

# Prehistoric exploitation of limnosilicites in Northern Hungary: Problems and perspectives

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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 limnosilicite 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–Sümege 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 *Archaeologia 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; Rác 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.

site	age	number of lithics	ratio of limnosilicites	reference
Acsa, Pest dist.	UP	2630	97.60%	Dobosi 2008
Andornaktálya, Heves dist.	UP	1541	21.35%	Mester and Kozłowski 2014
Arka, Borsod-Abaúj-Zemplén dist.	UP	956	55.35%	Vértes 1964–1965
Aszód, Pest dist.	LN	3794	28.65%	Biró, 1998
Bodrogkeresztúr, Borsod-Abaúj-Zemplén dist.	UP	2976	30.70%	Lengyel 2015
Boldogkőváralja, Borsod-Abaúj-Zemplén dist.	MN	1083	96.93%	Mester and Tixier 2013
Eger-Kőporos, Heves dist.	MP, UP	422	42.90%	Dobosi 1995
Füzesabony, Heves dist.	MN	942	22.82%	Biró 2002
Hidasnémeti, Borsod-Abaúj-Zemplén dist.	UP	3993	92.51%	Simán 1989
Jászfelsőszentgyörgy, Jász-Nagykun-Szolnok dist.	UP	1303	60.97%	Dobosi 2001
Megyaszó, Borsod-Abaúj-Zemplén dist.	UP	8263	63.03%	Dobosi and Simán 1996
Mezőkövesd, Borsod-Abaúj-Zemplén dist.	MN	896	19.31%	Biró 2002
Nagyréde, Heves dist.	UP	191	77.35%	Lengyel <i>et al.</i> , 2006
Polgár-Csőszhalom, Hajdú-Bihar dist.	LN	12268	86.52%	N. Faragó, own study
Püspökhatvan, Pest dist.	UP	2966	98.55%	Csongrádi-Balogh and Dobosi 1995
Szécsény, Nógrád dist.	MN	438	24.43%	Biró 1998
Szeleta Cave, Borsod-Abaúj-Zemplén dist.	MP, UP	1364	40.62%	Ringer and Szoltyák 2004
Ványarc, Nógrád dist.	MP/UP	1949	62.03%	Markó 2009

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).

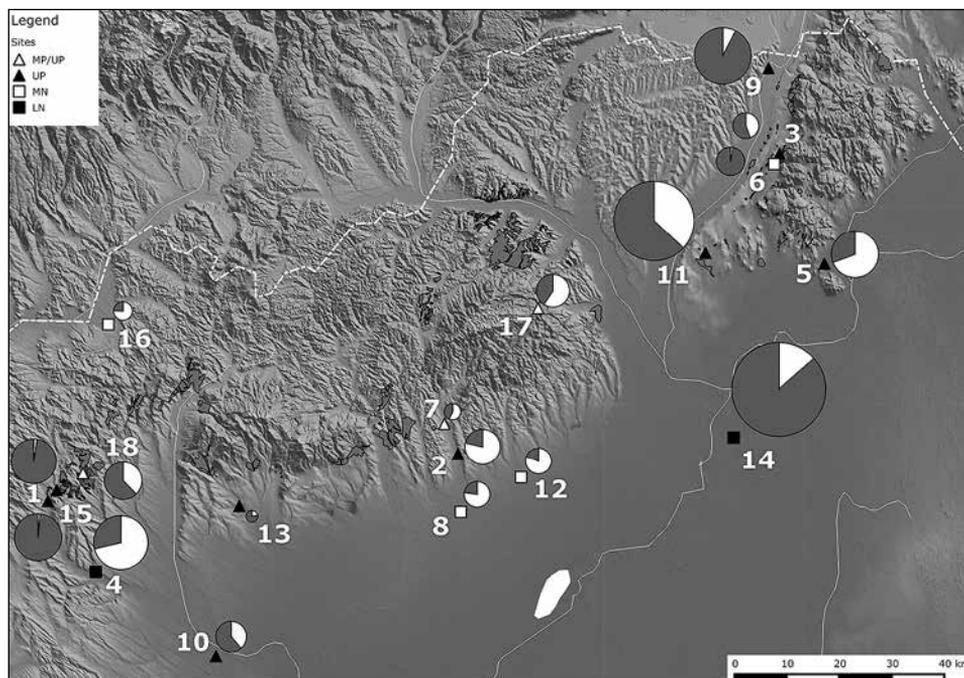


Fig. 1. Geological formations containing 'limnic quartzites' in the Northern Hungarian Range (Budai and Gyalog 2009), and selected Palaeolithic (MP/UP and UP) and Neolithic (MN and LN) sites with important ratios of limnosilicites in the lithic assemblages (see Table 1). The selected formations are marked 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 – Boldogkőváralja, Borsod-Abaúj-Zemplén dist.; 7 – Eger-Köporos, 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 – Ványarc, 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

