ORIGIN, MINERALOGY, NOMENCLATURE AND PROVENANCE OF SILICA AND SIO_2 ROCKS

A KOVAKŐZETEK EREDETE, TERMINOLÓGIÁJA ÉS SZÁRMAZÁSI HELYE

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Abstract

The various modifications of silica, especially quartz, play a central role in the composition of geological materials. Owing to their abundance and properties, SiO_2 minerals and rocks have been used since the beginning of human being in different applications such as tools, weaponries, jewelleries or building materials. The occurrence of different silica minerals within SiO_2 rocks and the similarity in mineral composition of those stones require a clear terminology and nomenclature of both the silica polymorphs and varieties as well as the different types of SiO_2 rocks and their genesis. Because of the often monotonous composition of these rocks, they only differ in texture, grain size, kind and content of binding agents and thus, are hardly to be classified in a hand specimen or by routine polarizing microscopy. Therefore, an integrated mineralogical and geochemical analysis is necessary for a detailed characterization. The present review gives an overview concerning the state of the art of the mineralogical and petrographical nomenclature of silica and SiO_2 rocks and the analytical approach for the identification and classification of these materials.

Kivonat

Az uralkodóan kovasavból (SiO_2) álló ásványok, elsősorban a kvarc, központi szerepet játszik a kőzetek felépítésében. Gyakoriságuknak és tulajdonságaiknak köszönhetően a SiO_2 ásványokat és kőzeteket az emberi fejlődés kezdetétől gyakran felhasználták, eszközként, fegyverként, ékszerként vagy építőanyag formájában. A kovakőzeteken belül a különféle SiO_2 ásványok előfordulása és ezeknek a kőzeteknek az ásványi összetételének ismeretéhez világos és egyértelmű terminológiára és pontos kőzetgenetikai ismeretekre van szükség mind a SiO_2 ásvány módosulatok, mind a kovakőzetek tekintetében. Ezek a kőzetek, gyakran monomineralikus felépítésük következtében, szinte csak szövetben, szemcseméretben illetve az esetleges kötőanyag jellegében és minőségében különböznek, ezért nagyon nehéz őket makroszkóposan vagy polarizációs mikroszkóppal elkülöníteni és osztályozni. A részletes jellemzésükre mindenképpen integrált ásványtani és geokémiai elemzésre van szükség. Az alábbi összefoglaló az ásványtani és kőzettani nevezéktan aktuális állásáról ad áttekintést a SiO_2 ásványok és a kovakőzetek tekintetében és bemutatja az azonosításukra és rendszerezésükre alkalmazható vizsgálati módszereket.

KEYWORDS: QUARTZ, SIO_2, SILICEOUS ROCKS, SILICICLASTIC ROCKS, PROVENANCE

KULCSSZAVAK: KVARC, SIO_2 KOVAKŐZETEK, HOMOKKÖVEK, SZÁRMAZÁSI HELY MEGHATÁROZÁS

Introduction

The various modifications of silica (SiO_2) play an important role in geological as well as industrial processes. Quartz is with more than 12 weight-% one of the most abundant minerals in the Earth crust and the most important silica mineral, occurring in large amounts in igneous, metamorphic and sedimentary rocks. Due to its highly stable nature, quartz is especially enriched in all siliciclastic sediments and rocks, which may consist of up to ≥99% quartz and other silica minerals (Götze, 2009).

In addition, silica can be enriched and siliceous rocks formed during diagenesis, metamorphosis and magmatism, such as in the case of chert, flint, quartzite or obsidian. The alteration and diagenesis of organic silica materials (e.g., diatoms, radiolaria, siliceous sponges) result in the formation of porcellanites, diatomites or radiolarites (Füchtbauer, 1988).

Owing to their abundance and properties, SiO_2 minerals and rocks have been used in different applications (e.g. tools, weaponries, jewellery, etc.) since early human being and as traditional building materials (e.g. sandstones) worldwide for centuries. A lot of ancient buildings as well as sculptures and tombstones are made of different types of local siliceous stones. The provenance determination of this stone material and its assignment to certain deposits or quarry regions has become an important scientific tool in answering cultural and historical questions (Götze & Zimmerle, 2000). It aims at the reconstruction of political and trade relations, the understanding of the management of historic building sites, technical development of quarrying and transport, etc. In addition, the knowledge about the provenance of siliceous rocks on buildings is also important for the assessment of their weathering behaviour and for practical restoration activities.

Because of their widespread occurrence, sedimentary SiO_2 rocks play the most important role. Their composition is often monotonous. In most cases, quartz is the dominant mineral, and only low contents of other silica polymorphs, feldspar and a few other minerals (e.g. detrital mica, clay minerals or heavy minerals) may occur. Depending on their geological formation, these SiO_2 rocks only differ in texture, grain size, kind and content of binding agents and thus, are hardly to be classified in a hand specimen or by routine polarizing microscopy. Up to now, the nomenclatures are not always sharp with partly overlapping terms. In addition, the situation is hindered due to the use of regional names for several SiO_2 rocks. The occurrence of different silica minerals within siliceous rocks and the similarity in mineral composition of those stones require a clear terminology and nomenclature of both silica polymorphs and different types of siliceous rocks and their genesis.

The SiO_2 system

Silica (SiO_2) makes up 12.6 weight% of the Earth's crust as crystalline and amorphous silica in at least 15 ***modifications*** (**Table 1**), i.e. mineral phases with the formula SiO_2 but a different crystal structure. In respect to the occurrence in nature and the amount of technical material used, quartz is the most important silica modification. At 573°C the trigonal alpha quartz transforms reversible into the hexagonal high-temperature quartz.

The crystal structure of alpha quartz is composed exclusively of $[SiO_4]^{4-}$ tetrahedra with all oxygen joined together in a three-dimensional network. Thus, the formula is SiO_2 and the atoms are arranged in a trigonal symmetry. The properties of quartz are determined by its real structure. The type and frequency of lattice defects are influenced by the thermodynamic conditions during mineralization or subsequent processes during metamorphism or natural irradiation. These defects can be classified according to their structure and size as point defects (zerodimensional, < 10...30 Å), dislocations (linear defects), subgrain or twin boundaries (two-dimensional), and three-dimensional defects due to microinclusions of minerals and fluids.

Table 1.: The SiO_2 system (modified after Strunz & Tennyson, 1982)

1. táblázat: SiO_2 ásványok rendszere (Strunz & Tennyson, 1982 nyomán)

Quartz-tridymite-cristobalite group (atmospheric and low pressure)	
Quartz	trigonal
High-quartz	hexagonal
Tridymite	monoclinic
High-tridymite	hexagonal
Cristobalite	tetragonal
High-cristobalite	cubic
Melanophlogite	cubic
Fibrous SiO_2 (syn.)	orthorhombic
Moganite	monoclinic
Keatite-coesite-stishovite group (high and ultra-high pressure)	
Keatite (syn.)	tetragonal
Coesite	monoclinic
Stishovite	tetragonal
Seifertite	orthorhombic
Lechatelierite-opal group (amorphous phases)	
Lechatelierite	natural silica glass
Opal	water bearing, solid SiO_2 gel

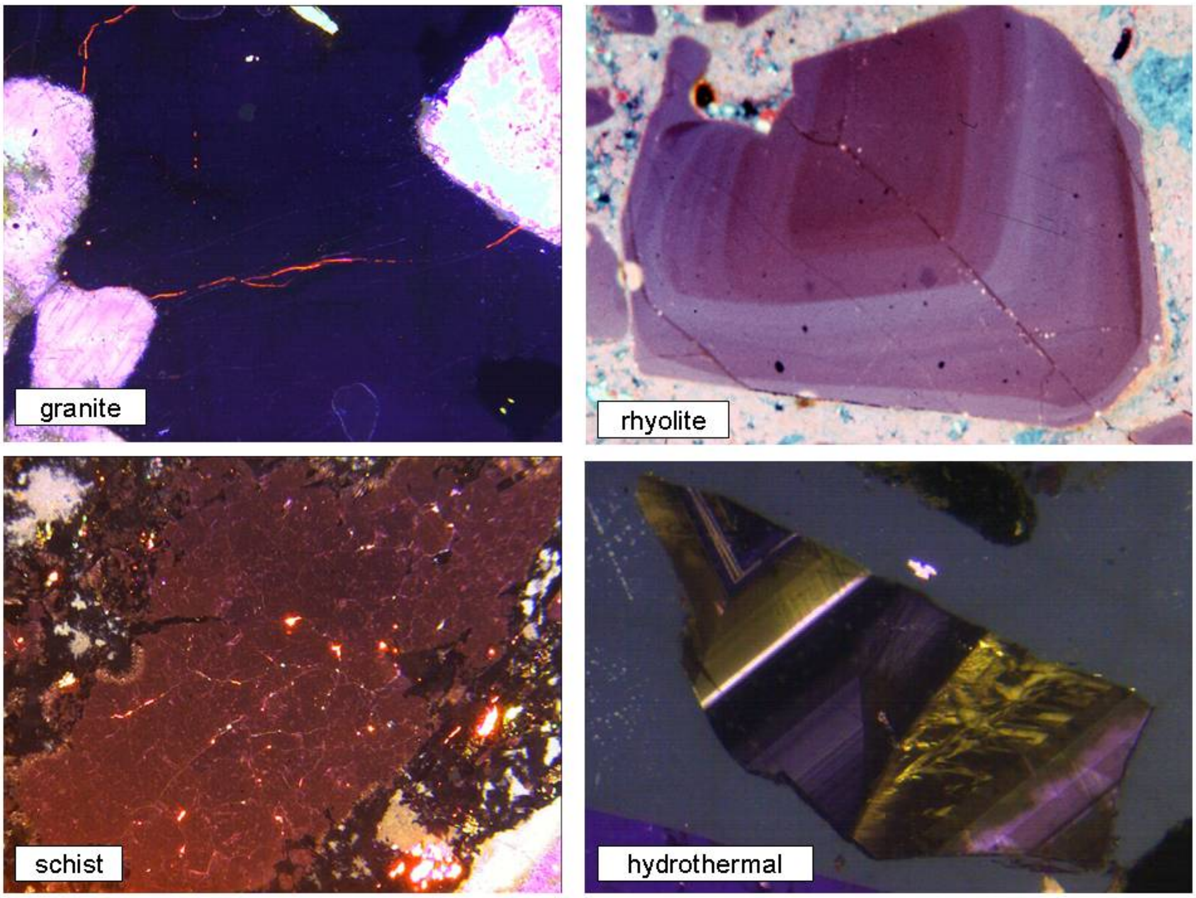

Fig. 1.: Diversity of cathodoluminescence (CL) colours of quartz from different parent rocks

1. ábra: Kvarc kristályok változó katódlumineszcens (CL) színe különböző eredetű kőzetekben

Because of the close relation between different defect types and specific genetic conditions, typomorphic properties (e.g., crystal shape, trace-element composition, luminescence properties, etc.) can be used to reconstruct geological conditions of formation. One prominent example, which is commonly used in geosciences, is the diversity in cathodoluminescence (CL) colours of quartz from different host rocks (**Fig. 1**). For instance, these properties provide the basis for provenance analyses of clastic sediments, where the detrital quartz grains can be related to possible parent source rocks.

The varying properties of quartz and other silica minerals result in the existence of numerous ***varieties***, i.e. mineral phases with the same chemical composition of SiO_2 and the same crystal structure, but different appearance in shape, colour or other physical properties (**Fig. 2**). These varieties are sometimes used as material such as in the case of rock quartz, milky quartz (vein quartz), agate or jasper and, therefore, can be used for the identification and classification of several frequent silica minerals.

On the other hand, certain non- and microcrystalline silica polymorphs and varieties, respectively exist (**Table 2**). These mineral phases play an important role as constituents of preferentially sedimentary rocks and, therefore, have to be considered for the characterisation and nomenclature of SiO_2-bearing rocks.

Origin and nomenclature of SiO_2 rocks

Despite the simple chemical formula SiO_2 of quartz, the system of silica and SiO_2 rocks is very complex. This is on one hand due to the various silica modifications and quartz/silica varieties and on the other hand the various SiO_2 rocks with partially unclear nomenclature. The basis for a useful classification is probably given by the petrological classification into magmatic, metamorphic and sedimentary rocks.

Since siliceous rocks are especially enriched at the Earth's surface, the present topic has to be dealt comprehensively under the aspect of mineralogy and sedimentary petrology. From the group of magmatic and metamorphic rocks, only fine-grained, SiO_2-rich rocks have to be taken into account such as rhyolite (20-60% quartz) and volcanic glasses (obsidian, perlite) as well as metamorphic quartzite.

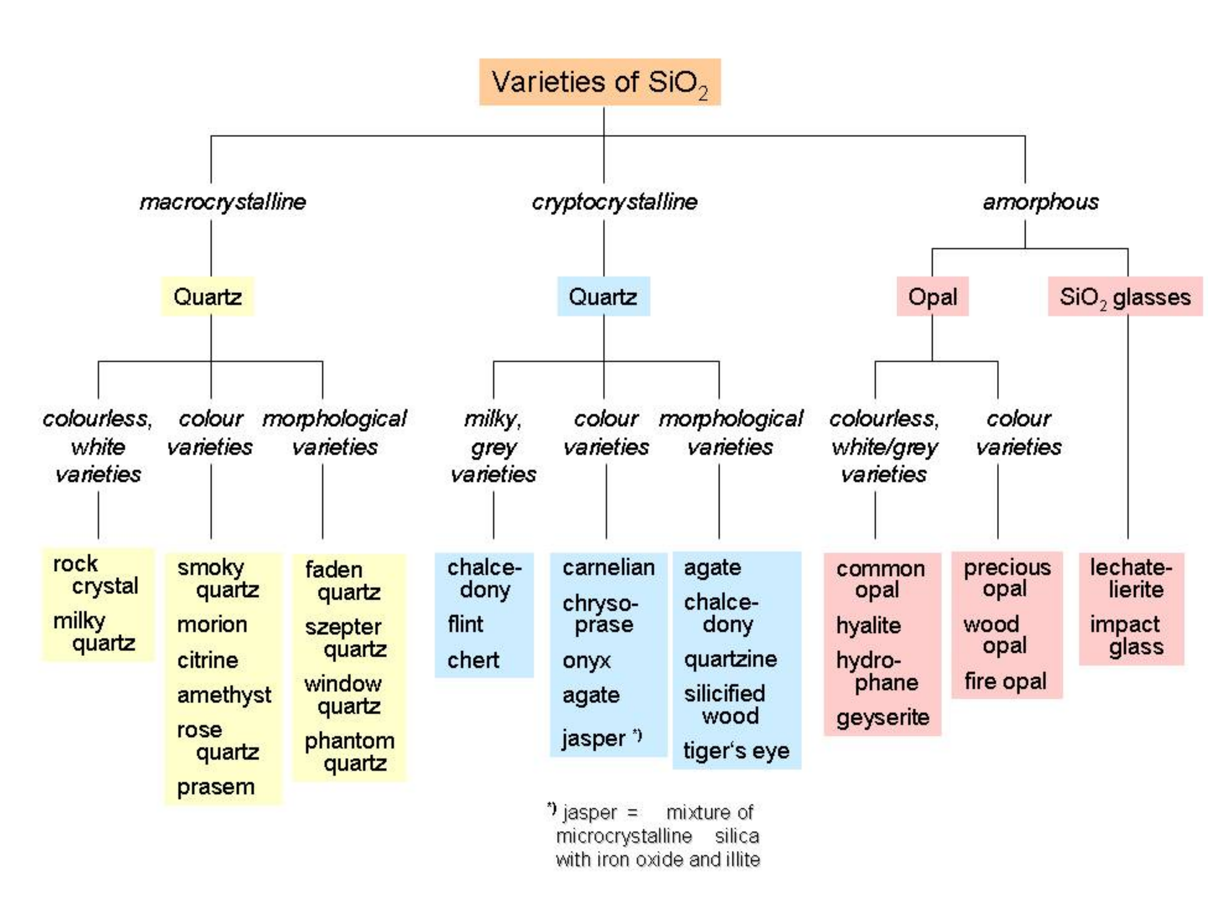

Fig. 2.: The system of different varieties of quartz and other silica phases

2. ábra: Kvarc változatok és egyéb SiO_2 ásványok rendszere

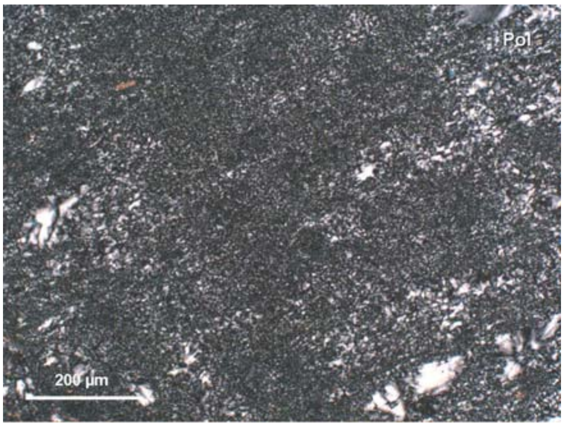

Fig. 3.: Micrograph in polarized light of massive chert with fine-grained granular quartz and chalcedony

3. ábra: Tömeges kovakőzet (s.l. tűzkő) mikroszkópos képe polarizált fényben

To cover the whole group of sedimentary SiO_2 rocks, the term ***silicite*** could probably be used without overlapping with more detailed nomenclatures. Taking into account the genetic aspect of classification, the groups of siliceous rocks and siliciclastic rocks should be distinguished.

Siliceous rocks are rocks with >50% non-detrital silica minerals such as opal-A, opal-CT, chalcedony, quartzin and/or (micro-)quartz (Füchtbauer, 1988).

In contrast, the group of ***siliciclastic rocks*** includes rocks with preferentially detrital quartz from previously existing rocks, accumulated and compacted during weathering, transport, sedimentation and diagenesis.

Siliceous rocks

A further differentiation and nomenclature within the group of siliceous rocks is possible due to aspects of formation, mineral composition and texture.

Siliceous rocks consisting almost completely of opal-CT are called ***porcellanite***, whereas those with (micro-)quartz and chalcedony belong to the group of chert. According to Knauth (1994), the term ***chert*** (= ***hornstone***, in German ***Hornstein***) is used for rocks with interlocking grains of complexly twinned, hydrous, granular microcrystalline quartz that has replaced pre-existing sediments such as opal, carbonate, or evaporate minerals (**Fig. 3**).

Table 2.: Classification of non- and microcrystalline silica phases (modified after Graetsch, 1994)

2. táblázat: Kristályos és amorf SiO_2 fázisok osztályozása (Graetsch, 1994 nyomán)

Crystal structure or phase	Variety	Subvariety/ synonymous name	Microstructure	Optical character	Water content (weight-%)
quartz	microquartz		granular	positive	< 0.4
disordered quartz	chalcedony		fibrous $[11\bar{2}0]$	length-fast	0.5 - 2
(often with moganite)	quartzine		fibrous [0001]	length-slow	0.5 - 1
moganite			platy (110), lepidospheric	length-slow	1.5 - 3
disordered cristobalite	opal-C	lussatine	platy (111)*	length-fast	1 - 3
cristobalite/tridymite	opal-CT	lussatite	fibrous [110]*	length-slow	3 - 8
		common massy opal	platy, lepidospheric	nearly isotropic	3 - 10
non-crystalline	opal-AG	precious opal	close packing of homometric spheres	play of colour, anomalous birefringence	4 - 8
		potch opal	heterometric spheres	isotropic	4 - 8
	opal-AN	hyalite	botryoidal crusts and masses	strain birefringence	3 - 7
	lechatelierite	fulgurites	vitrified tubes	isotropic	< 0.3
		impact glass	meteoritic silica glass	isotropic	< 0.3

C – cristobalite, T – tridymite, A – amorphous, G – gel-like, N – network (glass)-like

* indices refer to cubic setting of cristobalite

The formation of chert can occur by:

a) diagenetic transformation sequence from siliceous oozes (SiO_2 from diatoms, radiolarian or sponges and also volcanic glass): opal-A→ opal-CT→ microquartz or

b) direct diagenetic precipitation of microquartz (replacement of carbonate).

According to the siliceous precursors, radiolarite, diatomite or spiculite are formed. Synonymous for radiolarite the terms ribbon chert, novaculite and lydite (in German = Kieselschiefer) are used (compare **Fig. 4**).

Among the massive cherts, Precambrian cherts are sometimes named due to their origin as stromatolithic chert, which often occurs together with iron oxides in deposits of banded iron ore formations (BIF). It is recently assumed that silica-producing microorganisms play an important role in the formation of these siliceous rocks.

Nodular chert is formed during the diagenesis of carbonaceous muds by the dissolution and replacement of nodular carbonate in shallow coastal environment (**Fig. 5**). The term ***Flint*** (French: silex; German: Feuerstein) refers to nodular chert concretions in carbonate rocks, which are of preferentially Cretaceous and Jurassic age (Füchtbauer, 1988).

Another type of siliceous rocks is ***siliceous sinter***. This is a porous, layered and fine-grained siliceous rock, which originates from the evaporation of silica in hot springs (**Fig. 6**).

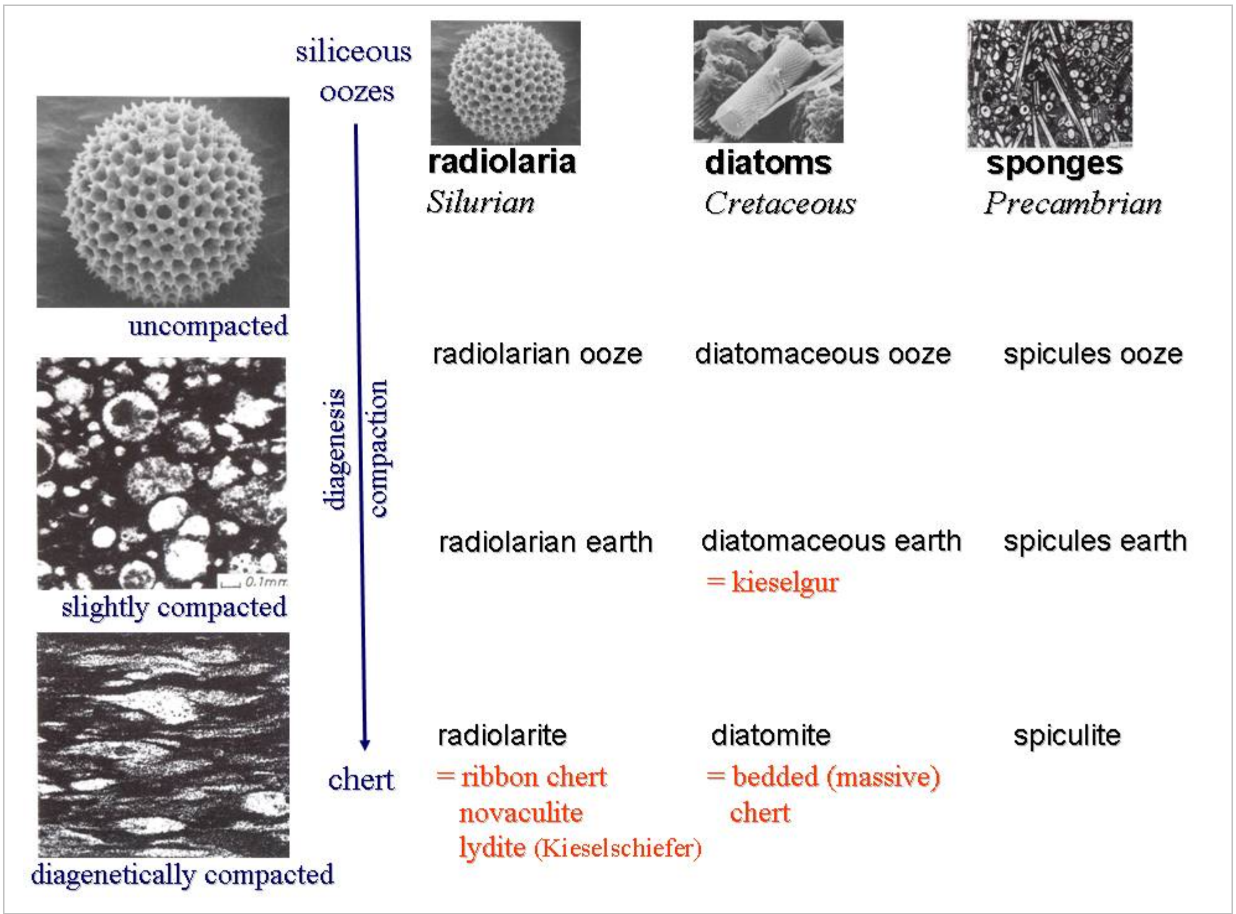

Fig. 4.: Formation of different types of chert by the diagenesis of opal-A precursors (siliceous oozes) during burial and solution-reprecipitation steps via opal-A→opal-CT →microquartz.

4. ábra: Különböző kovakőzetek képződése opal-A (kovaiszap) előzményekből (Knauth, 1994 nyomán).

