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The Skalka travertine mound at Hôrka-Ondrej near Poprad (Slovakia)

Výzkum travertinové kupy Skalka v Hôrce-Ondreji u Popradu (Slovensko)

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Abstract: The travertine mound at Skalka, also called Smrečányiho skala, in the village of Hôrka-Ondrej near Poprad, has been studied continuously since 1987. This important site has yielded not only a small-sized stone industry of Middle Palaeolithic age coming from at least three separate periods of time, but also ample palaeomalacozoological, palaeoosteological and palaeobotanical material. The geological, lithological and palaeopedological studies helped much to the stratigraphical classification. The articles presented in this volume assemble all the basic data so far available and provide information on the environmental conditions existing at the site during the last, Riss/Würm, interglacial in general. The geological and palaeopedological data, indicate the existence of one more earlier, Middle Pleistocene interglacial. From the articles included in this volume is apparent that there still is no agreement on the age of the locality under consideration. Additional analysis of Ford (see in this paper) have proved the hard travertines of the mound (underlying the interglacial deposits of trench C_1) to come from an older interglacial than is R/W.

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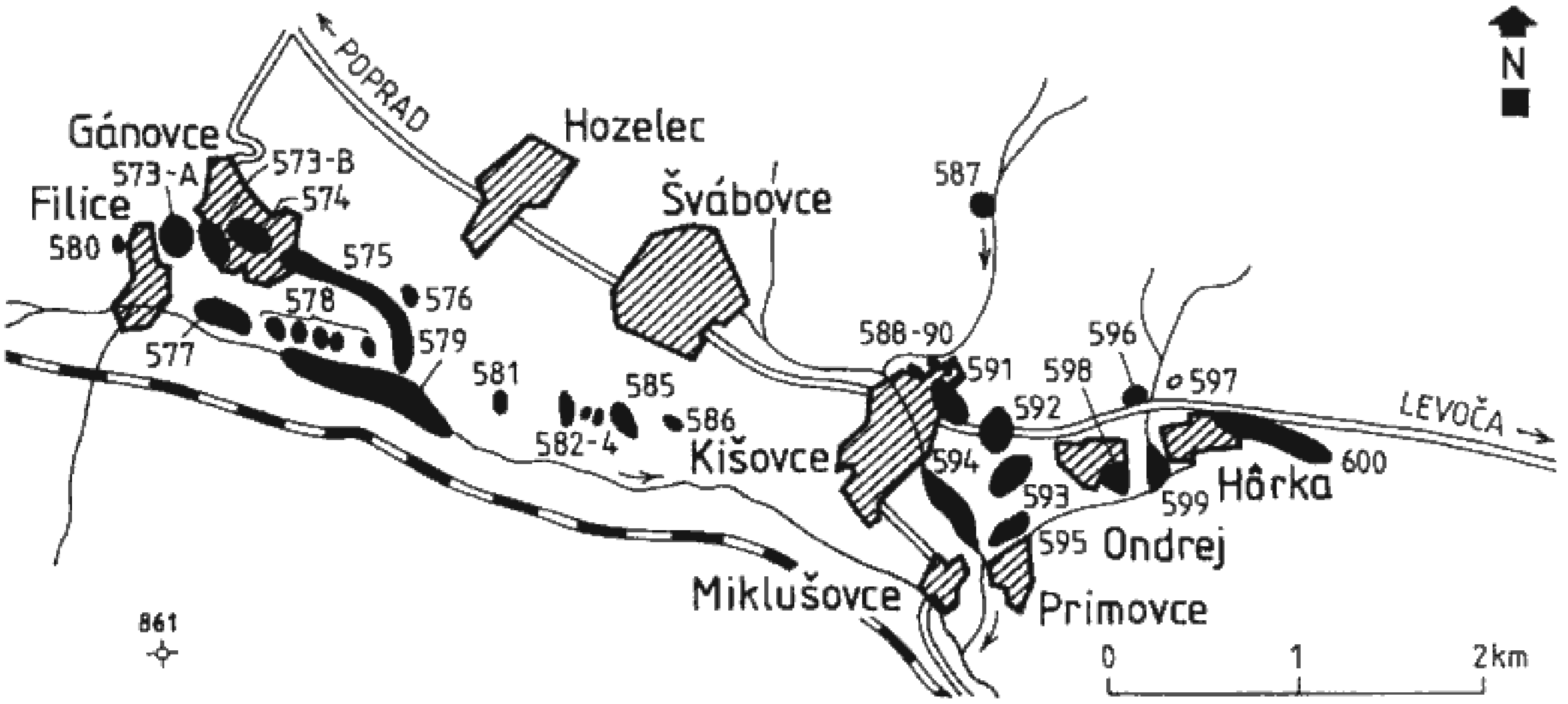
Introduction and history of investigations

Jiří Kovanda

The travertine exposed at Skalka, also called Smrečányiho skala or Kameň, lies on the north side of the village of Hôrka-Ondrej. It belongs to similar Quaternary calcareous deposits occurring abundantly in the Spiš area which extends between Kišovce, Ondrej, Hôrka and Primovce, just east-south-east of Poprad. This group of travertine mounds appears to be an eastern continuation of a similar group comprising various Quaternary limestones between Gánovce, Hozelec and Švábovce (Kovanda 1971 - fig. 1). Of particular scientific importance among these is the world-known travertine mound called Hrádok, not far from the Gánovce spa. This locality yielded much palaeontological material and provided evidence of its prehistoric occupation based on remains of fireplaces and largely small-sized stone artifacts in association with several bones and a travertine cast of the Neanderthaloid Man's cranium (see Vlček 1969).

The travertine at Skalka is a small, mound-like body lying about 300 metres northeast of Ondrej's church, just close to the north side of the road leading from Poprad to Levoča (fig. 2) at the elevation 635 m a.s.l. The body is approximately 60 by 65 metres in size, its thickness as seen now attaining only about 3 to 4 metres. No measures were taken in the past to control excavation of the hard compact travertines for building purposes. Large-scale exploitation took place especially in the thirties and small quarries were at times operated during and immediately after the Second World War.

The travertine known to occur close to the village of Hôrka-Ondrej was first mentioned by Kormos (1912) and



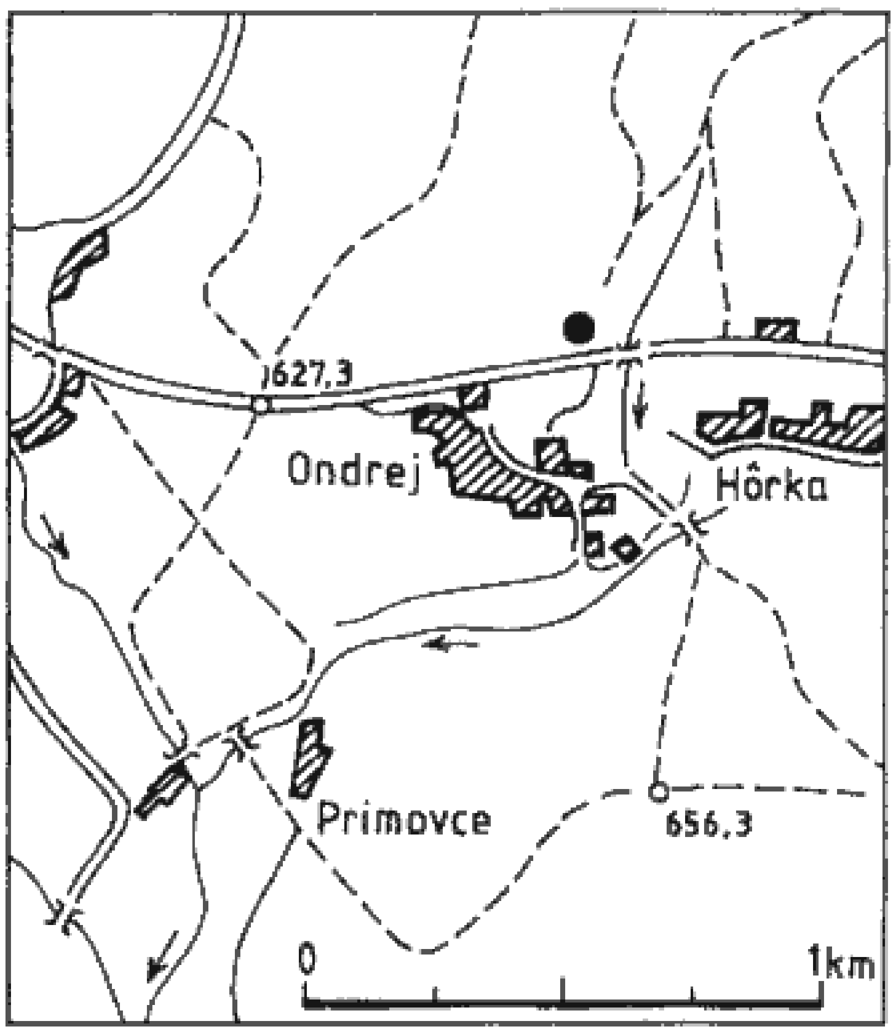
1. Survey of travertines between Gánovce and Hôrka near Poprad. The site at Skalka is given the number 596. As stated by Kovanda (1971), the locality mentioned on page 171 of his text is described incorrectly under the name of "Svätý Ondrej nad Hronom".

then by Prát (1927, 1929). There is no certainty, however, if the locality mentioned by both authors is that is dealt with in this paper or any other locality in the nearby surroundings (cf. Kovanda 1971). It was not until the quarry was open in a larger scale that fairly reliable data were provided by Petrbok (1937) and Němejc (1938). Both scientists independently concluded that the travertine was deposited first during a period dominated by pine and birch, and then at the time marked by widespread expansion of mixed oak forest. The latter indicates some unspecified interglacial. They believe there was a stage-by-stage deposition of calcium carbonate and describe unanimously beds overlying the travertine.

Ivan's (1943) monograph includes a photograph of thick hard travertine centred around the original crater to illustrate the degree and depth of weathering (fig. 3).

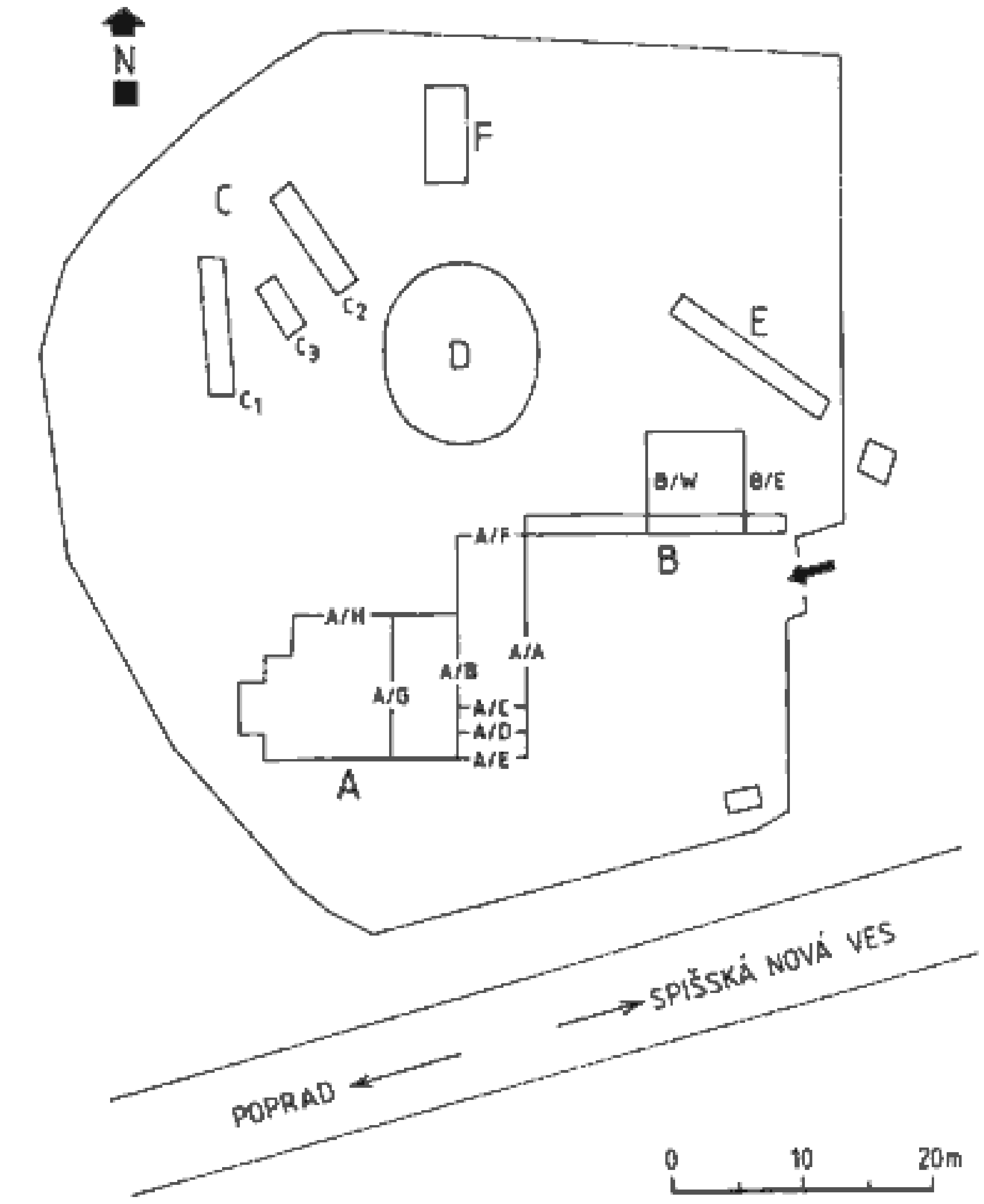
Prošek-Ložek's (1957) survey of Quaternary deposits in Czechoslovakia provides another source of information. Their paper contains a section drawn through platy travertines with four thin-bedded initial rendzinas yielding the Palaeolithic industry. Likewise important is the discovery of the snail *Helicigona banatica* (Rossm.) suggesting the interglacial climax time. The section also well documents the complex overlying sequence (fig. 5).

Information on the small-sized stone industry from Hôrka-Ondrej is also in papers by Vlček (1957), Prošek



2. Detailed location of the travertine mound at Skalka is marked with a black circle.

3. Photostatic copy from Ivan's (1943) paper. The travertine mound surface at Skalka is now completely stripped away from around the crater showing corrosion effects of great depth extension. Notice the figure at right edge of pillar. View looking westnorthwest.



4. Position of areas and trenches on the travertine mound at Skalka (Ľ. Kaminská).

(1958) and Bánesz (1961). In 1958 Ložek published a list of 25 mollusc species determined from the travertine, along with a bone of the rhinoceros *Dicerorhinus mercki* Jäger.

Řezáč (1959), in his article on the hydrogeology of the Švábovce-Kišovce area, says: "Acidulous waters from which travertine forms by deposition ascend to the surface near Hôrka .... at cross-points of longitudinal and transverse fault" .... "Springs are located mostly along transverse northeast-southwestward-trending faults roughly perpendicular to the Švábovce-Kišovce fault, that is, either along the Tarnov fault ..... or along other faults trending in the same direction near Svätý Ondrej and Hôrka".

Zýka - Vtělenský (1960) in their monograph on the geochemistry of Slovak travertines concluded that the travertine at Hôrka-Ondrej should be ranged to some of their textural types of groups A, H, K, N and O based on the static system they propose. Otherwise, however, both authors do not doubt the Riss/Würm interglacial age assigned for the Skalka travertine mound. This and the travertine called Hrádok near Gánovce were used by Ložek (1964) as examples of the last interglacial.

The picture taken in the mid-sixties of the last remaining part of the mound, probably the section published by Prošek - Ložek in 1957, was included in the paper by Šibrava - Fejfar - Kovanda - Valoch (1969).

Finally, all the data and material available on the locality by 1969 were assembled by Kovanda in his monograph (1971) on the Quaternary limestones of Czechoslovakia. There are brief statements in a number of subsequent papers referring to Skalka, but these are of limited value.

The travertine near Hôrka-Ondrej has been studied systematically by Ľ. Kaminská of the Košice Department of the Archaeological Institute of the Slovak Academy of Sciences, since 1987 (Kaminská 1988, 1990, 1991, 1992 and 1993). During this six-year period she was able to remove most of the spoil heaps and dumps covering the larger part of the travertine body. Kaminská also exposed several areas and new sections subsequently coded with the symbols A to F - fig. 4. At the same time, she was engaged in a study aimed to confirm the occupation of other palaeolithic sites at Skalka. Excavations did much to document in an excellent manner the structure and destruction of the whole body, as well as the overlying sequence (see also Bánesz 1990 and 1991).

Because Skalka has yielded, besides archaeological finds, ample palaeontological material, Ľ. Kaminská asked other specialists to assist in the studies, namely Ložek (1991, 1992, 1993 - palaeomalacozoology), Horáček (1992 - palaeosteology) and Kvaček (1990 - macrophytopalaeontology). Some charcoals and leaf impressions from the travertine were also determined by Hajnalová - Hunková (1990). In addition, the lithology and geology was studied by Kovanda (1993a, 1993b) and palaeopedology by Smolíková (1993). This report summarizes all the results as yet available in most of the disciplines mentioned above and hence gives a review of the current knowledge of the stratigraphy of both the travertines and the overlying beds.

The results presented above may be extended by unpublished reports stored at the Research centre of the Archaeological Institute in Košice. In his 1990 manuscript on the macroflora from the travertine at Skalka for the Archeological Institute, Slovak Academy of Science, Kvaček essentially supports Němejc's (1937, 1943) view that two horizons can be distinguished at the site: the lower is marked by widespread expansion of birch, pine and aspen; the upper is dominated by mixed oak forest. The only specimen Kvaček added to this list is mountain ash (*Sorbus*) stored in the collections of the National Museum, Prague. The macroflora from the hard, thick bedded travertine showing numerous leaf impressions in front of the trench C_1 section was correlated by Kvaček with Němejc's lower horizon from which are reported the *Pinus silvestris* L., *Betula verrucosa* Ehrh., *Salix cinerea* L. and *Salix* sp. From area D, which covers the travertine around a former crater, he described *Pinus silvestris* L., *Salix* sp., cf. *Rosacae, Monocotyledonae, Acer* sp., cf. *Picea, Populus tremula* L. and *Quercus robur* L. He considers that this assemblage is an equivalent of that found in Němejc's upper horizon. Only *Quercus robur* L. was yielded by area A (fig. 4).

After comparing the few macrofloral finds with the material from Gánovce-Hrádok (Kneblová 1960), Kvaček found that both show the onset and full development of an interglacial. Consequently, the site at Skalka was allocated by him to the last, Riss/Würm, interglacial.

Another palaeobotanical review was given by Hajnalová - Hunková (1990) reporting on the discovery of charcoal, as well as impressions of leaves and needles at the Skalka mound. Area A: *Pinus* cf. *silvestris, Alnus* sp. and *Carpinus betulus;* Area C: *Pinus* or *Picea* sp.; Area B: grass leaves and stems, *Picea* or *Larix* and *Betula* sp.; trench F: *Picea* or *Larix* and *Pinus* sp.

