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THE AGE OF THE OLDEST PALEOLITHIC ASSEMBLAGES FROM BIŚNIK CAVE (SOUTHERN POLAND) IN THE LIGHT OF GEOLOGICAL DATA

Biśnik Cave is a multi-layer site, which contains one of the oldest Paleolithic settlement levels in Poland. The character of the oldest inventory from the cave is depicted by the domination of the Levallois technique for obtaining flakes and blades. The tools included: forms with one side preparation technique connected with different types of side scrapers and small side scrapers, denticulate and notch forms. Bifacial artifacts are absent. Because of a small number of the inventory, we can only conclude that it is a typological collection of artifacts characteristic of the Mousterian tradition, broadly speaking. The oldest assemblages were found in Layers 19a, 19b, 19c and 19d. Sedimentological analysis show that the whole of Layers 19b-19c-19d should be treated as a deluvial sediment resulting from the series of several mudslides. The same interpretation could be concluded on the basis of geochemical data acquired for bone remains. Flint objects found in Layer 19a are the oldest artifacts in the position in situ. The date obtained for the Layer 19a (230 ± 51 ka) lets us determine the approximate age of the sediment and artifacts, which is oxygen isotope stage OIS 7. All of the older artifacts found in Layers 19d and 19b-19c are located on the secondary deposit. The TL date obtained for the sediment of one of the deluvial layers (569 ± 182 ka), as well as the date obtained for the burned flint tool (568 ± 131 ka) point to the early Middle Pleistocene age of at least some of the redeposited sediments and artifacts.

KEY WORDS: cave sediment, mudflow, Middle Palaeolithic, Lower Palaeolithic, Levallois technique, redeposition

1. INTRODUCTION

Biśnik Cave is a multi-layer site, which contains one of the oldest Paleolithic settlement levels in Poland. The oldest flint inventories can be found in layers 19b/19c and 19a, initially dated to OIS 9, approximately 350-300 thousand years ago (Cyrek et al. 2010). The dating is not definite (see chapter 3, current work). There are only few sites of similar age or older in Poland: Rusko, Trzebnica and Wrocław-

Hallera 1, the bottom layer, all situated in Lower Silesia (Burdukiewicz 1993; Burdukiewicz et al. 1994; Wiśniewski 2006) and Racibórz-Studzienna 2 in Upper Silesia (Wiśniewski 2006). The oldest assemblage from Biśnik Cave, marked as A7, has been dated to the Middle Paleolithic, but its cultural identity is not certain due to a small number of artifacts (Cyrek et al. 2009, see chapter 2, current work).

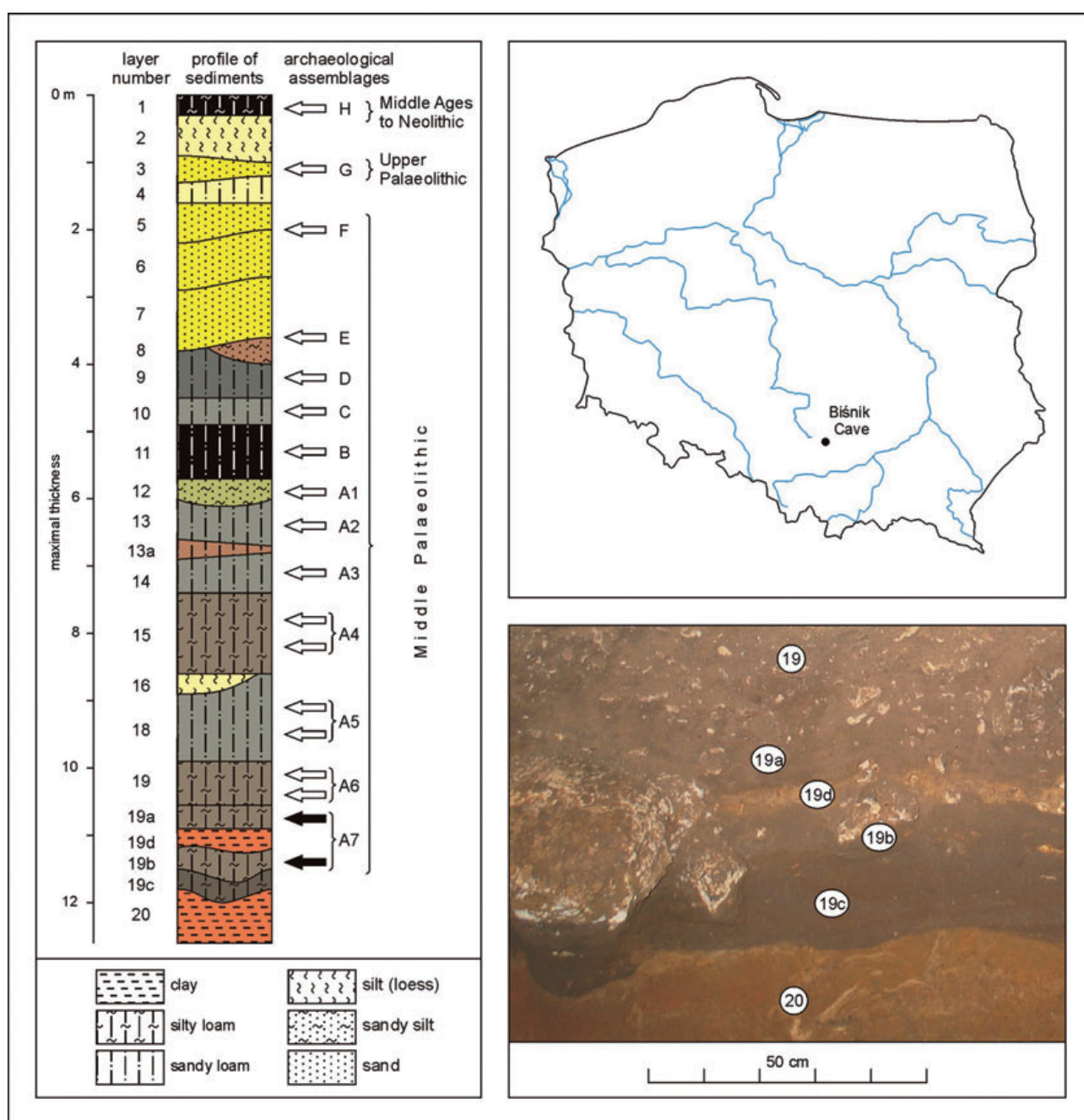


Fig. 1. A. Cross-section of the sediments from the Biśnik Cave with the numbering of the layers and location of archaeological artefact assemblages (after Cyrek et al. 2009, 2010, Krajcarz et al. 2010). Black arrows indicate location of the oldest inventories which are the subject of the present paper. B. Geographical location of the Biśnik Cave. C. The oldest part of stratigraphy in the cave's Main Chamber

The layers in Biśnik Cave are numbered downwards, with number 1 as the youngest Layer and number 19 as the oldest one (compare fig. 1). There are some exceptions though, e.g. there is no Layer 17, which is the result of change in field (temporary) numbering during research; there is Layer 13a, situated between Layers 13 and 14, and also Layers S1 and S2, not indicated in fig. 1, locally present and discovered after the numbering was

established. Underneath Layer 19 the numbering becomes more difficult to establish. Initially, the next lower layer in the sequence was red clay of terra rosa type, marked as number 20 (Cyrek 2002; Mirosław-Grabowska 2002). During further exploration it turned out that there are additional sediments in the form of lenses, which were marked as 19a, 19b and 19c (Cyrek et al. 2009, 2010). Next a lense of terra rosa clay was described, found with-

in the Layer 19a, and marked as 19d (Krajcarz et al. 2010). As a result the Layer 19a was divided into the upper part (situated above Layer 19d) and lower one. Both geochemical research, presented by Krajcarz et al. (2010) and sedimentological data discussed in the current work, clearly indicate that the two parts of layer 19a are of different origin, which makes applying the same number for both parts highly incorrect. The lower part of Layer 19a is more closely related to Layers 19b and 19c, and

therefore it is presented jointly with Layer 19b in fig. 1. The upper sediment is of different character, more similar to Layer 19 and it can be treated as a separate layer. In fig. 1 only this part was depicted as 19a and such is the meaning of that number in the further part of the text.

