Archaeologia Polona, vol. 60: 2022, 187–229
PL ISSN 0066-5924
DOI: 10.23858/APa60.2022.3084

Prehistoric Stone Raw Materials from the Bükk Mountains in Northeastern Hungary

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From the period of the Neanderthals to those of the Late Neolithic populations, the Bükk Mountains region played an important part in the lives of various prehistoric societies, and the varied geological history of this territory provided distinct circumstances for the production of stone implements. The major goal of our research is to outline the current state of information concerning the prehistoric use of the diverse silicified source materials of the Bükk mountains. The results of these studies are presented concerning four selected local rock types, cited in the archaeological literature as the silicified sandstone of Egerbakta, the radiolarite and hornstone (black chert), the silicified marlstone and the quartz-porphyry (metarhyolite). Except for the latter, little attention has previously been paid to studying them in detail. Our new petrographic analyses revealed two variants of the raw material from Egerbakta: a silicified sandstone and a diatomaceous detrital chert. The other samples turned out to be radiolarites. This result confirmed what was already suggested for the hornstones (black cherts), however, it has new consequences for the "silicified marlstone". Regarding the prehistoric use of the selected raw materials, archaeological data show interesting dynamics through time. The Mousterian groups of the region used a large spectrum of rocks for lithic tools with a preference for hornstone (black cherts) and radiolarite in the southern part, and the quartz-porphyry (metarhyolite) in the northeastern part. The Bábonyian/Micoquian assemblages are characterized by a bifacial toolkit and an apparent preference for quartz-porphyry (metarhyolite). At the beginning of the Upper Palaeolithic, a new attitude appears in the region: the Aurignacian

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Received 20 April 2022; Received in revised form 1 July 2022; Accepted 10 July 2022

groups almost completely ignored local sources. During the Neolithization of the Carpathian Basin, the lithic assemblages of the Alföld Linear Pottery culture became more and more habituated to the locally available rock types, albeit their raw material economy was based on limnosilicites and obsidian. Another change took place during the Late Neolithic when supra-regional sources became dominant over local or regional sources.

KEY-WORDS: petrography, raw material economy, quartz-porphyry (metarhyolite), silicified sandstone, radiolarite, Palaeolithic, Neolithic

INTRODUCTION

The region of the Bükk Mountains has an extraordinary place in the history of Hungarian prehistoric archaeology and is of special interest in the study of the Stone Age of Hungary. The first evidence of "Diluvial Man" in the territory of Hungary, the so-called "handaxes of Bársony's house" were found in 1891 here in Miskolc (Herman 1893). As a consequence, systematic excavations have been carried out in the caves of the Bükk Mountains from 1906 onward, yielding archaeological material from Palaeolithic and Neolithic times (Kadić 1934). The intensive archaeological research in the region has resulted in important assemblages which have constituted the basis for defining cultural units, like the Middle Palaeolithic Bábonyian (Ringer 1983), the Szeletian of the Middle to Upper Palaeolithic transition (Prošek 1953) and the Middle Neolithic Bükk culture (Lichardus 1974). The special interest is because the region is rich in various siliceous rocks of different geological origins that were used by prehistoric people as raw materials for their knapped stone tools (Biró and Pálosi 1985; Pelikán 2005).

Early on, petrographic characterization of the raw materials of the unearthed lithic industries was carried out for the publication of site monographs, like that of the Szeleta and Subalyuk caves (Vendl in Kadić 1916: 231–235; Vendl 1940). However, these were only suggestions concerning the sources of these siliceous rocks because the comprehensive study of the geology of the Bükk Mountains was conducted later (Balogh 1964; Pelikán 2005). Another problem with these former petrographic identifications is using varied rock names in archaeological studies (Biró 2010). Systematic study of rocks of archaeological interest in Hungary started in the 1970s at the Hungarian Geological Institute following the initiative of geologist József Fülöp, director of the institute, after the discovery of a prehistoric radiolarite mine at Tata (Fülöp 1973). The intensified investigations in this field were crowned with an international conference on flint mining and lithic raw material identification (Biró 1986; 1987a) and the establishment of the Lithotheca comparative raw material collection at the

Hungarian National Museum in Budapest (Biró and Dobosi 1991; Biró *et al.*, 2000). The siliceous rocks of the Bükk Mountains were only marginally covered by these investigations, only three of them have been analyzed in thin sections and by geochemistry and spectrometry (Biró *et al.*, 2000: 214–275). The reason is probably that the international research was mostly interested in the detailed study of more recognizable raw material types, such as Carpathian obsidians and Transdanubian radiolarites which were recorded on archaeological sites from Germany to the Balkans proving long-distance contacts of Neolithic communities (Mateiciucová 2007). Among the raw materials of the Bükk Mountains is one lithic source of interest for that reason, the quartz-porphyry (metarhyolite), which is recognized in some archaeological assemblages of neighbouring countries (Markó *et al.*, 2003).

During the 1980s and 1990s, the fieldwork and analytical studies related to siliceous rocks in Hungary were based on the "provenience approach" which generally compares raw materials found at the archaeological sites with rock samples of the known origin of already existing databases and lithothecas. This approach, completed by the geochemical fingerprinting methods, provided a considerable amount of knowledge about raw material sourcing, however, it also showed its limits too (Biró 2004; 2009). The distances calculated between archaeological sites and geological sources were interpreted as the "action radius" of a given human group or in terms of raw material circulation (Simán 1991; Dobosi 2009; Biró 2004; 2009; Markó 2009). However, a series of problems arise from both geological and archaeological points of view. The different silicification processes that happened under varied conditions could result in great variability in the same geological formation. This variability either allows us to differentiate raw material sources (e.g., obsidian, Williams-Thorpe *et al.*, 1984; Kasztovszky and Biró 2006) or prevents us from distinguishing between sources in a wider area (e.g., radiolarite, Biró *et al.*, 2009; Szilágyi *et al.*, 2020). In the case of post-volcanic (metasomatic) silicification, the characteristics of the original sediment could result in high variability even within one source (e.g., limnosilicites, Szekszárdi *et al.*, 2010; Mester and Faragó 2016). For a better archaeological interpretation, it is important to take into consideration the different ways in which a lithic raw material could arrive at the site through human activities, including mobility, network, exchange and supply (Renfrew 1984; Féblot-Augustins 1999; Gamble 1999; Lech 2003; Whallon 2006). Moreover, the organization of the raw material economy in time and space resulted in differences in the presence of raw materials on the site according to stages of lithic production (Geneste 1988; Otte *et al.*, 2001; Bonjean and Otte 2004). The "palaeoethnological approach" leads us to study these archaeological–anthropological problems through the pieces of evidence of the prehistoric human activities in a social context. All the activities of a human group form its technical system which is reflected in their technical behaviour during raw material procurement and stone tool production (Lemonnier 1986; Geneste 1991).

Applying the palaeoethnological approach, we started to study the technical behaviour of Stone Age human groups regarding the raw material sources in the northern part of the Carpathian basin (Mester *et al.*, 2012; Mester 2013; Mester and Faragó 2013). In the first stage of this research, we focused on two selected areas, the Mátra and Bükk mountains, in a diachronic approach, from Middle Palaeolithic to Middle Neolithic (Mester 2019). Based on the assumption that environmental and cultural changes were taking place over this long period, our research aims at reconstructing the potential natural lithic resources available for prehistoric people and recognizing the human choice among them with their behavioural background. For describing the interactions between lithic resources and human groups, we developed the Occurrence–Source–Archaeological site (OSA) model (Mester and Faragó in press). Each siliceous rock occurrence mapped in the region, available in a given period, is an Occurrence in the model. If the lithic analysis demonstrates that a variety of siliceous rocks was used for tool production by a human group in the period, the related occurrences become Sources in the model. If there is any archaeological evidence of human activity related to the siliceous rock at the source (exploitation, workshop), it becomes an Archaeological site in the model. In the archaeological and palaeohistorical interpretation, the OSA model allows us to manage the abovementioned problems originating from the variability or the weakness of our actual knowledge (e.g., wider distribution of variants in the geological formations, uncertainties in the petrographic identification and source location). Taking into account the consequences of the possibilities given by the model, we can formulate options in our interpretation and evaluate their probabilities and the resulting questions. Moreover, the OSA model allows us to study the dynamism of the region's human–lithic resource interaction through the changes in attributions of documented lithic resources.

METHODS AND MATERIALS

The application of the OSA model for human–lithic resource interaction requires a twofold study. The first one is the reconstruction of the locations of potential natural lithic resources in the region. It needs a comprehensive inventory of all kinds of occurrences of siliceous rocks. The basic methodology is well-known and widely used: field prospection and rock sampling of the outcrops of the geological formations which potentially contain siliceous rocks according to the geological map and its explanation (e.g., Turq 2000: 33–35; Féblot-Augustins 2009: 170–171). Observations gathered during archaeological field surveys about the presence of blocks of siliceous rock round out the picture (Faragó *et al.*, 2018: 117–119). To understand the occurrences within the framework of landscape history, the geomorphological and pedological characteristics of the region (Dövényi 2010) had been overlapped with the geological map of the Mining and Geological Survey of Hungary in a GIS-based database (Gyalog 2005). The data about the locations have to be checked in the field. Each occurrence is characterized according to source types (Turq 2000; 2005) and sampled for siliceous rock diversity. The samples are stored in the reference collection, established in 2011 at the Institute of Archaeological Sciences of the Eötvös Loránd University in Budapest (Mester *et al.*, 2012). The basic petrographic characterization of the samples is usually done at a macroscopic and microscopic level (water immersion; e.g., Turq 2000: 35–36; Féblot-Augustins 2009: 167–168; Přichystal 2013: 43–45; Brandl 2014: 39–40). Analysis by thin sections and by geochemical analytical methods (e.g., Brandl 2014: 40) are in progress or planned for the future.

The second required study is to reconstruct and understand how humans chose raw materials from available siliceous rocks. For this, a techno-economic analysis based on the technical reading method (Inizan *et al.*, 1999; Tixier 2012) is applied to the lithic assemblages of archaeological sites (Geneste 1988; Turq 2000: 39–43). The key concept behind this reconstruction is the notion of operational chain or *chaîne opératoire* (Pelegrin *et al.*, 1988; Karlin *et al.*, 1991; Sellet 1993; Audouze and Karlin 2017). The reference collection of the Institute of Archaeological Sciences Eötvös Loránd University, Budapest, aids in the identification of the used raw material and source type.

In this paper, we deal with the region of the Bükk Mountains (Fig. 1). Concerning the potential raw material sources, the study area is constituted by the mountains and their foothills (named Bükkalja), which together have a complex geological history (Pelikán 2005; Szederkényi *et al.*, 2012). From a structural point of view, the Bükk Mountains are a part of the ALCAPA Mega-unit which belongs to the African plate. The Mesozoic rocks of the mountains were formed in the western basin of the Tethys ocean (sited where now is currently the western basin of the Mediterranean Sea). They were moved to their present place through the process of the collision of the African and the Eurasian plates that lasted up to the Lower Miocene.

