POSSIBLE PROVENANCES OF NEPHRITE ARTEFACTS FOUND ON HUNGARIAN ARCHAEOLOGICAL SITES

(PRELIMINARY RESULTS)

MAGYARORSZÁGI RÉGÉSZETI LELŐHELYEKEN TALÁLT NEFRIT ESZKÖZÖK ÉS EZEK LEHETSÉGES SZÁRMAZÁSI HELYE

(ELŐZETES EREDMÉNYEK)

PÉTERDI, BÁLINT[1,*], SZAKMÁNY, GYÖRGY[2], BENDŐ, ZSOLT[2], KASZTOVSZKY, ZSOLT[3], T. BIRÓ, KATALIN[4], GIL, GRZEGORZ[5], HARSÁNYI, ILDIKÓ[3], MILE, VIKTÓRIA[3], SZILÁGYI, SZANDRA[3]

[1] Geological and Geophysical Institute of Hungary, Department of Geological and Geophysical Collections, H-1143, Stefánia út 14, Budapest, Hungary

[2] Eötvös Loránd University, Faculty of Science, Institute of Geography and Earth Sciences, Department of Petrology and Geochemistry, H-1117, Pázmány Péter sétány 1/C, Budapest, Hungary

[3] Centre for Energy Research, Hungarian Academy of Sciences, H-1121, Konkoly Thege Miklós út 29-33, Budapest, Hungary

[4] Hungarian National Museum, Múzeum körút 14-16, 1088 Budapest, Hungary

[5] University of Wrocław, Institute of Geological Sciences, Pl. Maksa Borna 9, 50-205 Wrocław, Poland

* corresponding author, e-mail: peterdi.balint@gmail.com

Abstract

Nephrite is mainly known in prehistoric context as raw material for polished stone tools. It is present among archaeological finds in Hungary only in a few numbers. They are known mostly from Transdanubian archaeological sites.

The general aim of our investigations is the detailed petrographic and geochemical examination of the nephrite artefacts found on Hungarian sites, and locating the origin of the raw materials. The material was basically investigated by non-destructive methods (PGAA, non-destructive SEM-EDX) to avoid invasive analyses on the complete artefacts. In this study, preliminary results are presented.

Based on their chemical composition, most of the artefacts measured so far belong to the S-type (serpentinite-related) nephrite deposits.

On the basis of their microscopic and mineral-chemical features, the artefacts investigated so far can be divided into five raw material types: (1) almost pure tremolite-nephrite with only a few fine grained magnetite or ilmenite grains and some pseudomorphs after pyroxenes; (2) almost pure actinolite-nephrite with only a few very fine grained magnetite or ilmenite grains; (3) almost pure tremolite-nephrite with a few chlorite and some pseudomorphs after pyroxenes; (4) actinolite-nephrite, with chlorite, relict clinopyroxenes (diopside), pseudomorphs after pyroxene, spinels and garnets. Magnetite, limonite, apatite and titanite also occur. There is a typical association of chromite spinel and grossular garnet in this type; (5) actinolite-nephrite – sometimes also tremolite - with chlorite, relict clinopyroxenes and spinel (chromite), but garnet is missing.

We have already built a database of the possible nephrite raw material sources of Europe - descriptions and survey data: mineral-, textural- and chemical composition (Péterdi et al., 2014.).

On the basis of our investigations the most probable raw-material sources are the following: type (1) and (3) belongs to Jordanów, Poland. The provenance of the other types is not so clear, but we have candidates from the Swiss Alps. There is a nephrite type in Jordanów, that looks very similar to type (4), but the main amphibole type is tremolite in all Jordanów samples, while actinolite in the type four artefacts.

Kivonat

Magyarországi régészeti leletanyagban nefritet csak kis számban ismerünk, főként csiszolt kőeszközök nyersanyagaként és többnyire dunántúli lelőhelyekről.

HU ISSN 1786-271X; urn: nbn: hu-4106

Munkánk célja a nefrit kőeszközök ismertetése, részletes kőzettani és geokémiai vizsgálata; nyersanyaguk szerinti csoportosítása, illetve a nyersanyagok származási helyére vonatkozó következtetések levonása. A kőeszközök épségének megőrzése érdekében csak roncsolásmentes vizsgálatokat alkalmaztunk (PGAA, roncsolásmentes SEM-EDX). Cikkünkben előzetes eredményeket közlünk.

Teljes kőzet kémiai összetételük alapján a már megvizsgált nefrit kőeszközök nagy része S-típusú (szerpentinesedett utrabázisos kőzetes-típusú) nefrit-lelőhelyekhez köthető.

Eredményeink alapján az eddig megvizsgált kőeszközök – nyersanyaguk mikroszkópos és ásványkémiai jellemzői alapján – öt csoportba sorolhatók: (1) szinte "tiszta" tremolit-nefrit, csak apró magnetit, ritkán ilmenit szemcséket tartalmaz, valamint piroxén utáni pszeudomorfózákat; (2) szinte "tiszta" aktinolit-nefrit, csak apró magnetit, ritkán ilmenit szemcséket tartalmaz; (3) szinte "tiszta" tremolit-nefrit, kevés klorittal és piroxén utáni pszeudomorfózával; (4) aktinolit-nefrit, klorittal, relikt klinopiroxénekkel (diopsziddal), piroxén utáni pszeudomorfózákkal, spinellekkel és gránátokkal. Magnetit, limonit, apatit és titanit szintén megtalálható ebben a típusban. Nagyon jellegzetes képet mutat a spinellek (krómit) és gránátok (grosszulár) együttes megjelenése. (5) aktinolit-nefrit (néhány esetben tremolit is megtalálható benne) klorittal, relikt klinopiroxénekkel és spinellekkel (krómittal); a gránátok ebből a típusból hiányoznak.

Az európai nefritlelőhelyek nyersanyagtípusairól – irodalmi adatok és általunk vizsgált minták alapján - általunk készített adatbázist (Péterdi et al. 2014) használtuk a lehetséges nyersanyagforrások azonosításához.

Az eddig megvizsgált nefrit kőeszközök makroszkópos megjelenése, ásványos összetétele, szövete, valamint teljes kőzet kémiai összetétele alapján a legvalószínűbb nyersanyag forrásterületek a következők:

Az (1) és (3) típus nyersanyagának forrása Jordanów (Alsó-Szilézia, Lengyelország). A többi típus nyersanyag-eredete még nem tisztázott, de egyes svájci lelőhelyek jellemzői nagy hasonlóságot mutatnak ezekkel a típusokkal. Az egyik jordanówi nefrit-típus nagyon hasonlít a (4) típusra, de a fő kőzetalkotó amfibol Jordanówban a tremolit, míg a 4. típusba tartozó régészeti leletek esetében aktonolit.

KEYWORDS: NEPHRITE, POLISHED STONE TOOL, PROVENANCE STUDIES

KULCSSZAVAK: NEFRIT, CSISZOLT KŐESZKÖZ, PROVENIENCIA-VIZSGÁLATOK

Archaeological background, aim of the study

Nephrite is mainly known in prehistoric context as raw material of polished stone tools. It is present among archaeological finds in Hungary only in few numbers. They are known mostly from Transdanubian archaeological sites, primarily in the material of old surface collections like the Miháldy Collection of Veszprém (Szakmány et al. 2001) and the Ebenhöch Collection of the Hungarian National Museum (Friedel 2008; Friedel et al. 2008; Friedel et al. 2011) that were systematically investigated from a petroarchaeological point of view.

The polished stone tools of these old collections typically cannot be identified according to either age or culture because of lack of information concerning their provenances (Horváth 2001). Recent surveys connected to modern excavations and archaeometrical programs (e.g. JADE 2 project), however, yielded some nephrite artefacts with known locality - and some cases with known context - as well (**Table 1., Fig. 1.**).

We have to emphasize that we do not know any nephrite sources in the Carpathian Basin, therefore the raw material must have been transported from distant source(s).

The general aim of our investigations is the detailed petrographic and geochemical examination of the nephrite artefacts found at Hungarian sites, and locating the origin of the raw materials.

In this study preliminary results are presented (nephrite artefacts of the Miháldy Collection, and artefacts with known locality, see **Table 1.**) further we are planning to complete our data with the results of the investigation of the artefacts of the Ebenhöch Collection, and other archaeological assemblages, too.

Methods

Due to the complete artefacts, the material of the nephrite artefacts was basically investigated by non destructive methods. On some broken pieces, however, we could also perform destructive analyses. The first method was always macroscopical description. Results were completed with petrographic microscopical and geochemical analyses. For bulk-rock chemistry, Prompt-gamma activation analysis (PGAA) was used; for mineral chemistry Electron Probe Micro-Analysis performed in a Scanning Electron Miscroscope (EPMA, SEM-EDX)] was applied. The results were compared to published data (Péterdi et al. 2014).

PGAA measurements were performed at the HAS Centre for Energy Research, at the PGAA and NIPS-NORMA stations of the guided external cold neutron beam of the Budapest Neutron Centre.

Table 1.: Samples and analyses.

