Non-destructive investigation of polished stone implements found in Hungary: Methodology and case studies

Magyarországon fellelt csiszolt kőeszközök roncsolásmentes vizsgálata: Módszertan és esettanulmányok.

PhD dissertation

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Chapter I: Introduction

I/1. Problem description

During the investigation of pieces of cultural heritage, like paintings, jewellery and sculptures, using non-destructive or micro-invasive methods are important to save these unique and unrepeatable items, especially when they are intact, good quality objects with detailed archaeological or historical records. Since the beginnings of the archaeometry, it was always a large problem, how to achieve as much information as we can, without to harm or destroy these objects with incredible historical background. During the development of analysis techniques, multiple answers were revealed, which can support the results of each other, however, none of them able to give all necessary answers alone. A few examples can be seen in a non-exhaustive list below:

A. Mass spectrometry methods like LA-ICP-MS and SIMS can provide in situ chemical analysis with incredible accuracy, and it is suitable to provide data on mineral chemistry on both gemstones and stone tools at that price of deepening a shallow and small diameter hole into the examined objects (just a very few examples: on gemstones: LA-ICP-MS: Wang et al. 2016, SIMS: Gaillou et al. 2012; on stone tools: LA-ICP-MS: Barca et al. 2011, Bellot-Gurlet et al. 2005).
B. Spectroscopic methods based on excitation the samples by light (e.g. Raman, FTIR) are very useful tools as they are completely non-destructive methods (e.g. Calligaro et al. 2002, e.g. Gaillou et al. 2012); however, they have their own limitations among the determinable phases.
C. Methods based on X-rays: X-ray diffraction and X-ray fluorescence.
    a. X-ray diffraction can be a very useful tool to determine loose gemstones (however, in gemmology, use of this tool is mostly restricted on identifying new gemstones (e.g. Shen 2020) or for the exact identification of minerals from a new gemstone locality (Agheem et al. 2011) and reveal to mineral assemblages of stone tools (e.g. Szakmány et al. 2013, Kristály 2014).
    b. X-ray fluorescence is a method to determine the bulk composition of a sample. In the latest years, portable XRF tools became more accessible, user friendly and thus widespread. Due to this fact, we can say that, there was an explosion in the number of articles about real valuable artefacts, about not only geological objects as ancient stone tools (Liritzis & Zacharias 2011) and gemstones (e.g.

Shen 2020), but real artworks, like paintings, sculptures or metallic artefacts, like jewellery etc (e.g. Trojek & Trojková 2015).

D. PGAA (Prompt Gamma Activation Analysis) is a derivate of NAA (Neutron Activation Analysis), which is using slow neutrons for excitation of the samples, and detecting the signals during the irradiation of the investigated objects. It is a very useful tool for achieving bulk chemistry results from large objects as stone axes (e.g. Szakmány & Kasztovszky 2004).

E. PIXE (Particle/Proton Induced X-ray Emission) is a non-destructive analytical technique for analysing solid samples. Samples are excited by large sized charged particles, like protons, this process generates characteristic X-rays. It is used for non-destructive analysis of both stone implements (e.g. Bellot-Gurlet et al. 2005) and gemstones (eg. Calligaro et al. 2002).

Other methods can be enlisted here; however, it was not an aim in this paper to have a complete list of analytical methods. However, when this list was piled up, one thing became very obvious: none of the enlisted methods can gave us a very important information about the investigated objects: a visual information about their texture.

These things along with the fact that the accessibility of the most methods was very limited, especially in Hungary, was led to the development of a completely non-destructive method described in chapter two.

I/2. Method used for the investigations

Needs of the completely non-destructive investigation of samples and the necessity of visual information led to develop a special sample preparation method allows us to investigate samples which were not possible to acquire detailed information without this method. This method called as “original surface method” since it is focusing on the surface instead of a freshly cut and polished surface of the investigated items. Main goals of this method to prepare a surface area can be investigated by traditional electron beam methods, for both textural and chemical analysis. Due to the reason, that the “original surface method” not requires any cutting, polishing or other destructive preparations, this method can be asserted non-destructive. Years later, when the method “stabilized” and lot of experience were collected, about a dozen of articles were born about both jewellery with gemstone inlays and stone tools which are not subject of this study.

However, to achieve this result, the usefulness and reliability of this method had to be proven. As it written in chapter two, our method has limits, especially in cases when the subjects of analyses are sensitive to the environmental circumstances in the soils. In these cases, the few thousand years spent in the soil made the determination of the lithic material harder because some mineral phases disappeared during the eras. One of the goals of this study is to answer these questions: Which kind of phases can be found on the original surface? Are these phases suitable for correct determination of the lithic raw material of stone tools? Are there very sensitive but also very important phases in the stone tools whose lack on the original surface made the raw materials determination impossible?

In general, a simple SEM equipped with EDS spectrometer is not a quite rare instrument, so this method can be a widely used one, especially in laboratories where the SEM has a quite large sample chamber without a sample changing lock system. A proper system calibration and standardization is necessary, of course, as the proper setting on the investigated artefacts to achieve the proper investigation geometry to have the correct results. As the system have been built and experience was piled up, this method can be a routine investigation.

Most important aim of this dissertation is not to determine the *exact* locality of the particular stone implements – however it is possible with this method along with a widescale database about the probable resources – but to prove the usefulness of the original surface investigation method as a tool of non-destructive method for exceptional pieces of cultural heritage.

I/3. Actual results on stone tools made of HP metaophiolites

Other two articles are concentrating on a special kind of lithic raw material of certain stone tools, the high pressure metaophiolites (like eclogite and different varieties of jadeitites (**jades**)). Their raw material is completely missing from the Carpathian Basin, at least from the surface, as well as the presence of HPM stone implements was practically unknown until 2008 (Friedel et al.). Since the discovery of their presence in old, large Hungarian collections (which were piled up from stray finds), like Miháldy collection of Laczkó Dezső Museum in city of Veszprém (Horváth T. 2001) and Ebenhöch collection of Hungarian National Museum in Budapest (Ebenhöch 1876; Friedel et al. 2008, 2011), they were found among the object assemblages of different archaeological surveys performed in XX. and XXI. centuries also (Dombay 1960; Biró et al. 2003, Ilon 2011; Horváth F. 2003, 2005; Szakmány et al. 2008; Starnini et al. 2015, Zalai-Gaál et al. 2011).