The aim of the current study is to present new data on the sedimentation environment and the age of layers containing the oldest artifacts in Biśnik Cave, i.e. Layers: 19a, 19b, 19c and 19d.

2. FLINT ARTIFACTS FROM LAYERS 19A-19B-19C-19D

Flint inventory unearthed in the oldest (19a, 19b, 19c, 19d) Layers of Bisnik Cave is of complex and ambiguous character. Bone remains and flint artifacts found in the layers were located in the southern part of the Main Chamber, in two, not very clearly outlined concentrations, on both sides of a rock, whose whole area was 18 square meters. Relevant elements of planigraphy were provided by irregular clusters of small pieces of charcoal from a birch tree (botanical analysis done by R. Stachowicz-Rybka – sample P-07/05) and coal dust, covering the area of a few dozen centimeters each. They can be interpreted as remnants of washed hearths. Such a view is supported by the observation of two artifacts found in the layers which underwent intense overheating. All artifacts are characterized by a similar state of preservation. They are all lightly polished and covered with milky patina, the intensity of which differs from one specimen to the other. In some cases the patina is ginger in colour. The way flint artifacts have been preserved suggests their analogous post-deposition conditions, connected with moist sediment.

On the basis of the micro-stratigraphic analysis, which allowed a precise three-dimensional location (with 1 cm accuracy) of each artifact, several levels of their occurrence have been distinguished in relation to the explored sediments (compare chapters 3, 5 and 6, see fig. 2 and fig. 3). Thus the inventory from Layers 19a-19b-19c-19d, consisting of 57 specimens, was divided into three groups of artifacts.

The first one comprises 17 artifacts, coming from the complex of Layers 19b-19c-19d. Basing on the planigraphic analysis of charcoal and bones, it seems that the primary location for some of the artifacts may have been the bottom part of Layer

19b in the Main Chamber. It was here, at the level 5 cm thick, that a cluster of a few dozen bones, several flint artifacts and 3 compact concentrations of charcoal were found (fig. 2). However, approximately 10-15 centimeters above at the top of Layer 19b, analogous findings are clearly more scattered and do not form any concentration.

The second group includes 6 artifacts, whose origin as regards the deposit is impossible to determine.

The third group contains artifacts found in Layer 19a. Basing on the sediment analysis it is the oldest sediment preserved in situ in the Main Chamber (compare chapters 3-6). As a consequence, it can be assumed that about 10 artifacts (8 retouched forms and several chips) have been deposited within Layer 19a, which was their primary deposit. This can be supported by the thickness of their occurrence, which was 17 cm, and to a lesser extent their planigraphic layout, comprising a concentration 12 square meters big (fig. 3). An exception is one artifact (W-02562) which got into Layer 19a secondarily, most probably from Layer 18 above. This is indicated by a clearly different state of its preservation (lack of patina, polishing of artifact outward edges and edges on the surface of the artifact, between negatives (scars) of the flakes removed in previous preparation process.

The description of artifacts from Layer 19a:

1. Straight single side-scrapers made from blade-like Levallois flake with usage retouch (?) of opposite edge (Chert). Inventory number W-04010 (fig. 4: 1).

2. Notch-denticulate tool made from thick Levallois flake with arrangement of radial negatives (scars) patterning surface morphology of the artifact. Heavy white patina. Undetermined flint. W-04020 (fig. 4: 3).



Fig. 2. Horizontal distribution of the finds from Layer 19a. Legend: 1 – flint artifacts; 2 – borders of research trench; 3 – explored area; 4 – unexplored area; 5 – rock; 6 – cluster of charcoal dust; 7 – cluster of charcoal

3. Thick thermal flake fragment chopped of the prepared pre-flaking surface with parallel, bidirectional negatives (scars). Burned specimen, dated to 230 ± 51 ka (TL). W-04029 (fig. 4: 2).

4. Thin Levallois flake with radial negatives (scars) and alternating microretouch around the edges of the specimen. Heavy white patina. Undetermined flint. W-04115 (fig. 4: 9).

5. Micro flake with notch-retouch. Gray chert. W-05255 (fig. 4: 7).

6. Convex single side-scraper of La Quina type, made from thick blade with two notches.

Heavy ginger patina. Undetermined flint. W-06392 (fig. 4: 8).

7. Denticulate tool made from thin Levallois flake with bidirectional negatives (scars) and removed bulbus. Beige Jurassic flint. W- 07977 (fig. 4: 5).

8. Levallois flake with unidirectional negatives (scars) and para-burin negative (scar - spin off) on the tip, with the remnants of organic adhesive (Cyrek & Cyrek 2009). Jurassic Kraków flint. W-02562 (fig. 4: 4).

9. *Raclette* made from Levallois flake with bidirectional negatives (scars) (fig. 4: 6).



Fig. 3. Horizontal distribution of the finds from Layers 19b and 19c. Legend: 1 – flint artifacts; 2 – borders of research trench; 3 – explored area; 4 – unexplored area; 5 – rock; 6 – cluster of charcoal dust; 7 – cluster of charcoal

10. Chips obtained as a result of sediment flotation.

Several artifacts from group 1, i.e. from deluvial Layers 19b-19c (see chapters 4 and 5), bear a big technological and typological resemblance to artifacts from group 3, from Layer 19a. Their state of preservation is also similar. It seems that they might have previously formed one assemblage, later scattered by secondary processes of relocation of the artifacts from the primary deposit, i.e. Layer 19a into underlying Layers 19b-19c. This

is the more likely that the bottom part of Layer 19a borders with Layers 19b and 19c in the cross-section.

The artifacts in question are as follows:

1. “Proto-Levallois” core with parallel working surface preparation and around, non-continuous striking edge preparation and unidirectional patterns of blade and flake negatives (scars). Jurassic flint from nearby deposit in Udorz (?). Heavy milky patina. W-04480 (fig. 5).

