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Special theme:
Investigating geochemical and petrographic methods for identifying siliceous rocks in archaeology
The first scientific investigations of the sources of flint in Poland were undertaken by archaeologist Stefan Krukowski and geologist Jan Samsonowicz in the early 20th century. Krukowski used archaeological materials to identify the macroscopic characteristics of ‘chocolate’ flints, described their differences, and showed the potential location of the deposits (Krukowski 1920: 189–195; Budziszewski 2008: 33). In the search for deposits of flint, their outcrops, and prehistoric mines, Krukowski was accompanied by young geologist Jan Samsonowicz. The result of their cooperation was the discovery in 1921 of in situ deposits and surface accumulations of limestones containing fragments of flint and, in 1922, the identification of a prehistoric mine at Krzemionki Opatowskie (Krukowski 1923; Samsonowicz 1923; Bąbel 2014).

This long tradition of studying siliceous rocks has continued at the Institute of Archaeology and Ethnology, Polish Academy of Science. In 1965 Zygmunt Krzak published the first characterization of gray white-spotted (świeciechów) flint (Krzak 1965) and five years later he described Turonian flint from Ożarów (Krzak 1970). In 1971 Romuald Schild devised a classification of ‘chocolate’ flint from the north-east margin of the Holy Cross (Świątokrzyskie) Mountains (Schild 1971, 1976) and Bogdan Balcer investigated a flint mine in Świeciechów, Kraśnik district, and the use of gray white-spotted (świeciechów) flint during the Neolithic (Balcer 1975, 1976). In 1980 Jacek Lech discussed the geology of Jurassic-Cracow flint and showed its relevance to archaeology (Lech 1980). Since that time Polish archaeologists have carried out many investigations on different types of flint (e.g., Budziszewski and Michniak 1983/1989; Pawlikowski 1989; Budziszewski and Michinak eds 1995; Schild and Sulgostowska eds 1997; Matraszek and Sałaciński eds 2002; Gutowski 2004; Borkowski et al., 2008; Migaszewski et al., 2006, Krajcarz et al., 2014).

In addition to ongoing investigations describing the occurrence and geological nature of the raw material, determination of the number of levels at which the raw material occurs in the limestone, and the stratigraphic context and geological dating of the layers, a principal goal is to identify instrumental method/methods for accurately distinguishing siliceous rocks and applying the results in archeological studies. The cooperation between archeologists and geologists started by Krukowski and Samsonowicz continues and the collection of studies presented here are the latest results of those cross-disciplinary cooperative efforts directed to understanding the origin, occurrence and characteristics of siliceous rocks, and their exploitation and conveyance by prehistoric communities.
Ten years ago Zofia Sulgostowska and Andrzej Jacek Tomaszewski edited a volume celebrating Romuald Schild’s 70th birthday (Sulgostowska and Tomaszewski 2008) and, one decade later, we would like to dedicate this volume to him in celebration of his 80th birthday. The summary of Schild’s extensive scientific work appears in Zofia Sulgostowska and Andrzej Jacek Tomaszewski’s – On the 80th birthday of Professor Romuald Schild (pp. 11–13). The bibliography of Professor Schild was assembled and prepared by Katarzyna Kerneder-Gubała (pp. 15–19).

Most of the papers published here were presented in preliminary form at a conference held in the Institute of Archaeology and Ethnology Polish Academy of Science in Warsaw on May 12, 2015, entitled: Flint in time and space – Time and space in flint: Use of geochemical and petrographical methods in archaeology. The meeting was supported by Polish Academy of Science and the Institute of Archaeology and Ethnology PAS with the aim of fostering cooperation and communication between scientists from different fields (Fig. 1).

The first three papers in the volume provide information on new flint sources, new deposits, and outcrops. In Siliceous raw material from Bieszczady Mountains: Sources and use (pp. 21–31) Andrzej Pelisiak presents the results of his latest research connected with Late Neolithic and Early Bronze Age human occupation in the Bieszczady Mountains. Two researchers (Zsolt Mester and Norbert Faragó) present new information on Hungarian limnosilicates in Prehistoric exploitations of limnosilicates in Northern Hungary: problems and perspectives (pp. 33–50). The last paper in this group, by Jacek Kabaciński and Iwona Sobkowiak-Tabaka, A newly discovered source of ‘banded flint’ in the Polish lowlands (pp. 51–65), illustrates an important first step to distinguish a new
type of flint – Pęgów flint – by conducting instrumental neutron activation analysis (INAA). These four articles address the first step of work with siliceous rocks – field investigations and initial, mostly macroscopic, differentiation.