Investigation of these stone implements have high importance because of the scarcity, inaccessibility and distance of their raw material. The distance of the nearest geological locality is over 1000 kms, however these stone implements have really large distribution in Europe thanks to their very good quality and impressively nice green colour. These implements were investigated across through Europe from Scotland to Bulgaria and from the Iberian to the Scandinavian Peninsulas inside the frames of projects JADE[1] & JADE2[2], both coordinated by P. Pétrequin.

In Chapter III. 13 pieces of HPM stone artefacts were introduced with detailed data about their archaeological context (if they have), composition, textural analysis and mineral chemistry.

In Chapter IV altogether 25 pieces were described with 12 additional pieces, partially from archaeological surveys, and from the detailed reinvestigation of large collection piled up by Ebenhöch in the XIX. century.

Most pieces were found in Transdanubia area of Hungary with one exception, a piece was dug up in Gorzsa, Southeastern Hungary, close to Hódmezővásárhely. Ten of eleven pieces were found in archaeological context are belonging to Lengyel Culture, the only exception is the one from Gorzsa, which is belonging to the Tisza culture, a culture which was close relation with the Lengyel culture. 14 pieces are stray finds without archaeological context.

Raw materials of these artefacts were divided up to groups based on their bulk rock composition and mineral chemistry. Based on our results and data from the available papers on this topic (D'Amico et al. 2003, D'Amico 2012, Pétrequin et al. 2012a), our stone tools were transported from NW Italy, so they originated from the very same sources that were supplied all Europe from Scotland to Bulgaria. Our goal was to prove that these lithic raw materials came from the well documented western European source both primary sources, like Mon Viso area or the Voltri Massif, and secondary/tertiary sources like the resedimented Oligocene conglomerates of River Po, Staffora and Curone (D'Amico et al. 2003, D'Amico & Starnini 2006, 2012, Pétrequin et al. 2012a).

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[1] JADE: Jade. Grandes haches alpines du Néolithique européen (2007-2010)

[2] JADE2: Objets-signes et interprétations sociales des jades alpins dans l'Europe néolithique (2013-2017)

Chapter II

Non-destructive SEM-EDX analytical method for polished stone tools and gems: opportunities and limitations

Original title:

Csiszolt kőeszközök és ékkövek roncsolásmentes SEM-EDX vizsgálata: lehetőségek és korlátok

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II/1. Abstract

Recently we have developed a new method in the SEM laboratory of Department of Petrology and Geochemistry; Eötvös Loránd University, in order to perform *in situ* mineral chemical and textural examination of artifacts. This method called as "original surface investigation method" allows to complete non-destructive *in situ* textural and mineral chemical studies on the archaeological findings. Our SEM is equipped with quite large sample chamber, in which samples up to 300x200x55 mm can be analyzed. This special investigation needs special sample preparation process. The main steps of this process: cleaning, searching for a proper surface for investigation, wrapping the sample into aluminum foil, and at last carbon coating. After this process we can place the artifacts into the sample chamber of the scanning electron microscope, take photos and perform EDX measurements.

The aim of this work was a comparative chemical and textural analysis which was carried out on thin sections and original (more-or-less raw, polished during Neolithic era) surfaces of the same samples. Most of the investigated artefact was broken, and we were allowed to perform destructive investigations also. Method was tested on inlaid gemstones also, and gave acceptable results, without doing any harm to them or modifying their state.

According to our results this method is a useful tool to perform non-destructive archeometrical investigations in most cases. It can provide adequate chemical and textural information about several rocks' types and gemstones, however in some cases this method can provide only partial results. In these cases other – and maybe destructive – methods have to be involved to have proper results.

Keywords: non-destructive, SEM, EDX, stone tools, jewel, gemstone

II/2. Kivonat

A közelmúltban az ELTE Kőzettan-Geokémiai Tanszék Pásztázó Elektronmikroszkóp (SEM) laboratóriumában kialakítottunk, és rutinszerűvé tettünk egy eljárást, amit „eredeti felszín vizsgálati módszer”-nek neveztünk el. Ez a módszer lehetővé teszi, hogy a régészeti leleteken teljesen roncsolásmentes *in situ* ásványkémiai és szöveti vizsgálatokat végezzünk el. A laborban rendelkezésünkre áll egy nagyméretű mintakamrával felszerelt SEM, melyben meglehetősen nagy, akár 300x200x55 mm-es mintákat is megvizsgálhatunk. A minták egy speciális mintaelőkészítési eljáráson mennek keresztül, melynek főbb lépései a tisztítás, a vizsgálandó felület kijelölése, a felület beburkolása alufóliával, legvégül pedig az előző lépések során kialakított felület vezetővé tétele vékony szénréteg rágőzölésével, mely a vizsgálat után nyomtalanul eltávolítható. Ezek után kerülnek be a leletek a pásztázó elektronmikroszkóp mintakamrájába, ahol a korábban előkészített területről készíthetünk fotókat és méréseket.

Az itt bemutatott minták töredékesek voltak, ami lehetővé tette, hogy roncsolásmentes vizsgálataink eredményeit a kőeszközökből készített vékonycsiszolatokon elvégzett „hagyományos” SEM-EDX vizsgálatok eredményeivel hasonlítsuk össze, ezzel tesztelve módszerünket. A módszert nem csak kőeszközökön, hanem ékszerekbe foglalt ékköveken is sikeresen kipróbáltuk. Eredményeink azt mutatják, hogy az általunk alkalmazott teljesen roncsolásmentes módszer az archeometriai vizsgálatok során az esetek többségében jól használható, megfelelő képi és kémiai információt ad több kőzettípus, valamint az ékkövek vizsgálata esetén. Munkánk során kiderült, hogy néhány kőzettípus esetén az eredeti felszín vizsgálati módszer csak részeredményeket szolgáltat, ezekben az esetekben pontosabb eredményeket csak további – roncsolásos – vizsgálatokkal kaphatunk.