(Abbreviations: TLBC – Transdanubian Linear Pottery Culture; EH – Ebenhöch Collection; LDM – Laczkó Dezső Museum, Veszprém; MH – Miháldy Collection; HNM – Hungarian National Museum; PGAA - prompt-gamma activation analysis; RRM – Rippl-Rónai Museum, Kaposvár; SEM-EDX - non-destructive SEM-EDX, 'original surface investigation method'; SM – Savaria Museum, Szombathely)

1. táblázat: Minták és vizsgálatok

(Rövidítések: TLBC – Dunántúli Vonaldíszes Kerámia kultúra; EH – Ebenhöch gyűjtemény; LDM – Laczkó Dezső Múzeum, Veszprém; MH – Mihádly Gyűjtemény; HNM – Magyar Nemzeti Múzeum; PGAA - prompt-gamma aktivációs analízis; RRM – Rippl-Rónai Múzeum, Kaposvár; SEM-EDX – roncsolásmentes elektronmikroszkópos vizsgálat, 'eredeti felszín' vizsgálat; SM – Savaria Múzeum, Szombathely)

Sample	Locality	Culture	ID / inventory number	PGAA	SEM-EDX
Alattyán	Alattyán, Vízköz	Tisza Culture	private collection of Gy. Kerékgyártó (Jászberény)	+	+
Balatonőszöd	Balatonőszöd, Temetői-dűlő	Baden Culture IIB-III	B-991. pit (RRM, not inventorised)	+	+
Balatonszemes	Balatonszemes-Szemesi berek	Baden Culture or TLBC	18.3/696.1 (RRM)	+	+
Ikervár	Ikervár, Péterfa major	Baden Culture	4.12.5/3, 217 obj. (SM)	+	+
Gérce, Nemeshegy	Gérce, Nemeshegy alja	uncertain (field survey)	8.10.6/3 (SM)	+	+
Gérce, Római villa	Gérce, Római villa II.	uncertain (field survey)	Gy. 2004 (SM)	+	+
Lukácsháza	Lukácsháza	unknown	4150 (RRM)	+	+
Orci	Orci	unknown	4004 (RRM)	+	+
Szombathely	Szombathely, Táncsics M. u. 44.	Baden Culture	70. gödör (SM)	+	+
MH 1006	unknown	unknown	55.1006 (LDM)	+	-
MH 1010	unknown	unknown	55.1010 (LDM)	+	-
MH 1097	unknown	unknown	55.1097 (LDM)	+	+
MH 1109	unknown	unknown	55.1109 (LDM)	+	-
MH 1144	unknown	unknown	55.1144 (LDM)	+	+
MH 1145	unknown	unknown	55.1145 (LDM)	+	-
MH 1149	unknown	unknown	55.1149 (LDM)	+	+
MH 1152	unknown	unknown	55.1152 (LDM)	+	+
MH 1203	unknown	unknown	55.1203 (LDM)	+	+
MH 1275	unknown	unknown	55.1275 (LDM)	+	-
EH 248	unknown	unknown	300/876.248. (HNM)	+	-

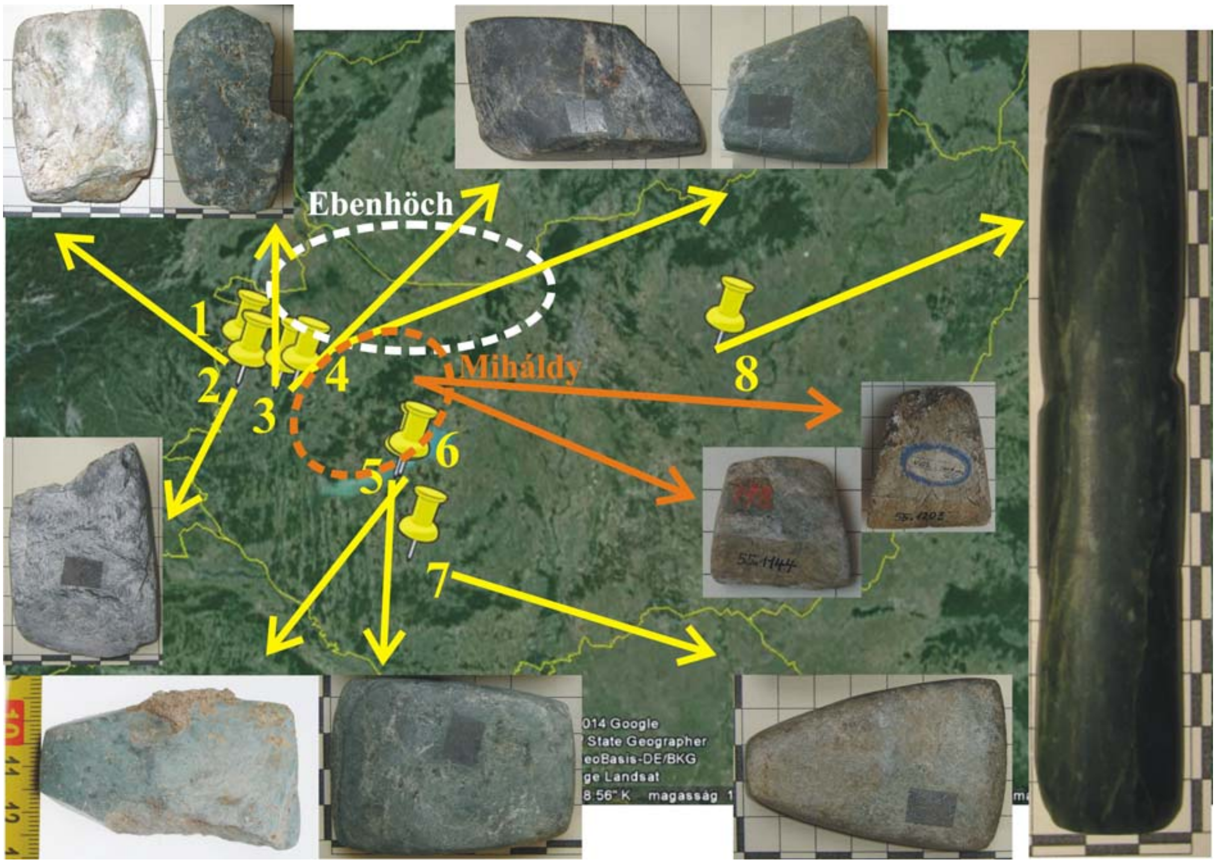


Fig. 1.: Studied artefacts and sites (abbreviations: 1. Lukácsháza; 2. Szombathely; 3. Ikervár; 4. Gérce; 5. Balatonszemes; 6. Balatonőszöd; 7. Orci; 8. Alattyán; Ebenhöch – Ebenhöch Collection, Hungarian National Museum, Budapest; Miháldy - Miháldy Collection, Laczkó Dezső Museum, Veszprém)

1. ábra: A vizsgált régészeti leletek és lelőhelyek (rövidítések: 1. Lukácsháza; 2. Szombathely; 3. Ikervár; 4. Gérce; 5. Balatonszemes; 6. Balatonőszöd; 7. Orci; 8. Alattyán; Ebenhöch – Ebenhöch Gyűjtemény, Magyar Nemzeti Múzeum; Miháldy - Miháldy Gyűjtemény, Laczkó Dezső Múzeum, Veszprém)

The thermal equivalent intensities at the target positions are $7.75\times10^{7}cm^{-2}s^{-1}$ and $2.75\times10^{7}cm^{-2}s^{-1}$, respectively. The PGAA station is suitable to study objects that are not bigger than 5 cm×5 cm×10 cm, while at NIPS-NORMA station one can investigate objects up to 20 cm×20 cm×20 cm. In case of the second station, it is possible to perform 2D or 3D imaging with neutrons besides the bulk elemental investigations; moreover, elemental mapping of the objects can be implemented, too.. The cross-section of the neutron beam can be adjusted between 5 mm^2 an 400 mm^2, and a selected part of the objects can be studied (Kis et al., 2015). The neutrons can enter into the material in more cm depth, thus PGAA is regarded as bulk method. A precisely calibrated HPGe-BGO detector system and a 16k multichannel analyser are used for detection of prompt gamma photons. The experimental set-up was described by Szentmiklósi et al. (2010). Quantitative determination of chemical elements is made on the bases of the PGAA library that has been compiled during standardisation measurements (Révay, 2009). In case of most geological samples, all major components and a few trace elements (B, Cl, Sc, V, Cr, Nd, Sm and Gd) can be quantified. PGAA is unique in the non-destructive determination of H and B in low concentrations.

Non-destructive mineral-chemical examination of the surface of the artefacts (SEM-EDX) was performed with the '*original surface investigation method*' (Bendő et al., 2012) at the Department of Petrology and Geochemistry of the Institute of Geography and Earth Sciences of the Eötvös University (ELTE). The instrument is an AMRAY 1830 type SEM, with an EDAX PV9800 energy dispersive spectrometer. Conditions of analyses: accelerating potential: 20kV; beam current: 1nA; focused electron beam (diameter: ~50 nm). Fairly large samples can be placed into the sample chamber of this electron microscope so the stone implements could be placed into the sample chamber without intrusive preparation.