The next group of papers feature collaborations between archaeologists and geologists, petrologists, and geochemists. In *Erratic flint from Poland: Preliminary results of petrographic and geochemical analyses* (pp. 67–82) Iwona Sobkowiak-Tabaka and colleagues present the results of petrographic and geochemical analyses of the erratic flint from present-day Poland using electron probe micro analysis (EPMA), scanning electron method (SEM) and energy-dispersive x-ray fluorescence (EDXRF) spectrometry. Next, Marcin Szeliga and Miłosz Huber, in *Mineralogical and petrographic characteristic of basic types of Turonian flints from the north–eastern margin of the Holy Cross Mountains: a preliminary report* (pp. 83–97) provide descriptions of the mineralogical-petrographical characteristics of Turonian flints from the Holy Cross (Świętokrzyskie) Mountains. In the following article *On the chemical composition of ‘chocolate’ flint from central Poland* (pp. 99–114) the editors of this volume and Rafał Siuda present the initial results of EDXRF spectrometric analysis of ‘chocolate’ flint from outcrops located on the northeastern slopes of the Świętokrzyskie (Holy Cross) Mountains. These three papers on employing instrumental methods are promising, while emphasizing that there is still much progress to be made along these lines. The last paper in this group *Reflectance spectroscopy as a chert sourcing method* (pp. 115–128) by Ryan Parish presents the results of analysis of a large number of chert artifacts from different geological formations to support his position that reflectance spectroscopy is a viable methodology for chert provenance research.

The next five articles are devoted mainly to archeological data. The first of these, Henrik Zoltán Tóth’s *Palaeolithic heat treating in Northeastern Hungary?: An archaeometric examination of the possible use of fire-setting in Stone Age quarries in the Bükk area* (pp. 129–135) discusses signs of thermal alternations supported by laboratory testing, concluding that the Paleolithic use of fire-setting to extract lithic raw material cannot be excluded. Next, in *Archaeometric study of some functional tools from the Sąspów and Wierzbica ‘Zele’ flint mines sites* (pp. 137–150), Jolanta Małecka-Kukawka and colleagues employ use-wear analysis, laser ablation, and SEM-EDS to examine red marks on the surface of flint tools, identifying the material traces as indicative of evidence for human processing of ochre. Next, in *The Lublin-Volhynian culture retouched blade daggers in light of usewear analysis of artefacts from burials at site 2 in Książnice, Poland* (pp. 151–165), Stanisław Wilk and Bernadeta Kufel-Diakowska present the results of use-wear analysis made on flint daggers to evaluate the suggestion that those artifacts signified social prestige in Lublin-Volhynian culture communities. They conclude that important social roles in Lublin-Volhynian culture may not have been determined exclusively on the basis of wealth. In *Early Neolithic flint mining at Södra Sallerup, Scania, Sweden, Åsa Berggren and colleagues (pp. 167–180)* describe the history of research at the mine and the most recent excavation, conducted in
2014. This article presents important facts about the mine (its geology, mining methods and tools, chronology, production and mining activity) as well as the social and cultural context of mining undertaken there. Finally, in The use of erratic stone by the communities of the Linear Pottery culture: a view from the excavations in Kostomłoty, site 27, province of Lower Silesia, Mirosław Furmanek and Mirosław Masoń (pp. 181–200) examine the differences in flintworking in the settlement at Kostomłoty, suggesting that observed differences were not related so much to the location of the site on the marginal of the centre of Linear Pottery culture settlement, as they were to the settlement reorganization and diminution of long-distance contacts characteristic of post-Linear Pottery culture groups.

Taken together, we hope that the chapters in this volume will contribute to, and advance, the research pioneered by Krukowski and Samsonowicz emphasizing interdisciplinary analysis and the contributions it can make to understanding the archaeological past.

Finally, we extend special thanks to all the reviewers of these chapters for their time and commitment; the volume could not have been completed without their cooperation and assistance. These individuals include: Katalin Biró (Budapeszt), Michael Brandl (Vienna), Ivan Cheben (Nitra), Jacek Lech (Warszawa), Jolanta Małecka-Kukawka (Toruń), András Markó (Budapeszt), Mirosław Masoń (Wrocław), Zdeňka Nerudová (Brno), Ryan Parish (University of Memphis, USA), Andrzej Pelisiak (Rzeszów), Antonin Přichystal (Brno), Joanna Pyzel (Gdańsk), Katarzyna Pyżewicz (Poznań), Romuald Schild (Warszawa), Rafal Siuda (Warsaw), Iwona Sokowiak-Tabaka (Poznań), Christoper Stevenson (Virginia Commonwealth University, Richmond, USA), Zofia Sulgostowska (Warsaw), Marcin Szeliński (Lublin), Paweł Valde-Nowak (Kraków), and Anna Zakościelna (Lublin). The English language translation of some articles was done in consultation between both volume editors, which hopefully allowed us to avoid substantive errors. Nonetheless, we take responsibility for errors that remain.