2. Multi-platform globular core. Jurassic flint. Ginger patina. W-08835 (fig. 6: 7).

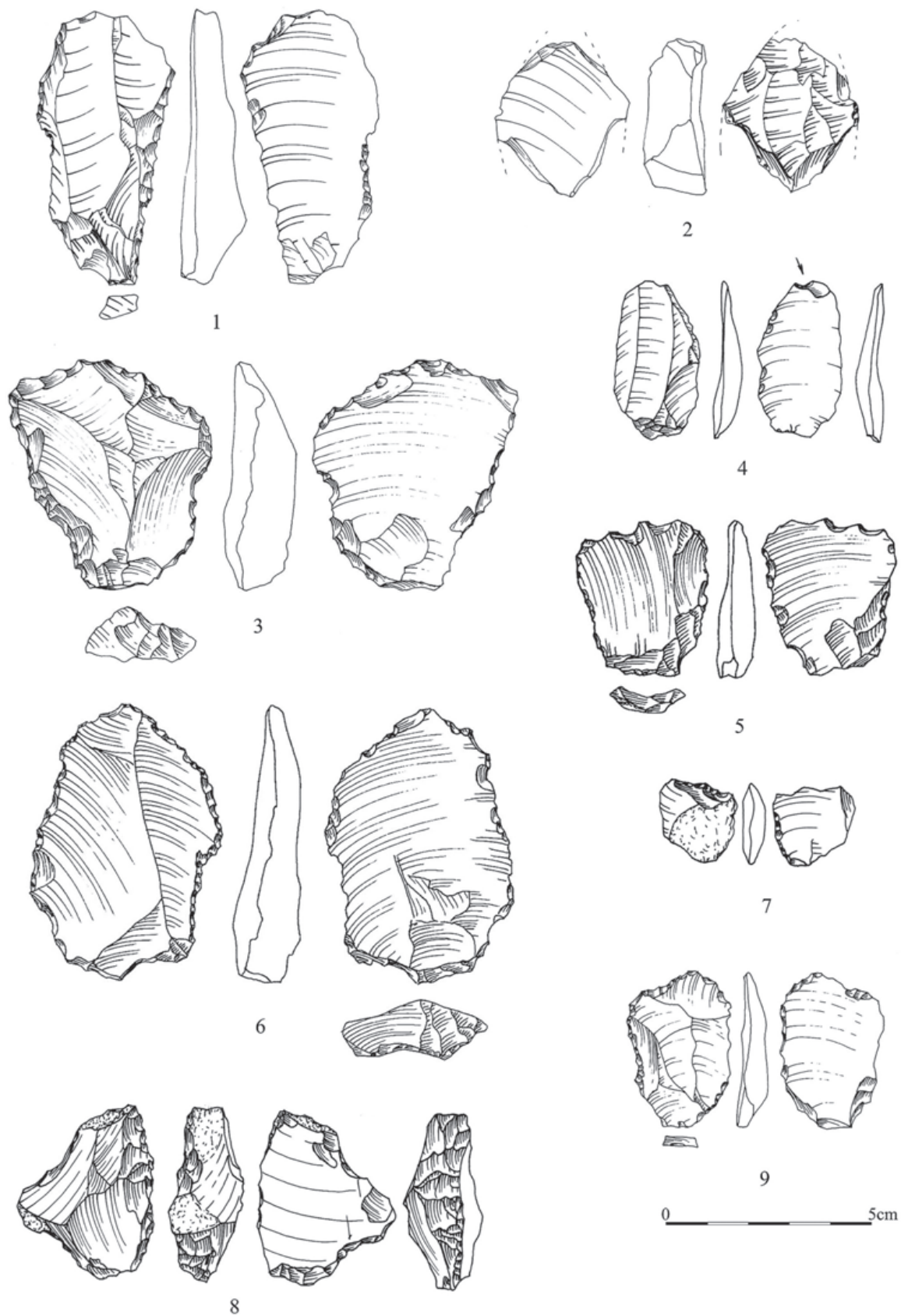


Fig. 4. Flint artifacts from the Layer 19a (inventory A 7). 1 – oval side-scraper; 2 – Levalloisian flake fragment; 3 – denticulate tool with a notch; 4 – Levalloisian flake with a spin off on the tip; 5 – denticulate tool made from thin Levalloisian flake; 6, 9 – tools of the *raclettes* type made from thin Levalloisian flakes; 7 – micro-flake with a notch; 8 – convex side-scraper of *La Quina* type. Drawn by M. Sudol

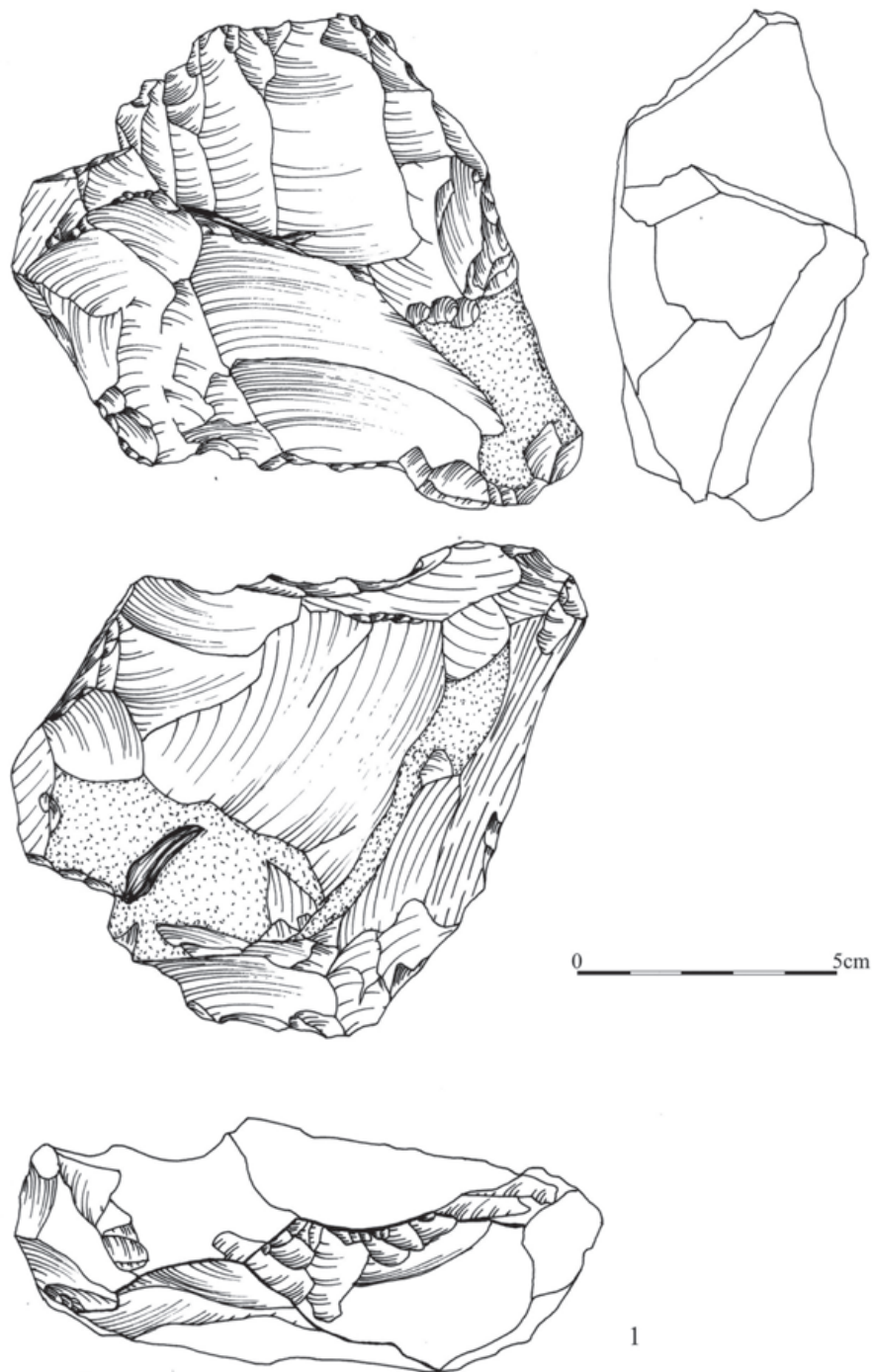


Fig. 5. Proto-Levalloisian core from the Layer 19b-19c, classified as inventory A 7. Drawn by M. Sudoł

3. Bitruncated blade fragment with denticulate retouch of the edge. Heavy milky patina. Undetermined flint. W-04692 (fig. 6: 1).

4. Knife-like tool or non-typical burin with natural back, denticulate edge and a trace of para-burin negative (scar) on its tip. Beige Jurassic flint. W-04385 (fig. 6: 3).

5. Convergent side-scraper made from thick Levallois flake of debordand type. Beige Jurassic flint. Light milky patina. W-04459 (fig. 6: 2).

6. Levallois blade fragment with striking platform and removed bulbus. Undetermined flint. Heavy milky patina. W-07672 (fig. 6: 5).



Fig. 6. Flint artifacts from Layers 19b-19c, classified as inventory A 7: 1 – fragment of a bladelet broken in two places; 2 – convex side-scraper made from thick Levalloisian flake; 3 – knife-like tool; 4, 6 – Levalloisian flakes with negatives (scars) on dorsal side pointed to the centre; 5 – Levalloisian blade fragment with a trace of removed bulbar scar; 7 – core for flakes without traces of preparation. Drawn by M. Sudol

7. Levallois flake with radial negatives (scars) and pseudo retouch. Jurassic flint. Burned specimen. W-07541 (fig. 6: 4).

8. Levallois flake with multidirectional negatives (scars). Jurassic flint. W-08498 (fig. 6: 6).

9. Chips obtained as a result of sediment flotation.

In this way an inventory of about 20 artifacts (17 + several chips) has been reconstructed and marked as A7. Its primary deposit was layer 19a.