The geoelectric survey focussed on determining the travertine thickness (Gajdoš - Tirpák 1989) was supplemented by data from three boreholes (Bosák 1990). Geophysical data indicate that the travertine attains the greatest thickness of 7 metres in its south-east part (facing areas A and B) and is 5 metres thick in front of trench C_1. However, borehole data show that the travertine is everywhere only about 3 metres thick.

Činčárová (1989) made the silicate analysis of colluvial loam and soil sediments from horizons B and G filling the joint in section A_1 (see fig. 6) and from the basal layers encountered in trench C_1 (samples taken from layers 12 a-c see fig. 11). Although these deposits differ in both origin and specially in lithology, the chemical composition of both sections is much alike and therefore any additional silicate analyses are considered as superfluous. The analytical results can not be reliably utilized. The same is the case of the analysis made in another review (Cílek - Tipková 1990) of two, more closely unspecified horizons filling the joint in section A/A (? A/B) - figs. 6, 7, or of the "gray clay in section C". The co-authors' review contains a description of the processes leading to the destruction of the travertine mound consequent on harmful postsedimentary activities shown by springs alone. The authors also assume that mineral waters were affected in an aggressive manner, e.g., the group of horizons A to G filling the joint in section A/A (fig. 6).

Basal clay layers of the succession encountered in trench C_1 and labeled 12 a-c (see fig. 11) are darkbrown or red but mostly grayish-black and black in colour, tightly compacted and broken into cubes. They can be interpreted as a bog mangan ore deposited from a spring flowing along a tectonic line from the nearby manganese deposit between Švábovce and Kišovce. For that reason three samples were taken from these markedly varicoloured deposits to determine Fe_2O_3, FeO and MnO_2; qualitative optical emission spectrographic analysis was also used. Analysis were performed by M. Mikšovský and E. Mrázová, both of the Chemical Analytical Laboratory, Czech Geological Survey, Praha - Barrandov:

All the three samples contain 5.55-6.33 percent Fe_2O_3, less than 0.03 percent FeO, and only 0.30-0.62 percent MnO_2. Elements such as Si, Al and Ca constitute more than 10 percent, Fe, K, Mg, Mn and Ti range from 1 to 9 percent, Ba, Na and P vary between 0.01 and 0.9 percent, B, Cr, Li, Sr, V, Zn and Zr between 0.01 and 0.09 percent, and As, Be, Co, Cu, Ga, Ge, Mo, Ni, and Pb range within such low limits as 0.0009 to 0.009 percent.

The above analysis lead us to the unambiguous conclusion that this conspicuous variegation in colour ending in black is caused by the presence of iron (Fe^{3+}) and hence it cannot be associated with the nearby manganese mineralization.

Geology of the travertine mound

Jiří Kovanda

Excavations made by the Archaeological Institute, Slovak Academy of Science, provided information on the structure of both the travertine and overlying beds. In 1987-1992, the travertine body was studied in areas and by trenches (see fig. 4).

The area in the southern part of the body, **coded by the symbol A**, is the most extensive. The continuous excavations drawn from the west to the east, exposed in ascending order, (i) the lower part consisting of thin bedded and locally varicoloured travertine, (ii) disintegrated parts of platy and thick bedded travertine having (iii) partly preserved original ripple marked surface with travertine dams, as well as (iv) the variegated succession filling an east-westward-trending joint, (v) a facies gradation of one of the layers filling the joint (from the north southward) to a layer of earthy, fine sandy travertine resembling chalk tufa and, finally, (vi) the surficial beds composed of colluvial loam with aeolian deposits, mantled by loose, weathered and corroded blocks and clasts of solid travertine.

Area B is a continuation of the east-westward-trending section published by Prošek and Ložek (1957) - fig. 5. It cuts the lower part of tabular travertine containing four to five layers of initial rendzina. This horizon shows beds underlying the travertine body as well as a well-developed surficial succession, as noted above (area A). The original, east-westward-trending section has now been drawn northward to recover additional stone industry and determine the position of rendzine within the travertine body. This resulted in two other sections extending north-southward and referred to as the eastern and western sections (figs. 9, 10, pl. IV/1).

Area C was explored by trenches C_1 and C_2 dug in the north-western corner of the travertine body. Trench C_1 (fig. 11) encountered the surface od previously quarried thick bedded travertine yielding numerous *Salix* leaves impressions and showing sings of corrosion.

Higher up, a complex succession of overlying sediments was found to fill a karst pocket. Trench C_2 (pl. V/2, fig. 12) encountered a younger overlying succession cut laterally into the older pocket infill just mentioned (C_1). The interval between trenches C_1 and C_2 was penetrated by trench C_3 to study the basal beds of the pocket infill encountered in trench C_1 (pl. V/1).

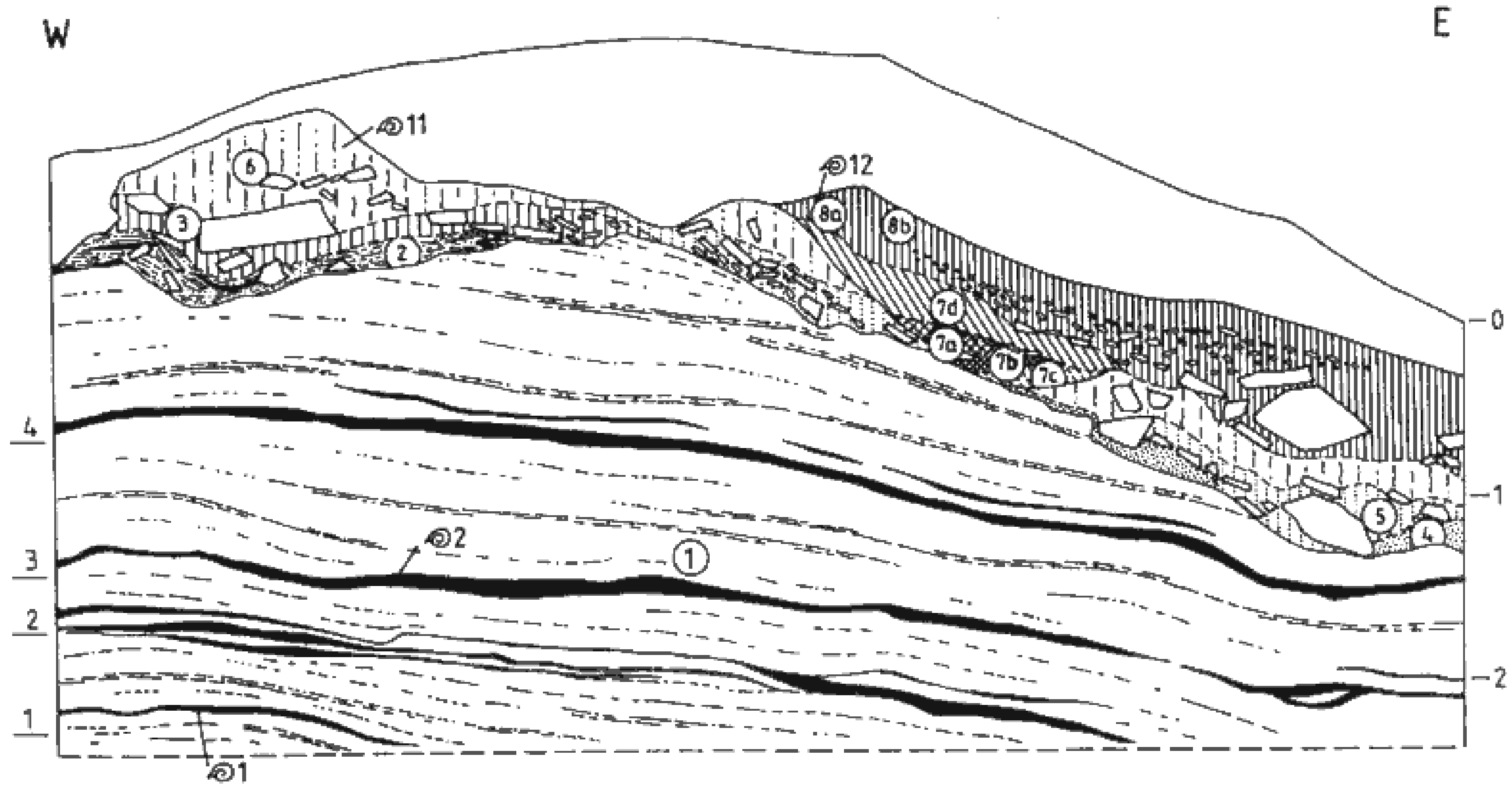
Area D was exposed by removing excessive material from the face of platy and thick bedded travertine previously quarried in the central part of the body. It also shows a section drawn through an original narrow crater filled with marl. The present-day surface has been lowered by the removal of weathered parts by at least 4 to 5 m (see photo by Ivan 1943 - fig. 3).

Trench E was located and terminated in the near-surface part of the eastern slope of the body and was not used for interpretation.

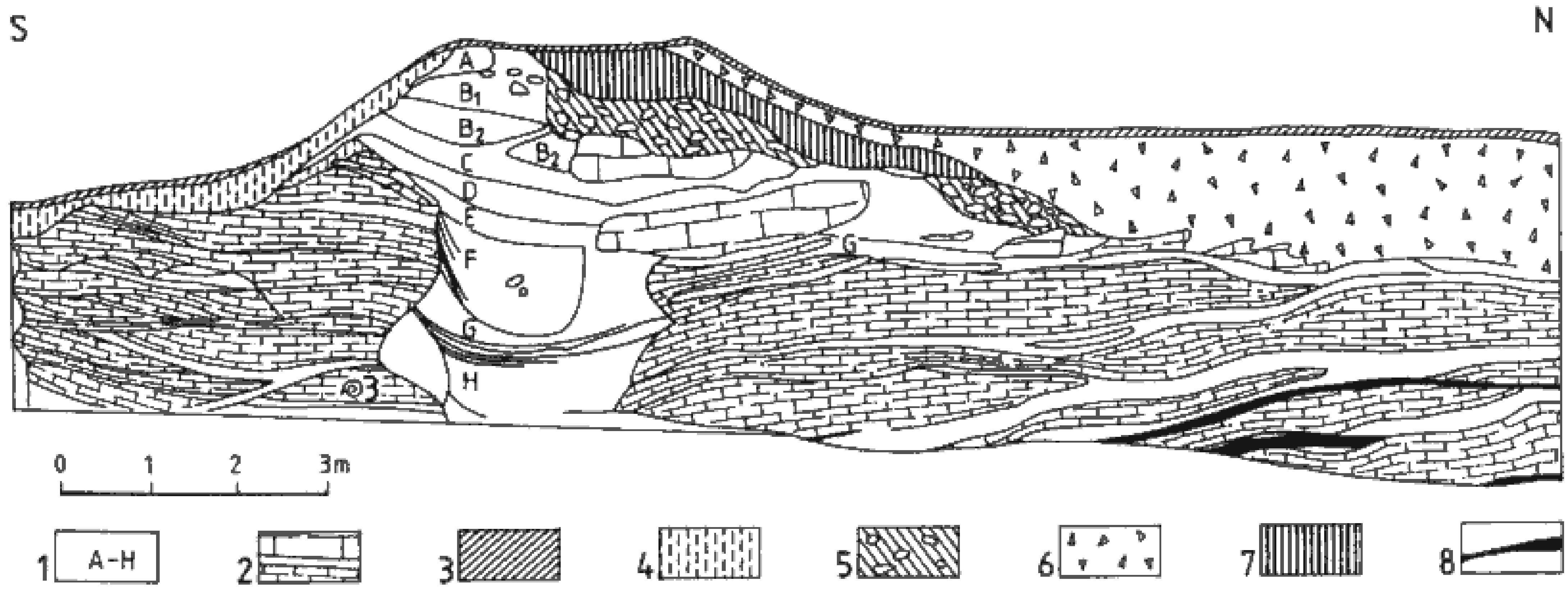
Trench F (pl. VI/1) penetrated the original weathered surface of compact travertine, including overlying colluvium and rather thin aeolian deposits, at the northern margin of the body.

The main geological conclusions drawn from all the excavations made by the Archaeological Institute, Slovak Academy of Science, can be summarized as follows (see also Kovanda 1993b):

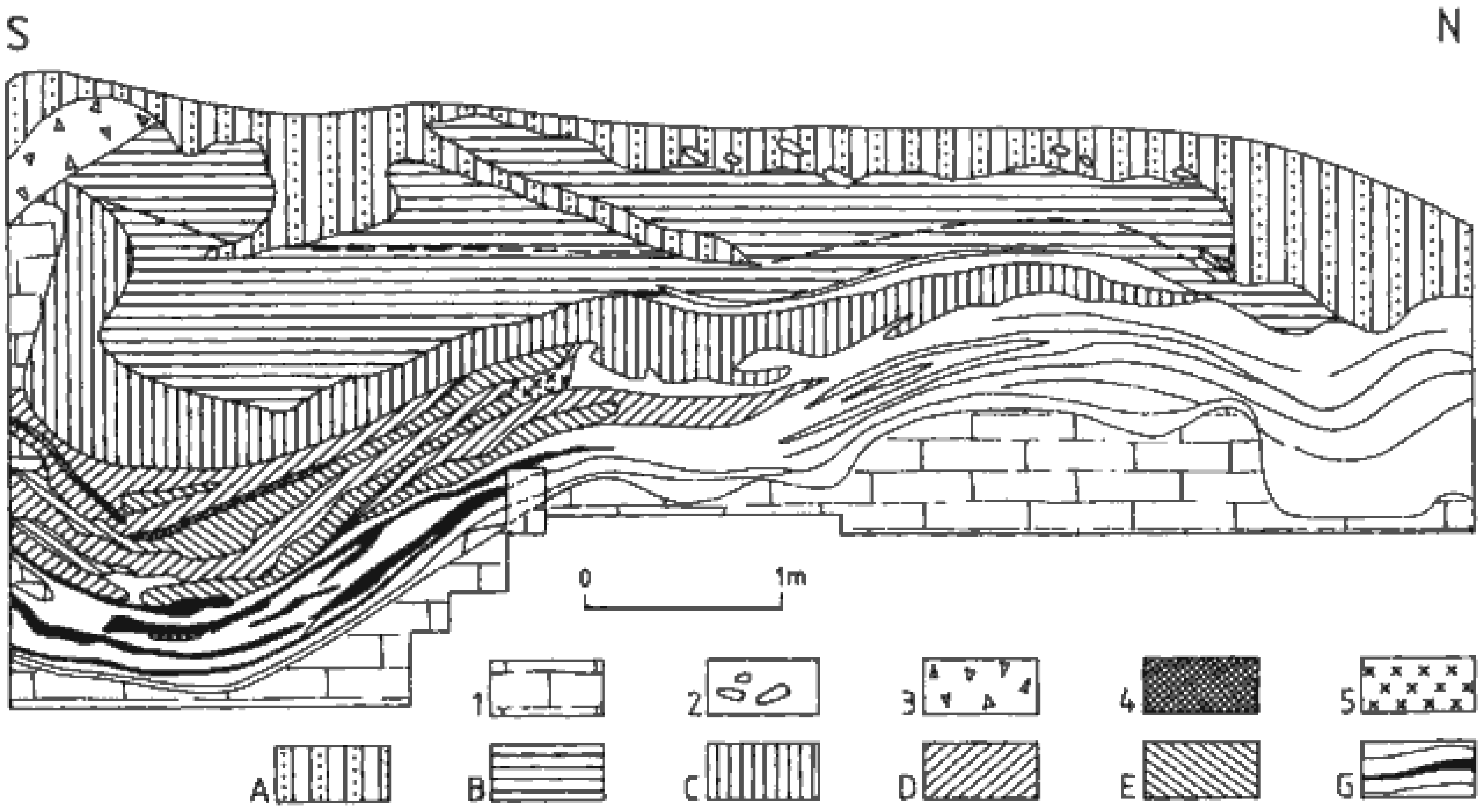
1. The travertine body formed by deposition from a



5. Original section drawn across area B (after Prošek - Ložek 1957). Encircled numbers: 1 - thin bedded travertine yielding the interglacial climax snail *Helicigona banatica* (Rossm.) and containing laminated initial rendzina yielding Ložek's (1993) malacofauna Nos. 1 and 2 and small-sized Palaeolithic stone industry; 2-6 - overlying succession containing blocks of travertine left by the last glaciation and yielding Ložek's malacofauna No. 11; 7a-d - cave fill of Bronze age; 8 - humic topsoil yielding Ložek's malacofauna No. 12.



6. Section A/A drawn in 1987: 1 - the material filling the younger joint trending in a north-south direction in the travertine mound consists of colluvial loam and soil sediments horizons A to H; 2 - travertine, thin and thick bedded; 3 - humic topsoil; 4 - loess loam with small fragments of travertine; 5 - grayish-black loam with fragments of travertines; 6 - dark gray loam with fragments of travertine; 7 - light brown colluvial loam; 8 - grayish-black layers of initial lamined rendzina in this bedded travertine. Ložek's (1993) malacofauna No. 3 comes from base of travertine (Ľ. Kaminská).



7. Section A/B drawn in 1989-1990: 1 - thick bedded travertine; 2 - fragments and cobbles of travertine; 3 - colluvial loam with fragments and cobbles of travertine; 4 - fireplace; 5 - scattered wood carbon. A-G - horizons of colluvial loam and soil sediment filling joint and overlying thick bedded travertine. Sampled for palaeopedological analysis Nos. 12-16 - see also pl. II/1 (Ľ. Kaminská).

mineral spring ascending towards the surface at the crossing of a longitudinal northwest-southeastward-trending fault and a transverse northeast-southwestward-trending fault nearly perpendicular to it within the Šváboyce-Kišovce tectonic zone. This locality is one of many travertines occurrences east of Poprad (fig. 1).

2. This body, originally at least 4 to 5 m higher than now, has been left after exploitation of compact travertine during the thirties and forties of this century. The crater lies in the central part of the circular travertine mound (area D).

