PART II.
OBSERVATIONS on the ISLANDS of the ARCHIPELAGO, ASIA MINOR, THRACE, GREECE, and some other Parts of EUROPE.

By *RICHARD POCOCKE*, LL.D. F.R.S.

LONDON,
Printed for the AUTHOR, by W. BOWYER.
MDCCXLV.

Fig 12: The title page of the volume of Pococke's book which describes the journey in Slovenia.

published at Utrecht in 1776-86. So the travels were widely known throughout Europe.

Of the manuscript sources the most detailed is Pococke's 'Journal of Travels' between 1733 and 1741, in 19 volumes, of which volume 16 (Pococke 1737) describes the journey through Slovenia and includes the detailed description of the Škadavnica cave printed here as an Appendix (pp. 000-000). Again, though, precise dates are often lacking. The letters that Pococke (1736-37) wrote to his mother have far less detail but do furnish reliable dates.

Milles's main travel diary (1736-37a) ends on 10 June 1737, just before arrival in Slovenia. But his volume of letters written to the Bishop of Waterford (Milles 1736-37b) covers the Slovene visit, providing considerable detail in places, and also dates. Although these sources differ in many ways it so happens that the descriptions of the caves around Postojna are almost identical in three of them, for the printed book is based on Pococke's journal, which in turn is copied from Milles's letters to the Bishop. Not so for the Škadavnica accounts, which are different (but not conflicting) in all the sources.

Carmichael (1991; 1992) has commented on their principal interests in Slovenia which she regards as mainly botany and architecture, and on the different styles of their writing.

The Journey

The two men entered Slovenia from Gorica on 7 July 1737 and travelled through Vipava to the mercury mines at Idrija, as most travellers did at that time. Thence they continued to Vrhnika (10 July) and, because the road to Ljubljana was so bad, they went there by boat down the Ljubljanica river, arriving at Ljubljana on 11 July. It was in the course of a four day excursion from there to Celje and back (Fig. 1) that they visited the Škadavnica cave,

Pococke's account of which (1737, ff.120-122) is considered later. Then they went to Cerknica (18 July) and stayed there for two days, giving a detailed description of the lake and its water sinks, followed by a short visit to Rakov Škocjan. At Planina (21 July) they saw the entrance of Planinska jama though the water was too high for them to enter, and on the same day they explored the main Predjama cave beneath the castle. On the following day they saw both Postojnska jama and Črna jama.

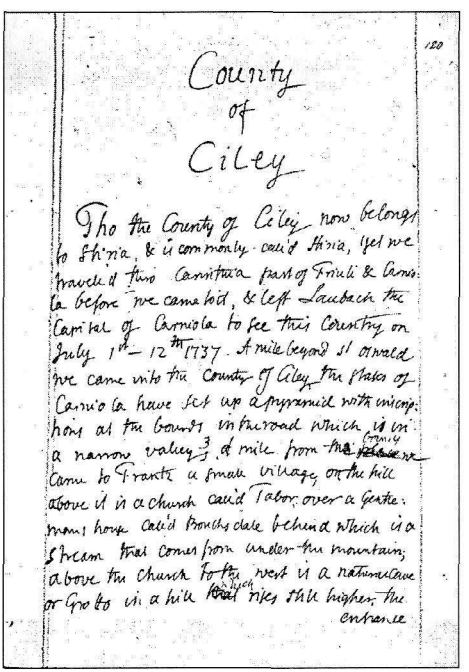
Overall, five of the eighteen days they spent in Slovenia were occupied in visiting caves including those at Cerknica. Of the 45 pages of Pococke's diary devoted to Slovenia, eleven describe caves and karst phenomena.

They left Slovenia and arrived in Trieste on 23 July, having travelled across the Classical Karst for most of the previous night "for coolness". Two days later they went by boat to Koper, and the next day on to Izola and Piran en route to Pula. Having returned to Trieste on 3 August, they visited Socerbska jama a few kilometres to the east, either the next day or the day after, noting the presence of stalactites and an altar (Milles 1736-37b, f.120v). On 6 August they left Trieste for the last time, looking at the Timavo rising Duino on their way on into Italy.

VISIT TO ŠKADAVNICA

The description of Škadavnica cave and of their visit to it in Pococke's manuscript journal is printed complete as the Appendix to this paper, and one page is reproduced in facsimile as Fig. 13.

The one fact which Pococke does not supply — namely the date of the visit — is provided from Milles's letters. They had left Ljubljana on 12 July and travelled via Trajaniberg [Trojane] to Frantz [Vransko] where they stayed the night. Then "the next morning [13 July] we saw a Grotto in the mountain pretty large and curious, but not abounding much with petrifactions." (Milles 1736-37b, f.92v). They went on to Celje the same day. The road from Ljubljana to Celje, then as now,


120

County
of
Cilley

Tho the County of Cilley now belongs to Stiria, & is commonly call'd Stiria, yet we travell'd thro Carnitia part of Friuli & Carniola before we came to it, & left Laubach the Capital of Carniola to see this Country on July 1st – 12th 1737. A mile beyond it we came into the County of Cilley the States of Carniola have set up a pyramid with inscriptions at the bounds on the road which is in a narrow valley ½ a mile from the [illegible] we came to Frantz a small village, on the hill above it is a church call'd Tabor, over a Gentleman's house call'd Boutsdale behind which is a stream that comes from under the mountain, above the church to the west is a natural cave or Grotto in a hill about sixty feet higher, the entrance

Fig. 13: Part of Pococke's detailed description of the Škadavnica cave on f.120 of his journal, vol. XVI, reproduced from the British Library Add. MS.22993 with their permission. The date "July 1st - 12th" is given in both the old and new styles.

suffered from heavy traffic and the road had been improved in 1728, just nine years before their visit (Natek 1976b).

Before considering Pococke's (1737) detailed description of the visit to the Škadavnica cave, the statements made about it in the other two sources are printed here for completeness.

In his published book, Pococke just records:

... saw a grotto at Frantz, where there are some curious petrifactions; but we could not find that it had any communication with the rivulet below it ...

(Pococke 1743-45 2(2), p.254)

And in his letter to his mother he wrote:

We went to see a natural Grotto in the side of a hill about 100 feet diameter and very curious, where we saw many stalactities or stone's like isicles formed by the dropping of the water; when broke it is like Alabaster, & one was large & rise up like a pillar to the top of the Grott.

(Pococke 1736-7, f.64v)

It is to be noted that this was written before he had seen the stalactities in Črna jama nine days later. Nevertheless the pillar, which is mentioned also in his fuller account, must have been quite impressive. It does not exist now.

As Pococke's (1737) entire journal account is printed in the Appendix, it is necessary here only to note those points that require comment such as those by which the identity of the cave has been confirmed.

(f.120) ... we came to Frantz [Vransko] a small village on the hill above it is a church call'd Tabor, over a Gentlemans house call'd Bouchsdale behind which is a Stream that comes from under the mountain;

The "Gentlemans house" is the house at Podgrad, Podgrajska graščina, shown on the map (Fig. 2). Its present appearance (Fig. 6), compared with the view engraved by Vischer (1681) (Fig. 14), shows that it has not greatly changed in three centuries. No doubt Vischer's picture is the closer representation of what Pococke and Milles saw. "Bouchsdale", recorded by Pococke as the name of the house, would be his understanding of the old German word Burckstal, which is what Vischer called it. The "Stream that comes from under the mountain" is the Podgrajščica, emerging from Pogreška jama.

The position of the "natural cave or Grotto in a hill which rises still higher ... above the church to the west" (f.120) is consistent with that of Škadavnica on the slope of Medvedica (604 m compared with 428 m for the church Tabor). The cave entrance is described as "about fifteen feet [4,6 m] wide & eight [2,4 m] high" (f.121), which is not significantly different from the 5 m by 3 m of the 1973 survey. "the cave seems to be about a hundred feet [30,5 m] in diameter being round" compares quite well with its measured dimensions of

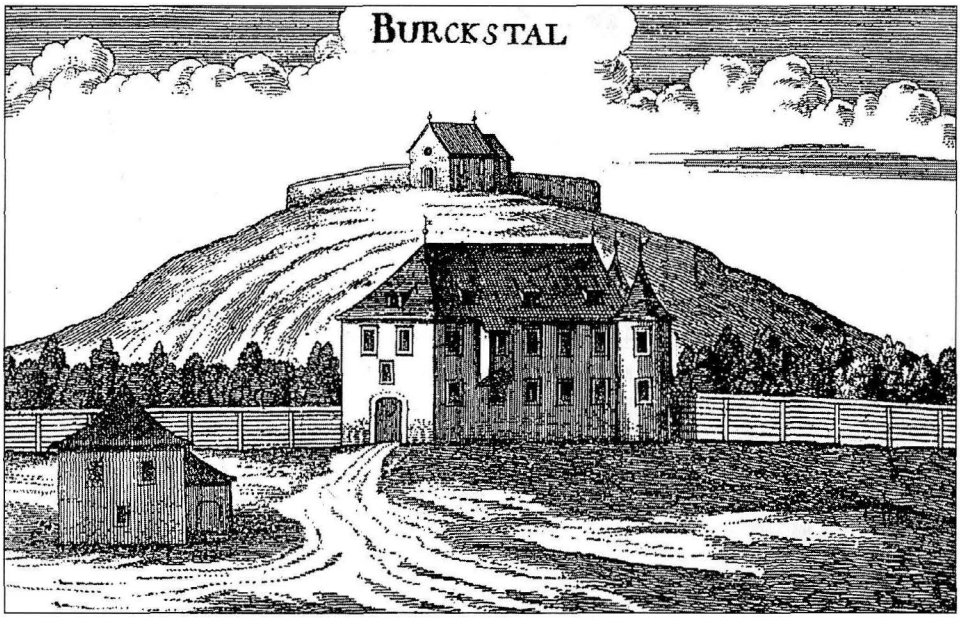


Fig. 14: Podgrajska graščina in 1681. An engraving by J. M. Vischer.

34 m by 41 m. Again, the "confus'd heap of great stones" on the floor and the "rough [ceiling], as if those stones had fallen from it" is a fair description of Škadavnica. The statement that "there are several holes & cavities round it especially three larger than the rest", matches with the holes shown in the 1973 plan (Fig. 3). The word "crow", to which Pococke likens some of the stalactites, is an obsolete English word meaning the membranes which secure the intestines within the abdomen of a pig or other animal. The evidently greater quantity of stalactites in 1737 than now is what would be expected of a cave known to the people of the local town, even if it were only occasionally visited by foreigners who brought away "one peice growing like a Coley flower [cauliflower] but in the shape of a Cone." (f.122).

CONCLUSION

Pococke and Milles's exploration of the Škadavnica cave is significant for two reasons.

Firstly, any previously unpublished information about a cave deserves being made accessible. It is particularly significant, at least in a local context, when it doubles the length of time since the previous earliest record of any cave in the region and more than doubles the period for which the cave itself has been known.

More generally, the interest which Pococke and Milles showed in caves, visiting most of the recognized tourist caves in Slovenia and even going out of their way to see a small and not very impressive cave, demonstrates that there were some highly educated travellers who regarded such natural phenomena as important and worth their attention. In this way they were somewhat similar to Edward Brown (1673) whose description of the Cerknica lake and the Idrija mine are well known. Many of the better-known early reports of caves had been either as part of a deliberate regional survey, as in Valvasor's *Die Ehre dess Hertzogthums Crain* (1689) or compiled on royal instructions as were those of Strein in Austria in 1592 (Schallenberg 1592; Schmidl 1857), and Nagel (1747) in Austria and (1748) in Moravia and Carniola.

Very many travellers had only the conventional interests of more conventional educated men, in art, architecture and antiquities — the subjects which were originally chosen to further the education of young men travelling with their tutors on the Grand Tour of parts of Europe.

It is the breadth of Pococke and Milles's interests which is important to the history of foreign travellers, while it is their specific interest in caves and other karst phenomena that is important for the historian of karst studies and of caves in Slovenia.

ACKNOWLEDGEMENTS

I am grateful to Tone Vedenik and members of the Jamarski Klub "Črni galeb" of Prebold for relocating the entrance of the Škadavnica cave and for taking me to it. They have also permitted reproduction of their 1973 survey with this paper. My colleagues in the Karst Research Institute at Postojna have helped, especially by accurate determination of the entrance position (Franjo Drole), taking photographs (Jurij Hajna), preparing the map for publication (Leon Drame) and for finding much of the 20th century literature (Andrej and Maja Kranjc). The staff of the British Library in London, which holds the 18th century diaries quoted here, have been their usual helpful and efficient selves.

APPENDIX

POCOCKE'S ACCOUNT OF THE VISIT TO ŠKADAVNICA CAVE ON 13 JULY 1737

FROM HIS MANUSCRIPT JOURNAL (BRITISH LIBRARY ADD. MS.22993)

Came to Frantz a small village, on the hill above it is a church call'd Tabor, over a Gentlemans house call'd Bouchsdale behind which is a Stream that comes from under the mountain; above the church to the west is a natural cave or Grotto in a hill which rises still higher, the entrance to it is about fifteen feet wide & eight high, it is a descent & the cave seems to be about a hundred feet in diameter being round, it is at bottom a confus'd heap of great stones, & the top is rough, as if those stones had fallen from it by some accident as an earth quake or a unhingin of the ground under, there are several holes & cavities round it especially three larger than the rest into which we went & saw the furthest extent of 'em being not above 4 or 5 yards, all over the Grotto are Stalactites or Stone made by the droppings of the water, but there are more in the holes than in the other part of the Grot, & one always sees the water dropping in several parts; some of these are of the Stalagmate kind that on the stones rising up about an inch & look like tallow growing cold, Some rise up like a cone, one to a good heigth, & large like a pillar broke off. & there is a pillar yt [= that] rises up to the very top as if it supported the arch, some are like Icicles hanging from the vault, & some hangs about six or eight inches deep for six or seven feet exactly like what is calld the crow in the entrails of swine, & is transparent, all this stone being of the nature of Alabaster is brittle & shining; we examin'd this Grotto very nicely because they said there was a hole which went down to the notch[?] by the Gentle mans house, before mentiond, & that a bull had fallen in & came out at that place, all which we found to be false, & concluded it was only a story to frighten children, & prevent the danger of breaking their legs or bones by going in which they might easily do; we brought away of the stalactites, particularly one peice, growing like a Coley flower but in the shape of a Cone. When we left Frantz the next day we came into the fine plain in which Ciley [Celje] stands.

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KAKO STA ANGLEŠKA POPOTNIKA 1737 RAZISKOVALA JAMO ŠKADAVNICO

Povzetek

Manjša jama Škadavnica leži 1,5 km SZ od Vranskega, med Ljubljano in Celjem v Sloveniji. Sestavlja jo en sam podzemlejski prostor, velik 41 x 34 m. Do sedaj se je mislilo, da je prvi dokumentiran obisk jame iz 902, ko so v njej lovili jamske živalice. Enako se je verjelo, da je prva jama, ki je omenjena v literaturi iz SV Slovenije, jama Pekel okoli 1860.

Ta prispevek predstavlja in tudi ponatisuje podrobni zapis o obisku dveh angleških popotnikov 13. julija 1737. To sta bila Richard Pococke (1704-1765), kasnejši škof v mestu Ossory in kasneje v Meathu na Irskem, in Jeremiah Milles (1714-1784), kasneje dekan v angleškem mestu Exeter. Popolnejši opis njunega obiska, ki je ponatisnjen v dodatku, je iz Pocockovega popotnega dnevnika v rokopisu (1737), je pa na kratko omenjen tudi v njegovi knjigi (1743-45) in v njegovih (1736-37) ter njegovega tovariša Millesa (1736-37 b) pismih.

Moža sta že prej, od 1733 do 1734, potovala skupaj. Slovenijo sta obiskala med potovanjem, ki sta ga pričela 1736 in na katerem sta obiskala velik del celinske Evrope. V Sloveniji sta bila 20 dni, med 7. in 23. julijem ter ponovno 25. in 26. julija ter 4. ali 5. avgusta. Pot ju je vodila preko Gorice v Idrijo, Ljubljano, Celje, v Cerknico, v Postojno in iz Trsta v Koper, Izolo Piran in na Socerb. Posebej ju je zanimalo Cerkniško jezero in 4 jame v okolici Postojne, o katerih sta pisala veliko več, kot pa o drugih krajih, ki sta jih obiskala. Konec leta 1737 se je Milles vrnil domov, medtem ko je Pococke šel še v Egipt, Izrael, Libanon, v Turčijo, Grčijo, na Ciper in na Kreto, preden je odpotoval preko Evrope nazaj v London, kamor se je vrnil 1741. Da ga zanimanje za jame ni minilo, dokazujejo misli na jame tudi v drugih deželah. Tudi na kasnejših potovanjih po Angliji in Škotskije obiskal več jam daleč izven njegove poti. Tudi Milles je ohranil zanimanje za jame.

Njuno zanimanje za jame ni pomembno le za krasoslovce. ampak tudi kot primer redkih popotnikov, ki so se zanimali tudi za druge zanimivosti, ne le ustaljeno za umetnost in starine.

Pocockov opis Škadavnice je zelo podroben in natančen, tako da jame, ki jo je videl, ni težko določiti po legi, merah in opisu. Tak natančen opis je nenavaden za tedanje čase. Poleg tega je obiskal tudi razmeroma majhno jamo brez posebnosti zgolj v lastno zabavo. Poleg Škadavnice si je ogledal tudi kraški izvir Pogreško jamo ter omenja graščino Podgrad (Burgstall), ki je še vedno bolj ali manj taka, kot jo je videl Pococke.

REMARK:

In April 1996, after the above paper was written and while revising the plan for publication, F. Drole of the Karst Research Institute ZRC SAZU found several fragments of pottery in a narrow passage leading from among the breakdown blocks at the NW side of Škadavnica Cave. After cleaning and treating them we established that they all belong to one pot. The partly preserved pot has a lip inclined outwards and its edge is shaped. The pot's shoulders are slightly embossed. The clay contains a lot of sand and is well baked. The colour outside and inside passes irregularly from grey-brown to black. The outer surface of the pot is decorated by a comb or twig brush before being baked. Due to its shape and decoration the pot may be dated as of Late Antiquity between the 4th and 5th centuries.

(By Alma Bavdek, Museum of Postojna)



Fig. 4: The entrance of Škadavnica cave, October 1997 (phot. J. Hajna, IZRK collection).



Fig. 5: The main chamber of Škadavnica (phot. J. Hajna, IZRK collection).



Fig. 6: Podgrajska graščina, 3 October 1995 (phot. J. G. Shaw).



Fig. 7: The rising at Pogreška jama, behind Podgrajska graščina, October 1997 (phot. J. Hajna, IZRK collection).

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ROBERT TOWNSON, TRAVELLER IN HUNGARY IN 1793 - HIS LIFE AND WORK

ROBERT TOWNSON, POPOTNIK PO MADŽARSKEM LETA 1793 - NJEGOVO ŽIVLJENJE IN DELO

TREVOR R. SHAW[1]

Izvleček UDK 55(439)(091):929 Townson R.

Trevor R. Shaw: Robert Townson, popotnik po Madžarskem leta 1793 - njegovo življenje in delo

Robert Townson (1762 - 1827) je študiral medicino, kemijo in naravoslovje na univerzah v Edinburgu, Parizu, Dunaju in Göttingenu in bil imenovan za častnega doktorja prava v Edinburgu leta 1796. Bil je na petmesečnem potovanju po Madžarski in Slovaški ter leta 1797 objavil knjigo Travels in Hungary. V tem delu opisuje jame pri Aggteleku, na Silicki planini ter brezna v Alsó-hegy. Dodana je tudi geološka karta, sestavljena na podlagi Townsonovih lastnih opazovanj. 1798 in 1799 je izdal še deli geološke in naravoslovne vsebine. 1807 se je izselil v Avstralijo.
Ključne besede: Townson, speologija, geologija, zgodovina, biografija, objave, Madžarska, Slovaška, Baradla, helektit.

Abstract UDC 55(439)(091):929 Townson R.

Trevor R. Shaw: Robert Townson, traveller in Hungary in 1793 - his life and work

Robert Townson (1762 - 1827) studied medicine, chemistry and natural history at the universities of Edinburgh, Paris, Vienna and Göttingen and he was made an honorary Doctor of Laws by Edinburgh in 1796. He made the 5-month journey in Hungary and Slovakia which resulted in his Travels in Hungary (1797). Besides describing the caves at Aggtelek and Silica, and mentioning the Alsó-hegy shafts, this book contained a very early geological map, prepared by Townson from his own observations of rocks. Other books on geology (1798) and natural history (1799) followed. Then in 1807 he emigrated to Australia.
Key words: Townson, speleology, geology, history, biography, publications, Hungary, Slovakia, Baradla cave, helictite.

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INTRODUCTION

Robert Townson's book Travels in Hungary... (1797a) is well known in Central Europe for its account of his visits to caves in Hungary and Slovakia.

The extracts containing the descriptions of Baradla cave at Aggtelek, the Silica ice cave and the open shafts in the Alsó-hegy plateau have frequently been reprinted (e. g. in Dénes 1972; and Hadobás 1991; 1992) with topographical and speleological comment. For convenience, and to make Townson's text more widely accessible, they are reprinted here as Appendix I.

There has previously been little written on Townson's geological background, and much of the biographical information provided has been incorrect.

Indeed, Townson's life has hitherto remained something of a mystery. What has been published about him in Europe has been largely wrong and seriously incomplete. His place of birth, for example, is recorded in The Dictionary of National Biography (Carlyle 1899) as "probably... Yorkshire", with no year given. Britten & Boulger (1914; 1931), Desmond (1977) state that he was born in Shropshire, again with no year. Goodin (1967) has him born in 1763; Hadobás (1992) states "He died in 1799". None of these 'facts' is true.

This paper therefore concentrates on his life, work and travels. In so doing it adds 28 years to the life previously recorded in European biographical dictionaries, takes him to a successful new career in another continent, and provides a portrait.

A further intention is to provide a fuller picture of Townson himself - his interests, abilities and achievements - so as to throw more light on the man that travelled in Hungary, the quality of his observations there and the authority with which he wrote on geological matters.

BIRTH AND YOUTH, 1762-1782

The clue to new sources of information on Townson's life came to the present author when he was using the much revised second edition of A Biographical Index of deceased British and Irish Botanists (Britten & Boulger 1931). Here, unlike the entry in the first edition of 1893 (one of the sources of the erroneous entry in the Dictionary of National Biography), is the key phrase "d[ied] Australia". No date of birth was given and much of the other information was incorrect but that one simple statement led to the examination of Australian publications and other sources in Australia. In the course of this, I learned that my friend Dr Hugh Torrens, geologist and historian of science at the University of Keele, was already aware of Townson's Australian existence and had done extensive research in the course of preparing a revised entry for The Dictionary of National Biography (as yet unpublished). Much of the biographical information in this paper is derived from his published work.

Robert Townson was born, not in Yorkshire or in Shropshire, but in

Richmond near London. Vallance & Torrens (1984) have investigated parish registers of baptisms, an act of parliament and family divorce papers, and establish that:

Robert Townson was born between January and March 1762 at Spring Grove, Marshgate, Richmond, Surrey and baptised there on 4 April 1762. His parents were married well over four years later at Richmond on 23 December 1766. His father John (c. 1720-1773) was a London merchant and insurer; his mother Sarah Shewell (1731-1805) came from a family with... connections with London brewing and publishing companies.

Robert's father died when he was only ten years old. He served an apprenticeship in Manchester and then, from 1777, lived with his brother-in-law, the Rev. John Witts (1750-1816), at Cardington near Church Stretton in Shropshire.

UNIVERSITIES AND EUROPEAN TRAVEL, 1783-1795

From 1783 to 1787 Townson travelled on foot through France and Italy to Sicily, and on his return from there he attended lectures in Paris on chemistry and probably on mineralogy also.

In December 1789 he enrolled as a medical student at the University of Edinburgh, where he remained for two years without taking a medical degree. Later, however, on 11 April 1796, he was made an honorary Doctor of Laws (LL. D.) by that University (Jo Currie, pers. comm. 1994, quoting the Senate Minutes). This is likely to have been in recognition also of his achievements elsewhere in Europe by the university of what had then become his 'home' town. This LL. D. degree was printed after his name on the title pages of all his books. While at the University he joined the student Natural History Society, appearing on the membership list of 7 January 1790 and presenting two papers on local geology which will be referred to again later, along with his other publications. In 1791 he was elected a Fellow of the Royal Society of Edinburgh, an honour he also used on his title pages.

The influence on Townson of his friends and teachers at Edinburgh will be referred to at the end of this paper. In 1791 they recommended that he be appointed as naturalist to accompany a new Lieutenant-Governor to Canada. This did not happen so he travelled in Europe again, via Uppsala (Sweden) and Copenhagen (Denmark) to Göttingen (Germany). There he enrolled as a student in the Department of Natural History on 19 December 1791 (Selle 1937, and Ulrich Hunger, pers. comm. 1994). Although The Dictionary of National Biography (Carlyle 1899, Desmond 1977) credit him with becoming a Doctor of Medicine there in 1795, and the Australian Dictionary of Biography (Goodin 1967) states that he was made a Doctor of Civil Law (DCL) there in the same year, Hunger (pers. comm. 1994) says that there is no evidence for either degree; furthermore the absence of any leaving certificate suggests that

he did not take any degree there at all. It is significant that neither MD nor DCL degrees are printed on the title pages of his books.

During his three and a half years at Göttingen University, Townson spent the winter of 1792-93 in Vienna, where he studied the respiration of amphibia. A paper written there on that subject, and another completed later in Göttingen, where later published. Leaving Vienna on 5 May 1793, he set off on his Hungarian travels, returning in the middle of October. The Hungarian tour, his geological observations there, and the resulting book, are considered separately.

WRITING, 1795-1806

In May 1795 Townson returned home from Göttingen to Edinburgh. He worked there on his Hungarian book and attempted, unsuccessfully, to get himself appointed by the East India Company to study the physical geography, mineralogy and natural history of India (Townson 1797a, p. vi; 1799, p. 150). It was at this time, as already mentioned, that his honorary LL. D. was awarded by the University of Edinburgh. His Travels in Hungary... was published in 1797 and two other books, also discussed later, in 1798 and 1799. After this he started preparing a "County History of Yorkshire", but it was never published.

AUSTRALIA, 1807-1827

When his mother died in May 1805 Townson decided to emigrate to Australia. His elder brother John (1760-1835) had served in New South Wales as a military officer from 1790 (Austin 1967) and returned there as a settler in 1806. Robert followed him, arriving in July 1807. As a naturalist and scholar, and known to the influential Sir Joseph Banks who had accompanied Captain Cook's expedition round the world in 1768-71, he was promised grants of land and also given a sum of money to buy books and laboratory equipment for use in the still young colony (where the first settlers had landed only 18 years before). Strangely, the then Governor of New South Wales (William Bligh, who had been on Cook's third voyage and is known as victim of the Bounty mutiny at Tahiti in 1789) seemed opposed to Townson. The promised grants of land were not made and his scientific work was hindered (Goodin 1967). Thus alienated, he joined other influential and dissatisfied settlers in forcing the deposition of Governor Bligh. Bligh's replacement, Lachlan Macquarie was governor from 1808 to 1821 and his name is remembered in the Macquarie River and Macquarie Island. The grants of land were at last made in 1810, and Townson established a farm at Varroville, near Sydney, as described later.

Perhaps still affected by the treatment he had received from Bligh, Townson

seemed to lose almost all interest in scientific matters, and became discontented and unsociable. Many letters of this period are in the Mitchell Library in Sydney. He devoted himself almost exclusively to developing his farm, where he raised cattle and sheep, planted experimental crops and established a thriving vineyard (Anon. 1827; 1963: Leister, pers. comm. 1995). He was associated with the Philosophical Society in Sydney about 1820 (Finney 1993) but this was more a social club for those opposed to Governor Macquarie than a learned society.

When Macquarie left in 1821, Townson became a more normal member of the community. He was vice-president of the Agricultural Society of New South Wales (Goodin 1967) and worked on its committees, he supported the foundation of a Sydney Dispensary to provide free medical attention for the poor, gave dinners at his home, and in 1826 was appointed a magistrate.

He died at Varroville on 27 June 1827, aged 65, and was buried on 2 July at Parramatta.

PORTRAIT

An oil painting of Robert Townson in his later years (Fig. 1) was made by Augustus Earle (1793-1838), who a few years later was the artist in HMS Beagle during her South American voyage with Darwin. The picture is undated but must have been painted between 1825, when Earle arrived in Australia, and 1827 when Townson died. It was presented to the Australian Museum in 1873 and transferred to the Mitchell Library, in the National Library of New South Wales, in 1961. Although untitled, the recorded identity of the sitter is supported by the lettering on the spines of the books on the table by his right hand, all of which were written by him.

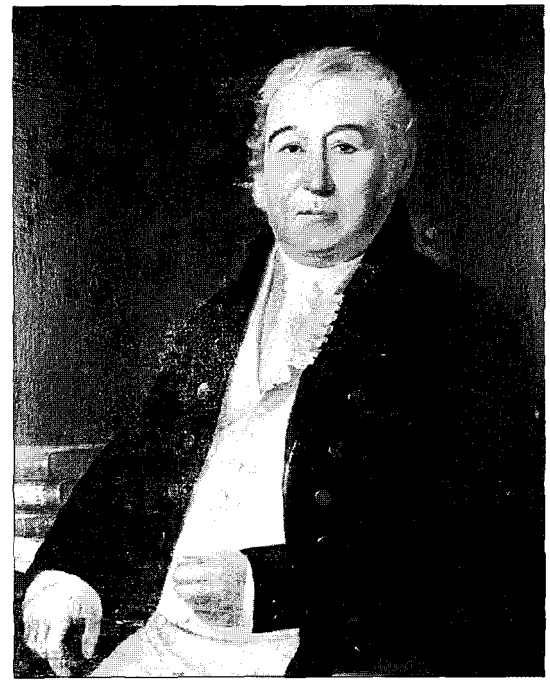


Fig. 1: Robert Townson between 1825 and 1827, a portrait by Augustus Earle. Oil painting 81,3 x 64,5 cm. Reproduced by permission of the Mitchell Library in Sydney.

VARROVILLE, HIS HOME IN AUSTRALIA

The delayed grants of land near Sydney were made by Governor Macquarie in 1810 (Anon. 1963), but there still was some further administrative delay after that. The area granted, on which Varroville was built and the farm created in the present-day district of Minto on the south-west outskirts of Sydney, was 1000 acres (404,7 hectares) and there was more land near Botany Bay. Macquarie visited the place in 1810 and remarked in his diary that Townson's land and some more nearby "are by far the finest soil and best pasturage I have yet seen in the Colony" (Anon. 1963). Townson named his property Varroville after the Roman agricultural writer Marcus Terrentius Varro.

Just what remains of Townson's house is not completely clear.

There is no documentary evidence to prove that he built the [present] house at Varroville, but the two owners after Dr. Townson were not long in occupation, and it is reasonable to assume that Townson, a wealthy man, erected a comfortable house for himself on his land (Anon. 1963, p. 25)

Recent information received from Campbelltown City Council (1995) is accompanied by a map (Fig. 2) in which one building is labelled "House, c. 1816 (Robert Townson's)" and there is also, nearby, "Approx. site of house, c. 1810". A wooden 'slab hut' of about 1810 does exist but whether it was already on the land when it was granted to Townson, or whether he had it built as temporary accommodation, is not known. The house of c. 1816 (Fig. 3) also survives and is still occupied. The main house, "Varroville" (Fig. 4), a little to the north, was formerly thought to have been built, or at least much modified, in 1859. Its main character, including the cast iron columns on

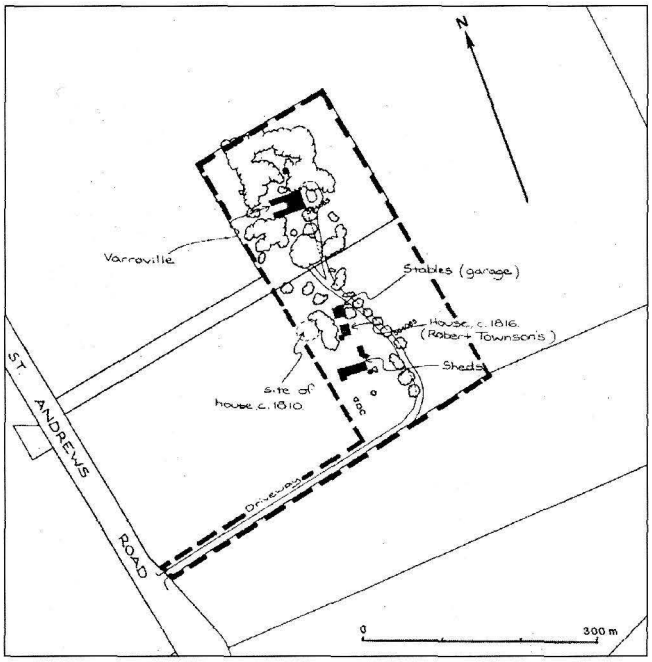


Fig. 2: The buildings at Varroville. A recent map supplied by the Campbelltown City Council.

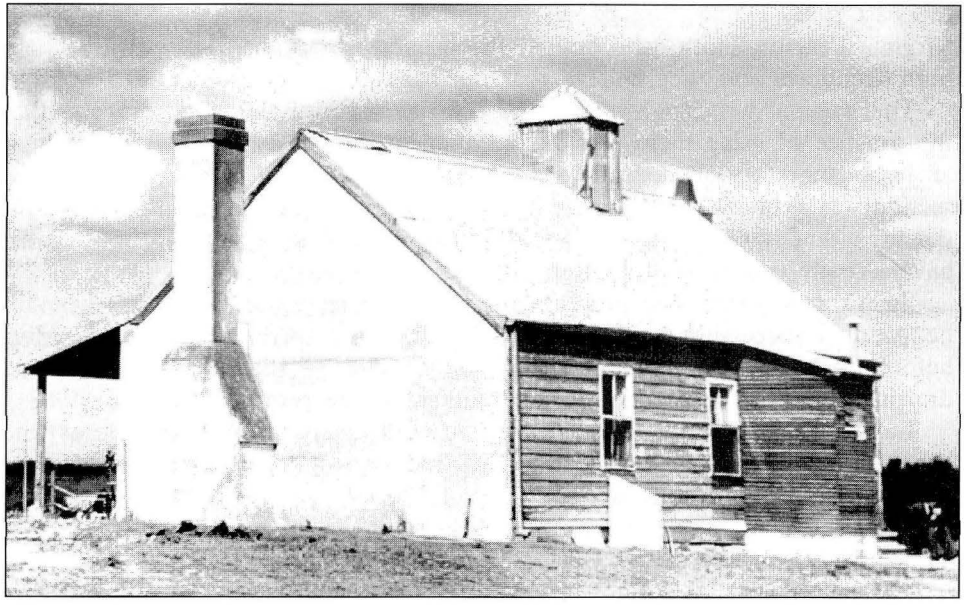


Fig. 3: The house of c. 1816-1820 at Varroville, which Townson probably occupied while the larger house was under construction. Photographed in 1950.



Fig. 4: Part of the south side of the main house at Varroville. The cast iron veranda columns on the right were added in 1859, but at least part of the house was built in the 1820s. Photograph by Ian Leister 17 Sept. 1995.

the east side (Fig. 4), are of that period. The present owners, Kenneth and Virginia Pearson-Smith, who bought the property from the National Trust, are both architects and they believe that the basic building is older.

The original wooden roof tiles exist under parts of the iron roof and that the practice of using these was discontinued in the 1830s. The two west wings, at least, therefore date from some time in the 1820s. Although the front section was probably modernised in 1859, Varroville was one of the houses in the area that was used for entertaining before that, so a sizeable house must have already existed (Ian Leister, pers. comm. 21 Sept. 1995).

So, to what extent the present house was known to Townson, and whether he lived in succession in the c. 1816 building and then the present building before its later modification, is uncertain. A plan of the present house, and drawings of its appearance from all four sides, are printed in Anon. (1963).

Later owners, after Townson's time, included Charles Sturt the explorer who in 1828 had been almost certainly the first person to explore the caves at Wellington, in New South Wales.

THE 1793 TRAVELS IN CENTRAL EUROPE

Townson's travels in Hungary and Slovakia during 1793 resulted not only in his classic descriptions of the Baradla and Silica caves, but also, and probably more importantly for the historian of geology, the very early geological map which accompanies the book and the observations on rocks which occur throughout. There are also accounts of towns and the people he met, travels over mountains, visits to mines and remarks on vine growing and wild plants.

His route, described below, is marked in red on his map. Where the spelling of place names differs between those on the map and in the text, the latter are used here. The equivalent modern names are given in brackets.

From Vienna he crossed the border into Hungary and passed through Oedinburgh (Sopron), Komorn (Komárom) and St. Andrée (Szentendre) to Bude and Pest (Budapest). After a spell there he travelled east to Gyongyes (Gyöngyös) and through Debretzin (Debrecen) to Gross Wardein (Oradea in Transylvania). Turning back there, he passed through Debrecen and went on to Tokay (Tokaj) before crossing the present-day frontier to Caschau (Košice) in Slovakia (which was then a part of Hungary). It was while he was at Košice that he was told of the caves and consequently visited those at Akteleg (Aggtelek) and Szilitze (the ice cave at Silica, now in Slovakia). He also saw, near Nadaska (Tornanádaska), the entrances of some of the deep shafts on Alsó-hegy (not named in the book or on the map). From Rosenau (Rožnava) he travelled north to Poprad and across the High Tatra to visit the Wieliczka salt mine and the nearby city of Krakow in Poland. Returning south again across the Tatra, he was unable to make his planned visit to the Demänova ice cave and went on south to the mining towns of Schemnitz (Banská Štiavnica)

and Kremnitz (Kremnica) which interested him particularly. On through Neitra (Nitra) to Presburg (Bratislava) and back to Vienna.

THE BOOK "TRAVELS IN HUNGARY" AND ITS GEOLOGICAL MAP

The resulting book, Travels in Hungary... (Fig. 5), is a substantial volume of xix + 506 pages, measuring about 27 cm by 21 cm. Besides the map, with the areas containing different rock types outlined in colours, there are 16 engravings, of hills, the entrance to the Silica ice cave, a section through the Wieliczka salt mine, minerals, insects and plants. The text provides not only a general account of his travels, including the visits to mines and an alum works, but throughout he is constantly describing rocks, soils, "pseudo-volcanic craters", etc.

The cave descriptions (see Appendix I) show no particular geological insights. He remarks that they are "like all that I have seen, in a primitive or unstratified compact lime-stone... I think they arise from the rock, whatever that might be, giving way which supports them." On another page he writes that the individual chambers in the Baradla cave "have been formed by the falling in of the rock"; so probably he means no more than that caves are enlarged by roof breakdown.

When going into the Silica ice cave (Fig. 6), he is concerned to counter the common view, held by Bel (1739) and others, that ice caves are colder in summer than in winter and that it is therefore in summer that the ice is formed. Townson pointed out that the apparent cold of such caves in summer was due to the contrast with the warm air outside. When he visited the Silica cave on 16 July the air temperature inside was 0° C and,

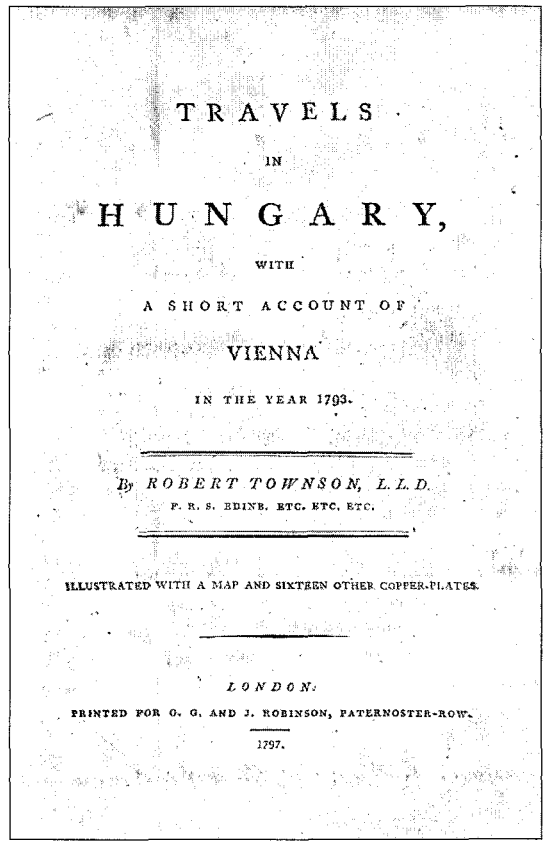

TRAVELS
IN
HUNGARY,
WITH
A SHORT ACCOUNT OF
VIENNA
IN THE YEAR 1793.
By ROBERT TOWNSON, L.L.D.
F. R. S. EDINB. ETC. ETC. ETC.
ILLUSTRATED WITH A MAP AND SIXTEEN OTHER COPPER-PLATES.
LONDON:
PRINTED FOR G. G. AND J. ROBINSON, PATERNOSTER-ROW.
1797.

Fig. 5: The title page of the book describing Townson's tour in Hungary and Slovakia.

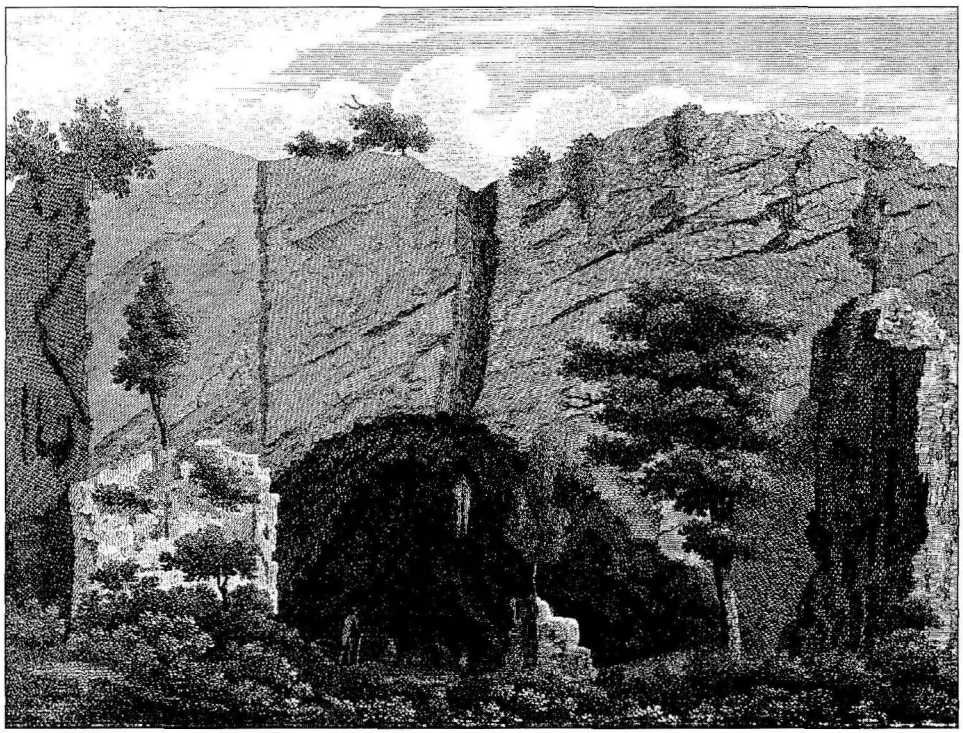


Fig. 6: The entrance of the Silica ice cave, opp. p. 319 of Townson's book of 1797.

although there were large masses of ice, they were wet and dripping as they very slowly melted. He believed that the ice is definitely formed in winter, though there is some delay before the low outside temperatures have an effect in the cave. Thus ice formation does not commence immediately with the beginning of winter, and the same slow reaction of the cave to external temperatures allows the ice to persist into the following summer. He held this common-sense and largely correct view fifty years before the theory of summer freezing was finally overcome. His idea had been put forward a century and a quarter earlier by Steno (1969) in 1671, but only in unpublished letters which Townson could not have seen.

It is the map, with "Petrography... added by the Author" (Fig. 7), which makes the book of wider significance than just a regional description. On the map are distinguished 13 kinds of rock types, including 'granit', volcanic tufa, stratified and unstratified sandstone, 'shistus', saline limestone, unstratified compact limestone, stratified limestone, and calcareous tufa. It appears to be the first such map published in England. The somewhat similar "Mineralogical

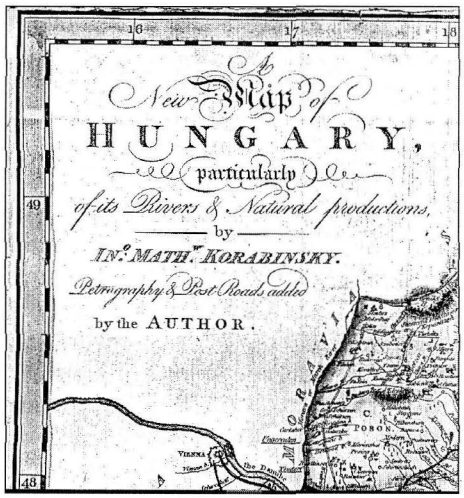


Fig. 7: The title block of the map in Townson's 1797 book.

map, of the western counties of England" was published later in the same year (Maton 1797) with the different rocks distinguished by cross-hatching instead of colour. In fact, Maton's whole book is rather similar to Townson's in that the text includes many geological observations made in the course of his journeys in south-west England in 1794 and 1796. Vallance & Torrens (1984) point out that an earlier German example of such a map occurs in a book by Charpentier (1778), which Townson had seen in 1792 in Göttingen.

The arrangement of rock types in the key does not show any particular stratigraphic order, but some indications of this are given in the text where certain rock types are described as occurring between two others. Presciently he wrote:

When mineralogy and physical geography shall be more cultivated, which one day they certainly will, these maps will become common, and their union will give an easy and visible representation of the coating of our globe, that is, of its rocks and strata and their relative situations. (Townson 1797, p. xii)

He went on to say that this would be of practical use when particular minerals were recognized as occurring in certain strata.

The basic map from which Townson prepared his modified version and then added to it the geological information, was published by Johann Matthias Korabinsky in 1791. This original Korabinsky map showed the location of more caves than the one produced by Townson (Plihal 1992), who had presumably decided to simplify his in places so that it was able to receive his additional information without becoming overcrowded. His intention was evidently to produce a good 'petrographic' map from his observations throughout the tour, rather than a location map for the places he had visited. Thus, although the map in the 1797 book does have a cave symbol at "Szilitze", there is neither symbol nor name at Aggtelek.

The influence of Townson's Travels in Hungary..., which in English appeared only in a single edition, was greatly extended by its translation into French and Dutch. Editions in French were published in Paris in 1799 (Voyage en Hongrie, 3 vols.) and 1803, and at Leipzig in 1800; Dutch editions (Reize in Hongarijen) were issued in 1800 and 1801 at Den Haag (Darvas 1964). It was

the French language editions which made the book known in Hungary where little English was then spoken (Hadobás 1992).

The description of the Baradla cave at Aggtelek, only, was translated into Hungarian and included in Almasi Balogh's (1820) study of the cave. It may have been from this that Imre Vass (1831a; b), who wrote an entire book about the cave, learned about Townson's visit.

Contemporary reviews of Travels in Hungary... do not add to our knowledge of the book. Certainly, as was their purpose, they made it known to potential readers. They assess it from the point of view of the general reader, and not that of a geologist, speleologist or historian of science. The lengthy review by Thomas Beddoes (1797) in The Monthly Review is mainly descriptive of the journey, with many quotations; and a single-paragraph review elsewhere (Anon. 1798) laments that although the book covers "ground untrodden by any of our late tourists", its author has "unclassical taste" and was presumably considered at fault for examining rocks rather than the classical architecture of the Grand Tour.

TOWNSON'S OTHER PUBLICATIONS

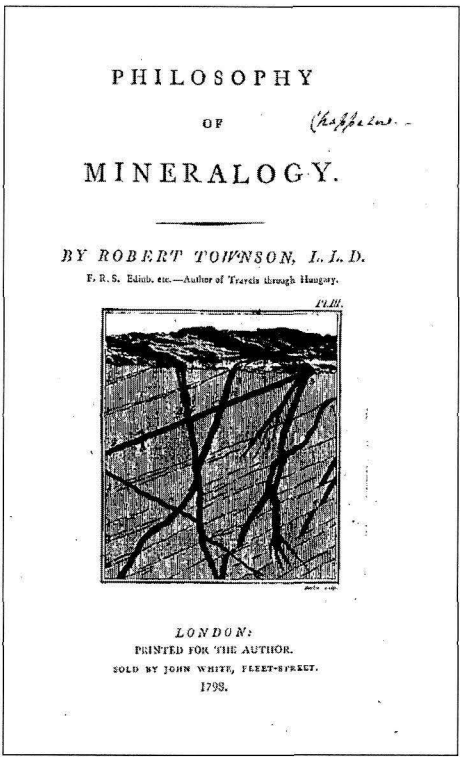
All Townson's publications, both before and after his Travels in Hungary..., reflect his interest in natural history and especially mineralogy and the wider subject of geology.

His lectures to the student Natural History Society at Edinburgh in 1790 were not printed until 1799, so his earliest publication was a botanical paper read to the Linnean Society in London in 1792 and printed in their Transactions two years later (Townson 1794). It was reprinted in his book of 1799, but otherwise his interest in botany diminished with time, though there was a botanical appendix of 18 pages in the Travels..., as well as a slightly longer one on entomology. These publications justified his inclusion in the book, A Biographical Index of deceased British and Irish Botanists (Britten & Boulger 1931), which led to the writing of the present paper.

Townson's papers on the physiology of amphibia, already mentioned as being written at Vienna and at Göttingen in 1793 and 1795 respectively, were published separately in Göttingen (Townson 1794, 1795). An English reviewer (Anon. 1796) comments that "These tracts contain, in a small bulk, a very interesting series of curious and accurate observations". Both were reprinted, in English, in Townson's book of 1799.

An extract from his 1797 Travels in Hungary, describing a method of bread-making at Debrecen, was published separately as a short paper in the same year (Townson 1797b).

The Philosophy of Mineralogy (Townson 1798) (Fig. 8) is a book of 233 pages overall and covers some aspects of what would now be called geology, as well as mineralogy. The 1790s were a particularly interesting time for anyone


PHILOSOPHY

OF

MINERALOGY.

BY ROBERT TOWNSON, L. L. D.

F. R. S. Edinb. etc.—Author of Travels through Hungary.

LONDON:
PRINTED FOR THE AUTHOR.
SOLD BY JOHN WHITE, FLEET-STREET.
1798.

Fig. 8: Townson's 1798 book on mineralogy and geology.

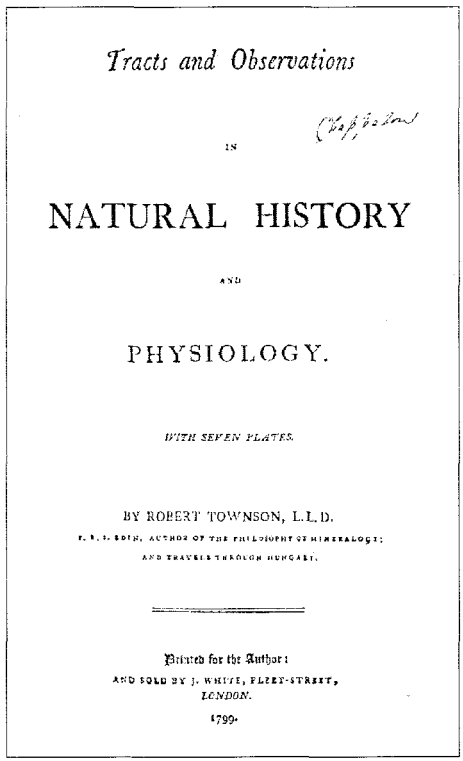
to study and write about these subjects. There were two conflicting schools of thought about how rocks had originally been formed. The Neptunists accepted Werner's belief, published in 1787, that all rocks had been formed by deposition from the primaeval ocean. The Plutonists, on the other hand, followed Hutton (1795) in thinking that the earliest rocks were the result of volcanic action, and that only later were fragments eroded from these laid down as sedimentary rocks in the sea. Townson was mainly a Neptunist, though with some reservations.

The 1790s were also a period in which oxygen was being recognized and phlogiston rejected, and the significance of carbonic acid in dissolving limestone was being realised. Townson himself (1798, p. 114) wrote:

Chemistry of late years has made a most rapid progress, and every branch of human knowledge within its reach has been advanced by it. Mineralogy should be the first to speak its eulogium... Chemistry has done much for mineralogy: it has raised it from a frivolous amusement to a sublime science...

On page 26 of the same book he speaks of carbonic acid "being a constituent of limestones... and acidulous waters". He does not comment on its role in the formation of speleothems. In his Hungarian travels (1797) he was more concerned with description than explanation, and The Philosophy of Mineralogy is an outline of the subject rather than a treatise. A reviewer (Anon. 1799a) criticised it for just this, but its author explains (p. ix) that this was because there was insufficient support for the larger work, to be called "Elements of Mineralogy", that he had announced the year before (Townson 1797a, between pages 494 and 495). Stalactites are mentioned in The Philosophy... but only as examples of minerals of a particular colour (p. 122) and of one of the shapes in which minerals occur (p. 140).

Tracts and Observations in Natural History (Townson 1799) (Fig. 9) is a collection of papers of various lengths. The first two parts of his "Physiological Observations on the Amphibia", already published in Latin in 1794 and 1795,



Tracts and Observations

IN

NATURAL HISTORY

AND

PHYSIOLOGY.

WITH SEVEN PLATES.

BY ROBERT TOWNSON, L.L.D.

F. R. L. EDIN. AUTHOR OF THE PHILOSOPHY OF MINERALOGY;
AND TRAVELS THROUGH HUNGARY.

Printed for the Author:
AND SOLD BY J. WHITE, FLEET-STREET,
LONDON.
1799.

Fig. 9: Townson's 1799 book on natural history and geology, which includes his paper on flos ferri.

are printed here in English together with a third part, previously unpublished. "Memorandums on the rocks in the immediate vicinity of the City of Edinburgh" is based on the two papers he read to the student Natural History Society at Edinburgh in 1790. The Linnean Society paper on the growth of plants is also reprinted. Besides these, the book contains 21 original papers of which the most important is "A sketch of the Mineralogy of Shropshire". There is also the short "Remarks on the Flos-ferri", reprinted here as Appendix II, to make it available to karst researches. Flos ferri is normally a fine quill-like form of anthodite occurring in clusters, but Townson's description suggests that he is thinking of helictites. He is unable to explain their formation, though stalactites, he thinks, result from simple evaporation of water. A reviewer (Anon. 1799b) may have found most of the book too technical: the Shropshire mineralogy is appreciated, but the papers on amphibian respiration are considered too lengthy, and the rest is "unimportant matter".

After this, Townson planned to write a three-volume "County History of Yorkshire" (Anon. 1802). He worked at it until 1805, when it was seen that there was insufficient demand to cover the cost of publication (Vallance & Torrens 1984). By then, too, he was planning to emigrate. A few years later it was recorded as having been an "unsuccessful attempt" (Anon. 1809).

At the end of his mineralogy book Townson (1798, p. [220]) announced as žpreparing for the Press' a book to be called "Benevolence, considered as a source of happiness" but this too seems never to have appeared.

It has been stated (Vallance & Torrens 1984) that "The Poor Man's Moralist", which reached a 3rd edition in 1799, was written by Robert Townson. The British Museum General Catalogue of Printed Books firmly attributes this to the Rev. Thomas Townson (1715-1792), but in view of the previous paragraph it might be questioned whether its identification of the "Dr. T." of the title page is correct.

CONCLUSION

This paper provides information, not hitherto published in the field of karst studies, describing Robert Townson's life after he apparently "disappeared" from European view in 1799. He emigrated to Australia, became a successful vine-grower and farmer, and died in 1827. By drawing heavily on a paper published by Vallance & Torrens in 1984, together with other sources, it has been possible to provide more information about his earlier life in Europe, and to resolve some of the anomalies in the standard biographies.

Throughout the whole of his life up to his emigration in 1807, it will have been seen that Townson's main and continuing interest was in natural history and especially in mineralogy and geology:

a) 1789-91. The friends who influenced him when he was studying at the University of Edinburgh included Joseph Black (Professor of Chemistry), James Hutton (geologist), Alexander Monro (Professor of Anatomy), Daniel Rutherford (Professor of Botany) and John Walker (Professor of Natural History). Later he came to know Sir Joseph Banks, for 45 years President of the Royal Society.
b) 1790. The two papers he presented as a student at Edinburgh were on local geology.
c) 1791. He was recommended for a post as naturalist in Canada.
d) 1791-95. He studied in the Department of Natural History at Göttingen.
e) 1793. Geological observations were an important part of his travels in Hungary.
f) 1795. The studies he proposed to carry out in India were to be on its mineralogy, geology and physical geography.
g) 1797. Publication of Travels in Hungary... with its petrographic map.
h) 1798. Publication of The Philosophy of Mineralogy.
j) 1799. Publication of his "Mineralogy of Shropshire", for which much of the research had been done some ten years earlier, with a collection of other natural history papers including "Remarks on the Flos-ferri".
k) 1802. Intention to publish on the geology of Yorkshire.

The 1790s were a particularly active time in the development of geology, both because advances in chemistry were making it possible to understand more about rocks and minerals and because the fundamentally opposed ideas of the Neptunists (including Townson) and the Vulcanists explained their origin in totally different ways.

So it was an exciting time to be a naturalist and geologist. Whether or not his geological background made Townson any better an observer or recorder of caves is open to question. His view that caves "arise from the rock... giving way..." certainly did not advance knowledge of speleogenesis. On the other hand, he measured temperatures deep inside the cave at Aggtelek "with a view

to a scertain the medium temperature of this part of Hungary". And in the Silica ice cave his observations and temperature measurements enabled him to refute Bel's (1739) statement, sent to the Royal Society, that the ice formed there during the summer.

Nevertheless his purpose in the Travels in Hungary... was mainly to describe these caves and not to conjecture how they had been formed. It was in his observation of the different kinds of rock in the country he visited, showing them on his žpetrographic' map and occasionally noting their relative positions, that his geological experience was of benefit.

At least the caves were seen by someone who was familiar with geological phenomena, and it may be that this was why he visited several during a relatively short visit. The shafts on the Alsó-hegy plateau would have been unlikely to attract the attention of a more conventional tourist.

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Biographical information came from Miss Broughton archivist of the Shropshire Record Office, Mrs Jo Currie of Edinburgh University Library, Dr Ulrich Hunger archivist of the Georg August University in Göttingen, and the staff of the Mitchell Library in Sydney who also arranged for the portrait of Townson to be copied. Chris Howes, FRPS, made the copy photographs for publication. I thank them all.

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ROBERT TOWNSON, POPOTNIK PO MADŽARSKEM LETA 1793 - NJEGOVO ŽIVLJENJE IN DELO

Povzetek

Robert Townson (rodil se je v bližini Londona leta 1762, umrl leta 1827 v Avstraliji) je študiral medicino, kemijo in naravoslovje na univerzah v Edinburgu, Parizu, Dunaju in Göttingenu. Čeprav ni dokončal študija na nobeni od univerz, so ga imenovali za častnega doktorja prava v Edinburgu leta 1796. Potoval je po Italiji in Skandinaviji, nato pa je odšel na petmesečno potovanje po Madžarski in Slovaški. Rezultat tega potovanja je leta 1797 objavljena knjiga Travels in Hungary. V tem delu opisuje jame pri Aggteleku, na Silicki planini ter brezno Alsó-hegy. Delu je dodana tudi geološka karta, sestavljena na podlagi Townsonovih lastnih opazovanj. Strani, ki vsebujejo njegove opise jam so ponatisnjene v dodatku. 1798 in 1799 je izdal še deli geološke in naravoslovne vsebine.

1807 se je izselil v Avstralijo, kjer je nameraval nadaljevati z znanstvenim delom. Zaradi nesporazuma z guvernerjem države New South Wales je to opustil, nato pa se je preselil v bližino Sydneya, kjer je kmetoval in se ukvarjal z vinogradništvom. V prispevku je tudi reprodukcija njegovega portreta iz šestdesetih let in ocena njegovih knjig.

APPENDIX I

THE CAVE DESCRIPTIONS IN TOWNSON (1797)

Saturday, July 14th, I left Caſchau; but I again left the direct road to the Carpathian Alps, and ſtruck off to the weſt. I was induced to this from hearing at Caſchau, and not from the vulgar, but from learned doctors and profeſſors, that at the diſtance of about a day's journey there were two great caverns; in one of which water froze during the ſummer, and ice thawed during the winter: whilſt *the other was ſo vaſt that one might wander about in it for a week* without finding an end. Soon after leaving Caſchau, I came to a quarry of the *Cornua foſſilia* of Wallerius. At Cſees, where I changed horſes, the road began to draw nearer the hills, and the country became more pleaſant: this is chiefly a corn country, Indian wheat was a good deal cultivated. Early in the evening I reached Nadaſka, the ſeat of Counteſs Cinlais. The hills here, which are very high, are of unſtratified compact limeſtone, without any petrifactions, but it is full of holes; ſome of theſe are ſo deep, and at the ſame time ſo round, that they look as if they had been formed by art. I paſſed the evening in a very dull manner; a rough gloomy prieſt was come here to be ready to perform divine ſervice the next day; and though he ate copiouſly himſelf, he allowed none of the family to do ſo; and the Counteſs, and her niece, who was a very nice girl, and ſpoke very good French, who were all that ſat down to ſupper, faſted. I was a dreadful thorn in the ſide of this fellow, and vexed him grievouſly by eating a hearty ſupper, the whole of which he ſeemed to wiſh to poſſeſs.

Next morning I ſet out again for the caverns. I travelled at the foot of the ſame chain of hills; now and then ſome *Schiſtus* made its appearance, but in general the lately mentioned limeſtone prevailed. About half way I changed my horſes for oxen; but as they were only to draw me, or rather my baggage, over a high hill, where horſes could have gone no faſter, I did not ſuffer as in the laſt horned cattle expedition. About one o'clock I reached Akteleg, and I took up my quarters with the Calviniſt pariſh miniſter: he knew not a word of German, much leſs French or Engliſh, only the Hungarian and the Latin. Though this was Sunday, and the villagers were Calviniſts, they were dancing and making merry.

I procured a guide, and the ſame evening I entered the cave; but it was chiefly with a view to aſcertain the medium temperature of this part of Hungary. The thermometer in the ſhade, in the open air, ſtood at 15 above 0 of Reaumur, but in the cave, a good way from the mouth, immerſed in a running ſtream in different places, it ſtood at ſeven degrees; yet out of the water by the ſide of the rock it ſtood at ſeven and an half. Shall we ſuppoſe that all, or part of this water, came from melting ſnow, which, hid in ſome deep hole or cavern, had now only begun to thaw? this would render every experiment fallacious: or ſhall we ſuppoſe that the rock, however thick, was nevertheleſs affected by the heat of the atmoſphere? As I left my thermometer an hour, it certainly, as it had but a ſmall bulb, had time to take the true temperature of the medium which it was in. The water in the wells in the village was eight degrees. The above obſervations, though rendered leſs deciſive by this difference, agree pretty well with thoſe made by Mr. Haquet on the *medicinal waters of Bartfeld: he ſays,* "*at ſix o'clock in the morning,* the water was ten degrees of Reaumur colder than the atmoſphere, which was then 16 degrees." This brings the temperature of the waters to ſix degrees, which is a degree colder than that of this cavern; but Bartfeld is about half a degree of latitude further north, and in a more elevated ſituation.

In the morning I returned to the cavern, to ſee how far I could penetrate into it, and to repeat my experiment with the thermometer, but by accident this was left behind. The report here is, that this cavern extends ſeveral miles under the hills, and that it would require ſeveral days to ſee the whole of it. The mouth of it is at the bottom of a precipice about 150 feet high, at the weſt end of a compact unſtratified limeſtone hill, which runs eaſt and weſt. This entrance is about two yards broad, but ſo low that I was obliged to bend conſiderably to get in. I deſcended rapidly for a ſhort diſtance, and then I found myſelf in an immenſe cave, with a very lofty vault; this has in different parts communication with other caves and paſſages, and theſe again with others. Some of theſe caverns are over one another; in ſome places I came to conſiderable ſtreams of water; in one great cave my guide conducted me over a hill formed of great blocks of ſtone, which moſt probably had fallen down from the roof: in one place I had to get down a hole like the funnel of a chimney; then I was led into a cave where large ſtalactites, as thick as my body, hung pendent from the roof, and I was ſhown others where the ſides were ornamented in the manner of the moſt curious Gothic workmanſhip. In ſome the ſtalactites were ſo thick and cloſe together, that we were in danger of loſing one another if we ſeparated but a few yards. Here aged ſtalactites, overloaded with their own weight, had fallen down, and lay proſtrate; and there an embryo ſtalactite was juſt ſhooting into exiſtence. The moſt curious cavern was one apparently of modern date; the ſides, and particularly the roof, ſeemed as if recently ſeparated: and it was probably ſo, for I *think moſt of theſe caverns have been formed by the* falling in of the rock: very white and ſlender ſtalactites were only found here.

After I had wandered about for three or four hours in this awful gloom, and had reached the end of the caverns in one direction, I thought it time to come out, and I desired my guide to return. After we had returned, as we thought, some way, we found no passage further; yet the guide was sure he was right. I thought I recognised the same rocks we had just left, and which had prevented our proceeding further, but the guide was positive he was in a right direction. Luckily for us I had written my name on the soft clay of the bottom of the cave, which had been the extent of our journey; on seeing this the guide was as thunderstruck, and ran this way and that way, and knew not where he was, nor what to do. I desired him not to be frightened, but to go calmly to work to extricate us from this labyrinth. As the wood which we burnt instead of lamps was nearly exhausted, and as I never adverted either to one of the guides whom we had left above, who by being charged with wood could not get down the funnel-like hole, being so near; nor to the people of the village being acquainted with our being in the cavern, who no doubt would have taken every possible means of coming to our assistance had we stayed much longer than usual, I was a good deal alarmed for our safety, and there was good reason: had our torches gone out, we should never have been able to find our way out; nor, had any accident have happened to our guide, could we by ourselves, though we had had lights, have had any hopes of extricating ourselves. After wandering about till all our wood was nearly exhausted, we found a great stalactite from which, on account of its remarkable whiteness, I had been induced to knock off a specimen as I came by: I recollected how I stood when I struck it: this at once set us right; and after walking a little further we made ourselves heard to the other guide, from whom we got fresh torches, and we then continued our route homewards without further difficulty.

So complete a labyrinth as these caverns are in some places, is not I am sure to be found but in similar caverns: large open passages proved *cul de sacs*, whilst our road was over and under, through and amongst grotto-work of the most intricate nature. I firmly believe, that though a man should have lights and food enough to last him a month, he would not be able to find his way out.

On the soil at the bottom of the cavern, my guides shewed me impressions which, they said, were from the wheels of a carriage. I thought immediately to have detected the error by measuring the distance of the marks of the two wheels at different distances: but I was mistaken; the marks were throughout parallel. Whether these were really the marks of a carriage I cannot say: I only observed them in the first part of the caverns. If the soil at the bottom at the mouth of the cave was taken away, I do not see any impossibility, through the assistance of men, to get such a thing in thus far. It is known to have served as a *hiding-place to the weak and unfortunate* in time of war, and a fitter hiding-place there cannot be.

I thought it probable that I was the first English traveller who had examined this immense cavern; but Mr. Korabinsky says *, "that it is of such astonishing dimensions in length, that two members of the Royal Society of London, who were sent some years ago into Hungary by the Society, to examine this and other curiosities, after remaining in it three days, could never get to the end of it, nor find an opening."

After dining with the pastor, who seemed to possess but a small portion of the good things of this world, I set out for the other famous cavern near Szilitze. I travelled by a bye road through a pleasant, hilly, and woody country, chiefly with pasture land. There I saw again my favourite little animal the Earless Marmot, which I had not seen since I left the great plain. I reached Szilitze early in the evening, and as before, I asked hospitality of the Calvinist minister, who likewise only knew his own language, the Hungarian, and the Latin. He seemed to be in more easy circumstances than the last, and to be a considerable farmer: all this district is inhabited by Calvinists. As the cavern is a mile from the village, I deferred seeing it till the next morning, when my host, who had nothing of the four Calvinist about him, accompanied me.

The immense vaults, and the glittering stalactites arranged in Gothic style, of the last cavern, are not to be sought for here. This is only famed for possessing the remarkable nature of being *really* colder in summer than in winter; so that when the north east in winter blows, and the whole country is defaced with ice and snow, then the ice within this cavern begins to thaw; but when the parching heat of the canicule reigns, then its dripping rocks begin to be adorned with pellucid icicles.

This is not the opinion of the vulgar alone, but, in this country, of the learned likewise; it has even reached our country, and found its way into our Philosophical Transactions. The celebrated Hungarian historian Matthew Bell sent the following account of it to the Royal Society, who have inserted it in the 41st volume. "Natura Antri id habet prodigii, quod cum extus brumæ intensissimus riget, tepido sit intus aëre; frigido contra, immo glaciali, cum sunt fervidissimi soles. Nimirum, simul diffugientibus nivibus ver inire cœpit, interior antri concameratio, qua ea meridiano soli dorso objicit, aquam limpidam et passim distillantem exsudat: quæ, interni frigoris vi, in pellucidam glaciem concrescens, stirias efficit, ad ingentium doliorum molem crassas, ac pendulas, inque ramos abeuntes miris illusos speciebus." And further adds, "Glaciale istud spectus ingenium, totum æstivum est: quod ideo admirationis habet plurium; augescit enim cum increscente solis ardore. Primo, nimirum, vere, hibernus ille tepor cessare; mox, ubi id adolevit, intendi frigus occipit, tantis accessionibus, ut quo magis aër incalescit, eo antrum frigeat ex-

* Lexicon von Ungarn, page 6.

quiſitius. At ubi æſtas inſit, jamque fervet canicula, in glacialem brumam intus abeunt omnia."

This account agrees perfectly with the information I received at Cafchau, and with what I heard on the ſpot likewiſe. Yet I know I ſhall have no difficulty to perſuade Natural Philoſophers of the preſent day, that there is a fallacy in the obſervations, and that this has ariſen from depending too much on our feelings, and neglecting the only proper gage of heat and cold, the thermometer.

This cavern is about a hundred feet broad, a hundred and fifty deep or long, and twenty or thirty feet high at the mouth or entrance which faces the north: the deſcent is pretty rapid, the laſt third part of the bottom or floor was covered with ice; but this was ſo thin that I could ſee the rock under it. From the roof at the further end, which was here much lower than at the entrance, hung an immenſe icicle, or rather a congeries of icicles; and in a corner to the right, which was not only deprived of the influence of the ſun, as the whole cavern is, but likewiſe of light, there was a great maſs of ice. It was a fine forenoon when I viſited this natural ice-houſe; and the air was heated by a July ſun: as ſoon as I approached the mouth of the cave, I felt a chill, which increaſed the further I went in, and which rendered my continuance there, to obſerve the ſtate of the thermometer, very diſagreeable.

Ice I truly found here in abundance, and it was near midſummer, but in a ſtate of thaw: the bed of ice, which covered the floor of the cavern, was thinly covered with water, and the icicles dropped: every thing announced a thaw. I had no need to uſe my thermometer: however, I placed it in the ice, and it fell to 0 of Reaumur; I then wiped it and placed it in a niche in the rock, at the further part of the cavern, a yard above the ice, and here it remained near an hour: when I returned I found it at 0. Thinking it might not have had time to take the real degree of heat of the medium in which it was in; I tried this by breathing upon it till it roſe one degree above 0; I then left it for a quarter of an hour only, and when I returned I found it again at 0. Every thing here, therefore, ice, water, and the atmoſphere in the neighbourhood of theſe, had the ſame temperature, and that was the temperature of melting ice, 0 of Reaumur.

When then is the ice which is found here, and in ſuch quantities that this cavern ſerves the few opulent nobility in the neighbourhood as an ice-houſe, formed? Surely in winter, though not by the firſt froſt, not ſo ſoon as ice is formed in the open air. No doubt, from the little communication this cavern has with the atmoſphere, it will be but little and ſlowly affected by its changes. Should, therefore, Mr. Bell, or any of his friends, have come here to verify the common report at the commencement of a ſevere froſt, when the whole country was covered with ice and ſnow, they might ſtill have found here nothing but water, or the ice of the preceding winter in a ſtate of thaw, and the cavern relatively warm: and likewiſe, ſhould they have viſited it in a warm ſpring, which had ſucceeded to a ſevere winter, they might have found nothing here but froſt and ice; and even the freſh melted ſnow, percolating through the roof of this cavern, might again have been congealed to ice.——I obſerved frequently in Germany, in the ſevere winter of 1794-5, on a ſudden thaw, that the walls of churches and other public buildings, on the outſide were white, and covered with a hoar froſt, and their windows on the ſame ſide covered with a rime. I certainly ſhould not have ſaid ſo much on this ſubject, were not the opinion I have been combating ſo very general. This cavern is like all that I have ſeen, in a primitive or unſtratified compact lime-ſtone; and it is curious to obſerve, that the moſt famous in the world are in this kind of rock. I think they ariſe from the rock, whatever that may be, giving way which ſupports them.

APPENDIX II

TOWNSON'S PAPER ON FLOS FERRI, FROM HIS 1799 BOOK

Remarks on the Flos-ferri.

THE manner in which ſtalactites are formed, is, I believe, well understood. It is eaſy to conceive that by the gradual diſſipation of a ſolvent the matter held in ſolution may be depoſited, and aſsume all the various forms that the ſolution at one or different times had been in. Thus we can account for the form of any ſtalactite which has ſuch a one as the dripping fluid can have exiſted in, either through its own natural gravitation or through the joint powers of gravitation and the attraction of ſome body in contact, but by no means of thoſe forms in which we know a fluid body could not in any circumſtances have been.

Reaſoning thus, I am unable to account for the formation of that beautiful foſsil the Flos-ferri, found in its greateſt perfection in the iron mines of Eiſenärtz in Styria, which not only differs from all other ſtalactites in its forms but in its texture. In regard to its form it is generally branched, but whether ſimple or branched the parts are by no means ſtraight but curved, and in the ſame ſpecimen curved in very different directions. Where the branches ſhoot out, that is at the *axillae*, it is no thicker than in other parts, and frequently a ſimple undivided ſhoot, three inches long, is no thicker towards its baſe than towards its point. In the direction of its growth, the Flos-ferri differs not leſs from the common ſtalactites, whoſe long cylindrical forms are never found in a horizontal ſituation, and in which direction we know they never can be formed. Yet in the great mine of ſpatous iron ore of Styria, I have ſeen both the ſides of a vertical fiſsure covered with the flos-ferri. The texture of this foſsil likewiſe greatly differs from the common ſtalactites. It is not compact, nor is it compoſed of concentric cylindrical plates, but of obliquely divergent fibres.

These peculiarities lead me to think that it is formed in a different manner from common ſtalactites, and I offer theſe remarks to thoſe who have an opportunity of obſerving this foſsil in its birth-place, that they may inveſtigate its formation.—It is not foreign to the preſent ſubject to mention that a few years ago I found on the ſide of a chalk rock on the turnpike road, ſomewhere between Portſmouth and Guildford, a fine white light body reſembling very much in its ſtructure, the *byſſus aurea*; being in haſte I put a ſmall ſpecimen between the aſs-ſkin leaves of my pocket book, which, when I went to examine, I found reduced to powder. It was inſoluble in water, but ſoluble with effervescence in nitrous acid. It is probable that this ſingular production was of the nature of the flos-ferri, and might be denominated Inolithus-byſſoides, or Stalactites-byſſoides. But theſe remarks are only offered as hints to future obſervers.

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PUBLISHED IN 1796...

IZŠLO V LETU 1796...

KINGA SZÉKELY

Izvleček UDK 551.44(439)(091)
Kinga Székely: Izšlo v letu 1796...

1796 so izšle tri knjige v madžarskem jeziku, s pomembnimi podatki o jamah. Pred tem je bilo omenjenih le nekaj jam v latinsko ali nemško pisanih dokumentih. 1796 je Valyi izdal prvi del "Opisa Madžarske" in prevod Korabinskijeve "Geografske enciklopedije" (1786). Istega leta je izšel Telekijev popotni dnevnik, s prvo upodobitvijo 2 jam na Madžarskem. Tudi Szallerjeva "Geografija Madžarske" vsebuje opise jam.
Ključne besede: zgodovina speleologije, Madžarska, Slovaška, Romunija, Korabinsky, Szaller, Teleki, Valyi.

Abstract UDC 551.44(439)(091)
Kinga Székely: Published in 1796...

Three books containing information on caves, written in Hungarian language, were published in 1796. Before that only the existence of certain caves had been recorded in Latin or German. Valyi published the first volume of "Description of Hungary" and the translation of Korabinszky's (Korabinsky) Enciklopedia. Teleki produced travel book containing the earliest engraved views of two caves. Szaller's "Geography of Hungary" appeared in 1796 too, with descriptions of caves.
Key words: history of speleology, Hungary, Slovakia, Romania, Korabinsky, Szaller, Teleki, Valyi.

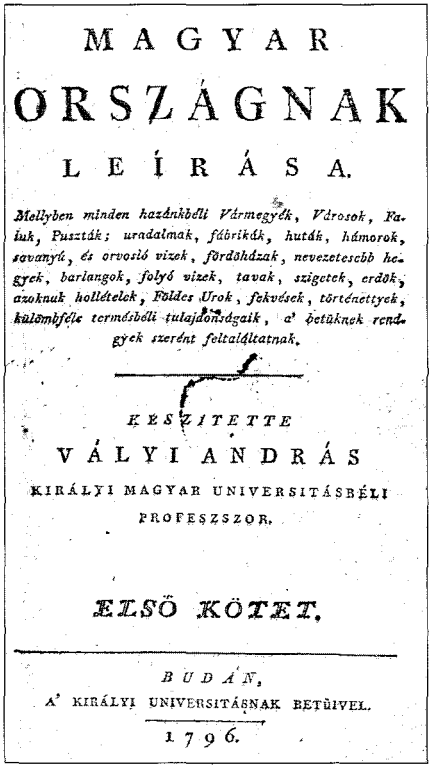
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Felolvasta Takácsné Bolner Katalin az ALCADI 96 on Postojnán 1996. május 24-én. Fordította Székely Zsolt és Szabolcs, javította Takácsné.

From the earliest times until 1796 there are approximately 90 historical publications relating to the caves of Hungary. The first documents are charters in the Latin language, in which we can find geographical names referring to caves (*Odvaskô 1037, Ravaszlik, rókalyuk 1055. Likaskô, 1355*). The first cave name *(Deményfalva Cave/Demänovská jaskyňa, Slovakia)* can be found in a document of the Archiepiscopal Archives of Esztergom, which was written in Latin in *1299*. From the middle of the 1500s, more and more cave descriptions were published in Latin or German in scientific publications. Most of the earliest publications in Hungarian are references only to the existence of caves *(Pozsonyi Magyar Hírmondó 1781; Benkô József, 1784, 1786; Losontzi István 1788; Zay Sámuel, 1791; Gvadányi József, 1792)* .

Outstanding events in the early period of Hungarian speleology were the publication of some books in 1796 - exactly 200 years ago - which became the fundamentals in the Hungarian language speleological literature.

The "Description of Hungary" *(Magyarországnak leírása)* by **VÁLYI K. András**, Volume 1 *(Fig. 1)*, was published in Buda and it was followed in 1799 by



MAGYAR
ORSZÁGNAK
LEÍRÁSA.

Mellyben minden hazánkbéli Vármegyék, Városok, Faluk, Pusztak; uradalmak, fábrikák, hutak, hámorok, savanyú, és orvosló vizek, fördöházak, nevezetesebb hegyek, barlangok, folyó vizek, tavak, szigetek, erdök, azoknak hollételek, Földes Urok, fekvések, történettyek, külömbféle termésbéli tulajdonságaik, a' betüknek rendgyek szerént feltaláltatnak.

KESZITETTE
VÁLYI ANDRÁS
KIRÁLYI MAGYAR UNIVERSITÁSBÉLI
PROFESZSZOR.

ELSÖ KÖTET.

BUDÁN,
A' KIRÁLYI UNIVERSITÁSNAK BETÜIVEL.
1796.

Fig. 1



Geographisch-Historisches
und
Produkten
Lexikon
von
Ungarn,
in welchem
die vorzüglichsten Oerter des Landes in alphabetischer Ordnung angegeben, ihre Lage bestimmt, und mit kurzen Nachrichten, die im gesellschaftlichen Umgange angenehm und nützlich sind, vorgestellet werden.
Von
Johann Matthias Korabinsky.

Mit einer Postkarte
durch deren Beyhülfe man sich einen vollständigen Ideal-Atlas dieses Reichs selbst entwerfen kann.

Preßburg,
zu finden im Weber und Korabinskyschen Verlage.
1786.

Fig. 2

Volumes 2 and 3. As mentioned in its subtitle, one can find in alphabetical order the descriptions of all the counties, cities, villages, hamlets, mines, factories, smelting works, hot springs, bath houses, important mountains, rivers, lakes, islands and forests, as well as of some caves.

Vályi András was born on the 30th of November, 1764 in Miskolc. He was the inspector of schools in the Kassa *(Košice, Slovakia)* educational district. Later, in 1792, he became the first professor of the Department of Hungarian Language and Literature at the University of Pest. His death was recorded in Pest on December 2nd, 1801.

Due to the public interest, Vályi translated from German to Hungarian the Encyclopaedia of Geography published by **Korabinszky János (Johan Matthias Korabinsky)** in 1786 *(Fig. 2)*, which he supplemented with data collected by himself. With his work, he laid the foundation for the detailed Hungarian dictionary of geography, where the well-known Hungarian caves are described under individual entries.

Under the entry of Agtelek, Korabinszky described both the village and the cave *(Baradla)*, but Vályi discusses them in two separate entries. The two cave descriptions are almost identical, except for the last sentence. Vályi does not include the information on utilisation of finely ground dripstones as a paint substitute; instead of that he provides an important fact in the history of the cave, namely, that it was discovered by János Farkas in 1794. If the historians had paid attention to this new information, we might know the original of the first map of the cave, as well as the first Hungarian language description of the cave by Farkas, which were lost without a trace.

Vályi's one-column description of the Cave of Benikova *(Jaskyňa Beníková, Slovakia)* gives the general location and size of the cave as well as mentioning the dripstones therein. He also goes into details regarding "the dragon bones", the healing power of the cave springs, and the fact that the cave had been surveyed by Buchholtz and its map published by Bél Mátyás *(1723)*. In a much shorter description of Deményfalva Cave *(Demänovská jaskyňa, Slovakia)*, the most important information revealed is that the cave was explored and surveyed by Buchholtz at the request of Bél's. This map also was published in Prodromus.

Under the entry for Fonátza or Funátzai Cave *(Peştera de la Fînaţe, Romania)*, the only information was that it was surveyed for 4 hours by Nedeczky Elek in 1772. His observations were published in the same year in Vienna and a summary was published in Hungarian Geography by Windisch (1780). The detailed description of the cave can be found under the entry of Bihar County, together with the description of Esküllő Cave *(Romania)*.

On numerous occasions when Vályi described counties, mountains, rivers, hamlets or forts; he also mentioned caves. In Borsod County, one can find three caves. First, he writes about Felete-lyuk (cave), which is one hundred steps long and sixteen steps wide - an ideal hiding place for the local popula-

tion during the Rákóczi revolution. This cave's name is unknown now, and most likely is a misspelling, but due to the to the given sizes it can be assumed to be Szeleta Cave. The other two caves, Kecske-lyuk Cave and Diósgyőr Cave, are still called by the same names today. At the Gerets Mountains, he describes a cave without a name. According to the location, size and historical data, this cave can be identified as Szelim Cave.

From among the settlement entries, at Borzova *(Silická Brezová, Slovakia)* the ice cave and at Csobánka the Kis-Kevély Cave are mentioned. At the Boi stream *(Romania)* the entrance to the Cave of Boli is described. At the Castle of Csesznek three caves are mentioned: the first is under the fort, the second one is on the opposite side, and the third one is further away and has water which smells like snake and tastes bad but is healthy for bathers.

It is interesting that some of the caves known at the time are not mentioned in the Encyclopaedia, namely the Abaliget Cave, Detrekő Cave *(Plaveská jaskyňa, Slovakia)*, and Veterani Cave *(Peştera de la Pînza Curii, Romania)*.

The second important literary work is **TELEKI Domokos,** travel book published in Vienna and describing four visits to Hungary between 1793 and 1795 *(Fig. 3)*. Teleki Domokos, the son of Teleki Sámuel the Transylvanian Chancellor, was born in Transylvania on September 5, 1773. He was brought up in Marosvásárhely *(Tirgu Mureş, Romania)* and Nagyszeben *(Sibiu, Romania)* and he later studied at the universities of Pest and Vienna. Due to his poor health, he sought relief through travels. He became acquainted with Hungary from north to south, and with Transylvania and Saxony. During his stay in Jena he was elected a member of the Scientific Society, and in 1798 he became the first chairman of the Mineralogical Society. He died at the age of 25 on September 16, 1798 in the town of Marosvásárhely.