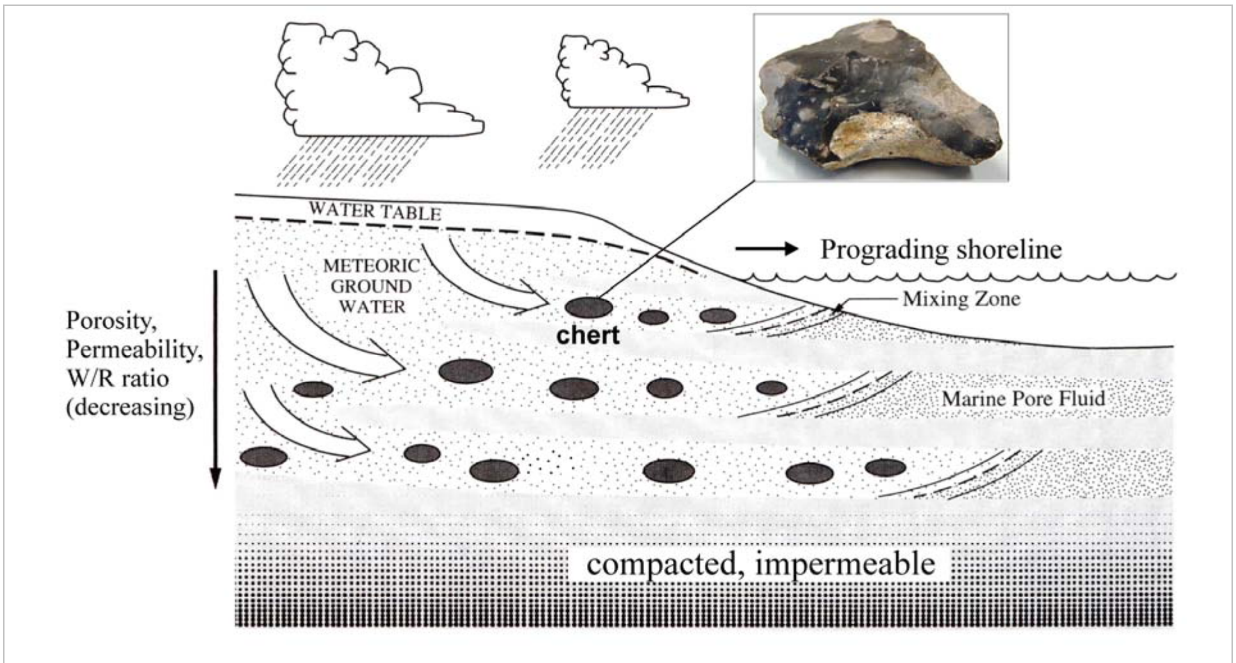

Fig. 5.: Scheme of the formation of nodular chert by dissolution and replacement of nodular carbonate in shallow sediments (modified after Knauth, 1994)

5. ábra: Gumós tűzkő képződése karbonátok helyettesítésével sekélytengeri üledékekben (Knauth, 1994 nyomán)

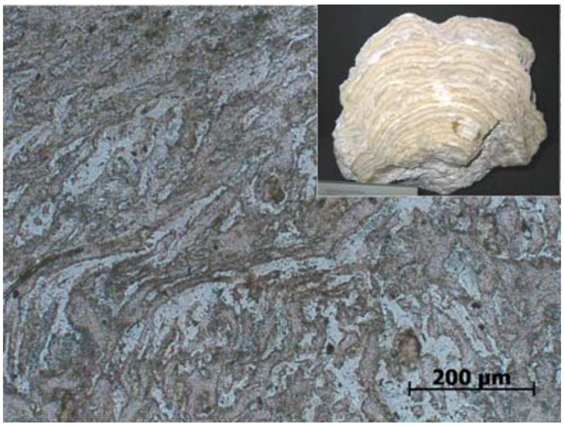

Fig. 6.: Hand specimen (upper right) and transmitted light micrograph of a typically layered siliceous sinter showing the typical microstructure

6. ábra: Kézipéldány (jobb felső sarok) és áteső fényben készült mikroszkópos felvétel egy tipikus kovás bekérgeződésből

In contrast, ***tripoli*** (or ***polishing slate***, German: Polierschiefer) is a fine-grained siliceous rock with inorganic silica source and high porosity.

A special group of siliceous rocks is represented by ***silcretes***. This group of terrestrial siliceous rocks is especially reported from Australia (silcrete) and Europe, where the rocks are called ***Tertiary quartzite*** (because of the preferred occurrence in Tertiary sediments) or ***cement quartzite*** (in contrast to metamorphic quartzite). This discrimination is necessary, since the general term "quartzite" is used for all very hard, resistant rocks with quartz contents >90%, independent on their geological formation.

These rocks originate from the silicification of pre-existing surface rocks (mostly sediments) by silica rich weathering solutions and may cover large areas (**Fig. 7**). Because of the intergrowth of both detrital and secondary quartz and silica material, these rocks represent more or less the interface between siliceous and siliciclastic rocks. The texture and appearance of the silcretes can drastically vary due to the amount of detrital material and the kind of cementing matrix material (**Fig. 7**). Probably the term ***limnoquartzite*** (or opalite) also describes this type of rocks considering that a significant amount of silica may originate from volcanic and/or hydrothermal activities.

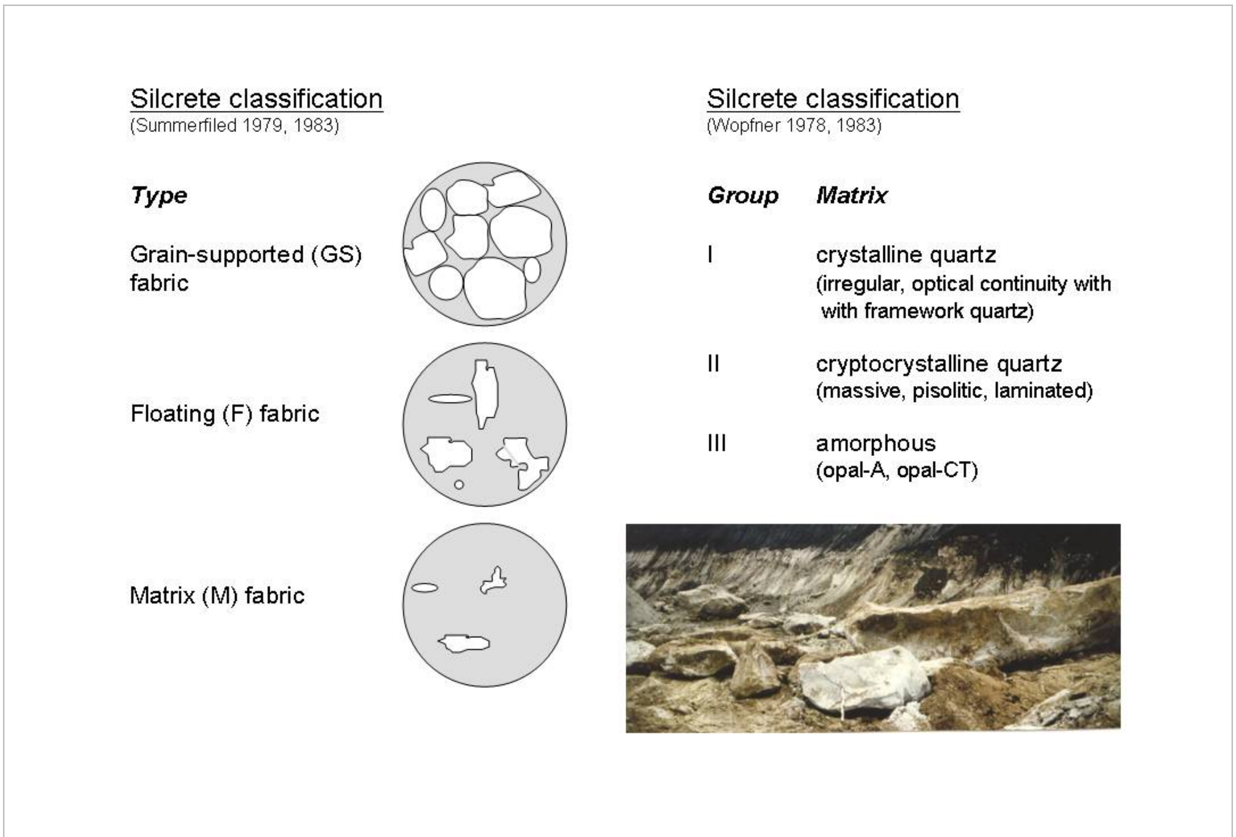

Fig. 7.: Classification criteria of silcretes based on textural features (left) and the kind of cementing material (right) and example of a dense Tertiary quartzites in the lignite open pit mine of Zwenkau, Germany.

7. ábra: Kvarchomokkövek osztályozása a szöveti bélyegek szerint (bal oldalon) és a kötőanyag szerint (jobb oldalon) Zwenkau harmadidőszaki lignitbánya feltárás példáján.

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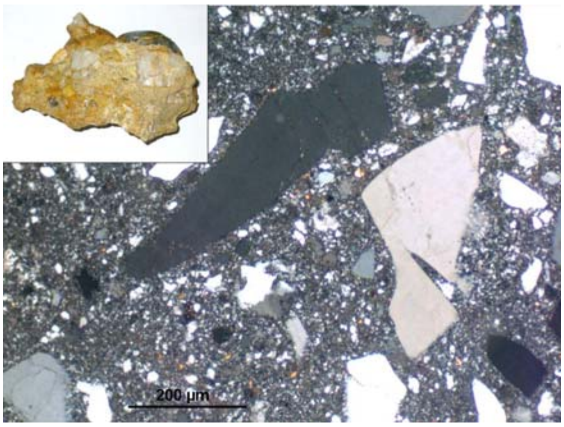

Fig. 8.: Tertiary quartzite with fine-grained siliceous matrix and large detrital quartz grains in a hand specimen (upper left) and micrograph in polarized light

8. ábra: Harmadidőszaki kvarcit finom szemű kovás alapanyaggal és nagyméretű kvarc-szemcsékkel, kézipéldány (bal felső sarok) és polarizációs mikroszkópos felvétel

These mineralogical and textural differences between different types of silcretes are clearly detectable in the hand specimen and under the microscope (**Figs. 8, 9**).

3.2. Siliciclastic rocks

Siliciclastic rocks have a different origin compared to siliceous rocks. They especially form due to the accumulation of physically and chemically resistant quartz during weathering, transport, sedimentation and diagenesis (metamorphosis). Siliciclastic rocks preferentially consist of detrital quartz from previously existing rocks. The general mineral composition and textural characteristics depend on the properties of the primary host rocks and on the sedimentary/diagenetic conditions during rock formation. Pettijohn et al. (1987) summarized main factors of this sedimentary cycle in a general scheme (**Fig. 10**).

Starting with a distinct source rock, the changes in mineral composition are mainly determined by morphological and climatic conditions. Rapid erosion as well as cold and dry climate cause a rapid mechanical destruction of the host rocks and minor chemical alteration with slow decomposition of unstable minerals. In result, the mineral composition is complex and reflects at least partially the primary composition of the host rocks (e.g. **Fig. 17**). In contrast, relatively slow erosion in the lowland together with warm and wet climatic conditions cause a rapid decomposition of unstable minerals and result in a sedimentary rock with high amounts of detrital quartz.

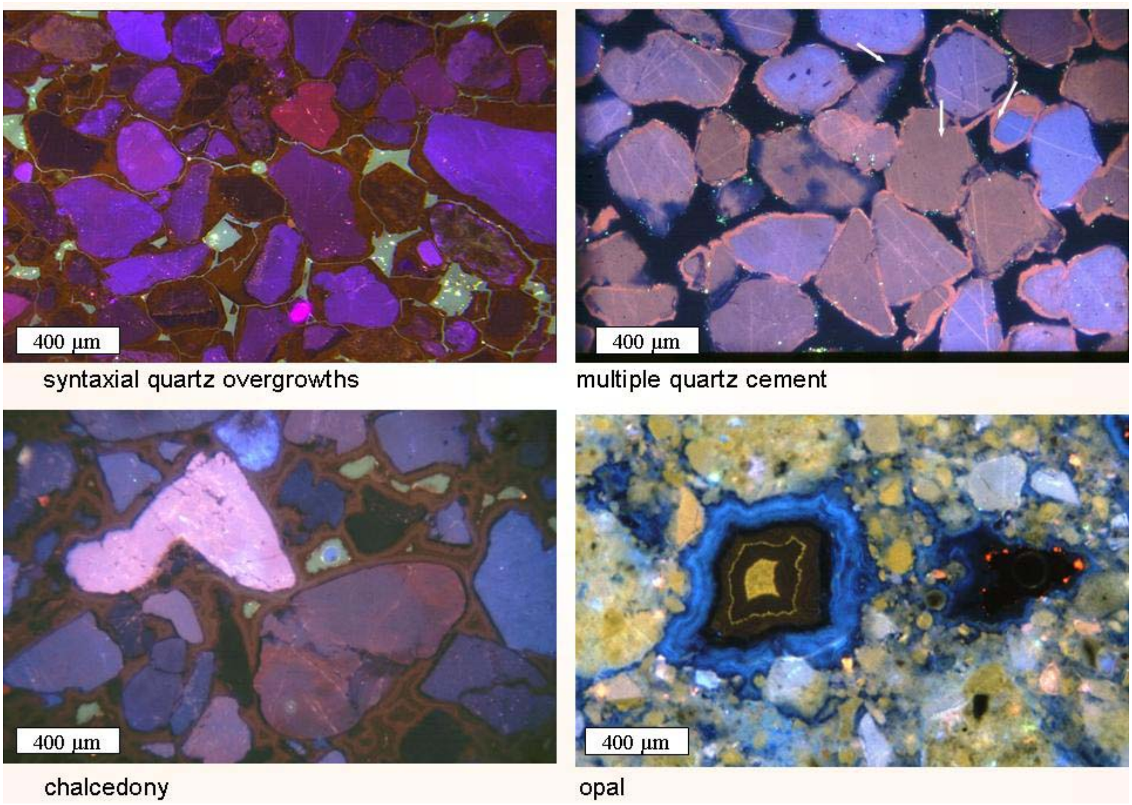

Fig. 9.: Cathodoluminescence (CL) micrographs of different types of diagenetic silica cements in silcretes/Tertiary quartzites.

9. ábra: Katódlumineszcens felvétel (CL) különféle képződésű diagenetikus kvarchomokkövekben

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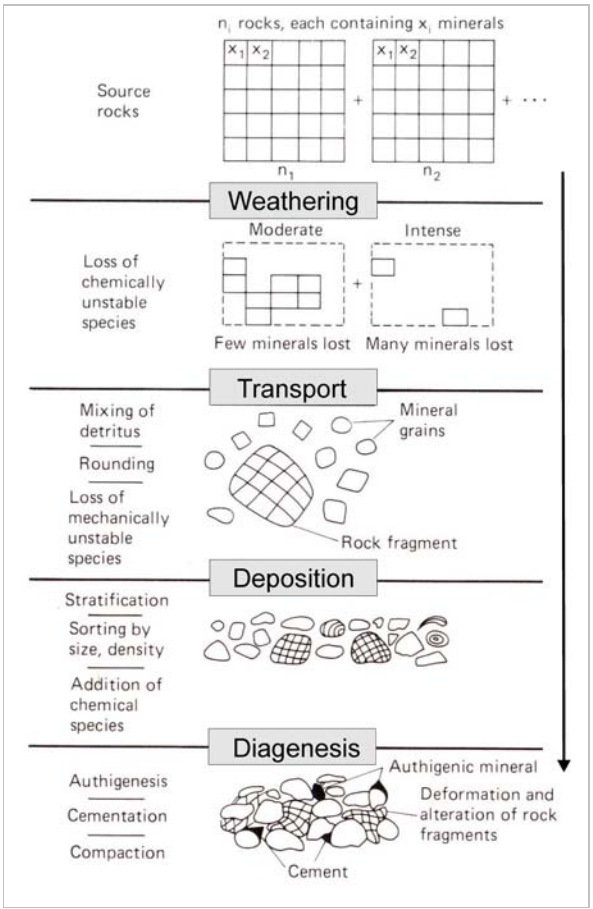

Fig. 10.: Scheme of geological processes in the sedimentary cycle (modified after Pettijohn et al., 1987).

10. ábra: Az üledékes ciklus folyamatainak vázlata (Pettijohn et al., 1987 nyomán).

The primary information of the host rock(s) is more or less lost. In these cases, the typomorphic properties of quartz may inherit important information about the origin of the material. In addition, the granumlometric properties of the sedimentary rocks are especially influenced by the distance and intensity of the transport conditions and can, therefore, provide information concerning the geological environment during rock formation. During diagenesis, compaction / cementation as well as alteration and neoformation of minerals can significantly change the properties of the rocks. According to these facts, the classification of siliciclastic rocks is mainly based on the two parameters mineral composition and grain size (**Fig. 11**).

For instance, sandstone is a sedimentary rock with quartz as main detrital mineral and an average grain size of 0.063-2.0 mm. Depending on the amount of additional mineral or rock components, we can distinguish e.g. mature quartz sandstone, feldspathic sandstone (arcose) or glauconitic sandstone (**Fig. 12-15**).

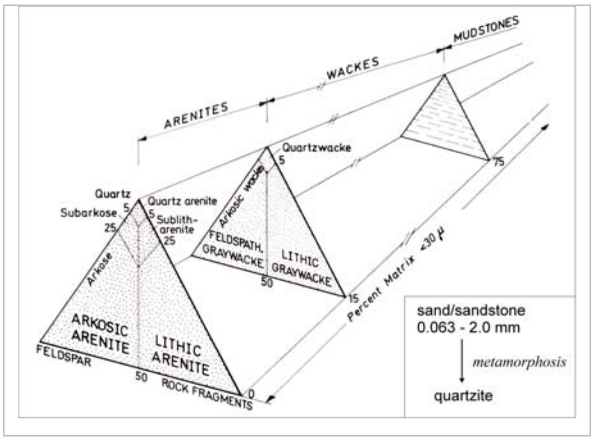

Fig. 11.: Classification of clastic sediments and sedimentary rocks based on mineral composition and grain size (modified after Pettijohn et al., 1987).

11. ábra: Klasztikus üledékek osztályozása ásványos összetétel és szemcseméret alapján (Pettijohn et al., 1987 nyomán)

During metamorphosis, sandstone can be compacted and transformed into quartzite (**Fig. 16**).

Analysis and provenance of quartz and SiO_2 rocks

The evaluation and classification of SiO_2 rocks is based on their characteristic properties. Depending on the specific direction of the investigations and the availability of analytical equipments the following properties should be analyzed:

1. Macroscopic rock properties (texture, colour, etc.)

2. Mineral composition (rock fragments, SiO_2 minerals, feldspar minerals, sheet silicates, carbonates, heavy minerals, organic compounds)

3. Granulometric properties and porosity

4. Specific properties of quartz/silica.

Therefore, a classical petrographic investigation (macroscopic appearance, thin section analysis) has to be combined with modern analytical methods. The detailed analytical scheme is mainly based on the combination of polarizing microscopy (mineral composition, texture, grain size distribution), cathodoluminescence (CL) microscopy (quartz types, feldspar, clay mineral content) coupled with image analysis, scanning electron microscopy (accessories, pore cement, diagenetic features), and analysis of pore space data (**Fig. 18**).

Several applications have shown that such an analytical procedure will provide best results.

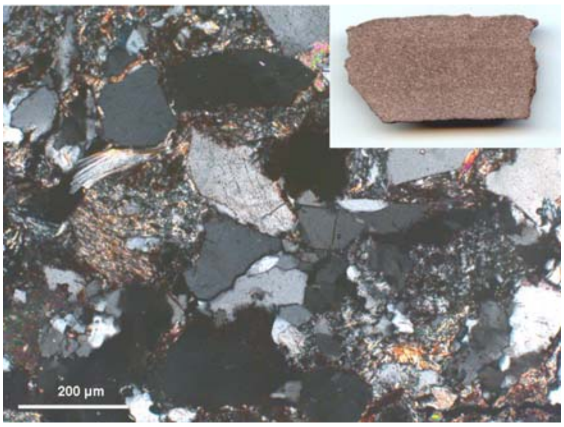

Fig. 12.: Feldspathic sandstone (arcose) in a hand specimen (upper right) and micrograph in polarized light

12. ábra: Földpátos homokkő (arkóza) kézipéldány (jobb felső sarok) és polarizációs mikroszkópos felvétele

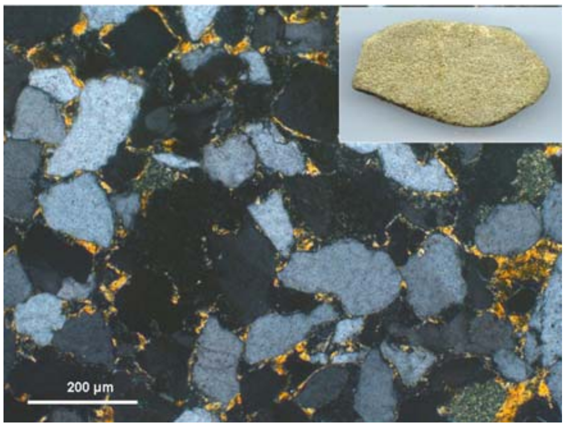

Fig. 13.: Glauconitic sandstone in a hand specimen (upper right) and micrograph in polarized light

13. ábra: Glaukonitos homokkő kézipéldány (jobb felső sarok) és polarizációs mikroszkópos felvétele

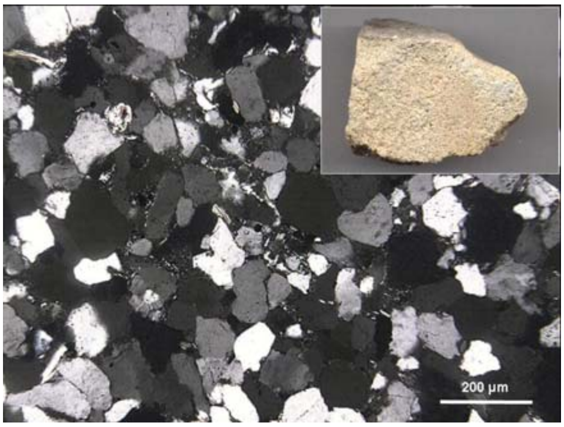

Fig. 14.: Mature, quartz rich sandstone in a hand specimen (upper right) and micrograph in polarized light

Fig. 14.: Kvarcban gazdag homokkő kézipéldány (jobb felső sarok) és polarizációs mikroszkópos felvétele

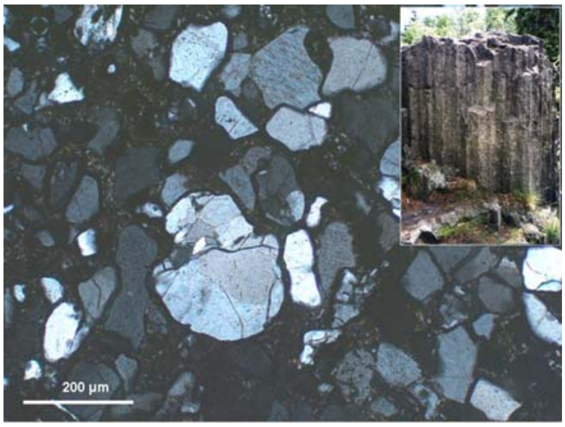

Fig. 15.: Baked (thermally overprinted sandstone) in the field (upper right) and micrograph in polarized light; note the fracturing of the detrital quartz grains due to the volume expansion during heating

15. ábra: Átsült (utólagos hőhatáson átesett) homokkő a terepen (jobb felső sarok) és polarizációs mikroszkópos felvételen. A kvarcszemcsék a hőhatás miatt töredezettek

Based on the data it was possible to distinguish and classify historical building materials (mature sandstones) from different geological provinces of Germany (e.g. Michalski et al., 2002; Götze & Siedel, 2004; Götze et al., 2007; Siedel et al., 2010 – compare **Fig. 19**).

Conclusions

SiO_2 minerals and rocks are not only important constituents in the composition of the Earth's crust, they also play an important role as usable material since the beginning of human being. Owing to their abundance and properties, SiO_2 minerals and rocks have been used in different applications such as tools, weaponries, jewelleries or building materials. The identification and differentiation of these SiO_2 materials require both a valuable analytical approach and a clear nomenclature.

In general, the characterization and classification of silica minerals and rocks could be based on the mineralogical and petrographical nomenclatures. Accordingly, we have to differentiate between SiO_2 minerals (including different varieties) and SiO_2 rocks. Among the SiO_2 rocks, in particular sedimentary rocks have to be considered. Exceptions are given by volcanic rocks (e.g., rhyolite or volcanic glass such as obsidian) or some metamorphic rocks (e.g. quartzite), which have also been used as materials.

The sedimentary SiO_2 rocks (silicite) may be subdivided into the two groups of siliceous rocks and siliciclastic rocks. The composition of these rocks is often monotonous. In most cases, quartz is the dominant mineral, and only low contents of other silica polymorphs, feldspar and a few other minerals (e.g. detrital mica, clay minerals or heavy minerals) may occur.

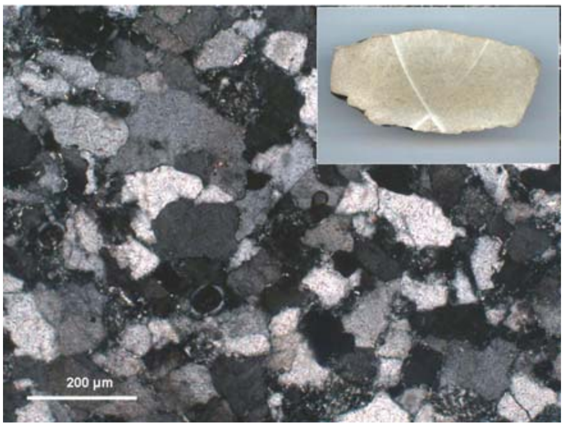

Fig. 16.: Metamorphic quartzite formed during high pressure (and temperature) from a quartz rich sediment in a hand specimen (upper right) and micrograph in polarized light; note the typical sutured grain contacts

16. ábra: Metamorf kvarcit kézipéldány (jobb felső sarok) és polarizációs mikroszkópos felvétele

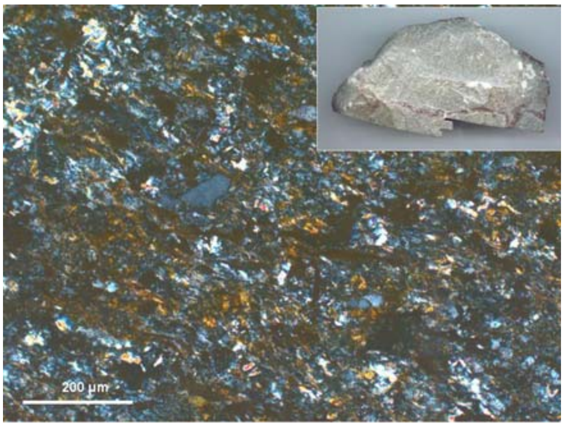

Fig. 17.: Fine-grained greywacke with complex mineral composition in a hand specimen (upper right) and micrograph in polarized light.