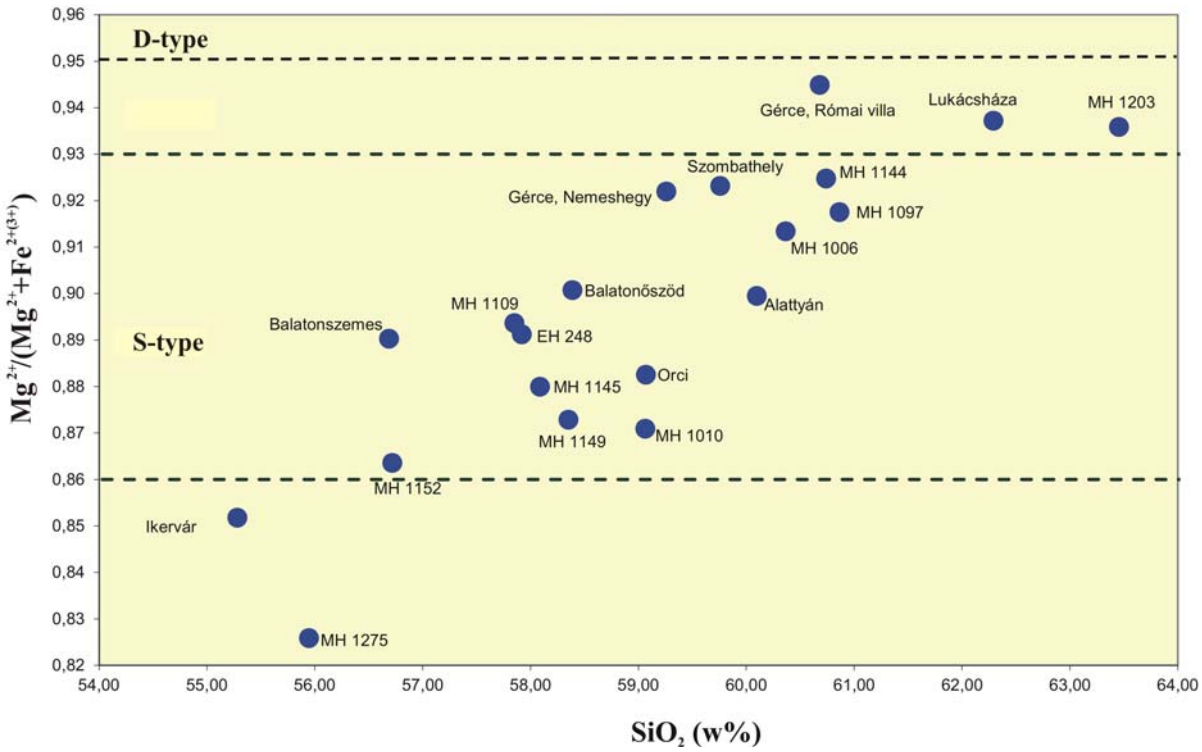


Fig. 2.: Bulk-rock chemistry (PGAA-results): studied artefacts. (Abbreviations: MH - Miháldy Collection, Laczkó Dezső Museum, Veszprém; EH - Ebenhöch Collection, Hungarian National Museum Museum, Budapest)

2. ábra: Teljes kőzet kémiai összetétel (PGAA-eredmények): vizsgált régészeti leletek. (Rövidítések: MH - Miháldy Gyűjtemény, Laczkó Dezső Múzeum, Veszprém; EH - Ebenhöch Gyűjtemény, Magyar Nemzeti Múzeum)

Results - macroscopic features

The colour of the studied nephrite artefacts is varied: white, shades of pale green to dark green. The surface of the white ones - as an effect of the weathering and burying - may become light or dark grey, in some cases bluish gray coloured. On some artefacts two or more basic colours can appear like white-pale green, pale bluish green colours. In the surface of every colour-variant reddish brown patches can occur, but these patches are absent in the interior parts (or on broken surfaces) of the artefacts. The characteristic texture is based on fibrous amphibols: these fibres are wavering and making fan-shaped structures ('nephrite-texture'). (**Fig. 1.**)

Results - bulk rock chemistry (PGAA)

Nephrites can be classified into two groups according to their formation: the first one is formed by contact metasomatism between intermediate-acidic intrusions and dolomitic marbles (dolomite-related deposits, D-type), the other type is formed by contact metasomatism between serpentinite and magmatic body (serpentinite-related deposits, S-type) (Zhang et al 2011.).

There is a significant difference in the chemical composition between the two types. The difference can be best expressed with the $Mg^{2+}/(Mg^{2+}+Fe^{2+(3+)})$ mol-ratio, witch varies between 0.930-1 in D-type and varies between 0.860-0.930 in S-type nephrites (Zhang et al 2011.). The marking of the boundary between the two types, however, was probably arbitrarily, because among the Chinese geological samples there were no values observed between 0.920-0.950.

Most of the artefacts measured so far belong to the S-type (**Fig. 2.**), only three belongs to the D-type (but the values of these not exceed 0.950). It must be pointed out that the geochemical boundary between the two nephrite types is not so sharp: because of the deviations of the non-destructive methods, the samples with values close to the boundary need individual consideration and comparison with results of other methods of investigations.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

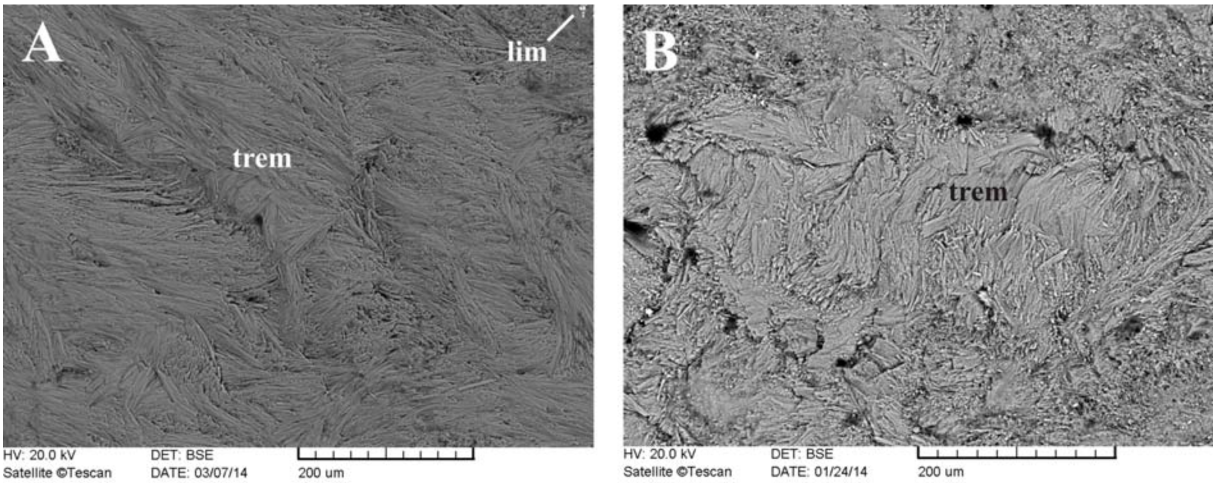


Fig. 3.: A-B) BSE-photomicrograph: rock texture (type 1). (Abbreviations: trem - tremolite, lim - limonite)

3. ábra: A-B) Visszaszórt elektronkép fotó: szöveti kép (1. típus). (Rövidítések: trem – tremolit, lim – limonit)

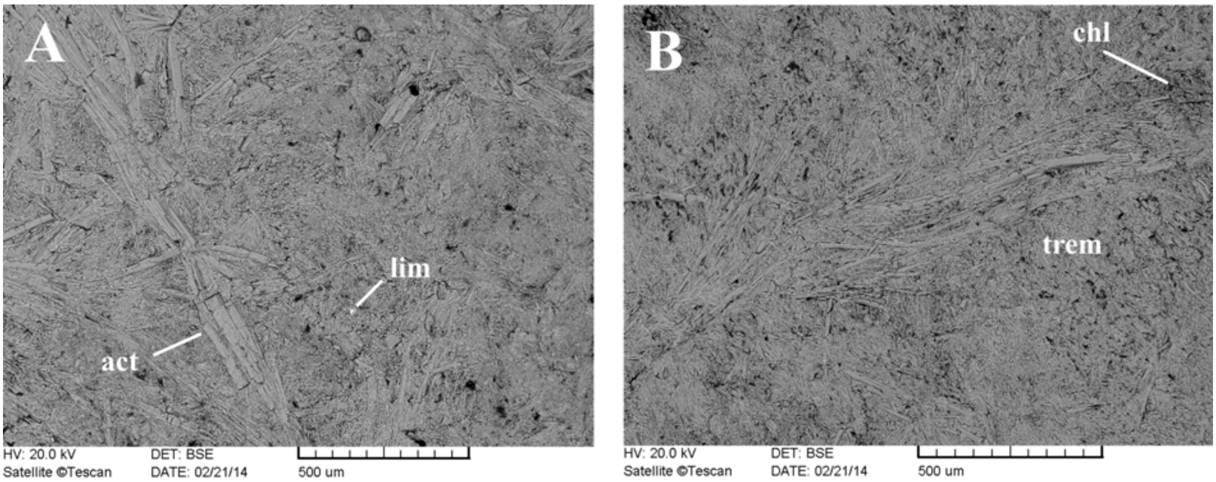


Fig. 4.: A) BSE-photomicrograph: rock texture (type 2). (Abbreviations: act – actinolite, lim – limonite)
B) BSE-photomicrograph: rock texture (type 3). (Abbreviations: trem – tremolite, chl – chlorite)

4. ábra: A) Visszaszórt elektronkép fotó: (2. típus). (Rövidítések: act – aktinolit, lim – limonit)
B) Visszaszórt elektronkép fotó: szöveti kép (3. típus). (Rövidítések: trem – tremolit, chl – klorit)

Results - microscopic features (mineral-compositon, fabric etc.), mineral-chemistry (non-destructive SEM-EDX)

Some of the artefacts (see **Table 1.**) were investigated with non-destructive SEM-EDX, with the '*original surface method*'. Based on these data, the artefacts investigated so far can be divided into five types.

The first type is almost pure tremolite-nephrite with only a few small magnetite, limonite or ilmenite grains and some pseudomorphs after pyroxene (**Fig. 3.**).

The second type is almost pure actinolite-nephrite with only a few minute magnetite, limonite or ilmenite grains (**Fig. 4A.**).

The third type is almost pure tremolite-nephrite with a few chlorite and some pseudomorphs after pyroxene (**Fig. 4B.**).

Type four is actinolite-nephrite, with chlorite, relict clinopyroxenes (diopside), pseudomorphs after pyroxene and relatively large enclosed minerals: spinels and garnets (**Fig. 5.**). In relict diopsides tremolite may occur as veins (**Fig. 5A.**). Magnetite, limonite, apatite and titanite also occur. There is a typical association of chromite spinel and grossular garnet in this nephrite type (**Fig. 5C-D.**).

