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EXHUMED PALEOKARST TRACES IN THE BIELE HORY MTS. (MALÉ KARPATY MTS.)

From the wide scale of the frequently injustly neglected problems of the ancient West Carpathian dry lands the problem of the paleokarst belongs to the most neglected one. This happens in spite of the quite evident fact that extensive carbonate complexes of various ages, belonging to various tectonic units, especially to the Central and Inner Carpathians and — to a lesser extent — also to the Outer Western Carpathians were exposed to subaerial processes during periods of different lengths in the Mesozoic and Cenozoic.

In the rather limited literature dealing with fossil karst of the Western Carpathians we find most often information on paleokarst of Mesozoic age. Lower Cretaceous karst found in the Štramberg limestones was mentioned by Panoš (1964), its filling was dealt with by Houša (1976, 1983). A note on karst processes developing in Urgonian limestones during an emergence phase between the Urgonian and Albian can be found in a paper by Andrusov (1959). Data on pre-Upper Albian karst processes affecting Urgonian limestones in the Tatra Mts. are reported by Lefeld (1968). The filling of Upper Cretaceous karst cavities is known from the Gombasek quarry in the Slovak Karst (Mello, Snopková 1973). In the surroundings of Mojtin in the Stražovske vrchy Mts. bauxites are filling karst sinks, widened cracks and small depressions in Triassic carbonate rocks (Borza, Martiny 1964; Andrusov 1965). This paleokarst is older than the basement of the Lower or Middle Eocene. Pre-Paleogene karst forms are mentioned in a work dealing with the Paleogene of the Liptov Basin (Gross, Köhler *et al.* 1980). The authors cited described various depressions probably of karstic origin which developed in the Triassic limestones underlying the basal transgressive Paleogene lithofacies.

Miocene sinters and stalactites have been found to fill the deeper parts of cracks in the Mesozoic rocks forming the south-western part

of the Malé Karpaty Mts. These cracks also contain terrestrial micro-Vertebrates of Lower Badenian age (Mišik 1980).

The hitherto known paleokarst phenomena include mostly depressions which are filled with predominantly allochthonous material, i.e. the Chlebovice conglomerates in the Štramberg limestones, bauxites at Mojtin, black shales in the Slovak Karst and Badenian sands in the Malé Karpaty Mts. Recently extensive complexes of collapse breccias which once filled old caves have been recorded by Činčura (1990a, b).

A SHORT CHARACTERISTICS OF THE GEOLOGICAL SETTING OF THE STUDY AREA

The Malé Karpaty Mts. are the westernmost core mountain range of the Central Western Carpathians. Because of their morphology and structure they are considered as a link between the Carpathian and Alpine mountain systems.

The Biele hory Mts. are situated approximately in the middle of the Malé Karpaty Mts. They consist predominantly of Triassic carbonate rocks forming the Veternik and Havranica nappe units. The lower member of the carbonate Veternik unit are the basal Guttenstein dolomites, 30—50 m thick. Brecciated dolomites which in fact are typical breccias are sometimes classified with them. However, their formation is related to later paleokarst processes. Overlying are the thick-bedded and massive Annaberg limestones (120—200 m thick), thick-bedded Reifling limestones (20—30 m thick) and the Wetterstein limestones and dolomites (50—100 m thick). Sometimes these also are described as being brecciated. Shales and sandstones of the Lunz beds separate the "lower" carbonate complex from the "upper" complex comprising the Opponitz limestones and Hauptdolomit, either 10—20 or 5—10 m thick. The total thickness of the lower carbonate complex could exceed 400 m.

The geology of the Havranica unit is very similar to that of the Veternik unit. The uppermost member of the Havranica unit is the Dachstein limestone. In contrast to the Veternik unit, the overlying Lunz beds here are a complex of limestones and dolomites, 150—300 m thick.

Above the carbonate Veternik and Havranica units there may occur denudational remnants of the basal transgressive lithofacies of Paleogene age. These are mostly organogenic and organodetritic limestones (Činčura *et al.* 1991).

THE PRESENT STATE OF KNOWLEDGE OF THE BIELE HORY MTS. KARST

The Biele hory Mts. karst includes three karst regions, namely Plavec, Smolenice and the Kochyňa—Orešany Karst (comp. Stankoviansky 1974). The core of the whole region is the Plavec karst. I shall treat this region with special attention.