Kulcsszavak: roncsolásmentes, SEM, EDX, kőeszköz, ékszer, ékkő

II/3. Introduction

In archaeological find assemblages, very well elaborated, spectacular, intact, precisely polished stone tools are frequent finds and they are often very valuable from archaeological point of view. These objects may not be the subject of any destructive material analysis method, like thin section petrography, which is the most basic method for determining rocks, however without proper information about mineral chemistry and texture, even the rock type cannot be determined precisely. The best possibility in these cases to use non-destructive methods (e.g. Raman spectroscopy[3], PIXE[4]), but none of these methods can provide the information of minerals, mineral chemistry and texture that can be obtained during a routine optical microscopy investigation or a SEM-BSEI (scanning electron microscope backscattered electron imaging) and/or electron microprobe analysis of a thin section. At contrary, these analyses may increase the scientific value of the investigated archaeological items by adding reliable data about texture and mineral composition, and thereby the exact determination of raw materials and the provenance of the objects at final. Identification of the local raw material sources is also crucial, but the importance of objects brought from distant areas is even greater, as they allow us to reconstruct trade links in the discussed time period through the archaeological objects. Environmental simulating electron microscopes (E-SEMs) can be used to examine non-conductive samples without carbon layer deposition, but they may have sample size and other technical limitations also. In many cases the size of the sample chamber is too small, but even if the size is sufficient, electron scattering on air molecules causes the electron beam to focus over a larger area of the surface instead of a small (spot-like) area, and finally the results will not be reliable sufficiently. (For a more detailed description of electron microscopy, see the digitally available textbook by Szakáll (2011).)

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[3] Quickly evolving, non-destructive, modern analytical technique. It is using monochromatic light (mostly laser sources) for exciting samples, and evaluates the reflecting light from the samples. Molecules structures, crystal latices can be identified with it. It can be used on gas, liquid and solid sample equally. (http://en.wikipedia.org/wiki/Raman_spectroscopy)

[4] Non-destructive, modern analytical technique. It is using large sized charged particles, generally protons for exciting samples. Chemical information can be achieved from the X-ray generated by the sample – proton. It is used for analysing solid samples. (http://en.wikipedia.org/wiki/Particle-induced_X-ray_emission)

II/4. Archaeological back-ground

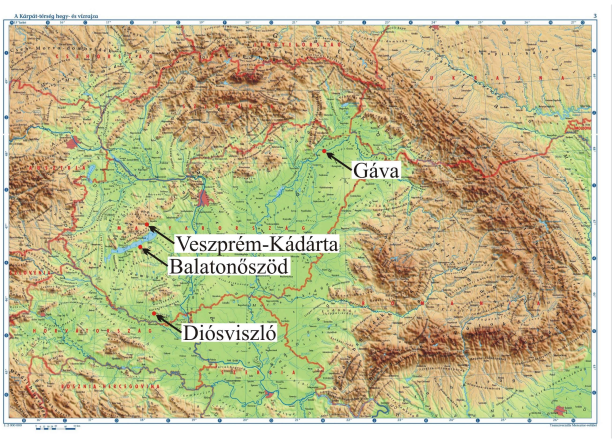

Figure II/1. Archeological sites of the presented samples.

II/1. ábra. A bemutatott tárgyak régészeti lelőhelyei. Térkép forrása/Map source:

http://www.map.hu/galeria/orig/1258_a_karpat-terseg_hegy-_es_vizrajza.jpg

Archaeological objects presented in this paper were recovered from four archaeological sites (*Figure II/1*). The aim of the analysis was to identify the raw material of the stone tools (and inlaid gems) as precisely as possible, based on their lithological and geochemical characteristics, and to determine the most potential source of their raw material based on the results.

Diósviszló (Baranya County)

Larger part of the objects were found in Diósviszló during a preventive excavation "HT-104 of Diósviszló" perfomed by the Hungarian National Museum's National Heritage Protection Centre (MNM-NÖK) in 2010. Other part of the collections was donated to the Museum by a private person. A detailed description of this object assemblage can be found in this issue of Archeometriai Műhely (Oláh et al. 2013) also, so we will not discuss it in detail here.

Veszprém-Kádárta (Veszprém County)

Nine semi-finished stone tools made of basaltic raw materials were found during the preventive excavation of construction of junction of two main roads in Kádárta area of Veszprém, at the Gelemér - Ráchalála site. They are presumably belonging to the Lengyel culture (Antoni, 2012a; Oláh et al. 2012a).

Archaeological excavations in the above-mentioned area have revealed traces of several successive cultures, suggesting that the area has been continuously inhabited since about 5000 BC. The site of the nine basaltic stone tools was a shallow pit on the north side of the main road number "8", Presumably these semi-finished stone tools were simply thrown into this pit, probably in a bag. These stone tools are showing various degrees of workmanship, ranging from barely worked pieces which have a preliminary shape of a tool only, to an almost finished artefact with only the shaft hole missing (Antoni, 2012a).

Balatonőszöd (Somogy County)

Balatonőszöd Temetői dűlő is the largest and longest inhabited area of the Báden culture sites excavated in Hungary. Traces of both Balaton-Lasinja culture and Boleraz culture were found at this site also (Péterdi, 2011, Horváth T. & Péterdi 2012).

In total, more than 500 items made of different types of rock were discovered during the excavation, mainly grinding stones and stone axes. Their raw material is also differed according to their use; while the majority (90%) of stone axes are basalt, dominant part (62%) of grinding stones made from sandstone (Péterdi, 2011).

Gáva (Szabolcs-Szatmár-Bereg County)

At the beginning of the 20th century, precisely in 1910, a unique archaeological assemblage was discovered in Gáva (present days Gávavencsellő) (Hampel, 1911), including a pair of unusually large bow-brooches, a belt buckle with a particular figural ornamentation, elements of various necklaces and a toilet-set. The artefacts, kept in the Jósa András Museum in Nyíregyháza, are dated to the mid-5th century, covering the Gepidic period in the Tisza-region. They probably formed the grave goods of a high-status female burial, although due to the circumstances surrounding the discovery we have no record concerning the skeleton and the details of the construction of the burial.

These archaeological objects were made of different materials according to their function. Toilet-set was made of silver, jewellery was made of gold, and the dress accessories, i.e., the belt buckles and the two large brooches were made of gilded silver. The investigated garnet inlays decorate both the jewellery and the dress accessories (Horváth E. 2012, Horváth E. et al. 2013).

II/5. Analytical methods

Main goal of this study is to compare the results obtained both on the original raw surface of stone tools and in thin section analogues of all presented objects, and to prove the potentials of our non-destructive method. Due to this reason, only fragmentary or semi-finished stone implements were investigated during this study; and destructive methods were allowed to use on them, so thin sections were made from all stone implements as a reference material.

(No destructive methods were used on metallic items from Gáva, of course).

Figure II/2. The AMRAY 1830 SEM in our laboratory with a prepared stone tool on its sample holder.

II/2. ábra. A laboratóriumunkban lévő AMRAY 1830-as SEM készülék, mintatartóján (balra középen) egy vizsgálatra előkészített kőeszköz.

