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A LITTLE CONTRIBUTION TO THE KARST TERMINOLOGY: SPECIAL OR ABERRANT CASES OF POLJES?

PRISPEVEK H KRAŠKI TERMINOLOGIJI: PRIMER KRAŠKEGA POLJA – POSEBNOST ALI ZMOTA?

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Jean Nicod: A little contribution to the karst terminology : special or aberrant cases of poljes?

A usual definition of polje states that it is “great closed karst basin with flat bottom, karstic drainage and steep peripheral slopes”. But the Dinaric karst shows a wide range of poljes. The article discusses the main criteria of polje definition and the different degrees of evolution of the polje are emphasised. The essentials are gathered in the table with new tentatives on classification of poljes and comparing the Dinaric karst with other Mediterranean and Alpine countries.
Key words: karst terminology, polje, Dinaric karst, Alpine karst, Mediterranean.

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Jean Nicod: Prispevek h kraški terminologiji: primer kraškega polja – posebnost ali zmota?

Običajna definicija kraškega polja je »velika zaprta kraška depresija z ravnim dnom, kraškim odtokom in strmimi pobočji«. Toda na dinarskem krasu je cela vrsta različnih kraških polj. V prispevku so navedeni glavni kriteriji za razvrščanje polj ter posebej poudarjeno vprašanje različne stopnje v razvoju kraškega polja. Vsebina je zbrana in povzeta v preglednici, ki obenem ponuja nove rešitve pri razvrščanju kraških polj ter podaja primerjavo med dinarskim krasom ter krasom v drugih sredozemskih in alpskih deželah.
Ključne besede: kraška terminologija, kraško polje, dinarski kras, alpski kras, Sredozemlje.

According to the usual definition « a polje is defined as a great karst closed basin, with flat bottom, karstic drainage and steep peripheral slopes » (GAMS 1974, 1978). But the Dinaric karst shows a wide range of poljes, some fully in carbonatic terrains, other partly in impervious rocks or *border poljes* (ROGLIĆ 1972, 1974) and *peripheral poljes* (GAMS 1978).In addition, some typical poljes are studied in the Mediterranean countries by recent authors. As part of the structural and morphoclimatic classification, we are looking to the evolution of poljes, in relation with neotectonic stress, the activity of hydrology, changes of water-table level, and the degree of karstic evolution, particularly marked by the forms of the bottom and the peripheral slopes.

MAIN CRITERIA ON KARST POLJES DEFINITION

The poljes are no elementary form, and cannot be defined by one and two criteria, but on the contrary by various conditions and processes on the whole of the *karstic geosystem.*

There are distinguished :

1- *The topography* : generally an elongated closed basin (except some semi- and open poljes...).

2- *The structural conditions* :
contact by fault, fault field, anticlinal, synclinal, overthrust etc...;
possible impervious areas (border & peripheral poljes) ;
- possible *aquiclude* or *aquitard* (the latter frequently in dolomitic areas, example of the fault-line poljes in the karst of El Hammam, Middle - Atlas, MARTIN 1981).

3- *The part of active tectonics*,
particularly the play of the transverse fault, and the general overstretching, factors of the development of the groundwater network. In some large poljes, the hydrogeological working is in relation to the neotectonic activity, particularly with the distensional and/or transcurrent faults : classical examples of Minde (Portugal), Cerknica (Slovenia), El Yammoűné (Lebanon)….

4- *The morphoclimatic heritage*.
Most poljes are formed pre-Pleistocene, developed initially in conditions of tropical karst.
They are filled by various deposits according to morphoclimatic episodes : morainic, (the classical example of the Campo Imperatore in Abruzzo), cryoclasts, or loam (from the ferralitic soils of the near slopes, or transferred by a tributary stream as the Trebišnjica in the Popovo polje). In some cases, allogenic siliceous deposits can fill the polje bottom and play a main part in the processes of *crypto-corrosion* : in the typical example of polje of Zafarraya (Betic Ranges,) alluvia originated from the weathered schists of the Sierra Tejeda compose the main cover on the bottom (LHÉNAFF, 1968). In and near the volcanic countries, as San Gregorio polje, Campania; Alte Murge (SAURO, 1991) and karst of Azrou, Middle-Atlas, the ashes and lapillis contribute to the same processes.