Local Jurassic flint, gray-beige in colour, was certainly the material for the production of 8 artifacts and probably 4-6 others, covered with milky patina. Local flint was used to produce 3 artifacts. 2 objects have not been identified as regards the raw material, due to the excessive overheating. 3 small nodules of Jurassic chert, found at the discussed level and probably coming from the valley, situated just below the cave, give an idea of the type of raw material that was available for the cave dwellers of those times. The finding of a large lithic core (W-04480, fig. 5) indicates that bigger concretions of gray Jurassic flint were also in use. The material was probably obtained from the nearby outcrops of weathered limestone (a few kilometers away).

The core is characterized by the atypical form and type of preparation and exploitation. It is prepared and exploited with the use of technique similar to the Levallois one i.e. preparing of the working surface. The preparation was made by a series of blows directed from the edge to the center of the artifact. Afterwards, blades and blade-like flakes were produced with single platform and parallel blows – indicated by negatives (scars). The atypical character of the technique used is proved by the irregular and incomplete preparation around the artifact, Levallois in character, but made with a hammerstone and in an inconsistent way, which caused its irregular shape, not similar to classic Levallois standards. The core bears resemblance to a variant of the Levallois technique in the form of the Victoria-West method, but it is at the same time slightly similar to proto-prismatic forms exploited with the use of the Levallois recourt technique (Chabay & Sitlivy 1993, pp. 21, 33). The nearest territorial analogies to the used method of flint processing come from the Levallois assemblages of Piekary, in the southern part of the Kraków-Częstochowa Upland, southern Poland (PyIIE, layer 4 and Py I) (Sachse-Kozłowska & Kozłowski 2004, table VII: 1, LX). Also at the bottom level of the Lower-Sile-

sian site Wrocław-Hallera 1, south-western Poland, there were cases of the Levallois technique being used for the reduction of cores (Wiśniewski 2006, fig. III.11). Another analogy comes from the Late Acheulean inventory from Markleeberg, eastern Germany, where a large number of Levallois cores are characterized by center core direction of pre-flaking preparation and parallel, single- or double-platform blade and flake core exploitation (Baumann & Mania 1983, Abb. 38, 41, 44, 46, 47, 50, 51). A similar core was part of the Acheulean-Mousterian complex at Velykyi Glybochok in Podolia region, western Ukraine (Sytnyk 2000, fig. 46: 1, 3). Also in Kůlna Cave in Moravia, eastern Czech Republic, similar morphological core forms were found in the early Paleolithic inventory from layer 14 (Valoch 1988, Abb. 52:7).

Most flakes and blades (6 pieces) display a clear Levallois character, which is indicated by prepared striking platforms and surface negatives (scars) arrangement. Only 2 flakes are void of these features. Out of 8 retouched forms, 6 were made of Levallois flakes or blades. The atypical core with Levallois traits, which was discussed above, implies Levallois preparation process directed into the center of the artifact and one direction of exploitation with hammerstone. This is proved by a pattern of negatives (scars) on the upper side of flakes and blades, removed bulbs of percussion, bulbar scars (erailles) and the diversity of flakes thickness. This technical uniformity of the described inventory may be an indication of its cohesion.

Among the 10 retouched forms there were: 3 side-scrapers (among them one of La Quina type), 2 or 3 small side-scrapers/raclettes, 2 denticulate-notch tools and one atypical knife-burin. The assemblage is supplemented with a bladelet broken at both sides; its edge was retouched in denticulate form, but its shape and size is similar to the negatives (scars) visible on the above described Levallois core – its negatives (scars) are similar. It could have been an example of composed tools that were recognized in the Lower Paleolithic and later in the Middle Paleolithic, in microlithic techno-complex especially.

Summing up the character of the oldest inventory in Biśnik Cave, we have to underline the domination of the Levallois technique for obtaining flakes and blades. The tools included: forms with one side preparation technique connected with different types of side-scrapers and small side-sca-

pers, denticulate and notch forms. Bifacial artifacts are absent. Because of a small number of the above mentioned inventory, we can only conclude that it is a typological collection of artifacts characteristic of the Mousterian tradition, broadly speaking. At the same time the inventory cannot be regarded as the Levallois-Mousterian culture, due to a high percentage of retouched forms.

As regards chronology of the analyzed assemblage, important information is provided by TL dating, obtained for flakes (W-04020), which equals 230 ± 51 ka and which amounts to OIS 8-7. In this context, the age of the above mentioned assemblages can be presented here, i.e. Markleeberg: OIS 8-7; Velykyi Glybochok, Layers III/IIIB/IIIA: OIS 7-6; Kůlna Cave, Layer 14: OIS 6-5e; Piekary: OIS 5 a-d; and Wrocław-Hallera 1: OIS 7. They point to a long period of about 180,000 years of the development of the Mousterian tradition with the

use of the Levallois technique in the Middle Paleolithic, in this part of Europe.

According to Sytnyk et al. (2010, p. 45), the quoted assemblages from Velykyi Glybochok provide evidence for the local origin of Mousterian with the use of the Levallois technique in the vicinity of Dniester river basin. It seems that the discussed inventory from Biśnik Cave may be considered as a proof of a local origin of the Levallois-Mousterian culture on the territory of southern Poland. Taking into consideration the age of layer 19a and the discovered inventory A7 (OIS 7 or OIS 8), it can be supposed that there is a local origin of the Mousterian culture with the use of the Levallois method. The findings link with the early Middle Paleolithic phase of the Mousterian culture, developing in some parts of Central Europe, as marked off by Wiśniewski (2006, pp.112-113, fig. III.46-47).

3. PROBLEMATIC STRATIGRAPHY

Dating of the layers which include the oldest artifacts from Biśnik Cave turned out to be a difficult task, even in spite of broad, multi-disciplinary researches. The most definite is the relation between the age of the layers and the Eemian Interglacial (OIS 5e), which is linked with Layer 13 (Cyrek et al. 2010), and possibly Layer 12 (Mirosław-Grabowska 2002). Data on paleo-vegetation obtained by Krajcarz et al. (2010) and paleo-climate (Krajcarz 2009) suggest that the Eemian Interglacial is rather represented by Layers 13a and 14. All these layers (12-13-13a-14) linked with the Eemian Interglacial are situated much higher in the cross-section in comparison with the layers discussed in the current work. It clearly indicates the pre-Eemian age of Layers 19a, 19b, 19c, and 19d. Their more precise dating is difficult to be established. First of all, a small number of dating samples of the so called absolute age has been obtained so far. For the overlying Layer 19, the U/Th dating has been carried out (table 1), and the dating was obtained through two different geochemical models. The results of the dating are highly ambiguous. Both models indicate quite different age (table 1). The date for EU model (112 ± 56 ka) can be rejected as highly unlikely for pre-Eemian sediment. The real age of the sediment dated by U/Th method ranges from EU to LU results (Hercman & Gorka 2002, tab. 2). Older

layers have been dated by TL method. One date was obtained for Layer 19a (according to the numbering adopted for the current work) and the result is possible to be accepted in the light of U/Th dating of the younger Layer 19. Two dates have been obtained for Layer 19b (section which in previous publications was regarded as the lower part of Layer 19a), thanks to dating both quartz grains from the sediment and the burned flint artifact. Both dates revealed similar age (table 1). However the error range of both dates, which equals 360 thousand years, is huge. This makes their usefulness rather limited, but the date from a flint artifact seems more reliable than the one obtained from the sediment. However, the dating definitely points to the older age of Layer 19b than the upper Layers 19 and 19a.

