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ASPECTS OF CONTACT KARST IN THE VENETIAN FORE-ALPS

PRIMERI KONTAKTNEGA KRASA V BENEŠKIH PREDALPAH

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Ugo Sauro: Primeri kontaktnega krasa v Beneških Predalpah

V Beneških Predalpah je veliko primerov kontaktnega krasa. Da bi bilo mogoče prikazati nekaj tipičnih primerov, je treba določiti vsebino kontaktnega krasa, tako v ožjem kot v širšem pomenu. V ožjem pomenu vsebuje kontaktni kras pojave in oblike, na katere vpliva stik med zakraselimi in nezakraselimi kamninami. V širšem pomenu pa je kontaktni kras tudi kras na stiku zakraselih kamnin, ki imajo različne značilnosti, npr. kemično sestavo, poroznost in gostoto razpok, itd. Po tej tipologiji je kontaktni kras lahko stratigrafski, tektonski ali sedimentni. Prispevek prikazuje nekaj tipičnih primerov.
Ključne besede: kraška geomorfologija, kontaktni kras, Beneške Predalpe, Italija.

Abstract UDC: 551.44(234.3)(450)

Ugo Sauro: Aspects of contact karst in the Venetian Fore-Alps

In the Venetian Fore-Alps there is a wide range of situations of contact karst. To illustrate some of the more typical situations it is necessary to define the concept of contact karst, which may be considered both in a strict and in a wide sense. In a strict sense we consider, as contact karst, the karst phenomena and forms influenced by the contact between a karstifiable rock and a non-karstifiable rock. In a wide sense also the karst phenomena and forms influenced by the contact between two karstifiable rocks different in some characters, as chemical composition, porosity and fracture density, etc., are cases of contact karst. The types of contact may be stratigraphic, tectonic, and sedimentary. In the contribution, some typical examples are presented.
Key words: karst geomorphology, contact karst, Venetian Fore-Alps, Italy.

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EXAMPLES OF STRICT SENSE CONTACT KARST

Between the many cases of strict sense contact karst (Fig. 1), only some of the most remarkable are illustrated:

- a type of not well-expressed pocket valley in the marly limestone very near to the contact of marly limestones and intrusive rocks of the Euganean hills (Fig. 2); the springs at the head of the valleys are mostly temporary and are fed by the aquifers hosted inside the subvolcanic bodies of laccolith type; an important spring has been captured since from Roman time to fed the roman aqueduct of Este;

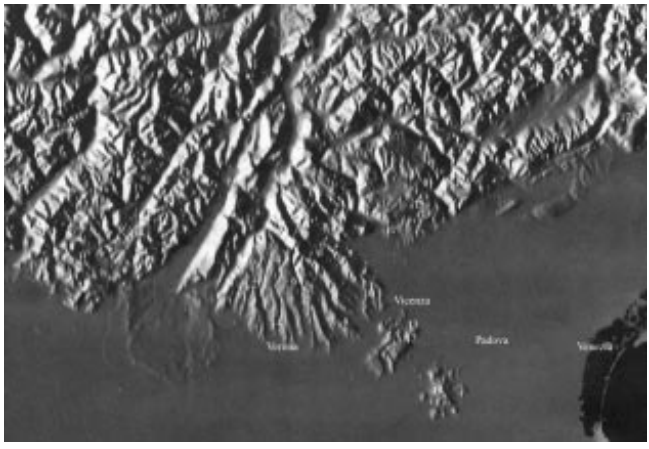

Fig. 1: In the d.e.m. of the Veneto region (from Reichenbach et alii, 1992) are located some of the localities cited in the paper: 1) San Rocco di Valpolicella, 2) natural bridge of Veja, 3) Scol Basin and Abisso dei Lesi, 4) Laorno Basin, 5) Grotta dell'Arena, 6) Covoli di Velo, 7) Montorio spring, 8) Agugliana basin, 9) Grotta della Rana, 10) Valdimolino and Val d' Onte, 11) Sarcedo hills, 12) Grotta della Guerra, 13) dolina di S. Rocco, 14) Monte Vendevolo in the Euganean hills, 15) southern part of Sette Comuni plateau, 16) Grappa massif, 17) Piano del Cansiglio polje.