5- *Recent and present hydrology.*
The functional poljes have an active hydrology :
- inflow by springs or tributaries;
- meandering stream in bottom ;
- outflow by ponors ;
- the most typical are ± in piezometric level - possible working of estavelles ;
- overflow by excess of inflow/possible outflow and obstruction of the ponors,

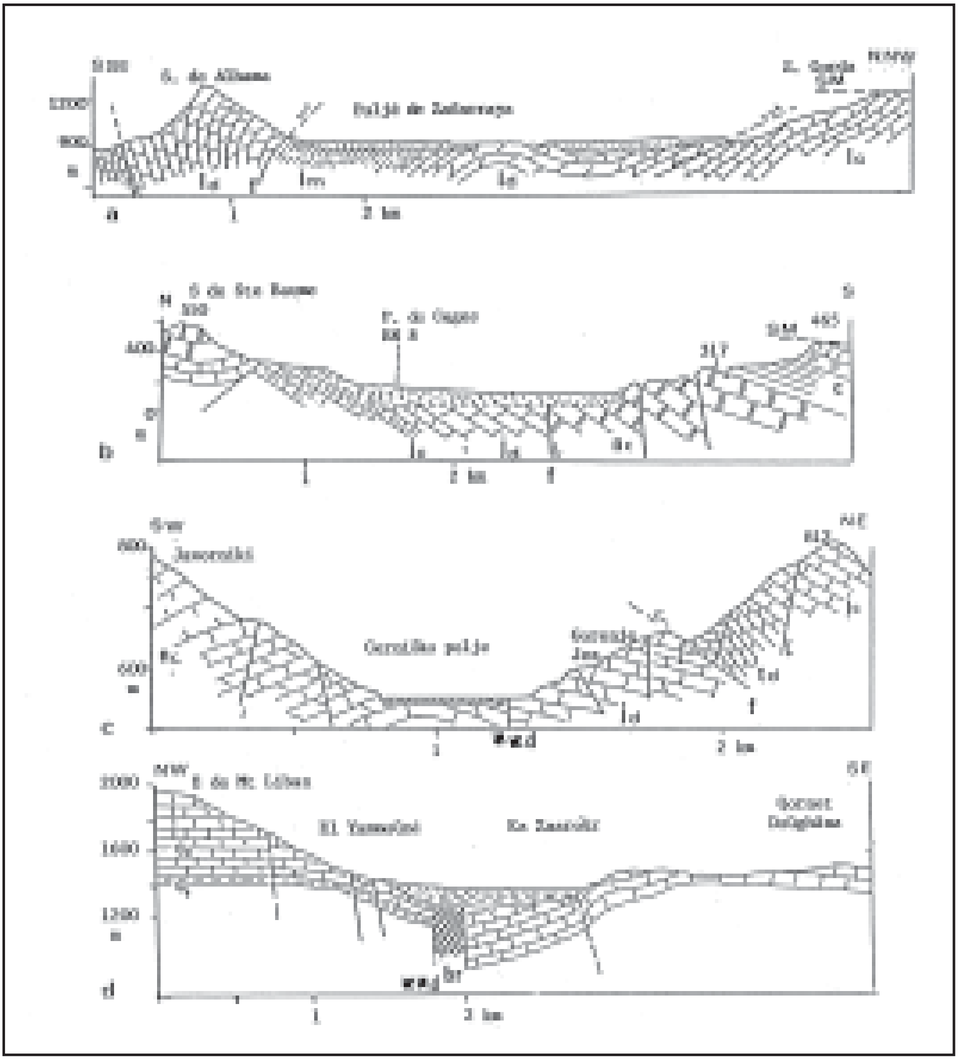

Fig.1: Compared cross-sections of four tectonic poljes (NICOD 1996)

a- Zaffaraya (Betic ranges) from LHÉNAFF, 1968 : lc-Lias limestones, ld-Lias dolomites, nc-marly lower Cretaceous, f-main overthrust, SM-Miocene planation.