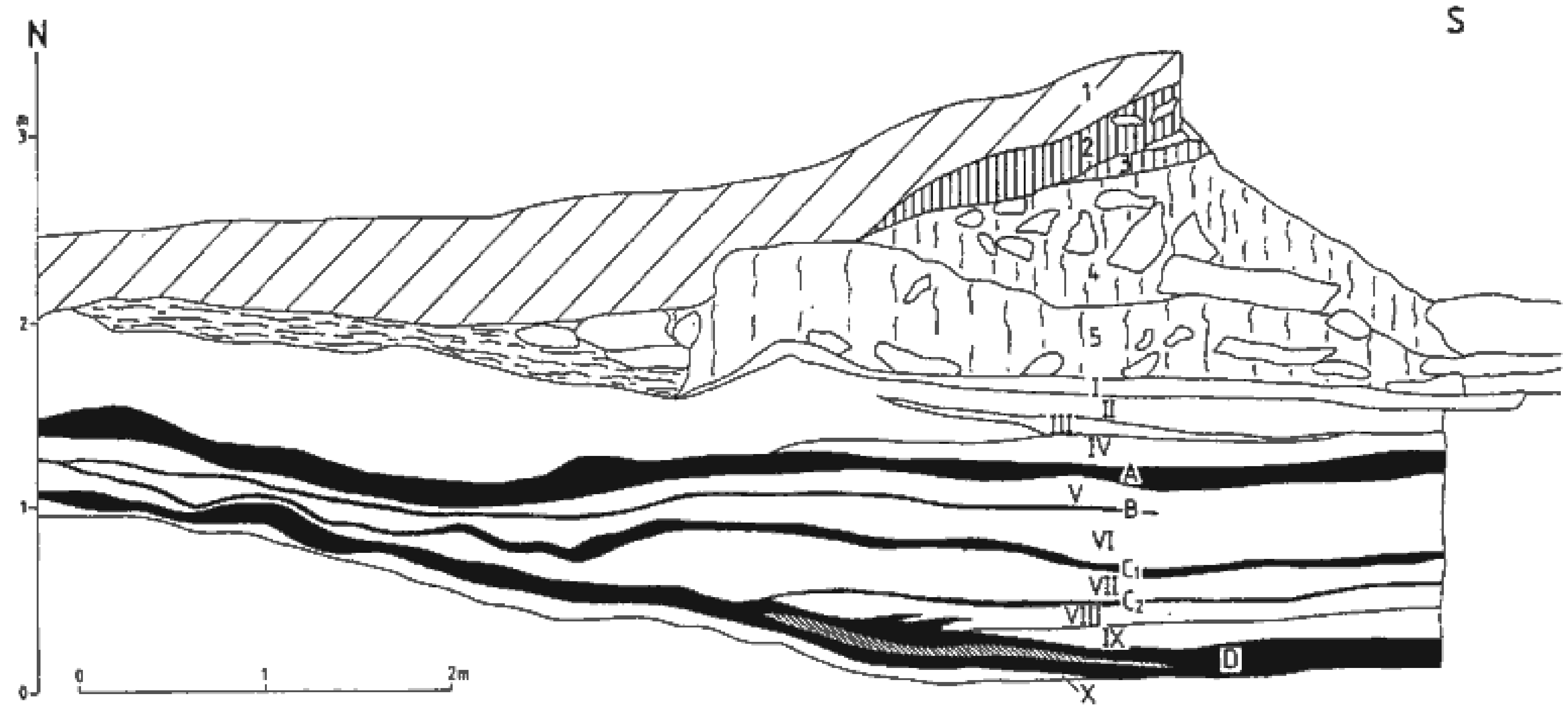
3. The body is underlain by weathered Paleogene rocks of the Inner Carpathian flysch exposed only in a shallow excavation on the eastern footslope of the body and at the base of the travertine mound in area B. It is bluish and greenish gray, calcareous and sandy clay to marl with scattered fragments of Palaeogene sandstone occurring sporadically also in the lower parts of the travertine body.

4. Exposed parts of the travertine body show that it consists of **two principal successions**: (i) the **lower** lies (figs. 5, 6 and pls. II, IV) at the southern margin of the body and in areas A and B; it consists of thin-bedded and tabular layers easily susceptible to disaggregation and displaying, especially in the south part of the body, a variety of colours, with a few initial rendzinas 5 to 50 mm thick; this succession yielded malacofauna described by Ložek (1993) as Mf 1, Mf 2 and Mf 3 - figs. 5 and 6; its surface is strongly weathered and corroded, thereby suggesting a hidden break in deposition. Resting erosionally unconformably on this tabular travertine, (ii) the **upper accumulation** is composed of white, compact, platy to thick bedded travertine almost completely exploited in the past and found in areas A, C, D and F (figs. 13, 14); its surface (Ložek's Mf 6, fig. 11) is either preserved in original form (with travertine dams and tufa pools seen locally in area A - pl. VII/2), or is strongly weathered (trench F - pl. VI/1) or by exploitation in area D - see photograph by Ivan 1943 - fig. 3 or karstified (base of trenches X_1 and C_2). From the north-west part now represented by area D. Ložek (1993) described his MF 5. **An-**

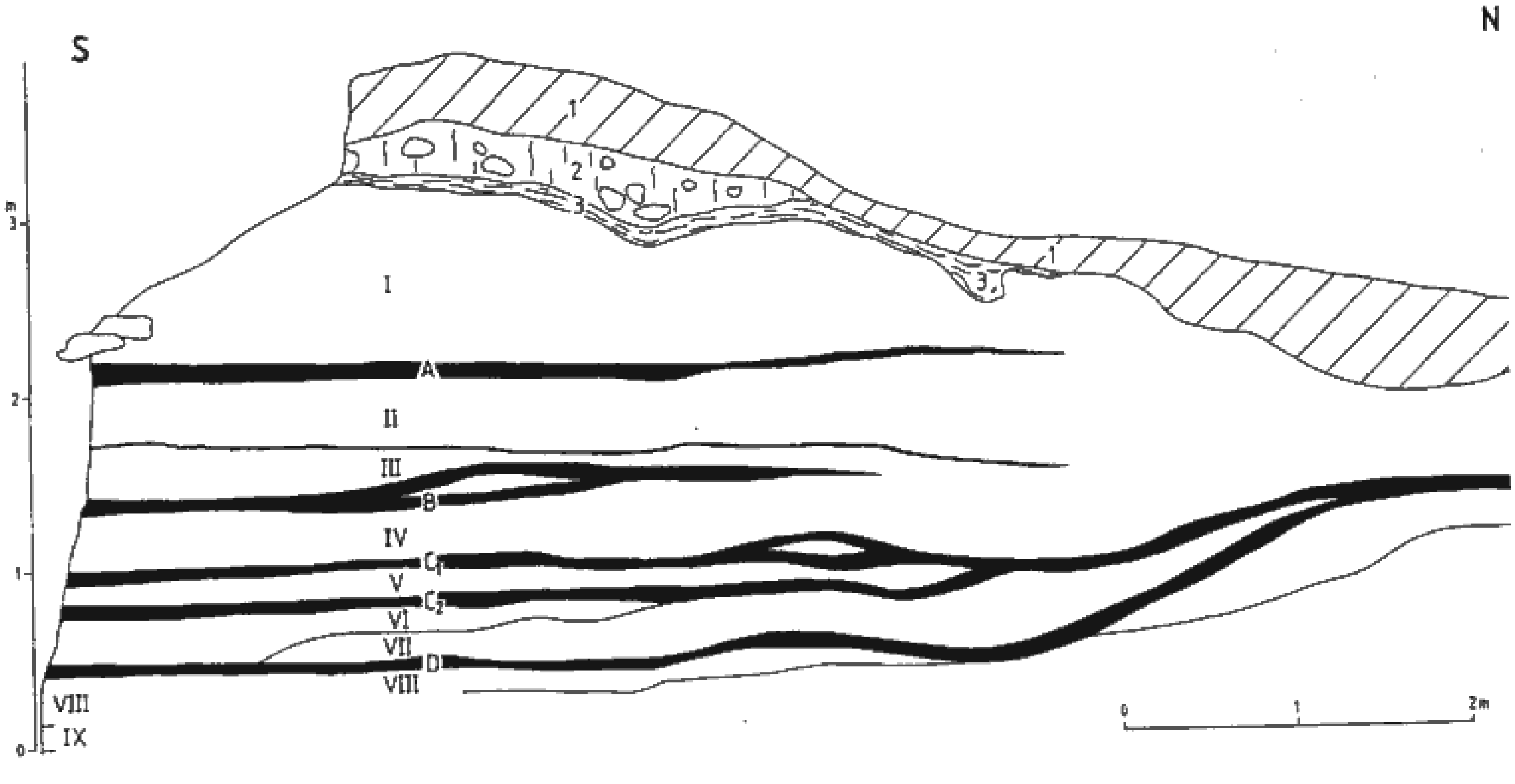
8. So called "bubble-shaped" travertine sporadically forming the surface of the lower accumulation of thin bedded travertine, as yet known only as aragonite at Karlovy Vary (Carlsbad) (see Kovanda 1971). Photo by A. Marková.

other thin accumulation of earthy, chalky and sandy travertine was found at the southern margin of the body. It rests erosionally unconformably on remains of the upper travertine and represents a facies continuation of the C horizon of soil sediment (see further text) filling the younger joint in the travertine body. These layers were reported by Ložek (1993) to have yielded his MF 4 and Horáček's mammal fauna A/D2-X (tab. 4) - pl. III/2, fig. 16.

5. Besides signs of weathering and karstification on its surface, the travertine body is cut by several joints extending down to the rocks below. The largest joint is that trending in an east-west direction in area A along with a part of the travertine body was shifted southward. It is filled with a succession of colluvial loam soil sediments having horizons A to G (fig. 6, pls. II/1,2, III/1). The youngest joints observed in the travertine are slightly open and not filled with



9. Eastern section (B/E) of area B: 1 - artificial fill; 2 - grayish-black humic soil with corroded travertine fragments; 3 - gray loam with small fragments of travertine; 4 - loess colluvial loam with corroded blocks and cobbles of travertine; 5 - light brown colluvial loam with loess and corroded travertine blocks. I-IX - beds of thin bedded, structural and easily crumbling travertine; X - travertine platy, compact, with scattered fragments of flysch sand-stone; A-D - gray and dark gray laminae of initial rendzina (Ľ. Kaminská).



10. Western section (B/W) of area B: 1 - artificial fill; 2 - loam, ochreous-light-brown, with fragments, cobbles and blocks of corroded travertine; 3 - loamy clay, rusty and bluish; I-VIII - travertine, thin bedded, structural and easy to crumble; IX - travertine, compact, locally brecciated; A-D - initial rendzina (Ľ. Kaminská).

any material (area D). Joint infillings are part of the overlying successions since at favourable places they extend discontinuously into the surface of the travertine to form an unconformable cover (area A - pl. III/1, trench C_1 - fig. 11).

6. Collective opinion exists regarding different age for the material filling the east-westward-trending joint mentioned above (see point 5). This agreement was reached for the profile of section A/A. A lower age was assigned to lithologically invariable material, and a higher age, to horizons A to G - pl. II/1.

7. Data from the trenches in area C indicate that the succession encountered in trench C_1 (Ložek's Mf 7 to Mf 10 and Horáček's mammal fauna C_1 (12c - 8, tab 5) is older than the joint infilling embedded in it, as seen in trench C_2. It is considered with respect to lithology to be an analogue of the joint infill noted earlier (area A - fig. 6, pl. II/1).

8. The youngest sheet at Skalka consists of colluvial (re-deposited loess) loam mixed with corroded blocks and stones of solid travertine (area A and B), equated with Ložek's Mf 11 - fig. 5, 9, 10.

9. The surficial soil type recognized at the site is represented by rendzina Ložek's Mf 12 - fig. 5.

From that results the following sequence of processes (fig. 13, 14 - see Kovanda 1993b):

a) deposition of lower thin bedded travertine containing initial laminated rendzinas (I);

b) break in deposition, surficial corrosion, weathering to disaggregation of individual laminae, e.g., of algal travertine;

c) deposition f upper platy and thick bedded travertine quarried in the past (II);

d) termination of travertine deposition, local strong destruction with weathering and disaggregation of thick bedded travertine; the karstification phase is followed by the formation of older joints and local karst pockets;

e) accumulation of loose, sandy limestone precipitated from springs and in marshy environment and formation of colluvial material deposited in older open joints and karst pockets (III);

f) formation of younger joints accompanied by subaerial denudation and erosion of the upper parts of the older overlying successions. These younger joints were gradually filled first with an older material in the lower part (IV - section A/A) and then with loessic colluvial loam and soil sediments (with horizons A-H) in the younger part (V - sections A/B to A/G, trench C_2). Deposition of the soil sediment of layers C and D occurred contemporaneously with the formation of the youngest earthy, chalky and sandy, loose travertine (fig. 16), the latter apparently resulting from an episodic outflow from an adventive crater;

g) subaerial denudation of some of the youngest deposits and accumulation of redeposited (loess) loam containing blocks and stones of compact travertine (VI);

h) formation of subfossil soil at the surface of colluvium in trench C_2 (VII);

i) development of surficial rendzina (VIII).

Stratigraphy of travertine and the overlying sediments

Jiří Kovanda

Before embarking on the subject aided by Ložek's (1964) paper devoted to the possibility of determining the relative age of the travertine in the Spiš area, it is necessary beforehand to provide the following information (see also Kovanda 1993e):

1. The surface of the main accumulation of the travertine body is strongly weathered (trench F - pl. VI/1 or area B - see photograph by Ivan, 1943 - fig.3), and karstified and cut by older joints (trench C_1).

2. The micromorphology of fossil soils proved the existence of immature terra fusca at the travertine weathered surface in trench F and in several layers of both joint infills and the deposits above (Smolíková 1993). Rendzina, a surficial soil type, developed only as topsoil on all the deposits containing relics of terra fusca.

3. Both the snail *Helicigona banatica* (Rossm.) and the rhinoceros *Dicerorhinus mercki* Jäger, reported by Prošek-Ložek (1957) in travertine are the representatives of interglacial climax faunas.

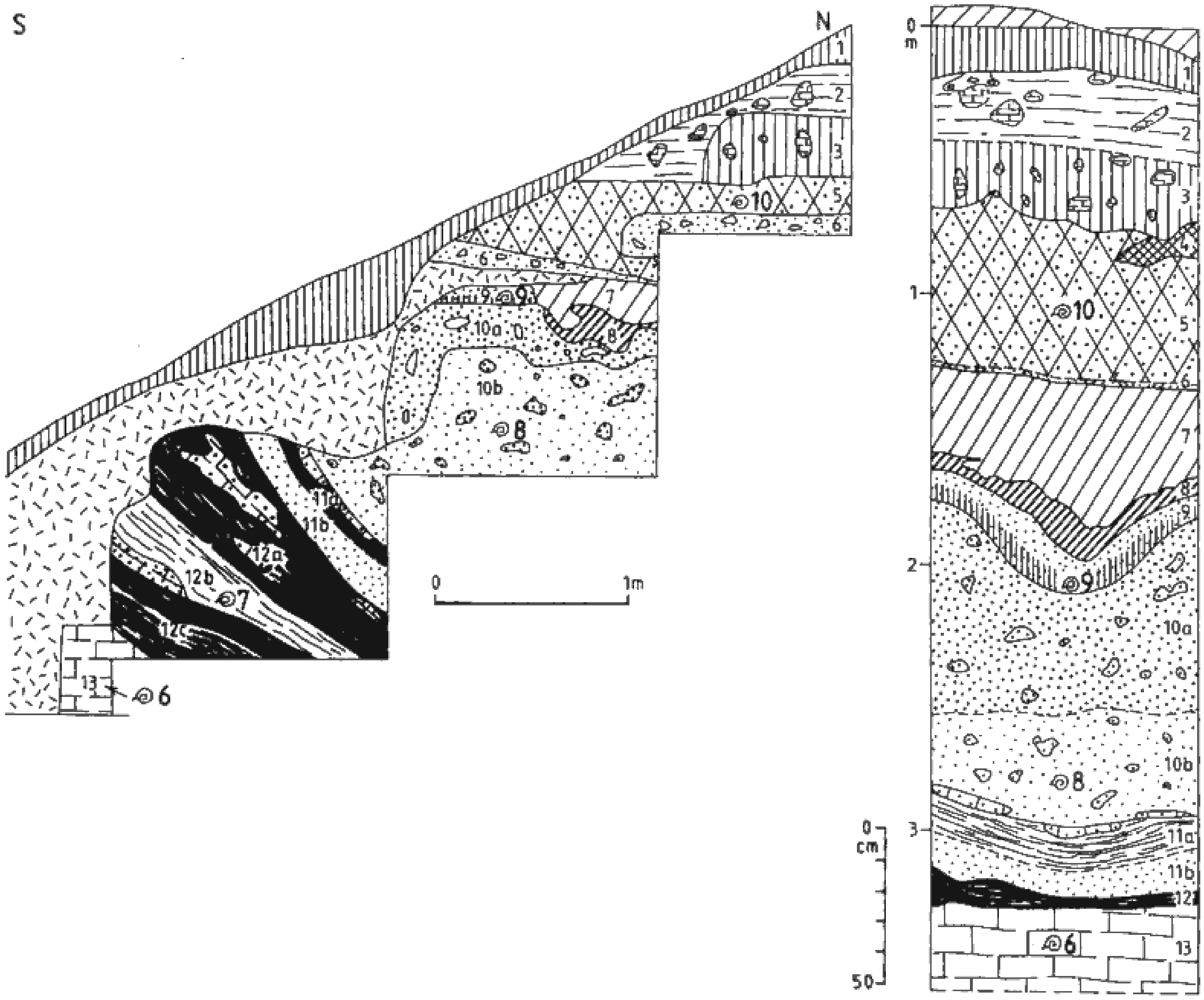
4. From the succession of marsh and spring limestones encountered in trench C_1 (i.e. above the travertine body) evidenced by molluscan fauna, the onset, full development and close of an interglacial was interpreted by Ložek (1993). Consequently, with regard to the disturbed surface of the underlying travertine also yielding typical interglacial fauna the existence of two superimposed interglacials is supposed.

5. The younger interglacial (trench C_1) is overlain unconformably by another succession represented by redeposited loess and soil sediments. It fills the younger joints (trench C_2 - pl. V/2 and fig. 12) and is an equivalent of the joint infill in area A (figs. 6, 7).

This evidences that **the mound-like travertine as a whole, is one interglacial older than the pocket infill on its surface in trench C1**. Considering that relics of terra fusca from the last interglacial have been found on travertine neither in our territory nor in neighbouring countries, and with regard to the fact that a double last interglacial is likewise unknown, it seems logical to put forward the following argument: Had the interglacial encountered in trench C_1 been identical with the last interglacial period (Riss/Würm), the lower travertine accumulation would have most likely been assignable to the last-but-one interglacial (? Treene), though not typified by faunas containing *Helicigona banatica* (Rossm).

Disturbance and jointing of the travertine body would thus have been allocated to the young Riss and onset of the last interglacial immediately before deposition of the basal beds of the succession seen in trench C_1.

The material filling the younger, east-westward-trending joint in area A unfortunately yielded no fossil molluscs and, by lithologies, is an equivalent of the deposits penetrated in trench C_2. Since it rests unconformably on beds suggesting



11. Section exposed in face and west side of trench C_1 in 1990 above thick bedded travertine containing numerous leaf impressions of *Salix* and Ložek's (1993) malacofauna No. 6. The succession overlying travertine is indicated with the numbers 1 through 12c; its lower part consisting of layers (Nos. 12 to 5) accumulated in marsh or glades and contains Ložek's (1993) malacofauna (Nos. 7-10) indicating the onset, full development and retreat phase of the (?) last interglacial. From basal beds the samples were also taken (Nos. 2-7) by Smolíková (this volume) for palaeopedological analysis; colluvial mantle consisting of layers No. 4 to 1 sampled (Nos. 8-11) for palaeopedological analysis (Ľ. Kaminská).

a closing phase of the last interglacial, it is clear that the younger joint infill can be assigned either to the close of the Riss/Würm or to the earlier period of the last, Würm, glacial. It should be noted that the infill is covered by colluvial loam mixed travertine clasts and contains, as stated by Ložek (1993), cold-loving loess malacofauna (Mf 11).

With these facts in mind, much more weight should be placed especially on archaeological findings. This is because the small-sized stone industry comes not only from both main accumulations of the travertine, i.e. not only from the older interglacial, but also from deposits corresponding to the last interglacial (trench C_1), and, what is more important, even substantially from the infill of the younger joint (area A) and the same layers overlying the western margin of the travertine - fig. 16, pl. VII/2. It seems, therefore, that the site at Skalka was occupied by people during the Palaeolithic period recurrently, at intervals fairly distant from each other, which of course is a rare phenomenon (cf., e.g., the site at Hrádok near Gánovce for which evidence of only an interglacial and the last glacial period is available).