For comparison of results of mineral chemistry analyses, characteristic and chemically resistant minerals were chosen. For textural analyses, areas with typical textures were chosen on both thin section and on the original surface. Results are concluded at the end of this study in both sample by sample and as a summary of the complete study altogether with the pros, contras and the limitations of the "original surface investigation method".

Instruments and methods

Measurements were performed at the Department of Petrology and Geochemistry, Institute of Geography and Earth Sciences, Eötvös Loránd University. The instrument used for the investigations is an AMRAY 1830 scanning electron microscope with tungsten filament, and equipped with an EDAX PV9800 energy dispersive spectrometer (*Figure II/2*). The instrument has a five-axis manual sample holder (X, Y, Z, R, T), which allowed us to reach the optimal horizontal setup of the surfaces to be investigated; which is necessary to achieve the most accurate results.

Figure II/3. The presented six stone tools after the cleaning. Areas to be investigated has been chosen also.

II/3. ábra. Hat darab kőeszköz a mintaelőkészítés első két lépcsőfoka után, vagyis a vizsgálandó területek kiválasztása és megtisztítása után.

Sample chamber of the SEM instrument is quite large, allowing objects up to 300x200x55 mm to be analysed. 20kV accelerating voltage and 1 nA beam current was used during the investigation. Beam diameter was equivalent with the diameter of the focused electron beam (~50 nm). All presented SEM micrographs were taken by backscattered electron (BSE) detector. For evaluating of mineral chemistry data, a set of international standards[5] and ZAF correction were used. The analyses were performed under high vacuum, at pressures of ~10^{-3} Pa, so samples had to be coated with a conductive carbon layer in order to be conductive. A JEOL JEE-4B type carbon/gold coater was used for this surface preparation.

Original surface investigation method

The most important and most unique part of our test procedure is the special sample preparation, which was developed and refined in our laboratory. This preparation process is presented below step by step.

Step 1: Find and select the best surface on the sample (*Figure II/3*). This process is starting with a simple geometrical checking to find the most stable positions of the sample where the specimen is sitting in stable position on the SEM's sample holder. As a result of this checking, surface to be analysed is defined. Then a surface with representative texture and mineral composition has to be chosen for further preparation. From point of view of the analysis, a smooth, well-polished, visibly not altered and flat part of the surface is the best choice. If necessary, multiple areas can be selected on the surface of the sample. For large sized samples, a suitable compromise must be found during the determination of areas to be investigated,

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[5] International microanalytic standards were used for analysis: albite: Amelia # AS5010-AB; orthoclase: MAD-10; augite: ENM-augite; chromite: Australia, C. M. Taylor Company; titanite: C. M. Taylor Company; kaersutite: Glen Innes, Australia, C. M. Taylor Company; biotite: LP-6; apatite: Wilberforce apatite # AS1040-AB; Ba-, Zn-, U-containing artificial glass: K-378 F. G.; olivine: AS5200-AB; spessartine: garnet No. 3d.

measuring points shall be defined by both the characteristic of the sample and load and movement capabilities of the sample holder of the SEM. Surfaces with visible preparation /usage marks should be avoided during the investigation.

Step 2: Selected surface(s) have to be cleaned carefully by using organic solvents (e.g. acetone, petroleum ether). If there are no areas without usage or preparation marks, sample have to be cared with particular attention to avoid damaging these marks during cleaning. Then apply thin strips of conductive adhesive on the sides of the selected area to be analysed.

Step 3: The specimen has to be wrapped in aluminium foil, then a window has to be cut in the foil at the location(s) selected for analysis. Sample ID-s have to be written on Al foil, and areas have to be marked also with permanent marker. (*Figure II/4, Figure II/5*).

Figure II/4. The six stone tools presented on the Fig. II/3. wrapped into aluminium foil and prepared for the selected area carbon coating.

II/4. ábra. A II/3. ábrán bemutatott kőeszközök alufólia burkolatban, a szelektált területű gőzöléshez előkészítve.

Step 4: Next step is to make the samples conductive by carbon coating. The possible thinnest carbon layer has to be applied on the surface of the specimens (*Figure II/6*).

Step 5: Place the specimen onto the sample holder of the SEM. Geometry is very important, the investigated surface has to be set as close to horizontal as it possible for the most accurate results (*Figure II/7, Figure II/8*).

After the conductive surface has been prepared, SEM-EDX analysis can be performed any time, however it is recommended to perform the tests as soon as possible after the carbon coating, and remove the carbon layer immediately after the investigation.

Note: The preparation procedure described so far applies to the jewellery also. The only difference that after step 4. the aluminium foil, which in this case only has a protective role, can be removed from the jewellery as it is conductive itself.

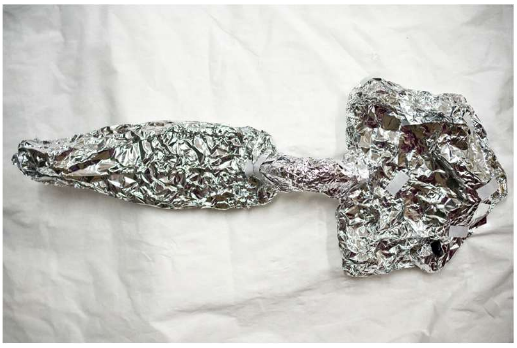

Figure II/5. The large brooch wrapped into aluminium foil (the horizontal edge of the picture about 35 cm long).

II/5. ábra. Az egyik nagyméretű gávai fibula alufóliába burkolva, gőzölés előtt (képszélesség kb. 35 cm).

Figure II/6. Carbon coated samples.

II/6. ábra. A kőeszközök vizsgálatra kijelölt felülete legőzölve.

II/6. Case studies

Detailed results of the case studies presented below have been announced in several papers and conferences (Oláh et al., 2012a, 2012b, 2012c, Bendő et al. 2012) moreover some of them are also presented in this volume (Oláh et al. 2013), therefore detailed archaeological and provenance descriptions have been limited in this paper.

