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*A foto of the Levallois point found in the Paleolithic site Tvarožná-  
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# TVAROŽNÁ-ZA ŠKOLOU. THE RESULTS OF 2008 EXCAVATION SEASON

## TVAROŽNÁ-ZA ŠKOLOU. VÝSLEDKY VÝZKUMU Z ROKU 2008

Petr Škrdla, Gilbert Tostevin, Daniel Nývlt, Lenka Lisá, Ondřej Mlejnek, Antonín Přichystal, Daniel Richter

### Abstract

The Middle to Upper Paleolithic (MP/UP) transitional period and the question of a replacement of Neanderthals by Anatomically Modern Humans is a crucial question in current Archaeology and Anthropology. However, without the discovery and excavation of new Early Upper Paleolithic (EUP) sites, no progress in the issue of the MP/UP transitional period in the Middle Danube Region would be possible.

The systematic and repeated surface surveys on the site of Tvarožná-Za školou (Fig. 2) resulted in an important Bohunician artifact assemblage. Among the important features of this assemblage is an equal ratio of Stránská skála type and Krumlovský les type cherts, which are supplemented by non-specified Moravian Jurassic cherts, Cretaceous spongolite cherts, radiolarite, and erratic flint. The industry is characterized by the absence of bifacial reduction and the application of Levalloisian technology on all recognized types of raw material. Because the test pits excavated during 2006–2008 yielded artifacts within intact sediments, a larger and more complex excavation was realized during summer 2008 and a continuation is planned for 2010. The stratified collection from Tvarožná will contribute to the knowledge about the EUP in Moravia by clarifying the chronology and homogeneity/heterogeneity of Bohunician collections (cf. hypothesis in Tostevin, Škrdla 2006). Another important issue is the comparison of the surface and excavated collections from the same site. While the surface collection was already published (Škrdla 2007), this article presents field results and preliminary interpretations from the 2008 season.

Four main stages of geological development may be differentiated in the studied section. The first stage comprises geliflucted layers without archaeological finds. The second stage is composed of colluvial sediments transported for only a short distance, containing artifacts. The archaeological situation was not significantly affected by slope and frost processes based on a geological point of view. The first two stages likely developed during OIS 3. The third stage is typified by aeolian deposition, which took place in the pleniglacial conditions of OIS 2. These pleniglacial conditions disturbed the underlying colluvial sediments in the form of 0.5–1.0 m wide orthogonal ice-wedge polygons filled by homogeneous loess. The last stage of development comprises the uppermost layer (A), which is strongly affected by Holocene climate, erosion and the recent repeated plowing.

### Keywords

Moravia, Bohunician, Middle/Upper Paleolithic transition, Levalloisian technology, Geoarchaeology, Micromorphology

## Introduction

The problem of the Bohunician chronostratigraphic position, its homogeneity/heterogeneity, and its relation to other EUP technocomplexes in Moravia has only been studied to date on the materials from the site clusters in Bohunice and Stránská skála. For a better understanding of the role of the Bohunician in the MP/UP transitional period it is necessary to excavate more stratified sites (Tostevin, Škrdla 2006). Therefore, an intensive survey for new sites is currently being realized by P. Škrdla. The first results of this survey project were the discoveries of *in situ* artifact horizons at the known surface sites of Tvarožná-Za školou and Líšeň-Čtvrť (for the later, see Škrdla *et al.*, chapter Paleolithic and Mesolithic in this volume).

Oliva, who intensively surveyed the area and cooperated with local amateur archaeologists (including Bajer from Tvarožná), did not report any finds from the area of the Tvarožná-Za školou site (cf. Oliva 1989). The first artifacts at the Tvarožná-Za školou site were collected in 1990 and from that time the continuous plowing

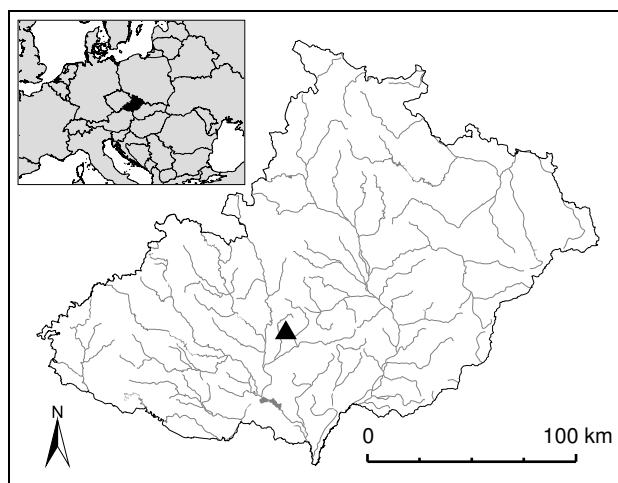


Fig. 1: Location of the Tvarožná-Za školou site on the map of Moravia. Obr. 1: Poloha lokality Tvarožná-Za školou na mapě Moravy.

of the field unearthed more artifacts and the destruction of site has continued. In a series of test pits during 2006–2008, an area of *in situ* sediments with artifacts was discovered, followed by a salvage excavation in the most promising area (Fig. 3). The excavation was realized in collaboration between the Institute of Archaeology, Academy of Sciences, CR (P. Škrdla) and the Department of Anthropology, University of Minnesota, USA (G. Tostevin).

### Location of the site

The site is located 3.7 km to the east of the margin of the current city of Brno, in the field on the southern margin of the Tvarožná village with a local field name of “Za školou” (translation: “behind the school”). As this is the tenth site locality recognized in the vicinity of the Tvarožná village (see below), the locality can also be referred to as “Tvarožná X.” The field with the site is bordered by Tvaroženský potok stream to the north, by Santon Hill to the west, and by a low un-named elevation to the south and east. The altitude of the site ranges between 265 to 270 m and the relative elevation above the closest stream (Tvaroženský potok stream flowing 100–200 m to the north) is only 20 m. The site does not provide a direct view into the main valley (unlike the sites of Bohunice, Stránská skála, and Líšeň) and is protected by the rugged topography of the southern margin of the Drahany Upland to the north of the site. The above-mentioned geographic parameters are not very characteristic for Bohunician settlement strategies (nor EUP sites in general) within Moravia (Škrdla 2002, 2005). The distance from the Stránská skála hillside to Tvarožná is 6.4 km to the east and from Bohunice to Tvarožná 13.8 km to the east. The nearest stratified Bohunician site – Líšeň-Čtvrtě – is located 5 km to the west (there is a direct visual connection between Líšeň-Čtvrtě and Tvarožná-Za školou). The site of Tvarožná-Za školou lies in the Šlapanice Hilly Land, a naturally shaped corridor connecting the Brno Basin, through the Vyškov Gate, to the Upper Morava Valley and other important EUP site clusters (the Prostějov area with sites such as Ondratice, etc.) and further to the north to the Polish border with the isolated site Třebom/Dzierzyslaw.

### The EUP occupation in the area

The Tvarožná-Za školou site is located in a region with intensive EUP occupation, where the Early Upper Paleolithic is represented by three cultural units – Bohunician, Szeletian, and Aurignacian (Svoboda *et al.* 1996, 99–130).

The Bohunician in the Brno Basin (the center of the Bohunician occupation in the Middle Danube area) is known from the excavation of two large site clusters and several smaller satellite (often surface) site clusters (see Fig. 2). The first site cluster – the type locality – represents Bohunice (Bohunice Kejbaly I–IV: Valoch 1976a, 1982; Bohunice 2002; Škrdla, Tostevin 2005) on the western margin of the Brno Basin. The elevation of the site cluster is about 275 m a.s.l. The second site cluster is on the Stránská skála hill (Stránská skála IIa, III, IIIa, IIIb, IIIc and IIId:

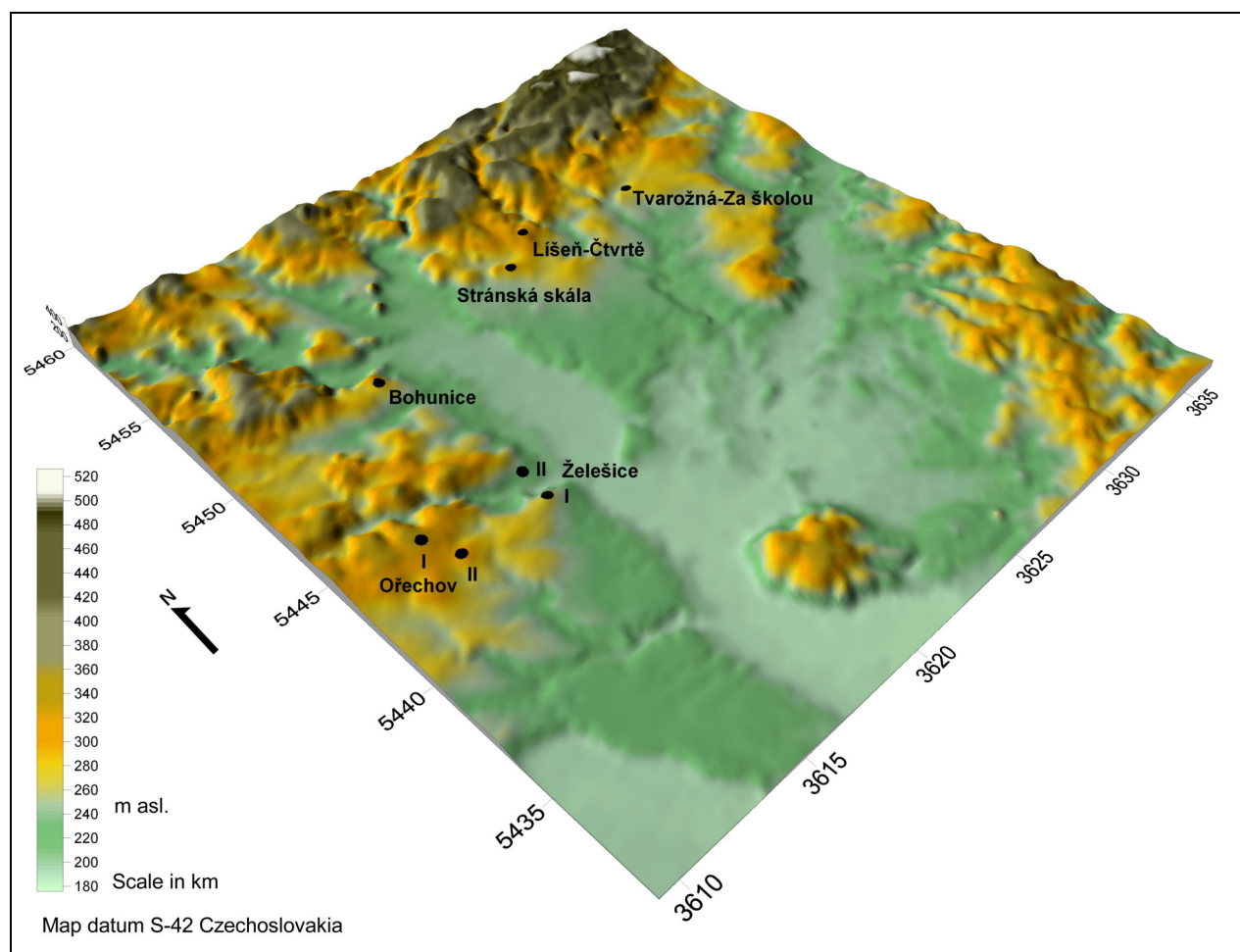
Svoboda 1987; Svoboda, Bar-Yosef 2003) on the opposite – eastern – margin of the Brno Basin. The elevation of this site cluster is about 295–300 m a.s.l. Located approximately 1.4 km to the east from Stránská skála, the Líšeň site cluster (Oliva 1985; Svoboda 1987; Škrdla 2000) is a rich surface accumulation where artifacts were recently excavated from intact sediments. The elevation of the site cluster is about 290–330 m a.s.l. Another site cluster is located near the southwestern margin of the Brno Basin in the Bobrava River valley and includes several sites on the cadastral territories of Želešice and Ořechov (Valoch 1956). However, the Bohunician classification of the latter sites is not generally accepted.

Several small Szeletian surface sites with isolated Levalloisian artifacts were reported from the Vyškov Gate area, cca 16 km northeasterly from Tvarožná on the cadastral territories of Opatovice (Lány and Fršlůch sites) and Drnovice (Končiny–Kněží háj, Za horkó, and Chocholík sites) (Svoboda 1994; Mlejnek 2005a, 2005b). An isolated Szeletian surface site was reported at the northwestern vicinity of the Brno Basin in Rozdrojovice (Valoch 1955). An important Szeletian site cluster is also located in the highlands along the Bobrava River (Valoch 1956) near the southwestern margin of the Brno Basin. The Levalloisian technique is observed to a certain extent within these mentioned Szeletian surface collections. As these localities represent strategic positions above rivers that were suitable for hunting camps and were likely repeatedly occupied during EUP and later periods, it is quite possible that discrete occupations were recovered in surface collection as geologically mixed assemblages. The interpretation of the Levalloisian technique in these contexts as Bohunician contamination of Szeletian occupations cannot be excluded.

Aurignacian occupations are known particularly from the Brno Basin. The excavated collections were recovered from Stránská skála (Stránská skála II, IIa, IIIa, IIIb, IIIc: Svoboda 1987; Svoboda, Bar-Yosef 2003), where the Aurignacian layers overlay the Bohunician (Svoboda, Bar-Yosef 2003). In addition, surface collections were obtained in Stránská skála (cadastral territory of Slatina), Maloměřice-Občiny, Vinohrady-Borky, Líšeň-Čtvrtě, and Líšeň-Kopaniny (Oliva 1987 with ref.; Svoboda 1987, 95; Škrdla 2000).

Focusing on the Tvarožná cadastral territory, two important Aurignacian surface sites have been documented. The first site is located cca 2 km northerly from Za Školou site in the field of Nová pole (Valoch 1976b) at an altitude of 327 m. The site is characterized by a high percentage of radiolarite in its raw material spectrum and prevailing busqued burins in the typological spectrum, indicating that the site belongs to the later phase of the Aurignacian (Valoch 1976b; Oliva 1987).

The second Aurignacian collection, made mostly from local cherts, was collected 200 m farther to the south-west from Nová pole in the field of Velatické vrchy (Oliva 1987; Škrdla, Kuča 2007). Oliva reported 9 sites and find-spots in total within the cadastral territory of Tvarožná. In accepting Oliva's numbering, the Za školou site may receive the number ten (X).



**Fig. 2:** Location of Tvarožná-Za školou site within the Brno Basin and other EUP sites. *Obr. 2: Poloha lokality Tvarožná-Za školou vzhledem k Brněnské kotlině a ostatním vybraným časně mladopaleolitickým lokalitám.*

Small undiagnostic collections of probable EUP artifacts and isolated finds were collected in the cadastral territories of the neighboring villages including Svice, Pozořice and Jiřkovice (Oliva 1987, 1989 with ref.).

### History of research

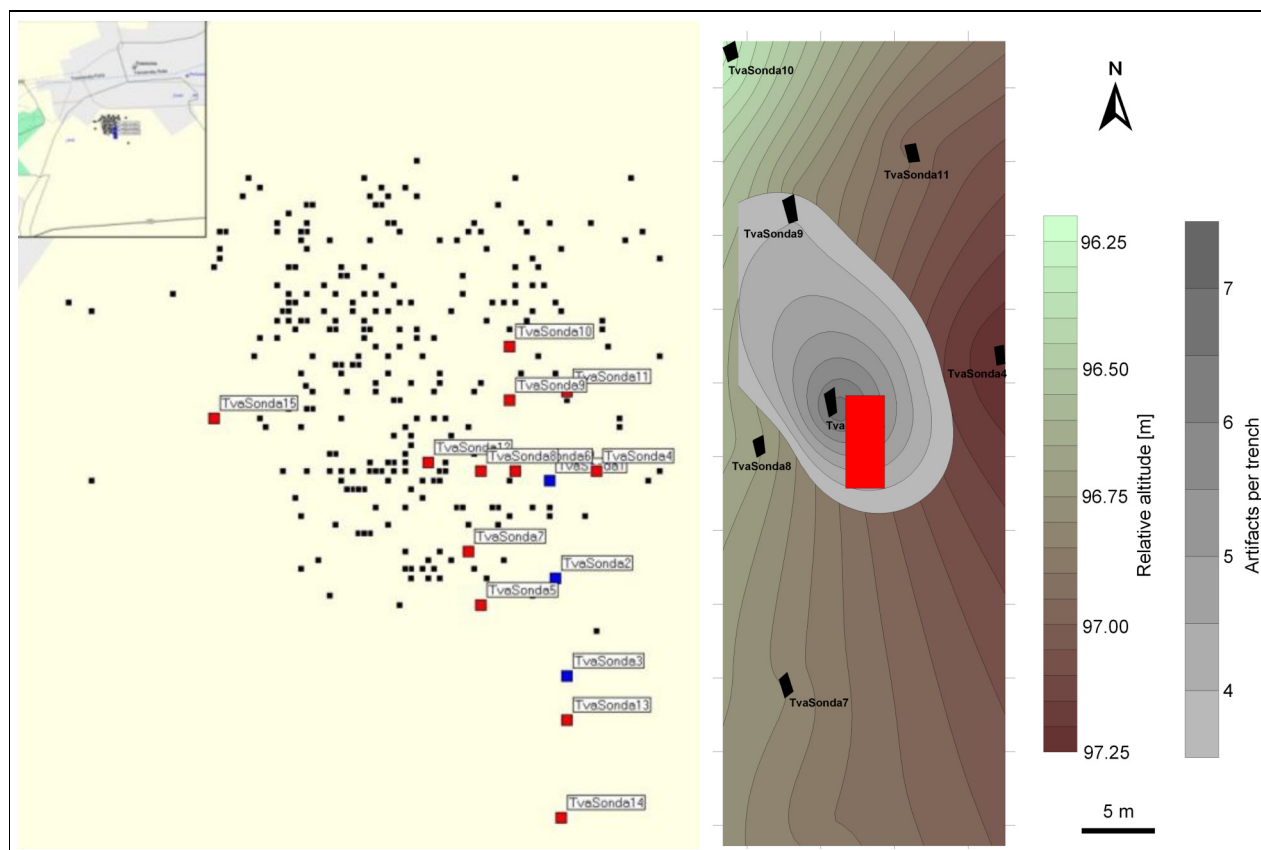
The site was discovered in the autumn of 1990 during the surface survey of Petr Kos. While the first survey yielded a collection of 20 white patinated artifacts, the repeated surveys in the decade 1990–2000 resulted in a collection reaching 193 artifacts (Škrdla, Kos 2002). We did not continue with surveys over the following few years, as attempts were unsuccessful due to the field conditions. As Škrdla, Kos (2002) noted, surface finds were concentrated in a shallow erosional depression. Calcium carbonate coating on the artifact surfaces indicate that the surface artifacts originate from intact sediments (loess and paleosols). P. Škrdla conducted intensive surface surveys during the spring and autumn seasons of 2005 and 2006. The positions of artifacts were recorded using a handheld GPS device (currently 261 records in total), allowing the production of a scatter plot map, which were used for selecting the appropriate location of test pits – at the margin as well as in the center of the artifact cluster. The test pit TvaSonda1, dug on September 21, 2006 near the margin of surface artifact cluster, revealed intact sediments with *in situ* artifacts (Škrdla 2007). Test pits