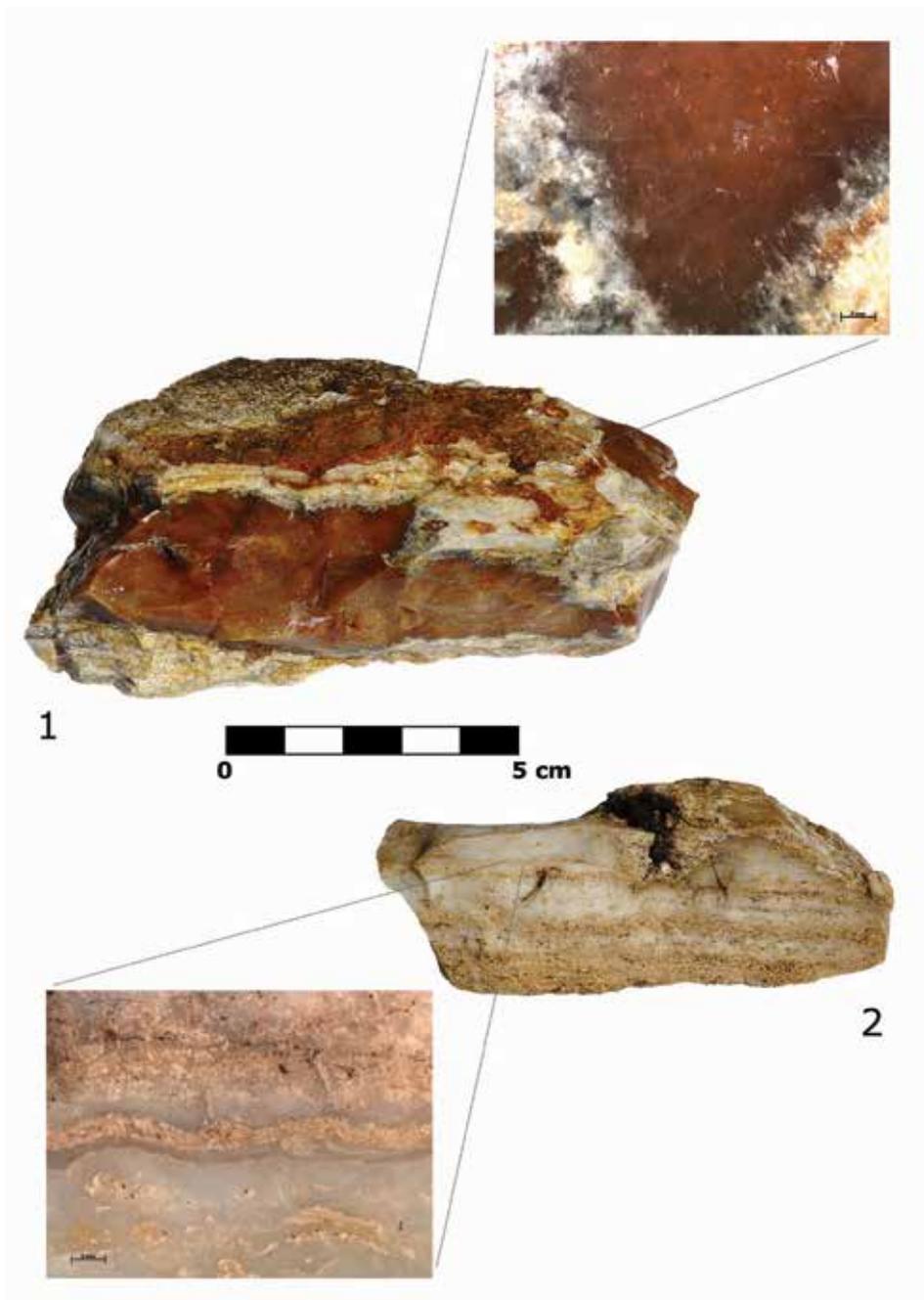


Fig. 2. Limnosilicites of the Avas Hill in Miskolc: 1 – from Tűzköves locality; 2 – from Pergola locality.  
Photos: N. Faragó, microphotos: Zs. Mester, magnification 10x and 12.5x respectively.