Beside the major mechanism of nephrite formation (diopside recrystallization to tremolite / actinolite), there is another mechanism: garnet retrogression with chlorite and spinel as common products (Gil et al. 2015). In this type the relict garnets are still existing.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

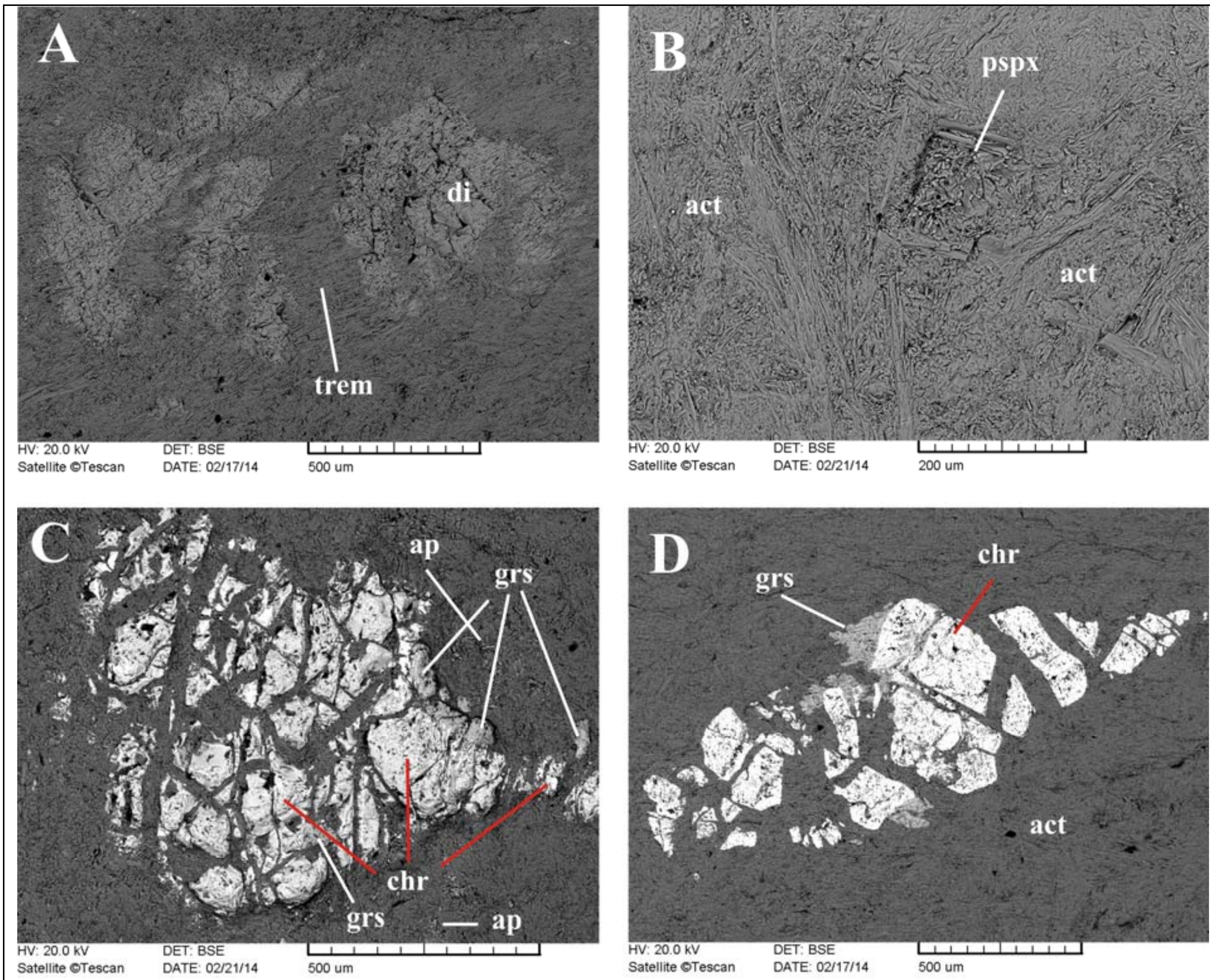


Fig. 5.: A) BSE-photomicrograph: rock texture (type 4). (Abbreviations: trem – tremolite (chemical composition on the boundary between tremolite/actinolite), di – diopside)

B) BSE-photomicrograph: rock texture (type 4). (Abbreviations: act – actinolite, pspx – pseudomorph after pyroxene)

C) BSE-photomicrograph: rock texture (type 4). (Abbreviations: grs – garnet, chr – chromite, ap – apatite)

D) BSE-photomicrograph: rock texture (type 4). (Abbreviations: grs – garnet, chr – chromite, act – actinolite)

5. ábra: A) Visszaszórt elektronkép fotó: szöveti kép (4. típus). (Rövidítések: trem – tremolit (a tremolit/aktinolit határon elhelyezkedő összetételű), di – diopszid)

B) Visszaszórt elektronkép fotó: szöveti kép (4. típus). (Rövidítések: act – aktinolit, pspx – piroxén utáni pszeudomorfóza)

C) Visszaszórt elektronkép fotó: (4. típus). (Rövidítések: grs – gránát, chr – krómit, ap – apatit)

D) Visszaszórt elektronkép fotó: szöveti kép (4. típus). (Rövidítések: grs – gránát, chr – krómit, act – aktinolit)

Type five is actinolite-nephrite with chlorite, relict clinopyroxenes and spinel (chromite). ; Tremolite was also measured, but garnet is missing (**Fig. 6.**).

In this type the relict garnets are missing, but spinel with chlorite are typical.

The main amphibole type (tremolite or actinolite) varies, even within one sample (**Fig. 7.**).

Possible source regions

Its pleasing aesthetic appearance and its toughness, ensured by the compact fabric consisting of interweaving and interlocking thin, fine amphibole fibres, makes nephrite an excellent raw material for polished stone tools, and so it became a widespread raw material all over Europe in the Neolithic Period and the Bronze Age.

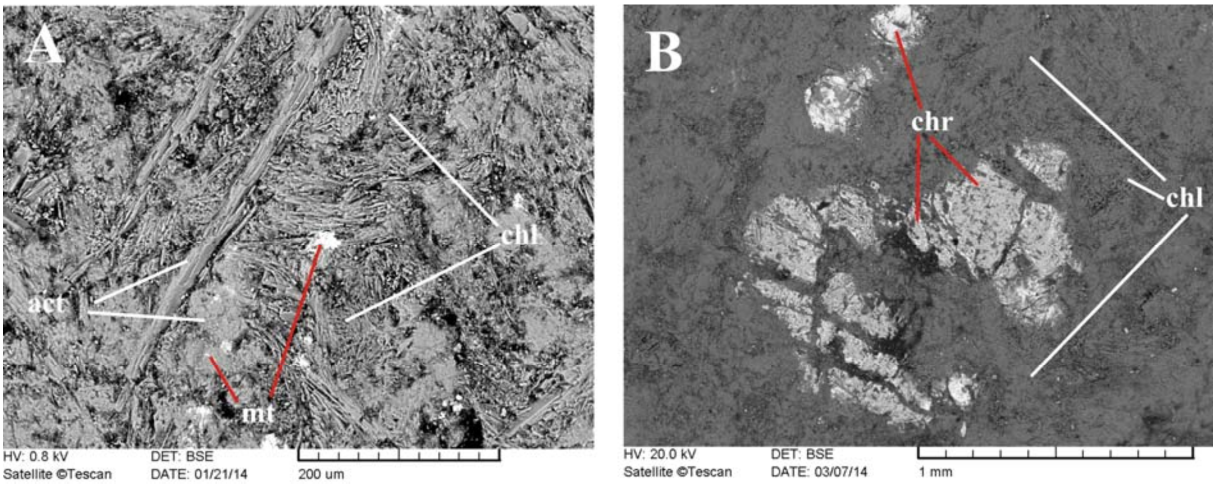


Fig. 6.: A) BSE-photomicrograph: rock texture (type 5). (Abbreviations: act – actinolite, chl – chlorite, mt – magnetite)
B) BSE-photomicrograph: rock texture (type 5). (Abbreviations: chr – chromite, chl – chlorite)

6. ábra: A) Visszaszórt elektronkép fotó: szöveti kép (5. típus). (Rövidítések: act – aktinolit, chl – klorit, mt – magnetit)
B) Visszaszórt elektronkép fotó: szöveti kép (5. típus). (Rövidítések: chr – krómit, chl – klorit)

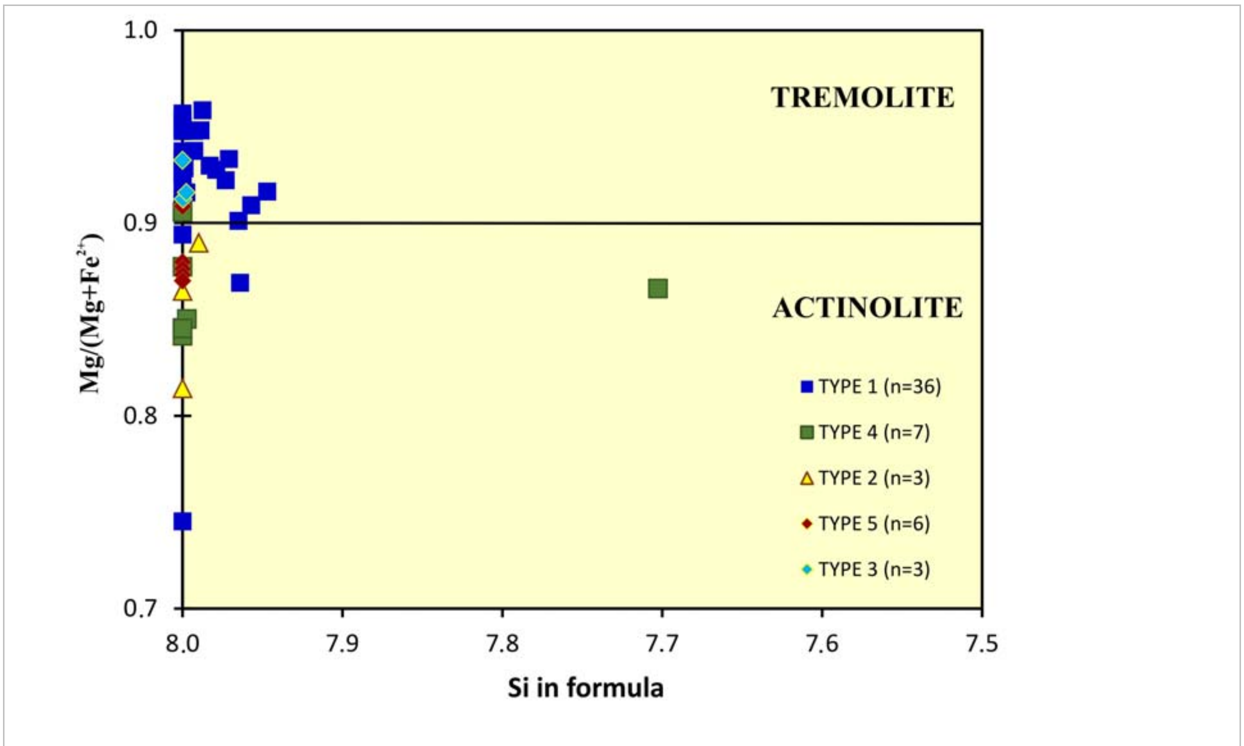


Fig. 7.: Main amphibol type (non-destructive SEM-EDX results): studied artefacts (diagram modified after Leake et al. (1997))

7. ábra: A fő kőzetalkotó amfibol típusa (roncsolásmentes SEM-EDX eredmények): régészeti leletek. (Amfibol-besorolás Leake et al. 1997 alapján.)