during 2007–2008 (currently 15 test pits in total) resulted in the definition of an area of 200 m<sup>2</sup>, where artifacts were found in intact sediments (Škrdla, Tostevin 2008). The maximum density was 5 artifacts per m<sup>2</sup>. However, the number of artifacts found may have been affected by the recovery method (which lacked wet-screening). Based on the test pits and the distribution of artifact density within these test pits, we were able to locate a promising area, which was opened for excavation in summer 2008. We hope to double the extent of the excavated area in 2010.

### The 2008 excavation: aims and methodology

With the recognition of the artifact density in the test pits at the Tvarožná-Za školou site being lower than that at the site clusters of Bohunice or Stránská skála (Škrdla, Tostevin 2008), the goals of the 5-week excavation season in July/August 2008 included two main aims, 1) the excavation of a continuous area to provide a large enough artifact assemblage for refitting studies and the statistical characterization of the assemblage's lithic attributes, and 2) the integrated pursuit of luminescence dating and geological investigation of the Tvarožná-Za školou locality.

The excavation methods utilized were based on the excavation of Brno-Bohunice conducted in 2002 (Škrdla, Tostevin 2005; Tostevin, Škrdla 2006), methods consistent with international standards for digital provenienc-



**Fig. 3:** Left: Scatter plot of individual surface finds (black squares) and location of test pits (blue 2006, red 2007); right: Location of the 2008 excavation trench (red) relative to the test pit locations and intra-pit artifact density contours on top of an elevation model of the slope. North in both figures is at the top of the figure. *Obr. 3: vlevo: Distribuce jednotlivých povrchových nálezů (černě) a poloha pokusných sond (modře 2006, červeně 2007); vpravo: Umístění výzkumu z roku 2008 (červeně) vzhledem k pokusným sondám s počtem artefaktů nalezených v jednotlivých sondách. Sever je na obou obrázcích nahoře.*

ing in Paleolithic sites using a total station (McPherron, Dibble 2002; McPherron et al. 2005). Software designed by S. McPherron, H. Dibble for Paleolithic excavations (available at [www.OldStoneAge.com](http://www.OldStoneAge.com)) was used to run the total station in association with a site computer and printer for artifact labels. During excavation, all worked lithics and manuports with a minimum dimension of 2.0 cm in length were measured in place according to a three-dimensional coordinate system. Objects with an obvious linear axis were measured as two points to allow for taphonomic analysis of the vertical and horizontal orientations. Objects smaller than 2.0 cm were collected in 10 liter aggregate samples (a “bucket shot sample”). Charcoal, ochre, geological and pollen samples, and features were point-provenienced regardless of size. Geological boundaries (including both geological strata and the horizon boundaries of the sedimentary units) were similarly recorded digitally. All samples and artifacts were digitally coded by geological stratum, paleosol horizon, cultural layer, and date. All aggregate “bucket shot” samples were wet sieved through  $3 \times 3$  mm mesh and air-dried, adjacent to the excavation area. A micromorphological sample column and geological sediment samples were taken to cover the whole stratigraphic sequence of the site while loose sediment samples and pollen analysis samples of 0.25 liter were taken in every square meter for every 5 cm in depth for future studies. Excavation by hand trowel and putty knives con-

stituted the recovery method from the depth of the upper loess layer through the Pleistocene sediments.

The local site grid for the 2008 excavation trench was designed for easy accommodation of future expansion of the trench in any direction in subsequent seasons, laterally or up or downhill. The local site grid zero point ( $x=0, y=0, z=0$ ) was thus defined as distant to the trench (close to the northern edge of the Tvarožná-Za školou field), so that negative coordinates would be avoided no matter where in the field the excavation or test pits should move. The local grid axis was also oriented with grid north (*i.e.*, increasing “y”) pointing upslope in the field. This resulted in the local site grid being oriented  $177^\circ$  clockwise from local Magnetic North. The reasoning for a local grid orientation with a y-axis baseline beyond the northern edge of the Tvarožná-Za školou field was to facilitate the reestablishment of the local grid system between excavation seasons. Since the northern edge of the field provided opportunities for fixing permanent datums, this orientation was deemed preferable to placing the baseline of the grid in the expansive agricultural fields to the south of the site, where there was little opportunity for establishing long-lived datums (see McPherron, Dibble 2002: chapter 3). With the local grid established in this way, the surface of the northeast corner of the excavation trench at the beginning of the season was established as  $x=112.00$  m,  $y=110.00$  m, and  $z=100.00$  m. The coordinates connecting the local site grid to the near-

est Czech geodetic point will be provided in a future publication. To facilitate communication during excavation and to provide reasonable square-id labels for all coordinated points (artifacts, samples, etc.), each square meter was given an identification based on its x-axis (alphabetically from the origin) and its y-axis (numerical). Thus point x=112.00 m, y=110.00 m defined the lower-left point (in the local grid) of square M11, point x=112.00 m, y=111.00 m defined square M12, point x=113.00 m, y=110.00 m defined square N11, etc. (see Fig. 4),

The chronometric dating of the cultural material at the Tvarožná-Za školou locality was considered paramount as an objective of the 2008 field season. As argued by Richter *et al.* (2008, 2009), the clarification of the chronostratigraphic position of the Bohunician requires more chronometric studies utilizing a calendric rather than radiocarbon time scale (see also Richter 2007). Consequently gamma-ray spectrometric readings with a portable instrument were conducted during the excavation in order to obtain the gamma dose rates for both thermoluminescence (TL) and optically-stimulated luminescence (OSL) dating. Several readings were taken for the layer containing the artifacts in order to obtain a measure of the variability of the environmental gamma dose rate for burnt flint dating throughout the site. Light sealed samples for OSL dating were taken from the profiles and a preliminary sorting of the lithic assemblage for potentially burned artifacts (currently three in number) for TL dating was conducted. Preliminary tests of the sediments obtained indicate that a general OSL-SAR protocol (Murray, Wintle 2000) on the 100–200  $\mu$  m grain fraction might be possible, which will be compared to a similar protocol obtained on quartz minerals as well, but by the pulsing technique (Denby *et al.* 2006).