Fig. 2: Monte Vendevolo in the Euganean hills is an example of a dome-like morphostructure, made up by an intrusive magmatic body (pattern) surrounded by marly limestones. Very near to the contact intrusive rocks limestones, springs and not well-expressed pocket valleys, called "calti" are frequent. The aquifers, hosted inside the bodies of laccolith type, feed the springs (the sides of the squares correspond to 1 km; the sector is part of the Topographical Map of Italy at the scale 1:25.000, 64 IV NO, Lozzo Atestino, of the Italian Military Geographical Institute).

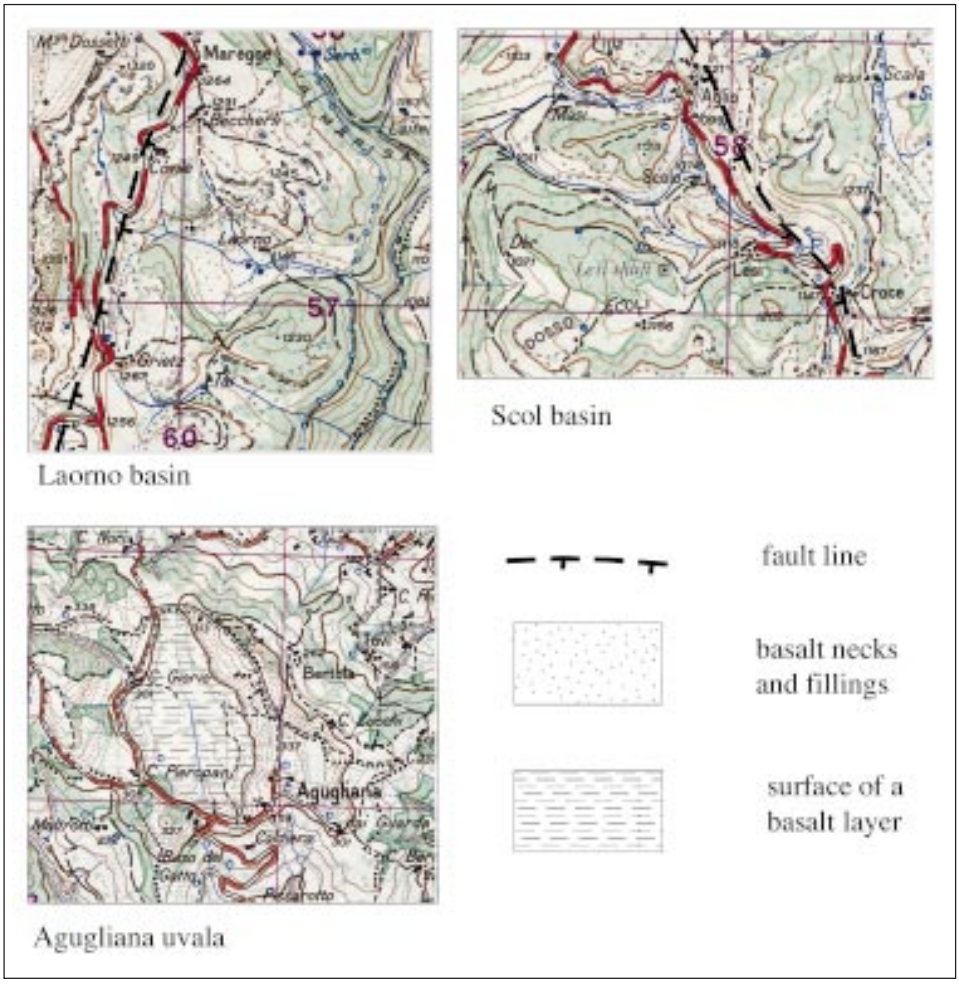

Fig. 3: The open basins of Laorno and Scol in the central Lessini Mountains have developed along fault line scarps in correspondence with basaltic dikes and chimneys. Some caves have developed in the surrounding limestones, probably fed by the aquifers hosted in the volcanic rocks (the sides of the squares correspond to 1 km; the sectors are part of the Topographical Map of Italy at the scale 1:25.000, 49 IV NO, Bosco Chiesanuova, of the Italian Military Geographical Institute).
The lower map shows the uvala of Avigliana in eastern Lessini. The floor of the basin is made up by basalt and the surrounding slopes by limestones; a cave drains the depression (the sides of the squares correspond to 1 km; the sector is part of the Topographical Map of Italy at the scale 1:25.000, 49 II NE, Montebello Vicentino, of the Italian Military Geographical Institute).