It was; however, not used (as raw material) in large quantities because of the small size and limited occurrence of the nephrite bodies.

The identification of the provenance for nephrite artefacts is rendered more difficult because far too many 'green-colour' rocks have been named nephrite in the course of time. For example, the labelling of amphibole-types has changed several times so in earlier literature we are to look for 'grammatite', even for 'hornblende' and not necessarily for tremolite or actinolite.

Geological occurrences of nephrite are fairly rare in Europe. Known nephrite sources are the following: the Alps (on the territory of Switzerland, Italy, France, Germany and Austria), the Apennines (Liguria), the Harz Mts. and Scandinavia; also in the metamorphosed basic and ultrabasic complexes of the boundaries of the Bohemian Massif. Nephrite occurs among glacial erratics carried there by ice from Scandinavia in periods of glaciation on the Rügen-island, and in the environs of Potsdam and Leipzig (Gunia 2000). (**Fig. 8.**)

The so-called 'Mur Nockerls' – nephrite-gravels, nephrite-boulders originating from the alluvium of the river Mur between Leoben and Graz – also deserve mention. The Mur flows into the Drava so it is nearer the Carpathian Basin than the other known provenances. Along its upper course (before it is breaking through the Glein Alm) several serpentinized rock masses occur, but the parent material of the nephrite-gravels is unknown as yet (Giess, 2005). The 'Mur Nockerls' belong to the tremolite-nephrites (Giess, 2005), but detailed descriptions or analyses are not available.

Since a significant number of polished tools made of nephrite have been found on the Balkan Peninsula a raw material source for nephrite has been suggested to be there by archaeologists. However, the potential geological source have not been found yet (Kostov, 2005).

Data available from two probable source areas consist of descriptions and survey data and concerns mineral-, textural- and chemical composition. These two regions are the Swiss Alps (canton Graubünden / Grisons) and the Boundaries of the Bohemian Massif. (Meyer 1884; Traube 1885a, 1885b, 1887; Heierli 1902; Sachs 1902; Kalkowsky 1906; Welter 1911a, 1911b; Schneider 1912; Staub 1915, 1917; Schmidt 1917; Preiswerk 1926; Dietrich and de Quervain 1968; Gunia 2000; D'Amico et al. 2003; Giess 2003, Gil 2013, Gil et al. 2015)

Here we show only a few examples (**Fig. 9-11.**). For the database and detailed descriptions see Péterdi et al. 2014.

From Polish Lower Silesia we have also new samples from Jordanów and Złoty Stok, with modern chemical analysis data (PGAA, EPMA and non-destructive SEM-EDX) (Gil 2013; Péterdi et al. 2014). Many types of nephrite can be found on these localities.

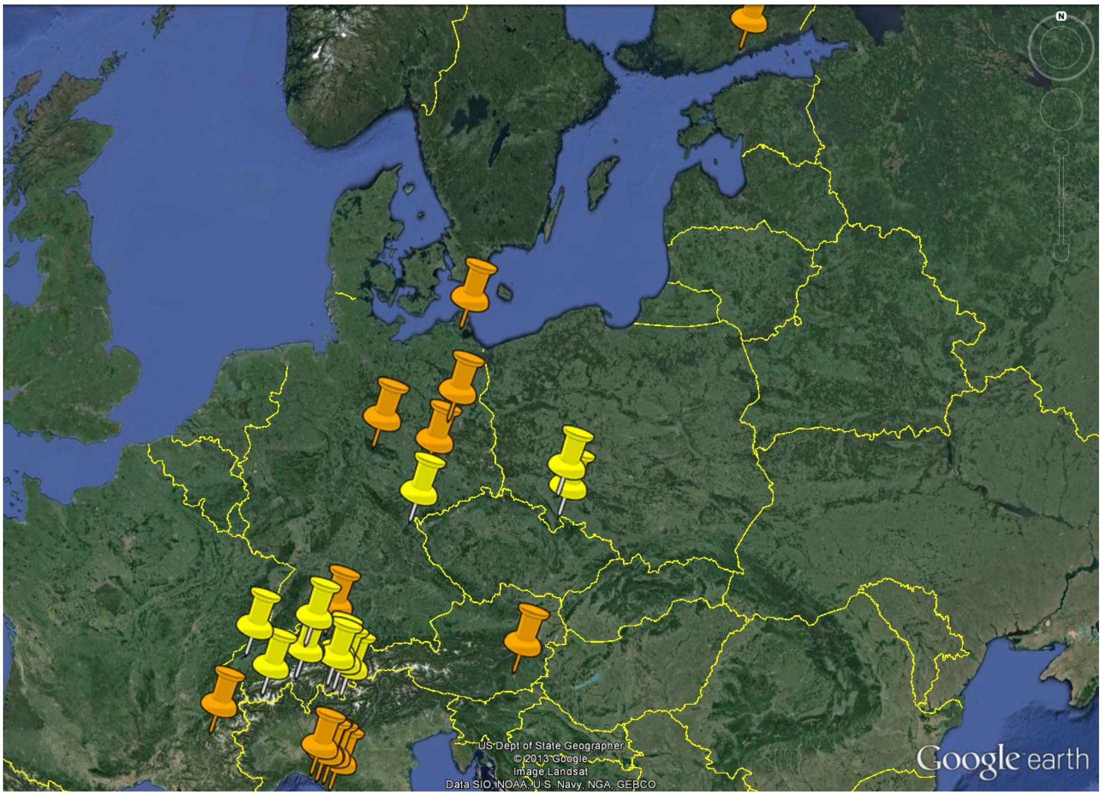
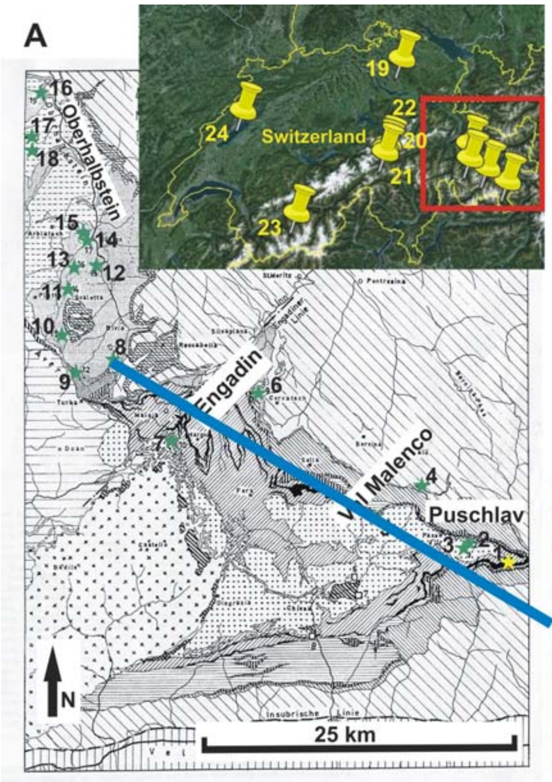


Fig. 8.: Known nephrite raw-material sources in Europe (yellow sings - nephrite sources with detailed descriptions and survey data; orange signs - nephrite sources without detailed data).

8. ábra: Ismert nefrit nyersanyag-források Európában (sárga jelzés – nefrit lelőhelyek részletes leírásokkal és elemzési adatokkal; narancs jelzés - nefrit lelőhelyek részletes adatok nélkül).