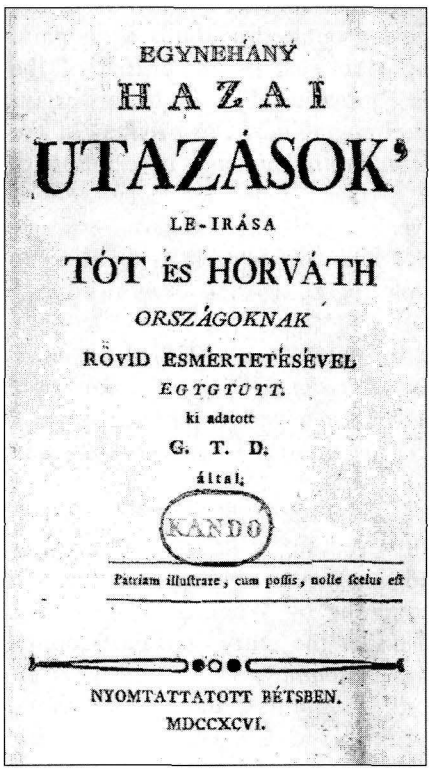

EGYNEHÁNY
HAZAI
UTAZÁSOK'
LE-IRÁSA
TÓT ÉS HORVÁTH
ORSZÁGOKNAK
RÖVID ESMÉRTETÉSÉVEL
EGYGYÜTT
ki adatott
G. T. D.
által;
KANDO
Patriam illuſtrare, cum poſſis, nolle ſcelus eſt
NYOMTATTATOTT BÉTSBEN.
MDCCXCVI.

Fig. 3

During his Hungarian and Transylvanian travels he visited many caves such as Baradla Cave, Szilice Ice Cave *(Silická ladnica, Slovakia)* Szkleno Cave *(Jaskyňa Parenica, Slovakia)* and the Torja cavities *(Peştera Pucioasade la Turia, Romania)*. Besides the detailed descrip-

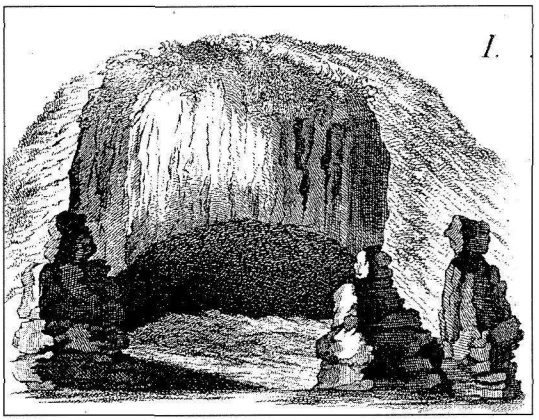


Fig. 4

tions of his visits to these caves, he also mentions the cave origin of the Golumbács fly *(Romania)* in his book. In Teleki's 333-page book, we can find, beside maps, two engravings of Szilice Ice Cave *(Silická ladnica, Slovakia)* and one of the entrance to Baradla Cave *(Fig. 4-5)*. These engravings are the first pictures of the entrances of these caves. The book was also published in 1805 in Pest in German and it was used as a basis for the books of Sartori *(Vienna, 1807-1810)* and Engelhart *(Vienna, 1816)*.

In addition, in 1796 **SZALLER György** published the Geography of Hungary. The date and place of his birth is unknown; he died on October 30, 1807. The only other information about his life is found on the title page of his book. He was a surveyor in Pest and the Hungarian Language Instructor at the Pozsony College *(Bratislava, Slovakia)*. Hungarian geographers honour him as the one of first persons to describe Hungary's geography in Hungarian, in which work he provided a map of the country, too. His work is a dry database listing of the counties and urban areas; it also reflects the country's people and economy. The first part of the 250-page book describes the natural environment of the country, where the ninth section discusses waterways and caves. The caves are mentioned by names such as the Okno Cave *(Demänovská jaskyňa Okno, Slovakia)*, Szentivány Cave *(Staniš-ovská jaskyňa, Slovakia)*, and the caves of Deményfalva *(Demänova, Slovakia)*, the perennial icy cave of Szilice *(Silická ladnica,*

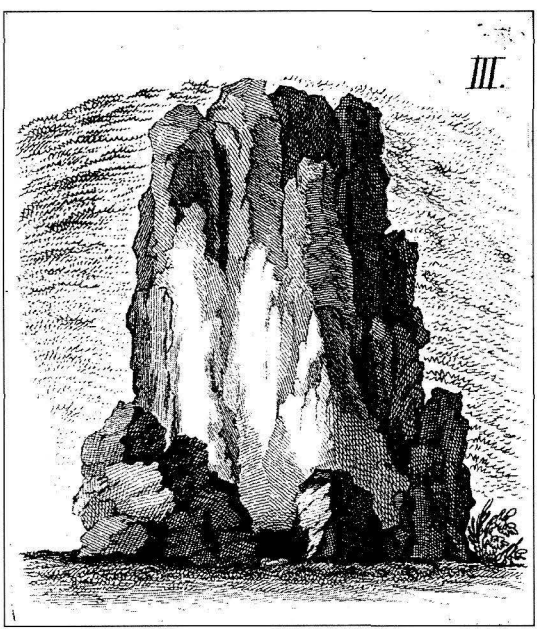


Fig. 5

Slovakia) and Fonácza Cave *(Peştera de la Finaţe, Romania)* are discussed, and the presence of caves in Túrócz and Gömör Counties is mentioned. Under the counties one can read about the dragon bones of Deményfalva Cave in Liptóv county; the Mazarna and Dupna caves in Túrócz county *(Mažarná a Dúpna jaskyňa v Turci, Slovakia)*; the cave on the hill at Dobsina and the bottomless Csörgőlyuk *(Zvonivá diera, Slovakia)* at Pelsőc in Gömör county; the Szádelő *(Zádielská jaskyňa, Slovakia)*, and Szilice and Borzova caves *(Silická ladnica a Brezovská jaskyňa, Slovakia)* in Torna county. It is interesting that Szaller does not mention Baradla, even though it was known to exist then. It is also interesting that the description of Dobsina rather fits that of Baradla. Here we can read the same as in the later Baradla descriptions: the water dripping down the walls and changing into stones, which were used for their clean white colour as paint and also as medicine for bovine.

In 1796 Hungarian language geographic studies and publications began to replace the previously prevailing Latin and German publications. This development provided new, previously unknown facts and information regarding caves in Hungary. These Hungarian publications were based not only on translations but also on new data and personal experiences.

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IZŠLO V LETU 1796...

Povzetek

1796 so izšle tri knjige v madžarskem jeziku, z zelo pomembnimi podatki o jamah na Madžarskem, Slovaškem in v Romuniji. Pred tem je bilo vsega skupaj omenjenih le nekaj jam v 90 rokopisih in knjigah, pisanih v latinskem ali nemškem jeziku, s prvo jamo, omenjeno leta 1037. 1796 je K. A. Valyi izdal prvega od treh delov svoje knjige "Opis Madžarske" ter prevod Korabinskyjeve "Geografske enciklopedije" (1786), dopolnjen z novimi podatki, kjer so tudi jamam namenjena posebna gesla. Istega leta je izdal D. Teleki svoj popotni dnevnik, kjer sta poleg opisov tudi gravuri dveh jam, to sta prvi upodobitvi znanih jam Baradle in Silicke ledenice. Tudi "Geografija Madžarske" G. Szallerja, na 250 straneh, ki je izšla 1796, vsebuje opise številnih jam, ki so danes na Slovaškem in v Romuniji.

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CAVES IN THE WORKS OF THE HUNGARIAN NOVELIST MÓR JÓKAI

JAME V DELIH MADŽARSKEGA PISATELJA MÓRA JÓKAIA

KATALIN BOLNER - TAKÁCS [1]

Izvleček

UDK 821.511.141 Jókai M.
551.44(439):927 Jókai M.

Katalin Bolner-Takács: Jame v delih madžarskega pisatelja Móra Jókaia

V delih M. Jókaia (1825-1904) se kaže njegovo poznavanje geologije (vključno krasa in jam), mineralov, rastlin, živali, itd. Njegovi romani se dogajajo v odmaknjenih delih zgodovinske Madžarske ali tujine. Prizori iz jam vključujejo podzemeljske reke, kapniške jame, ledene in termalne jame ter lavine cevi. Med njimi opisuje tudi resnične, npr. Veterani, Örvénykő, Szkerisora in Modra jama na Kapriju. Enega izmed njegovih romanov so navdihnile Škocjanske jame. Jókai je 1853 obiskal jami Homoródalmás in Torja, 1876 in 1883 jamo Balika ter 1883 Dobšinsko ledeno jamo.
Ključne besede: jama v umetnosti, literatura, Madžarska, Jókai M.

Abstract

UDC821.511.141 Jókai M.
551.44(439):927 Jókai M.

Katalin Bolner-Takács: Caves in the works of the Hungarian novelist Mór Jókai

The books of the M. Jókai (1825-1904) incorporate scientific knowledge about geology (including karst and caves), minerals, plants, animals etc. The novels are set in remote parts of historical Hungary or abroad. The cave scenes involve underground rivers, stalactite caves, thermal caves and lava tubes. Real caves include those of Veterani, Örvénykő, Szkerisora and the Capri Grotta Azurra. Another book was inspired by Škocjanske jame. Jókai visited Homoródalmás and Torja caves in 1853, Balika cave in 1876 and 1883, Dobšina ice cave in 1883.
Key words: cave in art, literature, Hungary, Jókai M.

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Fig. 1: Mór Jókai (1825 - 1904).

Mór Jókai is one of the greatest personalities of Hungarian prose literature. Lasting already for one and a half century, his popularity is based upon his poetic personality, his rich imagination, idiom and humour, and, above all, his unequalled talent for story-telling. Besides these literary merits, his works also represent an extremely rich collection of knowledge on history, ethnography, botany, and zoology, as well as on geosciences - geography, astronomy, meteorology, hydrology, mineralogy, paleontology and, last but not least, karstology and speleology.

Mór Jókai was born in 1825 in Komárom, the prosperous commercial town on the Danube, as the third child of a noble family. He was educated in Komárom, Pozsony /Bratislava and Pápa; then he studied law in Kecskemét and after a two years apprenticeship in Komárom and Pest, he took his degree in law in 1846. He evinced his wide-ranging talent at an early age: his first poem was published at the age of 9, at the age of 15 he spoke German, English, French, and Italian, and had a talent for drawing and painting as well; in Kecskemét he staged plays and acted in them, and his first stories were written also at that time.

After the success of his first novel in 1846, he devoted his talent definitely to literature, and took an active part in public life, too. He participated in the 1848-49 revolution as a popular speaker, then as a journalist, and after its failure he had to live in exile for a few months. Returning to Pest in 1850 he published under a pseudonym, but soon was active again not only as a novelist, but as editor and also founder of almost a dozen newspapers and periodicals. He was a hard-working writer throughout his long lifetime: he got up at 5 o'clock in the morning every day, and by 10 o'clock he was ready with his work running to 1 or 2 printed sheets. With his life-work consisting of 64 novels, some 300 novellas and short stories, dozens of poems and dramatic works, and several hundred articles and speeches, Mór Jókai is also the most productive Hungarian writer. His most popular works have been translated into

several languages: in his lifetime 137 of his novels and stories were published in German, 48 in Polish, 30 in Russian, 23 in English, 22 in Czech; and there are translations into Croatian, Danish, Estonian, Finnish, French, Italian, Rumanian, Serbian, Slovakian, Slovene, and Swedish languages, too.

Jókai hed already gained exceptional recognition in his lifetime. The Hungarian Academy of Sciences elected him a corresponding member in 1858, an ordinary member in 1861, an honorary member in 1883 and a member of the board of directors in 1892. In 1861 he was elected Member of Parliament, and held this post for more than 30 years. On the occasion of the 50th anniversary of his literary activity in 1894, he was overwhelmed with honours: the freedom of the capital and other cities was presented to him, Budapest University conferred an honorary degree on him, and a hundred-volume special edition of his works was published. He died at the age of 80 in 1904; at his catafalque in the hall of the National Musem, representatives of the king, the government, the judiciary, as well as delegations of all social strata and all regions of the country payed tribute to him.

Jókai's art is a special mixture of romanticism and realism. Most of his works are historical novels, for which he took subjects from the most different centuries of the Hungarian and universal history; but his imagination was also inspired by legends, folk heroes and adventurers as well as by the national industrialization and the future of the country. Considerable merits of his novels and stories are the artistic and lively landscape descriptions, by which he guides the reader not only through the romantic scenes of historical Hungary, from Lake Fertő to the Great Hungarian Plain, from the Lower Danube to the Tatra Mountains; but to all the continents, from Italy to Siberia and China, from South America to the North Pole.

These descriptions involve a number of karst features: sinkings streams and resurgences [e.g. 7: in Vargyas Valley /Cheile Vîrghişului/; 17: in the Karst Mts.]; periodical springs [e.g. 4, 17: in the vicinity of Kolozsvar/Cluj]; travertine deposition [e.g. 11: in a tributary of the Maros]; limestone gorges [e.g. 9, 17: Torda Gorge /Cheile Turzii]; dolines [e.g. 19: near Fiume/Rijeka]; karrenfelds [e.g. 17: at Trieste, 22: at Raguza/Dubrovnik]; and, of course, caves. Besides several unnamed and very probably imaginary caves and cavities mentioned when describing different sceneries in the ALCADI region, especially in Transylvania [e.g. 3] and in Dalmatia [e.g. 22], we find *Veterani Cave* /Peştera Veterani/ at the description of the Lower Danube [13], the *Blue Grotto* in a short paragraph concerning Capri [23], *Szkerisóra Ice Cave* /Gheţarul Scărişoara/ referred as the 'Gyetzár' among the sights of Transylvania [11, 15], as well as *Örvénykő Cave* in the Bükk Mts. [24], the caves of Székelykő Hill at Torockó/ Rimetea [17], and the rock bridge in Stratenská Valley [21].

But caves are not only elements of the landscape in Jókai's works. He frequently cites caves, cavities and rock niches as hiding places for various animals (bear, wolf, lion, hyena, snake, panther, dragon, etc.) as well as for

robbers, refugees, and hermits [e.g. 3, 4, 5, 17, 20, 22]. It is strange, but all the caves well known in the last century within the boundaries of modern Hungary, such as *Baradla Cave, Szelim-lyuk* and *Abaliget Cave* are mentioned in this way only [4]. Some other actual or legendary caves — such as *Szilice Ice Cave* /Silická l'adnica/ [17], the crystall-lined cavities of the Alps [16], or the biblical cave of Saint Anthony [19] — are cited as analogues; and he often uses the word 'cave' for fortress, blocks of flats, gambling-clubs or ornamented rooms, too [e.g. 14, 15, 17, 19].

In addition to this list, there are at least 24 novels and short stories, in which caves are scenes for more or less important events in the plot. These cave scenes involve a surprisingly great variety of caves: stream caves offering not only refuge but also water supply [4, 9, 17] or used to drain a marsh [27]; through caves, that serve as pathways for escape or attack [6, 11, 18, 22]; a multilevel system, where the heroes have to fight not only against offensive troops, but the evil dwarfs living in the deeper levels, too [7]; caves decorated with dripstones [1, 17, 19] or ice formations [21] as solemn sites of tragic events and secret meetings; a shaft used for prison by pirates [19]; a water-filled cavern endangering coal mining activity [12]; thermal caves with warm lakes or hot springs in them [2, 22]; glacier caves [2, 8, 16] carved partly by warm springs into ice; a coral grotto providing tomb for the victims of a shipwreck [15]; a lava tube, through which Chilean aboriginals escape from Spanish conquerors [10]; other volcanic caves heated by solfatara-activity [26] or exhaling deadly sulphuric gas [20]; as well as crystal caves [25], or archaeological and paleontological sites [14, 16, 22]. Though most of these caves are suspected to be fictions in the given location, Jókai's imagination has usually translated literary-hearsay data or personal experiences to the scene of the plot. It is documented that the writer has visited at least four caves — it is not by chance that his most detailed and valuable cave descriptions concern these caves.

On the evidence of his travel notes, Jókai paid his first visit to a cave area in 1853, when he visited Homoródalmás Cave and Torja Cave during a three-weeks journey in Transylvania, and his experiences soon appeared in his books, too. *Homoródalmás Cave* (P. Mare de la Mereşti), referred by Jókai as 'the cave of Nagy Mál Hill' is the scene of his 1854 short story "The Hargita" [7] based on local legends, according to which the inhabitants of the nearby village were hidden here during the Tartar invasion. The story also recalls the discovery of the inner parts of the cave by following the bats that disappear in a narrow passage, where a blockage had to be removed to go on; and describes the purposes for which certain rooms were used by the refugees, citing the rooms by numbers — as it is shown on the 1836 map of István Fekete, who was Jókai's guide to the cave. In this story two more caves of the Vargyas Valley occur by name: *Ugron's Cave* and the *Horse-Barn* (P. Calului).

The gas-exhaling *Torja 'Stinking' Cave* (P. Pucioasa de la Turia) is mentioned in several stories [7, 9, 14]; and its detailed description is presented in Jókai's

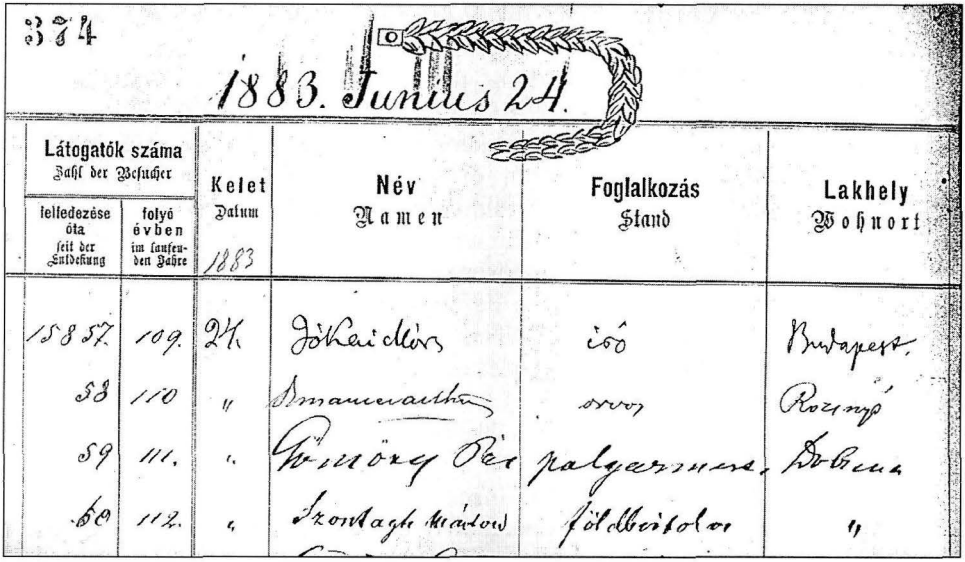


Fig. 2: The writer's signature in the visitor's book of Dobsina Ice Cave.

1882 novel "The Castle of Idols" [20], that takes place in the 12th century. Here, the cave serves as an ideal background for the young hero to meet with an old woman who is thought to have a pact with the devil; whilst we get information on the surroundings of the cave, the sulphur deposition around its entrance, its length of ten yards, and the deadly effect of the sulphurous gas on animals in front of the cave, on the gas-level inside (defined as "not higher than ones head") so it can be visited on stilts and as far as the torch remains alight, and that the gas is believed to heal rheumatic diseases.

Jókai's experiences in Torda Gorge during his 1876 journey in Transylvania are used in his 1877 novel 'There is a God' [17]. In this book, the gorge with its famed *Balika Cave* (P. Mare a lui Balica) — that had already appeared in some early works [4, 5], too — provides a safe way with night shelter for the heroes to by-pass the enemy troops during the 1848-49 revolution. Besides describing the environs and the fortified entrance hall of the cave, and recalling a local legend about its last lord, a robber, the writer reports on its ground-plan and its ascending character; as well as on its counterpart (P. Mică a lui Balica) opening at the same level in the opposite wall of the gorge, and on the nearby dripstone-decorated *Porlik Cave*, where the stalactites — just like organ-pipes — are suitable to play melodies on.

Jókai's most artistic cave description concerns *Dobsina Ice Cave* (Dobšinská l'adová jaskyňa), that he visited in 1883. In his 1884 novel "The white lady of Lőcse" [21] Jókai devotes a whole chapter to this cave, referring it as the scene of a secret meeting during the Rákóczy war of liberty. The section title

itself is "The Ice Cave", where Jókai describes not only the different ice speleothems, comparing them to pillars, waterfalls, altars, mirrors, carpets, lacework and tents; but also mentions the cave's formation by carbonic acid and water; as well as the layered structure of the ice laid down year by year; and he describes the equipment by which one can climb the ice wall. He links the huge breakdown at the bottom of the cave with the collapse on the surface, and explains them by a thunderbolt; and his imagination creates another entrance to the cave from Hanneshöhe, which has been verified almost one hundred years later by the discovery of Stratenská Cave.

A further, similarly detailed cave description can be found in Jókai's 1886 novel "Three heads of marble" [22]. This novel takes place in the 12th century in Dalmatia, and comparing the former scenery with the modern landscape of karst, the writer stresses the role of human impact by timberfelling and the introduction of goats, which have resulted in deforestation, soil denudation and even change of local climate. The key scene of this novel is a river cave system, through which the hero gets from the inside of the country to a valley near the sea. The river, that re-appears at the sea under another name, enters the cave after a short surface course and forms waterfalls at the entrance. The cave is accessible through a dripstone-decorated, dry higher passage; the hero finds stairs cut into the rock wall; and the path runs high above the thundering river that ends in a lake with no visible outlet. Though the site is placed in the Raguza (Dubrovnik) area, these elements give a strong hint that this scene has been inspired by Škocjanske Jame, that Jókai might have seen — or at least heard about it — on his 1876 journey via Trieste to Italy.

The investigation of Jókai's life-work from a speleological point of view is far from being completed, but the data obtained so far seem already to prove the potential speleohistorical importance of literary works. Jókai's novels and short stories are significant not only because of his artistic cave descriptions: considering the fact that almost all the well-known caves of his age are presented in his works, either directly or indirectly, and are enhanced by a wide range of information comprising almost all branches of speleology, his life-work can also be regarded as giving a summary of the speleological knowledge available in Hungary in the second part of the last century.

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JAME V DELIH MADŽARSKEGA ROMANOPISCA M. JÓKAIA

Povzetek

Dela Móra Jókaia (1825-1904), največjega madžarskega romanopisca, temelje tudi na njegovem poznavanju zgodovine, etnografije in tudi geologije (vključno krasa in jam), mineralov, rastlin, živali, itd. Njegovi romani in novele se dogajajo v skrajnih in odmaknjenih delih zgodovinske Madžarske (Transilvanija, Višavje, Velika madžarska ravnina) ali eksotičnih celin: Daljni Vzhod, Južna Amerika, itd. Njegova najbolj znana dela so bila prevedena v tuje jezike, toda večji del njegovega opusa, ki vključuje 54 romanov, okoli 300 novel in stotine člankov, je dostopen le v madžarščini.

Prizori njegovih del vključujejo jame kot skrivališča, puščavniška zavetišča in bivališča raznih živali. V opise pokrajin vključuje kraške oblike in pojave, kot so intermitentni izviri, lehnjak, vrtače, škraplje, itd., kot tudi izmišljene in prave jame (Veterani, Örvénykő, ledenica Szkerisora, Stratenska kamenita vrata in Modra jama na Kapriju). V okoli 20 njegovih del so prizori iz jam, včasih je jama tudi vodilno prizorišče. V jamskih prizorih so opisane najrazličnejše jame: kapniške in vodne jame, jame v nadstropjih, ponorne, izvirne, ledene in termalne jame ter jame s strupenimi plini.

Kot dokazujejo njegovi zapiski, je Jókai 1853 obiskal jami Homoródalmás in Torja, 1876 jamo Balika in sotesko Torda, 1883 pa Dobšinsko ledeno jamo. Opirajoč se na podrobne opise v enem izmed njegovih zadnjih romanov, ki se dogaja v Dalmaciji (in razpravlja o antropogenih vplivih na kraško denudacijo), je zelo verjetno, da ga je navdihnil obisk Škocjanskih jam, kar bi se lahko zgodilo med njegovim obiskom Italije 1876 ali 1887.

ACTA CARSOLOGICA	XXVI/2	24	265-275	LJUBLJANA 1997

FEDERICO DE COMELLI: GLI STUDI IN MERITO ALL'APPROVVIGIONAMENTO D'ACQUA POTABILE PER LA CITTÀ DI GORIZIA

FEDERICO DE COMELLI IN NJEGOVA ŠTUDIJA O OSKRBI GORICE S PITNO VODO

DI MAURIZIO TAVAGNUTTI [1]

Izvleček UDK 556.3(450.36)"18"

Di Maurizio Tavagnutti: Federico De Comelli in njegova študija o oskrbi Gorice s pitno vodo

V prejšnjem stoletju so v Gorici sklenili rešiti vprašanje pitne vode. Pripravljalnih raziskav se je lotil F. De Comelli (1826-1892). V zvezi z izkoriščanjem izvira Mrzlek je raziskoval jame v okolici Grgarja. Zaradi tega ga štejejo za pionirja tamkajšnje speleologije. 1887 je končal študijo, ki je bila tudi kasneje vedno upoštevana (Taramelli 1903). Njegov projekt "Mrzlek" (to je danes najpomembnejši vodni vir v vsej regiji) ni bil odklonjen zaradi pomanjkljivosti, kot piše Boegan, ampak ker so ga šteli za predragega.
Ključne besede: hidrologija krasa, zgodovina speleologije, Italija, Slovenija, Goriško, Mrzlek, De Comelli F.

Abstract UDC 556.3(450.36)"18"

Di Maurizio Tavagnutti: Federico De Comelli and his study of water supply of Gorizia

In the 19th century the decision to settle the water supply problem was accepted. F. De Comelli (1826-1892) started the investigations. He proposed to use the Mrzlek spring and therefore he explored caves in the surroundings of the Grgar village. That is why he is considered the pioneer of the speleology of this region. In 1887 he finished his study which was also later considered as a basic one. According to Boegan the project "Mrzlek" (this is the most important spring of the whole region) was not rejected because of imperfection but it was too expensive.
Key words: karst hydrology, history of speleology, Italy, Slovenia, Nova Gorica region, Mrzlek, De Comelli F.

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LA VITA E LE SUE RICERCHE

La ricerca di fiumi e acque sotterranee in genere, è sempre stata una delle attività principali dei gruppi speleologici.

Il Friuli Venezia Giulia, tra l'altro, vanta antiche tradizioni in questo campo: troviamo infatti già nella seconda metà del 1800 studiosi ed appassionati che si dedicano attivamente a questa nuova scienza per la quale viene coniato il nuovo termine "speleologia".

E' proprio dal nostro Carso che deriva, inoltre, il termine "carsico" universalmente impiegato per indicare il tipico paesaggio calcareo traforato da doline e grotte, mentre con il termine carsismo viene definita quella scienza che studia l'instaurarsi di tale fenomeno.

Stimolato da tali premesse e grazie all'aiuto del Centro Ricerche Carsiche "C. Seppenhofer" di Gorizia per le ricerche storiche, ho riesumato una vicenda legata all'ambiente isontino del 1887 in cui spicca una singolare figura, quella dell'ingeniere gradiscano Federico de Comelli.

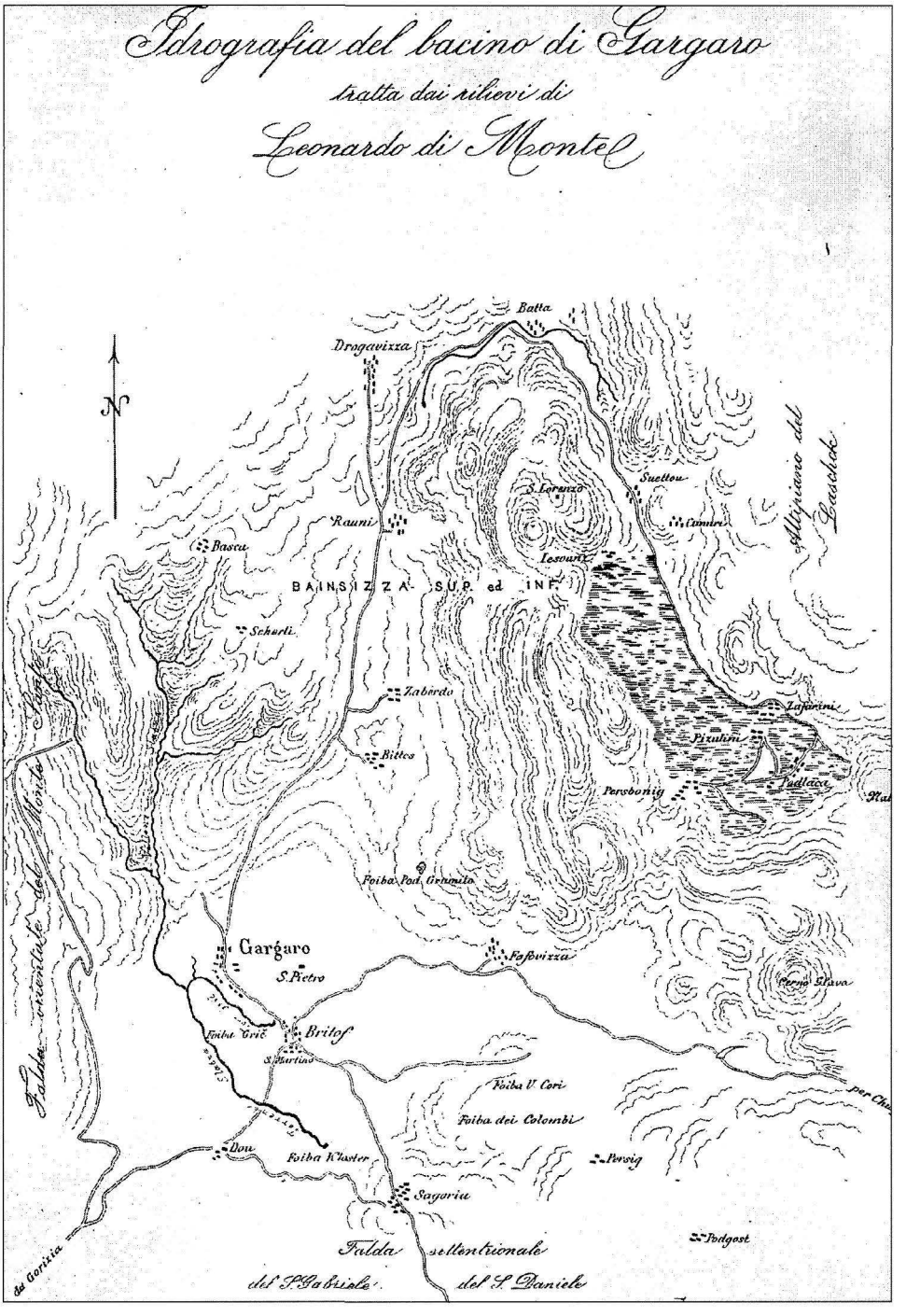
Verso la fine dello scorso secolo, Gorizia era alle prese con un problema di vitale importanza: quello della ricerca d'una fonte d'acqua potabile capace di soddisfare le esigenze della sua sempre crescente popolazione. E' vero che la città disponeva di un numero di pozzi artesiani pubblici sufficienti a garantire i bisogni igienici e alimentari della popolazione, ma i goriziani dell'epoca cominciavano a sentire in modo sempre più insistente la necessità di un vero acquedotto.

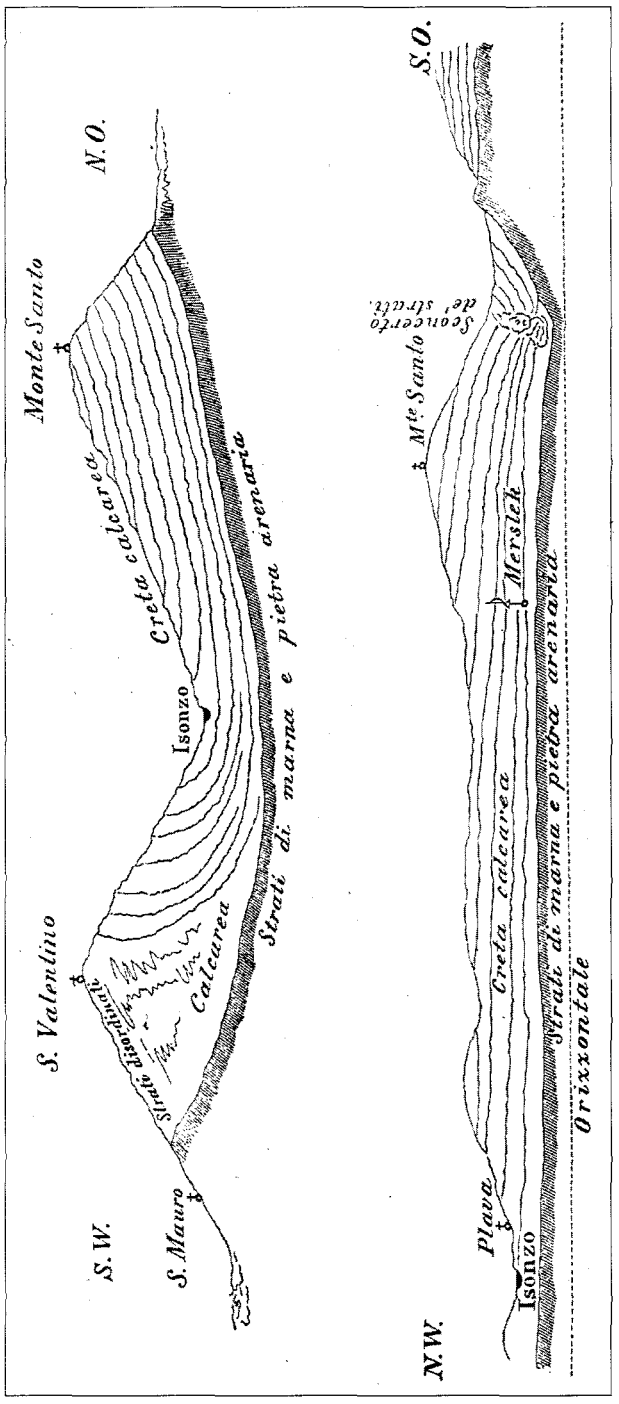
E' proprio in quegli anni che molti studiosi o addirittura semplici letterati, si occuparono di questo problema a dimostrazione che i disagi di doversi rifornire alle pubbliche fontane, anche per le piccole esigenze, dovevano farsi particolarmente sentire a tutti i livelli sociali. Una vicenda storica questa che ho voluto approfondire, in quanto avevo casualmente scoperto essere legata a dei risvolti della storia speleologica della nostra città, mettendo in luce, tra l'altro, l'opera di un ingegnere gradiscano che per gli studi di idrologia sotterranea eseguiti in quel periodo, deve essere senz'altro rivalutato e considerato, oserei dire, tra i più grandi precursori della speleologia moderna.

Così, sotto quest'ottica, dopo un'accurata ricerca sono riuscito a raccogliere una serie di dati che, seppur frammentari, sono sufficienti a comporre parte della storia riguardante la travagliata vicenda della ricerca d'acqua potabile a Gorizia e soprattutto è venuta alla luce la storia di un personaggio affascinante e dalla cultura veramente poliedrica: Federico de Comelli.

Federico de Comelli von Stuckenfeld nacque a Gradisca da nobile famiglia nel 1826 e vi morì nel 1892; suo padre Giuseppe fu ricco possidente terriero. Sposò Anna Galvagni da cui ebbe tre figli e tre figlie.

Tra questi Attilio fu pittore di fama e lavorò soprattutto a Londra ove morì nel 1929. I de Comelli abitavano a Gradisca dove un magnifico palazzo che porta ancora il loro nome, rimane a testimoniare la loro presenza in questa


Idrografia del bacino di Gargaro
tratta dai rilievi di
Leonardo di Montel
N
Batta
Dragavizza
Suettou
S. Lorenzo
Rauni
Basca
Lesouni
BAINSIZZA SUP. ed INF.
Schurli
Altipiano del Carsolot
Zabordo
Bittes
Persbonig
Foiba Pod Grmilo
Gargaro
S. Pietro
Britof
Foiba Crič
S. Martino
Foiba V. Cori
Foiba dei Colombi
Dou
Foiba K'luster
Persig
Sagaria
Podgost
Falda settentrionale del S. Gabriele
del S. Daniele
de Gorizia



cittadina. Federico studiò e si laureò in ingegneria a Vienna ed inoltre fu uno scrittore di notevole pregio; dopo il 1848 capeggiò col Favetti il movimento patriottico goriziano, esprimendo così tutta la sua vocazione irredentista al punto che dovette abbandonare il Friuli perché perseguitato dall'Austria. In giovane età lo troviamo in qualità di redattore dell' "*Eco dell'Isonzo*", un giornale la cui stampa viene effettuata dalla Tipografia Seitz a Gorizia, ma la cui redazione si trova a Gradisca in Casa Comelli.

Nelle mani di Federico la pubblicazione diventa ben presto un'arma per diffondere il proprio patriottismo. Con gli stessi intenti pubblica la strenna per il 1855, intitolata "il mè pais", scritta quasi interamente da lui. Come scrittore ebbe in prosa uno stile sostanzioso, solido e ricco di pensiero; alcuni suoi articoli comparvero anche sul "Politecnico" diretto in quegli anni dal Cattaneo. La sua fama di poeta inoltre ci viene tramandata da quattro poesie pubblicate su "il mè pais": Buona sera, Il varda-fuc, Il ciant dell'armentar e Il ciazzador.

Ebbe la stima e l'amicizia di noti letterati e studiosi dell'epoca quali il Cattaneo, il Prati, il Fusinato, il Crispi, il Correnti, il Martini, il De Gubernatis, il Dall'Ongaro, il Duprè ed altri. In esilio diresse i lavori della ferrovia umbra, ed inoltre elaborò numerosi altri progetti, ma a noi piace ricordarlo soprattutto per la pubblicazione di uno studio riguardante l'approvvigionamento d'acqua potabile per la città di Gorizia, opera che, dopo la sua morte, meritò il plauso da parte dello stesso Torquato Taramelli impegnato anch'egli a risolvere l'analogo e spinoso problema. Dopo trenta anni di esilio Federico ritorna finalmente nella sua cittadina natale. Ad un primo esame ci sorprende che una mente abituata al calcolo ed al pensiero razionale come quella di un ingegnere, possa conciliarsi con l'attività di scrittore, poeta e non da ultimo ricercatore d'acque sotterranee.

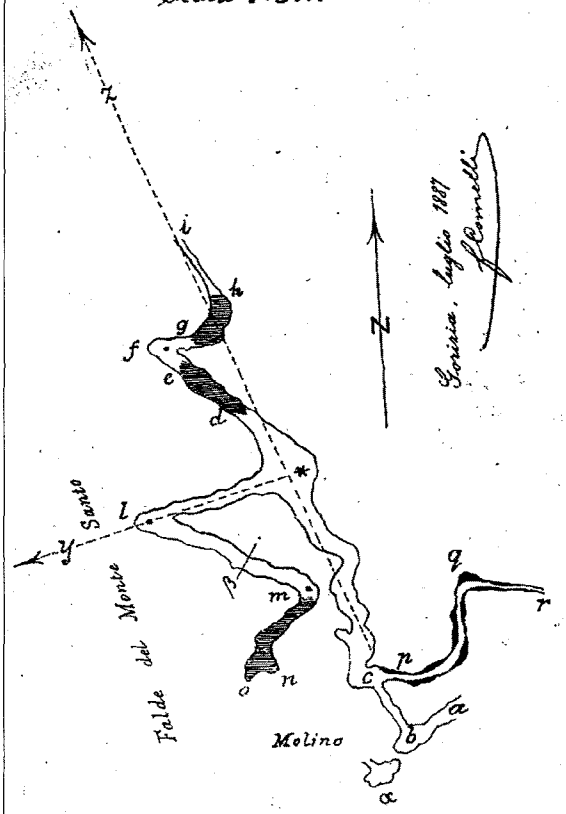
Ma se facciamo un'attenta analisi della vita di questo illustre personaggio, possiamo constatare come, nel corso di tutta la sua frenetica attività, la parte *emotiva emerge quasi sempre su quella raziocinante dell'ingegnere. Possiamo* infatti notare proprio nel suo lavoro, sullo studio delle acque sotterranee del Merzlek (Mrzlek), come egli si sia dedicato con vero e proprio entusiasmo al problema dell'approvvigionamento d'acqua potabile per la città di Gorizia; dagli studi eseguiti risulta evidente che egli va ben oltre il proprio compito professionale. Si trasforma perciò in uno speleologo e con pochi amici esplora sistematicamente numerose cavità nei pressi di Gargaro (Grgar) (ora in Slovenia).

Purtroppo non ci sono molti dati che documentino l'attività di Federico Comelli nel campo speleologico ma presumiamo che sia stata notevole. A tal proposito ricordiamo una dettagliata relazione sull'esplorazione della Grotta di Gargaro, esplorazione che egli compie in merito agli studi sulle acque sotterranee del Merzlek e che pubblicherà nella sua pregevole opera, presentata all'Amministrazione Civica di Gorizia, riguardante il provvedimento d'acqua per la città.

Questa relazione a mio avviso è un raro esempio di studio speleologico condotto con cognizione, scrupolo e metodi professionali, ben difficilmente riscontrabili in altri analoghi lavori apparsi in quell'epoca. La pubblicazione di questo lavoro, infatti, sarà presa per molti anni come punto di riferimento da numerosi autori, che, come il Comelli, hanno cercato di risolvere l'annoso problema dell'acqua potabile a Gorizia. Tutti però confermano le ipotesi che da tempo l'ingegnere gradiscano aveva formulato nel suo lavoro, e cioè della non convenienza finanziaria e impossibilità pratica a realizzare tale impresa.

Pertanto il progetto di alimentare l'acquedotto goriziano con le aqcue sotterranee del Merzlek fu definitivamente abbandonato per ragioni pratiche e non perché gli studi fossero stati eseguiti poco correttamente come sosteneva il triestino Boegan. Infatti, tra gli autori che si occuparono del problema, il più autorevole, Torquato Taramelli, in un suo lavoro (1903) riferendosi allo studio eseguito dal Comelli sul Merzlek afferma: - *Devo però osservare che allora*

Pianta dei sotterranei di Gargaro.



Spiegazione della pianta e dei rispettivi sotterranei.

a	*Ingresso alla foiba. Altezza al piano di campagna m. 278 sul livelo del mare.*
a	*Foiba scoperta: prof. m. 11.30; inaccessibile dall'alto, ma in comunicazione, mediante un passaggio coperto, col punto* b.
a — b	*Discesa erta ma praticabile, a cielo libero, fino a m. 11.30 sotto il piano di campagna.*
b	*Altezza sul livello del mare m 266.70.*
b — c	*Piano inclinato sotterraneo, ripidissimo, largo da 0.80 a 0.50, a volta acuta, in forma di crepaccio, che mette alle grotte inferiori. Vi si scende con le funi.*
c	*Altezza aneroidale m. 255.*
c — d	*Sotterraneo; asciutto il 13/7; leggermente inclinato.*
x	*Punto centrale. Parte più ampia della grotta. Altezza aneroidale m. 252.*
d	*Ristringimento della grotta.*
d — e	*Parte più depressa. Stagno d'acqua, in cui guizzano de' ranocchi; prof. 0.20.*
f	*Punto in rialzo; asciutto il 13/7. Pertugio praticabile verso* g. *Inclinazione degli strati da* f *a* g *35° S.*
g — h	*Nuova depressione. Acqua. Altezza aneroidale 245. Temperat. dell'aria 9°: dell'acqua 8° 2 R.*
h — i	*Parte asciutta, con inclinazione inversa. Il 13/7 un liccc filo d'acqua corrente, proveniente da* l.
i	*Estremità del sotterraneo in direzione nord-nord-ovest, oltre la quale non è possibile inoltrare.*
* — l — m	*Altro braccio della galleria. Asciutto il 13/7.*
β	*Galleria a volta naturale regolarissima, con allargamenti laterali, larga 1.80, alta 1.25.*
m	*Altezza aneroidale 255. Temperatura 10° 2.*
m — n — o	*Acqua; profondità media 0.50. Temperatura dell'acqua 10° 1.*
n	*Braccio morto.*
o	*Breve pertugio di scarico delle acque. Il 13/7 lambito dalle acque fino alla soglia. Oltre il pertugio cedesi una piccola grotta risaliente. Passaggio impossibile.*
p — q — r	*Terza diramazione del sotterraneo, alla volta (sembra) di Chiapovano: ingombra parzialmente di depositi di fango argilloso, avvicendati sui finochi; inclinazione spezzata da* q a c e da q a r.
r	*Estremità del sotterraneo, senza continuazione visibile.*
y	*Direzione verso il Monte Santo.*
z	*„ alla vetta del monte Kobilik (Veggasi la carta militare).*

Le punteggiate segnano le direzioni riferite sopraterra.

Estese: Ramo principale b — l, *lunghezza sviluppata sull'asse* m. 64.00
Ramo laterale * — o, *sviluppo c. s.* „ 42.00
Ramo „ c — r, „ „ „ 26.00

Riassunto delle altezze barometriche:

al piano di campagna	m. 278.00
principio del pozzo di discesa (b, *altezza rilevata*)	„ 266.70
punto c	„ 255.00
„ *	„ 252.00
„ g	„ 245.00
„ m	„ 255.00

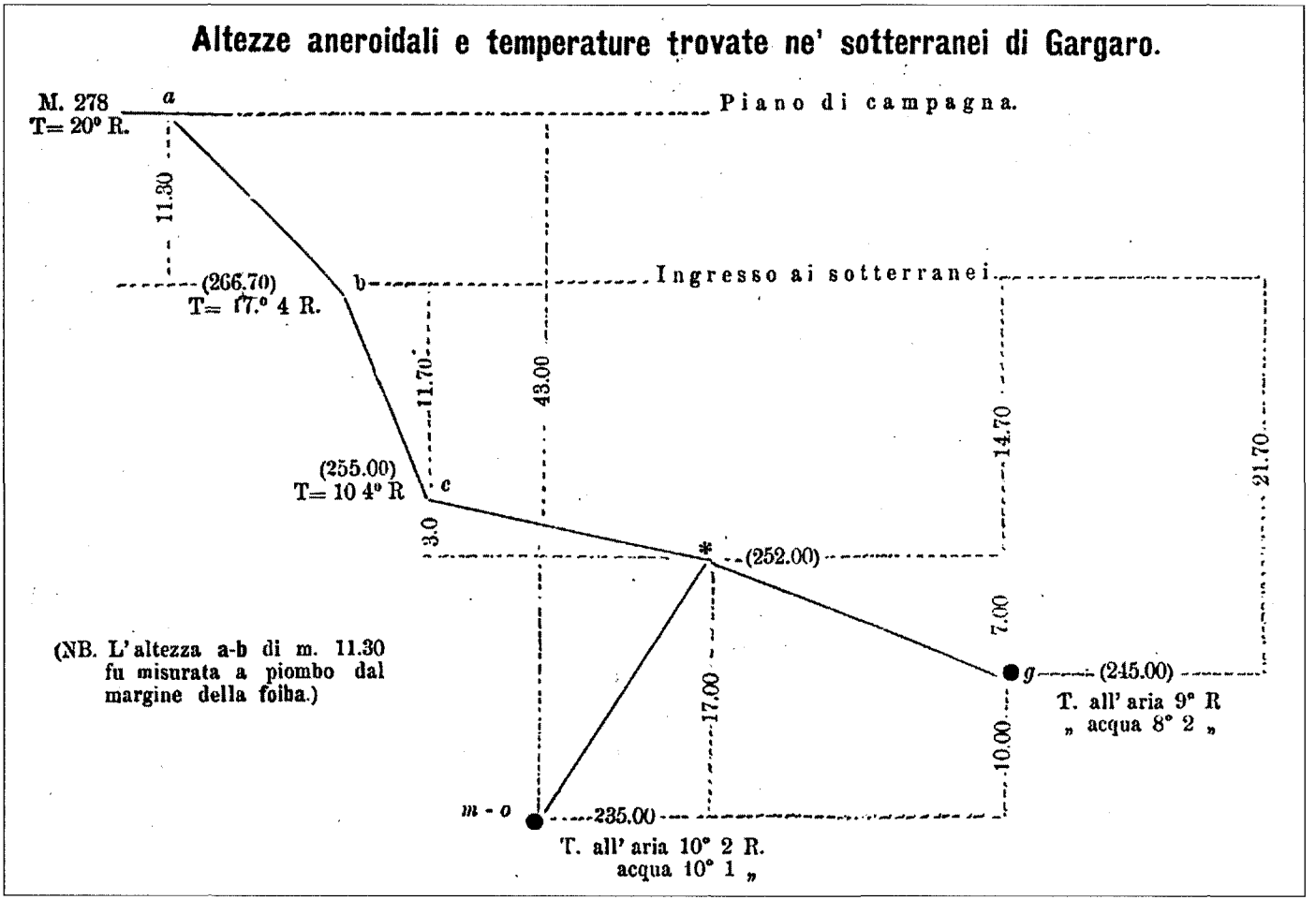
Temperature sotterranee: punto c 10° 4 R. *aria*
„ f 9° 0 „ *aria*
„ g 8° 2 „ *acqua*
„ m — o 10° 2 „ *aria*, 10° 1 „ *acqua*

mancava uno studio diligente della Merzlek; e questo fu eseguito ed esposto nel miglior modo dal compianto ingegnere Federico Comelli, autore di una relazione molto pregevole, pubblicata nel 1887, sulla quale è indispensabile che richiami l'attenzione della spettabile Amministrazione Civica, poiché, non avendo potuto trattenermi a lungo nella regione, debbo far tesoro delle osservazioni e delle considerazioni di questo Autore, che ben a ragione dichiara di "aver studiato con passione e giudicato senza passione" e che ha considerato l'argomento della provvista d'acqua per Gorizia con larghezza di concetti, estendendo le sue ricerche a molte altre fonti,... -.

Lo stesso Autore, sempre nella sua relazione presentata all'Amministrazione Civica di Gorizia, nel precisare i rapporti stratigrafici tra il Monte Santo e l'opposto Monte S. Valentino, cita nuovamente il Comelli avendo quest'ultimo affermato: - *... le condizioni idrografiche interne della Merzlek non mi sembrano tali da potersi con asservanza assicurare la riuscita d'un lavoro, nel quale siano i mezzi meccanici eliminati.* -. E poi aggiunge: - *Sebbene non abbia a lamentare di aver incoraggiato la ricerca della fonte ad altezze tali da non richiedere l'innalzamento meccanico, tuttavia, se avessi allora avuto in mente il concetto che mi sono fatto dappoi dell'andamento delle acque sotterranee nei terreni permeabili e particolarmente nei calcari, non mi sarei nemmeno azzardato a proporre lo scavo del breve cunicolo di presa allo scopo di tentare un leggero sollevamento di una parte dell'acqua della fonte.*-.

Il Taramelli, nel corso di tutto il suo lavoro, cita continuamente il Comelli dimostrando l'estrema validità dell'opera di quest'ultimo. Bisogna inoltre ricordare che Federico Comelli, pur non essendo stato uno speleologo nel senso stretto della parola, si dedicò attivamente alla esplorazione delle cavità circostanti il paese di Gargaro. Sebbene queste esplorazioni siano strettamente collegate con lo studio del percorso sotterraneo del Merzlek, dimostrano come quest'uomo, oltre ad essersi dedicato con vero amore a questo tipo di ricerche, abbia precorso i tempi, impegnandosi con criteri rigorosamente scientifici in una disciplina nuova per l'ambiente isontino dell'epoca, anche se per la verità il goriziano Carlo Seppenhofer, suo contemporaneo, aveva già esplorato alcune cavità vicino alla nostra città ed aveva cominciato un'attenta opera di sensibilizzazione presso la cittadinanza.

Ritornando allo studio del Merzlek, il Taramelli aggiunge: - *Secondo ogni probabilità le acque che si perdono nelle fratture del calcare, entrando nella massa di questo a preferenza per quelle numerosissime foibe che appunto si osservano nell'altopiano di Laschik, nel raccogliersi per originare la Merzlek e le fonti che la fronteggiano, si abbassano rapidamente in corrispondenza allo stesso altipiano; epperò il Comelli giudica che "l'andare sottoterra alla ricerca di quelle acque sarebbe uno sprecare tempo, lavoro e quattrini" (pag. 22). L'autore (il Comelli, n.d.a.) non ommise di studiare accuratamente le foibe della valle del Gargaro, così nella loro topografia come per la temperatura delle acque; traendone sicura dimostrazione che da quelle foibe non può essere alimentata la Merzlek, dicui le*


Altezze aneroidali e temperature trovate ne' sotterranei di Gargaro.
M. 278
T= 20° R.
a
Piano di campagna.
11.30
(266.70)
T= 17.° 4 R.
b
Ingresso ai sotterranei
11.70
43.00
14.70
21.70
(255.00)
T= 10 4° R
c
3.0
*
(252.00)
7.00
(NB. L'altezza a-b di m. 11.30
fu misurata a piombo dal
margine della foiba.)
g
(245.00)
T. all' aria 9° R
„ acqua 8° 2 „
17.00
10.00
m - o
235.00
T. all' aria 10° 2 R.
acqua 10° 1 „

acque, sprofondandosi direttamente sotto l'altopiano più a nord-est, non devono però abbassarsi di tanto da raggiungere quell'ambiente di calore che troppo scemerebbe la loro freschezza originaria. -. Ed aggiunge: - *Ciò non toglie che le osservazioni dell'ingegner Comelli sulla temperatura dell'aria e dell'acqua nelle grotte di Gargaro costituiscono un materiale assai prezioso per la speleologia e per l'idrografia sotterranea e convalidino l'opini - one che la Merzlek abbia origini lontane ... -.*

Tuttavia a Gorizia il pressante problema dell'approvvigi - onamento d'acqua era particolarmente sentito e lo si riscontra anche in altri scritti di autori vari. Tra questi spicca la singolare figura di un ispettore montanista che propone alcune soluzioni per la cattura delle acque sotterranee del Merzlek, soluzioni giudicate dal Taramelli con scetticismo al punto da dichiarare, sempre interponendo lo studio del Comelli: - ... Tuttavia il parere di una persona (il Comelli, n.d.a.), che aveva studiato con amore e con molta perspicacia la questione dell'ap - privvigionamento d'acqua per la città di Gorizia, doveva rendere più guardingo il signor Ispettore Montanista Tchebull, che in uno dei suoi rapporti dichiara di conoscere il libro del Comelli, nelle sue assicurazioni all'Amministrazione Civica, la quale desiderosa com'essa è di non tralasciare tentativo per riuscire nella importante impresa, era naturalmente disposta a prestar fede ad una così asservante promessa di trovare, di seguire e di raccogliere l'acqua della Merzlek alla desiderata altitudine. Anche il Comelli, in teoria, ammetteva la possibilità di rintracciare il corso della fonte anche oltre il Gargaro; ma soggiungeva: "Intanto chi vorrebbe arrischiare un tempo ed una somma considerevole dietro tale ricerca? E trovatolo il Merzlek, nelle sue profondità misteriose, sarà possibile (e con che spesa?) portarlo sopraterra per condurlo in città? (pag. 103)." -

Infine sempre il Taramelli aggiunge, quasi ad eliminare ogni dubbio: - ... *Per le ragioni, che verrò esponendo, io poi dubito che esiste in realtà un corso sotterraneo individuato in uno o due rami e che quindi le opere di ricerca, di inseguimento e di cattura proposte dal signor Tchebull siano in opposizione alla più probabile struttura dell'apparato acquifero sotterraneo.* -

Nel 1903, un altro goriziano, Giuseppe Bramo riprende l'argomento e pubblica un fascicolo riguardante l'importante problema. Nel suo lavoro l'Autore elenca, tra l'altro, le possibili fonti d'approvvigionamento d'acqua esistenti nel territorio goriziano. E' curioso osservare che anch'egli spesso deve rifarsi agli studi eseguiti da Federico Comelli di cui cita, proprio in questa pubblicazione, alcune osservazioni e dati inediti che non sono riuscito a rintracciare da nessun'altra fonte. La cosa è molto evidente nell'elenco delle riserve d'acqua, a disposizione di Gorizia, che Bramo riporta dettagliatamente e che io riassumo brevemente qui di seguito.

LE RISERVE ACQUEE A DISPOSIZIONE DI GORIZIA.

... *3. Acqua del sottosuolo* (qui l'Autore suddivide diversi casi)... *Se le circostanze imponessero di dovervi ricorrere ad ogni costo, tenendo conto delle fatte enunciazioni, converrebbe pensare ad un impianto di sottosuolo sito sulla plaga compresa tra Vipacco e l'Isonzo, al di là di S. Andrea, mentre un impianto a monte della città arrischierebbe cogliere acque della sottogiacente formazione eocenica, cui allude il Professor Taramelli a pag. 38 del suo opuscolo "Risposte ad alcuni quesiti..." e che suole contenere acqua meno buona per l'uso potabile.*

4. Ad oriente di Gorizia, distanti 20 Km circa, abbiamo le sorgenti di San Paolo, rappresentate da sette polle di varia portata. La principale diede al Sig. Streiz il 16 agosto 1887, 1018 m.c., all'Ing. Comelli il 14 settembre 1887, 2186 m.c. il Signor Streiz ne aveva misurato solo 1578.
Considerando che l'anno 1887 era d'una siccità eccezionale, mai riscontrata da prima per 53 anni, l'Ingegner Comelli inclinava a ritenere che la portata media delle sorgenti sul finire dell'estate degli anni normali, potrebbe calcolarsi in 2200 m.c. ...

7. Le sorgenti di Chiapovano. Le polle che scaturiscono a nord di Chiapovano costituiscono le omonime sorgenti. L'Ing. Comelli, che ne misurò la portata, constatò il 27 luglio 1887, 2000 m.c., e fu subito indotto ad esclamare: "la portata non franca la spesa d'una conduttura", visto il numero degli abitanti ed i bisogni della città di Gorizia.

8. Le sorgenti della valle di Tribussa. L'Ing. Comelli, a pag. 66 e seg. della sua bella ed istruttiva relazione ne enumera 4 di principali, di rendimento incostante, variabile tra 300 e 1600 m.c. giornalieri. ... -

Sul problema dell'acqua potabile a Gorizia si soffermarono in seguito altri Autori ma sempre con minore incisività, visto che tra l'altro, con l'avvento di nuove metodologie e diverse tecnologie, l'acquedotto venne ugualmente costruito. Resta comunque la validità del lavoro svolto dai primi pionieri dello studio e della ricerca delle acque sotterranee.

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FEDERICO DE COMELLI IN NJEGOVA ŠTUDIJA O OSKRBI GORICE S PITNO VODO

Povzetek

V prejšnjem stoletju so v Gorici sklenili rešiti vprašanje pitne vode s pomočjo vodovoda. Do takrat so dobivali vodo iz številnih vodnjakov, ki pa niso več zadoščali. Pripravljalnih raziskav se je lotil F. De Comelli (1826-1892). Doma je bil iz Gradisca d'Isonzo (Gradišče ob Soči). Po študiju na Dunaju, kjer je dosegel stopnjo inženirja, se je vrnil domov. Priključil se je gibanju za zedinjenje Italije in bil nekaj časa urednik časopisa "Eco dell'Isonzo". V zvezi z izkoriščanjem izvira Mrzlek je raziskoval jame v okolici Grgarja. Kot je razbrati iz študije, je jame raziskoval zelo podrobno. Prav zaradi tega ga štejemo za pionirja speleologije na Goriškem. 1887 je končal študijo, ki je bila tudi kasneje vedno upoštevana (Taramelli 1903). Prišel je do enakih zaključkov, kot tudi številni njegovi nasledniki: zajetje podzemeljske vode iz Mrzleka bi bilo tehnično zahtevno in drago delo. Njegov projekt "Mrzlek" (ta izvir je danes najpomembnejši vir za oskrbo s pitno vodo cele regije) ni bil odklonjen zaradi pomanjkljivih in nepopolnih raziskav, kot piše Boegan, ampak ker so ga šteli za predragega.

PAPERS PRESENTED AT 4TH INTERNATIONAL KARSTOLOGICAL SCHOOL "CLASSICAL KARST" POSTOJNA 1996

PREDAVANJA, PREDSTAVLJENA NA 4. MEDNARODNI KRASOSLOVNI ŠOLI "KLASIČNI KRAS", POSTOJNA 1996

An important contribution at gathering and preparing the papers was given by the karstological club Anthron (Postojna).

Pri zbiranju in pripravi prispevkov je veliko pomagalo krasoslovno društvo Anthron (Postojna).

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MEDJAME (SAMOBORSKO GORJE, CROATIA) - AN EXAMPLE OF SPELEOLOGICAL FEATURES FORMED IN UPPER TRIASSIC DOLOMITE

MEDJAME (SAMOBORSKO GORJE, HRVAŠKA) - PRIMER SPELEOLOŠKIH POJAVOV V ZGORNJETRIASNEM DOLOMITU

NENAD BUZJAK[1]

Izvleček UDK 551.44(497.5)

Nenad Buzjak: Medjame (Samoborsko gorje, Hrvaška) - primer speleoloških pojavov v zgornjetriasnem dolomitu

V Samoborskem gorju (SZ Hrvaška), na planoti Medjame, so speleološki pojavi v različnih razvojnih fazah, v triasnih in miocenskih kamninah. Deloma ali v celoti so zapolnjeni s podornim materialom. Ob vhodih in v podzemlju je opazno grezanje, povezano z rapokami. Okoli 500 m SZ od Medjam ponika potok Podzvir. Na dan pride v vznožju planote Medjame, na stiku neprepustnih spodnjetriasnih plasti in zgornjetriasnega dolomita.

Ključne besede: speleomorfologija, speleogeneza, kompleksne speleološke oblike, podor, onesnaženost, Hrvaška, Samoborsko gorje, planota Medjame.

Abstract UDC 551.44(497.5)

Nenad Buzjak: *Medjame (Samoborsko gorje, Croatia) - an example of speleological features formed in Upper Triassic dolomite*

The speleological phenomena in Samoborsko gorje (NW Croatia, Medjame plateau) are in Triassic and Miocene rocks. They are in different stages of development. They are partially or completely filled with falling rocks. Along entrances and underground there are subsidences that suggest the presence of fissures. About 500 m NW of Medjame area, the Podzvir stream sinks. It reappears at the foot of the Medjame plateau on the contact of impermeable Lower Triassic beds and Upper Triassic dolomite.

Key words: speleomorphology, speleogenesis, complex speleological features, breakdown, pollution, Croatia, Samoborsko gorje hills, Medjame plateau.

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INTRODUCTION

Samoborsko Gorje is a northeastern part of Žumberačka Gora mountain in north-west Croatia. It is a hilly fluviokarstic area with many exo- and endokarst features (dolines, uvalas, blind valleys, caves, pits) and hydrological features (karst springs, sinking streams).

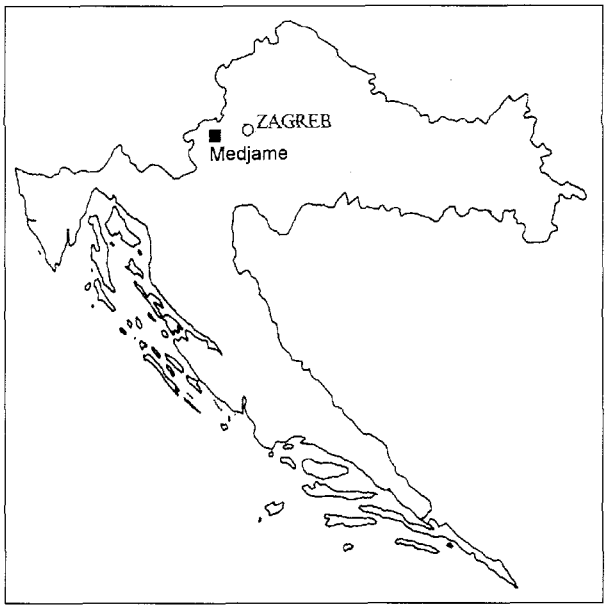


Fig. 1: Position map of the Medjame plateau.

The Medjame area is located between the villages of Dubrava and Rešetari near the town of Samobor, about 25 km NW from Zagreb (Fig. 1). It is a small karst plateau intersected by fissures along which entrances to five underground cavities of different dimensions were opened by breakdown. About 500 m NW from Medjame, the Podzvir creek sinks. After 500 m of underground flow its water rises at Podzvir cave at the foot of the Medjame plateau.

FORMER INVESTIGATIONS

Medjame was for the first time described by N. Reizer in his article about karst relief of Samoborsko Gorje. He describes three shafts (he also uses term "cave", probably because he noticed that their length is bigger than depth) which were originated by widening of fissures due to sinking of precipitation water from the surface. Therefore breakdown occures along the passages. Reizer classes these features as dry fissure caves. He also describes Podzvir cave, which he classes among caves developed by the activity of underground streams (Reizer 1911).

In 1933 J. Poljak described Podzvir cave in detail and published its plan. He classes it with geologically younger caves formed along a fissure (which was additionally widened by neotectonic movements) by an underground stream (Poljak 1933).

In 1950 Z. Dugački published the first sketch of the Medjame plateau. Its speleological features he considered a result of karst erosion and breakdown. He also described Podzvir cave as one originated due to the activity of an underground stream at the contact of Upper Triassic dolomite and impermeable Lower Triassic slate (Dugački 1950).

After Z. Dugački, these features were investigated in the 1970s and 1980s by cavers from Samobor and Zagreb, but they did not publish their results. New investigations made during 1995 and 1996 give new data about its genesis.

GEOLOGICAL AND HYDROGEOLOGICAL SITUATION

Many authors have written about relief, geological and hydrogeological conditions in Žumberačka Gora mountain and Samoborsko Gorje (Gorjanović-Kramberger 1894; Herak 1956; Herak et al. 1969; Prelogović 1970; Šikić & Prelogović 1970; Šikić et al. 1979; Šuklje 1938).

According to classification of relief in Croatia, Žumberačka Gora mountain was classed as a faulted-folded massive of Mesozoic folding of heterogeneous type (Bognar 1980). Its heterogeneity is conditioned by complexity of its geological constitution and tectonic structure. Investigated area of Samoborsko Gorje is a part of a tectonic unit, the Žumberačko-Medvednička nappe (built of Triassic, Jurassic and Cretaceous sediments), which was napped over autochthonous Paleozoic beds of eastern part of Žumberačka Gora mountain during the Sava orogenetic phase. This nappe was by additional movements divided into smaller structural units. In Samoborsko Gorje there are fault systems of NE-SW, NW-SE and N-S directions (Šikić et al. 1979).

Although on impermeable Paleozoic base in places crops out due to neotectonic movements and exsogenic modelling (Bognar 1980), fluviokarst relief predominates in the Samoborsko Gorje area, since most of its surface is covered by karstifiable rocks - Upper Triassic dolomite, Jurassic, Cretaceous and Miocene Lithotamnium limestone.

The Medjame area is built of Upper Triassic dolomite which, as the part of the above-mentioned nappe dominating in constitution of this part of Samoborsko gorje, covers impermeable Lower Triassic beds (clastites). The dolomite is of massive structure, unobservable stratification and low $CaCO_3$ content - less than 10% (Šikić et al. 1979). At some places (particularly in researched features) it is very fragile and crumbly, so dolomitic sand, rock debris and blocks often occur. Nevertheless, its karstification is, along with other relevant factors, accelerated owing to numerous fissures which intersect it. The southern edge of the Medjame plateau is a fault of NW-SE direction, along which the valley of Podzvir creek was formed. Its bed was, owing to fluvial erosion, cut into less resistent dolomite to the impermeable base. On the Medjame plateau fissures of NE-SW, NW-SE and N-S directions occur. It is supposed that its

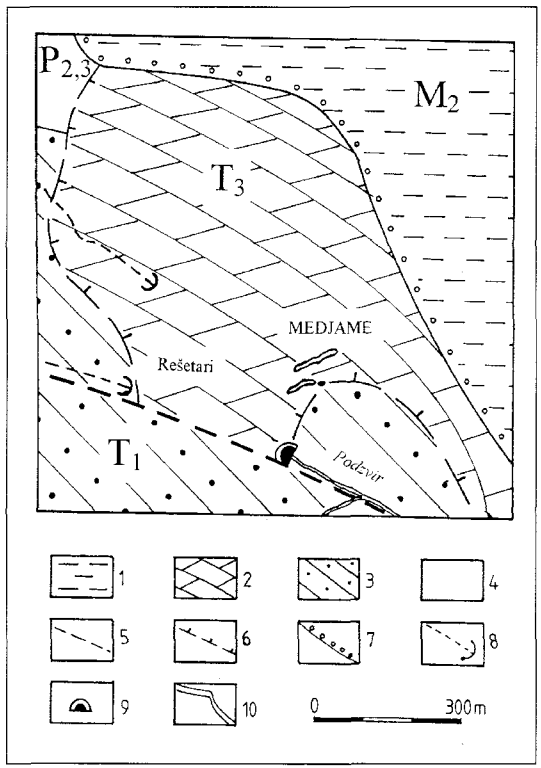


Fig. 2: Geological map: 1-Miocene Lithotamnium limestone, 2-Upper Triassic dolomite, 3-Lower Triassic beds (clastites and carbonates), 4-Middle and Upper Permian beds (clastites), 5-fault, 6-front of nappe, 7-front of transgression, 8-ponor, 9-cave, 10-creek.

origin is connected with tectonic movements on the abovementioned fault. Along them were developed the investigated speleological features (Fig. 2).

Due to the small thickness of karstifiable rocks, the depth of karstification is also small. Underground water flow is directed along the contact between permeable Upper Triassic dolomite beds and impermeable Lower Triassic beds at which the Podzvir spring cave occurs (Dugački 1950).

SPELEOMORPHOLOGY

On the Medjame plateau five speleological features of similar origin and morphology occur (Fig. 3). They mostly consist of one main passage of fissure cross-section without any longer branching passages. Its extension corresponds to extending of fissures which initiated its origin. Long and narrow entrances are result of ceiling breakdown along passages, which had a big part in the development of all investigated features.

The largest among them is called Duga Jama, entrance of which is 95 m long. According to results of investigation by cavers from Samobor and Zagreb, its branching passages are over 100 m long and 15 to 20 m deep. During their researches and specially today it was filled in by falling rocks and waste in most parts, so it was impossible to measure true dimensions. Its ceiling is completely fallen in along the whole passage, so its entrance chamber is of almost the same length as the passage. In the first part of Duga Jama falling rocks completely isolate one part of the passage, so it seems like a separate feature. In central its part the passage is partially blocked due to construction of a macadam road.

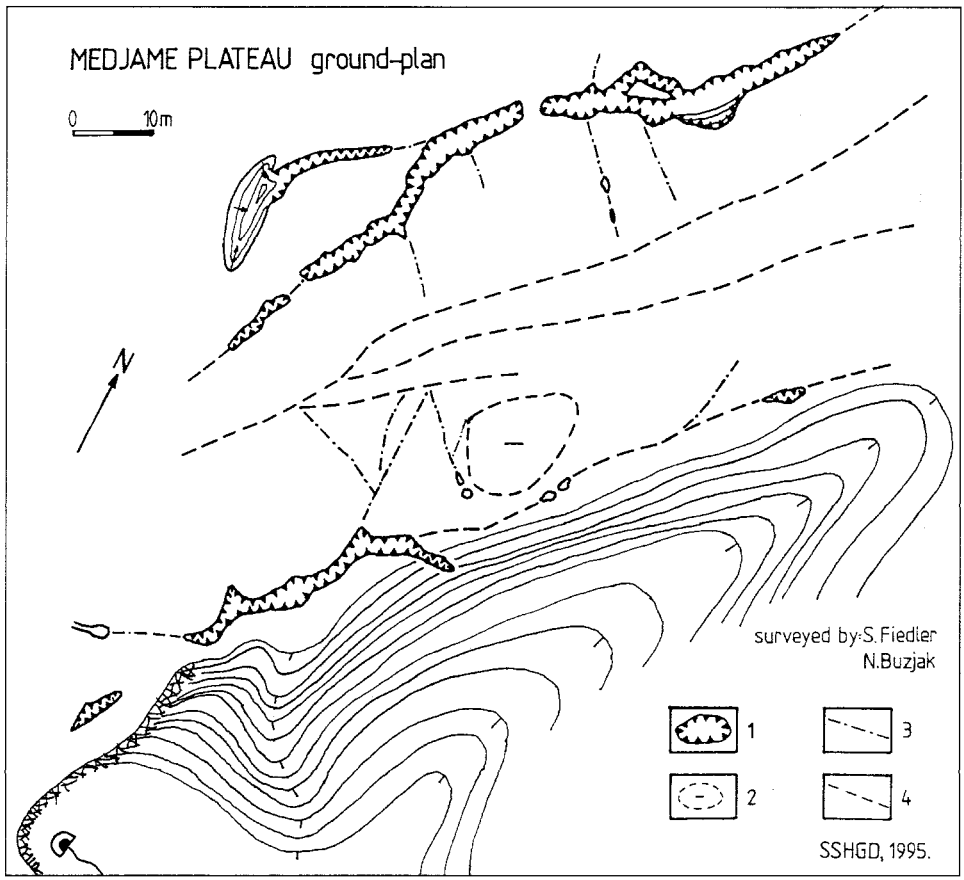


Fig. 3: Map of the Medjame plateau: 1-entrance, 2-larger subsidence, 3-fissures, 4-elongated subsidences.

Duga Jama was connected with a fossil ponor called Medjame ponor by a passage also blocked by breakdown (Fig. 4). This feature consists of one mostly horizontal passage with a funne-llike entrance. It is 15 m long and 6,5 m deep. The bottom is covered by rock debris, blocks and soil drifted from the surface. The water which probably formerly sank into Medjame ponor flowed into Duga Jama.

Another branch of Duga Jama is also a feature called Jamica, whose entrance is located 7 m south of the central part of Duga Jama. Its passage is 9 m deep, 11 m long and up to 4 m wide, and it ends in a narrow, impassable fissure. This fissure can be followed at the surface and it extends vertically toward the Duga Jama passage. Jamica's entrance is shorter and narrower than the entrances of other features (3 x 0,5 m) because no breakdown occurred along whole passage.

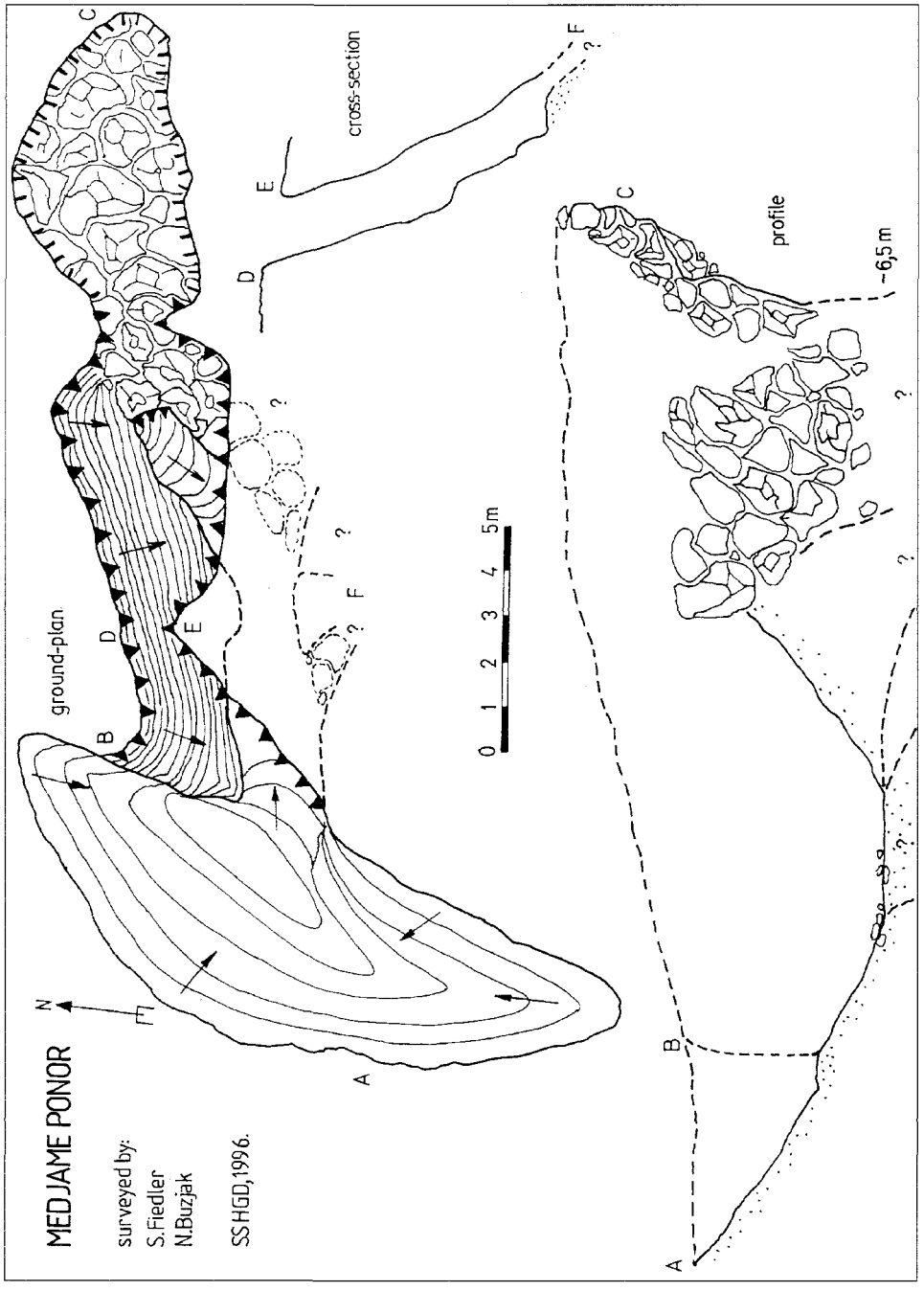


Fig. 4: Medjame ponor.

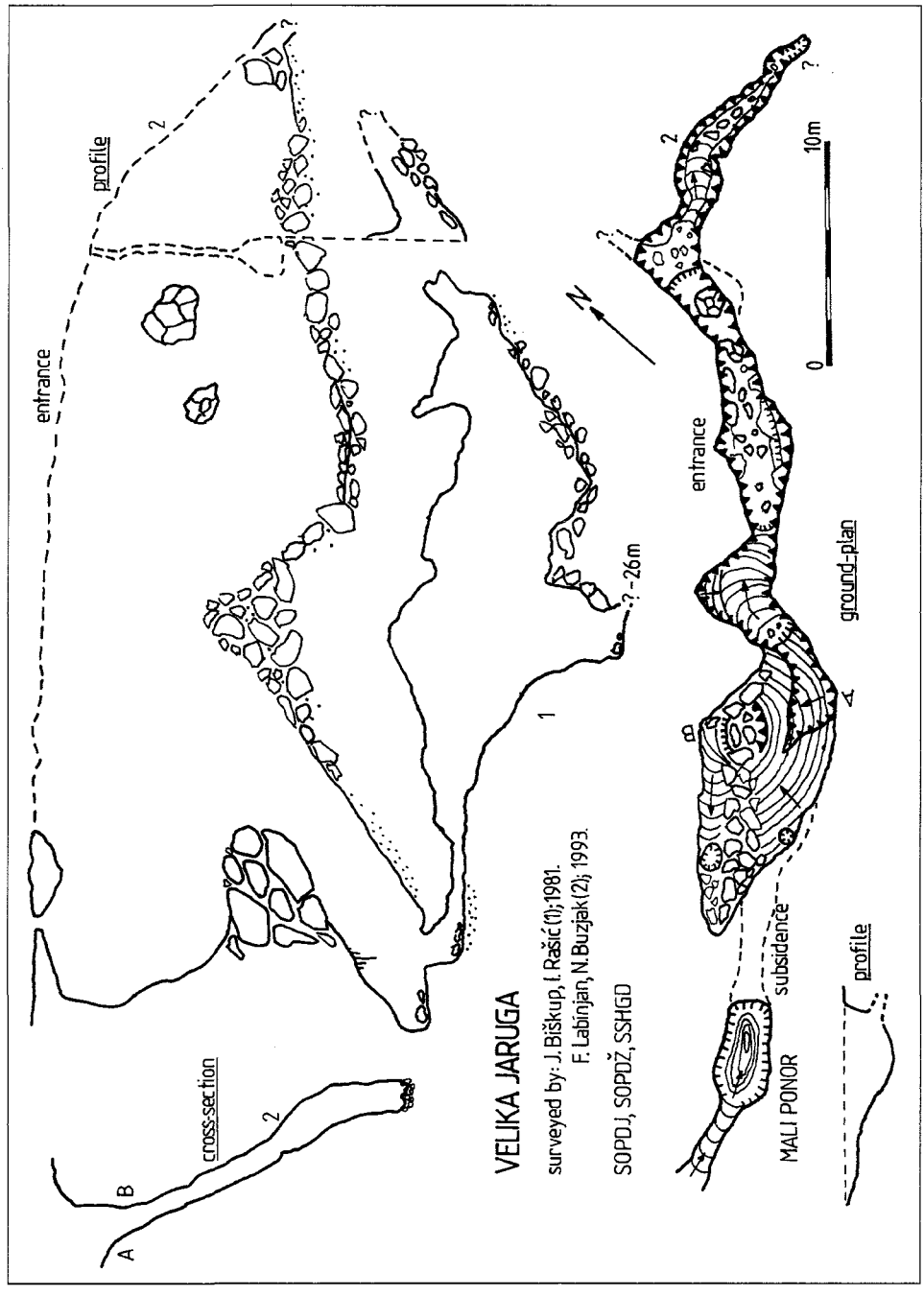


Fig. 5: Velika Jaruga.

Velika Jaruga is a feature similar to Duga Jama (Fig. 5). It is located at the edge of the plateau where it steeply falls towards Podzvir creek valley. Bouth have similar orientation and passage morphology (Phot. 1). According to earlier investigations made by cavers from Samobor, Velika Jaruga is 73 m long and 26 m deep. Today it is 45 m long, due to breakdown which blocked one part of the passage, and its entrance is of similar length (36 m) and width (1-3 m) as the passage. It is deepest in the part where breakdown did not occur (-19 m) and where it does occur it is up to 11 m deep (Buzjak 1994).

The main fissure along which Velika Jaruga occurs, continues towards NW and SE and one can follow it on the surface. One of the wider fissures from the passage, also clearly visible at the surface, continues toward the north but it is passable for only 4 m. Its end is narrow and filled in by falling rocks.

Along with this above-mentioned fissure, another one extends, along which Dubrava pit occurs (Fig. 6). It has two smaller entrances opened also by breakdown. Its passage also is of fissure cross-section and it extends vertically toward the main fissures. It is 11 m deep, up to 8 m high and 1 m wide. After 14 m of length it continue as a fissure too narrow for further exploration.

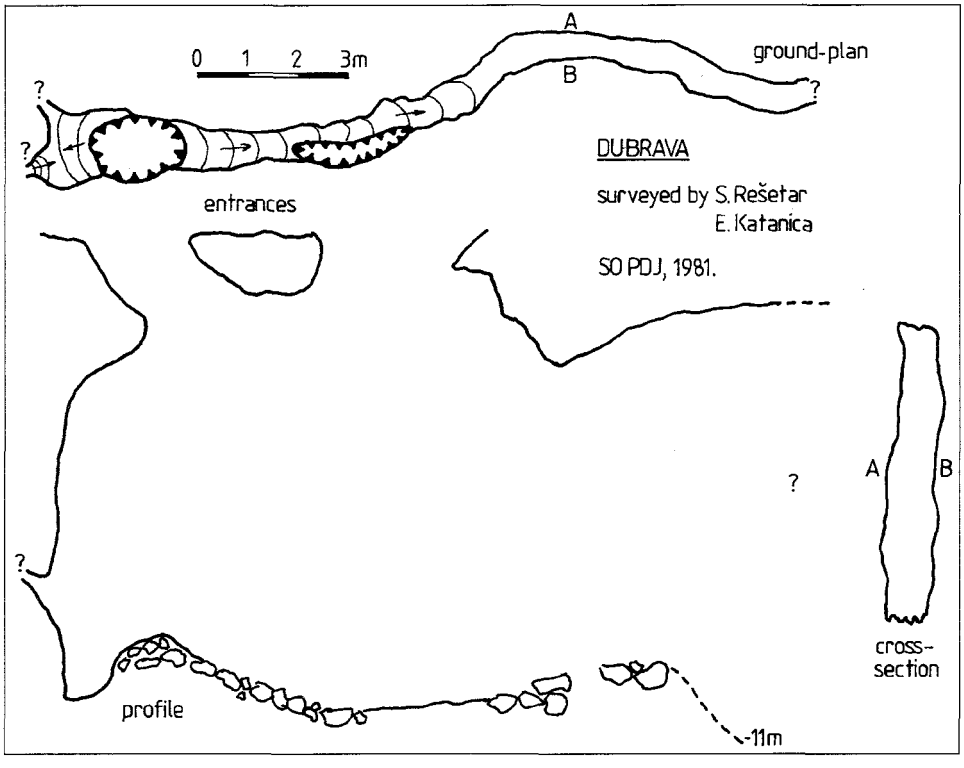


Fig. 6: Dubrava pit.