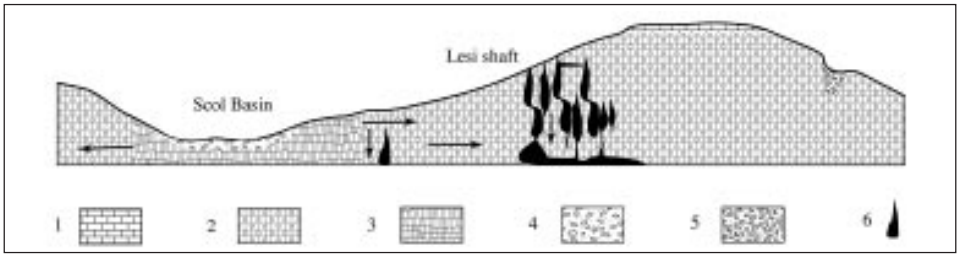

Fig. 4: Schematic profile of the Scol basin with the underground system of Abisso dei Lesi. This complex system, made up of many interconnected ogival shaped cavities, was probably fed by the aquifer hosted inside the volcanic body.

- some open hollow in the central Lessini developed along fault lines scarps elongated mostly N-S and NNE-SSW; these fault planes firstly formed during the Jurassic by strain tectonic; during the Paleogene some of these structures were interested by the ascent of basaltic magmas with development of dikes and chimneys; during the Neogene many structures have been reactivated by the compressive tectonic of the Alpine orogenesis; at present old magmatic bodies are exhumed by erosion and accumulated at the bottom of the hollows that host suspended aquifers and whose bottoms enlarge by contact karst with development of contact caves; examples of hollows of this type are the Scol basin, the Laorno basin near Bosco Chiesanuova (central Lessini Mountains) (Fig. 3); on the slope of Scol basin is located the entrance of Abisso dei Lesi, one of the most interesting cave system of Lessini mountains (Rossi & Sauro, 1977) (Fig. 4);
- some dolines and uvalas in eastern Lessini as the Agugliana depression, a basin about 800 m long with a nearly flat bottom developed at the contact limestone-basalt; a cave drains the depression southwards (Fig. 3) (Gleria & Zampieri, 1978; Mietto and Sauro, 1989, 2000);
- some cave systems have developed near or at the contact volcanic rock of basalt type and overlying limestones; some lava tabulates of lower Eocene have been covered by formations of marine carbonates and later crossed by later explosive volcanic chimneys during upper Oligocene and lower Miocene; the best example of contact cave is that of Grotta della Rana (Figs. 5, 6), a cave system more than 20 km long near Monte di Malo, western Lessini, where the tunnels of the the lower level develop at or near to the interface basalt-limestone (Allegranzi et alii, 1960; Gleria & Zampieri, 1978; Gleria, 1982); the development of the cave has been probably favoured by the presence of explosive type necks crossing both the volcanic and carbonate formations and acting as water reservoirs feeding the underground system; one other similar cave is Grotta della Poscola (Bartolomei, 1957);
- one small cave near S. Rocco di Valpolicella (western Lessini) develops at the contact hyaloclastitic magmas-limestone;
- some active caves in the Sarcedo hills NE of Vicenza, where also some blind valleys and dolines are controlled by the contact paleogene basalt-limestones;
- some dolines in the Berici hills, developed near a volcanic chimney; the best example is that of “dolina di San Rocco” NE of Villabalzana not far from Vicenza; this is a very large doline containing thick fillings of aeolian quartzitic sands of Neogene age (Bartolomei, 1958);

