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[New Observations on Karstic, Parakarstic and Pseudokarstic Phenomena]
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**Page 166, para 2 & 3....**

In a note of mine from ten years ago (Anelli 1963) I had occasion to record the first revolutionary exhortations to Italian speleologists by the late Maestro Prof. Michele Gortani (Gortani 1933, 1937) with the aim of establishing clear premises in the classification of karstic processes in tune with the geololithological nature of the terrain, but principally with the solubility of the rocks keeping in mind the original prekarstic morphology of the rocky massifs, past climatic conditions, and oscillations in the level of the orogenetic and eustatico-glacial ground.

Starting from the above considerations, I proposed to my fellow scientists to keep quite distinct the phenomena specifically named karstic, both from karstic phenomena that are less developed, less typical, for which I have proposed the term *parakarstic phenomena*, and above all from phenomena that have in common with karstism only a more or less strong analogy in the external morphological characters; it being a question of processes in which chemical alteration prescinds [*sic*] from the solvent action of rain waters, I have judged it opportune to unite them in a separate group from the two preceding ones and to indicate them by the more appropriate term of *pseudokarstic phenomena*, already noted to the speleologists.
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**Page 170, para 2 to p.176, para 4. ...**

PARAKARSTIC PHENOMENA

Besides the phenomena recorded in the preceding chapter, having conspicuous morphological characteristics, which can be observed in the most important karst areas of our homeland, the object of study with a lot of dedicated exploration through extensively developed subterranean passages and considerable differences in depth not always easily traversed, also worthy of our attention and of careful study are some modest manifestations of the karst phenomenon which assume no common speleogenetic importance through the particular conditions in which they have originated and subsequently developed.

We are talking here, we should specify, of manifestations that do not arise by the description familiar to speleologists but which have come about in the past and come about still today in rocky complexes less typical than calcareous ones, with a lower grade of solubility than pure calcite, in rocks which Gortani (1937) has indicated by the term *semikarstic rocks* or weakly karstic. Faced with phenomena observed in the Murge and the Salento in Puglia represented by poorly marked karst forms in arenaceous, sometimes clayey, limestones, *the tuffs of the Murge* (Valduga, 1965), I have judged it opportune to suggest a new term, that of *parakarstic phenomena*, which seemed to me better suited to indicate, even in the literary meaning of the word, karstic forms that are attenuated with respect to those typical of limestone; that is, faced, as I have already said, with forms which have the same general characters as those typical of limestone, but which have a more reduced development, sometimes extremely reduced through the briefest duration of the karstic cycle occurring in geolithological complexes of limited potential, of more recent age such as the Miocene limestones of the Solento, most notably *pietra leccese* and the Murge tuffs deposited on Cretaceous limestones essentially neriticised by the Quaternary ingression of marine action on the surface, successively reduced to isolated plates and to littoral borders of exogenous erosion; not forgetting thin phreatic layers in the calcarenites of Puglia (Azzaroli et al 1968) which sometimes feed spontaneous water springs, known locally as *marane*. Rare karst phenomena can also be observed in the Quaternary benches of coarse breakdowns with calcite cement that are seen along the old coastal shores of Puglia.

The term Parakarstic Phenomena, which I have introduced to indicate the recorded manifestations, corresponds in a certain sense to the terms *semikarst areas* [**footnote:** The Italian term *semikarstic areas* is in concordance with that of *HalbKarst* proposed by Grund 1914], *second-rate karst areas*, or *less developed karsticity* all suggested by Gortani 1937 underlining their importance deriving from the general morphological lineaments which clearly illuminate, as I have already revealed (Anello 1963), the genetic aspects of karst, for example:

1 – the formation of thin phreatic water layers which are not deep and which feed resurgences at the bottom of depressions in their own karst;

2 – the formation, sometimes very rapid, of dolines and subterranean cavities by suberosion, followed by a progressive and no less rapid enlargement of the cavities by internal breakdown;

3 – the consequent accumulation of deposits of fill, quite often important in containing faunal fossil remains, which give evidence of local phyto-climatic conditions in the past.