SPELEOGENESIS

The origin of speleological features on the Medjame plateau was, along with other relevant conditions, initiated by occurrence of fissures which are result of tectonic movements along a fault in its vicinity. But its origin must also be seen as a part of processes by which the relief of the wider area between villages Rešetari and Dubrava was formed.

About 500 m NW from the Medjame plateau, a short creek sinks in a Kaćnak blind valley located in Rešetari village at an elevation of 328 m. Its ponor occurs at the fault and contact between Upper Triassic dolomite and Lower Triassic beds. At that place a short cave formerly existed, but it was destroyed by breakdown (Reizer 1911). After 500 m of underground flow the creek issues from Podzvir cave, at an elevation of 255 m. The cave originated below a steep slope of Medjame plateau in the same situation as the ponor in Kaćnak blind valley. After 175 m of surface flow, the Podzvir creek flows into Ludvić creek.

The continuation of Kaćnak blind valley is a meandering step-like line of dolines, Duga Njiva (as Reizer called it). In his opinion it originated by the karstification of a former valley cut before the ponor in Kaćnak blind valley became active. Dolines are remains of former blind valleys (Reizer 1911). The contours of the former valley are still observable and can be connected with present Podzvir creek valley.

And what is connection of this theory with the origin of the Medjame plateau speleological features? Although Reizer probably visited some of this features himself, he did not associate their origin with his above-mentioned theory. He considers them to be the result of widening of fissures which drained precipitation water from the surface. The rock debris and blocks at passage bottoms he considers as the remains of fallen ceilings (Reizer 1911).

Z. Dugački accepts Reizer's theory about Kaćnak blind valley, the Duga Njiva doline line and Podzvir creek valley as being the results of fluvial erosion and karst process combination. He then unclearly connects the origin of Medjame speleological features with this theory. He considers that they originated along fissures widened by an underground stream which finally resulted in the ceiling breakdown. In his opinion Velika Jaruga was, before breakdown occurred, a cave similar to Podzvir cave (Dugački 1950).

These opinions of former researchers and the results of my own observations leads to the conclusion that the origin of these speleological features must be considered in the framework of the relief development of the whole area. It consits of a few linked and mutually conditioned phases.

As N. Reizer already stated and according to preserved traces, Podzvir creek was formerly the surface stream whose catchment area was (and still is) the terrain built of impermeable Lower Triassic beds west from Rešetari. In that phase fluvial processes predominated. They formed the still visible valley.

Since the creek flowed over Upper Triassic dolomite, karstification also occured. It was probably slower than the fluvial process, not only because of the previously mentioned characteristics of dolomite (massive structure, low content of $CaCO_3$), but also due to the fact that dolomitic sand originated by crumbling and creek alluvion transported from the impermeable catchment area blocked the fissures and so slowed down its widening.

The karstification process was fastest in the middle part of the valley, where tectonic movements crushed the dolomitic block and made a network of fissures across it. Its widening resulted in opening of ponors and therefore a blind valley formed. Its end was at the edge of the Medjame plateau and it is preserved at the bottom edge of the last doline of the Duga Njiva doline line. Two ponors were opened: Medjame ponor and Mali ponor. So, the former surface stream flowed underground from that point and formed the passages of Duga Jama and Velika Jaruga. The rest of the valley downstream remained occasionally, and finally completely, dry.

The position of entrances and passage dimensions of Medjame ponor and Duga Jama, compared with Mali ponor and Velika Jaruga shows that Medjame ponor is older (or opend earlier). Its entrance is 4 m higher than the entrance of Mali ponor and it is of larger dimensions (similar to the dimensions of Duga Jama compared with Velika Jaruga), which leads to the conclusion that is was active for a longer time.

The progress of karstification resulted in the opening of a new ponor upstream in Kaćnak blind valley. It developed, as already stressed, at the fault when the creek reached the contact between Upper Triassic dolomite and impermeable Lower Triassic beds. In the same conditions downstream, Podzvir spring cave occurs. According to J. Poljak, the cave was earlier formed by dripping water drained by smaller fissures from surrounding terrain. In that phase it deposited speleothems at the ceiling. Since they are broken, J. Poljak supposes that the fissure along which the cave originated was later widened by tectonic movements and after that time enlarged by the underground stream. This theory agrees with the relief development described above. Nearly fifty years after Poljak published its article, cavers from Samobor discovered a new narrow passage close behind the entrance, branching from the main one (Fig 7). It extends towards a wide fissure SW from Velika Jaruga. It is 26 m long and rises 19 m above the entrance level. The passage developed at the intersection of fissures of NW-SE and NE-SW directions, what also defined its direction. It branches in two directions. The shorter and narrower southern branch is connected with the surface by the small opening. The northern branch is longer and up to 5,5 m high. Water drained from the plateau flowed away by this passage. Inverse karstification is most intensive at the place of its highest concentration in the passage's northern branch, where it is closest to the surface. Therefore that part of the passage is of typical acutely cross-section.

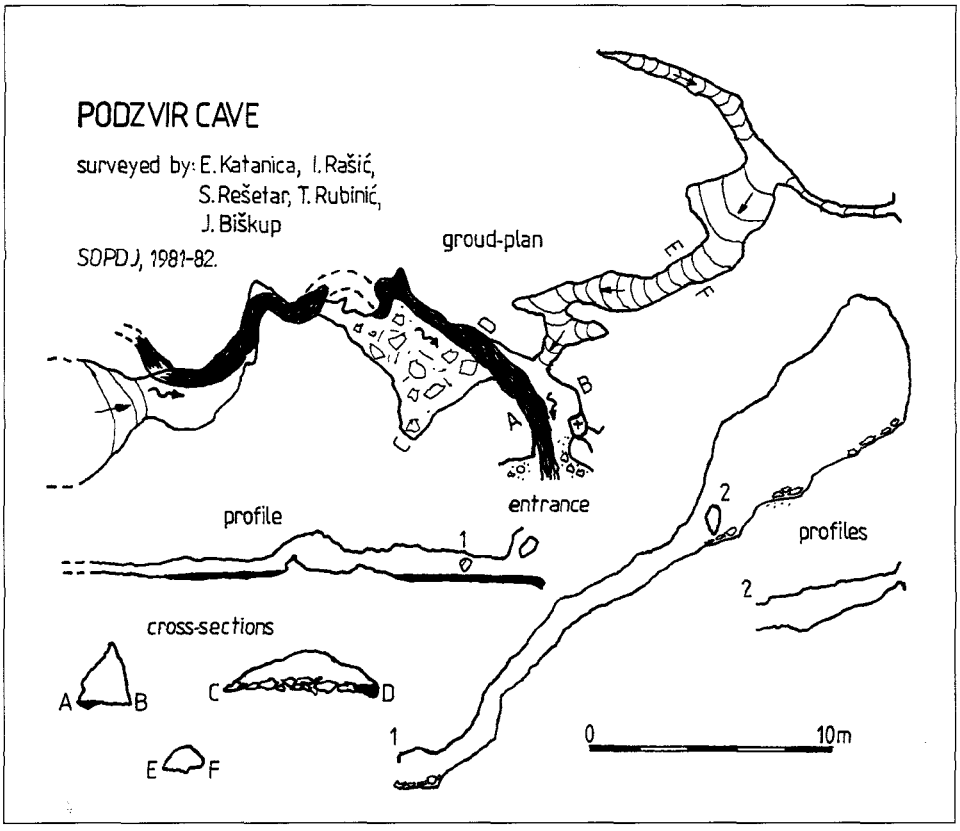


Fig. 7: Podzvir cave.

So, after the new ponor in Kaćnak blind valley became active, the blind valley at the edge of Medjame plateau and its underground passages remained dry. From that time the passages were enlarged only by dripping water. Due to the large quantities of falling material from breakdowns covering the bottoms or blocking the entire passages (for example, the rock debris pile in Velika Jaruga is over 6 m high), it can not be determined if the underground stream reached the impermeable base (which is about 30 m deep) during the cutting of its bed.

Finally, it can be concluded that speleological features on Medjame plateau originated as caves through whose passages Podzvir creek flowed underground. That is observable from its morphology and from the length/depth ratio. Nevertheless, due to its vertical entrances the inhabitants of neighbouring villages call them shafts (Medjame means "between shafts"). Although in all cases its length exceeds its depth, due to their particular morphology I class

them in the group of complex speleological features. Due to their morphology these features (often alternation of horizontal and vertical passages) can not be classed as caves or shafts (Garašić 1991). Because of the big changes of passages induced by breakdown, it is hard to affirm were they interconnected.

It is obvious that breakdown occurred at the final phase of passage development, when the underground stream found another route. If falling material preserved in passages had fallen into a stream, it would be transformed or dissolved and transported downstream. There can be few causes of breakdown: disturbances caused by lowering of water level, neotectonic movements or gravitational movements of rock mass at unstable base caused by retroactive cutting of Podzvir creek valley. At the edge and at the foot of the plateau one can find blocks which look as if they have slipped from above, curved trunks of trees and opened meandering fissures narrowed toward to the bottom. Proof of intensive disturbances can also be found at the entrance of Duga Jama whose northern edge is up to 2 m higher than the southern one and also in the plateau's steplike cross-section in N-W direction.

The breakdown process still occurs. It is visible from the "fresh" debris in some passages and also in the cases of tree roots growing over the narrower part of the Duga Jama entrance or smaller opened fissures. It is obvious that roots would not grow over such features in normal circumstances. The breakdown also shortens Podzvir cave. According to the rock debris and form of its entrance, the cave was probably much longer than it is today.

The crumbling of dolomite is also in progress. After large entrances opened, it was intensified by the more frequent changes of climatic conditions (like the accumulation and longer presence of snow and ice or a bigger influence of exterior air temperature, etc.) and biogenic processes. It is especially visible on the passage walls below the entrances.

The next characteristic of Medjame plateau is the occurrence of a few clearly visible parallel groovelike subsidences which are more than 100 m long, up to 2,5 m wide and in places up to 0,8 m deep. They extend between Duga Jama and Velika Jaruga and are interconnected by smaller fissures of different lengths and directions (Phot. 2). They show that there exist other similar fissures or even wider passages under the plateau. Very interesting is the subsidence of square ground-plan found near Dubrava pit.

CONCLUSION

The Medjame plateau located in Samoborsko Gorje (NW Croatia) contains several interesting speleological features. They originated in the Upper Triassic dolomite beds, along clearly observable fissures of NW-SE, N-S and NE-SW directions. They were widened by the activity of the underground stream and dripping water, so breakdown occurs in most parts of the passages. Therefore all features have narrow elongated entrances. Whose directions and dimensions

correspond to the directions and dimensions of passages. Besides the entrances there are some clearly observable groovelike subsidences that suggest the presence of similar fissures found underground.

At the foot of the plateau, Podzvir spring cave is located. It developed at the contact of Upper Triassic dolomite and impermeable Lower Triassic beds. The cave is the spring of the creek which sinks at the contact of same character in Kaćnak blind valley (NW from the Medjame plateau).

According to their morphological characteristics, speleological features on the Medjame plateau are similar to the features developed in Triassic dolomite in other Croatian karst areas. Their passages are of fissure cross-sections and access to some parts is often difficult as they become too narrow (Garašić 1995). Their formation is due in great part to breakdown process besides other relevant factors (Roglić 1965).

Since all features were partially or completely filled in by waste, pollution is due to the existence of many interconnected fissures, undoubtedly transporting to the underground stream of the Podzvir creek and then downstream. Due to specific movement of water in karst, the pollution of these speleological features would be fatal for wider area and its habitants.

ACKNOWLEDGMENTS

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MEDJAME (SAMOBORSKO GORJE, HRVAŠKA) - PRIMER SPELEOLOŠKIH POJAVOV V ZGORNJETRIASNEM DOLOMITU

Povzetek

Kraški pojavi v Samoborskem gorju so vezani predvsem na zgornjetriasne dolomite in miocenske litotamnijske apnence. Najzanimivejše so oblike na planoti Medjame, pri mestu Samobor, ker so v različnih razvojnih fazah. Oblike v zgornjetriasnem dolomitu nastajajo tako, da se razpoke širijo v večje odprtine, vzdolž katerih prihaja do podiranja in imajo zato take votline podolgovate vhode. So različnih velikosti, vendar je težko določiti njihovo pravo globino, saj so zapolnjene s podornim kamenjem ali smetmi. Ponekod je ob vhodih moč najti žlebaste razpoke, ki kažejo na podobne razpoke tudi v podzemlju. 500 m SZ od Medjam ponika potok Podzvir. Ponovno se pojavi na površju v vznožju planote Medjame, iz jame Podzvir, na stiku neprepustnih spodnjetriasnih plasti z zgornjetriasnim dolomitom. Ker teče potok Podzvir pod planoto Medjame, odpadki, ki jih mečejo v brezna, onesnažujejo vodo. Sicer pa je potok onesnažen že prej, saj je tudi njegov ponor zatrpan z odpadki. Glede na značilnosti kraške hidrologije, je lahko onesnaževanje obravnavanih speleoloških objektov usodnega pomena za širše območje in za tamkajšnje prebivalstvo.



Photo 1: Velika Jaruga passage.



Photo 2: Subsidence near Duga jama.

ACTA CARSOLOGICA	XXVI/2	26	295-314	LJUBLJANA 1997

STRUCTURAL POSITION OF VERTICAL KARST OBJECTS ON POSTOJNSKA GMAJNA[3]

STRUKTURNA LEGA VERTIKALNIH KRAŠKIH OBJEKTOV NA POSTOJNSKI GMAJNI[3]

JOŽE ČAR[1] & STANKA ŠEBELA[2]

Izvleček UDK 551.442(497.4)

Jože Čar & Stanka Šebela: Strukturna lega vertikalnih kraških objektov na Postojnski gmajni

Ob podrobnem tektonsko-litološkem kartiranju Postojnske gmajne so bili preučevani tektonsko-strukturni elementi. Pri tem so bile zabeležene udorne vrtače, jame, brezna in spodmoli. Upoštevani so tudi podatki iz Katastra jam. Postojnsko gmajno sekajo dinarsko usmerjene (SZ-JV) prelomne cone s spremljajočimi deformacijami po teoriji možnih deformacij ob zmičnih prelomih. Večina vhodov v brezna in udornih vrtač leži v strukturah vzdolž desnozmičnih prelomov, ki so nastali pri nateznih napetostih. Navpični vhodi v kraške objekte so v osnovnih strukturnih položajih.

Ključne besede: geologija, tektonika, speleologija, geomorfologija, speleomorfologija, prelomna deformacija, kinematski model, udorna vrtača, Slovenija, Postojna.

Abstract UDC 551.442(497.4)

Jože Čar & Stanka Šebela: Structural position of vertical karst objects on Postojnska Gmajna

During detailed tectonico-lithological mapping of Postojnska Gmajna attention was paid to tectonic-structural elements. Collapse dolines, caves, shafts and rock-shelters were noted and the data in the Cave Register considered. Postojnska Gmajna is cut by a Dinaric (NW-SE) trending fault zone with accompanying deformations according to theory of probable deformations along strike-slip faults. Most entrances to shafts and collapse dolines lie in structures along dextral strike-slip faults due to tension. Vertical entrances into karst objects are in basic structural locations.

Key words: geology, tectonics, speleology, geomorphology, speleomorphology, fault deformation, kinematic model, collapse doline, Slovenia, Postojna.

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[3] At 4th International karstological School the paper of "Geological structures and location of shafts in Postojnska gmajna" was presented. This article represents a supplemented and rewritten presentation.

INTRODUCTION

In 1980 detailed geological mapping began anew in the area between the SW border of Planinsko Polje up to Strmica and Studenške Ponikve to the north; and Postojnska Gmajna, Magdalena Gora, a part of the Postojna gap between Unec and Ravbarkomanda and the wider vicinity of Rakov Škocjan to the south. The mapping was carried out at 1:5.000 scale, having a lithologic-structural character. A considerable part of the field data was published in 1984 (Čar & Gospodarič 1984), while a lithologic-structural map between Sovič and Nemčji Vrh is prepared for print (Šebela 1994). Not only lithological and macroscopical petrographic changes and structural elements, but also various karstological properties of the mapped area were noted. More than a thousand dolines and collapse dolines were checked (Čar 1982) and their genetic relation to various geologic elements stated (Čar, in press). In addition, all the cave entrances were located and structurally defined. It was shown that most of the vertical entrances into caves lie in genetically related tension tectonic structures. The location of some shaft entrances and some collapse dolines on Postojnska Gmajna are commented upon without considering the genesis of single objects.

General Geological Data

Placer (1981, 1996) explained the Tertiary geometrical model, the origin of thrust structure from a kinematics point of view and the general tectonic complex with principal thrust and strike-slip tectonic elements of the western Slovenia. From a structural point of view a vast area of Postojna and Javorniki belongs to Snežnik thrust sheet (Placer 1981). Recent mapping has shown that in the area of Unec and Ivanje Selo there is a series of thrust units which are not yet included into a general thrust model of this part of Slovenia (Čar 1982). In addition numerous fault systems with complicated mutual relations have been ascertained (Čar 1982; Čar & Gospodarič 1984). To date Gospodarič and Čar reported on meso deformations in rocks related to thrust and strike-slip faults in the area of Postojna and Unec (Gospodarič 1965, 1976; Čar 1982; Čar & Gospodarič 1984). However it must be stressed that not all the criteria needed to distinguish deformations related to thrusting in the rocks from those due to disjunctive tectonics were worked out. So far the model for unequivocal distinguishing of both systems does not exist; this is why the present paper deals only with those karstological objects that are clearly related to strike-slip tectonics.

For further discussion the most important conclusions of the previous studies (Čar & Gospodarič 1984) must be mentioned also. The area between Postojna, Unec and Cerknica belongs to the transitional area between the Idrija fault, at the north-eastern part of Planinsko Polje, and the Predjama

fault, at the eastern border of Pivka basin. Crushed, broken and fissured zones (Fig. 1) were determined in the field according to procedures and criteria

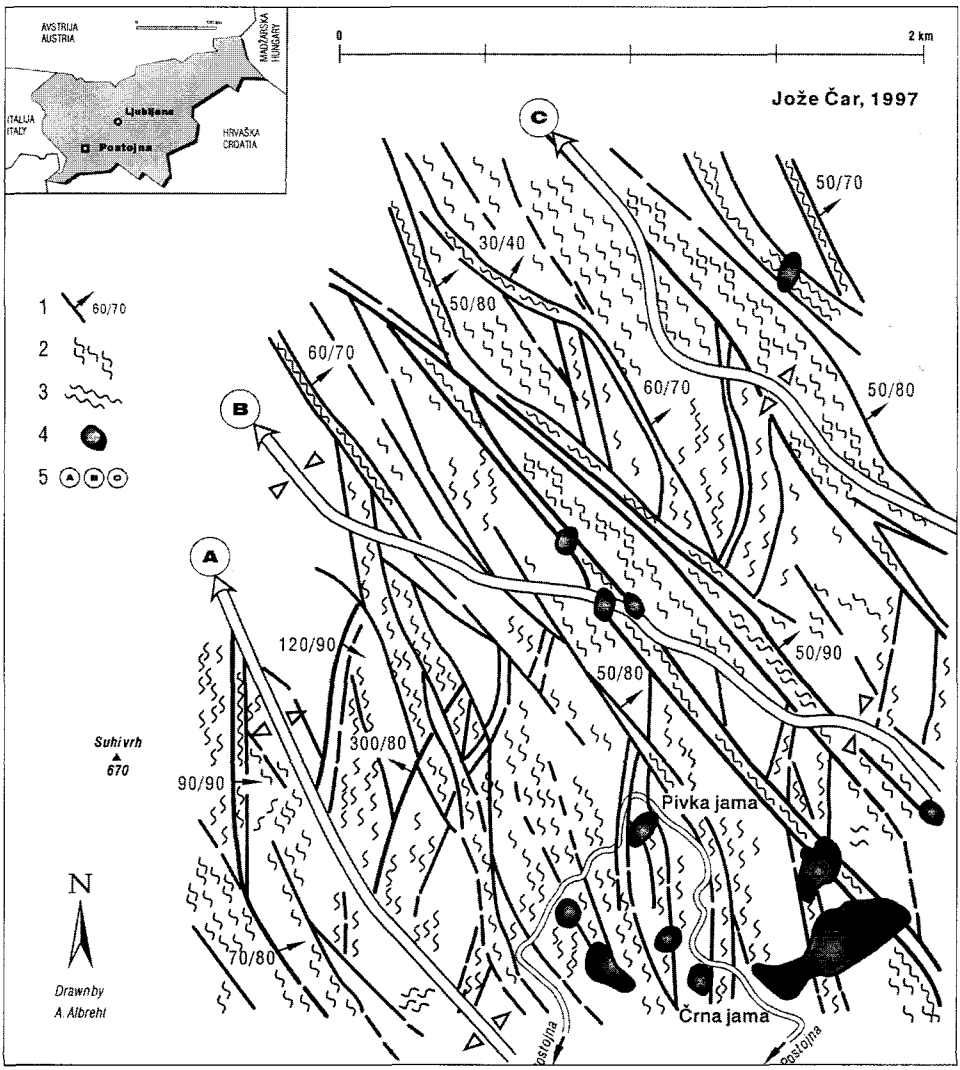


Fig. 1: Structural conditions in Postojnska Gmajna area. Mapped by J. Čar. 1-strike and dip of fault zone, 2-fissured zones, 3-broken zones, 4-bigger collapse dolines, 5- A=Postojna anticline, B=Studeno syncline, C=Bukovje anticline.

Sl. 1. Strukturne razmere na področju Postojnske gmajne. Kartiral J. Čar. 1-slemenitev in vpad prelomnih ploskev, 2-razpoklinske cone, 3-porušene cone, 4-večje udornice, 5-A=Postojnska antiklinala, B=Studenška sinklinala, C=Bukovška antiklinala.

defined in 1982 (Čar 1982) and later supplemented (Čar & Pišljar 1993). It must be remembered that different tectonic zones drawn in figures represent more or less crushed rocks without explaining their kinematics meaning. In the area between Unec and Postojna four periods of disjunctive movements were established, probably within the same tectonic phase (Čar & Gospodarič 1984), and the same might surely be applied for the treated area of Postojnska Gmajna.

The vicinity of Magdalena Gora and Postojnska Gmajna is folded into the rather distinctive Postojna anticline (Gospodarič 1976; Čar & Gospodarič 1984). East of Nemčji Vrh (633 m) the anticline crest is less distinct than to the south of Magdalena Gora. Near Nemčji Vrh the axis plane is dipping of 7 to 14^0 towards SW (Šebela 194).

The area of Vodni Dol and Magdalena Gora consists of light grey to white organic limestones passing to lumachelle; near Črna Jama and Suhi Vrh (680 m) one finds grey to light grey thick-bedded organic limestones of Upper Cretaceous age (Čar & Gospodarič 1984).

Nemčji Vrh (633 m) consists of white massive limestone extremely rich in chondrodonta (Šebela 1994). According to Šribar (1995) the horizon with chondrodontas belongs to the Upper Cenomanian and at least to the Lower Turonian. To the south of Nemčji Vrh grey to light grey, thick-bedded or massive limestones prevail; they belong to the Turonian and the Senonian. NE of Nemčji Vrh, thinner bedded grey to dark grey Turonian limestones prevail including some chert inliers. The same lithological links may be seen in the cave system of Postojnska Jama (Gospodarič 1965; Šebela 1994).

Strike-slip faults and associated deformations

Regional Idrija and Predjama faults of a strike-slip character are, in addition to vast thrusts, the basic structural elements of the tectonic setting in northern Primorska and Notranjska. The area of Postojnska Gmajna, the wider vicinity of Magdalena Gora and Pivka Jama that geographically lies between both regional faults, is intersected by numerous fault zones parallel to the Idrija and Predjama faults (Čar & Gospodarič 1984; Šebela 1994). Consequently they are trending NW-SE; they are predominantly of strike-slip character and displacements are mostly subhorizontal. According to displacements of lithological contacts and structural lines between the Snežnik thrust sheet and the Hrušica nappe to the north, near Strmica, displacements are at utmost 10 m or less. Hence the faults of smaller dimensions were involved. At Dinarically-trending strike-slip faults several, differently oriented related fault zones developed. The size of displacement, the geometry of deformations and the rate of crushed rock may be clearly defined by a method of detailed lithologic-structural mapping at a scale of 1:5000 and at smaller scales (Čar, in preparation).

Along strike-slip faults and related fault deformations different types of crushed rocks occur depending on the length of displacement and the energy involved. There are crushed, broken and fissured zones connected by longitudinal and transverse passages (Čar 1981; Čar & Pišljar 1993). As is known, similar changes may be observed in the vertical direction also (Šebela & Čar 1991; Šebela 1994). This is important in studying the changes of karst superficial morphology depending on corrosion-erosion processes in time. About the deformation geometry and tension conditions that controlled them one may say that along the faults almost all the features, supposed by a general theory of possible deformations along strike-slip faults, developed (Twiss & Moores 1992; Ramsay & Huber 1987; Davison 1994 in Hancock/Ed.; Woodcock & Schubert 1994 in Hancock/Ed.). Due to local lithological setting and structure properties of the rocks (for example non-bedded, thin-bedded etc.) and also due to gradual changing of local stress field, the strike-slip faults are almost never entirely straight. Often the direction of faults is inclined to the direction of displacement. Beside usual fissured zones typical of strike-slip faults, defined by a model of Riedel, there are also the areas of tension and releasing bends or compression and extension conditions. In the area under discussion some local faults end and others start and overlap partly. All this causes corresponding deformations manifested in smaller local folds, shorter and weak reverse faults and thrusts, or shorter normal faults and variously shaped uplifted and subsided parts. Thus in some places developed a very complex, sometimes complicated system of deformations either blurred or accentuated by corrosion processes.

Geographical location and speleological data

The studied area covers the topographic maps Postojna-33 and part of Postojna-43 at a scale of 1:5.000. Postojnska Gmajna is depicted on the map as a wide area reaching in the SE to Postojnska Vrata (Ravbarkomanda); in the SW it is delimited by Otoška Gmajna which is a belt about 500 m wide consisting of limestones at the contact with Eocene flysch. In the north, Postojnska Gmajna is delimited by Bukovec.

According to the Cave Register of the Karst Research Institute ZRC SAZU there are 21 caves known in the area covering about 6,8 km^2. During detailed geological researches in the field (Čar 1983) another 5 entrances to caves were discovered; they were not speleologically explored. The average density of karst caves in this area is 3,8 cave/km^2. The deepest shaft is Brezno v Hrenovških Talih (cad.no. 930), 104 m deep. The longest horizontal cave is the system of Postojnska Jama, 19.555 m long and 115 m deep; there are also the entrances into Črna Jama and Magdalena Jama, being a part of the Postojnska Jama system.

Tabela 1. Osnovne speleološke značilnosti obravnavanih in omenjenih jam na območju Postojnske gmajne in Magdalene gore (vir Kataster jam IZRK ZRC SAZU).

kat. št. cad. no	VG reg. no.	ime name	tip type	dolž. (m) length (m)	glob. (m) depth (m)	karta map 1:5.000
42	562	Ruglovica	5.5	52	52	Postojna-33
471	80	Črna jama	5.3	3294	39	Postojna-33
472	314	Pivka jama	4.2	794	77	Postojna-33
747	108	sistem Postojnskih jam	4.2	19555	115	Postojna-43
820	110	Magdalena jama	4.2	1395	89	Postojna-33
930	3041	Brezno v Hrenovških talih	5.3	165	104	Postojna-33
1608	1614	Kotova jama	5.3	322	45	Postojna-33
1629	1591	Medvedja jama	5.3	122	28	Postojna-33

5.5-brezno (shaft)
5.3-poševna jama (horizontal cave)
4.2-jama s stalnim tokom (cave with permanent water flow)

Structural location of chosen karst objects

Shafts in tension frectured zones

Many entrances into the shafts of Postojnska Gmajna lie en echelon or in braided tension subvertical frectured systems. They are at an angle from 35 to 45^0 to the direction of displacement of Dinarically (NW-SE) trending faults, either in their outer fault zone or in wide frectured zones having approximately the same direction between two faults. Transverse to them are older Dinaric (NW-SE) trending fissures of compressed character. Near strike-slip fault zones the frectured en echelon are usually rather dense, at a distance they are scarcer and in alternating. Braided frectured systems are usually less clearly defined on the flanks, they are shorter with atypical ends.

To illustrate the described conditions two cave entrances (Fig. 2) are drawn, located about 900 m north from Pivka Jama. These are two karst caves that were discovered in 1983 (Čar 1983) but are not yet registered in Cave Cadaster. The caves are not speleologically explored; probably they are only short. The kinematics model is shown in Fig. 2B.

Karst objects related to wedge-shaped depressions

Numerous local faults in the treated area fork. The faults sheered off may join again, but most frequently they associate with a nearby fault. In intermediary block compression or extension conditions, it may occur thus that wedge-shaped block may either uplift or subside (Woodcock & Schubert 1994). The area treated in Fig. 3 displays extension conditions. Block subsidence and a group of weak normal faults related to tension joints occurred. Although the faults are weak and cause relatively small displacements they shaped a typical shallow wedge-shaped basin. Corrosion processes partly transformed this and elongated it along broken and fissured zones at the main fault and the fissured zone that forks northwards. The entrance into Kotova Jama (cad.no. 1608) opens in the middle of normal fault group (Fig. 3).

Kotova Jama consists of a 45 m deep entrance shaft (Fig. 4) and a 227 m long horizontal passage. It is located about 650 m NW from Magdalena Gora and isonly about 150 m SW of the Postojna anticline crest. 200 m to the north of it there is a smaller cave, similarly developed in an open fissured zone, trending from N to S. The cave is small, an inclined cave about 4 m long; the bottom is covered by breakdown blocks.

It must be stressed that only the genesis of the entrance shaft of Kotova Jama is associated with the fissured system while its horizontal passage is due to different genesis.

Vertical karst objects in releasing bends of strike-slip faults

Most of the mapped Dinaric (NW-SE) faults in the area of Postojnska Gmajna with the dextral strike-slip are bending. In left bends (a bend towards the east) compression conditions occur and thus uplifting of the terrain. In right bends (bends towards south-east) tension regions and smaller depression occur which may be, if the displacements were bigger, initial structures for pull-apart basins. It is typical of right bending, dextral strike-slip areas with a very complicated relation between single crushed zones. The rocks in the lowered parts are intersected by numerous fault planes, parallel to main bend trending and related tension fissured or broken zones. Karstification in such areas is very strong.

To illustrate these conditions we selected the area of Postojnska Gmajna with a system of collapse dolines (Fig. 5).

Cave entrances in overlap zones of two en echelon dextral strike-slip faults

From a structural point of view the cave entrances of Pivka Jama, Ruglovica and Črna Jama and several collapse dolines are located in the area of 400 to 500 m overlap of two dextral strike-slip Dinarically (NW-SE) trending faults

(Fig. 6). The one more to the north comes from the area of Globušaki. Its narrow fault zone is relatively narrow, and rocks are crushed to the stage of being broken. North of the entrance of Pivka Jama the fault zone starts to widen and gradually bends southwards to be lost to the south of the entrance into Črna Jama in a wide fissured zone. The south-western fault passes two collapse dolines on the east from Magdalena Gora northwards. Southwest from the entrance into Pivka Jama the rather wide fault zone in a strict sense becomes less defined and it slowly gets lost along a slight bending towards north. In a releasing stepover between the both faults there is a less distinctive extension situation which could represent, if the displacements were bigger, the beginning of a pull-apart basin (Woodcock & Schubert 1994). The subsided area was additionally reshaped by corrosion and lowered. The map (Fig. 6) shows that the area is extremely complicated in its structure. It is intersected by numerous normal faults and wide tension fractured zones. During the development of the subsided area a secondary strike-slip fault occurred cutting the structure and connecting both main faults. Along it and along normal faults wedge-shaped basins developed, contributing their part to the diversity of this area. Explaining the origin of karst poljes Vrabec (1994) stressed the mechanism of pull-apart tectonics along the Idrija fault.

The collapse doline of Pivka Jama is 77 m deep; it is located in the NE limb of the Postojna anticline. The active water flow of the Pivka river obtained a direct connection with the surface by development of this collapse doline.

Similar circumstances may be met near the entrance into Medvedja Jama (Cad.no. 1629), only that in this case the tension conditions occurred in a bridge, releasing stepover between the final parts of two faults. Medvedja Jama consists of an inclined entrance shaft, 28 m deep, and a horizontal passage, 94 m long.

CONCLUSIONS

After 1980 the area between the south-western border of Planinsko Polje and Pivka basin was geologically mapped anew at a scale 1:5000 having lithologic-structural character. Not only lithological and macroscopical petrographic changes and structural elements were noted but also various karstological properties of the mapped area. In addition all the cave entrances were located and structurally defined.

With rare exceptions all the entrances into vertical karst objects (collapse dolines, shafts and vertical entrance parts of the caves) open in a sphere of tension conditions that locally occur at Dinarically (NW-SE) trending strike-slip faults as follows:

- in subvertical tension fissured systems at angles from 30 to 45^0 according to the direction of displacement of dextral strike-slip Dinarically (NW-SE)

trending faults, in the outer fault zone, in the inner fault zone or between the two faults (Fig. 2),
- in subsided diverged wedge-shaped depressions (Fig. 3),
- in releasing bends of dextral strike-slip faults (Fig. 5),
- in releasing bends between the final parts of two en echelon strike-slip faults or in their overlap area (Fig. 6).

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STRUKTURNA LEGA VERTIKALNIH KRAŠKIH OBJEKTOV NA POSTOJNSKI GMAJNI

Povzetek

UVOD

Po letu 1980 smo na novo podrobno geološko kartirali ozemlje med jugozahodnim obrobjem Planinskega polja tja do Strmca in Studenških ponikev na severu, Postojnsko gmajno, Magdaleno goro, del Postonjskih vrat med Uncem in Ravbarkomando ter širšo okolico Rakovega Škocjana. Kartiranje je potekalo v merilu 1:5000 in je imelo litološko-strukturni značaj. Dobršen del terenskih podatkov smo objavili leta 1984 (Čar & Gospodarič 1984). Litološko-strukturna karta med Sovičem in Nemčjim vrhom pa še čaka na objavo (Šebela 1994). Poleg litoloških in makroskopskih petrografskih sprememb ter tektonsko-strukturnih elementov smo beležili tudi različne krasoslovne značilnosti kartiranega ozemlja. Pregledano je bilo čez tisoč vrtač in udornih vrtač (Čar 1982) ter ugotovljena njihova genetska povezanost z različnimi geološkimi elementi (Čar v pripravi). Poleg tega so bili zabeleženi vsi najdeni jamski vhodi, ki so bili tudi strukturno opredeljeni. Pokazalo se je, da se velika večina vertikalnih vhodov v kraške objekte nahaja v genetsko sorodnih, nateznih tektonskih strukturah. V prispevku komentiramo lega nekaterih vhodov v brezna in udorne vrtače na Postojnski gmajni, ne da bi se lotevali geneze posameznih objektov.

V 90-ih letih so bile raziskave financirane v okviru akcije 2.000 mladih raziskovalcev Ministrstva za znanost in tehnologijo RS ter v okviru temeljnih raziskovalnih projektov Inštituta za raziskovanje krasa ZRC SAZU Kras v Sloveniji I in II, ki jih financira Ministrstvo za znanost in tehnologijo RS.

Splošni geološki podatki

Terciarni geometrijski model, nastanek narivne zgradbe s kinematskega vidika ter splošni tektonski sklop z glavnimi narivnimi in zmičnimi tektonskimi elementi zahodne Slovenije je razložil Placer (1981, 1996). Obsežno postojnsko

- javorniško ozemlje, pripada v strukturnem pogledu Snežniški narivni grudi (Placer 1981). Novejša kartiranja so pokazala, da najdemo na območju Unca in Ivanjega Sela vrsto narivnih enot, ki še niso natančneje vključena v splošni narivni model tega dela Slovenije (Čar 1982). Poleg tega so bili ugotovljeni številni prelomni sistemi z zapletenimi medsebojnimi povezavami (Čar 1982; Čar & Gospodarič 1984). O mezo in mikro deformacijah kamnin, ki spremljajo narivanje in zmikanje na postojnskem in unškem prostoru sta doslej poročala Gospodarič in Čar (Gospodarič 1965, 1976; Čar 1982; Čar & Gospodarič 1984). Poudariti je potrebno, da pri tem niso bili izdelani kriteriji za ločevanje na narivanje vezanih spremljajočih deformacij v kamninah od tistih, ki so nastale zaradi disjunktivne tektonike. Ker doslej še nimamo izdelanih modelov za nedvoumno ločevanje obeh sistemov, obravnavamo v tem prispevku le tiste kraške objekte, za katere je bilo mogoče jasno ugotoviti njihovo navezanost na zmično tektoniko.

Za naše nadalnje razpravljanje moramo omenit nekaj najpomembnejših zaključkov dosedanjih raziskav (Čar & Gospodarič 1984). Ozemlje med Postojno, Uncem in Cerknico prištevamo k prehodnemu območju med Idrijskim prelomom, ki poteka po severovzhodnem delu Planinskega polja in Predjamskim prelomom na vzhodnem obrobju Pivške kotline. Zdrobljene, porušene in razpoklinske cone (Slika 1) so terensko opredeljene po postopkih in kriterijih, ki so bili definirane leta 1982 (Čar 1982) in kasneje še dopolnjeni (Čar & Pišljar 1993). Pri tem moramo opozoriti, da predstavljajo na prilogah izrisane različne tektonske cone bolj ali manj pretrte kamnine, ni pa razložen njihov morebitni kinematski pomen. Na ozemlju med Uncem in Postojno so bila ugotovljena štiri obdobja disjunktivnega premikanja, verjetno v okviru iste tektonske faze (Čar & Gospodarič 1984), kar gotovo veljala tudi za obravnavano območje Postojnske gmajne.

Okolica Magdalene gore in Postojnske gmajne je previta v dokaj izrazito postojnsko antiklinalo (Gospodarič 1976; Čar & Gospodarič 1984). Vzhodno od Nemčjega vrha (633 m) je teme antiklinale manj izrazito, kot južno od Magdalene gore. V okolici Nemčjega vrha vpada osna ravnina proti JZ za 7-14° (Šebela 1994).

Območje Vodnega dola in Magdalene gore gradijo svetlo sivi do beli organogeni apnenec s prehodi v lumakelo, v okolicu Črne jame in Suhega vrha (680 m) pa najdemo sive do svetlo sive debeloplastnate organogene apnence zgornje kredne starosti (Čar & Gospodarič 1984).

Nemčji vrh (633 m) gradi bel masiven apnenec izredno bogat z ostanki hondrodont (Šebela 1994). Po Šribarju (1995) uvrščamo hondrodontni horizont v zg. cenoman in vsaj sp. turon. Južno od Nemčjega vrha pa prevladujejo sivi do svetlo sivi apnenci, ki so lahko debeloplastnati ali masivni. Prištevamo jih turoniju in senoniju. SV od Nemčjega vrha prevladujejo tanjše plastnati sivi do temno sivi turonijski apnenci, ki vsebujejo vložke rožencev. Prav take litološke člene lahko sledimo tudi v sistemu Postojnskih jam (Gospodarič 1965; Šebela 1994).

Zmični prelomi in deformacije ob njih

Regionalna Idrijski in Predjamski prelom zmičnega značaja sta poleg obsežnih narivov temeljna strukturna elementa tektonske zgradbe severne Primorske in Notranjske. Ozemlje Postojnske gmajne, širšo okolico Magdalene gore in Pivke jame, ki se geografsko nahaja med obema regionalnima prelomoma, sekajo številne idrijskemu in predjamskemu prelomu vsporedne prelomne cone (Čar & Gospodarič 1984; Šebela 1994). Imajo torej smer severozahod-jugovzhod, so v splošnem zmičnega značaja, premiki pa predvsem subhorizontalni. Kinematika ob njih sicer ni natančneje študirana. Po premikih litoloških kontaktov in narivnice med Snežniško narivno grudo in Hrušiškim pokrovom severno od tod pri Strmci pa so premiki največ nekaj 10 metrov in manj. Gre torej za prelome manjših dimenzij. Med dinarsko usmerjenimi zmiki so razvite številne različno usmerjene spremljajoče prelomne cone. Velikosti premikov, geometrijo deformacij in stopnjo pretrtosti kamnin lahko jasno opredelimo z metodiko detajlnega litološko-strukturnega kartiranja v merilu 1:5000 in manjših merilih (Čar v pripravi).

Ob zmičnih prelomih in spremljajočih prelomnih deformacijah so razviti različni tipi pretrtih kamnin odvisno od dolžine premika in energije, ki se je pri tem sprostila. Opazujemo zdrobljene, porušene in razpoklinske cone z medsebojnimi vzdolžnimi in bočnimi prehodi (Čar 1981; Čar & Pišljar 1993). Kot je znano, bi podobne spremembe opazovali tudi v vertikalni smeri (Šebela & Čar 1991; Šebela 1994). To je pomembno pri študiju spreminjanja kraške površinske morfologije v odvisnosti od korozijsko-erozijskih procesov skozi čas. Glede geometrije deformacij in napetostnih razmer ob katerih so nastale lahko zapišemo, da so ob prelomih razvite skoraj vse oblike, ki jih predvideva splošna teorija možnih deformacij ob zmičnih prelomih (Twiss & Moores 1992; Ramsay & Huber 1987; Davison 1994, v Hancock, /urednik/, 1994; Woodcock & Schubert 1994, v Hancock, /urednik/, 1994). Zaradi lokalne litološke zgradbe in teksturnih posebnosti kamnin (npr. neplastnatosti, tanko plastnatosti, itd.) kot tudi postopnega časovnega spreminjanja regionalnih napetostnih razmer, zmični prelomi skoraj nikdar niso povsem ravni. Dostikrat potekajo trase prelomov poševno na smer premika. Poleg običajnih, za zmične prelome značilnih, spremljajočih razpoklinskih con, ki so definirane z Riedlovim modelom, se v odvisnosti od smeri prevojev pojavljajo še območja tlačnih in nateznih razmer oziroma transpresijske in transtenzijske razmere. Poleg tega se tudi na obravnavanem ozemlju nekateri lokalni prelomi zaključujejo, drugi začenjajo, pa tudi delno prekrivajo. Vse to povzroča ustrezne deformacije v obliki manjših lokalnih gub, krajših in šibkih reverznih prelomov in narivov, oziroma krajše normalne prelome ter različno oblikovane vzdignjene in spuščene dele. Tako je nastal na nekaterih območjih zelo kompleksen, včasih težko pregleden splet deformacij, ki jih korozijski procesi zabrišejo ali pa poudarijo.

Geografska lega in speleološki podatki

Raziskovani teren leži na topografski karti 1:5.000 Postojna-33, deloma pa tudi Postojna-43. Kot Postojnska gmajna je na topografskih kartah označen širok predel, ki na JV sega vse do Postojnskih vrat (Ravbarkomande). Na JZ je Postojnska gmajna omejena z Otoško gmajno, ki predstavlja do 500 m širok pas v apnencu, tik ob meji z eocenskim flišem. Na severu je Postojnska gmajna omejena z Bukovcem.

Po Katastru jam IZRK ZRC SAZU je na okrog 6,8 km^2 velikem terenu znanih 21 jam. Ob podrobnih terenskih geoloških raziskavah (Čar 1983) pa je bilo najdenih še 5 vhodov v kraške jame, ki pa niso bile speleološko raziskane. Povprečna gostota kraških jam na tem ozemlju je torej 3,8 jam na 1 km^2. Najglobje brezno je Brezno v Hrenovških talih (kat. št. 930), ki doseže globino 104 m. Najdaljša vodoravna jama pa je sistem Postojnskih jam, ki meri 19.555 m, globina 115 m, na obravnavanem terenu (Slika 1) pa lahko sledimo tudi vhodom v Črno jamo, Pivko jamo, Magdaleno jamo (tabela 1), ki so del sistema Postojnskih jam.

Strukturna lega izbranih kraških objektov

Brezna v nateznih razpoklinskih conah

Veliko vhodov v brezna na Postojnski gmajni se nahaja v ešaloniranih ali prepletajočih nateznih subvertikalnih razpoklinskih sistemih. Potekajo pod kotom 35 do 45° na smer premika dinarsko potekajočih (SZ - JV) prelomov bodisi v njihovi zunanji prelomni coni ali v širokih razpoklinskih conah približno z isti smerjo med dvema prelomoma. Prečno na njih potekajo starejše dinarsko usmerjene razpoke tlačnega značaja. Ešalonirane razpoke so v bližini zmičnih prelomnih con največkrat precej goste, z oddaljenost od prelomov pa postajajo redkejše in izmenične. Prepletajoči razpoklinski sistemi so običajno bočno manj jasno definirani, so krajši in se neznačilno končujejo.

Za ilustracijo opisanih razmer smo izrisali dva jamska vhoda (Slika 2), ki ležita okrog 900 m severno od vhoda v Pivka jamo. Gre za dve neregistrirani kraški jami, ki smo ju našli leta 1983 (Čar 1983). Jami nista speleološko raziskani, verjetno pa gre le za krajše jamske objekte. Na sliki 2 podajamo še kinematski model.

Kraški objekti v območjih klinastih divergentnih jarkov

Številni lokalni prelomi na obravnavanem območju se cepijo. Odcepljeni prelomi se lahko ponovno združijo, največkrat pa se priključujejo na sosednji prelom. V vmesnem bloku se lahko ustvarijo stiskajoče (transpresijske) ali sproščujoče (transtenzijske) razmere, tako da se zaklinjeni blok dvigne (izsti-

sne) ali spusti (pogrezne) (Woodcock & Schubert 1994). Na območju, ki ga obravnavamo na sliki 3, so se oblikovale sproščujoče razmere. Blok se je pogrezal in nastal je snop šibkejših normalnih prelomov s spremljajočimi nateznimi razpokami. Čeprav gre za šibke prelome in zato sorazmerno majhne premike, se je oblikoval značilen plitev klinast jarek. Korozijski procesi so ga delno preoblikovali in razpotegnili vzdolž porušenih in razpoklinskih con ob glavnem prelomu in razpoklinski coni, ki se odceplja proti severu. Vhod v *Kotovo jamo, kat. št. 1608* se odpira sredi snopa normalnih prelomov (Slika 3).

Kotova jama je sestavljena iz 45 metrov globokega vhodnega brezna (Slika 4) in 277 metrov dolgega horizontalnega rova. Leži okrog 650 m SZ od Magdalene gore in le okrog 150 m JZ od poteka temena Postojnske antiklinale. 200 metrov severno zasledimo manjšo jamo, ki je prav tako kot Kotova jama razvita v odprti razpoklinski coni smeri N-S. Ta jama nima katastrske številke, gre pa le za manjšo, okrog 4 m dolgo, poševno jamo, katere dno je prekrito s podornimi bloki.

Pri tem moramo opozoriti, da je na razpoklinski sistem vezana le geneza vhodnega brezna Kotove jame. Horizontalni rov je nastal na drugačni genetski osnovi.

Vertikalni kraški objekti v nateznih območjih prevojev zmičnih prelomov

Velika večina kartiranih tras dinarskih prelomov z desnimi zmiki na območju Postojnske gmajne povija. V levih prevojih (prevoj proti vzhodu) nastajajo tlačne razmere in zaradi tega dviganje terena. V desnih prevojih (prevoj proti jugovzhodu) pa se oblikujejo natezna območa in manjše depresije, ki bi bile v večjih razmerah lahko tudi inicialne strukture za nastanek razpornih (pull-apart) bazenov. Za desno prevojna, desno zmična natezna območja so značilni zelo zapleteni odnosi med posameznimi pretrtimi conami. Kamnine v znižanih delih preprezajo številne, glavnima prevojnima trasama vsporedne prelomne ploskve normalnih prelomov s spremljajočimi nateznim razpoklinskimi ali porušenimi conami. Zakrasevanje je v takih območjih zelo intenzivno.

Za prikaz opisanih razmer smo izbrali območje Postojnske gmajne s sistemom udornih vrtač (Slika 5).

Jamski vhodi v območjih prekrivanja dveh ešaloniranih desnozmičnih prelomov

Jamski vhodi v Pivko jamo, Ruglovico in Črno jamo ter več udornih vrtač se nahajajo v strukturnem pogledu v območju 400 do 500 meterskega prekrivanja dveh desnozmičnih dinarsko usmerjenih prelomov (Slika 6). Severnejši poteka iz območja Globušakov. Njegova ožja prelomna cona je sorazmerno ozka, kamnine so pretrte do stopnje porušenosti. Severno od vhoda v Pivko jamo se začne prelomna cona širiti, postopno previjati proti jugu in se južno od vhoda v Črno jamo izgublja v široki razpoklinski coni. Jugozahodni prelom

sledimo mimo udornih dolin vzhodno od Magdalene gore proti sever. Jugozahodno od vhoda v Pivko jamo postaja sicer precej široka ožja prelomna cona manj definirana, nato pa se ob rahlem povijanju proti severu postopno izgublja. V premostitvenem območju med obema prelomoma je nastalo izrazito natezno (sproščujoče) stanje, ki bi pri večjih premikih lahko predstavljalo zasnovo razpornega bazena (Woodcock & Schubert 1994). Pogreznjeno ozemlje je bilo dodatno korozijsko preoblikovano in znižano. Iz priložene karte (slika 6) vidimo, da je območje strukturno izjemno zapleteno zgrajeno. Preprezajo ga številni normalni prelomi s širokimi nateznimi razpoklinskimi conami. Pri nadalnjem razvoju pogreznjenega območja se je oblikoval sekundarni zmični prelom, ki seka strukturo in povezuje oba glavna preloma. Ob njem in normalnih prelomih so nastali še klinasti jarki, ki povečujejo strukturno pestrost ozemlja. Pri razlagi nastanka kraških polj je Vrabec (1994) izpostavil mehanizem razporne tektonike ob Idrijskem prelomu.

Udornica Pivka jama je globoka 77 metrov. Leži v SV krilu Postojnske antiklinale. Z nastankom in oblikovanjem udornice je jamski rov z aktivnim tokom reke Pivke dobil direktno povezavo s površjem.

Podobne razmere imamo tudi v okolici vhoda v Medvedjo jamo (kat. št. 1629), le da so v tem primeru natezne razmere nastale na premostitvenem terenu med zključkoma dveh prelomov. Medvedja jama ima poševno vhodno brezno globine 28 m ter vodoravni rov dolžine 94 m.

ZAKLJUČKI

Po letu 1980 je smo na novo geološko kartirali ozemlje med jugozahodnim obrobjem Planinskega polja in Pivško kotlino. Kartiranje je potekalo v merilu 1:5000 in je imelo litološko-strukturni značaj. Poleg litoloških in makroskopskih petrografskih sprememb ter tektonsko-strukturnih elementov smo beležili tudi različne krasoslovne značilnosti kartiranega ozemlja. Zabeleženi in geološko opredeljeni so bili vsi najdeni jamski vhodi.

Razen redkih izjem se vsi vhodi v vertikalne kraške objekte (udornice, udorne vrtače, brezna in vertikalna vhodna brezna v jame) odpirajo v območjih nateznih razmer, ki nastajajo lokalno ob dinarsko usmerjenih zmičnih prelomih in sicer:

- v subvertikalnih nateznih razpoklinskih sistemih pod kotom 30 do 45 stopinj na smer premika desnozmičnih dinarsko potekajočih prelomov, v njihovi zunanji prelomni coni, v notranji prelomni coni ali med dvema prelomoma (Slika 2),
- v spuščenih divergentnih klinastih jarkih (Slika 3),
- v nateznih prevojnih območjih ob desnozmičnih prelomih (Slika 5),
- v nateznih območjih med zaključkoma dveh ešaloniranih zmičnih prelomov ali v območju njunega prekrivanja (Slika 6).

Fig. 2: A. Position of two unregistered vertical cave entrances in tension fissured zones on Postojnska Gmajna north from the entrance of Pivka Jama. B. Kinematics model

Sl. 2: A. Lega dveh doslej še neregistriranih navpičnih jamskih vhodov v nateznih razpoklinskih conah na Postojnski gmajni severno od vhoda v Pivko jamo. B. Kinematski model. Skupna legenda za slike 2, 5 in 6 je prikazana na sliki 3.

Fig. 3: A. Entrance to Kotova Jama, NE from Magdalena Gora lies in area of tension conditions within a wedge-shaped depressions. North from there lies an unregistered (in Cave Cadaster) cave entrance in tension fissured zone.

1-strike and dip of bedding planes, 2-strike and dip of fault zone, 3-strike-slip fault, 4-normal fault, 5-tension deformations, 6-broken zone, 7-compression fissures, 8-doline, 9-collapse doline, 10-corrosional lowered area, 11-direction of mechanical deformations, 12-relative direction of movement, 13-vertical entrance of registered cave, 14-vertical entrance of unregistered cave in Cave Cadaster.
B. Kinematics model.

Sl. 3: A. Vhod v Kotovo jamo severovzhodno od Magdalene gore se nahaja v območju nateznih deformacij klinastega divergentnega jarka. Severno od tod leži doslej še neregistriran jamski vhod v natezni razpoklinski coni.
B. Kinematski model.

1-slemenitev in vpad plasti, 2-slemenitev in vpad prelomne cone, 3-zmični prelom, 4-normalni prelom, 5-natezne razpoke, 6-porušena cona, 7-tlačne razpoke, 8-vrtača, 9-udornice in udorne vrtače, 10-korozijsko znižano območje, 11-smer mehanskih napetosti, 12-relativna smer zmika, 13-navpični jamski vhod registrirane jame, 14-navpični jamski vhod doslej še neregistrirane jame.

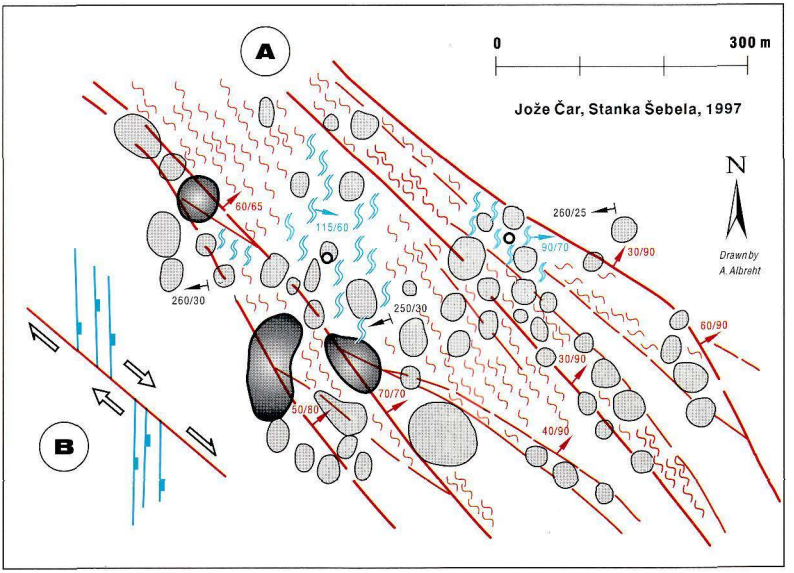


Fig. 2 - Sl. 2.

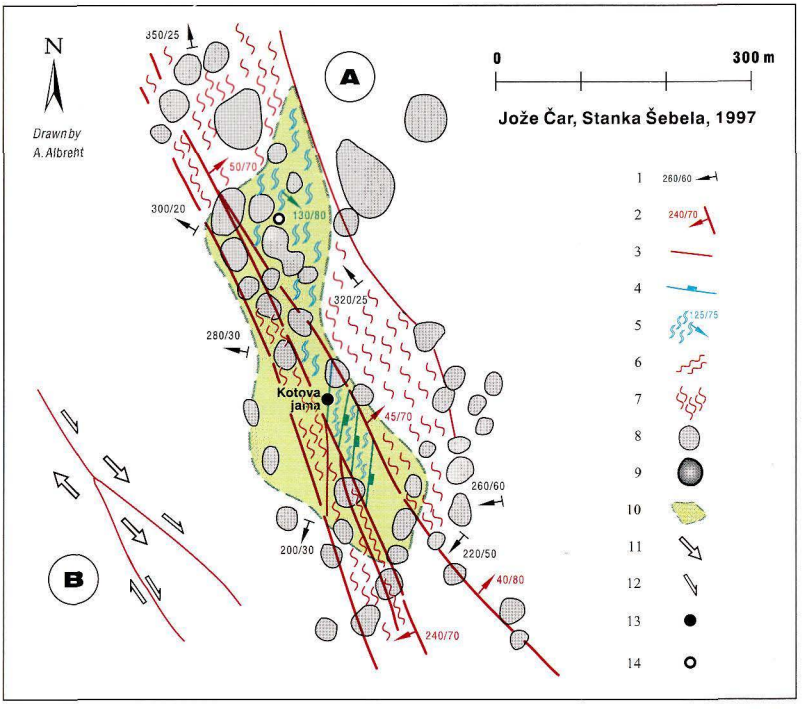


Fig. 3 - Sl. 3.

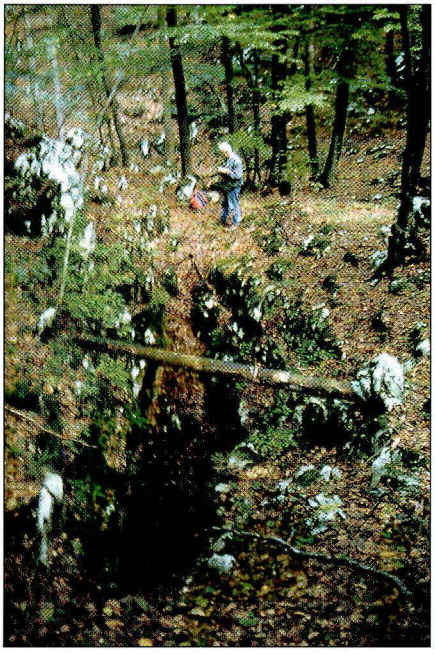


Fig. 4: Entrance shaft of Kotova Jama (photo by S. Šebela)

Sl. 4: Vhodno brezno v Kotovo jamo (foto S. Šebela)

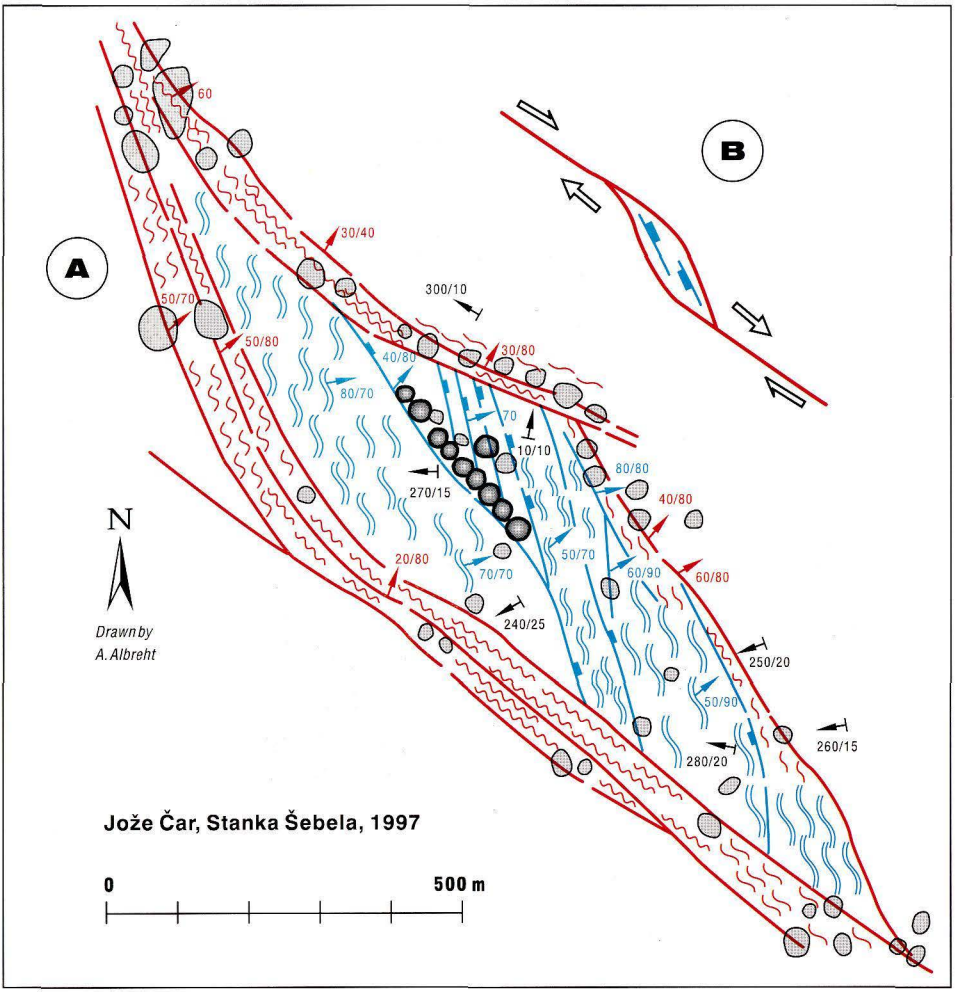


Fig. 5: A. Example of system of collapse dolines in extension area along the bend of a strike-slip fault in Postojnska Gmajna. B. Kinematics model.

Sl. 5: A. Primer niza vrtač v relaksacijskem prevojnem območju zmičnega preloma na Postojnski gmajni. B. Kinematski model.

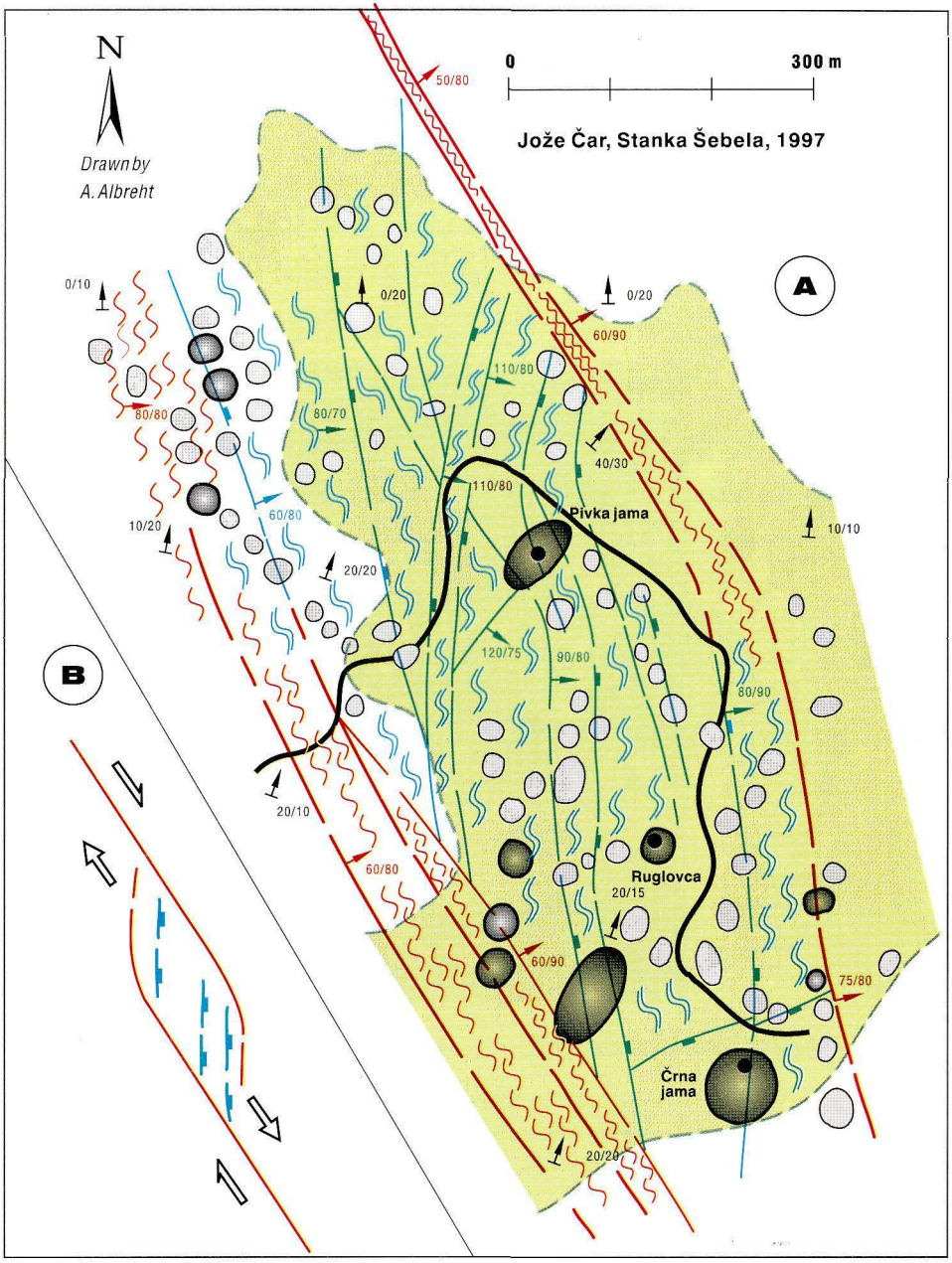


Fig. 6: A. Entrances of Pivka Jama and Črna Jama lie in corrosional lowered tension area in the sphere of overlap of two en echelon faults. B. Kinematics model. Sl. 6: A. Vhoda v Pivko in Črno jamo ležita na korozijsko znižanem nateznem območju prekrivanja dveh ešaloniranih prelomov. B. Kinematski model.

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THE SHAFT BREZNO POD VELBOM

BREZNO POD VELBOM

FRANCI GABROVŠEK [1]

Izvleček UDK 551.44(497.4)
Franci Gabrovšek: Brezno pod Velbom

Kaninsko pogorje vsekakor predstavlja eno zanimivejših kraških področij v Sloveniji. Da gre za močno razvit visokogorski kras ne kažejo le površinske oblike, temveč tudi vse večje število raziskanih globokih jam. Kar tri od teh so globje od 1000 m. Posebej zanimiva pa sta v zadnjih letih raziskana Brezno pod Velbom in brezno Vrtiglavica. Prvo je globoko 850 metrov in se ponaša s 501 meter globokim enotnim vhodnim breznom, Vrtiglavica pa je eno samo enotno brezno, globoko 643 metrov. Brezni zasedata vrh seznama najglobjih svetovnih vertikal.
Ključne besede: speleologija, brezno, vertikala, Slovenija, Kanin.

Abstract UDC 551.44(497.4)
Franci Gabrovšek: The shaft Brezno Pod Velbom

Kanin mountains in western Julian Alps, Slovenia, is one of the most promising caving areas. On two high karstic plateaus many very deep caves have been explored, three of them beyond -1000 m. Brezno Pod Velbom, which is now 850 meters deep, was found in 1989. It is the 501 meters deep entrance shaft, that makes the cave especialy interesting. It is the world's second deepest vertical, after the shaft Vrtiglavica, which is a single 643 meters deep shaft. Both entrances lie not more than 2 km apart.
Key words: speleology, shaft, vertical, Slovenia, Kanin Mt.

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HISTORY OF EXPLORATIONS IN THE KANIN AREA

Caves in the Julian Alps have been intensively explored during the last few decades. Among many high Alpine karstic plateaus, two of them, Kaninski and Rombonski Podi (Goričica) above the Soča valley near Bovec, have the greatest prospects for cavers. These plateaus are the main parts of the Kanin mountains. Upper Triassic (Dachstein) micritic limestone and dolomite are the most occurring rocks there. Kaninski podi spreads over an area of about 9 square kilometres, between 1950 and 2300 m a.s.l..

The plateau was intensively explored during the seventies and not many deep caves were discovered. First success was Skalarjevo Brezno, where a depth of 911 m was reached in late eighties.

On the other hand, not much attention was paid to the lower Rombonski Podi plateau, just a few kilometres to the NE. Than Italian cavers began exploration there and explored the first Slovenian -1000 m cave, Črnelsko Brezno. Since 1990 three caves deeper than one kilometre have been explored there; Črnelsko Brezno (-1198 m), Čehi II. (-1370 m), both explored by Italians, and Vandima (-1182 m), explored by cavers from the Ljubljana Caving Club (DZRJL).

SHAFTS IN KANIN MOUNTAINS CAVES

Almost all deep the caves in the area have at least one extremely deep shaft. The exception is Vandima, where the deepest vertical is 'only' 90 meters deep. On the other hand, Čehi II., Črnelsko Brezno and Skalarjevo Brezno all have an interior shafts ranging between 170 and 250 meters. Cave Zlatorog near Črnelsko Brezno, has 360 meters deep interior shaft, which was the world's deepest interior shaft when explored in 1991.

Brezno Pod Velbom, which will be presented in this paper begins with the 501m deep entrance shaft and is recently (September 1997) 850 m deep. Until October 1996, Brezno Pod Velbom had been the world's deepest shaft.

In August 1996 another shaft, now called Vrtiglavica, was found only about two kilometres far from Brezno Pod Velbom. The cave is one single 643 m deep shaft, now world's deepest.

EXPLORATIONS OF BREZNO POD VELBOM

The area of Kaninski Podi ranks among the areas with the highest cave density in Slovenia, i.e. 25 caves per sq. km. The caves are concentrated in the area near the ski cableway station and the Peter Skalar mountain hut (254 caves in an area of 6 sq. kilometers). But there are only few caves in less accesible western part of plateau.

There, almost no prospecting had been done between the seventies an late eightees. The entrance of Brezno Pod Velbom was found in 1988, but no serious expeditions had been done until 1993, when the depth of 106 m was reached. In 1994 we reached the bottom of the entrance shaft, 501 meters below the vault-shaped entrance. In 1995 we explored the big collapse chamber at the bottom and reached the depth of 541 m. In 1996 big efforts were made to find a continuation at the bottom. We passed the boulderchock and found another series of shafts which lead us to the -850 meters, where cave seems to end. The final depth was achieved in August 1997. There are small possibilities for continuing the explorations from the deepest parts. But there might some overlooked branches leading deeper from some of the shafts between the big chamber and the bottom.

The cave has been explored by the members of Ljubljana Caving Club (DZRJL).

MORPHOLOGY OF THE CAVE

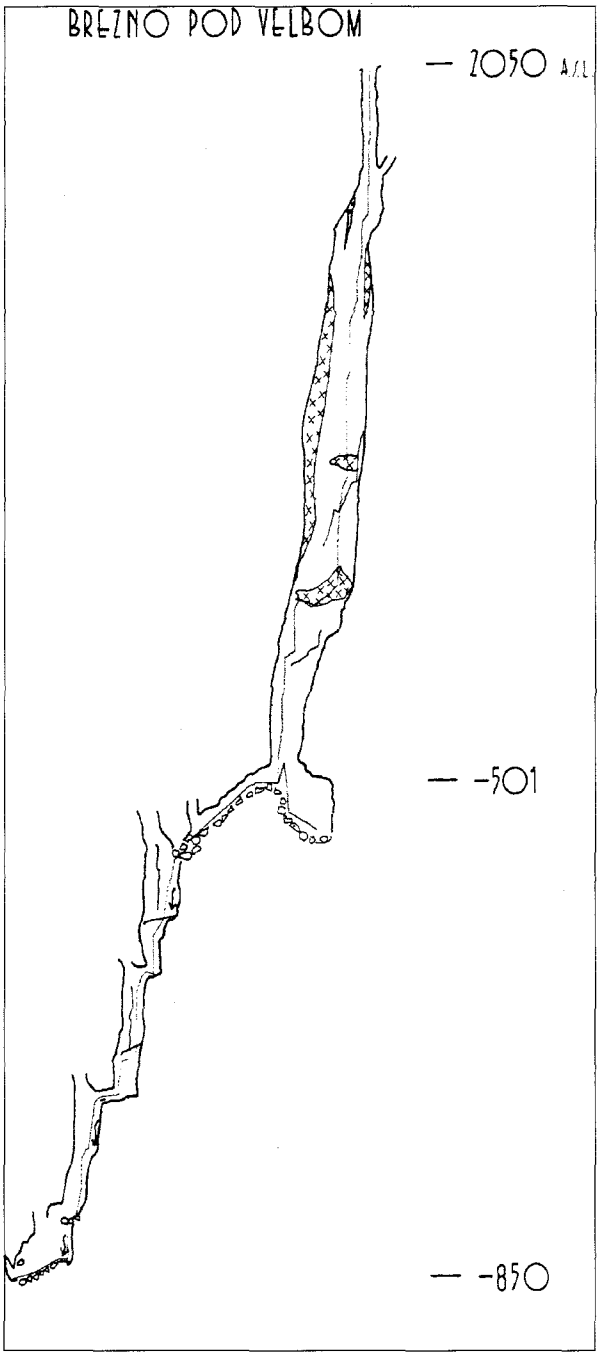
The shaft is located at the edge of a collapse depression between peaks Laška Planja and Vrh Žlebi. The altitude of the entrance is 2050 m. As many other deep caves in the area, the shaft is near the edge of the plateau (the feature not yet explained).

The entrance is quite large, since, the northern part of the wall obviously collapsed into the shaft, which causes the vault shape. Until -120 m, the cross-section of the shaft is relatively small, between 5x10 and 10x15 m. At -100 m the shaft is divided by a natural bridge (until 1996). Below 120 meters the shaft widens as far as -300 m, where the cross-section is largest, 30x10 m approximately. At -377 m the snow-ice blockade breaks the monotony. The ledge of snow and ice was formed around the rock blocks wedged between the walls of the shaft.

Passage between the ice and solid rock took us below the blockade to where the shaft continues. The cross-section is then smaller again. About 100 m lower, at -470 m, the shaft enters a big collapse chamber, where it ends at the top of a collapse cone, at -501 m. The shaft was developed in the N-S (10°-190°) fissured (fault) zone.

The chamber is very big for the area, measuring about 100x40 m in plan. The ceiling and the walls of the chamber are extremely unstable, with many signs of recent breakdowns. The big collapse cone is about 40 meters high and easily scalable on one side of the chamber. There is a very unstable 12 m high vertical step on the other side of the chamber. There, to reach the base of the cone, a traverse below the ceiling, where the only good rock to fix the spits is, had to be made.

The passage through the boulderchock leads to a series of shafts (90, 50, 30, 80, 30) down to the bottom at -850 m.



The horizontal distance from the entarnce to the bottom is 100 m (N-S). All the shafts were developed along the fissure zone with the N-S orientation. Limestone beds are 3-5 meters thick with the dip of about 15°. In the surface and in the cave Jurassic neptunic dikes are observable.

Ice begins about 30 meters below the entrance. Various forms of ice cover the walls down to the snow-ice blockage at -377. Very interesting is a small glacier in the chamber at -530, where the snow is about one meter thick and spreads over the area of 5x10 m. It proves that the blockade at -377 is not permanent.

The temperature in the shaft is moving around the freezing point, according to the year-season. Falling icicles and blocks of ice mean the biggest threat to cavers, especially during the period when ice melting reaches deep into the shaft.

Percolating water starts below the ledge at -377, where the climate usualy changes from sub to above 0°C. Affluence of wa-

After Stopar & Pintar 1996.

ter enters the passages in the shaft series below the chamber. In the lower part the explorations during the rainy season could be dangerous.

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BREZNO POD VELBOM

Povzetek

Kaninsko pogorje vsekakor predstavlja eno zanimivejših kraških področij v Sloveniji. Da gre za močno razvit visokogorski kras, ne kažejo le površinske oblike, temveč tudi vse večje število raziskanih globokih jam. Kar tri od teh so globje od 1000 m.

Prve resne raziskave na področju Kaninskih podov se se začele v sedemdesetih letih. Odkrito in raziskano je bilo veliko število brezen, vendar jih je razmeroma malo presegalo globino 100 m. Raziskave na italijanski strani masiva so bile, vsaj kar se tiče globokih jam, bolj uspešne. V osemdesetih letih pa bilo na naši strani raziskano 911 m globoko Skalarjevo brezno. Vendar pa se je pozornost jamarjev kmalu za tem preusmerila na Rombonske pode, kjer so leta 1989 italijanski jamarji v Črnelskem breznu prvič v Sloveniji presegli gobino 1000 metrov. V naslednjih treh letih sta bili na Rombonskih podih raziskani se dve jami globji od tisoč metrov, Čehi 2, ki jo je raziskala ista skupina kot Črnelsko brezno in Vandima, ki so jo raziskali jamarji Društva za raziskovanje jam Ljubljana.

Ves ta čas so jamarji raziskovali tudi na Kaninskih podih. Tudi tu uspeh ni izostal. Posebej zanimivi sta v zadnjih letih raziskani Brezno Pod Velbom in brezno Vrtiglavica. Prvo je globoko 850 metrov in se ponaša s 501 meter globokim enotnim vhodnim breznom, Vrtiglavica pa je eno samo enotno brezno, globoko 643 metrov. Brezni zasedata vrh seznama najglobjih svetovnih vertikal.

RAZISKAVE BREZNA POD VELBOM

Vhod v Brezno Pod Velbom je bil najden leta 1988. Prve resne raziskave so stekle v letu 1993, ko je bila dosežena globina 106 metrov. V letu 1994 je bilo doseženo dno 501 meter globoke vhodne vertikale. V letih 1995-1996 je potekalo iskanje možnih nadaljevanj v podorni dvorani na dnu vhodne vertikale. Prehod skozi podor na najnižjem delu dvorane je pripeljal v v niz brezen, ki se konča na globini 850 metrov (avgust 1997). Nadaljevanje na dnu je le

malo verjetno, možni pa so odcepi v breznih med dvorano in dnom. Jamo so raziskali člani Društva za raziskovanje jam Ljubljana.

MORFOLOGIJA JAME

Vhod v Brezno pod velbom leži ob robu večje depresije med Vrhom Laške Planje in Vrhom Žlebi. Nadmorska višina vhoda je 2050 metrov. Vhod je lijakaste oblike, ki ga ne eni strani lepo zaključuje obok (ime!). Do globine 120 metrov je presek brezna razmeroma majhen, le redko preseže dimenzije 10x5 metrov. Pod 120 metri je presek vse večji, do 30 x 10 m. Na globini 370 metrov brezno prekinja ledeni čep. Pod tem so prečne dimenzije brezna zopet manjše. Približno 470 metrov pod vhodom brezno prebije strop velike podorne dvorane in se trideset metrov nižje konča na vrhu podornega stožca, 501 meter globoko.

Dvorana je razmeroma velika za to področje, v tlorisu meri do 40 x 100 metrov. Relativno sveži bloki pričajo o recentnem podiranju stropa in stranskih sten. Izredno pretrta kamnina na stenah in labilen podorni stožec sta ne eni strani onemogočala dostop do dna dvorane. Tu je bilo potrebno delati prečko pod stropom dvorane. Nadaljevanje jame pa je na drugi, lažje dostopni strani dvorane, kjer prehod med podornimi bloki pelje v niz brezen (globine 90, 50, 30, 80, 30) do globine 850 metrov.

Horizontalna razdalja med vhodom in dnom jame je le 100 m. Vsa brezna so razvita v N-S orientirani razpoklinski coni.

Vhodno brezno zaznamuje predvsem velika količina ledu, ki oklepa stene vse od globine 30 metrov, do velikega čepa na globini 370 metrov. V poznem poletju in zgodnji jeseni, ko je taljenje na višku, raziskovanja resno ogrožajo padajoči kosi ledu. Sneg in led je tudi v podorni dvorani, na globini 530 metrov.

Vodo v jami srečujemo od ledenega čepa naprej, kjer temperatura navadno preseže ledišče.

V dvorani in pod njo priteka voda v brezna iz večih kaminov, zato je raziskovanje v deževnem obdobju vsaj neprijetno, če že ne nevarno.

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CLIMATIC AND LITHOLOGICAL INFLUENCE ON THE CAVE DEPTH DEVELOPMENT

LITOLOŠKI IN KLIMATSKI VPLIV NA GLOBINSKI RAZVOJ JAM

IVAN GAMS [1]

Izvleček UDK 551.584:551.44

Ivan Gams: Litološki in klimatski vpliv na globinski razvoj jam

Pod golim površjem visokega Alpskega krasa (primer Triglav) agresivna padavinska voda votli globoka brezna do piezometrične vodne globine. Na nižjem Dinarskem krasu (primer Postojnska jama), ki ga je v hladnih dobah Pleistocena zajela tundra, v globjih jamah in votlinah, razkritih v kamnolomih, in globljih cestnih usekih, v toplejši holocenski klimi prevladuje fosilizacija votlin zaradi zvišane korozijske fronte, in nadaljuje korozijsko poglabljanje v podaljšku subkutanih jaškov in plitvih votlin, zapolnjenih z vodoprepustno ilovico.

Ključne besede: speleologija, speleomorfologija, odlaganje sige, epikarst, brezno, Slovenija, alpski kras, dinarski kras.

Abstract UDC 551.584:551.44

Ivan Gams: Climatic and lithological influence on the cave depth development

Below the bare surface of the high Alpine karst (example Mt. Triglav), the aggressive precipitation water generates deep potholes to the piezometric water level. In the lower, covered Dinaric Karst (example the Postojna Cave), invaded by tundra in the cold periods of the Pleistocene, and in the deep caves and voids revealed in quarries and deep cuttings for roads, in the warmer Holocene climate flowstone accumulation prevails due to the higher solution/accumulation front, and continues the deepening of the shallow subsoil pockets and shallow pits filled with the permeable loam.

Key words: speleology, speleomorfology, flowstone accumulation, epikarst, shaft, Slovenia, Alpine karst, Dinaric karst.

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The longest and deepest caves are in the forefront of popular interest. They are generated mostly along the underground flow of so-called sinking rivers (called also allogenic rivers), which drain the surface built of impermeable sediments and sink in the contact karst (in Slovenia: Gams 1959). Their number is limited.

In this paper, smaller voids disclosed below the karst surface are of particular interest. According to the new karst monographs (Ford & Williams 1989, p. 342) a karst cave is defined as "a solutional opening that is greater than 5-15 mm in diameter or width". In Slovenian speleology, a cave is called "void" which is penetrable by men and is at least 5 m long and/or deep. By 1995 more than 6,600 caves have been registered in Slovenia (Brenčič 1995). In 25% of them, their depth was less than 14 m and their lenghts less than 12 (and in 50%, the depth was less than 27 m). Taking into account the lowering of the karst surface, which in Slovenia amounts annually to 40-100 microns, and considering the 2 million years' duration of the Quaternary period, about 50% of the caves in Slovenia could have developed in conditions observed at present in the walls of deeper limestone quarries. These conditions, however, are different from those in the high Alpine karst. The differences between bare and covered karst are illustrated in two examples in our sketch.

BARE ALPINE KARST

The first type is illustrated by the high Alpine karst in Slovenia on the plateaus below the highest peak in Slovenia - Triglav (alt. 2864 m). There, at the contact of the Triglav crest with the small Triglav plateau a small glacier (the Triglav glacier) there is. The melting water from this glacier flows on the limestone surface to the nearby sink in the Triglav pothole at an altitude of 2400 m. During our research in 1961 (Gams 1962), the water discharge in the upper part of the pothole was about 3 l/sec, the temperature 0,2°C, and the total water hardness 36.5 mg/l of $CaCO_3$ and $MgCO_3$. In September 1994, the total hardness of water draining the mixture of ice and rubble on the left flank of the Triglav glacier was 81 mg/l (Gams 1994, p. 108). Such hardness is often found in water draining the heaps of rubble mixed with humus on the surface of the Julian Alps. In the nearby cave Ivačičeva jama the total hardness of the water dripping from the ceiling was 66 mg of $CaCO_3$ + $MgCO_3$/l (Gams 1962). At this amount the water CO_2 pressure in solutes is in equilibrium with the PCO_2 0,03% in the free atmosphere (Ford & Williams 1989, p. 53-63).

In August 1964, the water in the upper end of the Triglav pothole was traced with fluorescein. The tracer was registered in the spring of the Bistrica stream at the end of the Vrata valley, 1220 m below the entrance into the Triglav pothole and 1250 m from it in horizontal distance. For the underground flow, the water needed 23 hours and 40 minutes (Gams 1966). This

speed is probably greater than under the surface without ice melt water. The average total hardness of the Bistrica spring is 73 mg of $CaCO_3$ + $MgCO_3$/l (Gams 1966). This content proves that the soil CO_2 is nearly absent from the river basin. Standard limestone tablets exposed at Kredarica in a heap of rubble mixed with humus which is frozen 8 months per year resulted in 13,9 microns of the limestone dissolved annually. The tablets exposed on the stony surface on Mt. Kanin with double the amount of precipitation was 6,14 mm annually, representing nearly 15% of the total denudation (94 $m^3/km^2/yr$), calculated on the basis of the runoff and total water hardness for Mt. Kanin (Kunaver 1976). It is evident that the bulk of solution in the rocky Alpine karst occurs in the deep endokarst.