Regarding possible raw materials, these rock formations contain siliceous rocks of volcanic and sedimentary origins. The Bagolyhegy Metarhyolite Formation's grey "quartz-porphyry", which dates to the most likely Early Carnian era, is the one that is most well-known archaeologically (Pelikán 2005: 191–192). Because the "hand-axes of Bársony's house" as well as the majority of the "laurel leaf points", found at Szeleta Cave at the beginning of the Palaeolithic research in Hungary, were knapped from this raw material, it became well-known and studied several times. In the case

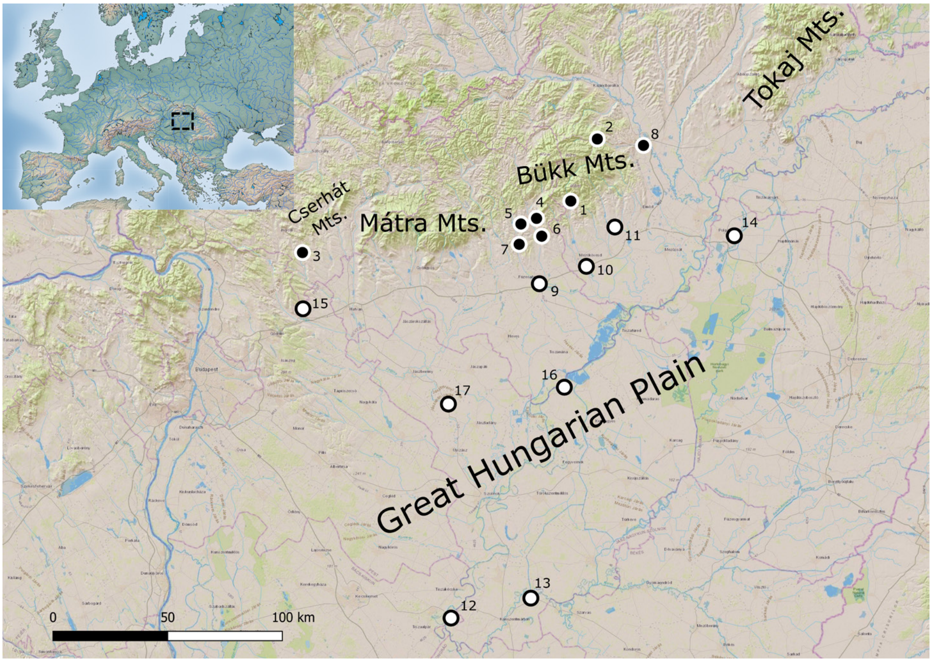

Fig. 1. Location of the Bükk Mountains in Northern Hungary with the archaeological sites mentioned in the text. Archaeological sites: 1 – Subalyuk Cave; 2 – Büdöspest Cave; 3 – Vanyarc-Szlovácka-dolina; 4 – Eger-Kőporos; 5 – Egerszalók-Kővágó; 6 – Andornaktálya-Gyilkos, Andornaktálya-Zúgó; 7 – Demjén-Szőlő-hegy III; 8 – Miskolc-Molotov Street; 9 – Füzesabony-Gubakút; 10 – Mezőkövesd-Mocsolyás; 11 – Bükkábrány-Bánya VII; 12 – Tiszaug-Vasútállomás; 13 – Öcsöd-Kováshalom; 14 – Polgár-Csőszhalom; 15 – Aszód-Papi földek; 16 – Pusztataskony-Ledence; 17 – Alattyán-Vízköz. CAD by N. Faragó.

of the tools of Szeleta Cave, A. Vendl considered that it was "ash-grey chalcedony" (Kadić 1916). Using spectroscopic analysis, L. Vértes and L. Tóth (1963) renamed it "vitreous quartz-porphyry". After new petrographic data, K. Simán (1986) used the name "felsitic porphyry" which was modified later to "Szeletian felsitic porphyry" (Biró and Dobosi 1991; Markó *et al.*, 2003). During the revision of the geology of the mountains, this rock was revealed to be a slightly silicified metarhyolite (Pelikán 2005). Using different names for the same raw material type introduces confusion. The term "Szeletian felsitic porphyry" is a wrong denomination because it has neither geologic nor petrographic meaning. The Szeletian is an archaeological cultural unit that used local and regional raw materials: in Northern Hungary this metarhyolite, in Moravia the Krumlovský les type chert, in Western Slovakia the Carpathian radiolarite

(Kaminská *et al.*, 2011; Mester 2014). Moreover, this metarhyolite was used by other Middle and Upper Palaeolithic industries in Northern Hungary: Mousterians, and Micoquians (Ringer 1983; Mester 2004; Markó 2009). For this reason, we propose to name this raw material in the publications by the combination of its archaeological and petrographic names: "quartz-porphyry (metarhyolite)". The sedimentary siliceous rocks in the Mesozoic formations are radiolarites and radiolarian cherts of Middle and Upper Jurassic age: Csipkéstető and Bányahegy Radiolarite formations, Bükkzsérc Formation (Pelikán 2005: 198–199, 201–202). The colour of these radiolarites varies from red to grey. The Bükkzsérc Formation contains black chert which is usually named in the archaeological literature as hornstone (Pelikán 1986; Biró 2010). By the former suggestion, we propose to use also the combination of archaeological and petrographical names in this paper: "hornstone (black chert)".

During the Palaeogene period, the mountains ascended and descended several times (Pelikán 2005; Szederkényi *et al.*, 2012). As a result, while these formations were covered by the Pannonian Sea, shallow marine sediments (marl, clay, sand) were deposited, and extensive erosional processes took place, resulting in denudation when they were raised. During the Neogene period, intensive volcanic activities took place on the border of the Pannonian Sea. Other members of the North Hungarian Range (Börzsöny, Mátra, Tokaj mountains) were formed by this volcanism (Harangi 2001; Seghedi *et al.*, 2005; Harangi and Lenkey 2007). On the foothills of the mountains, extended rhyolite tuff bodies were deposited in this period (Felnémet, Gyulakeszi, Harsány Rhyolite Tuff formations). Silica-containing hot water erupted during linked post-volcanic processes, causing metasomatic silicification in the lake and lagoon strata. These processes formed a high variety of siliceous rocks: silicified sandstone, silicified marlstone, silicified tuff, geyserite, limnic quartzite/chalcedony/opal (Szekszárdi *et al.*, 2010; Přichystal 2013; Mester and Faragó 2016). Because of the difficulties in determining exactly the petrographic characteristics of these latter rocks without detailed analyses, we use the term "limnosilicites" for them, following A. Přichystal's (2010) proposition (Mester and Faragó 2016). Several raw material types in the Bükkalja region belong to this group of rocks. The sources of silicified sandstone which are known at Egerbakta is also named "Mátraháza–Felnémet type opal" (Biró and Pálosi 1985). The so-called "silicified marlstone" was identified by Vendl (1940), however, its sources have not been located yet within the territory of Bükkalja (Kozłowski and Mester 2003–2004). The limnosilicites that come from the known source near Kács (Schréter 1916; Biró and Dobosi 1991: 39, 121) are very varied in terms of colour and texture.

In this paper, we deal only with selected raw materials for which we have new petrographic data, field observations concerning occurrences and archaeological data of prehistoric use: the silicified sandstone of Egerbakta, the radiolarite and hornstone (black chert), the silicified marlstone and the quartz-porphyry (metarhyolite). The new petrographic data for these raw materials have been obtained by thin section analysis at the Laboratory for Applied Research of the Hungarian National Museum. The samples were collected during fieldwork in the framework of the ongoing research project (NRDI Fund grant no. K 124334). Archaeological data of published sites concerning the prehistoric use of these raw materials come from our direct lithic analyses or literature.

RESULTS

Field observations

In the framework of the ongoing research project, field surveys have been undertaken for verifying already known siliceous rock occurrences and looking for new ones (Mester and Faragó 2013). The documented occurrences were categorized according to Turq's source types (Turq 2000; 2005). Until now, we have not observed the primary autochthonous type of source of radiolarite in the mountains. However, an outcrop with red radiolarite lenses embedded in limestone was observed at Bánya-hegy hill near Répáshuta (Bányahegy Radiolarite Formation; Fig. 2:1). But the lenses were compressed by metamorphic processes (Pelikán 2005: 199) and, thus, were not suitable for knapping (Fig. 3). Similarly, black cherty layers were documented in limestone at Hódos-hegy hill beneath Patkó-sziklák cliffs near Bükkzsérc (Bükkzsérc Formation) in an abandoned modern quarry (Fig. 2:2). The layers showed a huge amount of cracks inside which makes the material from it unfavourable for knapping (Fig. 4). Macroscopically similar black chert blocks were picked up from a nearby modern dirt road which could represent a secondary autochthonous source type as eroded slope sediments, but the blocks are dispersed (Fig. 2:3). Small grey and greenish-grey blocks of siliceous rock were sampled from slope sediments on the territory of the Csipkéstető Radiolarite Formation near Felsőtárkány (Fig. 2:4). Thus, the possibility of secondary autochthonous sources arose for this raw material too. On the contrary, outcrops of the silicified sandy and tuffic sediments were documented on the top of Tó-hegy hill near the village of Egerbakta (Felnémet Rhyolite Tuff Formation; Pelikán 2005: 216; Fig. 2:5). Blocks outcropping on the surface could be exploited, even knapped flakes were recorded at the source (Fig. 5). Some of them are of Middle Palaeolithic character at first appearance. The same concerns the outcrops of the quartz-porphyry (metarhyolite) in the eastern part of the mountains between Bükkszentkereszt and Bükkszentlászló villages (Bagolyhegy Metarhyolite Formation; Fig. 2:6). Large blocks outcrop on the slope of Bagoly-hegy hill, as well as fragments of different sizes, can be found on the surface (Fig. 6:A) and in the streambed in the nearby valley (Fig. 6:B).