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 microfossils), 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 Tüzköves. 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 (Háamor 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 variable 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 misakenly be interpreted as coming from different varieties of limnosilicites.

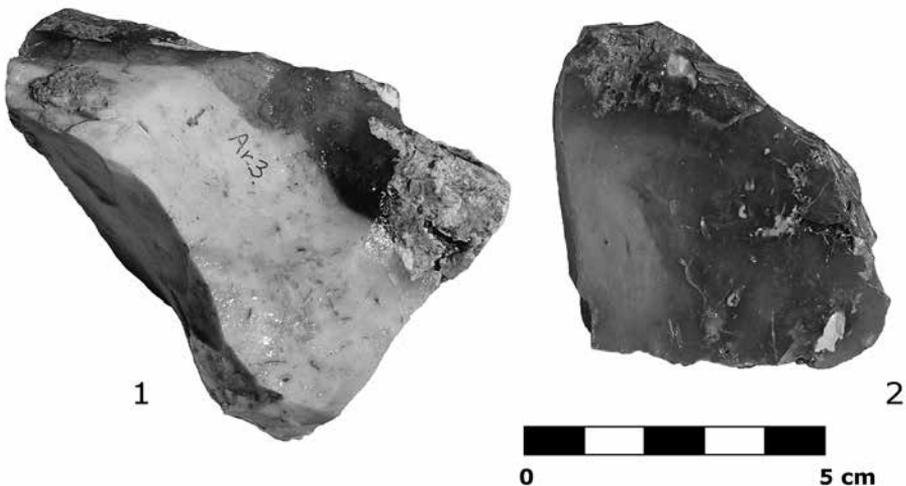


Fig. 3. 1 – Block of limnosilicite with different macroscopic appearance from Korlát–Arka area; 2 – Blade core made of similar raw material from the Boldogkőváralja site. Photo: N. Faragó.

## 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 limnosilicites 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

material sources which were on the surface several millennia ago. For example, during our field survey near Mád in the Tokaj Mountains, we found a layer of limnosilicite blocks, seemingly in eroded and redeposited position, at the bottom of a dirt road which cut between two vineyards (Fig. 4). Despite cultivation, the vineyard areas did not yield any limnosilicites 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. Allochthonous and secondary autochthonous 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 autochthonous and sub-allochthonous 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



Fig. 5. Limnosilicite extraction site at Gyöngyöstarján-Köves-tető (Mátra Mountains).  
Photo: M. Gutay.

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 limnosilicites 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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#### REFERENCES

- Andrefsky, W.Jr. 1994. Raw-material availability and the organization of technology. *American Antiquity* 59(1): 21–34.
- Bácskay, E. 1981. Zum Stand der Erforschung prähistorischer Feuersteingruben in Ungarn. In G. Weigerber, R. Slotta and J. Weiner (eds), *5000 Jahre Feuersteinbergbau. Die Suche nach dem Stahl der Steinzeit*, 179–182. Bochum.
- Bácskay, E. 1995a. H2. Sümeg-Mogyorósdomb, Veszprém country. *Archaeologia Polona* 33: 383–395.
- Bácskay, E. 1995b. H5. Erdőbénye-Sás patak, Borsod country *Archaeologia Polona* 33: 395–400.
- Bácskay, E. 1995c. H7. Bakonycsérnye-Tűzkövesárok, Fejer country. *Archaeologia Polona* 33: 402–402.
- Bácskay, E. 1995d. H9. Hárskút-Édesvízmajor, Veszprém country. *Archaeologia Polona* 33: 408–409.
- Bácskay, E. 1995e. H10. Dunaszentmiklós-Hosszúvontató, Komárom country. *Archaeologia Polona* 33: 409–410.