Dagmara H. Werra
Richard E. Hughes

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Online access to previous volumes of Archaeologia Polona is available at the address:

Profesor Romuald Schild
at Nabta Playa (Western Desert, Egypt, 2005)
at the quarry of quartzite sandstones used for steles
Prehistoric exploitation of limnosilicites in Northern Hungary: Problems and perspectives

Zsolt Mester\textsuperscript{a} and Norbert Faragó\textsuperscript{b}

Limnosilicites constitute a specific group of siliceous rocks originating in freshwater limnic (lake) environments. They are very common in the north Hungarian Range, due to the complicated plate tectonic movements building up the Carpathians and the related Tertiary volcanism. Because the local conditions were quite dynamic during their formations, limnosilicites show great petrographic variability. The archaeological record of northern Hungary documents that these siliceous rocks have been used by prehistoric human groups as raw materials for tool production. The identification of the provenience of raw materials is a very important but difficult task in most of the cases. More petroarchaeological investigations are needed to complement the good results obtained in the Tokaj Mountains, and even more work is required in the Cserhát, Mátra and Bükk mountains where systematic field surveys are lacking.

To better understand the procurement strategies and technical behaviour of prehistoric groups inhabiting the region, it is indispensable to have a comprehensive knowledge of potential raw materials and their sources. Geological maps and local geographical names could help to discover them during field surveys. Because intensive erosional processes have affected the foothill regions of the North Hungarian Range during the Pleistocene and the Early Holocene, geomorphologic studies are also crucial for estimating the accessibility of the limnosilicate sources.

KEY-WORDS: siliceous rocks, post-volcanic hydrothermal origin, lithic raw material sources, procurement strategy, Carpathian basin

INTRODUCTION

Twenty-one years ago, volume 33 of Archaeologia Polona published a series of papers as an appendix to the Bochum catalogue of prehistoric flint mines in Europe. Among them the Hungarian flint sources were summarized (Bácskay 1995a, 1995b, 1995c, 1995d, 1995e, 1995f, 1995g; Biró 1995; Simán 1995b). This publication represents the end of a period that began twenty years earlier (Bácskay 1981), during which intensive

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archaeological field work was carried out by Erzsébet Bácskay, Katalin T. Biró and Katalin Simán to study prehistoric flint mines and exploitation sites in Hungary. The signal event of this flourishing research period was the Budapest–Sümeg Conference in 1986 devoted to flint mining and lithic raw material identification (Biró 1986, 1987). The raw material samples collected from participants during the conference formed the base of the Lithotheca at the Hungarian National Museum (Biró and Dobosi 1991; Biró et al., 2000). Unfortunately, field investigations centered on evidence for prehistoric raw material exploitations nearly ceased in late 1990s due to unfavourable research conditions and raw materials research shifted to analytical provenience studies and related archaeometry (Biró 2004).

As it is demonstrated by the site list in the abovementioned catalogue in Archaeoloxia Polona, field investigations were conducted mainly the western part of Hungary. Eight from the twelve sites are located in the Transdanubian Range, where the raw materials exploited were different radiolarites or radiolarian cherts of Mesozoic age. These kind of raw materials are almost exclusive in Transdanubia, while a wider range of siliceous rocks are known from the north Hungarian Range in the eastern part of the country (Biró 1985, 1988). This latter condition is the result of different volcanic activities occurring within the more complicated geological history of the inner part of the Carpathian arch, including territories in Slovakia, Transcarpathian Ukraine, and Romania (Harangi 2001; Harangi and Lenkey 2007). Different limnosilicites are of primary importance in these regions (Mišík 1969, 1975; Cheben and Illášová 2002; Kaminská 2013; Rácz 2013; Crandell 2014).

LIMNOSILICITES: A SPECIFIC GROUP OF SILICEOUS ROCKS

Antonín Přichystal (2010: 180) defined limnic silicites as a ‘variety of silicite originating in freshwater limnic (lake) environment. The presence of plant relics is a typical sign for their determination.’ Přichystal proposed the term as a possible solution for a never-ending terminological debate (Přichystal 2013: 48–50), but the term of limnosilicite (or limnic silicite) is not yet common in Hungarian archaeological literature although Slovakian scholars have introduced it in theirs (e.g. Kaminská 2013 vs 2001).