## Stratigraphy and micromorphology

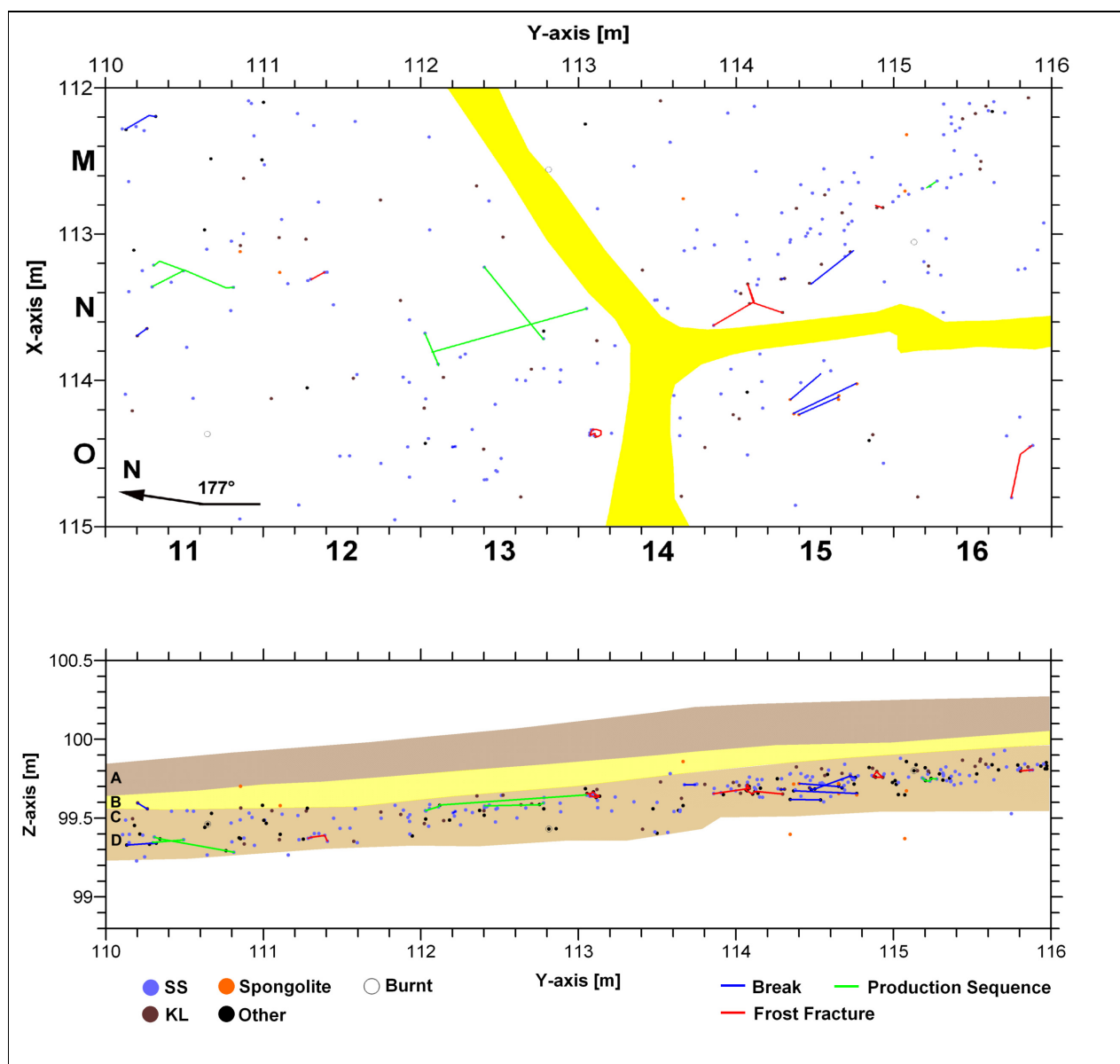
The stratigraphic logging was undertaken on the downhill side of the studied polygon, 1 m towards its centre from the right downhill corner (local coordinate: X=114, Y=110, *cf.* Fig. 4). Individual lithological units are marked A–H from the top towards the bottom. Lithological description was undertaken in the field and for the uppermost 60 cm of the section the methods of grain-size distribution, magnetic susceptibility and micromorphological analyses were applied. The lower part of the section, being archaeologically uninteresting, was only lithologically described and we have not conducted any further detailed studies there. The micromorphological approach covers descriptive microstratigraphical analyses (Bullock, Murphy 1983) including microfabric type, structural and porosity features, natural inclusions, anthropogenic inclusions and pedofeatures (Macphail, Cruise 2001). Such an application of soil micromorphology to archaeology was introduced mainly by Goldberg (1983) and lately well established in the literature (French 2003; Goldberg, Macphail 2006). Magnetic susceptibility was measured by KLY-4s CS3 equipment in the Institute of Geology of AS CR, v. v. i. in Prague. Carbonate content was removed by boiling in HCl and then the grain-size distri-

bution was measured by laser granulometry (CILAS 1064 Liquid) at Masaryk University in Brno. Lithology, stratigraphy and micromorphological results and their interpretations for the upper 60 cm are summarized in Fig. 6.

The uppermost horizon (A) was determined as a plowed and eroded slightly humic horizon (Apk) which contains rather large amounts of carbonate concretions and pebbles due to active agriculture and surface erosion. Therefore the thickness of this humic horizon is limited and reaches a depth of only 8–35 cm, with higher thickness in the uphill (southern) part of the studied polygon. It is clearly delineated from the underlying loess by a sharp plow boundary. Grain size distribution is typical by the dominance of silt fraction (85 %). The high clay fraction content in the upper part (14–15%) corresponds well with highest magnetic susceptibility ( $300 \cdot 10^{-9} \text{ m}^3 \cdot \text{kg}^{-1}$ ) and is connected with lowest sand content (0.3 %). The influence of the underlying loess is well visible in the grain size change towards the lower part of the plowed soil horizon, where the sand content increase up to >3 % with decreasing clay content (up to 10 %). This horizon has compact grain channel microstructure (see Fig. 8). Voids have the shape of channels and do not show any presence of hypocoating or coating. Coarse fraction is composed mainly of disturbed calcite crystals and quartz grains. Calcite crystals are partly dissolved. Matrix is bioturbated and contains excrement of micro- and mesofauna (see Fig. 8). Decomposed organic matter is still present and partly changed into amorphous pedofeatures. Close compact grain channel microstructure with an amount of partially dissolved non-disturbed calcite crystals and a number of micritic calcite concentrations is visible in the lowermost part of (A). These concentrations composed plow-marks and contain decomposed organic matter (Fig. 6).

The topsoil developed on a typical light ochre-colored homogeneous loess (B) with a small amount of calcareous concretions, infiltrations and some Fe and Mn mottles. The loess horizon is only 16 cm thick in the studied section, but it is generally very thin varying between only 10 and 25 cm of thickness. Grain size composition is quite monotonous with prevailing silt fraction (86 %) and contrary to (A) with higher sand content (3–3.5 %) and lowest clay fraction content (10–11 %); magnetic susceptibility is quite low ( $150 \cdot 10^{-9} \text{ m}^3 \cdot \text{kg}^{-1}$ ). This horizon looks macroscopically massive and homogenous, but micromorphological differences are obvious. The upper part of (B) has compact grain microstructure with a common presence of non-disturbed calcite crystals, which represent calcified root channels. Disturbed calcite crystals are also common and compose the coarse grain fraction of the loess. Calcite dissolution is visible and also calcite hypocoating and concentrations are common. Few amorphous pedofeatures are present. The lower part of (B) is composed of a channel grain microstructure (see Fig. 8) with abundant presence of calcite crystals both in *in situ* and reworked. Calcite dissolution is rare and there are few calcite hypocoatings present. Root channels filled by calcite crystals are abundant. Some *in situ* developed and re-deposited amorphous pedofeatures are present. Needle calcite crystals infillings of younger root channel were





**Fig. 4:** Horizontal (above) and vertical (bottom) distribution of finds. The yellow area in Fig. 4 (above) is the ice-wedge from layer B penetrating into layers C–F. Stratigraphy in the bottom picture consists of (from above) a plough horizon (A), 0–10 cm thick layer of loess (B) and of a soil sediment containing artifacts (C–D). *Obr. 4: Horizontální (nahore) a vertikální (dole) rozptyl nálezů. Žlutě vybarvená struktura v horním obrázku znázorňuje průběh mrazových klínů. Stratigrafie v dolním obrázku sestává (od vrchu dolů) z ornice (A), která je ostrým rozhraním oddělená od nesterjnoměrně dochované vrstvičky spráše 0–10 cm (B) a půdního sedimentu s nálezy (C–D).*

also detected. It is evident that the former loess accumulation was affected by post-glacial erosion, which decreased its thickness and degraded the topsoil. It must surely have affected also the underlying artefacts, as the erosion seems to be anthropogenically accelerated towards the present.

The loess horizon (B) is followed by a thin (5 cm) brown yellowish layer (C), which represents a transition from typical colluvial toward the aeolian deposition. There is a slight increase of clay content (12.5 %) compared to the overlying loess, which is connected with a slight sand content decrease. Magnetic susceptibility does not show any distinctive changes. This horizon has channel to vughy microstructure with unsorted coarse grain fraction. The presence of non-disturbed calcite crystals as infilling of root channels is abundant (see Fig. 8) and few disturbed calcite crystals and calcite

hypocoatings are present. Re-deposited amorphous pedofeatures and rock fragments are common there. The underlying slightly darker brown-colored highly calcareous clayey silty colluvium (D) with soil formation indicators contains higher amount of previously fluviually transported gravel clasts, together with archaeological finds, fragments of bones, charcoals and calcareous concretions. Plenty of subvertical infiltrations continue from the overlying loess. Calcareous concretions mostly of 3–4 cm form individual subhorizontal laminas. Large concentrations of concretions up to 20–30 cm in dimension were observed in other parts of the excavated polygon. There is a marked increase of clay content throughout all colluvial units (C–F), with a decrease in the middle of the unit (D) connected with higher sand content due to admixture of calcareous concretions and gravel clasts. This hori-



zon has micromorphologically channel to vughy grain microstructure with abundant presence of calcite crystals as infilling of root channels. Amorphous re-deposited pedofeatures (see Fig. 8) as well as rock fragments are common there. It is evident that this unit originated as a deposit of former paleosoils and may be assigned as soil sediment.