The transitional zone between the flowstone forming and aggressive percolation water lies in the caves in the Slovene Alps at altitudes ranging from 1000 to 1500 m. In the cave Babji zob near Bled at an altitude of 1000 m the dripping water from the ceiling does not deposit flowstone nor is it erosionally active in the colder entrance channel (6,7°C), but it does deposit flowstone in the final, warmer separate part (7,2°C) under the forested surface (Gams 1975). The 400 m long horizontal cave is namely open to the cold winter air penetrating from the outside. The boundary zone between the soil cover and the rocky surface lies between 1000 and 1600 m on the carbonate surface of the Julian Alps. Depending on special lithology, special solutes in water and special cave air circulation, this zone can be higher or lower.

COVERED DINARIC KARST

The second type presented in our sketch is the most known Slovenian karst, the karst at Postojna. The difference in annual temperature between the two environments is 10°C (in the first case -1,6°C, and at the station of Postojna +8,4°C (1960-1990). A different role of highland and lowland environment derives mostly from the effect of soil cover in covered karst. This role resulted in the difference of the solution process of carbonate rocks, in our case limestone and dolomite, and different the depth of solution front. Under the bare karst, the solution front is up to one thousand metres (locally even more) below the stony surface. There, the corroding water is in contact only with the air and with its CO_2 concentration of 0,03%, as it is in the free atmosphere. By equilibration of its CO_2 and the CO_2 in the air the water is able to dissolve up to 70-80 mg of $CaCO_3$/l (or $MgCO_3$/l). Due to the absence of soil cover the precipitation water immediately sinks into the underground (endokarst). The cave air is there connected with the free atmosphere as the fissures are not blocked on the surface by soil, loam or silt or impermeable sediments. So the CO_2 needed for the solution of carbonates is available during the penetration of the precipitation water down to the deep piezometric water level. Due to the fact that at least two days are needed to establish the final equilibrium

when the maximum saturation with CO_2 is obtained, not all waters can get the full content of 70-8O mg of $CaCO_3$/l, so solution occurs nearly within the whole aerated zone.

The surface above the Postojnska jama cave is at an altitude of 540-620 m. The mean annual precipitation amounts to 1579 mm (compare Kredarica at the Triglav glacier - 1994 mm). The total hardness of the flowstone-forming water which penetrates through the nearly 100 m thick ceiling is about 187-205 mg of $CaCO_3$ + $MgCO_3$/l. The mean hardness mentioned above demands about 0,4% of the CO_2 in the soil atmosphere. Regular measurements of CO_2 began on 18th March, 1997, where the first measurements (done with the assistance of A. Mihevc) have taken place on the southern border of the levelled surface about 80 m above the cave channels north of the Biospeleological Station. In this area, the land is an abandoned pasture partially overgrown by bushes and pine trees. In the reddish-brown loamy soil below the O horizon, the following concentrations of CO_2 were found before the vegetational period: at a depth of 20 cm below the surface 3400 ppm of CO_2, at 30 cm 4000 ppm, and at 50 cm 4100 ppm of CO_2. Its texture of mixed A and B horizont is: 2.9 % of coarse and 27.1 % of fine sand, 31.3% of silt and 48.6 % of clay. The 50 cm soil depth is hard to find there and it is traced only in the soil pockets. In the Postojna Cave the air has between 0,03 and 0,1 % of CO_2 (Gams 1970).

The precise depth of the solution front under the soil and vegetation cover in the low and middle high karst is still a matter of discussion in Slovenia. The following facts speak in favour of the assumption of the solution front near the karst surface:

1. In the shallower caves around Postojna, the ceilings of which are around 10 m thick (in some cases even less), the dripping water normally deposits flowstone (for example the cave at Groblje, Skednena jama, Gams 1966).
2. The CO_2 pressure at 0,4% concentration in the free air is more than 10 times higher than in the cave air. The penetrating water in equilibrium with the 0,4% CO_2 pressure in the soil begins the flowstone deposition in the first void of endokarst connected with the free air. For this reason, we must assume a quick solution immediately below the soil cover, pocket or shallow voids filled with loam. Also the subsoil rocky forms (Gams 1971) prove the intensive solution by means of soil moisture.

Very few dripping waters in the Postojna cave are agressive. The aggressive water in the Pisani rov of the Postojna Cave was examined more closely as an example (Gams 1966, Kogovšek 1983, trickle point No.7) and different reasons were found. Its total hardness (between 105 and 130 mg of $CaCO_3$/l) indicates the mixing of waters penetrating through the surface with the soil cover and without it. The trickling water has a higher hardness and it is flowstone-forming at the low water stage. At high discharge, the hardness is reduced and the water is aggressive. In this cave the dripping water after a longer

stagnation in limestone pools has been losing solids to about 80 mg of $CaCO_3$/l. (Gams 1967). Their mean hardness (175-220 mg of $CaCO_3$/l) of 80 measurements of the penetrated water demands about 0,4% of the CO_2 in the soil atmosphere (see Ford & Williams 1989, p. 57).

CONSEQUENCES OF CHANGED CLIMATE FOR THE CAVE DEPTH DEVELOPMENT

In the coldest Pleistocene periods which were more numerous than previously presumed, tundra vegetation spread over the lower Notranjsko karst and invaded the Slovene Littoral as well (Šercelj 1996). The altitude of the grass-growing line, where the roots only partially prevented eroded soil from being transported into the fissured bedrock, is not known exactly even for the last final cold Wurmian period (W3). At least the steeper slopes were liable to erosion of the loam and soil, not only along the surface but also into opened fissures below roots. It is the general opinion that the colder periods of the Pleistocene coincide with the phase of accumulation of loam, sand and pebble in caves and poljes (Gospodarič 1976). During the period 32.000 - 125.000 BP, flowstone datings show a reduced growth of stalagmites and stalactites (Zupan 1991). These phenomena indicate a deeper solution/flowstone deposition front and a deeper zone of cave and pit forming than it is at present. In this sense, the Holocene period has brought a blockage of water conduits leading to deeper voids as the snow cover was renewed. This and the forest caused relatively faster subsoil solution, the faster lowering of the surface and thus faster disclosing of the voids filled with loam and soil.

However, in some cold spots in the high Dinaric karst plateaus between the Trnovski gozd plateau and Mt. Snežnik the deep solution front, where the winter snow cover is locally thick, still exists. On Mt. Nanos (meteorological station at 915 m), 394 mm of precipitation form about 2,3 m thick snow cover in three winter months. The cover is thicker in the bottoms of deep colapse dolines where the accumulated snow persists nearly all the year round. A century ago, firn and ice in the potholes below them were still excavated from these "glacières" and used. The participants of the Karstological School in 1996, whose main aim was to visit some of the ice shafts on Nanos, could observe the circular cross-section of their upper parts. Such profiles can be generated only if the pothole is filled with fine sediments or ice, both in contact with limestone.

In order to prove the thesis of climatic influence on the shifting of the solution/accumulation front, many quarries in Central Slovenia have been analysed. The karst with the quarries referred to belongs to the hydrological type with radial underground drainage. So allochtonous sediments in caverns disclosed there are exceptions. Sediments in the dolines (Habič 1987) and caves in the Kras region with allochtonous rivers and sediments (Mihevc &



Fig. 1: Below the dolines in quarries and cuttings for roads more fragmented rock mixed with soil and loam is usually revealed. Since the solution is faster in the cracked rock, the doline formation and the beginning of the pit formation are genetically linked. Photograph taken at Verd.

Sl. 1: Pod vrtačami je v kamnolomih in usekih za ceste običajno razkrit bolj razlomljen apnenec. Ker je korozija hitrejša v zdrobljeni kamnini, sta nastanka vrtače in začetka izvotljenja jaška genetsko povezana. Fotografirano na Verdu.

Zupan Hajna 1996, Slabe 1996) are different and controlled also by the sinking rivers from the nearby Eocene flysch which remained in patches on the top of Gradišče hill (714 m), N of Lokve and in the near western Brkini hills (see geological map 1:100.000 of the sheets Triest and Gorica).

In quarry walls and cuttings for roads the revealed rock under dolines is usually more cracked and fissured. Between blocks in the upper part the soil prevails, and in the lower part rubble mixed with soil and loam (Fig. 1 taken at Verd). There, the lowering of the doline bottom is due to faster solution of fractured rock (compare Šušteršič 1994).

If the filling in the pit gets less permeable, the precipitation water sinks through the lateral fissures and voids. The funnel-like doline is thus enlarged and transformed into bowl-like doline. The large doline in the Fig. 2 taken in 1973 is at this stage. The colour picture of the same doline has already been published in Acta carsologica 23, 1994, Fig. 13, pp. 156-157. Its author is standing in a side pit seen in our photograph on the right side. In Fig. 3 this pit and the neighbouring side pit are shown on a larger scale.



Fig. 2: The doline above the wall of the quarry at Verd where the soil was stripped off in 1993. At this stage of the doline development, karren and projecting out blocks below hinder the subsoil flow of the precipitation water toward the central pit seen on the bottom. F. Šušteršič is standing on the right side in a lateral pit (the right slope).

Sl. 2: Vrtače nad odkopno steno kamnoloma Verd, kjer so l. 1963 postrgali prst. V tej razvojni stopnji vrtače razčlenjena skalna podlaga preprečuje podtalno odtekanja padavinske vode proti osrednjemu jašku na dnu. V stranski odprtini na desnem pobočju stoji F. Šušteršič.

There the initial soil pocket has grown down in a filled pit often found as subsoil form.

As previously noticed in some cases in the quarry of Verd, the lateral infilled pits continue at the flank of the central pit. The Fig. 4 (taken in the 1960s) shows as an example the central pit in Palaeocene limestone in an abandoned quarry in Izola. In the picture the pit is filled with reddish loam. The lateral voids are destroying the rock as the penetrating aggressive water dissolves it. At the right side of the picture, there is the neighbouring filled central pit. After the intermediate rock is dissolved, the central pits will join



Fig. 3: Revealed side pits of the doline pictured in the photo No. 2, in closer view. Bedding planes and karren are making the rock permeable even between the pits. Photograph taken in the 1960s.

Sl. 3: Podrobnejši pogled na stranske jaške ob vrtači s slike 2. Kamnina je prepustna zaradi lezik in škrapelj celo med temi jaški. Fotografirano v 60-tih letih.

into one larger void. Many open potholes are a system of combined pits connected with steps.

After the infiltration water is transformed into soil/loam moisture, the precipitation waters remain aggressive regardless of their depths in the pockets, fissures or pits if the filling is permeable for water. The filling found in pits during the construction of the Vrhnika - Postojna motorway consists mostly of sand (the yellow sand contains up to 15% of quartz) and silt. There is only 1% of clay particles in them. The volume of the fillings which were observed there in the pockets and pits, distributed on the surface, is equal to 1 m thick soil cover (Šušteršič 1978). On the bottom of these permeable fillings at Verd and other quarries, signs of active solution deepening and widening of the rocky cavities were registered and many forms, similar to those on the cave rocky surface, appear there. T. Slabe (1995) classified them as solution bevel, channel, niche, roof pendants, solution cup, corrosion notches and box-work. In my opinion, one of these forms is also the so called recess, known as the subsoil form (Gams 1971). It is similar to an open large scallop having a smooth surface. This form is often found also in the revealed voids in the escarpments of quarries.

The upper zone of a quarry escarpment with its filled fissures and loam pockets is obviously the zone of the recent intensive void forming. The voids follow the bedding planes or cracks in the rock and are at their first stage strongly lithologically controlled. In this zone, filled caves are more numerous than empty ones (Šušteršič 1977). They can all be generated out of the soil pockets, subsoil pits and larger voids in shallow endokarst.

The zone of the present cave formation is shallower where voids in endokarst have no connection with the free atmosphere or where narrow fissures are filled only with the percolating water after heavy rain. If the percolating water in endokarst cannot absorb fresh CO_2 from the air and can not emit the CO_2 in the void air, it is solutionally inactive regardless of the depth below the surface. The flowstone sedimentation then begins in the first lower cavity connected with the surface air. The air permeability and its circulation within cavities is forced by the changing air pressure due to predominance of anticyclonic and cyclonic weather. This connection can use also the tiny, longer fissures running in all directions. Gravitational flowing water uses only the downward ways.

Solution below the soil pockets and on their flanks depends on the pH of the soil, and mostly on the humus and organic matter in general. The permeability of the infilling clay, loam soil, or sand controls the relation between the lateral or downward growth of the void/cave. Sands from the Eocene flysch enhance the genesis of deep potholes.

The lithological strength which controls the width of the voids has great influence on the form and situation of cavities. Nearly no voids occur in the cracked Triassic dolomite (for example in the quarry above the village Dešno in the valley of the Sava River, parts of the quarry above the village Povodje in the hills of Rašica near Ljubljana, the quarry Pirešica north of Žalec and two in the valley Paka north of Velenje). If along the faults the carbonate rock is cracked into small rubble mixed with silt and the whole mass is under pressure of blocks, the water percolation is often hindered and caves are absent. If rock is fragmented and mixed with permeable loam, the voids occur mostly inside the blocks. The deep filled potholes and voids occur mostly in the stratified solid limestone cracked in larger blocks (see also Čar & Gospodarič 1984). Not all open voids are used for penetrating water there. Some fissures are blocked with flowstone and the void get no more moisture.

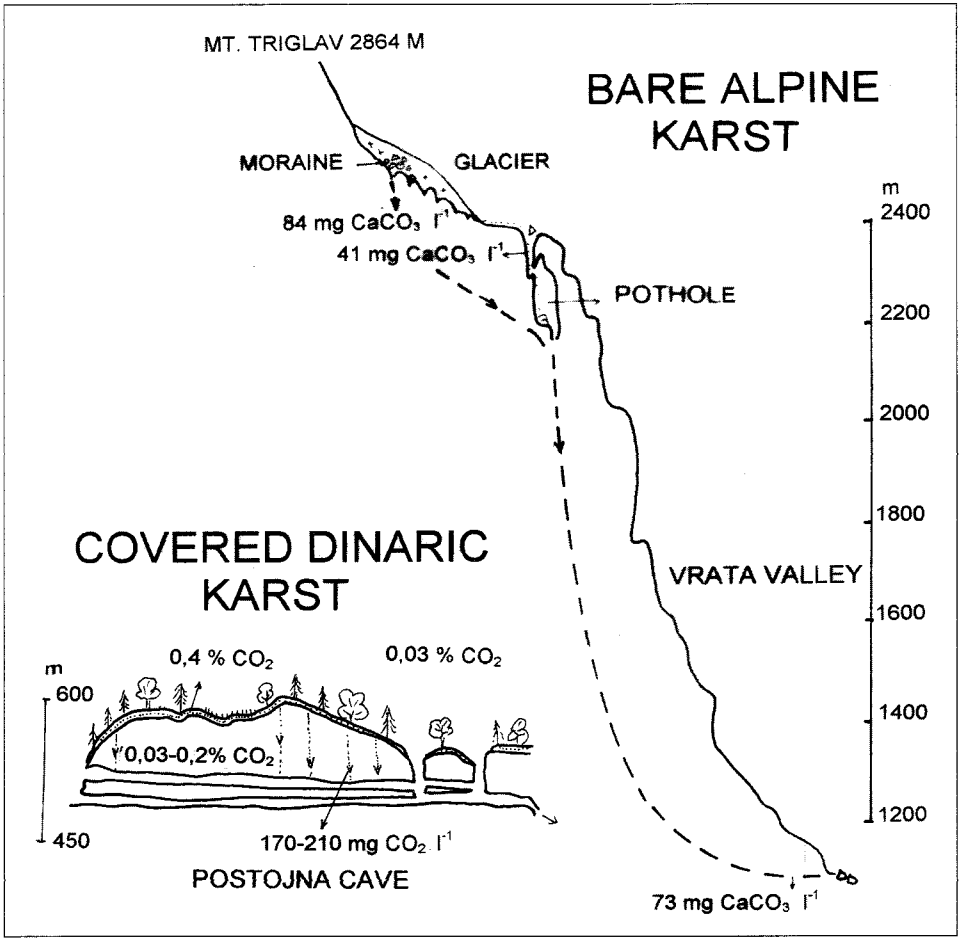
The average altitude of the surface in Slovenia is 551 m and the average altitude of the entrance into the cave is 785 m (Verša 1995). Higher altitudes and colder climate are obviously favourable for the development of voids. The predominance of potholes above the horizontal caves in Slovenia can be partially explained as the consequence of the pits forming in the Pleistocene.

Due to fast changes in filling and evacuation of the pits, due the changed permeability for precipitation water and changes of the local depth of solution front, the effects of the transition from the Pleistocene to Holocene climate

are less evident. They are more clear in cases where more development stages can be recognized in sequence from the bottom to the upper end of one larger cave.

The Fig. 5 and 6 taken in 1996 from two nearby disclosed filled pits. In the first pit the following development stages were evident:

1. Solution of the rock and forming of the void. No signs of the running water can be found. Solution by stagnant water is possible, but no proof for that exists. In the last stage of the pit widening, the contact solution loam/ rock resulted in the smooth surface of the limestone face and slower solution of the calcite veins (Fig. 5) which project from the wall. The only possible explanation for this formation is: aggressive water gliding in the



overhanging position. Some parts of the filling are coloured differently, but the contacts were not sharp and the climatic influence on its formation is not clear (compare Urushibara 1976). The lower infilling is in general more red and with more clay particles.

2. End of loam accumulation.
3. Formation of the flowstone sheet which covers the loam infilling, thus fossilizing the pit about 25-30 m below the (present) surface. Stalactite formation on the ceiling.
4. Blocking of the pipe above the pit which previously served for the inflow of water, enriched with CO_2 in the soil on the surface.

In the neighbouring pit, the first process of widening the void was solution by stagnant water (phase no. 1). The proof is a rough rocky face (Fig. 6). Phase no. 2 followed, during which the filling of the void with reddish loam occurred and it has remained in the lower part of the pit, while in phase no. 3 the process of erosion of loam occurred in the upper part. It has remained where the crust was hardened with flowstone (phase no. 4). Stalactites are a sign of the general accumulation of flowstone (phase no. 5).

The stated solution phase followed by flowstone accumulation and thus fossilisation and accumulation phase occurred in both pits. The last phase can be regarded as an indicator of the higher Holocene solution/flowstone accumulation phase, although the bedrock was at the time getting thinner thus open the pits on the surface by roof collapse (comp. Maucci 1975).

A. Mihevc from the Karst Research Institute ZRC SAZU in Postojna began to date with U/Th methods a piece of the flowstone sheet from the pit shown in the Fig. 5 in the Uranium Series Dating Laboratory of the University of Bergen (Norway). According to the written report sent to the author, the analyses failed, probably due to mixed material.

In the light of the cited climatic speleogenesis, the phase of pit solution and accumulation of loam can be placed in the cold Pleistocene period with deep solution/sedimentation front and aggressive penetrating water. The phase of loam erosion probably occurred in the course of transition from the Pleistocene glacial period to the warm interglacial period, whereas the phase of flowstone accumulation can be attributed to the warmer Holocene period with forest and thicker soil on the surface.

The traces of the older loam accumulation phase was found in many caves (Slabe 1995, Gospodarič 1988). Pits of this type are often below the steep slope (Gams 1955). The ancient loam filling remains in many fissures and notches in the cave ceiling and walls.

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LITOLOŠKI IN KLIMATSKI VPLIV NA GLOBINSKI RAZVOJ JAM

Povzetek

V članku je navedena vrsta objav in pojavov, ki dokazujejo, da poteka na Dolenjskem in nizkem Notranjskem krasu v sedanjosti prehod iz vrhnjega pasu s prevlado korozije v nižji pas odlagajanja sige v modelu t.im. čistega krasa v glavnem nekaj metrov pod tlemi. Globlji je pod ilovico v žepih, podtalnih jaških in votlinah, zapolnjenih z prepustnimi klastičnimi sedimenti. To ne velja za brezna, ki jih dolbejo ponornice in povsod tam, kjer skozi karbonatno kamnino penikajoča voda ne more priti v stik z okoliškim zrakom, in tam, kjer parcialni pritisk CO_2 ni nižji kot v zraku v prsti. V Sloveniji je 25 % vseh registriranih jam manj globokih od 14 m in krajših od 12 m, 50 % pa jih je manj globokih od 27 m. Torej je vrhnjih 20 m prepustnih karbonatov glavno območje recentnega nastajanja votlin, nižje pa prevladuje zapolnjevanje jam, povezanih z zunanjim zrakom. Take razmere so razkrite v globljih kamnolomih in cestnih usekih.

Razmere med votljenjem jam in njihovim zapolnjevanjem v alpskem krasu pod skalnato površino brez prsti in vegetacije so na skici prikazane za primera visokega alpskega in nižjega dinarskega krasa. V primeru Triglavskih podov je prikazan primer, ko agresivna voda ponira v n.v. 2400 m v Triglavsko brezno. V enem dnevu se je obarvana voda pojavila v 1220 m nižjem izviru Bistrice s povprečno trdoto 73 mg $CaCO_3$/l. Taka trdota je plod dinamičnega ravnovesja s tlakom 0,03 % v prosti atmosferi, torej brez obogatenja CO_2 v prsti. Taka voda ne odlaga sige in korodira tamkajšnji endokarst do 1200 m pod površjem.

Ker je z našega nižjega dinarskega krasa v hladnih obdobjih pleistocena obdobno izginila gozdna zarast in prevladala tundra ter je prst zapadla eroziji oz. spiranju v špranje, so korozijsko - sigotvorne razmere postale podobne sedajim v visokogorstvu. Zato je v tem času logično pričakovati tudi na dinarskem krasu nastajanje globljih brezen v pogojih t.im. čistega krasa (korozija ponornic v podzemlju ne zapade klimatskim vplivom), v sedanjem času pa njihovo zapolnjevanje s sigo spričo višje korozijske fronte.

To tezo je avor preverjal z analizo korozijsko - akumulacijskih razmer v stenah kamnolomov, kjer je število zapolnjenih votlin znanto večje kot odprtih. Ob odsotnosti absolutnih datacij sedimentov se je avtor oprl na skalne oblike, ki jih korozija izdela na stiku vlažne prsti oz. ilovice s karbonatno skalo. Te potrjujejo zastavljeno tezo. Oblike, nastale s korozijo tekoče, po previsu polzeče ali stoječe vode ali s kontaktno korozijo, ostanejo na skalnem obodu po odstranitvi klastičnih sedimentov. Po avtorjevih opažanjih potrjujejo starejšo fazo izvotljevanja votlin in recentnega zasigavanja. Odkriteljem jam je namenjen zato nasvet, da naj zabeležijo te oblike in ostanke klastičnih sedimentov v razpokah jamskih sten.

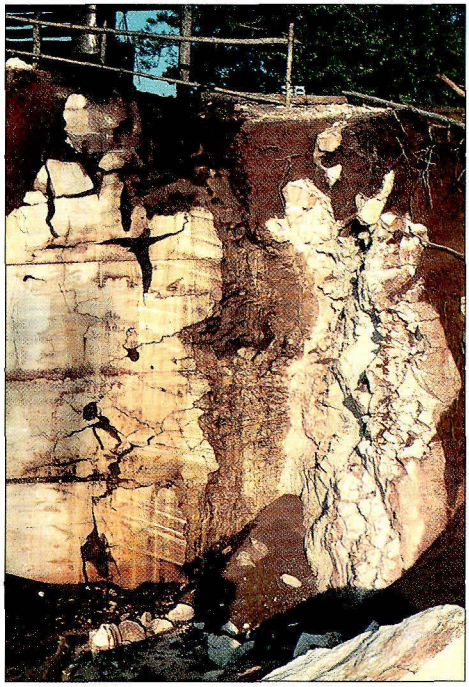


Fig. 4: The analysis of the disclosed pit in the quarry at Izola (1963) reveal that the filled pits are growing not only with the contact loam/rock solution of the central pit, but also with the solution of the intermediate rocky mass where lateral pits with aggressive waters begin to grow.

Sl. 4: Analiza razkritega brezna v kamnolomu pri Izoli (1963) razkrije, da se zapolnjeni jaški ne večajo samo s kontaktno korozijo na stiku ilovice in stene osrednjega jaška, ampak tudi s korozijo vmesne skalne gmote, kjer nastajajo bočni jaški z agresivno vodo.

Fig. 5 - Sl. 5

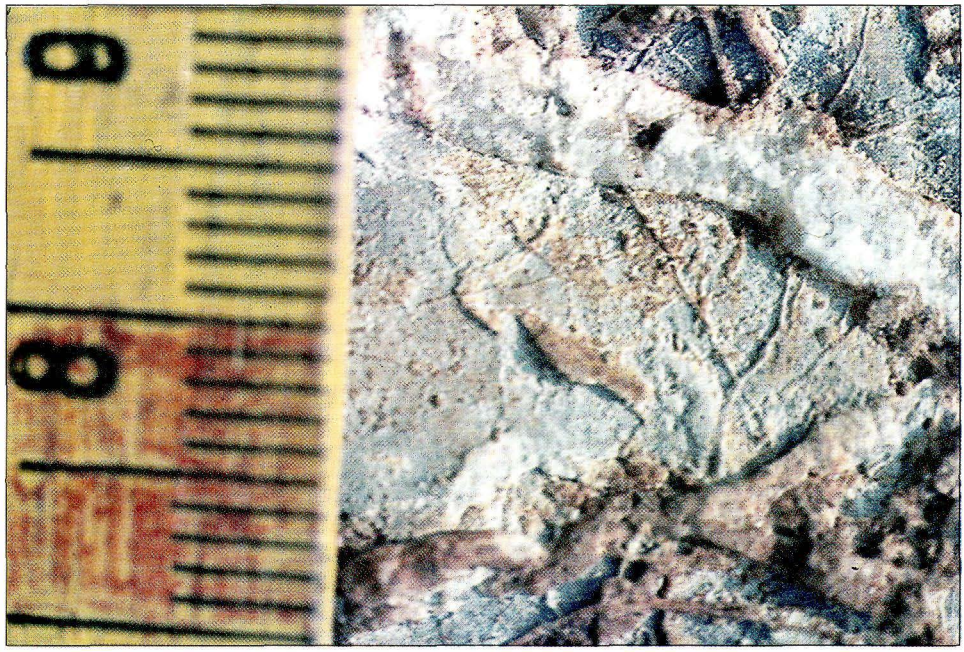


Fig. 5: The smooth wall face disclosed 30 m below the surface in the upper part of the pit in the quarry of Verd proves the action of contact loam/limestone solution. The calcitic veins protruding on the surface exclude the possibility of stagnant water solution or the contact loam/rock solution. The only possible explanation is the solution of water gliding on the overhanging position.

Sl. 5: Gladka stena zapolnjenega in zdaj razkritega brezna 30 m pod površjem dokazuje kontaktno korozijo ilovica/apnenec. Vložki iz kalcitnih kristalov, ki molijo iz stene, izključujejo možnost korozije stoječe vode ali kontaktne korozije ilovica/skala. Edina možna razlaga je korozija vode, drseče po previsu.



Fig. 6: The rough rocky face in the disclosed neighbouring pit proves stagnant water solution as the process of void enlargement. Then follows the phase of filling with loam, its erosion and its remains where the flowstone accumulation stuck them on the wall. The dripstone formation is the last development phase, attributed to the Holocene period.

Sl. 6: Robata skalna površja v sosednjem razkritem jašku dokazujejo korozijo stoječe vode kot proces razširjanja votline. Sledi faza zapolnitve votline z ilovico, njene erozije, kar pričajo ostanki, ki jih je na skalo prilepila siga. Tvorba stalagmitov je poslednja razvojna faza, pripisana holocenu.
All photographs taken by I. Gams.

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A STUDY OF SOLUTION PIPES PRESERVED IN THE MIOCENE LIMESTONES (STASZÓW, POLAND)

PREUČEVANJE ZAPOLNJENIH KOROZIJSKIH BREZEN (GEOLOŠKIH ORGEL) V MIOCENSKIH APNENCIH (STASZOW, POLJSKA)

IWONA MORAWIECKA & PETER WALSH[1]

Izvleček UDK 551.4(438)

Iwona Morawiecka & Peter Walsh: Preučevanje zapolnjenih korozijskih brezen (geoloških orgel) v miocenskih apnencih (Staszów, Poljska)

V sarmatskih karbonatih Jarosławske formacije (miocen) pri Staszówu so stotine korozijskih brezen (geoloških orgel), zapolnjenih s sanskim morenskim gradivom. Volumen brezen je 1 - 15 m^3, povprečna globina 1,9 in premer 0,6 m. V kamnini so vodilne tenzijske razpoke, toda niso vplivale na nastanek in razporeditev brezen. To naj bi bilo odvisno od stika kamnina - pokrov, v kemizmu pokrova in v naravi hidrološkega ali kriološkega režima. Staszówski paleokras predstavlja pokriti kras, nastal zaradi deglaciacije in "depermafrostizacije" konec sanske mrzle dobe.
Ključne besede: speleogeneza, korozijsko brezno, kvartar, Staszow, Poljska.

Abstract UDC 551.4(438)

Iwona Morawiecka & Peter Walsh: A Study of solution pipes preserved in the Miocene limestones (Staszów, Poland)

Hundreds of solution pipes are in quarries near Staszów. The pipes are in Sarmatian carbonates of the Jarosław Formation and are filled with sediment from Sanian till cover. The pipes have the volume of 1 to 15 m^3, the average depth is 1.9 m, the diameter 0.6 m. In the host rock are tensional master joints but the structure of the host rock had no influence in determining pipe locus and form. These has to be in the nature of the interface host - cover, in the chemistry of the cover, and in the nature of the hydrologic or cryologic regime. Staszów piping palaeokarst represents a covered karst system, developed as the product of deglaciation and "depermafrostisation" at the end of the Sanian cold period.
Key words: speleogenesis, corrosion pipe, Quaternary, Staszów, Poland.

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INTRODUCTION

A solution pipe may be defined as a cylindrical, vertical, suberosional landform produced by the removal of a soluble host beneath an insoluble cover. Most often, pipes are exposed only in profile, such as in quarry walls (Harasimiuk *et al.* 1975) or in natural cliffs (Coetzee 1975; Morawiecka 1993), where they are often difficult to access. Occasionally, they are visible in plan on erosional features such as intertidal beach platforms (Kaye 1959; Baughen, Walsh 1980; Morawiecka *et al.* 1996). If they are developed at all, it is uncommon to find them as isolated forms and their occurrence in large pipe populations is very characteristic. At Staszów, in SE Poland, the large pipe population contained in a Miocene limestone host is well exposed in low quarry walls and also on near-horizontal quarry floors. In these respects, the Staszów area must represent one of the most favourable situations in the world in which to study this little-understood karstic phenomenon.

FIELD SETTING AND GEOLOGY

The pipes of the Staszów system are exposed in about 15 small limestone quarries situated N and NE of the town (Fig. 1) near Podmaleniec, Kopanina, Dobra, Sztombergi, Karolinów and Smerdyna. Only some of the quarries are currently worked; about half are disused. The quarries are situated within the outcrop of Sarmatian limestones known as the Jarosław Formation (Jurkiewicz, Woliński 1981) which outcrop in an E-W band along the southern borders of the Holy Cross Moun-

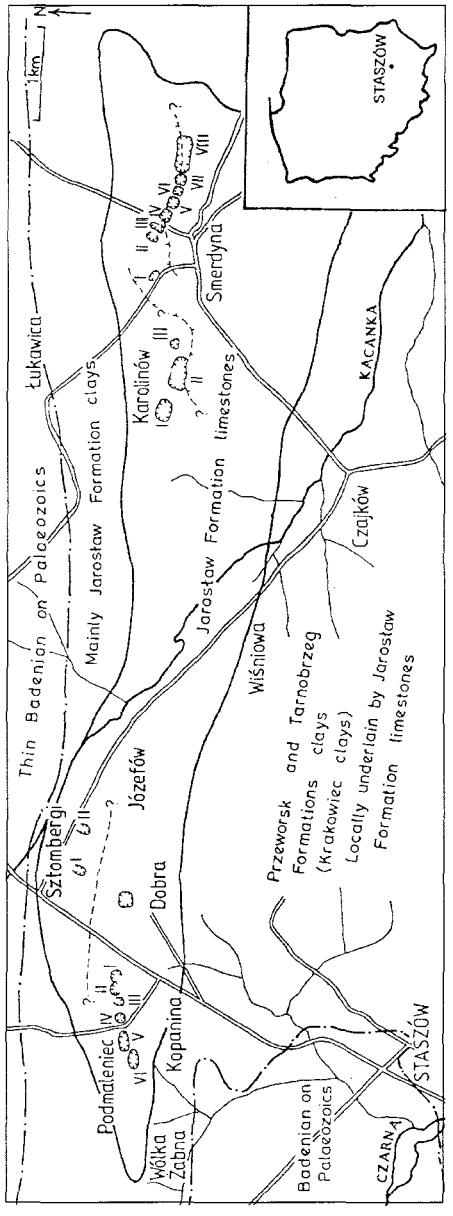


Fig. 1: Map of the study area to show the outcrop of the Jarosław Formation reef limestones (after Jurkiewicz and Woliński 1981) and the location of the quarries which display pipes.

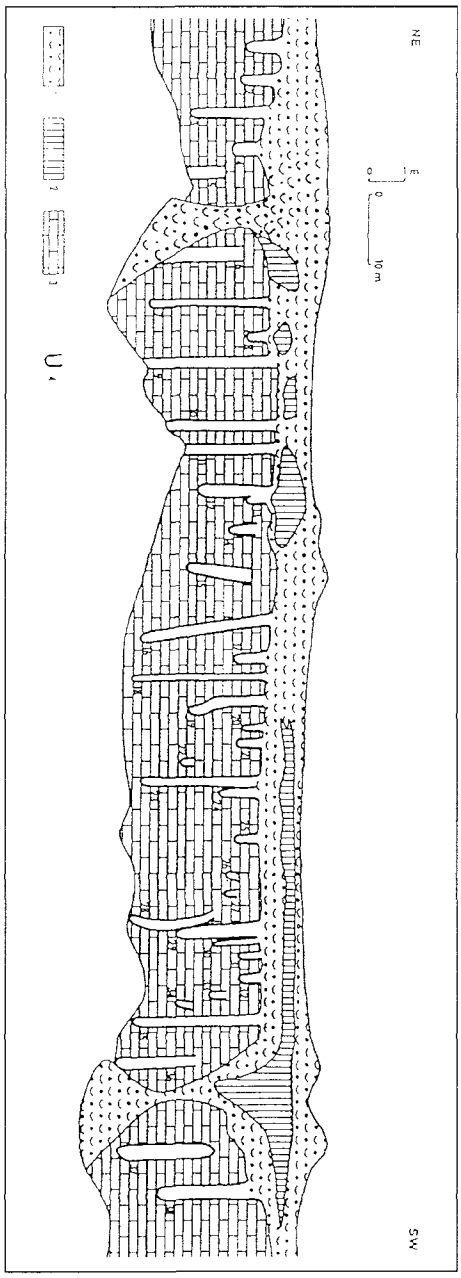


Fig. 2: Geomorphological sketch of the north-western wall of the Podmaleniec II Quarry.

tains of SE Poland. The general elevation of this piped, plateau-like area is c. 230-240 m a.s.l.

The thickness of the host limestone is up to 40 m. It is a cross-bedded, bioclastic forereef limestone, constructed mostly from *Lithothamnium* (Rutkowski 1969). The $CaCO_3$ content of the hostrock is 93% and the porosity is about 35% (Bugajska-Pajak 1974).

The Sarmatian limestone is riven by numerous sets of tensional master joints. Two sets are usually dominant, the one close to regional strike and the other, the dip. The open master joints are seldom wider than 2 cm or so. Many are iron-stained; however, very few of them show any evidence of solution widening by karstic fluids or infilling with insoluble residue from above.

The limestone is overlain by a till of the Sanian (Mindel) glaciation (Rózycki 1980). The till is up to 4 m thick locally and is formed by a sandy-clay diamict containing a suit of far-travelled erratics. No pipe so far surveyed was observed to have any surface expression, whether topographical, pedological or vegetational. In this respect, we presume that piping was an event which took place before the Holocene erosion cycle was instituted; the Staszów piping karst may thus reasonably be regarded as a covered (or subjacent) palaeokarst system.

THE NATURE OF THE PIPES

About 300 pipes have been mapped so far in the quarries studied. Most are exposed only in the quarry walls, where they occur as vertical or near-vertical funnel-shaped hollows (Fig. 2).

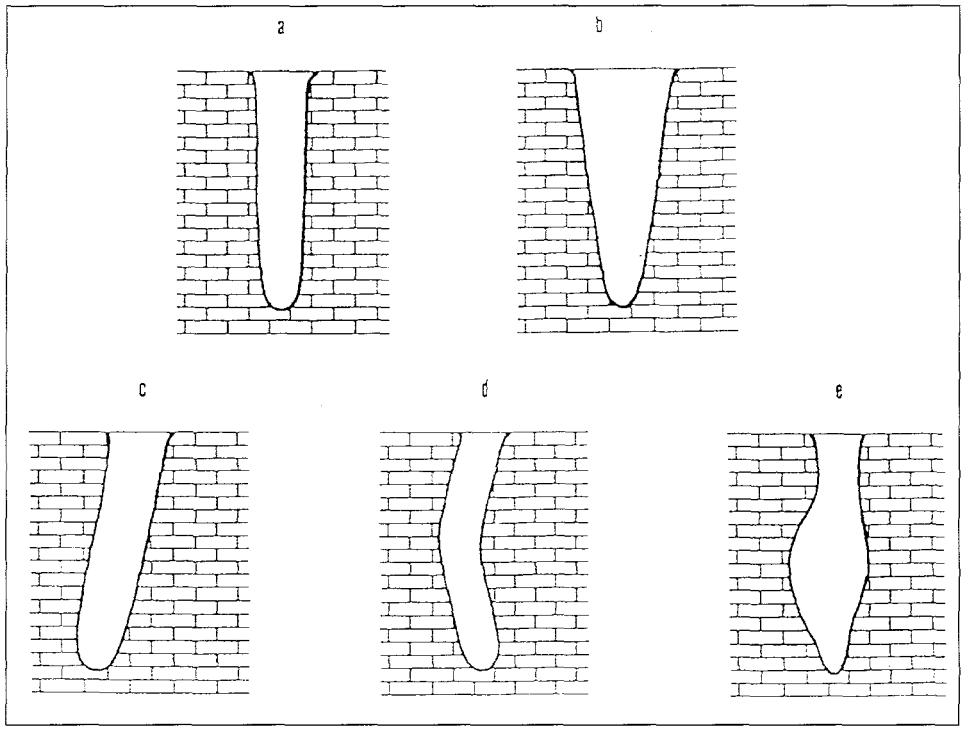


Fig. 3: Types of the Staszów pipes according to their shape. 1 - vertical-cylindrical, 2 - inverted conical, 3 - inclined, 4 - doubly inclined, 5 - bulbous.

The largest pipe so far observed is about 8.2 m deep and has a diameter of about 1.5 m (Photo 1). On average, however, pipes are about 1.5 m deep and 0.5 m in diameter.

The walls of the pipes are generally smooth and laminations of the hostrock are not usually visible. Sometimes, a well-developed crust about 2 cm thick is present on the pipe walls.

In terms of their shape, 5 types of pipe have been distinguished: vertical-cylindrical, inclined, doubly inclined, inverted conical and bulbous (Fig 3); however, the three first predominate.

Additionally, about 170 pipes have been mapped in cross-section. These were exposed in a scraped surface of about 700 m^2 in one of the quarries studied, Smerdyna I (Fig. 4). The pipes here were revealed to be both circular and ovate in plan and appeared to be quite randomly distributed. Preliminary analysis to try to determine whether there is any positive relationship between the alignments of nearby vertical joints and the long-axes of ovate pipes (Fig. 4) indicated that this is not possible, because the master joint systems

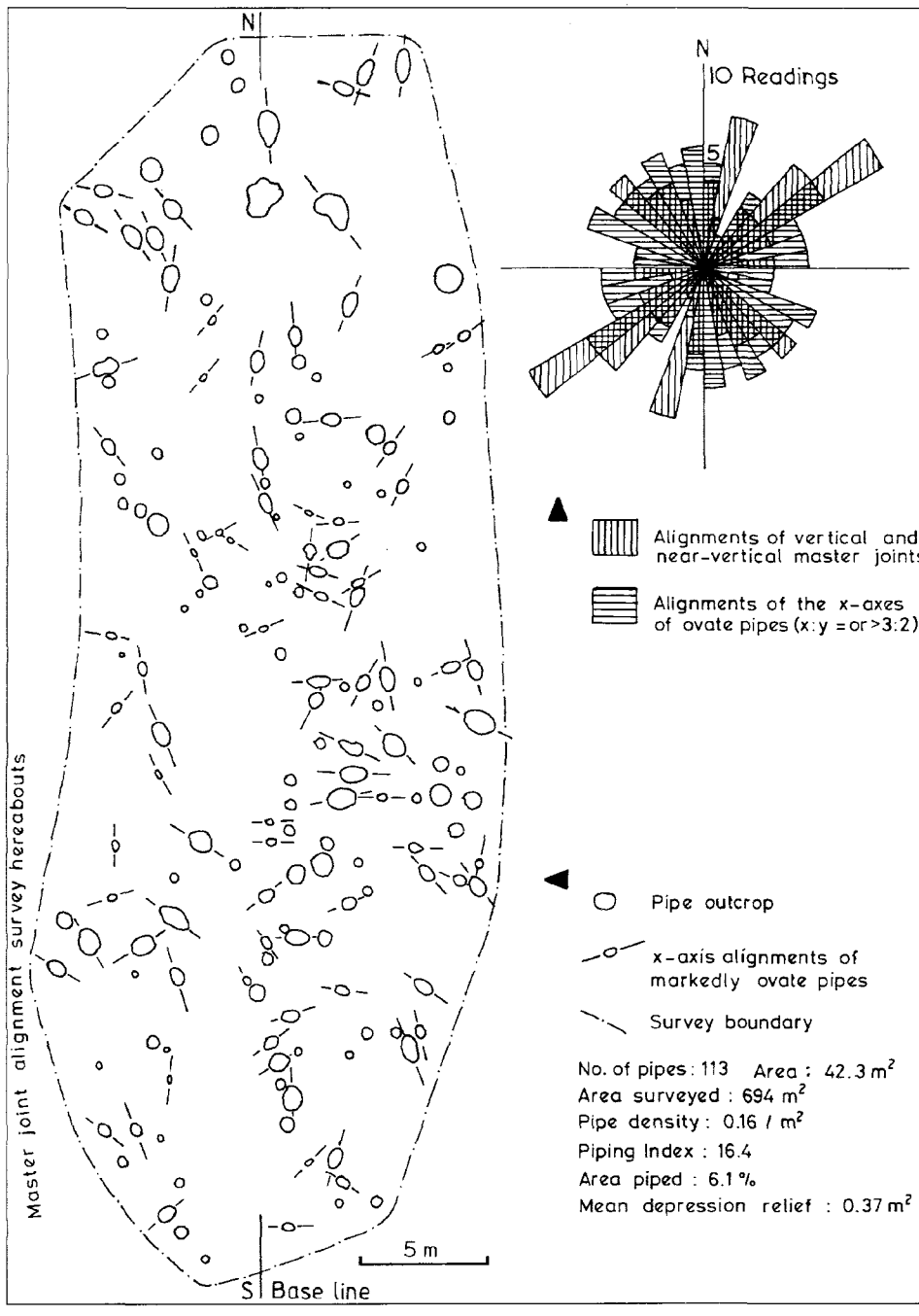


Fig. 4: Survey of a selected area of Smerdyna I Quarry.

(as revealed on Fig. 4) are themselves fairly evenly distributed at this particular locality.

The field evidence is unequivocal that pipes are not usually associated with master joints. Certainly, less than 10% of the pipe population showed any coincidence with joints, when seen in profile. In many instances, it was noted that a pipe had developed in "solid" limestone only a few centimetres away from an open master joint (Photo 2). It is, therefore, very difficult to avoid the conclusion that the locus of master joints at the interface with the till cover was not one of the major controls which determined the locus of pipe development.

Only some of the pipes at Staszów now contain fills. It is presumed, however, that all the pipes once contained a fill, and, in most cases, the fill has been removed as a result of quarrying. In all pipes where the fill has been preserved, two components are easily recognized (Photo 3): a cortex, forming the lining, which consists of brown silty clay, and a central core which consists of sandy-clayey-stony material, megascopically identical to the till overlying the limestone. In case of the larger pipes, the brown clay is up to 30 cm thick and it is presumed to be a mixture of both a solutional residue and illuviated fine-grained till sediment. Diffractometric analysis showed that it comprises 87% quartz, 9.5% illite and 3.5% montmorillonite. The core matrix comprises 90% quartz, 7% illite and 3% montmorillonite (Morawiecka 1994).

Piping is certainly not evenly developed across the outcrop of the limestone hostrock. In the study area, some of the quarries display hundreds of pipes; in others there is no trace of piping whatever. Where piping is present, it seems to be fairly evenly developed. Morawiecka (1994) demonstrated that, in one section, Podmaleniec II, which exposes 37 pipes (Fig. 2), the linear density of piping is about 1 pipe/2.5m.

Field mapping reveals a marked relationship between the piping and the cover sediment: (1) piping is very closely coterminous with the existing till cover; (2) piping is only very rarely found without a cover of till being present; (3) whenever a till cover is present, some degree of piping is usually evident.

THE ORIGIN OF THE STASZÓW PIPES

There is no evidence that piping ever took place in the Staszów area more than once, i.e. during or after the Sanian tills were deposited. There is no trace whatever of pre-Sanian solution subsidence (though, of course, it is possible that this was once present and evidence for it has been entirely removed by the Sanian ice); nor is there any evidence to hand to indicate that the same source sediment (the Sanian till) was involved in two or more phases of piping (it is acknowledged that it might be difficult to establish criteria on which to recognize separate phases of piping). But the exact relationship between piping and the Sanian till is by no means obvious; in our present

state of knowledge, two hypotheses must be considered: firstly, that the piping was a Neopleistocene event and developed only at a time when the Sanian till cover was worn back more or less to its present limits. Alternatively, the piping is a process contemporaneous or penecontemporaneous with deglaciation and that the present-day limits of the Sanian till sheets are, therefore, little different from those resulting from deglaciation of the area.

With respect to the first alternative, there is no positive evidence to support this view, which is based solely on an intuition that, after 500 ka, it would be extremely unlikely for the Sanian tills to have exactly the same distribution as that in which they were originally formed. Certainly, if the piping at Staszów was exclusively a Neopleistocene event, this then begs the question why hundreds of cubic meters of rather cold meltwater per square metre of host limestone surface failed to produce some piping effect here at the end of the Sanian cold period. For the present, we have not rejected either of these working hypotheses.

That the pipe-forming fluids have "ignored" the multiplicity of open master joints during pipe formation is a feature of the Staszów palaeokarst which, at present, is not easy to explain. The most obvious explanation for this is that the master joints (or at least their openness) were formed after the pipe-forming processes had ended. However, given the antiquity of the host and the youthfulness of the till cover, such a notion seems very unlikely.

Another explanation we are at present considering is that, at the time when the piping was initiated, the joints existed in much their present form, but were then filled with something which precluded their utilisation by groundwater fluids; in which respect, sealing of the joints by ground ice seems to be the only realistic possibility. Because the rock cover in this karst system is clearly a cold-climate sediment, this notion seems to be quite reasonable. Moreover, it is well known that water which has a temperature only a little above freezing point is a much more effective solvent of carbonates than one of temperate nature (Pulina 1974). Indeed, it is hard to see how any attempt to explain the development of the Staszów piping karst can avoid considering the possible effects of climatic amelioration at the end of Sanian period, which certainly produced a deglaciation, and, probably, a concomitant "depermafrostisation", as a likely major influence.

Therefore the following working hypothesis concerning the origin of the Staszów piping system and the sequence of subsequent events in this area has been formulated:

During the Pliocene, the area of Staszów was uplifted above sea level. Denudational processes of various kinds affected the area but no pipes developed in the Sarmatian limestones for no insoluble cover was yet present (Fig. 5A). Towards the end of the Sanian cold period, the area studied was overwhelmed by a continental glacier. It is envisaged that, at the time it was overridden by the ice, the permafrost zone extended down to below the

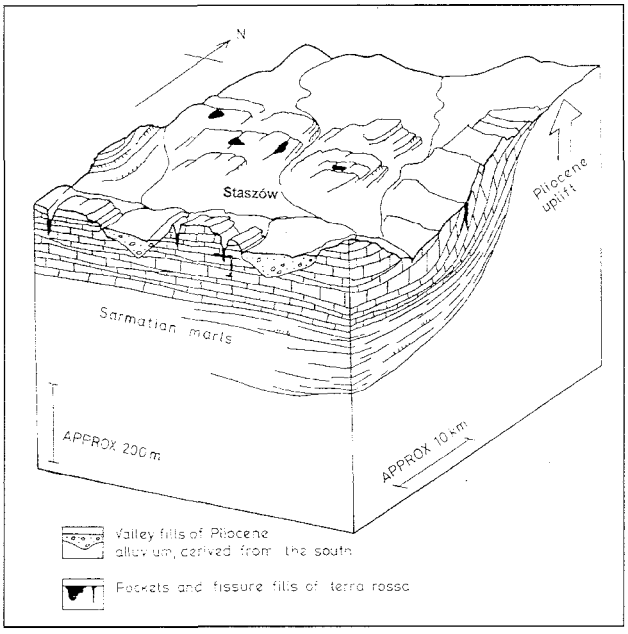


Fig. 5A: The Staszów area in the Pliocene.

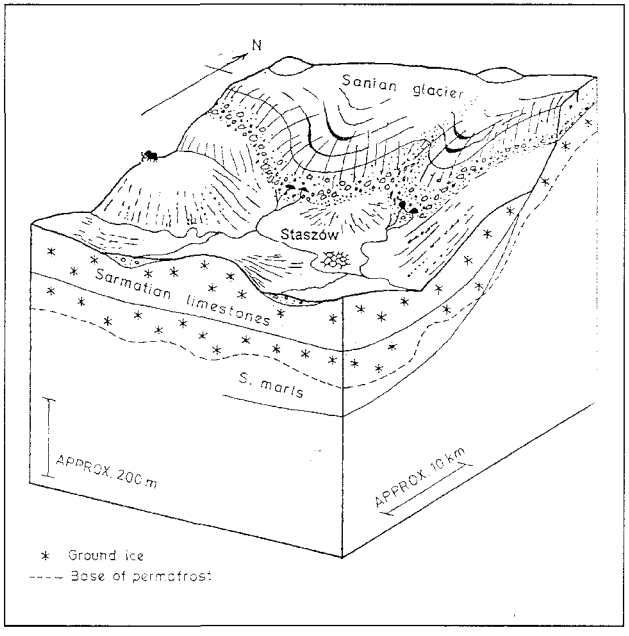


Fig. 5B: The Staszów area near the end of the Sanian cold period.

Sarmatian limestone (Fig. 5B). As a consequence, any open joints present in the host limestone were sealed up by ground ice, both before and during the glaciation. At the end of the Sanian cold period, possibly about 5 ka later, the decay of the ice sheet began, consequent upon the climatic amelioration. Within the decaying glacier body and associated tills, zones of local vertical percolation developed, possibly associated with zones of relatively coarse and relatively permeable moraine material (Fig. 5C). In our provisional model, at the beginning of the post-Sanian warm period the glacier decay left behind rafts of dead ice, themselves underlain by local blocks of discontinuous permafrost. We envisage that piping was controlled initially by combinations of relatively permeable till above, with avenues of first-to-decay permafrost below, and that, once started, the piping process was extremely rapid, piping outlets in the subglacial drainage system capturing the percolation selectively (Fig. 5D). We

speculate that piping may have been enhanced by the presence of any depressions in the limestone surface, such as kamenitzas, which may have survived the initial glacial advance over the area (these would presumably have been destroyed by the piping process); we also speculate that piping may have been enhanced by the former presence in the local moraines of organic material such as frozen peat, which, during deglaciation, for a time released aggressive acid radicals into descending meltwater. In our provisional model of pipe development, piping would have ceased (or at least very much diminished) when either the flush of meltwater had ceased or when the acid radicals in the till had all been leached out. It must be stressed, however, that there is not, so far, any positive evidence for the former existence of either organic material in the till cover, significant depressions in the surface of the limesone host, or selectively permeable zones in the till sediment. On the other hand, our

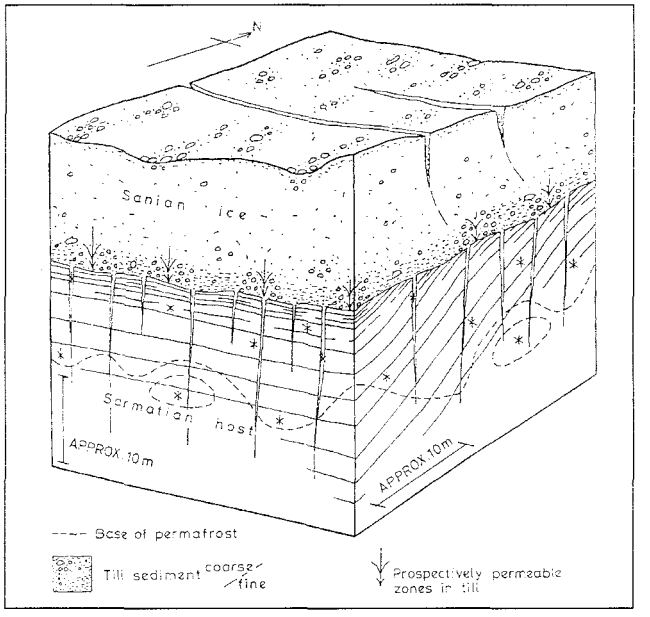


Fig. 5C: The Staszów area when covered by the Sanian ice sheet.

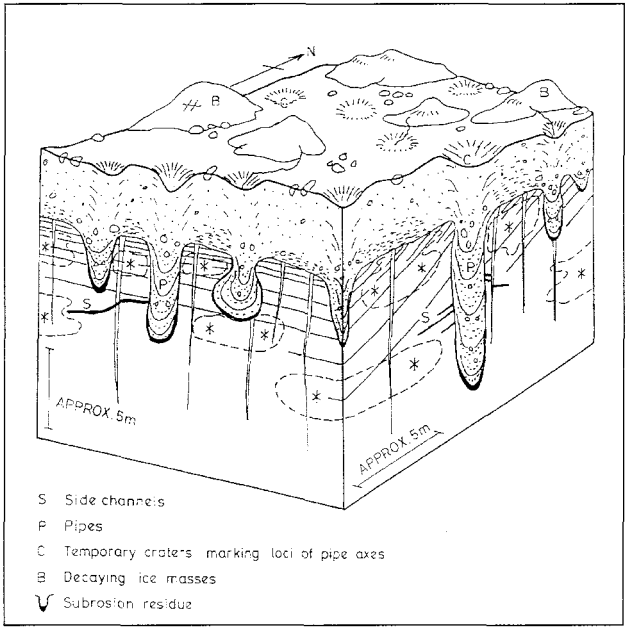


Fig. 5D: The Staszów area at the beginning of the post-Sanian warm period.

"depermafrostisation" model does, at least, have the advantage of explaining why some pipes are non-vertical or doubly-inclined - these features are neatly explained by the presence of permafrost blockages to vertical percolation, any development out of the vertical denoting the former presence of a lens of ground ice which acted as an umbrella to the percolation which created the pipes (Fig. 5D).

PROVISIONAL CONCLUSIONS

At present, we consider that the piping karst at Staszów has been produced by quasi-catastrophic geomorphic agencies, clearly related to deglaciation and probably also to "depermafrostisation" at the end of the Sanian cold period. In our view, the whole of the piping karst development probably took place in not more than a few hundred, and certainly not more than a thousand years. The field and laboratory programmes in this study are to continue. Work in the immediate future will concentrate on gathering data about the nature of the interface between the till cover and limestone host, the brown clay lining of the pipes and about pebble fabrics in the till cover and pipe cores.

ACKNOWLEDGEMENTS

The University of Silesia internal research grant nr BW13/93 is acknowledged for providing financial support for the field work in the Staszów area.

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PREUČEVANJE ZAPOLNJENIH KOROZIJSKIH BREZEN (GEOLOŠKIH ORGEL) V MIOCENSKIH APNENCIH PRI STASZÓWU NA POLJSKEM: PREDHODNI IZSLEDKI

Povzetek

V sarmatskih karbonatnih kamninah Jarosławske formacije (zgornji miocen) pri Staszowu na osrednjem Poljskem so v kamnolomu prerezane stotine korozijskih brezen (geoloških orgel), zapolnjenih s sanskim (srednjepleistocenskim) morenskim gradivom. Volumen brezen znaša povprečno 1 m^3, vendar dosežejo največja 15 m^3. Povprečno globino teh brezen je 1,9 m, povprečni premer pa 0,6 m. V matični kamnini so gosto razporejene vodilne tenzijske razpoke, toda terenske raziskave jasno kažejo, da je igrala struktura matične kamnine zelo majhno ali sploh nobene vloge pri nastanku in razporeditev teh brezen. To naj bi bilo odvisno od stika matične kamnine in morenskega pokrova, v kemizmu pokrova in oziroma ali v naravi hidrološkega ali kriološkega režima, ki je vladal takrat, ko so ta brezna nastajala. Staszówska paleokraška brezna predstavljajo pokriti kras. Ta naj bi predvidoma nastal "nenadoma" zaradi taljenja ledu oziroma izginotja permafrosta konec sanske mrzle dobe.

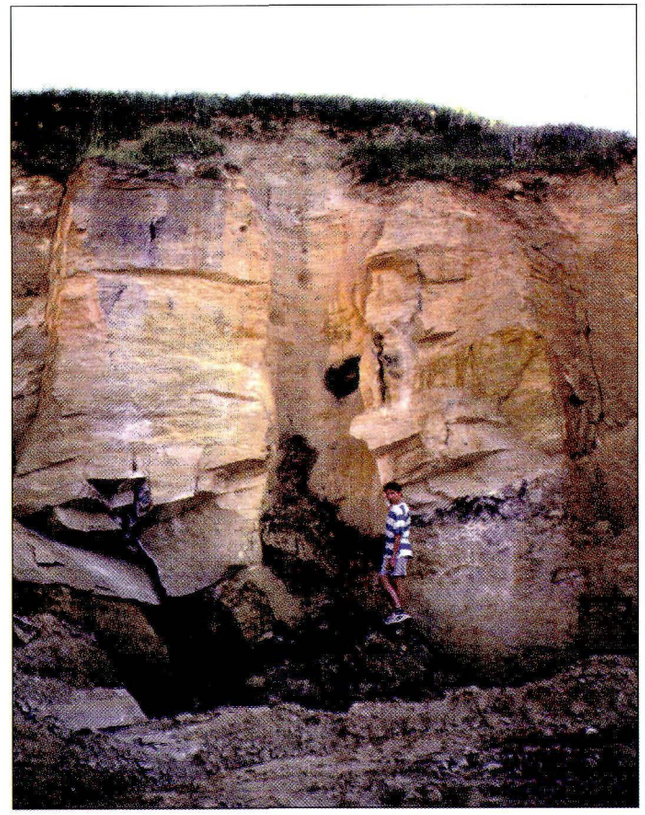


Photo 1: One of the largest pipes recorded in the quarries studied. Podmaleniec V Quarry.

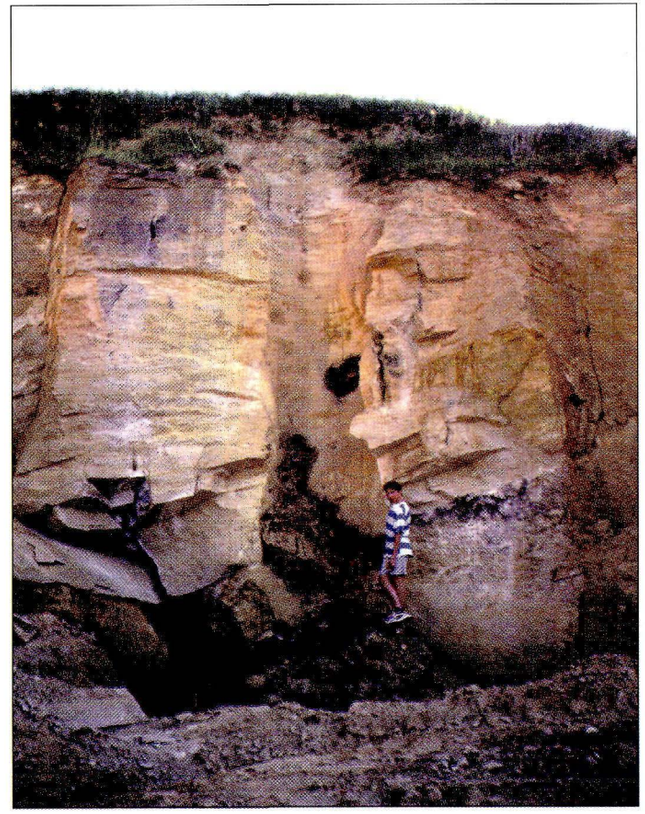


Photo 1: One of the largest pipes recorded in the quarries studied. Podmaleniec V Quarry.

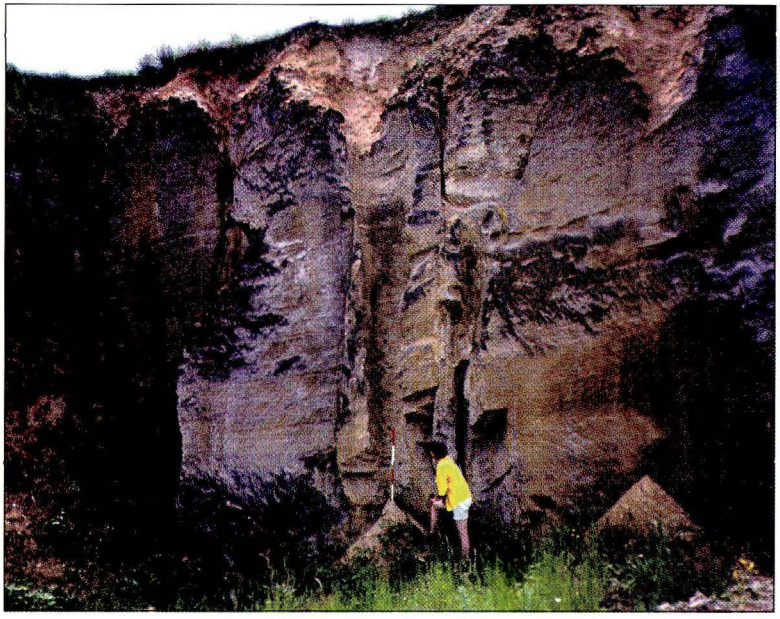


Photo 2: An example of a pipe developed about 0.5 m to the left of a master joint. Podmaleniec IV Quarry.



Photo 3: An example of a pipe with the fill still preserved. Smerdyna I Quarry.

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A CLASSIFICATION OF THE SUBTERRANEAN ENVIRONMENT AND CAVE FAUNA

KLASIFIKACIJA PODZEMELJSKEGA ŽIVLJENSKEGA OKOLJA IN JAMSKE FAVNE

SLAVKO POLAK [1]

Izvleček UDK 591.542

Slavko Polak: Klasifikacija podzemeljskega življenskega okolja in jamske favne

Veliko je bilo poskusov klasifikacije in sistemizacije jamskega okolja ter jamskih živali. Klima v podzemeljskem okolju je specifična na kar so jamske živali tudi podobno prilagojene. Danes je najbolj sprejeta delitev podzemeljskega okolja na akvatično in terestrično. Obe se dalje delita na različne tipe. Najpogostejša delitev jamskih živali je na lažne jamske prebivalce, ki so v jamah le občasni obiskovalci ter na prave jamske živali. Slednje delimo na troglobionte, troglofile in trogloksene.

Ključne besede: speleobiologija, podzemeljsko okolje, prilagoditve, jamske živali, klasifikacija.

Abstract UDC 591.542

Slavko Polak: A classification of the subterranean environment and cave fauna

There have been many attempts to classify and systemize cave environment and cave animals. The climate is specific to the subterranean environment and the cave animals are adapted to it in a similar way. The most accepted division of the underground environment is now into aquatic and terrestrial. Both of these are further divided into different types. The most used classification of underground animals is into false cave-dwellers, which are occasional visitors to the caves, and on the true cave-dwellers. The latter we usualy divide into: troglobiontes, troglophiles and trogloxenes.

Key words: speleobiology, subterranean environment, adaptations, cave animals, classification.

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INTRODUCTION

The first more or less objective statement about the occurrence of cave animal came from Janez Vajkard Valvazor, who commented on the existence of a sort of dragon inhabiting subterranean lakes near Ljubljana in Slovenia. In 1768, Joseph Nicolaus Laurenti formally described the animal under name *Proteus anguinus* and noted, that the animal has nothing to do with dragons, and that it is indeed an amphibian.

Discovery of thes first cave vertebrate, which is the largest cave animal in Europe, was followed by the discovery of the first cave insect, *Leptodirus hochenwarti* - a bizarre beetle, blind and unpigmented, by Luka Čeč in the Postojna cave during one of his explorations. During the nineteenth century numerous other discoveries were made in Slovenian caves, the Balkan Peninsula, the Pyrenees and also in North America. Outside these main regions, some new discoveries were recorded from Japan, New Zealand and Mexico. However, in the last fifteen years, there has been an extraordinary increase in information about cave faunas in the tropics and in non-limestone subterranean habitats (Belles 1992).

The subterranean environment is not simpler than any surface environment. It is composed of a mosaic of microhabitats, each one with its own peculiarities. Moreover, subterranean environment isolation is relative. What is generally called "cave" is just a small part of the whole subterranean environment, and it is connected to the surface through fissures, cracks, microfissures, galleries, shafts, etc.

The subterranean environment being directly related to the exterior as we have seen, by means of fissures, cervices and ducts, so it is under direct influence of the regional microclimate. There are a few principles with govern the meteorology of caverns. These are low and constant temperature, permanent darkness and high humidity.

The only stable factor in this environment is the total darkness and, therefore, the absence of a photo period, a determining factor for adaptation of animals to this habitat. The only primary production comes from autotroph organisms such as Tiobacteria and Ferrobacteria, that live in clay. The main part of the food comes from the surface. Another part comes from the subterranean environment itself, from excrements of transient or permanent fauna. The animals that die in these places are also the part of the food resources.

The responses given by the subterranean animals are very different, although the environmental conditions are uniform in each specific habitat. A certain trend of features can be found, like depigmentation, loss of eyes, metabolic economy, increase in tactile sensitiveness, predominance of K strategy and others (Camacho et all. 1992).

SUBTERRANEAN ENVIRONMENT

Man has always attempted to "organise" the objects which surround him in the world, including the fauna. Racovitza (considered the Father of Biospeleology) was the first to make a coherent classification of the subterranean environment and of cave animals. He was the first to realise the true extension of its environment. He defined 6 divisions of the subterranean environment:

- **The caves** (accessible to humans), the only environment which had previously been considered.
- **The fissures and cracks** (not accessible to humans)
- **The interstitial spaces** such as sands and gravel, where the water saturates the soil and fills only the capillary interstices separating the soil fragments.
- **Hypogeus environment**. Mentions the existence of animals which live in the soil, both in the humus and in the clay, and which present the same characters as cave species and which seem to live in the soil and the caves indiscriminantly.
- **Microcaverns**, refers to the dark cavities built or excavated in soil and wood by animals (insects, reptiles, birds and mammals) and which some others animals choose as normal habitat.
- **Artificial caves**, includes all the cavities, mine galleries, catacombs, tombs, tunnels, etc., created by man.

Since this early classification many authors tried others, eliminating, adding or redefining some terms. An accepted division of underground environment is into aquatic and terrestrial subterranean environment (Camacho 1992).

The **terrestrial subterranean environment** is formed by caves, with all their habitats and microhabitats and underground superficial spaces (Fig. 1). The invertebrates (no terrestrial vertebrates are found in the caves, with the exception of bats, some birds and small rodents) which are found inside the cavities can move freely not only in caves accessible to man, and therefore where they can be directly observed, but also in the microcaverns burrows, holes etc. made by animals, under stones and adjacent microspaces and crevices, (not accessible to man). Subterranean fauna can also be found On the artificial tunnels and mines. In deposits of bat guano, the guanobionts form communities which are not real cave animals. They are the same species that can be found in the guano in other epigean environments. Superficial underground compartment was discovered by Juberthie et all. (1994) when they were looking for the frontier between the subterranean and ground fauna in a noncalcareus area. It is formed of cracks and fissures in rock in collapsed slopes. The species of this environment are connected with deep fissures and its fauna can be studied in artificial tunnels and caves.

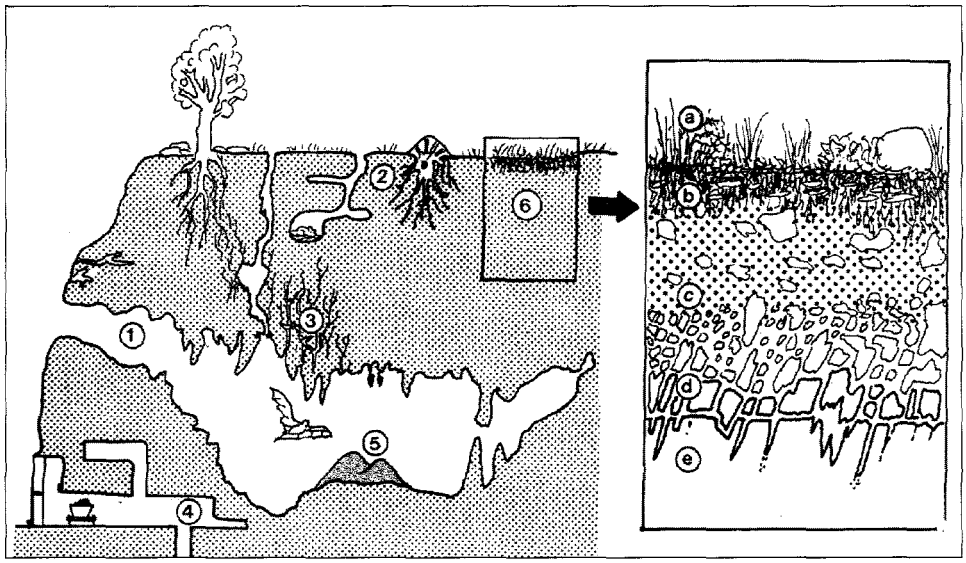


Fig. 1: The terrestrial subterranean environment. 1- caves (accessible to man), 2- microcaverns, 3- microspaces and crevices, 4- artificial tunnels, mines, 5- guano, 6- superficial underground compartment (a-moss, b- humus, c- soil, d- superficial underground compartment, e- deep underground compartment, rock with cracks)

Sl. 1: Terestrično podzemeljsko okolje. 1- jame (človeku dostopne), 2- rovi malih živali, 3- razpoke, 4- umetni tuneli, rudniki, 5- gvano, 6- površinski podzemeljski kompartment (a- mah, b- humus, c- prst, d- površinski podzemeljkski kompartment, e- globok podzemeljski kompartment, razpoke v matični kamnini)

The **subterranean aquatic environment** is initially more diversified than the terrestrial one. It is sometimes difficult to delimit the terrestrial and aquatic environment, since in environments saturated with humidity typically aquatic species can be seen mowing along subterranean biotopes.

Biologists, following the recommendations of Rough, should distinguish two fundamental types recognised by hydrogeologists (Camacho 1992).

Areas on permeable - karstic terrain is divided into an upper zone with capillary waters and lower zone subdivided into a part containing permanent waters and an part flooded only in high waters (Fig 2.). The springs of rivers also have specific aquatic fauna. The Interstitial environment was discovered by microscopic analysis of water of wells in order to check their suctability for drinking. All the studies show the great faunal richness of these environment also in the non-karstic areas.

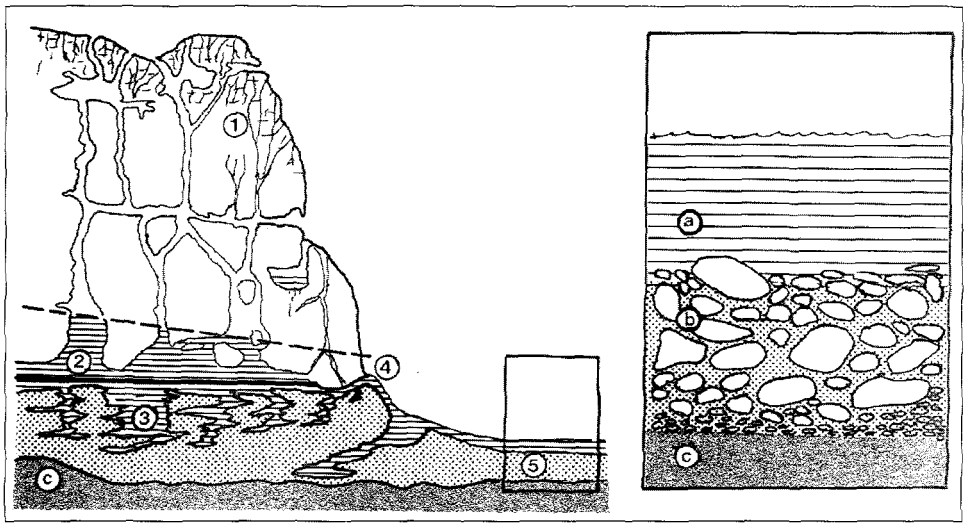


Fig. 2: The subterranean aquatic environment. 1- upper zone with capillary waters, 2- amphibian zone, 3- permanent flooded zone, 4- springs, 5- Interstitial environment (a- stream, b- Interstitial environment, c- impermeable rock)

Sl. 2: Vodno podzemeljsko okolje. 1- zgornja cona z kapilarnimi vodami, 2- občasno poplavljana cona, 3- stalno poplavljena cona, 4- izviri, 5- intersticielno okolje (a-vodni tok, b- intesticielno okolje, c- nepropustna kamnina)

CAVE FAUNA

Since subterranean animals werefirst discovered there has been an attempt to classify not only the environments, but also the fauna which inhabit them. Multiple criteria have been used such as topographical, ecological, etological, etc., some with more success than others.

It is very difficult to list animals as cave species with certainty. For many of reputed cave taxae their presence in surface habitats (particularly in soil) is very likely although not yet proved. The most used classification of subterranean animals (considered by Schiner 1854, Racovitza 1904, and Leruth 1939, after Camacho 1992), is based on etological classification, although it is really more ecological. There are proposed two large groups.

1. **False cave-dwellers:** Their presence in caves is not due to the search for determined meteorological conditions but they are occasional visitors. They are those who live by exploiting others in two different forms: in a direct form, the parasites; and in an indirect way, the guanobionts.

2. **The true cave-dwellers:** They were oldest colonists, who sought out he subterranean environment for its meteorological conditions (especially for its abundant humidity in the case of terrestrial species).
   It includes:
- **Troglobiontes:** only found in the caves and which are relicts totally pecialised to this lifestyle, They do not have near relatives among the pigean fauna, or else they belong to a group whose representatives are confined to the caves or where the related epigean forms are extinct or exist only in very distant regions.
- **Troglophiles**, which live in caves for meteorological reasons but can be found outside too, always in very humid environments (moss, dead leaves, humus, etc.). For some species the epigeic and hipogeic ecophasis is considered. Troglophiles can breed in the caves.
- **Trogloxenes,** which voluntarily penetrate into the underground environment for its trophism and attracted by the humidity They are incapable of breeding in this environment, do not present special adaptive features and live mainly at the cave entrances.

In Slovene caves we can find troglobiont representatives of diverse animal groups such as gastropods, worms, crustaceans, arachnids, myriapods and insects, especially beetles. Great number of troglophile (Fig. 4) and trogloxene animal species are also occur in caves.

Even some species of vertebrates, like fishes, birds, rodents, carnivores and bats occasionally penetrate caves, crevices and shafts, but they are, with the exception of *Proteus anguinus* (Fig. 3) not adapted to a troglobiotic lifestyle.

Taxonomical and faunial studies will continue to be presented in biospeleological literature. The character of relict species of many troglobites gives to them an exceptional value as paleogeographical indicators, and this will be revitalised, especially now when it seems that it is time to revive systematic and biodiversity studies. Cave animals, some of them at the extreme of K-strategies, can serve as suitable models to test theories on physiological ecology.

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KLASIFIKACIJA PODZEMELJSKEGA ŽIVLJENSKEGA OKOLJA IN JAMSKIH ŽIVALI

Povzetek

Odkritju človeške ribice Proteus anguinus, največje med evropskimi jamskimi živalimi, so v devetnajstem stoletju sledila odkritja in opisi številnih novih jamskih nevretenčarskih taksonov. Večina teh so endemiti, kar pomeni, da so zelo lokalno razširjeni.

Podzemeljsko okolje je z zunanjim povezano prek špranj in razpok ter tako pod neposrednim vplivom regionalne mikroklime. Nekaj glavnih parametrov karakterizira klimo v jamah. To so nizka in stalna temperatura, popolna tema, velika vlažnost in običajno pomanjkanje hranljivih snovi oziroma plena. Prilagoditve jamskih živali na te pogoje so razmeroma različne navzlic dokaj homogenim življenskim pogojem podzemeljskega okolja. Med pogostejšimi prilagoditvami so odsotnost pigmenta, izguba vida oziroma oči, racionalnost metabolizma, povečana taktilna čutnost in prevladovanje K razmnoževalne strategije.

Jamske živali je pogosto težko z gotovostjo opredeliti za prave jamske. Za številne prepoznane jamske vrste se predpostavlja da žive tudi v površinskih habitatih.

Najbolj je sprejeta delitev jamskega življenskega okolja na akvatično in terestrično jamsko okolje. Vsaka od teh ima številne različne tipe. Najpogosteje uporabljana delitev jamskih živali je na lažne jamske živali, ki so v jamah le občasni gosti ter prave jamske živali. Zadnjo skupino običajno delimo dalje na troglobionte, ki so popolnoma prilagojeni na življenje v podzemlju ter troglofile, ki se zatekajo v jame iz meteoroloških zahtev in v podzemeljskem okolju obligatno prežive del življenja. Tretja skupina so troglokseni, ki zahajajo v jame zaradi prehranjevalnih zahtev vendar se tu niso sposobne razmnoževati.

Med temi skupinami najdemo v Sloveniji številne predstavnike polžev, rakov, pajkovcev, stonog in žuželk, med katerimi prevladujejo hrošči ter drugi.

Celo nekateri vretenčarji kot ribe, ptice, glodalci in zveri se občasno zatekajo v jame in podzemlje, vendar z izjemo človeške ribice niso prilagojeni na podzemeljski način življenja.



Fig. 3: Proteus anguinus LAURENTI, 1768 the biggest and the best known European troglobiontic animal (Photo S. Polak).

Sl. 3: Človeška ribica Proteus anguinus LAURENTI, 1768 je največja in najbolj poznana europska troglobiontska žival (Foto S. Polak).



Fig. 4: Cave cricket Troglophilus cavicola KOLLAR, 1833 is a common troglophile cave-dweller (Photo S. Polak).

Sl. 4: Jamska kobilica Troglophilus cavicola KOLLAR, 1833 je pogosta troglofilen obiskovalec jam (Foto S. Polak).

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THE CAVES IN THE MOTORWAY DANE - FERNETIČI

JAME V TRASI AVTOCESTE DANE - FERNETIČI

TADEJ SLABE [1]

Izvleček UDK 551.44:656.1(497.4)
Tadej Slabe: Jame v trasi avtoceste Dane - Fernetiči

Pri gradnji avtocest na Krasu so bile odkrite številne stare jame in brezna. Stare jame, ki so votle ali pa zapolnjene z drobnozrnato naplavino ali gruščem, nam veliko povedo o zgodnjem razvoju tega dela vodonosnika. Kras je zelo prevotljen. Pri gradnji in uporabi avtoceste je treba zato preprečevati onesnaženje podtalnice, velika pa je tudi nevarnost vdiranja tal zaradi pogosto tankih stropov nad jamami.
Ključne besede: gradnja avtocest, Kras, Slovenija.

Abstract UDC 551.44:656.1(497.4)
Tadej Slabe: The caves in the motorway Dane - Fernetiči

During the construction of motorway over the (Classical) Karst several old caves and shafts were discovered. Old caves, that are either void or filled up by fine-grained sediments or rubble provide useful indication of early stages of of this part of the aquifer development. Kras is very cavernous. During the construction and use of the motorway, pollution of the groundwater must be prevented; an important danger presents subsidence-prone land due to thin ceilings above the caves.
Key words: motorway construction, Kras, Slovenia.

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INTRODUCTION

In Slovenia the motorways are planned to be located in Kras (the classical Karst). Karstologists take part in road planning, trying to avoid superficial karst phenomena such as larger dolines, collapse dolines and karst walls or other distinctive morphological features and caves. Due to the extremely cavernous aquifer with interconnected underground water courses and the importance of karst water resources, the new motorways are supposed to be impervious. Only treated waters should reach the karst surface. The karstologists also take part in road construction when numerous and diverse karst caves are being discovered. A part of the results I already presented at the Karstological School at Postojna (Slabe 1996). These are old caves, either void or filled up by fine-grained sediments and rubble, and shafts through which the water infiltrates from the permeable karst surface. Newly discovered caves provide a useful indication of the early stages of development of the central part of the Kras aquifer.

The waters from flysch Brkini Hills, Senožeče, Vipava and Pivka valleys and from gravel of the Soča valley are drained through the karst aquifer. Larger swallow-holes are located at the contact with flysch. Diffuse waters disappear from the permeable surface until they reach the underground flows which are now 300 m deep below the surface. Karstologists (Gams 1974, 197) consider that Kras attained its main relief properties when it was lower than Brkini and Vipava flysch. According to its superificial features and slops Melik (1960, 201) concluded that the former superficial drainage was over the dammed limestones and Radinja (1972, 13) came to the same conclusion from the sediments on the surface.

The motorway between Dane and Fernetiči cuts the karst ridge near Sežana and runs over the lowland towards the Italian border. Karst developed in Cretaceous limestones intersected by smaller faults that were the best seen during the tunnel digging. The karst surface is dotted by larger, mostly funnel-like dolines. Other parts, although covered by vegetation have a lack of soil. At the surface the longitudinal depression are filled up by loam. We assessed that these are old caves without roof already and filled up by fine-grained sediments.

THE CAVES IN THE MOTORWAY

The caves (72 newly discovered, Fig. 1) may be divided into old caves, remnants of former underground drainage, and shafts.