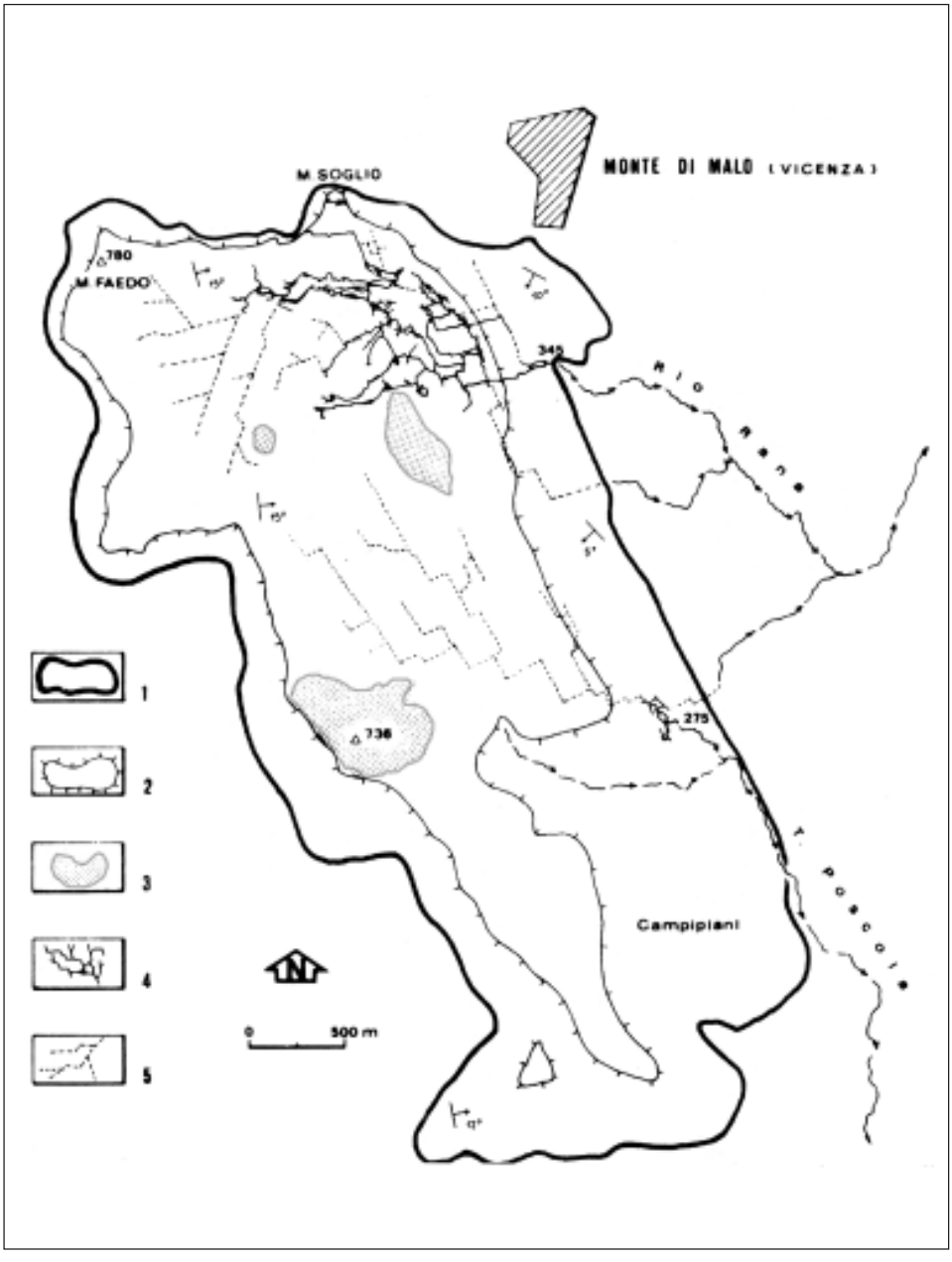

Fig. 5: Sketch of the Monte Casaron plateau in the eastern Lessini Mountains (from Gleria, 1982, modified). Legend: 1) boundary of the reef limestone karstifiable formation, 2) edges of the limestone plateau, 3) explosive volcanic chimneys, 4) cave networks, 5) presumed development of the underground networks.

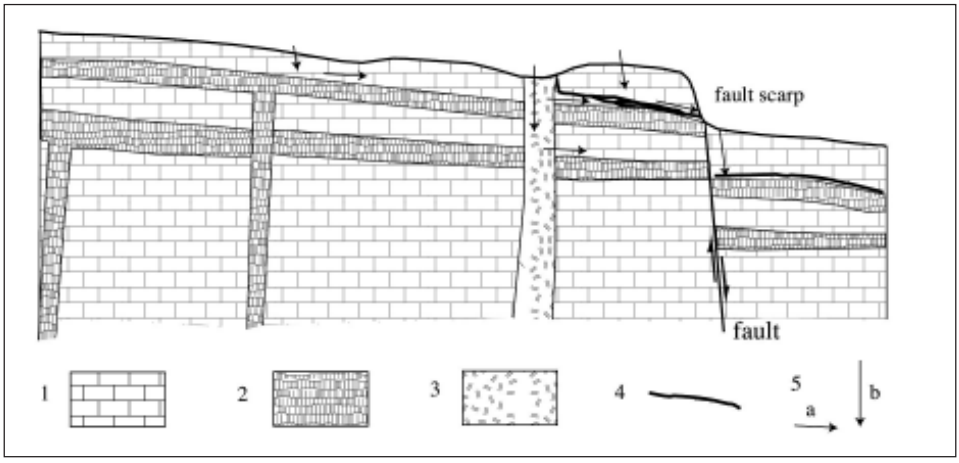

Fig. 6: Schematic profile of the morphostructural setting of the M. Casaron area (eastern Lessini Mt.). Legend: 1) limestone, 2) low permeability basalt type magmas, 3) lava breccia chimney, 4) cave system developed near or at the contact volcanic rock of basalt type and overlying limestones, 5) sub-horizontal and vertical circulation inside both the carbonatic formations and the volcanic structures.