Here we intend to bring this term into use in Hungarian prehistoric research. Until recently Hungarian scholars used the terms of hydroquartzite and limnoquartzite (or limnic quartzite) for identifying raw materials of post volcanic hydrothermal origins in the archaeological record (e.g. Dobosi 1978; Simán 1986; Biró 1998, 2010). In discussing the great variability of this group of raw materials, Biró (1998: 34) wrote that: ‘its macroscopic features can be most varied even within a single source while different macroscopically similar types can be found at several localities within Hungary’. These raw materials dominate in the lithic materials of the majority of Palaeolithic and Neolithic
Table 1. Ratios of limnosilicites within the lithic assemblages of selected archaeological sites from the eastern part of Hungary. Age categories: MP – Middle Palaeolithic; UP – Upper Palaeolithic; MN – Middle Neolithic; LN – Late Neolithic.

<table>
<thead>
<tr>
<th>site</th>
<th>age</th>
<th>number of lithics</th>
<th>ratio of limnosilicites</th>
<th>reference</th>
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<tr>
<td>Acsa, Pest dist.</td>
<td>UP</td>
<td>2630</td>
<td>97.60%</td>
<td>Dobosi 2008</td>
</tr>
<tr>
<td>Andornaktálya, Heves dist.</td>
<td>UP</td>
<td>1541</td>
<td>21.35%</td>
<td>Mester and Kozlowski 2014</td>
</tr>
<tr>
<td>Arka, Borsod-Abaúj-Zemplén dist.</td>
<td>UP</td>
<td>956</td>
<td>55.35%</td>
<td>Vértes 1964–1965</td>
</tr>
<tr>
<td>Aszód, Pest dist.</td>
<td>LN</td>
<td>3794</td>
<td>28.65%</td>
<td>Biró, 1998</td>
</tr>
<tr>
<td>Bodrogkeresztúr, Borsod-Abaúj-Zemplén dist.</td>
<td>UP</td>
<td>2976</td>
<td>30.70%</td>
<td>Lengyel 2015</td>
</tr>
<tr>
<td>Boldogkővárálja, Borsod-Abaúj-Zemplén dist.</td>
<td>MN</td>
<td>1083</td>
<td>96.93%</td>
<td>Mester and Tixier 2013</td>
</tr>
<tr>
<td>Eger-Köporos, Heves dist.</td>
<td>MP, UP</td>
<td>422</td>
<td>42.90%</td>
<td>Dobosi 1995</td>
</tr>
<tr>
<td>Füzesabony, Heves dist.</td>
<td>MN</td>
<td>942</td>
<td>22.82%</td>
<td>Biró 2002</td>
</tr>
<tr>
<td>Hidásnémeti, Borsod-Abaúj-Zemplén dist.</td>
<td>UP</td>
<td>3993</td>
<td>92.51%</td>
<td>Simán 1989</td>
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<tr>
<td>Jászfelsőzentgyörgy, Jász-Nagykun-Szolnok dist.</td>
<td>UP</td>
<td>1303</td>
<td>60.97%</td>
<td>Dobosi 2001</td>
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<tr>
<td>Megavsó, Borsod-Abaúj-Zemplén dist.</td>
<td>UP</td>
<td>8263</td>
<td>63.03%</td>
<td>Dobosi and Simán 1996</td>
</tr>
<tr>
<td>Mezőkövesd, Borsod-Abaúj-Zemplén dist.</td>
<td>MN</td>
<td>896</td>
<td>19.31%</td>
<td>Biró 2002</td>
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<tr>
<td>Nagyréde, Heves dist.</td>
<td>UP</td>
<td>191</td>
<td>77.35%</td>
<td>Lengyel et al., 2006</td>
</tr>
<tr>
<td>Polgár-Csőszhalom, Hajdú-Bihar dist.</td>
<td>LN</td>
<td>12268</td>
<td>86.52%</td>
<td>N. Faragó, own study</td>
</tr>
<tr>
<td>Püspökkhatvan, Pest dist.</td>
<td>UP</td>
<td>2966</td>
<td>98.55%</td>
<td>Csongrádi-Balogh and Dobosi 1995</td>
</tr>
<tr>
<td>Szécsény, Nógrád dist.</td>
<td>MN</td>
<td>438</td>
<td>24.43%</td>
<td>Biró 1998</td>
</tr>
<tr>
<td>Szeleta Cave, Borsod-Abaúj-Zemplén dist.</td>
<td>MP, UP</td>
<td>1364</td>
<td>40.62%</td>
<td>Ringer and Szolyák 2004</td>
</tr>
<tr>
<td>Vanyarc, Nógrád dist.</td>
<td>MP/UP</td>
<td>1949</td>
<td>62.03%</td>
<td>Markó 2009</td>
</tr>
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sites locating to the east of the Danube River (Table 1; Fig. 1), but very little is known about their petrography and geology. At least, there are few publications on this topic (Biró et al., 1984; Szekszárdi et al., 2010).