Cross-sections of newly discovered passages in old caves are from 1,5 to 8 m in diameter. They are mostly filled up by fine-grained sediments (16), only smaller caves (10) which by rule do not exceed 50 cubic meters of volume are void (Fig. 2). Speleothems in them are frequent, flowstone covering either

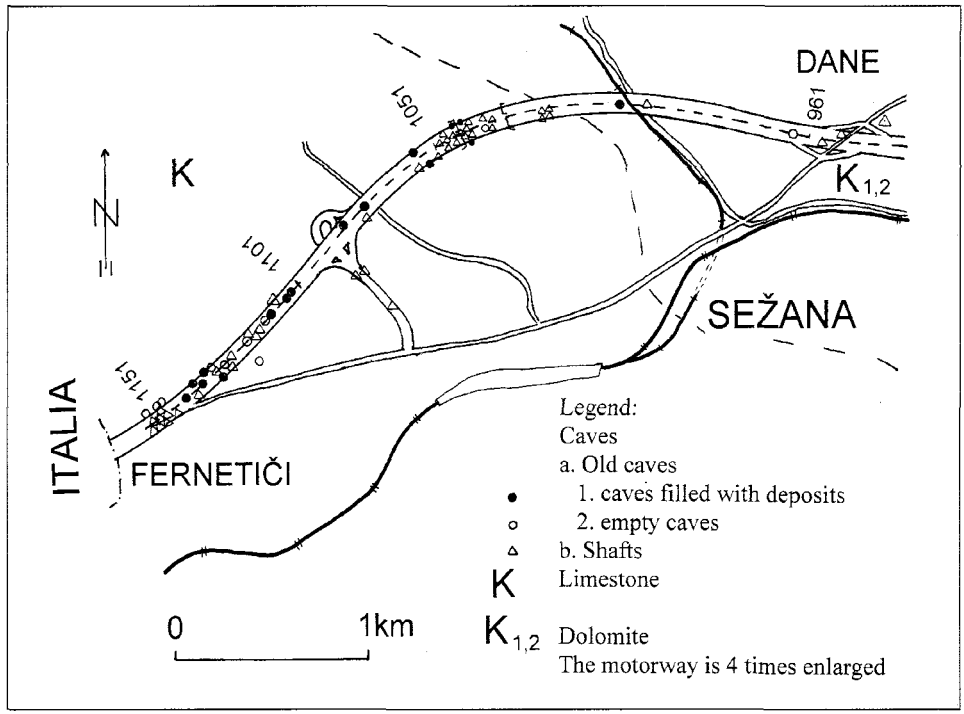
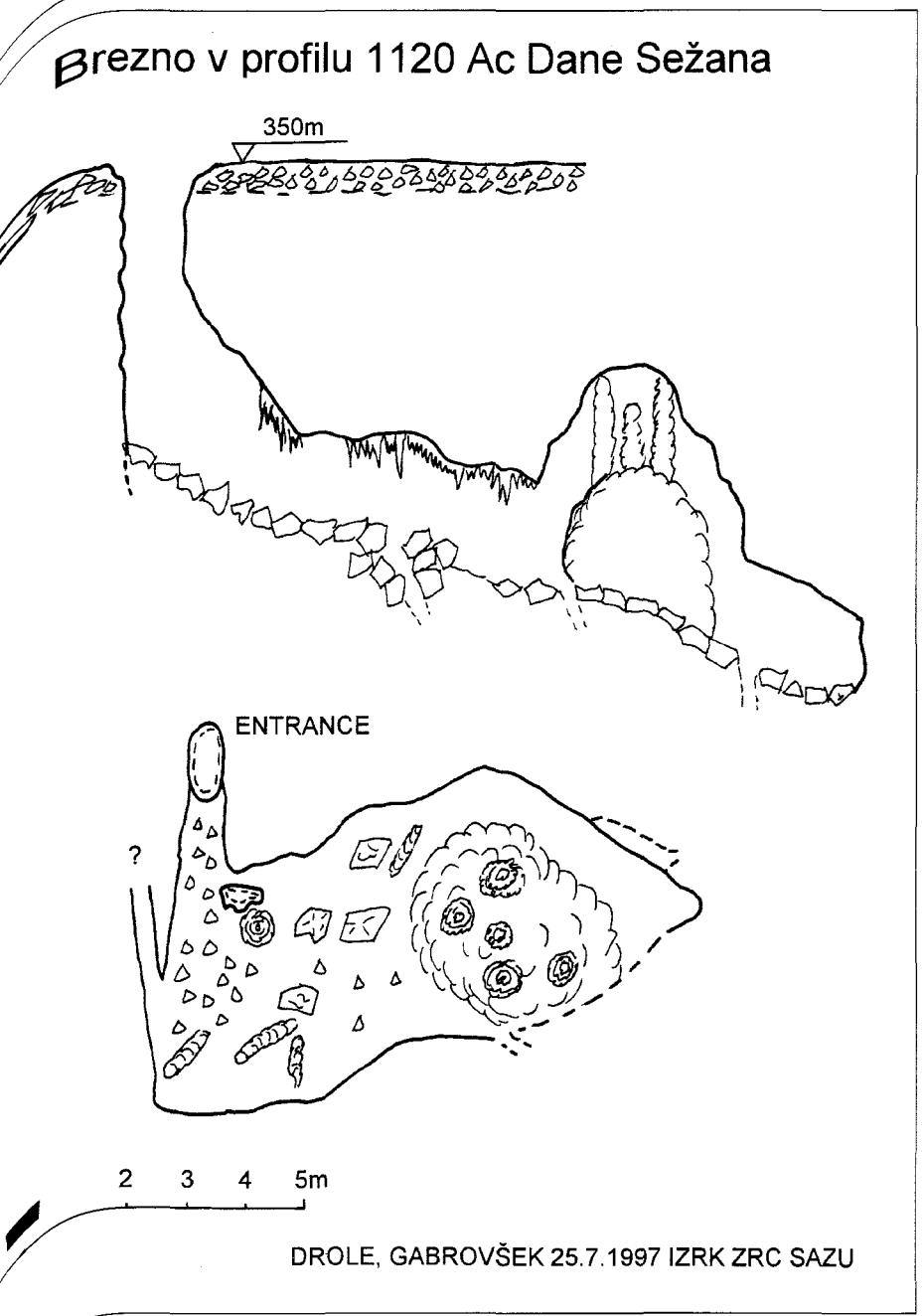


Fig. 1: Caves in the laying-out.
Sl. 1: Jame na trasi.

walls or floor. The ceilings above such caves are thin, from 1 to 2 m at the most. The network of pasages, their form and the rocky perimeters of these caves indicate that they were mostly controlled by slow water drainage in the phreatic zone.

Many old caves filled up by fine-grained sediments are already without roof (Fig. 3). The pasages wind like shallow indentations over the karst surface. They may be perceived even before the earthworks start. In road cuttings and tunnels the passages, filled up by fine-grained sediments, are seen in cross-section. The caves are filled up by layers of yellow loam and sand, frequently consolidated, and above them are ususally red loams and brown soil. The deposits cover the speleothems and calcite formations rarely is the deposit covered by flowstone. Relatively rare are traces of faster flows, such as small scallops; there were no pebble deposits found in these caves though they are frequent in old caves near Divača. The passages of old caves are frequently intersected by shafts and the sediments are there removed in a funnel shape. Old caves may be intersected by dolines also. A modest amount of water meandered in the bottom of some, usually smaller, passages (Fig. 4). The



Old cave.
Jama.

patches of flysch remained on some places on the surface for a longer time and water drained off them into the limestone.

Parts of newly discovered passages are filled up by coarse rubble (Fig. 5). Rubble, with sides mostly 5 cm in length, is due to weathering of the karst surface in one of the Pleistocene cold periods. Mostly it is found in parts of caves from where the fine-grained sediments were removed due to vertical permeability of the aquifer, and the thin roof collapsed just before the infill by rubble. In the passages the sections filled by loam and rubble alternate.

It seems that some newly discovered and relatively large old caves, either void or filled up by fine-grained sediments or rubble, in the western part of the motorway actually make part of a larger horizontal and vertical cave system that was unearthed during motorway construction over slightly undulating karst surface.

The water from the surface infiltrates underground by shafts and fissures. On the planned motorway two shafts were already known, the deeper one reaching 20 m deep. By denuding the surface during the earth works several other shafts (46) were discovered in relatively cavernous limestone, up to 110 m deep (Fig. 6). They may be divided into shafts with distinctive traces of percolation water, having ususally circular cross-sections and cracks of various dimensions that developed along the fissures, and with their walls often covered by flowstone; larger cracks developed along wrench-faults in fissured zones (Čar 1981). A lot of cracks are filled by flowstone, some of them widen in the shafts. Spacious, well decorated shafts make part of old cave systems that supposingly developed in a phreatic zone (cross-section 1122). Hollows, similar to shafts, developed among the breakdown boulders within disintegrated old caves. The most frequent were newly discovered shafts through which the water percolates into the aquifer. Most of them are located in the slopes or in the bottom of larger, funnel-shaped dolines. Most of shafts were without visible natural entrances. Narrow openings of difficult access appeared when the earth was removed. On the other hand spacious shafts were discovered and explored when digging the road cuts and tunnel, some 10 to 30 m below the surface. This is the consequence of water accumulation coming from a scattered infiltration through the permeable surface, which is being considerably lowered (Slabe 1996), and shafts are, also those with a natural entrance, collectors of this water. Klimchouk (1995) also assessed the diffuse water percolation into epikarst and converging of this water at the contact with vadose zone.

THE INFLUENCE OF THE MOTORWAY CONSTRUCTION ON CAVES

The deepest known shaft remained untouched at the border of the tunnel. By revealing the karst surface numerous smaller entrances into shafts appeared. Most of them were in the bottom of dolines. The workers blocked them

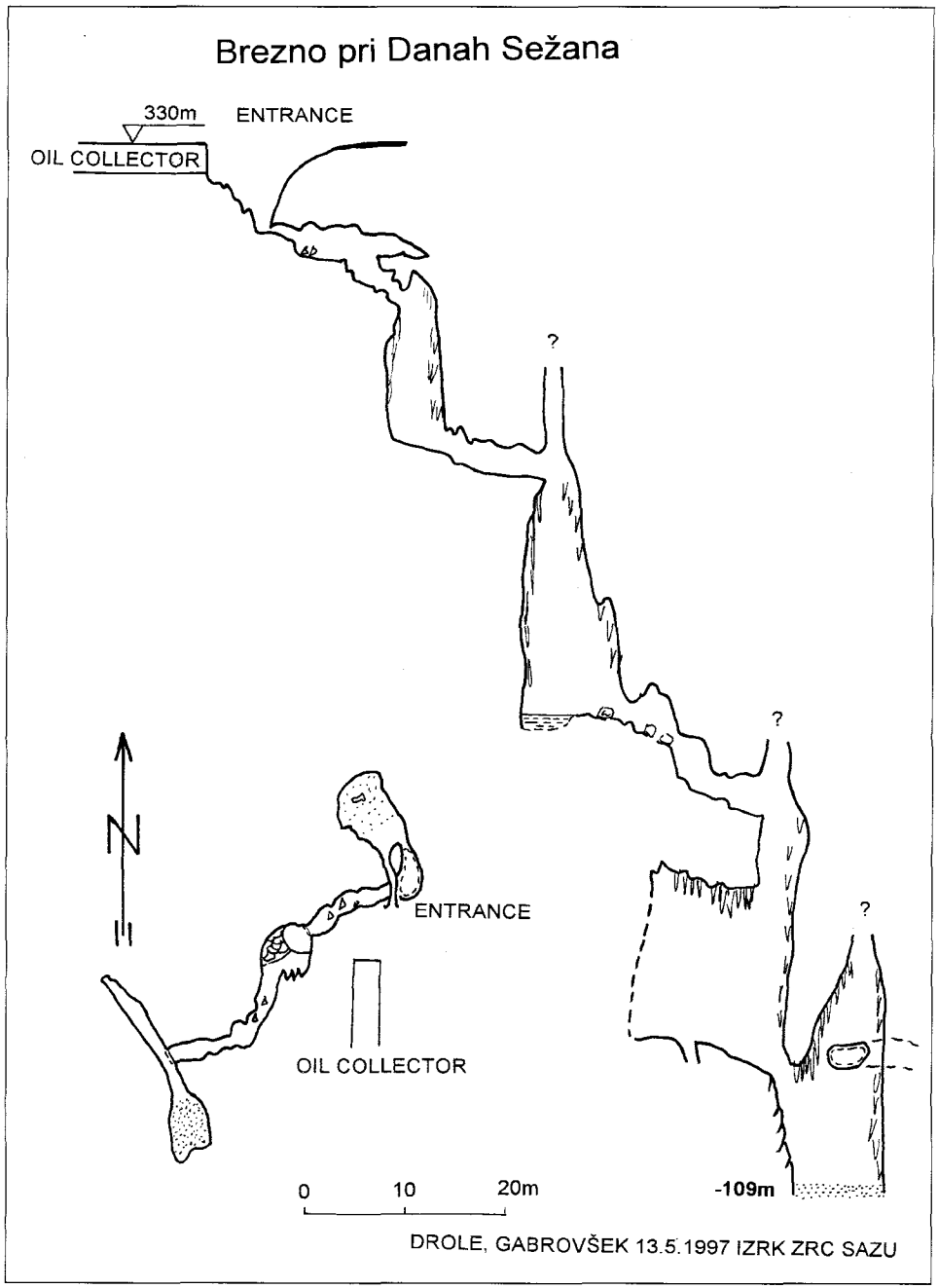


Fig. 6: Shaft.
Sl. 6: Brezno.

by large rocks cemented by a concrete. Dolines were later filled up by layers of stones and rubble and consolidated by a vibration roller. Also the fine-grained deposits and rubble were removed from the old caves and they were filled up by rocks and concrete.

Larger shafts frequently opened in roadcutings. The exploration was a demanding task as the perimeters of the entrance parts were very crushed and the rocks unstable due to blasting. Smaller shafts below the laying-out were filled up by rocks and consolidated by concrete. One of bigger shafts was unaccessible (cross-section 1048) because larger rocks collapsed in it. During the earth works the shaft was filled up. We suggested consolidating the area above it by strong concrete.

Fine-grained sediments from old caves located in the sides of road-cuts were washed to the roadway. The caves were sealed by walls.

During the digging of a tunnel several old caves and shafts opened. As they were of smaller dimensions they were closed by the concrete arch of the tunnel. The caves in the ceiling of the tunnel were unaccessible. The rocks of their perimeter were crushed due to blasting, rocks and rubble poured out and the perimeter was disintegrating.

CONCLUSION

A large share of the surface of this part of the Kras aquifer is occupied by old caves, filled up by fine-grained sediments and rubble and already unroofed. The upper parts of the aquifer have been affected by infiltration water for a long time. Mostly large old caves evidence the time when the ground water was close below the actual surface. Supposedly close to them a flysch nappe remained and from it smaller superficial waters drained. The ponor properties of some caves indicate the same. Their bottoms are meandering and deepened by smaller water flows. Flysch remained over the limestone long after the lowering of the underground water table, yet the water reached the caves during high waters and finally filled them with fine-grained sediments. During cooler periods of the Pleistocene some of old caves were filled up by rubble. The great cavernosity of this part of Kras is evidenced by the numerous shafts and fissures that were discovered during the earth works. Also in this part of the karst there were no traces of superficial water flows that could belong to the time when the limestone was still dammed. The same was noted on the section of the motorway between Čebulovica and Dane. All the discovered sediments are of cave origin.

Great cavernosity is one of the most reliable indicators of permeability, warning us again how carefully the rodas must be constructed and later used. The roadway should be impermeable in order to assure that only treated waters drain off it each day, and the road surface should be protected against

accidental spills of harmful substances. When the rubble on the roadway had been consolidated by a vibration roller some sinkholes appeared. The roof above smaller caves collapsed. Considering this great cavernosity, there exists the possibility that some larger cave is hidden underneath. This it means that the georadar survey is very important for safety of the roads.

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JAME V TRASI AVTOCESTE DANE - FERNETIČI

Povzetek

Na slovenskem krasu se hitro gradijo avtoceste. Krasoslovci sodelujemo pri načrtovanju avtocest, ko se izogibamo površinskim kraškim pojavom kot so večje vrtače, udornice in kraške stene ter značilno oblikovane večje skalne površine, in večjim jamam. Sodelujemo tudi pri gradnji avtocest, ko se odkrivajo številne in raznolike kraške jame. Del sem jih že predstavil (Slabe 1996). To so stare jame, ki so votle ali pa zapolnjene z drobnozrnato naplavino in gruščem, ter brezna, skozi katera prenika voda s prepustnega kraškega površja. Novoodkrite jame nam veliko povedo o razvoju osrednjega dela vodonosnika Krasa.

Skozi kraški vodonosnik se pretakajo vode s flišnih Brkinov, Senožeške, Vipavske doline in Pivške kotline ter iz proda Soške doline. Na stiku s flišem so večje ponorne jame. S prepusnega površja vode razpršeno prenikajo do podzemeljskih voda, ki so danes več kot 300 m globoko pod površjem. Krasoslovci (Gams 1974, 197) menijo, da je kras dobil glavne reliefne značilnosti, ko je bil nižje od brkinskega in vipavskega fliša. O sledeh prvotnega površinskega odtoka po zajezenih apnencih sklepa Melik (1960, 201) po obliki površja in njegovih strmcih, Radinja (1972, 13) pa po naplavinah na površju.

Trasa med Danami in Fernetiči predre kraški hrbet pri Sežani in nato poteka po ravniku do italijanske meje. Kras se je oblikoval v krednih apnencih, presekanimi z manjšimi prelomi, ki so najlepše razvidni pri kopanju predora. V kraški ravnik se zajedajo večinoma večje, lijakaste vrtače. Tudi na ostalem, večinoma poraslem površju je le malo zemlje. Površje prepredajo tudi večje zajede, v katerih je ilovica. Ugotovili smo, da so to stare jame, ki so že brez stropa in zapolnjene z drobnozrnato naplavino.

Presenetljivo velik delež površja tega dela vodonosnika Krasa zavzemajo stare jame, ki so zapolnjene z drobnozrnato naplavino in gruščem in so že brez stropov. Zgornji deli vodonosnika so že dolgotrajno preoblikovani s prenikajočo vodo. Stare jame so torej sledi časa, ko je bila podzemeljska voda še tik pod današnjim površjem. To je seveda zaradi stalnega nižanja kraških predelov nižje od prvotnega. Velikost rovov priča, da so se skozi njih pretakali večji vodni tokovi, ki so rove sprva povsem zalivali. V bližini pa je bil verjetno tudi ostanek flišnega pokrova, s katerega so se stekale manjše površinske vode. Na to kažejo ponorne značilnosti nekaterih jam. Njihova dna so namreč vijugasto poglobljena z manjšimi vodnimi tokovi. Fliš se je na apnencu ohranil še dlje časa po znižanju gladine podzemeljske vode, ki pa je jame ob izjemnih poplavah še dosegala in končno celo zapolnila z drobnozrnato naplavino. Del starih jam je bil v hladnejših obdobjih pleistocena zapolnjen z gruščem. Veliko prevotljenost tega dela krasa dokazujejo tudi številna brezna in špranje, ki so bila odkrita pri zemeljskih delih. Tudi v tem delu krasa ni bilo najti sledi površinskih vodnih tokov iz časa, ko je bil apnenec še zajezen. To smo ugotovili tudi na trasi med Čebulovico in Danami. Vse odkrite naplavine so jamske.

Velika prevotljenost eden izmed najbolj zanesljivih kazalcev prepustnosti, kar nas še enkrat opozarja na izredno pazljivost pri gradnji ceste in nato pri njeni uporabi. Cestišče bi moralo biti neprepustno, tako da bi se z njega resnično stekale le prečiščene vsakodnevne vode, površje pa bi moralo biti zavarovano tudi pred morebitnimi nesrečnimi razlitji škodljih snovi. Tudi pri utrjevanju grušča na cestišču s tresočim valjarjem so nastajali grezi. Udrli so se stropovi nad manjšimi jamami. Ob veliki prevotljenosti pa bi bila lahko tik pod površjem še kakšna, tudi večja jama. Pregled takšnih tras z georadarjem je torej zelo pomemben za varnost cest.



Fig. 3: Roofless cave.
Sl. 3: Jama brez stropa.

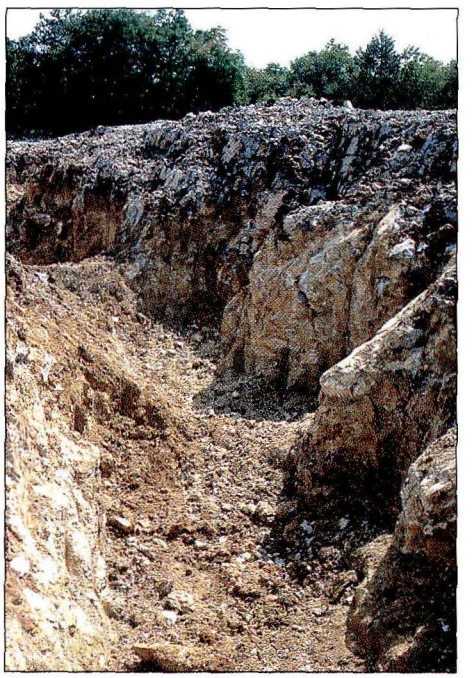


Fig. 4: Old swallow-cave without roof.
Sl. 4: Stara ponorna jama brez stropa.

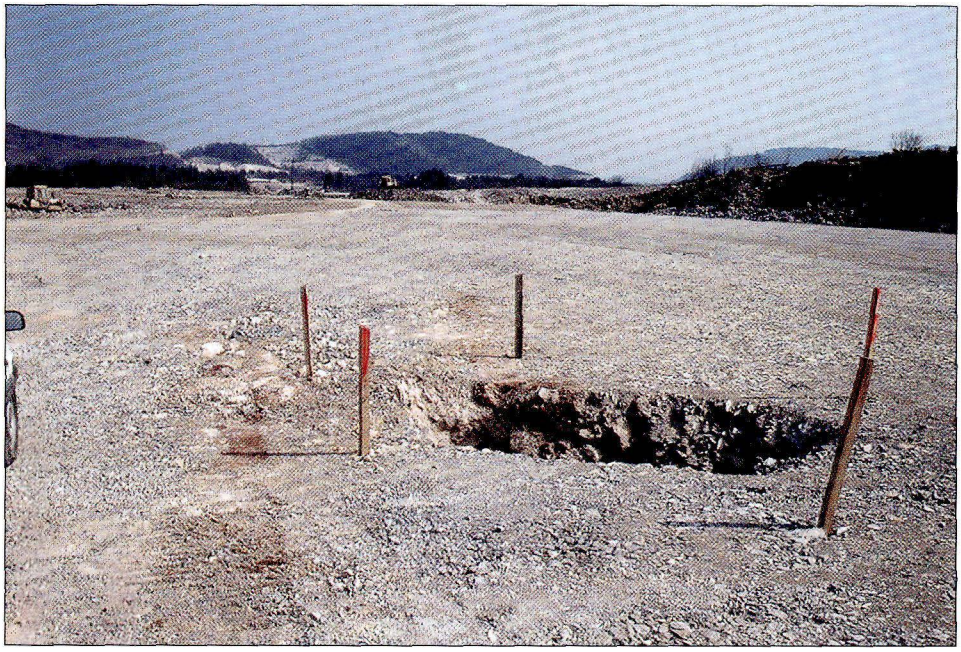


Fig. 7: Collapse can occur even when the earth-works are finished.
Sl. 7: Do udora lahko pride tudi po zaključku zemeljskih del.

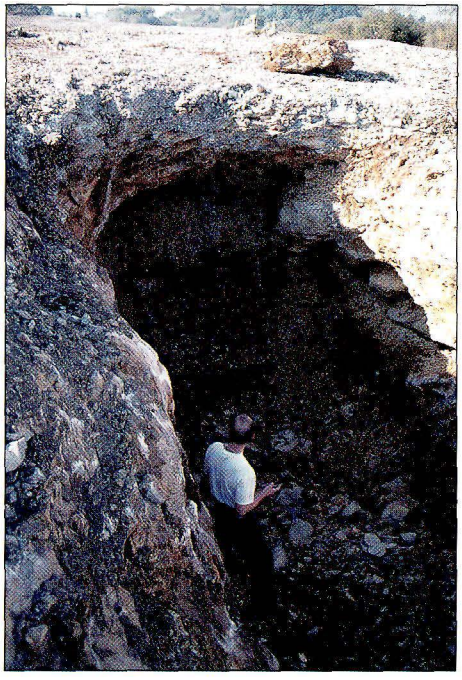


Fig. 5: Cave filled up by rubble.
Sl. 5: Jama zapolnjena z gruščem.

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SPRING CHEMOGRAPH ANALYSIS - THE INFLUENCE OF THAW EFFECT AND DISPERSED POLLUTION IMPULSES (CRACOW-CZESTOCHOWA UPLAND, POLAND)

ANALIZA KEMOGRAMOV IZVIROV - VPLIV EFEKTA TALJENJA SNEGA IN IMPULZOV RAZPRŠENEGA ONESNAŽEVANJA (KRAKOWSKO-CZESTOCHOWSKO VIŠAVJE, POLJSKA)

ANDRZEJ TYC [1]

Izvleček UDK 556.33/.34(438)

Andrzej Tyc: Analiza kemogramov izvirov - vpliv efekta taljenja snega in impulzov razpršenega onesnaževanja (Krakowsko-Czestochowsko višavje, Poljska)

Napajanje, tok in vskladiščenje podzemne vode so v karbonatnih vodonosnikih zelo spremenljivi. Skladno z različnimi stopnjami zakraselosti je napajanje v razponu od koncentriranega do razpršenega. Članek predstavlja rezultate proučevanja onesnaženja glede na različne načine napajanja v karbonatnih vodonosnikih, s pomočjo monitoringa temperature vode in koncentracij glavnih ionov. Na podlagi analize kemogramov kraških izvirov in ocene tradicionalnih modelov napajanja, avtor predlaga nov model. Taljenja snega se odraža v kemizmu voda (Ca^{2+}, SO_4^{2-} in NO_3^-, celokupna trdota, specifična električna prevodnost).

Ključne besede: hidrologija krasa, kraški izvir, kemograf, Poljska.

Abstract UDC 556.33/.34(438)

Andrzej Tyc: Spring chemograph analysis - the influence of thaw effect and dispersed pollution impulses (Cracow-Czestochowa Upland, Poland)

Groundwater recharge flow and subsurface water storage can be extremely variable in carbonate aquifers. Owing to different degrees of karstification, recharge can range from concentrated to dispersed. The paper outlines the results of an investigation of pollution in respect of different recharge situations in carbonate aquifers including of monitoring of water temperature and ion concentration. According to the chemograph analysis, the author suggests modifications to the traditional models. The thaw effect is demonstrated by water chemistry (Ca^{2+}, SO_4^{2-}, NO_3^-, total hardness, specific conductivity).

Key words: karst hydrology, karst spring, chemograph, Poland.

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INTRODUCTION

For several decades, karst hydrology has used different indirect methods to investigate groundwater systems in karst aquifers. These have included analysis of karst spring hydrographs and chemographs (Mangin 1975; Bakalowicz 1979; Bonacci 1987; Ford & Williams 1989; Bonacci 1993). The analysis of a spring runoff hydrograph during individual flushes has successfully been applied in hydrology, in respect that it enables us to classify karstic aquifers according to the degree of karstification they exhibit and to the state of development of the groundwater circulation system. With the general growth of hydrochemical investigations in karst areas, this kind of analysis has advanced to a stage where detailed spring chemographs have been drawn up for short spring flushes (Jakucs 1959; Bonacci 1987). Certainly, this method of indirect hydrological investigation has gained many advocates in recent times and its popularity is, no doubt, due to the increasing availability of automatic measuring stations in the field and the computer in the laboratory. Spring chemographs may be used in the cases of both a single flush and in the analysis of seasonal variability of spring hydrochemical conditions (see also, e.g. White & Stellmack 1968; Shuster & White 1971; Tyc 1992; Reeder & Day 1993; Tyc 1994; Lackey & Krothe 1996).

Research into changes of karstic water chemistry where influenced by anthropogenic pollution, which have been carried out in several karst areas, has provided much new data for the interpretation of spring chemographs. On the one hand, pollution represents a valuable chemical marker, whereas, on the other, it makes the evaluation of karst aquifer activity even more complicated than it usually is. In cold-temperate karst areas, where there is a regular annual snow cover, thaw flushes are an important factor in influencing the hydrological and hydrochemical regime of a karst aquifer.

With respect to the author's own observations carried out in the central part of the Cracow-Czestochowa Upland, and by analysing the results of the research from other areas (e.g. Reeder & Day, 1993; Lakey & Krothe, 1996), it became apparent that the generally accepted interpretation of karst spring chemographs should be modified for those areas where thaw flushes occur and where the groundwater environment is considerably polluted.

Classical chemograph analyses

Long-term research in different karst areas all over the World shows that there is a positive relationship between spring regimes, the types of circulation in the aquifer and the temporal variability of some physical features and chemical composition of spring water. The theoretical basis for the application of spring hydrographs analysis gave L. Jakucs (1959) (who investigated springs

in Kolmos, Hungary); W.B. White & J.A. Stellmack (1968), W.B. White (1969), and E.T. Shuster & W.B. White (1971) (the Nittany Valley, Pennsylvania); R. Gospodarič & P. Habič (1976) (the Dynaric karst); S.R.H. Worthington (1991) (the Rocky Mountains of the U.S.A.) and, particularly, A. Mangin (1975), M. Bakalowicz (1979) and M. Bakalowicz & A. Mangin (1980) (the Aliou, Baget and Fontestorbes systems in the Pyrhenees, France). Recently, the latter investigation has been enlarged by A. Pulido-Bosch in the Torcal de Antequera System of Spain (e.g. Padilla *et al.* 1995). These authors all assume that karst aquifers are heterogeneous and represent all possible combinations and organisational stages of runoff which can range between the diffuse flow and conduit flow systems. The hydrological and hydrochemical regimes of springs (spring yields, temperature and specific conductivity and the temporal variability of the chemical properties of spring water) are in a direct relationship with the structure and condition of water circulation in the karst aquifer. This regime is modified by the limiting conditions of the aquifer. The variability of karst spring discharge relates to the variability of precipitation, the intensity of thawing and the volume of aquifer recharge by allochthonous surface streams. Therefore, the hydrological and hydrochemical regime of springs is mainly dependent on the recharge conditions. According to L. Jakucs (1959), it is important to recognise the relationship between the nature of the karst aquifer recharge and the spring response; springs of small variability are associated with autochthonous recharge (percolation and infiltration) whereas there is another type represented by springs of great variability, where, usually, allochthonous recharge by surface streams is a strong influence. According to S.R.H. Worthington (1991), the location of a spring at a particular altitude in relation to neighbouring springs which drain the same karst system, may also be an important factor in influencing variability of discharge.

From these considerations, it follows that any classification of springs in a karst area must contain the following: (1) full-flow springs, which drain the whole aquifer (2) underflow springs, which mainly drain basic underground runoff (3) overflow springs, which mainly drain flush runoff, and (4) underflow-overflow springs, which represent a transitional type. Springs which drain a whole aquifer are very rare in carbonate karst areas; they normally occur only in those areas where there are no overflow springs and the single spring is then situated at the lowest topographical point in the whole catchment. S.R.H. Worthington (1991) also assumed that each overflow spring must have a complementary underflow spring; however, in as much as these are seldom recorded in any survey of a karst area, they are often difficult to find. In such cases, the basal runoff goes beyond the aquifer, without surface discharge (therefore it is not possible to measure it). Thus, it is the overflow springs which tend to be the most frequently investigated (and, also, supposedly, the commonest) in carbonate karst terrains.

The best-known and commonly applied analysis of karst spring chemograph

in the international literature assumes that, during a flush, the water comes from different parts of the aquifer and that its occurrence in discharge causes changes in the physical features (mainly the temperature, the specific conductivity and the amount of suspended matter and microorganisms) and chemical features such as total hardness, content of calcium or hydrocarbonates (Bonacci, 1987; Ford & Williams, 1989) (Fig. 1). This model further assumes that the maximal yield during a flush relates directly to a spring discharge which comes from the epikarst zone and karst conduits in the vadose zone. Later, during the flow recession, these coefficients increase slowly, eventually to revert to their original value. At this time, the base flow of the phreatic zone emerges as spring water discharge.

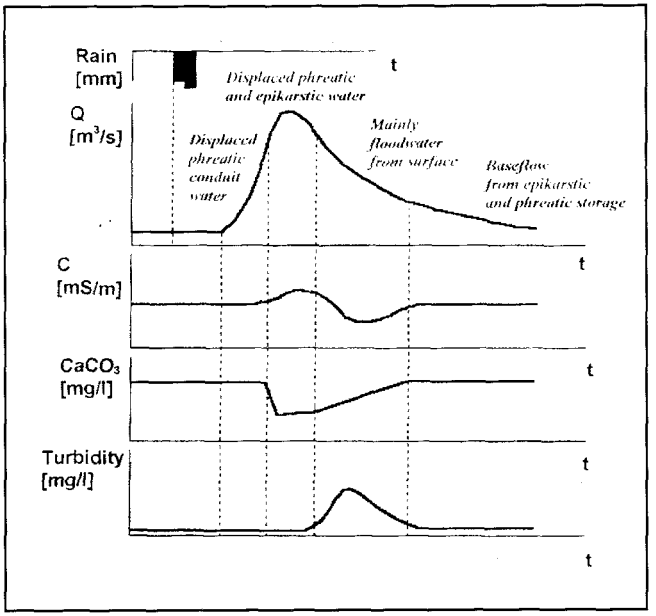


Fig. 1: Spring chemograph showing the origin of water discharging in spring during flood event in natural conditions without influence of thaw (after O. Bonacci, 1987 and D. Ford, P. Wiliams, 1989 - modified).

CASE STUDIES IN THE CRACOW-CZESTOCHOWA UPLAND

The results of investigations concerning the yield and physico-chemical properties of several springs in the central part of the Cracow-Czestochowa Upland now permit an evaluation of the hydrological regime and contemporary karst processes in the Upper Jurassic Aquifer. Special attention has been paid to the anthropogenic influences in the zone of spring recharge during the flush periods; the importance of these in the analysis of spring chemographs cannot be emphasised too much.

The area studied embraces the central part of the Upper Jurassic Aquifer between Olkusz and Zawiercie (Fig. 2). The aquifer is mostly unconfined and only a small area is overlain by Quaternary sediments and these are freely permeable. Cryogenic disturbance of the epikarst zone is very characteristic of

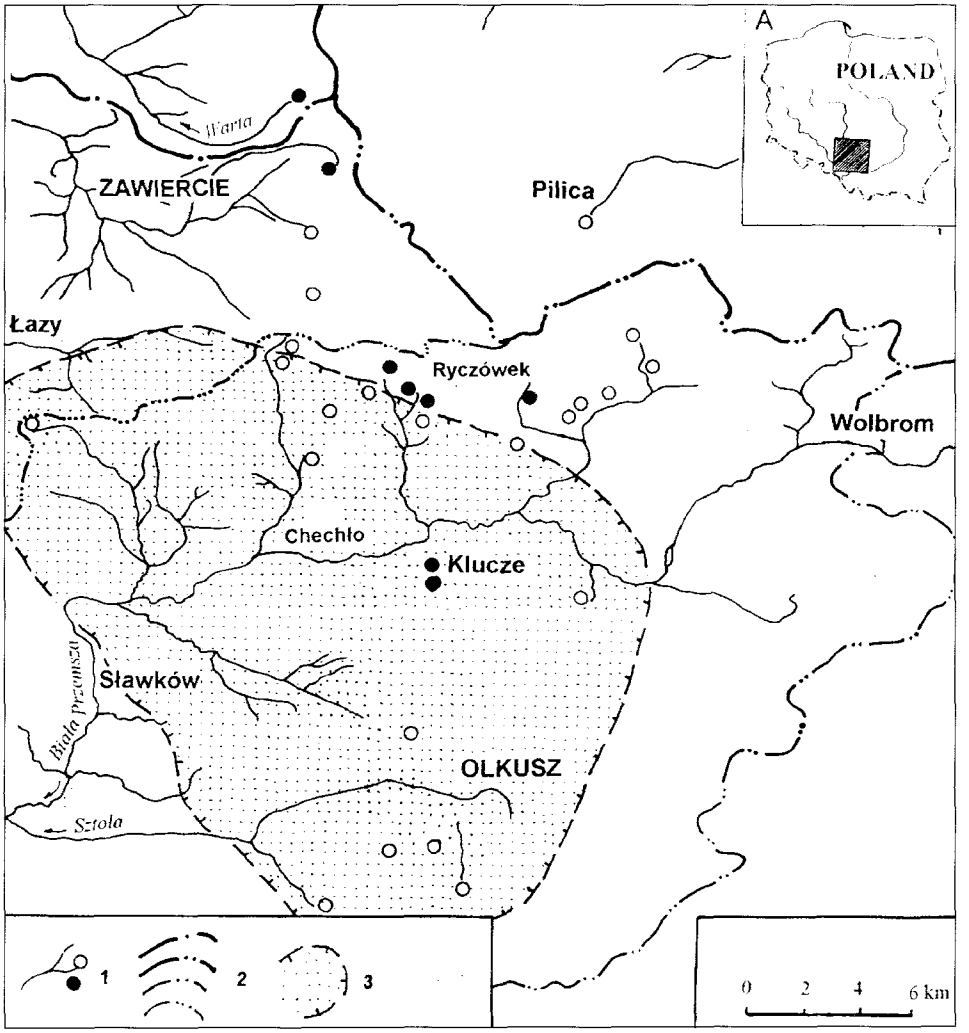


Fig. 2: Location and hydrographic network of the Olkusz-Zawiercie region (Cracow-Czestochowa Upland). 1-rivers and springs (filled circles show detail studied springs); 2-boundaries of topographic rivers basins: 1st, 2nd, 3rd and 4th order; 3-range of cone of hydraulic depression within Olkusz-Zawiercie Aquifer developed under artificial drainage.

the area (Tyc, 1996). The confining layer below is formed from Lower Oxfordian and Middle Jurassic clays. The Upper Jurassic limestone aquifer is variable in its lithology, comprising massive, platy and chalky types. Its thickness ranges from 50 to 400 m.

In the Cracow-Czestochowa Upland, the karst morphology and the groundwater drainage system are polygenetic. The karst drainage system takes two forms: (i) hydraulically inactive forms in the subsurface zone (including caves), and (ii) active forms in the deeper part of the aquifer (some of which may be sediment-filled). Recharge takes place over the entire outcrop, either directly or through the Quaternary cover. The mean annual precipitation in the area studied is 700 mm and 30% of this is snow-meltwater (Tyc, 1994)

Drainage from the aquifer takes place mainly from the springs but about 15% discharges north-eastwards through deep-level drainage below the Cretaceous cover into the Nida Basin. The hydrological regime of the springs in the area studied is thus a thaw-rain type (Tyc, 1994). The maximum yields usually occur during flushes, mostly in the period from February to April (the "flush maximum"). A second peak occurs in June or July (the "rain maximum"). Sometimes the peak yields are associated with excessive precipitation and may also occur in Autumn or even Winter, depending on the occurrence of unusual meteorological conditions. Normally, the precipitation maximum is two or three times lower than the maximal yields after thaws. Minimal spring discharges are normally in the winter months from October through to February or even March.

The temperatures of the spring water is another feature of the spring systems studied and normally, there are very few fluctuations, whether in the short- or the long-term. The water temperature is very closely related to the differences in spring-discharge during the year, especially so in the case of the Winter-Spring recharge periods. Intensive Winter recharge (e.g. during snow-free Winters) generally results in a decrease in the annual amplitude of fluctuation. By contrast, in the years when Spring-thaw is intensive, the annual amplitude of fluctuation increases markedly and minimal water temperatures occur one or two months later. At the end of the Summer, when cold water from thaw recharge runs off, the groundwater is recharged only by warm rainwater; this results in an increase of water temperature in the springs.

CHEMOGRAPH ANALYSIS OF SELECTED SPRINGS WHICH ARE INFLUENCED BY HUMAN IMPACT

A great deal of information may be obtained about the physical and chemical properties of water which circulates in the Upper Jurassic Aquifer by careful studies of the spring discharge. The Ryczowek II and Klucze I and II Springs, all located in the central part of the Cracow-Czestochowa Upland, are described here in order to illustrate the way a spring chemograph may be modified where there is a strong anthropogenic influence (Fig. 2). Figure 3 shows the seasonal variability of chemical properties and yields of the Ryczówek II Spring in the period 1989-90.

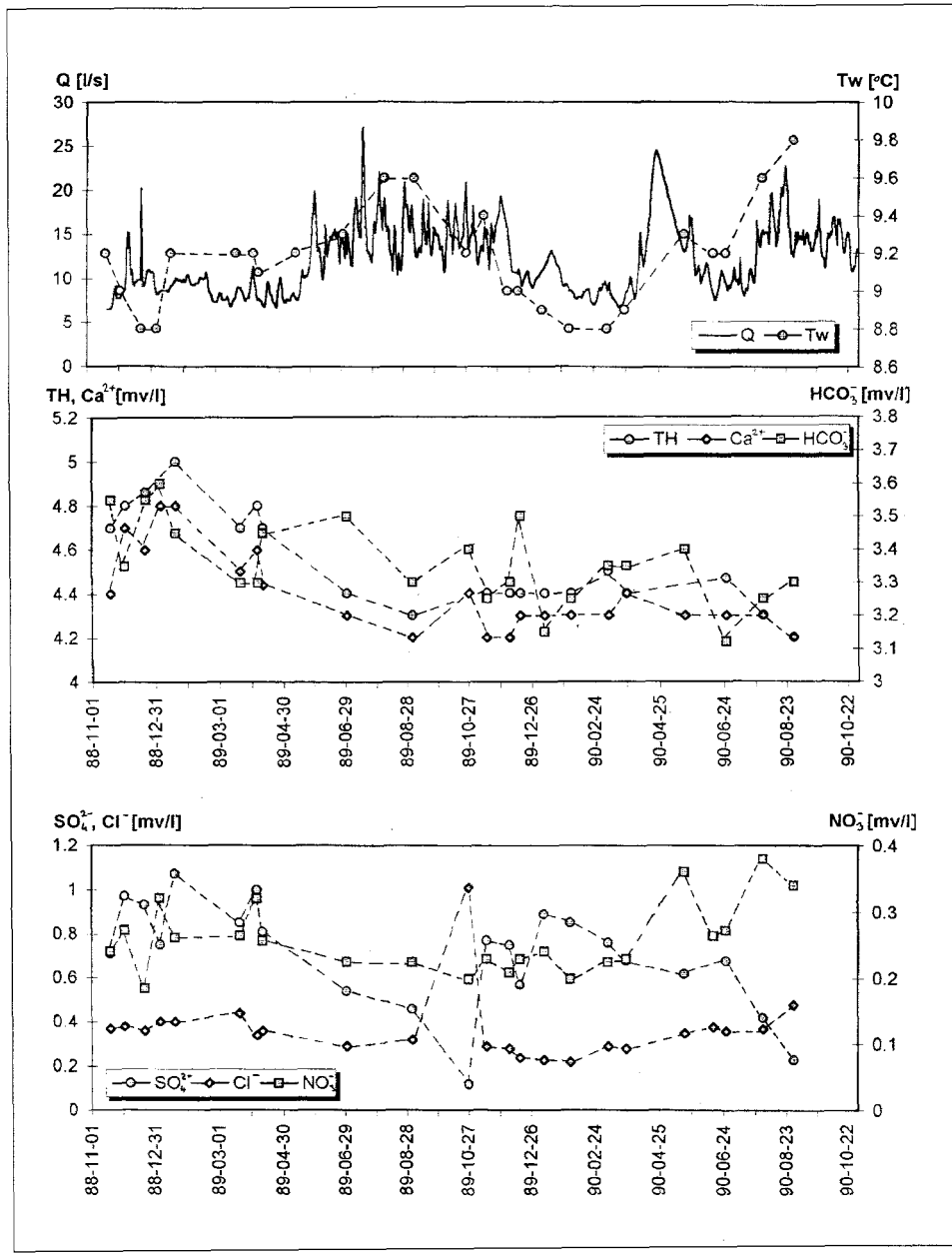


Fig. 3: Seasonal varibility of physical and chemical properties in spring water in Ryczowek II in the period of 1989-1990. Q-mean daily discharge, T_w-water temperature, TH-total hardness, Ca^{2+}-calcium, HCO_3^--bicarbonates, SO_4^{2-}-sulphates, Cl-chlorides, NO_3^--nitrates.

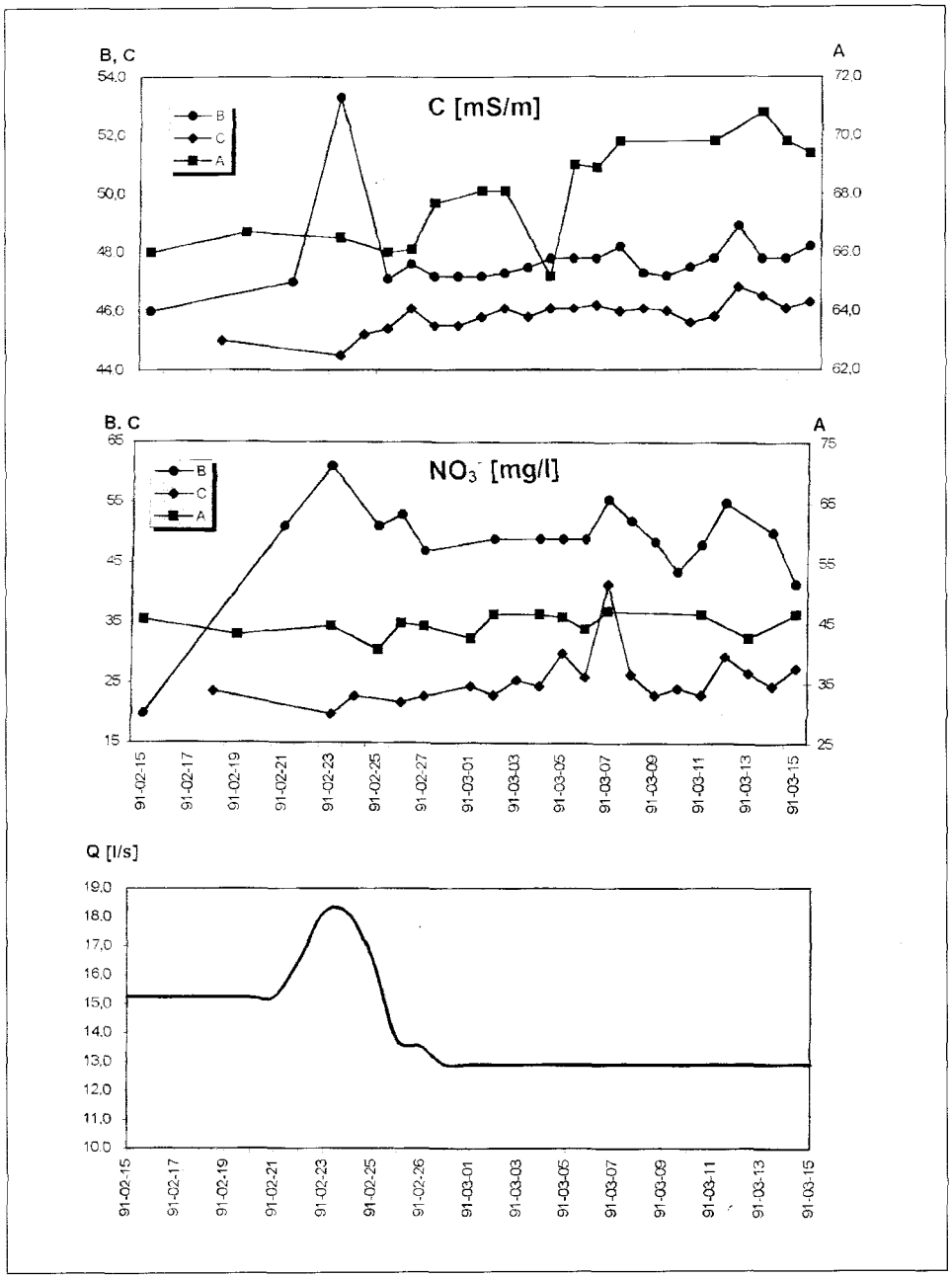


Fig. 4: Variability of specific conductivity (C mS/m) and nitrates (NO_3^- mg/l) in water of Klucze II (a), Klucze I (B) and Ryczowek II (C) springs during thaw season of 1991. Q-mean daily discharge in Ryczowek II.

In the karst areas which are not influenced by human activity, an increase in the yield is accompanied by a decrease of TH values and mineralisation. In the case of the Cracow-Czestochowa Upland, the spring chemographs are more complicated. Maximum discharge takes place during thaws and, at these times, there is an obvious increase in the values for specific conductivity, total hardness and ionic content which come mainly from pollutants. Detailed measurements during the thaw period were made at the Ryczówek II (a spring which has a fairly consistent flow), Klucze I (one with variable flows) and Klucze II (one which has consistent all-year-round flows) in the thaw period of 1991 (Fig. 4). This chemograph showed that the accepted view concerning changes of mineralisation and the amount of dissolved Ca^{2+} and Mg^{2+} salts during thaws is not wholly acceptable. The traditional view holds that, only in the case of Summer precipitation recharge does meteoric water infiltrate into the karst aquifer quickly. However, this does not adequately relate to the mineralisation and chemical composition of spring water which comes from thaw or thaw-rain recharge, which is an important element of spring discharges in such situations. This may be explained by considering in detail the relationship between the runoff hydrograph and the zones of the carbonate aquifer which are drained during the individual phases of a flush. During thaws, when a spring flush is preceded by the long contact of the water (i.e. that which comes from melting snow covers) and the ground, the increase of minerlaisation and total hardness is associated in the spring recharge with water from the the epikarst zone and the upper part of the vadose zone (this is the converse of previously accepted interpretation of spring chemograph). In the early phases of thawing (and also during winter thaws), water which migrates through the epikarst zone has a specific chemical properties, which, later, influences the "thaw effect" in water which discharges from the springs. This is well illustrated by the analyses of the soil water and water from weathered zone below soil cover at Książa Góra, in Ryczówek (456.2 m a.s.l.), which forms the recharge zone of the Ryczówek II Spring. The water sampled directly after the melting of an unusually thin snow cover here in February 1990 shows physical and chemical properties which are quite different from those exhibited by water which percolates through the soils and remains in the epikarst zone in a late spring (Tyc 1994, 1996) (Table 1). In case of the water sampled in Fubruary 1990, very large levels of Ca^{2+} (5.5 mv/l), total hardness (5.9 mv/l) and mineralisation (C = 69.1 mS/m) were recorded; these are all considerably larger than the maximal values noted during the whole study period at the Ryczówek Springs, whereas the content of hydrocarbonates in the water studied was small (0.4 mv/l) and the contents of other anions very large (SO_4^{2-}, 2-4 mv/l; NO_3^-, 1.1 mv/l). These are much larger than the values obtained from the Upper Jurassic Aquifer groundwater in other periods, whether before or after thaws. It is concluded, therefore, that Ca^{2+} content and total hardness of the epikarst water in these periods are more closely associa-

	C [mS/m]	TH [mg/l]	Ca^{2+} [mg/l]	Mg^{2+} [mg/l]	HCO_3^- [mg/l]	SO_4^{2-} [mg/l]	Cl^- [mg/l]	NO_3^- [mg/l]
THAWING SEASON								
Snow	5,3	8,0	8,0	0,0	17,1	11,0	2,5	3,2
Epikarstic zone ***(dispersed flow)***	69,1	118,0	110,0	4,8	24,4	196,8	14,0	69,3
Spring water ***(fed by dispersed flow)***	50,8	108,0	100,0	4,8	210,5	60,5	16,8	31,5
LATE SUMMER								
Rain water	6,0	8,4	6,8	1,0	3,1	10,1	3,5	5,7
Epikarstic zone ***(dispersed flow)***	31,0	54,0	48,0	3,6	48,2	75,4	3,5	23,9
Spring water ***(fed by dispersed flow)***	47,4	92,0	88,8	1,92	208,6	32,2	13,0	18,3

Table 1: Chemical comosition of water in recharge and discharge zones of Ryczowek II spring. Water samples represent thawing and late summer seasons of 1990 (after A. Tyc, 1996).

ted with sulphates and nitrates than with the $CaCO_3$ forthcoming from rock dissolution. This, in turn, shows that the spring water of a thaw flush maximum contains mainly Ca^{2+} and Mg^{2+} salts (probably sulphates and nitrates) which are associated with processes taking place in the soils and in the epikarst zone, and which are not the results of solution processes.

One result of the research described is the realisation that there is an artificial variability of the total hardness in the hydrological cycle. The natural changes in total hardness, which are influenced by environmental factors associated with solution of carbonates, overlap with the changes influenced by the cycles of pollution supplied to the aquifer. In a cold-temperate climatic zone, spring thaws play an important role. Fig. 5 shows the changes of total hardness values (TH) against a background of pH for the Ryczówek Spring.This shows that the pH-TH relationship takes two forms: (i) the pH and the TH both increase or decrease concomitantly, (ii) a pH decrease is accompanied by a TH increase. The first form is typical of groundwater in carbonate rocks. The reaction of the water reflects the level of saturation of dissolved carbonates; an increase of $CaCO_3$ reflects a more alkaline environment and *vice versa*. The second type of relationship shows that there are cases in the hydrological cycle when a decrease in the water reaction is demonstrably associated with an increase in the total hardness. This is probably caused by an increase in the amount of pollution in the groundwater and the content of calcium salts which come from outside the local $H_2O \rightarrow CO_2 \rightarrow CaCO_3$ system. This phenomenon

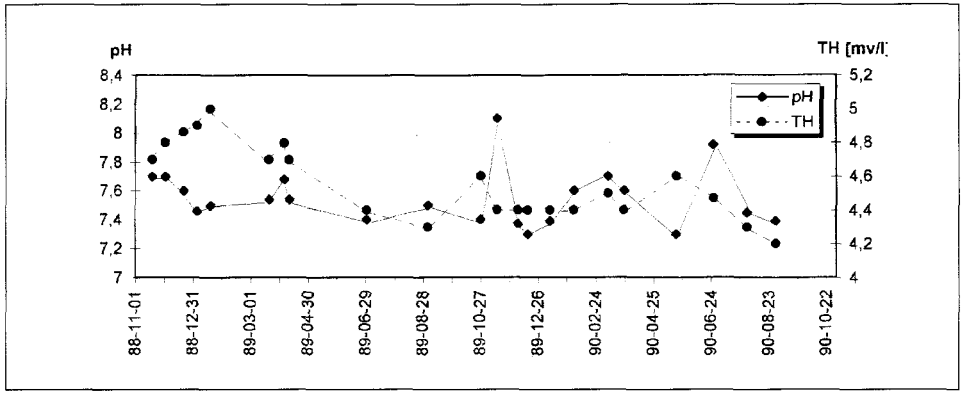


Fig. 5: Variability of pH and total hardness (TH) in water in Ryczowek II spring in the period of 1989-1990.

occurs during the runoff of the water from thaw recharge (and also during the Winters). This is also an element of the so-called "thaw effect" where human influence on the karst system is considerable.

This research suggests that the natural hydrochemical regime of the groundwater in the karst of the Cracow-Czestochowa Upland is influenced by human impact during periods of thaw and thaw-rain recharges in the epikarst zone and in associated soil covers (the "thaw effect"). This is illustrated in the chemograph of the thaw period for 1991 and the third week of December 1988, when a sudden thaw took place (thereby increasing the values of some chemical components in most of the springs studied (see Fig. 3).

CONCLUSIONS

The analysis of spring chemographs in the area of the Cracow-Czestochowa Upland shows that previously held views on changes of the dissolved calcium and magnesium salts during thaw discharges should be modified. This view seems also to be true in the case where spring recharge by summer rainwater takes place following meteoric water infiltrates relatively quickly into the karst aquifer and when the conduit system of water circulation predominates. However, it does not apply in the case where mineralisation and chemical composition of that spring water which comes from thaw or thaw-rain recharge takes place, i.e., normally in the Spring seasons of cold-temperate climates. It is emphasised here that, hitherto, classical elaborations of this problem concerned mainly the areas where rapid thaws have not occurred. Moreover, the karst in those areas was not significantly affected by human impact, a factor which appreciably affects the interpretation of karst aquifer behaviour. The

monitoring of karst springs using automatic recording devices, which is being carried out in many parts of the World, should provide much new information about this problem. The springs of the Cracow-Czestochowa Upland are currently being monitored in this way.

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ANALIZA KEMOGRAMOV IZVIROV V PRIMERU VPLIVA EFEKTA TALJENJA SNEGA IN IMPULZOV RAZPRŠENEGA ONESNAŽENJA (NA PRIMERU IZVIROV V KRAKOWSKO-CZESTOCHOWSKEM VIŠAVJU)

Povzetek

Napajanje, tok in vskladiščenje podzemne vode so lahko v karbonatnih vodonosnikih ekstremno spremenljivi. Skladno z različnimi stopnjami zakraselosti je lahko napajanje v razponu od koncentriranega do razpršenega. Članek predstavlja rezultate proučevanja onesnaženja glede na različne načine napajanja v karbonatnih vodonosnikih. V ta namen je bil izpeljan monitoring temperature vode in koncentracij glavnih ionov v nekaterih izvirih višavja Krakow-Czestochowa v južni Poljski.

Analize kemogramov kraških izvirov, ki jih običajno srečujemo v mednarodni literaturi, so bile pregledane in ponovno ovrednotene. Tradicionalni modeli napajanja zaradi taljenja snega na kraških območjih zmernega podnebja in človeškega vpliva v zmerno-hladni klimi so bili ocenjeni in predlagane so bile nekatere spremembe. V predlaganem novem modelu se efekt taljenja snega in impulzi onesnaženja odražajo na kemizmu voda - značilna povečanja koncentracij Ca^{2+} , SO_4^{2-} in NO_3^-, celokupne trdote in specifične električne prevodnosti vode v tleh, epikraške vode in vode na izvirih - pri maksimalnih vrednostih napajanja zaradi taljenja snega. To spremlja še relativno nizka vsebnost bikarbonatov. Koncentracija kalcija in celokupna trdota v staljeni vodi sta bolj povezani s sulfati in nitrati iz onesnaženja kot pa z efektom raztapljanja v sistemu $CaCO_3$ - H_2O - CO_2.

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A COMPARISON OF RED SOILS FROM SOUTH AUSTRALIA AND JAPAN

PRIMERJAVA RDEČIH PRSTI IZ AVSTRALIJE IN JAPONSKE

KAZUKO URUSHIBARA-YOSHINO [1]

Izvleček: UDK 631.44(94+520)
Kazuko Urushibara-Yoshino: Primerjava rdečih prsti iz Avstralije in Japonske

Avtorica je vzorčevala prsti s karbonatnih peskov in terciarnih apnencev v južni Avstraliji, kjer je tipično mediteransko podnebje. S starostjo peščin se manjšajo kalcitna zrna v prsti, s starostjo pa upada tudi aktivnost železa. Po drugi strani pa s starostjo narašča kristalizacija železa. Aktivnost železa postane izredno majhna v istem starostnem razredu, a v monsunskem podnebju otočja Nansei (Japonska). Tudi tekstura B horizonta se spremeni, namesto grobega peska je visoka vsebnost gline. Drugi namen prispevka je tudi primerjava hitrosti razvoja lastnosti prsti na Kitajskem.
Ključne besede: krasoslovje, pedologija, rdeča prst, Avstralija, Japonska.

Abstract UDC 631.44(94+520)
Kazuko Urushibara-Yoshino: A comparison of red soils from South Australia and Japan

The soils formed from calcareous sands and from the Tertiary limestone in South Australia were sampled. The climate in the area is a typical Mediterranean. The calcite grain in the soils decreases with the age of the sand dunes. The iron activity in the soils decreases with age. On the other hand, the iron crystallinity increases with age. The iron activity became extremely small during the same age under Monsoonal climate of Nansei Islands (Japan). The texture of B horizons also change from rich coarse sand to high clay contents. Second purpose is to compare the development speed of soil properties in the Karst areas in China also.
Key words: karstology, pedology, red soil, Australia, Japan.

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INTRODUCTION

In areas of calcareous rocks, the rate of soil development is extremely slow, when we compared it in areas with non-calcareous rocks. The dating of soils is very difficult in karst areas. In this paper the dating of mother materials is used to make a relative time scale for the soils. Of course, it must have some time lag in forming soils from the mother materials.

The first purpose of the present paper is to find better indices of soil properties that change with time. The study areas are, therefore, very limited, because the mother materials have to be dated. As examples, the Nansei Islands of Japan and the south-east coastal region of South Australia have been chosen as study areas.

The second purpose of the study is to compare the development speed of soil properties under the influence of different climates - the Monsoon climate areas of Japan as an example of rather wet climate areas, and the Mediterranean climate area of South Australia as rather dry climate areas.

The results of previous studies have made clear the following. The younger processes of the soil developments (A/C) are similar, and have been named Rendzina in areas of different climate. Rich humus can remain for a longer time, because of the combination with rich calcium ion. After the soils were matured as (A/B/C) profile, the clay contents became higher. The heavy soil was called as Terra Rossa in the Mediterranean climate. The rich bases have been kept for a longer time in soil profiles in the dry and summer season.

In the Nansei Islands of Japan, local people called the clayish soils on the uplifted coral reefs Shimajiri Maji. However, the properties of mature soils in limestone areas in Japan may not accurately correspond to Terra Fusca and Terra Rossa in the Mediterranean climate areas. Kato (1989) describes the progressive series from Rendzina-like soil, Terra Fusca-like soil, Terra Rossa-like soil (dark red soil) to ferrallitic red soil in East and South-East Asia. The reaching of bases and de-silicification and aluminisation also occur predominantly in the older soils in the karst areas in China (Nanjing Institute of Soil Sciences, Academia Sinica, 1978).

The South-East of South Australia

The study area chosen is from Naracoorte to Robe (about 100km) in the south-east of South Australia, in where Schwebel (1983, 1984) had done the sequence dating of calcarenite dunes using ^{14}C dating, Uranium Series, ^{18}O and Palaeomagnetism. The study area is shown in Fig. 1. The climate of this area is Cs by Köppen's classification. The annual precipitation is 580 mm, and the annual mean air temperature 8,1°C. Original vegetation with *Eucalyptus* and *Acacia* remain on the ridges of the dunes, but the other flat lands are used for pastures. A soil map has made by Blackburn (1983). In the coastal sand dune

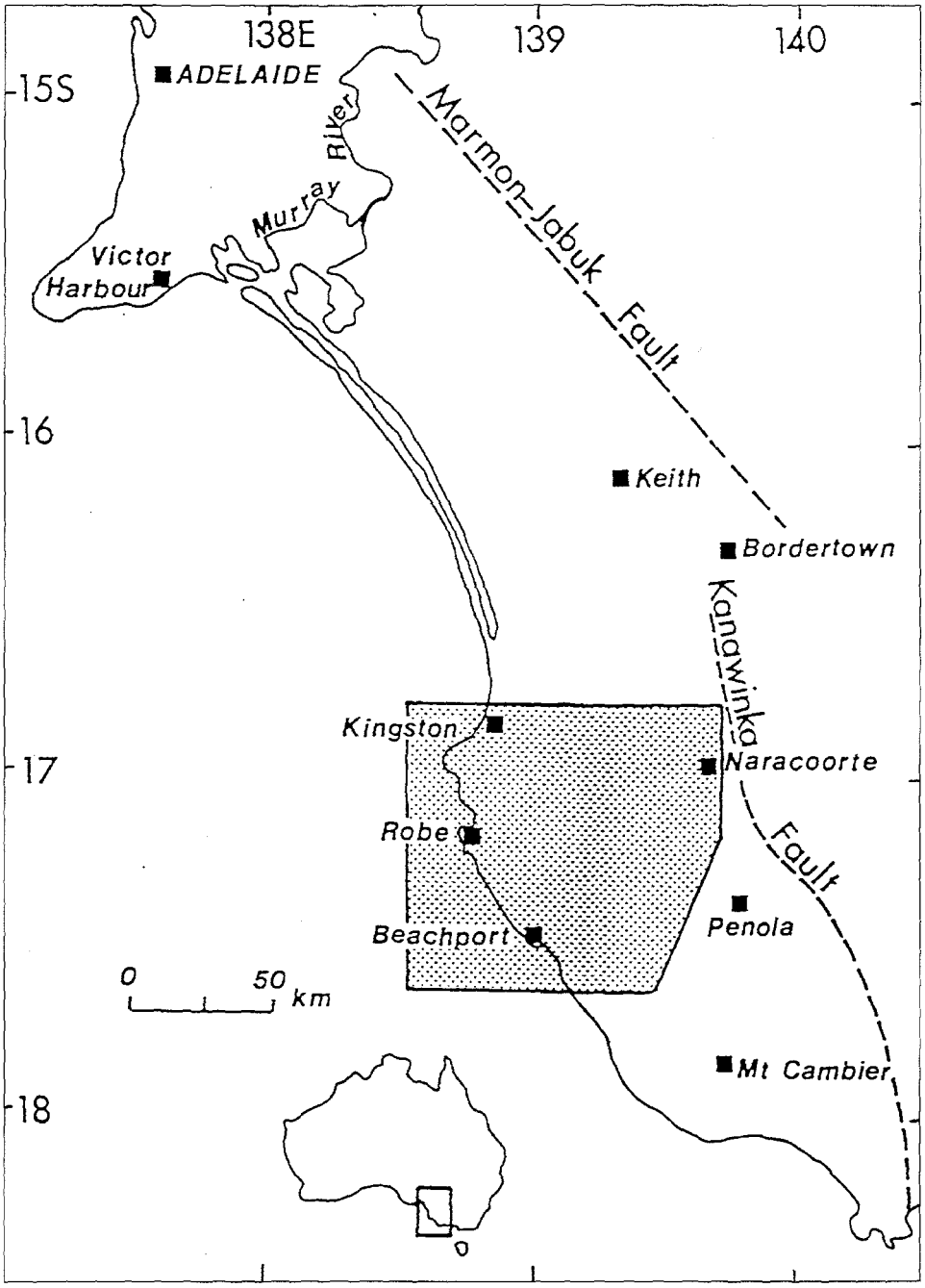
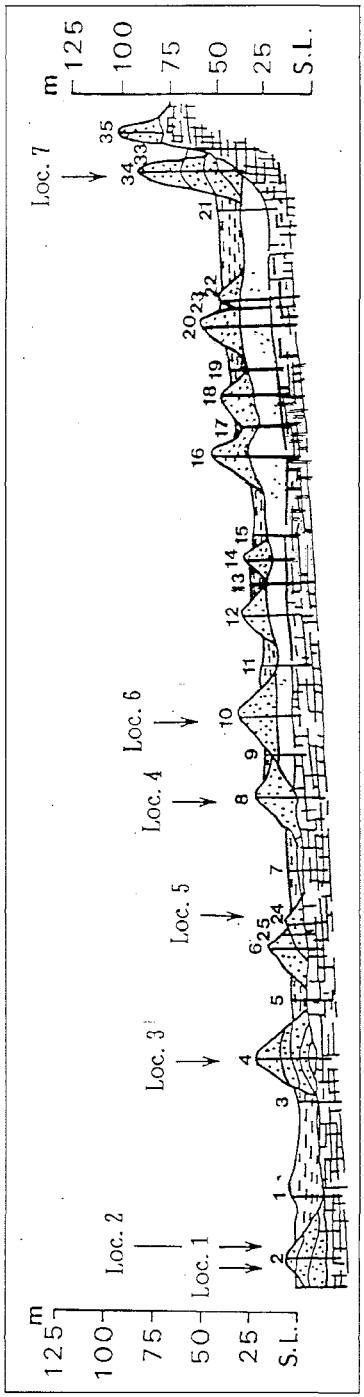


Fig. 1: Study areas of south-east South Australia.



areas, ^{14}C dating has done by Ohmori et al. (1987). The results are from 1,500 yr. B.P. to 5,000 yr. B.P.. Schwebel (1983, 1984) dated sand dunes as follows. The soil sample places and dating points are shown in Fig. 2.

Dating as

BMR 2 RI (4,300±100 yr. B.P.)
:Soil sample Locality 1

BMR 2, RII, RIII (83,000–93,000 yr. B.P.)
:Soil sample Locality 2

BMR 4 (125,000 yr. B.P.)
:Soil sample Locality 3

BMR 8 (248,000 yr. B.P.)
:Soil sample Locality 4

BMR 24, ED (309,000 yr. B.P.)
:Soil sample Locality 5

BMR 10, WA (347,000 yr. B.P.)
:Soil sample Locality 6

BMR 34, WNIV (690,000 yr. B.P.)
:Soil sample Locality 7

Miocene, Tertiary limestone
:Soil sample Locality 8

The calcite contents of A_1 horizon in Locality 1 is higher than the quartz. But in the B horizon at Locality 2, where the dune is dated as 83,000–93,000 yr. B.P., the calcite contents is only 1%. Especially, calcite is non-existent in the B_2 horizon at Locality 7 (690,000 yr. B.P.) and Locality 8 in the area of Tertiary limestone.

The texture of B horizons also changes from rich coarse sand to high clay contents with increasing age of the sand dunes. The iron in a typical horizon in each soil profile has been analysed by three methods (Nagatsuka 1975), as follows:

Fig. 2: Profile of sand dunes by Schwebel, 1983 and the Locality numbers of soil samples.

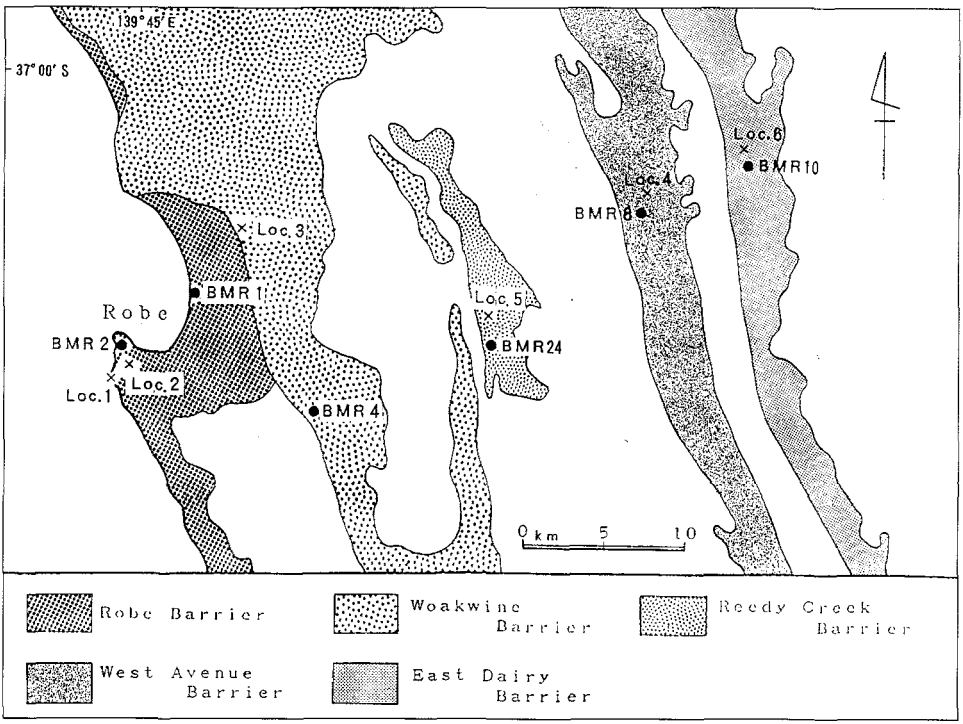


Fig. 2a: Map of sand dunes by Schwebel, 1983 and the Locality numbers of soil samples.

Fe_o: Tamm solution (Tamm 1934), was used for extraction. This solution can extract free irons of absorbed states, free iron combined with organic matter, amorphous ferric hydroxide and almost all of lepidocrocite, magnetite and some goethite.

Fe_d: Free iron oxide extracted by the dithionite-citrate-bicarbonate solution is expressed as Fe_d (Mehra and Jackson 1960).

Fe: Total iron, which is expressed as Fe_t, is extracted in a specially designed vessel made of Teflon by hydrochloric acid, nitric acid and hydrogen fluoride.

Fe_o/Fe_d is expressed as activity ratio of free iron oxide. $(Fe_d - Fe_o)/Fe_t$ shows the crystallinity ratio of iron oxides.

The iron activity (Feo/Fed) shows a high value in younger dunes. On the other hand, iron activity decreases with the age of sand dunes. The iron crystallinity, $(Fe_d - Fd_o)/Fe_t$, ranges from 0.3 to 0.55 according to age. However, the value from 125,000 yr. B.P. shows an anomalous positive deviation from the general trend curve.

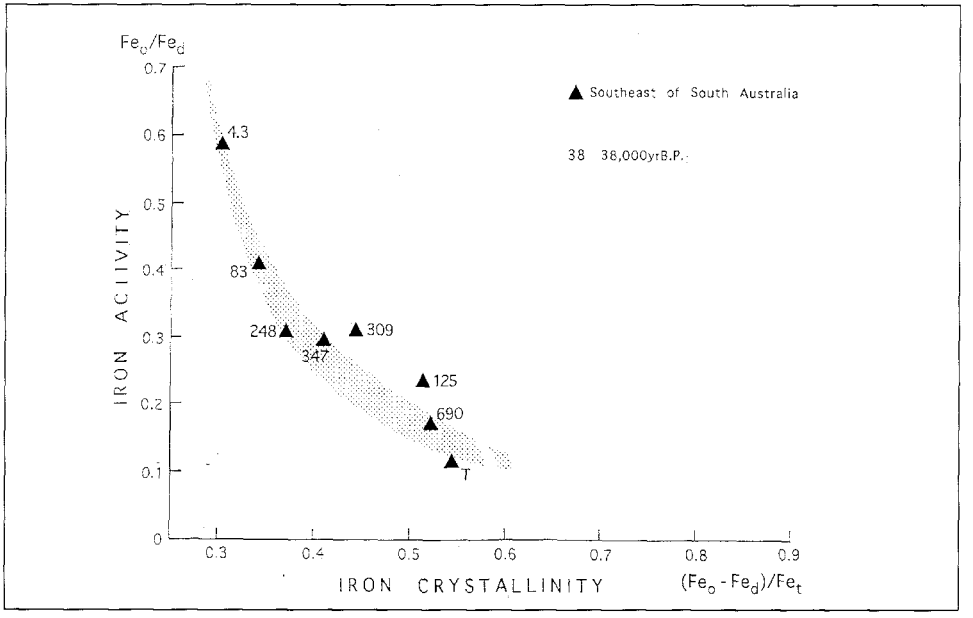


Fig. 3: The iron activities and iron crystallinities of typical horizons in south-east South Australia.

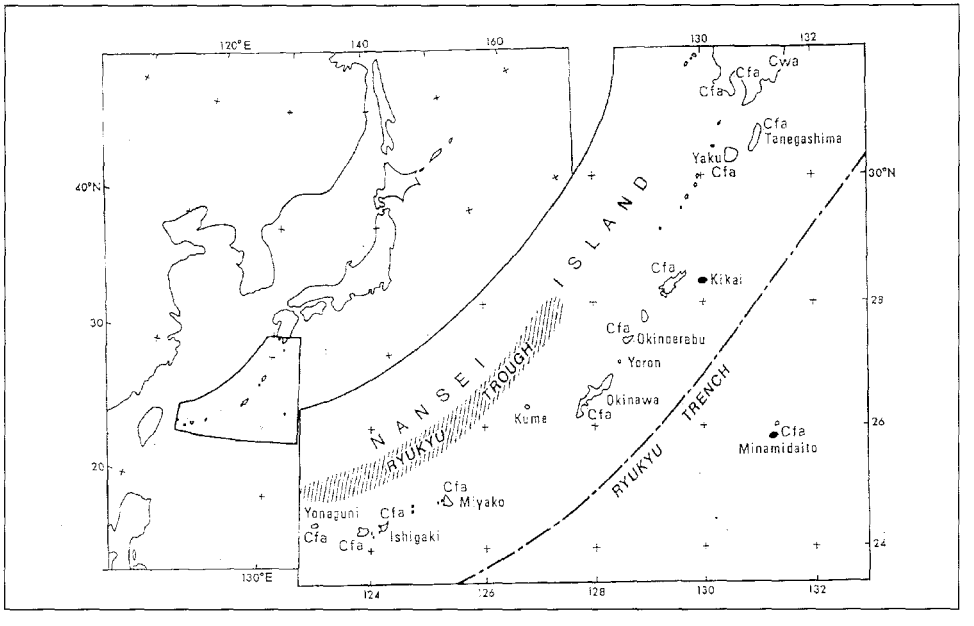


Fig. 4: The distribution of prevailing Köppen's climate in Nansei Islands in Japan and the location of the study islands.

The relationship between iron activity and iron crystallinity with age is shown in Fig. 3. An anomalous value for 125,000 yr. B.P., as mentioned above, is clearly seen in this figure. It is estimated that calcite increases and quartz amounts decrease around 125,000 yr. B.P. The soils iron activity decreases and iron crystallinity increases under the local conditions, especially under the wetter conditions of the soils rather than the other calcareous dunes.

Nansei Islands in Japan

In the Nansei Islands, the highest uplift rate is 1.8-2.0 mm/year, which is estimated by the sequence of uplifted coral terraces on Kikai Island. The soils have been taken on each terrace, of which corals were dated as 125,000 yr. B.P., 90,000~80,000 yr. B.P., 65,000~55,000 yr. B.P., and 38,000 yr. B.P. (Konishi et al. 1974). Then the soils were analysed. Furthermore, soils on terraces older than 125,000 yr. B.P. had been taken from Minamidaito Island. The oldest part of this island is estimated as at least one million years old. Both islands are shown in Fig. 4.

These areas belong to the subtropical Monsoon climate. In Köppen's climate classification, Cfa appears dominantly (Urushibara 1980). The Nansei Islands are relatively humid in contrast to the surrounding areas, because the Pacific Polar Frontal Zone is located over these islands in winter. The annual temperature is 22.9°C and the annual precipitation is 1673 mm in Minamidaito island.

The soil profiles on the old terraces are thicker than on the younger terraces. The results of iron activities and iron crystallinities of soils were analysed and considered with the age of terraces (Urushibara-Yoshino 1989, 1992). The crystallinity of iron in B_2 horizons increases with decreasing iron activity in accordance with the age of terraces as shown in Fig. 5. The free iron oxides in the soils decreased rapidly with the age of the terraces. These conditions were thought to result from the Monsoon, wet and hot climate.

Comparison of Red Soils

Iron crystalline properties of red soils formed from calcareous materials were compared in the south-east of South Australia and in the Nansei Islands of Japan. The iron activities of soils are very high in south-east South Australia, and the iron crystallinities are smaller than that of the Nansei Islands. The trend curve of both indices is more steep in south-east South Australia than in the Nansei Islands.

The soils, whose mother materials were dated as around 80,000 yr. B.P., were compared in both areas. The iron activities of soils in south-east South Australia are about 10 times higher than that of the Nansei Island's soils. The crystallinity of iron in soils in the Nansei Islands, of same age, is twice that of

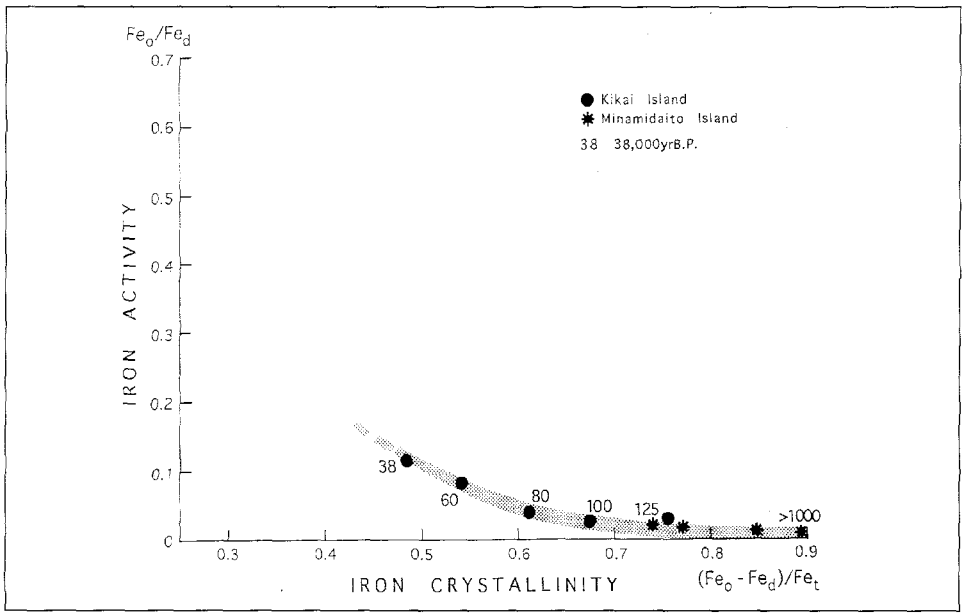


Fig. 5: The iron activities and the iron crystallinities in B_2 horizon in Nansei Islands.

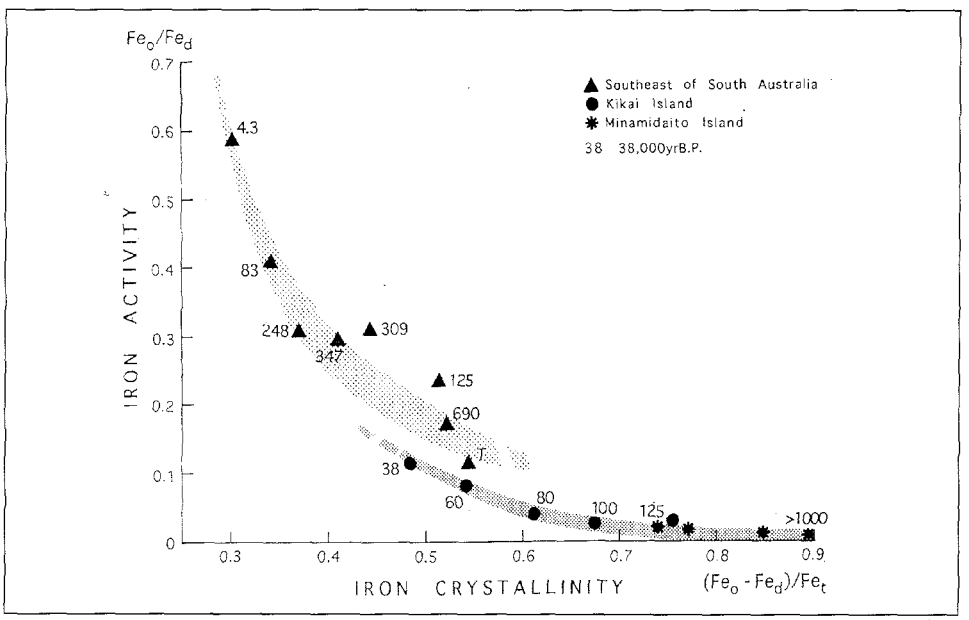


Fig. 5a: The iron activities and the iron crystallinities in B_2 horizon in South Australia.

the South Australian soils. The trends of both indices is same in the other ages also. From these results, it can be concluded that free iron can keep for a longer time in the Mediterranean climate than in the Monsoon climate. On the contrary, the iron crystallinity of soils increases more rapidly under the Monsoon climate than the Mediterranean climate. It should be stressed that the speed of the soil formation process is different under different climate conditions, even though the shape of the trend curves is almost similar.

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PRIMERJAVA RDEČIH PRSTI IZ AVSTRALIJE IN JAPONSKE

Povzetek

Avtorica je vzorčevala prsti s karbonatnih peskov na koralnih grebenih japonskega otočja Nansei (domače ime zanje je Shimajiri Maji), dvignjenih nad morsko gladino, in s terciarnih apnencev v jugovzhodni Avstraliji, kjer je tipično mediteransko podnebje. S starostjo peščin se manjšajo kalcitna zrna v prsti, kvarcitna zrna so vedno bolj zaobljena, s starostjo pa upada tudi aktivnost železa. Po drugi strani pa s starostjo narašča kristalizacija železa. Prsti s karbonatnih sipin so stare med 4.300 leti B.P. in 690.000 leti B.P. V monsunskem podnebju otočja Nansei, postane aktivnost železa izredno majhna v istem starostnem razredu. Tudi tekstura B horizonta se spremeni, namesto grobega peska je visoka vsebnost gline. S starostjo se v vlažni in vroči klimi delež prostega železa zelo hitro manjša. Bogatenje z bazami, desilifikacija in aluminizacija so procesi, ki prevladujejo tudi v starejših prsteh na kitajskem krasu.

ACTA CARSOLOGICA	XXVI/2	34	397-407	LJUBLJANA 1997

KARST DEPRESSIONS WITH PRECIPICED WALLS ON THE SOUTHERN SLOPE OF SNEŽNIK MOUNTAIN, SLOVENIA

KRAŠKE DEPRESIJE S PREPADNIMI STENAMI NA JUŽNEM POBOČJU SNEŽNIKA, SLOVENIJA

NADJA ZUPAN HAJNA[1]

Izvleček UDK 551.4(497.4)

Nadja Zupan Hajna: Kraške depresije s prepadnimi stenami na južnem pobočju Snežnika, Slovenija

Snežnik (1796 m) je visoka kraška planota, s kopastimi vrhovi in velikimi depresijami, s številnimi vrtačami in snežnimi kotliči. Na nagnjenih apnenčevih plasteh so žlebiči. Med jamami prevladujejo brezna. Snežnik gradijo jurski in kredni apnenci ter dolomiti, veliko je ledeniškega in periglacialnega gradiva. Kraške depresije s prepadnimi stenami so tipične za področje Ždrocel, južno od vrha Snežnika, na nadm. v. 1300 - 1400 m. Oblikovane so v spodnjekrednih apnencih z dolomiti in dolomitnimi brečami. Prepadne stene so izoblikovane v razpoklinski coni v smeri N-S.

Ključne besede: speleologija, speleomorfologija, kraška depresija, Ždrocla, Snežnik, Slovenija.

Abstract UDC 551.4(497.4)

Nadja Zupan Hajna: Karst depressions with precipiced walls on the southern slope of Snežnik Mountain, Slovenia

Snežnik (1796 m) is a high dissected karst plateau with cone summits, large depressions, and snow kettles. On some limestone surfaces are grooves. The shafts prevail. The Snežnik region consists of Jurassic and Cretaceous limestones and dolomites, yet there is glacial and periglacial material. Karst depressions with steep and precipiced walls are typical of the area of Ždrocle, south of the Snežnik summit at 1300 - 1400 m a.s.l. They developed in Lower Cretaceous limestones with dolomites and dolomitic breccias. The precipiced walls are controlled by fissured zone trending N-S.

Key words: speleology, speleomorfology, karst depression, Ždrocla, Snežnik Mt., Slovenia.

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INTRODUCTION

Snežnik is a high karst plateau in the south of Slovenia, near the border with Croatia. The massif of Snežnik mountain is a prolongation of Javorniki mountain, which starts E from Postojna. Snežnik's highest peak is 1796 m. At its dissected elevations cone summits with, large depressions among them are very frequent (Habič 1981). It is generally valid that the formation of deep karst depressions depends upon how much the carbonate rocks are fissured and crushed (Habič 1986). Large depresions were influenced by glaciation during the last Ice Age (Habič 1978). On levelled areas there are numerous dolines, snow kettles and larger gently sloping dolines. There are also caves, and them shafts prevail. There are almost no superficial flows, just very short ones from small local springs. The springs are at about 600 m a.s.l., so the vadose zone may be about 1000 m deep. Almost all area is covered by forest, except the slopes of highest peak and some grassy areas (Fig. 1).