- Bácskay, E. 1995f. H11. Lábatlan-Margittető, Komárom country. *Archaeologia Polona* 33: 410–411.
- Bácskay, E. 1995g. H12. Lábatlan-Pisznicetető, Komárom country. *Archaeologia Polona* 33: 411–411.
- Binder, D. and Perlès, C. 1990. Stratégies de gestion des outillages lithiques au Néolithique. *Paléo* 2: 257–283.
- Biró, K.T. 1985. Neogene rocks as raw materials of the Prehistoric stone artifacts in Hungary. In J. Hála (ed.), *Neogene mineral resources in the Carpathian Basin: historical studies on their utilization*, 383–396. Budapest: Hungarian Geological Survey.
- Biró, K.T. (ed.) 1986. *Papers for the 1st International Conference on Prehistoric Flint Mining and Lithic Raw Material Identification in the Carpathian Basin, Budapest–Sümeg 1986, vol. 1*. Budapest.
- Biró, K.T. (ed.) 1987. *Papers for the 1st International Conference on Prehistoric Flint Mining and Lithic Raw Material Identification in the Carpathian Basin, Budapest–Sümeg 1986, vol. 2*. Budapest.
- Biró, K.T. 1995. H8. Szentgál-Tűzköveshegy, Veszprém country. *Archaeologia Polona* 33: 402–408.
- Biró, K.T. 1988. Distribution of lithic raw materials on Prehistoric sites: an interim report. *Acta Archaeologica Academiae Scientiarum Hungaricae* 40: 251–274.
- Biró, K.T. 1998. *Lithic implements and the circulation of raw materials in the Great Hungarian Plain during the Late Neolithic Period*. Budapest.
- Biró, K.T. 2002. Advances in the study of Early Neolithic lithic materials in Hungary. *Antaeus* 25: 119–168.
- Biró, K.T. 2004. Provenancing: methods, possibilities, problems. *Antaeus* 27: 95–110.
- Biró, K.T. 2010. Terminological practice for siliceous rocks in Hungary from petroarchaeological point of view. *Archeometriai Műhely* 2010 (3): 195–201.
- Biró, K. and Dobosi, V. 1991. *Lithotheca – comparative raw material collection of the Hungarian National Museum*. Budapest.
- Biró, K., Dobosi, V. and Schléder, Zs. 2000. *Lithotheca II – the comparative raw material collection of the Hungarian National Museum, Vol. II*. Budapest.
- Biró, T.K., Simán, K. and Szakáll, S. 1984. A characteristic SiO<sub>2</sub> raw material type group used in Prehistoric in Hungary. In K.S. Kunchev, I. Nachev and N.T. Tcholakov (eds), *IIIrd Seminar on Petroarcheology, Plovdiv, 27–30 August, 1984, Bulgaria*, 103–127. Plovdiv.
- Bradák, B., Kiss, K., Barta, G., Varga, Gy., Szeberényi, J., Józsa, S., Novothny, Á., Kovács, J., Markó, A., Mészáros, E. and Szalai, Z. 2014. Different paleoenvironments of Late Pleistocene age identified in Verőce outcrop, Hungary: Preliminary results. *Quaternary International* 319: 119–136.
- Budai, T. and Gyalog, L. (eds), 2009. *Geological map of Hungary for tourists – 1:200 000*. Budapest.
- Cheben, I. and Illášová, L. 2002. Chipped industry made of limnoquarzite from Žiarska kotlina hollow. In I. Cheben and I. Kuzma (eds), *Otázky neolitu a eneolitu našich krajín – 2001*, 105–112. Nitra.
- Crandell, O. 2014. Knappable lithic resources of North-Western Romania: A mineralogical study. *Journal of Lithic Studies* 1 (1): 73–84.
- Csongrádi-Balogh, É. and Dobosi, V.T. 1995. Palaeolithic settlement traces near Püspökhatvan. *Folia Archaeologica* 44: 37–59.
- Dobosi, V.T. 1978. A pattintott kőszközök nyersanyagáról. (Über das Rohmaterial der retuschierten Steingeräte.) *Folia Archaeologica* 29: 7–19.
- Dobosi, V.T. 1995. Eger–Kőporostető. Révision d'une industrie à outils foliacés. In *Les industries à pointes foliacées d'Europe centrale. Actes du Colloque de Miskolc, 10–15 septembre 1991*, 45–55. Les Eyzies. Paléo – Supplément N° 1.
- Dobosi, V.T. 2001. Antecedents: Upper Palaeolithic in the Jászság region. In R. Kertész and J. Makkay (eds), *From the Mesolithic to the Neolithic. Proceedings of the International Archaeological Conference held in the Damjanich Museum of Szolnok, September 22–27, 1996*, 177–191. Budapest.
- Dobosi, V.T. 2008. Acsa: new open-air Aurignacian site in Hungary. In Z. Sulgostowska and A.J. Tomaszewski (eds), *Man – Millennia – Environment. Studies in Honour of Romuald Schild*, 151–159. Warsaw.