b- Cuges (Provence) in NICOD (1967) :

jc- Jurassic limestones, jd-Jurassic dolomites, nc-Lower-Cretaceous limestones, c-Upper-cretaceous series.

c- Cerknica (Notranjsko, Slovenia), eastern part, from GOSPODARIČ & HABIČ, 1978 :

t- Trias dolomites, jc-Jurassic limestones, jd-Jurassic dolomites, nc- Lower-Cretaceous limestones, d-transcurrent fault (active Idrija lineament).

d- Yammouné (near the Beqaa, Lebanon), from BESANÇON, 1968 :

c_1- marly Aptian, c_2-Cenomanian limestones, br-tectonic breccia, d-active transcurrent fault (branch of the W fault system of the rift valley).

- or in some case by the play of estavelles.
- seasonal lakes and marshes, some permanent lakes,particularly in coastal area, according to the sea-level. So the tough problem of the Vrgorac drain (near the Neretva delta) results from the little gradient to the sea-level (BONACCI, 1992).

The hydrology conditions contribute to the solution rate, particularly in the calcareous bottom of the basin : the denudation rate is generally high in the active poljes.

6- *The geomorphological features.*

The incipient poljes are mainly fluvial forms, above all proceeding of the fluvial erosion processes in impervious layers (particularly in the border poljes).

The more characteristic forms in the functional poljes are :

- the embayements of border, in keeping of the ponors and estavelles (and suffosion and collapse processes) ;
- the residual hills (= *hums*) ;
- the corrosion levels, terraced according to the sucessive deepening of the polje bottom.

The process of the *crypto-corrosion* is very active in the actual polje bottom under the alluvial or colluvial deposits. The old (and occasionally in steps) rocky corrosion-plains and rock-fans result mainly from this process in the past (*cf.* ROGLIĆ 1972, DUFAURE 1984, NICOD 1992).

Table I gives an attempt at polje classification in connection with the combination of these various main criteria. Only the typical functional poljes can give the whole of these criteria (e.g. : polje of Cerknica).

THE DIFFERENT DEGREES OF EVOLUTION: SOME PROBLEMS.

1- *Many poljes are in incipient stage* **:**

- blind valley, in contact karst; some *piedmont poljes* may proceed from this form;
- uvala in extension, some structural poljes . Some poljes may proceed from connection of uvalas, as the « Llanos de Libar », synclinal polje in the Serrania de Grazalema, Betic ranges (DELANNOY 1997) ;
- structural basin, from erosion, excavated in only impervious rocks of the bottom ; examples of the poljés of Caille and Caussols in the subalpine range of the Alpes Maritimes. The development of these forms arises mainly from the fluvial erosion from the ponor in the synclinal trough, and the episodic overflow depends only from the blocking of this ponor.
- recent filled graben, with peripheral slopes constituted by fault scarp, as the polje of Cinquemiglia in Abruzzo (DEMANGEOT 1965) ; *cf.* the south side of Cuges (Provence) ;
- valley or graben blocked by scoriae cone and lava flow : example of the « Rug » (or Roudj), adjacent to the Ghor rift valley, in Syria (BESANÇON & GEYER 1995).

2- *The problem of base-level in the active poljes.*

Two main problems are to discern :

- the base level in the polje is controled by the hydrogeologic conditions in the karst unit below, and its fluctuations are a function of the seasonal climatic events ;
- near the coast, the base-level depends mainly on the sea-level.

This distinction has played an important part in the polje evolution during the Pleistocene in relation to the morphoclimatic events and the variations of the sea-level.