17. ábra: Finom szemű grauwacke kézipédány (jobb felső sarok) és polarizációs mikroszkópos felvétele

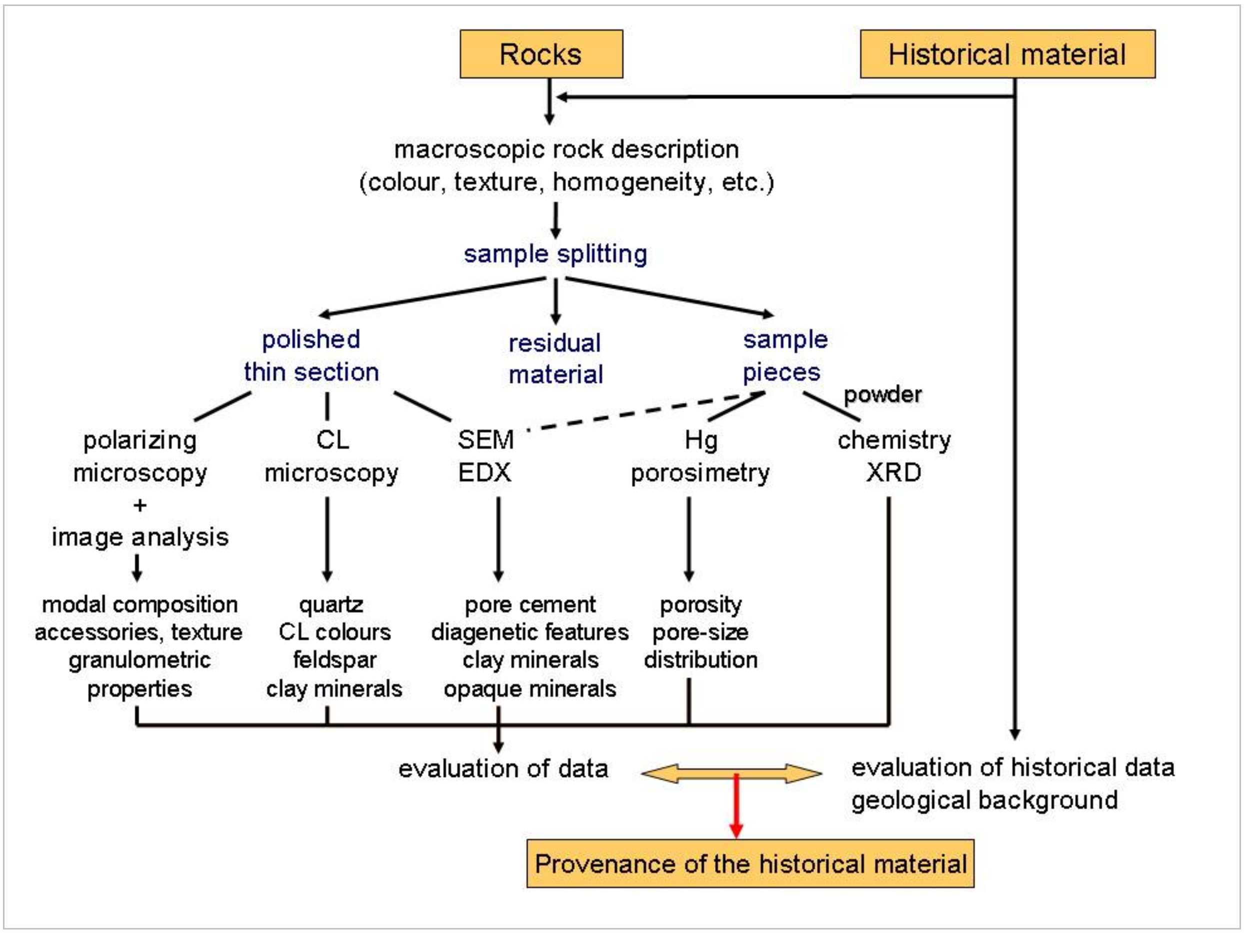

Fig. 18.: General analytical scheme for the identification and classification of SiO_2 material (modified according to Götze & Siedel, 2004)

18. ábra: A SiO_2 anyagú kőzetek azonosításának folyamatábrája (Götze & Siedel, 2004 nyomán)

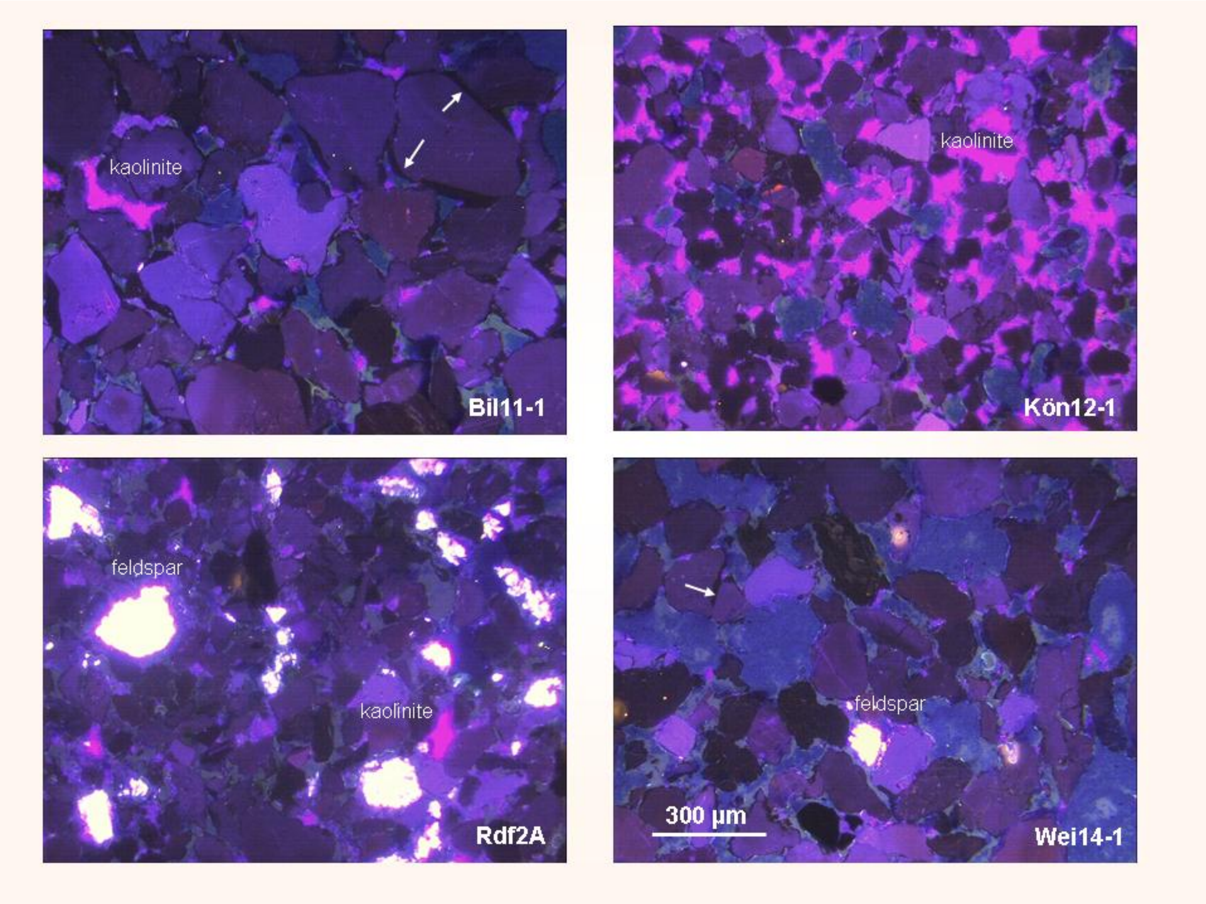

Fig. 19.: Cathodoluminescence micrographs of historical building sandstones from different quarries of the Dresden area (Saxony, Germany) illustrating the potential of advanced analytical methods to distinguish monotonous quartz-rich material

19. ábra: Történeti bányahelyek homokköveinek katódlumineszcens felvételei Drezda környékéről

Depending on their geological formation, these SiO_2 rocks only differ in texture, grain size, kind and content of binding agents and thus, are hardly to be classified in a hand specimen or by routine polarizing microscopy. Therefore, an integrated mineralogical and geochemical analysis is necessary for a detailed characterization.

However, such a detailed investigation is often not possible. Limitations in sample material or analytics (e.g. preparation) do not allow a detailed mineralogical or geochemical investigation. In such cases, the classification of the artefact should be done only as far as it is possible according to the hierarchic nomenclature and a clear identification may sometimes be impossible. Therefore, the question concerning the importance of a pure theoretical background or the practical usability of such a classification has to be answered. Another problem arises from the fact that the characterization and classification of SiO_2 rocks inherits a genetic component, which is often unknown in the case of artefacts found without geological background.

In summary the proposed classification scheme in the present study may provide a usable basis for applications, but will also be further discussed and modified in future.

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CLASSIFICATION OF LITHIC RAW MATERIALS USED FOR PREHISTORIC CHIPPED ARTEFACTS IN GENERAL AND SILICEOUS SEDIMENTS (SILICITES) IN PARTICULAR: THE CZECH PROPOSAL

JAVASLAT A PATTINTOTT KŐESZKÖZÖK KÉSZÍTÉSÉRE HASZNÁLT KŐESZKÖZÖK OSZTÁLYOZÁSÁRA, ÁLTALÁNOS TEKINTETBEN, KÜLÖNÖS TEKINTETTEL A KOVAKŐZETEKRE ÉS A KOVÁS ÜLEDÉKEKRE

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Abstract

Lithic raw materials for chipped artefacts can be divided into five groups: a) siliceous sediments (silicites); b) minerals of SiO_2*; c) natural glasses; d) clastic silica sediments; e) other rocks. Special attention has been devoted to the most important group of siliceous sediments. It is proposed to use one-word term silicite as the comprehensive one for all varieties such is chert, flint, spongolite, radiolarite, lydite, limnic silicite. As the flint should be called only the silicite originating in Upper Cretaceous chalk (and may be in Lowermost Tertiary – Danian limestones). Typical feature of silicites is a presence of microfossils in contradiction to minerals of* SiO_2 *that include quartz, rock crystal, chalcedony, opal and their coloured varieties (smoky quartz, citrine, jasper, agate etc.) and occur as filling of cavities in igneous rocks, hydrothermal veins or products of intensive weathering. Natural glasses suitable for chipping are represented by obsidian, pitchstone and tektites. Clastic (detrital) silica rocks are composed especially of quartz or chert clasts and incorporate quartz sandstones, orthoquartzites and chert breccias. The group of other rocks comprises for example porcellanites and hornfelses (thermally metamorphosed sediments), silicified woods, fine grained acid volcanics, silicified fossils etc.*

Kivonat

A pattintott kőeszközök nyersanyagait öt csoportba sorolhatjuk: a) kovás üledékek (szilicitek); b) SiO_2 *ásványok; c) természetes üvegek; d) törmelékes kovás üledékek; e) egyéb kőzetek. Kiemelten foglalkozom az alábbiakban a legfontosabb csoporttal, a kovás üledékekkel. Javaslom, hogy a kovakőzetekre (szarukő, tűzkő, spongolit, radiolarit, lidit, tavi üledékes kovakőzetek) egységesen a „*szilicit*" terminust használjuk. Tűzkőnek (*flint*) csak a felső kréta/ alsó harmadidőszaki fehér mészköveket nevezzük. A szilicitek általános jellemzője lehet, hogy mikrofossziliákat tartalmaznak, szemben a* SiO_2 *ásványokkal mint a kvarc, a hegyikristály, kalcedon, opál és ezeknek a színes változatai (füstkvarc, citrin, jáspis, achát stb.) amelyek magmás kőzetek üregeiben, hidrotermális erekben vagy mállási termékekben fordulnak elő. A pattintott kőzetek készítésére alkalmas természetes üvegek közé tartozik az obszidián, a szurokkő és a tektitek. A törmelékes kovás üledékeket elsősorban kvarc vagy kova törmelékek alkotják; ide tartozik a kvarchomokkő, az ortokvarcit és a kovabreccsia. Az egyéb kőzetek közé sorolom például a porcelanitokat és a szaruszirtet (hő hatására átalakult üledékes kőzeteket), kovásodott fát, finom szemű savanyú vulkanitokat, kovásodott fosszuiliákat stb.*

KEYWORDS: CHIPPED ARTEFACTS, LITHIC RAW MATERIALS, SILICEOUS SEDIMENTS (SILICITES)

KULCSSZAVAK: PATTINTOTT KŐESZKÖZÖK, KŐESZKÖZ NYERSANYAGOK, KOVÁS ÜLEDÉKEK (SZILICITEK)

Introduction

Because of many large archaeological excavations or systematic surface field explorations conducted during the 20th century we have at our disposal numerous collections of thousands chipped artefacts of the Palaeolithic and Neolithic age. How to evaluate them from the raw material point of view? There is no doubt that the first step of such an evaluation is a correct and generally accepted classification of lithic raw materials used. Inspecting archaeological and petroarchaeological papers focussed on this problem, one can see very different approaches concerning the stone material terminology. It follows partly from early and therefore very broad use of such term as is flint or hornstone, partly from disunited terminology of the mentioned rocks in various European countries. In many papers from the first half of the 20th century the term flint (or hornstone, silex, silexite) represented an indication of almost all raw materials used for chipping and only rock crystal and volcanic glass (obsidian) were differentiated. In recent times when we want and need to follow distribution of various lithic raw materials without regard to state and language boundaries, we all feel the necessity of correct terminology for lithic raw materials.

Division of lithic raw materials for chipped artefacts

The author of this contribution has had the possibility to investigate thousands of chipped lithic artefacts in the Czech Republic, Slovakia, Poland and Austria since 1979. Since the beginning of the studies he started to divide used raw materials into five basic groups (Přichystal 1984, 1997):

a) Siliceous sediments (silicites);
b) Minerals of SiO_2;
c) Natural glasses;
d) Clastic silica sediments;
e) Other rocks.

Siliceous sediments (silicites)

In English geological dictionaries and books one can find as the prevalent synoptic term for this group of sedimentary rocks usually siliceous sediments (Blumel – Rappaport, eds. 2005: 507; Nichols 1999: 204). A similar but one-word petrographical term for these sediments exists in other European languages: in German - Siliziten (Pfeiffer et al. 1985: 210), in Czech – silicity (Petránek 1963: 433), in Slovak – silicity (Vozárová 2000: 140); in Russian – силициты (Švecov 1948: 280); in Polish – silicyty (but prevalently in Polish geological literature they use the two-words term skały krzemionkowe, e. g. Żaba 2006: 402). Under the influence of central and eastern European terminology the term silicites used also some non-native English written authors (e. g. Tomkieff 1983, Kukal 1970: 394). From a practical point of view and to be unambiguous, the author also prefers this one-word term silicites (not to be confused with the term silicates, i. e. the most important group of rock-forming minerals).

Silicites are undoubtedly the most significant raw materials for chipped artefacts in almost all Europe. They are sedimentary siliceous rocks originating from chemical, biochemical, or diagenetic precipitation of SiO_2 and consisting of its various mineral modifications, first of all of cryptocrystalline silica, chalcedony, and opal; in some cases also tridymite and alpha-cristobalite are ascertained. The contents of cementing material other than siliceous or clastic (fragmentary) components may not exceed 10 %. This group is capable of embracing all chert types (including flint as one of its varieties), radiolarites, spongolites, lydites, phthanites, and limnic silicites. They form concretions (nodules) or layers, particularly in limestones and other carbonate rocks, in majority of cases of marine origin. When they originate in a lake environment, they are designated as limnic silicites. In Eastern Central Europe, it is possible to encounter in papers the term limnic quartzite as a consequence of old translations from the German language. This term should be abandoned because the term quartzite is reserved for a clastic rock (orthoquartzite) or even a metamorphic rock (metaquartzite).

As a well-defined term from the viewpoint of petrography, the term silicite may be recommended in all cases where the researcher is not sure of a reliable classification of a raw material, where he/she wants to use a general term for this extensive group of raw materials, or where differing opinions exist as to its designation due to historical development (this particularly relates to the different perceptions of the terms chert and flint). The decisive factor for placing of an unknown silica substance among silicites is finding microfossils, or their parts, in the silica substance. This term may not comprise such SiO_2 minerals as quartz, rock crystal, jasper, chalcedony or opal (i. e. substances that have originated due to magmatic, hydrothermal or metamorphic activity, in some cases also from weathering), natural glasses, or clastic silica rocks. The silicite is more unambiguous than the occasionally used terms silex or silexite (i.e. the French terms for flint and chert); moreover, the term silexite is understood by some authors of geological literature as a silica rock of igneous origin.

Moreover, in the archaeological literature we find the phenomenon that practically all well-chipping raw materials are designated as “flint, chert, hornstone”, and usually only obsidian, rock crystal and quartzite are differentiated but not always. As has already been pointed out by a number of authors, the terms flint and chert were very often used without a clear definition, or as synonyms, thus being rather profane in view of a correct terminology.

Chert and flint

Within this group of raw materials the terms flint and chert present a specific problem.

As a result of the historical development there is no conformity existing in the European geological literature regarding the definition of flint and chert either. In the Anglo-Saxon literature, the definition of flint as a special variety of silicite (or of chert as the case may be) originating from chalk of the Upper Cretaceous age has prevailed since the end of 19th century. The outstanding American mineralogist and geologist J. D. Dana (1895: 281) has written: “Quartz occurs .... as imbedded nodules or masses in various limestones, constituting the flint of the chalk formation, the hornstone of other limestones – these nodules sometimes becoming continuous layers". The same opinion one can find in almost all comprehensive petrological books published during the 20th century and at the beginning of the 21st century (Fairbridge & Bourgeois, eds. 1978: 120; Pfeiffer et al. 1985; Trewin & Fayers 2005). The Czech and Slovak petrographers and geologists (Petránek 1963, Konta 1973, Mišík et al. 1985) usually apply the term flint in compliance with Anglo-American authors. All other silicites may be designated as cherts. According to the prevailing fossils their names may be further specified as radiolarite, spongolite, and diatomite. However, it is true that in some countries the definition of these two rocks is based on a different principle. In particular, the Russian (e. g. Švecov 1948) and Polish (Bolewski & Parachoniak 1978) scientific literatures define flint (krzemień, silex) as the nodular silicite, whilst stratified silicite is defined as chert (czert, silexit). Yet it is hard to be in agreement with this concept as the same silicite can often form both concretions and horizontally elongated lenses or even layers. Similarly, due to the historical development, in the Czech and Slovak Republics flint was supposedly a silicite of erratic origin from the sediments of the continental glaciation, and all local silicites were designated as cherts. Later on, this designation was taken over by e.g. Polish colleagues, who wrote about cherts of the Stránská Skála Hill, cherts of the Krumlovský Les Upland, although from the perspective of the Polish classification they should have designated them as flints. As is the modern Hungarian geological literature concerned, the term chert is used both for nodular and bedded silicites of marine origin (Haas, ed. 2001: 180).

The question of Scandinavian silicites of the Danian age

A really hard nut to crack are the Scandinavian silicites of the Danian (i. e. Early Tertiary) age that occur in Bryozoan limestones lying in the immediate superposition of the Maastrichtian chalk. In addition, the Danian silicites are substantially represented in glacial sediments of the Pleistocene continental ice sheet that are spread over a large area of Northern and Central Europe. Considering the above mentioned definition of flint, they should be termed as cherts. This problem is also evident to Danish archaeologists but in a comprehensive book on Scandinavian silicites they prefer "to follow the Scandinavian practice and refer to all chert varieties as flint" (Högberg & Olausson 2007: 25). In this case there are two possibilities: to extend the definition of flint for the silicites of Danian age as well or to use the term silicites as the author of this proposal has done for many years.

Which is the correct term: chert or hornstone?

If you hesitate between the terms chert and hornstone, the English and American geological dictionaries from the end of the 20th century and the beginning of 21st century prefer unambiguously the term chert and do not recommend using the term hornstone (Bates & Jackson, eds. 1987, 313) and already this term is usually not included in their contents (e. g. Allaby & Allaby, eds. 2003).

Conclusion

It is recommended to use the petrographically well-defined term silicite (or siliceous sediments according to dictionaries of English or American origin) in all unclear cases when there are different opinions on the rock classification. If we want to specify siliceous raw material, it is necessary to add the name of the type occurrence (banded silicite of the Krzemionki type, silicite from glacial sediments etc.). As far as the term flint is concerned, it cannot be based on its colour, lustre, translucency, shape or the fact that it appears to the observer as a high-quality, well-chipping material, sharply bordered against the limestone mass as we are again aware of silicites from a single outcrop showing different stages of silicification, and therefore with differing above-mentioned properties. In accordance with prevalent opinion and tradition in the world geological literature, it is proposed to use the term flint only for nodular siliceous rocks of the Upper Cretaceous - Maastrichtian (and may be also of Lowermost Tertiary - Danian) age coming from chalk formations or similar limestones.

Proposed definitions of selected siliceous raw materials

Silicites. Group of sedimentary siliceous rocks originating from chemical, biochemical, or diagenetic precipitation of SiO_2 and consisting of its various mineral modifications (especially of cryptocrystalline silica, chalcedony, and opal). The contents of other cementing material than siliceous or clastic (fragmentary) components may not exceed 10 %. If yes, the rock should be named silicified limestone, silicified sandstone etc. Presence of microfossils or their relics is a typical sign for classifying of a siliceous raw material into this group.

Cherts. Group of compact silicites originating in all marine sediments (limestones, marls, calcareous sandstones etc.) without regard to their age or shape (concretions, layers).

Flint. A concretional variety of silicite (chert) coming from chalk or high-quality limestone of Upper Cretaceous (Maastrichtian) and Lowermost Tertiary (Danian) age.

Radiolarite. A variety of silicite (chert) composed prevalently (more than 50 %) of the siliceous tests of the marine zooplankton called radiolaria. It can form both concretions and layers. If the presence of radiolaria is under 50 %, the rock should be called radiolarian chert. The term radiolarian jasper should not be used because in this contribution is proposed to define jasper as a variety of mineral (chalcedony) of igneous, hydrotermal or weathering origin. In Central Europe, for chipped artefacts radiolarites of Mesozoic and Paleozoic age were used.

Spongolite (spongiolite, spiculite). Variety of silicite (chert) with significant content of sponge spiculas.

Phthanite. Variety of silicite (chert) of the Proterozoic age, usually of dark color. Composed prevalently of fine-grained quartz, often with thin quartz veins.

Lydite. Variety of dark to black bedded silicite (chert) of the Paleozoic age.

Limnic silicite. Variety of silicite originating in freshwater limnic (lake) environment. The presence of plant relics is a typical sign for their determination. In Central Europe limnic silicites of the Upper Tertiary (Miocene) and Upper Carboniferous – Permian age were used for knapping (Přichystal 2009). Do not use the term limnic quartzite because the quartzite is a sedimentary clastic rock or even a metamorphic rock (metaquartzite).

Silica minerals

A group of SiO minerals and their varieties such is quartz, rock crystal, citrine, smoky quartz, rose quartz, chalcedony, jasper, agate, plasma, opal. They are the result especially of magmatic, hydrotermal or metamorphic origin, and in part of weathering. Compared to silicites, no remains of microfossils are to be found, but they can often contain other minerals (chlorites, micas, tourmaline, rutile, amphibole).

Jasper. A variety of chalcedony of magmatic, hydrotermal and maybe weathering origin. It usually has a brown, red or green colour. It occurs as dykes or filling of cavities in igneous rocks. No presence of microfossils.

Siliceous weathering products of serpentinites (plasma). In Central Europe, varieties of green, yellow and brown coloured chalcedony can be found as products of intensive weathering during Tertiary and Mesozoic especially on ultrabasic rocks (serpentinites), rarely on marbles or gneisses.

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The green variety can be called plasma. No presence of microfossils but relicts of mother-rock minerals (especially chlorites, micas) are to be found.

Natural glasses

This group includes some glasses of volcanic origin suitable for chipping (obsidian, pitchstone) and tektites (moldavites).

Obsidian. A volcanic glass of acidic (dacite or rhyolite) composition with very low H_2O content (under 1 %). If the content of H_2O is more than 1 %, the volcanic glass is classified as pitchstone or perlite (the last one has perlitic texture with curved or sub-spherical cracks in addition).

Moldavites. Natural glasses from the group of tektites. They are represented by small fragments of green or greenish-brown glass originated as ejecta of melted terrestrial silica-rich rocks from the impact crater of Nördlingen Ries in Bavaria. They have the most important natural occurrences in southern Bohemia and western Moravia (Czech Republic).

Clastic (detrital) siliceous sedimentary rocks.

Quartzite (orthoquartzite). Unmetamorphosed quartz sandstone (clastic rock) with a silica cement.

Chert breccia. Clastic rock composed substantially of chert chips with a silica cement.

Other rocks.

Metaquartzite. A metamorphic rock usually formed by metamorphism of quartz sandstone. Because the metamorphosis is almost always accompanied by deformation, the metaquartzite has a planar or linear fabric within the rock (metamorphic foliation or lineation). If the rock contained clayey admixture, it has been changed to fine-grained muscovite.