In addition to the archaeological findings, the material obtained from this locality includes numerous charcoals, impressions of wood leaves and needles, herbs (Hajnalová - Hunková 1990, Kvaček 1990), moss thalluses, green algae, etc., followed by numerous fossil molluscs (Ložek 1993), bones and teeth of fossil vertebrates (Horáček 1992). An attempt was also made to determine, at least preliminary the age of fossil snail shells from the travertine using the amino acid method by J. Mirecki, of the Memphis State University, Tennessee, but no closer statement can yet be made owing to the lack of comparable standards.

Additional measurement of absolute age of travertines

(Ford in this paper) has proved the original structure of the mound to be more complicated than described above. Hard travertines of the mound (underlying the interglacial deposits in trench C_1) have, nevertheless, been explicitly dated to an older interglacial than is R/W.

Soil micromorphology of the travertine mound at Hôrka-Ondrej near Poprad

Libuše Smolíková

Soils or their derivatives occur in a number of profiles exposed at the Skalka locality. The soils may be classified especially as **mixed fossil sediments** (cf. Kubiena 1956a) accompanied by two soils: **fossil parautochthonous and subfossil autochthonous.** The method of **soil micromorphology** has been used to elucidate their origin and typology by both detailed analysis and synthesis (Kubiena 1970) needed for reconstruction of the environment during the last interglacial (Riss/Würm, Eemian) or the last-but-one first-order warm period to the Holocene.

Thirty-five samples were taken successively during archaeological investigations from the sections under study (F, C_1, C_2, C_3 and A/G) and from checkpoints (see fig. 13). Results obtained by soil micromorphology studies of thin sections are presented in the following text (see also Smolíková 1993).

Travertine surface, weathered, tabular, platy; **oldest sequence member (profile F** - pl. VI/1, sample 1 - 7,5YR 5/6 - examined dry - pl. IX 1): Redeposited material of the terra fusca B horizon mixed with corroded fragments of travertine; with admixture of allochthonous component and subsequently exposed to hydromorphic effects.

Lower part of **older infill above travertine (section C1-** figs. 11, 13, layers 12 and 11 based on samples 2 - 7.5YR 4/2; 3 - 5YR 4/6 - pl. IX/2; 27 - 7.5YR 4/4; 4 - 7.5YR 3/2 - pl. X/1; 26 - 7.5YR 4/2; 5 - 10YR 2/1 - pl. X/2; 6 - 10YR3/2, and 7 - 10YR3/3): The lower part of the profile exposed by trench C_1 consists of a highly varied succession of soil sediments. The lower three members are dominated by boluses of redeposited material resembling rather untypical terra fusca mixed with humic soils and allochthonous components found as aeolian deposits or resulting from surface runoff. The nature of terra fusca has been best preserved in the bed documented by sample 3. Of the samples taken from all the other members of the succession, only sample 5 is characterized by being very rich in carbonate. Soil deposition recurred above, with humic sediments (showing highest biogenic activity in sample 7) predominating over redeposited material of terra fusca. While this terra fusca was redeposited within the confines of the site, the humic material comes from the adjacent area and genetically most likely corresponds to the A horizon of brown soils and pseudogley. Some layers yield bone fragments or opal phytoliths; the whole profile contains coalified wood remains and exhibits distinct hydromorphic features increasingly prominent downwards. The frequency and intensity of these features suggest that the soil deposits were being laid down in an environment saturated with water, e.g. swamp, which in turn obliterated some of their original characters, e.g. primary fabric of humic soils, etc.

The lower part of section C_1 is remarkable mircomorphologically because it contains two types of braunlehm nodules. One type is represented by minute nodules quite smooth in outline but sharply bounded against the surrounding soil matrix, whereas the other is represented by large nodules faintly bounded against the surrounding soil matrix and having a distinct inner concentric structure. The fact that both forms occur in soil deposits but not in soils in situ may be explained in two ways:

(a) Let us assume the existence of two terra fusca-type soil generations to which the two different forms of nodules might correspond. However, these soils form at a very slow rate, and since more than one interglacial would have been required for their development it would be necessary to recognize another first-order warm period pre-dating the last interglacial. Micromorphologically, however, apart from the two forms of nodules described above, there is nothing in the soil deposits to indicate or corroborate the existence of two generations of terra fusca. Moreover, no typical terra fusca has been found in situ.

(b) It is likely that the large "uncompleted" braunlehm nodules having a distinct inner concentric structure correspond to the terra fusca formed without reaching a final stage of development, while the minute, sharply bounded nodules can be assigned genetically to pseudogley (cf. Kubiena 1956b; for example, samples 25 and 24 (pl. XII/1) taken from trench C_3 - continuation of the basal layers from trench C_1 - show the gA and gB horizons of the soil sediments containing abundant nodules of the latter type, whereas the other form is entirely lacking owing to the absence of terra fusca). This assumption is emphasized by the fact that both terra fusca and pseudogley formed in the same environment occurr synchronously but on different substrata. This soil additionally incorporated a component of humic brown soil, collovium and aeolian deposits, and was subsequently removed from its source area and mutually mixed in various proportions documenting the complex depositional dynamics of the whole profile.

Note: Samples 21, 22 and 23 were taken from **section** C_3, too. Sample 21 (7.5YR 5/4) is similar in micromorphologic features to sample 4 from trench C_1 and to sample 26 from the surface plane separating trench C_1 from trench C_3. In this case its plasmatic parts contain locally-preserved fluvial textures with optically aligned clay. - Sample 22 (10YR 3/2) differs in having predominant flocculated humus forming mull with unevenly coloured soil matrix and no traces of edaphic effects; it consists of a large amount of soil (micro) skeleton unsized in grain, the fabric being tight and compact, without any sign of aggregation and with voids represented by joints and fractures. - Sample 23 (10YR 4/3) shows highest variability within the group of the three samples in question. It shows polyhedrons of braunlehm plasma incorporating locally preserved, fluvial textures: weakly birefringent humus-depleted aggregates with less numerous earthworm excrements; and subpolyhedrons of humus-free but flocculated soil matrix of close fabric with scattered pseudogley nodules. This mixed soil deposit consists of redeposited terra fusca, humic soil and pseudogley with braunlehm and black nodules, the latter formed of manganese compounds; soil skeleton also contains lesser amounts of fragmentary travertine and sediment clusters also found in sample 20. Sparsely preserved channelways are rimmed with black manganese oxide thinly coated by amorphous calcium carbonate. The soil matrix shows distinct bedding throughout.

In broad features profile C_3 agree genetically with the lower part (layers 12 and 11) of section C_1.

Continuation of the older infill above earthy and sandy travertine - surface of trench C_1 (see fig. 13) **and material exposed above trench C_3**. Samples: 8 - 7.5YR 4/4; 9 - 7.5YR 5/4; 10 - 7.5YR 5/6; 11 - 10YR 5/4 - pl. XI/1: This profile is marked by recurrent alteration of soil sediments originally corresponding to the terra fusca-type soil on travertine substratum; to the pseudogley with its parent rock represented by flysch colluvium and aeolian deposits; and to the brown humic soils derived from the same substrata as noted above. These sediments were redeposited only at places but in a quick manner attested by unrounded skeleton and relics of various soils mostly preserved as polyhedrons, subpolyhedrons or clods. The basal layers of the profile are dominated by terra fusca bolluses, while the material above is composed predominantly of pseudogley, humic soil and colluvium. If we judge by the close fabric of these mixed soil sediments, along with conspicuous coatings of manganese oxide, the whole soil complex must have been exposed at least in part or at repeated intervals, to hydromorphic effects.

Younger sequence member filling the fracture above travertine (section A/G - fig. 13, pl. III/1 - based on samples 12a - 10YR 5/6; 12b - 2.5YR 6/2 and 10YR 5/8 where rusty; 12c - 10YR 5/3; 15 - 7.5YR 4/2; 29 - 7.5YR 4/2; and 16 - 10YR 6/4 - fig. 13, pl. XI/2): This succession is dominated by recurrently alternating soil sediments of various systematic assignment such as pseudogley, brown-earth humic soils and terra fusca, all varying highly in their proportions. Sample 12b contains the smallest amount of soil and is represented chiefly by calcareous tufa showing remarkable traces of secondary deformation, like sample 16 essentially corresponding to colluvium. Conversely, samples 15 and 29 are represented by redeposited terra fusca exposed to intense but unequal biogenic activities operative contemporaneously with deposition of the allochthonous component; its material was ultimately subject to broad hydromorphic changes.

Trench C_3. Samples: 24 - 10YR 5/4, pl. XII/1; 25 - 7.5YR 4/2: Samples 24 and 25 differ markedly from those representing the other profiles in the absence of terra fusca bolluses occurring in various proportions in almost all the layers of the profiles exposed at the locality under study. This is because samples 24 and 25 can be interpreted respectively as the redeposited g(B) and gA horizons of fossil pseudogley derived from weathered flysch with admixed aeolian deposits.

Base of trench C_2 - fig. 12, pl. V/2. **Thin layer (26) on the surface of corroded travertine** underlying the colluvial loam complex (sample 20 - 5YR 4/6 - pl. XII/2) terminated pedogenetically by Holocene soil (samples 17 - 19): Sample 20 is neither a soil nor derivate but is interpreted as having been formed by deposition from mineralized (i.e. with dissolved solids) and probably thermal spring waters as bog iron ore. The chemical composition (and hence the pH of water) and temperature of these waters changes rapidly, as is reflected in the alternating coatings of iron (Fe^{3+}) and manganese (Mn) hydroxides and oxides, as well as of carbonates. After a spring had become inactive (or shifted its activity to another place) and gone dry, the original jelly-like (Fe^{3+}) compounds disaggregated and have been partly preserved as layers consisting of separate clods. Allochthonous irreversible braunlehm nodules are the only soil material preserved in these wide voids formed by secondary processes.

Trench C_2 - upper part of profile (chronologically above younger sequence member of horizons B-H in section A/G) - based on samples 17 - 10YR 6/4; 18 - 10YR 4/3 and 19 - 10 YR5/6: Autochthonous illimerized soil (layer 4) referred to as illimerized soil (Parabraunerde) derived from loess loam with a weak admixture of redeposited terra fusca. The soil was subsequently modified by biogenic activities trace-able down to its B horizon and then was subject to pseudogleying; its top part, A_3 horizon (sample 19), was slightly redeposited in highly disturbed depositional conditions evidenced by the supply of unweathered coarse-grained soil particles.

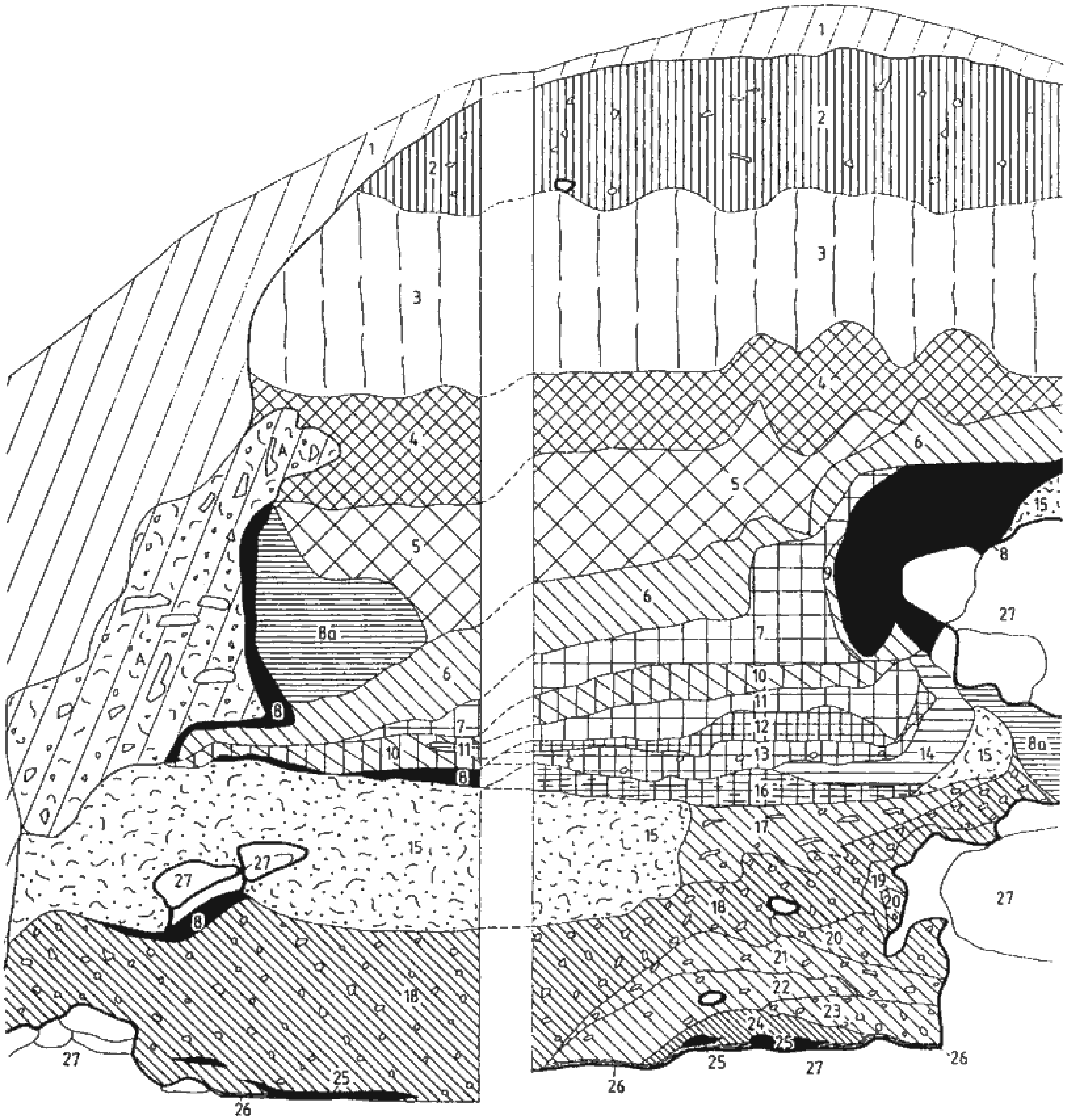
The chief value of studies, if considered from the palaeopedological point of view, lies in the recognition **of terra fusca** at the locality. Support for this statement may be derived from the **following findings:**

1. This soil forms at a very slow rate (cf. Werner 1958, 1959), and therefore it evidences an interglacial of long duration. There was not time enough for terra fusca to form during short-lived and climatically insignificant interstadials permitting only rendzine-type soils to form on equivalent substrata.

2. Terra fusca developed mainly in warmer and especially wetter climatic conditions than those prevailing in postglacial times (cf. Kubiena 1953).

3. If terra fusca occurs in the mode of relict soil, it often exhibits polycyclic characters in response to its formation at one site during two or more first-order warm periods (Smolíková 1963).

4. The thickness of this soil or the degree to which it was subject to lessivation depend on the number of warm periods during which it developed in a polycyclic manner



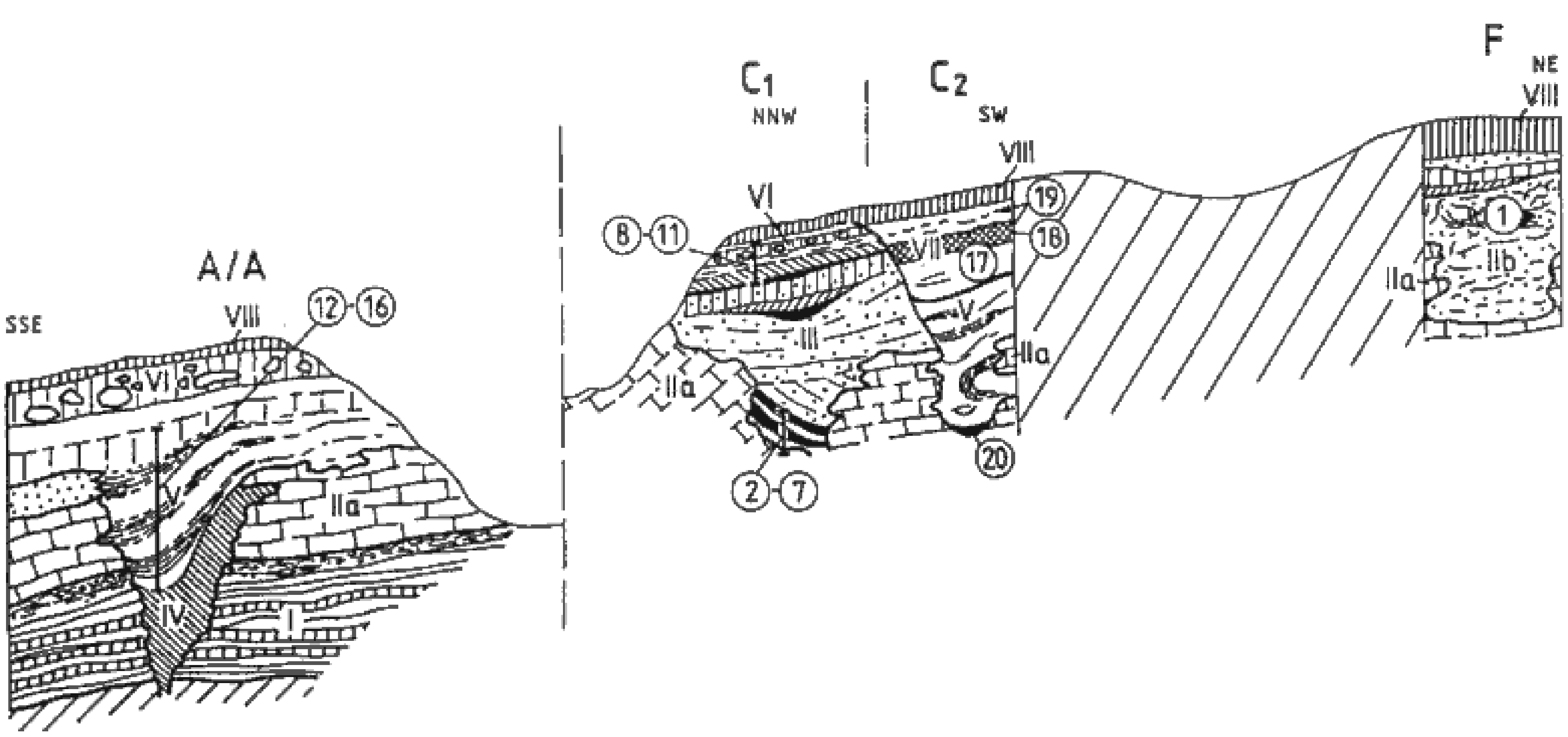
12. Section exposed in face and south side of trench C_2 in 1989: 1 - artificial fill; 2 - humic topsoil, dark gray, with fragments of flysch rocks; 3 - colluvial loam; 4 - B horizon of subfossil soil (Smolíková's palaeopedological sample No. 18 - this paper); 5 - loam, colluvial, clayey; 6-24 - various types and kinds of scattered colluvial loam, clay and soil sediments (equivalent to the joint infill in sections drawn in area A); 25 - sandy-clayey loam, rusty-brownish-black to black, scattered, lenticular; subjacent material filling joint, with horizons 6-24; equivalent to lower layers in trench C_1 (Smolíková's palaeopedological sample No. 20); 26 - olive-light-gray, sandy-clayey, thin coatings; 27 - strongly corroded, thick bedded travertine; A - continuation of layers from middle part of section C_1 (Ľ. Kaminská).

contemporaneously with the additional supply of an allochthonous component. For this reason only rendzina-type soils lie predominantly on travertines dating from the last interglacial (Smolíková - Ložek 1962).