Slightly darker colluvial clayey silts (D) are followed by better-assorted and brown yellowish loess like deposit (E). However, it contains a higher proportion of clay fraction (>14 %) and the sand fraction diminishes; therefore a mixture of different grain-size sources by colluvial transport is obvious. Magnetic susceptibility values are lowest in the studied section falling down to  $120\text{--}130 \cdot 10^{-9} \text{m}^3 \cdot \text{kg}^{-1}$ , which is even lower than in typical loess. This horizon has channel to vughy grain microstructure with abundant presence of calcite crystals in root channels. Calcite dissolution and calcite hypocoating and concentrations are also abundant. Bioturbations and *in situ* re-deposited amorphous pedofeatures are few. Lighter colluvial clayey silts (F) continue up to the depth of 65 cm. They contain nearly no sand admixture and the clay content is higher (15 %), the magnetic susceptibility value is still low. This layer has close compact grain channel microstructure with abundant presence of calcite crystals composing infilling of root channels. Calcite hypocoatings and concentrations are also abundant. Both types of amorphous pedofeatures are common (see Fig. 8). No micromorphological studies have been undertaken below this unit. Coarser colluvial slightly clayey silts (G) with abundant concentrations and gravel clasts continue up to the depth of 81 cm. Calcareous concretions form individual laminas of a few cm in thickness. This bed is lithologically rather similar to the bed (D), but may also originate as a deposit of former paleosoils, and could be assigned as soil sediment. The lowermost lithostratigraphic unit (depth 81–120 cm) in the studied section is made of laminated geliflucted silty clayey colluvium (H). The thickness of individual geliflucted beds varies between 3 and 10 cm. Some gravel clast of fluvial origin may also be found in this unit. Small lenses of disintegrated Neogene calcareous sandstones up to 2–3 cm thick repeat in vertical intervals of 5–10 cm. The studied section terminated in the depth of 120 cm.

The soil sediments and underlying geliflucted colluvium (C–H) was disturbed in the central part of the studied polygon by an ice wedge cast filled by homogeneous loess (Figures 4 top and 7). The pseudomorph is typically 0.5–1.0 m wide and it is apparent that the ice wedges here linked to orthogonal ice-wedge polygons (as may be seen on Fig. 7).

### Interpretations

The uppermost horizon (A) was determined as a plowed and strongly eroded slightly humic horizon (Apk), which remains from degradation of the originally much thicker soil A horizon. We are not able to systemize this horizon more precisely in the soil nomenclature, because human and erosion impact was so high during plowing, that no typical features of soil types were pre-

served, however it is very probable that the soil originally belonged to the suite of chernozem soil types. Plowing was interpreted according to a typical sharp boundary between brown colored plowed horizon and yellow loessic subsoil below. This homogeneous soil horizon was produced by repeated plowing, which is historically documented in this area. High magnetic susceptibility values in this soil horizon were induced by pedogenetic processes. Plowing can initiate or increase rates of accumulation of illuvial silt, clay and humus just under the plow zone. A 5 mm thin zone, just under the sharp plowing border, is typical for concentrations of micritic dissolved calcite concentrations containing decomposed organic matter. Plowed zone also typically lacks non-disturbed calcite crystals composing root infillings. Single cells isolated in the groundmass are preserved there. The formation of calcified root cells is related with the period of loess deposition with a pronounced dry season and typical steppe pedogenesis. However, modern agricultural impact degraded the original chernozem soil and enhanced superficial erosion of the soil horizon.

The macroscopically massive ochre-colored loess horizon with a small amount of calcareous concretions and infiltrations and some Fe and Mn mottles is composed of silt material deposited by aeolian processes. The accumulation likely took place in the pleniglacial condition of the last glacial, *i.e.* 25–15 ka BP, when the landscape was sparsely vegetated and aeolian deflation and deposition was the most active phenomenon in the periglacial zone of Moravia. OSL and IRSL data of Southern Moravian loess accumulation centered at 20 ka BP, with most ages in the time interval 17–23 ka BP (Musson, Wintle 1994, Frechen *et al.* 1999). The prevailing coarse grain fraction is not composed by quartz as is the case of most southern Moravian loess deposits (Lisá 2004), but by partly dissolute calcite crystals. These crystals originally composed root infillings of older deposits and were lately re-deposited by wind to this position and compacted by grass roots. The new compaction was caused by calcification. Jaillard (1987) described the origin of these features as a typical biomineralisation process of roots mainly in strongly calcareous soils. Calcium carbonate in the soil matrix is dissolved by  $\text{H}^+/\text{HCO}_3^-$  exchange and the excretion of organic acids as visible mainly in A and E horizons. The available  $\text{Ca}^{2+}$  is taken up by the roots, absorbed by the cells and accumulates in the vacuole, where it precipitates as calcium carbonate (Bezce-Deák *et al.* 1997). This process is quite rare and occurs mainly in the well-drained soils (Jaillard 1985). As *in situ* calcium crystals on root infillings or reworked calcium crystals with primarily same origin compose the loess all the area had to be probably well drained, not only during the Holocene, but already since the loess deposition. Together with loess material some amorphous pedofeatures and small rock fragments were reworked, which suggests admixture of soil material as well as the material from underlying colluvial layers. Magnetic susceptibility values of loess are low and correspond to those of typical loess in the Moravian area (*e.g.* Lisá, Buriánek, Uher 2005; Škrdla, Nývltová Fišáková, Nývlt 2006).

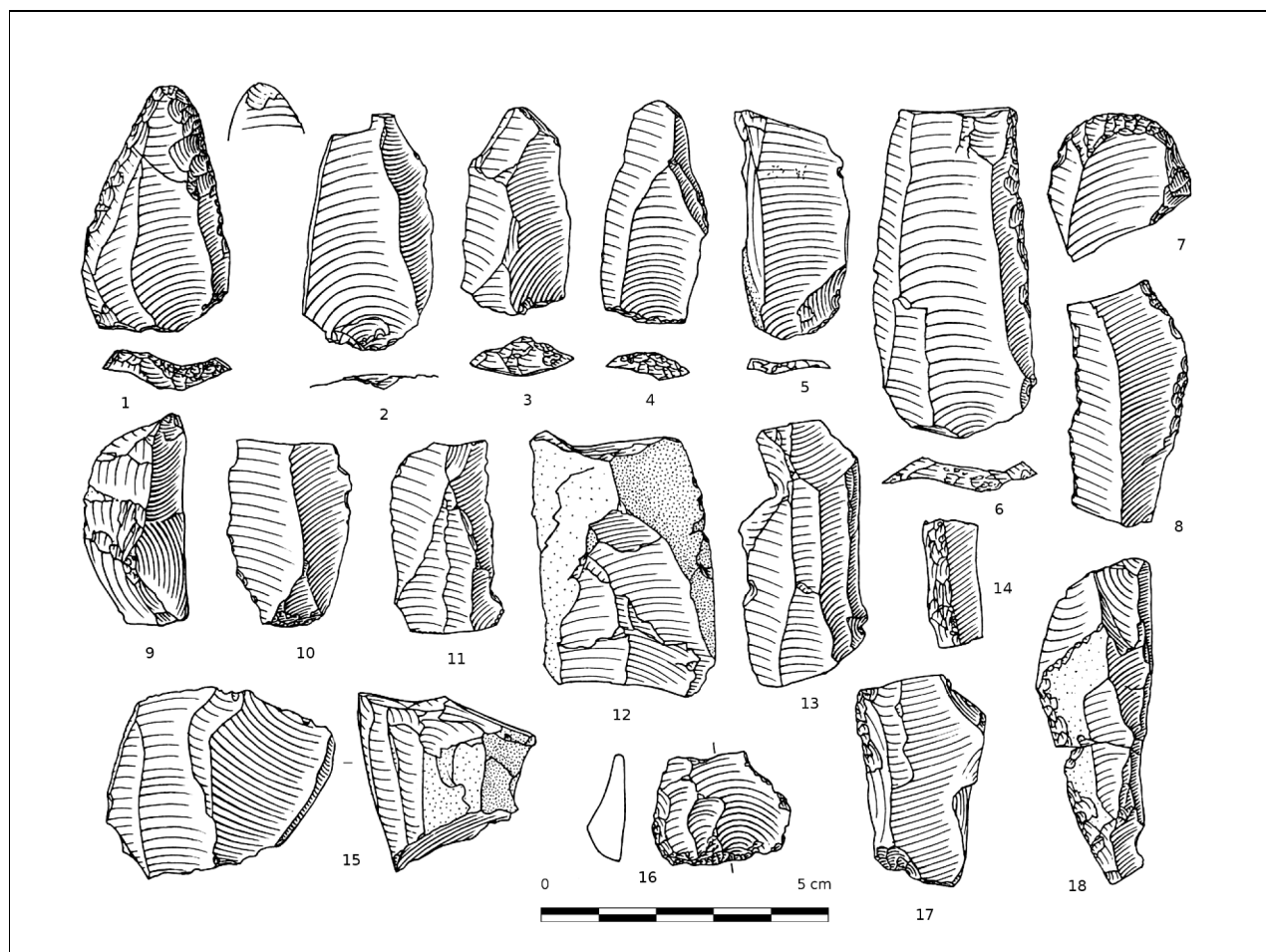


Fig. 5: Selected artifacts. Obr. 5: Výběr nálezů.