This paper will represent the interesting geomorphological feature from Snežnik mountain, the so called Ždrocle (Ždrocla, in the singular). Ždrocle are karst depressions with steep and precipiced walls. They are typical of the area of Ždrocle, in the south from the Snežnik summit at 1300 to 1400 m a.s.l.. Southwest from the small source "Andrejev Studenec", the area takes its name from the 1478 m high summit called Ždrocle, and the same name is in local use for big depressions (Šušteršič 1977). Snow that may stay all the year round is additionally reshaping their bottoms. Andrejev Studenec is located on the north part of a bigger grassy area. Traces of periodical water flows and some small sink holes are situated at the south part of it.

By aerial photography at scale 1 : 30000 the location and shape of large depressions were registered as well as the main fault directions of the Ždrocle area. During the field work in 1995 and 1996 the positions of depressions were defined and measurements of geological structural elements were done. I am grateful to colleagues from the Karst Research Institute who did the field work with me, because the area is unusually wild, covered by untouched forest and inhabited by bears.

SPELEOLOGICAL RESEARCHES IN ŽDROCLE

The area was first researched by Italian speleologists before World War II. About 20 years ago same research was done by Karst Research Institute SAZU from Postojna. Big depressions with precipice walls were found and they named them Ždrocle (Šušteršič 1975). After that a lot of caving exploitation of the area was done by caving clubs from Rakek, Ljubljana, Postojna and others. According to data from the Cave Register there are about 20 caves, all of them vertical shafts 10 to 30 m deep on average. The deepest shaft is of U-profile and is more than 100 m deep, but has no plan in the cave register. The second is Andrejevo Brezno which is 70 m deep.

Karst depressions with precipice walls are big snow kettles or shafts and they are about 30 to 50 m deep. According to the Cave Register five of them are recorded. Only two have ground plans and cross-sections; these are Ždrocla 1 and Ždrocla 3. Ždrocla 3 is a shaft about 65 m deep. The others have only registration numbers and descriptions of their location. For the determination of positions of the depressions I have used topographical and aerial-photo maps.

From the topographic map and the co-ordinate system I have determined position of Ždrocla 1, 2, 3 and 5, but the position and even the existence of Ždrocla 4 is in doubt.

Descriptions of depressions from the cave register are as follows:

Ždrocla 1: Reg. No.: 4261; a.s.l.: 1401 m; depth: 54 m; type: 6.6 - shaft with permanent ice; lithology: $K_{1,2}$ - limestone and dolomite and breccia; genesis: obvious connection to a N-S fissure zone;

Ždrocla 2: Reg. No.: 4262; a.s.l.: 1405 m; depth: - m; type: 6,4; lithology: $K_{1,2}$ - limestone and dolomite and breccia; genesis: obvious connection to a N-S fissure zone;

Ždrocla 3: Reg. No.: 4263; a.s.l.: 1398 m; depth: 89 m; type: snow kettle with shaft 6,4; lithology: $K_{1,2}$ - limestone and dolomite and breccia; genesis: obvious connection to a N-S fissure zone;

Ždrocla 4: Reg. No.: 4297; description of its shape and location is bad; there is no such depression in the area.

Ždrocla 5: Reg. No.: 4298; a.s.l.: 1395 m; depth: - m; type: 6,4; lithology: $K_{1,2}$ - limestone and dolomite and breccia; genesis: obvious connection to a N-S fissure zone; other: without ground plan.

GEOLOGY OF THE AREA

According to Placer's (1981) the explanation of the geologic structure of south-western Slovenia, Snežnik is a thrust sheet of carbonate rocks over flysch rocks. The plateau is built of Jurassic and Cretaceous limestones and dolomites and their breccias. Also periglacial and glacial material can be found on its surface. According to the Basic geological map, sheet Ilirska Bistrica (Šikić, Pleničar and Šparica 1972), the area is built in Lower Cretaceous limestone, dolomite and breccias. On the southern slope of Snežnik on the surface are: K_1- limestones, dolomitic and limestone breccia, mostly recrystalized; $K_{1,2}$ - limestone, dolomite and dolomitic breccia; $J_3^{2,3}$ - light and dark grey limestone with clipeinas and salipingoporelas. All over the plateau a lot of glacial material could be found, first mentioned by Pleničar in 1956. The detailed research of glacial material from Snežnik was done in 1959 by Šifrer. He described the glacial material from its slopes and he defined the location of the ice and snow line and also the routes of glacier movements. From this area the glacier flowed probably towards E and SE. It is important that during

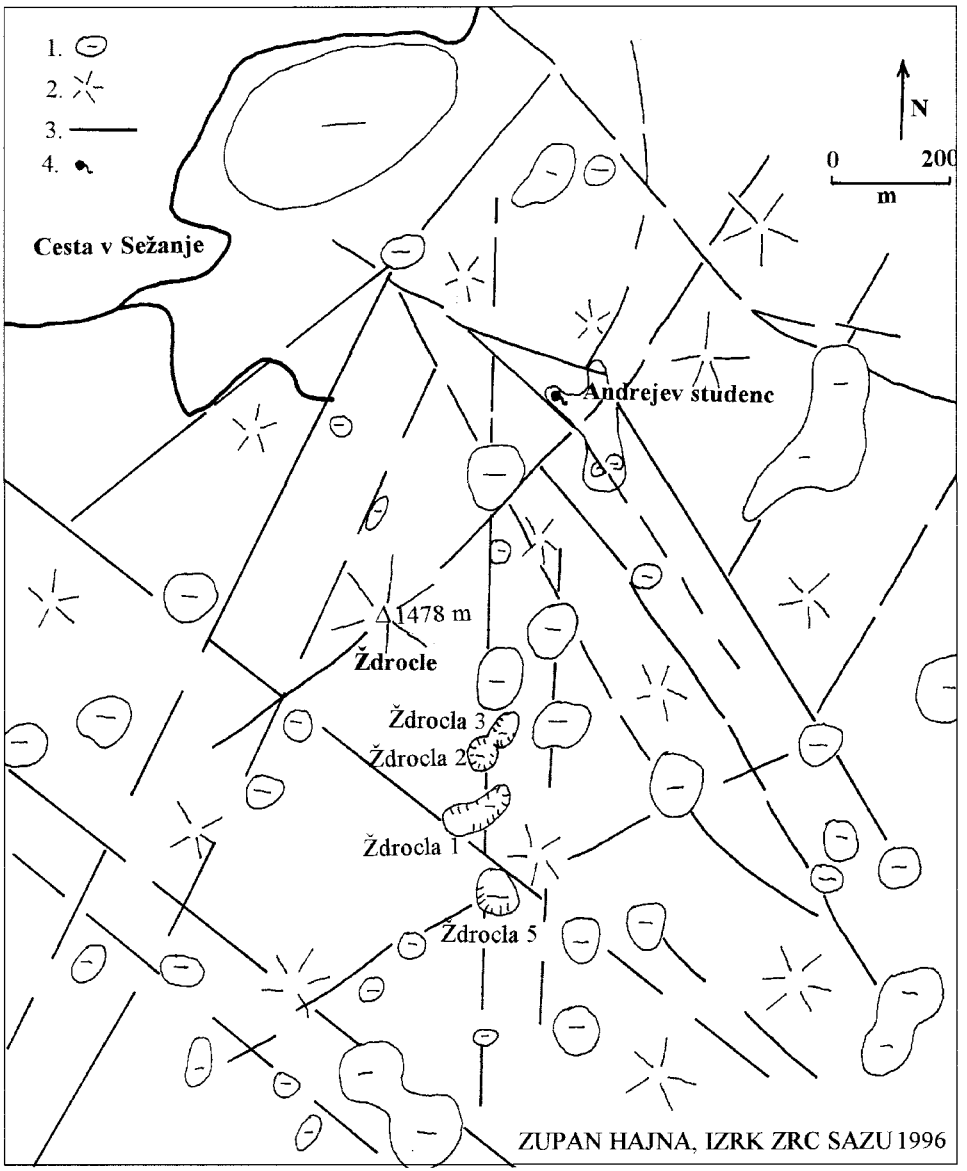


Fig. 2: Photo aerial interpretation of locations of the faults and depressions, Ždrocle, Snežnik Mt. (1. depression, 2. summit, 3. fault, 4. spring).

Sl. 2: Fotoaero interpretacija položaja prelomov in depresij, Ždrocle, Snežnik (1. depresija, 2. vrh, 3. prelom, 4. izvir).

the last glaciation the area of Ždrocle, at 1400 m a.s.l., was higher above the perpetual snow line and that it was covered by permanent ice.

By aero-photography at scale 1:30000 the location and shape of the larger depressions was registered as well as main tectonic directions (Fig. 2). The most distinctive are Dinaric trending faults yet there are also transverse faults. Less distinctive, but traced by a series of depressions, is N-S direction; the same trends were defined by mapping in the field.

RESULTS OF TECTONIC MEASUREMENTS IN THE AREA

For better explanation, why these big depressions with vertical walls are situated in this area I did some geological research during July and September 1995 and in June 1996.

In the area limestone beds generally dip toward N - NE; measured directions of dips are from 10^0 to 40^0, with dip angle from 10^0 to 30^0; at some places they are almost horizontal and at others their dips are very steep. Just at the most east part of the area I measured the dip toward NW, with dip angle 20^0. The thickness of the beds is half a meter on average. More dolomitic breccia located on west side of the area is not stratified. After Čar (1982) and Šebela (1995) I have distinguished three different types of fractured carbonate rocks: crushed zone, broken zone and fissured zone (Fig. 3).

Very well expressed are faults and crushed zones in Dinaric (NW-SE) direction. On the west side of Ždrocla 1, directly through Ždrocla 2 and 3, is situated, a strong crushed zone in cross Dinaric (NE-SW) direction. The same type of crushed zone goes through Ždrocla 5. A wide crushed zone is also situated south of Andrejev Studenec in N-S direction. But in other places the N-S direction is represented by fissures in more or less wide zones.

At a levelled surface at about 1400 m a.s.l., north from source Andrejev Studenec, really interesting rough karst terrain is situated. The closest to the road and easiest to reach is the smallest Ždrocla - Ždrocla 3. **Ždrocla 3** is snow kettle about 30 m deep connected to fissured zone in N-S direction. The fissured zone is a series of parallel fissures where no displacement is seen. Also the fault in E-W direction is well expressed and it crosses Ždrocla on the north side. Limestone beds are almost horizontal with slight dip towards NE. The north slope is not so steep and the bottom, which is covered by snow, is easily reached by it. In the east wall the entrance to a shaft about 60 m deep. In the middle of south wall a big fissure is located. The wall is opened by it from the top to the bottom. The fissure is a few cm wide and it is prolonged to the Ždrocla 2 which is located close towards the south.

Ždrocla 2 is a depression about 40 m deep, all walls are vertical. At a depth of 30 m is a small almost horizontal step and after this there is precipiced wall down to the bottom, where snow lies during whole year (Fig. 4). The N-S fissured zone is well expressed in the south and north walls and

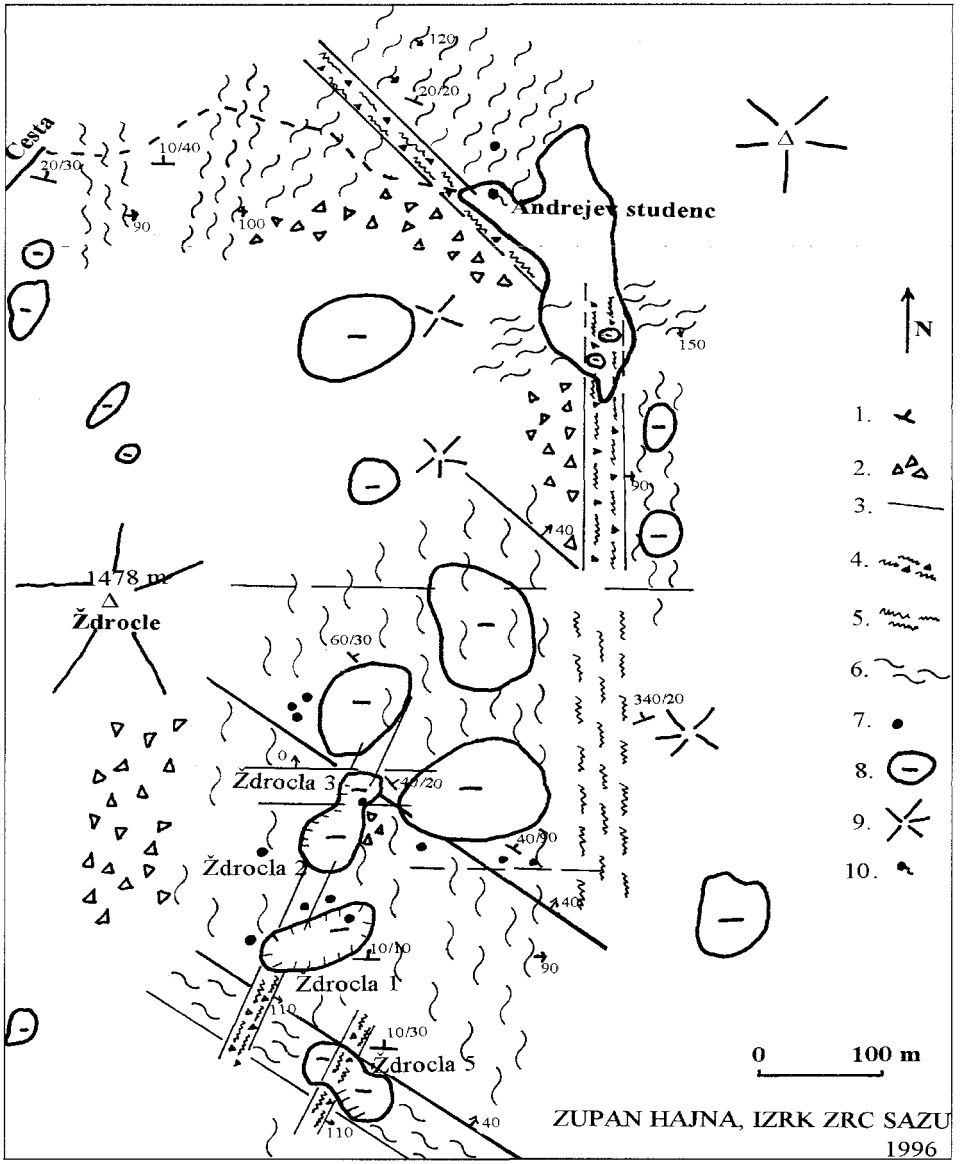


Fig. 3: Geological structural elements of the Ždrocle area.
1. dip and strike of the strata, 2. dolomitic breccia, 3. fault, 4. crushed zone, 5. broken zone, 6. fissured zone, 7. cave, 8. depression, 9. summit, 10. spring.

Sl. 3: Geološki strukturni elementi na področju Ždrocel.
1. vpad in smer plasti, 2. dolomitna breča, 3. prelom, 4. zdrobljena cona, 5. porušena cona, 6. razpoklinska cona, 7. jama, 8. depresija, 9. vrh, 10. izvir.

along the east and west walls. At the surface above the east wall of Ždrocla 2 big grikes from 0,5 m to about 2 m high are well expressed. They are also developed in a N-S direction.

South of Ždrocla 2 is located **Ždrocla 1.** With its 54 m depth and about 80 m width, it is the largest Ždrocla. All its walls are vertical; just at the SW slope the bottom can be reached without ropes. This slope is cut by a zone some meters wide of very crushed rocks. From this slope also a lot of gravel is sliding towards the bottom and the slope is covered by it. The bottom of Ždrocla 1 is covered by snow long into the summer.

The most southern depression with precipiced walls is **Ždrocla 5**. This one is not so deep; just one wall is really vertical but its bottom also was still covered by snow in June.

CONCLUSIONS

Four depressions with precipiced walls to the South of the spring Andrejev Studenec display the most prominent features. All of them are developed in Lower Cretaceous limestones with dolomites and dolomitic breccias. The precipiced walls are controlled specially by fissures trending from N to S. By aero-photography the most distinctive are Dinaric-trending faults, yet there are also transverse faults, less distinctive, but traced by a series of depressions in N-S direction. In conclusion I can say that big depressions with vertical walls are developed in Lower Cretaceous well-bedded limestones with dolomites and limestone breccias and that precipiced walls are controlled specially by a fissured zone trending from N to S. But in more dolomitic breccias north of Andrejev Studenec, where karst terrain is not so rough, the surface is more gentle, and the depressions and grikes are not developed. Their connection with lithology and tectonic structure is obvious. Genesis of depressions is linked with corrosion along N-S fissure zone, where limenstone is more crushed and with this more prepared for solution. Corrosion is forced also by snow which may stay in the bottoms of depressions all the year and it can strongly reshape their bottoms. And we also have to take into account that during last glaciation this area was covered by ice (Šifrer 1959). Arguing against the possibility that they are collapse dolinas is fact that the origin of collapse dolines is attributed to collapse of large horizontal passages above underground water flows (Mihevc 1995), and in this area no horizontal galleries were found. But the question of they are shafts or snow kettles is still open.

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KRAŠKE DEPRESIJE S PREPADNIMI STENAMI NA JUŽNEM POBOČJU SNEŽNIKA, SLOVENIJA

Povzetek

Snežnik je visoka kraška planota, ki ima razčlenjene povprečne višine, z najvišjim vrhom 1796 m. Velika večina površja je porasla z gozdom (Sl. 1). Področje Snežnika gradijo jurski in kredni apnenci ter dolomiti, veliko je pa tudi ledeniškega in periglacialnega materiala. Poledenitve na področju Snežnika je opazil že Pleničar (1956), podrobneje jih je pa opisal Šifrer (1959). O preoblikovanju kraških depresij z ledom, je na področju visokih kraški planot v Sloveniji pisal tudi Habič (1978).

Kraške depresije s prepadnimi stenami so tipične za področje Ždrocel, južno od vrha Snežnika, na nadmorski višini med 1300 in 1400 m. Globoke depresije so oblikovane v spodnje krednih apnencih z dolomiti in dolomitnimi brečami.

Italijani raziskovali tu pred II. svetovno vojno. Velike snežne kotle so našli člani Inštituta za raziskovanje krasa ZRC SAZU pri pripravi Speleološke karte, ko so iskali udornico že s prej obstoječe italijanske specialke, in so jih poimenovali Ždrocle (Šušteršič 1975). Na tem področju je raziskanih tudi veliko brezen, nekatera od njih imajo vhode v samih Ždroclah, na njihovem robu ali pa v neposredni bližini. Po Jamskem katastru je tu registriranih 20 jam, načrte pa jih ima 13. Vse so brezna globoka med 10 m in 30 m, najgloblje pa je brezno U-profil z več kot 100 m, vendar njegovega načrta ni v katastru.

Ker je sama orientacija na terenu otežena zaradi prekritosti z gozdom in slabih kart, sem si pomagala s fotoaero posnetki v merilu 1 : 30000. Tako sem lahko določila lego večjih globeli in njihovo število ter glavne smeri prelomov (Sl. 2). Najlepše so izraženi prelomi v dinarski smeri in prečno nanje. Slabše opazna, vendar sledena z nizom globeli, je smer N - S. Vse smeri prelomov opazne na aero posnetkih so bile določene tudi na terenu. Po Čaru (1982) in Šebeli (1992) sem na terenu ločila tri različne tipe tektonsko pretrtih karbonatnih kamnin: zdrobljeno cono, porušeno cono in razpoklinsko cono (Sl. 3).

Po podatkih iz Jamskega katastra, foto-aero posnetkih in terenskem kartiranju sem določila lego Ždrocle 1, Ždrocle 2, Ždrocle 3 in Ždrocle 5. V obstoj Ždrocle 4 pa glede na podatke dvomim, možno je, da obstaja, vendar precej drugje kot je opisano. Največja je Ždrocla 1, Ždrocla 2 in 3 pa sta povezani skozi nekaj centimetrov široko razpoko. V vzhodni steni Ždrocle 3 se odpira vhod v okrog 60 m globoko brezno. Ždrocle so globoke med 30 in 50 metri, različno široke, za vse pa so značilne prepadne stene vsaj s treh strani. Prepadne stene so kontrolirane z razpoklinsko cono v smeri N-S, vzhodna in zahodna stena, in s prelomi v dinarski smeri (NE-SW), južna in severna stena. V dnu Ždrocl se zadržuje sneg, včasih tudi čez vse leto in tako preoblikuje njihovo dno. Proti možnosti, da so te depresije po svojem nastanku udornice, govori dejstvo, da je nastanek udornic povezan z velikimi vodoravnimi jamami nad vodnimi tokovi (Mihevc 1995), na tem področju pa ni znanih večjih vodoravnih jam. Vprašanje ali so te depresije s prepadnimi stenami po svojem nastanku brezna ali snežni kotliči pa še vedno ostaja odprto.



Fig. 1: Snežnik is a high karst plateau; it has a dissected average elevation; the highest peak is 1796 m; almost all area is covered by forest.

Sl. 1: Snežnik je visoka kraška planota; ima razčlenjene povprečne višine, z najvišjim vrhom 1796 m, skoraj vsa površina je pokrita z gozdom.

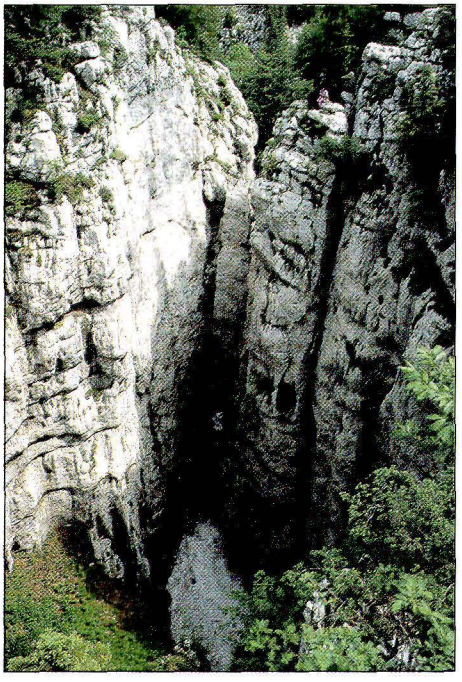


Fig. 4: Ždrocla 2, about 40 m deep depresion, with snow at the bottom and with fissures in N-S direction.

Sl. 4: Ždrocla 2, okrog 40 m globoka depresija s snegom v dnu in razpokami v smeri N-S.

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ACTA CARSOLOGICA	XXVI/2	35	411-430	LJUBLJANA 1997

PONOVNO O LUKNJAH V NOSOROGOVIH KOSTEH IZ DOLARJEVE JAME

NEW DISCUSSION ABOUT THE HOLES IN RHYNOCEROS' BONES FROM DOLARJEVA JAMA

PAVEL JAMNIK[1]

Izvleček UDK 902.035(497.4)

Jamnik Pavel: Ponovno o luknjah v nosorogovih kosteh iz Dolarjeve jame

V članku so ponovno obravnavane luknje v fosilnih nosorogovih kosteh iz Dolarjeve jame pri Logatcu. V ohranjeni zbirki kosti iz te jame je bilo odkritih še pet lukenj, tako da jih je sedaj skupno enajst na devetih kostnih fragmentih. Obravnavan je vnos ilovnatega sedimenta in kosti v jamo, opravljena je bila kemična analiza obloge na kosteh in ugotovljeno, da v oblogi prevladujejo fosfati. Izražena je možnost, da bi te specifične luknje, ki jim je podobna le še luknja v mamutovi petnici iz Nevelj, izdelali polži. Dokaza za enkrat še ni, vendar polži dolbejo tem primerljive luknje tudi v apnenec in gobe.

Ključne besede: luknje v kosteh, fosilne nosorogove kosti, mamutova petnica, polži, Dolarjeva jama, Nevlje.

Abstract: UDC 902.035(497.4)

Jamnik Pavel: Once more about the holes in the rhinoceros' bones from Dolarjeva jama cave (Logatec)

Holes in the fossil rhinoceros' bones from Dolarjeva jama cave (Logatec) are discussed. The author found 5 another holes, so they are known 11 altogether in 9 bone fragments. The transport of bones and clay material is discussed; the chemical analysis of bones' crust was made and the phosphates were found prevailing. The author suppose that the holes could be made by snails. Similar hole to those one from Dolarjeva jama was found in the mammoth's heel-bone from Nevlje (Kamnik). There is no proof, but the snails are making holes in limestone as well as in mushrooms.

Key words: palaeontology, speleology, hole in bone, snail, rhinoceros, mammoth, Slovenija, Dolarjeva jama cave, Nevlje.

[1] Kočna 5, SI - 4273 BLEJSKA DOBRAVA, SLOVENIJA

UVOD

Leta 1933 je Rakovec objavil najdbo fosilnih ostankov nosoroga (Coelodonta mercki Jag.) iz Dolarjeve jame pri Logatcu (Rakovec 1933). Takrat je opisal tudi nekaj "lepo izvrtanih lukenj". Leta 1985 je Brodar podal pregled zbirke 83 lukenj v kosteh z slovenskih najdišč in navedel tudi vzroke nastanka lukenj (Brodar 1985). Ker so bile ob tem pregledu prezrte luknje na kosteh iz Dolarjeve jame in luknja v mamutovi kosti z Nevelj je Brodar čez nekaj let podrobno obdelal še ti dve najdbi in obenem analiziral možnosti, ki bi prišle v poštev kot vzrok za nastanek teh lukenj, ob tem pa zapiše, da tak pojav, "drugje ni bil registriran in je ugotovljen samo v teh dveh najdiščih" (Brodar 1989, str. 100).

Polži pogosto izjedo v gobe tudi luknje, ki so tako po obliki kot po velikosti identične tem v nosorogovih in mamutovi kosti. Do neke mere se je zdela misel, da bi polži lahko naredili luknje tudi v kosteh, verjetna, oziroma vsaj vredna preverjanja. Ponoven pregled zbirke kosti, obisk jame, flotacija ilovice, kemična analiza obloge na kosteh, rentgensko slikanje in poskusi z polži ideje niso neposredno potrdili, niso pa je niti ovrgli. Vseeno pa je vse našteto prineslo nekaj rezultatov, ki jih bo pri nadaljnem ukvarjanju z temi luknjami potrebno upoštevati. Najdeno je bilo nekaj novih lukenj, nekatere dosedanje domneve pa se ne zdijo več povsem prepričljive.

NOVE LUKNJE IN UGOTOVITVE

Rakovec razmišlja o vzrokih nastanka lukenj le na treh fragmentih, ob tem pa omeni, da je "na odlomkih še nekaj bolj plitvih lukenj oziroma jamic, ki pa so povsem nepravilne oblike" (Rakovec 1933, 26). Ko v nadaljevanju obdeluje možnost nastanka lukenj zaredi kapljajoče vode, zapiše: "Za tovrsten nastanek pa govore nadalje tudi še druge luknje in vdolbinice oziroma jamice v kosteh, ki so mnogo bolj plitve od zgoraj naštetih. Pri slednjih je celo dobiti vtis, kot da bi predstavljale začeten stadij nastajanja lukenj po kapljajoči vodi" (prav tam, 26). Brodar v svojem članku omenja le tri kostne fragmente z luknjami. Na podlagi tega je bilo slutiti da je, poleg treh dosedaj objavljenih kostnih fragmentov z luknjami, imel Rakovec v rokah še več kosti iz Dolarjeve jame, ki imajo "luknje, vdolbinice oziroma jamice." Zaradi tega je bilo treba najprej ugotoviti koliko in kakšnje luknje so še v depoju, pa še niso bile objavljene. Na tem mestu se zahvaljujem ga. Katarini Krivic iz Prirodoslovnega muzeja Slovenije, ki mi je omogočila ogled najdb v depoju muzeja.

Ugotovljeno je bilo, da je lukenj res več. Niso tako izrazite kot na že objavljenih fragmentih, vendar sta dve identični z največjo, podolgovato oziroma ovalno luknjo, ki jo Brodar obravnava kot fragment a (Brodar 1989, 93), v dveh primerih pa gre za manjše luknjice.

Fragment d)

Luknja se nahaja na stranskem, odlomljenem robu, po vsej verjetnosti metakarpalne kosti. Luknja je narejena v spongiozo in kompakte ne načenja. V globino prehaja ovalno oziroma poševno (Sl. 1). Za ugotovitev, da gre za identično luknjo s tisto na fragmentu a, je v tem primeru indikativno dno. Je lepo zaokroženo in z vseh strani poševno preide v stene luknje. Stene so tako kot pri fragmentu a gladke oziroma je spongioza enakomerno odstranjena, zato, če po steni luknje potegnemo z prstom ne čutimo grbinic spongioze, ki bi jo čutili v primeru, da bi bila luknja posledica poškodbe kosti, ob kateri bi se odlomil tudi del spongioze. Luknja je v kost narejena v delu kjer se je ob nekem starejšem odlomu kosti pokazalo največ spongioze. Smer luknje sledi spongiozi in ni orientirana na kostni fragment (smer nakazuje merilo na sl. 1).

Ne da se ugotoviti ali je bila kost po tem, ko je bila v njej že narejena luknja še dodatno poškodovana ali je bila luknja narejena v tak fragment kot je ohranjen danes. To je pomembno zaradi ugotavljanja kakšen je bil prvotni rob luknje. Na dveh straneh luknjo omejuje kompakta, na dveh pa spongioza. Ostrih robov začetka luknje ni, temveč gre prehod v globino enakomerno poševno. Ker je zaradi opisanega višina robov različna, najlaže rečemo, da je luknja globoka okoli 2 cm.

Fragment e)

Naslednja na novo najdena luknja je na robu prečno odlomljene desne strani diapofize ali krila nosorogovega atlasa. Narejena je v spongiozo in jo lahko uvrstimo med ovalne luknje. Tako kot pri fragmentu d tudi to z dveh strani omejuje kompakta, z dveh pa spongioza. Dve tretjini luknje ima spongiozo enako gladko zaokroženo kot luknje na ostalih fragmentih, na eni strani pa luknja preko manjše grbine v spongiozi prehaja v drugo poglobitev spongioze. Ta druga poglobitev se od luknje razlikuje v tem, da spongioze nima gladko zaokrožene, prav tako pa se dno ne konča polkrožno temveč razbrazdano. Pri pregledu z vrha je jasno zaznati, da je del spongioze, ki ločuje luknjo od sosednje poglobitve odlomljen. Še vedno pa se vidi, da se zaokrožena stena luknje malenkostno nadaljuje v del, ki manjka, zato ni dvoma, da je bila to nekoč v celoti zaokrožena luknja. Globina luknje, merjena glede na najvišji ohranjen rob je 2,1 cm, široka, ob upoštevanju mankajoče stene je z ene strani najmanj 2,8 cm, z druge, kjer sta ohranjeni obe steni pa 1,9 cm (sl. 2).

Poleg teh lukenj sta bila najdena še dva kostna fragmenta z luknjami, ki jih je verjetno omenjal Rakovec kot luknje, ki zbujajo vtis, kot bi bile začeten stadij nastajanja lukenj, po njegovem poskusu razlage, zaradi kapljajoče vode.

Fragment f)

V nekaj več kot polovici ohranjene epifize sta ne zgornjem delu, v kompakto narejeni dve precej okrogli luknjici. Večja ima premer okoli 1,5 cm in je globoka okoli 0,5 cm, druga je nekoliko manjša in tudi nekoliko manj izrazito

okrogla. Luknjici nista mogli nastati zaradi poškodbe kosti, ker bi bila v tem primeru kostna struktura poškodovana, kar pa ni. Te vdolbinice bi še najlaže označili kot izjedenje ali izpraskanje v kost. Obe luknjici, predvsem pa večja resnično dajeta vtis, da gre za začetek večje luknje. Luknjici sta narejeni v kompakto, zato je rob prehoda luknje v globino oster, le na manjšem delu, kjer je kompakta poškodovana tega ostrega robu ni, ni pa moč ugotoviti ali je do poškodbe prišlo ko sta bili luknjici že narejeni ali že prej (sl. 3).

Fragment g)

Na sredini odlomka metakarpalne kosti je ovalna luknjica globoka okoli 0.5 cm. Nahaja se na delu kosti kjer je kompakta najbolj odstranjena. Dno luknjice ni tako izrazito zaokroženo, kot pri ostalih primerkih. Tudi rob luknjice ni popolnoma oster in ni značilnega poševnega prehoda proti dnu. Luknjica se ne začenja zaokroženo temveč bolj "kvadratno". Na desni strani se luknjica poglobi in preide v slabše zaokroženo dno. (sl. 4) Čeprav se še najbolj razlikuje od vseh do sedaj opisanih lastnosti lukenj, pa tudi ta nima stlačenega dna kakršen bi nastal ob mehanski poškodbi kosti. Kot zanimivost in v prid uvrstitve tudi te luknjice k ostalim je treba povedati, da tudi luknja na fragmentu c, čeprav ima stene lepo zaokrožene, robu luknje nima okrogle temveč bolj nekakšne "kvadratne" oblike. Izgleda kot bi šele poglabljanje dalo značilen okrogel oziroma ovalen izgled (sl. 5).

Poleg zgoraj opisanih lukenj je bil ob ponovnem pregledu kosti na enem od prstnih členkov najden podoben pojav kot ga je opisal Brodar s fragmenta b: "Na kostnem odlomku, ki ima dve luknji opazimo še nekaj nenavadnega. Gre za 3.5 cm dolg žleb, ki je do 2 mm globok... Ne gre za zarezo, ki bi se na dnu ostro zaključila, torej za obliko črke V. ...vidimo da je na dnu okroglo zaključen." (Brodar 1989/98) Bližnji posnetek žleba na fragmentu b kaže sl. 6.

Fragment h)

Gre za 4.8 cm dolg žleb, na prstnem členku, ki pa dna nima po vsej dolžini tako enakomerno zaokroženega v obliku črke U, kot žleb na fragmentu b. Novo odkriti žleb ni nastal kot poškodba ob izkopavanju, saj po barvi žleb ne odstopa od okoliške fosilne kosti. Nove poškodbe so videti drugače. V smeri proti debelejšemu koncu kosti je žleb najglobji in tudi nekoliko širši kot v ostalem delu. Čeprav žleb ni popolnoma raven, pa poteka vsaj približno v isti ravnini, zato je globina žleba odvisna od višine dela kosti ki ga seka. Na sprednjem in zadnjem delu, kjer je kost najvišja je žleb poglobljen do spongioze (sl. 7). Tu so stene žlebu zaradi mehkejše spongioze, celo nekoliko pomaknjene pod vrhnjo kompakto. V sredini žleb poteka preko kompakte in tu je dno popolnoma identično dnu žleba na fragmentu b.

Koliko in kakšne luknje imamo torej iz Dolarjeve jame?
Najdbe lahko razvrstimo v štiri skupine in sicer:

1) Luknje z okroglo odprtino in z relativno ostrim robom prehoda v globino ter zaokroženim dnom (fragment b, c).
2) Ovalne luknje brez izrazitega prehoda v globino temveč s poševno spuščajočimi se stenami proti zaokroženemu dnu (fragment a, d, e).
3) Manjši luknjici, ki bi lahko predstavljali začetek večjih lukenj z relativno ostro mejo prehoda v globino (fragment f).
4) Manjša luknjica, ki bi lahko predstavljala začetek večje luknje z neizrazitim prehodom v globino (fragment g).

Poleg teh štirih skupin pa je treba v posebno skupino uvrstiti še oba žleba na kosteh (fragment b, h).

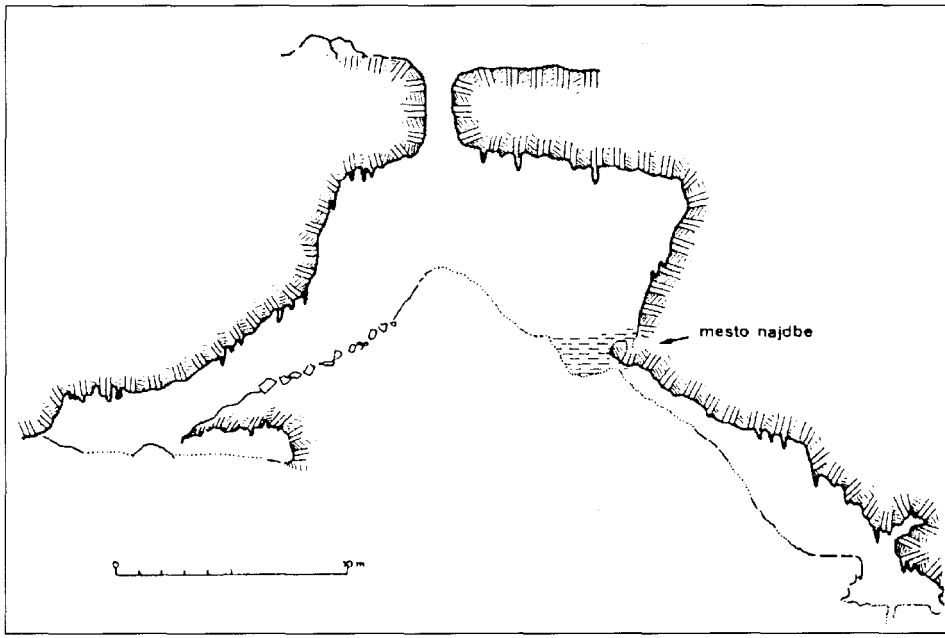
Ob na novo najdenih luknjah na kosteh se postavlja še eno vprašanje. Ko Rakovec opisuje izkopavanje, omeni, da so "odkopali tudi nebroj kosti raznih manjših živali..." (Rakovec 1933, 6) Drugega o teh kosteh ne zapiše. Danes se ne ve kje so, ni pa bilo moč najti niti načrtov v katere Rakovec pravi, da so vsako najdbo točno zarisali. Ker je v 111 kostnih fragmentih nosoroga sedaj znanih kar 9 lukenj na 7 fragmentih bi bilo zanimivo pregledati tudi ta žal izgubljeni "nebroj" kosti.

Ker je za razmišljanje o nastanku lukenj v kosteh pomemben podatek, kako so nosorogovi ostanki prišli v jamo, smo J. Broder, T. in P. Golja ter avtor 21.4.1996 jamo obiskali.

Rakovec domneva, da so nosorog ali že samo njegovi ostanki popadali v jamo skozi danes zaprt vhod v jamo, ki naj bi bil tik nad najdiščem kosti. Za potrditev svoje ideje je celo izkopaval nad jamo in prebil strop nad nosorogovim rovom (Rakovec 1933, 7). Brodar za Rakovčevo domnevo pravi: "Pri ogledu jame se vidi, da ne more biti govora o dovolj veliki luknji v stropu skozi katero bi mogel pasti nosorog. Rakovec je naletel le na špranjo v stropu." (Brodar 1989, 93) V nadaljevanju Brodar postavi hipotezo, da so kosti prišle v jamo s spiranjem s površja skozi razpoke v stropu jame. To utemeljuje še z Rakovčevo navedbo, da so našli kosti celo v steni rova 2 in 2,30 m od tal, kar je "razložjlivo samo z omenjeno hipotezo." (prav tam).

Po ogledu jame se mi zdi potrebno Brodarjevi hipotezi dodati še nekaj podrobnosti v zvezi z samim vnosom kosti v jamo.

Še enega vhoda v jamo, nad najdiščem kosti ni bilo nikoli. V prid tej trditvi govori predvsem velik nasipni stožec pod današnjim vhodom. Zapolnil je že tudi del rova kjer so bile najdene kosti. Odsotnost kakršnih koli sledi nasipnega stožca na mestu, kjer vhod domneva Rakovec, dodatno govori proti taki misli. V jami se dobi vtis, da je nasipni stožec že zelo star in da je zasul že precejšen dal jame. Ob večanju je drsel v oba kraka jame, ker pa je desni, ta z nosorogovimi kostmi, manjši predvsem pa ožji, ga je nasipanje zapolnilo več kot levega. V nekem obdobju je začelo skozi razpoke v stenah ali stropu, s pomočjo meteorne vode v jamo prihajati več ilovice. Odlagala se je na dnu, v obeh krakih, jame. Ob tem se ja v desnem kraku dokončno zaprla ožina v



Sl. 8: Načrt Dolarjeve jame (povzeto po načrtu Mihevca, v Brodar, 1989, 91).

nadaljevanje rova, ki se je ponovno pokazal ob izkopavanju kosti (sl. 8). Rakovec za ilovico na mestu izkopavanja pravi: "Ugotovilo se je, da je ilovica, ki prekriva tla desnega rova debela 80 cm do 1 m. Do globine pol do tričetrt metra je bila še precej čista, nato pa je bila pomešana z gruščem in z odbitimi kapniki, končno so sledile večje skale, ki izhajajo brez dvoma od večjega podora. Pod temi skalami se je na več mestih pokazala odprtina, ki je vodila v spodnji rov. V zgornjem delu t.j. nekako do globine 10-15 cm je bila ilovica zelo mastna... V nižjih plasteh je bila ilovica že precej prhka, mestoma pa celo skrilova, tako da se je luščila v tankih plasteh." (Rakovec 1933, 6).

Te t.i. varvaste plasti ilovice pomenijo večkratno zaporedno odložitev, osušitev in ponovno odložitev ilovice. Ker se spodnja plast ilovice pred odložitvijo nove že toliko osuši in strdi med njima ne pride do popolnega zlepljenja, temveč do plastovitosti. Tak način sedimentacije ilovice pa v konkretnem primeru pomeni daljše časovno obdobje odlaganja in ne enkraten nanos. Edino dotok ilovice v jamo v zelo kratkem času bi dovoljeval misel, da je z spiranjem ilovice, neposredno s površja nad jamo, istočasno prineslo v jamo tudi kosti. Kosti so bile najdene v različni globini. Rakovec pravi, da so: "... največ kosti dobili v zgornjih plasteh povprečno do globine 20 cm, navzdol so bile kosti čedalje bolj redke, najglobje ležišče kosti smo ugotovili v globini 90 cm." (Rakovec 1933, 6). Ko pa v nadaljevanju opiše še kasnejše Dolarjevo izkopavanje in pove, da je

prišel do globine 2 m. " Pri tem kopanju je našel Dolar 5 zobnih in 4 kostne odlomke in to približno v sredini rova v globinah 84 cm, 95 cm, 108 cm, 150 cm in 180 cm. Zobne odlomke je našel le v zgornjih plasteh t.j. 84 do 96 cm globoko." (prav tam, 7). Za del kosti v različnih globinah je logično pričakovati, da so med podornimi skalami, gruščem in odlomljenimi kapniki skupaj z ilovico drseli navzdol, saj naj bi bilo takih sedimentov več pod gornjim enim metrom ilovice. Vendar pa imamo nad spodnjima, podorno in bolj gruščnato plastjo, plast plastovite ilovice, skozi katero pa kosti niso mogle spolzeti niže. Premik navzdol bi bil sicer mogoč, kot posledica krioturbacijskih in denudacijskih procesov, vendar se zdi, da ti procesi ilovice niso mogli kaj dosti premikati. V tem primeru bi drsela proti rovu, ki se je odprl ob izkopavanju in s tem rov zasipavala. Rov pa je bil z odstranitvijo zapore prehoden. Če ni pod dnom tega desnega kraka jame še kakšen rov, za katerega ne vemo, se zdi, da se ilovica zaradi ozkega in nasploh majhnih dimenzij rova ni imela kam premikati. Sedimentacija ilovice govori bolj v prid odlaganju skozi daljše časovno obdobje. Ob sprejeti tezi, da so kosti v jamo prišle skupaj z ilovico, pa to pomeni, da ilovica v jamo ni mogla pritekati neposredno s površja nad jamo. Kosti namreč tako dolge direktne izpostavitve ostalim naravnim procesom, ki kosti uničujejo v naravi ne bi vzdržale.

Proti direktnemu naplavljenju kosti s površja govori tudi čistost ilovice. Vsaj v zgornjem delu je zelo čista, pa tudi v spodnjem delu ni zaobljenega grušča, ki bi bil izpostavljen transportu, temveč le skale, ostrorobi grušč in odpadli kapniki. Vse to je popadalo s sten in stropa jame. To lahko pomeni dvoje. Ali so bile razpoke skozi katere je prihajala ilovica v jamo tako majhne, da večji material ni mogel skozi ali pa je bila v okolici jame le čista ilovica brez skal in kamenja? Če bi bile razpoke dovolj velike le za ilovico, tudi kosti ne bi mogle skozi. Če pa so razpoke dovolj velike za prehod kosti, bi z kostmi prihajal v jamo neposredno s površja tudi drug material, ki je bil tam, glede na geologijo okolice, nedvomno prisoten.

Ker so bile kosti pri transportu zaobljene bi bilo pričakovati, da bi bil v jami tudi vsaj delno zaobljen grušč, ki ga pa ni.

Ilovica v razgaljenem profilu je zelo mastna, zato se samo z vizualnim ogledom ni dalo ugotoviti, koliko je čista in če vmes le ni tudi kaj zaobljenega materiala. S tem namenom je bila opravljena flotacija skupno 5 kg ilovice, vzete z dveh mest v razgaljenem profilu.

VZOREC A

1,60 kg ilovice je bilo sprane skozi sito 0,4 cm. Na situ ostane 0,17 kg sedimenta. To so redki največ 4 - 5 cm veliki koščki od stropa in sten odpadlega grušča in sige. Kar je ostalo je bilo ponovno sprano skozi sito 0,1 cm.

VZOREC B

3,40 kg ilovice je bilo spirane skozi sito 0,1 cm.

REZULTAT

A	1,60 kg	sito 0,4	ostanek 0,17 kg	10,65 %
		sito 0,1	ostanek 0,14 kg	8,75 %
			0,31 kg	19,40 %
B	3,40 kg	sito 0,1	ostanek 0,57 kg	16,47 %

SKUPAJ

5 kg	nad 0,1	0,87 kg	17,40 %
	pod 0,1	4,13 kg	82,60 %

Zaobljenega materiala ni. Edini sediment poleg ilovice in organskih ostankov so manjši kosi sige in droban grušč odpadel z sten in stropa jame.

Poleg do sedaj opisanega pa je treba upoštevati,da se ta svetlo rjava ilovica odlaga še danes in, da zato proces odlaganja še ni končan. Če odlaganje ne bi več potekalo, bi bila nad ilovico odložena že plast sige, tako kot je zasigan ostali del jame, celo nasipni stožec.

Kosti, ki so gledale iz ilovice, ko jih je leta 1933 v jami našel Dolar, niso mogle biti, v smislu sedimentacijskega časa v jamah, tam prav dolgo. Nanje bi se drugače že odložila nova ilovica ali siga. Na nosorogovih kosteh skorje sige ni, čeprav se drugače v sigotvornih jamah siga na kosti odloži relativno hitro.

V prid temu, da se je ilovica odložila v jami kot zadnja govori tudi sledeče. Ob izkopavanju kosti je bila ilovica odstranjena po celi širini rova. Ob tem sta bili razgaljeni steni rova. Na eni se vidi, da so šle kapniške tvorbe pod ilovico. Ti kapniki niso stari saj se na tej steni siga odlaga še danes in je verjetno večina kapniškega okrasja v jami nastala po koncu zadnje ledene dobe. V tem primeru bi bila ilovica od nekje presedimentirana šele v holocenu.

Pri flotaciji ilovice so bili najdeni tudi kostni ostanki malih sesalcev, ki jih je določil B. Kryštufek iz Prirodoslovnega muzeja Slovenije, za kar se mu najlepše zahvaljujem. Ugotovil je naslednje vrste in najmanjše število osebkov:

Sorex araneus 1 (gozdna rovka)
Glis glis 1 (polh)
Arvicola terrestis 1 (veliki voluhar)
Clethrionomys glareolus 2 (gozdna voluharica)
Microtus arvalis/agrestis 1 (travniška/poljska voluharica)
Dinaromys bogdanovi 1 (Dinarska voluharica).

Najdba ostankov Dinarske voluharice je pomembna, ker je bila do sedaj poznana le iz dinarskega in šarsko-pindskega gorstva, od Velebita na severu do Galičice na jugu. V pleistocenu je živela tudi na ozemlju današnje Slovenije

(Kryštufek 1991, 262). Ker so vse ostale najdene vrste recentne, so verjetno recentni tudi ostanki Dinarske voluharice. Ti sesalci so lahko poginili v sami Dolarjevi jami in jih je ilovica s časom prekrila ali pa so bile z ilovico in nosorogovimi kostmi vred presedimentirane od drugod.

Poleg ostankov malih sesalcev je bilo v ilovici tudi nekaj celih in polomljenih polžjih hišic, za katere je Velkavrh s fakultete za biologijo, ki se mu za pomoč prav tako najlepše zahvaljujem, ugotovil, da pripadajo recentnim površinskim vrstam.

Pri vizualnem pregledu ilovice v profilu, in na izkopanem materialu v jami je bil poleg deset od 1,5 do 5 cm velikih zaobljenih fragmentov kosti, najden tudi 15 cm velik kos odlomljenega kapnika, ki je imel po eni strani črno oblogo. Na nekaterih mestih se je videla le še sled, ponekod pa jo je bilo še dovolj. Obloga je bila na videz identična oblogi na kosteh, o kateri je pisal tudi Rakovec (Rakovec 1933, 25). Pričakovati je bilo, da sta oblogi na kosteh in kapniku sorodni tudi kemično, kar bi pomenilo, da sta bila verjetno blizu eden drugemu, ko se je obloga ustvarila. Za opravljeno kemično analizo se najlepše zahvaljujem J. Legatu iz kemijskega laboratorija Železarne Jesenice.

	KAPNIK	KOSTNA OBLOGA	
Fe(total)	0,68 %	1,35 %	
Fe_2O_3	0,98 %	1,93 %	
Ca	32,75 %	30,64 %	(izračunan iz CaO)
CaO	45,90 %	42,90 %	
Mg	0,13 %	0,14 %	
MgO	0,28 %	0,24 %	
Mn	0,09 %	4,10 %	
MnO	0,12 %		
SiO_2	4,40 %		
C	7,00 %		
Al	0,96 %		
PO_4	13,05 %	41,39 %	
P		13,50 %	(izračunan iz PO_4)

Rezultat potrdi Rakovčevo analizo in pokaže, da tako na kosti kot kapniku prevladuje fosfatna obloga. Razlika v % gre na račun različne možnosti odstraniti oblogo s podlage.

V posušeni ilovici, ostanku flotacije je bilo opaziti tudi do 0,1 veliko granulirano črnorjavo snov. Če bi bila to fosfatna snov, bi kazalo, da je obloga na kapniku in kosteh nastala zaradi ležanja v s fosfati nasičeni ilovici. Nabrana sta bila dva vzorca, ki sta po sestavi sledeča:

	VZOREC 1	VZOREC 2
Fe(total	37,07 %	31,50 %
Fe_2O_3	53,00 %	45,10 %
Ca	2,30 %	
CaO	3,22 %	3,40 %
Mg	0,22 %	
MgO	0,47 %	0,35 %
Mn	2,59 %	
MnO	3,34 %	3,30 %
Ni	0,02 %	< 0,01 %
Cu	0,01 %	< 0,01 %
Cr	0,03 %	< 0,01 %
Zn	0,015%	< 0,01 %
Pb	> 0,01 %	< 0,01 %
PO_4	0,83 %	
SiO_2	14,10 %	10,50 %
Al	5,15 %	
C	6,70 %	9,00 %
Na_2O		0,08 %
K_2O		0,31 %

Kemična sestava granulatnih zrnc je podobna rezultatom analize bobovcev v Triglavskem pogorju, ki sta jih opravila R. Gospodarič in J. Pohar (1966, 7-25), zato teh granulatnih zrnc in fosfatne obloge na kosteh ter kapniku ne moremo neposredno povezovati.

Pri nas je fosfatne vključke v sedimentih raziskoval I. Turk s sodelavci in sicer na primeru paleolitskega najdišča Divje babe I (1988). V tekstu podajo različne možnosti akumulacije in koncentracije fosfatov v zemlji in sedimentih različne starosti. Ugotovijo, da so v primeru Divjih bab I glavni prispevek fosfatov v sedimentih dali mehki deli mrtve združbe jamskega medveda, ki niso bili konzumirani (prav tam, 124).

V našem primeru je fosfatna obloga le na večini kosti in na fragmentu kapnika in ne tudi kot poseben element v sedimentih. Ob upoštevanju kemične analize, se zdi verjetno, da je v tem primeru glavni vzrok oblogam razpad kadavra nasoroga. V tem primeru, bi moral biti kapnik v času razpadanja nosoroga v stiku ali vsaj v neposredni bližini tanatomase.

Na podlagi vsega opisanega, se mi zdi verjetnejša možnost, da so bile kosti prenešene neposredno s površja na današnje mesto v jami takoj po razpadu trupla, in sicer tako, da je bila v neposredni bližini Dolarjeve jame še neka manjša jama ali vsaj večja skalna razpoka v katero so se na nek način ujele nosorogove kosti. Lahko celo, da se je nosorog v taki razpoki zagozdil in tam poginil, potem pa je del kosti popadal nižje, del kosti pa je propadel ali so jih

uničile druge živali. V tem primeru bi kosti popadale na ilovico na dnu, ki pa je, ko so bile kosti že na mestu, še naprej počasi zasipavala razpoko ali manjšo jamo in s tem tudi kosti. Za ilovice rjavih in rdečih odtenkov, ki so bile včasih poimenovane tudi jamske ilovice, danes prevladuje mnenje, da so produkt kemičnega preperevanja apnenca (Osole 1986, 8). Ta manjša jama ali razpoka se je kasneje s podorom v Dolarjevi jami, katerega ostanke je Rakovec našel kot najnižjo odkopano plast, preko razpok povezala z Dolarjevo jamo. Takrat se je začela, skozi to na novo ustvarjeno povezavo, v Dolarjevo jamo s pomočjo meteorne vode periodično odlagati ilovica, ki je bila prej akumulirana na dnu razpoke ali manjše jame. Ob tem so v Dolarjevo jamo popadale tudi nosorogove kosti, ki pa so se na tej poti zaradi transporta in težje prehodnosti ogladile, zdrobile in polomile. Vse to je potekalo skozi daljše časovno obdobje, zaradi česar so kosti v različni globini ilovice. Ker se v jami odlaga siga so se s časom razpoke zmanjšale, tako da jih danes ni mogoče z zanesljivostjo najti. Lahko bi bile prav na mestih, kjer je Rakovec našel kosti 2 in 2,30 m nad dnom desnega kraka Dolarjeve jame.

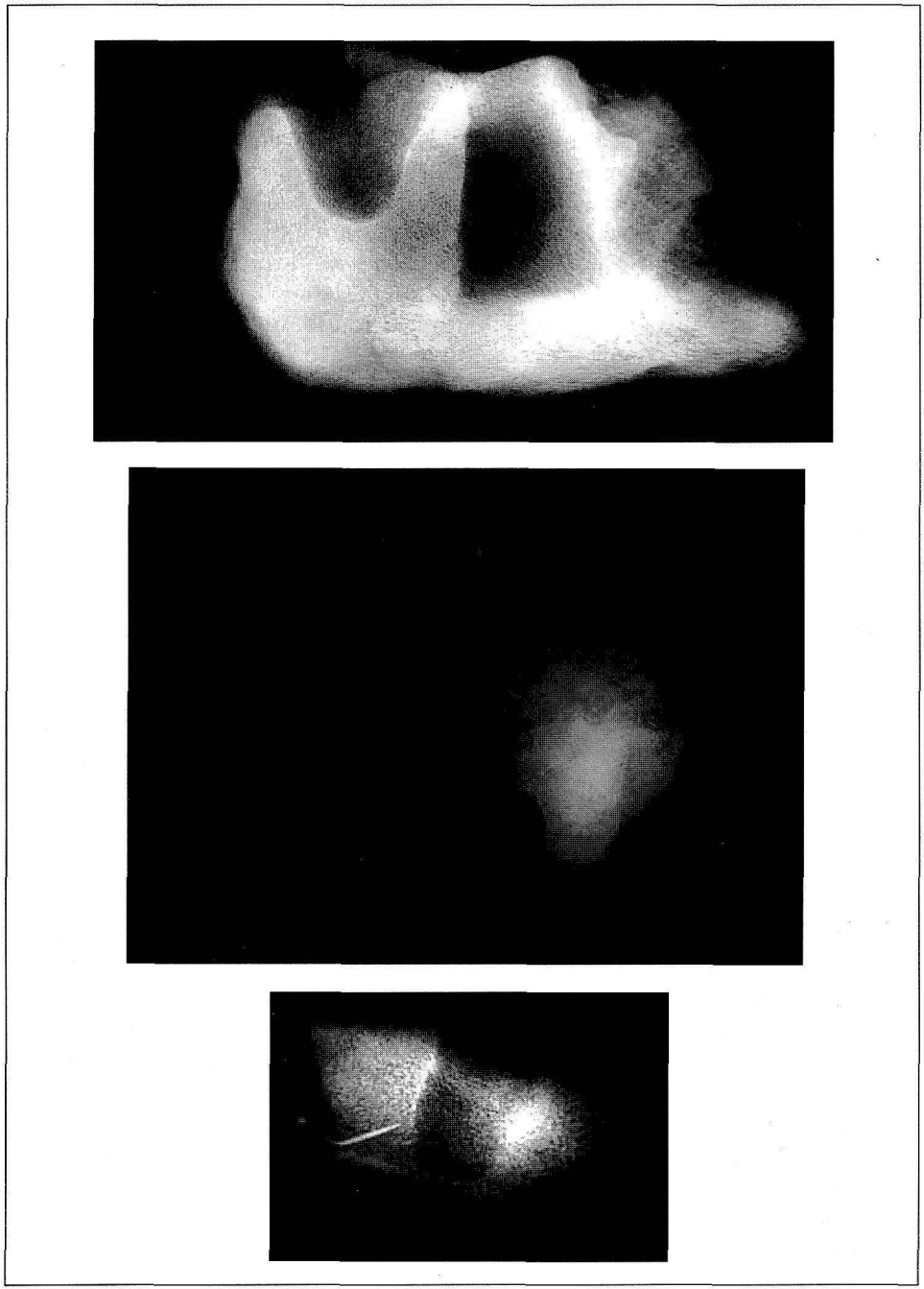
DISKUSIJA O MOŽNEM VZROKU NASTANKA LUKENJ

Ko Brodar obdela možnosti nastanka lukenj v kosteh (Brodar 1985, 1989), poudari, da se je med pregledom skoraj 400 lukenj iz vse Evrope, pokazalo presenetljivo dejstvo, da ni med njimi niti ene, ki bi jo bilo mogoče primerjati s temi iz Dolarjeve jame in Nevelj. Že prej pa za luknje iz Dolarjeve jame pravi; "Kakor je nastala ena, tako so nastale tudi druge luknje." (Brodar 1989, 79).

Novoodkrite luknje tega dejstva ne spreminjajo, nasprotno še dodatno prepričujejo, da gre v tem primeru za nekaj izjemnega in karkoli je že naredilo luknje tega drugje ne počne pogosto. Ta izjemna situacija mora biti vzrok, da je ravno v tej jami, na samo 111 kosih, kosteh narejenih najmanj 6 večjih lukenj.

Brodarjevi argumenti, s katerimi izključuje možnosti, da bi luknje nastale kot posledica ugrizov, kemičnih procesov, poškodb z orodjem, bolezenskih procesov, zaradi pritiska ali ležanja v sedimentih in kot posledica kapljajoče vode, so popolnoma prepričljivi, zato v tej smeri ni več smiselno iskati rešitve. Nekoliko več pozornosti Brodar nameni tudi analizi možnosti, da bi luknje izdelal človek. Njegovim argumentom proti tej misli, (da bi morale biti že kje odkrite podobne luknje, da se luknje v večjem številu pojavijo šele sredi Würma in, da ni jasno čemu naj bi te na nosorogovih kosteh, izdelane že v interglacialu, sploh služile) je morda treba dodati še nekaj.

Človek bi luknje na teh kosteh naredil lahko le takrat, ko so bile še na površju, oziroma, ko kosti še niso imele fosfatne obloge. Na kosteh, ki oblogo imajo, se jasno vidi, da je bila pri transportu odbrušena in da je bila odložena na kost preden je prišlo do poškodb in obrušenja kosti. Torej pred transpor-



Sl. 10: Rentgenski posnetki fragmenta a (1), b (2), c (3).

tom. Če bi bile luknje narejene takoj v sveže kosti, bi se kasneje obloga naredila tudi v luknjah ali vsaj na razgaljeni spongiozi pri ovalnih luknjah. Tega pa ni. Pri ovalnih luknjah se vidi, da gre obloga po kompakti do roba luknje. Kjer prehod v luknjo med kompakto in spongiozo ni poškodovan oziroma zglajen se lepo vidi, da gre obloga le do roba (sl. 9).

Človek bi torej luknje lahko naredil le v stare kosti, ki jih je našel na mestu kjer je poginil nosorog, in na katerih je že bila obloga. Če so se kosti res ujele v razpoki ali manjši jami bi jih bilo težko že sploh najti, predvsem pa bi v tem primeru človek luknje naredil z nekim namenom in jih ne bi vrgel nazaj k ostalim kostem, kjer jih je pobral in odkoder bi jih kasneje skupaj z ostalimi odplavilo v Dolarjevo jamo. Že samo število lukenj v nosorogovih kosteh pa je v tem primeru takšno, da bi bilo upravičeno pričakovati še kakšno sled človekovega posega, ki pa je ni. Samo prelomljene metakarpalne kosti in drobci oglja v sami jami so v tem primeru, kakor zapiše že Brodar, premalo. Kakšne so izgubljene kosti manjših živali ne vemo, zato jih tu ne moremo upoštevati.

Vrtanje lukenj brez sile, ki odstranjuje (spodriva ali drobi) spongiozo, ni mogoče. Rakovec je ugotovil, da "v kolikor ni struktura spongioze zakrita z vmes nahajajočo se ilovico, je še prav dobro videti, da ni bila spongioza pri nastajanju lukenj prav nič stlačena." (Rakovec 1933, 25) Da bi ta vizualni vtis še potrdili, so bile vse kosti z luknjami rentgensko slikane. Na slikah se jasno vidi, da spongioza ni, ne na stenah, ne na vhodu v luknjo in ne na dnu, prav nič stlačena in poškodovana (sl. 10).

Edina možna razlaga tega dejstva je, da pri nastajanju lukenj ni bilo uporabljeno orodje ali sila v smislu pritiskanja proti kosti. Brez pritiskanja oziroma uporabe sile pa bi lahko luknje v kost izdelale le živali, ki bi jih naredile z izjedanjem.

Brodar omenja pri vzrokih nastanka lukenj v kosteh tudi črve. V nekaterih glinastih sedimentih postanejo kosti popolnoma mehke. V takem primeru je možen prehod črvov, ki na ta način naredijo luknje. V nobenem od naših najdišč iz katerih kosti z luknjami izvirajo, takih sedimentov ni in ta možnost pri nas odpade. (Brodar 1985, 43) Tudi v Dolarjevi jami glinastih sedimentov ni, zato tudi tu s črvi ni računati. Kost se zmehča zaradi raztapljanja kalcijevega karbonata tudi v kislih sedimentih, nosorogove kosti iz Dolarjeva jame pa so kompaktne in trde. Ker je tako zmehčanje, ko enkrat nastopi, trajno, bistvene spremembe v trdoti kosti v konkretnem primeru ne moremo pričakovati.

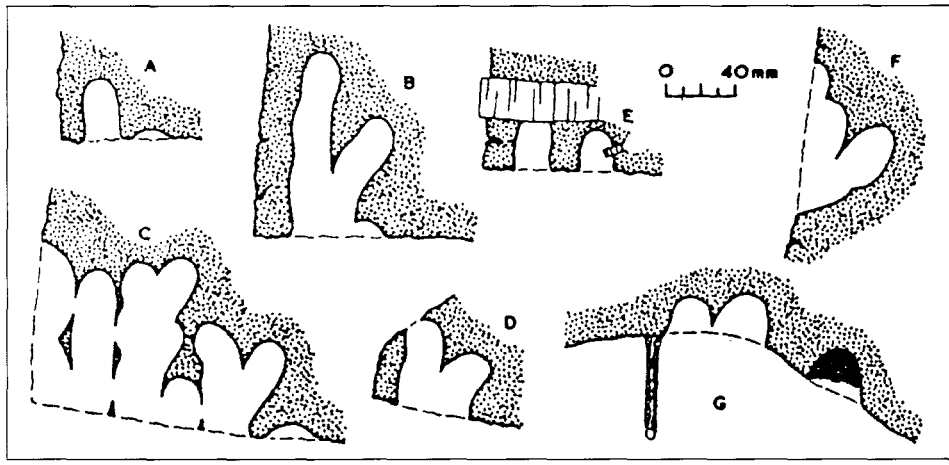
Živali, ki oblikujejo oziroma izjejo popolnoma identične luknje tem v nosorogovih kosteh, so polži. Luknje, ki jih kopenski polži izjejo v gobe so tako okroglih kot ovalnih oblik (sl. 11).

Prvi argument proti tej primerjavi je sam material. Goba je mehka, kost pa trda, čeprav pa je spongioza, kamor so v večini primerov narejena luknje, še najbolj krhka in do neke mere spužvasta, še posebej, če je kost dolgo mokra. Toda samo trdota ne more biti temeljni argument proti. Kopenski polži dolbejo

luknje celo v kamen. Ta fenomen je v Angliji preučeval geolog William I. Stanton na apnencih v Mendipu (Stanton 1984, 15-18). Na več kot 60 različnih lokacijah je pregledal več 1000 lukenj in ugotovil, da jih dolbejo predvsem gozdni polži *Cepaea Nemoralis*. Luknje so izdelane v skale apnenca ali celo v apnenčevih prodnikih v konglomeratu. Luknje so narejene v obliki plitvih vdolbinic, preprostih lukenj premera od 20 mm in do 50 mm, pa do kompleksnih lukenj v obliki satovja, globokih do 200 mm (sl. 12). Ugotovil je da polži izdolbejo cca 15 mm luknje v 100 letih, kar pomeni, da polži isto luknjo poglabljajo skozi veliko generacij. Kaj je vzrok takega početja polžev ni znano, po nekaterih mnenjih, h katerim se nagiba tudi Stanton, naj bi šlo za "homing instinct", oziroma za počivališča, skrivališča polžev, ne pa tudi za prostor hibernacije. Stanton je ugotovil, da polži delajo luknje na apnenčevih skalah, ki so blizu vegetacije, dolbejo pa jih navpično tako, da je luknja pod previsno površino kamnine, da je zaščitena pred vplivom okolja.

Podobnost naših lukenj z luknjami, ki jih opisuje Stanton kot enostavne - preproste luknje je velika. Z okroglimi luknjami gre za identičnost tako po dimenzijah kot po obliki in zaokroženem dnu. Zaradi tega sem za mnenje o luknjah v kosteh pisno zaprosil Stantona, ki je na pismo takoj prijazno odgovoril, za kar se mu najlepše zahvaljujem.

Stanton piše, da lukenj, ki bi jih v kosti naredili polži, ne pozna. Dodatno pojasni, da ni našel lukenj niti v dolomitu, temveč le v apnencu, kar si razlaga s tem, da polže očitno odbija Mg. Po njegovem mnenju, bi tudi P v kosteh lahko deloval enako odbojno. Glede samega načina izdelave lukenj Stanton pravi, da še ni jasno, ali kopenski polži luknje v apnenec naredijo z raztapljanjem s pomočjo kisle sline ali pa jih izpraskajo z radulami. Če jih izpraskajo, bi



Sl. 12: Oblike lukenj, ki jih polži Cepaea Nemoralis dolbejo v apnenec (povzeto po Stanton 1984, 15).

za izdelavo takih lukenj kot so v kosteh, če bi jih delali z enakim vzrokom kot v apnenec, polži potrebovali več kot sto let.

Drug argument proti je lahko vprašanje zakaj podobne luknje niso bile najdene še kje. Odgovor na to ni tako preprost. Navsezadnje imamo opraviti z dvema najdiščema in sicer Dolarjevo jamo in Nevljami pri Kamniku. V obeh primerih so si ovalne oz. poševne luknje toliko podobne, da lahko za oba najdišča iščemo isti vzrok nastanka. Luknje iz Dolarjeve jame, ki imajo okrogel oster rob so tako izrazite, da takoj padejo v oči, kar pa za tiste, ki gredo poševno v dno ne bi mogli reči. Še vedno pa velja, da tako kot je nastala ena so nastale vse. Zakaj takih lukenj ni bilo doslej najdenih več se zaenkrat ne da reči, le ugibamo lahko, da je vzrok nastanka nekaj izjemnega.

Glede na to, da tudi kopenski in ne le morski polži dolbejo luknje v kamen, ideja, da bi jih lahko naredili tudi v kosti ni nemogoča, čeprav neposredne potrditve še nimamo. Kopenski polži v Dolarjevo jamo zahajajo. Njihove hišice so prišle na dan ob flotaciji ilovice, Rakovec pa jih je tudi našel v "privršnjih plastah ilovice." Lupine so bile zdrobljene, vendar mu je uspelo določiti dve hišici, ki pripadata vrsti *Aegopis verticillus* Fer (Rakovec, 7). Polži so torej luknje lahko naredili v jami ali pa že prej, ko so bile kosti še v razpoki, oziroma pred presedimentacijo v Dolarjevo jamo. Na vsak način pa so morali luknje narediti že po tem, ko je bila na kosteh odložena fosfatna obloga, saj gre ta le do roba lukenj. Ker se struktura kosti razlikuje od apnenčevih skal, se zdi, da v tem primeru polži lukenj v kosti ne bi delali z enakim vzrokom kot v skale. Vzrok bi bil lahko v neki nevsakdanji situaciji, ki bi se za polže pojavila v tistem trenutku in na tistem mestu, in bi se zato lotili kosti. Ali bi bil ta vzrok lahko hranjenje, je le ugibanje, čeprav se prav to zdi precej verjetno. Vsekakor je z idejo o polžih kot povzročiteljih lukenj, moč najti skupni imenovalec za luknje v Dolarjevi jami in Nevljah, čeprav je med nastankom enih in drugih velika časovna razlika. V obeh primerih so polži imeli možnost dostopa do kosti. Tudi dve luknji na fragmentu b, ki sta si skoraj nasproti, tej razlagi ne nasprotujeta.

Na koncu je treba nekaj reči še o obeh žlebovih. Brodar za žleb na fragmentu b pravi, da podoben žleb nastane, če po kosti potezamo sem ter tja z mehkim tkivom, npr. kito, vendar pravi, da bi bilo v konkretnem primeru "trditi, da je žleb delo človeka, vendarle preveč tvegano." (Brodar 1989, 98). Sedaj imamo dva žleba. Drugi se od tega na fragmentu b razlikuje v tem, da je na koncih globji in da načenja spongiozo, v sredini pa je enak prvemu. Kljub temu, da Brodar pravi; "Ne poznamo primera, da bi kdo tak žleb poskušal razložiti kot naraven pojav..." (prav tam), se mi zdi, da je rešitev prav tu. Žleb gre na fragmentu b po spongiozi. Če je kost suha se spongioza od dotiku in pritiskanju nanjo drobi v različno velikih koščkih, nasprotno pa z vodo prepojena kost, predvsem spongioza, postane nekako prožnejša - spužvasta. V tem primeru se spongioza ob pritisku drobi v enakih majhnih "drobtinicah." Če bi torej namočen in z vodo prepojen fragment kosti sediment pritiskal oz. tiščal

na nek rob kamnine, bi se ta rob vtisnil v spongiozo. Žleb ki bi tako nastal, bi imel zaradi malenkostnega premikanja kosti skozi daljše časovno obdobje, zaokroženo in zaglajeno dno. Zaradi dolgotrajnega enakomernega pritiska in morebitne vmesne osušitve bi vtisnenje ostalo trajno. Enako bi lahko nastal žleb na fragmentu h, le da je v tem primeru skalni rob zaradi drugačne oblike kosti šel na najvišji točki najglobje in na tem mestu, zaradi prevelike globine spongiozo že krušil in ne več le stisnil oz. vtisnil. Na sredi, kjer je žleb plitek, pa je prišlo le do vtisnenja in zato do enakega izgleda kot na fragmentu b.

Hipoteza o polžih kot možnem povzročitelju lukenj v nosorogovih kosteh iz Dolarjeve jame in mamutovi petnici iz Nevelj, je le še eden od poskusov pojasniti njihov nastanek. Ker so te luknje res nekaj posebnega je prav, da se upošteva čim več možnosti, ki bodo morda nekoč pripeljale do nedvomno dokazljivega vzroka nastanka lukenj.

OPOMBE: Ker Brodar dosedaj objavljene kostne fragmente z luknjami označuje z oznako "fragment a, b in c", novoodkrite luknje označujem z nadaljevanjem abecede.

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ONCE MORE ABOUT THE HOLES IN THE RHINOCEROS' BONES FROM DOLARJEVA JAMA CAVE NEAR LOGATEC

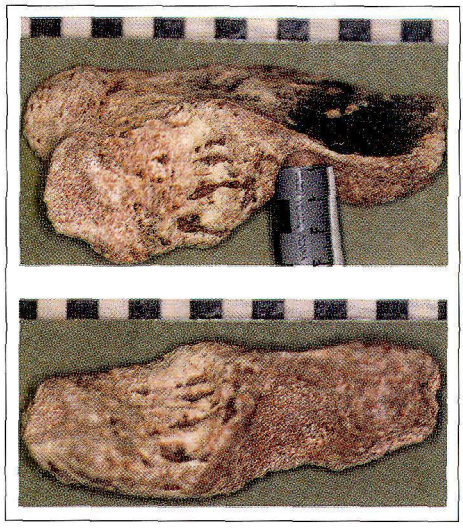
Summary

Because the holes in the fossil rhinoceros' bones are specific, the only comparision can be made with the hole in mammoth's heel-bone found at Nevlje near Kamnik. Up to now it was not possible to explain the origin of the holes, therefore the possibility that snails made them was taken into account. Looking seriously through the collection of the mentioned bones, additional five holes were found. With previous ones they are now 11 altogether. Three of the new found ones are smaller, looking as they were the first phase of hole making. The other two are bigger and having all the characteristics of the previously known holes.

Taking into account that the holes in rhinoceros' and mammoth's bones can not be compared to any known holes in fossil bones, also their origin have to be different. It can not be explained by beasts' bites, by chemical processes, by action of a tool, by pathological processes, or by the pressure of the overlying sediment load. There are no arguments to think that the holes are man made, just opposite, because the holes are made in such a manner that the "spongiosis" is completely intact, which would be impossible if the holes were made by boring.

Without any pressure or force, the holes could be made by a sort of corrosion. Bigger animals can not be taken into account regarding the fact that their traces on bones are different and known already a long time. One possibility is that the holes were made by snails. They make identical holes in mushrooms to those in rhinoceros' and mammoth's bones. English geologist N. I. Stanton found that the snails *Cepaea nemoralis* are making holes in limestone too. There is a great similarity between the so-called simple holes in limestone and the holes of the mentioned bones. For the moment it is not possible to say that the snails are making holes in the bones. But if they do it, the reason why they are making holes in the bones has to be different from those made into limestone.

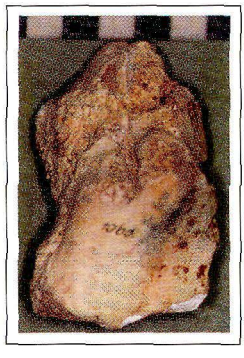
The paper thus presents one more explanation of the origin of the holes. In any case if the "snails' theory" should be accepted, there is a parallel between the holes in rhinoceros' bones to those in the mammoth's, although there is a great difference in time between them. If the snails made the holes they had to be made in a very exceptional, peculiar situation. Otherwise many more of such holes have to be found.



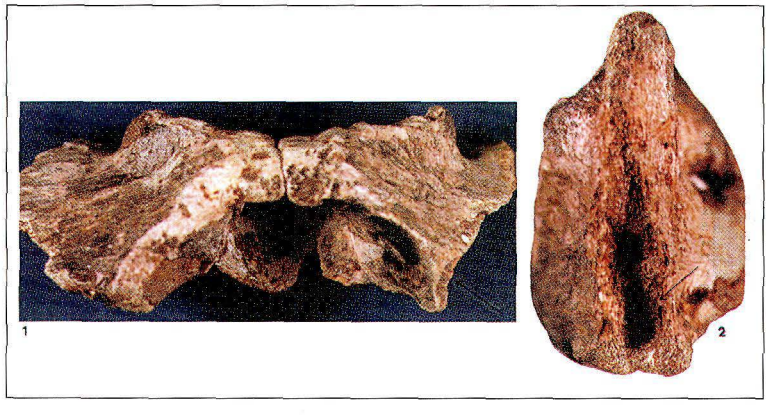
Sl. 1: Fragment d; ovalna luknja v prelomljeni metakarpalni kosti.



Sl. 3: Fragment f; mali luknji na delu epifize.



Sl. 7: Fragment h; žleb na prstnem členku.



Sl. 2: Fragment e; 1: prvo vratno vretence s prečno odlomljeno desno stranjo krila, puščica kaže mesto luknje, 2: frontalni pogled priti luknji.



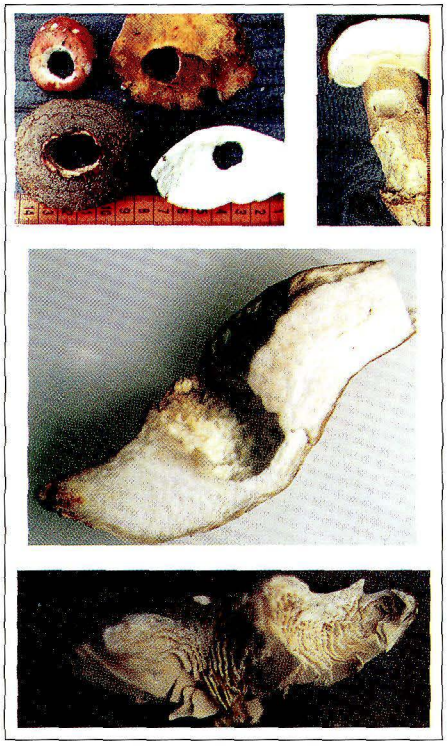
Sl. 4: Fragment g; ovalna "kvadratna" luknjica na sredi kosti.



Sl. 5: Fragment c; "kvadraten" rob luknje.



Sl. 6: Fragment b, bližinski posnetek žleba.



Sl. 11: Luknje ki jih v gobe izjejo polži, zgoraj okrogle, spodaj ovalne luknje.



Sl. 9: Fragment a; obloga gre le do roba luknje in v luknjo ni odložena.

ACTA CARSOLOGICA	XXVI/2	36	431-439	LJUBLJANA 1997

PRVI REZULTATI RAZISKAV KAMNINE V TREH LUNANSKIH KAMNITIH GOZDOVIH (YUNNAN, KITAJSKA)

FIRST RESULTS OF ROCK RESEARCH IN THREE LUNAN STONE FORESTS (YUNNAN, CHINA)

MARTIN KNEZ [1]

Izvleček UDK 551.44(510) 552.54(510)

Martin Knez: Prvi rezultati raziskav kamnine v treh lunanskih kamnitih gozdovih (Yunnan, Kitajska)

Kamnina je v nekaterih predelih lunanskega področja izredno monotone sestave, ponekod pa v geoloških profilih zasledimo pestro menjavanje različnih tipov apnencev in dolomitov. To se odraža na selektivni koroziji in eroziji karbonatov in s tem na oblikovanosti in morfološkem izgledu posameznih kamnitih stebrov, večjih kamninskih blokov in reliefu pokrajine.

Ključne besede: krasoslovje, geologija, litologija, selektivna korozija, kamniti gozd, Yunnan, Kitajska.

Abstract UDC 551.44(510) 552.54(510)

Martin Knez: First results of rock research in three Lunan Stone forests (Yunnan, China)

In some areas of Lunan county the composition of the rock is very monotonous but in some places the geological profiles show alternation of different types of limestones and dolomites. This results in selective corrosion and erosion of carbonates and therefore affects the appearance of separated stone pillars, of the bigger rock blocks and of the landscape relief.

Key words: karstology, geology, lithology, selective corrosion, stone forest, Yunnan, China.

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UVOD

Raziskave v treh kamnitih gozdovih (Shilin, Naigu in Laoheigin) v bližini kraja Lunan (Yunnan) so potekale v sodelovanju med Yunnanskim geografskim inštitutom (Centrom za zaščito narave in kulture) in Inštitutom za raziskovanje krasa Znanstvenoraziskovalnega centra SAZU. Delo na meddržavnem projektu z naslovom *Študij značilnosti krasa lunanskega Kamnitega gozda in študij podzemnega odtekanja vode* je finančno podprlo Ministrstvo za znanost in tehnologijo Republike Slovenije.

Glavne značilnosti krasa v pokrajini Yunnan

Geološka struktura kamnin v pokrajini Yunnan (v kitajščini pomeni Yunnan *južno od ozir. pod oblaki*; v resnici je večji del pokrajine visoka planota z nadmorskimi višinami okrog 2000 m) se kaže kot serija izmenjujočih grebenov in udorin (tektonskih grabnov) v smeri sever-jug. V splošnem pa je znano, da sta bili področji vzhodnega in centralnega dela pokrajine v celoti tektonsko dvignjeni v kenozoiku in danes tvorijo obsežne visoke planote. Večinoma spodnjepaleozoiske in triasne karbonatne kamnine se razprostirajo predvsem v vzhodnem Yunnanu. Prav tako tudi v nekaterih delih zahodnega Yunnana (Zhongdian, Dali in Lincang) zasledimo posamezna manjša karbonatna področja. V provinci Yunnan, ki meri okrog 97 000 km^2, je skoraj 26% ozemlja kraškega (Sweeting 1995).

Naj omenim v literaturi dosegljiv podatek, da ima celotna Kitajska okrog 3,4 milijona km^2 karbonatnih kamnin, to je približno tretjina državnega teritorija (Yuan 1991). Kljub temu pa je razgaljene karbonatne kamnine le za okrog 0,91 milijona km^2, kar je ena desetina njenega ozemlja.

V različnih geoloških in klimatskih pogojih so se izoblikovali trije različni tipi kraške pokrajine:
a) kras tropskega deževnega gozda v Xishuangbanna na jugu,
b) kras tektonskih udorin (grabnov) in
c) kras visokih planot s "kamnitimi gozdovi".

Kras tropskega deževnega gozda v Xishuangbanna na jugu

V pokrajini Xishuangbanna se razteza najobsežnejša robni tropski predel celinske Kitajske. Dve kraški področji posebej izstopati: pokrajina Mengla s površino okrog 500 km^2 in ozemlje vzdolž reke Lancang s površino okrog 450 km^2. Apnenci v pokrajini Mengla so pretežno permijski in srednjekarbonski sivi masivni apnenci, biomikritni in bisparitni apnenci, psevdooolitni apnenci, bioklastični apnenci in triasni dolomitni apnenci. Skladovnica karbonatov je debela preko 2000 m. Pod vplivom vlažne tropske klime so apnenci v kvartarju

intenzivno zakraseli. Značilnosti kraške pokrajine vzdolž reke Lancang se kažejo v številnih depresijah in slepih dolinah, kjer so dokaj pogosti tudi t.i."kamniti zobje" pa tudi posamezni kamniti stebri.

Kras tektonskih udorin (grabnov)

Kras v tektonskih udorinah (Song & Liu 1992) je močno razširjen pojav v pokrajini Yunnan, kjer je vsaj 28 ločenih predelov od katerih ni nobeden manjši od 100 km^2. Največji je t.i. kunminški bazen (po glavnem mestu pokrajine Yunnan, Kunming), ki presega površino 1100 km^2 in ima preko 3000 km^2 vodozbirnega zaledja. Nevezan kamninski pokrov v kunminškem bazenu znaša okrog 1000 m.

Kras visokih planot s "kamnitimi gozdovi"

"Kamniti gozdovi" kažejo poseben tip kraške pokrajine, za katero so značilni skupine stoječih apnenčastih stebrov, ponekod visokih preko 30 m. Apnenčasti stebri stojijo navadno na rahlo valoviti podlagi.

Kamnite gozdove delijo glede na njihovo pokritost z nevezanim sedimentom na gole, pokrite in skrite. Glede na geomorfološko pojavljanje pa na kamnite gozdove na dvignjenih področjih, kamnite gozdove v depresijah in kamnite gozdove na pobočjih.

Splošne značilnosti karbonatnih kamnin

Glavne značilnosti karbonatne kamnine so velika koncentracija le-teh, velika debelina in precejšnja starost kamnine, ki gradijo obsežnejše karbonatne komplekse. So večinoma platformnega tipa in se odlikujejo po precejšnji čistosti, enakomernosti v razporeditvi različnih karbonatnih tipov in enakomerni debelini. Nadalje je za te kamnine značilno, da so bile, tudi zaradi svoje starosti, podvržene močnemu vplivu diagenetskih procesov. Te značilnosti pa se neposredno odražajo tako na hidrološkem odzivu matične kamnine (Kogovšek, Liu & Petrič 1997) kot na razvoju krasa v splošnem.