5. Most of the terra fusca-type soils have been found preserved as autochthonous or paraautochthonous deposits (Smolíková 1990).

Application of what has been said above to the locality under consideration inevitably leads us to the **following conclusions:**

a) The terra fusca as described above has not developed in quite a typical manner and did not achieve a peak in formation. It is strongly contaminated by allochthonous components and its braunlehm fabric plasma is optically



13. Sketch showing development of the travertine mound and its overlying deposits at Skalka. Phases of accumulation and sampling sites for palaeopedological analysis indicated with the Roman numbers I-VIII and encircled numbers 1-20 respectively (J. Kovanda).

inactive throughout soil matrix, etc.

b) Because this soil was mantled by other deposits, it is neither polycyclic (as is the case of the same soils developed on older substrata) nor harmonic in nature.

c) Because this soil was destroyed and overlain by soil sediments, colluvium and aeolian deposits, it does not occur in the mode of relict soil and hence may not have been exposed to postglacial climates.

d) This soil has a small thickness (but this may also be due to subsequent redeposition) and has hitherto faintly developed corroded forms at its lower contact.

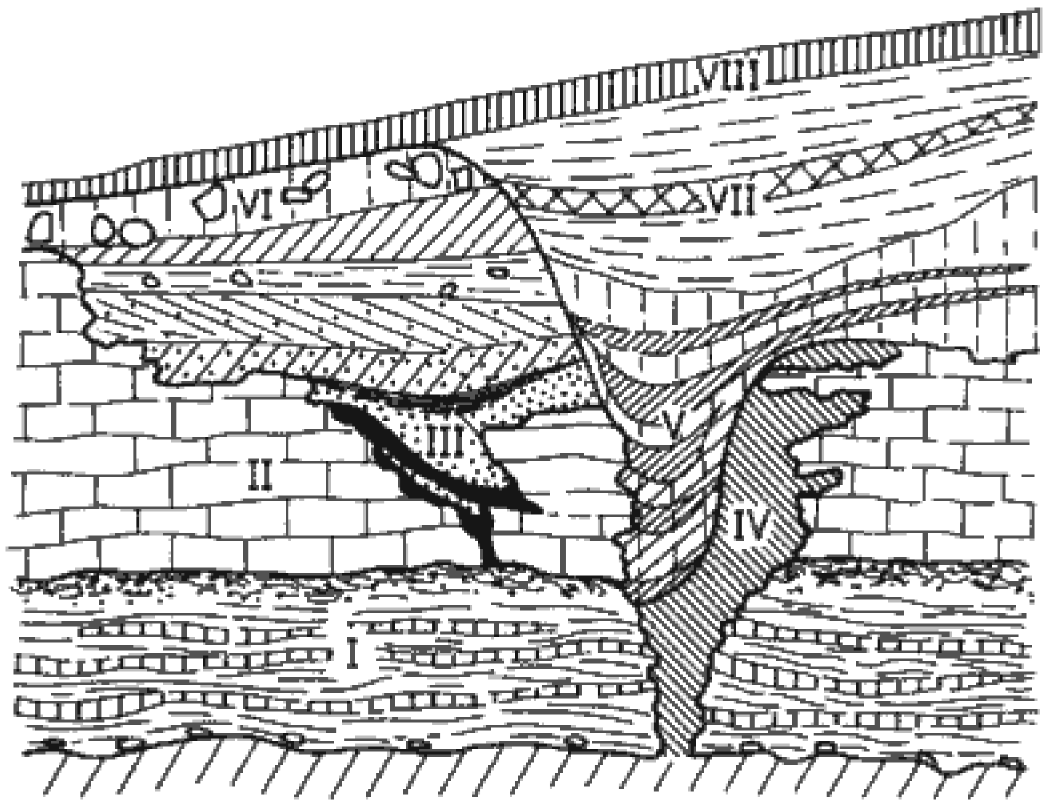
e) The occurrence of terra fusca in the mode of paraautochthonous fossil has been recorded only on weathered surfaces of tabular or thick bedded travertine (trench F). However, the high pedochemical stability of terra fusca allowed it to occur in the mode of soil sediment bolluses in a number of overlying layers, a discovery hitherto not confirmed to such extent from any other locality.

f) Since terra fusca in Czechoslovakia is as yet known only from travertines demonstrably older than the last interglacial (Ložek 1964), it is to be expected that the compact travertine at this locality may be of pre-Riss/Würm (pre-Eemian) age - see Kovanda (1993b).

Only one autochthonous soil has been found preserved at the locality, namely in the upper part of the trench C_2 section (thin section 17-1). This is an illimerized soil developed from loess loam, weakly mixed with humus by secondary processes and subject to pseudogleying, its upper subhorizon being slightly redeposited.

Considering that its material, which may well be diagnosed micromorphologically, has not been observed in any of the other profiles at this site, it is likely that this soil is Holocene in age. Further, it is not mantled by aeolian deposits but only by sediments laid down by runoff.

By comparing the different development of soils on the same substratum, (pure aeolian deposits or mixed with collovium), i.e. illimerized soils on one hand, and pseudogley on the other, it is obvious that climatic conditions controlling pedogenetic processes at this site were considerably wetter in the past than today.



14. Idealized scheme showing the succession of depositional patterns observed by phases of accumulation I-VIII in the travertine mound at Skalka (J. Kovanda).

Summary

The results of detailed soil micromorphological study of all the profiles can be summarized as follows:

1. The bulk of the soils studied at the site occurs in the mode of soil sediments represented by (i) redeposited terra fusca derived from travertine, (ii) pseudogley on the substratum of flysch colluvium mixed with aeolian deposits and (iii) brown humic soils coming from the same substratum as described under (ii), all found in greatly varying

proportions. The recurrent alternation of these soil sediments, coupled with the varied composition pronounced in the allochthonous components of aeolian deposits or in those transported by surface runoff, is a response to the high rate of accumulation and removal of sediments at the locality and in its immediate vicinity.

2. All the soil sediments show hydromorphic features varying in both frequency and intensity. Particularly prominent are the hydromorphic features observed in the older layers above the weathered travertine with deposits suggesting undoubtedly marshy environment, e.g. swamp (see the lower part of section, trenches C_1, C_3 and C_2).

3. Soil derivatives are accompanied by layers of calcareous tufa and sediment formed by deposition from mineralized (i.e. with dissolved solid) and probably thermal spring waters. Coatings of iron (Fe^{3+}) oxides and hydroxides alternate with those consisting of manganese compounds and carbonates.

4. Most of the mixed soil sediments contain numerous fragments of coalified wood, mollusc shells and opal phytoliths.

5. Of greatest importance in the palaeopedological aspect is the recognition of terra fusca. It occurs on the surface of weathered tabular travertine (trench F) in the mode of paraautochthonous fossil soil. Fortunately, its high pedochemical stability allowed it to occur as fossil sediment bollus in several everlying beds. Because it was mantled by other deposits without reaching a maximum strength of development, it is neither polycyclic not harmonic in nature.

6. Since terra fusca in Czechoslovakia is so far known only from the surfaces of travertines older than the last interglacial, it is to be expected that the travertine at this locality may pre-date the Riss/Würm (Eemian). It should be noted, however, that terra fusca-type soils are known to have developed in a complete manner, but the equivalent soil at Hôrka failed to attain its full development. The corrosion forms, are developed faintly at the lower boundary of the soil which attains a small thickness, but this may be due to subsequent redeposition, etc. In addition, incomplete braunlehm nodules can be seen on micromorphological grounds, among others. It is therefore not possible to interpret the stratigraphical meaning of terra fusca at Hôrka with higher precision.

7. The only soil occurring at the site in the mode of autochthonous subfossil soil is the illimerized soil derived from loess loam. Considering that its material has not been observed in any of the several members of all the profiles studied at the site, with only thin colluvial loam above, it is likely that this soil is Holocene in age.

Translated by V. Marek

U series dating of the Hôrka travertine samples

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Introduction

The ^{230}Th:^{234}U dating technique is now well established for determining the ages of suitable calcite precipitates that are younger than ~400,000 y BP. Two assumptions must be made in its application: 1. that U isotopes form soluble complexes in water of the common environmental pH range and thus may be co-precipitated in the calcite ($CaCO_3$) lattice but that Th isotopes are insoluble. ^{230}Th measured in the calcite is presumed to derive from decay of ^{234}U (half life = 2.5 x 10^5 years). In practice, it is recognized that some ^{230}Th will be present initially in most natural calcites, held on detrital clay colloids, etc. trapped within the crystal layers. Its effect as a contaminant is judged by also measuring the abundance of common thorium, ^{232}Th. A ratio, ^{230}Th:^{232}Th, of $\geq$ 20:1 is taken to imply that there was negligible detrital ^{230}Th present at precipitation. 2. that once precipitated the calcite is "closed" to any subsequent alteration such as recrystallisation or preferential leaching of U that might disturb the radiometric clock. In addition, it is desirable that the calcite contain more than ~0.1 ppm of uranium because of the large sample masses required and difficulties of clean extraction that may be encountered where the abundance is much lower (see e.g. Ivanovich - Harmon 1992, Ford - Williams 1989).

In our 25 years of experience with terrestrial calcites at McMaster University, natural spring travertines are generally less well suited to U series dating than speleothem deposist in caves because they tend to conform poorly to these requirements. U content is often much less than 0.1 ppm. Airborne dust and clay in aqueous suspension is trapped in large quantities, yielding ^{230}Th:^{232}Th ratios that are frequently <10:1. The calcite crystal structure is very porous and earthy as consequences of decay of incorporated plant remains or of local evaporation, which may permit post-depositional leaching of U. Residual organic matter can chelate the U isotopes during the chemical extraction procedures, leading to their complete loss from an analysis.

Standard U series dating practice is to estimate the U and Th isotope ratios by counting disintegrations in an alpha spectrometer (Ivanovich - Harmon 1992, op. cit). The technique yields accurate to ± 5-10 % at one standard deviation. Suitable amounts of calcite are dissolved in weak acids and passed through cation or anion exchange columns to separate the uranium and thorium. Column extracts are plated on to stainless steel discs for counting. A more modern technique mounts the extracts on vanadium filaments that are burned off in a mass spectrometer (thermal ionisation mass spectrometry - "TIMS"): this permits direct counting of all U and Th atoms (not merely those that are decaying

Table 1. Values of measurements of absolute age of U - dated samples from the travertine mound Hôrka near Poprad

Sample #	U content (ppm)	% yield U	Th	$^{234}U/^{238}U$	$^{234}U/^{238}U_o$	$^{230}Th/^{234}U$	$^{230}Th/^{232}Th$	Age (years)	1 Standard deviation error
95 Hôrka 1	1.511	36 %	11 %	1.055	1.086	0.777	56	159,000	+15,900 -13,900
95 Hôrka 2	0.653	19	31	1.081	1.123	0.755	53	148,000	+10,500 -9,600
95 Hôrka 3	0.453	20	29	1.034	1.057	0.826	65	186,000	+18,400 -15,000
95 Hôrka 4B	0.517	49	9	0.993	0.989	0.733	83	143,600	+17,500 -15,100
95 Hôrka 4T	0.438	25	17	1.011	1.017	0.735	25	143,500	+15,200 -13,300
95 Hôrka 5	0.389	11	16	1.124	1.168	0.666	14	116,000 (uncorrected 109,000)	+12,000 -11,000
95 Hôrka 6	0.42	11	23	0.971	0.944	0.871	31	228,000	+48,000 -33,000

during the measuring period), allowing considerable reduction in necessary sample sizes and improving accuracy to ~1 % at one or two standard deviations (Edwards et al. 1986/1987).

The Hôrka Travertine Samples

Six small travertine blocks from the Hôrka deposits were submitted to the McMaster laboratory in November 1994. Seven samples were taken from them for $^{230}Th:^{234}U$ dating by alpha spectrometry. All seven analysis yielded acceptable results. They are presented in Table 1. In light of the difficulties mentioned above, the results are very good, amongst the best that the McMaster laboratory has encountered when working with spring travertines. It is seen in Table 1 that all measured U concentrations are well above the 0.1 ppm desirable minimum. Yields of ^{233}U or ^{229}Th, (artificial radio isotopes placed in each sample at dissolution to trace the efficiency of the chemical extraction) are satisfactory. In only one example, Hôrka 5, is the $^{230}Th:^{232}Th$ ratio below 20: this implies that there was remarkably little detrital contamination when the calcites were precipitated at this open air site. In summation, the sample set can be expected to yield ages of very high precision by the TIMS method if further archaeological work at the site warrants its application.

Detailed notes are:

95 Hôrka 1 - section (area) B - above the second initial Rendzina soil (counted from bottom) - is a very dense, porcellaneous travertine layer 18 mm in thickness. A sample of 36 gm was taken across the entire layer. The result is analytically good. The mean age of the sample is ~160,000 (± 10 %) years.

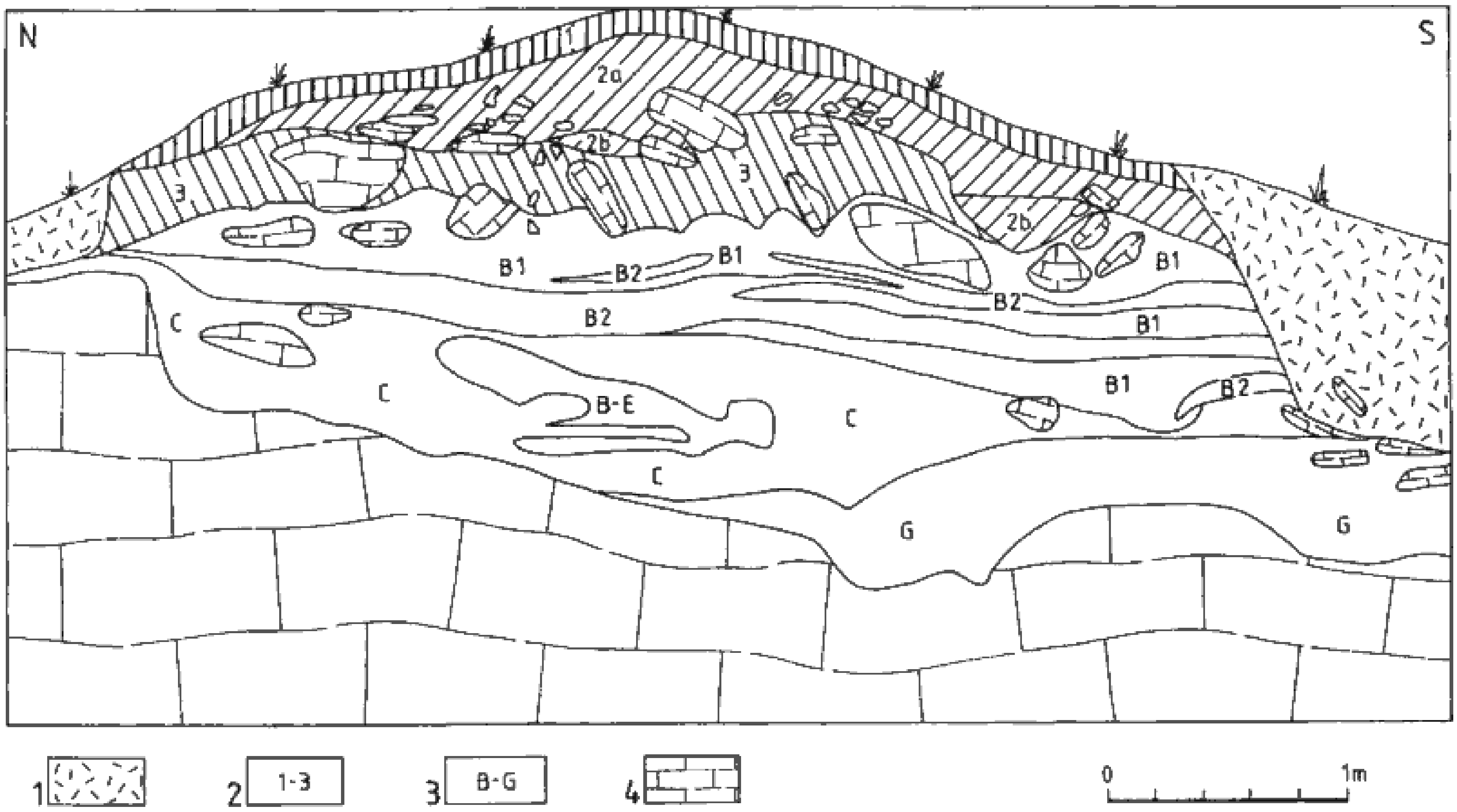
95 Hôrka 2 - section D in area A - upper part of thick bedded travertines - is a dense porcellaneous travertine layer 30 mm in thickness. It contains many vugs, thus there may have been U leaching. A 37 gm sample was taken across the layer. The result is analytically good, however, and the mean age is 148,000 (± 7 %) years.

95 Hôrka 3 - section B in area A - base of the thick-bedded travertines - is a 20 mm travertine layer very similar to Hôrka 2. A 38 gm sample was taken from the entire layer. The result is analytically very good. The mean age of the sample is 186,000 (± 10 %) years.

95 Hôrka 4 - section C - hard, platy travertine with leaf-impressions (below section in trench C1) - is a dense porcellaneous travertine layer 36 mm thick. The upper half of the sample displays higher vug porosity. Two samples were taken from this layer: -4B = the basal 18 mm. 4T = the upper 18 mm. Sample weights were 33 and 36 gm, respectively.

Hôrka 4B displays a depleted ^{234}U:238U ratio. The suggests that there may been a loss of ^{234}U, which would result in too great an age obtained. However, there is no detrital contamination ($^{230}Th:^{232}Th = 83$), so that leaching loss was probably minor. Hôrka 4T displays a higher detrital Th ratio (25). If it is assumed that detrital Th was deposited in the ratio, $^{230}Th:^{232}Th = 1.25$ (which often occurs in natural systems), then the age estimate is 139,000 (± 14 %) years. If a ratio of 1.0 is assumed, this increases to 143,500 (± 10 %) years.

From the results of 4B and 4T taken together it is probable



15. Area A, section A/G: 1 - dump; 2 - Holocene layers; 3 - slope loam and soil sediments of horizons B-G; 4 - travertine thick bedded (Ľ. Kaminská).

that this layer accumulated in just a few thousand years around 140-145 ka BP.

95 Hôrka 5 - trench F - lense in weathered travertine (near surface of an infill above hard thick-bedded travertine) - is travertine that has vugs is less vitreous than the previous samples. It is 30 mm in thickness. The stratigraphic orientation of this sample is not apparent. 50 gm was taken across it. This specimen displays significant detrital contamination. If an initial depositional $^{230}Th:^{232}Th$ ratio of 1.25 assumed it is ~110,000 years BP in age. If 1.0 is taken, it is ~115,000 years.