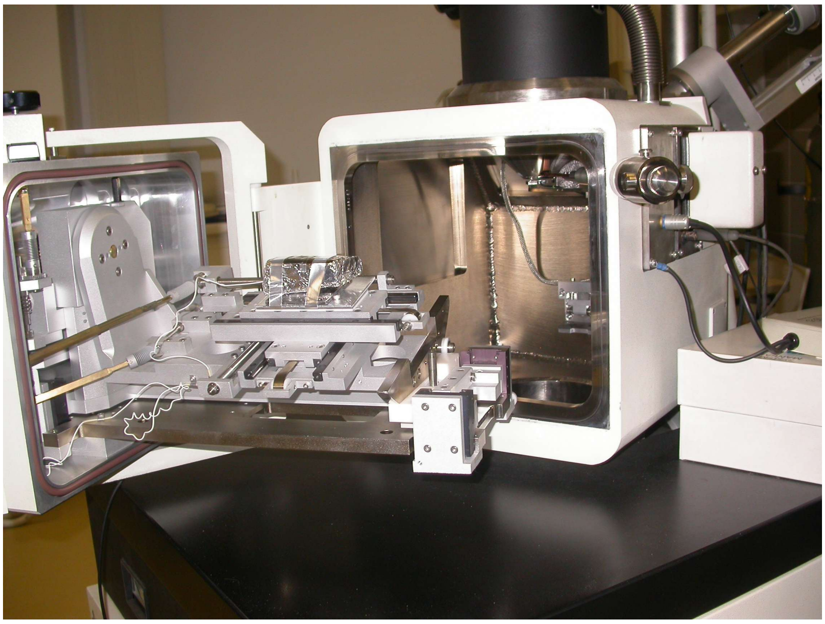

Figure II/7. Sample Dv-346 on the sample holder of SEM, prepared for SEM-EDX investigation.

II/7. ábra. A Dv-346 jelű minta vizsgálatra bekészítve az elektronmikroszkóp mintatartójára.

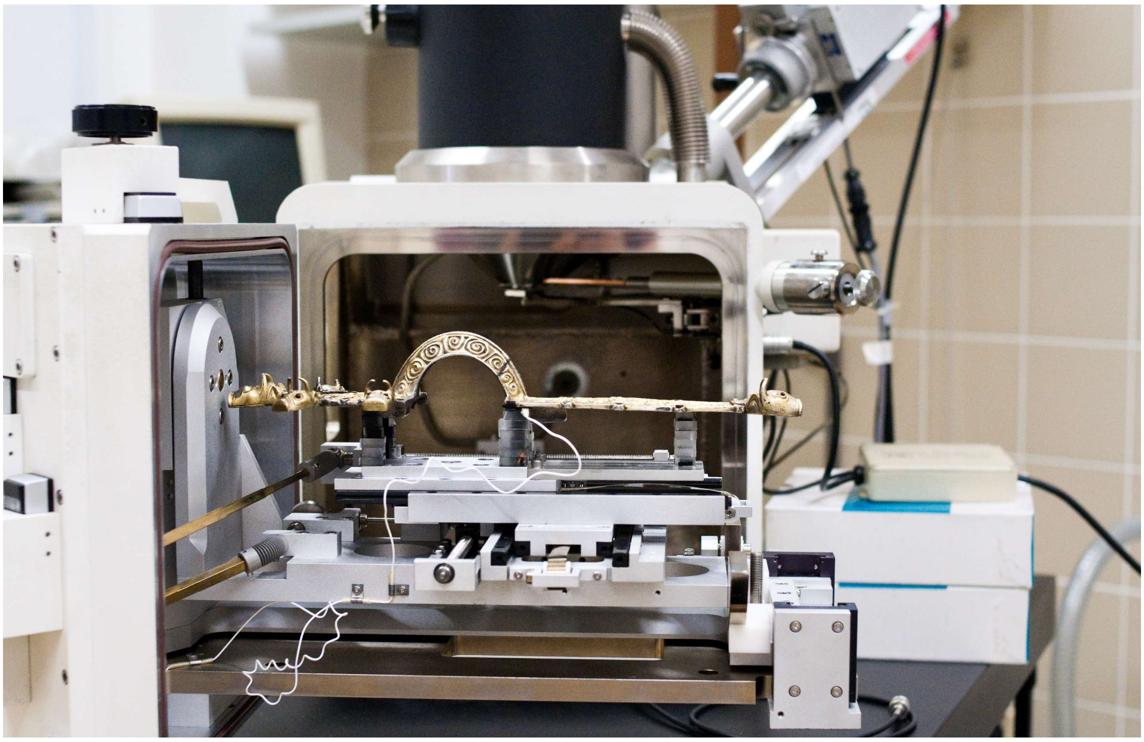

Figure II/8. The large brooch from Gáva mounted onto the sample holder of the SEM.

II/8. ábra. A 6. ábrán is bemutatott nagyméretű gávai fibula vizsgálatra előkészítve.

Sample ID	Locality	Type	Investigations			
			VCS	MS	PGAA	EMPA
Dv-349	Diósviszló	shoe last axe	+	+	-	-
Dv-346	Diósviszló	axe	+	+	-	-
Dv-347	Diósviszló	perforated axe	+	+	-	-
Dv-zz	Diósviszló	flat chisel	+	+	-	-
Dv-q	Diósviszló	semi-finished flat chisel	+	+	-	-
Vpk-1004	Veszprém-Kádárta	semi-finished axe	+	+	+	-
Bot-X5	Balatonőszöd	flat chisel	+	+	+	+

Table II/1. List of the stone implement samples with archaeological sites, type of artifacts and the used investigation methods. All of the samples were investigated by stereomicroscope and the original surface method, therefore these methods aren't on the list. Abbreviations: VCS: SEM-EDX examinations on thin section, AMRAY 1830, ELTE; MS: magnetic susceptibility, Kappameter KT-5, ELTE; PGAA: prompt gamma activation analysis, KFKI; EMPA: thin section EMPA examination, JEOL Superprobe 733, MTA Institute of Geology and Geochemistry.

II/1. táblázat. A kőeszközök lelőhelye, típusa, és a rajtuk elvégzett vizsgálatok. Az összes mintát megvizsgáltuk sztereomikroszkóppal és az eredeti felszín vizsgálati módszerrel, így ezek külön nem szerepelnek a táblázatban. Rövidítések: VCS: vékonycsiszolat SEM-EDX vizsgálat, AMRAY 1830, ELTE; MS: mágneses szuszceptibilitás, Kappameter KT-5; PGAA, ELTE: prompt gamma neutronaktivációs analízis, KFKI EK; EMPA: vékonycsiszolat mikroszondás vizsgálata, JEOL Superprobe 733, MTA, Földtani és Geokémiai Intézet.