Fig. 1. Geological formations containing ‘limnic quartzites’ in the Northern Hungarian Range (Budai and Gyalog 2009), and selected Palaeolithic (MP/UP and UP) and Neolithic (MN and LN) sites with important ratios of limnosilicates in the lithic assemblages (see Table 1). The selected formations are marked with dark grey, as well as the ratio of the ‘limnic quartzite’ within each pie chart. The size of each chart indicates the extent of the given assemblage. 1 – Acsa, Pest dist.; 2 – Andornaktálya, Heves dist.; 3 – Arka, Borsod-Abaúj-Zemplén dist.; 4 – Aszód, Pest dist.; 5 – Bodrogkeresztúr, Borsod-Abaúj-Zemplén dist.; 6 – Boldogköváralja, Borsod-Abaúj-Zemplén dist.; 7 – Eger-Kőporos, Heves dist.; 8 – Füzesabony, Heves dist.; 9 – Hidasnémeti, Borsod-Abaúj-Zemplén dist.; 10 – Jászfelsőszentgyörgy, Jász-Nagykun-Szolnok dist.; 11 – Megyaszó, Borsod-Abaúj-Zemplén dist.; 12 – Mezőkövesd, Borsod-Abaúj-Zemplén dist.; 13 – Nagyréde, Heves dist.; 14 – Polgár-Csőszhalom, Hajdú-Bihar dist.; 15 – Püspökhatvan, Pest dist.; 16 – Szécsény, Nógrád dist.; 17 – Szeleta Cave, Borsod-Abaúj-Zemplén dist.; 18 – Vanyarc, Nógrád dist. Graphics: N. Faragó.
PETROGRAPHY OF LIMNOSILICITES: DISTINGUISHING AND IDENTIFYING

Petrographic characterizations of rocks found at Palaeolithic cave sites first appeared around the beginning of the 20th century (Kadić 1916; Vendl 1933, 1940). The rock types which currently are attributed to the group of limnosilicites were then described as quartzites, chalcedonies, chalcedony-opals, etc., according to characteristics observed in thin sections. The original geological context of the given siliceous rock was rarely taken into account during these determinations. However, this context should be essential for applying Přichystal’s definition because until now, only two examples of combined geological and petrographical investigations on limnosilicites have been undertaken in Hungary – one in the Avas Hill in Miskolc (Hartai and Szakáll 2005), the other in the Tokaj Mountains (Szekszárdi et al., 2010).

Problem of the limnosilicites of the Avas Hill in Miskolc

The Avas Hill in the centre of Miskolc (Northeast-Hungary) was well-known for ‘flints’ since the Middle Ages – even a workshop for producing gunflints operated in the town (Simán 1995b: 382). Investigations related to limnosilicite outcrops have been made at two localities on the hill about 500 m distant from one another: at Pergola on the northern edge of the plateau (Simán 1995b) and at Tűzköves on the northeastern slope of the hill (Ringer 2003; Fig. 2).

According to Katalin Simán’s observations (1995b: 375), the geological sequence at Pergola consists of three layers of andesite tuff separated by marl and sandy marl layers. Only the two lower layers evidence hydrothermal activities containing ‘hydroquartzite’. Referring to Simán’s publication, Přichystal (2013: 132–133) characterizes this raw material as a geyserite originating from thermal spring activity cropping out as lenses in the Tertiary rhyolite tuffs and marlstones. Using samples found at Karel Žebera’s collection for analyses under stereomicroscope and in thin section, Přichystal describes this silicite as being smudged to banded rocks, of light brown to reddish colours, presenting small cavities (up to 1.5 cm) filled by chalcedony or fine crystallized quartz. No microfossils have been detected in the samples, which reinforces the determination as geyserite.