In combination with the general karstic aquifers, the groundwater of the alluvia may play important part in the polje evolution. Let us quote as examples :

- in the Lassithi, high tectonic polje of Crete, the important groundwater in the alluvia is supported by the *aquiclude* constituted by an old clayey karstic formation ; like the case of Campo Imperatore, in Gran Sasso d'Italia massif, that show a rich hydrologic network and little lakes in keeping with its thick morainic cover;
- the *semi-poljes* of Mislina and Hutovo blato, near the lower Neretva valley, partly in lakes, has been blocked from the Holocene deltaic filling.

*3- The open and paleopoljes***.**

In contrast with these active forms, in the Mediterranean karsts, many poljes are only inherited forms :

- open poljes, partly drained by an permanent or intermittent stream ;
- paleo-poljes or « fossil » poljes.

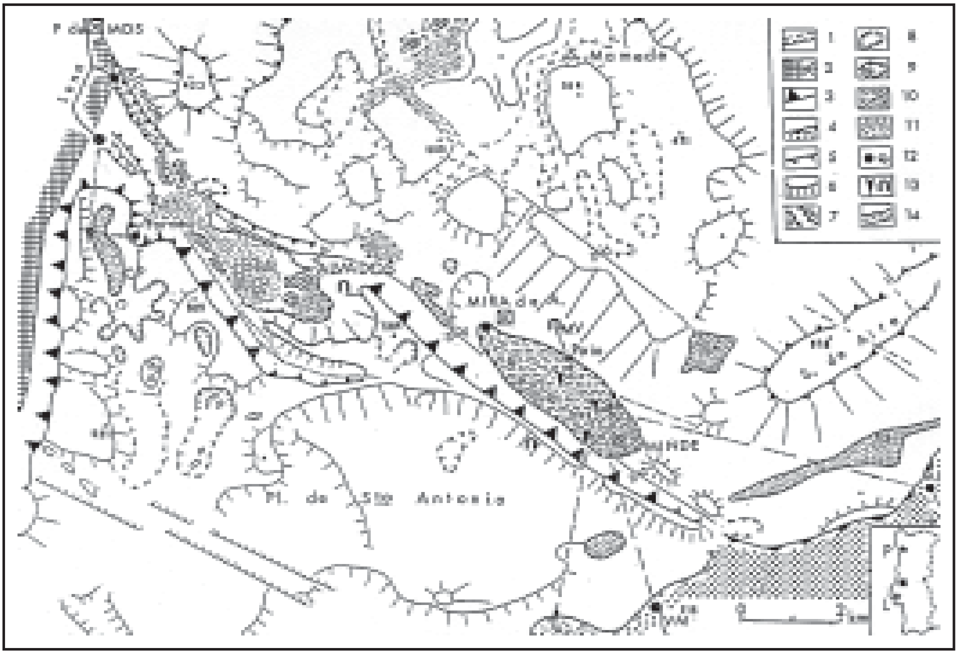

Fig. 2: The structural polje of Minde and the open polje of Alvados (Estramadura, Portugal). Map from the documents of M.L. RODRIGUES 1995, FERREIRA et al.*, 1988, & J.A. CRISPIM,1993, 1995,* in *NICOD, 1996, fig.1.*

*Keys: 1-faults, 2- tectonic limit of the Infra-lias sandstones (triassic diapir), transcurrent fault, 3-tectonic scarp, 4-*id.*, of overthrust on the Tage basin, 5-structural scarp, 6-gentle slope, 7-canyon, old corrosion level, 8-uvala, karstic basin, 9-polje contour, 10-lacustrine bottom, terra-rossa, 11-periglacial cone and deposit, 12-spring, seasonal lake, 13-ponor, cave, 14-permanent, temporary stream, water-tracing.*

Abbreviations : Al-Almonda spring, Av-tracing Olhos de Aviela main spring, CP- Chao das Pias, MV-Moinhos Velhos cave, VM- Vila Morena spring.