Fig. 7: A karst conduit in the Covoli di Velo cave system (Lessini Mountains) filled by basalt magma. This cave system developed starting from a paleokarstic network fossilized by volcanic magmas. The solutions circulating at the interface magma-limestone caused both the weathering of the fillings and the solution of the limestones.

- some caves systems developed starting from paleokarstic networks fossilized by volcanic magmas and others sediments; the solutions circulating at the interface filling materials-limestone caused both the weathering of the fillings and the solution of the limestones; the solution has been certainly aided by the ions released by the not karstifiable rocks; important systems of this type are some caves of the Veja natural arch system (western Lessini Mt.), the cave system of Covoli di Velo in the central Lessini Mt. (Fig. 7) (Rossi and Zorzin, 1989, 1991) the Grotta della Guerra system in the Berici Hill (Fig. 8) (Dal Molin, Mietto and Sauro, 2000); the first speleogenetical stages of these caves have been probably determined by the circulation of hydrothermal waters during the volcanic episodes; after that, most voids were filled by magmas; the second speleogenetical phase occurred during Neogene and Quaternary.

Fig. 8: A blind hole in the walls of a gallery in the Grotta della Guerra cave (Berici Mountains). A residual part of the fillings of magmas is still present and documents that the first speleogenetical phase of the system occurred, probably in a hydrothermal environment, before the last volcanic activities.

EXAMPLES OF WIDE SENSE CONTACT KARST

Between the many cases of wide sense contact karst, only some of the most remarkable are illustrated:

- in the western groups of the Venetian Fore-Alps, the both stratigraphic and tectonic contacts between Biancone (middle and lower Cretaceous marly limestone similar to the Chalk of the Parish basin) and the Jurassic limestones are marked by high densities of karst features as dolines and shafts, and sometimes also by parts of large karst systems; this density is explain-