Porcellanite. Thermally metamorphosed very fine-grained sediment (mudstone, marl, siltstone) with a dull lustre and conchoidal fracture, similar to porcelain. The thermal metamorphosis can be a consequence either of igneous rock intrusions into a sedimentary formation or can be caused by natural burning of a coal layer.

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CLASSIFICATION OF ROCKS WITHIN THE CHERT GROUP: AUSTRIAN PRACTICE

KOVAKŐZETEK OSZTÁLYOZÁSA: AZ OSZTRÁK GYAKORLAT

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Abstract

The detection of raw materials used in the production of flaked stone tools has served as a necessary methodological component within the field of archaeology. Nevertheless, controversial debates concerning accurate terminology for Sio_2 varities have inspired a terminological lacuna between the fields of geology, mineralogy and archaeology. This is due to the fact that SiO_2 rocks never formed the main focus of Earth Sciences, resulting in an inconsistent terminology and at times lacking a proper definition. As a result of years of research, a classification system for rocks from the chert group has been developed at the Austrian Academy of Sciences. This paper intends to give a practical approach to this classification system based on petrological, mineralogical and archaeological demands.

Kivonat

A pattintott kőeszközök nyersanyagának azonosítása fontos része az őskori régészetnek. Mindazonáltal, a terminológiai gyakorlat ellentmondásos a kovakőzetek tekintetében, figyelembe véve a geológiai, ásványtani és régészeti megközelítést. Ennek részben oka az is, hogy a kovakőzetek a földtudományokban nem kerültek a figyelem középpontjába, ezért a terminológia következetlen és a megfelelő definiciók sem alakultak ki. Több éves kutatás eredményeképpen as Osztrák Tudományos Akadémia munkacsoportja kialakított egy osztályozási rendszert az érintett kőzetekre. A tanulmány célja, hogy bemutassa ezt a gyakorlatot amely törekszik arra, hogy megfeleljen a kőzettani, ásványtani és régészeti szükségleteknek.

KEYWORDS: RAW MATERIAL DETERMINATION, CHERT GROUP, RADIOLARITE, FLINT, TERMINOLOGY

KULCSSZAVAK: NYERSANYAG MEGHATÁROZÁS, KOVAKŐZETEK, RADIOLARIT, TŰZKŐ, TERMINOLÓGIA

Introduction

The detection of raw materials in archaeological contexts is one of the most challenging undertakings in interdisciplinary studies. This is especially true for SiO_2 rocks belonging to the chert group.

What is chert?

Chert is a micro- or cryptocrystalline sedimentary rock composed of silicon dioxide (SiO_2). It occurs as nodules, concretionary masses and as layered deposits. Chert breaks with a conchoidal fracture, producing sharp edges. In geological terms flint and chert are the same, with the term "flint" referring to chert found in chalk. Cherts are formed in limestone.

Both archaeologists and mineralogists are concerned with the determination and with provenance studies of rocks used for stone tool production in prehistoric times. Different approaches to such a complex issue must necessarily lead to misunderstandings.

Before physical science can be applied to clarify systems of lithic raw material procurement of prehistoric groups, the most important step is the correct classification of the rock materials. Intense discussions with colleagues from Central and Eastern Europe showed high accordances as well as divergences defining SiO_2 rock materials. A commonly accepted working basis implicates a generally applicable terminology in terms of determining these lithic resources.

Basic overview

Basically, rocks used for knapping activities in terms of producing stone tools are confined to SiO_2 – varieties. A general overview of the lithic materials in the study area used for this purpose is given in the **Appendix** (**Table 1**). Members of the chert – group are highlighted.

According to these primary definitions narrowing down the field of research, the rocks belonging to the chert – group will be discussed in detail. A definition of terms used in the system and a characterisation of these rock varieties leads to the final step, a formalized determination system.

The basic framework has been developed at the Austrian Academy of Sciences in the course of determining the lithic assemblage from Krems-

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Hundssteig and Krems-Wachtberg (Brandl and Reiter 2008). The high variability of raw materials found in the Upper Palaeolithic sites initiated this approach, extended experience in raw material detection in different projects all over Europe completed the coherent classification system (Antl - Weiser 2008; Binsteiner, Ruprechsberger, Brandl et al 2006; Brandl 2009a; Brandl 2009b; Brandl 2010a; Brandl 2010b; Einwögerer in press; Neugebauer – Maresch 2008; Nigst et al. 2008; Ziehaus 2007).

Definition of terms used in the Classification System (categories)

General terms

Fissures

Fissures are naturally occurring clefts caused by tectonic activity. They are often filled either with quartz or foreign minerals like calcite (which leads to the well known "vein-structure"). Mainly they are characteristic for alpine cherts, which where highly stressed imbedded in the carbonatic host rocks.

Fracture Properties

The way different raw materials break naturally is not necessarily equatable with their knapping properties. This term is more speaking of breaking schemes in general than only of those deriving from intentional knapping actions, although in many cases they definitely coincide. The knapping properties are always contingent to the general fracture properties, but not the other way round.

Speaking of the chert group, the following fracture features can be noticed:

- Conchoidal - smooth.

- Amorphous - rough.

Granularity

The grain size is generally defined by DIN[1] (EN ISO) – standards. In this system they vary between very rough and coarse grained to very fine grained. A closer definition is not useful for a general classification, within certain varieties a higher resolution has to be applied.

Carbonate content

Rocks with silicified matrix originating from limestone or chalk, generally can contain a certain amount of carbonate. This carbonate reacts with hydrochloric acid (HCl) foaming up due to escaping CO_2. The degree of the frothing depends on the amount of carbonate present in the actual sample. Often, the carbonate content is only detectable in the cortex region and sometimes it is only preserved there.

Matrix

The term "matrix"defines the general rock constituents of lithic raw materials. This is the basic composition of a rock.

Orthosilicic acid forms the cementing material of silicified rocks emerging from carbonatic bedrocks. A certain granularity is discernable in the matrix of most of those rocks, especially in alpine chert occurances or in siliceous limestone. In many cases the material is very fine grained and granularity is not perceptible at all (like in Baltic flint). This fact mostly coincides with a high homogeneity of these raw materials.

Inclusions

Fossil inclusions

Fossil inclusions only occur in rocks, they are never contained in minerals. Micropalaontology is an especially important tool for the determination of sedimentary rocks. In alpine limestone nappes ("kalkalpin") the following fauna remains can be distinguished:

Radiolaria

Marine protozoans of the order Radiolaria, having rigid siliceous skeletons and spicules. Radiolarians occur almost exclusively in the open ocean as part of the plankton community. Their skeletons occur abundantly in oceanic sediments.

Sponge remains

Most of the sponge remains found in cherts are members of the class *Demospongiae* (phylum *Porifera*). Their skeletons consist of the fibers of the protein spongin and spicula ("skeletal needles"). Some sponges either consist completely of spongin or of spicula. The spongin basically binds the spicula; if there are no spicula present, the skeleton is kept together with very dense fibres of spongin. In cherts, parts of sponges in every stage of preservation can be included, even entire "body parts" are preserved in rare cases.

Spicula

Spicula are pointed structures serving as a skeletal element in various marine and freshwater invertebrates. Mostly they are the skeletal needles originating from marine sponges (*Demospongiae*), consisting of silica.

Crinoidea

Crinoids, also known as "sea lilies" or "feather-stars", are marine animals that form the class *Crinoidea* of the *echinoderms*. They can either live in shallow water or in deep sea regions. Crinoids are characterized by a mouth on the top surface that is surrounded by several feeding arms. Usually they

1 Former DIN 4022, since 2007 EN ISO 14688 (classification for soils) respectively EN ISO 14689 -1 (classification for bedrock).

have a stem attached to a substrate. In most cases only the wheel - like joints of the stem of the fossil crinoidea, the so called “trochites”, are preserved in cherts, forming rectangular shaped inclusions.

Foraminifera

Foraminifera (“hole bearers”) or Forams are marine microorganisms forming a large group of amoeboid protists with reticulating pseudopods. They typically produce a test, or shell, which can have either one or multiple chambers, some becoming quite elaborate in structure. These shells are made of calcium carbonate ($CaCO_3$) or agglutinated sediment particles. Most commonly Foraminifera are found in Cretaceous sediments containing siliceous rocks.

Additional to those, other characteristic fossil inclusions can be distinguished in varieties of the chert group. Bryozoa, diatoms, stings from sea urchins, skeletal remains from various marine creatures, seashells of all different kinds, algae and detritus are common inclusions in cherts and complete the spectrum of possible fossil remains.

Non-fossil inclusions

The commonest non-fossil inclusions in alpine SiO_2 – rocks are heavy minerals like garnet, tourmaline, rutile, ilmenite, cassiterite, etc. Some chert varieties contain certain amounts of mica. Quartz geodes and SiO_2 precipitations are common non-fossil inclusions as well, the precipitations can show a high variation in colour. In most cases a closer determination of foreign minerals contained in siliceous rocks can only be done accurately by applying geochemical analysis.

Definition of raw materials of the chert group

Chert:

In the broad sense, all sedimentary, organically formed SiO_2 – rocks can be defined as “chert”. For a closer definition, the members of the chert – group are gouped as chert and flint, regarding their geological genesis. Chert in the classical terminology systems refers to SiO_2 - rocks formed in Jurassic sediments, whereas flint originates from Cretaceous formations.

Generally, the matrix of chert is silicified and mostly contains fossil inclusions. In that sense, chert is closer defined as “Jurassic chert”. Taking into account that other SiO_2 rocks of Cretaceous age exist besides the “sensu stricto flint”, the term “Cretaceous chert” is a compromise for these raw materials.

Fossil inclusions are basically used to define chert closer. Predominating microfossils are used to create subvarieties in the chert – group, such as radiolarite, spiculite or spongiolite (spongilite). Characterising these varieties, researchers concerned with raw material description are facing a terminology problem. Usually these subvarieties are defined depending on the percentage of microfossils included in the material. Scientists with different research background apply these characterisations to cherts at 30%, 50% or not until 70% fossils of one kind visible under the microscope (**Fig. 1**). That causes misunderstandings in international discussions and falsifies interpretation models of archaeological complexes.

A solution of this problem might be a definition after the index fossil, which defines a rock of the chert – group as a radiolarite, a spiculite or a spongiolite regardless of rating percentages. An accurate a priori valuating of international standard is barely achievable and highly prone to errors.

Flint

Basically, every silicified rock concretion of Cretaceous age can be defined as flint. In the narrow sense flint refers to Baltic, respectively Northern European deposits in chalk – context only. The surface of flint when fractured is very smooth and satiny and has in most cases no recognisable granularity. The material can contain a high amount of fossil inclusions, some of them can be of excellent preservation and therefore very helpful in terms of determination. Due to the genesis in chalky environments, alpine fissures are rare, which makes the material preferable for stone tool production. The “patination”, caused by surface changing processes, creates a whitish – blue coloration.

Siliceous limestone

This rock material is very similar to chert and occurs in the same geological contexts. Siliceous limestone can contain high amounts of all fossil inclusions the host rock is bearing. In order to discriminate chert from siliceous limestone, some test methods have to be applied. In some cases the high similarity forces to combine several methods. In many cases, the scratch test using a steel needle shows the difference in the scratch pattern. Best results can be achieved applying the carbonate test using HCl; siliceous limestone holds carbonate remains in all cases. Calcite surfaces in the rock matrix flashing up under a reflected light microscope are further indicators.

Lydite (“Flinty slate”)

Lydite is a slight metamorphic, mostly thin layered siliceous rock with a dense, slated structure. In most cases the colour is black due to organic substances. The metamorphosis usually causes the destruction of the fossil remains in the rock material, so that fossil inclusions are barely visible under the microscope.

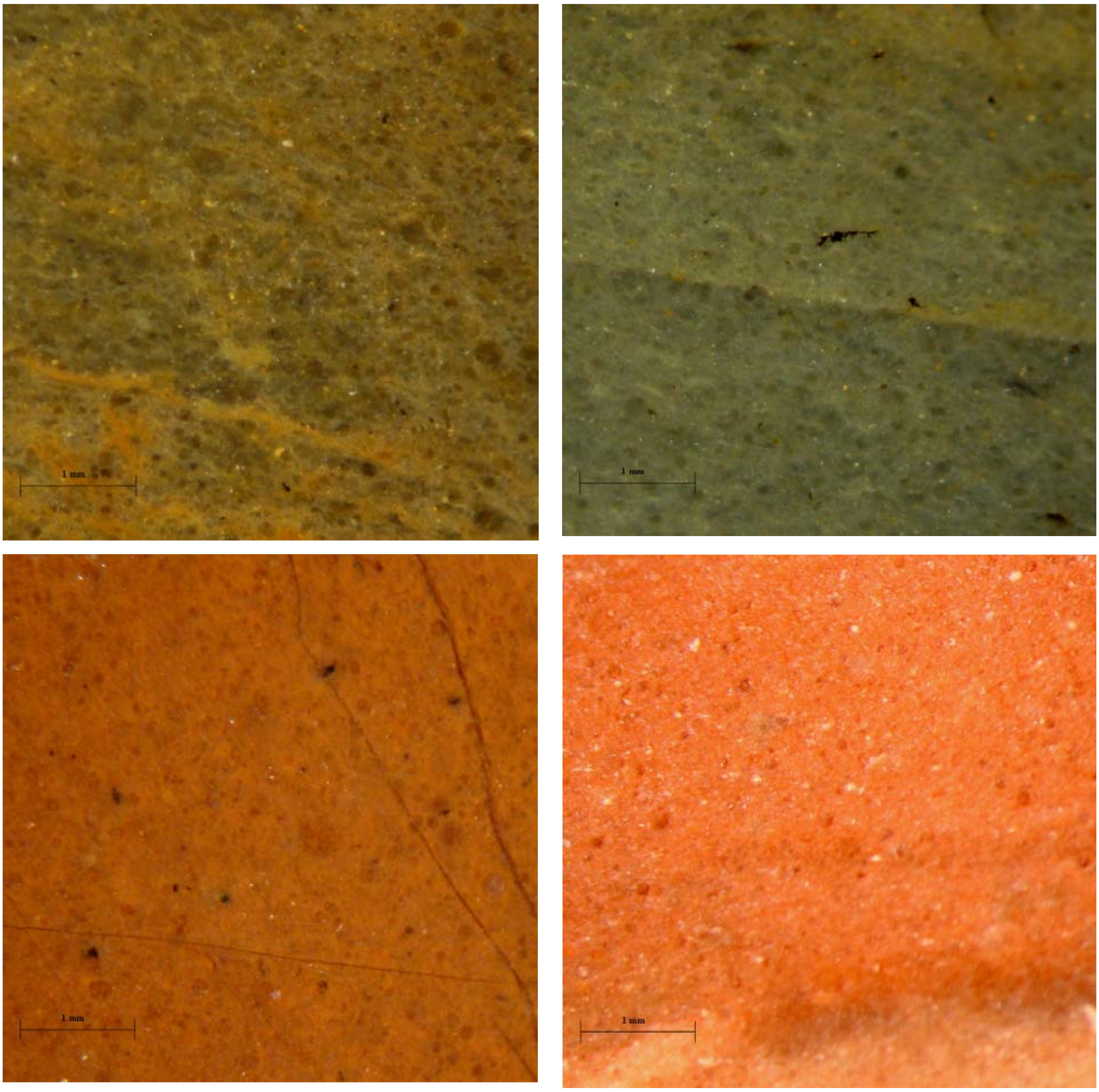

Fig. 1: Micropictures of alpine “radiolarites” 1. Feuersteinmähder, Vorarlberg; 2. Rothornjoch, Allgäuer Alps, Northern Tyrol; 3. Rothornjoch, Allgäuer Alps, Northern Tyrol; 4. Grubalacke, Northern Tyrol

1. ábra: Mikroszkópos felvételek alpi „radiolaritok”-ról

A case in point: Alpine radiolarites

Depending on the definition based on the percentage of included microfossils, not all shown examples in **Fig. 1** would be determined as “radiolarites”. The chert banks of the Rothornjoch (No. 3 and 4) barely carry more than 50% radiolarian in the visible spot under the reflected light microscope (20x magnification). And there is more to it than that: from experience every raw material scientist knows about the effect that in certain parts of chert banks the fossil content can be very high, whereas other parts lack those inclusions almost completely. Particularly in nodular cherts this can be easily observed at the regions towards the cortex, where fossil remains regularly occur concentrated.

In the course of refitting archaeological artefacts, the grotesque situation of two raw material varieties coalesced in one nodule can emerge. The author has experienced this phenomenon himself, when a chert (without any visible inclusions at all) and a radiolarite (with approximately over 50% radiolarian content) perfectly matched.

This underlines the urgent needs of a terminology system that is at the same time easy to handle and produces accurate results. Of course not every insecurity in raw material detection will be clarified applying the Classification System, accuracy will

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definitely increase with strict adherence to it though.

Guide to the usage of the Chert Group Classification System (see **Appendix, Tables 2 and 3**)

All parameters defined above are evaluated in the Chert Group Classification System. The categories which are typical for members of the chert group are itemised in the tables according to their relevance for a raw material analysis. The analysis is structured in a multiple choice model, the majority of positive matches define the questionable affiliation of sedimentary, organically formed SiO_2 raw materials.

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Appendix

Table 1.: Lithic raw materials used for stone tool production. Chert Group Classification System I: Chert

1. táblázat: Kőeszköz készítésre használt nyersanyagok rendszerezése

Opal	historic	mineral	metamorphic, sedimentary or hydrothermal	amorph, teilkristallin	inorganic / organic
Petrified wood	after source material	mineral (if petrified as quartz or opal)	Pseudomorphosis	depending on petrifying material	inorganic / organic
Obsidian	historic name of a person (*Obsius*)	igneous glass	igneous	amorphous, rarely partly crystalline	inorganic
Tectite	after event	impact glass	impact of a meteorite	amorphous	inorganic
Quartzite	after source material	rock	metamorphic	rough- fine-crystalline	inorganic

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Table 2.: Classification system for members of the chert - group.

2. táblázat: Kőeszköz készítésre használt nyersanyagok rendszerezése - kovakőzetek

Genesis		**generally jurassic**	**sometimes cretaceous**
Fissures	yes	often	
	no	rarely	
Fracture properties		conchoidal - smooth	
		amorphously - rough	
Granularity		very rough - very fine grained	
Carbonate content	yes	not always detectable	
		highly calcareous	**siliceous limestone**

Matrix	silicified					
Inclusions	fossil	Fossil type	Count			
			0%	< 10%: Index fossilisation detectable		
		A.a Radiolaria	**chert**	**radiolarite**		
		A.b Spicula	**chert**	**spiculite**		
		A.c Sponges remains	**chert**	**spongiolite (spongilite)**		
		A.d Crinoidea	**chert**	stays **chert**		
		A.e Foraminifera	**chert**	stays **chert**		
		A.f Seashells	**chert**	stays **chert**		
		A.g Detritus	**chert**	stays **chert**		
	non - fossil	Type	count			
			none	some	many	very many
		A.a. Heavy minerals (garnett, tourmaline,…)	x	x	x	rarely
		A.b. Mica	x	x	x	rarely
		A.c. Quartz geodes	x	x	x	x
		A.d. SiO2 - precipitations	x	x	rarely	very rarely
		A.e. Various foreign minerals	x	x	x	x
	none	no (detectable) inclusions				

metamorphic genesis layered structure black colour dense matrix	**Lydite**

Table 3.: Classification system for flint

3. táblázat: Kőeszköz készítésre használt nyersanyagok rendszerezése - tűzkő

<table>
<tr><td colspan="2">Genesis</td><td>cretaceous</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Fissures</td><td>yes</td><td>rarely</td><td colspan="4"></td></tr>
<tr><td>no</td><td>often</td><td colspan="4"></td></tr>
<tr><td colspan="2">Fracture properties</td><td>conchoidal - smooth</td><td colspan="4"></td></tr>
<tr><td colspan="2">Granularity</td><td>very fine grained</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Carbonate content</td><td>yes</td><td>in the cortex</td><td colspan="4"></td></tr>
<tr><td>no</td><td>in the matrix</td><td colspan="4"></td></tr>
<tr><td colspan="2">Matrix</td><td>very densly silicified</td><td colspan="4"></td></tr>
<tr><td rowspan="17">Inclusions</td><td rowspan="9">fossil</td><td>Fossil type</td><td colspan="4">Count</td></tr>
<tr><td></td><td>0%</td><td colspan="2">many</td><td>very many</td></tr>
<tr><td>A.a Radiolaria</td><td>always</td><td colspan="3">never</td></tr>
<tr><td>A.b Spicula</td><td>rarely</td><td colspan="2">often</td><td>possible - rarely</td></tr>
<tr><td>A.c Sponges remains</td><td>rarely</td><td colspan="2">often</td><td>possible - rarely</td></tr>
<tr><td>A.d Crinoidea</td><td>often</td><td colspan="2">possible</td><td>possible - rarely</td></tr>
<tr><td>A.e Foraminifera</td><td>often</td><td colspan="2">possible - often</td><td>possible - rarely</td></tr>
<tr><td>A.f Seashells</td><td>possible</td><td colspan="2">possible - rarely</td><td>possible - rarely</td></tr>
<tr><td>A.g Detritus</td><td colspan="3">often</td><td>possible - rarely</td></tr>
<tr><td rowspan="7">non fossil</td><td>Type</td><td colspan="4">Count</td></tr>
<tr><td></td><td>none</td><td>some</td><td>many</td><td>very many</td></tr>
<tr><td>A.a. Heavy minerals (garnett, tourmaline,…)</td><td>always</td><td>never</td><td>never</td><td>never</td></tr>
<tr><td>A.b. Mica</td><td>always</td><td>never</td><td>never</td><td>never</td></tr>
<tr><td>A.c. Quartz geodes</td><td>possilbe</td><td>possible</td><td>rarely</td><td>rarely</td></tr>
<tr><td>A.d. SiO2 - precipitations</td><td>often</td><td>often</td><td>possible</td><td>possible</td></tr>
<tr><td>A.e. Various foreign minerals</td><td>possible</td><td>rarely</td><td>very rarely</td><td>very rarely</td></tr>
<tr><td>none</td><td colspan="5">no inclusions</td></tr>
</table>

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PROBLEMS OF SILICEOUS ROCK TERMINOLOGY IN CROATIAN ARCHAEOLOGY

A KOVAKŐZETEK NEVEZÉKTANÁVAL KAPCSOLATOS PROBLÉMÁK A HORVÁT RÉGÉSZETBEN

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Abstract

This paper will give a short overview on the problems concerning terminology of siliceous rocks in archaeological context in Croatian language. Short history of the use of specific terms will be presented, as well as some discrepancies in use of certain terms in archaeological and geological context.

Kivonat

A cikk rövid összefoglalást ad a régészeti kontextusban előforduló kovakőzetek nevezéktanának problémáiról a horvát nyelvű szakirodalomban. Bemutatja a speciális szakkifejezésének használatának rövid történetét és rámutat néhány ellentmondásra és hiányosságra a régészeti és a geológiai terminológiai gyakorlatban.

KEYWORDS: TERMINOLOGY, SILICEOUS ROCKS, CROATIA

KULCSSZAVAK: TERMINOLÓGIA, KOVAKŐZETEK, HORVÁTORSZÁG

Introduction

Research of siliceous rocks in archaeological context is rather a new discipline of interest in Croatian archaeology. Palaeolithic, the period most closely related to chipped stone industries was not subject of research of Croatian archaeologists until the middle of the 1990s. There was the same lack of interest in chipped stone tools in later prehistoric periods as well. Research on Palaeolithic archaeology for most of the 20th century, was conducted by two geologists; D. Grojanović Kramberger and M. Malez. D. Grojanović Kramberger was also the first one to register data on radiolarian cherts and radiolarites associated with magmatic rocks at Medvednica Mt (Gorjanović-Kramberger 1908). Mirko Malez did not have particular interest in siliceous rocks, so he did not make many efforts to improve the nomenclature. At present, there is growing number of both archaeologists and geologists working on prehistoric chipped stone assemblages, facing many problems concerning terminology.

As main problems we can identify the lack of tradition in systematic analysis of the artefacts, general lack of interest in stone artefacts, and scarce cooperation with geologists. Further on, we meet inadequate translations and there is no consistency in using specific terms. There has been some amount of cooperation and consultation with geologists, but not nearly adequate or enough. Therefore, use of adequate and uniform terminology is still far from being satisfactory.

Frequently used terms

Kremen

There are two words most commonly used as general name for siliceous rocks used as raw material for chipped stone tools. One is “kremen”, and the other is “rožnjak” (chert). The word that is most commonly used when describing chipped stone industries is „kremen“. Origin of that word is in the old Slavic language, word *kremy* (Croatian language portal). We can say that the word *kremen* as a general term has a long history in Croatian language and archaeology. Translation of that word means *Feuerstein* in German, and *tűzkő* in Hungarian. It is used by the archaeologists for all siliceous rocks used for prehistoric tools and it is also widespread in everyday language. It has been used since the beginnings of archaeology in Croatia (Ljubić 1876). Also, it is in the root of the word for gunflint - *kremenjača*. Toponyms with word *kremen* indicate either archaeological sites (usually Neolithic open air sites, abundant with chipped stone artefacts on the surface) or geological formations with siliceous rocks. This word has traditional and almost historical use and meaning among people and archaeologists and is part of

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everyday language, understandable for all. On the other hand, in Croatian geological literature *kremen* means the mineral, quartz. So, it can be misunderstood when reading geological literature as an archaeologist (for example Marić 1953). The situation is the same in other countries with similar Slavic languages, such as Serbia. For example in the Archaeological lexicon kremen is defined as a: "Sedimentary rock consisting of cryptocrystalline quartz, chalcedony and opal, white grey or yellow coloured, with hardness of 6-7 Mohs; not translucent, 97-99% SiO2, **"most frequently used raw material before the use of metal"**. Difference is that it has conchoidal fracture while chert (rožnac) has flat. Also, "there are opinions that kremen is just synonym for chert and that the use of that term is justified only in archaeology" (Jović, V. 1997, 524). Another aspect causing further confusion is translation: the word kremen is usually translated to English (in archaeological literature) as *flint*, which is incorrect and deepens the misunderstanding.