95 Hôrka 6 - floating block (boulder) of a hard travertine in loamy colluvial deposit overlying both the hard travertines of the mound and the infill of trench C1 - is a 30 mm sample that is similar to Hôrka 5 in appearance. A 50 gm sample was taken.

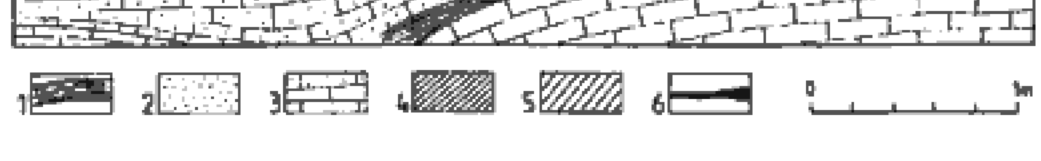
The result displays a minor analytical problem - like Hôrka 4B the $^{234}U:^{232}U$ ratio suggests that post-depositional preferential leaching of ^{234}U may have occurred. This problem plus low U content and low yields lead to the calculation of an age of 228,000 ± 20 % error.

Archaeological data from the Middle Palaeolithic Locality at Hôrka-Ondrej

Ľubomíra Kaminská

Few archaeological investigations of travertine localities in Slovakia have so far usually carried out on remains of travertine mounds left after their exploitation. The locality at Hôrka-Ondrej is no exception to the situation encountered elsewhere.

Between 1955 and 1960, the locality was studied by F. Prošek, V. Ložek and E. Vlček. A short paper on the locality was published by Bánesz in 1961. Four to six layers yielding archaeological material were distinguished in the main section (see fig. 5). Finds from a "crater" were accompanied by about 500 pieces of chipped stone industry, along with ample faunal and malacofaunal material. Since the Middle Palaeolithic chipped industry shows close relationships to interglacial fauna, the travertine under study was classified into the same time interval as that at Hrádek mound in the



16. Area A, section A/D2: 1 - travertine layers orange or black; 2 - travertine light gray chalky - Horáček's layer A/D2 X with Ložek's (1993) malacofauna No. 4 (see this volume); 3 - travertine thin bedded; 4 - clay grayish brown; 5 - clay burnt; 6 - clay dark brown to black (Ľ. Kaminská).

village of Gánovce, i.e. to the last interglacial (Prošek - Ložek 1957, p. 57; Bánesz 1991, p. 51).

Systematic archaeological investigations were initiated in 1987. The locality, about 60 by 65 m in size, was divided into areas A to F (Kaminská 1991, 1992, 1993). New material continuously discovered in several areas permitted them to be correlated with one another (fig. 4).

Most extensive investigations have so far been carried out in area A lying southwest of the locality. Published sections show complicated structure (figs. 6, 7, 15). Top parts of the sequence consist of clayey deposits which also fill depressions in the underlying travertine. The lower parts are locally composed of sandy travertine. The clayey deposits, especially horizons C to G, and the travertine layers also yielded numerous chipped stone tools and bones of hunted animals, i.e. remains of a primeval settlement. A hearth was uncovered in horizon D, with its south side destroyed by quarrying the travertine. The hearth consists of a layer of burnt clay mixed with animal bones and stone artifacts. Its reviewed part was irregular in ground plan locally showing signs of landslipping.

The chipped stone industry is Middle Palaeolithic in nature. The artifacts were produced by the Clactonian stone-chipping technique using especially quartz followed by radiolarite. Typologically, side-scrapers and knives predominate over points (fig. 17). The stone inventory largely includes flakes and pieces; i.e. byproducts originating during the artifacts manufacturing and provide evidence that this production comes directly from an area of primeval settlement.

A characteristic feature of the stone industry is the wide use of flat retouche on various tools, such as side-scrapers, knives, point or flakes, especially when made from a higher-quality raw material, i.e. radiolarite.

The chipped stone industry from clayey deposits in area A is somewhat analogous to the Middle Palaeolithic industry recorded from Slovakia and neighbouring countries. As far as travertine localities are concerned, finds showing closest relationships to the site at Hôrka-Ondrej are those from Gánovce (Vlček 1969, p. 48) and Beharovce, two sites yielding material ranged to a group of Mousterian cultures known from the last interglacial (R/W, Eemian - Bánesz 1990, pp. 68, 69). In addition to the travertine localities in the Spiš area, the industry from Hôrka-Ondrej offers some parallelism with the finds from Bojnice I and III (Bárta 1972). Flatly retouched radiolarite side-scrapers were found in the Myjavská paHôrkatina Uplands as a part of another Mousterian finds (Bárta 1984, pp. 13, 14). Re-examination of the Middle Palaeolithic industry from Trenčín-Zamarovce has revealed that it can be identified as Micoquian, its inventory also containing flatly-worked-out side-scrapers (Bárta 1990, pp. 125, 126).

In the Transcarpathian Ukraine, closest resemblance to the finds Hôrka-Ondrej bears the Mousterian group of industries known as Korolevo IIa (Kulakovskaja 1989, p. 106). ^{14}C dates indicate that the industry from Korolevo IIa is more than 60 000 years old and is thus assigned to the beginning of the Last Glacial, i.e. between the close of the Riss/Würm and the Brörup Interstadial (Gladilin 1989, p. 101).

Compared with the Hungarian finds, it should be noted that the Hôrka-Ondrej industry is analogous to that suggesting the beginning of the Würm at the travertine localities called Tata (Gábori - Csánk 1968) and Érd (Vértes 1964), as well as to the material recently described by Gábori-Csánk (1983, pp. 284, 285) as Jankovician.

The chronological classification of the cultural layer yielding industry in area A and ranged to the beginning of the last glacial is also supported by charcoal pieces obtained from the hearth in horizon D. This material belongs to wood species typically occurring when less favourable climatic conditions are approached, namely *Alnus* spec., *Carpinus betulus, Pinus* spec. cf. *sylvestris*, etc. (Hajnalová - Hunková 1990). The initial phase of glaciation is also attested by analytical data recently obtained for the fauna from horizons D to G in area A (Horáček 1992).

The underlying travertine in area A continues also in area B. Four to six travertine layers yielding the Middle Palaeolithic chipped industry were originally found, then completely exploited and classified by Bánesz (1990 pp. 50-55) to the last interglacial. In 1992 only a few rather untypical pieces of the industry were obtained from the settlement horizon destroyed by the travertine quarrying.

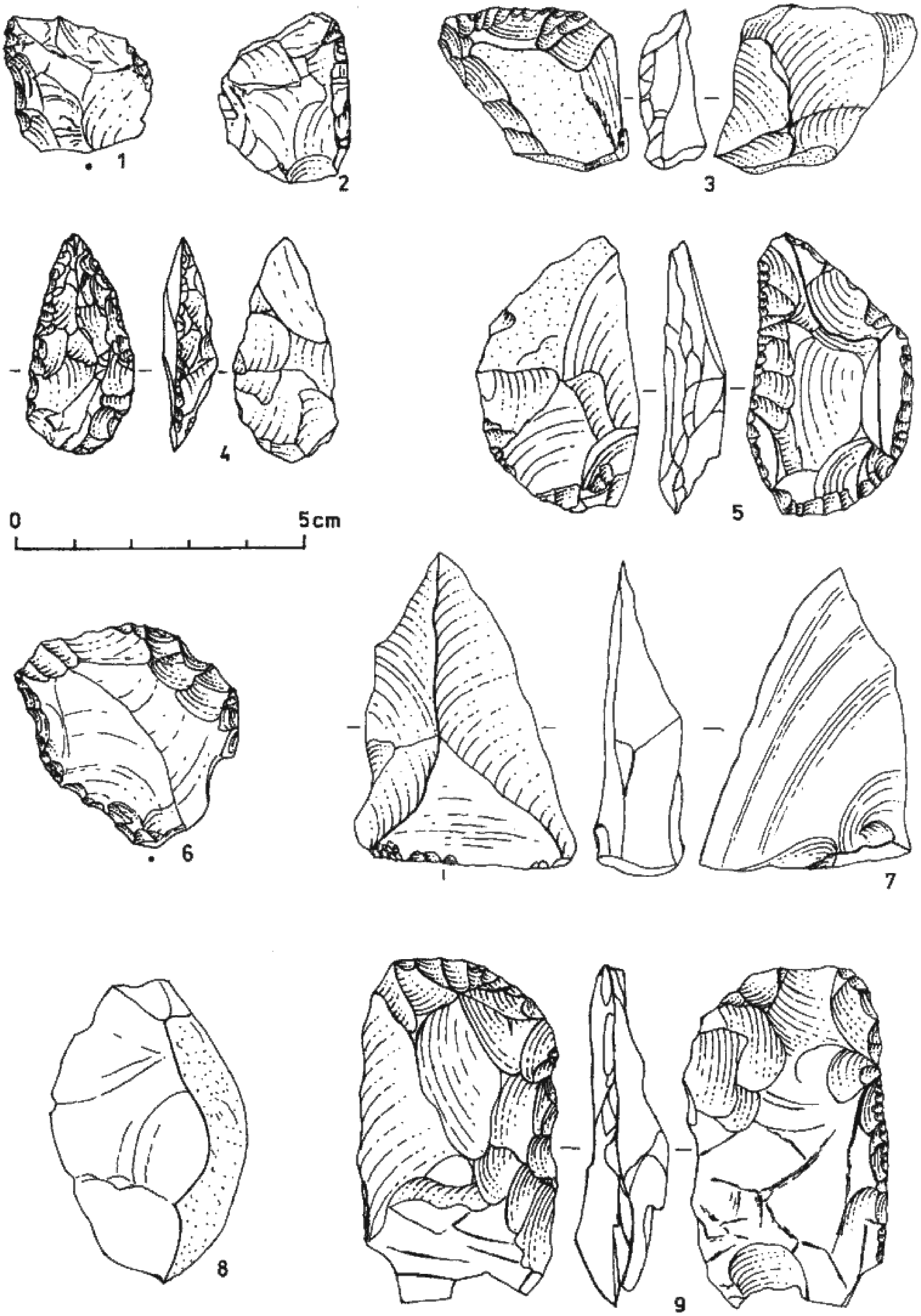
A characteristic feature of area C is the upper part of the travertine sequence. The base consists of compact travertine which grades upward into thick layers of sintered limy and clayey deposits terminated by a rendzine. In layer 12 of section C_1 (fig. 11) charcoal pieces were found together with burnt animal bones and several chipped stone tools made of quartz. These finds suggest a possible presence of a hearth. Sporadic finds of chipped tools from the base of the strata in section C_2 are also noted (fig. 12).

The remaining part of the mound, referred to as area D, can perhaps be regarded as the central part of the site. The upper parts of the travertine are less compact and pass gradually downwards into massive parts showing bedding. A chipped stone industry, faunal remains and floral impressions were found in less compact travertine.

Valuable information on the development of the travertine was obtained from trenches E and F, in particular from the section drawn in trench F (pl. VI/1).

The travertine at Hôrka-Ondrej evidences that the nearby surroundings of mineral springs was occupied recurrently by man during the Middle Palaeolithic period. The chipped stone industry from the travertine layers in areas B and D can be regarded as the earlier evidence of human settlement. The finds obtained from layer 12 in section C_1 are younger. The material gained from the clayey deposits in area A is the youngest as it corresponds to the end of the Middle Palaeolithic.

Additionally it should be noted that this site was inhabited in the Early Bronze Age by people of the Ottomanic culture,



17. Chipped stone industry from area A (Ľ. Kaminská).

since they have left their mark, e.g., in the upper part of trench F. Evidence is also available indicating the settlement during the Middle Ages, as supported by objects found in the pit dug in the southern section of area B.

Translated by E. Gromová

Molluscan fauna from the travertine at Hôrka-Ondrej

Vojen Ložek

Petrbok (1937) was the first to record the occurrence of molluscs at the locality, but he made no stratigraphical or chronological evaluation of his findings. As matters now stand, it is very problematic to correlate his finds with the stratigraphy of recently exposed sections. Of palaeoclimatic importance is only *Helix pomatia* reflecting interglacial conditions. Other species record only grassland, wetland or aquatic environment of minor palaeoclimatic significance.

During the investigations of the adjacent Middle Palaeolithic site of the travertine mound at Gánovce attention was also paid to the travertine quarry at Hôrka-Ondrej. It was this locality where F. Prošek discovered Middle Palaeolithic artifacts and documented a profile which roughly corresponds to the section B (see fig. 5) exposed by new excavations (Prošek - Ložek 1957). At that time molluscs were collected which predominantly came from loose tufaceous layers yielding only species reflecting grassland, wetland and aquatic environments. Fragments of a few thermally demanding species were obtained only from separated blocks of solid travertine. These are: *Aegopinella* sp. and *Drobacia banatica*, both documenting an interglacial age of the travertines (Ložek 1958).

Excavations made by Ľ. Kaminská produced a rather rich molluscan fauna coming from different stratigraphic levels and sections (Ložek 1993). Table 2 of molluscan fauna includes the results of analyses from twelve selected sampling sites. These represent all the main stratigraphic horizons and various sediment facies. Table 2 also gives basic information on the stratigraphic and palaeoenvironmental significance of individual species.

Samples 1 and 2 have been taken from thin humic horizons within the thin bedded travertine exposed in section B (fig. 5). They include a terrestrial assemblage dominated by openground species, such as *Pupilla muscorum*, both *Vallonia* and *Vertigo pygmaea* all associated with *Bradybaena fruticum* and *Euomphalia strigella*. These indicate a parkland under rather mild climatic conditions, which is equally supported by the occurrence of *Cochlicopa lubricella*. Of stratigraphic importance is the record of *Discus ruderatus*, a species characteristic of initial phases of warm periods. The composition of the whole assemblage supports this interpretation.

Sample 3 also falls within the initial phase of travertine formation (fig. 6), but it represents a swamp facies as documented by the presence of species from ecological group 9 as well as by comparatively high numbers of *Radix ovata* and *Stagnicola turricula* which live in small pools with clear stagnant water. Of biostratigraphic importance is the record of *Vertigo moulinsiana* indicating a relatively warm climate.

Sample 4, taken from the uppermost horizon of the tufa succession in section A/D (fig. 16), is likewise characterized by numerous open-ground species of group 5, and also includes true steppe elements such as *Chondrula tridens* and *Pupilla triplicata*. *Euomphalia strigella* is also important. In addition, there are records of *Acicula polita* and of a fragment of *Helix pomatia* (?), again both characteristic of warm, i.e. interglacial phase. Swamp species of group 9 occur in abundance, which is particularly true of *Anisus leucostomus* indicating ephemeral waters. These lines of evidence indicate that a warm damp forest existed in a close vicinity of the travertine deposit covered only by herb vegetation. Such landscape character may correspond to the early phase of an interglacial climatic optimum.

From loose layers in the top part of the truncated central spring cone (area D - sample 5) a snail assemblage has been extracted which predominantly consists of marshland (Gr. 9) and aquatic species (Gr. 10) and hence documents that small but rather persistent water bodies existed in a sedimentary environment. There also occurs an admixture of xeromesic open-ground elements (Gr. 5), whereas several fragments of *Bradybaena* and *Euomphalia* suggest a near occurrence of scrub and woodland mantle formations. In contrast to this, the white travertines with numerous leaf impressions before trench C_I (fig. 11; sample 6, pl. VII/1) are so poor in shells that their fauna can only document a swampy environment.

Of particular biostratigraphic importance is the molluscan sequence from section C_I (fig. 11). The oldest fossiliferous horizon (12b) containing shells (sample 7) is developed as a calcareous interlayer in black loams covering the solid, heavy bedded, steeply-dipping travertine. Its fauna includes, besides marshland (Gr. 9) and grassland species (Gr. 5), large amounts of *Bradybaena* and *Euomphalia* accompanied by *Discus ruderatus*, which indicates conditions similar to those of early warm phases.

From the biostratigraphic point of view, the fauna from sample 8 (layer 10b) is of prime importance. It is characterized by high amounts of woodland elements, including interglacial index species, such as *Drobacia banatica*, *Discus perspectivus* or *Cepaea vindobonensis*, as well as other climatically demanding snails. However, these are associated with a number of openground, indifferent, marshland and aquatic species in substantial amounts. This composition of malacofauna suggests that during the formation of this layer dry and moist terrestrial habitats as well as small pools occurred in the area of the travertine mound. They were surrounded by a damp woodland under climatic conditions that were moister and warmer than those at present. Such a palaeoenvironmental pattern corresponds to the culmination of an interglacial.