rövidítés	angol ásványnév	magyar ásványnév
ab	albite	albit
act	actinolite	aktinolit
adr	andradite	andradit
aeg	aegirine	egirin
aega	*aegirine-augite*	*egirinaugit*
afs	alkaline feldspar	alkáliföldpát
alm	almandine	almandin
amp	amphibole	amfibol
an	anortite	anortit
ap	apatite	apatit
aug	augite	augit
chl	chlorite	klorit
cl	*clay mineral*	*agyagásvány*
cpx	clinopyroxene	klinopiroxén
cum	cummingtonite	cummingtonit
en	enstatite	ensztatit
ep	epidote	epidot
fs	ferrosilite	ferroszilit
grs	grossulare	grosszulár
grt	garnet	gránát
hbl	hornblende	hornblende
ilm	ilmenite	ilmenit
jd	jadeite	jadeit
mag	magnetite	magnetit
mnz	monazite	monacit
ort	orthoclase	ortoklász
pl	plagioclase	plagioklász
prp	pyrope	pirop
ser	sericite	szericit
sps	spessartine	spessartin
trm	tremolite	tremolit
wo	wollastonite	wollastonit
zrn	zircone	cirkon

Table II/2. Abbreviations of the mineral names used on pictures and diagrams are after the international articles except the two abbreviations in italics.

II/2. táblázat. A képeken és a diagramokon használt ásványnevek rövidítései a nemzetközi irodalom alapján, ez alól csak a két dőlt betűvel jelzett rövidítés kivétel.

To have a good comparison, fragmentary or semi-finished stone tools were chosen for the investigation, so we had the opportunity to prepare petrological thin sections from all of them (*Table II/1*). A short description have been given for each specimen, based on the results of electron microscopic petrography and SEM-EDX investigation of the original surface. In the second part of the description, results of tests performed on the original surface and on the thin sections were compared to each other. Data obtained by the two sets of tests are evaluated, and the differences between the data (for both imaging and chemistry) have been summarized, and finally the applicability of the original surface test method have been determined for the particular rock type. Detailed descriptions of the optical microscopic and SEM-EDX analyses of thin sections of the investigated stone tool samples are available in Oláh et al. (2012a); Péterdi (2011); Horváth T. & Péterdi (2012); Oláh et al. (2013). Results of the gemstone analysis can be found in Horváth E. et al. (2013).

The abbreviations used in the figures and diagrams are in line with international practice (Whitney & Evans 2010), and they are shown in *Table II/2*. For feldspars and pyroxenes, the accepted nomenclature diagrams have been used (pyroxenes: Morimoto et al. 1988). For amphiboles, the cation numbers of the characteristic elements of the respective amphibole types are shown. In all diagrams, mineral chemistry data measured from the original surface are represented by *blue empty circles* ○, while data obtained from thin sections are represented by *red solid circles* ●.

Sample Dv-349

Fragment of an alkaline dolerite stone tool, with well polished flat part and less polished convex part. Its texture is porphyritic, with clinopyroxene as phenocrysts and microphenocrysts (*Figure II/9*). Fine grained matrix of the rock is consisting mainly albite, with epidote, K-feldspar, ilmenite and phyllosilicates. The clinopyroxene crystals are zoned, however this is not visible on the original surface, but detectable in the EDX data. Large apatites with high Cl content are common, while zircons are rare accessories.

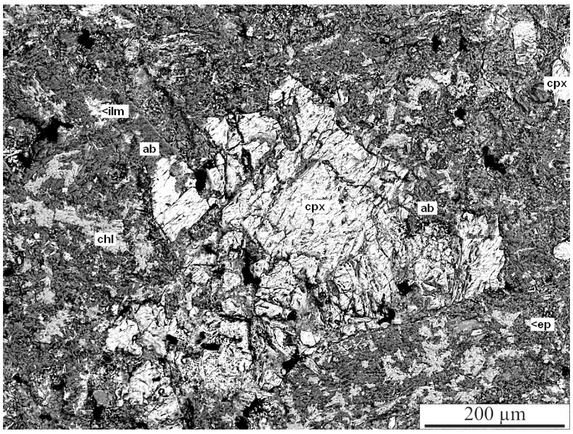

Figure II/9. Texture of the original surface of the sample Dv-349. There is a large apparently homogenous clinopyroxene crystal in the center.

II/9. ábra. A Dv-349 jelű minta eredeti felszínéről készített szöveti képe, középen egy nagyméretű, homogénnek tűnő klinopiroxén kristállyal.

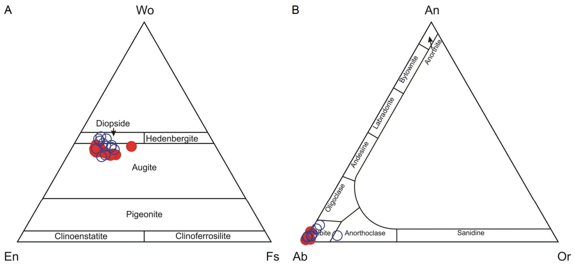

Figure II/10. Diagrams of mineral chemistry analyses of comparing results of sample Dv-349 obtained on the original surface and thin section. A: pyroxene, B: feldspar

II/10. ábra. A Dv-349-es minta eredeti felszínéről és a vékonycsiszolatból származó ásványkémiai adatok összehasonlító diagramjai, A: piroxén, B: földpát.

In the thin section amphiboles can be found in addition to the minerals listed above; with barkevikitic composition as primary amphibole phase, and as a result of clinopyroxene alteration (uralithization). Those textural characteristics can be seen on the original surface are also visible in thin section. All mineral phases are observable on the original surface except amphiboles; however, neither alteration nor zonation of the clinopyroxene are not visible on the original surface. The mineral chemistry data are showing good correspondence. As it can be seen on the triangle diagrams, data fields are overlapping, however the deviation is larger among the data obtained from the original surface (*Figure II/10*). Although zonation is not visible on the BSE images of pyroxenes were taken about the original surface, it can be observed in the mineral chemistry data.

Despite the loss of information described above, this rock type can be identified by original surface investigation method only with a fair confidence.

Sample Dv-346

A fragment of stone tool made of sodalitic phonolite, well elaborated, with various quality of polishing on the different sides. The porphyritic texture of the rock is clearly visible on the original surface (*Figure II/11*). The phenocrysts are alkaline feldspars and zoned pyroxenes, while the matrix is composed of alkaline feldspars and aegirine-augite mainly, with apatite and monacite as accessories. The matrix contains a large amount of clay minerals, which cannot be defined more precisely by SEM-EDX; they are filling the surface pits of the stone tool.