Main Types in comparison with structure & geomorphology	Examples *(références)*	Structural control *Possible part of aquiclude or aquitard*	Specific geomorphological forms	Hydrological features : *ponors, (Seasonal) overflow Lakes*
Incipient stages				
Blind valley	Brkini[1] (Slovenia)	In contact karst	Widened blind val.	*Stream loss in cave*
Graben polje	Cinquemiglia[2] Abruzzo	Graben	Tectonic slopes	*Peat-bog*
Synclinal polje.	Caille[3] (Subalpine range AM) Caussols[3]	Synclinal -idem-	Fluvial erosion from the ponor	*Overflow by ponor obstruction*
Special cases		***Special evolution*** :		*Drain by*
Graben-polje	Rug[4] (Roudj) (Syria)	barred by lava flow	volcanic dam	*lateral ponors*
Active border (&	**peripheral) poljes**[3]			
(Graben) border polje	Duvno[5] (Bosnia)	Graben or synclinal with thick	Embayement in downstream side	*Seasonal overflow*
Peripheral & complex	Livno[6] (Bosnia)	no-carbonate rocks → *aquicludes.*	Erosion & corrosion levels	*Overflow, partly in piezometric level*
Border polje	Zafarraya[7] (Andalucia)	Contact of tectonic units by active transverse fault→ *id.*	Corrosion level Bottom filled by siliceous deposits	*Episodic overflow*
Active polje fully	**in carbonate rocks**	± *in*	***piezometric level***	**base-level poljes**[3]
Piedmont poljes	Zadlog[5-16] (Slov.) Grahovo[5] (Herceg.)	Any fault area in former glacial mout.	Thick morainic deposits	*Often swamp & peat-bog*
Plateau poljes	El-Hammam[9] Middle-AtlasCausses	Dolomitic faulted plateau→*aquitards*	Some corrosion levels	*Seasonal lakes « daias »*
Graben polje	Minde[10] (Portugal) Yammouné[11] (Lebanon)	½ graben breccia zone in active transverse f.	Old lake level Filled by thick deposits	*Seasonal lake* *Seasonal lake*
Anticlinal polje	Cerknica[12] (Slovenia) Imotski[13] (Croat.Bos.)	Anticlinal + active transverse fault. -idem-	Embayement in downstream side Corrosion level	*Overflow & local perennial lake* *-idem-*
Active poljes in	***complex system***			
	Nikšic[14] (Montenegro) Lassithi (Crete)	active overthrusts → *aquicludes* -idem- *aquiclude* ←	Embayments and hums Thick alluvial filling /impervious deposits	*Seasonal lakes* *Groundwater in alluvia*
Old valley	Popovo[15] (Hercegovina)	Old valley in tectonised area	«Lug» corrosion lev. Loam filling	*Seasonal overflow by Trebišnjica*
Paleopoljes	**with relict forms**		± *perched over*	*deep groundwater*
Open (border) polje	Upper Pivka[16] (Slov.) St Barnabé[17] (AM)	Fully in carbonate	Old corrosion plain partition → uvalas	*Temporary lakes*
monoclinal & faulted plateau	Larzac (Causses) L'Hospitalet[18] small polje of Larzac	rocks, sp.dolomites → *aquitards* along one fault	K. valleys & uvalas Old evolution under weathering deposits	*Ephemeral lakes* ***most perched :*** *over near reculée*
synclinal	Grand Canjuers[19] (Provence)	Large synclinal of thick carbonate serie	Rock-fans & *Rundkarren* fields	*over Verdon canyon paleo-ponor*

References- 1- MIHEVC 1994 ; 2- DEMANGEOT 1965 ; 3- JULIAN-NICOD 1986/89 ; 4- BESANÇON-GEYER 1995 ; 5 GAMS 1974/78 ; 6- HERAK 1972, ROGLIĆ 1974 ; 7- LHÉNAFF 1968 ; 9-MARTIN 1981 ; 10-CRISPIM 1995, NICOD 1996 ; 11- BESANÇON 1968 ; 12- GOSPODARIČ-HABIČ 1978, KRANJC 1985 ; 13- ROGLIĆ 1974 ; 14- HERAK, 1972, BONACCI 1992 ; 15- id. + MILANOVIĆ 1979 ; 16- HABIČ 1991 ; 17- JULIAN-NICOD 1989 ; 18- AMBERT 1990, BRUXELLES 2001 ; 19- NICOD 1998.