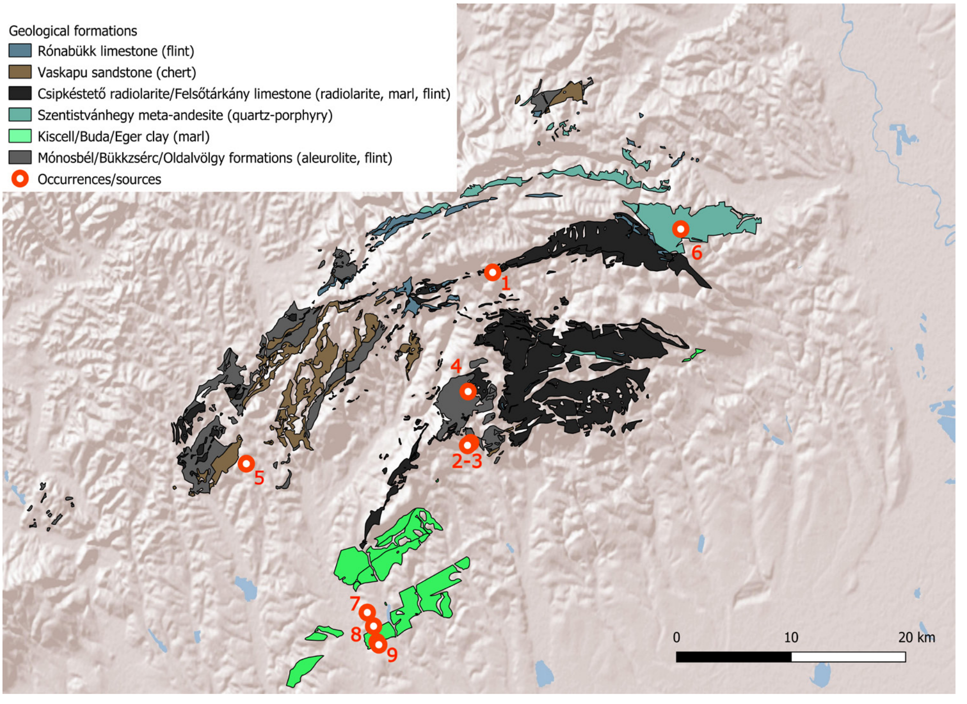

Fig. 2. Geological formations in the Bükk Mountains with siliceous rocks according to the geological map of the Mining and Geological Survey of Hungary 1: 100 000 (https://map.mbfsz.gov.hu/fdt100/). In this scale, the Szentistvánhegy Metaandesite Formation contains the Bagolyhegy Metarhyolite Formation, as well as the Felsőtárkány Limestone Formation, contains the Bányahegy Radiolarite Formation, distinguished in scale 1: 50,000. Sampled localities: 1 – Bánya-hegy hill; 2 – Hódos-hegy hill, quarry; 3 – Hódos-hegy hill, dirt road; 4 – Csipkés-tető hill; 5 – Tó-hegy hill; 6 – Bagoly-hegy hill; 7 – Kőporos-tető hill; 8 and 9 – dirt road and wineyard near Ostoros. CAD by N. Faragó.

During the fieldwork, we regularly observed smaller or bigger blocks or pebbles of different siliceous rocks, including radiolarite, silicified marlstone and limnosilicites, on the dirt roads (Fig. 7:A) and in the vineyards (Fig. 7:B) of the Bükkalja foothill area (Fig. 2:7–9). Their presence should be related to the erosional and planation processes of the formation of the foothill region during the Pliocene and Pleistocene (Pinczés 1980; Pinczés *et al.*, 1993; Karátson 2006). Along the North Hungarian Range, this formation is due to the continuous uplift of the mountainous area parallel to the subsidence of the basin (Great Hungarian Plain). As a consequence, these occurrences could be considered sub-allochthonous sources in Turq's categorization.

Fig. 3. Radiolarite lenses in limestone at Bánya-hegy hill near Répáshuta. Photo: N. Faragó.

Fig. 4. Black cherty layers in limestone at Hódos-hegy hill near Bükkzsérc. Photo: N. Faragó.

Fig. 5. Outcrop of silicified sandstone at Tó-hegy hill near Egerbakta. Photo: N. Faragó.

Petrography

During the study of archaeological and unworked materials, we observed a certain variability within rock types. In particular, the silicified sandstone of Egerbakta has varieties by the grain size of the silicified sediment suggesting different conditions of formation (sand or tuff). In the case of the silicified marlstone, there are two variants: one with black veins in the matrix, and another with patches (MP13 and MP14 in Mester 2004). Pelikán (1986) pointed out that the samples examined by Vendl (1940) in thin sections and classified as hornstone (chert) or chalcedony can be reinterpreted partly as radiolarite. Regarding these problems, we decided to carry out detailed petrographic analyses. The first examinations concerned the four macroscopic variants of the silicified sandstone of Egerbakta, the radiolarite of the Bükk Mountains, the local black chert (hornstone) and the silicified marlstone.

Fifteen rock samples from nine sites in the Bükkalja region have been selected for petrographic study. All but two were collected during field surveys, the two others were chosen from the unworked flakes of the surface material of the Andornaktálya--Gyilkos open-air site (Table 1). The samples were subjected to macroscopic examination, thin section analysis, rock identification, fabric description, and compositional analysis. Following the Prehistoric Ceramic Research Group criteria (PCRG 2010),

Table 1. Raw material samples selected for petrography.

Sample	Locality	Archaeological name	Petrographic name
1	Bükkzsérc-Csipkés-tető hill	hornstone	radiolarite
2	Bükkzsérc-Csipkés-tető hill	radiolarite	silicified aleurolite
3	Bükkzsérc-Hódos-hegy hill, from dirt road	hornstone	radiolarite or radiolarian chert
4	Bükkzsérc-Hódos-hegy hill, from dirt road	hornstone	partially transformed radiolarite
5	Bükkzsérc-Hódos-hegy hill, quarry beneath Patkó-cliffs	black chert	silicified limestone
6	Bükkzsérc-Hódos-hegy hill, quarry beneath Patkó-cliffs	black chert	silicified limestone
7	Egerbakta-Tó-hegy hill	silicified sandstone,variant 3	diatomaceous detritic chert
8	Egerbakta-Tó-hegy hill	silicified sandstone,variant 4	silicified sandstone
9	Egerbakta-Tó-hegy hill	silicified sandstone,variant 4	silicified sandstone
10	Egerbakta-Tó-hegy hill	silicified sandstone,variant 1	diatomaceous detritic chert
11	Egerbakta-Tó-hegy hill	silicified sandstone,variant 1	silicified sandstone
12	Egerbakta-Tó-hegy hill	silicified sandstone,variant 2	silicified sandstone
13	Eger-Kőporos-tető hill, southern slope	silicified marl	silicified aleurolite with radiolarite lenses, bands
14	Andornaktálya-Gyilkos site	silicified marl	radiolarite
15	Andornaktálya-Gyilkos site	silicified marl	radiolarite

a petrographic examination was performed to identify the volume-percentage ratio of the components, their size categories, grading, and roundness. Percentage by volume ratios: dispersed (less than 3%), few (3–9%), medium (10–19%), many (20–29%), very many (30–39%), abundant (more than 40%). Extremely fine (<0.1 mm), fine (0.1–0.25 mm), medium (0.25–1 mm), coarse (1–3 mm), and very coarse (>3 mm) are the size categories. Components are classified according to their size: badly graded, medium graded, well-graded, and very well graded. Aggregate roundness can be angular, slightly angular, somewhat rounded, rounded, and well rounded.

The full rock analysis report is published on the Archaeology Database of the Hungarian National Museum (https://archeodatabase.hnm.hu/en/node/62012), here we describe the macroscopic and microscopic study of the rock samples previously assumed to be hornstone and silicified sandstone.

Fig. 6. Blocks of quartz-porphyry (metarhyolite) at an outcrop (A) and in the streambed (B) near Bükkszentlászló. Photo: Zs. Mester and N. Faragó.

Fig. 7. Blocks and pebbles of different siliceous rocks found on the dirt road (A) and in the vineyard (B) near Ostoros. Photo: Zs. Mester.

Sample 1: radiolarite (Fig. 8:A)

The sample was collected at Csipkés-tető hill in the slope sediment of the road cut between Felsőtárkány and Bükkzsérc villages.

Macroscopically, it is a large rock that fractures in a clam-shell or splintery way, with a dull sheen on the fracture surface, and dark greenish-grey on the unaltered surface. The worn surface has a yellowish-brown, somewhat reddish hue, and a limonitic crust with a greasy-greenish feel, the crust is not separated from the rock body. The rock is punctured by cracks, with limonitic-coloured surfaces along the crevices. The rock has a subtle banding pattern.

By microscopic examination, it is a very fine-grained clayey-aleuritic clastic sedimentary rock with more than 50% radiolarian remnants (predominant grain size 0.03 mm). The majority of the rock is made up of radiolarian bands, with patches or distinct bands of more clayey-aleuritic material interspersed throughout. The amount of radiolarian remnants is low in clay-aleuritic locations, and the parent material is less recrystallized. The radiolarian remains (0.05–0.14 mm) are primarily circular or

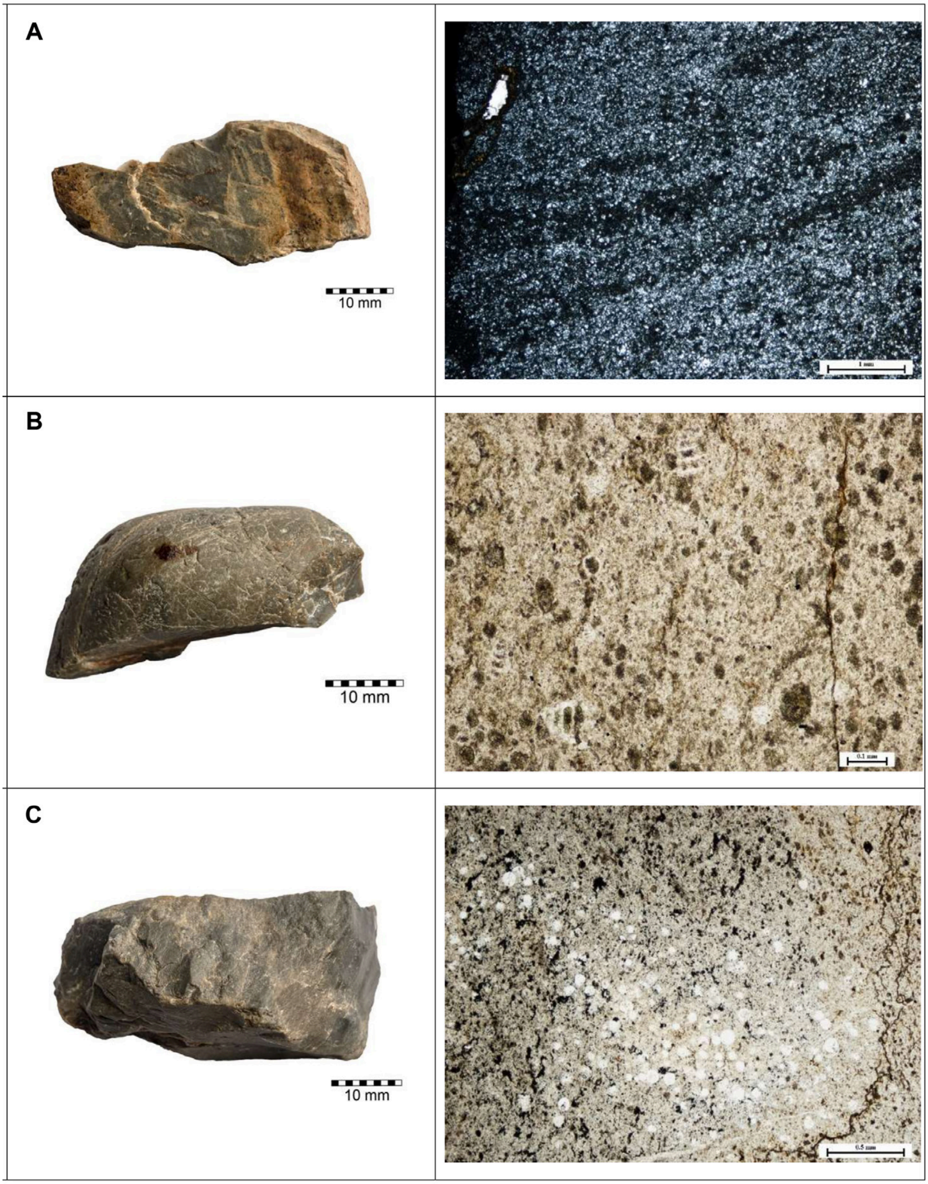

Fig. 8. Raw materials analyzed macroscopically and in thin section (see Table 1). A – Sample 1; B – Sample 3; C – Sample 4. Photos: R. K. Péter, O. Viktorik and L. Máté.

irregularly shaped portions of chalcedony or microcrystalline silica material, which are entirely in the clay-aleuritic areas but more fractured in the radiolarian-rich parts. A radiolarian skeleton piece has also been discovered.