In previous studies the stratigraphic position of the oldest layers in Biśnik Cave were differently interpreted (table 2). Most commonly layer 19 was linked with stage OIS 8 and the Odranian stadial of the Saalian Glaciation. The older layers (19a-19c) in turn were associated with OIS 9. The views presented by Krajcarz (2009) and Krajcarz et al. (2010) suggested a younger age of the layers, associated rather with OIS 6, but also with the Odranian stadial. To some extent the confusion may result from the changes which have taken place in the Polish stratigraphy of the Pleistocene in recent

Table 1. TL and U/Th dating of the oldest layers from Biśnik Cave

layer	method	date range (ka)	references
19	U/Th (bone, EU)	112±56	Hercman & Gorka (2002, tab. 2), Cyrek et al. (2010, tab. 3)
19	U/Th (bone, LU)	346±25	Hercman & Gorka (2002, tab. 2), Cyrek et al. (2010, tab. 3)
19a	TL (burned flint)	230±51	new data (Lab No: Lub. 4470)
19b*	TL (sediment)	569±182	Cyrek et al. (2009, tab. 1, 2010, tab. 3)
19b*	TL (burned flint)	568±131	Cyrek et al. (2009, tab. 1, 2010, tab. 3)

EU – early uranium accumulation model; LU – linear uranium accumulation model

* in original publication called 19a, however it was the lower part of the layer, attached here to the layer 19b (see explanation in chapter 1)

Table 2. Current views on chronostratigraphy of the oldest layers in Biśnik Cave

layer	Mirosław-Grabowska (2002)	Cyrek et al. (2009)	Cyrek et al. (2010)	Krajcarz (2009), Krajcarz et al. (2010)
19	OIS 8	OIS 8 ?	OIS 8	OIS 6 or 7 ?
19a-19d	–	OIS 9-11 ?	OIS 9 ?	OIS 6 or 8 ?

Table 3. Various suggestions of stratigraphic division of the Saalian Glaciation in Poland. The Odranian stadial (a different term is applied by various authors) in bold. Int. – Interglacial, st. – stadial, intst. – interstadial

oxygen isotope stage	Lindner (1992)	Lindner et al. (2004), Ber et al. (2007)	Mojski (2005)	Lindner (2005)
OIS 6	Mława st. Wkra st. Warta st.	Wartanian st. Odranian st.	warta st.	Warta st. Kamienna st.
OIS 7	Lubavian Int.	Lubavian Int.	prewarta intst.	Lublinian Int.
OIS 8	Radomka st. Krzna st.	Krznanian st.	maximal st.	Krzna st.
OIS 9	Zbójnian Int.	Zbójnian Int.	premaximal intst.	Zbójnian Int.
OIS 10	Liwiec st.	Liwiecian st.	premaximal st.	Liwiec st.

years. First of all, the position of the Odranian stadial, linked with the maximum range of the ice sheet during Saalian Glaciation is questionable. The older concepts dated the stadial to OIS 8,

i.e. before the Lubavian interglacial (= Lublinian, Schönigen, OIS 7). At present, some researchers are inclined to link that stadial rather with OIS 6 (table 3).

4. GEOLOGICAL DATA

4.1. Sedimentology

Sedimentological observations carried out in the cave revealed that layer 19a is the oldest typical cave loam. Thus it is characterized by the following features: it is humus sediment of weathering origin, undergoing sedimentation processes in very low-energy environment. It is situated in a horizontal position and is characterized by constant thickness horizontally. It contains limestone rubble and dispersed calcite and does not reveal traces of inner lamination. It contains numerous post-sedimentary structures. Layers situated below (19d, 19b and 19c) are of different character. The most important feature which makes them different from the upper layers is the erosion character of the bottom surfaces of each layer (fig. 7). In some places the sediment reveals traces of clear sinusoid lamination of trough cross-stratification character. The layers which were marked as 19b and 19c during excavations are, as a matter of fact, a larger number of sediment lenses, whose whole array should be jointly treated as one archaeological layer 19b-19c.

The sediment from the layers are almost completely void of limestone rubble, or post-sedimentary structures connected with the falling of rubble clasts. Such a phenomenon may have an accidental character, but it is more likely that it is connected with a fast sedimentation rate, which prevented the accumulation of stone rubble, slowly falling from the ceiling of the cave. A characteristic feature is also the lack of dispersed calcite in the discussed layers. Their pH (established by pedological methods in KCI) is lower than 6.0. This implies contribution of water to the accumulation of sediment and rinsing off calcite. Bottom boundaries of layers are characterized by considerable undulation, but generally a NE inclination can be observed, with 4-5° angle of dip.

All the features discussed above let us unambiguously determine the sedimentary environment during sedimentation processes. The accumulation occurred quickly and was accompanied by presence of pour water. The occurrence of erosion indentations in terra rosa clay, which is compact sediment, and therefore quite difficult to explore, implies that

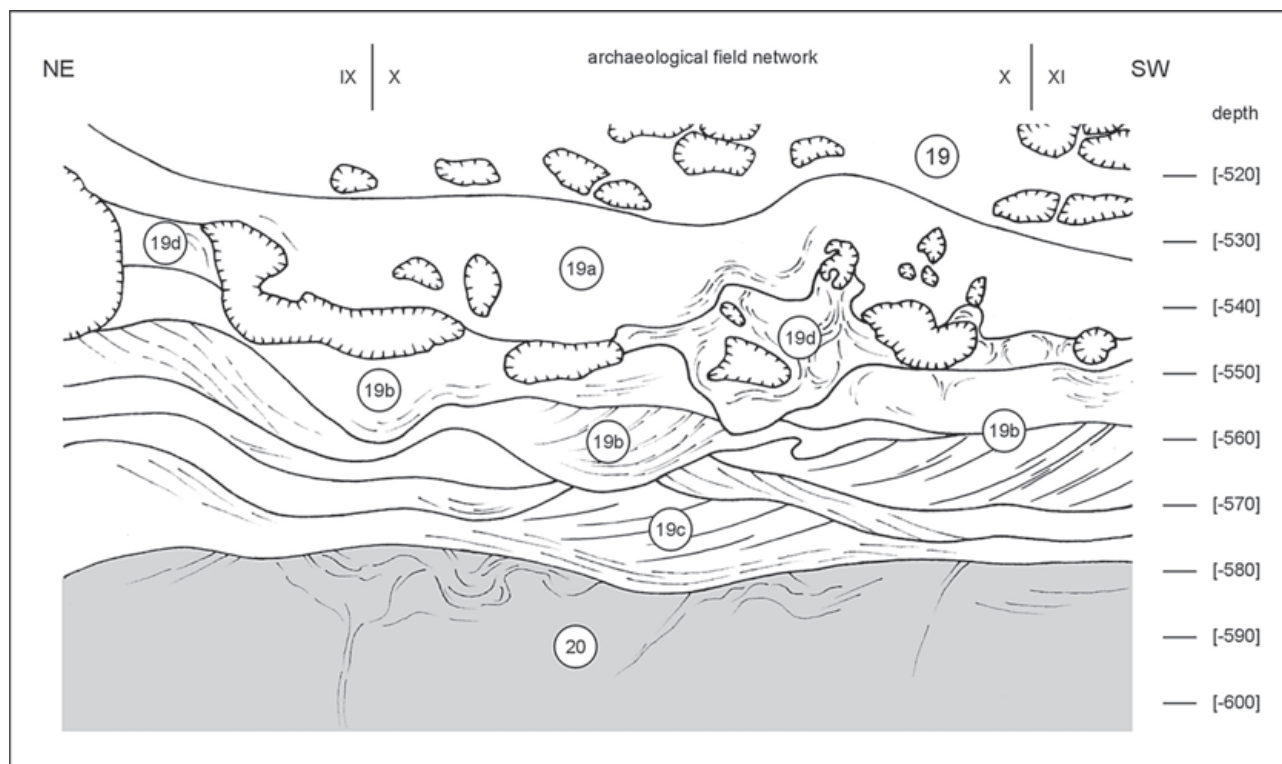


Fig. 7. Demonstration of sediment structures from the oldest layers in the Biśnik Cave. The presented cross-section is situated in the strips of land IX, X, XI and meters 9/10 of the archaeological projection of research trenches. Depth in the cm below the benchmark