In my note cited above (Anelli 1963) I have judged it opportune to include within parakarstic phenomena manifestations of solvent and erosive actions of rain water on arenaceous rocks with calcareous or siliceous cement, on dolomitic limestones limited, these last, to superficial or deep forms of little extent, excluding of course karst areas of the extensive Pre-Cretaceous calcareo-dolomitic masses such as those of any zone of the Karst (and I refer in particular to the spacious subterranean cavities of the Cavern of Planina confluent with the system of the Caves of Postojna.)

In a careful study of karst and parakarst phenomena of Venezia (Giulia and Friuli) D'Ambrosi & Forti 1967, agreeing with my proposed term of parakarstic phenomena, recognised the discriminatory value of this term to indicate the alterations that develop in less soluble carbonatic rocks and in many sandstones which appear – these are the authors' words – as phenomena that are attenuated, atypical and yet diverse, recognizable in some impure carbonate rocks, with irregular stratifications, comminuted fractures, of northern and south-western Istria, in the Karst of Buie, near Trieste (in the calcareous series of the Paleocene and Eocene), in the calcareous conglomerates of the Eocene Flysch near Pisino in Istria, in the locality of Draga S. Elia in Eocene sandstones over Paleocene limestones. In Friuli the authors have recorded caverns in the limestones of the basin of Sappada and in the Veneto in formations analogous to the mouth of the Val Visdende.

Even for parakarstic phenomena the beginning is always, at the outset of the karstic genetic cycle, by a subterranean circulation through slender passages, minute fractures, channels with the tiniest cross-section along diaclases or stratification junctions.

From a cursory study of the hydromorphic profiles of subterranean cavities it is easy to recognise the prevalence sometimes of mechanical erosion (marmites of evorsion and [efforation]), sometimes of chemical alteration, of solution attested by the clayey and sandy deposits left by the water along the paths of subterranean flow in arenaceous rocks cemented with calcite. In Italy we recall the modestly developed karst phenomena of the calcareous sandstones of the Appennino Emiliano brought to notice in 1943 by the late Malavolti.

In my note (1963) in which I opened the discussion about classification and terminology of subterranean and superficial karst forms, I included within the specific type of parakarstic phenomena also those of sandstone terrain with siliceous cement for which Renault 1953 has introduced the terms: *sandstone karst, sandstone lapies, sandstone caves, caves of the Inselberg gara, cliff caves* [all these terms are in French]; the terms associated with caves refer to natural holes in the walls of a rocky spur, a Cambrian-Silurian sandstone Inselberg with siliceous cement in the Tassili of In Guezzam in Algerian Hoggar (southern Sahara). The holes in the cliffs are excavated in poorly cemented sandstones, lying below a stratum of quartzites that have not been altered by erosion; some of the caves contain little basins of water fed from strong external precipitation via short natural passages and from [subalveal = sub-channel?] water from a circulating reservoir basin. One cave, excavated entirely in the siliceously cemented sandstones, has the typical Gothic cross-section which recalls the karst cavities of calcareous terrain, but it is barely 2.6 m high and less than 4 m long; small siliceous stalactites hang from the roof.

Renault (1953) observed that their origin and development are analogous to those of cavities in dolomite terrains and in sandstones with calcareous cementing. The caves in the Saharan sandstones recall, in their structure, typical diaclastic karst caves in which distinct fracturing of the calcareous masses has had a major part in their genesis and development by the enlargement of internal gaps following breakdowns along the walls and detachments from the ceilings. The same causes have evidently determined the accumulation of impressive cones of breakdown inside.

What significance can be attached to the terms sandstone karst, sandstone lapies, sandstone caves and cliff caves? [all these terms are in French]. The author [Renault?] believes that these terms deserve to be preserved even though it makes them a group apart; through the particular geolithological nature of the rocky edifice the phenomena recorded – similar, as I have recorded above, to those of calcite-cemented sandstones – can of course be included within parakarstic phenomena.

Natural subterranean cavities in Triassic quartz sandstones, weakly cemented and traversed by ferriferous veins, have been noted by Sommaruga 1949 in the *Cave of the Galleries* (2001 Lo) in Valganna in the north of Varese. The sandstone stratum, about forty metres thick, is delimited beneath by Permian porphyry and above by dolomitic limestones of Anisico (mid Trias).