The matrix is mostly made up of micro- and cryptocrystalline silica and clay minerals, with some chlorite thrown in for good measure. It contains a fewer amount of clay minerals than Sample 2 which was collected likewise at the same location. Monocrystalline quartz, mica flakes (sericite, muscovite, 1 discoloured), chlorite flakes, rutile (max. 0.09 mm), tourmaline (greenish-brown, greenish-yellow, 0.03–0.04 mm), opaque minerals (3%, locally limonitised/hematitised), unrelated feldspar carbonate single crystals and mineral clusters, organic matter (1N: opaque or brownish dark grey, irregularly shaped, diffuse-edged clusters, patches).

Limonitic, chloritic, and clayey post fractures have a directional angle of around 40° to the layers. Green chlorite formations can be found in cracks surrounding radiolarian relics in one location. The material is saturated in the vicinity of another limonitic-chlorite vein, and the radiolarian remains are saturated to varying degrees: some are merely coated on the outside, while others are filled on the interior. Fractures were found to be related to feldspar carbonate mineral clusters and solitary crystals (0.02–0.2 mm). The feldspar clasts' crystals sometimes exhibit an abraded outline, which could indicate disintegration. In addition, the sample has a feldspar inclusion around which numerous minerals have precipitated: limonite, chlorite, siderite, and zeolite.

Sample 3: radiolarite or radiolarian chert (Fig. 8:B)

The sample was collected on a dirt road under the Hódos-hegy hill near Bükkzsérc village.

Macroscopically, it is a large rock that fractures in a splintery, slightly fragmented manner with slightly oily fracture surfaces, dark greenish-grey on the unaltered surface. The worn surface is yellowish greyish-green in colour, somewhat glazed, oily, and only mildly earthy to the touch, and it is not separated from the pure rock surface. The rock is laced with cracks, the surfaces of which are limonitic in colour.

By microscopic examination, it is a very fine-grained clayey-aleuritic clastic sedimentary rock (predominant grain size <0.03 mm) containing more than 50% of radiolarian remnants in various states of preservation. Lenses with significantly weaker clay mineralization and chalcedonic radiolarian remnants are observed in addition to the more clayey section of the rock.

The radiolarian remnants are predominantly chloritic-sericitic internal fillings with no external cortical skeletal remains and range in size from 0.05 to 0.16 mm.

Those with exterior cortical skeletal remains of chalcedony material, the bulk of which are chloritic-sericitic and some with micro-cryptocrystalline silica interiors, are far less common. Only chalcedony radiolarian remnants, the majority of which are not intact, are found in a 1.3 mm long lens, which is poorer in clay fossils. Even if entire, chalcedonized radiolarian remains are rare in the clayey sections of the chloritic-sericitic remains. The chloritic-sericitic radiolarian remnants are also penetrated with limonite near the limonitic veins.

Micro- and cryptocrystalline silica, as well as clay minerals, make up the substance. Monocrystalline quartz, mica flakes (muscovite, sericite), chlorite, rutile, titanite, leucoxene, hematite, tourmaline (greenish-yellow to brownish-yellow 0.02–0.05 mm), zircon, opaque minerals (<1%; locally limonitised/hematitised, sometimes leucoxene?), and organic materials are also found (1N: opaque or brownish dark grey, irregularly shaped, diffuse-edged clumps, patches). The sericites in the clay-aleurithic matrix are arranged in a directed pattern, and the matrix brightens in specific directions as the slide is turned. (Note that this is not the case for samples 1 and 4, and only to a lesser extent for sample 2.)

The rock body is littered with stylolites containing limonite, chlorite, and sericite, as well as limonitic fissures and quartz-filled fissures. Limonitic veins go through quartz-filled fissures, forming ridges. Quartz is the first mineral to be deposited on the vein wall in the quartz vein, and the inner half of the vein is covered in limonitised mica and chlorite. Patches of pale brownish residues of once biotitic clay that afterwards became chloridized can be seen near the quartz grains, but also elsewhere in the matrix.

Sample 4: partially transformed radiolarite (Fig. 8:C)
The sample was collected on a dirt road under the Hódos-hegy hill near Bükkzsérc village.

Macroscopically, it is a large rock with a greenish tint to dark grey on a unaltered surface, with a clam-shell, flaked fracture, dull, slightly oily fracture surfaces. The aged surface is brownish grey with a reddish tinge and a greasy, glaze-like texture that does not separate from the unaltered stone. Darker grey patches and streaks punctuate the slightly worn, brownish-grey surface. Cracks in the rock can also be noticed, some of which have limonitic staining along the surface and others that have small cavities.

By microscopic examination, it is a very fine-grained clayey-aleuritic clastic sedimentary rock (predominant grain size <0.03 mm), including more than 50% of radiolarian remnants preserved in diverse forms (0.04–0.13 mm). Lenses with significantly weaker clay mineralization and chalcedonic radiolarian remnants are observed in addition to the more clayey section of the rock.

The majority of the rock is brownish-greenish in colour, with irregular patches of lighter grey (1N) material. Two varieties have been identified. One is enriched in chalcedony-filled radiolarians (chalcedony radiolarian lenses), and it is surrounded by the other development, in which greyish brown (1N) clumps of microcrystalline and cryptocrystalline silica (XN) filling the interiors of former radiolarian skeletons become dominant, black-coloured, tufted, or mossy or mottled organic matter, as well as sporadic amounts of chalcedony-filled radiolarians. In the grey areas, there is less sericite.

Clumps of what used to be/are filling the inside of previous radiolarian skeletons can also be seen in places with a brownish-greenish tint (1N), but they are red, reddish-brown, or greenish-brown (limonitic-chloritic). Chalcedony-filled radiolarians can also be found here, but only in irregular clusters. Limonitic veins pervade these brownish-green sections, which may be responsible for the brownish-green colouration of this section of the rock.

Due to the greater organic matter concentration, there are lenses and patches of slightly darker-coloured (1N) material in both the brownish-green and grey sections, primarily in the form of deeper staining.

Microcrystalline and cryptocrystalline silica, as well as clay particles, make up the matrix. Monocrystalline quartz, mica flakes (muscovite, sericite), chlorite, hematite, zircon, rutile, titanite, tourmaline (yellowish-green, greenish-yellow, brownish yellow, bluish greenish-yellow, 0.03–0.04 mm), opaque minerals (3–5 percent, often limonitised/hematitised), organic matter (1N: opaque or brownish dark grey, irregularly shaped, diffuse, non-radiolarian in origin).

The chalcedony-filled radiolarians' placement reveals a sense of directionality, with the limonite vessels' and the coarctation's directions running at distinct angles. The coarsening veins divide the orientation at 60°, but the limonitic fissures are mostly perpendicular to it. The earlier styolitic surfaces, running roughly perpendicular to the original stratigraphy, were subsequently infiltrated with limonite.

Samples 14 and 15: radiolarite (Fig. 9:A)

The samples were selected from the unworked lithic material of Andornaktálya--Gyilkos open-air archaeological site.

Macroscopically, it is a huge boulder with a shelly to splintery fracture, greenish-grey on the unaltered surface. The worn crust is reddish-brown in colour, glaze-like, and oily to the touch, and is not separated from the pure rock surface. The fissures in the rocks are limonitic in hue, and they cleave the rocks. Small voids can also be visible along some of the fissures.

By microscopic examination, it is a very fine-grained clayey-aleuritic clastic sedimentary rock (predominant grain size <0.03 mm) with radiolarian bands and lenses,

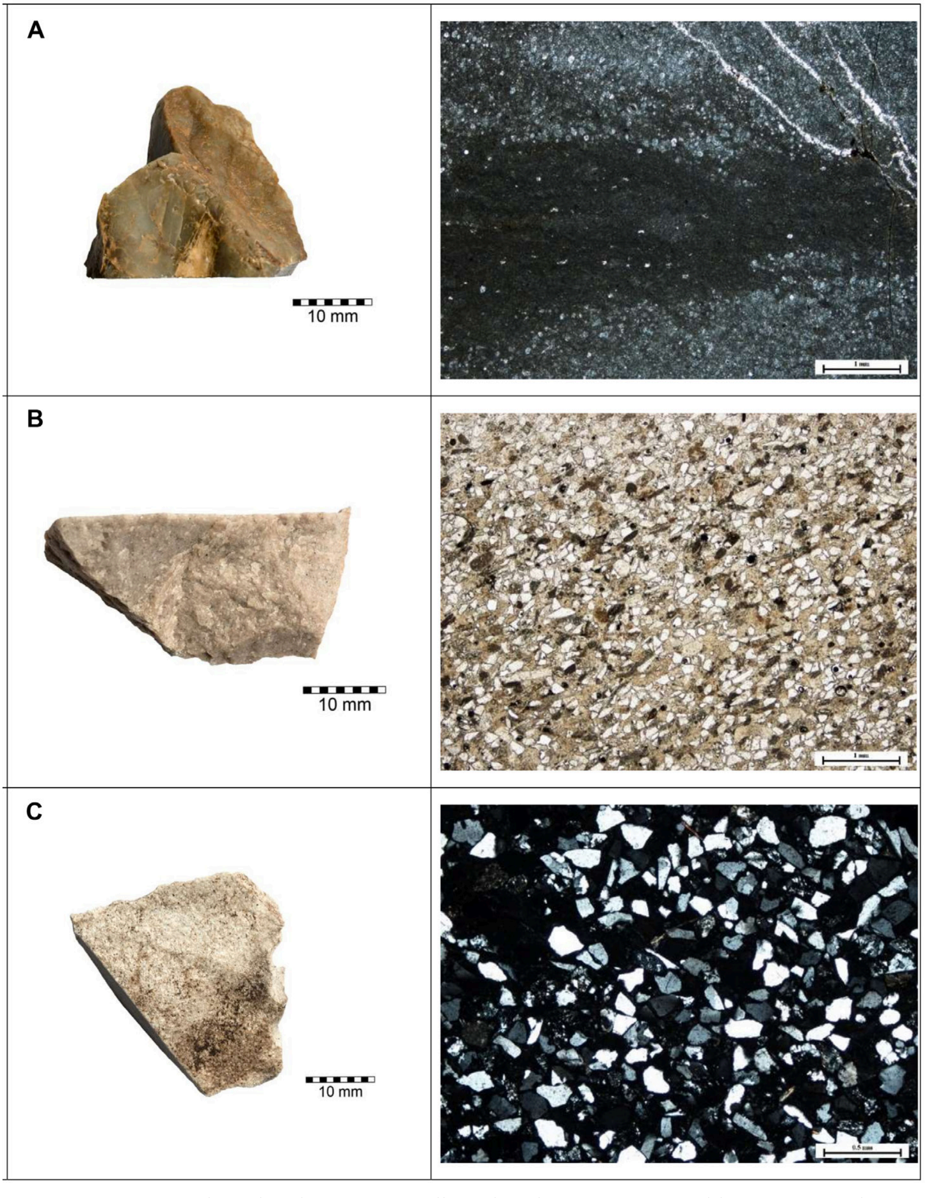

Fig. 9. Raw materials analyzed macroscopically and in thin section (see Table 1). A – Sample 14; B – Sample 9; C – Sample 11. Photos: R. K. Péter, O. Viktorik and L. Máté.