Chert

According to the geological definition chert is cryptocrystalline silica which may be of organic or inorganic origin. It occurs as bands, layers or nodules in sedimentary rocks. Sometimes it is a primary deposit, sometimes formed by the confluence of disseminated silica in rocks and sometimes as secondary replacement material (replacement cherts). Such definition covers various siliceous rocks and could be adequate for general use. In Croatian language the word for chert is *rožnjak*. It is the same word as Hornstein in German, hornstone in English and szarukő / kova in Hungarian. Next to kremen, it is the second most popular term among Croatian archaeologists as a general term for siliceous rocks. Some authors claim that this rock was "used in Palaeolithic for tools and weapons and in Roman period for gems" (Jović 1997, 900). It is more accurate to use it as a general term instead of "kremen", but further education is required in order not to be mixed with other types of siliceous rocks.

Flint

According to some of the geological literature the word flint is a "synonym for cryptocrystalline chert of nodular or laminal shape, usually of Cretaceous age; used by prehistoric people (Tišljar, 1994, 281)." However, prehistoric people used other cherts as well, so the definition is – although not incorrect, - insufficient. Flint is also most frequently used in English translations of Croatian texts, as a general term for siliceous rocks, which is also the case in other languages.

Radiolarite

Generally, radiolarites *sensu stricto* are cherts with more than 50% of radiolarian tests embedded in a siliceous matrix (Ruitz-Ortiz et al. 1989). On the other hand, radiolarian cherts are cherts with less than 50% radiolarian tests embedded in siliceous matrix. In archaeological literature, radiolarite is sometimes used to describe siliceous rocks, without information about their geological origin. It is also used in wrong context such as to emphasize good quality of the raw material, or sometimes the raw material is recognized as radiolarite because of its red colour. Jasper and opal are also used to describe good quality, nice or unusual pieces. Radiolarites are often equalled with cherts, but it is necessary to provide geological analysis in order to determine whether the raw material is radiolarite, radiolarian chert or chert. Such research is especially required in some areas where radiolarites occur, such as Hrvatsko Zagorje. The detailed geological map of the magmatic-sedimentary complex of Ivanščica, Kalnik and Medvednica Mts. revealed many occurrences of radiolarian cherts and radiolarites of Triassic and Jurassic age (Halamić & Goričan 1995; Halamić 1998; Halamić et al. 1999; Halamić et al. 2001, 2005). It would be useful to determine whether this raw material was used by the Vindija Neandertals (Blaser et al. 2002; Kurtanjek & Marci 1990).

Silex

Silex (with Croatian spelling) is sometimes used, mostly by archaeologists influenced by the French tradition. It seems to be a very useful term in cases when detailed explanations are not available, but unfortunately it is used very rarely.

Conclusions

It is important to continue and strengthen cooperation with geologists which started during the last decade (for example Forenbaher 2003, Karavanić et al. 2008, Crnjaković 2009). Also, petrological and geochemical analysis should become a standard in analysis of chipped stone assemblages. Some of the terms describing siliceous rocks became "rooted" in the language, so it is to be expected that they will still be used in the future. It is very important to have clear image and consensus about the meaning of a specific term. Joint efforts among geologists and archaeologist from the neighbouring countries are crucial in making such consensus possible. Further on, it is important to establish strict criteria for distinguishing siliceous rocks (by the geologists) and to present in a form understandable for archaeologists.

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TERMINOLOGICAL PRACTICE FOR SILICEOUS ROCKS IN HUNGARY FROM PETROARCHAEOLOGICAL POINT OF VIEW

KOVAKŐZETEK TERMINOLÓGIÁJA: A MAGYARORSZÁGI GYAKORLAT PETROARCHEOLÓGIAI SZEMPONTBÓL

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Abstract

The terminology of siliceous rocks is an important issue for archaeometry, in the first place, petroarchaeology. It is imperative that scientific communications should use sound nomenclature with stable disciplinary background that are recognised and acknowledged by scholars of other disciplines and other countries as well. This paper aims at summarising the Hungarian practice on the basis of mapping geology, lithostratigraphic units and petroarchaeological practice.

Kivonat

A kovakőzetek nevezéktana fontos kérdés az archeometriai (elsősorban, petroarcheológiai) megközelítés szempontjából is. Alapvető, hogy az e tárgyban írt tudományos közlemények diszciplinárisan megalapozott, egyértelmű neveket használjanak, amelyek felismerhetők és elismertek, a társtudományok és a nemzetközi kutatási gyakorlat számára. A jelen közlemény a Magyarországon használt és elfogadott terminológiát gyűjti össze, a földtani térképezési gyakorlat, a litosztratigráfiai egységek és a petroarcheológiai gyakorlat alapján.

KEYWORDS: TERMINOLOGY, SILICEOUS ROCKS, HUNGARY

KULCSSZAVAK: TERMINOLÓGIA, KOVAKŐZETEK, MAGYARORSZÁG

Introduction

Siliceous rock terminology is a very topical problem. These rocks are composed basically of SiO_2 minerals, quartz, chalcedony and opal. The SiO_2 content of these rocks is typically over 90%. We can find them in various context: sedimentary, igneous/volcanic (postvolcanic) context and metamorphic environment. They may be important constituents of regional lithologies. Fine grained, micro- and cryptocrystalline varieties with homogeneous texture and conchoidal fracture were preferentially used for the production of chipped stone artefacts; hence the distinguished interest of archaeologists for these rocks, their possible sources and possibilities for source identification (provenancing, characterisation). Correct nomenclature may help us to delimit potential source regions; a chaos in terminology, at the same, time, will blur the identity or differences. Therefore we are absolutely interested in clearing concepts and are grateful for the IMA'2010 Congress held in Budapest for the possibility.

Apart from their importance in natural sciences, siliceous rocks have a special importance in human history, especially in the most ancient times, the Palaeolithic Age and the older phase of prehistory (Neolithic and Aeneolithic periods). Chipped stone artefacts, i.e. tools made by knapping suitable rocks (hard, fine grained rocks with homogeneous texture and chonchoidal fracture), were mainly made of siliceous rocks of various type and origin, from different geological sources, different genetical record and geological age. The localisation of these sources may essentially help in reconstructing prehistoric technology and trade routes.

Identification, characterisation and research of the provenance of siliceous rocks as basic raw materials for stone artefacts dates back to more than hundred years in Hungary (Biró 2008, 2009 with further references). The first students of these problems were pioneering figures of Hungarian archaeology and geology. The systematical investigation of the chipped stone artefact raw materials sources took place in the 1980-ies, resulting in one of the first large comparative collections for lithic raw materials, the Lithotheca of the Hungarian National Museum (Biró & Dobosi 1991, Biró et al. 2000).

In discribing the specimens of the collection we were always trying to conform to the nomenclature used by mapping geology. It was often observed, however, that the different names used by different experts varied according to the background information of the researchers, leaving us with synonymes and conflicting nomenclature, in some cases, directly mistaken terminology. Moreover, the

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effort of allocating raw material type groups separated in the material of archaeological lithic assemblages to distinct source regions created a special petroarchaeological terminology implying in the name, possibilities of geographical provenance (Biró 1988, 1998).

As an archaeologist, it is not my duty to give and even less, to correct mineralogical and petrographical names. At the same time, petroarchaeological characterisation studies require to call „a spade a spade", i.e., separate the separable under different names. In this paper I am trying to collect existing practice in Hungary. In the followings, I will systematically „neglect" sandstone (which, in a sense, can be a siliceous rock itself) where I do not see terminological problems and that plays a different role in petroarchaeology.

Mineralogical and petrographical works on siliceous rock terminology in Hungary

There are relatively few works specifically concentrating on the terminology of siliceous rocks. One of them is by E. Károly, on the Buda **hornstone** (= **szarukő**, Károly 1936). In the same year, E. Lengyel published a paper on another type of siliceous rock with basically different conditions of formation, i.e. **jasper** (=**jáspis**, Lengyel 1936). There is, to my knowledge no other paper specifically dedicated to siliceous rock terminology on the Hungarian side. Closely related to the subject, there are a number of mineralogical treatises on SiO_2 minerals in textbooks (Koch 1985, Szakáll 2005 etc.) and specialist's studies (Takács 1983) and also useful bits of information in classical petroarchaeological studies.

Textbooks of mineralogy/petrology on siliceous rocks

In the applied geological manual by Mrs. Végh (1968) on the geology of non-metallic/ore mineral raw materials (*Nemércek földtana*), she systematised siliceous rocks the following way:

Minerals of magmatic origin / hydrothermal phase (pp. 58-62)

Minerals of sedimentary origin / siliceous sediments (pp. 73-101)

The following terms were used:

Quartz, rock crystal, opal, chalcedony (for minerals)

„Sandstone quartzite", quartz arenite / hu: homokkőkvarcit (kvarchomokkő) (=young)

metamorphic quartzite / hu: metamorf kvarcit (=old)

vein quartzite / hu: telérkvarcit

limnic quartzite / hu: limnokvarcit

limnic opalite / hu: limnoopalit

limnic chalcedonite / hu: limnokalcedonit

siliceous earth, diatomaceous earth / hu: kovaföld, diatomaföld

flint (=chert), hornstone / hu: tűzkő, szarukő

In a three-volume textbook on sedimentology (Balogh ed. 1991), Kálmán Balogh consecrated a chapter to the problematics of siliceous rocks (Balogh 1991).

He used the following main terms:

siliceous sediment / hu: kovaüledék

opal / hu: opál

geyserite / hu: gejzirit

limnic opalite / hu: limnoopalit

limnic chalcedonite / hu: limnokalcedonit

flint / hu: tűzkő

radiolarite / hu: radiolarit

spiculite / hu: spiculit

porcelanite / hu: porcelanit

The scheme on the division of siliceous rocks suggested by Balogh is reproduced here in the **Appendix** in English

Siliceous rocks in geological (mapping) practice

The most important "guideline" for a petroarchaeological terminology is the result of standard regional geology, which is best reflected in mapping. For the current summary, I am presenting the nomenclatural practice reflected in nearly 200 years of geological mapping. The electronical publications of MÁFI are of special help in this (esp. Gyalog et al. 2005).

In the geological mapping of the Tokaj Mts., especially rich in varied siliceous rocks (Gyarmati 1977), the following lithological units were used for siliceous rocks:

limnic quartzite / hu: limnokvarcit

geyserite / hu: gejzirit

hydroquartzite / hu: hidrokvarcit

On the detailed geological map of the Cserhát Mts. (Compiled by J. Noszky, 1940), no siliceous rock formations are mapped, though the area is rich in siliceous rocks from the Triassic/Jurassic as well as the Miocene period as surveyed recently by A. Markó (2005)

On the 1: 300,000 geological map of Hungary (Balogh et al. 1958), the following lithological units were separated and mapped:

Quartzite / hu: kvarcit (Pe1[1])

Hornstone (limestone with hornstone) / hu: szaruköves mészkő (T2, T3)

Siliceous schist / hu: kovapala (T2)

Siliceous marl and limestone / hu: kovás márga / mészkő (J3)

Hydroquartzite / hu: hidrokvarcit (M2)

On the 1:200,000 the geological map of Hungary, presented on 23 sheets, the following siliceous rock lithological units were separated and mapped[2]:

L-33-V. Sopron (1981) – **quartzite / hu: kvarcit** (Paleozoic)

L-33-XII. Veszprém (1972) – **flint, cherty (=siliceous) limestone, dolomite with flint nodules /hu: tűzköves, kovás mészkő, dolomit tűzkőgumókkal** (Triassic), **cherty (=siliceous) limestone, nodular limestone, platy radiolarite, limestone with flint (=siliceous) veins, radiolarite / hu: tűzköves, gumós mészkő, lemezes radiolarit, mészkő tűzkőerekkel, radiolarit** (Jurassic)

L-34-I. Tatabánya (1968) - **cherty (=siliceous) dolomite, limestone, limestone with flint nodules / hu: tűzköves dolomit, tűzköves mészkő** (Triassic), **tűzkőgumós mészkő** (Jurassic)

L-34-II. Budapest (1966) - **cherty (=siliceous) limestone hu: tűzköves mészkő** (Triassic), **hydroquartzite / hu: hidrokvarcit** (Miocene)

L-34-VII. Székesfehérvár (1972) - **cherty (=siliceous) limestone / hu: tűzköves mészkő** (Triassic), **nodular limestone with flint (i.e., chert) / hu: tűzköves gumós mészkő** (Jurassic), **postvolcanic hydrothermal silicification / hu: utóvulkáni hidrotermális kovásodás** (Eocene)

M-34-XXXII. Salgótarján (1966) – **quartzite / hu: kvarcit** (Triassic)

M-34-XXXIII. Miskolc (1975) **- cherty (=siliceous) limestone / hu: tűzköves mészkő** (Perm), **cherty (=siliceous) limestone, siliceous schist, flint / hu: tűzköves mészkő, kovapala, tűzkő** (Triassic)

M-34-XXXIV. Sátoraljaújhely (1966) – **siliceous sediments (hydroquartzite, geyserite, limnic quartzite, diatomaceous earth) / hu: kovaüledékek (hidrokvarcit, gejzirit, limnokvarcit, kovaföld** (Miocene)

This summary is obviously incomplete, however, it demonstrates clearly that terminology as well as mapping practice was not consequent even in the more recent times.

Siliceous rocks in the Lithostratigraphical Formations

Closely related to mapping, the list of lithostratigraphical formations also contain a highly standardised and unified nomenclature, including, among others, siliceous rocks. As it is well known, the constructors of the lithostratigraphical units aimed at putting the most characteristic rock types into the name of the formation or its subordinate members. For the survey of siliceous rocks among accepted lithostratigraphical units, two basic publications were used in which lithographical units were systemathised and, later, completed (Császár ed. 1997; Gyalog & Budai eds. 2004).

Name of the siliceous rock included in formation name:

Lókút Radiolarite Formation (lJ2-3)

Csipkéstető Radiolarite Formation (cJ3)

Bányahegy Radiolarite Formation (bJ2)

Darnó Radiolarite Formation (dT2-3)

Szárhegy Radiolarite Formation (sT2-3)

Siliceous rock names occurring in the lithological descriptions (not in the formation name):

radiolarite (hu: radiolarit, 16) + Bódvavölgy Ophiolite Formation (bvT2-3); Buchenstein Formation (bT2) as "calcareous or siliceous tuffite (radiolarite)";

flint (~chert) (hu: tűzkő, 8) Lábatlan Sandstone Formation (lK1-2); Lókút Radiolarite Formation (lJ2-3) "Póckő Flint Member and Margithegy Flint Member"; Isztimér Limestone Formation (iJ1) "spongiolite cherty limestone and spongiolite limestone"; Kishát Limestone Formation (kJ1) (with manganese-containing cherty beds); Csővár Limestone Formation (cT3-J1) (with flint lenses)

"flinty" (~cherty) (hu: tűzköves, 23) Szentivánhegy Limestone Formation (sJ3-K1) (cherty limestone); Márévár Limestone Formation (mvJ3-K); Pálihálás Limestone Formation (pJ3) cherty limestone); Lókút Radiolarite Formation (lJ2-3); Várkony Limestone Formation (vJ3); Eplény Limestone Formation (eJ1-2); Telekesvölgy Komplex (TT3-J); Isztimér Limestone Formation (iJ1); Rezi Dolomite Formation (rT3) (cherty dolomite); Veszprém Marl Formation (vT3) (cherty limestone); Rónabükk Limestone Formation (rbT3); Felsőtárkány Limestone Formation (ftT3);

[1] In brackets, the standard abbreviations for geological age
[2] only the siliceous rock lithological units listed here

Hollóstető Limestone Formation (htT3); Szinva Metabasalt Formation (snT3); Pötschen Limestone Formation (pT3); Szőlősardó Marl Formation (saT3); Buchenstein Formation (bT2); Felsőörs Limestone Formation (fT2); Bódvarákó Formation (brT2) (cherty dolo-marl, siliceous aleurolite);

silex (hu: kova, 1) Hárshegy Sandstone Formation (hOl1) "binding matter";

siliceous (hu: kovás, 17) Kálla Gravel Formation (klPa2) (siliceous sandstone quartzite); Tard Agyag Formation (tOl1) (siliceous schistose marl); Lókút Radiolarite Formation (lJ2-3); Telekesoldal Komplex (TJ) (siliceous marl-claystone); Várkony Limestone Formation (vJ3) (siliceous limestone); Fonyászó Limestone Formation (fJ3) (siliceous limestone and radiolarite); Dorogó Calcareous Marl Formation (dJ2) ("siliceous marl"); Csővár Limestone Formation (cT3-J1); Vasas Marl Formation (vJ1) (siliceous sandstone); Buchenstein Formation (bT2); Csernelyvölgy Sandstone Formation (cO3); Rágyincsvölgy Sandstone Formation (rO3);

limnoopalite (hu: limnoopalit, 1) Sajóvölgy Formation (sMb-Pa1)

quartzite (hu: kvarcit 8) Zámor Gravel Formation (zPa1); Nadap Andesite Formation (nE2-3); Recsk Andesite Formation (rE3); Mályinka Formation (mC2); Balatonfőkajár Quartzphyllite Crystalline Schist Komplex (FPz)

Further data in Gyalog & Budai eds. 2004:

quartzite (hu: kvarcit): Murakeresztúri Tuffaceous Sandstone Formation (muT); Darnó Conglomerate Formation (dMe); Magasbörzsöny Andesite Formation (mbMb); Ligetmajor Diatomaceous Earth Member (eb lMs2–Pa1); Rátka Quartzite Member (eb rMs2–Pa1); Megyaszó Conglomerate Formation (maPa1)

The Geological Map of Hungary (Gyalog et al. ed. 2005)

On the most recent and widely available digital geological map, the following siliceous rocks are treated as individual lithological units:

Eponym units:

Radiolarite (hu: radiolarit)

Szárhegy Radiolarite Formation

Dallapuszta Radiolarite Formation / Darnóhegy Radiolarite Formation

Lókút Radiolarite Formation

Bányahegy Radiolarite Formation

Csipkéstető Radiolarite Formation

Flint (hu: tűzkő)

Póckő Flint Member

Margithegy Flint Member

Limnic quartzite (hu: limnokvarcit)

Gyöngyöspata Limnic Quartzite Member

Rátka Quartzite Member (sic!)

Quartzite

Seprőkötőhegy Quartzite Member

Nagyfüzes Quartzite Member

Other lithological units with siliceous rocks specifically mentioned:

Radiolarite (hu: radiolarit (33)[3]): Várhegy Formation, Buchenstein Formation, Bódvavölgy Ophiolite Formation, Hídvégardó Olistostrome, Szárhegy Formation, Telekesvölgy Komplex (radiolarite-spiculite), Eplény Limestone Formation, Darnó Conglomerate Formation,

Flint[4] (hu: tűzkő (8)): Pötschen Limestone Formation, Isztimér Limestone Formation, Lókút Radiolarite Formation, Iharkút Formation

Siliceous... (hu: tűzköves... (29)): Bódvarákó Formation (siliceous dolomarl, siliceous aleurolite), Felsőörs Limestone Formation, Buchenstein Formation, Reifling Limestone Formation, Bódvalenke Limestone Formation, Szinva Metabasalt Formation, Szőlősardó Marl Formation, Pötschen Limestone Formation, Felsőtárkány Limestone Formation, Veszprém Marl Formation, Sándorhegy Formation, Rezi Dolomite Formation, Telekesvölgy Complex, Csővár Limestone Formation, Isztimér Limestone Formation (spongiolite), Eplény Limestone Formation, Lókút Radiolarite Formation, Oldalvölgy Formation, Pálihálás Limestone Formation, Szentivánhegy Limestone Formation, Várkony Limestone Formation, Márévár Limestone Formation

Silex (hu: kova (3)) Hárshegy Sandstone Formation - binding material of the sandstone matrix; Keszthely Mts.: young hot water sediments

Quartzite (hu: kvarcit (23)) Füzesárok White Schist Formation, Balatonfőkajár Quartzphyillite Formation, Mónosbél Formation, Nadap Andesite Formation, Recsk Andesite Formation, Darnó Conglomerate Formation, Erdőbénye Formation, Rátka Quartzite Member,[5] Megyaszó Conglomerate Formation, Zámor Gravel Formation, Kálló Gravel Formation,

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[3] the numbers in brackets are sum of instances of mentioning in the explanation text, an index of the "popularity" of the term

[4] "tűzkő" is often used in a wider sense for silex in general or chert. Therefore "siliceous" will mean partly *tűzköves* and *kovás,* inconsequently.

[5] meaning, hydro- and/or limnic quartzite

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Limnic quartzite (hu: limnokvarcit (7)): Gyöngyöspata Limnic Quartzite Member; Szurdokpüspök Formation, Erdőbénye Formation

Limnoopalite (hu: limnoopalit (1)): Sajóvölgy Formation

The following terms, used in other mapping practice were also tested:

Hydroquartzite (hu: hidrokvarcit 0)

Hornstone (hu: szarukő 0)

Jasper (hu: jáspis 0)

3. Classical petroarchaeological literature

Starting from the first works on chipped stone artefacts in Hungary, the raw material of the tools was of primary concern. The first descriptions separated "**obsidian**" and "**silex**" (**hu: kova**). (e.g. Rómer 1878 with distribution map: re-published by Biró 2005 *Fig.1.*). Later on, the term "**tűzkő**" (i.e., **flint**) was introduced meaning silex in general (Papp 1907). In the description of the first large Palaeolithic sites, the following terms were introduced[6]:

Tata (Kormos 1912):

flint (hu: tűzkő)

quartzite (hu: kvarcit)

hornstone (hu: szarukő)

lydite (hu: lidit)

stomolite (hornfels)

jasper (hu: jáspis)[7]

limestone

silex (hu: kova)

Szeleta-cave (Vendl in Kadić 1915) using thin section petrography:

ash-grey chalcedony (Szeletian felsitic porphyry / metarhyolite, Dobosi 1978)

chalcedony (various colours) **(hu: kalcedon)**[8]

chalcedony-opal (various colours) **(hu: kalcedon-opál)**[9]

opal (hu: opál)

quartzite (hu: kvarcit)

limnic quartzite (hu: limnokvarcit)

Subalyuk-cave (Vendl 1933, 1935, Vendl in Kadic 1915) using thin section petrography:

hornstone (hu: szarukő)

sandstone

silicified marl

chalcedony (hu: kalcedon) [10]

jasper (hu: jáspis)

milky quartz (hu: tejkvarc)

radiolarite (hu: radiolarit)

obsidian

The next important step in lithic artefact petroarchaeology is the time of the great monographs in the 1960-ies. For Tata, Érd and later on Vértesszőlős professional petrographic studies were made, finding the local resources mainly for the Middle and Lower Palaeolithic industries. László Vértes collected the available natural scientific data on Hungarian sites including petrographical identification (Vértes 1965, Biró 2008a) and came up with the following terms:

obsidian (hu: obszidián)

Szeletian felsitic porphyry/metarhyolite (hu: Szeletai kvarcporfír/metariolit)

hydroquartzite (hu: hidrokvarcit)

porphyryte (hu: porfirit)

block silex (hu: tömbös kova)

pebble silex (hu: kovakavics)

silex (hu: kova)

Pebble (hu: kavics)

quartzite (hu: kvarcit)

wood opal (hu: faopál)

bone (hu: csont)

others (hu: egyéb)

Additional terms Vértes was using in his other works:

stone marrow (hu: kővelő)

limnic quartzite (hu: limnokvarcit)

Swieciechów silex (hu: Swieciechówi kova)

sandstone (hu: homokkő)

radiolarite / jasper (hu: radiolarit/jáspis)

Following the period of the "great monographs" Viola Dobosi in an important article (Dobosi 1978)

[6] siliceous rocks marked **bold**
[7] in fact, it is radiolarite (Végh-Viczián 1964, Biró 2004)
[8] in fact, hydro- and limnic quartzites
[9] basically, limnic quartzites
[10] limnic quartzite and, partly Szeletan felsitic porphyry

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asked for the help of professional geologists, working at that time on petroarchaeological problems, to help in clarifying siliceous rock nomenclature. The study was concentrated on, mainly, lithic raw materials from North-East Hungary. The specimens were divided into two classes, i.e. „**Tűzkövek**” (=**flint**) and „Kőzetek” (=rocks). Among the former, types with radiolaria (=**radiolarite**), types with large amount of **opal** and types with large amount of plant fossils (=**hydroquartzite**[11]) were separated by the geologist, Ms. Ravasz-Baranyai. Among the „rocks” she also mentioned opal and opalised rhyolite tuff as well as hyalitic rhyolite.

Discussion

The author was first facing the problem of siliceous rock nomenclature in the early 1980-ies while mapping, registering and collecting rocks viable for chipped stone artefacts in Hungary (Biró 1984a,b, Biró & Pálosi 1986). The lesson I could draw from my initial efforts was to respect the opinion of geologists, in the first place, mapping geologists and record terminological practice in standard descriptions based on a database and collection approach (Biró & Dobosi 1991, Biró et al. 2000 Biró 2005). We collected hand specimens with all available information: provenance data, geology, lithology and complete it with as much as we know by analytical data (thin section, geochemistry, palaeontology and geochronology).

In a recent summary on Hungarian lithic raw materials (Biró 2009) I made the following scheme (**Fig. 1.**, after Biró 2009 fig. 2)[12]. At the same time I am aware of existing conflicting terminologies that make our regional and inter-regional work (=provenance analysis of lithic material) really difficult, sometimes contradictory.