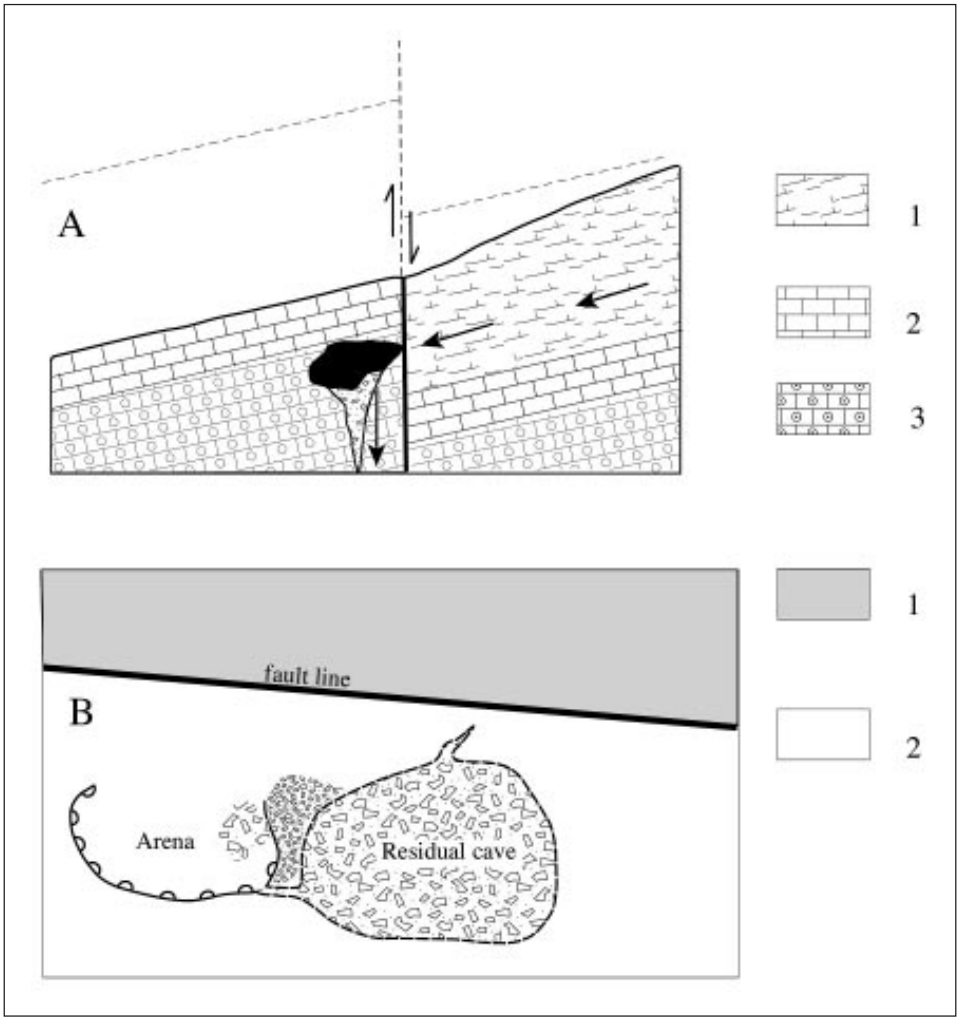

Fig. 9: This schematic profile shows the development of Grotta dell'Arena in the Alti Lessini Mt. (A), a cave developed near to the contact by fault between Biancone and the Jurassic limestones. The water lost by the hanging aquifers of Biancone towards the nearby jurassic limestones has caused the development of the cave [legend: 1) Biancone, 2) Rosso Ammonitico, 3) Oolitic and biosparitic limestones]. In the present situation, illustrated in the map (B), part of the cave collapsed with development of an open depression (arena) [legend: 1) Biancone, 2) Jurassic limestones] (modified from Sauro 1974).

able with the hanging aquifers hosted inside the dense network of fractures of Biancone, that lose water towards the nearby limestones; some typical examples are illustrated in Sauro (1973, 1974); here only the case of Grotta dell'Arena in the Alti Lessini Mt. is discussed, one of the most important karst biotopes of the Alps: this cave is developed in the jurassic limestones very near to a tectonic contact by fault with Biancone (Fig. 9); the water circulation fed laterally by the hanging aquifer of Biancone is responsible both to the speleogenesis of the cave and to the peculiar environment characterized by a very interesting fauna of invertebrates (Caoduro, Osella & Ruffo, 1994; Caoduro & Ruffo, 1998);

- a well known example of contact karst of the Venetian Fore-Alps is that of Piano del Cansiglio polje basin in the Cansiglio-Cavallo mountain group (Fig. 10), described by Lehmann (1959), Castiglioni (1960, 1964), Fuchs (1969), De Nardi (1976) and Mietto & Sauro (1989, 2000); the Piano del Cansiglio polje basin is developed inside a tectonic depression, an asymmetric syncline crossed by some faults; the western side and part of the bottom of the basin are constituted by the feebly karstifiable marly limestone called "Scaglia Cinerea" deposited dur-

Fig. 10: Map of the Piano del Cansiglio polje basin in the Cansiglio-Cavallo mountain group (after Castiglioni, 1960). The western side and part of the bottom of the basin are formed by the feebly karstifiable marly limestone called "Scaglia Cinerea", while most of the bottom, the western slope and the plateaus encircling the basin are mainly in reef limestones of early and middle Cretaceous (Calcare di Monte Cavallo). Consequently Lehmann described this inactive polje as a "Gesteingrenzenpolje" (polje of lithological contact, a kind of "borderpolje").