Table 2. Mollusca from the travertine mound at Hôrka-Ondrej

Ecologic and biostratigraphic characteristics				List of species	SAMPLE											
					1	2	3	4	5	6	7	8	9	10	11	12
A	1		!	*Acicula polita* (Hartmann)	-	-	-	G	-	-	-	G	-	-	-	-
			!	*Cochlodina laminata* (Montagu)	-	-	-	-	-	-	-	G	-	-	-	-
			!!	*Discus perspectivus* (Mühlfeldt)	-	-	-	-	-	-	-	M	-	-	-	-
			(G)	*Discus ruderatus* (Férussac)	G	-	-	-	-	-	G	-	-	-	-	-
			!!	*Drobacia banatica* (Rossmässler)	-	-	-	-	-	-	-	G	-	-	-	-
			!	*Helicodonta obvoluta* (Müller)	-	-	-	-	-	-	-	M	-	-	-	-
			!	*Isognomostoma isognomostoma* (Schröter)	-	-	-	-	-	-	-	G	-	-	-	-
			!	*Ruthenica filograna* (Rossmässler)	-	-	-	-	-	-	-	G	-	-	-	-
			!	*Vitrea subrimata* (Reinhardt)	-	-	-	-	-	-	-	G	-	-	-	-
	2	W(M)	!	*Discus rotundatus* (Müller)	-	-	-	-	-	-	-	G	-	-	-	-
		W(S)	!	*Aegopinella minor* (Stabile)	-	-	-	-	-	-	-	G	-	-	-	-
			(!)	*Bradybaena fruticum* (Müller)	G	M	-	-	G	-	H	M	M	M	-	(G)
			(G)	*Cochlodina cerata* (Rossmässler)	-	-	-	-	-	-	-	-	-	-	-	H
			!	*Helix pomatia* Linné	-	-	-	G?	-	-	-	G	-	-	-	-
	3		(G)	*Clausilia pumila* C. Pfeiffer	-	-	-	-	G?	-	-	-	-	-	-	-
			!	*Macrogastra ventricosa* (Draparnaud)	-	-	-	-	-	-	-	G	-	-	-	-
			(G)	*Monachoides vicina* (Rossmässler)	-	-	-	-	-	-	-	G	-	-	-	-
B	4		(+)	*Chondrula tridens* (Müller)	-	-	-	G	-	-	-	G	M	M	-	M
			M	*Oxychilus inopinatus* (Uličný)	-	-	-	-	-	-	-	-	-	-	-	G
			(+)	*Pupilla triplicata* (Studer)	-	-	-	G	-	-	G	M	G	-	-	-
			!!	*Cepaea vindobonensis* (Férussac)	-	-	-	-	-	-	-	G	-	-	-	G
	5		++	*Pupilla loessica* Ložek	-	-	-	-	-	-	-	-	-	-	H	-
			+	*Pupilla muscorum* (Linné)	G	M	G	M	M	-	M	-	H	M	-	G
			(!)	*Truncatellina cylindrica* (Férussac)	-	-	-	G	G	-	G	-	G	G	-	M
			(+)	*Vallonia costata* (Müller)	G	M	-	H	G	-	H	M	H	M	-	G
			G	*Vallonia pulchella* (Müller)	H	M	M	M	M	M	G	M	-	-	-	M
			(G)	*Vertigo pygmaea* (Draparnaud)	H	H	M	G	G	-	G	G	-	G	-	-
C	6		(!)	*Cochlicopa lubricella* (Porro)	G	G	-	-	-	-	-	G	G	-	-	-
			(!)	*Euomphalia strigella* (Draparnaud)	G	-	-	M	G	-	H	G	M	H	-	G
	7		(+)	*Limacidae/Agriolimacidae* (kleine Arten)	-	-	-	G	G	-	-	G	-	-	-	-
			(+)	*Nesovitrea hammonis* (Ström)	G	-	-	-	-	-	G	G	-	-	-	-
			(+)	*Punctum pygmaeum* (Draparnaud)	G	-	G	G	-	-	-	G	-	-	-	-
	8		!	*Carychium tridentatum* (Risso)	-	-	-	G	G	-	-	G	-	-	-	G
			(+)	*Succinea oblonga* Draparnaud	G	-	G	G	-	-	G	G	-	G	G	(G)
			(G)	*Vertigo substriata* (Jeffreys)	-	-	-	-	-	-	-	G	-	-	-	-
D	9		G	*Carychium minimum* Müller	-	M	G	G	G	-	-	G	-	G	-	-
			G	*Euconulus alderi* (Gray)	G	-	-	-	G	-	-	G	-	-	-	-
			(G)	*Oxyloma* cf. *elegans* (Risso)	-	-	M	M	M	-	G	G	-	G	(G)	(G)
			G	*Pupilla alpicola* (Charpentier)	G	M	-	M	G	-	G	M	G	-	-	-
			(+)	*Succinea putris* (Linné)	-	-	-	M	M	-	-	G	-	-	-	-
			(!)	*Vallonia enniensis* Gredler	-	-	-	G	-	-	-	G	-	-	-	-
			(G)	*Vertigo angustior* Jeffreys	-	H	-	M	M	-	G	G	-	-	-	(M)
			(G)	*Vertigo antivertigo* (Draparnaud)	-	-	G	G	G	G	G	M	-	-	-	-
			!	*Vertigo moulinsiana* (Dupuy)	-	-	G	-	-	-	-	-	-	-	-	-
	10		(+)	*Anisus leucostomus* (Millet)	-	-	-	M	M	G	G	H	-	-	-	-
			(+)	*Galba truncatula* (Müller)	-	-	-	-	G	-	-	-	-	-	-	-
				Gyraulus crista (Linné)	-	-	-	-	G	-	-	G	-	-	-	-
			(+)	*Pisidium obtusale* (Lamarck)	-	-	-	-	-	-	-	G	-	-	-	-
			(+)	*Radix ovata* (Draparnaud)	-	-	M	-	G	-	-	M	-	-	-	-
			(+)	*Stagnicola turricula* (Held)	-	-	M	G	G	-	-	M	-	-	-	-
				Valvata cristata Müller	-	-	-	-	-	-	-	-	-	-	-	(G)

However, the overlying layers (samples 9 - layer 9 and 10 - layer 5) in turn include an assemblage without characteristic woodland elements reflecting a steppe-like parkland. Of particular interest in this context are the peculiar dwarfed forms of *Bradybaena fruticum* and, in particular, of *Euomphalia strigella*.

In section B, the most complete terrestrial sequence covering the travertines has remained preserved. Its basal member is a scree with boulders of solid travertine and loess-like matrix. Upwards, it grades into a loess-like loam capped by medium-coarse scree with dark rendzina matrix, overlain by a thick black mull rendzina soil on the surface. The "loess" includes a fauna (sample 11 - fig. 5, layer 6) poor in species and dominated by *Pupilla loessica* reflecting a loess steppe under pleniglacial conditions. The overlying scree (sample 12 - fig. 5, layer 8) contains a steppe community which also includes *Cochlodina cerata* in high amounts, indicating an open woodland or parkland.

The evidence presented here demonstrates that the composition of the molluscan fauna is rather monotonous, indicating that the great majority of travertine layers exposed in areas A, B and D formed in a parkland under climatic conditions corresponds to those of early warm periods. The interglacial climatic optimum is documented only by the fauna of sample 8, whereas the assemblages from samples 9 and 10 reflect a rather dry parkland of declining interglacial. The covering terrestrial sequence preserved in section B (fig. 5) formed during the Weichselian Pleniglacial-Holocene period after the phase of overall denudation (Ložek 1980) resulting in a considerable disturbance of the original surface of the mound at Skalka as is evidences by replaced boulders of compact heavy bedded travertine.

The fauna from the travertine, if expressed in terms of species composition, shows Upper Pleistocene characteristics. No species has been recorded to suggest an age prior to the last interglacial. This finding is in harmony with the development of the overlying terrestrial sequence and is in good accord with the evidence provided by older molluscan records from this area (Ložek 1958, 1961).

Translated by the author

Ecologic characteristics
Main ecologic groups: A - woodland, B - open country, C - woodland/open country, D - marshlands, banks, waters
Ecologic groups: 1 - closed woodland, 2 - predominantly woodland and partly mesic (W/M) or dry (steppic) (W/S) habitats, 3 - damp woodland, riverine forests, 4 - steppes and xerothermic rocks, 5 - open habitats in general (rocks, steppes to moist meadows), woodland or open habitats (indifferent species), 6 - predominantly dry, 7 - mesic or indifferent, 8 - predominantly moist, 9 - moist terrestrial habitats (swamps, moorlands, banks), 10 - aquatic habitats
Biostratigraphic characteristics
! - species characteristic of warm phases, !! - interglacial index species, (!) - tolerant species of warm phases, + - loess species, ++ - index species of loess, (+) - local or occasional loess species, G - species surviving the glacial out of the loess zone, (G) - dtto as relicts, M - modern immigrants
Quantity
Number of individuals (in samples): H - high, M - medium, G - low, (M) - reworked from older strata, G? - determination approximate

Survey of Upper Pleistocene vertebrate remains from the Palaeolithic site at Hôrka-Ondrej

Ivan Horáček

Vertebrate remains have nowhere been found in especial abundance but they are distributed in almost all the members of sedimentary sequences overlying the compact travertines. The remains surveyed in this report were obtained either from samples taken continuously during excavations producing most of the large mammals (see further text), or by washing large samples of deposits taken from individual layers of the section under study (see also Horáček 1992). The material thus obtained altogether includes remains of at least 460 individuals belonging to 40 species. Detailed faunal lists are given in tabs. 3, 4 and 5. Descriptions of the individual samples follow those used in papers by Kaminská - Smolíková - Kovanda - Ložek (this volume). The following is a complete list of vertebrate taxa discovered at the site (tab. 3):

Table 3. Complete list of vertebrate taxa from Hôrka-Ondrej

Amphibia, Anura 3 spp.	*Microtus oeconomus*
Reptilia	*Microtus arvalis*
Lacerta cf. *vivipara*	*Microtus agrestis*
Ophidia g.sp.	*Microtus gregalis*
Aves	*Dicrostonyx gulielmi*
Lyrurus tetrix	*Mammalia, Lagomorpha*
Passeriformes	*Ochotona* cf. *pusilla*
Mammalia, Insectivora	*Lepus* sp.
Sorex minutissimus	*Mammalia, Carnivora*
Sorex cf. *araneus*	Mustela cf. *nivalis*
Talpa europaea	*Putorius* sp.
Crocidura cf. *suaveolens*	*Ursus* cf. *spelaeus*
Neomys anomalus	*Vulpes* cf. *vulpes*
Mammalia, Rodentia	*Vulpes* gr. *corsac*
Citellus cf. *citelloides*	cf. *Felis sylvestris*
Marmota cf. *bobak*	*Mammalia, Artiodactyla*
Sicista cf. *subtilis*	*Bison* cf. *priscus*
Castor fiber	*Capra* sp.
Hystrix vinogradovi	cf. *Rangifer tarandus*
Apodemus (*Sylvaemus*) sp.	*Mammalia, Perissodactyla*
Cricetus cricetus	*Equus*, cf. *germanicus*
Clethrionomys sp.	*Coelodonta*
Arvicola terrestris	*antiquitatis*
Microtus nivalis	

Table 4. List of vertebrate records (minimum number of individuals) in sections A and B (washed samples)

Area (section) Layer (horizon) - figs 4, 5, 9, 14	A/A-A/D	A/E J	A/D_2 X	A/D_2 Y	A H	A G	A F	A E	A D	A C	A B	B *	B H
Reptilia													
Lacerta cf. *vivipara*	-	-	-	-	-	-	-	-	-	-	-	1	-
Ophidia g. sp.	-	-	-	-	1	-	-	-	-	-	-	-	-
Aves													
Lyrurus tetrix	-	-	-	-	-	2	-	-	?	-	-	-	-
Passeriformes	1	-	-	-	-	-	-	-	-	-	-	-	-
Mammalia, Insectivora													
Sorex minutissimus	1	-	-	-	-	-	-	-	-	-	-	-	-
Sorex cf. *araneus*	-	-	-	1	1	-	-	-	-	-	-	-	-
Talpa europaea	1	2	1	-	1	2	-	-	-	-	-	-	-
Crocidura cf. *suaveolens*	-	-	-	-	-	-	-	-	-	-	-	-	-
Neomys anomalus	-	-	-	-	-	-	-	-	-	-	-	-	-
Mammalia, Rodentia													
Citellus cf. *citelloides*	-	-	-	1	-	-	?	-	-	-	-	2	-
Marmota cf. *bobak*	-	-	-	-	-	-	-	-	-	-	-	-	-
Sicista cf. *subtilis*	-	1	-	-	-	-	-	-	1	-	-	-	-
Castor fiber	1	-	-	-	-	1	-	1	-	-	-	-	-
Hystric vinogradovi	-	-	-	-	-	1	1	-	-	-	-	-	-
Apodemus (Sylvaemus) sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricetus cricetus	-	-	1	1	-	-	-	-	1	-	-	-	-
Clethrionomys sp.	-	1	-	-	-	-	-	-	-	-	-	-	-
Arvicola terrestris	5	6	2	-	1	2	2	1	3	1	-	1	1
Microtus nivalis	-	1	-	-	-	-	-	-	-	-	-	4	-
Microtus oeconomus	-	1	-	-	-	-	1	-	-	-	-	-	-
Microtus arvalis	9	14	6	4	6	-	8	1	5	-	-	8	5
Microtus agrestis	2	-	1	1	-	-	-	-	-	-	-	-	-
Microtus gregalis	-	-	-	-	-	-	-	-	-	-	-	4	-
Dicrostonyx gulielmi	-	-	-	-	?	-	-	-	-	-	-	13	-
Mammalia, Lagomorpha													
Ochotona cf. *pusilla*	-	-	-	-	-	-	-	-	-	-	-	1	-
Lepus sp.	-	-	-	-	-	2	-	1	-	1	-	-	-
Mammalia, Carnivora													
Mustela cf. *nivalis*	1	-	-	-	-	-	-	-	-	-	-	-	-
Putorius sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ursus cf. *spelaeus*	1	-	-	-	-	1	-	-	1	-	-	-	-
Vulpes cf. *vulpes*	-	-	-	-	-	1	1	1	-	-	-	-	-
Vulpes gr. *corsac*	-	-	-	-	-	1	-	-	-	-	-	-	-
cf. *Felis sylvestris*	-	-	-	-	-	-	-	-	-	-	-	-	-
Mammalia, Artiodactyla													
Bison/Bos	1	-	-	-	1	1	-	-	-	-	-	-	-
Capra sp.	-	-	-	-	-	-	-	-	1	1	-	1	-
Mammalia, Perissodactyla													
Coelodonta antiquitatis	-	-	-	-	1	1	1	1	-	-	-	-	-
Equus cf. *germanicus*	-	-	-	-	1	1	1	1	-	1	-	-	-
Total/species	10	8	5	5	6	13	8	7	9	4	2	9	2
Total/individuals (180)	23	26	11	8	11	16	16	7	15	4	2	35	6

Note: Section A/D_2, layer Y - humic layer overlying chalky-sandy travertine (pl. III/2), section B, layer H - Holocene topsoil

B * = B loess + boulders

Stratigraphic aspect

1. Basal layers of the sedimentary cover, which lie mostly in area A, section A/A, A/B and A/G, horizons D-F, yielded especially numerous remains of large mammals. The whole sample, expressed in minimum number of individuals, includes the following:

Lyrurus tetrix	1	*Microtus oeconomus*	1
Talpa cf. *europaea* (mft. *magna*)	3	*Lepus* sp.	5
Castor fiber	1	*Vulpes* cf. *vulpes*	3
Hystrix vinogradovi	2	*Vulpes* cf. *corsac*	1
Sicista cf. *subtilis*	1	*Ursus* cf. *spelaeus-denningeri*	2
Cricetus cricetus	1	*Bos* sp.	2
Arvicola terrestris	8	*Coelodonta antiquitatis*	2
Microtus arvalis-agrestis	21	*Equus* cf. *germanicus*	3

The following features of the assemblage seem to be especially worth mentioning:

a) The forms characteristic of pleniglacial and/or late Weichselian age (*Dicrostonyx, Lemmus, Microtus gregalis, Ochotona*), are entirely absent, while

b) the forms suggesting interglacial habitats (*Clethrionomys, Gliridae, Microtus subterraneus, Soricidae*, etc.) are also absent.

c) A highly characteristic feature is the appearance of *Hystrix vinogradovi*, a smaller form closely related to *Hystrix cristata*. In central Europe, only few records of this genus are available, namely from Germany (Saalefeld, Pottenstein, Neumühle - Nehring 1890, Fuchsloch - Brunner 1954, etc.), Serbia (Veternica - Malez 1958), Hungary (Kalmán-Lambrecht Höhle - Jánossy 1964, Tarkö-niche part, Köhati Cave, Kiskevélyi Cave - Jánossy 1986), Austria (Repolusthöhle bei Peggau - Mottl 1960, Tropfsteinhöhle im Kugelstein - Fladerer 1989), and from Bohemia (Praha-Kotlářka - Kafka 1892, Žižkova díra Cave and Švédův stůl Cave in the Moravian Karst - Zázvorka 1944, Vaňura 1982). Following Jánossy (1986) I wish to stress that most (if not all) of these records seem to come from the same period - the earliest beginning of the of the Weichselian, i.e. Varbóian sensu Jánossy (1986).

d) The dominant representation of *Arvicola terrestris*, and the appearance of *Cricetus cricetus, Ursus* cf. *spelaeus-denningeri*, and a large-sized horse, *Equus germanicus* are as characteristic as the absence of *Dicrostonyx, Lemmus* and/or *Microtus gregalis*. All in all, this is in good accord with the faunal characteristics suggested for the period under consideration (cf. Jánossy 1986). Consequently, evidence given above suggests that the assemblage under study can be regarded as evidencing the beginning of a glacial, most probably the Weichselian.

Table 5. List of vertebrate records in section C_1 (minimum number of individuals)

Section (trench)	C_1						
Layer (horizon) - see fig. 9	12c	12	11b	10b	10a	9	8
Amphibia							
Rana sp.					1		
Rana cf. *temporaria*				1	1		
Bufo cf. *bufo*					1		
Reptilia							
Lacerta cf. *vivipara*	2	1	2				
Aves							
Lyrurus tetrix					1		
Mammalia, Insectivora							
Sorex cf. *araneus*	1		2		1		
Talpa europaea	1	2	1	1	4		
Crocidura cf. *suaveolens*			1				
Mammalia, Rodentia							
Hystrix vinogradovi					1		
Citellus cf. *citelloides*	1						
Apodemus (Sylvaemus) sp.		1					
Cricetus cricetus	2						
Clethrionomys sp.	1		1				
Arvicola terrestris	3	6	7	3	7	2	1
Microtus oeconomus	3		1				
Microtus arvalis	35	4	9	9	21	2	5
Microtus agrestis	2		2		1		
Mammalia, Lagomorpha							
Ochotona cf. *pusilla*	1						
Lepus sp.	1		1				
Mammalia Carnivora							
Putorius sp.			1				
cf. *Felis sylvestris*				1			
Mammalia Artiodactyla							
Bison / Bos				1			
Mammalia							
Equus cf. *germanicus*			1				
Total/species (28)	12	7	10	6	10	2	2
Total/individuals (163)	53	16	27	16	41	4	6

2. Middle and upper layers in the areas (sections A/C and A/D) yielded only poor faunal remains. It seems that some of the deposits are not calcareous and do not contain any fossils at all. The fragmentary material obtained from the

middle and upper layers (tab. 3) consists of infrequent remains of large mammals and a microfauna indicating poor monotonous assemblages with *Microtus arvalis, Arvicola terrestris, Cricetus cricetus*, etc. Worth mentioning here is *Sicista* cf. *subtilis*, a form characteristics of moderately warm open ground habitats. It typically occurs at the onset of the Holocene (Preboreal stage), and it may be assumed that under similar conditions it also appeared by the end of interglacials. A late Weichselian/Holocene age can be here excluded because of the absence of *Microtus gregalis* and/or *Dicrostonyx*, two leading elements of mammalian communities throughout the second half of the Weichselian and in early Holocene times.

3. The sections in trenches C_1, C_2, C_3 and F_1, drawn north of the base of the main excavation, revealed a situation that merits special attention. This can be accounted for not only by a fairly high content of fossils but especially by providing evidence of a sequence that exhibits a regular but quite a specific development not observed in the other sections. The bulk of bone material was obtained from section C_1 (fig. 11) and is discussed first here (tab. 5). Contrary to expectations, vertebrate fauna is fairly monotonous throughout the section, as are other sections. This applies to both species composition, at least as far as core community elements are concerned, and to the morphotypic structure of the commonest species (*Microtus arvalis, Arvicola*). Anyway, the appearance of *Clethrionomys* in layers 11b and 12c, as well as that of *Apodemus (Sylvaemus)* sp. in 11b, may be significant, at least in part, as an indicator of tree vegetation. This, in conjunction with *Microtus oeconomus* and *Microtus agrestis*, suggests that the site was a marshy, mesic and spatially variegated habitat. In contrast to molluscs, which unfortunately are absent in the basal layers of a dark brown clay (No. 12), the vertebrate communities of layers 10a, do not exhibit any more pronounced differences from the other in species assemblage, ecological structure and/or general patterns. There is thus no unambiguous support to the view that the layers formed at an interglacial climatic optimum, as is suggested by mollusc evidence. Only a poor assemblage of *Microtus arvalis, Arvicola terrestris, Talpa europaea*, and *Sorex araneus* has been found, i.e. without thermophilous and/or other demanding species but it shows a largely general community pattern characteristically occurring throughout the sedimentary sequence.

Although the material available is not ample enough to permit quantitative comparisons, it seems clear that species diversity is somewhat higher in layer 11b or 10a than in 12c where *Microtus arvalis* is the only species to make up 66 percent of the whole community. In association with the appearance of *Citellus citelloides, Cricetus cricetus* and *Ochotona* cf. *pusilla*, all being restricted only to this layer, the whole assemblage allows the impression that it can be attributed to a milder part of a glacial. Since both the compact travertine immediately underlying layer 12c and the soft travertine of layers collectively numbered 10 seem to have yielded interglacial (cf. Ložek this paper, Kovanda this paper, etc.), the situation encountered in layer 12c deserves special comment.