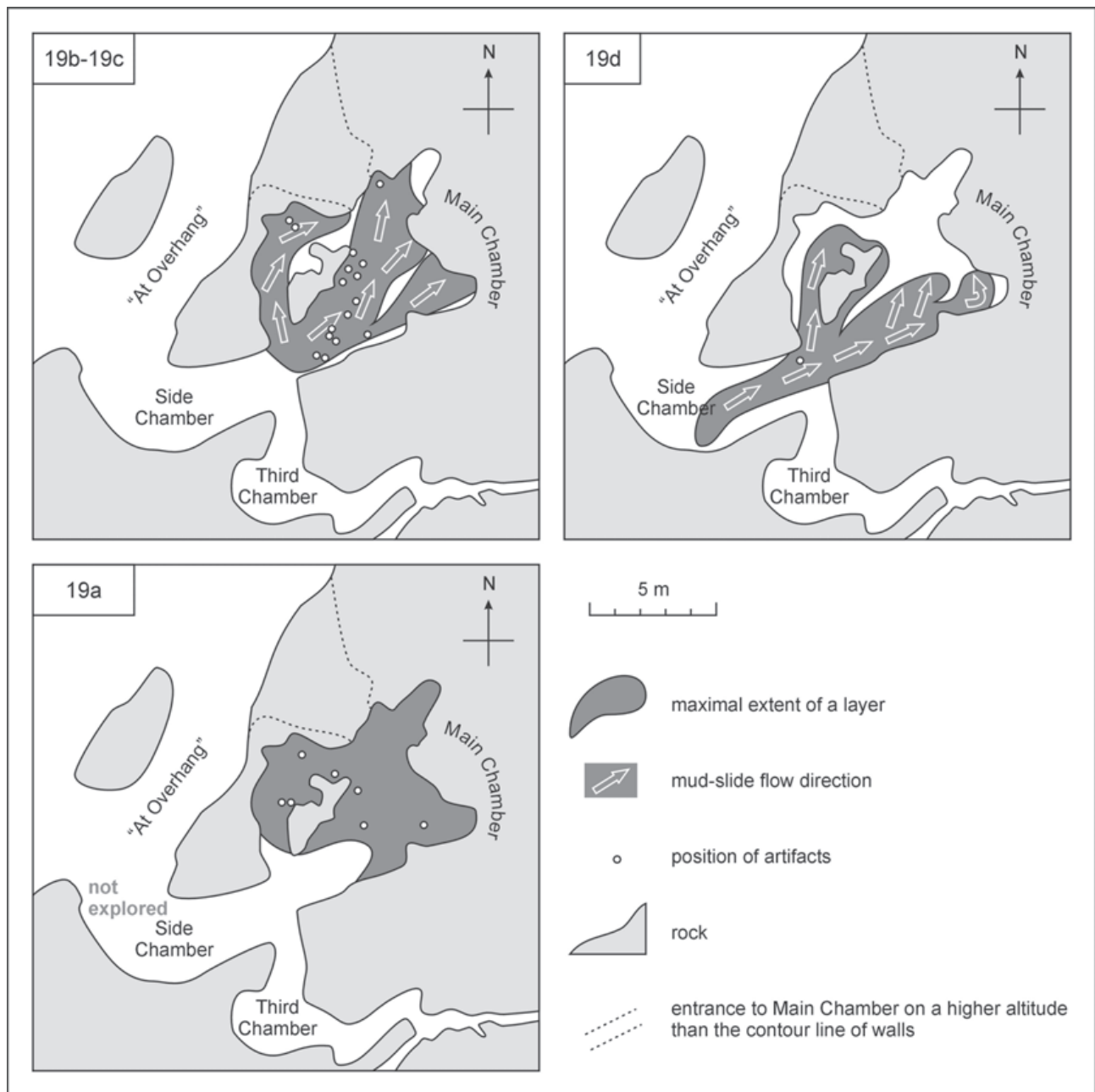


Fig. 8. Maximum extents of sediments of layers 19b-19c, 19d and 19a in the Biśnik Cave with general mudflow directions, reconstructed on the basis of archaeological field documentation, with the scattered diagrams of artefacts from the shown layers. The NW and W parts of Side Chamber have not been explored yet, so it is possible to find undisturbed sediments, especially of layer 19a in that place during the future works

clay from the bottom of the cave was plastic at that time, and consequently saturated with water (compare with analogous situations described by Dylík et al. 1954, pp. 56-57, or lastly Hunt et al. 2009). Moreover, the development of layer 19d, resembling terra rosa clay in terms of granulometry and colour, also indicates that clay from the bottom of the cave partly underwent erosion and were redeposited as a layer 19d. A similar situation was observed at the cave at Kozi Grzbiet (Głazek et al.

1977, pp. 18-19) and the Tunel Wielki cave (Madeyska 1988, p. 122), both from southern Poland. The lack of inner lamination in some lenses indicates that the sediment was at least partly relocated as a result of cohesive flow, i.e. in the conditions of big coherence and plasticity of the relocated sediment. It seems that the whole of layers 19d-19b-19c can be treated as the sediment resulting from the series of several mudslides, with a different degree of compactness, which was connected with a differ-

ent level of water saturation to sediments and was probably the effect of changes in the intensity of delivering water to the cave. The inclination and dispersion of layers makes it possible to indicate the general direction of the flow from SW to NE (fig. 8). Nevertheless the directions of the flow of particular tongues or some part of those considerably wavered (compare changeability of directions of sedimentation structures in fig. 7). Alimentary sediments occurred to SW of the current position of the layer, i.e. within the Side Chamber. The composition of the layers allows to reconstruct the approximate primary sediment structure, which became the alimentary material. These sediments were mostly silty loams, humic, containing bone remains and archaeological artifacts, i.e. typical cave loams. In the explored parts of the cave these alimentary sediments were not preserved and became completely eroded. Their material was entirely re-deposited by mudslides and deposited in the form of layers 19b-19c. Terra rosa clays were also partly joined to the sediment of mudslides and redeposited as layer 19d.

4.2. Geochemistry

The so called fossil provenance analyses are carried out on paleontological sites, especially multi-layer ones, when the primary location of fossils is questionable (Trueman et al. 2006). The method is based on the phenomenon of the chemical composition of fossils (e.g. bones) under the influence of the surrounding sediment, shortly after deposition (Denys et al. 1996, Patrick et al. 2004, Trueman et al. 2004, 2006). In the case of multi-layer sites, containing lithologically diverse layers, we deal with the phenomenon of geochemical diversification of bones between particular layers (Plummer et al. 1994,

Sillen & Morris 1996). The phenomenon is used for the purpose of determining the origin of bones, whose primary location is undetermined (e.g. coming from old research, when the documentation is missing). They also allow to determine any possible natural redeposition (post-sedimentary relocation of bones between layers). The current work focuses on the latter option and aims to verify whether layers 19a-19c are of deluvial character and determine the primary origin of bones found in the layers.

The research was carried out on bones from layers 19, 19a, 19d, 19b and 19c (details in table 4). From some layers, with worn sparse bones, only 2 samples were analyzed. For comparison, additional analyses of four samples from layer 18 have been included. The analysis of chemical composition was conducted with the ICP-MS method. The presence of the following elements was determined: K, Mg, Ca, Sr, Ba, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb, As. Because of analytical difficulties, nonmetals were not analyzed. Elements from detritic minerals, which occur in the greatest concentrations in the sediment (e.g. Si, Al, Ti, Zr) were also ignored in order to avoid the contamination of the bone material with sediment. Elements occurring in very small quantities (close to detection limits or below) did not undergo the analysis either. The results underwent statistical clustering analysis, in the computer program StatistixXL. The analysis through calculating the distance, with the use of Bray-Curtis method, leads to generating the dendrogram, i.e. a kind of graph joining the most similar samples in the clusters. The dendrogram obtained for the samples from Biśnik Cave is presented in fig. 9.

The dendrogram presents several clearly visible clusters, marked on fig. 9 as I, II, III, IV and V. Each cluster corresponds with the population of bones with a similar chemical composition, which indicates their common diagenesis in one layer.