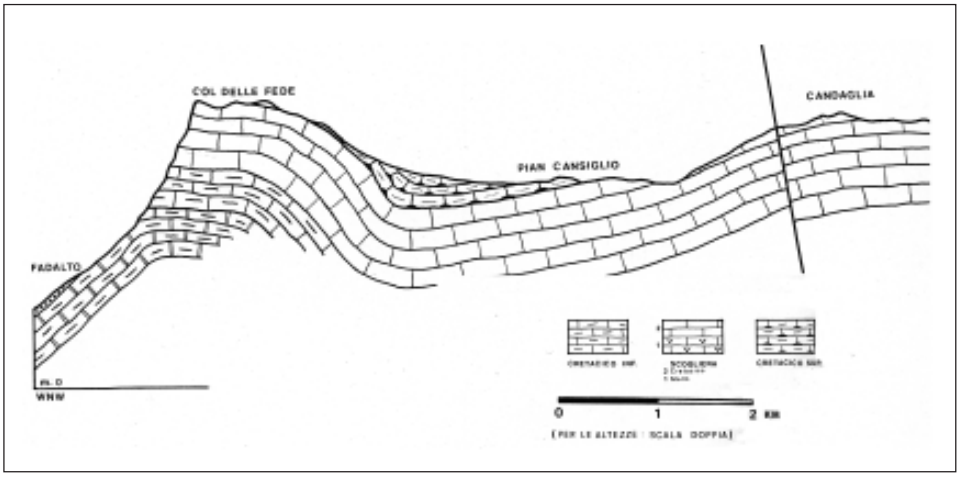

Fig. 11: Schematic geological profile of the Piano del Cansiglio basin showing the upper Cretaceous and lover Eocene marly limestones at the core of the syncline, overlying the reef limestones, where the karst forms are very well expressed (after De Nardi 1976).

ing late Cretaceous and, while most of the bottom, the western slope and the plateaus encircling the basin are mainly in reef limestones of early and middle Cretaceous (Fig. 11) (Calcare di Monte Cavallo), so, here two different landscapes and geomorphological environments meet: a fluviokarstic landscape on the western side and typical karst landscapes on the eastern side; for this reason Lehmann described this inactive polje as a "Gesteingrenzenpolje" (polje of lithological contact, a kind on "borderpolje"); in the zone are recognisable forms as not well expressed rocky cones, pediments, rocky terraces, planation surfaces.

SOME OTHER PECULIAR ASPECTS OF CONTACT

Some landforms impressed on areas of the karst plateaux of the Venetian Fore-Alps are the result of a long geomorphological history. Characteristic is the exhumation of the cretaceous and jurassic limestones from a cover of not or feebly karstifiable formations of tertiary age (Castiglioni et alii, 1988); a hydrographic network developed in the cover rocks is often inherited by the limestone surface and is interested by a progressive karstification with development of dry valleys. Nice examples of this type of evolution are recognizable in the southern part of Sette Comuni plateau and in the Grappa massif. This type of karst may be better defined a "transitional karst" more than a "contact karst".

Some plateaux, as that of the Berici hills, are the result of the uplifting of a planation surface in limestones covered by old continental loose deposits of different types: alluvial, sheet-flood, eolian. The cover deposits have favoured the development of a fluvial network later inherited by the limestones; in some uvalas and dolines developed inside the valley bottoms the presence of thick fillings made up of clastic fine sediments sometimes favours the flooding of the bottoms.

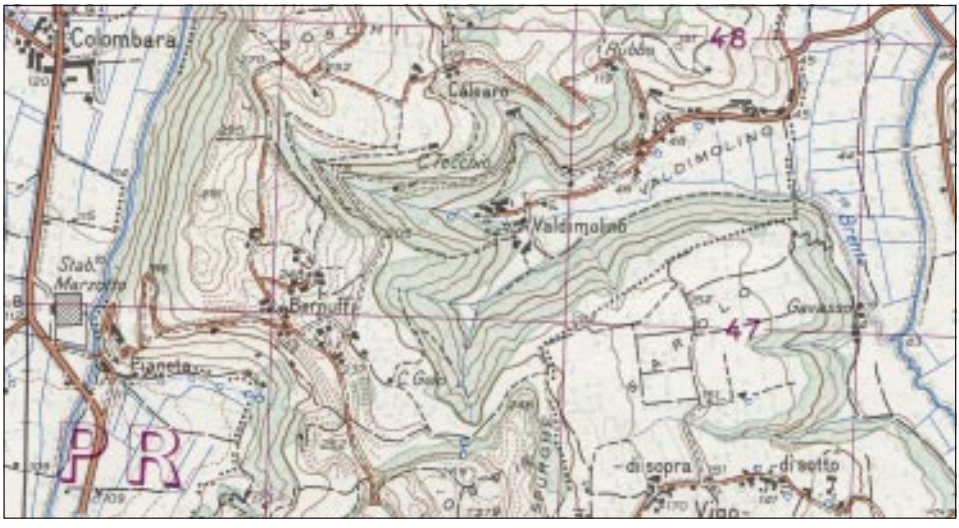

Fig. 12: The aquifer in the alluvial deposit of the bottom of Valdagno (left side) loses water across the ridge feeding the karst spring of the pocket valley of Valdimolino a tributary of Val d'Onte (right side) (Lessini Mt.) (the sides of the squares correspond to 1 km; the sector is part of the Topographical Map of Italy at the scale 1:25.000, 49 I SE, Arzignano, of the Italian Military Geographical Institute).