Tabl. 1: New tentative classification of some classical karst poljes, with comparison between Dinaric Karst and other Mediterranean and alpine countries.

These old forms proceed generally from a long evolution, largely pre-Pleistocene.

a) *The open polje* (or rather better *opened* after evolution as closed basin ?).
   They may have hydrogeological features, as the poljes in piezometric level :
   Example: the Upper Pivka valley, with the two variable-level lakes with the fluctuations of the water-table, and inherited corrosion surface and some *hums* (HABIČ 1991).
   The open polje of Alvados, near that classical one of Minde (Portugal), and on the same transverse fault, has only some inherited forms (CRISPIM 1995, NICOD 1996).

b) The paleo-poljes.
   - *Hydrology* :

- Generally, the paleo-poljes arise from the canyon cut and drastic lowering of the piezometric level, more often correlated to the regional uplift. They have only a residual hydrographic network (example of Grand Plan de Canjuers, near the Great Canyon of Verdon, in Subalpine Ranges in Provence). Their hydrological working is episodic (the surface runoff occurs only

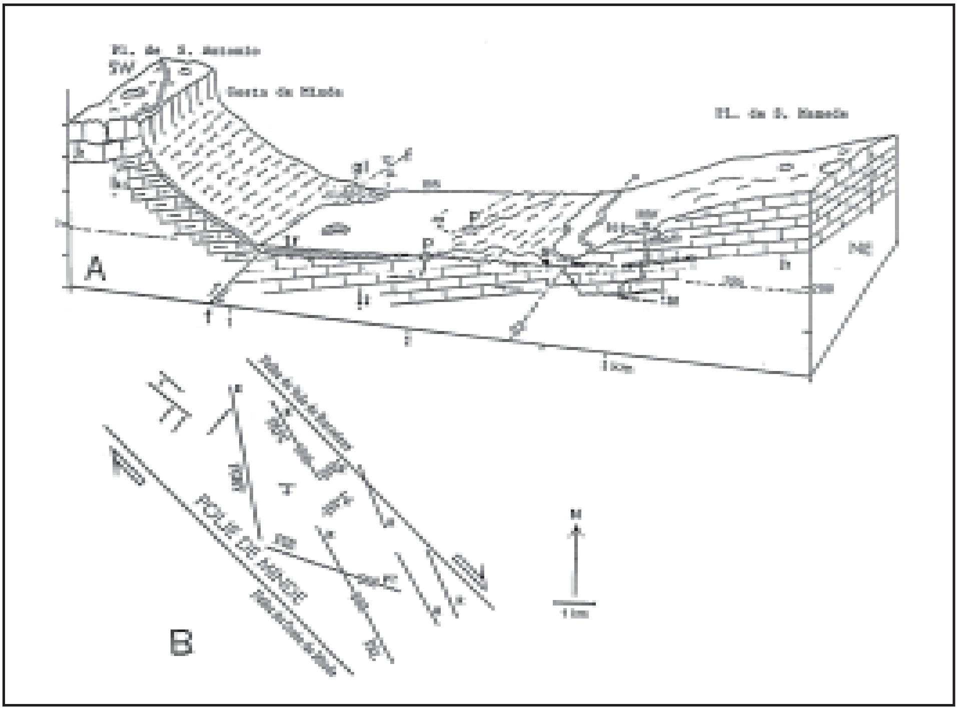

Fig.3: The structural polje of Minde (Middle Portugal).

A- Sketch from the documents of M.L. RODRIGUES 1995, FERREIRA et al., 1988, & J.A. CRISPIM,1993, 1995, in NICOD, 1996, fig.2.

Keys: l_{4-5}-Upper-Lias limestones , J_1- Bajocian massive limestones, J_2-Bathonian limestones, gl-scree (grčzes litées cone), p p'-ponors, s-Poio estavelle, MV-Monhos Velhos cave.