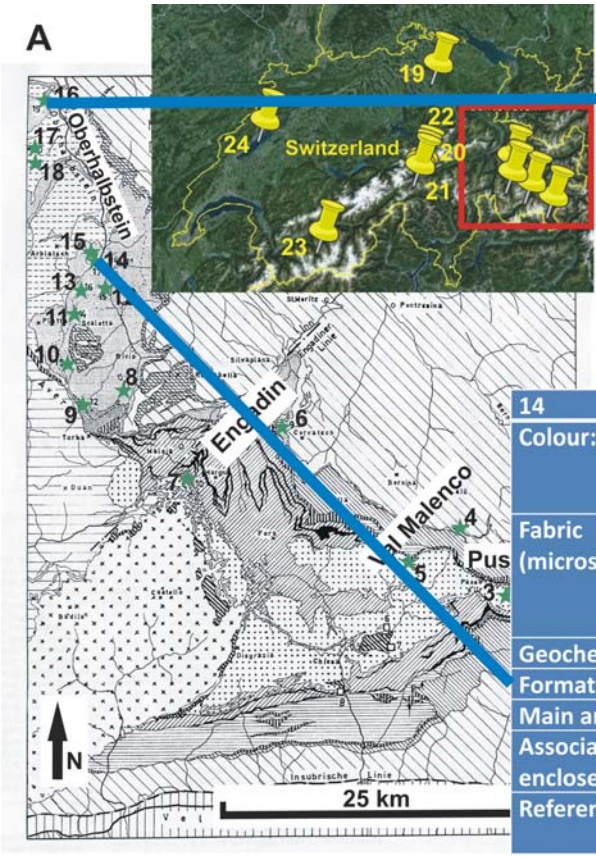
HU ISSN 1786-271X; urn: nbn: hu-4106



8	Cuolms
Colour:	dark green
Fabric (microscopic fabric):	compact fabric
Geochemical data:	+
Formation type:	S
Main amphibol type:	A
Associated and enclosed minerals:	magnetite (isolated)
References:	Dietrich and de Quervain 1968

Fig. 9.: Example from our „nephrite-database” (Péterdi et al. 2014): Cuolms

9. ábra: Példa a „nefrit-adatbázisból” (Péterdi et al. 2014): Cuolms



16	Salux (Salouf)
Colour:	dark green
Fabric (microscopic fabric):	compact fabric / foliated (parallely fibrous, very tough)
Geochemical data:	+
Formation type:	S
Main amphibol type:	
Associated and enclosed minerals:	yellowish-green garnet, picotite, chlorite, magnetite (isolated pathes)
References:	Welter 1911

14	Mühlen (Mulegns)
Colour:	1: dark green 2: light green, white 3: spring-onion green to pistachio green
Fabric (microscopic fabric):	1: foliated (parallely fibrous) 2: parallely fibrous (parallely fibrous) 3: extremely foliated with lamellar jointing
Geochemical data:	+
Formation type:	S
Main amphibol type:	A
Associated and enclosed minerals:	chlorite, magnetite, picotite, green garnet (epidote, calcite)
References:	Welter 1911; Dietrich and de Quervain 1968; Giess 2003

Fig. 10.: Example from our „nephrite-database” (Péterdi et al. 2014): Mühlen, Salux

10. ábra: Példa a „nefrit-adatbázisból” (Péterdi et al. 2014): Mühlen, Salux

26	Jordanów (Jordansmühl in Schlesien)
Colour:	white, greenish-creamy, bright green (light green) to dark green, greyish-blue, blue, pink
Fabric (microscopic fabric):	compact fabric or foliated or schistose (typical non-directional, fibrous, parallely fibrous)
Geochemical data:	+
Formation type:	S
Main amphibol type:	T
Associated and enclosed minerals:	1: pure nephrite 2: pseudomorphs after pyroxene 3: diopside, chlorite (common) 4: grossular, hydrogrossular, prehnite, antigorite, Cr-spinel, titanite, apatite, monacite, zircon
References:	Traube 1885a, 1885b; Sachs 1902; Gunia 2000; Mazur et al. 2006; Gil 2013

Fig. 11.: Example from our „nephrite-database" (Péterdi et al. 2014): Jordanów

11. ábra: Példa a „nefrit-adatbázisból" (Péterdi et al. 2014): Jordanów

Evaluation of the results, and the most probable sources

Fig. 12. shows the bulk rock chemical data of the measured artefacts and the possible raw-material sources. We used data of analyses from the literature and from our new investigations.

Fig. 13. shows the main amphibole types of Jordanów and Zloty Stok samples together with the artefacts.

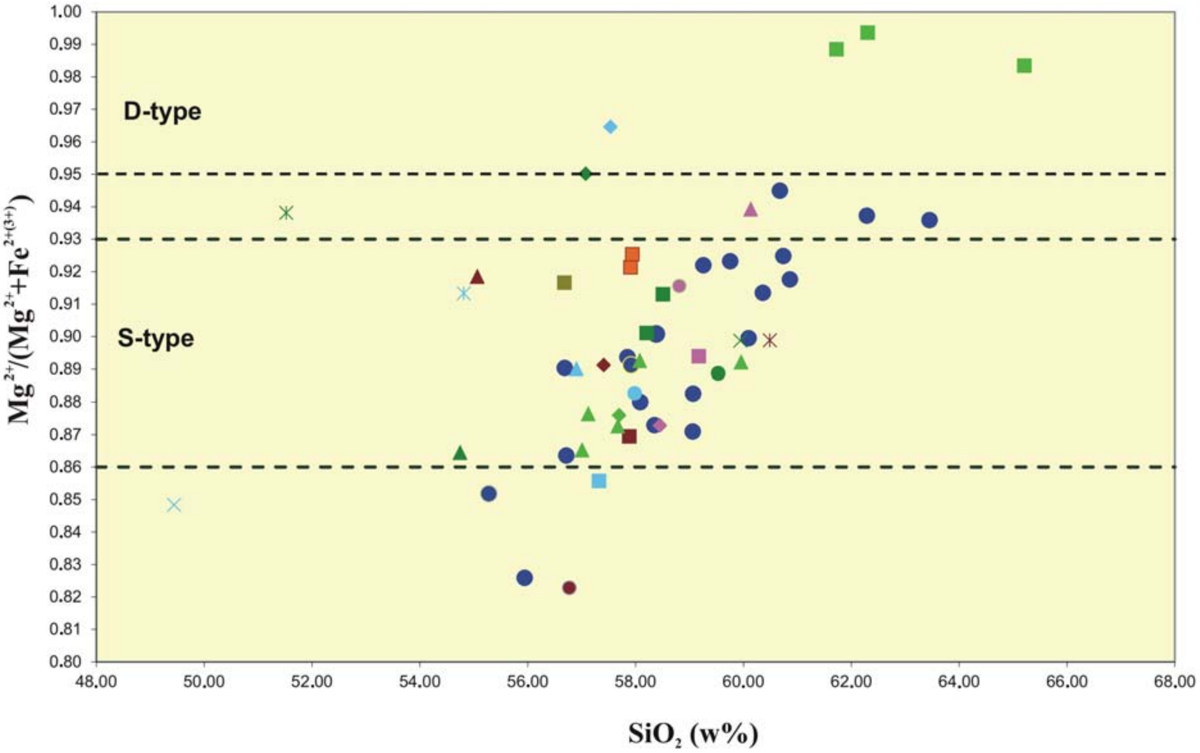
On the basis of macroscopic appearance, mineral composition, fabric character and bulk chemical composition the most probable raw-material sources of the so far investigated artefacts are the following:

Type one and three belongs to Jordanów. The provenance of the other types are not so clear, but we have candidates from the Swiss Alps. (**Table 2., Fig. 14.**) Unfortunately about the source nearest to the Carpathian Basin i.e., the 'Mur Nockerls', there are no detailed descriptions or analyses available.

There is a nephrite type in Jordanów, that looks very similar to type four (for example the chromite-grossular association), but the main amphibole type is tremolite in all Jordanów samples, while actinolite in the type four artefacts.

For green nephrite-types of Jordanów, however, the green colour can be associated with not only the small amount of chlorite in them, but also due to the presence of actinolite, occurring in small veins (Gil et al. 2015). So it is probable that the raw material of this type (type four) also belongs to Jordanów.

It must be pointed out that stone axes made of Jordanów nephrite were found about 15 km north of Jordanów (Neolithic); in the central part of Poland (Danubian culture); and also in Upper Silesia (Funnel Beaker culture, Corded Ware culture) (Foltyn et al., 2000; Gunia, 2000) and probably from a Late Neolithic Silezian site (Přichystal et al., 2012). We know cultural connections between this nephrite source and the Carpathian Basin in the Late Copper Age (Baden Culture) (Přichystal 2000).



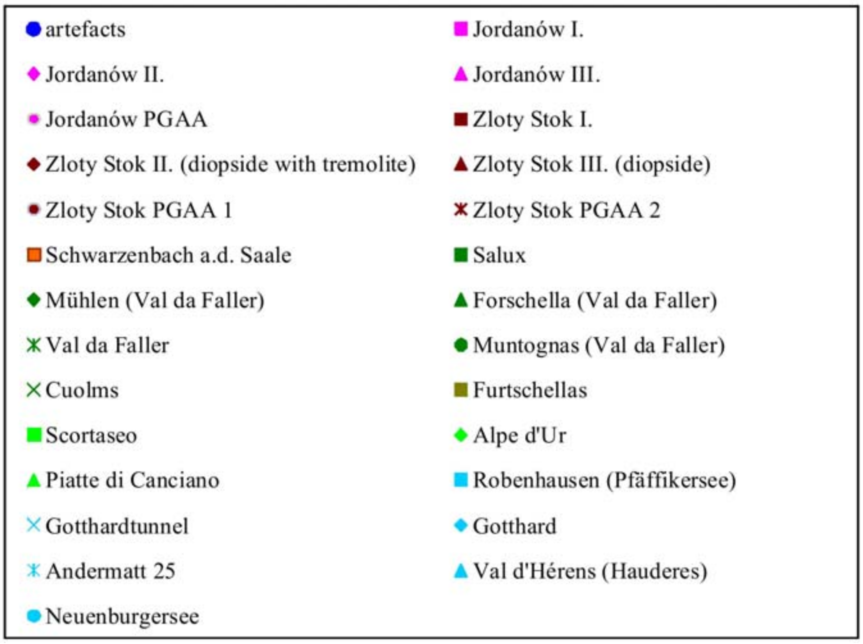


Fig. 12.:

Bulk-rock chemistry (PGAA-results): studied artefacts; nephrite raw-material sources (PGAA-results and data from literature, references in the text).

12. ábra:

Teljes kőzet kémiai összetétel (PGAA-eredmények): vizsgált régészeti leletek, nefrit-nyersanyagforrások (irodalmi adatok és saját PGAA-mérések, hivatkozásokat ld. a szövegben).