The basic features of the region are both structural landforms and erosional landforms. The structural landforms are represented by monoclinal ridges of crête or hogbacks type (Stankoviansky 1974, 1982; Liška 1976). On the monoclinal ridges there may be found grikes. Subterranean forms occur more frequently. These include joint caverns

Fig. 1. Location of the Biele hory Mts.
Ryc. 1. Lokalizacja gór Biele hory

and precipices (comp. Stankoviansky 1982). The erosional landforms are represented by remnants of extensive, monotonous levelled surfaces, e.g., in the surroundings of Červenica (510 m), Baborská (541 m), Javorinky (462 m) and Kršlenica (505 m). On these extensive levelled plateaus there occur sinkholes.

Remnants of the levelled surfaces are believed to be equivalent to the midmountain niveau of Pannonian age (Stankoviansky 1982). According to Jakál *et al.* (1988) their formation has taken place during a shorter period of quiescence in the Rhodanian phase of movements.

From the above mentioned data it follows that the present karst cycle in the Biele hory Mts. began in the last phases of the Miocene (comp. Stankoviansky 1982; Jakál 1983; Jakál *et al.* 1988). The oldest phenomena are represented by the karst plateaus, i.e. the remnants of the midmountain surface. The beginning of the formation of large caves is assigned to the Pontian, whereas the formation of the smaller caves and precipices and of large sinkholes is related to the period of Walachian movements (Stankoviansky 1982).

EXHUMED PALEOKARST TRACES IN THE BIELE HORY MTS.

Exhumed paleokarst is represented by karst landforms and sediments from which the younger overlying strata have been removed by subsequent erosion and denudation.

Sinters and stalactites of Badenian age known to occur in the southwestern part of the Malé Karpaty Mts. (Mišik 1980) prove unambigously that karst processes here antedate the formation of the mid-mountain niveau as well as the alleged remnants of the oldest relief, i.e. the so-called inselbergs Vápenná, Záruby etc.

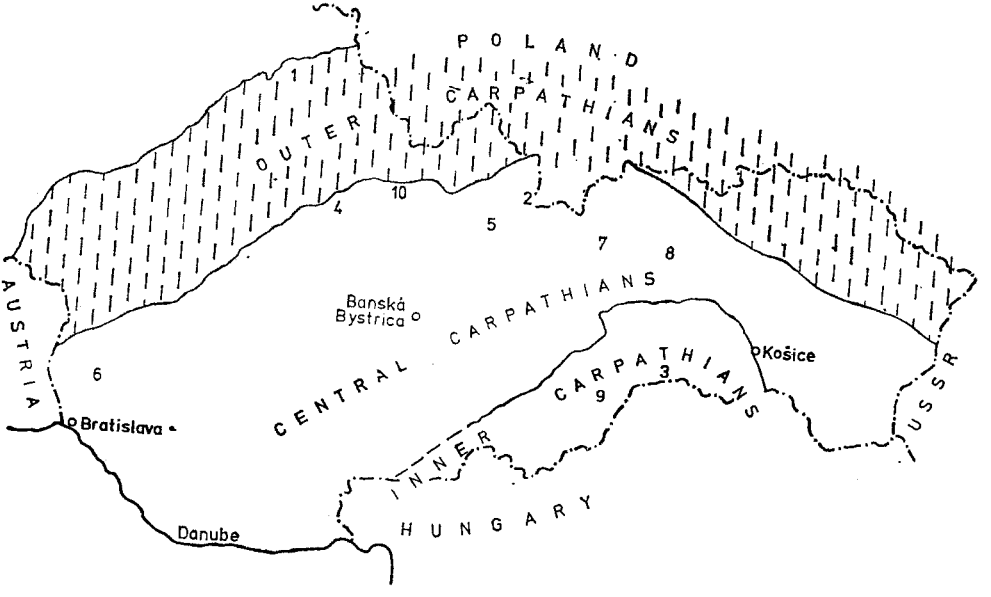

Fig. 2. Cretaceous and Paleocene paleokarst sites in the Western Carpathians: 1 — Štramberk, 2 — Tatra Mts., 3 — Slovak Karst (Gombasek), 4 — Stražovské vrchy Mts., (Mojtin), 5 — Liptovská kotlina Basin, 6 — Male Karpaty (Biele hory Mts.), 7 — Slovenský raj Mts., 8 — Slovenské rudohorie Mts. (Galmus), 9 — Drienčany karst, 10 — Biele Karpaty Mts.