- Dobosi, V.T. and Simán, K. 1996. New Upper Palaeolithic site at Megyaszó-Szelestedő. *Communicationes Archaeologicae Hungaricae* 1996: 5–22.
- Féblot-Augustins, J. 1997. *La circulation des matières premières au Paléolithique*. Liège.
- Fober, L. and Weisgerber, G. 1981. Feuersteinbergbau – Typen und Techniken. In G. Weisgerber, R. Slotta and J. Weiner (eds.), *5000 Jahre Feuersteinbergbau. Die Suche nach dem Stahl der Steinzeit*, 32–47. Bochum: Deutschen Bergbau-Museum Bochum 22.
- Gyarmati, P. 1977. A Tokaj-hegység intermedier vulkanizmusa. *Magyar Állami Földtani Intézet Évkönyve* 58: 1–195.
- Hámor, G. 2001. *A Kárpát-medence miocén ösföldrajza: Magyarázó a Kárpát-medence miocén ösföldrajzi és fácies térképéhez 1:3 000 000*. Budapest.
- Harangi, Sz. 2001. Neogen to Quaternary Volcanism of the Carpathian-Pannonian Region—a review. *Acta Geologica Hungarica* 44: 233–258.
- Harangi, S. and Lenkey, L. 2007. Genesis of the Neogene to Quaternary volcanism in the Carpathian-Pannonian region: Role of subduction, extension, and mantle plume. In L. Beccaluva, G. Bianchini and M. Wilson (eds), *Cenozoic Volcanism in the Mediterranean Area*, 67–92. Boulder: Geological Society of America Special Paper 418.
- Hartai, É. and Szakáll, S. 2005. Geological and mineralogical background of the Palaeolithic chert mining on the Avas Hill, Miskolc, Hungary. *Praehistoria* 6: 15–21.
- Kadić, O. 1916. Ergebnisse der Erforschung der Szeletahöhle. *Mitteilungen aus dem Jahrbuche der königlichen Ungarischen Geologischen Reichsanstalt* 23: 161–301.
- Kaminská, L. 2001. Die Nutzung von Steinrohmaterialien im Paläolithikum der Slowakei. *Quartär* 51/52: 81–106.
- Kaminská, L. 2013. Sources of raw materials and their use in the Palaeolithic of Slovakia. In Zs. Mester (ed.), *The lithic raw material sources and interregional human contacts in the northern Carpathian regions*, 99–109. Kraków–Budapest.
- Karátson, G. 2006. Aspects of Quaternary relief evolution of Miocene volcanic areas in Hungary: A review. *Acta Geologica Hungarica* 49: 285–309.
- Lech, J. 2003. Mining and siliceous rock supply to the Danubian early farming communities (LBK) in Eastern Central Europe: A second approach. In L. Burnez-Lanotte (ed.), *Production and Management of Lithic Materials in the European Linearbandkeramik*, 19–30. Oxford: Archaeopress. British Archaeological Reports International Series 1200.
- Lemmonier, P. 1983. L'étude des systèmes techniques: une urgence en technologie culturelle. *Techniques et culture* 1: 11–26.
- Lemmonier, P. 1991. De la culture matérielle à la culture ? Ethnologie des techniques et Préhistoire. In *25 ans d'études technologiques en Préhistoire. XI<sup>e</sup> Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*. Éditions APDCA, Juan-les-Pins, 15–20.
- Lemmonier, P. 2010. Retour sur 'L'étude des systèmes techniques'. *Techniques et culture* 54–55 (1): 46–67.
- Lengyel, Gy. 2013. Knapping experiments on lithic raw materials of the Early Gravettian in Hungary. In Zs. Mester (ed.), *The lithic raw material sources and interregional human contacts in the northern Carpathian regions*, 39–51. Kraków–Budapest.
- Lengyel, Gy. 2015. Lithic raw material procurement at Bodrogkeresztúre Henye Gravettian site, northeast Hungary. *Quaternary International* 359–360: 292–303.
- Lengyel, Gy., Béres, S. and Fodor, L. 2006. New lithic evidence of the Aurignacian in Hungary. *Eurasian Prehistory* 4 (1–2): 79–85.
- Markó, A. 2005. Limnokvarcit a Cserhát hegységben. *Archeometriai Műhely* 2005 (4): 52–55.
- Markó, A. 2009. Raw material circulation during the Middle Palaeolithic period in northern Hungary. In J. Gancarski (ed), *Surowce naturalne w Karpatach oraz ich wykorzystanie w pradziejach i wczesnym średniowieczu*, 107–120. Krosno.