B- Fault system of NE slope of polje of Minde (from CRISPIM, 1995, fig.66).

R- Synthetic fault (Riedel), R'-antithetic fault.

from heavy rain). An other example is the paleo-polje of Elsarré, in the Arbailles Massif (Western Pyrenées), raised up the Bidouze *reculée* and its spring, according to the mountain uplift (VANARA 2000).

- However, in the dolomitic areas, the play of *aquitards* may give ephemeral lakes, as in the Causses of Larzac, by heavy rain. Likewise, but in limestones, on the high plateau of Ad't Abdi (> 2300 m, in the Central High Atlas), the little poljes, though disconnected from the main *aquiclude*, can offer some *daias* (ephemeral lakes), in spring with the snow melting (PERRITAZ 1995/96).

- *Paleeogeomorphology* :

The paleo-poljes preserve some characteristic forms, particularly the hums and the corrosion levels. The bottom changes with the *crypto-corrosion* in the contact of fersiallitic soils and and siliceous residues

A good example is the little polje of l'Hospitalet, in the Causse of Larzac : the three successive levels have proceeded from this process under the siliceous deposits, mainly flint clay (*cf.* BRUXELLES 2001/2002).

The crypto-corrosion gave back again possible the development of the old *rock-fans* and *Rundkarren* fields as those of the Grand Plan de Canjuers.

The paleo-poljes may been filled by deposits coming from the weathering on the slopes, according to morphoclimatic processes, particularly in periglacial phases. Now, the bottom changes slowly with the corrosion in the contact of fersiallitic soils that give back again possible the development of *Rundkarren* and dolines development from the suffosion processes.

BIBLIOGRAPHY

AMBERT P., 1990 - L'évolution géomorphologique des Grands Causses méridionaux depuis le Néogene ; *Z. Geomorph. N.F.*, Suppl. Bd. 77, p.1-24.

BESANÇON J., 1968 - Le poljé de Yammouné; *Hannon*, Beyrouth,, III, p.1-62.

BESANÇON J. et GEYER P. 1995 - Le Rüg (Syrie du N) ; *SYRIA* (Paris) LXXII, 3-4, p.307-354 + 3 cartes h.t.

BLANC A., 1958 - Répertoire des études sur le relief karstique en Yougoslavie depuis J. Cvijić ; *Mém. et Doc. CNRS*, Paris, VI*,* p.135-227.

BONACCI O., 1992- Karst Hydrology...; Springer Verlag, Berlin-Heidelberg, 184 p.

BRUXELLES L., 2001 - Reconstitution morphologique du Causse du Larzac, rôle des formations superficielles dans la morphogenèse karstique ; *Karstologia,* 38, p.25-40.

CRISPIM J.A., 1995 - Dinamica carsica e implicaçoes ambiantais nas depressoes de Alvados e Minde ; Th. Dept. Geologia, Lisboa, 394 p.

DELANNOY J. J., 1997 - Recherches géomorphologiques sur les massifs karstiques du Vercors et de la transversale de Ronda (Andalousie). Les apports morphologiques. Th. Grenoble 1, 678 p.

DEMANGEOT J., 1965- Géomorphologie des Abruzzes adriatiques, *Memoires et Documents du CNRS,* Paris.

DUFAURE J.J., 1984 - Modelés quaternaires et ensembles lithologiques, *in « La mobilité des paysages méditerranéens ; Rev. géog. Pyrénées et SO,*Toulouse, Trav. II, chap. VIII.

FORD D. & WILLIAMS P., 1989 - Karst Geomorphology & Hydrology, Unwin Hyman, London, 601 p.

GAMS I., 1974 - *Kras* ; Slovenska Matica, Ljubljana, 359 p.

GAMS I., 1978 - The polje : The problem of definition ; *Z. Geomorph. N.F.*, 22-2, p.170-181.