Ryc. 2. Stanowiska kopalnego krasu wieku kredowego i paleoceńskiego w Karpatach Zachodnich: 1 — Štramberk, 2 — Tatry, 3 — Kras Słowacki (Gombasek), 4 — Stražovské vrchy (Mojtin), 5 — Kotlina Liptowska, 6 — Małe Karpaty (Biele hory), 7 — Słowacki Raj, 8 — Slovenské rudohorie (Galmus), 9 — Drienčanski Kras, 10 — Białe Karpaty

One of the typical features of the Biele hory Mts. is the common occurrence of carbonate breccias on the surface or in the near-surface parts of the territory. The extent of the breccia complex was determined by detailed mapping (Michalik 1984; Bučeк 1988). Carbonate breccias occur above the Triassic limestones and dolomites of the Veternik and Havranica units. If we neglect their presence in the basement of the Paleogene fill of the neighbouring Bukova depression, carbonate breccias can be found on and below the levelled plateaus and in the monoclinal structures (Činčura 1990b).

In the surface and near-surface parts of the levelled karst plateaus also isolated occurrences of limestones and dolomites are found. The

breccia occurrences often exceed 1 km² in area. The thickness of the breccia complex surely exceeds several tens of metres, in places it reaches more than 150 m. Breccia occurrences on the levelled plateaus are related to the occurrences of Triassic limestones and dolomites.

Carbonate breccia bodies also can be found in the monoclinal limestone and dolomite ridges. These smaller bodies often have a lenticular, sometimes almost linear shape.

Photo. 1. Levelled surface on breccia complex, Biele hory Mts. — Amon
Fot. 1. Zrównana powierzchnia ścinająca brekcje, Biele hory — Amon

Breccia clasts are characterized above all by the chaotic distribution of the angular blocks. Grain size varies greatly from several centimetres to several hundreds of cubic metres.

The Annaberg limestone is overlain by breccias containing more than 70 per cent of Annaberg limestone clasts. The remainder consists of dolomites, Reifling limestones etc. Breccias overlying the Wetterstein limestones contain a similar amount of their clasts, and breccias resting on dolomites have an even more uniform composition, with an absolute predominance of dolomite clasts.

Thus the petrographic composition of the breccia clasts indicates that this is autochtonous material which was derived exclusively from rocks forming the present base of the breccia complex. The local origin of the clasts also is indicated by the angular shapes and great sizes of the largest blocks.

A great part of the breccias has a red matrix. At sites of mega-

breccia occurrences the red matrix also fills frequently the wider spaces between the individual blocks as well as joints and various cavities due to dissolution. The matrix is nonsorted or poorly sorted. The content of the clay fraction in it varies from between 43% and 78%, the silt content is 11—40% and that of sand 10—20%.

In the breccia complex speleothems can be found at various sites. It is the fossil form of the generally known decoration of the present caves. The presence of speleothems indicates their deposition in the former upper, vadose zone in which infiltrating water tended to circulate. Although the occurrences of speleothems are not abundant, the latter are found throughout the Biele hory Mts. Speleothems have been disclosed in carbonate breccias forming both the levelled karst plateaus and parts of the monoclinal ridges.

Photo. 2. Speleothems contained in the breccia complex, Biele hory Mts. — Baborská

Fot. 2. Nacieki jaskiniowe wydobyte z brekcji, Biele hory — Baborská

Up to now, carbonate breccias have been considered as the products of mechanical weathering (Michalik 1984; Buček 1988). However, the high Al_2O_3 content (25—35%) in the matrix indicates the opposite, namely intensive chemical weathering prevailing during the period of breccia formation.

The petrographic composition of the clasts indicates the strictly local character of the material. The occurrence of the clasts within the depressions of the underlying limestones and dolomites as well as the

existence of positive paleolandforms which are buried in the breccia complex all indicate the differentiated process of karstic dissolution. The presence of large blocks in the breccia complex cannot be explained by any kind of transport. The most probable explanation of their origin is the gravitational fall of particles to the floor of the caverns due to loss of stability of the cave roof and walls. The former existence of caves is indirectly indicated by the presence of speleothems in the breccias.