The geological situation at Tűzköves was studied by Éva Hartai and Sándor Szakáll (2005). The geological sequence seems to be more complicated than described at Pergola. The main mass of the hill is composed of andesitic and rhyolitic pyroclasts of Badenian-Sarmatian age (Middle and Late Miocene). In the deeper sections of the formation rhyolitic tuffs are characteristic, and above these tuffs andesitic pyroclasts and sedimentary layers form a sequence built up of highly variable layers. In its upper portion travertine layers and limnic silica beds and lenses occur. Due to volcanic activities there are silica-containing layers within the travertine where silica replaced calcite: the solution of vitric volcanic ash in the lacustrine environment acidified the water
Fig. 2. Limnosilicites of the Avas Hill in Miskolc: 1 – from Tüzköves locality; 2 – from Pergola locality. Photos: N. Faragó, microphotos: Zs. Mester, magnification 10x and 12.5x respectively.
and promoted the precipitation of silica. Therefore, with further volcanic activity, pure silica layers could form. The characterization of this ‘limnoquartzite’ by microscopy is very similar to the abovementioned one published by Přichystal (colours, infillings by chalcedony, absence of microfossiles), the main difference being the presence of opal-CT among the microcrystalline silicate minerals.

We cannot resolve the question of whether these differences demonstrate the variability of this silicite or if they suggest the existence of different conditions of formation (springs and lake). On the one hand, further field investigations are needed to verify the geological situation at Pergola and to check the possibility of lacustrine environment. On the other hand, a thorough selection of more variants from both localities with detailed petrographic analyses should clarify the degree of the variability of this raw material. Regardless, this case study provides a good illustration of our problems from the petroarchaeological point of view. Even though both descriptions noted the absence of the microfossils which could lead us to the determination of geyserite for both localities, the lacustrine environment is strongly supported by geological survey at Tűzköves. Therefore, it seems reasonable for archaeological purposes to consider the group of limnosilicites more broadly than Přichystal’s strict definition.

Problem of the limnosilicites of the Tokaj Mountains

The formation of the Tokaj Mountains was related to the history of the Pannon-Sea in the Neogene, featuring a series of volcanic activities from the Badenian to Pannonian periods. Due to tectonic ascension and sediment in-filling from neighboring Carpathian regions, lagoons and lakes developed at the northeastern part of the basin (Hámor 2001). Rocks building up the Tokaj Mountains originate from the Neogene volcanism between 15 and 9 million years ago (Gyarmati 1977). Related postvolcanic hydrothermal activities caused the formation of limnosilicites in the lacustrine environments in Late Badenian and Sarmatian periods (Szekszárdi 2005; Szekszárdi et al., 2010). A comprehensive study of limnic siliceous rocks within five lacustrine basins from the Tokaj Mountains (Szekszárdi et al., 2010: Fig. 1) has been performed by different analytical methods for petroarchaeological purposes (Szekszárdi 2007).

According to the published data (Szekszárdi et al., 2010), the classification based on macroscopic differences was not always correlated with microscopic characteristics. In the southern part of the mountains, at the Rátka–Mád area, limnosilicites occur in three levels which are macroscopically different. The uppermost level yielded grey-blue colored rocks rich in plant fossils, showing microcracks in thin section. Limnosilicites from the middle level are yellowish or light brown with dark brown or blackish bands, due to the presence of organic matters and limonite, without fossils and microcracks. A special variant from this level is the so-called stone-marrow which was formed probably in a transition zone by the silicification of a fine-grained clayey sediment. In thin section, it consists of isotropic opal. Fifteen km to the northeast, at the Erdőbénye
area, siliceous rocks are quite uniform. Opals and limnoopals dominate, and fossils are extremely rarely. The uniformity is especially evident in thin sections. Twenty more km to the northwest, at the Arka–Korlát area, limnosilicites are brownish, sometimes translucent, in color with a white patina, and they contain a significant amount of fossils. In thin section, they are highly variabile due to differences in the degree of silicification of plant fossils, as well as to the presence of chalcedony filling cracks and places of fossils. Ten km to the east of this locality, at the Óhuta area, limnosilicites form two distinct groups according to the presence of fossils: one is rich, the other is poor. As might be expected, the groups have very different thin sections. At the northern part of the mountains, the Gönc–Telkibánya area shows the highest variability, both macroscopically and in thin section. No special features occur, but some variants are very similar to the limnoopals of the Erdőbénye area.

Our field survey observations (Mester and Faragó 2013) made it abundantly clear that one can observe variability in texture and color even within blocks. At the Korlát–Arka area, we collected samples showing a combination of three different characteristics (Fig. 3): translucent, silica gel-like appearance; light brown and opaque part; white opal or opalized component. Very often, there are intergradations from one to another, suggesting that, in the absence of this knowledge, the knapped items found in archaeological sites could mistakenly be interpreted as coming from different varieties of limnosilicites.