GOSPODARIČ R. & HABIČ P., 1978 - Karst phenomena of Cerkniško polje, *Acta carsologica*, Ljubljana, VIII-1, 156 p.

GÜLDALI N., 1970 - Karstmorphologische Studien im Gebiet des Poljesystem von Kestel (W Taurus, Turkey) ; *Tűbinger geog. Studien*, 104 p.

HABIČ P., 1991 - Geomorphologic classification of NW Dinaric Karst ; *Acta carsologica* XX, p.135-164.

HERAK M., 1972 - Karst of Yugoslavia ; *in* HERAK & STRINGFIELD » *Karst, important karst regions of Northern Hemisphere »*, Elsevier, Amsterdam, chap.2

JULIAN M. et NICOD J., 1986 - La région karstique Audibergue-Mons ; *Z. Geomorph. N.F.* Suppl. Bd. 59, p.1-25.

JULIAN M. et NICOD J., 1989 - Les karsts des Alpes du Sud et de la Provence ; *Z. Geomorph. N.F.* Suppl. Bd. 75, p.1-48.

KRANJC A., 1985- The lake of Cerknica and its flood ; *Geografski zbornik,* Ljubljana, XXV-2, p. 75-123.

LEHMANN H., 1959 - Studien über Poljen in den venezianischen Voralpen und in Hochapennin ; *Erdkunde*, Bonn, Bd. XIII, p.258-289.

LHÉNAFF R., 1968 - Le poljé de Zafarraya (Province de Grenade) ; *Mélanges de la Casa Velazquez*, Madrid, IV, p.5-25 + carte h.t.

MARTIN J., 1981 - Le Moyen-Atlas Central, étude géomorphologique ; Service géologique du Maroc (Rabat) 445 p. + cartes h.t. (sp. Causse d'El -Hammam).

MIHEVC A., 1994 - Brkini contact karst ; *Acta carsologica* XXIII, p.99-108.

NICOD J., 1967 - Les poljés karstiques de Provence, comparaison avec les poljés dinariques ; *Méditerranée, Etudes et Travaux* I, p. 53-75.

NICOD J., 1978- Les eaux et l'aménagement des poljés du karst dinarique ; *Méditerranée*, 1-2,p.85-103.

NICOD J. ,1992 - Formes d'aplanissement et de régularisation des versants dans les roches carbonatées...; *Tübinger geog. Studien*, 109, p.1-22.

NICOD J., 1996 - Le poljé de Minde (Portugal central) type de poljé tectonique *; Rev. Analyse Spatiale Quantitative et Appliquée*, Nice, n° 38/39, P.143-151.

NICOD J., 1998 - Paléomorphologies et morphogenčse récente/actuelle sur les massifs au N du Grand Canyon du Verdon ; *Etudes de Géog. physique, Suppl.Travaux n° XXVI,* p.17-30 +carte h.t.

PERRITAZ L., 1995 - Contribution ŕ l'étude géomorphologique et et hydrogéologique d'un karst perché en domaine méditerranéen : le plateau des Ad't Abdi (Haut Atlas) ; Th. Fribourg (CH), 178 p. + cartes h.t.

PERRITAZ L., 1996 – Le « karst en vagues »des Ad't Abdi »(Haut Atlas central) ; *Karstologia* 28-2, p. 1-12.

ROGLIĆ J. 1972 - Historical review of geomorphic concepts, *in* HERAK & STRINGFIELD « *Karst, important karst regions of Northern Hemisphere* », Elsevier, Amsterdam, chap.1.

ROGLIĆ J., 1974 - Les caractčres spécifiques du karst dinarique; *Mém. et Doc. CNRS, Phénomenes karstique II* p.269-278.

SAURO U., 2001 - Aspects of contact karst in the Venetian Fore-Alps ; *Acta carsologica* , 30-2, p. 89-102.

SWEETING M.M, 1972 - Karst landforms, Macmillan, London, 362 p. (chap. 10).

VANARA N., 2000 - Le karst des Arbailles; *Karstologia*, 36, p. 23-42.