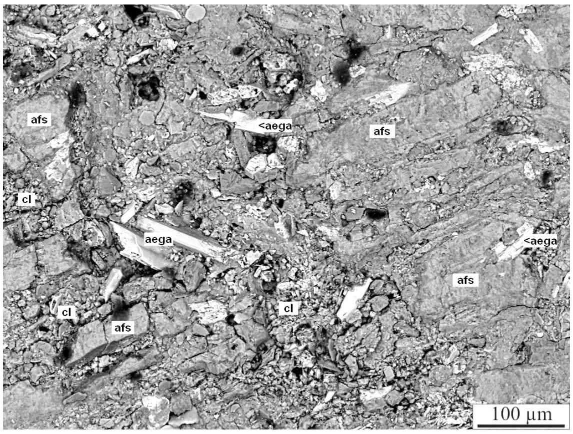

Figure II/11. Texture of the original surface of the sample Dv-346. Alkaline feldspar and aegirine-augite crystals can be seen in the surface. Cl: clay mineral which is unidentifiable by EDX.

II/11. ábra. Eredeti felszínről készített szöveti kép a Dv-346 jelű minta alapanyagáról. A képen összesen háromféle ásvány azonosítható, alkáliföldpát, egirinaugit és a cl jelzésű nem azonosítható agyagásvány.

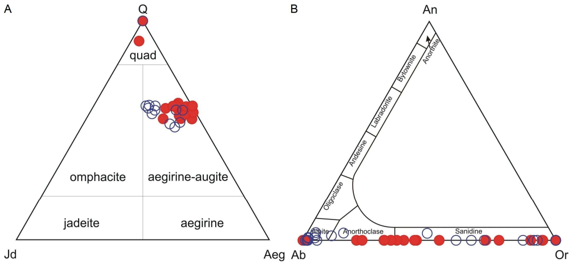

Figure II/12. Diagrams of mineral chemistry analyses of comparing results of sample Dv-346 obtained on the original surface and thin section. A: pyroxene, B: feldspar.

II/12. ábra. A Dv-346-es minta eredeti felszínéről és a vékonycsiszolatból származó ásványkémiai adatok összehasonlító diagramjai, A: piroxén, B: földpát.

During the investigation of the thin section, several mineral phases were identified which are not present on the original surface, like feldspathoids, hainite, namansilitic pyroxene and kaersutite. On the contrary, during the investigation of the original surface, we found large amounts of clay minerals, which were not present in the thin section. These phases have formed probably during the weathering of various minerals, especially feldspathoids. The characteristics of texture can be seen on the original surface and in the thin section is identical. Accordingly, the mineral chemistry data of the mineral types present on the original surface (feldspar, aegirine-augite) is very similar to the data measured in the thin section (*Figure II/12*).

Based on the results, SEM-EDX examination of the original surface method only is not providing sufficient data to proper identification of this rock type, since lot of mineral phases are missing from the surface. Without thin section, this rock is cannot be identified properly. However, the presence of a large amount of clay minerals is an important information also, because their presence indicates that certain mineral phases are missing from the original surface. These minerals have been altered and/or disappeared in the soil during the burial. Some sensitive minerals playing essential role for classification of rocks, are unstable among the conditions in the soil. Fortunately, they are leaving some altered phases on the surface to sign that further, possibly destructive testing necessary.

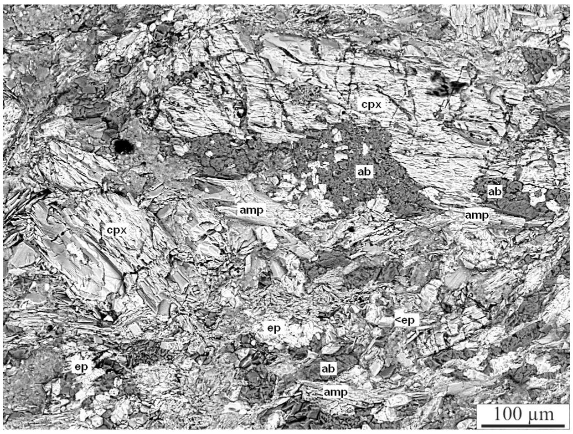

Figure II/13. Texture of the original surface of the sample Dv-347. There are two large apparently homogenous clinopyroxene crystals on the left and the upper side of the picture.

II/13. ábra. A Dv-347 jelű minta szöveti képe, balra és felül egy-egy nagyméretű, látszólag homogén klinopiroxén kristállyal.

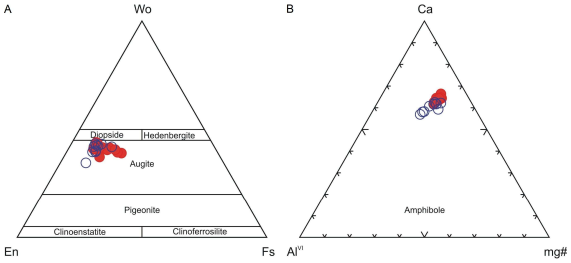

Figure II/14. Diagrams of mineral chemistry analyses of comparing results of sample Dv-347 obtained on the original surface and thin section. A: pyroxene, B: amphibole

II/14. ábra. A Dv-347-es minta eredeti felszínéről és a vékonycsiszolatból származó ásványkémiai adatok összehasonlító diagramjai, A: piroxén, B: amfibol.

Sample Dv-347

This is a fragment of stone tool made of greenschist with well-polished flat surfaces. Raw material is strongly schistose, its texture is porphyroblastic, with clinopyroxene crystals with pre-tectonic origin (*Figure II/13*). EDX analysis revealed that these crystals are zoned, however it is not visible on the original surface. The matrix contains large amounts of chlorite, actinolite and epidote. Albite appears in bands and knots. Hornblende is not frequent component in this rock. Accessory minerals are titanite and apatite.

Thin section analysis of the sample proved that the texture and all mineral phases can be identified by investigation of the original surface. The only difference is a textural one: the zonation of the clinopyroxene was not visible on the original surface. Mineral chemistry is showing good correspondence also, especially for amphiboles and pyroxenes (*Figure II/14*). These data are proving that this rock type can be identified with a very good confidence by examination of the original surface of the stone implement only.