The following questions arise in this context: (1) can the assemblage discussed above be actually regarded as of glacial origin ?; if so, the compact travertine and soft material of layer 10 must inevitably be referred to different interglacials or (2) does the assemblage indicate a temporary fluctuation within one and the same interglacial stage to which both the compact and soft travertines belong. Unfortunately, there is little chance to answer these questions unambiguously. In any case, it can be stated with certainty that the assemblage of 12c cannot be assigned to any pleniglacial stage. The appearance of *Ochotona, Sicista subtilis* and some other openground elements in this layer might lead us to the conclusion that these forms survived in the wider surroundings of the site, (i.e. the Spišská kotlina basin in the piedmont area of the Tatra Mountains) over the whole of an interglacial period and then possibly migrated from the site any time they encountered a temporary decline in tree cover. Under this assumption, layer 12 would be a response to a temporary approach to cold dry climate within a terminal interglacial phase, as can be demonstrated by zone 5e of the ^{18}O sequence (Guiot et al. 1989). Most of the sedimentary sequence, i.e. layers 11 to 8 in trench C_1 and horizons G to D in section A would reflect a situation occurring in the Brörup Interstadial, i.e. zones 5a-c in terms of the ^{18}O sequence.

Roughly speaking, the same type of assemblages as seen in trench C_1 was also found in the lower part of section F. In the lower horizon of this section, the faunal situation resembles closely that existing in section A of horizon D. The assemblage for section F included, besides common species, *Citellus* sp., *Sicista subtilis, Marmota* sp. and *Hystrix vinogradovi*.

4. The uppermost layers of the sedimentary cover were studied in section E (from which *Rangifer tarandus* was obtained, for example) and, in particular, in section B. The loess loam in close travertine yielded an assemblage dominated by *Dicrostonyx gulielmi, Microtus arvalis, Microtus gregalis, Microtus nivalis*, etc. Apparently its composition represents a typical community of the late Weichselian, probably just prior to the onset of the Holocene period (cf. a relatively high percentage of *Microtus arvalis* and *Microtus nivalis*). Humic soil samples taken from this site indicate that *Microtus arvalis* and *Arvicola terrestris* also predominated in the Holocene (tab. 3).

Taphonomical notes

It seems probable that most of the assemblages under study were thanatocoenoses. This would partly explain why their composition is so simple and monotonous, especially as compared with the great majority of cave records that mostly represent taphocoenoses, source areas of which may be quite large.

Extensive post-mortem dispersals are to be expected for bones of large mammals. Fragments of single bones of a rhinoceros were found dislocated up to 5 m in area A, horizons F-G, as in some other remains. Dislocation of separate fragments of single bones is particularly frequent in the deformed clayey layer F where material (including fragmentary teeth of the rhinoceros) was transported, supposedly by subrosion, into collapsed channel-like fissures in the travertine body. Judging from such cases, one cannot exclude the possibility that fairly considerable post-sedimentary changes occurred on the surface of both the blocks or the travertine mound and of the deposits that cover them (as suggested by their lithologies, at least, in section A) and hence also in the position of the bones contained in individual beds. Anyway, if an assessment is made on the basis of osteological data alone, it seems impossible to recognize to what degree the observed pattern of bone spatial dispersal is due to direct carnivore or human activity.

In this context, emphasis should also be placed on the appearance of *Hystrix* at the site. Percupines are known to burrow extensively and, as a rule, they frequently exploit underground cavities available, supposedly, for instance, subrosive fissures in the travertine body. Porcupine burrowing activity might also contribute to post-sedimentary or nearly synsedimentary irregularities in the dispersal of bone material.

Conclusions

In conclusion, from the stratigraphical point of view, the following seems to be especially worth consideration:

1. The osteological material does not provide any convincing evidence for the deposits older than the last interglacial, i.e. the Eemian period. This applies not only to the absence of palaeochoric elements (*Pliomys, Drepanosorex*, etc.) but also to the morphometric status of some index forms. Thus, in a locally very common form of *Arvicola terrestris* there are no *mosbachensis/cantiana* morphotypes as would be expected if the form would have come from the early Middle Pleistocene.

2. Faunal records that may indicate interglacial conditions are limited to the basal layers in area A, sections A/A - A/J, and to layers 10b-11 of section C_I. Anyhow, besides *Clethrionomys glareolus, Apodemus (Sylvanus)* sp., *Sorex araneus* or *Felis sylvestris*, all indicating at least some traces of woodland or bush cover, there are no thermophilic or thermally demanding species characterizing interglacial conditions unambiguously.

3. In general, all assemblages are remarkably monotonous and poor, both in species composition and structural pattern. This fact can be explained by specific conditions occurring at the site, i.e. a travertine spring surrounded by alkaline swamps, and is supported by evidence indicating that the source of vertebrate fossils was probably limited to the site itself. With all these observations in mind, it seems that rather moderate but invariable conditions existed at the site during most of the period covered by the faunal sequence under study.

4. The absence of pleniglacial and/or late Weichselian elements, such as *Microtus gregalis, Dicrostonyx*, etc. in all the material available (except the one obtained from the uppermost loess in section B) suggests an early Weichselian age for most of the deposits. This view is also supported by the appearance of *Hystrix vinogradovi, Marmota* sp., *Citellus citelloides* or *Sicista* cf. *subtilis*.

5. A very similar faunal pattern characteristic of the site under study has also been recognized in the assemblages obtained from the base of the sedimentary cover (layers E, F 1-3) at the neighbouring Palaeolithic site, Gánovce, assigned to the same period as is supposed for the site at Hôrka-Ondrej (cf. Ložek 1955, Horáček - Sánchez 1984). This may also refer to a locally specific environment and palaeobiogeographical situation existing in the Spišská kotlina Basin.

Translated by the author

K tisku doporučili Oldřich Fejfar a Slavomil Vencl

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Výzkum travertinové kupy Skalka v Hôrce-Ondreji u Popradu (Slovensko)

(Résumé anglického textu)

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Travertinová kupa Skalka (či Smrečányiho skala) v Hôrce-Ondreji u Popradu se od roku 1987 těšila systematickému výzkumu, neboť jde o významnou lokalitu, z níž pochází vedle nálezů drobnotvaré industrie středního paleolitu (nejméně ze tří časově vzdálených intervalů) i bohatství paleomalakozoologického, paleoosteologického i paleobotanického materiálu. Travertinová kupa je pozoruhodná i složitými geologickými, litologickými a paleopedologickými poměry, jejichž řešení přispívá k stratigrafickým závěrům. Předložený soubor článků shrnuje dosavadní hlavní poznatky a podává informace o vývoji přírodního prostředí na lokalitě během posledního (R/W) a zřejmě také některého staršího, středně pleistocenního interglaciálu. Jak vyplývá z příspěvků, názory na stáří lokality se zatím neshodují. Světlo do tohoto problému přineslo dodatečné datování travertinů (viz Ford v tomto článku). Prokázalo, že původní stavba kupy byla ještě o něco složitější, než se předpokládalo. Pevné travertiny kupy (v podloží interglaciálních uloženin v šachtici C1) byly jednoznačně zařazeny do staršího interglaciálu než je R/W.

Vysvětlivky k obrazkům

1. Přehled výskytů travertinů mezi Gánovci a Hôrkou u Popradu. Popisovaná lokalita „Skalka" je označena číslem 596 (podle Kovandy 1971 - lokalita v textu na str. 171 špatně popsaná jako „Svätý Ondrej nad Hronom").
2. Bližší situace travertinové kupy „Skalka" je vyznačena černým kroužkem.
3. Kopie fotografie Ivana z jeho publikace z roku 1943. Dnes zcela odtěžený povrch kupy „Skalka" kolem kráteru s patrnou hlubokou korozní frontou (viz postavu při pravém okraji pilíře). Pohled od ZSZ.
4. Rozložení výzkumných ploch a šachtic na kupě „Skalka" (Ľ. Kaminská).
5. Původní profil v sekci B podle Proška - Ložka (1957). Čísla v kroužcích: 1 - destičkovitý travertin [s nálezem vrcholně interglaciálního plže *Helicigona banatica* (Rossm.)] s tenkými iniciálními rendzinami, obsahujícími Ložkovy (1993) malakofauny č. 1 a 2 a drobnotvarý paleolit; 2-6 - krycí souvrství s bloky travertinů z posledního glaciálu s Ložkovou malakofaunou č.11; 7 a-d - výplň jámy z období bronzu; 8 - povrchová humózní půda s Ložkovou malakofaunou č. 12.
6. Profil A_1 z roku 1987: 1 - výplň mladší pukliny s.-j. směru v travertinové kupě. Sestává ze svahových hlín a půdních sedimentů označených symboly A-H; 2 - destičkovitý a lavicovitý travertin; 3 - povrchová humózní půda; 4 - sprašovitá hlína s drobnými úlomky travertinů; 5 - černošedá hlína s úlomky travertinů; 6 - tmavě šedá hlína s úlomky travertinů; 7 - světle šedá svahová hlína; 8 - šedočerné polohy iniciálních rendzin v destičkovitém travertinu. Z báze travertinů pochází Ložkova (1993) malakofauna č. 3 (Ľ. Kaminská).
7. Profil A_2 z let 1989-1990: 1 - lavicovitý travertin; 2 - úlomky a kameny travertinů; 3 - svahová hlína s úlomky travertinů; 4 - ohniště; 5 - roztroušené dřevěné uhlíky. A-G - různé polohy svahových hlín a půdních sedimentů ve výplni pukliny a nad lavicovitými travertiny. Pocházejí odtud vzorky pro paleopedologii č. 12-16. Viz i příl.. II. 1 (Ľ. Kaminská).
8. Tzv. „bublinovité travertiny" z povrchu spodní akumulace (destičkovitých) travertinů, dosud známé pouze z aragonitů Karlových Var (viz Kovanda 1971). Foto A. Marková
9. Tzv. východní profil na sekci B (= B/E): 1 - navážka; 2 - černošedá humózní půda s korodovanými úlomky travertinů; 3 - šedá hlína s drobnými úlomky travertinů; 4 - sprašovitá svahová hlína s korodovanými bloky a kameny travertinů; 5 - světle hnědá svahová hlína se sprašovým materiálem a korodovanými bloky travertinů. I-IX - polohy destičkovitých, strukturních i rozpadavých travertinů; X - deskovité pevné travertiny s roztroušenými úlomky flyšových pískovců; A-D - šedé a tmavě šedé polohy iniciálních rendzin (Ľ. Kaminská).
10. Tzv. západní profil na sekci B (= B/W): 1 - navážka; 2 - okrově světle hnědá hlína s úlomky a kameny korodovaných vápenců; 3 - rezavý a namodralý hlinitý jíl; I-VIII - destičkovité, strukturní a rozpadavé travertiny; IX - tuhé deskovité, místy brekciovité travertiny; A-D - polohy iniciálních rendzin (Ľ. Kaminská).
11. Profil čelem a z. bokem šachtice C_1 z roku 1990 v nadloží lavicovitých travertinů [s četnými otisky listů vrby a Ložkovou (1993) malakofaunou č. 6]. Čísla 1- 12c označují souvrství výplně (drobné deprese vzniklé korozí či tektonicky). Souvrství dole (polohy č. 12-5) je výsledkem bažinné (či mokřadní) sedimentace a obsahuje Ložkovy malakofauny č. 7-10, odpovídající nástupu, plnému rozvoji a ústupu (zřejmě) posledního interglaciálu. Z bazálních poloh pochází také paleopedologické vzorky Smolíkové (v této práci) č. 2-7. Svrchní polohy (vrstvy č. 1-4) jsou krycími deluvii. Odtud byly odebrány paleopedologické vzorky č. 8-11 (Ľ. Kaminská).
12. Profil čelem a j. bokem šachtice C_2 z roku 1989; 1 - navážka; 2 - tmavě šedá humózní půda s úlomky flyšových hornin; 3 - svahová hlína; 4 - B horizont subfosilní půdy [paleopedologický vzorek Smolíkové (v této práci) č. 18]; 5 - jílovitá svahová hlína; 6-24 - různé typy a druhy rozvlečených svahových hlín a jílů a půdních sedimentů (ekvivalent výplně pukliny v profilech A); 25 - rezavě hnědočerné až černé rozvlečené čočky písčitojílovitých hlín (= podloží výplně s horizonty č. 6-24); ekvivalent spodních poloh v sondě C_1 - paleopedologický vzorek Smolíkové (č. 20); 26 - olivově světle šedé písčitojílovité tenké povlaky na travertinu; 27 - podložní, mohutně korodovaný lavicovitý travertin (Ľ. Kaminská).
13. Schéma vývoje travertinové kupy „Skalka" a jejích krycích sedimentů. Římská čísla I-VIII udávají akumulační fáze, čísla v kroužcích označují místa odběrů vzorků pro paleopedologii (J. Kovanda).
14. Idealizované schéma vývoje sedimentačních poměrů travertinové kupy „Skalka" po akumulačních fázích I-VIII (J. Kovanda).
15. Area A, profil A/G: 1 - navážka; 2 - holocenní polohy; 3 - svahové hlíny a půdní sedimenty horizontů B-G; 4 - lavicovité travertiny (Ľ. Kaminská).
16. Area A, profil A/D_2: 1 - oranžově a černě zbarvené travertinové polohy; 2 - světle šedý křídovitý travertin [u Horáčka (v této práci) poloha A/D_2 s Ložkovou (1993) malakofaunou č. 4]; 3 - tence destičkovitý travertin; 4 -

šedohnědý jíl; 5 - vypálené jíly; 6 - tmavě hnědý až černý jíl (Ľ. Kaminská). 17. Ukázka štípané kamenné industrie z výzkumné plochy A (Ľ. Kaminská).

Vysvětlivky k přílohám

I. 1. Celkový pohled (od východojihovýchodu) na výzkumnou plochu A; v pozadí plocha C.

Foto J. Kovanda

2. Celkový pohled (od jihovýchodu) na výzkumnou plochu C, D; v popředí plocha B.

Foto J. Kovanda

II. 1. Profil A_1 z roku 1987. Pohled (od V) na dvě generace výplně mladší pukliny v travertinové kupě.

Foto E. Javorská

2. Profil A_2 z roku 1987-1988. Pohled (od V) na pokračování archeologických výkopů směrem k Z. Provizorní schůdky jsou ve výplni pukliny kupy.

Foto E. Javorská

III. 1. Pokračování profilu A_2 dále k Z. Situace z roku 1988. Výplň pukliny přechází k S (tj. na snímku vpravo) do pokryvu nad pevnými lavicovitými travertiny, zatímco k J prstovitě přechází do nejmladších křídovitých písčitých travertinů s malakofaunou Ložka (1993) č. 4.

Foto E. Javorská

2. Profil A_4 z roku 1987. Pohled od J. Nad destičkovitými na bloky rozpadlými travertiny je uložena poloha tmavě hnědých půdních sedimentů (polohy D a E z předchozího obrázku), krytá bíle skvrnitými křídovitými písčitými travertiny s uvedenou Ložkovou (1993) malakofaunou č. 4 (viz i Horáčkovu obratlovčí faunu z polohy A/D_2 v jeho tab. 3) - laterální facie výplně pukliny (polohy C z předchozího obrázku) - viz obr. 14.

Foto E. Javorská

IV. 1. Pohled na výzkumnou plochu B - tzv. západní profil B/W z roku 1992, jdoucí kolmo (S-J) na profil Proška a Ložka (1957) - viz obr. 5.

Foto J. Kovanda

2. Pohled na z. bok šachtice C_1 - spodní část výplně s Ložkovou (1993) malakofaunou č. 7-10, zachycující nástup, plný rozvoj a ústup (zřejmě posledního) interglaciálu.

Foto J. Kovanda

V. 1. Pohled (od JV) na bok šachtice C_1. Uprostřed snímku je zářez C_3 a vpravo část čela šachtice C_2.

Foto J. Kovanda

2. Pohled na čelo šachtice C_2 s výplní mladší pukliny - stav z roku 1990. Na snímku vpravo je mohutná koroze pevných lavicovitých travertinů.

Foto E. Javorská

VI. 1. Pohled na čelo šachtice F (z roku 1990) zachycuje rozvětralý povrch svrchní polohy (lavicovitých) travertinů. Roztroušeně jsou zachována parautochtonní rezidua půd ze skupiny terra fusca.

Foto E. Javorská

2. Zachovaná hrázka „jezírka" na povrchu lavicovitých travertinů kupy. Výzkumná plocha A - před profilem A_3 (stav z roku 1991).

Foto J. Kovanda

VII. 1. Povrch lavice pevných travertinů svrchní akumulace před šachticí C_1 obsahuje četné otisky listů vrby a Ložkovu (1993) malakofaunu č. 6.

Foto J. Kovanda

2. Archeologický výkop odhalil povrch korodovaných a rozpadavých lavicovitých travertinů, krytý rozvlečenými půdními sedimenty (polohy C, B-G profilu A_2 - viz II/1, obr. 15) s hojnými nálezy paleolitu.

Foto J. Kovanda

VIII. 1. Levý bok při bázi šachtice F. Komplikovaná série fosilních půdních sedimentů - výplň mladší pukliny travertinové kupy Skalka.

Foto J. Kovanda

2. Zachované mikrokaskádky na povrchu bloku z někdejšího povrchu travertinové kupy Skalka.

Foto J. Kovanda

IX. 1. Redeponovaný materiál horizontu B terra fusky, tvořený braunlehmovým stavebním plazmatem, soustředěný v hrudkách a promísený s korodovanými úlomky travertinů. Uprostřed fragment měkkýší konchylie. Výbrus 1. Zvětšení 30x.

2. Fosilní koprogenní elementy žížal v humózní půdní matrici. Výbrus 27. Zvětšení 30x.

X. 1. Braunlehmová konkrece s vnitřní koncentrickou stavbou (pravý horní kvadrant) ve smíseném fosilním půdním sedimentu, tvořeném materiálem terra fusky a humózních půd. Výbrus 4. Zvětšení 30x.

2. Fragment zuhelnatělého dřeva s dobře zachovanou celulózní strukturou v sedimentu humózní půdy, porušeném sítí puklin a trhlin. Výbrus 5. Zvětšení 30x.

XI. 1. Rozměrná konkrece, tvořená pouze sloučeninami Mn ve fosilních smísených půdních sedimentech. Výbrus 11. Zvětšení 3Ox.

2. Braunlehmová konkrece (pravý dolní kvadrant) a hojné vyloučeniny Mn ve fosilním půdním sedimentu pestrého složení. Výbrus 16. Zvětšení 30x.

XII. 1. Nepravidelně paprsčitě omezené pseudoglejové konkrece v redeponovaném materiálu horizontu G (B) fosilního pseudogleje. Výbrus 24. Zvětšení 30x.

2. Páskovaná základní hmota, sestávající z vrstviček hydroxidů a oxidů Fe^{3+}, sloučenin Mn a pramenitů. Výbrus 20. Zvětšení 30x.

Mikrosnímky (příl. IX-XII) I. Fischer