Lunanski kamniti gozd

Najbolj značilen kitajski kamniti gozd je nedvomno kamniti gozd v neposredni bližini mesta Lunan (Lunan Shilin). Tam so kamniti stebri z izrazitimi ostrimi vrhovi, ki so pogosto tik pod vrhom ločeni od spodnje, bolj ali manj enakomerno debele baze, z leziko. V splošnem so stebri visoki praviloma več kot 10 m. Sicer pa kamnite gozdove najdemo tudi v provincah Guizhou, Guangxi in Fujian (Habič 1980; Waltham 1984; Song 1986). V Provinci Yunnan je preko 400 km^2 površine pokrite s kamnitimi gozdovi.

Lunanski kamniti gozd leži na valoviti kraški planoti na nadmorskih višinah od 1720 do 2000 m (Sweeting 1995). V omenjenem gozdu zasledimo pestro paleto kraških oblik, med katerimi so nedvomno najpomembnejši karbonatni stebri, visoki od 10 do 30 m. Manjši, do 10 m visoki stebri stojijo na višji nadmorski višini, medtem ko najvišji stebre najdemo v depresijah (Sweeting 1995). Pod kamnitimi gozdovi so pogosto tudi jame in podzemni vodni tokovi.

Vzrok tako izrazito razvitemu globokemu krasu v okolici Lunana je posebna kombinacija klimatskih, litoloških, strukturno geoloških in geomorfoloških pogojev (Yuan 1991).

Bistvene značilnosti karbonatnih kamnin na področju Lunana se kažejo v več nivojih. Ena pomembnejših lastnosti je nedvomno njihova spodnjepermijska starost. V splošnem gradijo tipične kamnite gozdove grebenski biomikriti in biospariti, ki so se odložili na blagih plitvomorskih brežinah. Takšne karbonatne kamnine, ki jih dodatno odlikujejo debele plasti in enakomerna kemična sestava, naj bi bile najbolj primerne za oblikovanje visokih kamnitih stebrov. Dodatno pa naj bi stratigrafske in litološke posebnosti, ki smo jih ugotovili v geoloških profilih, doprinesle k tvorbi izjemnih oblik. Letos opravljene uvodne analize so nekatere domneve pomagale ustrezno razrešiti.

Druga pomembna lastnost, ki omogoča razvoj kamnitih gozdov je blag naklon plasti. V lunanskem kamnitem gozdu je vpad plasti večinoma manjši od 5^0. Različni tektonski pritiski so povzročili tvorbo številnih, v gosto mrežo razporejenih, razpok (cf. Šebela 1996). Zaradi svoje usmerjenosti so dovoljevale vertikalno migracijo vadozne vode in s tem intenzivno raztapljanje.

Različna višina kamnitih gozdov na različnih področjih se kaže kot tretja pomembna lastnost. Najvišji stebri (20-40 m) so se oblikovali v velikih skledastih udorinah z velikim vodnim zaledjem.V skledastih udorinah z zelo majhnim naklonom pobočji "zrastejo" stebri tudi nad 10 m. Kjer pa je matična kamnina še vedno pokrita s prstjo, najdemo le t.i. "kamnite zobe", stebre visoke do nekaj metrov (Yuan 1991; Song 1986).

Poleg navedenih značilnosti pa je oblikovanje stebrov tesno povezano z podpovršinskim raztapljanjem matične kamnine, kjer je glavni agens s CO_2 bogata vadozna voda. Ostri vrhovi kamnitih stebrov naj bi nastali z raztapljanjem kamnine s pomočjo površinske vode v brezzračnem horizontu površinskega nevezanega in z organskim materialom bogatega sedimenta (Chen, Song & Sweeting 1985).

Litološke in stratigrafske značilnosti karbonatov lunanskega kamnitega gozda

Kamniti gozdovi, tako v splošnem kot tudi na področju Lunana, nastajajo primarno v zelo debeloplastnatem in kemično čistem apnencu. Po nekaterih podatkih naj bi se lunanski kamniti gozd razvil v karbonatnih plasteh, ki so debele tudi preko 30 m (Song 1986). Debelina plasti v drugih kamnitih gozdovih južne Kitajske je znatno nižja, saj znaša le okrog 2 m.

Lunanski kamniti gozd je nastal v spodnjepermijskih apnencih. Ti so bili tektonsko sicer močno porušeni, nagnjenost plasti pa kljub temu v povprečju ni večja od 10^0. V nekaterih sosednjih kamnitih gozdovih je povprečna nagnjenost skladov izjemoma tudi prek 20^0. Ugotovljeno je, da pri nagnjenosti plasti, ki presega 15^0, ne more priti do večjih kamnitih stebrov (Song 1986).

Pri svojem delu nisem temeljil zgolj na vzorčevanju kamnine iz posameznih kamnitih stebrov, pač pa sem največ pozornosti posvetil stikom različnih kamnin v geološkem stolpcu. V nekaj primerih je tak stik razkrila močnejša korozija določenega dela profila, ki se je morfološko jasno odražala v kamnini. Večkrat pa je za ugotovitev stika litološko različnih kamnin botrovalo le zvezno vzorčevanje.

V lunanskih kamnitih gozdovih je bilo že na terenu ugotovljeno, da ima poseben pomen pri selektivni koroziji tudi različna stopnja poroznosti karbonata. Že makroskopsko je bilo ponekod opaziti, da so posamezni predeli geološkega profila oz. kamnitih stebrov bistveno bolj podvrženi vplivu korozije in erozije (sl.1, 2). Tudi raziskave na mikroskopskem nivoju, ki še niso zaključene, to dejstvo potrjujejo.

Karbonatna kamnina (stopnja Maokou) v Shilin kamnitem gozdu, le-ta meri 11 km^2 (Salomon 1997), se, z izjemo nekaterih krajših odsekov, iz strukturnega in teksturnega vidika skozi geološki profil praktično ne spreminja. Vsi vzorci, raziskani z mikroskopom kažejo, da je bila 350 milijonov let stara kamnina močno diagenetsko spremenjena. Fosilni ostanki so večinoma nerazpoznavni, čeprav tektonsko niso poškodovani. Tudi vpad plasti, ki je večinoma okrog 5^0, in le redko večji od 10^0, kaže na majhne regionalne premike. Hkrati pa rezultati mikroskopskih opazovanj kažejo na to, da danes opazovani vpad plasti najverjetneje odraža le relativno kratko fazo nagibanja terena v nevertikalni smeri, oziroma, da so bloki med sicer ne prav gostimi razpokami ostali malo poškodovani. Ne glede na to pa v kamnini zasledimo številne, s kalcitom zapolnjene drobne razpoke, ob katerih ni prišlo do opaznih zmikov. Zaradi čistosti in prekristaljenosti karbonata matične kamnine je kalcitne žilice marsikdaj že makroskopsko težko ugotoviti. Regionalno obsežno blago antiklinalno dviganje kamnine se je vršilo v več različnih fazah in obdobjih. Na ne le eno deformiranje permijske kamnine opozarja tudi drugi raziskovalci (cf. Yuan 1991).

Kamniti gozd Naigu ima površino 8 km^2 (Salomon 1997). Gradijo ga kamnine iz Qixia formacije, ki se skozi geološki profil nekajkrat spremenijo. Večkrat zasledimo spremembo v barvi, plastnatosti, poroznosti, spremembi vključkov in drugo. Baza najnižjega razkritega dela Naigu kamnitega gozda je sestavljena iz svetlorjavega do oranžnega masivnega in homogenega karbonata. V profilu sledijo kamnine, ki so slabše odporne na korozijo in erozijo. Tvorijo nekakšen ožji del stebra pod sicer širšim in s tem odpornejšim zgornjim delom.

Laoheigin kamniti gozd leži okrog 20 km severno od Shilina. Posamezni kamniti stebri in večji korozijsko in erozijsko preoblikovani bloki kamnine

zavzemajo le okrog 2 km^2. Morfološko so kamniti stebri zelo podobni tistim iz Naigu kamnitega gozda.

Zanimiva so mnenja o vplivu litologije na morfologijo krasa, posameznih kamnitih stebrov in kamninskih blokov. Nekateri krasoslovci trdijo (Zhang 1997), da ni nobenega vpliva karbonatne sestave in strukture kamnine na razvoj in obliko krasa ter kraških oblik. Omenjeni avtor nadaljuje, da se kamniti gozdovi lahko razvijajo tako na dolomitu kot na apnencu, z vključki roženca ali brez, ter da se razvijajo lahko na karbonatnih kamninah različnih strukturnih in genetskih tipov. Drugi pa so mnenja (Salomon 1997), da so litološke posebnosti kamnine bistveni faktor pri razvoju, oblikovanju in današnjem morfološkem izgledu kraških oblik skozi ves razvoj; od kamnitih zob do kamnitih stebrov.

Literature o podrobnih mikroskopskih raziskavah vzorcev iz geoloških profilov raziskovanih kamnitih gozdov nisem našel. Kljub temu pa je v eni od objav omenjeno, da je bilo iz vzorcev kamnine iz kamnitega gozda Shilin izdelanih nekaj mikroskopskih preparatov. Kje so morebitni rezultati mikroskopskih analiz, nisem uspel ugotoviti. V delu geološkega profila, ki ga je mogoče zajeti v neposredni bližini Shilina sem ugotovil, da mikroskopske analize večjih biostratigrafskih sprememb v kamnini ne pokažejo. Pač pa so v vseh treh raziskovanih gozdovih pomembnejše litološke anomalije.

Kljub temu, da se pogosto med rezultati različnih raziskav pojavljajo tudi rezultati kalcimetričnih analiz, pa ni opaziti, da bi kdo podrobneje raziskoval tudi stik litološko različnih kamnin, kjer je selektivna korozija pogosto jasno izražena in tam izvedel mikroskopske in kalcimetrične analize. Kot primer navajam rezultate kalcimetrične analize dveh karbonatov. Da sta vzorca A in B (razdalja med njima je v vertikalni smeri le 0,5 cm) pravzaprav dve povsem različni kamnini je bilo v profilu opaziti le po rahli spremembi barve.

VZOREC	CaO*	Mgo	kalcit	dolomit	skupni karbonat	$CaCO_3$	$MgCO_3$	Ca0/MgO
A	51,76	3,23	84,38	14,75	99,13	92,38	6,75	16,02
B	32,41	20,16	7,82	92,21	100,00	57,87	42,13	1,61

Tabela 1. Primer dveh karbonatov, na stiku katerih je prišlo do intenzivne korozije.
** Vse vrednosti, razen v zadnjem stolpcu, so v %.*

ZAKLJUČEK

Glede na prve makroskopske in mikroskopske raziskave kamnine iz treh kamnitih gozdov iz bližine Lunana je bilo ugotovljeno, da se tip kamnine jasno odraža na selektivni koroziji in eroziji karbonatov in s tem na oblikovanosti in morfološkem izgledu posameznih kamnitih stebrov in večjih kamninskih blokov.

Kalcimetrično analizo (Tabela 1) je na Inštitutu za raziskovanje krasa naredila Mateja Zadel.

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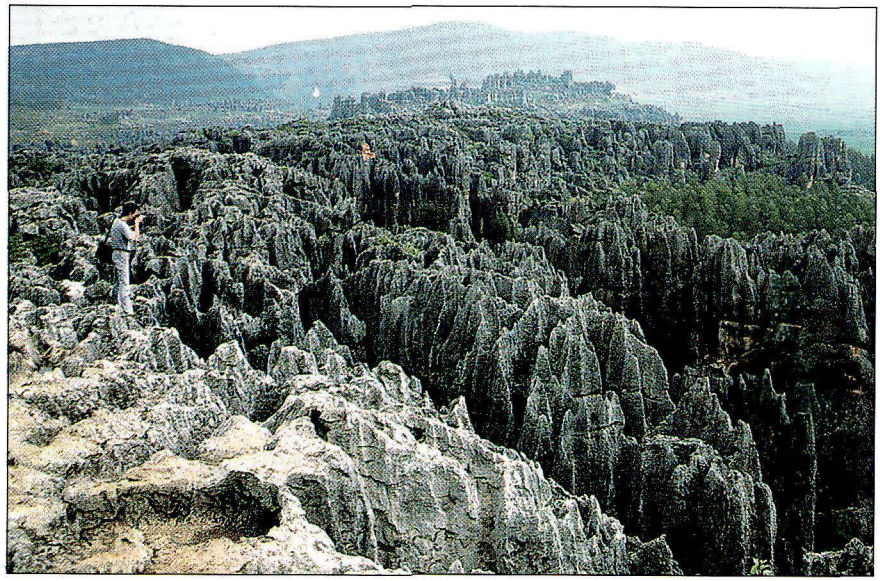
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Sl. 1: Vrh ene od skupin kamnitih stebrov v Naigu kamnitem gozdu (Foto: M. Knez). Fig. 1: Top of one group of the stone pillars in Naigu Stone Forest (Photo by M. Knez).



Sl. 2: Značilna oblika kamnitih stebrov v Laoheigin kamnitem gozdu (Foto: M. Knez). Fig. 2: Tipical shape of the stone pillars in Laoheigin Stone Forest (Photo by M. Knez).

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NEKATERE ZNAČILNOSTI PRENIKAJOČE VODE NA LUNANSKEM KRASU, YUNNAN, KITAJSKA

SOME PROPERTIES OF THE PERCOLATION WATER IN THE KARST OF LUNAN, YUNNAN PROVINCE, CHINA

JANJA KOGOVŠEK[1]

Izvleček UDK 556.3(510)

Janja Kogovšek: Nekatere značilnosti prenikajoče vode na Lunanskem krasu, Yunnan, Kitajska

Julija 1996 in septembra 1997, v začetku in ob koncu deževne dobe, so bile na krasu v kitajski provinci Yunnan ugotovljene osnovne značilnosti prenikajoče vode v podzemnih jamah Jiuxiang, Baiyun, Xin-Shi in Wayao. Podane so osnovne značilnosti dežja in nekatere analize zemljin na tem krasu. Ugotovljene so tudi tiste komponente zemljin, ki jih padavine lahko spirajo in tako vplivajo na proces raztapljanja kamnine oz. zakrasevanje. Visoka vsebnost karbonatov (do 7.7 mekv/l) v prenikli vodi, ki je bila izmerjena v sigastih ponvicah v jamah Jiuxiang in Baiyun, pogojuje izločanje sige.
Ključne besede: krasoslovje, prenikajoča voda, raztapljanje in izločanje, Yunnan, Kitajska.

Abstract UDC 556.3(510)

Janja Kogovšek: Some properties of the percolation water in the karst of Lunan, Yunnan province, China

In July 1996 and in September 1997, at the beginning and at the end of the rainy season, we studied the basic characteristics of the percolation water in the Jiuxiang, Baiyun, Xin-Shi and Wayao caves in the Chinese province of Yunnan. The basic characteristics of rainfall and some analyses of soil there are given. Those soil components that may be washed away by rainwater and thus influence rock solution or karstification are identified. High carbonate levels (up to 7.7 mekv/l) in the percolation water, measured in micro-gours in the Jiuxiang and Baiyun caves, control the flowstone deposition
Key words: karstology, percolation water, solution and deposition, Yunnan, China.

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UVOD

V juliju 1996 smo v okviru mednarodnega znanstvenega sodelovanja med Slovenijo in Kitajsko, ki ga je omogočilo Ministrstvo za znanost in tehnologijo RS, raziskovali v sodelovanju s kitajskimi kolegi z Geografskega inštituta iz Kunminga tudi značilnosti kraške vode na njihovem krasu v okolici Lunana. Povprečna letna količina padavin območja je 796 mm, povprečna relativna vlaga 75.3 % in povprečna letna temperatura 15.6°C. Sicer pa letna količina padavin od leta do leta zelo niha. Več kot 80 % vseh letnih padavin pade v deževnem obdobju nekako od junija do oktobra.

Metodologija dela

Preniklo vodo v podzemnih jamah smo vzorčevali v večini primerov neposredno na jamskem stropu. Pretoke smo v večini primerov ocenili glede na ulovljeno količino v določenem času. Ob zajemu vodnih vzorcev smo na terenu določili temperaturo na desetinko natančno in specifično el. prevodnost - SEP na 1 μS/cm (julija 1996 z aparatom LF 91-WTW, septembra 1997 pa z LF 196) ter pH vzorcev (aparat pH 90-WTW). Primerjava - interkalibracija obeh konduktometrov je pokazala dokaj dobro ujemanje. V območju 150 do 250 μS/cm smo z LF 91 določali od 1 do 0 % prenizke vrednosti in v območju 250 do 500 μS/cm od 0 do 1 % previsoke vrednosti.

SESTAVA DEŽJA

Daoxian (1991) navaja sestavo dežja: pH, vsebnost kalcija, magnezija, natrija, kalija ter kloridov, sulfatov, nitratov in amonija za nekaj območij Kitajske, vendar ne tudi za območje Yunnana. Ugotavlja vpliv matične kamnine, kot tudi vplive človekove dejavnosti, kot so dim in onesnaževanje zaradi cementarn in kamnolomov. Navaja, da je vsebnost kalcija v dežju na krasu znatno večja, preko 5 mg/l (oz. 12.5 mg $CaCO_3$/l) kot na nekraškem svetu, kjer je pod 0.1 mg/l.

Prva naša vzorčevanja in meritve dežja smo opravili v Kamnitem gozdu v juliju 1996. Od 9. do 14. julija je padlo skupno 87 mm padavin. Ozračje je bilo tako 16. julija zvečer, ko je začelo ponovno deževati, dokaj dobro sprano. V času pred polnočjo je padlo po naši oceni 10 mm dežja, od polnoči do jutra pa po naših meritvah še nadaljnjih 42 mm dežja. Tedaj smo tudi zajeli 1. vzorec dežja. Padavine so se občasno nadaljevale še preko dneva, ko je padlo 14 mm dežja in smo zajeli 2. vzorec dežja. Te naše meritve količine dežja so se dobro skladale z meritvami na padavinski postaji Dakenyan. Po podatkih te padavinske merilne postaje je padlo 16. julija 56.6 mm dežja, 17. julija pa 11 mm, skupno 67.6 mm.

Naslednji, zelo skromen dež je padel ponoči z 20. na 21. julij in sicer je bilo to le počasno pršenje. V Kamnitem gozdu smo izmerili 3.5 mm, v Dakenyanu pa so zabeležili 5.5 mm. Nekoliko več dežja pa je padlo naslednjo noč, v Kamnitem gozdu po naših meritvah 10 mm, pri Dakenyanu pa 26.5 mm. Tudi opazovanje vodostaja voda ob vzorčevanju voda je dajalo vtis, da je v približno 7 km oddaljenem Dakenyanu in na območju NO od Kamnitega gozda v primerjavi s Kamnitim gozdom padlo več padavin, da gre občasno za lokalne razlike.

V vseh primerih smo vzorčevali dež od začetka do konca padavin, tako, da sem analizirala kompozitorne vzorce dežja. Rezultati meritev so razvidni iz tabele 1. Temperatura ozračja je preko dneva in noči le malo nihala okoli vrednosti 20°C. SEC vzorcev je obratno sorazmerna količini padavin, kar se zdi logično, saj se je onesnaženje iz zraka spiralo z manjšo ali večjo količino dežja, ko so nastopili manjši ali večji razredčevalni učinki. Ob nizkih vrednosti SEP in pH (v noči na 22.7.96) je dež vseboval 0.12 mekv/l (6 mg $CaCO_3$/l) kalcija in magnezija. Ob pršenju 20. julija smo izmerili znatno višjo SEP in tudi pH, zaradi česar sklepamo, da je bila tudi vsebnost raztopljenih karbonatov tedaj verjetno višja.

Ob ponovnem obisku 25. septembra 1997 je rosilo in preko dneva je padlo le 7 mm dežja. Popoldne pa je začelo močneje deževati in kasneje v presledkih deževalo še preko naslednjega dne. Močno se je ohladilo, saj smo izmerili 14°C. Skupno je padlo 25 mm dežja, ki smo ga analizirali (tabela 1). Dež je vseboval 0.2 mekv/l kalcija in magnezija (10 mg $CaCO_3$/l). Tudi naslednja dva dni je počasi deževalo z občasnimi prekinitvami, ko je padlo 10 mm dežja, ki je vseboval 14 mg $CaCO_3$/l.

Tabela 1: Značilnosti dežja v Kamnitem gozdu.
Table 1: The characteristics of rain in Stone Forest.

Čas vzorčevanja	Količina dežja	T	SEP	pH	Karbonati	Ca+Mg
Time of sampling	Quantity of rain	T	SEC	pH	Carbonates	Ca+Mg
	mm	°C	µS/cm		mekv/l	mekv/l
16.-17.7.96	42	19.5	29	7.15	0.12	0.06
17.07.96	14	18.5	44	7.95		
20.-21.7.96	3.5	20.5	76	8.24		
21.-22.7.96	10	19.0	44	7.18		0.12
25.-26.9.97	25	14.0	17	7.12	0.12	0.20
26.-28.9.97	10	20.5		7.72		0.28

V okviru meritev in analiz padavin v Postojni v času od 1985 do 1987 smo izmerili nihanja SEP med 10 in 285 µS/cm s povprečno vrednostjo 45 µS/cm. Dež z višjo SEP, ki je vseboval več kalcija in karbonatov, je imel tudi povišane vrednosti pH, kar smo pripisali burji oz. raztapljanju karbonatnih delcev

matične kamnine v zraku. Povprečna vrednost vsote kalcija in magnezija v dežju je bila 6.8 mg $CaCO_3$/l in povprečna vrednost pH 4.5. Občasno smo zabeležili tudi opazneje povišane vrednosti sulfatov, nitratov in kloridov (Kogovšek & Kranjc 1988).

Za podrobnejšo sliko sestave padavin v Kamnitem gozdu bi bile potrebne obsežnejše analize ob najrazličnih padavinskih dogodkih, poleg pH, SEP, vsebnosti karbonatov, kalcija in magnezija, pa še določitve vsebnosti nitratov, sulfatov in kloridov.

ZNAČILNOSTI PRENIKAJOČE VODE V PODZEMNIH JAMAH

Padavinska voda, ki prenika najprej skozi tanjšo ali debelejšo plast zemljin z vegetacijo, v primerih ko te ni, pa neposredno skozi različno debele karbonatne kamnine, se pojavi kot prenikla voda v podzemnih jamah. Vse dogajanje *na poti do podzemne jame se odrazi v sestavi prenikle vode v jami.*

K raztapljanju karbonatnih kamnin lahko pomembno prispevajo zemljine z vegetacijo nad njo. Da bi spoznali vpliv zemljin, smo na površju zajeli nekaj vzorcev prsti in jim določili vsebnost karbonatov, organskega ogljika in fosfatov (tabela 2). Da bi določili, katere komponente padavine lahko spirajo iz prsti, pa smo zmlete vzorce ob občasnem mešanju namakali v destilirani vodi (5g v 500 ml 6 dni) in po centrifugiranju določali v vodni ratopini vsebnost: kloridov, nitratov, sulfatov, fosfatov, silicija, kalcija in magnezija ter pH. Rezultati so zbrani v tabeli 3.

Tabela 2: Analize zemljin.
Table 2: Soil analyses.

Vzorec	Karbonati	organski C	P2O5
Sample	Carbonates	organic C	P2O5
	%	g/100g	mg/100g
Kamniti gozd	0	0.39	24
P1- pri Maoshuidong	1.08	1.7	48
P2 - pri Guanyindong	0.8	1.4	28

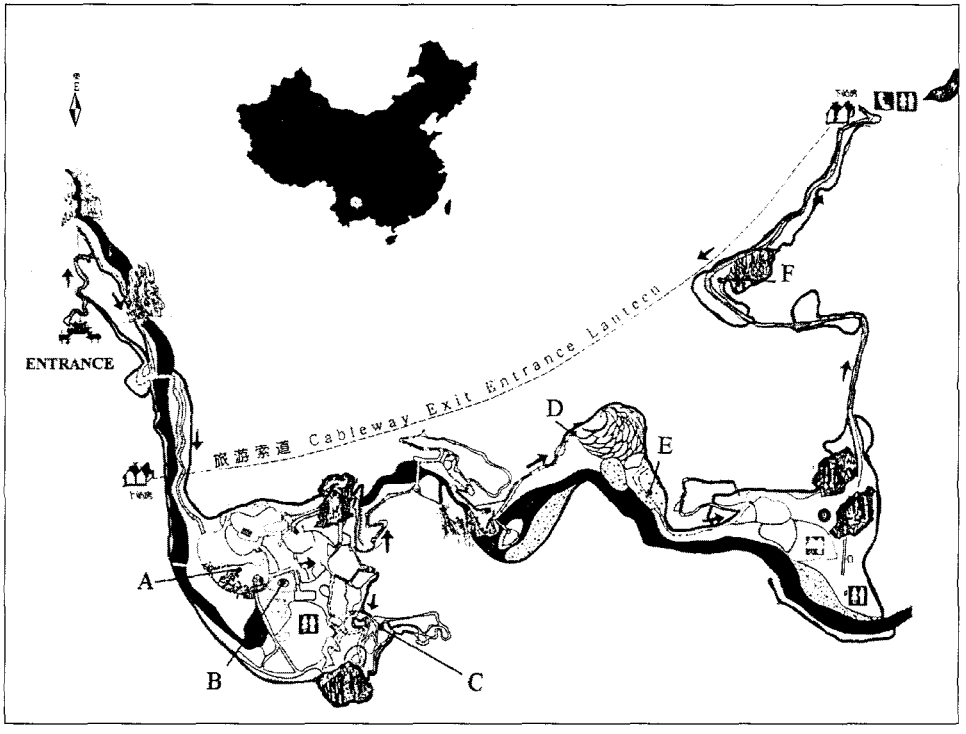
Tabela 3: V vodi topne komponente zemljin.
Table 3: Components of soil soluble in water.

Vzorec	pH	Kalcij	Magnezij	S ilicij	Kloridi	Nitrati	Fosfati
Sample	pH	Calcium	Magnesium	Silica	Chlorides	Nitrates	Phosphates
		mg/100g	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g
Kamniti gozd	6.65	50	3.6	170	5	9	1
P1-pri Maoshuidong	6.3	20	1.2	78	5	2.2	0.2
P2 - pri Guanyindong	8	8	2.4	99	5	11	0.4

Ob obisku podzemnih jam Jiuxiang, Baiyum, Xin-Shi in Wayao v Yunnanu smo zajeli več vzorcev prenikle vode, opravili meritve in nekatere analize, ki so pokazale osnovne značilnosti preniklih voda tega dela kitajskega krasa. Daoxian (1991) ugotavlja za prenikajočo vodo v jami Muyuanfu (Guilin) karbonatno trdoto med 1.6 in 5.7 mekv/l (100 - 350 mg HCO_3^-/l), medtem ko nismo zasledili podatkov za Yunnan, da bi primerjali naše meritve.

Jama Jiuxiang

Ogled jame Juixiang nam je dal vtis podobnosti s Škocjanskimi jamami. V jamo ponika reka Mai Tian. Turistična pot poteka vzdolž njenega površinskega in podzemnega kanjona in dalje v obsežne dvorane. Opazili smo več kapljanj in manjših curkov prenikle vode. Dva tedna pred našim obiskom julija 1996 ni bilo večjih padavin. Zajeli smo vzorec reke Mai Tian in tri vzorce prenikle vode (slika 1). Ob obisku septembra 1997 smo ponovno zajeli vzorec reke Mai Tian, štiri vzorce prenikle vode in dotekajočo vodo v velike in manjše ponvice.



Sl. 1: Jama Jiuxiang: zajemna mesta prenikle vode A, B, C, D, E in F.
Fig. 1: Jiuxiang Cave: sampling points of percolation water (A, B, C, D, E and F).

Reka Mai Tian

Dne 13.7.1996 je bila voda reke Mai Tian pred ponorom ob 13.00 srednje kalna z nekoliko povišanim pretokom, izmerili smo temperaturo 20.1 °C, specifično električno prevodnost (SEP) 184 μS/cm in pH 8.26. Vzorec smo pred nadaljnjimi analizami prefiltrirali skozi filter modri trak, vendar je ostal tudi po filtraciji še moten, kar kaže na prisotnost zelo finih trdnih delcev. Voda je vsebovala 1.76 mekv/l (107 mg HCO_3^-/l) karbonatov in 0.88 mekv/l (17.6 mg Ca^{2+}/l) kalcija. Vsebnost magnezija je bila enaka vsebnosti kalcija, tako da je znašalo razmerje Ca/Mg 1, kar pomeni da reka dobiva vodo z dolomitnega območja.

Naslednje leto smo zajeli vzorec Mai Tian na istem mestu 23. septembra ob nekoliko višjem vodostaju, ki pa je bil v upadanju. Voda je imela temperaturo 17.7 °C, SEP je znašala 147 μS/cm in pH pa 8.95. Voda je vsebovala 1.42 mekv/l karbonatov, 0.84 mekv/l kalcija in 0.64 mekv/l magnezija, tako de je razmerje Ca/Mg znašalo 1.3. V primerjavi s preniklo vodo v jami, so vrednosti SEP in trdot opazno nižje, kar govori o neprimernosti uporabe te vode za zapolnjevanje preko leta pretežno suhih velikih ponvic v jami.

Prenikla voda

Tudi vzorci prenikle vode v jami Juixiang so imeli razmerje Ca/Mg okoli vrednosti 1, kar pomeni, da padavinska voda prenika skozi dolomitno oz. dolomitizirano kamnino. Vzorec A-97 (slika 1) smo zajeli septembra 1997 in je kapljanje s pretokom okoli 10 ml/min v sicer zelo suhem delu jame na vrhu stopnic v prehodu iz kanjonskega v suhi del jame. Vzorec B-96 smo zajeli julija 1996 in je močnejše kapljanje oz. že kar curek, ki s 5 m visokega stropa in s pretokom približno 70 ml/min pada v zbiralnik v prostrani dvorani. Že takojšnja meritev SEC te vode je pokazala visoke vrednosti, zaradi česar sem predpostavljala morebiten vir onesnaženja na površju. To je nakazala tudi kasnejša primerjava vsebnosti karbonatov in celokupne trdote te vode z drugimi preniklimi vodami. Po končanem obisku jame smo se s sedežnico odpeljali na izhodno točko. Ugotovili smo, da je končna postaja te sedežnice nad dvorano, kjer smo zajeli omenjen vzorec in tako obstaja možnost onesnaževanja s površja. Žal tedaj nismo imeli možnosti opraviti še analiz nitratov, kloridov in sulfatov, ki bi naše predvidevanje tudi lahko potrdile.

Septembra 1997 smo ponovno zajeli vzorec te vode B-97 in ugotovili nižje vrednosti SEP in vseh trdot, 9 mg/l kloridov ter večjo prisotnost sulfatov, ki pa smo jih določili le kvalitativno. Vse meritve in analize so razvidne iz tabele 4 ter slik 2 in 3. Tudi izdatnejše kapljanje na točki C v stranskem rovu dosega visoko SEP in predvsem celokupno trdoto, vsebovala pa je še 6 mg/l kloridov, medtem ko sulfati niso bili povišani. Žal tudi tokrat nismo mogli določiti nitratov.

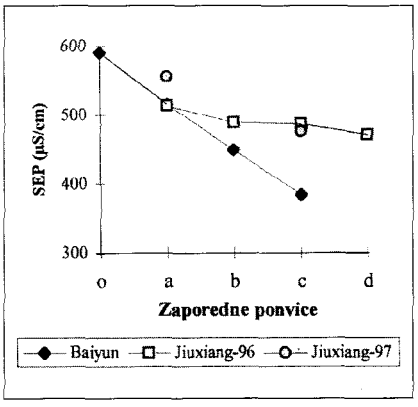
Tabela 4: Značilnosti prenikle vode v kraških jamah Jiuxiang, Baiyun, Xin-Shi in Wayao.
Table 4: The characteristics of percolation water in Jiuxiang, Baiyun, Xin-Shi and Wayao caves.

Jama	Mesto	Pretok	T	SEP	pH	Karbonati	Ca	Mg	Celok. t.	Ca/Mg	Nekarb.t.
Cave	Place	Dischar.	T	SEC	pH	Carbonat.	Ca	Mg	Total h.	Ca/Mg	Noncar.h.
		ml/min	oC	µS/cm		mekv/l	mekv/l	mekv/l	mekv/l		mekv/l
Jiuxiang	A - 97			331	8.40	3.36	1.28	2.07	3.35	0.6	
	B - 96	70	20.0	605	8.40	5.12	2.72	2.88	5.60	0.9	0.48
	B - 97		17.2	500	8.15	4.75	2.47	2.44	4.91	1.0	0.16
	C - 97	100	15.9	615	8.03	5.28	3.19	4.15	7.34	0.8	1.06
	D - 97			692	7.68	7.70	3.47	4.27	7.74	0.8	
	E - 96		17.5	514	7.80	5.04	2.80	2.80	5.60	1.0	0.56
	E - 97		15.9	556	7.70	5.75	3.35	2.99	6.34	1.1	0.59
	F - 97		15.2	394	8.40	4.21	1.88	1.62	4.39	1.2	0.18
Baiyun	G -96	100	17.3	550	7.75	6.08			6.16		0.08
	G - 97	50	17.6	594	7.44	6.32	5.35	1.19	6.54	5.5	0.22
	H - 97	10		645	8.03	7.05	5.75	1.67	7.42	3.4	0.37
	I - 96	400	18.0	590	7.15	6.52			6.68		0.16
	I - 97	50	16.4	527	7.97	5.43	4.27	1.36	5.63	3.1	0.2
	J - 97	100	16.4	532	7.88	5.63	4.47	1.59	6.06	2.8	0.43
	K - 97			398		4.54	2.63	2.16	4.79	1.2	
	L - 97		16.8	511	7.63	5.59	4.63	0.88	5.51	5.3	
Xin-Shi	M	3	20.4	405	8.45	4.00			4.24		0.24
	N	20		478	8.15	4.88			5.20		0.32
	O	10		515	8.40				5.52		
	P	80	19.8	545	7.53	5.76			6.00		0.24
	R		18.6	470	7.52				5.12		
Wayao	S		16.2	355	8.27	2.75	3.31	0.2	3.51		0.76
	T		15.9	461	8.11	3.77	4.59	0.16	4.75		0.98

IZLOČANJE SIGE V PONVICAH

Jamo Jiuxiang krasijo kar na štirih mestih različno obsežne sigaste ponvice. Največje ponvice so na obsežnem pobočju, in so kar nekajkrat večje kot v Škocjanskih jamah. Tudi te ponvice, podobno kot ponvice v Škocjanskih jamah, nimajo stalnega dotoka vode. Ob njihovem vznožju so manjše ponvice, ki pa so stalno zapolnjene z vodo.

Ob obisku septembra 1997 smo uspeli zajeti dotekajočo vodo v velike ponvice, vzorec D-97, ki pa so bile le delno zalite s to vodo. Leto poprej, v juliju, ko se je šele dobro začelo deževno obdobje, dotoka ni bilo. Meritve in analize te vode so pokazale najvišje do sedaj izmerjene vrednosti SEP in trdot v okviru naših analiz preniklih voda na yunnanskem in slovenskem krasu. Ker pa dosegajo trdote v svojem sezonskem nihanju, verjetno podobno kot izvirne vode na tem krasu, najvišje vrednosti na začetku deževne dobe, sklepamo, da bi tedaj izmerili lahko še nekoliko višje vrednosti. Analize so



Sl. 4: Izločanje sige v ponvicah v jamah Baiyun in Jiuxiang.
Fig. 4: Flowstone deposition in massive gours in the Baiyun and Jiuxiang caves.

pokazale višje vrednosti magnezija v primerjavi s kalcijem (v mekv/l), kar na slovenskem krasu še nisem zabeležila. Različnost sestave preniklih voda vzdolž jame pa nakazuje pestrost geološke zgradbe, ki jo bodo, kot pričakujemo, potrdile podrobnejše analize kamnine, saj so bili vzeti številni vzorci.

Že ob prvem obisku julija 1996 smo zajeli vzorce vode v manjših, niže ležečih ponvicah, in sicer dotekajočo vodo v 1. ponvico (E_o - 96) in opraviti meritve v nižjih zaporedno si sledečih ponvicah (tabela 5 in slika 4). Meritve SEP so pokazale zaporedno nižanje vrednosti, zato sklepamo na izločenje sige, oz. recentno rast ponvic. Ker nismo uspeli zajeti dotekajoče vode pred 1. ponvico, sklepamo, da ima ta še višjo SEP oz. večjo vsebnost karbonatov.

Tabela 5: Izločanje sige v povicah v jamh Jiuxiang in Baiyun.
Table 5: Flowstone deposition in gours in Jiuxiang and Baiyun caves.

Jama	**Mesto**	**Pretok**	**T**	**SEP**	**pH**	**Karbon.**	**Ca**	**Mg**	**Celok.t.**	**Ca/Mg**	**Nekarb.t.**
Cave	Place	Dischar.	T	SEC	pH	Carbonat.	Ca	Mg	Total h.	Ca/Mg	Noncar.
		ml/min	oC	µS/cm		mekv/l	mekv/l	mekv/l	mekv/l		mekv/l
Jiuxiang	Eo - 96		17.5	514	7.80	5.04	2.80	2.80	5.60	1.00	
	Ea - 96		17.8	489							
	Eb - 96		*17.8*	*488*							
	Ec - 96		18.0	472							
	Eo - 97		15.9	556	7.70	5.75	3.35	2.99	6.34	1.10	0.59
	Eb - 97		*15.7*	*477*	*8.24*	*4.9*	*2.35*	*2.84*	*5.19*	*0.83*	*0.29*
Baiyun	Io - 96	100	18.0	590	7.15	6.52			6.68		
	Ia - 96			515							
	Ib - 96			450							
	Ic - 96			385							
	Ko - 97			398		4.54	2.63	2.16	4.79	1.2	
	Ka - 97			385							
	Kb - 97			375							
	Kc - 97			337		3.65	2.07	1.6	3.67	1.3	

Za "oživitev" velikih ponvic bi torej potrebovali vodo z visoko vsebnostjo karbonatov. Voda reke Mai Tian ni primerna, saj ima do 5-krat manjšo karbonatno in celokupno trdoto, ker bi lahko povzročila raztapljanje ponvic.

Jama Baiyun

Jama Baiyun leži v Naigu Kamnitem gozdu. D. Ford, J. N. Salomon in P. Williams (1997) ugotavljajo, da je Naigu stone forest v osnovi iz homogenega sivega apnenca, nad njim pa je plast približno 1.5 m srednje plastovitega masivnega dolomitnega apnenca. Dolomit se pojavlja v obliki "mozoljčkov", ki so nastali z rekristalizacijo in so zato bolj odporni proti raztapljanju kot fino zrnati kalcitni matriks in izstopajo iz osnove.

Prenikla voda

Strop jame je visok le nekaj metrov, njegova debelina pa je več 10 metrov. Jama je lepo zasigana s številnimi drobnimi kapljanji, na nekaterih mestih pa so bili tudi manjši curki prenikle vode. Od vstopa v jamo do njenega konca nas spremlja bister potok. Jamo smo obiskali 18.7.1996, ko so bile dva dni prej izdatne padavine, ki so pogojevale večje pretoke. Vzorec prenikle vode G-96 smo zajeli julija 1996 na stropu. Pretok drobnega curka je znašal 200 ml/min. Voda je po slabem metru poti skozi zrak padala na sigasto kopo ob turistični poti, kjer so bili znaki vidnega odlaganja sige. Značilnosti preniklih voda so razvidne iz tabele 4 in slik 2 in 3.

Ob obisku septembra 1997, ko smo beležili vzdolž jame nižje pretoke prenikle vode kot julija 1996, smo ponovno zajeli vzorec tega curka G-97, ki je dosegal višje vrednosti SEP in trdot, kar pa je verjetno odraz načina in manjše hitrosti pretakanja skozi jamski strop. Razmerje med vsebnostjo kalcija in magnezija je bilo 5.5. Le nekaj metrov stran smo zajeli kapljanje H-97, kjer smo izmerili najvišjo SEP in trdote prenikle vode v jami. Karbonatna trdota je bila 7.05 mekv/l, celokupna pa 7.42 mekv/l.

Sigaste ponvice

Julija 1996 smo nekoliko globlje v jami zajeli vzorec curka I-96 s pretokom 400 ml/min, ki je padal v ponvico, voda pa se je nato zaporedno prelivala v več niže ležečih ponvic. Meritve SEP so pokazale znatno upadanje vrednosti, iz česar smo sklepali na opaznejše izločanje karbonatov, oz. rast ponvic. Do druge ponvice je SEP upadla za 13 %, do tretje še za 11 % in do četrte pa še za 11 %. Na razdalji nekaj metrov se je torej SEP zmanjšala kar za 35 %. Ker ni bilo vidnih možnih onesnaževalcev na površju nad jamo, sklepamo, da so spremembe SEP sorazmerne vsebnosti karbonatov. Seveda bi to predpostavko lahko potrdile le vzporedne analize. Ta prenikla voda je imela najvišje vsebnosti karbonatov (6.52 meq/l) in najvišjo celokupno trdoto (6.68 meq/l) od vseh naših meritev prenikle vode julija 1996 na tem območju yunnanskega krasa. Nekarbonatna trdota je bila zelo nizka, žal pa nismo mogli zaradi omejene opreme določiti kalcija.

Septembra 1997 je bil ta curek le počasno kapljanje, popnvice pa so bile le delno zalite z vodo, napeljano iz potoka, tako, da smo zajeli vzorec vode 1 m oddaljenega kapljanja s pretokom okoli 50 ml/min I-97, ki pa je dosegal nižjo vrednost SEP in nižje trdote kot I-96. Vzorčevali smo še le 3 m oddaljen droben curek s pretokom 100 ml/min J-97, ki pa je imel nekoliko višje trdote kot kapljanje I-97. Sklepamo, da so razlike odraz različnega načina pretakanja.

Septembra 1997 smo vzorčevali vodo tudi v manjših ponvicah v začetnem delu jame na točki K. Preko zaporednih ponvic je SEP postopoma upadala od prve do četrte ponvice, skupno za 61 μS/cm. Pri tem se je izločilo 56 mg $CaCO_3$. Vendar je bila vsebnost karbonatov dotekajoče vode (4.54 mekv/l) sorazmerno nizka, saj je dotekajoča voda v velike ponvice v jami Jiuxiang dosegala kar 7.7 mekv/l.

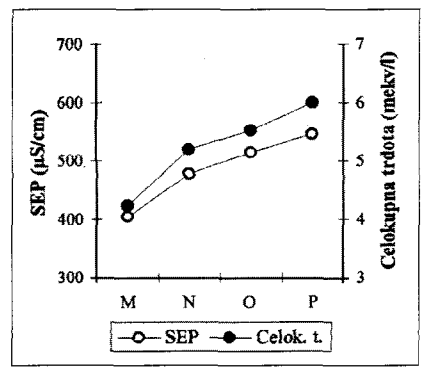
Potok

Vse prenikle vode v jami Baiyun so bile prenasičene in povsod so bili vidni znaki svežega izločanja sige ob polzenju vode. Tudi potok (L), ki spremlja obiskovalca vzdolž turistične poti od začetka do konca jame, ima zelo visoke vsebnosti karbonatov in kalcija, magnezij pa je nekoliko nižji, tako, da znaša razmerje Ca/Mg 5.3. Je prenasičen in izloča sigo, saj mu SEP na nekako 400 m dolgi poti po jami upade za 25 μS/cm. Upravljalci jame so to vodo upravičeno napeljali na bližnji stalagmit in nato v sigaste ponvice na točki I, čeprav verjetno prej niso preverili njene sestave. Že na 3 m dolgi poti po stalagmitu upade SEP za 42 μS/cm, kar pomeni sorazmerno hitro izločanje sige.

Najvišje vsebnosti karbonatov v prenikli vodi smo na območju Slovenije zabeležili v jamah Krasa, v Škocjanskih jamah 6.3 mekv/l in v Vilenici 6.6 mekv/l, vendar le pri kapljanjih s pretokom le nekaj ml/min (Kogovšek 1984).

Jami Xin-Shi in Wayao

V Naigu kamnitem gozdu smo 22. julija 1996 raziskovali tudi v neturistični jami Xin- Shi, ki je bila dalj časa zaprta z veliko skalo. Medtem ko so kolegi opravili izmero jame za izdelavo njenega načrt, sem zajela več vzorcev prenikle vode.



Sl. 5: Jama Xin-Shi: Celokupna trdota in SEP z debelino jamskega stropa naraščata.
Fig. 5: Xin-Shi Cave: Total hardness and SEC is proportional to increase of the cave roof thickness.

Površje nad jamo je porasło s travo in redkejšim grmičevjem. Višina stropa v jami je le do nekaj metrov in opazili smo vidne znake, da se v nižjem delu jame voda občasno dvigne skoro do stropa. Verjetno so bila v jami prav zaradi dežja, ki je padel v noči pred našim obiskom, kar številna drobna kapljanja. Jama leži namreč plitvo pod površjem, z debelino jamskega stropa od 2 m na vhodnem delu do nekako 10 m globlje v jami. Opazili smo precej drobnih kapljanj s pretokom le nekaj ml/min, ter le nekaj izdatnejših. Največji pretok, 80 ml/min, je imel droben curek najgloblje v jami. Meritve in analize so pokazale naraščanje SEC, vsebnosti raztopljenih karbonatov in celokupne trdote v smeri od vhoda v notranjost jame, oz. z večanjem debeline jamskega stropa (tabela 4 in slika 5) kar pomeni, da na najtanjših delih jamskega stropa še ne pride do nasičenja oz. prenasičenja prenikajoče vode.

Vzorec R je voda iz malega jezerca v najnižjem delu jame in njene značilnosti odražajo preniklo vodo, ki se zbira na neprepustnem dnu s finim sedimentom. Tudi prenikle vode v tej jami, podobno kot v jamah Jiuxiang in Baiyun, imajo nizko nekarbonatno trdoto.

Podobne značilnosti prenikle vode smo izmerili tudi v jami Wayao, kjer je prenikla voda, ki priteka skozi približno 3 m debel strop (S) dosagala nižje vrednosti trdot kot pa globje v jami z debelino stropa okoli 8 m (T). V obeh vzorcih smo zabeležili opazno višjo nekarbonatno trdoto, kot pri ostalih preniklih vodah, povečano vsebnost kloridov in sulfatov.

ZAKLJUČEK

Opazovanja dežja na območju Kamnitega gozda, Yunnan, so pokazala, da lahko pade večja količina dežja v sorazmerno intenzivni obliki (julija 1997 40 mm v 6 urah) ali pa kot počasen dež, ko dnevna količina ne preseže 10 mm. Spec. el. prevodnost dežja je znašala od 17 do 76 μS/cm, pH od 7.1 do 8.25, skupna vsebnost kalcija in magnezija pa je bila od 3 do 14 mg $CaCO_3$/l. Daoxian (1991) navaja, da je vsebnost kalcija v dežju na kit ajskem krasu znatno večja kot na nekraškem svetu in presega 12.5 mg $CaCO_3$/l. K raztapljanju karbonatnih kamnin pa na pokritem krasu pomembno prispevajo zemljine, oz. topne komponente v njej, ki jih lahko spira dež. To so predvsem silikati, nitrati in kloridi.

Preniklo vodo smo vzorčevali (skupno 25 vzorcev) v štirih jamah julija in septembra ob različnih hidroloških pogojih. Prenikla voda v Jami Jiuxiang je dosegala razmerje Ca/Mg od 0.6 do 1.2, podobno kot tudi reka Mai Tian, ki ponika vanjo. Spec. el. prevodnost, ki odraža količino prisotnih raztopljenih snovi, je znašala od 331 do 692 μS/cm, vsebnost karbonatov je bila od 3.36 do 7.7 mekv/l in celokupna trdota od 3.35 do 7.74 mekv/l. Najvišjo vrednost trdot smo zabeležili pri prenikli vodi, ki napaja velike ponvice, in sicer septembra ob višjem vodostaju. Določili smo ji tudi višjo vsebnost magnezija v primerjavi s

kalcijem, česar na slovenskem krasu še nismo izmerili. Ker pa verjetno dosegajo trdote preniklih voda v svojem sezonskem nihanju, podobno kot izvirne vode na tem krasu, najvišje vrednosti na začetku deževne dobe, sklepamo, da bi tedaj zabeležili še nekoliko višje trdote.

Zanimivo je, da ima tudi dotočna voda v ponvice v Škocjanskih jamah najvišjo trdoto v vsej jami, da je ta dotok občasen in nastopi le po res izdatnih, dalj časa trajajočih padavinah. Vendar ima ta voda le nizko vsebnost magnezija, njene trdote pa so v primerjavi z dotekajočo vodo v velike ponvice v jami Jiuxiang za nekako 15 % nižje.

Prenikla voda v jami Baiyun odraža drugačno kamninsko sestavo kot je v jami Jiuxiang, saj dosega razmerje Ca/Mg vrednosti od 2.8 do 5.5. Voda je prenasičena in izloča sigo. Septembra 1997 so bili pretoki nižji kot julija 1996. Na primerjalni točki G smo izmerili višje trdote in spec.el.prevodnost septembra. Verjetno to odraža prevlado načina pretakanja v pogojih slabše zapolnjenosti zaledja curka v primerjavi s sezonskim nihanjem. Sezonsko nihanje trdit pa bi ga lahko potrdili le s pogostejšimi meritvami preko celega leta. V jami Xin-Shi smo zajeli vodo, ki je prenikala skozi 2 do nekako 10 m debel jamski strop. Sorazmerno z naraščanjem debeline jamskega stropa smo izmerili tudi naraščanje trdot, oz. različno stopnjo nasičenosti oz. prenasičenosti vod.

Meritve izločanja sige v ponvicah so v jamah Jiuxiang in Baiyun pokazale, da se že na kratki poti preko nekaj ponvic na razdalji nekako 3 m iz 1 litra vode izloči od 20 % (56 mg CaCO3) do 35 % od vseh raztopljenih karbonatov. Sigo pa izloča tudi potok, ki teče skozi jamo Baiyun, ki ga tako lahko uporabljajo tudi za napajanje ponvic in bližnjega stalagmita, ki imata slab dotok prenikle vode.

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SOME PROPERTIES OF THE PERCOLATION WATER IN THE KARST OF LUNAN, YUNNAN PROVINCE, CHINA

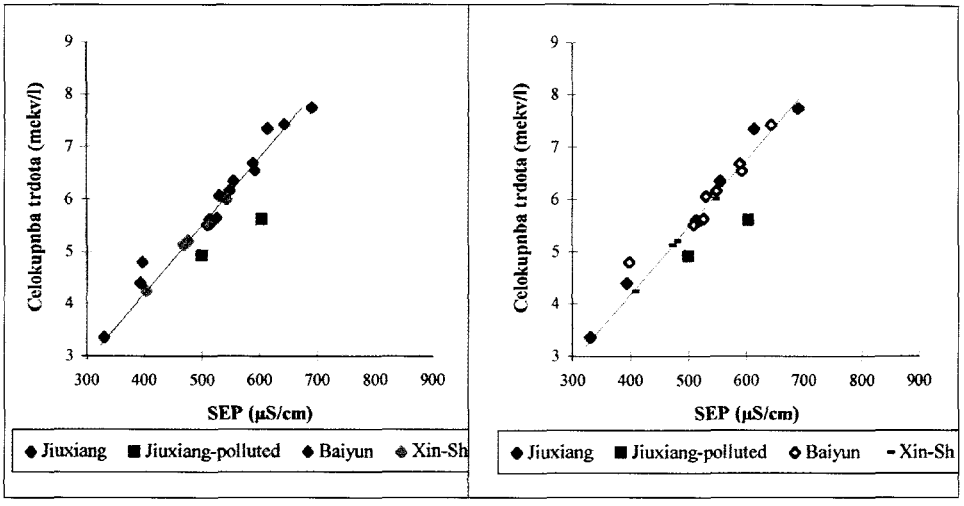
Summary

Rainfall in the Stone Forest area, Yunnan, appears either as a relatively intensive rain giving a higher quantity of water (40 mm in 6 hours in July 1997) or as a soft rain when the daily amount does not exceed 10 mm. The specific electrical conductivity of rain varies from 17 to 76 mS/cm and pH from 7.1 to 8.25; the total calcium and magnesium level was from 3 to 14 mg $CaCO_3$/l. Daoxian (1991) cites that the calcium level in rain in the Chinese karst is essentially higher than the one on non-karst areas and exceeds 12.5 mg $CaCO_3$/l. On covered karst an important contribution to rock solution is provided by the soil, or the more soluble components of it that may be washed out by rain. We established higher levels of silicate, nitrate and chloride.

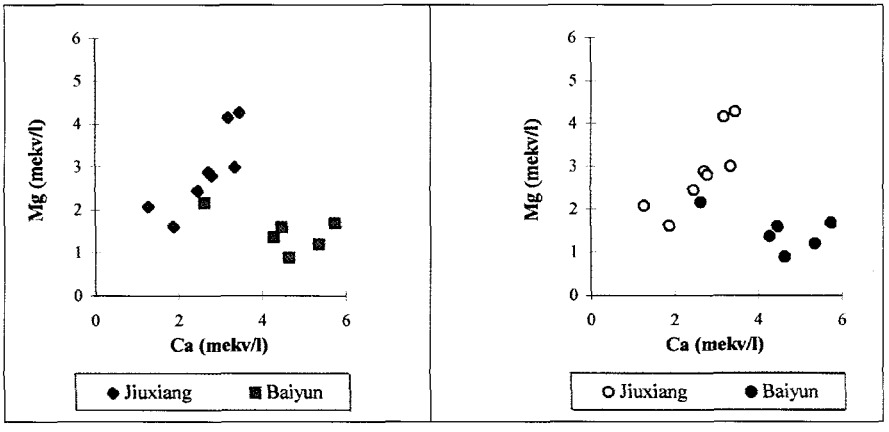
Percolation water was sampled (altogether 23 samples) in three caves in July and September during different hydrological conditions. The Ca/Mg proportion in percolation water in Jiuxiang cave was from 0.6 to 1.2, as were the levels of the Mai Tian river sinking into this cave. Specific electric conductivity, which shows the quantity of dissolved matter, was from 331 to 692 mS/cm, the carbonate level from 3.36 to 7.7 mekv/l and total hardness from 3.35 to 7.74 mekv/l. In September the highest hardness level was recorded in the percolation water feeding the massive gours when the water level was higher. We also recorded a higher proportion of magnesium to calcium which was never met in the Slovene karst. The level of the percolation water hardness varies seasonally and is highest at the beginning of the rainy season as it is in spring waters also; if we measured in that time, the hardness level would probably be even higher. A similar case was met in Škocjanske Jame where the massive gours are seasonally fed by very hard water; but the absolute level is 15% lower.

The percolation water in Baiyun Cave indicates a different rock structure to the one of Jiuxiang Cave; the Ca/Mg proportion was 2.8 to 5.5. The water is supersaturated and deposits flowstone. In September 1977 the discharges were lower than in July 1996 and at the same point we measured higher hardness levels and higher specific electrical conductivity. In Xin-Shi Cave we sampled the water infiltrated through the cave roof, which is from 2 to 10 m thick. The increase in hardness level, and the level of saturation or supersaturation of water is proportional to increase of the cave roof thickness.

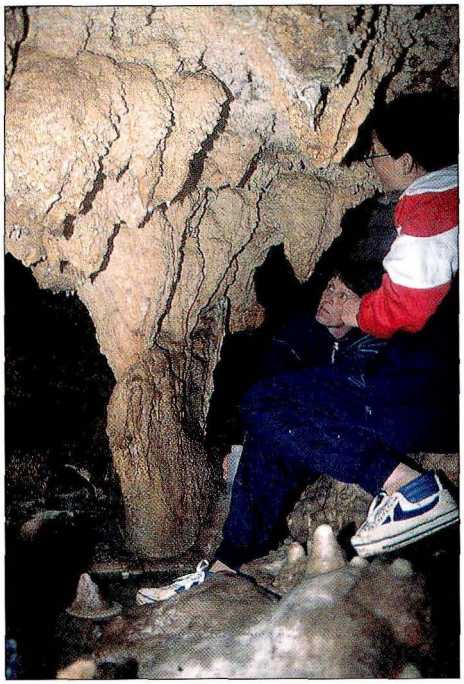
The measurements of the flowstone deposition in massive gours in the Jiuxiang and Baiyun caves showed that during the short flow of about 2 m over three grours, 56 mg $CaCO_3$ deposits from 1 l of water; this is approximately 20% of all the carbonates. But also the stream flowing through Baiyun Cave deposits flowstone and it is used to feed the gours and the nearby stalagmite where the inflow is weak.



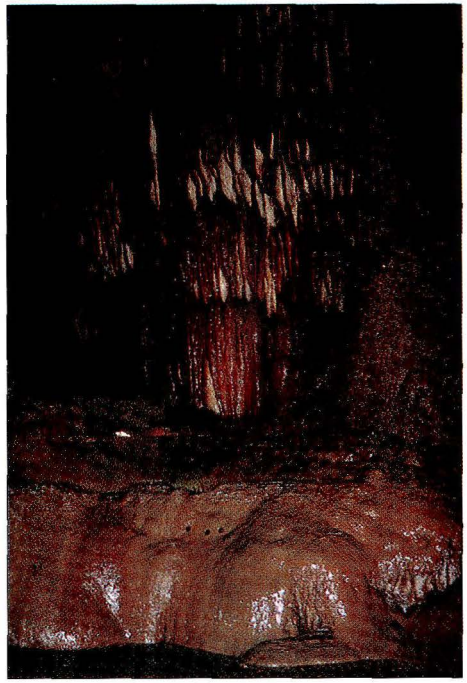
Sl. 2: Celokupna trdota in SEP vseh merjenih preniklih voda.
Fig. 2: Total hardness and conductivity (SEC) of measured percolation waters.



Sl. 3: Kalcij in magnezij v prenikli vodi v jamah Baiyun in Jiuxiang.
Fig. 3: Calcium and magnesium of percolation water in the Baiyun and Jiuxiang caves.



Sl. 6: Vzorčevanje prenikle vode v jami Baiyun.
Fig. 6: Sampling of percolation water in Baiyun Cave.



Sl. 7: Izločanje sige v malih ponvicah v jami Baiyun.
Fig. 7: Flowstone deposition in small gours in Baiyun Cave.

ACTA CARSOLOGICA	XXVI/2	38	457-488	LJUBLJANA 1997

CARBONATE SPELEOGENESIS: AN INCEPTION HORIZON HYPOTHESIS

SPELEOGENEZA V KARBONATNIH KAMNINAH: HIPOTEZA ZAČETNIH HORIZONTOV

DAVID LOWE & JOHN GUNN [1]

Izvleček UDK 551.44:552.54

David Lowe in John Gunn: Spelogeneza v karbonatnih kamninah: hipoteza začetnih horizontov

Procesi, ki oblikujejo kraške prevodnike in jame v karbonatnih kamninah so sorazmeno dobro poznani, manj pa je bilo poskusov razložiti najzgodnejšo, začetno fazo speleogeneze. Temeljno vprašanje je: "Zakaj in kako karbonati doživijo prehod iz kamnine brez kanalov v prevotljeno gmoto?" Podrobna proučitev kemizma raztapljanja in mehanike tekočin, spoznanje o vlogi sindiagenetskih procesov in temeljita razširitev spelogenetske časovne lestvice so omogočili oblikovanje učinkovtite hipoteze začetnih horizontov, ki nudi nove odgovore na mnoga vprašanja speleogeneze in z njo povezanih dogajanj.
Ključne besede: apnenec, jame prevodniki, hipoteze o začetnih horizontih.

Abstract UDC 551.44:552.54

David Lowe and John Gunn: Carbonate speleogenesis: An inception horizon hypothesis

Processes whereby conduits, and ultimately caves, develop in carbonate rocks are relatively well understood but there have been few attempts to explain the earliest, inception, stage, of speleogenesis. The fundamental questions are: "Why and how do carbonates undergo the transition from *rock without conduits* to *rock with conduits*?". Re-examination of dissolution chemistry and flow mechanisms, recognition of the role of syngenetic processes, and a radical expansion of potential speleogenetic timescales have allowed the development of a versatile *Inception Horizon Hypothesis*, which provides alternative answers to many of the questions of speleogenesis and related subjects.
Key words: limestone, speleogenesis conduits caves, inception horizon hypothesis.

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1. INTRODUCTION: CONDUITS AND CAVES IN CARBONATE ROCKS

The terms conduit and cave are commonly used interchangeably, although strictly a conduit is a void greater than 100mm in diameter and a cave is a void large enough to permit human access. In this paper we follow these strict definitions and ask, "Why and how do carbonates undergo the transition from *rock without conduits* to *rock with conduits*?". These questions are significant because flow is generally laminar in aquifers without conduits and hence transfer of pollutants is slow, with significant decay and dilution. Conduit flow is usually turbulent, allowing transport of suspended sediment and rapid pollutant transfer with little or no decay or dilution.

As commonly used, the term speleogenesis includes the origin of caves (Lowe & Waltham 1995), but many classical cave formation papers have addressed only the question of processes responsible for developing conduits into caves (eg Davis 1930; Swinnerton 1932; Gardner 1935; Warwick 1953; Davies 1960; Ford 1965; Palmer 1975, 1991). These processes are moderately well known, but still far from fully understood. In contrast, little has been written about the earliest development phase, which we term inception.

Karstification occurs continuously in young carbonate sequences with a relatively high porosity and permeability, particularly on carbonate platforms. Well developed cave systems are described in Pleistocene limestones on Tonga (Lowe & Gunn 1986) and the Bahamian archipelago (Mylroie & Carew 1990). Some such caves, and by inference smaller conduits, may survive ongoing diagenesis and later tectonism and play an important role in subsequent speleogenesis (Lowe & Gunn 1986 & in preparation; Lowe 1989). In considering speleogenesis it is commonly assumed that older, better indurated, carbonates are characterised by a low primary permeability and an absence of integrated conduits. Our aims in this paper are to consider factors influencing conduit inception in such carbonate sequences and to outline a synthesis of conduit inception and later speleogenesis that provides a working model of cavern origin mechanisms. Particularly important is the potential role of *non-karstic* processes in speleogenesis (Lowe 1992a; Lowe & Gunn 1995). Those karst processes *(sensu stricto)* and related landform evolution, including cave development, involving carbonate rocks (loosely termed limestones) are generally assumed to reflect the effects of carbonic acid upon calcium carbonate. The importance of carbonic acid to ongoing cave development cannot be disputed, but its role in speleo-inception is less clear (Lowe & Gunn 1995).

2. DEFINITION OF INCEPTION AND INCEPTION HORIZONS

The term inception, used here to describe the earliest phase of speleogenesis in carbonate sequences, is only partially synonymous with *initiation*. Use of

Simplified view of the life cycle of conduits/caves within a single "tier" of a typical carbonate succession, indicating:

① Terminology in common and informal use;
② Part of the terminology developed by Worthington (1991);
③ Terminology used by Lowe (1992a).

Elapsed **TIME**, increasing from left to right, is not to scale.

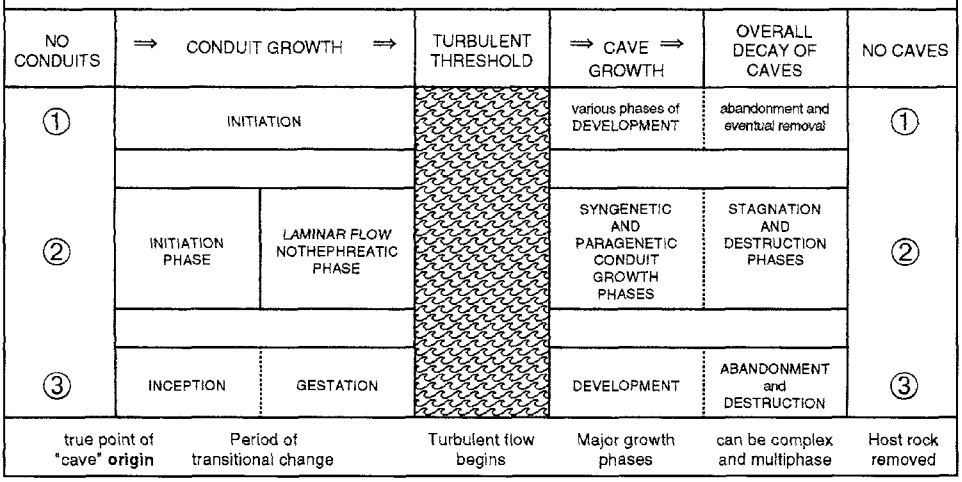


Fig. 1: Simplified view of some different terminology schemes covering phases of cave development in carbonate rock sequences.

the latter term by some earlier workers assumed speleogenetic processes to be active before the establishment of local hydraulic gradients, viable underground drainage systems and conduit flow, without considering their nature, mechanism, guidance and duration. The inception concept allows closure of an obvious but unexplained interregnum during early speleogenesis, inherent in some descriptions of *initiation*. If the inception concept is accepted, the terminology of workers whose *initiation* did include primitive processes is necessarily superseded, though not invalidated. If terminology to cover the phase between inception and the start of turbulent flow is also defined, the misleading term *initiation* can be ignored in future discussions of speleogenesis. We suggest the term *gestation* to describe growth during the laminar flow phase between the conception [inception] and birth [break-out] of a conduit system (Fig. 1).

The term inception horizon (Lowe 1992a) describes: **Any lithostratigraphically controlled element of a carbonate sequence that passively or actively**

favours localized inception of dissolutional activity, by virtue of physical, lithological or chemical deviation from the predominant carbonate facies within the sequence. There is commonly a link between inception horizons and boundaries between lithostratigraphical divisions or depositional cycles *(sensu lato)*. The variety of physical, lithological and chemical boundary signatures necessitates a flexible definition. Although discussion in this paper is limited to cave development in carbonate rock sequences, similar arguments can be applied to void inception in more soluble rock types (such as evaporites) and in less soluble rocks such as sandstones.

Many authors (eg Gardner 1935; Ford & Ewers 1978) have noted that not all bedding planes in a carbonate sequence support speleogenesis. The general understanding was summed-up by Ford (1976: p.29): *"In speleogenetic studies it is common to speak of 'favourable' or 'unfavourable' beds: these are simply reflections of greater porosity and permeability, impurities, pyrite inclusions and so on. Much more study is required before the nature of the favourability can be fully understood."*. Thus, the importance of favourable horizons in supporting speleogenesis is recognised and acknowledged, but effort to link them into a cave inception and development hypothesis has been limited.

3. THE NATURE OF INCEPTION HORIZONS

Commonly held views that bedding planes and/or *impermeable horizons* exercise stratigraphical *control* are inadequate to explain all elements of speleogenesis, but there is no doubt that many such horizons, and others, influence localization of cave inception, and continue to guide later speleogenesis. Inception elements formed along these horizons during the early life of carbonate successions may escape subsequent tectonic obliteration and influence later cave development in folded and faulted sequences (Lowe & Gunn 1986; Šušteršič 1997). At least four broad and overlapping categories of inception horizon can be identified (Lowe 1992a).

Aquifuge, aquiclude, aquitard and aquifer horizons.

These rock properties may appear dissimilar. However, in the inception horizon context, allocation of such terms to beds within a carbonate sequence or (in the case of the term aquifer) to the whole sequence, should be viewed with suspicion. The terms identify overlapping segments of a continuum, and beds may exhibit more than one such property during different stages of speleogenesis. For example, prior to and during inception, the entire carbonate mass, rather than being an aquifer, may be essentially impermeable, and beds that will later be aquicludes can provide the earliest viable water routes (Lowe, 1992a; Klimchouk In Press). Some clayrocks, particularly shales, may possess sufficient linked primary porosity, relative to that of enclosing carbonates, to

allow pore fluid bleeding through or from these supposed aquicludes (eg. Neuzil 1986, 1994). Adjacent crystalline carbonates may initially exhibit relatively lower primary porosity and associated permeability. Values included in Table 1 illustrate the range of porosity, primary permeability and secondary permeability in a selection of rock types. The overlap between porosity and, particularly, permeability values for some carbonates, sandstones and shales is significant.

Clay beds *(sensu lato)* in a carbonate succession act as barriers to significant water movement on a local basis, but mere presence of clay does not necessarily localise speleo-inception above it. Water movement conditions before conduit flow begins are totally unlike those affecting later development. Primitive seepage is driven largely by mechanisms unrelated to hydraulic gradients (eg. Davies 1960; Davis 1966; Pye & Miller 1990), though normal hydraulic flow becomes increasingly important later. Early oscillatory or directional water movement is as likely (or more likely) in sandstones and some shales, with linked primary porosity, as in crystalline carbonates (Table 1). Any related acid generation or physical dissolution effects can be localised against adjacent carbonates, the earliest dissolution affecting the contact zones.

Some carbonates in potential inception situations are permeable due to linked primary porosity. Syngenetic dissolution in the littoral (freshwater/saltwater interface) environment has attracted much recent research (eg Back & others 1986; Bottrell & others 1990; Mylroie & Carew 1990; Whitaker & Smart 1990) and is not re-examined here. Discussion of these important processes in the inception horizon context is presented by Lowe (1992a: Chapter 3). Oolites and similar rocks may exhibit primary porosity and permeability, though diagenesis and secondary processes can obscure original rock properties. Some coarse shell beds, reef limestones and pseudobreccias exhibit an apparently primary porosity and permeability that is actually imposed by post-depositional dissolution. It is debatable whether these are primary inception horizons or a secondary manifestation of speleo-inception *(sensu lato)*.

Of great potential relevance to speleo-inception is the apparent interchangeability of aquifers, aquitards and aquicludes (but not true aquifuges) with respect to time (Lowe 1992a: p.161). A viable aquifer before inception, because of (albeit minimal) permeability related to linked primary porosity, may almost instantaneously invert to aquiclude status when linked dissolutional voids form at its boundaries. Open-textured sandstone provides an ideal inception aquifer (*sensu* Gardner 1935), but cannot compete as a drainage route with dissolutional conduits that develop at its boundaries. After the onset of speleogenesis the sandstone still transmits water, but its permeability is orders of magnitude less than that provided by conduits (Table 1). Pre-speleogenesis bleeding through cemented sandstone, shale or clayrock with poorly linked porosity is less than seepage in open-textured sandstone and the

Table 1: Selected values of porosity, primary permeability and secondary permeability for various rock types and open caverns (compiled from published sources including Smith, D.I. et al, 1976, and various British Geological Survey publications). Where a range of source information was consulted, a range of values is quoted, to illustrate potential variation even within a single named rock unit. The values quoted are not claimed to be definitive, either for specific lithologies or for a particular named unit.

Rock type	Porosity %	Primary Permeability mm/day	Secondary Permeability mm/day
Basalt	7.7	0.014	-
Typical clay	30 - 60	0.01 - 2.5	-
London Clay (Tertiary)	37 - 59	0.026	-
Gault Clay (Cretaceous)	31 - 48	0.00017	-
Lower Oxford Clay (Jurassic)	30 - 54	0.043	-
Typical quartzite	0.5	0.0019	-
Typical sandstone	10 - 30	500	-
Sherwood Sandstone (Triassic)	0 - 30	0.86 - 3340	-
Fell Sandstone (Carboniferous)	9.8	150	-
Chatsworth Grit (Carboniferous)	14.6	170	-
Mudstone/shale	2 - 25	0.000086 - 0.86	-
Sandy or silty shale	3 - 30	86	-
Recent coral limestone	20.0 - 45.0	1,000,000	-
Oolite	1.0 - 10.0	10 - 1,000	1,500
Chalk	14.0 - 40.0	10 - 1,000	60,000
Massive limestone	0.1 ~ 1.0	1 - 10	8 - 60,000
Marble	0.1 ~ 0.4	1	20,000
Caverns	-	-	10^8 -10^9

contrast between pre- and post-inception permeabilities is more pronounced. Commonly, non-carbonates are labelled aquicludes or aquitards, whilst greater thicknesses of initially low-porosity, effectively impermeable, carbonate are assumed to be aquifers. In reality, many carbonate rocks exhibit aquifer properties only because of the presence of voids achieved due to dissolution, which in this context is inseparable from speleogenesis. Development of conduits in indurated carbonate rock increases nominal permeability more than 10 million times (Smith & others 1976: p.184) (Table 1).

Trans-bedding contrasts ***(sensu lato)***

These inception horizons are difficult to describe and to justify. Instinctive expectation is that well-marked bedding planes provide, by their mere presence, potential inception foci, as deduced by Gardner (1935) and reiterated by many later authors. If so, it might be expected that more bedding plane guided passage would exist in most carbonate successions, where generally only a proportion of available bedding plane fissures are affected by dissolution (eg Ford and Ewers 1978). It is unprovable whether most supposedly *open* bedding plane fissures existed before dissolution/speleogenesis, but assuming such existence, it is unlikely that this alone can provide conditions suitable for inception under most circumstances. Trans-bedding contrasts include real and incipient partings. The former, deduced to exist as voids before speleogenesis, are relatively rare. The latter, emphasised by dissolution along a plane of lithological contrast, are relatively common. Many bedding planes reflect hiatus during sedimentation, but a smaller number of *master bedding planes* (Schwarzacher 1958) represent substantial temporal breaks between cycles of deposition. The British Dinantian cycles approximate to defined Regional Stages, and facies changes between them commonly define lithostratigraphical boundaries. Detailed re-examination (Mundy *in* Arthurton & others 1988) after Schwarzacher's work, confirmed complex cyclicity, with some major breaks marked by karstified surfaces and terrigenous deposits (Fig. 2).

Other major bedding planes are simply breaks, representing time gaps, separating beds that may differ greatly in chemistry/purity and crystallinity. Such contrasts are less easily identified than breaks with karstic surfaces and/or terrigenous deposits, yet they are particularly important in sequences that lack other, more favourable, inception horizons. Ideal development shows a sharp contrast between fine-grained, lime-mudstone, deposits below and coarsely crystalline carbonates above. Sweeting & Sweeting (1969: p.209) noted: *"A study of the landforms suggests that sparry limestones are more impermeable than the biomicrites..."*, but Rauch (1972) argued that an increase in crystal size, and especially in sparry cement content, leads to increased dissolutional development. Contrasts between micritic and sparry rocks can signify change from regressive to transgressive depositional conditions. As deposited, the lower beds

WATER DEPTH	DOMINANT LITHOLOGY	THICKNESS AND PERMEABILITY	INCEPTION ROLE
first bed of overlying cycle			
at or above sea-level	coal, seatearth, volcanic fallout and other terrigenous deposits	relatively thin; some beds with significant primary permeability	generation/transfer of sulphuric acid from *in situ* pyrite (etc)
shallow water ⇑	calcite mudstone, with dolomite and evaporite minerals such as gypsum	thin; initially impermeable; possible horizon of syngenetic **(palaeo) karstification**	Sulphuric acid from evaporite; dolomite/clay mineral reactions; aqueous dissolution
⇑ these rocks make	mainly oolitic limestone	*relatively thin, with potential primary permeability*	upper surface is favoured *location of early dissolution*
⇑ up	pale, thicker-bedded bioclastic limestone	thick **[major part of cycle]**; initially impermeable	early dissolution restricted to tectonic or lithogenetic fissures
⇑ most of	dark, thinner-bedded bioclastic limestone	relatively thin; initially impermeable	as above
⇑ the *cycle*	calcareous mudstone	thin; very low primary permeability	as above; possibly some sulphuric acid from pyrite oxidation
deep water	non-calcareous mudstone	thin; very low primary permeability	sulphuric acid formed from pyrite
last bed of underlying cycle			

Fig. 2: Schematic view (not to scale) of the rocks comprising a single idealised major carbonate depositional cycle [shown within a thick border] and the thick, relatively pure rocks [shaded] that comprise the majority of the cycle. Most inception activity takes place within the thinner and less pure beds [unshaded] The beds at the bottom of the cycle are deposited in deep water, and those above in progressively shallower water.

commonly include minerals that can generate strong acid, or be dissolved physically, producing solutions of salts, such as gypsum or epsomite, that will attack sparry beds above more readily than the source micrite below (cf. Gillott 1978).

Acid-generating horizons

Howard (1964) demonstrated theoretically that early speleogenesis depends upon acid generated in the rock mass, rather than externally derived carbonic acid. He stated that even if minute voids exist at depth and even if a

mechanism exists to drive fluid motion through them, surface-derived groundwater would be non-aggressive due to saturation with calcium carbonate. This view was less revolutionary than ideas of sulphuric acid dissolution presented by Durov (1956). Howard stressed the need for locally generated acid during early speleogenesis, followed by gradual domination by carbonic acid. Durov suggested that sulphuric acid is of relatively great importance throughout speleogenesis, though carbonic acid is also involved. Only a difference of degree separates the interpretations. Strong acid is essential to speleo-inception in some situations, and acid generation continues throughout the life of the cave, but quantitatively its relative importance commonly diminishes as caves develop. Meteoric carbon dioxide and carbon dioxide produced as a reaction by-product enter the system and mixture dissolution (eg Bögli 1964) begins to operate, swamping groundwater with bicarbonate and masking background sulphate levels. Possible explanations of high sulphate levels in limestone springs have been discussed by Worthington and Ford (1995).

Chemical and microbial processes that generate sulphuric acid, reviewed by Lowe (1992a: chapter 7) and Lowe & Gunn (1995), depend upon sulphides or sulphates occurring in the rock, though sulphur-bearing organic material (eg hydrocarbons) may be important locally. Reactions can be simple and direct, such as sulphide oxidation to sulphuric acid, or via several steps, such as reduction of sulphate to sulphide followed by oxidation to sulphur and thence to sulphuric acid. Bacterial and/or chemical oxidation of organic or inorganic sulphur also occur. Horizons that can supply raw material for oxidation and reduction reactions include:

a) Evaporitic sulphates
b) Regressive (lagoonal or near-sabkha) carbonates with evaporite inclusions
c) Regressive, dark carbonates with organic content
d) Carbonates with sulphide inclusions
e) Coals and associated pyritic seat-rocks
f) Proximal volcanic and (possibly) high-level intrusive rocks containing sulphides
g) Distal volcanic rocks: fine sulphide-rich air-borne fallout onto the carbonate surface or into the sea over the carbonate (clay *wayboards*, palaeosols and some shales).

These horizons include carbonate as well as non-carbonate lithologies, but acid-producing material is generally concentrated at or near the levels of hiatuses between depositional cycles (Fig. 2). Increased salinity, locally subaerial conditions and long periods of air-fall, contributed relatively small, but vitally important, quantities of sulphate, sulphide and organic-rich material against a background of decreased overall carbonate deposition. Only at or near cycle boundaries was carbonate deposition sufficiently limited to allow relative domination of acid-forming and/or readily soluble impurities.

Physically soluble horizons

The physical solubility of calcium carbonate and dolomite in pure water is relatively insignificant. Other minerals within carbonate successions are more soluble. Polyhalite, kieserite (or epsomite), carnallite, silvite (together termed *bittern salts*) and halite precipitate during total evaporation of a stagnant seawater body (Scoffin 1987), but are the last minerals to crystallize, due to their high solubilities. Earlier, first calcium carbonate and then calcium sulphate are precipitated. Bittern salts are commonly absent and the halite sequence depleted (Scoffin 1987: p.100), However, precipitation of lime-mudstone (approximately synonymous with porcellanous limestone, chinastone, calcilutite or - in some contexts - micrite) and gypsum/anhydrite is common. Ideally the least soluble mineral precipitates first, followed by the next most soluble, but some concurrent deposition occurs, and the resultant lime-mudstone can contain calcium sulphate inclusions.

Survival of calcium sulphate in carbonate sequences, particularly those re-exposed to surface or near-surface weathering, is uncommon, except in arid areas. Calcium sulphate within lime-mudstone is less prone to removal by surface effects, though some may be lost due to *karstification* during ongoing regression. Surviving calcium sulphate may dissolve later, due to speleogenesis or speleogenesis-like processes, if within zones of groundwater movement. The argument is chicken and egg, as it cannot clearly be demonstrated whether water movement initiates dissolution or whether voids created by dissolution encourage water movement. In either case a potential link between calcium sulphate and speleogenesis is suggested.

Much sulphate in young carbonate sequences probably re-dissolves in groundwater, causing major or minor matrix readjustment. Early re-dissolution may trigger formation of carbonate pseudobreccias, just as a more easily demonstrated evaporite removal at depth formed breccias in English Triassic mudstones (Elliott 1961; Firman & Dickson 1968). Pseudobreccias present potential hydraulic pathways during subsequent speleogenesis. Only in deeply buried sequences, where groundwater motion is relatively slight (though, in context, potentially increasing), are significant sulphate levels preserved, as beds or inclusions within a carbonate matrix (cf. Dunham 1973). As surface modification effectively lifts gypsiferous rock into zones of more active groundwater movement, the amount of sulphate preserved decreases (cf. Krothe & Libra 1983). Theoretically, sulphate loss is complemented by void creation, probably only partially realised due to redistribution of carbonate matrix and insoluble residues. The potential porosity increase may be vital in the speleogenetic context.

Sulphates may have two other speleo-inception roles. Gillott (1978) showed that dissolved calcium sulphate, epsomite and halite accelerate aqueous (rather than acid) dissolution of calcium carbonate. The potential that such processes

are involved in speleo-inception cannot be ignored. Finally, sulphates can be converted to sulphuric acid by chemical and bacterial means, as discussed above. Thus, soluble minerals within carbonate successions can influence inception in at least three ways. As calcium sulphate commonly occurs as distinct beds or concentrations of inclusions within specific but relatively limited thicknesses of rock, it is valid to deduce that such zones act as inception horizons. Whether it is also valid to include horizons that have lost sulphate (eg pseudobreccias) and gained porosity, among such horizons is merely a philosophical conundrum. Realistically, speleogenesis is well advanced (but potentially quiescent following gypsum removal) by the time the new rock fabric is created.

Other potential inception horizon functions

This discussion mainly concerns cave development in well-indurated carbonate sequences, of limited permeability before speleo-inception. A major exception is that of syngenetic or penecontemporaneous development in young (eg aeolian or reef) limestones (Lowe 1992a: Chapter 3). Other carbonate sequences that are permeable due to linked primary porosity are common within the geological column. Such rocks are not found consistently at specific chronostratigraphical levels, but reflect local depositional facies and subsequent diagenesis. The Upper Cretaceous Chalk of south-eastern England is not identical to rocks of the same name and age in northern England and differs from carbonates of the same age beneath much of France. Variation also occurs within some Jurassic carbonate formations and less widespread Permian carbonates of northern England. The potential relevance of the Inception Horizon Hypothesis to cave development in Chalk and other porous rocks, and the probable nature of the inception foci within these sequences are discussed by Lowe (1992b).

4. APPLICATION OF THE INCEPTION HORIZON HYPOTHESIS TO CARBONATE SPELEOGENESIS

The Inception Horizon Hypothesis includes many diverse elements. Not all are implicated in cave development in every cavernous sequence nor in the same sequence in different settings. This section outlines application of the hypothesis to indurated carbonate successions. Important processes of littoral zone dissolution and the question of palaeokarsts are reviewed elsewhere (Lowe 1992a).

Speleo-inception in indurated carbonate successions is probably driven by mechanisms other than simple hydraulic/gravitational flow, such as capillarity, earth tides (Davis 1966) or ionic diffusion (Pye & Miller 1990). These promote directional or oscillatory water transfer in or adjacent to the carbonate,

generally within buried sequences, across great distances. Water transfer may begin along incipient or real structural or stratigraphical partings (Davis 1966) and/or palaeokarstic voids within the carbonates. Alternatively progressive transmission may be from and into adjacent porous rocks (Palmer 1975; Klimchouk In Press) or via fractures penetrating adjacent non-porous rocks. As water moves in the rock mass, enlargement of proto-routes begins due to physical and chemical changes including dissolution of sulphates, oxidation and reduction reactions involving sulphates, sulphides and native sulphur (with or without microbial mediation) and dissolution of carbonate by strong acids produced *in situ* (eg Durov 1956; Howard 1964; Worthington 1991)). Carbon dioxide produced by some of these reactions enables further dissolution (eg. Ball & Jones 1990).

These processes begin deep below the water-table and are unrelated to surface topography and local hydraulic gradients. Inputs of solvent water to the initially low permeability carbonate mass are diffuse or concentrated along fissures, and derived from relative aquifers above or below. Output from the carbonate is from its boundaries (or across/via faults) into adjacent, more permeable, beds. In suitable structural situations concentrated movement against gravity will occur due to artesian pressure (see also Klimchouk In Press). As buried dissolution continues, the full lateral extent of inception horizons may be incipiently affected. Some areas will, however, be more favourable to water movement and/or dissolution, due to structural effects, local chemical incentives or the presence of open or loosely-filled palaeokarstic voids. Entire susceptible beds can be removed or modified, resulting in the formation of regionally extensive features that will have the superficial appearance of stylolites, or the widespread development of pseudobreccias. Simultaneous inception at several horizons may be linked by dissolutionally widened fractures.