containing more than 50% radiolarian remains. A smaller region of a more clayey--aleuritic layer with sporadic to low levels of radiolarian remnants may be found in Sample 14. The radiolarian remnants (0.04–0.11 mm) are made of chalcedony and have circular to largely elliptical sections, with some radiolarians' cortical skeletons intact. The ellipses' longitudinal axis defines a direction that is at a 55° angle to the initial stratification. The ellipsoidal sections indicate that they were bent by pressure, which is most likely why the rock fabric looks to be a little blurry. Only minor patches of cryptocrystalline silica and clay fossils are found in Sample 15, which is predominantly microcrystalline silica.

Microcrystalline and cryptocrystalline silica, as well as clay particles, make up Sample 14. Monocrystalline quartz, mica flakes (muscovite, sericite), chlorite, tourmaline, rutile, zircon, and zoisite/clinozoisite have also been discovered, as well as opaque minerals (<1% outside the veins, also occur in small nests, possibly limonitised/hematitised), carbonate feldspars (calcite?, also in the parent material and quartz, single crystal along with quartz, small nests), organic matter (1N: brownish dark grey, irregularly shaped, diffuse-edged clusters, patches, locally carbonated or clay mineralized). As accessories, tourmaline, rutile, zircon, titanite, hematite, and carbonate minerals are found in Sample 15.

The rock body is laced with limonitic and opaque mineralization, as well as siliceous fissures. The amount of limonite in the limonite and opaque mineral veining is various. The silicic veins are nearly parallel to one another, forming a 45° angle with the initial layers. Some limonitic veins run parallel to the siliceous veins, whereas others run perpendicular to the siliceous veins. Smaller styrolitic surfaces can be seen running nearly parallel to the initial layering, where limonite was deposited.

Samples 8, 9, 11 and 12: silicified sandstone (Fig. 9:B and C)

The samples were collected on the hilltop of Tó-hegy hill near Egerbakta village.

Macroscopically, the unaltered surface of the rock is somewhat yellowish to whitish-yellowish shades of light grey, with a flaky, shell-like fracture. Except for Sample 12, where the fracture surfaces are dull, earthy, slightly gritty to the touch, and occasionally crumbly, the fracture surfaces are oily. On the dazzling surface, tiny sheets of colourless crystals shine through, along with a few black crystals and a narrow band of greyish colour. The aged surface feels slightly abrasive to the touch, not lustrous, and has the same colour as the unaltered surface, with some blackish discolourations. The aged surface of Sample 12 is slightly darker in colour, gritty to the touch, earthy in texture, crumbly at times, and has blackish-brownish discolourations.

By microscopic examination, there are certain areas where grain orientation is weak, and grains are not evenly dispersed throughout the material in Sample 8. The arrangement of elongated and platy minerals in sample 9 indicates irregular orientation. Sample 11 seems to have "layers". The components are more densely arranged in one layer of the rock, and the rock is more granular here, in other layers, they are more sparsely arranged, there is more volcanic sediment, and the mica appears to be aligned.

With scattered fossils (siliceous sponge, diatomite), quartz, and muscovite, the matrix is isotropic, opalized, and silicified. Samples 8 and 9 have fewer fossils than Samples 7 and 10. Siliceous sponges are the most common fossils, but radiolarians and diatoms have also been discovered. Opal/chalcedony grain inclusions can be seen in some instances.

Angular, splintery, infrequently abraded debris grains with a predominant grain size of 0.1–0.3 mm (max. 0.7 mm) are seen in the material. Debris grains make up around 50–60% of the total, with thinner and denser sections, due to their unequal distribution. Metamorphic rocks make up the majority of the abraded grains. Quartz (volcanic origin, siliceous, spheroidal, and deep-formed with a more isometric appearance), transformed, faded biotite, muscovite, fine crystalline silica, microcrystalline silica, chalcedony, polycrystalline quartz, altered rock fragments, rock fragments with equilibrium crystallization, quartzite, metagranitoid, muscovite can be observed among the clastic components. Rutile, zircon, tourmaline, and opaque minerals occur as accessories.

The deteriorated grains have undergone severe alteration and have consequently been assimilated (alteration) into the sandstone, as indicated by of altered biotite. The most common mineral found in the rock is quartz, while feldspars are rare.

Samples 7 and 10: diatomaceous detrital chert (Fig. 10:A and B)

The samples were collected on the hilltop of Tó-hegy hill near Egerbakta village.

Macroscopically, the rocks have a subtle greenish-yellowish tinge to light grey on the unaltered surface, and a flaky, shelly fracture, and greasy fracture surfaces. Sheets of very small, colourless crystals glitter on the unaltered surface, together with a few black crystals. In Sample 7, there is no worn surface or cracking visible. On the unaltered surfaces of Sample 10, a faint or somewhat darker reddish-brown staining may be seen. The worn surface – which may have been a crack – is only slightly rougher to the touch than the unaltered surface, not lustrous but matching or slightly darker in colour, with blackish discolouration, more microscopic black crystals, and slightly larger than the unaltered surface. The worn surface is not separated from the pure rock body. In Sample 7, a small band of off-white to brown "interlayer" may be seen.

By microscopic examination, the rock has a weak orientation due to the matrix's distinct colouration (1N). Local orientation is widespread in platy minerals (mica), but not in the rock fabric. In comparison to Sample 7, Sample 10 is more directed. It's

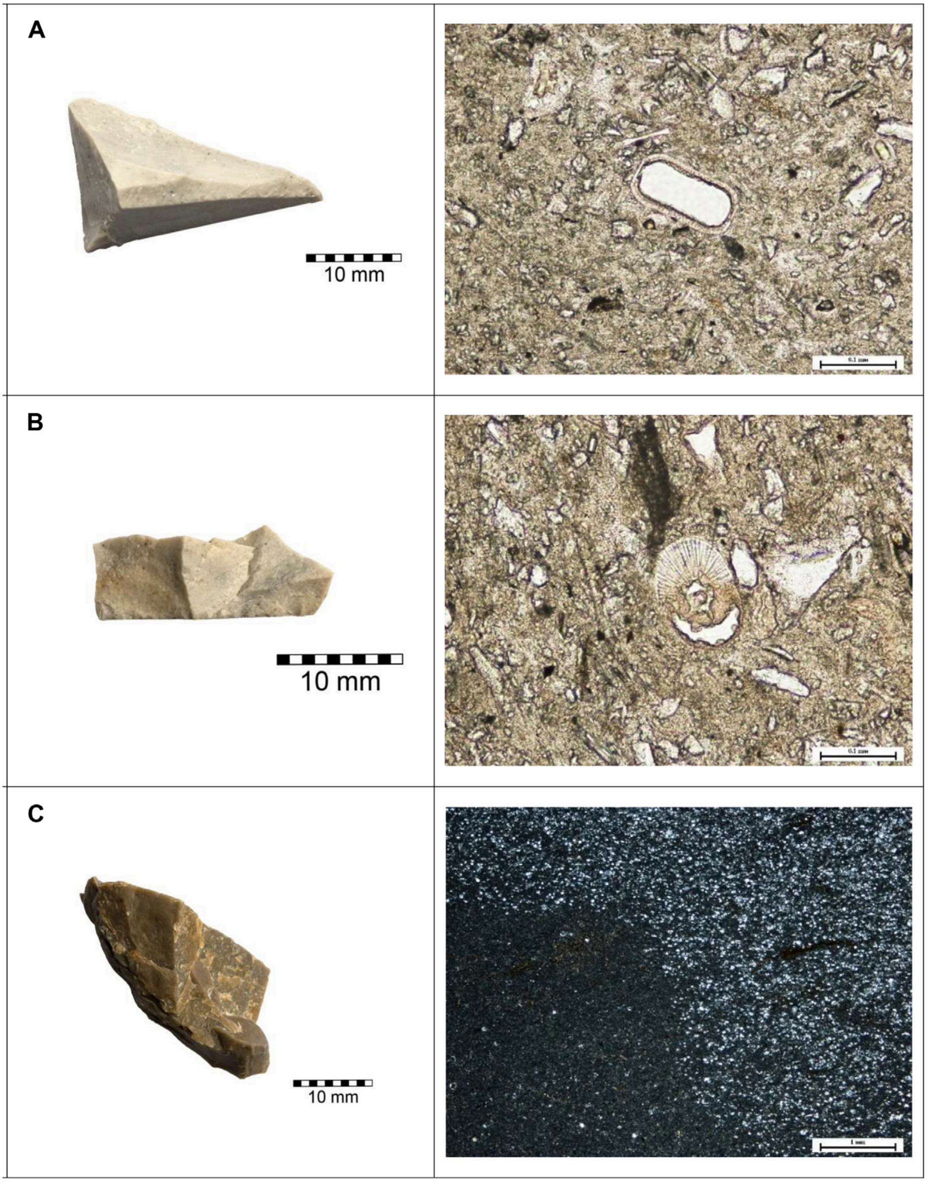

Fig. 10. Raw materials analyzed macroscopically and in thin section (see Table 1). A – Sample 7; B – Sample 10; C – Sample 13. Photos: R. K. Péter, O. Viktorik and L. Máté.

very fine-grained (<0.03 mm), isotropic, opalized, silicified, matrix-rich, and contains quartz and muscovite. The source material contains angular, siliceous debris grains, as well as fossils (a few radiolaria, siliceous sponge, and diatoms), all of which could be lens enriched. The majority of the debris is 0.07–0.3 mm in size (max. 0.6 mm). Quartz (volcanic, splintery, flaked), polycrystalline quartz, muscovite, microcrystalline silica, chalcedony, volcanic glass, quartzite, micritic limestone pieces, opaline-edged shards, faded biotite, and hematite inclusions make up the debris grains, which range from 5% to 7%. More fine crystalline rocks can be found in Sample 7. Tourmaline, rutile, titanite, zircon, and opaque are examples of accessory minerals.