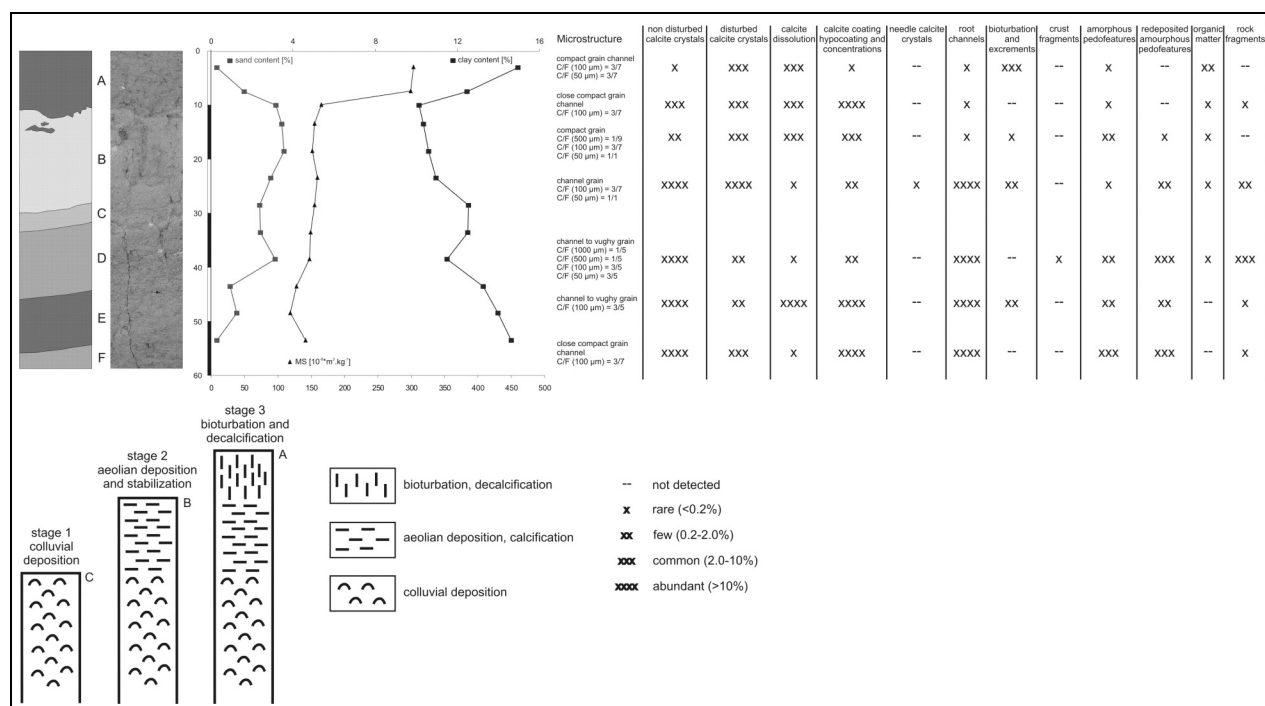
The lower part of the studied section containing artifacts, gravel clasts, and calcareous concretions was deposited by colluvial processes. Material of horizons C–F is typified by the presence of abundant reworked calcite crystals from some older loessic deposits and by common re-deposited amorphous pedofeatures. It is evident that some layers (especially D, F) originated as deposits of former paleosols and may be assigned as soil sediment, as they contain common amorphous pedofeatures. The climate conditions during this re-deposition had to be quite dry and sometimes also moist, because this colluvial part of the section is typified by calcite hypocoating and concentrations re-deposited from dissolved calcite crystals above. According to Wieder and Yaalon (1982) hypocoatings are the result of rapid precipitation of  $\text{CaCO}_3$  from the water suction and desiccation effect due to root metabolism. On the other hand Brewer (1964) proposed that calcium hypocoating could originate from the evaporation of Ca-rich solution by precipitation from soil solutions percolating along the pores and penetrating into the soil matrix. According to Kemp (1995), impregnative hypocoating is most widely associated with vertical leaching from surface to sub-surface horizons under semiarid regimes. Horizons are on the other hand typified by the presence of *in situ* originated calcite crystals composing infillings of root channels, which is typically key to stabilization. Some lensing of coarse gravel clasts implies water saturated

slope movement, however other abovementioned micro-morphological features imply rather dry colluvial transport. It is also apparent from the distribution of broken and frost cracked artifacts (see below) that the transport of these layers before deposition was on the order of decimeters up to a few meters; therefore pedofeatures and calcite crystals infillings are well preserved here.

Interestingly no freezing processes are present in the matrix microstructures for layers D–F. This is very important from an archaeological point of view, because we may be fairly sure, that the archaeological situation was not significantly affected by slope and frost processes.

Macroscopically visible traces of freeze-thawing processes are visible in the lowermost G and H layers. The thin lamination shows one-sided gelifluccion processes, which transported superficial material due to the seasonal thawing of the uppermost part of the active permafrost layer. Common occurrences of Neogene calcareous sandstone clasts indicate the bottom of the Quaternary sequence. The transport distance of the material from these layers was much higher than for the above lying colluvial units (C–F).

The permafrost cracks penetrating through the Quaternary strata must have formed during the last pleniglacial (25–15 ka BP), when the land surface was vegetation free and permafrost table was seasonally chilled to temperatures of at least  $-20^\circ\text{C}$  to form contraction cracks in silts



**Fig. 6:** Overview of lithology, grain-size, magnetic susceptibility and micromorphological results and interpretations for the uppermost 60 cm of the studied section. *Obr. 6: Přehled litologie, zrnitosti, magnetické susceptibilitě, mikromorfologických výsledků a jejich interpretace pro svrchních 60 cm studovaného profilu.*

and clays (French 2007) and when loess deposition occurred (see above). The wedge growth is generally very slow, usually <1 mm and cracks do not occur annually (Harry, Gozdzik 1988), therefore the development of ice wedge of up to 1 m width may take thousands of years to form. It is generally assumed, that ice wedges form in a climate with mean annual air temperature below -6°C (Pewé 1966). However, more recent studies show that winter air temperatures and winter snowfall affect their formation more than the summer climatic conditions (Murton, Kolstrup 2003, French 2007).

### Artifacts from the 2008 excavation: a preliminary report

The collection of artifacts from the 2008 excavation are currently being analyzed in detail. The following paragraphs provide a preliminary raw material, technological, and typological description.

The assemblage of provenienced artifacts over 2.0 cm consists of 249 items. More artifacts, currently unstudied, are within the sieved aggregate samples. A small collection of lithics was also collected during the removal of the topsoil and disturbed sediments over the Pleistocene loess of layer B.

In the raw material spectra, the Stránská skála-type chert and cherts, which originate in a gravel nearby to the Stránská skála hill, prevail, reaching together 70 % in total. The Krumlovský les chert makes up only 19 %, which contrasts with the surface collection (*cf.* Škrdla 2007), where proportions of the Stránská skála-type and the Krumlovský les-type cherts were balanced. The stratified collection is similar, however, to the surface collection, in possessing artifacts made of Cretaceous spongolite chert (4 %), radiolarite or radiolarite-

chert (2 %), and a strongly patinated silicite representing probably erratic flint or Moravian Jurassic chert (1 %; it is not possible to distinguish between these options because of the deep patination of the artifact surfaces). The other raw material types (limnic siliceous rock, Moravian Jurassic chert, and another unspecified chert) are only represented by one artifact each. Three artifacts were burnt. The assemblage is supplemented by two quartz flakes, which are questionable as worked pieces and may represent ecofacts.

A preliminary technological analysis shows a prevalence of debitage, including flakes (61 %), fragments (13 %), broken blades (8 %), cores (6 %), blades (5 %), and a bladelet. The curated tools represent 4 % of assemblage. The collection of tools is supplemented by partly retouched flakes (3 pieces) and a partly retouched broken blade.