Table 4. Bone samples chosen for *fossil provenance analysis*

layer	number of samples	sample symbols
18	4	18.1, 18.2, 18.3, 18.4
19	10	19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8, 19.9, 19.10
19a	2	19a.1, 19a.2
19d	7	19d.1, 19d.2, 19d.3, 19d.4, 19d.5, 19d.6, 19d.7
19b	7	19b.1, 19b.2, 19b.3, 19b.4, 19b.5, 19b.6, 19b.7
19c	2	19c.1, 19c.2

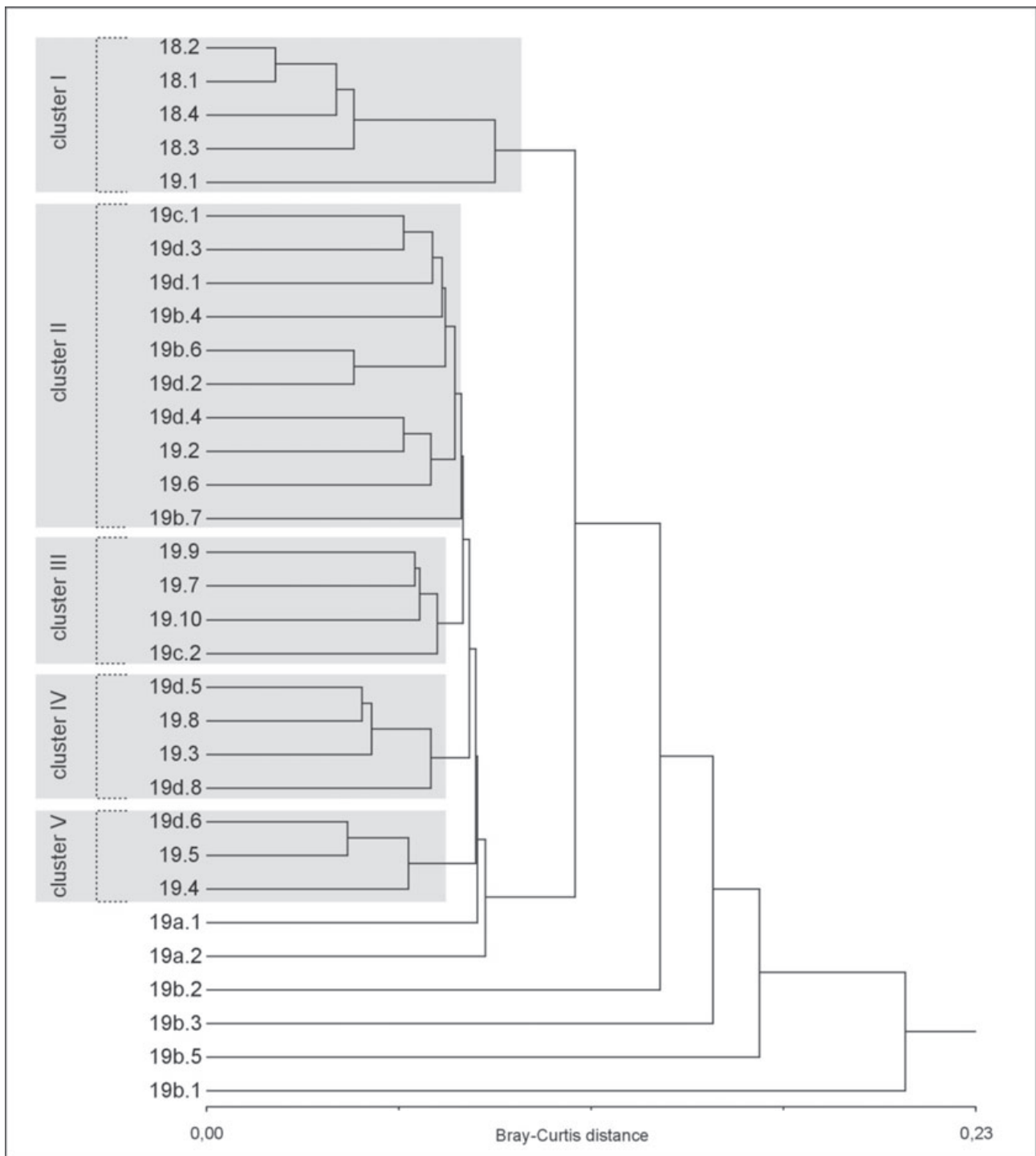


Fig. 9. Dendrogram of the samples from the layers according to the similarity of chemical composition

Cluster I clearly corresponds with layer 18, whereas three other clusters (III, IV and V), joining mainly samples from Layer 19, can be linked with Layer 19. The presence of three clusters connected with one layer, instead of one indicates that the layer may not be lithologically homogeneous. A few bones corresponding to the presented clusters have been

found in other layers (samples 19d.5, 19d.6, 19d.8 and 19c.2), which may result from the redeposition of the bones or errors in obtaining the samples.

Cluster II, the largest of the ones presented, is similar to clusters linked with layer 19. It contains samples from all deluvial Layers, i.e. 19b, 19c and 19d. This clearly indicates that the majority of bones,

which are now found in different deluvial Layers (i.e. 19b, 19c, 19d) in Biśnik Cave had a common diagenesis in one layer. As a result of mudslides, bones from one layer were relocated and deposited in different flow tongues. The vicinity of the cluster to those corresponding with layer 19 indicates that the destroyed layer was geochemically similar to the preserved younger layer 19.

Two bones from Layer 19a (samples 19a.1 and 19a.2) correspond to clusters II, III, IV and V, but they are distinct. This shows that despite lithological similarity to layers 19, 19b and 19c, the layer 19a is geochemically different. This is also supported by research of Krajcarz et al. (2010), referring

to the composition of organic matter in the layers of Biśnik Cave. Layer 19a may be therefore distinguished from deluvial layers, which is also supported by its sediment features.

Several samples in the dedrogram do not match any of the discussed clusters, and they do not form a cluster on their own (samples 19b.2, 19b.3, 19b.5, 19b.6). They represent bones geochemically different, which underwent diagenesis in various layers, that were lithologically distinct from the layers discussed hitherto. These bones were all found in deluvial Layer 19b. Most probably they come from several different unpreserved layers, which underwent complete destruction as a result of being eroded by mudslides.

5. THE AGE OF THE OLDEST ARCHAEOLOGICAL ASSEMBLAGES

In the light of recent geological and geochemical research, it has to be stated that not all of the oldest archaeological artifacts from Biśnik Cave can be regarded as homogeneous assemblage. Flint objects found in layer 19a (assemblage A7) are the oldest artifacts in the position in situ. All of the older artifacts found in layers 19d and 19b-19c, which have been also included in assemblage A7, are located on the secondary deposit. The redeposition of the artifacts was connected with mudflows and the re-location of the older sediments, along with the animal bones and archaeological artifacts (fig. 10). The occurrence of mudslide sediments in a cave is not a separate example and was noted from many sites from Poland and elsewhere (for example: Bosák et al. 1982, p. 220, Dylík et al. 1954, pp. 56-57, Głazek et al. 1977, pp. 48-49, 52, Hunt et al. 2010, p. 1604, Madeyska-Niklewska 1969, p. 350, Mallol et al. 2010, Pickering et al. 2007, pp. 606-607). The redeposited sediment and artifacts primarily occurred in the Side Chamber and the distance of the re-location can be estimated between a few and over a dozen meters.

The inventory of artifacts from deluvial layers is not homogeneous. The artifacts may be of different age and be connected with various stages of the inhabitation of the cave. The TL date obtained for the sediment of one of the deluvial layers (569 ± 182 ka), as well as the date obtained for the burned flint tool (568 ± 131 ka) point to the early Middle Pleistocene age of at least some of the redeposited sediment and artifacts. Thus they contain one of the oldest traces of human presence on the

territory of today's Poland, at the age comparable to that of the findings from Rusko or Trzebnica (Burdukiewicz 1993, 2003).

Palaentological data only partly support the age of the redeposited sediment. In the re-located sediments of the deluvial layers there is a marked presence of a rodent *Arvicola amphibious* with a lack of *Mimomys sp.*, which implies that the sediment was formed not earlier than 500,000 years ago (Cyrek et al. 2010). On the other hand, there is a marked presence of large mammal taxa, characteristic of the turn of the early and late part of the Middle Pleistocene, like *Panthera spelaea fossilis* (Marciszak & Stefaniak 2010) and *Ursus deningeri* (A. Marciszak and K. Stefaniak, pers. comm.).