Fig. 3. 1 – Block of limnosilicite with different macroscopic appearance from Korlát–Arka area; 2 – Blade core made of similar raw material from the Boldogkőváralja site. Photo: N. Faragó.
GEOLOGY OF LIMNOSILICITES: DISCOVERING AND CHARACTERIZING THE SOURCES

Many of the known outcrops of the limnosilicites in northern Hungary have been discovered by chance during field work by geologists, palaeontologists, archaeologists, and other professionals (e.g. Csongrádi-Balogh and Dobosi 1995; Markó 2005), including information from private collectors. Systematic field prospection for raw material outcrops has been rare, one of the few examples being the abovementioned investigation in the Tokaj Mountains (Szekszárdi et al., 2010).

The survey for sources of limnosilicites should be systematized using geological maps (Mester and Faragó 2013). Geological formations (e.g. Erdőbénye, Sajóvölgy and Szurdokpüspöki formations of the Miocene – Budai and Gyalog 2009) need to be field checked when limnic quartzite is mentioned by their descriptions (Fig. 1). The siliceous material in the embedding rock may sometimes appear to be very low quality for knapping, although macroscopically identical raw material is known in prehistoric toolkits. In addition as we have discovered, lack of obvious macroscopic similarity is not necessarily definitive, because better quality nodules from the same formation can sometimes be found in nearby eroded material, which is why surveying stream beds or river valley slopes can be fruitful (Mester and Faragó 2013). A recently developed method in sedimentary petrography, the fine-grained pebble examination (FPE), allows us to determine the geological background of a sedimentary sequence by examining the mineralogy and petrology of debris eroded from the source area (Bradák et al., 2014: 123–124). The method consists of a thorough selection of all types of rock pebbles on the sampling place from a fluvial deposit, followed by microscopic analysis of a thin section made on the artificial conglomerate of the selected small pebbles (2–2.5 mm). In this way, it is possible to discover siliceous rocks, including limnosilicites, which do not have outcrops now in the study area.

Another possibility is to check localities having a local geographic name with the reference ‘flint’ or ‘silex’ (in Hungarian: ‘tűzkő’ and ‘kova’). In northern Hungary, the referred materials are very often in fact limnosilicites or different silicified materials of metasomatic origin. On the Great Hungarian Plain (Alföld), these geographic names mainly refer to prehistoric (tell) settlements, but several times during our field surveys, such places actually proved to be Quaternary formations with redeposited sediments containing blocks of siliceous rocks.

From an archaeological point of view, it is also very important to characterize the sources. We use the classification published by Alain Turq (2000, 2005): 1 – primary autochthonous source: in the original context of the formation (embedded in the parent rock); 2 – secondary autochthonous source: extracted by erosion and accumulated in the vicinity of the original primary autochthonous source (in a slope deposit or in a stream bed); 3 – sub-allochthonous or residual source: in new geological con-
text resulted of transformation and re-deposition by weathering (in a weathered and decayed rock or colluvium); 4 – allochthonous or exotic source: the eroded and/or accumulated raw material had been transported long distances by water courses and deposited with fluvial sediments. We find these categories very useful for archaeological purposes because they correlate with types of accessibility and possibilities for human exploitation.

ARCHAEOLOGY OF LIMNOSILICITES: ACCESSIBILITY AND EXPLOITATION

For a better understanding of the behavior of prehistoric human groups, it is important to approach their archaeological remains as being the imprints of their past activities. Among these activities, humans transform natural resources to create artifacts using objects and the human body (Lemonnier 1991). All the related elements – i.e., the material to transform, the used objects, the processes of the transformation, and the necessary knowledge and skills – are components. These components – together with the relations and interactions between them – constitute the technical system of a given human group or society (Lemonnier 1983, 1991, 2010). This theoretical framework allows us to study past human technical activities in their complexity.

Raw material procurement constitutes one of the subsystems of the technical system of each human group. By technological analysis of the lithic assemblage, we are able to recognize strategies applied for the acquisition, the treatment, and the economy of the raw materials (Binder and Perlès 1990; Perlès 1990; Montet-White and Holen 1991; Féblot-Augustins 1997). The procurement strategies are determined by the conditions of the natural and cultural environment, which influence the accessibility and the modes of exploitation of raw material sources.

The cultural environment of the group consists of its technical traditions and its relations to other groups. Its effects could be evaluated by analysing archaeological data on local, regional or extraregional level, and confronting them eventually with anthropological models (Andrefsky 1994; Lech 2003; Whallon 2006; Mester and Kozłowski 2014).