This rock could be limnic-lagoonal silt with tuffaceous debris deposited in it, as well as a calm aquatic environment where muscovites could have settled.

Sample 13: silicified siltstone with radiolite lenses, bands (Fig. 10:C)
The sample was collected on the dirt road on the southern slope of Kőporos-tető hill, near Eger-Kőporos's open-air archaeological site.

Macroscopically, it is a massive rock with a shell-like, slightly splintered-particular fracture. Fracture surfaces are dull, slightly greasy, greenish tinted grey to dark grey on the unaltered surface. The aged surface is brownish grey-brown and has a greasy, glaze-like feel to it that does not separate from the pure rock body. Darker grey patches and streaks punctuate the slightly worn, brownish-grey surface. The rock has a slight banding that can be seen. Cracks in the rock may also be seen, some of which have limonite staining on the surface and others that are filled with white-coloured material.

By microscopic examination, there are radiolarian bands and lenses in very fine-grained clayey-aleuritic clastic sedimentary rocks (predominant grain size <0.03 mm). The presence of radiolarians in the clay-aleuritic region is sporadic. The clay-aleuritic sections and radiolarian-rich parts are similar to those in Samples 1, 2, 3 and 4. The radiolarian remains (0.06–0.11 mm) are round chalcedony sections that are entire in clay-aleuritic areas but fractured in radiolarian-rich areas. Some radiolarians have retained cortical skeletons, while others do not. Limonitic-chloritic-sericitic fill is used to fill the inner half of some radiolarian remnants along with fractures. The clay-aleuritic section also has chloritic-sericitic interiors (radiolarian remnants).

Micro- and cryptocrystalline silica, as well as clay minerals, make up the parent material. Monocrystalline quartz, mica flakes (muscovite, sericite), chlorite, rutile, titanite, leucoxene, tourmaline, epidote? metamorphic or granitoid lithic pieces (0.04 mm), opaque minerals (3–5%, locally limonitised/hematitised), organic matter (1N: brownish dark grey, irregularly shaped, diffuse-edged clasts, patches, locally carbonated or clay mineralised). Parallel and perpendicular to the banding, fissures permeate the rock. Limonite or sericite fills the cracks.

Concluding remarks of the petrographic analysis

Microscopic examination of three samples thought to be hornstones (black cherts) revealed that they are radiolarites. The two samples from the Andornaktálya-Gyilkos archaeological site, originally assumed to be silicified marlstones, were revealed to be also radiolarites. Among six samples thought to be silicified sandstones, two were discovered to be diatomaceous detrital chert. These results indicate that the identification of the varied local raw materials of the Bükkalja foothill region needs thorough petrographic analysis. It is impossible to carry out this analysis for all artefacts collected at archaeological sites. However, establishing a reference collection of identified variants is useful for archaeological investigations.

Taking into account the location where the analysed samples were collected, their geological context can be evaluated. The Hódos-hegy hill belongs to the Bükkzsérc Limestone Formation of Dogger–Early Malm age. The formation is composed of limestone with black chert nodules, and its body is dissected by aleurite-clay layers. It was formed by the partial sorting of flow-off silt so that the formation has a transition to the Oldalvölgy and the Mónosbél Formation. Its key section is located in an abandoned quarry beneath the Patkó-sziklák cliffs (Pelikán 2005: 202). The Csipkés-tető hill belongs to the Csipkéstető Radiolarite Formation. Based on the radiolarian fauna, its age may encompass the interval from the Late Bajocian to the Early Callovian. Two variations of this formation are known, one finely laminated, the other with fragments of varying size scattered or stratified. In the finer areas, shale is characteristic. Its key section is located in the road cut at Csipkés-tető (Pelikán 2005: 201). According to the location of the samples collected at Tó-hegy hill near Egerbakta, the geological context would be the Harsány Rhyolite Tuff Formation, related to the volcanism that took place between Late Badenian and the beginning of the Pannonian of the Miocene (Pelikán 2005: 214). However, the petrographic description of samples 8–12 suggests the Vaskapu Sandstone Formation of Dogger–Malm age (Pelikán 2005: 201). The key section of this latter is located in an abandoned quarry in the valley of the Eger stream. The Kőporos-tető hill in the southeastern part of Eger town belongs to the Gyulakeszi Rhyolite Tuff Formation of the Miocene age (Pelikán 2005: 212), but the sampled rocks can be related much more to the Kiscell Clay Formation of Oligocene age (Pelikán 2005: 207). Of course, the rocks may have been transported to their present position due to an erosional process.

Use at Palaeolithic sites

As already mentioned, research on the Palaeolithic in Hungary started in the Bükk Mountains in the early 20th century. After the evidence for Palaeolithic use had been found at Szeleta Cave (Kadić 1916), systematic excavations were carried out in all of the known cavities of the mountains until the Second World War (Kadić 1934; 1940; 1944; Kadić and Mottl 1938). The archaeological investigations on the foothills started after the War through some excavations (Vértes 1951; Dobosi 1976) and mainly by field survey (Ringer 1983; Fodor 1984). From 2000 onward, this intensified research has been yielding a considerable amount of open-air sites (Zandler 2012). Despite the increasing body of evidence, we can use the data of only a limited number of assemblages because of the uncertainties in chronological and cultural attribution (e.g., Zandler 2012) or the lack of detailed analyses (e.g., Ringer and Mester 2000; Markó 2015; Table 2, Fig. 1).

There is no clear evidence of human occupation from the Lower Palaeolithic in the region. The famous "handaxes of Bársony's house" are big bifacial leaf-shaped tools (Kadić 1934: 17). Both their cultural attribution and chronological position are uncertain (Szolyák and Lengyel 2014). The earliest inhabitants of the region were Neanderthals in the Middle Palaeolithic (Kozłowski 2006), documented in the stratigraphic sequence of Subalyuk Cave, with bone remains of two individuals (Bartucz *et al.*, 1940; Mester and Patou-Mathis 2016). Layers 1 to 6 (from bottom to top) represent the whole stage MIS 5 (Eemian and Early Weichselian, 130–71 ka BP), and layers 7 to 13 correspond to the stage MIS 4 (Lower Pleniglacial of the Weichselian, 71–57 ka BP), while layer 14 to the beginning of MIS 3 (Interpleniglacial of the Weichselian, 57–29 ka BP). In layers 1–7, occupations of human groups belonging to the Typical Mousterian were recorded, while archaeological materials from layers 7–14 are attributed to Quina type Mousterian (Mester 1990). The richest assemblages, respectively from layers 3 and 11, demonstrate their differences in the raw material economy (Mester 2004). The most common rock type used by both industries is the local hornstone (black cherts)/radiolarite, acquired probably in nearby sources. Although no blocks of this raw material have been found in either group of layers, flakes and tools with cortical surfaces suggest big pebbles as the original form of acquisition. The relatively small number of cores can indicate a production mainly off-site. The quartz-porphyry (metarhyolite) was also common for the two Mousterians, however, it was treated differently: the Typical Mousterian users of the site brought debitage products and tools to the cave, while the Quina type Mousterian community produced blanks at the site according to the presence of cores and flakes with natural surface of the block. The only source area of this rock is located about 20 km distance from the cave. The silicified sandstone of Egerbakta was the preferred raw material for the knappers of the Typical Mousterian, they made nice points and side scrapers of it, while those of the Quina type Mousterian did not use it at all, however, they knew this rock according to the presence of some flakes. During fieldwork, we also observed flakes of Middle Palaeolithic character with a patinated/eroded surface at the source lying about 20 km from the site.

Based on typological arguments (Mester 1995), these two facies of the Mousterian had short occupations at Büdöspest Cave also during the accumulation of layer 4 (probably MIS 4). The lithic assemblage unearthed from the layer is largely dominated (86.4%) by the quartz-porphyry (metarhyolite), the sources of which are located about 5 km from the cave. The whole sequence of the stone tool production process is represented, including raw material blocks, cores, blanks and retouched tools. The toolkit contains 20.5% of retouched tools made of other raw materials: half of it is of quartz and quartzite, but it includes a few hornstone (black chert)/radiolarite artefacts too. The cave site probably had a special function.

Among the tools found in layer 4 at Büdöspest Cave, there is an elongated asymmetrical bifacial artefact made of quartz-porphyry (metarhyolite; Kadić 1934: fig. 28). It resembles a *Keilmesser* and seems to be intrusive in the assemblage. It is worth mentioning that this tool fits into the Micoquian-like local Bábonyian industry not only typologically but by its raw material too. Quartz-porphyry (metarhyolite) is a preferred raw material on the open-air sites of this culture (Ringer 1983; Adams 2000). Moreover, this rock type constitutes one of the main raw materials of the Middle Palaeolithic bifacial industries in the Cserhát Mountains, a hundred kilometres from the Bükk Mountains to the west (Markó 2009). At Vanyarc-Szlovácka dolina open-air site, this rock type represents 23.8% of the lithic assemblage (Markó 2007). Although cores have not been found, on-site processing is demonstrated by refitted pieces.

During the Late Middle Palaeolithic and the Early Upper Palaeolithic, the region of the Bükk Mountains seems to have been a very populated area. Several cave sites yielded small assemblages with ambiguous cultural attribution (e.g., Mester 2000a; 2000b). Numerous open-air sites have also been identified in the territory of the foothills, especially in the western part near the modern town Eger, due to intensive field surveys (Zandler 2012). Carrying out archaeological investigations on these sites is difficult because the area belongs to one of the famous wine regions of Hungary. Four sites were excavated by a Polish-Hungarian collaboration project: Andornaktálya-Zúgó, Egerszalók-Kővágó, Eger-Kőporos and Andornaktálya--Gyilkos (Kozłowski and Mester 2003–2004; Kozłowski *et al.*, 2009; 2012; Mester *et al.*, 2021). They are located on hilltops on both sides of the valley of Eger stream. The hilltops were affected by erosional processes during the Upper Pleistocene. The sedimentological analyses of the stratigraphic sequences of Egerszalók-Kővágó and Eger-Kőporos revealed colluvium containing the archaeological material. According to the obtained radiocarbon and OSL dates, the redeposition of the sediments took place at approximately 28–30 ka BP (Kozłowski *et al.*, 2009: 416; 2012: 420).

Table 2. Distribution of selected raw materials from the Bükk Mountains in Palaeolithic and Neolithic assemblages.