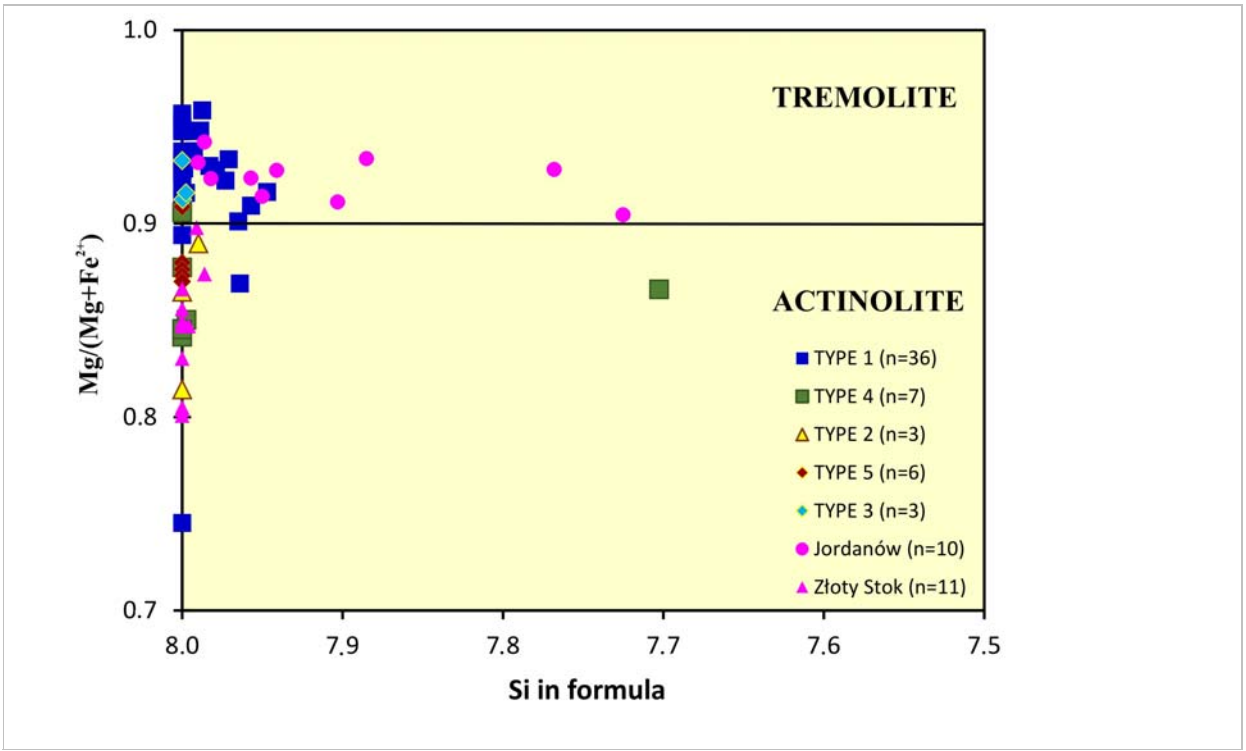


Fig. 13.: Main amphibol type: studied artefacts (non-destructive SEM-EDX results); nephrite raw-material sources (destructive and non-destructive SEM-EDX results, references in the text). (Diagram modified after Leake et al. (1997))

13. ábra: A fő kőzetalkotó amfibol típusa: régészeti leletek (roncsolásmentes SEM-EDX eredmények); nefrit-nyersanyagforrások (roncsolásos és roncsolásmentes SEM-EDX eredmények, hivatkozásokat ld. a szövegben). (Amfibol-besorolás Leake et al. 1997 alapján.)

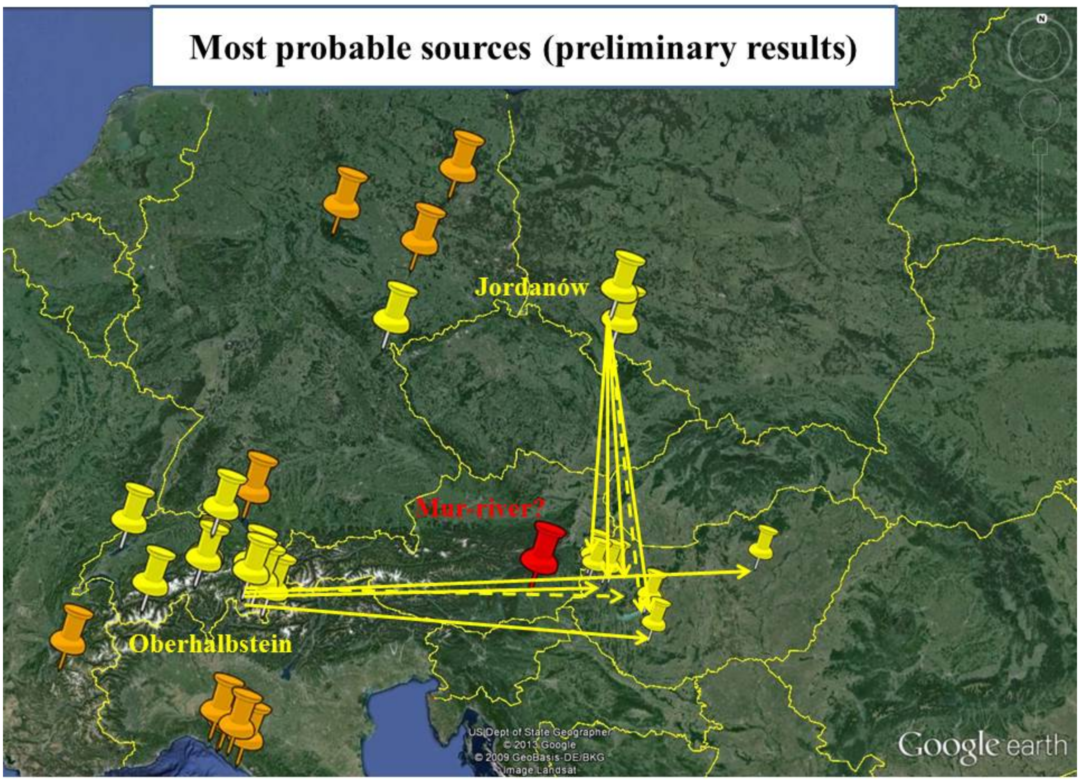


Fig. 14.: Most probable raw-material sources (preliminary results).

14. ábra: Legvalószínűbb nyersanyagforrások (előzetes eredmények).

Table 2.: Probable raw-material source-regions

2. táblázat: A nyersanyagtípusok valószínű származási helye

Type	Probable source
type 1: „pure” tremolite + minor magnetite, limonite, ± ilmenite ± pseudomorphs after pyroxene	**Jordanów** (Jordansmühl in Schlesien) (Lower Silesia, Poland)
type 2: „pure” actinolite + minor magnetite, limonite, ± ilmenite	**Cuolms?** (Oberhalbstein (Alpi di Platta), Switzerland)
type 3: tremolite + minor chlorite ± pseudomorphs after pyroxene	**Jordanów** (Jordansmühl in Schlesien) (Lower Silesia, Poland)
type 4: actinolite + chlorite, relict clinopyroxenes (diopside), pseudomorphs after pyroxene, spinel (chromite), garnet (relict grossular) + minor magnetite, ilmenite, ± apatite, ± titanite	**Val da Faller** (Faller valley): **Mühlen** (Mulegns), Forschella-peak, (Oberhalbstein (Alpi di Platta), Switzerland) **Salux?** (Oberhalbstein (Alpi di Platta), Switzerland) **Jordanów???** (Jordansmühl in Schlesien) (Lower Silesia, Poland)
type 5: actinolit and tremolite + chlorite, relict clinopyroxenes, spinel (chromite) + minor magnetite garnet is absent	**???** (Crap Farreras?) (Oberhalbstein (Alpi di Platta), Switzerland)

Moreover, it has been proved that serpentinites containing nephrite-bodies from this area were used to make stone-axes in the Neolithic Age (Majerowicz et al., 2000; Skoczylas et al., 2000). The territory’s serpentinite was quarried (Wojciechowski, 1995) and polished stone tools made of them got fairly far away (even to 340 kms) (Přichystal and Šebela, 1992.; Skoczylas et al., 2000). In the time of the Corded Ware culture, there was a centre for extracting and processing serpentinite on the territory; its most important products were the so-called ’Ślęża-type’ shaft-hole axes (Skoczylas et al., 2000).

Acknowledgements

We are indebted to the archaeologists for offering us the opportunity to study the artefacts (especially for Tünde Horváth, Erzsébet Nagy, Szilvia Honti, Péter Németh, Judit P. Barna, Csilla Száraz, László Horváth, Judit Regenye, Marcella Nagy, Ádám Kőszegi, Gábor Ilon, Gyula Kerékgyártó, Ernő Wolf).

We want to thank the colleagues and others for helping us in our work in many ways (especially for Veronika Szilágyi, Katalin Gméling, Boglárka Maróti, Ágnes Veres, Emma P. Szabó, Zoltán Lantos, Péter Papp).

We are thankful to Antonín Přichystal and Judit Antoni for revision and constructive comments that improved this paper.

Special thanks go to the Hungarian Scientific Research Fund OTKA Grant No. K 62874 and K 100385 for their financial support.

References

BENDŐ, Zs., OLÁH, I., PÉTERDI, B. & HORVÁTH, E. (2012): Case studies on a non-destructive SEM-EDX analytical method for polished stone tools and gems. In: BRAEKMANS, D., HONINGS, J. & DEGRYSE, P. eds., *39th International Symposium on Archaeometry*, Leuven, Abstracts p. 136.

D’AMICO, C., STARNINI, E., GASPAROTTO, G. & GHEDINI, M. (2003): Eclogites, jades and other HP-metaophiolites employed for prehistoric polished stone implements in Italy and Europe. *Periodico di Mineralogia* (*Special Issue 3*) **73** 17–42.