Conclusions

Since the 1980-ies, the necessity for a standard and applicable terminology in respect of siliceous rocks used for prehistoric stone tools is absolutely clear. The systematic unification of terminology should be based on clear mineralogical, genetical and lithostratigraphical criteria. Regional, ie. "fingerprinting" aspects should be based on these standards.

The attitude of mapping geologists is seemingly different. Some simplify all siliceous rocks under „tűzkő” (flint / chert, meaning silex); some do not even think they are diagnostic in separating different lithologies. Detailed regional maps can be more specific and exact, but not necessarily so.

There are, however, tendencies observable: **hornstone (hu: szarukő)** is seemingly going „out of fashion” while **radiolarite (hu: radiolarit)**, probably due to its excellent environment marker characteristics, is getting gradually more important.

Problematic issues

- **silex/chert/flint/** "hornstone" (for shallow water sedimentary siliceous rocks)

- "**-quartzite**" in non-metamorphic context e.g. limno-, hydroquartzites (even Rátka Quartzite Formation for Neogene sedimentary series!)

- **jasper** (for radiolarite)

- **radiolarite / chert / lydite /siliceous schist and slate / chert**

It would be really important to agree on proper nomenclature, maybe on a broad/more specific basis, first clearing the mineralogical and geological background and later adding the petroarchaeological information as well.

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[11] correctly: limnoquartzite
[12] omitting items which do not fall into the category of "siliceous rocks")

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DOUBLE INTERPRETATION OF ROCK NAMES IN THE WESTERN GEOLOGICAL TERMINOLOGY COMPARED TO THE FORMER SOVIET AND CURRENT RUSSIAN-UKRAINIAN PRACTICE; TERMINOLOGICAL SUGGESTIONS

KŐZETNEVEK KETTŐS ÉRTELMEZÉSE A NYUGATI ÉS AZ EGYKORI SZOVJET, MAI OROSZ-UKRÁN GEOLÓGIAI SZAKIRODALOMBAN, TERMINOLÓGIAI JAVASLATOK

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Abstract

This paper summarises siliceous rock terminology practice currently in use for the Transcarpathian Regions of Ukraine (=Kárpátalja). It is published in full text bilingual form for AM.

Kivonat

Ez a munka a kovakőzetek jelenlegi nevezéktani gyakorlatát foglalja össze Kárpátalja tekintetében. Az Archeometriai Műhely két nyelvi változatban (magyar és angol) közli a tanulmányt.

KEYWORDS: TERMINOLOGY, SLICEOUS ROCKS, TRANSCARPATHIAN UKRAINE

KULCSSZAVAK: TERMINOLÓGIA, KOVAKŐZETEK, KÁRPÁTALJA

Introduction

The aim of this paper is to draw attention to the sometimes ambiguous use of mineralogical / petrographical terms for siliceous raw materials currently in use mainly for the Transcarpathian Regions of Ukraine (=Kárpátalja). As it is basically intended to clear and explain existing terminology, the English version preserved the original (Ukrainian, Russian and Hungarian) names as well. Apart from this, elements of Hungarian terminology are also listed as comparative examples ((Balogh 1991, Wallacher 1992).

Jasper

Jasper (ru: „яшма"; ua: „яшма"; hu: jáspis) – sedimentary siliceous rock composed basically of cryptocrystalline chalcedony. It is often of variegated colour, sometimes striped. Radiolaria may occur in the jasper often preserving their original form. This rock is frequently occurring in the Palaeozoic period, less frequent in the Mesozoic. (Криштофорович 1955).

According to another interpretation, jasper is composed of microcrystalline chalcedony, its colour is black, red, sometimes greenish, with yellow or black stripes, patches. It is a hard and compact rock with conchoidal fracture. Under the microscope chalcedony and a large quantity of dispersed Fe-oxide components are observable as well as clay minerals and remains of Radiolaria. The Radiolaria are often observable in stripes within the rock. Other organic remains are very rare. In the stripes with Radiolaria, sometimes we can observe zeolite crystals. There are variants of jasper occurring where the Radiolarian remains are completely missing. According to the author, jasper is often erroneously described as metamorphic. (Швецов 1958)

Jasper in Hvorova I. V. (1983) is described as a mainly red rock with conchoidal fracture. Iron is present in the jasper mainly in the form of hematite and goethite, the SiO_2 content can reach 95-97 %. The author distinguished jasper with Radiolaria and sponge spicules, respectively further on, in footnotes (p. 170.) she made a remark on the existence of metamorphosed jasper formed in great depth already loosing its sedimentary character and mentioned the existence of non-sedimentary jasper as well.

Wallacher L. (1992) called the siliceous rocks coloured red by iron jaspilite (hu: jáspilit). In the Slavic language technical literature, jaspilite is a rock with quartz-hematite or quartz-magnetite composition, practically a siliceous iron ore. (Криштофорович 1955)

In a geological dictionary published in 1973, the following comments are made on the various formation of jasper: jasper is defined here as a sedimentary siliceous rock with or without Radiolaria. Variants with Radiolarian remains are

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considered epigenetic radiolarite (= slightly metamorphosed after diagenesis). Variants without Radiolaria are considered as of various origin, like volcanic sedimentary or chemical / biochemical origin. (Геологический словарь 1973)

Hornstone

Hornstone (ru: „роговик”, „роговиковая порода”; ua: „роговик” or „роговикова порода”, hu: szarukő) According to the Hungarian-Russian geological and geographical dictionary published in 1960 (Geiger 1960) the Russian equivalent of „szarukő” (=hornstone) is „роговик” or „роговиковая порода”. The expression „szaruszirt” (=hornfels) is also expressed by the terms „роговик” or „роговиковая порода”.

Hornstone (=hornfels) – contact metamorphic rock. It is of compact, grainy structure. "horny" structure. It is often mottled and has a conchoidal fracture. Its mineral composition is the following: quartz, mica, andalusite, sillimanite or cordierite, less frequently, amphibole or pyroxene etc. *(*Криштофорович *1955)*

Hornstone is a micro- or cryptocrystallyne contact metamorphic rock. Its colour is reddish brown or grey. It is composed of quartz, mica and garnet etc. (Білецький 2004).

Svecov M. Sz. (1958) has also mentioned hornstone in the description of siliceous rocks, only to note that the term is incorrect (Швецов 1958).

In his work on the petrographical classification of silex and siliceous rocks, Wallacher L. (1992) expressed his opinion that calling siliceous segregates "hornstone" is misleading and causes only trouble.

Geisirite

Geisirite (ru: „гейзерит”; ua: „гейзерит”; hu: gejzirit) – white or light coloured rock with large quantities of opal, formed from the precipitation of siliceous solutions in geisires and other hot water springs. Its synonyme is siliceous/silicified tuff. (Криштофорович 1955)

Geisirite is a tuff-like porose rock composed mainly of opal, deposited by hot underground waters striving towards the surface. In their precipitation, changes in temperature and pressure have a great role as well as expiration and the life activity of water plants. (Швецов 1958)

Geisirite is a sedimentary rock formed by the precipitation of siliceous solutions from geisires and other hot water springs. In another meaning it is a mineral, a white or grey opal the formation of which is the same as that of the rock. It is relatively rare, and synonymous with siliceous tuff. (Білецький 2004)

In the work of Hvorova I. V. (1983), geisirite is mentioned as a sedimentary siliceous rock formed around hot water springs having a layered structure due to gradual precipitation, formed around hot water springs. She does not identify them with siliceous tuffs. (Хворова 1983)

Wallacher L. (1992) identified geisirite as the same rock as hydroquartzite, explaining its formation by blocks of siliceous matter precipitated from hot springs with high silica water.

Lydite

Lydite (ru: „лидит”; ua: „лідіт”; hu: lidit) is named after the ancient kingdom of Lydia in Asia Minor. It was known as the touchstone of goldsmiths. It is a black, compact siliceous rock, composed mainly of chalcedony with some clay minerals. It has chonchoidal fracture and contains only Radiolaria as microfossils. Chemically, it is composed of silica (SiO_2) in 92-93 %, coloured black by bitumen (organic materials). According to some assumptions, certain varieties of lydite are fresh-water analogies of ftanites (ftanites are typically of marine origin). Its structure is mixed with apparent organic relict frame as well as the cryptocrystalline and micro-grained structure. (Геологический словарь 1973)

In the work of Wallacher L. (1992), lydite is described as a dark grey, black siliceous rock with schistose structure and abiomorphic structure, i.e., silexite.. Hungarian technical literature mentioned also other microfossils of siliceous skeletal elements as possible constituents for lydite (Balogh 1991 p. 39.)

Ftanite

Ftanite (ru: „фтанит”; ua: „фтаніт”; hu: ftanit) dark, sometimes black, hard rock with chonchoidal fracture. Its lustre can be shiny or dull. The texture is homogeneous, sometimes a slight layering can be observed in it due to the uneven distribution of mineral components and rock-forming organic components. The rock has a microcrystalline texture comprising mainly chalcedony, therefore it is also called chalcedonite. In some ftanites the organic remains are missing or they are very rare while in other cases they are present in rock-forming quantities. Accordingly, we can separate ftanite with radiolaria and ftanite with sponge spicules. The SiO_2 content is variable, it can reach 95 % as well. Another frequent constituent is clay, sometimes carbonates and piroclastic material. The organic carbon content of ftanites is high; additionally, pyrite can be present. Phosphatisation is often characteristic. Among the trace elements, it is relatively rich in V, Mo, Cu and Au. Ftanites get easily patinated.

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Ftanitoide rocks – resembling superficially to ftanites, but they are more dark with bluish, azure or green tint. The base material is more crystalline and contains Radiolaria and sponge spicules. Their chemical composition is similar to ftanite but with a lower carbon and phosphorous content. (Хворова 1983)

According to Wallacher 1992, ftanite is an abiomorphic, generally dark grey siliceous rock, a synonyme for „flint", i.e., silex.

Kiss J. (1998) considered lydite and ftanite as synonyme of radiolarites.

Other problematic cases in terminology - Continental / Terrestric siliceous rocks of postvolcanic origin

Metasomatites (~silicified volcanites)

Rocks coming through a metasomatic transformation can be specially varied. Their selected representatives were utilised by the prehistoric tool-makers as well. On the basis of chipped stone artefacts collected on the Palaeolithic settlements of the Beregszász Hills we can observe that several versions of local metasomatic rock were used. Petrographical thin section studies indicate the following:

- among the macroscopically very similar metasomatites that look on macroscopic grounds mainly as (limno)opalites several rock types can be separated, taking into consideration to original rock prior to the transformation;

- analysing the thin sections, three rock groups could be separated: silicified tuff (**Fig. 1.**), silicified tufite (**Fig. 2.**) and opalised rhyolite(**Fig. 3.**);

- due to recent petrographic analyses by B. Rácz the rocks enumerated in the second paragraph cannot be called hydroquartzite, geisirite or limnic opalite/quartzite/chalcedonite because the conditions of their formation does not agree with that of the latter.

Suggestion: we have to re-investigate rock samples named hydroquartzite, geisirite and other "problematic" names. In the case of silicified volcanites, one thin section can be enough to identify the original rock prior to silicification. It is possible, that part of the hydroquartzites / geisirites / limnic quartzites are actually metasomatically transformed (silicified, opalised) volcanic rocks.

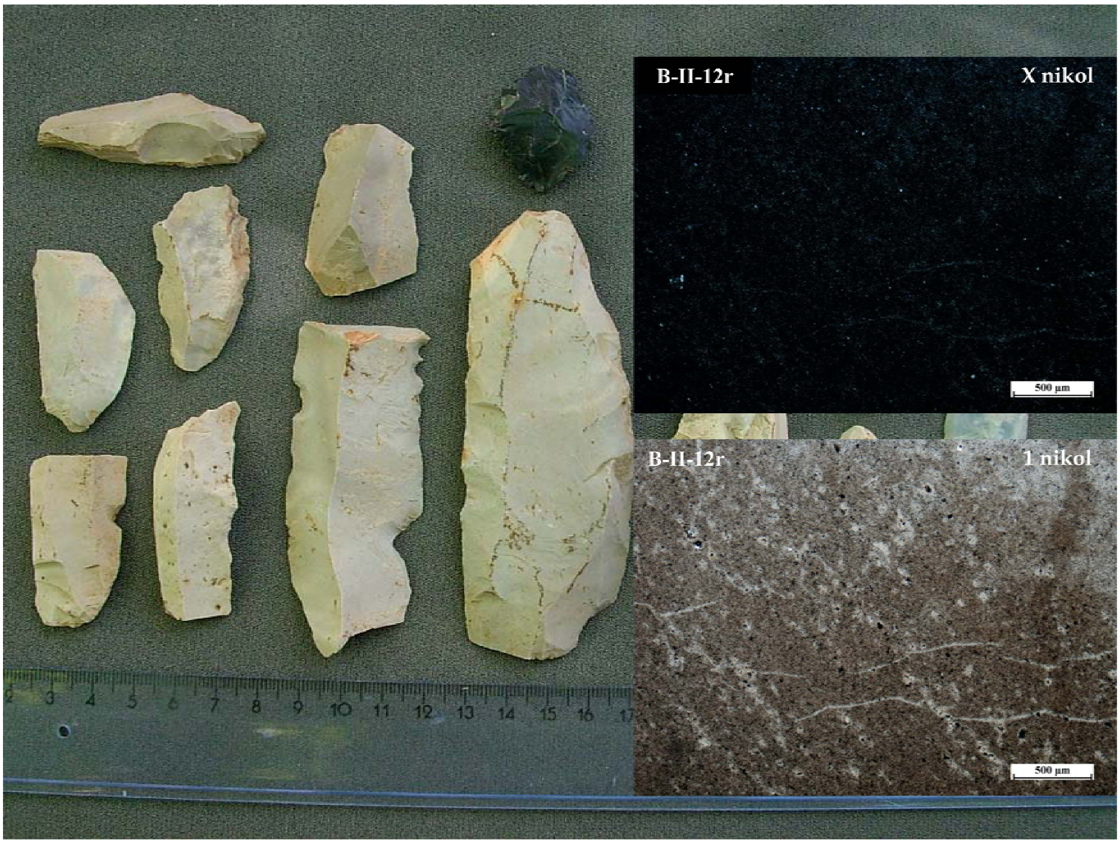

Fig. 1.: Metasomatic rhyolite tuff from the choice of Palaeolithic raw materials on the Western part of the Beregovo (Beregszász) Hills

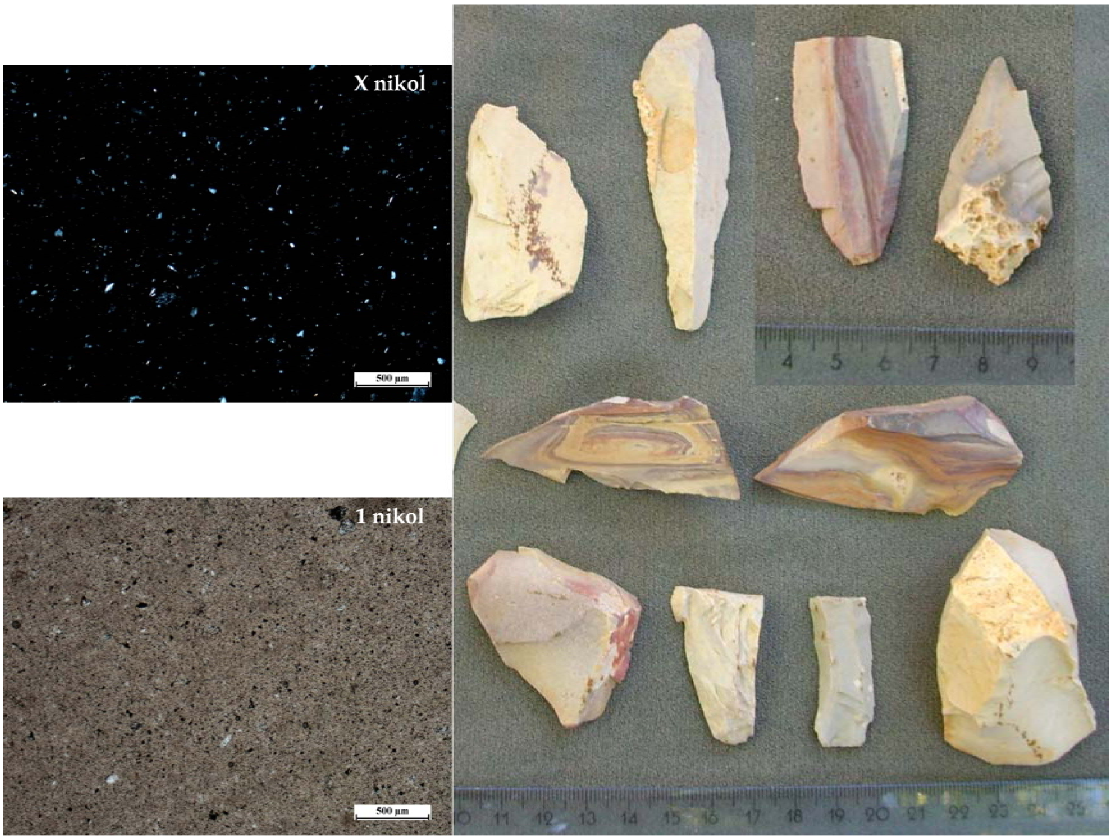

Fig. 2.: Metasomatic tuffite from the choice of Palaeolithic raw materials at the central part of the Beregovo (Beregszász) Hills

Fig. 3.: Metasomatic rhyolite from the choice of Palaeolithic raw materials on the Eastern part of the Beregovo (Beregszász) Hills

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Silicites

Due to the lack of proper descriptions the content of the following rock names are not clear or questionable: limnoquartzite, limnochalcedonite, limnoopalite. In the former Sowiet and the recent Russian-Ukrain technical literature these terms do not exist. According to Wallacher L. (1992), limnoopalites are formed in terrestrial environment precipitated from the water of hydroterms saturated with silica that turn (crystallise) into limnochalcedonite, limnoquartzite by the advance of time.

Suggestion: by petrographical thin section the rock substance (matrix) of the siliceous rocks with limnic origin can be easily observed, comprising dominantly opal, quartz or chalcedony (see Szekszárdi et al. 2010). The siliceous rock limnic should be named after the dominant mineral component. In the case the matrix is basically composed of isotrope opal, the name of the rock should be limnoopalite and, correspondingly, the other names should be made accordingly.

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REVIEW OF THE MINERALOGICAL SYSTEMATICS OF JASPER AND RELATED ROCKS[1]

A JÁSPIS ÉS A VELE ROKON KOVAKŐZETEK ÁSVÁNYTANI OSZTÁLYOZÁSA

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Abstract

A review of the genetic classifications of jasper based on mineralogical data outlines three main types of jasper and related rocks: 1 – jaspers; 2 – jasperoids; 3 – jasper-like rocks. True jasper has a quartz composition and is of metamorphic or metasomatic origin. Related in different colour and density to jasper other rocks of sedimentary or igneous origin can be found usually having a dominantly chalcedony-quartz and feldspar-quartz composition (jasperoids and jasper-like rocks). Main mineral impurities which cause the colour of the described rocks are listed.

Kivonat

A jáspis és a rokon kőzetek genetikai osztályozásával az ásványtani adatok szerint három fő kategóriát különíthetünk el: 1 – jáspis; 2 – jasperoid; 3 – jáspis-szerű kőzetek. A valódi jáspis ásványtanilag kvarckristályokból áll és metamorf vagy metaszomatikus eredetű. Hasonló, változatos színű és sűrűségű kőzetek a jasperoidok és jáspisszerű közetek melyek lehetnek üledékes és magmás eredetűek is, és ásványos összetételük uralkodóan kalcedon és kvarc, vagy földpát és kvarc. A tanulmány foglalkozik a fenti kőzetekben kis mennyiségben előforduló ásványokkal és színező anyagokkal is.

KEYWORDS: JASPER, JASPEROID, JASPER-LIKE ROCK

KULCSSZAVAK: JÁSPIS, JASPEROID, JÁSPIS-SZERŰ KŐZET

Jasper is a widely used term for SiO_2 bearing rocks of predominantly metasomatic or metamorphic origin. They have a variety of different colours and texture, which together with their technical properties, such as density, ability for polish and decorative impact makes them an important raw material for jewellery industry. This mineral aggregate has been used since prehistoric times and in antiquity for beads, ring insets and has been widely applied in glyptic art. Heliotrope, for example, is dark green jasper with small red spots.

The name *jasper* is from the Greek – *ϊασπις* and Latin – *iaspis* (probably related to the Assyrian *eshpu*, Persian *yashon* or *yasp,* or Hebrew *yashpheh*, meaning "spotty" or "flame-like"). According to Fersman (1962), in the Middle Ages in the Central Asian region the term jasper was used for nephrite.

In the classical study "Gemstones" (Smith, 1940) jasper is recognized as "impure opaque quartz, heavily impregnated with impurities, and according to their nature coloured red, yellow, or brown; in ribbon-jasper the colours run in stripes and in Egyptian-jasper in zones".

The wide variety of genetic environments, in which jasper is formed, in some cases has lead to their interpretation as sedimentary or volcanogenic products, and even as a dense variety of quartz (i.e. of hydrothermal genesis). In this respect, a review of the ideas on the origin of jasper, genetic classifications with reference to their mineralogical composition is considered as necessary. There are also classifications based on a decorative, formation and geological-economic principles. In several cases complex classifications are used.

[1] *This is an English translation with additions of: Kostov, R. I. 2006. Review of the mineralogical systematics of jasper and related rocks. – *Geology and Mineral Resources, 13*, 9, 8-12 (in Bulgarian with an English abstract).

According to Fersman (1962) jasper is an aggregate of quartz particles, cemented by quartz or chalcedony and containing an average of about 20% clay mineral impurities. Besides, because of the similarity to other jasper-like rocks (of volcanic or sedimentary origin) jaspers can hardly be distinguished and he assumes, that the term should refer not only to the mineral composition of the rock, but also its technical properties. Fersman (1962) introduces two types of classification for jaspers – a genetic classification including 5 main groups and a practical classification based on texture and colour properties, with 6 main groups.

The genetic classification includes: 1 – contact-alteration radiolarite mud in metamorphic rocks, often interlayered with green tuffs and diabases (ribbon-like jaspers); 2 – metamorphic schists, limestones, marls and other sedimentary rocks undergone replacement by quartz (layered to jasper breccia); 3 – jaspers, related to quartzites and hornfelses; 4 – felsitic porphyry and silicified porphyry rocks (often with a spherulitic composition); 5 – compact coloured varieties of quartz or chalcedony in the agates.

The practical (based on texture; colour) classification includes the following groups: 1 – massive (dense) jaspers with different uniform colour, in some cases with spots and inclusions; 2 – banded (ribbon-like, wavy) jaspers; 3 – porphyritic (with inclusions of feldspars, quartz, augite or amphibole); 4 – variously coloured (uniform with veins from another colour; grains of different colour with uniform in colour cement; with wavy, curly colours); 5 – jasper breccias and conglomerates; 6 – spheroidal ("kopeek"-like) and colomorph (agate) jaspers (coin-like; layer or vein agate; concentric-zonal).

A more detailed textural classification on the base of the Ural jaspers was made by Igumnov (1960), including 11 texture varieties (Semenov, 1979; Arinstein et al., 1986; Putolova et al., 1989): massive, banded (with stripes), brecciated, concentric, colomorphic, concretional, incrusted, cataclastic, curly (with folds), breccia-like, fluidal.

According to Frondel (1962) jasper is a dense opaque quartz rock with a high content (up and above 20%) of mainly iron impurities. Fine grained structure is characteristic especially among the metamorphic varieties. According to the genesis, jaspers are described as big bodies of metamorphic or sedimentary origin. Gradual transition from jaspers towards the varieties of chalcedony or on the contrary is also mentioned.

A non-uniform explanation of the origin of jaspers is observed among other researchers, too. Petrovskii (1969) describes jaspers as primary sedimentary silica rocks undergone intensive influence of effusive, dominantly underwater igneous activity in geosyncline regions (e.g., jasper formation in volcanogenic-flint association after N. S. Shatskii – 1954). According to him, SiO_2 is introduced to the sedimentary basin as a component of gas emanation in the postvolcanic stage accompanied by intensive fumarole activity. Jaspers are characterized with a quartz composition with a novaculite structure (c. Folk & Weaver, 1952) and differ from jasperoids, which are of chalcedony-quartz composition and have a replacement structure (Petrov et al. 1981). Jaspers are reviewed as sedimentary rocks (among the silicites – silica rocks) with a chalcedony and quartz-chalcedony composition in a textbook on sedimentology (Sultanov, 2005).

For comparison a short review has to be made of sedimentary silica formation. The flint rocks (silicites) are with a source of SiO_2 from the earth, igneous activity and water basins. The SiO_2 can be in an amorphous state or crystallized as quartz and other phases. Recrystallization takes part depending on depth (geothermal gradient) and time. Based on mineral composition several main types of sedimentary silica rocks are distinguished (Pettijohn, 1981; Vassoevich et al., 1983):

1. Opal-cristobalite rocks:

a. abiomorphic (with an aggregate-globular structure with 50-85% SiO_2 containing most often impurities of montmorilonite, glauconite, pyrite and zeolites) – represented by tripoli (density 0.7-1.2 g/cm^3); opoka (a bit harder; density 1-1.6 g/cm^3); porcelanite (recrystallized opoka); geyserite (colomorphic; silica-gel).

b. biomorphic (organogenic) – represented by diatomite (fine porous rock with dimensions of the particles 0.01-0.2 mm; it may contain up to 30-70 mln. fossil remains in 1 cm^3 (density up to 0.2-1 g/cm^3, contains up to 80-95% SiO_2); silicoflagelite (density 0.9-1.2 g/cm^3); radiolarite; spongolite (density 1-1.5 g/cm^3).