Inside the cavities one finds slender stalagmitic dripstones a few centimetres thick on the floor and aragonite shawls with coralloid efflorescences on the walls and under the roof. The origin of the natural cavities, which don't present particular morphological characteristics, is attributed by Sommaruga to erosive hydrodynamic actions favoured by extensive fracturing and by faulting, not excluding however the possibility of solvent action by water on the calcareous cement of the quartz sandstone.

It's worth recording at this point the idea of our colleague Geze (1951) according to which processes of

erosion and corrosion in silicised and calcareously cemented sandstones that are very fissured are analogous to those that occur in calcareous rocks; the forms that are derived from them are however much reduced recalling those of the siliceous sandstones of Fontainebleau where the modest cavities excavated by water slowly penetrating from the outside complete an erosive and solvent action, this last limited to the epigenetic calcites covering the sand.

I have already recalled (Anelli 1963) how tempting it is at this point to compare the term parakarst with that of *Merokarst* proposed, half a century ago now, by Cvijic (1925, 1960) to indicate a *partial or imperfect karst*, in particular that of the karst areas north of the alpine chain, of north-central Europe (northern France, Belgium, England) in Paleozoic marly and bituminous limestones, in Triassic and Jurassic dolomites with high magnesium, in the marly limestones of Podolia and of other localities in Europe. That author, who has a good claim to be considered the founder of karst studies, contrasted Merokarst with the *Holokarst* of limestone regions, typically of certain region of the Dinaric Karst. Not that we have to follow Cvijic in all his ideas beginning with the concept of Merokarst extended to typical forms of subdetritic [=subjacent?] karstic erosion represented by closed doliniform depressions in detritic terrains of eluvium or alluvium, or karst terrains of other origin covered by those [that are?] more calcareous.

Between Holokarst and Merokarst Cvijic places an intermediate type that he indicates with the term *transitional type* [in French] within which he then distinguishes two subtypes or secondary types, *Causses type* and *karstic type of Jura* [in French] (Cvijic, 1960, p.142). In transitional Karst the level of the karst base – contrary to what is seen in complete Karst – is not at an unknown depth or obviously below sea level, but is at a recognisable depth limited by being defined in correspondence to an aquifer lying over a stratum of impermeable rock. Of the two subtypes of transitional Karst, the first, Karst of Causses, is distinguished by having its base level at a depth that is identifiable but still considerable, which brings it closer to Holokarst than to Merokarst. However, karstic evolution more rapidly reaches the final stages of maturity and senility. The author places in this transitional subtype large parts of the karst limestone regions of France, the Swiss Alps, the eastern Bavarian and Austrian Alps (Dachstein, Tennengebirge), the Denaricas, Montello, the karst areas of the Balkans, of the Carpathians, of Moravia. In the second transitional subtype, in the Karst of Jura, through the greater frequency of alternation of impermeable marl strata with calcareous strata, the karst massifs have limited thickness compared to those of the Causses. Normal prekarstic erosion on easily erodible rocks such as marly rocks has favoured deepening of the fluvial water network and the consequent dismemberment of the original surface of the outcrop into isolated blocks separated from each other by marshy gullies of little depth. As well as in Provence and parts of the Dinaric Karst, the Jura type is recognisable in the western Balkans and in individual isolated massifs of Albania and the Crimea. Cvijic ascribes the Italian Appenine karst areas of Gargano and the Murgas to the Jural type of transitional karst.

It is not possible to agree with the eminent scholar's ideas about the two types of transitional Karst; one must dispute the validity of basing a whole classification on a few characteristics that are extremely variable and not always easy to determine. For example many reservations could be advanced regarding the Italian karst areas beginning with those of Gargano and the Murga in Puglia.