At the foot of the southern scarps of some fore-alpine groups, as Prealpi Bellunesi, Monte Grappa and Sette Comuni Plateau, dissected pediments exist cutting a homoclinal sequence of tertiary formations and covered discontinuously by deposits of different types. Here, it is possible to recognize many contact forms as elongated dolines and shallow holes.

The contacts between the filling deposits of some valleys of the Fore-Alps and the partly buried slopes in limestone have induced speleogenesis inside the ridges between the parallel valleys; two nice examples are recognizable in the lower Val d'Illasi and the parallel Val di Cazzano and in Valdagno and the parallel Val d'Onte (Lessini Mt.); because of the thick alluvial fillings, the bottoms of the Val d'Illasi and Valdagno are 60-80 m higher that those of the sub-parallel valleys nearby; important karst springs in the lower valleys are fed across the ridges by the alluvial aquifers of the main valleys; in particular on the left slope of Valdagno some contact forms are recognisable and in the right slope of the nearby valley a kind of pocket valley has developed (Valdimolino) (Fig. 12) (Antonelli and Ceccarelli, 1975); in the past this spring has been utilised to feed some mills; now the lowering of the water table in the main valley, caused by human impact, have caused the drying of the spring.

CONCLUDING REMARKS

The large variety of aspects of contact karst of the Venetian Fore-alps are known only for some features. Many situations of contacts between magmatic bodies and limestone have not jet

been carefully investigated. It is not clear, for example, why some volcanic bodies behave as resistant masses giving rise to hills of selective erosion like the "purghe" (form "Burg") of Lessini Mt., while others favours the development of depressions. Probably the ages and the structures of the two types of bodies are different, mostly constituted by massive basalt the first and by volcanic breccias the second. There is the necessity of further geological, geomorphological, and hydrogeological investigation, important also because the volcanic structures host aquifers.

Worthy of note also are both the stratigraphic and tectonic impact Biancone - Jurassic limestone formations. The chalk-like "Biancone" marly limestone represents both a filter rock and an important hanging aquifer loosing slowly water towards the close well karstified jurassic limestones. After two months without precipitation and snow melting in the mountain basin, the discharge of the base level springs of the Lessini Mt. (Montorio in the lower Vajo di Squaranto) was of about 2 m^3/s (about 15 $l/s\ km^2$). The average discharge of the same springs is estimated to about 4,5 m^3/s (Sorbini, 1993). So the amount of water crossing the interface Biancone - jurassic formation represents certainly a high percent age of the total karst water circulating in the massif.

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PRIMERI KONTAKTNEGA KRASA V BENEŠKIH PREDALPAH

Povzetek

Zelo različen kontaktni kras Beneških Predalp je znan samo po nekaterih oblikah. Številni stiki med magmatskimi kamninami in apnencem še niso bili skrbno preučeni. Ni jasno, zakaj so nekatera vulkanska telesa odporne gmote, iz katerih zaradi selektivne erozije nastanejo griči, kot so "purghe" (iz "burg") na planoti Lessini, medtem ko na drugih nastanejo depresije. Vzrok je najbrž v različni starosti in sestavi obeh teles: prvo je iz masivnega bazalta in drugo iz vulkanske breče. Potrebne so še nadaljnje geološke, geomorfološke in hidrološke raziskave, pomembne zaradi tega, ker so v vulkanskih strukturah tudi vodonosniki.

Vredno je opozoriti tudi na stratigrafski in tektonski vpliv, ki ga ima "Biancone" na jurske apnence. "Biancone", kredasti lapornati apnenec predstavlja tako filter kot tudi pomemben obviseli vodonosnik, iz katerega se voda počasi izgublja v bližnji dobro zakraseli jurski apnenec. Po dveh mesecih brez padavin ali talečega se snega v gorskem zaledju, je imel glavni izvir v vznožju planote Lessini (Montorio v spodnjem delu Vajo di Squaranto) okoli $2 m^3/s$ pretoka (okoli 15 $l/s\ km^2$). Povprečni pretok tega izvira je okoli 4,5 m^3/s (Sorbini 1993). Torej predstavlja količini vode, ki prečka stik "Biancone" - jurski apnenec, velik delež celotne kraške vode, ki kroži v pogorju.