Inception probably proceeds infinitesimally slowly, despite the potency of the dissolutional mechanisms. Initial slowness is indicative of relatively weak driving mechanisms, inevitable supersaturation of the migrating fluids and an original lack of a continuously linked set of proto-routes. If primitive water movement follows the junction between impermeable carbonate rock and an adjacent porous aquifer, considerable time may pass before activity extends beyond the contact zone and opens fracture planes sufficiently to reach inception horizons within the carbonate. Eventually, discrete zones of enhanced seepage propagate and transition from seepage to laminar flow occurs as the indeterminate threshold between inception and gestation is crossed. During gestation, laminar flow concentrates along preferred zones within inception horizons and their linking fractures. Seepage persists in peripheral parts of the inception horizons and effectively parallel, sub-parallel or dendritic sets of small tubes develop, each with ill-defined tributary seepage zones. Locally, single tubes become dominant in areas determined by structural factors and capture drainage from other inception/gestation seeps and flows within their

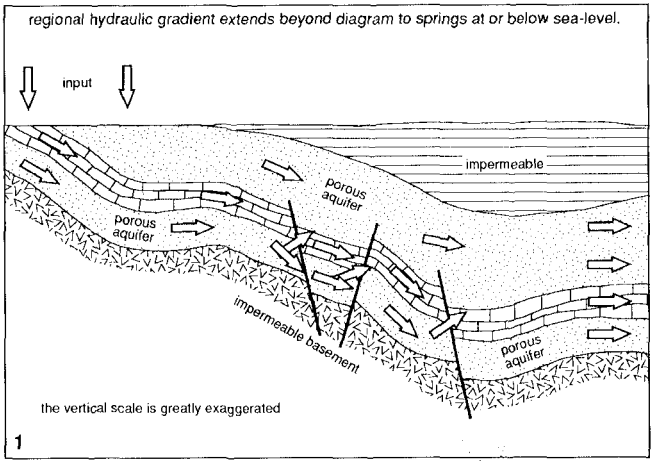
area of influence. These *victor tubes* transmit water by laminar flow until they achieve a diameter of 5-10mm, at which (breakthrough) point turbulent flow becomes dominant and the potential growth rate of the tubes increases (eg. White & Longyear 1962; Dreybrodt 1990).

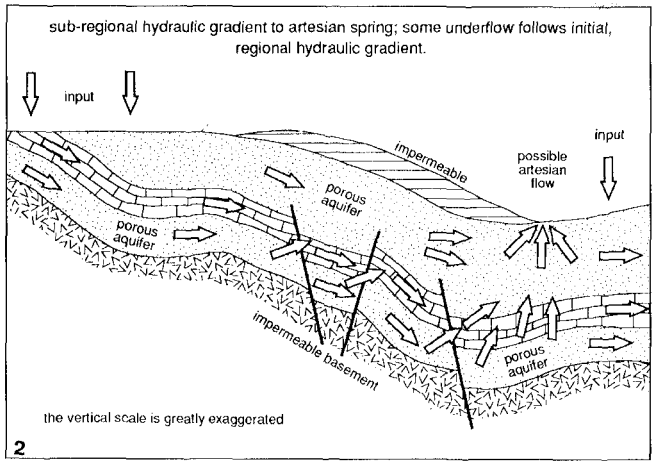
Throughout these processes the overall water motion need not be downwards or downdip, but lies along a regional hydraulic gradient (Fig. 3). Structural and hydrological settings in which all early movement within the carbonates is topographically and geologically upward are readily imagined and by no means contrived.

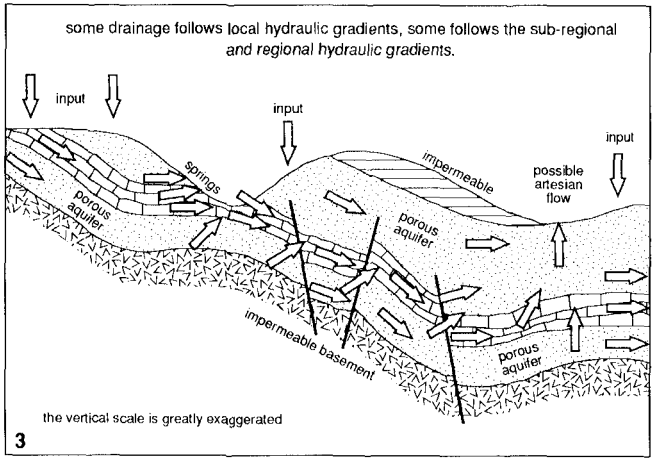
These processes and developments, and later stages discussed below, can affect undeformed, sub-horizontal, successions, gently tilted homoclinal sequences, or rocks that have suffered greater deformation. The potential for features conceived and enlarged in undeformed sequences to survive subsequent gentle or severe tectonism is important. Features that survive, intact or fragmented, continue to influence ongoing speleogenesis in their new structural setting (eg. Lowe & Gunn 1986; Šušteršič 1997).

Inception, gestation and later growth proceed in buried rocks, whether or not they suffer deformation, but eventually the incipient system will be intersected by the land surface. Such breaching disrupts the regional hydraulic regime. Depending on structural, stratigraphical and topographical considerations, input sinks, gravitational risings or artesian springs may develop, related to local hydraulic gradients (Fig. 3). Elements of the original, regional hydraulic gradient will continue to affect water movements above or below the newly exposed input/output area. Resurgences created by downcutting are generally associated with the highest inception horizon in the succession. Passages updip of such risings are drained and modified by vadose downcutting. Passages directly behind artesian risings remain flooded whilst more remote passages, confined at higher topographical levels, are drained.

Pre-existing conduits at lower stratigraphical levels than newly created risings remain in the phreatic zone, but if incipient fracture links exist, some underflow (cf. Worthington 1991; Klimchouk In Press) from deeper conduits can target on and rise towards the spring rather than following original routes along the regional hydraulic gradient. As surface topography cuts deeper, lower inception horizons are intercepted. Risings on higher horizons are abandoned to all but local percolation and/or flood water from the land surface or subsurface back-up. Thus, tiered cave systems are drained sequentially; dissolution continues at one or more lower levels, whilst vadose modification (accompanied by seepage from underdeveloped local feeders), abandonment and eventual erosional removal dominate above. Ultimately the lowest inception horizon in the succession, which need not be at the base of the carbonates, is unroofed. As surface downcutting extends below its level, drainage and vadose incision generally occur and in suitable geological settings an accessible canyon is cut back from the rising, with its floor entrenching underlying rocks. Rarely


regional hydraulic gradient extends beyond diagram to springs at or below sea-level.
input
impermeable
porous aquifer
porous aquifer
impermeable basement
porous aquifer
the vertical scale is greatly exaggerated
1


sub-regional hydraulic gradient to artesian spring; some underflow follows initial, regional hydraulic gradient.
input
input
impermeable
possible artesian flow
porous aquifer
porous aquifer
impermeable basement
porous aquifer
the vertical scale is greatly exaggerated
2


some drainage follows local hydraulic gradients, some follows the sub-regional and regional hydraulic gradients.
input
input
input
springs
impermeable
possible artesian flow
porous aquifer
porous aquifer
impermeable basement
porous aquifer
the vertical scale is greatly exaggerated
3

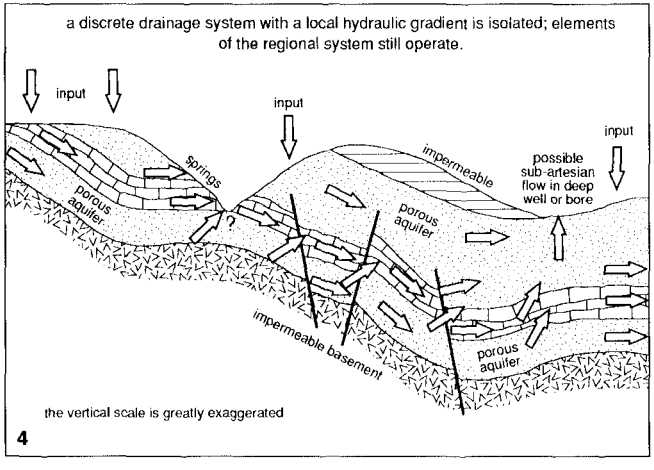

a discrete drainage system with a local hydraulic gradient is isolated; elements of the regional system still operate.
input
input
input
springs
impermeable
possible sub-artesian flow in deep well or bore
porous aquifer
?
porous aquifer
impermeable basement
porous aquifer
the vertical scale is greatly exaggerated
4

Fig. 3: Schematic view of the stages in the establishment of local hydraulic gradients in a carbonate rock unit and adjacent porous aquifers confined by impermeable rocks: (1) all underground drainage follows extended routes along regional hydraulic gradients under artesian or deep phreatic conditions; (2) confinement may be broken by erosion allowing establishment of upward movement under artesian conditions; (3) deeper surface erosion intersects the carbonate aquifer to establish the earliest local hydraulic gradient, but some drainage still follows the regional hydraulic gradient; (4) elements of the carbonate bad are isolated from the regional situation and have only local hydraulic gradients, but surviving parts of the regional drainage system continue to function.

there may be minimal inception-type development at the lower limit of the soluble rock, yet unless true inception conditions obtain at that level it is unlikely to capture the complete flow of the higher resurgence before a significant canyon forms above.

Throughout post-gestational (post-breakthrough) cave growth, stagnation and erosional removal, disused, underused or incipient fragments of original inception networks are preserved at higher levels. If low level routes are blocked by clastic debris, by back-up of surface or underground floodwaters or, exceptionally, by glacial ice, higher segments may be re-invaded temporarily or permanently. After early failure or abandonment, parts of higher, relict, systems might have been adopted by local percolation water or flow from isolated sinks. Such drainage could utilize and enlarge pre-existing inception horizon guided sections of the proto-system down gradient from open links to lower horizons. Thus, flood water can back up to invade and utilize significant conduits that did not exist when the higher tier was first abandoned. This explanation differs from earlier views of flood water overflows, such as that of Palmer (1975).

The Inception Horizon Hypothesis encapsulates the essence of many processes and relationships that contribute to an overall picture of speleo-inception and ongoing speleogenesis. Emphasis is placed on elements falling outside, or considered only locally within, most current models, and on elements relating to non-karstic dissolution, particularly where this is localized in the carbonate mass by the presence of inception horizons. The importance of carbonic acid dissolution to development, particularly at relatively shallow depth, is not belittled, but the vital importance of other processes to inception in young or mature indurated rocks, is emphasised. The role of bedding-related factors, together termed inception horizons, is stressed in the context of sequential tier and resurgence development, but fracture-guided links also carry drainage between inception horizons, capture drainage at the surface and deliver resurgent water back to the surface. In the remainder of this paper the Inception Horizon Hypothesis is used to provide possible explanations of the origins of various components of a typical cave system.

5. EXPLANATION OF UNDERGROUND FEATURES BY THE INCEPTION HORIZON HYPOTHESIS

Features commonly viewed as inherent parts of a typical carbonate cave system may be explained readily by the Inception Horizon Hypothesis, on the basis that not all parts of a carbonate sequence are equally prone to speleogenesis. The following considerations depart from some traditional views.

Vertical or sub-vertical shafts

The term shaft is used here to describe generally vertical or sub-vertical elements of cave systems, termed pitches or pits by explorers in Britain or the USA respectively. Other definitions that include considerations of supposed origins or observed morphology exist, but their sophistication is unnecessary for this discussion. As used here the term disregards elements of fissure-guided passages requiring vertical descent during exploration but reflecting the morphology of the fissure rather than the geological guidance of the cave skeleton. Inception horizon theory predicts that in undeformed terrains proto-shafts are conceived in the flooded (broadly artesian or phreatic) zones as (sub-) vertical links between (sub-) horizontal inception horizons. If bedding dip is closer to vertical, inception horizons guide shaft-like features, linked by sub-horizontal, structurally-guided elements. In the former situation, initial groundwater movement follows guiding fissures, notably joints and high-angle faults, probably driven initially by processes such as *groundwater pumping* (Davis 1966) and later by artesian pressure. Aggressive groundwater moves between inception horizons via the fissures, and dissolution occurs on a wide front. As gestation progresses in the inception horizons, flow from and into discrete conduits localises groundwater movement within the fissures, causing local widening. Drainage from an inception horizon might move vertically upwards, vertically downwards or in any lateral sense towards another favourable horizon. As the flooded dissolutional conduits grow and normal hydraulic laws begin to operate, all inception links will enlarge initially, but combinations with favourable hydraulic gradient will enlarge preferentially, eventually gathering most of the drainage.

Following uplift and drainage, when vadose gravitational flow replaces artesian and phreatic hydraulic flow, only vertically or obliquely downward linking-routes are followed by free drainage. Vadose flow along a relict dissolutional conduit will plunge down vertical links, or cascade along downward oblique links, opening shafts or descending, fissure-guided passages. (Sub-) vertical shaft lips are cut back and down by headward erosion as vadose trenches form in conduit floors. Cursory examination of passage morphology may fail to reveal that both passage and shaft originated under flooded conditions. At the shaft foot the vadose stream normally abandons the guiding

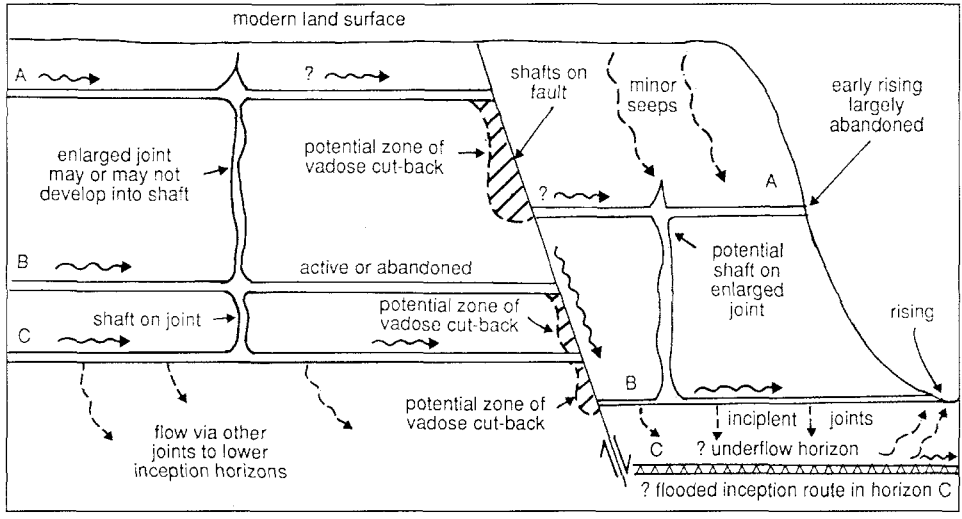


Fig. 4: Schematic representations of the role of joint- or fault-guided links in the formation of vertical and sub-vertical shafts. In this figure and in figures 5 and 6 the simplest possible two-dimensional view is presented. In reality, at any of the points where drainage diverges from bedding-guided routes, conduit development might propagate up, down or laterally along a guiding fracture to generate a three-dimensional system.

fissure for a conduit in a topographically lower inception horizon. More rarely, if only an immature conduit exists, flow below the shaft continues within the guiding fissure towards another inception horizon. This situation is commonly accompanied by ponding of water (cf sumps, below).

Shaft-forming fissure links are of two broad kinds, both potentially present in (sub-) horizontal and dipping situations. One develops along joint planes where seepage through the effectively saturated rock mass targets upon stratigraphically lower or stratigraphically higher inception horizons. Concurrently a route could pursue the original horizon across the fissure (cf abandoned high level passages, below). In the other, guided by fault planes, water travels upwards, downwards or laterally to reach a favourable target in stratigraphically higher or lower inception horizons, or the same horizon at another topographical level. Possible combinations are shown in a highly schematic, two-dimensional form, in Fig. 4. In the situations illustrated, fissure links may extend great distances in the third dimension.

Upward shafts (avens) and related features

The term aven is used in Britain to describe (sub-) vertical upward extensions from cave passages or chambers. Some avens have no negotiable

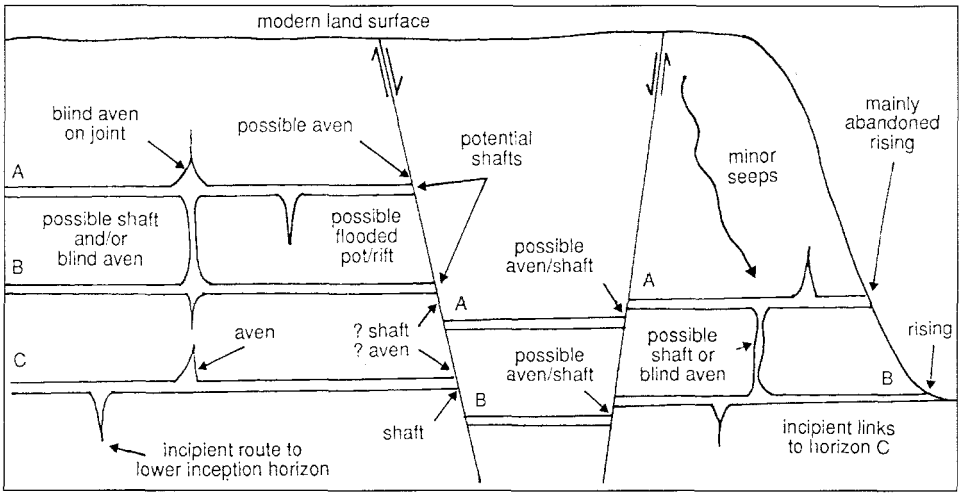


Fig. 5: Schematic representation of the formation of 'avens' [see explanation of Figure 4]

upward connection, others provide links to higher passages. In this context avens do not include generally-local dissolutional features that are not fracture-guided. The previous section provides a basis for examination of aven formation in the inception horizon context. If dissolutional links can form in any direction under artesian/phreatic conditions, when vadose conditions are established any pre-existing upward ramifications must become disused as drains from any lower horizon that was involved in their inception. Vadose streams occupying inception horizon conduits plunge down vertical shafts, cascade along oblique fissures or continue along the original inception level, but incipient or active upward routes are disregarded by that particular flow. However, upward development from one horizon could be downward development from a higher one. Three broad possibilities remain. There may exist blind upward ramifications that failed to establish a viable link to a remote target horizon. Secondly, an aven in the roof of one inception conduit may rise to join a higher abandoned inception conduit. Thirdly, an aven in a passage roof may be an active inlet shaft from a passage conceived along a higher inception level. These three categories, each expandable to fit many actual underground situations, are shown in a highly diagrammatic form in Fig. 5.

Abandoned high levels and passage continuations

Fig. 6 illustrates links that have formed where an inception horizon meets a joint and development continued along the inception horizon as well as along the joint. Such onward development probably pre-dated significant disso-

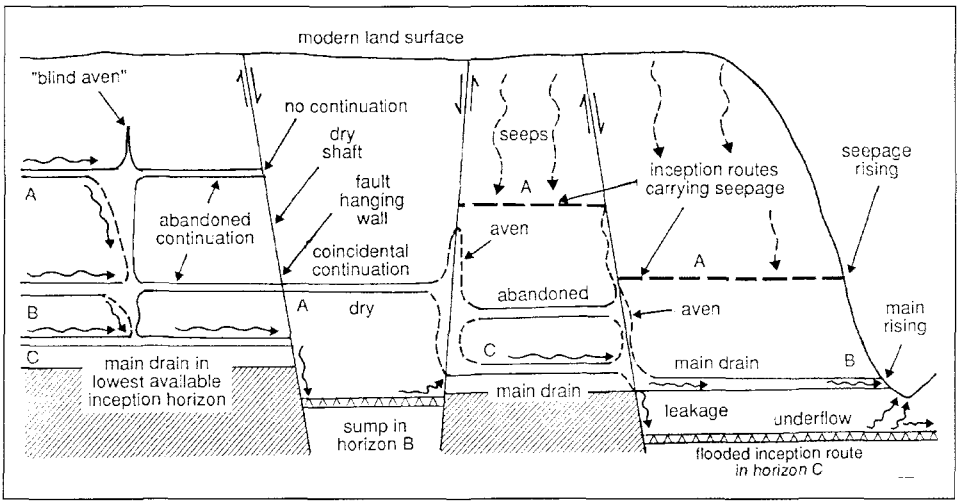


Fig. 6: Schematic representation of the formation of 'abandoned high level passages', 'avens', 'shafts' and 'sumps' [see also figures 4 and 5]

lution along the fissure. If, after uplift, vadose flow continued across any incipient links on the joint plane, the latter would become water-logged sites of continued dissolution. If dissolution along the joint link eventually broke through, the inception horizon would progressively be abandoned, as the lower, more favourable route enlarged. A parallel situation could be enforced at the time of vadose establishment, if a downward route along a suitable joint was already sufficiently open to permit capture of the flow (as discussed above). The observation that not all phreatic conduits continue across fissure-guided shafts is simply explained. No continuation will occur (except where inception horizons are coincidentally juxtaposed) across a fault-guided shaft.

Flooded passage sections

Negotiable cave passages may commonly appear to terminate where water meets the roof, forming features that have been termed sumps, syphons or (water) traps. Some are of limited horizontal extent and comprise water-filled conduits that re-connect to open passage beyond the flooded section. They may be passable or impassable to human explorers. Others may extend deep into the flooded zone with no readily accessible links back to unflooded conduits. Fig. 6 provides a two-dimensional schematic view of possible situations where links may form vertically or laterally along guiding fissures between inception horizons during inception. There will be situations where, after uplift, vadose drainage in an invaded inception conduit will find no advantageous onward route vertically or laterally downwards. This situation will

normally be encountered in the context of fault-guided rather than joint-guided links. In order that drainage from the invaded inception horizon may progress down the hydraulic gradient it must transfer to another, more suitable horizon. Initially, connections between the two horizons are flooded and may extend great distances laterally, though water levels are effectively identical at both ends. The simplest situation involves a short, flooded, downdip tube and a "phreatic" lift up the fault plane, but more complex links ramify laterally in three dimensions and may include several fault-guided links and sections guided by downfaulted inception horizons and other fissures.

General views of multi-level speleogenesis

A question that reappears throughout the history of publication on speleogenesis concerns the origin of multi-level or *tiered* caves. Awareness of the problem may be implicit, as in the case of early discussions by authors such as Davis (1930) and Gardner (1935) or explicit, as in the work of Swinnerton (1932). None of these achieved a fully workable hypothesis of multi-level speleogenesis, though Gardner's ideas included a view close to that in the Inception Horizon Hypothesis. The major conceptual problem in understanding the genesis of multi-level caves is that of providing a model applicable in folded as well as unfolded terrains. Superficially, it seems that Swinnerton (1932) addressed this more closely than did Davis (1930) or Gardner (1935). This is illusory; the supposed sub-horizontal situation within most of W.M. Davis's examples and the folded situation discussed by Swinnerton are points near the ends of a continuum, wherein Gardner's dipping sequence occupies a more central position. Not all earlier discussions of multi-level caves were misdirected, but many suffered from trying to link passage levels to a development chronology, the common assumption being that the highest passage in a multi-level system formed first and the lowest formed last. This view is modified in the Inception Horizon Hypothesis, which suggests that, potentially, all levels were conceived under artesian and/or phreatic conditions at approximately the same time. Bridging the gulf between this concept and earlier ideas is recognition that after artesian/phreatic inception at two (or many) levels in a carbonate block, development may be greatest in the highest incipient passage and least in the lowest. Downward decrease of development potential reflects more favourable hydraulic conditions near the water-table (shallow phreatic zone). However, the orderly sequence may be locally inverted if a lower inception horizon is significantly more favourable than those above, or if significant artesian activity continues at depth without affecting shallower passage development.

As surface topography and hence regional and local hydraulic gradients alter with time, the level of the water-table drops, eventually falling below the highest and (generally) best developed phreatic conduit system. Drainage may

be wholly or partly diverted from its original route to resurge at a spring manufactured by a surface valley intersecting the conduit. Part or all of the drainage might, however, divert to the next lower inception level, via fracture-guided routes, immediately or in due time. In some cases vadose conditions will take over for the up-gradient part of the original system as deduced by Gardner (1935) but, in complex structural situations, parts of the system will remain flooded. Even after transition of part of the underground drainage network to the vadose zone, a deeper flow component remains in lower inception horizons (and within the truncated down-gradient extension of the first). These will in turn be intercepted by the surface topography and the higher passages will be progressively abandoned by all but local seepages.

6. CONCLUSIONS

Much of this paper has involved description and lateral re-examination of elements that lie within the currently accepted concepts of speleogenesis or have contributed to them. Early ideas that were subsequently abandoned now appear to remain potentially valid to the overview of speleogenesis. Parts of the current view may be re-evaluated and concepts viewed as universal appear potentially less widely applicable, whilst concepts previously accepted as of only local significance are seen to be potentially of widespread importance.

The hypothesis discussed here does not replace existing cave development models, but expands upon them. In so doing, it provides a linking string, or strings, that allow concatenation of aspects previously seen as separate and specialized. In attempting to justify this linkage, some pre-existing relationships are questioned and new explanations are developed, but much of the background structure of speleogenetic dogma remains intact. If the qualitative hypothesis presented provides an acceptable working model and stimulates empirical studies that confirm its validity, much of the extant chemical and mathematical dataset about which current theories pivot may have to be more closely reconsidered.

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SPELEOGENEZA V KARBONATNIH KAMNINAH: HIPOTEZA ZAČETNIH HORIZONTOV

Povzetek

1. UVOD: KRAŠKE VOTLINE V KARBONATNIH KAMNINAH

V članku razpravljava, zakaj in kako nastanejo v kamnini, kjer prej ni bilo povezanih votlin, kraški kanali[1]. Osvetliti želiva dejavnike, ki vodijo k nastanku prevodnika in nadalnji speleogenzi ter podati delovni model mehanizmov, ki porajajo kraške votline.

Izraz speleogeneza, kakor ga običajno pojmujemo, naj bi pomenil **nastanek** jam (Lowe & Waltham 1995), vendar se mnoga klasična dela s tega področja posvečajo izključno vprašanju nadalnjega **razvoja** obstoječega prevodnika v jamo (n.pr. Davis 1939; Swinnerton 1932; Gardner 1935; Warwick 1953; Davies 1960; Ford 1965; Palmer 1975, 1991). Čeprav sodelujočih procesov še ne razumemo do zadnjih podrobnosti, lahko vendarle ugotovljamo, jih poznamo vsaj v precejšnji meri. Nasprotno pa je bilo o najbolj zgodnji razvojni fazi, ki jo imenujeva začetje[2], doslej napisanega le malo.

V speleogeteskih razpravah se zdi predpostavka, da imajo starejše, bolj sprijete karbonatne kamnine nizko primarno poroznost in da zveznih prevodnikov takorekoč ni, bolj ali manj samoumevna. Posebej na karbonatnih platformah poteka zakrasevanje v mladih karbonatnih skladovnicah s sorazmerno visoko poroznostjo in prevodnostjo skupaj z diagenezo. Dobro razviti jamski sistemi so znani s pleistocenskih apnencev otočij Tonga (Lowe & Gunn 1986) in Bahamov (Mylroie & Carew 1990). Nekaj takšnih jam, in po logiki stvari, tudi manjših prevodnikov, se ohrani skozi diagenezo in morebitno tektonsko preoblikovanje ter igra pomebno vlogo pri nadalnji spelogenezi (Lowe & Gunn 1986, v pripravi; Lowe 1989).

Za speleogenezo se nama zdi vloga *nekraških procesov* (Lowe 1982a, Lowe & Gunn 1985) posebnega pomena. Kraške procese (*v ožjem smislu*) na karbonatnih kamninah in razvoj geomorfnih oblik, ki iz tega sledijo (in kamor spada tudi razvoj jam), imamo običajno za izid delovanja ogljikove kisline na kalcijev karbonat. O pomenu ogljikove kisline za kasnejši razvoj jam pač ni potrebno razpravljati, manj pa je jasna njena vloga pri samem nastanku jam (Lowe & Gunn 1986).

2. DEFINICIJA ZAČETJA IN ZAČETNIH HORIZOTOV

Izraz *začetje*, kot ga uporabljava v tem besedilu, pomeni najbolj zgodnjo fazo v spelogenezi karbonatne sekvence in je je le delno soznačen izrazu *iniciacija*. Pojem začetja zapolnjuje neogibno vrzel v razumevanju speleogeneze,

ki ostaja doslej večinoma odprta. Če privzamemo misel o začetju in definiramo izraze, ki naj pokrijejo fazo med začetjem in pričetkom turbulentnega toka, lahko ohlapni pojem *iniciacija* v nadalnji razpravi o speleogenezi opustimo. Pač pa predlagava izraz *snovanje*, s katerim opišemo rast kanala v času laminarnega toka med začetjem in prebojem.

Izraz *začetni horizont* (Lowe 1982a) opisuje: **katerikoli element karbonatne sekvence, ki ga odrejajo litostratigrafska svojstva kamnine in ki, kot posledica fizikalnih, litoloških ali kemijskih razlik v prevladujočem karbonatnem faciesu znotraj skladovnice, pasivno ali aktivno proži raztapljanje**. Začetni horizonti se do neke mere skladajo z mejami med litostratigrafskimi členi oz. sedimentacijskimi cikli (*v širšem smislu*).

3. SVOJSTVA ZAČETNIH HORIZONTOV

Splošno razširjeno mnenje, da lezike in/ali nepropustni vložki po stratigrafski plati uokvirjajo spelogenezo, ne pojasni vseh njenih tančin; nedvomno pa ti elementi odrejajo mesto začetja v prostoru in usmerjajo nadalnji razvoj jame. Elementi začetja, ki se oblikujejo vzdolž teh horizontov v zgodnjih obdobjih nsatajanja karbonatne kamnine, lahko prestanejo tektonsko preoblikovanjo kamninske gmote in vplivajo na kasnejši razvoj jam v nagubanih ali razlomljenih kamninah (Lowe & Gunn 1986, Šušteršič 1997).

Horizonti z značajem akvifuga[3], akvikluda[3], akvitarda[3] oz. akviferja[3]

Na pogled so si naštete hidrogeološke kategorije zelo različne. V okviru razmišljanj o začetnih horizontih pa so le izseki kontinua, ki se med seboj lahko prekrivajo in v različnih fazah spelogeneze znotraj posamezne skladovnice tudi menjajo svoje vloge. Nekateri glinovci, še posebej skrilavi, morejo v primerjavi s sosednjimi karbonati izkazovati zadovoljivo zvezno primarno poroznost in dopuščajo mezenje skozi ali iz domnevnega akvikluda (Neuzil 1986, 1994). Tabela 1 (izvirno besedilo) kaže iznos poroznosti in primarne ter sekundarne prepustnosti nekaterih kamnin. Pomembno je prekrivanje iznosov poroznosti in še posebej prepustnosti med posameznimi karbonati, peščenjaki in glinastimi skrilavci.

V krajevnem merilu pomenijo glinaste plasti (*v šišem smislu*) v karbonatni skladovnici zaporo obilnejšemu prenikanju, vendar njihova navzočnost še ne potisne začetja više, proč od njih. Pogoji pronicanja vode so namreč pred vzpostavitvijo kanalskega toka popolnoma drugačni kot pozneje. V tem času je izmenično (ali usmerjeno) pronicanje vode bolj verjetno v peščenjakih kot v karbonatih. Če se pridružijo še nastajanje kislin, ali fizikalno raztapljanje, lahko uspešno načne sosednjo karbonatno kamnino.

Nekateri karbonati so prepustni zaradi svoje primarne poroznosti. Sindiagenetsko raztapljanje na stiku sladke in slane vode je bilo v zadnjem času

deležno velike pozornosti (Back & al. 1986; Bottrell & al. 1990; Mylroie & Carew 1990; Whitaker & P.L. Smart 1990). Podobno so že od vsega začetka lahko visoko porozne nekatere oolitne karbonatne kamnine. Peščenjaki z odprtimi razpokami so lahko idealen začetni akvifer (v smislu Gardnerja 1935), seveda pa ne moreje tekmovati z razvitim kraškim prevodnikom.

Dejansko zadobijo mnoge karbonatne kamnine lastnosti akviferja šele, ko raztapljanje povzroči nastanek votlin, kar je v smislu naše razprave neločljivo povezano s speleogenezo. Tedaj v trdnih karbonatih dotedanja prepustnost zraste več kot 10 milijonkrat (Smith & al. 1976: str. 184; Tabela 1).

Medplastovne razlike (*v širšem smislu*)

Medplastovne razlike se kažejo vzdolž obstoječih ali nakazanih presledkov med skladi. Za prve menimo, da se pojavljajo kot praznine že pred speleogenezo in so sorazmeno redke. Naprotno pa so slednji, ki jih raztapljanje v ploskvi litološkega kontrasta še poudari, sorazmerno pogosti. Mnoge lezike odsevajo vrzel v času sedimentacije, toda manjše število med njimi, po Schwarzacherju (1958) *vodilne lezike*, pomenijo pomebne časovne presledke med posameznimi cikli odlaganja.

Preostale odprte lezike so presledki, ki odsevajo časovne vrzeli in lahko ločijo plasti, ki se rezko razlikujejo po čistosti kamnine (kemizmu) in stopnji prekristaljenja. Običajno se v spodnjem skladu odlagajo minerali, ki ob oksidaciji spoščajo močne kisline ali pa se topijo fizikalno. Minerali kot sadra, epsomit ipd. razkrajajo sparite v zgornji plasti učinkoviteje kot mikrite, iz katerih izvirajo (Gillott 1978). Takšne kontraste je teže zaznati kot paleokraška površja ali sedimente kopenske faze, a so posebnega pomena kadar manjka drugih, začetju prikladnejših horizontov.

Horizonti ki sproščajo kisline

Howard (1964) je teoretično pokazal, da bolj kot na od zunaj dotekli ogljikovi kislini, zgodnja speleogeneza temelji na kislini, ki nastaja znotraj same kamninske gmote. Menil je, da bi tudi v primeru, ko na primerni globini drobne votlinice že obstojajo in ko mehanizmov, ki potiskajo tekočino skoznje ne manjka, voda ne bila agresivna, saj se prehitro zasiti s kalcijevim karbonatom. Še bolj prekucuška je bila misel Durova (1956), ki je predložil, da se prvo raztapljanje odvije s pomočjo žveplene kisline. Pristopa se razlikujeta edino v poudarkih. Vsekakor je v nekaterih okoliščinah navzočnost močne kisline za začetje bistvena. Taka kislina se seveda sprošča ves čas spelogeneze in se njen učinek absolutno ne zmanjša, vendar po pomenu reakcija ogljikove kisline kmalu popolnoma prevlada.

Kemični in biogeni procesi, ki sproščajo žvepleno kislino, koreninijo v sulfidih ali sulfatih, ki se pojavljajo v kamnini. Včasih je pomembna tudi

navzočnost organske snovi, bogate z žveplom (ogljikovodiki). Reakcije so lahko preproste in neposredne, ali pa postopne. Horizonti, ki lahko prispevajo reaktante za oksidacijo ali redukcijo so predvsem:

a) sulfatni evaporiti
b) regresivni (lagunarni ali sebkini) karbonati z vložki evaporitov
c) regresivni, temni karbonati z organsko primesjo
d) karbonati z vključenimi sulfidi
e) premogi in druge s piritom bogate kamnine
f) predornine oz. plitve globočnine z minerali, ki vsebujejo žveplo
g) piroklastiti, bogati z drobno razpršenimi sulfidi, ki so se usedli na kopne ali podmorske krbonatne površine.

Fizikalno topni horizonti

Fizikalna topnost kalcijevega karbonata in dolomita v čisti vodi je sorazmeno nizka, so pa bolj topni drugi minerali, navzoči v karbonatnih skladovnicah. V času hlapenja vodnega telesa se odlagajo polihalit, kieserit, epsomit, karnalit, silvin in halit (Scoffin 1987), a zaradi svoje visoke topnosti kristalijo poslednji. Večino haloidov in sulfatov v mladih karbonatih verjetno ponovno raztopi podtalnica. Teoretično to pomeni nastajanje votlinic, ki jih le delno zapolnijo netopne primesi oz. karbonat iz osnove. Dovolj zgodnje raztapljanje lahko sproži nastajanje karbonatnih psevdobreč, kar bi s stališča speleogeneze zopet pomenilo pomembno povečanje poroznosti.

Gillott (1978) je pokazal, da raztopljeni kalcijev sulfat, epsomit in halit pospešujejo neposredno raztapljanje kalcijevega karbonata. Možnosti, ki jih ta proces odpira začetju pač ne gre spregledati. Končno nekateri biogeni ali kemični dejavniki sulfate spremenijo v sulfide, s posledicami, o katerih smo govorili nekoliko prej.

Druge možnosti pojavljanja začetnih horizontov

V naši razpravi se oziramo predvsem na nastanek jam v dobro sprijetih karbonatnih skladovnicah, katerih prepustnost je bila pred začetjem omejena. Pomebna izjema je razvoj v najmlajših, subrecentnih eolskih ali grebenskih apnencih (Lowe 1982a). Teh kamnin še ne moremo šteti v določen stratigrafski nivo, ampak odsevajo, geološko gledano, trenutne pogoje odlaganja in takojšnje diageneze. Možno vlogo krede (kamnine) in drugih poroznih kamnin je obdelal Lowe (1982a).

4. APLIKACIJA HIPOTEZE ZAČETNIH HORIZONTOV NA SPELOGENEZO KARBONATOV

Hipoteza začetnih horizontov vključuje raznorodne dejavnike. V razvoj posameznega zaporedja kanalov niso vpleteni vsi, niti ni verjetno, da bi bili v enakih kamninskih skladovnicah navzoči vedno isti. Začetje v karbonatnih kamninah verjetno poganjajo drugačni mehanizmi kot preprost tekočinski tok na osnovi hidravličnih zakonov, ki ga poganja težnost. Verjetno gre za kapilarnost, plimovanje zemeljske skorje (Davis 1966) ali ionsko difuzijo (Pye & Miller 1990). Medtem ko se voda premika skozi kamninsko gmoto, se večajo njene prvotne poti, naj bo to zaradi fizikalnih ali kemijskih dejavnikov. Opraviti imamo predvsem z raztapljanjem sulfatov, z oksidacijo ali redukcijo sulfatov, sulfidov ali samorodnega žvepla (s pomočjo delovanje mikrobov ali pa ne) ter z raztapljanjem karbonatov s pomočjo močnih kislin, ki nastajjo na kraju samem (Durov 1956; Howard 1964; Worthington 1991).

Našteti procesi se odvijajo globoko pod gladino podtalnice in se ne ozirajo na oblikovanost površja in hidravlični gradient. Voda, ki vstopa v karbonatno gmoto prihaja z višje ali nižje ležečega vodonosnika in je potuje razpršena po nezveznostih v kamnini. Napredujoče raztapljanje postopoma zajame celoten začetni horizont. Posamezni predeli so premikanju vode in/ali raztapljanju prikladnejši, naj bo to zaradi strukturnih učinkov, krajevnih sprememb v kemijskih lastnostih kamnine ali navzočnosti slabo zapolnjenih/odprtih paleokraških votlin. Tako lahko izginejo celotne plasti, nagnjene k tovrstnemu razkroju in učinki dobijo regionalne razsežnosti.

Začetje se verjetno prične neznansko počasi, ne glede na možno učinkovitost sodelujočih dejavnikov. To kaže na sorazmerno šibko prenikanje, neogibno prenasičenje tekočine in začetni neobstoj povezanih vodnih poti. Posamezna območja hitrejšega prenikanja se postopoma povezujejo in ko je prag med začetjem in pripravo prekoračen, se pojavijo prehodi med preniklim in laminarnim tokom. V času priprave se laminarni tok zbira vzdolž najugodnejših smeri znotraj začetnih horizontov, oz. razpok, ki jih povezujejo. Posamezni kanali prevladajo in pritezajo nase vodo iz sosednjih območij začetja/priprave. Tok v teh *zmagovitih poteh* je laminaren, dokler njihov premer ne doseže 5 - 10 mm. Tedaj se prevrže v turbulentnega, stopnja večanja pa zelo naraste (White & Longyear 1962; Dreybrodt 1990).

V času teh procesov je smer vodnega toka v prostoru poljubna - globalno pa se pokorava regionalnemu hidravličnemu gradientu (Slika 3). Začetje, priprava in kasnejše večanje se odvijajo globoko v kamninski gmoti, vendar nastajajoči prevodni sistem slej najde stik s površjem. Glede na krajevne strukturne, stratigrafske in topografske danosti se pojavijo ponori, gravitacijski ali arteški izviri, kakršne pač so krajevne hidrogeološke razmere (Slika 3). Medtem ko se površje vse bolj znižuje, seka vse globlje začetne horizonte. Freatični dvigi na višje horizonte omrtvijo in poslužujejo se jih edino prenikla

deževnica oz. občasno poplavne vode iz večjih globin. Tako jamski sistemi postopoma osuševajo; raztapljanje se nadaljuje v enem ali več spodnjih svežnjih, medtem ko zgoraj prevlada vadozno preoblikovanje. Kljub temu se odlomki opuščenih, delno opuščenih ali komajda nakazanih spletov v višjih delih ohranijo. Če spodnje dele prekinejo podori, ali izjemoma led, jih voda lahko ponovno aktivira.

5. RAZLAGA PODZEMSKIH KRAŠKIH POJAVOV S POMOČJO HIPOTEZE ZAČETNIH HORIZONTOV

Če sprejmemo ugotovitev, da vsi členi karbonatne skladovnice niso enako primerni za spelogenezo, lahko s pomočjo hipoteze začetnih horizontov preprosto razložimo oblikovanst kraškega podzemlja.

Navpični in skoraj navpični jaški

Z izrazom jašek v tem besedilu navpične ali skoraj navpične elemente jamskih sistemov. Izraz ne obsega votlin, ki jih jamarji premagujejo s tehniko obvladovanja navpičnic in ki odsevajo neposrden razvoj iz tektonske(ih) razpok(e)[4].

Hipoteza o začetnih horizontih predvideva, da nastajajo v poplavljeni (freatični ali arteški) coni tudi v tektonsko nepoškodovanih gmotah embrionalne oblike jaškov, ki (skoraj) navpično povezujejo (skoraj) vodoravne začetne horizonte. Če je skladovitost skoraj navpična, so začetni horizonti vodila nastajajočim votlinam, ki spominjajo na brezna - le te pa povezujejo kanali, ki sledijo razpokam. Med začetnimi horizonti se agresivna voda pretaka po razpokah in preskoki se pojavljajo na široki fronti. Šele napredujoča *priprava* zbere tok znotraj začetnega horizonta v posamezen kanal; ta pa napaja le nekatere razpoke in povzroči, da se na tem odseku razširijo tudi same. Tok iz začetnega horizonta v smeri proti naslednjemu začetnemu horizontu lahko uporabi katerokoli prikladno smer v prostoru. Zato pri površnem ocenjevanju izvora oblikovanosti jamskega prostora hitro spregledamo, da sta tako rov kot jašek nastala v prežeti coni.

Jaški, ki nastajajo ob razpokah, so v grobem dveh vrst in morejo nastati enako v vodoravnih kot poševnih skladovnicah. Prvi nastajajo vzdolž razpok, kamor se usmerja prenikla padavinska voda, ko je že dosegla prežeto cono in išče poti do najbližjega s začetnega horizonta. V drugem primeru potuje freatična voda ob ploskvi preloma v poljubni smeri, z enega začetnega horizonta na drugega.

Kamini[5] in podobne oblike

V prežeti coni nastajajo jamski rovi v poljubni smeri v prostoru. Ko se gladina podtalnice zniža, preidejo višji predeli svežnja v vadozne pogoje.

Prenikle vode se zbirajo vzdolž začetnih horizontov, padajo po navpičnih jaških ali derejo po poševnih razpokah - ne morejo pa se po podedovanih votlinah vzpenjati. V grobem so možni trije osnovni izidi, ki jih prikazuje Sl. 5.

Opuščeni višji rovi in njihova nadaljevanja

Slika 6 prikazuje zveze, ki se pojavijo, kjer začetni horizont naleti na razpoko in se razvoj nadaljuje vzdolž obeh. Tak razvoj je starejši od pomembnejšega raztapljanje vzdolž razpoke. Če si po tektonskem dvigu vadozni tok najde pot vzdolž neke starejše zveze vzdolž razpoke, se bo ta širila dalje. Ko raztapljane znotraj dotlej še nenačetega predela končno utre novo pot razpoke, začetni horizont postopoma omrtvi, nižja, nova pot pa se širi dalje.

Poplavljeni odseki rovov

Prehodni rovi se često "končajo", kjer se stakneta strop in vodna gladina. Nastane položaj, ki mu pravijo jamarji sifon, smrk ali "ujeta voda". Slika 6 je shematiziran dvodimezionalen prikaz možnih izidov, kadar se zveze vzdolž vodilnih razpok med dvema začetnima horizontoma lahko pojavljajo v različnih smereh. Prvotno so zveze med dvema začetnima horizontoma poplavljene in mnoge se bočno raztezajo na velike razdalje. Najpreprostejši izid je kratka, zalita cev, ki se spušča ob leziki in ponovno dvigne ob ploskvi preloma. Bolj zapletene se vejijo tudi v bočni smeri in lahko vključujejo številne člene, ki so jim botrovale enako razpoke ali prelomi, kot začetni horizonti.

Splošno o nastanku jam v več nadstropjih

Med vprašanji, ki so v ospredju že vse od prvih pisanih/tiskanih razprav o spelogenezi, je vprašanje nastajanja jam v različnih višinskih pasovih. Večina zgodnjih del je iskala časovnih odnosov med "nadstropji", pri čemer je veljalo za samoumevno, da je najvišje "nadstopje" najstarejše in najnižje najmlajše. Hipoteza začetnih horizontov to gledišče popravlja, saj predvideva, da se je začetje vseh kanalov, v vseh "nadstropjih" lahko odvilo približno istočasno, v freatičnih/arteških pogojih.

Ker se površinska oblikovanost in zato hidrogeološke razmere s časom spreminjajo, se gladina podtalnice spušča in postopoma pade niže od najvišjega in večinoma najbolje razvitega svežnja. Kraške vode se preusmerjajo proti najgloblji zarezani površinski dolini, ki seka kraški prevodnik. Podzemsko pretakanje se, največkrat vzdolž razpok, postopoma prestavlja na nižje ležeče začetne horizonte, v višjih pa vladajo vadozne razmere.

6. ZAKLJUČKI

Večina članka obsega razpravo o temeljnih mislih, ki jih sprejema danes veljavno razumevanje spelogeneze, ali pa so neko vlogo odigrale v preteklosti. Nekatere so postopoma prešle v pozabo, a pri celostnem pogledu na spelogenezo spet pridobivajo veljavo; posamezni pogledi, ki so obveljali za splošne, pa se zdijo danes manj uporabni.

Hipoteza, o kateri razpravljamo na tem mestu, obstoječih modelov razvoja jam ne nadomešča, iz njih ampak raste. Predvsem plete vezi z mislimi, ki so doslej veljale za manj pomembne. S tem, ko jih skušava upravičiti, razvijava nove razlage, vendar ostaja osnovna speleogenetska dogma nedotaknjena. Predstavljena kvalitativna hipoteza omogoča delovni model, ki naj spodbudi empirično raziskovanje.

(Prevod France Šušteršič)

Prevajalčeve opombe:

[1] *Pri prevajanju besedila, ki novim mislim šele utira pot, so težave pri iskanju primernih izrazov neogibne. Da bo branje lažje, sem se naslonil na članek Prispevek k slovenskemu speleološkemu pojmovniku (Šušteršič, Knez, Naše jame, 37, 1995, str. 153-170). Polno pa se zavedam, da je to izhod za silo, saj je tam eksplicitno zapisano (str. 154), da besedilo nima normativnih namenov in da je predvsem namenjeno nadaljnji razpravi.*

[2] *Angleški izraz* inception *je nedvomno izpeljan iz latinskega neologizma* inceptio, *ta pa iz glagola* incipio *(=* začeti, začeti se*) (Bradač 1937: Latinsko slovenski slovar. Jugoslovanska knjigarna v Ljubljani, Ljubljana, str. 249). Zato menim, da je moje slovenjenje vsebinsko in formalno pravilno. Vsekakor ne vidom razloga, da bi na latinski koren cepil slovensko obrazilo in skoval še eno nepotrebno tujko več.*

[3] *Med naštetimi tujkami ima slovensko soznačnico edino izraz* aquifer *(=* vodonosnik*). Da bi bilo besedilo enotno, sem tudi to ohranil v poslovenjeni izvirni obliki.*

[4] *Anglosaško pojmovanje navpičnih kraških votlin se zdi nekoliko ohlapnejše, kot slovensko, terminologija pa enako nedosledna. Uporabljeni izraz* jašek *je pač izhod za silo.*

[5] *Angleškemu izrazu* aven *še najbolj ustereza naš* kamin. *Seveda pa sta obe besedi predvsem jamarski in izražata tehnično zahtevnost, manj oblikovanost, zagotovo pa ne izvora.*

REPORTS

POROČILA

Martin Knez, Janja Kogovšek, Tadej Slabe

KARST RESEARCHES IN YUNNAN PROVINCE, CHINA IN 1997

Between September 19 and October 3, 1997 members of our Institute, Mag. Janja Kogovšek, Dr. Martin Knez and Dr. Tadej Slabe, achieved the planned field work related to the project Study on Stone Forest Genesis, Functions and Structures of the Underground Karst Aquifers in Lunan, Yunnan Province, in co-operation with the Geographical Institute of Yunnan and sponsored by the Ministry of Science and Technology of Slovenia. They studied stone forests and carried out an underground water tracing test in the aquifer there. We would like to acknowledge the help of our Chinese partners for the successful work. A book about the research results is in preparation.

Study of Lunan Stone Forests

Stone forest is a special form of karrenfeld. Karren intersected by deep solutional channels, hollows or enlarged fissures on the surface of the rock are presented in the shape of pillars or teeth. Rock teeth are smaller forms. Pillars are from 5 to 50 m high; in the Lunan Stone Forest they are up to 35 m high and of various shapes. Their shape is controlled, as well as by past and present influences, by the lithology of the rock also, the extent to which it is bedded and crushed. A stone forest develops in thick-bedded, relatively pure limestones and dolomites; the strata are dipping 15^0 at the most and they are intersected by a network of vertical fissures.

In regard to location one may distinguish between two types of stone forest. Those in lowlands and valleys where large forests develop with interlying dolines and collapse dolines have underground water flowing beneath them; they are seasonally flooded or water flows through them. The second type develops on the ridges of mountains; their pillars are smaller (10-30 m), growing from a common base, and the sediment cover is thin. Stone forests appearing on the slopes present an intermediate form between the two described.

Usually a stone forest is described as a form of covered karst. The limestone where karren developed had been covered by thick sediments that decisively controlled the origin and the shape of the stone forest. Uncovered carbonate rocks are weathered by rainfall. Teeth are the first to appear, followed by a true forest.

Stone forests are a typical form of polytropical and subtropical climate.

The Lunan Stone Forest is one of the most famous. The central part (Shilin) covers about 80 ha, and bigger or smaller stone forests nearby are covering as much as 350 km^2. Tourist parts of the Lunan Stone Forest are visited by more than million visitors per year. This is a unique and integral

natural and cultural landscape where the Sani minority lives mostly on tourism.

Below the forest a complex system of water conduits developed. The shape of pillars and their height are controlled by the type of rock and by their topographic location.

The central part of the forest - Shilin - lies between 1625 to 1875 m a.s.l. It is located in a shallow lowland with underground water close to the surface and the water level rises by 10 m after heavy rain. Most of the rain, from 70 to 80%, from the total annual amount of 936,5 mm, falls from June to October. The average temperature is 16,3°, varying from -2 to 39°C. The pillars are highest in the central part of the lowland, there where the superficial waters flow underground; at the borders there are more sediments. In the lower part the water flows on the surface and in the rainy season it floods the tourist footpaths among the pillars.

The central part of the Lunan Stone Forest developed in thickly-bedded and vertically jointed Lower Permian carbonates of the Maokou period.

First the limestone was covered by a Permian basalt and tuff and later by Eocene (Miocene) lacustrine sediments. Thick layers of lateritic soil were deposited above them.

The stone pillars in the central part of the stone forest, which is located in lowland, are up to 30 m high; the spaces amon g them are mostly 1 to 5 m wide. In the central part the pillars are closely packed together; further out they stand separately also. They are relics of rock between the spaces and their shape corresponds; they may have either square or triangular cross-sections, and there are also elongated and narrow shapes. Pointed and blade-like shaped pillars with sharp peaks prevail. The more the limestones are homogeneous, the sharper are the shapes of the pillars. On such carbonates the effective rainwater has incised outstanding rock features.

The Naigu stone forest lies 20 km east of the central forest and is an important tourist destination also. The pillars are from 20 to 30 m high, tower-like with square cross-section often having several smaller, pointed peaks. The pillars are frequently connected into series between distinct fault areas and often they may be described as large rock masses with numerous sharp peaks. Some higher rock pillars stand separately, some are very slim. The tops of pillars that form a vast pillar area are at the same level. Many pillars are mushroom-like especially single ones. The edges of pillars are frequently rounded; only the crests between flutes are sharp. Their rock surface, specially in the smaller rock features, is less distinctive due to inhomogeneity of the rock, and the rock surface is rough.

This forest developed in Qixia rocks and this is reflected in its shape and relief.

The shape of subcutaneous rock teeth is not controlled by the rock structure. They are roundly pointed as are the subcutaneous teeth in other rocks.

Below the stone forest there is a show-cave showing, by its rock surface, several phases of its genesis. Scallops of not very distinctive shapes give evidence for a water flow of 0,5 m/s that flowed through the flooded passages. The scallops were covered by fine-grained sediments that filled the cave. On the roof there are big above-sediment ceiling channels, several metres across, and anastomoses. Above-sediment ceiling features give evidence of a long duration of cave formation by water flowing above the fine-grained sediments. The cave in the middle of the park shows cavernous karst underground below the stone forest and indicates the periods of fast water outflow from the surface transporting sediments that covered the limestones. But also relatively long were the periods when the cave was filled by fine-grained sediments and the surface above it was probably flooded. This shows the development of the stone forest in stages.

Examples of outstandingly mushroom-like pillars, from 35 to 40 m high, are found in Lao Hei Gin, 20 km NE from the "central park". The highest pillars are in the lowest part of the forest. They may be divided into huge rock masses intersected by narrower spaces and having several smaller pointed peaks and single pillars; among them are vast patches of sediments. Single pillars are square towers or like mushrooms. Often they consist of more squares, these are relics of rock layers between bedding-planes and fissures. The central part of the pillar is weathered and disintegrates strongly. The rock weathers in grains and the rock surface is rounded, being angular only below thin scales. The rock is very porous and the middle part of the pillars is intersected by numerous channels, from 1 cm to 1 m and even more across. Rainwater shapes the rock surface on the peaks of the pillars and at their foot, at the section of more resistant rock. So the rock surface reflects the structure and joint frequency; the rock was shaped below the soil and later transformed by rainwater.

Between pillars, dolines are frequent and in them are caves. Through some of these caves water flows from 30 to 50 m below the surface, having a discharge up to 3 m^3 and only exceptionally from 4 to 7 m^3. Taking into account that the underground water network is well developed also in this stone forest, we infer that the outflow from the surface is fast, and not only limestone and dolomite but also sediments and soil are transported underground. At the foot of single pillars there are big above-sediment channels incised deep into the rock. It seems that the entire aquifer was dammed. There had been enough rainfall and this is shown by above-sediment features in the rock. At that time water did not remove sediments from the surface and the growth of the forest was interrupted.

Martin Knez has sampled the rocks at some new locations in the stone forest and also at places already known, in order to establish, by later laboratory tests, the reasons for selective corrosion in three stone forests near Lunan. During this visit the geological investigations did not involve a regional

overview of the landscape and geologic processes from the Paleozoic to now, but just detailed researches of the parent rock mostly in such parts of the geological profile where selective corrosion occurred during karstification. The work was undertaken in the field at macroscopic level and at home in the laboratory it will continue at microscopic level in order to find out the basic reasons that conditioned essentially stronger and sometimes locally characteristic karstification at some sections of the geological column.

Tadej Slabe completed researches on single rock pillars in low stone forests. The underground rock surface developed below the sediments and soil, and the peaks of pillars were transformed by rainwater; composite rock features occur at the foot of pillars, at the contact with sediments and soil. Slabe linked rocky features into rocky relief revealing the factors controlling the stone pillar formation and frequently providing evidence of the development of the stone forest. For development of a stone forest the lithology is very important too. He complemented or changed the previous explanations about origin of some rocky features that he had found in literature; obviously the study must continue and several assumptions must be checked. He intends to make a research model of a stone forest in plaster of Paris.

Janja Kogovšek studied stone pillar solution in the Stone Forest and solution during the rainwater percolation in karst.

Processing of results of karst water properties obtained at the first visit to the Yunnan karst in July 1996, reflecting the process of carbonate solution, indicated a need for additional analyses at the surface and also in conditions when rainwater percolates through the vegetation and a thinner or thicker layer of soil and rock. In September 1997 she analysed the rainwater, which is the input parameter in the solution process in karst, and also the water that had, by trickling down variously tall bare rock pillars, already dissolved a certain amount of rock. Solution of rock pillars when the soil and vegetation are removed is controlled by the intensity of rain; the thickness of the water film that pours down the carbonate pillars depends on the amount of precipitation. The amount of limestone dissolved by a certain amount of rain trickling down the pillars depends on their height and on the length of the trickling way; usually equilibrium is not yet restored at the foot of a pillar. The rate of solution by a gentle rain in a warm season is the biggest and gerater effects of solution may be expected. The decisive factor in dissolving the limestone is the amount of rain, as has already been shown in the Slovene karst; in China there is also a high strength of solution. But already a small amount of rain causes the impermeable base at the foot of pillars to accumulate, and hold water; this water is still aggressive and capable of further solution of the rock at the contact, intensified by the influence of soil. Presumably the contact of pillars with soil and rainwater accelerates the solution effects and this may contribute to the explanation of some rocky features, which, however, must still be studied.

We analysed the percolation water in detail in the Baiyun and Jiuxiang caves where we sampled most of the abundant trickles and drips underground; this not only complemented our previous results but also provided new perceptions. The surface above the Jiuxiang cave is covered by soil and overgrown by grass and dense bushes. The water in the cave reflects dolomitic structure of the rock; Ca/Mg ratio was about 1, but there was also a percolation water with higher magnesium level compared to calcium showing relatively complex rock structure of the cave roof. The highest hardness levels during our researches in the Chinese karst were established; they exceed the levels measured in Slovenia by more than 15%. Baiyun cave lies in Naigu Stone Forest where the surface is bare and vegetation scarce. In supersaturated percolation water controlling recent flowstone deposition, calcium prevails, the Ca/Mg ratio being from 3 to 5. The stream flowing through the cave is very interesting, for it contains as much dissolved carbonates as the other percolation water and deposits flowstone. The cave managers felt justified, in leading this water to a nearby stalagmite with a weakened inflow and into nearby gours.

Water tracing test in the Lunan area

Water tracing tests in karst are used to discover and to prove the underground water connections. The method is widely used all over the world in order to protect water in karst and in particular to assure healthy drinking water. Already at the beginning of our co-operation, our Chinese colleagues expressed their wish to carry out such a test in their karst as in a dry season they are lacking water not only for drinking but also for irrigation; they planned to construct an underground reservoir. Before starting this they wanted to check the underground water flow by a water tracing test. By the first successful water tracing in July 1996 we established two main directions of the underground flow and measured its velocities at certain points. The sampling was carried out at 9 sampling sites, the tracing test was quantitatively evaluated and 55% of returned tracer was established. A directly useful result of the first water tracing was the conclusion that a layer of sandstones, previously supposed to be an important barrier for karst waters, is not so important to justify a construction of a big reservoir, for it only reduces the flow.

The relatively low quantity of returned tracer in the first tracing test indicated the possibility that water flows in another direction also. Unclear results obtained by natrium chloride, which is not a good tracer, in the southern part of the area, dictated the use of a more appropriate tracer. We therefore carried out another combined water tracing test in September 1997.

At the point Wayaodong on September 26 we injected 1 kg of Uranin, and on the point Qinhuadong 200 kg of Natrium chloride which was the only

possible second tracer. At both points the discharge was higher than during the first tracing test; the sampling was organised on all the sampling sites of the first test and at one additional site in the northern part of the aquifer. We contributed a plan of water tracing and this time samples will be analysed at the Geographical Institute at Kunming where they expect a new luminiscence spectrometer. At the same time as the water tracing test was carried out, we sampled the water of the whole area and determined its basic parameters (temperature, specific electric conductivity and pH) in the field and analysed the levels of carbonates, calcium, magnesium and chlorides. We shall process the hydrological data gathered and the results of fluorescence analyses of the water tracing test, together with basic water characteristics, and we shall synthetise the results and assessments of our researches in a common Slovene-Chinese monograph related to studies in China.

Stanka Šebela

6. MEDNARODNA KONFERENCA O VRTAČAH IN INŽENIRSKIH VPLIVIH IN VPLIVIH OKOLJA NA KRASU

Springfield / Missouri / ZDA / 6. - 9. april 1997

Ker sem bila v začetku leta 1997 na podoktorskem izpopolnjevanju v ZDA, ki mi ga je omogočila Slovenska Znanstvena Fundacija, je bila to tudi enkratna priložnost, da se udeležim mednarodnega simpozija o krasu v ZDA. Kot edina Slovenka in predstavnica Inštituta za raziskovanje krasa ZRC SAZU sem se tako že drugič (prvič leta 1995, Gatlinburg, Tennessee, ZDA) udeležila mednarodne konference, katere naslov je bil tokrat "The Engineering Geology and Hydrology of Karst Terranes". Sodelovanje na konferenci mi je omogočil IZRK ZRC SAZU, organizator srečanja dr. Barry F. Beck (P.E. LaMoreau & Associates, Inc., Oak Ridge, Tennessee) mi je ponudil ugodno možnost plačila kotizacije, soorganizator dr. Kenneth C. Thomson profesor na Department of Geography, Geology and Planning (Southern Missouri State University, Springfield) mi je ponudil brezplačno bivanje.

V štirih dneh se je simpozija udeležilo 123 udeležencev, izmed katerih jih je 47 predstavilo referate in 19 posterje. V nedeljo 6. aprila 1997 smo imeli uvodno enodnevno ekskurzijo, ki jo je vodil dr. Kenneth C. Thomson, izkušen krasoslovec, hidrogeolog in jamar. Springfield je tretje največje mesto v zvezni državi Missouri. Leži na platoju Ozark, ki ga gradijo mississippijske (karbon) karbonatne kamnine, predvsem apnenci. V okolici Springfielda smo si ogledali številne primere vrtač, ki so ob močnejših deževjih preplavljene z vodo. Mnogo je kraških jam, ki ob večjih padavinah predstavljajo izvire, ki ogrožajo naselja. Gradbeniki in načrtovalci stanovanjskih hiš so naselja postavili povsem na kraškem terenu, ki je premrežen z vrtačami, ne da bi se pri tem zavedali vseh nevarnosti. Ker je nad plastmi apnenca debela plast preperine, so vrtače v okolici Springfielda bolj nekakšni grezi v sedimentu in so tudi morfološko manj poglobljene in kamnite, kot smo jih vajeni iz naših krajev. Seznanili smo se tudi z rezultati barvanja kraških voda, kraškimi izviri in splošno hidrogeologijo območja. Videli pa smo tudi konkretne rešitve pred poplavami kot npr. regulacije terena za primer odvodnavanja po kanalih in urejenih strugah. Poleg kraških jam, vestno urejajo tudi kataster vseh vrtač.

Od 7.-9. aprila 1997 se je v treh dneh zvrstilo 47 referatov. Gostovali smo v hotelu Holiday Inn, University Plaza v Sprinfieldu. Poleg glavnega organizatorja P.E. LaMoreaux & Associates, Inc. so srečanje sponzorirali The Department of Geography, Geology & Planning of Southwest Missouri State University, The Mid-Missouri & St. Louis Sections of the American Society of Civil Engineers, The Association of Ground Water Scientists and Engineers (NGWA), The Association of Engineering Geologists, The Karst Waters Institute. Na

simpoziju so predstavili zbornik predavanj, ki na 516 straneh zajema 66 člankov (Beck, B.F. & Stephenson, B.J., 1997: The Engineering Geology and Hydrology of Karst Terranes.- Proceedings of the Sixth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst, Springfield/Missouri/6-9. april 1997, 516 p., A.A.Balkema, Rotterdam, Brookfield). Srečanje je imelo bogato mednarodno udeležbo, saj so bili poleg američanov prisotni predstavniki in predavatelji iz Belgije, Nemčije, Slovenije, Rusije, Litve, Kitajske, Indije, Kanade, Kuvajta, Irske, Velike Britanije, Madžarske in Portorika.

Uvodni referat je imel dr. John E. Mylroie (Department of Geosciences, Mississippi State University, Mississippi State) z naslovom: Land Use and Carbonate Island Karst. Sklopi predavanj so bili: Onesnaženje talne vode v kraških terenih, Geotehnične raziskave in inženiring na krasu I in II, Raziskave krasa z geofiziko, Kras v evaporitnih kamninah, Vladne zakonitosti za kraške terene, Drenaža ob nevihtah in problemi poplav na kraških terenih, Kraška hidrogeologija in oskrba z vodo, Pojavljanje vrtač na apnenčastem krasu. Ob reševanju in raziskovanju problemov posegov na krasu širom po svetu smo se seznanili s konkretnimi primeri reševanja pojavljanja vrtač, poplav, nenadnih udorov. Predvsem je šlo za konkretne primere iz gradbeništva. Med odmori smo si lahko ogledali razstavo posterjev, avtorji pa so bili vedno pripravljeni na konzultacije.

Že šesta konferenca po vrsti in predvsem letošnja velika udeležba neameričanov, kaže na veliko zanimanje za tovrstno temo širom po svetu. Simpozij organizirajo v zadnjih letih vsaki 2 leti, nekaj strokovnjakov pa se ga udeležuje že od začetka. Naslednji simpozij naj bi bil leta 1999 nekje v severnem delu ZDA. Vedno bolj je očitna želja in zanimanje za povezavo in izmenjavo znanj na področju krasoslovja med ZDA in ostalimi državami.

VIR

Beck, B.F. & Stephenson, B.J., 1997: The Engineering Geology and Hydrology of Karst Terranes.- Proceedings of the Sixth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst, Springfield/Missouri/6-9.april 1997, 516 p., A. A. Balkema, Rotterdam, Brookfield.

BOOK REVIEWS

KNJIŽNA POROČILA

Martin Knez

TRACER HYDROLOGY 97
(A. Kranjc, Ed.) Proceedings of the 7th International Symposium on Water Tracing

A. A. Balkema, Rotterdam, Brookfield, 1997, XIV+450 strani

V zadnjih petih letih je prišlo do številnih novih odkritji na področju kraške hidrologije, metodologije in tehnologije sledenja voda: od novih ugotovitev pri določanju sledil do uporabe novih sledil in poglobljenega znanja o njihovih lastnostih. Prav tako se je močno poglobilo znanje o vplivu sledil na okolje in človeka, kar pripomore k boljši, varnejši in kvalitetnejši uporabi le-teh. Najrazličnejše metode vodnega sledenja opisane v tej knjigi, v povezavi s številnimi drugimi metodami, so v tesni povezavi z teoretičnimi laboratorijskimi poizkusi in uporabnimi nalogami. Metode vodnega sledenja pa so bolj in bolj pomembne pri reševanju različnih hidroloških, hidrogeoloških in v zadnjem času vse pogostejših ekoloških vprašanj.

Knjigo, v celoti je v angleškem jeziku, sestavlja 63 referatov z že sedmega mednarodnega simpozija o sledenju voda, ki je eden mednarodno najodmevnejših in strokovno najpomembnejših tovrstnih srečanj raziskovalcev podzemnega pretakanja vode. Prispevke je pripravilo 177 avtorjev z najrazličnejših institucij iz praktično vsega sveta. Kljub obsežnosti knjige pa si jo moramo zaradi njene vsebinske pomembnosti nekoliko pobliže ogledati. Nastajala je takorekoč preteklih pet let. Zadnji simpozij o sledenju voda je namreč bil leta 1992 v Nemčiji (Karlsruhe).

Kljub temu, da je knjiga ozko strokovna, pokriva široko interesno področje. Bralec lahko v njej odkrije katera nova sledila so se pojavila, kako se le-ta uporabljajo v različnih situacijah in končno kakšne probleme lahko rešujemo in razrešimo s pomočjo metod podzemnih vodnih sledenj. Med referati lahko odkrijemo tudi razpravo, ki bo morda neposredno povezana z našim delom oz. nam bo v največji meri v pomoč, lahko pa takšno, ki predstavlja določeno regionalno problematiko in rezultate tamkajšnjih raziskav. Prav gotovo pa med referati ne manjka tudi besedil, ki opisujejo reševanje najrazličnejših težavnih situacij s pomočjo računalniškega modeliranja.

Knjiga je zbirka zapisnikov razprav, predstavljenih na simpoziju in je zato neprecenljiv priročnik za različna vprašanja povezana z podzemnim sledenjem voda, hkrati pa je zbirka znanja, ki prikazuje pregled, kako so se hidrologija, hidrogeologija in kraška hidrologija razvijali v zadnjem času, kakšne znanstvene dosežke so dosegle in kakšno usmeritev imajo v prihodnje.

Poglavjema Uvod in Organizacija sledi 6 vsebinskih sklopov referatov: Methods, Surface waters, Unsaturated zone, Aquifers, Contamination transport and protection in Aquifer parameters and modelling. Knjiga je zaokrožena s poglavjem Author index.

V prvem poglavju je zbrano gradivo o metodah sledenja podzemnih voda. Avtorji so predstavili pomen bakteriofagov pri podzemnem sledenju, nekatere laboratorijske eksperimente, nova fluorescenčna barvila, pomen radona (^{222}Rn), kot sledila pri ugotavljanju onesnaženja z naftnimi derivati, predstavili so toksičnost nekaterih fluorescenčnih barvil, uporabo optičnih sledil in drugo.

V poglavju Površinske vode (Surface waters), ki vključuje le pet referatov, so zbrana besedila o sledilnih poizkusih v površinskih vodnih sistemih.

Naslednje poglavje, ki nosi naslov Nenasičena cona (Unsaturated zone), je sklop zbranih predavanj o raziskavah pretokov v vadozni coni vodonosnika. Razprave so se med drugim osredotočile na raziskave nenasičene cone v gorskem okolju, obnašanju raztopljenega silicija in kisika-18, kot sledil med taljenjem snega, sledenje v nekarbonatnih kamninah.

Četrto poglavje je najobsežnejše in se nanaša na raziskovanje tako karbonatnega kot nekarbonatnega vodonosnika. Avtorji opisujejo hidrološke razmere od province Malataya v Turčiji, preko raziskav Kamniških Alp in Grintovca, predelov v bohinjskem predelu in okolici Pirana, kraških področji v Spodnji Avstriji, v osrednjih Pirenejih Španije, monitoring reke Reke, v Dinarskem krasu Hrvaške, različnih področjih Kitajske, kras jugozahodne Nemčije, izbranih vodonosnikov Indije in Anglije.

V naslednjem poglavju so prispevki, ki se večinoma nanašajo na raziskave migracije različnih fluidov v različnih medijih in načinu zavarovanja pred škodljivimi snovmi. Glavni poudarek je na kontaminaciji področji v neposredni bližini urbanih področjih, kjer je pomemben dejavnik tudi kmetijstvo.

Aquifer parameters and modelling, kot zadnje poglavje knjige prinaša predvsem zbirko teoretičnih študij razmer v vodonosniku, kot naprimer poskus simulacije podzemnega pretakanja na splošno, simulacija jamske hidrologije, ugotavljanje hidroloških zakonitosti v heterogenih vodonosnikih in drugo.

Kvalitetno oblikovana in urejena v trde platnice vezana knjiga je bila v za naše razmere visoki nakladi natisnjena v ugledni specializirani založniški hiši A. A. Balkema iz Rotterdama. Je v zbirki ostalih šestih od katerih imata zadnji dve enako naslovnico (razlikujeta se le po imenu urednika in letnici izdaje), kar je nedvomno dobrodošlo, hkrati pa to kaže na svojevrstno programsko kontinuiteto in usklajeno delo raziskovalcev iz različnih držav. Tracer Hydrology 97 vsekakor ni knjiga o nečem kar je bilo, pač pa knjiga, ki bo vsaj v naslednjem petletnem obdobju eden od temeljev pri raziskovanju in sledenju voda.

Andrej Kranjc

David Gillieson - CAVES: PROCESSES, DEVELOPMENT AND MANAGEMENT

Blackwell Publishers, Oxford & Cambridge (Mass.), 1996

The Blackwell Publishing House, well known among physical geographers, geomorphologists and karstologists, mostly those dealing with the karst surface, has published a book that will surely arouse a lot of interest even among those geographers and karstologists dealing with karst underground and among speleologists. It is in the collection The Natural Enviroment and among the editors is a geographer A. Goudie. Do not take me wrong; in this book there is a lot that is useful and interesting for everybody, from theorist to practical persons, either for the manager of a show cave, for instance, or for a landscape architect planning the revitalization of an abandoned quarry, on karst, of course.

The work of the distinguished Australian researcher of karst, and the karst underground in particular, David Gillieson, entitled Caves: Processes, Development and Management, tries to show the reader the themes announced by the title in a detailed and up-to-date way, considering the latest laboratory and field results and researches. What was stated at the start of the Natural Environment collection is also true of this book on caves: "This series will provide accessible and up-to-date accounts of the physical and natural environment in the past and in the present, and of the processes that operate upon it."

The book contains 324 pages divided into 10 chapters: The Cave System and Karst, Cave Hydrology, Processes of Cave Development, Cave Formations, Cave Sediments, Dating Cave Deposits, Cave Deposits and Past Climates, Cave Ecology, Cave Management, Catchment Management in Karst.

Single chapters are well sub-divided according to their contents very precisely. Let us look, first, at the short but important first chapter. Here are explained the author's views, essential in treating the whole subject. The title of this first subchapter is "What is karst?" We know that there is no uniform definition given either by authors of basic karstological works or followers of the same school or by the experts of different branches of natural science. The author did not define what is karst for him as a more or less short definition but he explains it in detail. Among other things he says: "This terrain (karst) is formed principally by the solution of the rock, most commonly limestone and its close relatives. But solution of rocks occurs in other lithologies, in particular in other carbonates such as dolomite, in evaporites such as gypsum and halite, in silicates such as sandstone and quartzites, and in some basalts and granites where conditions are favourable. All these are therefore true

karst... Karstic terrain can also develop by other processes - weathering, hydraulic action, tectonic movements, melt water and the evacuation of molten rock (lava). Because the dominant process in these cases is not solution, we can choose to call this suite of landforms pseudokarst." If we look in the Slovene karst terminology of 1973 (maybe this book needs to be modernized) its definition of karst does not disagree with the words of Gillieson but it is denied by the definition of pseudokarst: "karst phenomena in non-carbonate rocks (lava, salt)." For Gillieson also lava tubes are pseudokarst, but karst phenomena in salt are true karst for him and for us this is a pseudokarst. There is not a question who is "more correct" but it is important to consider the entire work from this point of view otherwise we may be surprised; in the chapter on speleogenesis there is an example from a "silicate karst in Venezuela", for example.

In such works that are basic and also manual at the same time I find it specially interesting and useful to establish how much the author knows and takes into account the examples from our karst, the results of our researches and our publications. After many years we find in this book again among the deepest caves a shaft from our karst, Čeki 2, Kanin Mountains placed in 11th place. In the chapter on speleothems there are data about flowstone growth and age in Postojnska Jama, and that on cave sediments is illustrated by Postojnska and Planinska Jama.

The last chapter offers directly useful guidelines or recommendations on the protection and restoration of different "wounds" on karst.

For us, being used to more or less "classical" examples mostly from Europe, the book seems at places slightly exotic. No wonder, for the author comes from Australia and he is more familiar with the karst of Australia and the southern Pacific as he did a lot of his researche there. Thus it is quite normal and right that the examples too are coming from there. Yet, it seems peculiar that the example of the Vauclusian spring is not La Fontaine de Vaucluse but the biggest spring in New Zealand. But also an expert can be surprised how much and what kind of karst there is in Australia, as for example the karst area Nullarbor plain covering 20.000 km^2.

Such a work provokes the question if it is possible that one man, specialised as men are today, can cover such a wide palette of natural sciences in the detail necessary for karst studies, ranging from chemistry and physics through geology and hydraulics to biology. This book is a proof that such men do exist although there are some details showing that the author is also near the limit of his capacity. An expert, for instance may find the equation 5.2, page 157 ($w=W/W=t_0n$) suspicious or not clear, as in my non-expert opinion, specific stream power is not a constant. Where on page 172 it is said that HCO_3 is ion, then the chemical formula must be written correctly, with charge. Maybe it is just a simple printing error. From a professional point of view it would be perhaps better if single chapters are written by different specialists but then

the book would loose its unity and would be less understandable and not as readable as it is.

As already mentioned, the virtue of this book is its contemporaneity; this is shown also by the references used being based on modern works and not on the usual older "classical" references. There are 484 cited professional works. I must remark that the author is extremely "English" oriented, most of used works are written in English language and others almost do not appear. There are 5 works of Slovene authors, all written in English. Out of works published in Slovenia there are two papers from Acta Carsologica, the others were published abroad. Gillieson's work may serve as a good example when we are in a dilemma, whether to publish in English or in Slovene language.

Maybe I have mentioned some slight imperfections, if they are imperfections at all, but this is mostly from our point of view and not related to the excellent entirety. I must stress, in order not to be misunderstood, that Gillieson's book is an excellent and useful work as much for students as for karstologists and experts. Everybody can find a lot that is new and interesting and I think that this book can join the modern karstological "breviary" Karst Geomorphology and Hydrology by Ford & Williams. I think that this is the best commendation.

The book is published in hard and soft cover; the paperback issue costs 18.99 pounds and such a price cannot be an obstacle for such a book to appear on shelves of relevant libraries.

Andrej Kranjc

D. André & M. Casteret & P. Carlier & A. Gautier & G. Kalliatakis & C. in L. Renouard, LA PLUME ET LES GOUFFRES

Correspondence de E.-A. Martel (1868 - 1936), Association E.-A. Martel, Meyrueis 1997

Leto 1997 so v francoskem departmaju Lozère poimenovali "Martelovo leto". Pred 100 leti je namreč ta znameniti francoski raziskovalec krasa in kraških jam, imenujejo ga "utemeljitelj sodobne speleologije" (pri nas sicer imenujemo "očeta sodobne speleologije" A. Schmidla), med drugim je tudi prvi prodrl po podzemeljski Pivki iz Postojnske do Magdalene jame, zaključil svoje drugo raziskovanje kraških planot Causses. Velik del departmaja Lozère obsega prav Causses in Martel jih je s svojimi raziskavami odkril Francozom in tako postavil temelje tamkajšnjega turizma, od katerega je v veliki meri odvisen tudi proračun Lozère.

V Martelovem letu so v Lozère pripravili celo vrsto prireditev, eden najpomembnejših dogodkov pa je bila gotovo izdaja Martelove korespondence v obliki knjige z naslovom "Pero in brezna". Knjiga je bila domači in tuji javnosti podrobneje predstavljena na posebnem simpoziju o Martelu, ki je bil 17. in 18. oktobra v prestolnici departmaja, v mestu Mende.

Kako težka in obsežna naloga je bila priprava te knjige, kaže že podatek o Martelovih objavah: izpod njegovega peresa je izšlo preko 1000 člankov in 24 knjig. Med knjigami je nekaj prav obsežnih, npr. Les Abîmes ..., knjiga velikega formata, kjer samo poglavje o našem krasu obsega 57 strani. Vendar ni pisal le člankov in knjig, tudi zbirka njegovih pisem je zelo velika.

Avtorji, med njimi naj kot zanimivost omenim s. Marie Casteret, hči znanega speleologa in publicista, katerega nekaj knjig je prevedenih tudi v slovenščino, Norberta Castereta, so uspeli nalogo opraviti pravočasno in pred nami je obsežno in tehtno delo, ki tudi kaže na Martelovo na videz neizčrpno energijo: knjiga velikega formata (25 x 35 cm) na 607 straneh kvalitetnega (in težkega!) papirja, v kateri je zbranih 1034 pisem Martelove korespondence. Da so delo zmogli, gre gotovo tudi zasluga številnim sodelavcem iz raznih dežel. V uvodu jih je naštetih 112, med njinmi tudi dva iz Slovenije.

Seveda knjiga ni le preprost ponatis oziroma transkripcija Martelovih pisem. Po uvodnih poglavjih na 35 straneh: Dediščina..., Dolga zgodovina pisem, Dopisovanje Martel - Casteret, Martel in njegova pisava, Osvetlitev Martelovega življenja, Literatura za Martelovo biografijo (upoštevanih je 6 prispevkov slovenskih avtorjev), se prične prava korespondenca.

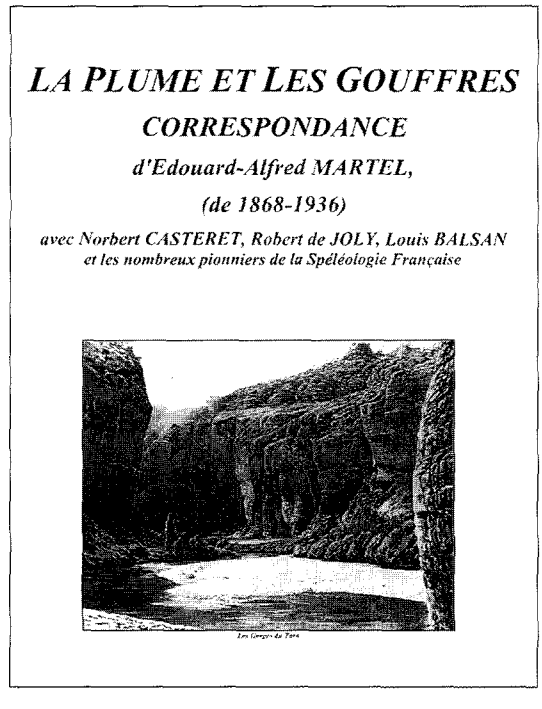
Tudi ta je razdeljena na več poglavij oziroma sklopov po letih: 1859 (potrdilo o rojstvu), Otroštvo in mladostna popotovanja (1868-1882), Uvod v raziskovanje podzemlja (1883-1887), Veliki podzemeljski podvigi (1884-1894),

Spelunca in Speleološko društvo (1895-1899), Leta uradnih raziskav (1900-1914), Leta sprememb (1915-1925), Čas Martelovih naslednikov (1926-1938). Sledijo pisma, ki se tičejo Martela po njegovi smrti, zadnje 1034., je pismo L. Balsana Martelovi vdovi iz l. 1949.

Delo zaključuje seznam pisem (prejetih in tistih, ki jih je sam pisal), seznam francoskih departmajev in tujih dežel, kjer je potoval, Martelov kronološki življenjepis ter prav na koncu nenavadni "postface" z naslovom "Marteloscopie *infernale" izpod peresa pred nekaj leti umrlega B. Gèza.*

Knjiga predstavlja predvsem dejstva, gradivo za nadaljnje delo tistih, ki se ukvarjajo z Martelovo biografijo kot tudi tistih, ki se ukvarjajo z zgodovino speleologije. Za nas je morda najzanimivejše, kako je v tej korespondenci zastopan naš kras in naše jame. Med korespondenco za leto 1893 (takrat je bil na "misiji" po dinarskem krasu) sta obširno pismo in poročilo ministru (na dobrih 3 straneh!), leto 1894 pa se začne s pismom postojnskemu okrajnemu glavarju - predsedniku Jamske komisije, v katerem priporoča, naj podpirajo postojnsko društvo Anthron. V preglednem življenjepisu je npr. po dnevih navedeno, kdaj je prišel na Kranjsko in kaj je kakšen dan počel. Tako piše za "23. september 1893 (sobota): obiskal je Škocjanske jame; meri višine stropov s papirnatim balonom." Pregled vseh objavljenih pisem s ciljem ugotoviti, katera se še morda tičejo našega krasa oziroma so pomembna za zgodovino našega krasoslovja in speleologije, bi bila že prava raziskava.

Posebno poglavje so ilustracije. Vsega skupaj je 551 črnobelih, med njimi največ fotografij (številne je posnel Martel), risb, faksimil pisem in jamskih načrtov, razglednic in dopisnic, zemljevidov, itd. Na 61 slikah je Martel, 11 pa jih predstavlja motive z našega krasa oziroma dokumente, ki se tičejo naših krajev. Poleg tega, da je to pravi Martelov album, zbirka slik iz številnih jam, zgodovina pionirskega obdobja francoske speleologije, je to tudi neke vrste ilustrirana zgodovina speleološke tehnike, kar je svetovnega in ne le francoskega pomena. Da ne omenjam portretov oziroma "akcijskih posnetkov" tako znanih jamarjev (Casteret, De Jolly, Gèze) kot tudi naravoslovcev in



sploh ljudi, pomembnih predvsem za znanost konec prejšnjega in v začetku tega stoletja.

La plume et les gouffres ni knjiga, ki bi jo človek prebral in odložil, sploh ne vem, če jo bo kdo prebral v celoti, saj je to delo, gradivo, ki mora biti nekje pri roki, saj človek nikoli ne ve, kdaj mu bo prišlo prav, kaj bo kdaj potreboval od nje: podatek, datum, ilustracijo? Žal te knjige verjetno ne bo v številnih knjižnicah po Sloveniji, vseeno pa je nobeden, kdor se bo ukvarjal z zgodovino našega krasoslovja in speleologije, z zgodovino jamarske tehnike, s krasoslovno in speleološko bibliografijo ali biografijo, ne sme prezreti.

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Zdenko Rudolf Postojna

Tisk
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