On the basis of the above mentioned facts it is assumed that before the formation of the breccia complex on limestones and dolomites of the Veternik and Havranica units there existed an extensive cave system in the Biele hory Mts. The subsequent collapse of this cave system * gave rise to a large part of the breccia complex.

Fine weathering products and soils were apparently transported by water into the cave system already at the time of its existence. Transportation and gradual filling of the interclast spaces continued probably even after the caves ceased to exist.

The enormous extent of the breccias (it is not possible to prove the origin of all of them by speleothem occurrences) indicates that not all of the breccias are due to collapse of caves. It is assumed that a part of the breccia complex also belongs to the so-called mantle breccias the formation of which is related to karst dissolution on the land surface and immediately below it.

Furthermore, the existence of paleocaves is evidenced by fossil fluvial cave sediments. In the monoclinal ridge of Vápenná, lenticular beds of a laminated red marl with a horizon of slightly rounded limestone gravels occur in the brecciated mass (Michalik 1984). It is not possible to explain the presence of fluvially reworked material within the breccia complex in any other way than that it is the sediment of a former cave stream.

The breccia complex contains fragments of Triassic limestones and dolomites and sporadically also clasts of Jurassic — Neocomian limestones (Michalik 1984). Thus it appears that the breccia complex is probably Middle to Upper Cretaceous in age. Available data on the paleogeography of the Western Carpathians suggest an Upper Cretaceous age.

Such an age of the breccia complex is also supported by the occurrences of erosional remnants of Paleogene sediments disclosed on the levelled karst plateaus. On the surface of the Baborská plateau, above

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* By this we can mean the natural destruction of senile caves, although seismic reasons cannot be fully excluded, especially if we take into consideration the location of the paleokarst region at the boundary of the Central Western Carpathians and the then rather mobile zone of the Outer Western Carpathians.

the breccia complex, a remnant of pinkish-yellow (after weathering pink) limestones with nummulites can be found. Furthermore, below the height point 517 m (Hruba Kržla) there is a grey organogenic to organodetrital limestone the Paleogene age of which is evidenced by large foraminifera (Köhler 1988).

The Upper Cretaceous karst cycle became interrupted by the Paleocene, locally only Eocene marine transgression. Exhumation of the upper Cretaceous paleokarst traces from below the Paleogene sediments was due to subaerial development during the Neogene. Karst processes were reactivated probably already in the Karpatian. At that time, the Neoalpine karst cycle started in the Biele hory Mts. It lasts until the present time.

CONCLUSIONS

1. Intensive karst processes which affected carbonate rocks of the Veternik and Havranica units in the Biele hory Mts. took place during the Upper Cretaceous.

2. The formation of a large cave system was followed by its destruction which gave rise to a carbonate collapse breccia complex containing speleothems and cave stream sediments.

3. The Paleogene sea transgressed onto the levelled karst surface. Consequently, the Upper Cretaceous karst forms and deposits became buried by marine sediments.

4. The exhumation of the Upper Cretaceous paleokarst traces took place during the Miocene simultaneously with the beginning of a new karst cycle in the Biele hory Mts.

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REFERENCES

Andrusov D., 1959. *Geológia československých Karpát II*, Vydavatelstvo SAV, Bratislava, 375.

Andrusov D., 1965. *Geológia československých Karpát III*, Vydavatelstvo SAV, Bratislava, 424.

Borza K., Martiny E., 1964. *Kôry vetrania, ložiská bauxitu a „terra rossa" v slovenských Karpatoch.* Geol. Sbor., 15, 1, Bratislava, 9—26.

Buček S., 1988. *Dasykladálne riasy a biostratigrafia triasu Bielych hôr (Malé Karpaty).* Manuscript, Geol. úst. SAV, Bratislava, 258.

Činčura J., 1990a. *Characteristic features of paleoalpine and epipaleoalpine landmass of the West Carpathians.* Geol. Zbor. Geol. carpath., 41, 1, 29—38. Bratislava.

Činčura J., 1990b. *Paleoalpínsky kras veternickej a havranickej jednotky Bielych hôr.* Manuscript, Geol. úst. SAV, Bratislava, 107.