2. Quartz (chalcedony-quartz) rocks (*=jasperoids, but not jaspers or jasper-like rocks* – comment by the author).

a. abiomorphic – represented by phtanite (lydite) (black compact rocks with clay minerals, organics and pyrite, containing up to 95% SiO_2); phtanitoid (bluish and greenish better crystallized rocks, often Mn-bearing); jaspers (hard, red, green and yellow rocks with uniform or banded texture, containing up to to 97% SiO_2, which can include also impurities of iron and manganese oxides and hydrooxides); novaculite ("Arkansas Stone"), which is milky white in colour, with conchoidal fracture, and contains up to 99% SiO_2.

Table 1.: Mineral phases other than quartz and chalcedony, causing different types of colouration in jaspers (after Yakovleva & Putolova, 1971)

1. táblázat: Egyéb ásványfázisok a kvarcon és a kalcedonon kívül, amelyek a jáspis és vele rokon kőzetek különböző színeit okozzák (Yakovleva & Putolova, 1971 nyomán)

Colour	**Mineral**
Gray	albite, K-feldspar, sericite
Black	magnetite, Mn-oxides
Red, pink	hematite, garnet
Brown	goethite, hematite
Yellow	goethite
Green	chlorite (penine), pumpellyite, epidote, actinolite, clinozoisite, celadonite
Blue, violet	magnetite, glaucophane-riebeckite, hematite

b. biomorphic (organogenic) – represented by radiolarite or spongolite jasper-like rocks and phtanites.

3. Postsedimentary silicites – diagenetic and catagenetic flints (concretions, lenses, layers) distributed in clay-bearing rocks with a dominantly cristobalite composition, and in limestones –with a dominantly quartz (chalcedony) composition; marshalite; silcretes.

The mentioned three types of silica rocks of sedimentary origin have to be differentiated from the typical (true) jaspers, despite the fact that in some cases they look similar and have the same physical properties ("sedimentary jaspers" after Frondel, 1962). The term jaspilite (jaspilyte) has to be added for interlayered jaspers (quartz) with hematite and magnetite in the metamorphosed Precambrian iron formations (iron quartzites). In the *Dictionary of Petrology* jasperoid "is a dense grey chert-like siliceous rock which consists of chalcedonic or cryptocrystalline quartz and which has formed through the silicification of limestone" and jaspilite – interbedded jasper and hematite with at least 25% iron (Tomkeieff, 1983).

The most important mineral impurities, which are the cause for the colouration in jaspers and related rocks, are listed in **Table 1.** According to the frequency of distribution, the SiO_2 varieties are followed by feldspars (up to 70-90%), garnets (up to 20-30%), epidote and pumpellyite (up to 20%), chlorites (up to 10%) hydromicas and amphiboles, and among the most important impurities responsible for colouration – hematite, magnetite and goethite (Barsanov & Yakovleva, 1978).

A common definition of jasper can be found in the *Petrographical Dictionary* (Petrov et al. 1981): a massive dense hard opaque material, with conchoidal fracture, frequently banded or spotted siliceous rock, composed of chalcedony and microgranular quartz with impurities of Al- and Ca-phases, coloured in yellow, redbrown and green colours with fine dispersed iron and manganese oxides. The genesis of the rock is related to metasomatic processes.

Barsanov & Yakovleva (1978), in reviewing the studies on jaspers, distinguish three main genetic cases of jasper formation: 1 – metasomatism during volcanic exhalations and diagenesis of basic volcanic and volcanic-sedimentary materials at near-surface and medium metamorphic facieses; 2 – hydrothermal SiO_2-autometasomatism of volcanogenic rocks; 3 – contact metamorphic rocks of a hornfels type and postvolcanic metasomatism of the tuffogenic covers.

According to Kievlenko (1980) jaspers are the result of metamorphic processes in low temperature metamorphic facieses, and different jaspers are described, as products of greenschist facies metamorphism or of metasomatic replacement and contact metamorphism. In the genetic and genetic-practical classification of jasper formations, Kievlenko & Senkevich (1983) distinguish 4 types: 1 – true jaspers (metamorphosed volcanogenic-sedimentary and hydrothermal-metasomatic formations) of dominantly quartz composition; 2 – jasper-like quartzites and hornfelses, which differ from jaspers with a higher degree of recrystallization of the main mass and by a lot of impurities; 3 – jasperoids (postvolcanic formations of dominantly chalcedony composition); 4 – jasper-like intrusive and effusive rocks with a feldspar-quartz composition. The same classification is accepted in another work about jaspers, where varieties are described with respect to their mineral composition, texture and structural peculiarities (Putolova et al., 1989).

Tomkeieff (1983) uses the description of jasper given by Pettijohn (1975) for rocks of sedimentary origin: "a dense cryptocrystalline, opaque or slightly translucent variety of chert which is usually red in colour, but may be yellow, brown, green or black".

In the definition of Arinstein et al. (1986) jaspers are rocks with SiO_2 composition, high hardness and decorative significance. In the group of "jasper rocks" three cases are listed: 1 – jaspers (dominantly quartz and chalcedony-quartz in composition), represented by altered (metamorphosed) massive microgranular rocks with a beautiful colour – they can be easily polished; 2 – jasperoids (with a dominantly chalcedony and quartz-chalcedony composition), which are considered as volcangenic-sedimentary rocks undergone strong alteration, poorly altered effusive containing SiO_2 and chert rocks originating from the impact of solutions on the contact of serpentinites and volcanogenic formations; 3 – jasper-like rocks (with a significant feldspar and quartz-feldspar composition) – sedimentary and sedimentary-volcanogenic abiomorphic and biomorphic rocks built by SiO_2 and remains of silica organisms, for example lydites (with a dominant chalcedony composition), phtanites (of dominantly quartz composition and with clay and graphite impurities) and tuffites.

Jasper rocks are separated in four groups in a monograph, related to decorative gemmological materials (Putolova et al., 1989): 1 – true jaspers, described as volcanogenic-sedimentary metamorphic and hydrothermal-metasomatic products of dominantly quartz composition; 2 – jasper-like quartzites and hornfelses with a higher degree of recrystallization; 3 – jasperoids represented by postvolcanic SiO_2 formations of dominantly chalcedony composition; 4 – jasper-like intrusive and effusive rocks, of dominantly feldspar-quartz composition. In most gemmological monographs genetic classification of jaspers is not reviewed. For example, O'Donoghue (2006) explains jasper as "the archetypal collectable beach pebble", which "consists of massive, fine-grained quartz, fairly dense, containing significant amounts of other materials, particularly iron oxides".

Jaspers in Bulgaria have been described in two regions – Srednogorie, related to Upper Cretaceous volcanism, and Eastern Rhodopes, linked to Paleogene volcanism, and in both cases the metasomatic replacement of the host carbonate rocks and organic remains is pointed out (Atanasov & Jordanov, 1986). They are considered as hydrothermal formations as they are related to the agates and are recognized not as true jaspers, but as *jasperoids*. In their mineral composition are included chalcedony, quartzine, quartz, lusatite, opal, hematite, goethite, celadonite, magnetite, pyrite, pyrolusite, calcite, siderite and zeolite. The same authors point out to other genetic manifestations of jasper in iron deposits (Kremikovtsi), in Permian breccia-conglomerates and in quartzites from the Paleozoic diabase-phillitoid complex. Secondary deposits of jasper are described in the same regions among the conglomerates of the Paleogene and Pliocene, as well as in the contemporary alluvial and deluvial sediments. In the Eastern Rhodopes good quality heliotrope is also described. Chalcedony composition is suggested for the jaspers (*jasperoids* – comment by the author) from the region of village of Chukovo in the Eastern Rhodopes, and jasper breccia is described at the village of Gaberovo (Iliev, 1996).

Probably the most broad and complete definition of true jasper is: "rocks or mineral formations, which are to be considered mainly among the metasomatic products, as a result of metasomatism (or autometasomatism) and recrystallization of the primary sedimentary-volcanic, effusive or intrusive rocks during the processes of diagenesis, regional, contact-metasomatic and postvolcanic hydrothermal metamorphism" (Barsanov & Yakovleva, 1978).

In conclusion, in contemporary mineralogical and gemmological literature, the following system with three groups has been introduced for jaspers and related rocks according to their mineral composition: true jaspers, jasperoids and jasper-like rocks (Kostov, 2003). The term jasper is suggested to be used only in the case with the first group with the corresponding genetic class (metamorphic or metasomatic) of deposits.

The macroscopic identification of "jaspers" is difficult according to the suggested classification. For their precise determination microscopic, X-ray, and in certain cases additional chemical and spectroscopic methods of study are recommended.

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KÉSŐ VASKORI (KELTA), KORAKÖZÉPKORI ÉS KORA-ÁRPÁD-KORI ŐRLŐKÖVEK FITOLITELEMZÉSE (VAS MEGYE, MAGYARORSZÁG)

PHYTOLITH ANALYSIS OF GRINDING STONES FROM THE IRON AGE, EARLY MIDDLE AND ARPADIAN AGES (VAS COUNTY, HUNGARY)

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Abstract

*Phytolith analysis is already an important method in geoarchaeological researches in Hungary. We analysed millstones from late Iron Age and early Middle Ages from two different sites (Kemenespálfa-Zsombékos, Celldömölk-Vulkánfürdő). We should like to know what kind of plants formed the grown plants by the analysis of the cereal phytoliths sticked on the surface of millstones derive from formerly milled seeds. Altogether 20 millstone-fragments were analysed from 12 different archaeological features. In case of the late Iron Age samples einkorn (*Triticum monococcum*) phytoliths were dominant (Kemenespálfa-Zsombékos) as well as emmer (*Triticum dicoccum*). Samples derive from the Middle Ages contained only common wheat (*Triticum aestivum*) phytoliths to such a degree that in Celldömölk-Vulkánfürdő site we could not clearly identify any other sort of cereals. It is maybe because of the phytolith-loss during the secondary utilisation of millstones (building stones). So the phytolith analysis of millstones can be very effective if we can collect quickly deposited stones without secondary usage.*

Kivonat

*A növényi opalitok vizsgálata hazánkban is kezd a bevett régészeti geológiai módszerek közé tartozni. Munkánk során a Kemenespálfa-Zsombékos valamint a Celldömölk-Vulkánfürdő lelőhelyről előkerült késő vaskori, valamint kora középkori őrlőköveket vizsgáltunk. A minták felületén megtapadt, az egykor megőrölt növényekből származó gabonafitolitok határozásával szerettük volna megtudni, milyen növények alkothatták az egykori őrleményeket. Összesen 20 kőtöredéket vizsgáltunk, melyek 12 objektumból kerültek elő. A késő vaskori (kelta) minták esetében (Kemenespálfa-Zsombékos) az alakor (*Triticum monococcum*) jelentős túlsúlya figyelhető meg, a tönke (*Triticum dicoccum*) mellett. A középkori minták esetében a közönséges búza (*Triticum aestivum*) fitolitjai a meghatározóak, mégpedig annyira, hogy a Celldömölk-Vulkánfürdő lelőhelyen nem is lehetett egyértelműen azonosítani más gabonafélét. Ugyanakkor ez utóbbi lelőhely mintáinak csak kis részéről sikerült fitolitokat kinyerni, aminek az oka a használt malomkövek másodlagos hasznosítása során jelentkező fitolitveszteség. Végeredményben megállapítható, hogy az őrlőkövek fitolitvizsgálata eredményes lehet, amennyiben sikerül megfelelő, azaz a használat után rövid időn belül betemetődött mintákat gyűjteni, elkerülve a másodlagos hasznosítású (pl.: építőkő) eszközöket.*

KEYWORDS: PHYTOLITH, MILLSTONE, GRINDING STONE, CEREAL, NW-TRANSDANUBIA, IRON AGE, MIDDLE AGES

KULCSSZAVAK: FITOLIT, MALOMKŐ, ŐRLŐKŐ, GABONA, NYUGAT-DUNÁNTÚL, VASKOR, KÖZÉPKOR

Bevezetés

A régészeti geológiai és a környezettörténeti kutatások során számos módszert alkalmaznak az egykori környezet és az ott élt emberi közösségek sokrétű kapcsolatának feltárásához. Ezen módszerek közé tartozik a fitolitelemzés, azaz a mikroszkopikus méretű növényi opalitok vizsgálata. A fitolit olyan biomorf részecske (Golyeva 2001), amely a szilícium-dioxid egy speciális szilárd fázisú, amorf megjelenési formája (Sauer et al. 2006). Keletkezésük a növények bőrszövetében történik, ahol a felvett talajvíz oldott kovasav tartalmából a növényi életműködés során hidratált kvarc (SiO_2 x nH_2O) keletkezik, mely felveszi a rendelkezésre álló tér alakját, ezáltal jól azonosítható, jellegzetes alakot ölt (Piperno 1988). A növényi szövetből a szerves anyag elbomlása után szabadulnak fel (Madella 2008).

A fitolitok meghatározásával, anyagi jellemzőikkel, kutatástörténetével az Archeometriai Műhely 2009/2. számában közölt publikáció részletesen foglalkozik (Pető 2009a), így erre mi nem térünk ki, ám néhány kiegészítés megtétele elengedhetetlen, ami a fitolitkutatás hazai eredményeit pontosítja.

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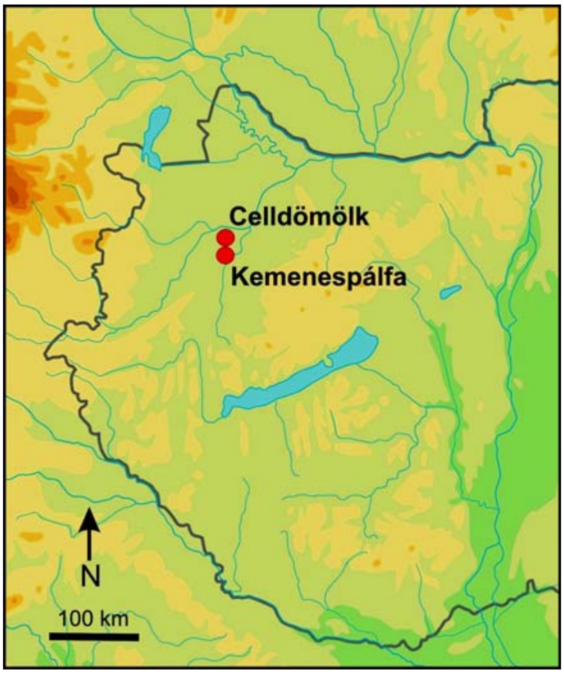
A fitolitok igen ellenállóak, szerkezetüket jól megtartják, különböző felületekhez kötődve (pl.: kémiai kötés a növényi nedvek segítségével vagy a felszín egyenetlenségeiben megbújva) hosszú időn keresztül is fennmaradnak (Ciochon et al. 1990). E tulajdonságaik alapján a fitolitok alkalmasak lehetnek arra, hogy a kőeszközök felületéről feltárva, meghatározzuk az egykor őrölt növényeket (Piperno 2006). Ilyen irányú vizsgálatok még nem történtek hazánkban, annak ellenére, hogy a magyarországi fitolitkutatás már nem előzmények nélküli, hiszen külföldi és hazai kutatók is dolgoztak magyarországi lelőhelyekről származó mintákon.

Külföldi kutatóként Salvatore Engel-di Mauro magyarországi löszszelvények paleotalajait vizsgálta, és egyben publikálta az első Magyarországról származó, komplett fitolit-adatsorokat (Engel-di Mauro 1995). Majd egy évtizeddel később, a Körös kultúra környezetre gyakorolt hatását próbálta fitolitok alapján kimutatni a Kiri-tóból vett fúrásmintákon Pia Windland oxfordi kutató (Windland 2007), míg ezzel párhuzamosan Marco Madella a Körös kultúra árkainak betöltését vizsgálta Ecsegfalván (Madella 2007). Kronológiai sorrendben az első hazai kutató Gyulai Ferenc volt, aki Balatonmagyaród-Hídvégpuszta bronzkori növényleleteit és élelmiszermaradványait dolgozta fel (Gyulai 1993, 1996). E munkák során a zürichi Benno Richter mikroszkópos megfigyelései eredményeképpen bronzkori „szamócás süteményben" mutattak ki többek között *Panicum* sp. és *Triticum* sp. fitolitokat (Gyulai 1996). A későbbiekben Pető Ákos (KÖSZ) újkőkori (Tiszasziget) ételmaradványból mutatott ki gabona fitolitokat, valamint keményítő és pollen maradványokat (Pető & Pópity 2010).

A hazai halomkutatás új kutatási iránnyal bővült, mikor első ízben vizsgálták kurgánok (Lyukas-halom, Csípő-halom) talajainak fitolitjait Alexandra A. Golyeva moszkvai kutató vezetésével (Pető 2006, Barczi 2007). Későbbiekben a fitolitvizsgálatok köre egyre bővült pl.: bakonyi recens talajok fitolitjainak vizsgálatával (Pető 2009a), a fertődi Hercegi és Hercegnői Kamarakertekben mélyített kutatóárokból származó minták elemzésével (Pető 2009b) és a hódmezővásárhelyi Kopáncs II/11. lelőhely avar épületéből vett minták vizsgálataival (Pető 2010).

A Szegedi Tudományegyetem Földtani és Őslénytani Tanszékén 2005-óta szerves része a régészeti geológiai és környezettörténeti kutatásoknak a fitolitelemzés. E munkák során kilenc magyarországi és egy hollandiai lelőhelyről, összesen 462 mintát dolgoztunk fel, melyek különböző régészeti objektumokból (pl.: kemence, gödör, árok, sír, kút, cölöplyuk, hombár, fog, koprolit), löszfalból, üledékgyűjtő medencékből (láp, morotva) származtak (Persaits et al. 2008, Persaits 2010, Persaits & Raemaekers 2010).



1. ábra: A vizsgált minták lelőhelyeinek elhelyezkedése a Dunántúlon

Fig. 1.: The location of sample sites in Transdanubia

Tapasztalataink alapján a malom- és őrlőkövek felületén megőrződött fitolitok elemzése egyedülálló lehetőséget kínál az egykori őrlemény azonosítására.

Célkitűzés

Kutatásaink során régészeti ásatásokról előkerült, különböző korú őrlőkövek felületén megőrződött, az egykor feldolgozott növényekből származó fitolit kinyerésének módszerével, majd a növényi opalitok határozását követően, a feldolgozott növények meghatározásával foglalkoztunk. Egy olyan rutinszerűen is használható módszert szerettünk volna kialakítani, mely gyorsan és költséghatékonyan használható hasonló vizsgálatok esetében. Az új módszer bevezetésével a sikeres fitolitfeltárás és határozás után, a lelőhelyre vonatkozó archeobotanikai adatok igen fontos ismeretekkel bővülhetnek.

A vizsgált minták és lelőhelyük ismertetése

Kutatásaink során két nyugat-magyarországi lelőhelyről előkerült őrlő- és malomköveket vizsgáltunk (**1. ábra**). Az első lelőhely Kemenespálfa határában található (Farkas 2008), a Marcal folyó bal partján, az egykori zsombékos, tőzeges, lápos árterület platószerűen kiemelkedő partján. A lelőhely feltárása a Boba-Ukk vasúti deltavágány rehabilitációja miatt vált szükségessé.

2. ábra: A Kemenspálfa-Zsombékos lelőhely mintái

Fig. 2.: Samples from the site Kemenspálfa-Zsombékos

Az ásatásokat Farkas Csilla, a szombathelyi Savaria Múzeum régésze vezette. A lelőhely újkori földkitermelés miatt bolygatott, több objektum elpusztult, az általunk elemzett minták mindegyike gödörből (közelebbi funkciójukat nem sikerült meghatározni) került elő. Az öt darab késő vaskori (kelta) minta a Kemenespálfa-Zsombékos lelőhely 49. objektumából, míg a szintén öt darab 9-10. század első harmadára tehető minta Kemenespálfa-Zsombékos 31. objektumából származik (**2. ábra**).

A második vizsgált lelőhely a Ság-hegy lábánál elhelyezkedő Celldömölk-Vulkánfürdő (Ilon & Pap 2004), melynek feltárása a celldömölki Vulkán Gyógy- és Élményfürdő építését előzte meg. Az ásatást Pap Ildikó Katalin, a szombathelyi Savaria Múzeum régésze vezette. A feltárt 13 minta 8 objektumból származik, melyek kora a 10-11. századra tehető (**3.ábra**). Két gödörből származó minta kivételével (52. objektum CVF-1 valamint 116. objektum CVF-5) másodlagos helyzetből kerültek elő, műhelyekből vagy éppen kemence szája mellől, ami a kövek utólagos hasznosítására utal.

A fitolitok feltárásának módszertana

A fitolitok talajból, paleotalajból vagy egyéb kőzetből való szeparálása rutin feladatnak tekinthető, számos eljárást dolgoztak ki a különböző beágyazó anyagokat figyelembe véve (Pearsall 1989, Piperno 2006). A malom- és őrlőkövek esetében a feltárást megnehezíti a fitolitoknak a kőzetről való leválasztása. Ennek egyrészt méretbeli korlátai vannak, hiszen az ultrahangos medence befogadóképessége fontos limitáló tényező, ami miatt nem is tudtuk valamennyi, a lelőhelyekről előkerült őrlőkövet feltárni (Ebben az esetben a kézi depurátor segítségünkre lehet, azonban ezt csak kiegészítő módszernek tekintjük, karakteres felületi egyenetlenségek alapos feltárásához. Természetesen a beágyazó közeg is tartalmaz fitolitokat, így a kövekre a betemetődés után is kerülhettek növényi opálszemcsék a talajból, melyek jelen esetben számunkra érdektelenek.

3. ábra: A Celldömölk-Vulkánfürdő lelőhely mintái

Fig. 3.: Samples from the site Celldömölk-Vulkánfürdő

A beágyazó talajmintából nem tudtunk mintát venni, mivel az ásatások óta a területre tervezett beruházások elkészültek (pl.: Vulkán Fürdő), a lelőhelytől távolabbról pedig már eltérő talajfejlődés tapasztalható. Véleményünk szerint a mintán található elsődleges, azaz csak az őrlés során megtapadt fitolitok kizárólagos szeparálása lehetetlen, teljes biztonsággal azonban sosem jelenthetjük ki, hogy egy adott fitolit biztosan az őrléskor került a felületre, mint ahogy azt sem tudjuk pontosan megadni, mekkora lehetett a betemetődés alatti fitolit veszteség. Mégis, két eszköz áll rendelkezésünkre, hogy a „találati arányt" pontosítsuk:

1. A minták megtisztítása oly módon, hogy csak a közvetlenül a kövek felületén található fitolitok maradjanak meg (pl.: repedésbe tapadva).

2. A határozás során csak a potenciálisan őrlésre szánt növények fitolitjait vizsgáljuk, melyek jó eséllyel valóban az őrlés során kerültek a mintákra, míg a többi fitolittal nem foglalkozunk.

A feltárás első lépéseként ecsettel tisztítottuk, majd a mintákat langyos folyó vízzel óvatosan, erős dörzsölés nélkül leöblítettük. Ezt követően speciális műanyag zacskóba, majd 30 percre ultrahangos fürdőbe helyeztük (Parr 2002). A kihullott fitolitokat zacskóban fogtuk fel, majd ebből nyertük vissza bepárlás után. Ezt követően a kinyert poron hajtottuk végre a fitolitextrakció lépéseit (Piperno 2006, Persaits 2010). A calgon-oldatos rázatást a szervesanyag, majd a karbonátok elroncsolása követte. Nedves szitálás segítségével leválasztottuk a 250 mikronnál nagyobb szemcsetartományt, míg Atterberg-féle ülepítéssel az agyagfrakciót, végül a megmaradt anyagot bepárlás után nehézfolyadékkal flotáltuk. Ehhez 2,3 g/cm^3 sűrűségű nátrium-poliwolframát vizes oldatot használtunk (Madella et al. 1998). Ekkor a fitolitok felúsztak az oldat felső részébe, míg a nehezebb ásványi kvarc lesüllyedt. Pasteur pipetta segítségével összegyűjtöttük a fitolitokat, melyeket glicerinbe ágyazva helyeztünk mikroszkóp alá. A határozás és számlálás 500x nagyítás mellett történt, háromszoros ismétléssel. Valamennyi minta fitolit morfotipusát dokumentáltuk Canon digitális fotófeltét segítségével.

A határozás során a nemzetközi szakirodalomban elfogadott (International Code for Phytolith Nomenclature 1.0, Madella et al. 2005) nevezéktant alkalmaztuk.

A gabonafitolitok azonosításának módszertana

A gabonanövények azonosítása, pontos meghatározása, a növénynemesítés állomásainak elkülönítése kiemelt jelentőségű valamennyi, a régészeti lelőhelyekről feltárt növényi maradványokkal foglalkozó tudományterületen. A fitolitkutatás egyik izgalmas kérdése a gabonafitolitokon belül a faj szinten történő határozás, melynek jelentősége az első régészeti lelőhelyről feltárt gabonafitolitok azonosítása óta egyre nő (Schellenberg 1908, Kislev 1984, Sallers 1991). Jelenleg a kutatások középpontjában az alakor (*Triticum monococcum* Schrank.), a tönke (*Tr. dicoccum* L.), a közönséges búza (*Tr. aestivum* L.) és az árpa (*Hordeum vulgare* L.) elkülönítésének vizsgálata áll (Rosen 1992, Ball et al. 1993, Tubb et al 1993, Ball et al. 1996, Ball et al. 1999, Berlin et al. 2003), melynek alapvető problematikája a fitolitformákban jelentkező redundanciára és sokszerűségre vezethető vissza.

A gabonafitolitok határozásának két megközelítése ismert:

1. A *morfológián* alapuló határozás lényege, hogy a kutató a rendelkezésre álló összehasonlító anyag segítségével, formai bélyegek alapján azonosítja a fitolitokat. Ennél a módszernél két fontos követelményt kell teljesítenie a kutatónak. Az alapos határozáson kívül el kell fogadnia, hogy bizonyos fitoliformákat nem lehet a kívánt rendszertani pontossággal meghatározni.