- Mester, Zs. and Faragó, N. 2013. The lithic raw material sources and interregional human contacts in the northern Carpathian regions: Report and preliminary results of the field surveys. In Zs. Mester (ed.), *The lithic raw material sources and interregional human contacts in the northern Carpathian regions*, 23–37. Kraków–Budapest.
- Mester, Zs. and Kozłowski, J.K. 2014. Modes de contacts des Aurignaciens du site d'Andornaktálya (Hongrie) à la lumière de leur économie particulière de matières premières. In M. Otte and F. Le Brun-Ricalens (eds), *Modes de contacts et de déplacements au Paléolithique eurasiatique. Modes of contact and mobility during the Eurasian Palaeolithic*, 349–367. Luxembourg, E.R.A.U.L. 140, *ArchéoLogiques* 5, Université de Liège–Centre National de Recherche Archéologique.
- Mester, Zs. and Tixier, J. 2013. 'Pot à lames': The Neolithic blade depot from Boldogkőváralja (Northeast Hungary). In A. Anders and G. Kulcsár (eds), *Moments in time. Papers presented to Pál Raczky on his 60th birthday*, 173–185. Budapest. Ősrégészeti Tanulmányok/Prehistoric Studies 1.
- Mester, Zs., Faragó, N. and Lengyel, Gy. 2012. The lithic raw material sources and interregional human contacts in the northern Carpathian regions: A research program. *Anthropologie* 50 (3): 275–293.
- Mišík, M. 1969. Petrografická príslušnosť silicítov z paleolitických a neolitických artefaktov Slovenska. *Acta geologica et geographica Universitatis Comenianae, Geologica* 18: 117–135.
- Mišík, M. 1975. Petrograficko-mikropaleontologické kritériá pre zisťovanie proveniencie silicitových nástrojov na Slovensku. *Folia Fac. Sci. Natur. Univ. Purkyn. Brunensis* 16, *Geologia* 27, 89–107.
- Montet-White, A. and Holen, S. (eds), 1991. *Raw material economies among Prehistoric hunter-gatherers*. Lawrence: University of Kansas. Publications in Anthropology 19.
- Perlès, C. 1990. L'outillage de pierre taillée néolithique en Grèce: approvisionnement et exploitation des matières premières. *Bulletin de correspondance hellénique* 114: 1–42.
- Pinczés, Z., Martonné Erdős, K. and Dobos, A. 1993. Elterések és hasonlóságok a hegyláb felszínének pleisztocén felszínfejlődésében. *Földrajzi Közlemények* 117: 149–162.
- Přichystal, A. 2010. Classification of lithic raw materials used for prehistoric chipped artefacts in general and siliceous sediments (silicites) in particular: the Czech proposal. *Archeometriai Műhely* 2010 (3): 177–181.
- Přichystal, A. 2013. *Lithic raw materials in Prehistoric times of Central Europe*. Brno.
- Rácz, B. 2013. Main raw materials of the Palaeolithic in Transcarpathian Ukraine: geological and petrographical overview. In Zs. Mester (ed.), *The lithic raw material sources and interregional human contacts in the northern Carpathian regions*, 131–146. Kraków–Budapest.
- Ringer, Á. 2003. Őskőkori kovabányászat és kovakő-feldolgozás a miskolci Avason. (Des mines et des ateliers de silex préhistoriques sur le mont Avas à Miskolc.) *Herman Ottó Múzeum Évkönyve* 42: 5–15.
- Ringer, Á. and Szolyák, P. 2004. A Szeleta-barlang tűzhelyeinek és paleolit leleteinek topográfiai és sztratigráfiai eloszlása. Adalékok a leletegyüttes újraértékeléséhez. (The topographic and stratigraphic distribution of the Palaeolithic hearths and finds in the Szeleta Cave. Contribution to re-interpretation of the assemblage). *Herman Ottó Múzeum Évkönyve* 43: 13–32.
- Simán, K. 1986. Limnic quartzite mines in Northeast-Hungary. In K.T. Biró (ed.), *Papers for the 1<sup>st</sup> International Conference on Prehistoric Flint Mining and Lithic Raw Material Identification in the Carpathian Basin, Budapest–Sümeg 1986, vol. 1*, 95–99. Budapest.
- Simán, K. 1989. Hidasnémeti – Upper Palaeolithic site in the Hernád valley (Northeast Hungary). *Acta Archaeologica Carpathica* 28: 5–24.
- Simán, K. 1995a. H4. The Korlát-Ravaszlyuktető workshop site in North-Eastern Hungary. *Archaeologia Polona* 33: 41–58.
- Simán, K. 1995b. H1. Prehistoric mine on the Avas Hill at Miskolc. *Archaeologia Polona* 33: 371–382.
- Simán, K. 1999. Bifaciális eszközök Korlát-Ravaszlyuk-tető lelőhelyen. (Bifacial implements on Korlát-Ravaszlyuk-tető site.). *Herman Ottó Múzeum Évkönyve* 37: 29–44.