The effects of the natural environment are much more important for understanding the role limnosilicates have played in raw material procurement and economy of prehistoric human groups. A series of factors have to be taken into consideration in relation to human technical behaviour (Tixier 2012: 80–84). The size, form and quantity of the lithic resource must be estimated by observations made in the field at potential sources, while the suitability of the material for tool production has to be evaluated by experimentation (Lengyel 2013). For studying accessibility it is crucial to keep in mind that the landscape might have been changed since the period in question. Geomorphological processes could result in the complete covering of raw
Prehistoric exploitation of limnosilicites in Northern Hungary: problems and perspectives

material sources which were on the surface several millennia ago. For example, during our field survey near Mát in the Tokaj Mountains, we found a layer of limnosilicate blocks, seemingly in eroded and redeposited position, at the bottom of a dirt road which cut between two wineyards (Fig. 4). Despite cultivation, the wineyard areas did not yield any limnosilicates but limnosilicates were encountered about 1 m below the actual surface. Because the foothills of the northern Hungarian Range were affected by intensive erosional processes during the Final Pleistocene and Early Holocene (Pinczés et al., 1993; Karátson 2006), raw material sources might be covered or even uncovered in the region.

The exploitation of raw material sources can be executed in several ways – from simple collecting on the surface to complex mining (Fober and Weisgerber 1981). There is a close relation between the modes of exploitation and the previously mentioned categories or types of raw material source. Allochtonous and secondary autochtonous sources yield raw material blocks or pebbles directly on the surface or slightly embedded in loose sediments. Acquiring raw materials from these sources does not require significant energy investment for extracting but it could take time to find material of appropriate quality (Mester et al., 2012). As a consequence, it is almost impossible to recognize and archaeologically document these forms of exploitation. In fortunate cases, traces of testing the collected material could support arguments for such an interpretation. Primary autochtonous and sub-allochtonous sources yield raw material blocks or nodules embedded in the body of the geological formation. Acquiring them necessitates extraction techniques or even mining, and these techniques have been applied from the Middle Palaeolithic onwards (Vermeersch 2005). For limnosilicites in northern Hungary, archaeological investigations document the existence of mines operating with extraction pits, thought to be in use from the Middle Paleolithic to the Neolithic or even the Bronze Age (Simán 1986, 1995a, 1995b, 1999). The main archaeological problem of these mines is the chronological and cultural attributions. Usually, extraction methods are not culturally specific and, if there are no mining tools made from organic materials, radiometric dating is almost impossible. Diagnostic tools are very rare in the lithic assemblages. The fact that the outcrops were exploited in different periods, even in modern times, causes further difficulties for archaeological interpretations. The same problems exist for extraction sites (Fig. 5).

CONCLUSIONS

Due to the complicated plate tectonic movements building up the Carpathians and related Tertiary volcanism, limnosilicites are very common siliceous rocks in the territory of northern Hungary. Geological formations containing ‘limnic quartzites’ were mapped in the north Hungarian Range, mainly in the foothill regions. Based on what we know from
Fig. 4. Limnosilicites blocks about 1 m under the actual surface, uncovered by a dirt road near Mád (Tokaj Mountains). Photo: N. Faragó.
the archaeological record, these siliceous rocks have been used extensively by prehistoric human groups as raw materials for tool production.

Because local geological conditions were varied and dynamic during their formations, limnosilicites show great petrographic variability, accounting for why the identification of the provenience of raw materials of artifacts in archaeological assemblages is a very difficult task in most of cases. Samples collected during field surveys demonstrate that macroscopically different parts could be present within one block. As a consequence, flakes or blades characterized as representing different variants of limnosilicites in an archaeological assemblage might actually have originated from the same block of raw material.

To achieve a better understanding the procurement strategies and technical behaviour of prehistoric groups inhabiting the region, it is indispensable to have a comprehensive knowledge about potential raw materials and their sources. Geological maps and local geographic names could help to discover them during field surveys. We believe that it is necessary to characterize the sources according to categories adopted from French prehistoric research (Turq 2000, 2005) because these types of sources
correspond to types of exploitation methods for prehistoric humans. Geomorphologic studies are also crucial for estimating onetime accessibility of the limnosilicite sources due to the intensive erosional processes which have affected the foothill regions of the north Hungarian Range during the Pleistocene and the Early Holocene. Finally, additional petroarchaeological investigations are needed to complement the good results obtained in the Tokaj Mountains (Szekszárdi et al., 2010), and even more research is needed in the Cserhát, Mátra and Bükk mountains where systematic field surveys have not been completed.

There is much research yet to do on the archaeological, geological, and petrologic problems of limnosilicates but, in the end, we will be better able to understand and reconstruct past human behaviors related to raw material economy.

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