DIETRICH, V. & De QUERVAIN, F. (1968): Die Nephrit-Talklagerstätte Scortaseo (Puschlav, Kanton Graubünden). Übersicht der Weiteren Nephritfunde der Schweizer Alpen Insbesondere der Vorkommen im Oberhalbstein (Graubünden). *Beiträge zur Geologie der Schweiz, Geotechnische Serie* **46** 1–78.

FOLTYN, E.M., FOLTYN, E., JOCHEMCZYK, L. & SKOCZYLAS, J. (2000): Basalte und Nephrite im Neolithikum Mittel-Westpolens und der oberschlesieschen Region. *Krystalinikum* **26** 67–81.

FRIEDEL, O. (2008): Az Ebenhöch csiszolt kőeszköz gyűjtemény archeometriai vizsgálatának eredményei. (*közöletlen diploma dolgozat*, ELTE TTK Kőzettan-Geokémiai Tszk, Budapest, 1–96.

FRIEDEL, O., BRADÁK, B., SZAKMÁNY, Gy., SZILÁGYI, V. & T. BIRÓ, K. (2008): Összefoglaló az Ebenhöch csiszolt kőeszköz gyűjtemény archeometriai vizsgálatának ereményeiről. *Archeometriai Műhely* (http://www.ace.hu/am) **5/3** 1–12.

FRIEDEL, O., BRADÁK, B., SZAKMÁNY, Gy., SZILÁGYI, V. & T. BIRÓ, K. (2011): Archaeometric Processing of Polished Stone Artefacts from the Ebenhöch Collection (Hungarian National Museum, Budapest, Hungary). In: TURBANTI-MEMMI, I (ed.): *Proceedings of the 37th International Symposium on Archaeometry*, 12th-16th May 2008, Siena, Italy, Springer-Verlag Berlin Heidelberg, 211–219.

GIESS, H. (2003): Jade in Switzerland – April 2003. *Friends of Jade* (http://www.friendsofjade.org)

GIESS, H. (2005): Mur Nockerln – Austrian Dumplings in Nephrite Jade! *Friends of Jade* (http://www.friendsofjade.org)

GIL, G. (2013): Petrographic and microprobe study of nephrites from Lower Silesia (SW Poland). *Geological Quarterly* **57/3** 395–404. + Appendices

GIL, G., BARNES, J. D., BOSCHI, C., GUNIA, P., SZAKMÁNY, Gy., BENDŐ, Zs., RACZY□SKI, P. & PÉTERDI, B. (2015): Origin of serpentinite-related nephrites from Gogołów-Jordanów Massif – update. *Geological Quarterly* **59/3** 457–472+ Appendices.

GUNIA, P. (2000): Nephrite from South-Western Poland as potential raw material of the European Neolithic artefacts. *Krystalinikum* **26** 167–171.

HEIERLI, J. (1902): Die Nephritfrage mit spezieller Berücksichtigung der schweizerischen Funde. *Anzeiger für Schweizerische Altertumskunde* **1** 1–7.

HORVÁTH, T. (2001): Polished stone tools of the Miháldy-collection, Laczkó Dezső Museum, Veszprém. (Archaeological investigation). In: REGENYE, J. (ed.), *Sites and stones. Lengyel Culture in Western Hungary and beyond. A review of the current research. Lengyel'99 and IGCP-442 Conference Veszprém, 1999*, Veszprém, Directorate of the Veszprém county Museums, 87–109.

KALKOWSKY, E. (1906): Der Nephrit des Bodensees. *Abhandlungen der Naturwissenschaftlichen Gesellschaft "Isis" in Dresden* **1** 28–44.

KIS, Z., SZENTMIKLÓSI, L. & BELGYA, T. (2015): NIPS–NORMA station - A combined facility for neutron-based nondestructive element analysis and imaging at the Budapest Neutron Centre, *Nuclear Instruments and Methods in Physics Research A* **779** 116–123.

KOSTOV, R. I. (2005): Gemmological Significance of the Prehistoric Balkan „Nephrite Culture" (Cases from Bulgaria). (Part I., Geology and Geophsics) A*nnual of the University of Mining and Geology „St. Ivan Rilski"* **48** 91–94.

LEAKE, B. E., WOOLLEY, A. R., ARPS, C. E. S., BIRCH, W. D., GILBERT, C. M., GRICE, J. D., HAWTHORNE, F. C., KATO, A., KISCH, H. J., KRIVOVICHEV, V. G., LINTHOUT, K., LAIRD, J., MANDARINO, J. A., MARESH, W. V., Nickel, E. H., ROCK, N. M. S., SCHUMACHER, J. C., SMITH, D. C., STEPHENSON, N. C. N., UNGARETTI, L., WHITTAKER, E. J. W. & YOUZHI, G. (1997): Nomenclature of amphiboles: report of the subcommittee on amphiboles of the International Mineralogical Association, commission on new minerals and mineral names. *Canadian Mineralogist* **35** 219–246.

MAJEROWICZ, A., WOJCIK, A., GUNIA, P. & CHOLEWA, P. (2000): Comparative study of serpentinite textures and rock material of Neolithic arefacts from Lower Silesia (SW Poland). *Krystalinikum* **26** 111–117.

MEYER, A. B. (1884): Ein weiterer Beitrag zur „Nephritfrage". *Mitteilungen der Anthropologischen Gesellschaft in Wien* **XV** 1–12.

PÉTERDI, B., SZAKMÁNY, Gy., JUDIK, K., DOBOSI, G., KASZTOVSZKY, Zs., SZILÁGYI, V., MARÓTI, B., BENDŐ, Zs. & GIL, G. (2014): Petrographic and geochemical investigation of a stone adze made of nephrite from the Balatonőszöd - Temetői dűlő site (Hungary), with a review of the nephrite occurrences in Europe (especially in Switzerland and in the Bohemian Massif). *Geological Quarterly* **58/1** 181–192 + Appendices

PREISWERK, H. (1926): Nephrit von Haudères (Wallis), Schweiz. *Mineralogische und Petrographische Mitteilungen* **6** 267–277.

PŘICHYSTAL, A. & ŠEBELA, L. (1992): Lithic raw materials used by the people with Corded Ware in Moravia and the adjoining part of Upper Silesia. *Scripta (Geology)* **22** 29–39.

PŘICHYSTAL, A. (2000): Stone raw materials of Neolithic-Aeneolithic polished artefacts in the Czech Republic: The present state of knowledge. *Krystalinikum* **26** 119–136.

PŘICHYSTAL, A., KOVÁŘ, J. J. & KUČA, M. (2012): A Nephrite Axe from the Jeseník Museum. *Časopis Slezského Zemského Muzea, Série B* **60**: 153–159.

RÉVAY, Zs. (2009): Determining elemental composition using prompt gamma activation analysis. *Analytical Chemistry* **81** 6851–6859.

SACHS, A. (1902): Der „Weissstein" des Jordansmühler Nephritvorkommens. *Centralblatt für Mineralogie, Geologie und Palaeontologie, Jahrgang* **1902** 385–396.

SCHNEIDER, A. (1912): Der Diallag-Peridotit und seine Umwandlungsprodukte auf Gigestaffel südlich Andermatt. *Diss. Univ. Zürich,* 7–68.

SCHMIDT, C. (1917): Asbest und Nephrit von Poschiavo in Graubünden. *Zeitschrift für praktische Geologie* 77–81.

SKOCZYLAS, J., JOCHEMCZYK, L., FOLTYN, E. & FOLTYN, E. (2000): Neolithic serpentinite tools of west-central Poland and Upper Silesia. *Krystalinikum* **26** 157–166.

STAUB, R. (1915): Petrographische Untersuchungen im westlichen Berninagebirge. *Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich* **60** 55–336.

STAUB, R. (1917): Bericht über die Exkursion der Schweiz. *Geologischen Gesellschaft. Eclogae Geologicae Helvetiae* **14** 509.

SZAKMÁNY, Gy., FÜRI, J. & SZOLGAY, Zs. (2001): Outlined petrographic results of the raw materials of polished stone tools of the Mihály-collection, Laczkó Dezső Museum, Veszprém (Hungary). In: REGENYE, J. (ed.): *Sites and Stones: Lengyel Culture in Western Hungary and beyond.* Directorate of the Veszprém county Museums, Veszprém 109–118.

SZENTMIKLÓSI, L., BELGYA, T., RÉVAY, Zs. & KIS, Z. (2010): Upgrade of the prompt gamma activation analysis and the neutron-induced prompt gamma spectroscopy facilities at the Budapest Research Reactor. *Journal of Radioanalytical and Nuclear Chemistry* **286** 501–505.

TRAUBE, H. (1885a): Ueber den Nephrit von Jordansmühl in Schlesien. *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie, Beilage-Band* **III** 412–427.

TRAUBE, H. (1885b): Über den Nephrit von Jordansmühl in Schlesien. *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie*, *Jahrgang 1885***. II** 91–94.

TRAUBE, H. (1887): Ueber einen neuen Fund von anstehendem Nephrit bei Reichenstein in Schlesien. *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie*, *Jahrgang 1887***. II** 275–278.

WELTER, O. A. (1911a): Ein Beitrag zur Geologie des Nephrits in den Alpen und im Frankenwalde. *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie*, *Jahrgang 1911.* **II** 86–106.

WELTER, O. A. (1911b): Nachtrag zu meinem Aufsatz über Nephrit (dies. Jahrb. 1911. II). *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie*, *Jahrgang 1911.* **II.** 163.

WOJCIECHOWSKI, W. (1995): Die neolitische Serpentinit Mine vom Jańjka Góra in Niederschlesien, Polen. *Veröffentlichungen des Brandenburgischen Landesmuseums für Ur- und Frühgeschichte* **29** 201–208.

ZHANG, Z.W., GAN, F.X. & CHENG, H.S. (2011): PIXE analysis of nephrite minerals from different deposits. *Nuclear Instruments and Methods in Physics Research B* **269** 460–465.