- Szekszárdi, A. 2005. A vizsgálati lehetőségek áttekintése a Tokaji-hegységi limnokvarciton és limnoopaliton, a pattintott kőszközök eredetének azonosítása céljából. *Archeometriai Műhely* 2005 (4): 56–61.
- Szekszárdi, A. 2007. *Tokaji-hegységi limnokvarcit-limnoopalit nyersanyagok és pattintott kőszközök archeometriai vizsgálati eredményei*. Unpublished MSc Thesis, Eötvös Loránd University, Budapest.
- Szekszárdi, A., Szakmány, Gy. and Biró, K.T. 2010. Tokaji-hegységi limnokvarcit-limnoopalit nyersanyagok és pattintott kőszközök archeometriai vizsgálata. I.: Földtani viszonyok, petrográfia. (Archaeometric analysis on limnic-quartzite limnic opalite raw materials and chipped stone tools, Tokaj Mts. NE-Hungary. I.: geological settings, petrography). *Archeometriai Műhely* 2010 (1): 1–17.
- Tixier, J. 2012. *A method for the study of stone tools / Méthodes pour l'étude des outillages lithiques*. Luxembourg.
- Turq, A. 2000. *Le Paléolithique inférieur et moyen entre Dordogne et Lot*. Les Eyzies. *Paléo Supplément* 2.
- Turq, A. 2005. Réflexions méthodologiques sur les études de matières premières lithiques. *Paléo* 17: 111–132.
- Vendl, A. 1933. Adatok a bükkhegységi paleolitos szilánkok közzetani ismeretéhez. *Matematikai és Természettudományi Értesítő* 50: 573–587.
- Vendl, A. 1940. Das Gesteinsmaterial der Paläolithen. In L. Bartucz, J. Dancza, F. Hollendonner, O. Kadić, M. Mottl, V. Pataki, E. Pálosi, J. Szabó and A. Vendl (eds), *Die Mussolini-Höhle (Subalyuk) bei Cserépfalu*, 169–199. Budapest.
- Vermeersch, P.M. 2005. Middle Palaeolithic chert extraction structures in Egypt. *Praehistoria* 6: 57–69.
- Vértes, L. 1964–1965. Das Jungpaläolithikum von Arka in Nord-Ungarn. *Quartär* 15–16: 79–132.
- Whallon, R. 2006. Social networks and information: non-‘utilitarian’ mobility among hunter-gatherers. *Journal of Anthropological Archaeology* 25: 259–270.