An interesting issue is the reason for mudflows in the cave. The development of those processes required entering large amounts of water into the cave in a short time span. Such a phenomenon can be explained in three ways (compare with Dylík et al. 1954, pp. 56-58, Hunt et al. 2010, p. 1607, Kos 2003, Madeyska-Niklewska 1969, p. 350, Pickering et al. 2007, pp. 604, 614-615): 1) the raising of the water level in the valley below the cave and the in-flow of river water into the cave; 2) particularly intensive rainfall, resulting in the in-flow of rainfall water into the cave; 3) melting of a permafrost, leading to the saturation of the surface layer of the sediment at the entrance zone of the cave. The first scenario may be ruled out, as no river sediments have been found so far in the lower part of the sediment profile. Scenarios 2 and 3 are practically impossible to be distinguished in the preserved

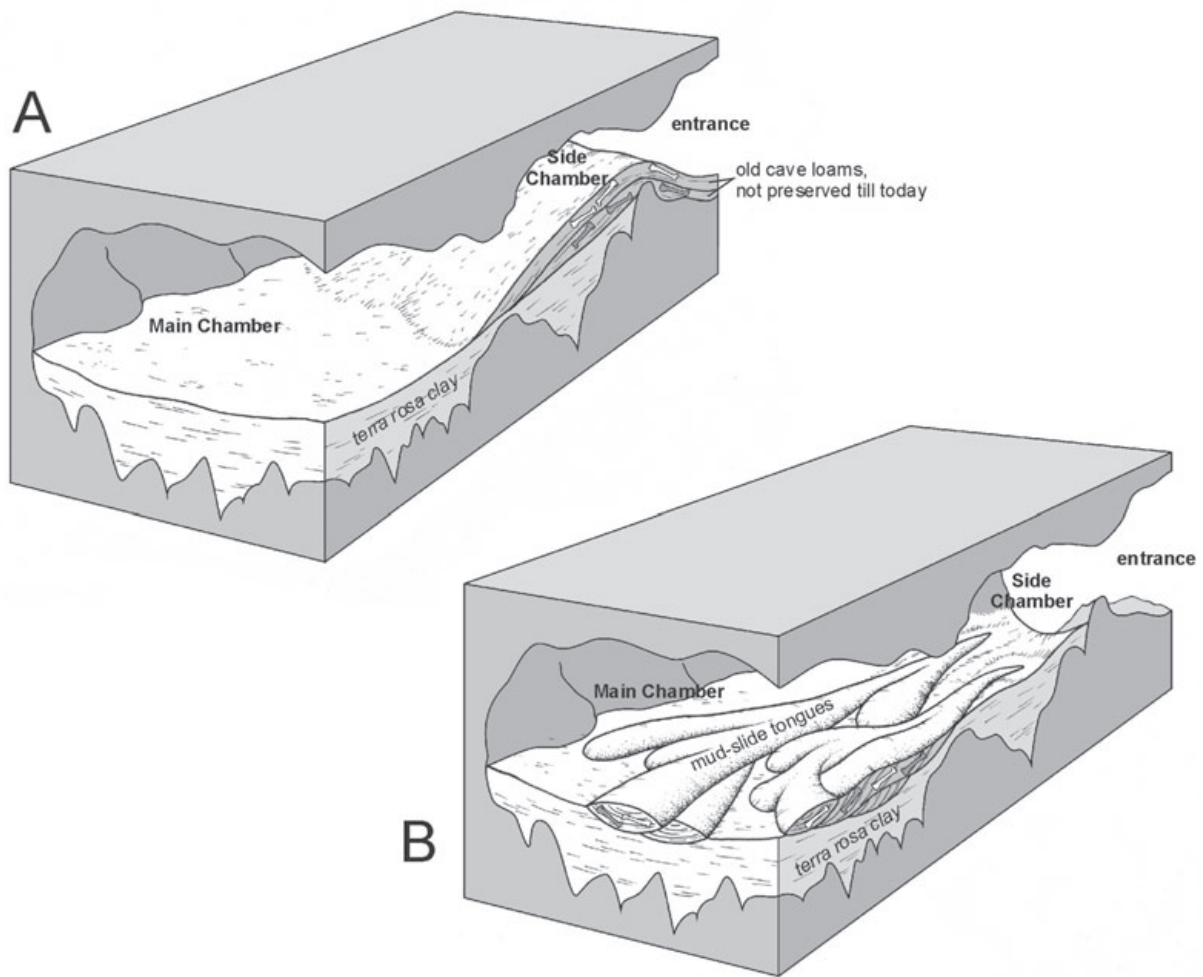


Fig. 10. Schematic reconstruction of artifacts redeposition and mixture in the layers 19b-19c. A – situation before the descent of mudflows where in the primal cave, loams with bones and archeological artifacts occur on *terra rosa* clay; B – situation after the descent of mudflows where in the Side Chamber loams have not been preserved

sediment. Moreover, it seems that they could have taken place simultaneously, because rainfall is one of the main reasons for ice melting. The analogous interpretation was given by Dylik et al. (1954) for the cave in Dziadowa Skała.

The date obtained for the oldest Layer (19a) situated in situ above the deluvial sediments (230 ± 51 ka) lets us determine the approximate age of

mudflows on the basis of *ante quem* dating. The date indicates the oxygen isotope stage OIS 7, i.e. warm climatic period. The beginning of that stage might be associated with the intensive melting of a long-lasting permafrost. This means that the artifacts found in the deluvial layers come from stage OIS 8 or older stages. Such a stratigraphic dating is confirmed by the TL dating of artifact.

6. CONCLUSIONS

The authors reckon that the presented data allow to draw interesting conclusions, both in geological and archaeological sense. The geological conclusions refer to the facies of cave filling in Biśnik Cave and at the same time present a picture

of overall rules of geological processes in cave sites. The most essential geological conclusions are as follows:

– Layer 19a is the first sediment in the Main Chamber (after the incident of mudflows) which

was deposited in situ as cave loam. Lower Layers (19b, 19c, 19d) were formed as deluvial sediment, as a result of mudflows in the cave;

– source material for deluvial sediments of mudflows was provided by the older cave sediments in the Side Chamber, destroyed as a result of mudflows. Most of the redeposited material comes from one destroyed layer, which in geochemical terms resembled the younger Layer 19 or 19a. Moreover, part of the material came from several other unpreserved layers, lithologically diversified. TL dating, obtained for deluvial layers indicate early Middle Pleistocene age for at least some of the destroyed sediments. There is a possibility that some of the sediments were preserved in the unexplored cave zone of the Side Chamber.

Archaeological conclusions refer to the age and the deposition method of the oldest archaeological artifacts in Bisnik Cave. They are as follows:

– assemblage preserved in Layer 19a is located in situ, likewise younger assemblages. Assemblage A7 from Layer 19a should be dated to OIS 7. On the basis of the technological analysis (compare chapter 2) several artifacts from deluvial Layers (19b-19c) should also be included in the same assemblage. Most probably they underwent relocation as

a result of natural post-sedimentary processes from the primary deposit, i.e. layer 19a;

– the older inventory (found in Layers 19b, 19c, 19d) is not homogeneous in terms of age and is not located in situ. It was mixed and relocated to the distance of several meters, as a result of mudflows, and enriched with later admixtures from layer 19a. Thus it does not constitute an assemblage made by Paleolithic people, but only an inventory found by archaeologists, and formed with artifacts coming from various assemblages. Geological and paleontological data cannot help date the assemblages as the processes of the relocation of mudflows led to the mixing of artifacts of various age, as well as animal bones and sediments. The only possibility to date the assemblages is a direct dating of separate artifacts. One of them has been dated in this way (table 1) and implies very old (even Lower Paleolithic ?) age of one of the destroyed assemblages.

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