Number on the map	Site	Age	Sum of assemblage (pc.)	silicified sandstone of Egerbakta				quartz-porphyry (metarhyolite)				Bükk radiolarite/hornstone			
				raw material	core	debitage product	tool	raw material	core	debitage product	tool	raw material	core	debitage product	tool
1	Subalyuk Cave layer 3	Middle Palaeolithic	758	-	-	9	7	-	-	30	14	-	2	201	27
1	Subalyuk Cave layer 11	Middle Palaeolithic	4328	-	-	3	-	-	45	684	58	-	2	2023	59
2	Büdöspest Cave layer 4	Middle Palaeolithic	697	-	-	-	-	1	21	518	62	-	-	6	4
3	Vanyarc-Szlo-vácka-dolina	Middle Palaeolithic	1368	-	-	-	-	-	-	351	11	-	-	-	-
4	Eger-Kőporos	Middle & Upper Palaeolithic	2208	8	3	136	17	-	1	374	73	11	4	183	20
5	Egerszalók--Kővágó	Middle & Upper Palaeolithic	681	5	3	231	31	3	1	52	30	6	1	22	3
6	Andornak-tálya-Gyilkos	Upper Palaeolithic	1156	-	2	30	1	-	3	30	3	5	7	53	5
6	Andornak-tálya-Zúgó	Upper Palaeolithic	1380	2	-	38	3	-	1	17	2	9	15	11	9
7	Demjén--Szőlő-hegy III	Upper Palaeolithic	81	-	-	1	-	-	-	-	-	-	-	1	-
8	Miskolc--Molotov St.	Upper Palaeolithic	142	-	-	-	-	-	5	8	1	-	-	-	-
9	Füzesabony--Gubakút	Middle Neolithic	942	-	3	6	2	-	-	-	-	-	-	-	-

Number on the map	Site	Age	Sum of assemblage (pc.)	silicified sandstone of Egerbakta				quartz-porphyry (metarhyolite)				Bükk radiolarite/hornstone			
				raw material	core	debitage product	tool	raw material	core	debitage product	tool	raw material	core	debitage product	tool
10	Mezőkövesd--Mocsolyás	Middle Neolithic	1398	-	-	3	2	-	-	2	1	-	-	2	-
11	Bükkábrány--Bánya VII	Middle Neolithic	2350	-	-	1	-	2	1	7	-	3	-	6	-
12	Tiszaug--Vasútállomás	Middle Neolithic	26	-	-	-	3	-	-	-	-	-	-	-	-
13	Öcsöd-Kováshalom	Late Neolithic	910	-	-	1	-	-	-	-	-	-	-	-	-
14	Polgár--Csőszhalom (horizontal)	Late Neolithic	12276	-	-	-	-	2	1	4	2	-	-	-	-
14	Polgár--Csőszhalom (tell)	Late Neolithic	6650	-	-	-	-	-	-	3	-	-	-	-	-
15	Aszód-Papi földek	Late Neolithic	3794	-	-	3	-	-	-	-	-	-	-	-	-
16	Pusztataskony--Ledence	Late Neolithic	449	-	-	10		-	-	-	-	-	-	-	-
17	Alattyán--Vízköz	Late Neolithic	40	-	-	2	-	-	-	-	-	-	-	-	-

As a result, the archaeological materials of both sites contain Middle Palaeolithic and Early Upper Palaeolithic components. Based on the technological and typological characteristics, the Middle Palaeolithic is represented by Mousterian, Bábonyian/Micoquian and Jankovichian elements, as well as elements of macroblade industry, and Early Upper Palaeolithic by Szeletian and Aurignacian ones. Although limnosilicite (partly from the Tokaj Mountains) was the most common raw material of the Middle Palaeolithic groups at the sites, the three rock types chosen for this study were used because we were unable to distinguish preferences based on cultural attribution. On the contrary, the macroblade industry of the Initial Upper Palaeolithic preferred the different limnosilicites that originated mainly from the Tokaj Mountains to the east of the sites. They used local rock types such as the silicified sandstone of Egerbakta also. The Szeletian component is dominated by the quartz-porphyry (metarhyolite), not only the bifacial tools but endscrapers were made of it. The Aurignacian knappers made endscrapers and burins at the two sites from limnosilicites and some local raw materials, but they used radiolarite too. At Egerszalók-Kővágó, even long-distance raw materials are present in the Aurignacian component of the assemblage, like Carpathian radiolarite from western Slovakia and flints from southern Poland (Kozłowski *et al.*, 2009: 447).

The dominance of long-distance raw materials is an apparent characteristic of the neighbouring Demjén-Szőlő-hegy III site too (Béres and Kerekes 2021). In this case, 68% of the lithic assemblage (72% of the retouched tools) is made of Carpathian radiolarite. Besides this, local limnosilicites (15%) and silicified marlstone (11%) constitute the basic raw materials of the assemblage. Other rocks, like obsidian, Volhynian flint, silicified sandstone of Egerbakta and radiolarite of the Bükk Mountain are represented by one or two flakes. The industry of the site can be attributed to the Early Aurignacian based on typological arguments.

Similarly, extralocal raw materials dominate the lithic material of the Late Aurignacian site at Andornaktálya-Zúgó (Kozłowski and Mester 2003–2004; Mester and Kozłowski 2014). The "erratic" flint from Silesia (southern Poland) and the Carpathian 1 type obsidian from eastern Slovakia each constitute almost one-quarter of the lithic finds, while local rock types do not reach ten percent each. The most interesting characteristic of this assemblage is that the Silesian flint and the obsidian had been treated by the knappers like local rocks from an economical point of view: all phases of the lithic tool production are present in the archaeological material from cortical flakes of the core preparation to retouched tools as endproducts. On the neighbouring hilltop at the Andornaktálya-Gyilkos site, two occupations of the Early Upper Palaeolithic can be distinguished in the assemblage: a macroblade industry like that at Eger-Kőporos and an Aurignacian one. These units differ from each other in the raw material economy too. The most common raw material was limnosilicite for both, respectively 32.1% and 48.5% for cores, 55.3% and 58.1% for tools (Mester *et al.*, 2021). However, the macroblade industry preferred the Mád-Mezőzombor type, of beige colour and banded pattern, originating from the southern part of the Tokaj Mountains about 75 km to the east, which was unknown to the Aurignacians. This latter used mostly local variants of limnosilicite. The second most frequent raw material of cores of the macroblade industry is the local silicified marlstone (25.4%), while this rock is rare among the cores of the Aurignacian (7.6%). On the other hand, the number of radiolarites and extracarpathian flints increases in the Aurignacian assemblage.

Unfortunately, the archaeological observations and documentation collected during the Miskolc-Molotov Street site rescue excavation in 1959 are insufficient to resolve the many concerns highlighted by this particular lithic assemblage. However, a probably Early Upper Palaeolithic workshop can be reconstructed thanks to the thorough technological and typological analysis that has been carried out recently (Szolyák 2019–2020). The site is located in Miskolc at the foot of Avas hill, situated in the very close vicinity of a limnosilicite source (Hartai and Szakáll 2005). The overwhelming majority of the archaeological material is of local limnosilicite (85.92%). However, the quartz-porphyry (metarhyolite) is also represented by cores, blades and core trimming removals. Moreover, a bifacial leaf-shaped tool was made from this raw material (Szolyák 2019–2020: fig. 16.3). A very similar artefact is published from layer 6 of the Nietoperzowa Cave in Poland attributed to the Jerzmanowician (Chmielewski 1961). The sources of quartz-porphyry (metarhyolite) are located about 10 km from the workshop site.

Use at Neolithic sites

The beginnings of the research on Neolithic knapped assemblages coincided with the intensive research and organised collection of siliceous raw materials in Hungary (Biró 1986; 1987a; 1987b; Bácskay and Simán 1987). It is interesting to note, however, that although the Neolithic assemblages are much more numerous and cover the territory of Hungary more evenly, they do not contain the same raw materials in the same ratio. Individual Palaeolithic assemblages were frequently dominated by raw materials found in the Bükk Mountains, such as quartz-porphyry (metarhyolite), silicified sandstone of Egerbakta, and Bükk radiolarite. During the Neolithic, however, they had a significantly less important role, at least east of the Danube, and were supplanted by various regional and distant raw materials (Biró 1998). So it is perhaps not surprising that systematic research on the raw materials of the Bükk Mountains, except for quartz-porphyry (metarhyolite), has of course been somewhat overshadowed by the radiolarites of the Transdanubian region (Szilasi 2017; Szilágyi 2018) or obsidian (Kasztovszky and Přichystal 2018; Szepesi *et al.*, 2018). However, if we want a more detailed picture of the paleoethnological behaviour of Neolithic raw material procurement, we need to go beyond the dominance of diverse limnosilicite and obsidian varieties, as well as rocks from outside the Carpathians (Table 2, Fig. 1).

From the context of the earliest Neolithic culture, the Körös culture (approximately 6000–5400 BC), we do not know of any assemblages containing lithic artefacts made of raw materials from the Bükk Mountains. However, from the emerging phase of the Alföld Linear Pottery culture, the Szatmár group (approximately 5500–5300 BC), we know of several sites where such stone tools have been found. One of the first sites of this age was excavated at Füzesabony-Gubakút, in 1995 and 1996, on the route of the construction of the M3 motorway (Domboróczki 2003; 2009). It was the first time that the world of longhouses and settlement structures of the emerging Alföld Linear Pottery culture could be explored over such a large area. Many of the settlement phenomena and finds are still awaiting a complete evaluation, but in any case, some preliminary reports on the stone tools that were found have been published (Biró 2002). From there, we know that, in addition to the limnosilicite variants and obsidian associated with the Tokaj Mountains, 11 of the 942 stone tools reported were of the silicified sandstone of Egerbakta. These were practically representative of the whole range of *chaîne opératoire*, as they included cores (three pieces), debitage products (six pieces), and finished tools (two pieces).

The second site of similar age from the Bükkalja region is Mezőkövesd-Mocsolyás, which, like Füzesabony-Gubakút, was also discovered in the 1990s during the construction works of the same motorway, and where we also have published data on the use of the selected raw materials (Kalicz and Koós 2014). Compared to the size of the excavated area and the number of excavated settlement features – five houses and their associated pits and graves – a large amount of knapped artefacts were found (Biró 2014). Of the 1398 finds, ten could be classified as raw materials from the Bükk Mountains. Besides the lack of cores, silicified sandstone of Egerbakta and quartz-porphyry (metarhyolite) tools were also found, three pieces in total, and all the other finds could be classified as debitage products. The other characteristics of the assemblage are identical to those of the two sites mentioned above, such as the dominance of obsidian and limnosilicites from the Tokaj Mountains, and a varied set of blade tools.

In 2011 and 2012, at Bükkábrány-Bánya VII salvage excavations in a lignite mine revealed an early Alföld Linear Pottery settlement. Here also a large area of 3 ha was excavated and numerous buildings, longitudinal pits, and burials were found (Faragó *et al.*, 2015; Füzesi *et al.*, 2021). The associated knapped lithic assemblage consisted of a total of 2350 finds, most of which were made of limnosilicite and obsidian.

The majority of these raw materials originated from the Tokaj Mountains, but several specimens represented the limnosilicite of the Avas hill at Miskolc, the eastern part of the Bükk Mountains. The seven pieces of quartz-porphyry (metarhyolite), nine pieces of Bükk radiolarite, and one piece of silicified sandstone of Egerbakta add to the extensive prehistoric knowledge of the region concerned. These raw materials could not only have had an occasional role, as all three varieties are associated with debitage products, and even a beautifully formed prismatic core of quartz-porphyry (metarhyolite) was found. However, no tools survive from any of the raw materials, only unworked pieces.