The collection of curated tools consists of 10 artifacts. The most frequent tool types are Levallois points, three are non-retouched (Fig. 4:2–4) and one is convergently retouched with a ventral impact scar on its distal end (Fig. 4:1). The group of Levallois artifacts is supplemented by a retouched Levallois blade (Fig. 4:6) with a broken tip—possibly originally an elongated Levallois point. The group of tools is completed by an endscraper (Fig. 4:7), a retouched blade fragment (Fig. 4:18; here already refitted with its distal part), a burin, a splintered piece, and a notch.

### Refittings

Only the artifacts over 2.0 cm, found during troweling and point provenienced, have been the subject of refitting attempts (*i.e.* without wet-sieved material). We were able to refit 19 groups among the 249 artifacts. How-



**Fig. 7:** Plan (above) and section (bottom) view of ice wedge pseudomorph penetrating through individual stratigraphic units.  
*Obr. 7: Půdorysný (nahore) a boční (dole) pohled na mrazový klín pronikající jednotlivými stratigrafickými jednotkami.*

ever, no technologically significant sequence was refitted. Similarly to Stránská skála, artifacts were often heavily damaged by frost and frost-fractures therefore prevail. The ratio of breaks/production sequences without frost fractures reaches a value of 10/7, including frost fractures equals 23/7. The index of conjoinability ( $I_c$ ) indicating the share of refitted artifacts over the total number of artifacts reaches value 6.83 (12.05 if including frost fractures). The inverse value of the index of size, or in other words the number of refitted artifacts in all sequences divided by the number of refitted sequences, reaches a value of  $1/I_n = 2.21$  (2.58 including frost fractures). When comparing these indices values and the breaks/production sequences ratios to other available assemblages from Stránská skála IIIc (a primary workshop site near the raw material outcrop) and the Bohunice 2002 collection (and Kejbaly II collection) (*cf.* Škrdla, Tostevin 2005, Obr. 8, Tab. 8), the Tvarožná-Za školou assemblage lies between Stránská skála and Bohunice, though much closer to Bohunice (Tab. 2).

### Horizontal and vertical distribution of finds

The horizontal distribution of artifacts shows a slight linear patterning from magnetic-southeast to magnetic-northwest (from upper-right to lower-left in Fig. 4), which is supported by the distributions of both the refitted breaks and the frost fractures. The broken and frost fractured pieces were moved between 1 and 45 cm. The breaks and the frost fractures have a similar order of magni-

tude of distance and the same down-hill tendency (toward the magnetic-northwest corner of the trench). This movement occurred after frost-fracturing of individual artifacts. The artifacts were already damaged by frost during OIS 3 and were re-deposited by colluvial processes (see above for details). The distance of artifact re-deposition was probably half a meter to a few meters (up to 3 m).

The vertical distribution of artifacts ranges from 20 cm in the southern (upslope) portion of the trench to 30 cm in the northern (downslope) portion of the trench. All but a handful of the artifacts were found within the sediment designated D in the micromorphological description.

We analyzed the distributions of different raw materials, as with Bohunice 2002 (Škrdla, Tostevin 2005, Obr. 4), and no horizontal, nor vertical, patterning was observed.

### Concluding remarks

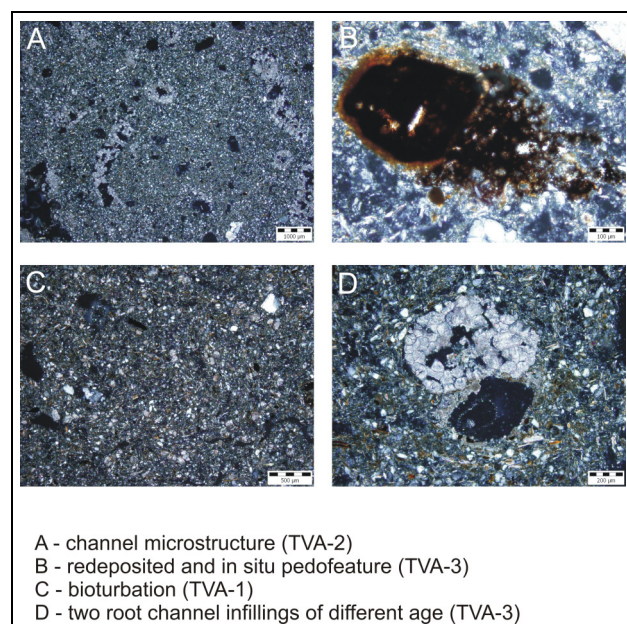
Four main stages of natural development may be differentiated in the studied section. The first stage comprising layers G–H was deposited in a seasonally changing climate, when the upper active permafrost layer thawed and one-sided sheet gelifluction transported this material for a significant distance before its deposition. The second stage, containing layers C–F, is composed of another type of colluvial sediments containing reworked calcite crystals and amorphous pedofeatures from older loess and soils without traces of frost action. They were transported for some decimeters up to a few meters before their deposition. These horizons were secondarily influenced by a short stage of a more moist regime, pronounced warm and dry seasons, when amorphous pedofeatures formed, calcite crystals were dissolved, and the micritic calcite fraction was deposited in layers E, F. Numbers of grass roots were stabilized by carbonates, dissolved and calcified from the calcium rich matrix. This stabilization is recently preserved in the form of calcite crystals composing root channel infillings. Artifacts appear in the younger phase of the second stage and are found in layer D. The geological conditions support the hypothesis, that the archaeological situation was not significantly affected by slope and frost processes. The first two stages developed during OIS 3. The third stage is typified by aeolian deposition, which took place in the pleniglacial conditions of OIS 2. The underlying colluvial beds were disturbed by 0.5–1.0 m wide ice wedge cast linked to orthogonal ice-wedge polygons. The ice wedge pseudomorph is filled by homogeneous loess and developed in the third stage during the pleniglacial conditions of OIS 2. The most typical part of the coarse fraction are calcite crystals, re-deposited from older loess material. The numbers of root channels infilled by calcite crystals reflect a stage of stable grass growth on a calcium rich substrate, continual loess material deposition, and a rather arid moisture regime.

The last stage of development comprises the uppermost layer (A), which is strongly affected by Holocene climate, erosional and recent anthropogenic processes. This horizon was repeatedly plowed with visible plowmarks and climatically driven bioturbation, decalcifica-



**Tab. 1:** Comparison of refitting indices (Škrdla 1997) for the currently analyzed assemblages. The index of conjoinability ( $ic$ ), defined as a ratio of refitted artifacts over the total number of artifacts in the site assemblage ( $ic = (ninref - nref) / n$ ) describes the degree to which it is possible to refit a collection. The index of size ( $in$ ) is defined as a ratio of refit sequences over the number of joined pieces ( $in = nref / ninref$ ). Its inverse value ( $1 / in$ ) indicates the size (number of joined artifacts) of average refitted sequence. Variables are defined as follows:  $n$  = total number of artifacts evaluated for refitting;  $nref$  = number of refitted sequences; and  $ninref$  = number of refitted artifacts in all refitted sequences. *Tab. 1: Porovnání indexů skládanek u dosud analyzovaných souborů.*

Soubor – assemblage	n	ic	in	1/in
Bohunice 2002	1620	4.44	40.50	2.47
Bohunice-Kejbaly II (Nerudová, Krásná 2002)	1084	4.15	38.36	2.6
Stránská skála IIIc	2398	16.47	26.72	3.74
Stránská skála IIIc (včetně mrazových zlomků – including frost fractures)	2398	21.68	28.96	3.45
Tvarožná-Za školou 2008	249	6.83	45.16	2.21
Tvarožná-Za školou 2008 (včetně mrazových zlomků – including frost fractures)	249	12.05	38.77	2.58

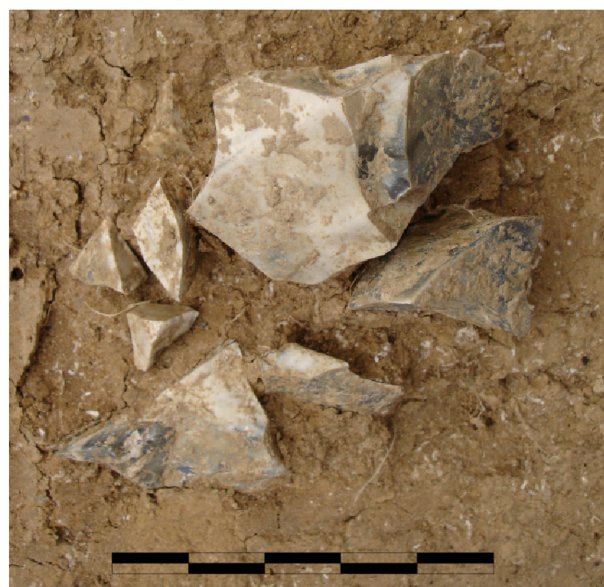


**Fig. 8:** Microphotographs of typical microstratigraphic features. *Obr. 8: Mikrofotografie typických mikrostratigrafických forem.*

tion and accumulation of illuvial silt composed by micritic carbonates below its base occurred during the Holocene.