2. A *morfometriai* méréseken alapuló eljárás a különböző fitolitformák lemért paraméterei alapján határoz, ami adott esetben akár tíz különböző hosszúsági (pl.: hosszúság, szélesség) és nyolc formára vonatkozó (pl.: kompaktság, nyúltság) adatot is jelenthet. A mért értékek segítségével történik egyes taxonok meghatározása, mégpedig táblázatban megadott, statisztikai számításokkal kialakított (diszkriminancia analízis) méretbeli osztályok segítségével (Ball et al. 1996, Ball et al. 1999, Berlin et al. 2003).

Kézenfekvőnek tűnik, hogy munkánk során az utóbbi, morfometriai méréseken alapuló megközelítést alkalmazzuk, azonban a "kevesebb néha több" elvét alkalmazva, mi a morfológiai határozást végeztünk a mintákon. A morfometriai megközelítésben bizonyos mérések számunkra értelmezhetetlenek (pl. törött fitolitok hosszmérése), továbbá a nehezen elkülöníthető formák esetében túlságosan nagy átfedést adnak az ismertetett adatsorok (Ball et al. 1996). Nem szabad figyelmen kívül hagyni azt a tényt, hogy az eddigi morfometriai megfigyelések egyrészt recens növényeken történtek (Ball et al. 1996, 1999), másrészt pedig, több mint 3000 éves közel-keleti mintákon (Berin et al. 2003), melyekkel a mi nyugat-dunántúli késő vaskori és Árpád-kori fitolitjaink nem biztos, hogy összevethetőek. Ennek oka egyrészt az, hogy a fitolitprodukciót nem csak a növény, hanem talaj és a klimatikus viszonyok is befolyásolják, nem beszélve arról, hogy a betemetődés után is sérülhet, változhat a fitolitok alakja úgy, hogy a mérések értelmüket vesztik (Piperno 2006, Boateng et al. 2007).

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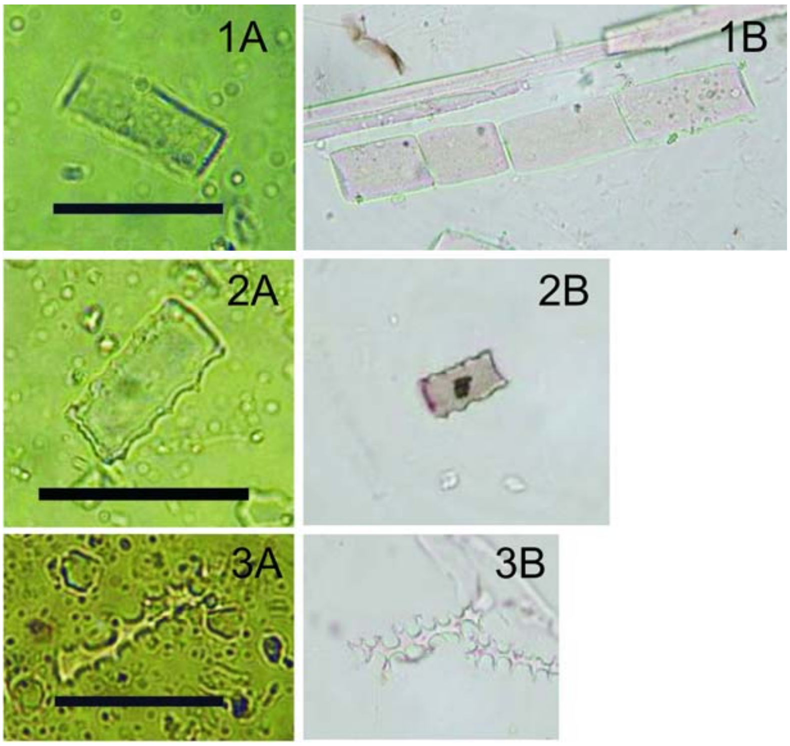
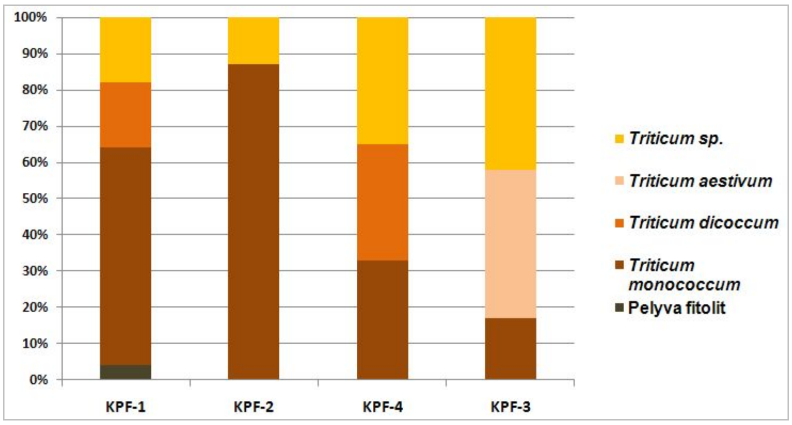


4. ábra: A feltárt minták felületéről feltárt válogatott fitolitformák referenciafotóval

1A = *Triticum monococcum* L. (KPF-2 minta) - Elongated epidermal long cell (stem)
1B = *Triticum monococcum* L. UCL OWRP referencia
2A = *Triticum dicoccum* Schrank. (KPF-1 minta) - Elongated sinuate epidermal long cell (chaff)
2B = *Triticum dicoccum* Schrank. UCL OWRP referencia
3A = *Triticum aestivum* L. (KPF-3 minta) - Elongated dendriform epidermal long cell (glume)
3B = *Triticum aestivum* L. UCL OWRP referencia
méretarány = 50 µm

Fig. 4.: Selected phytolith forms extracted from the surface of the samples with photos of reference types



5. ábra: A gabonafitolitok megoszlása az egyes mintákban (Kemenespálfa-Zsombékos)

Fig. 5.: The distribution of cereal phytoliths in the samples studied (Kemenespálfa-Zsombékos)

További problémát jelent az, hogy nem tudjuk pontosan, történt-e méretbeli változás a gabonanövények hosszú időbeli és térbeli vándorlása közben (neolitikus expanziót követő, hosszú ideig tartó lokális kultiváció, eltérő környezeti feltételek mellett). Összevethetőek-e egyáltalán eltérő korok és kontinensek fitolitparametriai adatai? (A tönke esetében a magok mérete eltér a késő bronzkori és a recens minták esetében (Kohler-Schneider 2003), de gabonapolleneknél is megfigyelhető méretbeli változás.) Amíg ezekre a kérdésekre megnyugtató választ nem kapunk, eltekintünk a különböző adatok kontroll nélküli hazai adaptációjától.

A gabonafitolitok határozása összesen kilenc forma (papilla, trichome base, dendriform, small-prickle, large-pricke, hair cell, stomata, epidermal long cell, subepidermal rod-shaped) alapján történhet (Ball et al. 1999), melyek közül mi minden esetben csak azokat a formákat vettük figyelembe, melyek morfológiai alapon egyértelműen azonosítható. A határozáshoz a szakirodalmakban fellehető fotódokumentáción (Kaplan et al. 1992, Mulholland & Rapp 1992, Rosen 1992, Ball et al. 1993, Tubb 1993, Lentfer et al. 1997, Ball et al. 1999, Berlin et al. 2003) kívül felhasználtuk a Colonial Williamsburg, az UCL Institute of Archaeology - Old World Reference Phytoliths (UCL OWRP), valamint az SZTE TTIK Földtani és Őslénytani Tanszék adatbázisát.

A Kemenespálfa-Zsombékos lelőhely mintáinak fitolitelemzési eredményei

A lelőhelyről előkerült alakor (1A), tönke (2A) és közönséges búza (3A) fitolitformáit a **4. ábra** tartalmazza a referenciafotókkal (1B, 2B, 3B) együtt, melyek az UCL IA adatbázisából származnak. A feltárt gabonafitoliok arányait az **5. ábra** szemlélteti. A mintából feltárt fitolitok az egykori gabonanövények pelyvaleveléből, toklászából esetleg szárából származhatnak, de semmiképpen sem a magból, mivel az nem tartalmaz fitolitokat. A fitolitok jelenléte a magok kevésbé alapos tisztításának köszönhető. Ezzel párhuzamosan a gabonafitolitok hiánya az őrlőköveken a magvak alapos tisztítására utal, mely összefüggésben lehet a mindenkori agrotechnikai ismeretekkel.

Kelta őrlőkő maradványok (KPF-1, KPF-2, KPF-4): A vizsgált minták közül egy alkalommal került elő pelyva fitolit (KPF-1). A gabonafitolitok esetében az alakor (*Triticum monococcum*) dominanciája a meghatározó, különösen a KPF-1 és KPF-2 minta esetében. Igen szembetűnő ez a középkori mintával összevetve (KPF-3). A KPF-1 és KPF-4 minták felületéről tönke (*Triticum dicoccum*) fitolitok is előkerültek, az első esetben kisebb, míg a második esetben az alakoréval közel megegyező arányban. A pontosabban nem határozható gabonafitolitok aránya 20% alatti a KPF-1 és KPF-2 minta esetében. A KPF-1 és KPF-4 őrlőkövek (fitolitformái közel azonos eloszlást mutatnak, míg a KPF-2 minta csak két fitolittípust tartalmazott, melyek között az alakor több mint 85%-ot tesz ki, ami azért is különös, mert az archeobotanikai maradványok alapján a vaskorban, az alakor jelentős visszaszorulását valószínűsítik (Gyulai 2001). Természetesen a vizsgált minták kis mennyisége messzemenő következtetéseket nem tesz lehetővé, de az biztosan kijelenthető, hogy ezekkel a kövekkel elsősorban alakort és tönkét őröltek.

Középkori malomkő (9-10. század első harmada) töredékei (KPF-3): A vaskori (kelta) töredékekkel szemben jelentős eltérés tapasztalható, ugyanis e malomkövek felületéről kinyert fitolitok között már a közönséges búza (*Triticum aestivum*) fitolitjai, valamint a pontosabban nem határozható gabonafitolitok dominálnak. Jelen van még az alakor is kisebb arányban (15%). Bár a közönséges búza megjelenése várható volt a mintákban, a fitolitok alapján egyértelműen továbbra is csak három őrölt gabonafélét különíthetünk el.

A Kemenespálfa-Zsombékos lelőhely mintáin végzett elemzés értelmezése

A vizsgált minták közül a késő vaskori (kelta) kövek eredménye különösen izgalmasnak nevezhető. A mintáról alakor (*Triticum monococcum*) és tönke (*Triticum dicoccum*) fitolitja került elő, és egyáltalán nem volt jelen a közönséges búza (*Triticum aestivum*). Gyulai Ferenc megállapítása szerint „a késő vaskorban csak szórványként, inkább csak gyomnövényként fordult elő” (Gyulai 2001) az alakor, bár a jelenlétét a vaskor közepéig folyamatosnak írja le (Gyulai 1991). Ennek ellenére a vizsgált mintákon 30-85 %-ban van jelen az alakor fitolitja. Árendás Veronika összehasonlító elemzésében (Árendás 1982), mely nem túl gazdag leletanyagon alapul, a vaskori növénytermesztést a bronzkorihoz tartja hasonlónak, mely azt támasztja alá, hogy az alakornak jelentősebb szerepe lehetett a mai Vas megye területén hajdan élt kelták életében is, mint pusztán gyomnövény. P. Hartyányi Borbála és Nováki Gyula összefoglaló munkáiban (P. Hartyányi – Nováki 1968, 1975a, 1975b) a nyugat-magyarországi régészeti lelőhelyeken mindenhol jelentős mennyiségű alakorról tesz említést, igaz, a tönke aránya mindenhol nagyobb, bár a lelőhelyek zöme kora vaskori és nem késő vaskori. Ugyanakkor több lelőhelyről (6 vaskor és 3 császárkori lelőhely) került elő az alakor mind a vaskori, mind a császárkori („római kori” a táblázataikban) anyagból, mint tönke (4 vaskori és 1 császárkori lelőhely). A *Triticum aestivum* pedig (ami a fitolitelemzés során a vaskori mintákról nem került elő) több nyugat-magyarországi lelőhelyről is előkerült, de ahol mennyiségi összehasonlításról is van adatunk (Celldömölk-Sághegy), ott arányaiban elmarad az alakortól és a tönkétől.

Az alakor jelentőségének megítélése nem lehetséges ilyen kevés őrlőkő vizsgálata alapján, azonban a későbbiekben sokat segíthet e kérdés tisztázásában. Felmerül ugyanakkor a kérdés, hogy lehetséges volt-e esetleg a különböző gabonák elkülönített, szelektív őrlése? Ebben az esetben, ha a vizsgált őrlőkővel utólag alakort őröltek, esetleg az alakor fitolitok felülreprezentáltak lehetnek.

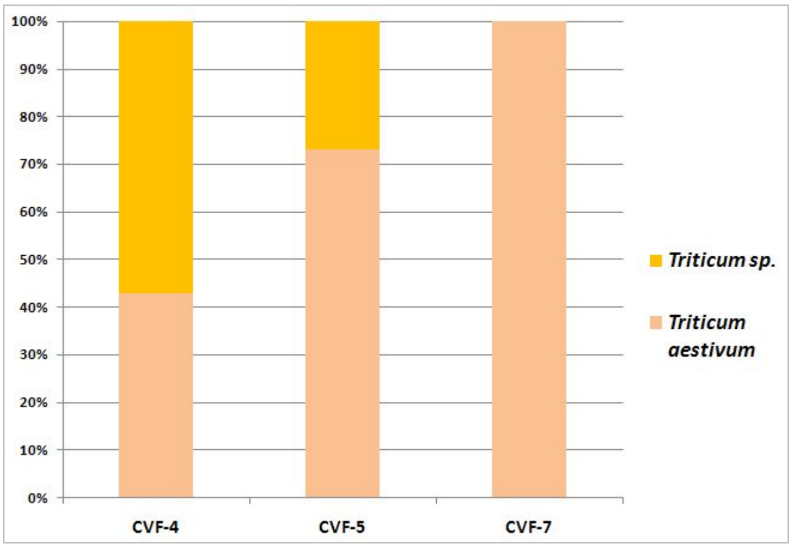
A tönke „továbbra is kiemelt fontossággal termesztett kenyérgabona” (Gyulai 2001), melyet a fitolitelemzés is alátámaszt a vaskori mintákon.

Fontos kiemelni, hogy a nyugat-magyarországi késő vaskori lelőhelyek növény, mag- és terméshleleteiről igen kevés információ áll rendelkezésre a kora vaskori, valamint a császárkori adatokhoz képest.

A középkori minták fitolitelemzése a várakozásoknak megfelelő eredményeket hozta, azaz a korai gabonafélék (alakor, tönke) aránya visszaszorult (Gyulai 2001).

Az őrlő- és malomkövek felületéről ultrahangos eljárással feltárt gabonafitoliok nagy valószínűséggel a növények őrlőse során tapadtak meg a kövek felületén. Ezek alapján feltételezhetjük, hogy a mintákból kimutatott gabonafajok jelenléte a vizsgált mintákkal összefüggésben biztosra vehető, hiszen a beágyazó talajból történt szennyezés esetén a minták hasonlósága nagyobb volna.

Arányaik vitathatóak, hiszen több tényező is befolyásolhatta megmaradásukat (pl.: mit őröltek utoljára, lehetséges volt-e a szelektív őrlés, stb.). Recens kísérleti régészeti vizsgálatokkal kiegészítve, melyek segítségével a fitolitok megőrződéséről kapnánk pontosabb információkat, a különböző korú őrlő- és malomkövek vizsgálata fontos eredményekkel szolgálhat a jövőben.



6. ábra: A gabonafitolitok megoszlása a vizsgált mintákban (Celldömölk-Vulkánfürdő)

Fig. 6.: The distribution of cereal phytoliths in the samples studied (Celldömölk-Vulkánfürdő)

A Celldömölk-Vulkánfürdő lelőhely mintáin végzett fitolitvizsgálatok eredményei

Összesen három mintából sikerült gabonafitolitokat kimutatni (**6. ábra**), azonban ezek a minták jelentős számú egyéb fitolitformát is tartalmaztak (melyek elemzésével nem foglalkoztunk), azonban a fennmaradó öt mintából az egyéb (nem gabona) fitolitok közül is csak 1-1 darabot sikerült leszámolni.

A CVF-4 (104. objektum) minta két darab kőminta felületéről származó fitolitokat tartalmazott. Összesen 7 darab gabonafitolitot sikerült kimutatni, melyek közül 3 volt azonosítható, mégpedig *Triticum aestivum* L. (közönséges búza) fitolitjaiként. A többi fitolitról nem lehet egyértelműen kijelenteni, hogy milyen gabonafélétől származik, azonban valószínűsíthető, hogy szintén a közönséges búzától.

A CVF-5 (116. objektum) minta viszonylag nagy felületéről 26 gabonafitolitot sikerült meghatározni. Ezek nagy része szintén a közönséges búzától származnak. A pontosabban nem határozható töredékek kisebb arányban szerepelnek.

A CVF-7 (126. objektum) minta összesen egy gabonafitolitot tartalmazott, mégpedig egy közönséges búzától származót.

A Celldömölk-Vulkánfürdő lelőhely mintáin végzett elemzés értelmezése

A vizsgált minták közül nem mindegyik tartalmazott fitolitot. A meghatározott fitolitok azonban egyértelműen a közönséges búza (*Triticum aestivum*) dominanciáját mutatják. Ez az adat hasonló a Kemenespálfa-Zsombékos lelőhelyről előkerült, hasonló, bár kissé idősebb korú minta eredményeihez. Vannak azonban fontos eltérések. Egyrészt, a kemenespálfai minta jóval több (50 db-ot meghaladó) fitolitot tartalmazott, másrészt pedig jelen voltak az alakor (*Triticum monoccoum*) fitolitjai is.

Annak ellenére, hogy a kutatási tapasztalatok még messze nem elégségesek (alacsony a vizsgált mintaszám őrlő- és malomkövek esetében), felmerül a kérdés, hogy mi okozhatja a celldömölki minták jóval alacsonyabb fitolittartalmát, a kemenespálfaiakhoz képest, mikor maga az őrlési technika és a növények nem térhetnek el jelentősen?

A feltárási módszer, a laboratóriumi körülmények, valamint a határozás metódusa azonos volt. Így a felmerülő okok ezek alapján a következőek lehetnek:

A vizsgált köveken nem is voltak fitolitok, azaz nem gabona őrlésére használták őket (pl.: festék alapanyag, kohósalak).

Annak ellenére, hogy a köveken/kövekkel gabonát őröltek, a fitolitok nem őrződtek meg a felületükön. A fitolitok eltűnhettek egyrészt az őrlés és a beágyazódás közti időben (2.1), vagy akár a beágyazódás során (2.2).

A beágyazódás (2.2) során a felületen kötött fitolitok viszonylag jó eséllyel fennmaradnak, azonban a kérdés alapos vizsgálata során fontos lenne a celldömölki és a kemenespálfai beágyazódási körülményeket (talaj, vízmozgás) összevetni, azonban erre már nincs lehetőség. Minden esetre a talajvíz okozta fitolit-lemosódásnak ellentmond, hogy a steril celldömölki minták nem csak gabonafitolitokat, de szivacstűket sem tartalmaztak. Az intenzív vízhatás mellett ugyanis számíthatunk az eltemetett malomkövek felületére utólagosan kötődő szivacstűk jelenlétére, melyek a mintát beágyazó talajból származnak. Mindezek után elképzelhető, hogy a gabonafitolitok az őrlőkő használaton kívül helyezése és a

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beágyazódás közti időben (2.1) váltak sterillé. A vizsgált minták közül mindössze kettő (CVF-1 és CVF-5) volt gödörben, míg a többi házakban, kemence szájából került elő, azaz az őrlés után egyéb építészeti/erősítési célokra használták. Ez utóbbi esetben azonban jóval több idő volt arra, hogy az őrlőkő felületéről a gabonafitolitok eltávozzanak (leöblítés, kopás, stb.). Részben ezt a feltételezést támasztja alá:

- a legtöbb fitolitot tartalmazó minta gödörből került elő

- a gödörből előkerült minták jóval nagyobb arányban tartalmaznak fitolitokat (50%) mint az egyéb helyekről előkerült minták (33%)

Természetesen a mintaszám alacsony, messzemenő statisztikai értékelésre nem alkalmas, különösen a beágyazódási körülmények alapos ismerete nélkül. Nem szabad elfelejteni továbbá, hogy gödörből is került elő gabonafitolitokat nem tartalmazó minta, amiről nem tudhatjuk, hogy az őrlés után milyen hamar került oda (valószínűleg ennek is volt másodlagos hasznosítása).

Összefoglalás

A malom- és őrlőkövek felületén megtapadt, az egykori feldolgozott növényekből származó fitolitok elemzése további fontos adatokkal bővítheti a régészeti növénytan eredményeit. Vizsgálatunk inkább nevezhető kísérleti munkának, mint átfogó kutatásnak, hiszen kis mintaszámot dolgoztunk fel. Mindazonáltal reméljük, hogy a jövőben mind több lelőhely, különböző korú kőeszközének felületéről származó növényi maradványok válnak ismertté.

A felmerülő kérdések tisztázásban, a minták értelmezésében nagy segítséget nyújtana a kísérleti régészet során felhasznált eszközök módszeres vizsgálata is, a rátapadt/megőrződött fitolitok szempontjából.

Köszönetnyilvánítás

Ezúton szeretnénk megköszönni a Vas Megyei Múzeumok Igazgatóságának valamint a Szegedi Tudományegyetem Földtani és Őslénytani Tanszékének minden támogatását, amivel a munkánkat segítették.

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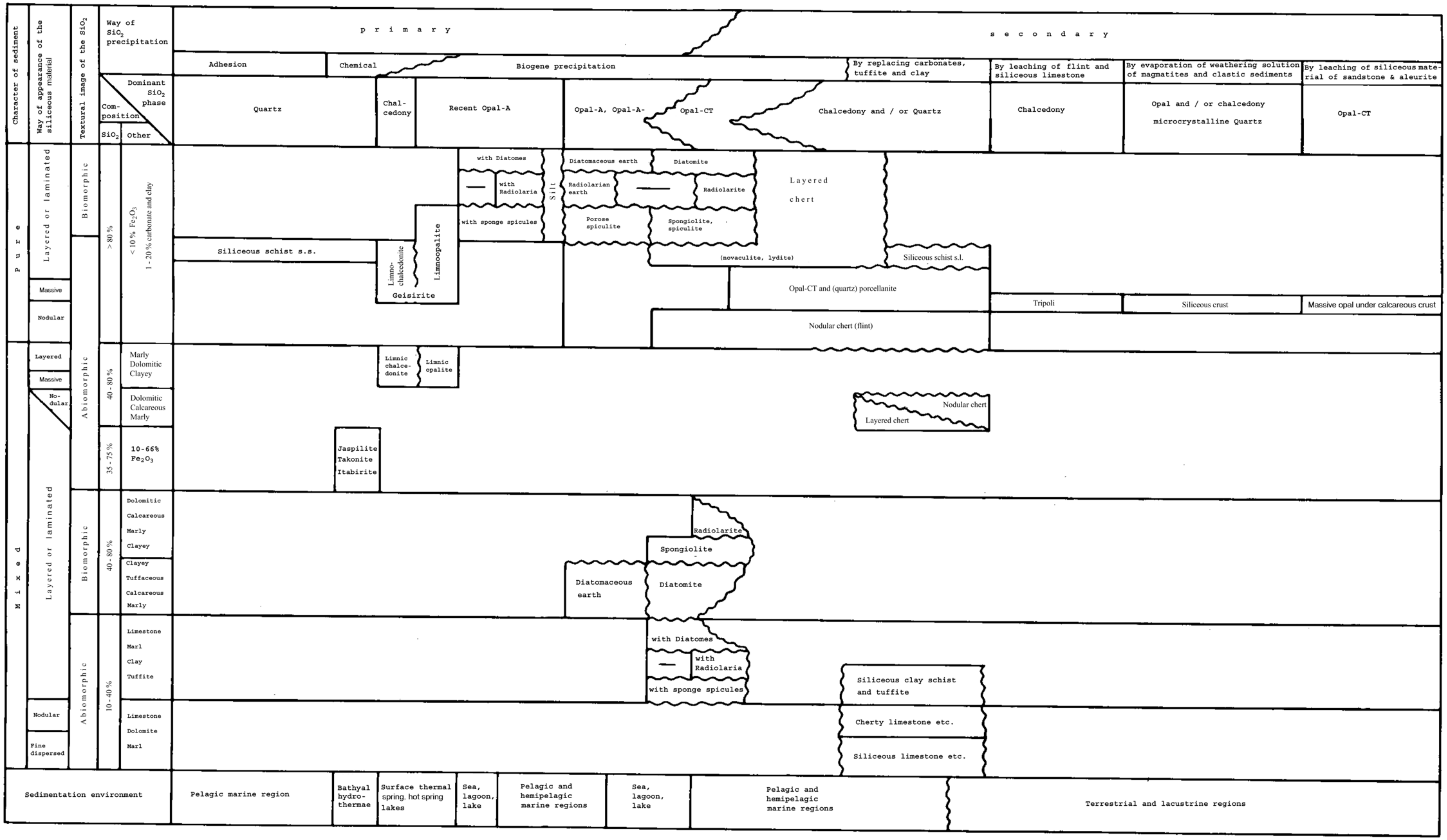
PETROGENETICAL GROUPING OF THE MOST IMPORTANT SILICEOUS SEDIMENTS



After BALOGH (1991) Fig 26.23/b