Činčura J., Gross P., Köhler E., 1991. *Dôkazy paleokrasu kriedovo-paleocénneho veku v Malých Karpatoch.* Slovenský kras, Liptovský Mikuláš, in print.

Gross P., Köhler E., *et al.* 1980. *Geológia Liptovskej kotliny.* Geol. úst. D. Štúra, Bratislava, 242.

Houša V., 1976. *Spodnokřídové formace doprovázející tělesa tithónskych vápenců u Štramberka.* Čas. Slez. Muz., Sér. A, 25, Opava, 63—85, 119—131.

Houša V., 1983. *Vznik těles štramberského vápence u Štramberka.* Věstník ÚÚG, 58, 4, Praha, 193—203.

Jakál J., 1983. *Krasový reliéf a jeho význam v geomorfologickom obraze Západných Karpát.* Geograf. čas. SAV, 35, 2, Bratislava, 160—183.

Jakál J., *et al.* 1988. *Morfoštruktúrna analýza Malých Karpát a prilahlých oblastí s ohladom na neotektonický vývoj.* Manuscript, Geogr. ust. SAV, Bratislava, 103.

Köhler E., 1988, *Ekosystémy rífových a biohermných vápencov paleogénu Západných Karpât,* Manuscript, Geol. úst. SAV, Bratislava, 86.

Lefeld J., 1968. *Stratygrafia i paleogeografia dolnej kredy wierchowej Tatr.* Studia Geol. Polon., 24, Warszawa.

Liška M., 1976. *Geomorfologické pomery Plaveckého krasu.* Slovenský kras, 14, Liptovský Mikuláš.

Mazúr E., Lukniš M., 1978. *Regionálne geomorfologické členenie SSR.* Geograf. čas. SAV, 30, 2, Bratislava, 101—125.

Mello J., Snopková P., 1973. *Vrchnokriedový vek výplní v dutinách triasových vápencov Gombaseckého lomu.* Geol. práce, Správy 61, Bratislava, 239—253.

Michalík J., 1984. *Some remarks on developmental and structural interpretation of the N part of the Malé Karpaty Mts. (West Carpathians).* Geol. Zbor. Geol. carpath., 35, 4, Bratislava, 489—504.

Mišík M., 1980. *Miocene sinter crusts (speleothems) and calcrete deposits from neptunian dykes, Malé Karpaty Mts.* Geol. Zbor. Geol. carpath., 31, 4, Bratislava, 495—512.

Panoš V., 1964. *Report on fossil karst forms research in reef limestones of the Štramberg-Highland (West Carpathians).* Zpr. Geogr. úst. Čs. Akad. Věd v Opavě, 5, 1, Opava.

Stankoviansky M., 1974. *Príspevok k poznaniu krasu Bielych hôr v Malých Karpatoch.* Geogr. čas., 26, 3, Bratislava, 241—257.

Stankoviansky M., 1982. *Geomorfologické pomery krasových území Malých Karpât.* Geomorfolog.. konference, Universita Karlova, Praha, 233—242.

STRESZCZENIE

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EKSHUMOWANE ŚLADY KRASU KOPALNEGO W MAŁYCH KARPATACH (BIELE HORY)

Cechą charakterystyczną gór Biele hory jest występowanie licznych brekcji powierzchniowych i przypowierzchniowych wieku górnokredowego, odsłoniętych w neogenie spod pokrywy morskich osadów paleogeńskich. Na rozległych, skrasowiałych płaskowyżach kopalne brekcje jaskiniowe i „pokrywowe" często zajmują obszar o powierzchni 1 km², grubość ich niejednokrotnie przekracza kilkadziesiąt metrów, a nawet 150 m. Brekcje są osadami autochtonicznymi, zawierającymi bloki i okruchy skał analogicznych do podłoża zbudowanego z triasowych wapieni i dolomitów, a często także naciek i i osady rzek jaskiniowych. Czerwone spoiwo brekcji zostało wymyte ze starych pokryw glebowych i zwietrzelinowych przez wody przesiąkające i wytrącone w podziemnych próżniach. Olbrzymie masy skalne, zawierające nacieki jaskiniowe, dowodzą bowiem, że w górnej kredzie wypełniały one rozległy system jaskiniowy, dziś już nie istniejący. Owczesne jaskinie zostały zniszczone przez procesy grawitacyjne (obrywy, zapadanie się stropów jaskiń).