The archaeological record at Tvarožná-Za školou or Tvarožná X is currently under study, with the attribute analysis of the debitage, tool kit, and microartifacts to appear in a subsequent publication. Our initial analyses, however, demonstrate the presence of Levalloisian debitage, with retouched Levallois points and an endscraper, typical of the Bohunician industrial type of the Early Upper Paleolithic in Moravia. Like the site of Bohunice, the Tvarožná X assemblage is not located immediately on a raw material source but unlike Bohunice has a more diverse raw material spectrum than previously recognized in other Bohunician assemblages. While the assemblage appears to have been moved by colluvial action to a moderate degree, estimated between 0.5 and 3 meters, the high potential for TL and OSL dates make this a promising location for future research.

As only one Bohunician site has been extensively dated with thermoluminescence techniques (Richter *et al.* 2009), the presence of three burnt flints at Tvarožná-Za školou encourages us that an expansion of the 2008



**Fig. 9:** A frost damaged artifact. *Obr. 9: Mrazem rozrušený artefakt.*

excavation will increase the sample of datable lithics and thereby potentially allow for a weighted mean-date for this Bohunician assemblage. As a weighted mean-date has the same statistical accuracy as the best AMS dates (see Richter *et al.* 2008), Tvarožná X represents an opportunity to improve both our behavioral and chronological resolution of the Bohunician.

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## Resumé

V roce 2008 byl proveden výzkum na lokalitě Tvarožná-Za školou.

Lokalita byla známa jako povrchová a pochází z ní kolekce, která byla zpracována dříve (Škrdla 2007). Charakteristický pro ni je vyvážený poměr rohovce typu Krumlovský les a typu Stránská skála v surovinovém spektru, aplikace levalloiské techniky na všechny typy surovin a absence bifaciální redukce.

Na základě přítomnosti krust vysráženého uhličitánu vápenatého na řadě artefaktů se od první publikace (Škrdla, Kos 2002) uvažovalo i o přítomnosti intaktních sedimentů. Ty byly doloženy sérií sond, vyhloubených na lokalitě v letech 2006–2008. S ohledem na distribuci artefaktů ve zkušebních sondách byla zvolena plocha pro výzkum (obr. 4).

Výzkum se zaměřil na získání stratifikované kolekce artefaktů a na studium jejich stratigrafické pozice.

Na základě studia odkrytého profilu byly rozeznány čtyři hlavní etapy geologického vývoje. První etapa zahrnuje vrstvy G–H, které vznikaly v sezónně proměnlivém klimatu. Svrchní aktivní vrstva permafrostu roztávala a jednostrannou geliflukcí docházelo k povrchovému svahovému transportu materiálu na větší vzdálenosti. Druhá etapa, zahrnující vrstvy C–F, je tvořena jinými typy svahových sedimentů obsahujícími resedimentované krystaly kalcitu a amorfní pedogenní znaky pocházející ze starších spraší a půd bez zjištěných mrazových projevů. Tyto sedimenty byly před vlastním uložením transportovány po svahu na vzdálenosti několika decimetrů až metrů a druhotně byly ovlivněny krátkým obdobím relativně vlhkého klimatu s poměrně teplými a suchými léty, kdy vznikaly amorfní pedogenní znaky, rozpouštěly se kalcitové krystaly a mikritický vápenec se srážel ve vrstvách E a F. Množství kořínků bylo potaženo karbonáty, rozpuštěno a provápněno z matrix bohaté na karbonáty, což je dnes zachováno v podobě kalcitových krystalů tvořících výplně po kořínkách. Artefakty se vyskytují v mladší části druhé etapy a nacházejí se ve vrstvě D. Výsledky geologických výzkumů ukazují na to, že archeologická situace nebyla významněji ovlivněna svahovými a mrazovými procesy. První dvě etapy vývoje proběhly během OIS 3. Třetí etapa je charakteristická eolickou sedimentací, která probíhala během pleniglaciálních podmínek OIS 2. Hrubší frakci ve spraši tvoří krystaly kalcitu pocházející zřejmě ze staršího sprašového materiálu. Množství karbonátových výplní po kořínkách ukazuje na stabilní období růstu travní vegetace na vápnitém substrátu, průběžnou akumulaci sprašového materiálu a poměrně aridní režim klimatu. Podložní vrstvy svahových sedimentů byly postiženy 0,5–1,0 m širokým mrazovým klínem spojujícím se do pravouhlých polygonů, který je vyplněn homogenní spraší. Jeho vznik je také spojen se třetí etapou geologického vývoje během pleniglaciálních podmínek OIS 2. Poslední časová etapa geologického vývoje zahrnuje nejsvrchnější vrstvu (A) – ornici, která je silně postižena holocenním klimatem, erozními a mladými antropogenními procesy. Tento horizont byl opakovaně orán s patrnými projevy orby a bioturbacemi, odvápněním a akumulací iluviálních siltů tvořených mikritickým karbonátem přímo pod svojíází.

V průběhu výzkumu byly odebrány vzorky na datování pomocí OSL a dále byla provedena potřebná měření pro datování pomocí TL (přepálené artefakty se však v první výzkumné sezoně našly pouze čtyři, a proto bude třeba získat další).

Výzkumem byla získána kolekce 249 artefaktů větších než 2 cm a zaměřených ve třech souřadnicích. Další artefakty, které byly získány plavením, jsou v dosud nezpracovaných výplavech. V surovinovém spektru převažuje rohovec typu Stránská skála (téměř 70 %), doprovázený rohovcem typu Krumlovský les (19 %), křídovým spongiovým rohovcem (4 %), radiolaritem a radiolaritovým rohovcem (dohromady 2 %), silně patinovanými silicity (kvalitní variety moravských jurských rohovců nebo eratický silicit; 1 %). Po jednom kusu byl zastoupen limnosilicit, moravský jurský rohovec a blíže neurčený rohovec. V technologickém spektru převažuje debitáž, jmenovitě úštěpy (61 %), zlomky (13 %), zlomky čepelí (8 %), já-



dra (6 %), čepele (5 %) a čepelka. Nástroje tvoří pouze 4 % souboru. Dopravázejí je ještě tři místně retušované úštěpy a místně retušovaný zlomek čepele. Kolekce nástrojů sestává z deseti kusů. Nejčastější nástroj představují levalloiské hroty. Tři jsou neretušované (obr. 5:2–4) a jeden je konvergentně retušovaný s výrazným impaktem na špičce (obr. 5:1). Skupinu levalloiských produktů doplňuje retušovaná levalloiská čepel s odlomeným distálním koncem (obr. 5:6). Ta mohla původně být také prodlouženým levalloiským hrotem, které jsou běžné na jiných bohunicenských lokalitách. Zbývající nástroje jsou nízké škrabadlo (obr. 5:7), retušovaná čepel (obr. 5:18), rydlo, odštěpovač a vrub.

Při skládání bylo složeno 19 sestav, ale žádná důležitá z hlediska technologie. Podobně jako na Stránské skále byly artefakty porušeny mrazem, a skládanky mrazových lomů proto převažují. Poměr lomy versus produkční sekvence je 10/7 (při započtení mrazových lomů 23/7). Index složitelnosti dosahuje hodnoty  $ic = 6,83$  (při započtení mrazových lomů 12,05) a průměrná velikost skládanky ( $1/in$ ) je 2,21 (respektive 2,58 při započtení mrazových lomů) artefaktů. Porovnáme-li hodnoty těchto indexů a poměru lomy versus produkční sekvence s dalšími lokalitami, Tvarožná je mnohem blíže Bohunicím než Stránské skále.

Sledována byla horizontální a vertikální distribuce skládanek. Posun mrazem porušených artefaktů v severozápadním směru (1–45 cm) naznačuje svahové přemístění sedimentu s artefakty na krátkou vzdálenost (do 3 m). Vertikální rozptyl artefaktů dosahuje 20 cm (výše ve svahu) až 30 cm (níže ve svahu). Artefakty byly nalezeny v horizontu označeném jako D. Přestože jsme podobně jako v Bohunicích analyzovali také vertikální i horizontální distribuci jednotlivých druhů surovin a technologických kategorií, nezjistili jsme žádnou koncentraci.

Archeologický materiál z Tvarožné-Za školou je dále studován a výsledky budou zveřejněny v následných publikacích. Tato první publikace přináší poznatky o charakteru industrie z Tvarožné, který je srovnatelný s dalšími moravskými lokalitami bohunicieny. I přes mírnou redepozici sedimentů se lokalita jeví jako vhodná pro další výzkum. Možnost provedení termoluminiscenčního datování souboru v budoucnu rozšíří naše poznatky o chronologii bohunicieny.