We do not have information on the further phases of the Alföld Linear Pottery culture, but an interesting assemblage from the late period, the Szakálhát culture, has been found at Tiszaug-Vasútállomás (Füzesi *et al.*, 2017). Salvage excavations were carried out at the relevant site in 1980, during work on a railway embankment damaged after a flood, and six pits containing pottery and stone tools were recovered from a 100×50 m area. The lithic finds are not very numerous, but they show a more pronounced connection with Transdanubia, the Tokaj, and the Bükk mountains. The raw material of the three tools was also associated with the latter region, all three were of the silicified sandstone of Egerbakta and all three were laterally retouched blades. Evidence of their intensive use was shown by one of the pieces, as it bears sickle-gloss. The dating of the site has raised further interesting questions, as the radiocarbon dates suggest that it is a very late site, partly coeval with the emerging and succeeding Tisza culture (4950–4841 calBC; 5023–4909 calBC).

Moving on to the Late Neolithic, and the Lengyel culture, we have extensive information on the knapped assemblage of Aszód-Papi földek, an iconic site east of the Danube. The half-hectare area, excavated for more than 20 years, has provided a wealth of new information on the spatial distribution, connection, and chronology of Late Neolithic cultures (Kalicz 2008), as well as on many specific details of contemporary life and material culture, including the stone tools used (Kaczanowska 1985; Biró 1998). Although the raw material of the 3794 pieces of knapped stone recovered from the site is very diverse and therefore seemed to be a solid basis for broad research on flint knapping in Hungary and the Carpathian Basin, information is only available on three pieces of raw material from the Bükk Mountains. All three are related to the silicified sandstone of Egerbakta, and all three are unretouched debitage products.

More south of the foothills of the North Hungarian Range, in the Jászság, there is reported information about a surface collection from which similar raw material has been found. Thanks to the fieldwork of Gyula Kerékgyártó in Alattyán-Vízköz, about 40 pieces of knapped stones were collected together with pottery from the Tisza and

Szakálhát cultures (Biró 1998). In addition to the dominance of limnosilicites from the Mátra, two finds made of silicified sandstone of Egerbakta were also recovered from the assemblage, both of which were defined as debitage products according to the technological classification.

The site of Pusztataskony-Ledence also dates to the Late Neolithic, and a large excavation of a Tisza culture settlement of about 5 hectares was found here, also linked to a large development (Sebők and Faragó 2018). The site is unique not only because of the relative size of the excavated area and the lack of a tell but also because of the high proportion of knapped raw materials from outside the Carpathians (Faragó 2021). A further indication of the intensive contact by the community living here over a large area is the ten finds of silicified sandstone of Egerbakta. None of these could be classified as a raw material fragment, core, or tool, yet the debitage products generally indicate the use of raw material.

Only two of the numerous Late Neolithic tell settlements in the Great Hungarian Plain have produced knapped raw materials from the Bükk area. In the first case, an excavation at Öcsöd-Kováshalom in the early 1980s revealed a multi-layered Middle Tisza settlement of outstanding importance, associated with the Tisza culture (Raczky 2009; Füzesi and Raczky 2018). Several studies on the knapped stone tools have been published (Kaczanowska *et al.*, 2009; Kaczanowska and Kozłowski 2015), so the assemblage can be considered relatively well processed, yet only one single piece of debitage product is known from the silicified sandstone of Egerbakta as raw material (Biró 1998). The relevant tell settlement is also interesting because it is relatively close to the previously mentioned Tiszaug-Vasútállomás site, and in addition, they can be considered to be partly contemporaneous.

The second site is Polgár-Csőszhalom, where only the tell settlement and its artefacts were known until the 1980s (Bánffy and Bognár-Kutzián 2007). Thanks to field research and preliminary studies, which can be considered as a fairly continuous process since the 1990s, not only the outer settlement surrounding the tell but practically the whole micro-region have become well researched (Raczky *et al.*, 2015). Several studies have been published in recent years on the knapped stones, providing insights into the highly diverse spatial and temporal behavioural patterns of the former community and the cognitive system behind them (Faragó 2017; 2019). The two parts of the settlement, the tell and the outer settlement, had fundamentally different raw material preferences, but from our point of view, it is the quartz-porphyry (metarhyolite) that is important. Out of more than 12,000 lithic artefacts in the outer settlement, only nine pieces belonged to this category, but they represented all elements of the sequence of the knapping operation (two raw material pieces, one core, four debitage products, and two tools). The picture was not so clear in the tell, but the three debitage products of quartz-porphyry (metarhyolite) proved that the presence of raw material on the site was not accidental.

CONCLUSIONS

The region of the Bükk Mountains is one of the most important regions in Hungary for the study of the life of the Stone Age population. Due to its complex geological history, the mountains and their foothills are rich in different siliceous rocks, including those of Mesozoic sedimentary and Tertiary metasomatic origin, used by prehistoric knappers for lithic tool production (Pelikán 2005). Although the petrographic determination of the raw materials of the archaeological assemblages of some important Palaeolithic sites has been published since the beginning of the research in the region, many questions concerning the petrographic identification and origin of the local siliceous rock types remained open or raised until now.

In the framework of an ongoing project, we are studying the human–lithic resources interaction in northern Hungary, including in the region of the Bükk Mountains (Mester and Faragó in press). For this study, a palaeoethnological approach is applied that encompasses field surveys for mapping siliceous rock occurrences, petrographic analyses for rock identification and study of archaeological lithic assemblages for reconstructing human technical behaviour and raw material economy. In this paper, the results of these studies are presented concerning four selected local rock types: the silicified sandstone of Egerbakta, the radiolarite and hornstone (black chert), the silicified marlstone and the quartz-porphyry (metarhyolite). Except for this latter, little attention has been paid to studying them in detail. The new petrographic analyses have revealed two variants of the raw material from Egerbakta: a silicified sandstone and a diatomaceous detrital chert. This result suggests that they had formed in different conditions. Further field surveys are needed to verify whether their occurrences are separate in the area where small lakes are located too. The other samples turned out to be radiolarites or radiolarian rocks. This work has confirmed what had already been suggested for the hornstones (black cherts), however, it has new consequences for the "silicified marlstone" because of the differences in formation processes. Moreover, the origin and connection of this raw material to a certain geological formation need reconsideration, taking into account that we found blocks of this kind of rock dispersed in the foothill area which suggests the sub-allochthonous source type.

Regarding the prehistoric use of the selected raw materials, archaeological data show some interesting dynamics through the periods of the Stone Age. The OSA model allows us to interpret the data for the palaeohistory of the Carpathian Basin. It is important to note that we use the archaeological denominations of the raw materials for this study because the data are recorded in this conceptual framework. After the new petrographic results, a re-analysis of the lithic assemblages will be necessary.

During the Middle Palaeolithic (MIS 5 to 3), groups of three cultural traditions inhabited the region. All of them had in-depth knowledge about available local siliceous rock occurrences but they had different raw material economies based on different technical behaviour. Both Typical and Quina type Mousterian groups used the large spectrum of rocks for lithic tool production with a preference for the most easily procurable ones: the hornstone (black chert)/radiolarite in the southern part, the quartz-porphyry (metarhyolite) in the northeastern part of the region. Aside from that, they exhibited behavioural differences in approach to some rock types that were recognised but not used (Occurrence in the model), such as silicified sandstone and silicified marlstone for the Quina type Mousterian, and local limnosilicite and porphyric tuff for the Typical Mousterian. This technical behaviour suggests a kind of limited mobility or a less extended territory. On the contrary, the groups of the Bábonyian/Micoquian, characterized by a bifacial toolkit, seem to be much more mobile. Their lithic assemblages testify to an apparent preference for the use of quartz-porphyry (metarhyolite) and certain types of limnosilicites. They obtained these raw materials from larger distances (from Bükk to Cserhát and from Tokaj to Bükk Mountains), up to a hundred kilometres away. Eventually, they had extracarpathian contacts too.

At the beginning of the Upper Palaeolithic, a new attitude appears in the region that is expressed in the increased role of long-distance raw materials. It is likely that the groups of anatomically modern humans (AMH), arriving in the Carpathian basin, had not enough knowledge about local siliceous rock occurrences, on the contrary, they probably had extended network contacts with other AMH groups. The Aurignacian groups in the region almost completely ignored the local sources. Instead, their raw material economy was largely based on extra local rocks, like obsidian, Carpathian radiolarite and extracarpathian flints. The interesting question is the raw material economy of the macroblade industry of the Initial Upper Palaeolithic, preferring selected local and regional raw material types, like the silicified sandstone and the silicified marlstone from the Bükkalja, as well as the Rátka and Mád-Mezőzombor type limnosilicites from the southern part of the Tokaj Mountains. Hunters of the Gravettian and Epigravettian lived farther from the mountainous area. Their sites are located mainly in the river valleys in the basin. However, they knew some sources of better quality raw materials convenient for blade production, like the limnosilicite of the Avas hill in Miskolc.

During the Neolithization of the Carpathian basin, new populations arrived from the Balkans. The Starčevo and Körös groups partly relied on the well-known lithic sources of the southern flint and chert types. In the meantime, they approached the source area of the Carpathian obsidian and started to change their raw material procurement strategies. It seems from the lithic assemblages of the settlements of the Alföld Linear Pottery culture that they became increasingly familiar with the locally available rock types over time. Their raw material economy was based on these limnosilicites and obsidian. Another change in technical behaviour took place during the Late Neolithic when extra local raw material had a more important role, but more in a social than economic sense.

To sum up the above palaeohistory, it is difficult to describe these selected raw materials of the Bükk Mountains as "Palaeolithic only", as was earlier thought. Two of them occur sporadically throughout the Neolithic period. The emergent phase of the Alföld Linear Pottery culture period is indicative of the journey that the forming community may have been going through as it tried to find its place in the landscape (Kozłowski 2009). The dominance of different limnosilicite variants, obsidian, and then long-distance raw materials could not make completely superfluous the experimentation with that of Egerbakta. Although the use of Bükk hornstone (black chert)/radiolarite has disappeared completely over time, the rediscovery of quartz-porphyry (metarhyolite) at Polgár-Csőszhalom means that Neolithic communities were an integral part of their immediate and wider environment (Füzesi 2019). Therefore, the outcrops of raw materials that we have recorded in the Bükk Mountains can be interpreted as true sources of this period too (Mester and Faragó in press).

This is precisely the important lesson of the palaeoethnological approach we promote, as opposed to the provenance approach: to reach prehistoric human behaviour in its totality. From this point of view, it is worth dealing not only with the dominant phenomena that are tangible but also with what is barely detectable or even absent.

ACKNOWLEDGEMENTS

We are indebted to Dagmara H. Werra for inviting us to publish this study in *Archaeologia Polona*. We thank Miklós Máté Beke for his help in collecting lithic assemblage data of archaeological sites from the literature. The "Lithic resource management dynamics from the Middle Palaeolithic to the Middle Neolithic in Northern Hungary" project is financed from the NRDI Fund (grant no. K 124334).

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