To close this chapter on parakarst phenomena I have decided to open a parenthesis in order to call attention to the particular karst forms, and their genesis, in a region very different from ours and very far away. I refer to an extensive altoplain emerging from the Venezuelan Grand Savannah in the equatorial band of 5 degrees 34' north latitude, constituted of a Proterozoic (Precambrian) orthoquartzite of Roraima, arenaceous in nature, red in colour, with a strongly degraded surface. The highest point of the altoplain, Mount Auyan-Tepui (Devil's Mountain) reaches 1000 m. The mean annual temperature is very high, the external temperature of the soil would reach 50 C; there is a remarkable amount of precipitation, exclusively rain needless to say, which in the highest areas is a good 7,600 mm annually. In the region is the famous Angel Falls, named for the aviator who first saw it when flying over the territory in a plane. It is the second highest in the world, reaching 980 m in two falls (the first, the higher, 800 m, the lower 180 m). [**Footnote:** the world's highest would be, according to recent statistics, the Tyssestrenge Cascade, whose waters fall from a height of 1083 m in a tributary of the Tyssa in Sofior-Ostufer in south-west Norway.] The water from the Angel Falls flows into the Caroni River, a tributary of the Orinoco. For more data refer to the note of White, Jefferson & Haman 1967. I will confine myself to a brief summary.

The water of the Angel Falls issues from a natural passage and is the outlet of a system of subterranean hydrological canals crossing deep faults in the above mass of orthoquartzites; the outlet is a spring which one could say is from the summit (Gortani 1948), fed by water of condensation from the vapour contained in the masses of hot and humid air carried by the north-east trade winds. The amount of precipitation on the Auyan-Tepui altoplain is among the highest in the country reaching, as I've already said, 7,600 mm annually. The fall of the water has excavated a vertical groove behind the 900 m high liquid blade.

On the surface of the altoplain it is the alteration of the quartzite that determines a complex of superficial characteristics which recall several morphological aspects of limestone karst terrains. In fact at the summit of the altoplain there appear karst grooves from faults (the *Kluftkarren* of German karst literature); the numerous water-filled fractures are between three and five metres wide and are up to three metres deep with steep walls; one observes also little canyons in the bottom of which is pooled water which increases in the most rainy period

of the year to the point where it feeds numerous springs which flow out from marginal clefts, forming cascades, excavating pipes [or mill-races] behind the liquid blades and eroding cauldrons at their feet.

They are not recorded by the authors but one can't exclude the possibility of eventual subterranean cavities from exogenous thermoclastic degradation or from solution. It is known that quartz can transform into opal, silicate hydrogel reddened by patinas of haematite deposited on quartzite granules. Not lacking in any of the fissures are dripstones of silicate similar to rudimentary stalactites. At the base of the exterior aspects of the altoplain, one can easily recognise the possibility of transformation – in favourable climatic conditions – of crystalline quartz into a colloid hydrogel, into opal, and successive transformation of the opal which, coagulating finally by slow evaporation, cements the granules of quartz and of calcedony.

Let's not forget that the red-brown colour in the quartzite surface promotes the heating of rock exposed to strong sunshine for the whole morning followed by torrential rain in the early afternoon. Such conditions promote alteration in the surface of the quartzite with formation of a porous crust of sandy character permeable to water, which in evaporating leaves in place colloidal silicate as a dry residue dissolved and carried away by successive rain events. Compared to the rapid superficial alteration there is no corresponding alteration within the mass of quartzite excluding therefore the possibility of formation of subterranean cavities.

However, if the degree of solubility of the quartzite were slightly elevated [***footnote*:** According to Krauskope 1956, cited by White, Jeggerson & Haman 1967, the solubility of amorphous silicates, which is around 100 ppm at 25 C, reaches 400 ppm at the temperature of boiling water, above that of calcite.] then one would recognise a certain karstic character in the form of erosion on the altoplain of the Devil's Mountain in Venezuela for which one could immediately accept the new term *quartzite karst* proposed by White, Jefferson & Halman, which is close to the term karst greseux [French for *sandsone karst*] proposed by Renault for the Saharan sandstones. It's a case, in other words, of a new term to include in the nomenclature of karst phenomena applicable to the action exerted by falling water independent of chemical reactions (Mauggi 1961) and it can figure, in my opinion, in the picture of karst phenomena examined in this chapter.