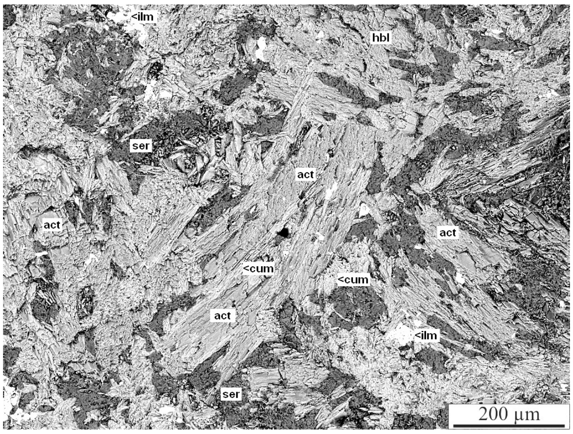

Figure II/15. Texture of the original surface of the sample Dv-zz. There is a large, obviously multiphasic amphibole crystal in the center.

II/15. ábra. A Dv-zz jelű minta szöveti képe, középen jól láthatóan többfázisú amfibol-kristállyal.

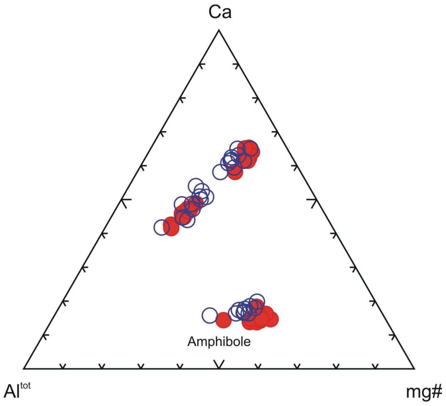

Figure II/16. Comparing amphibole chemistry diagram of the sample Dv-zz results obtained on the original surface and thin section.

II/16. ábra. A Dv-zz jelű minta eredeti felszínéről és a vékonycsiszolatból mért amfibolok ásványkémiai adatainak összehasonlító diagramja.

Sample Dv-zz

A stone tool fragment with well-polished surfaces made of biotite-containing contact metabasite raw material. Its texture is nemato-fibroblastic, containing three different type of amphiboles (actinolite, cummingtonite or antophyllite, and Mg-hornblende), chlorite and sericite (*Figure II/15*). The three different amphiboles are usually occurring together (but they did not form simultaneously), with a core of actinolite composition overgrown by a rim of cummingtonite and/or Mg-hornblende composition. The accessory minerals are ilmenite, titanite and apatite. No feldspar and/or quartz was found in this sample.

Examination of the thin section of this item proved that the textural features are visible on the thin section are recognisable by investigation of the original surface also for this rock type. Besides biotite, all minerals have been found on the original surface. The mineral chemical data of the amphiboles is showing a good correspondence also (*Figure II/16*), so this rock type can be identified by the original surface method with a good confidence.

Sample Dv-q

Semi-finished stone tool made of greenschist, with some well-polished sides. The raw material is strongly schistose, its texture is nematoblastic, main mineral phases are albite, actinolite, epidote and chlorite (*Figure II/17*). Titanite is present in small amount as accessory component.

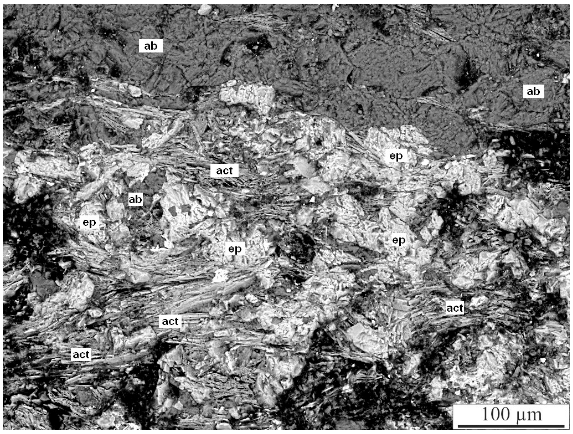

Figure II/17. Texture of the original surface of the sample Dv-q. There is a characteristic albite band in the upper part, and epidot crystals among the orientated actinolite grains in the lower part of the sample.

II/17. ábra. A Dv-q jelű minta szöveti képe, felül egy jellegzetes albitsáv, az alsó részen pedig az irányított aktinolitkristályok között véletlen-szerűen elhelyezkedő epidotszemcsék láthatók.

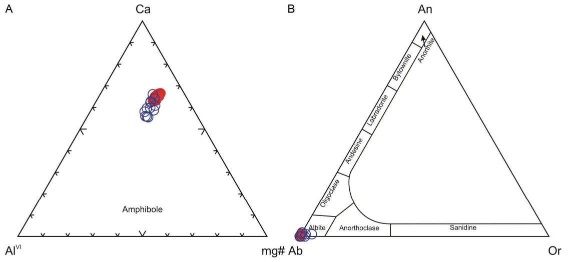

Figure II/18. Diagrams of mineral chemistry analyses of comparing results of sample Dv-q obtained on the original surface and thin section. A: amphibole, B: feldspar

II/18. ábra. A Dv-q jelű minta eredeti felszínéről és a vékonycsiszolatból származó ásványkémiai adatok összehasonlító diagramjai, A: amfibol, B: földpát.

The rock's texture is well recognisable on the original surface of the sample, however higher magnification had to be applied, than in case of thin section investigation, to identify all the individual mineral phases. Mineral chemistry data from the two test series are very similar also (*Figure II/18*), so this rock type can be properly identified by investigation of the original surface.

Sample Vpk-1004

Semi-finished stone axe with a very rough surface made of olivine basalt. Its texture is porphyritic intersertal, olivine is the main phenocryst phase, augites are the microphenocrysts (*Figure II/19*). Iddingsitic alteration can be observed at the rims of large olivine crystals. Matrix is consisting of plagioclase, clinopyroxene, fine-grained, partially iddingsitic olivine; titanomagnetite and glass; and a small amount of apatite. Texture of the matrix is homogeneous and hypocrystalline. Plagioclases are occurring in the matrix only and based on the measurements, their composition falls within the labradorite-bytownite fields (*Figure II/20*). Several xenoliths from the Earth's crust can be found in the sample, they are showing zonal structure.

Texture of the rock is well visible, and all mineral phases and crustal inclusions can be found on the original surface, the only missing phase is the glass in the matrix. Chemical analyses from the two test-series are showing a good correspondence (*Figure II/20*). For the feldspars, the overlapping of data fields is good, with all results are falling into the fields of typically basic plagioclases (labradorite and bytownite, *Figure II/20B*). The pyroxene data sets are showing differences. Data from the original surface shows a significantly higher Ca content (*Figure II/20A*), which can be a result of several factors (e.g. zonation, weathering, pyroxenes originated from alteration of crustal inclusions, etc.). Despite of these few differences, this rock type can be properly identified by investigation of the original surface.

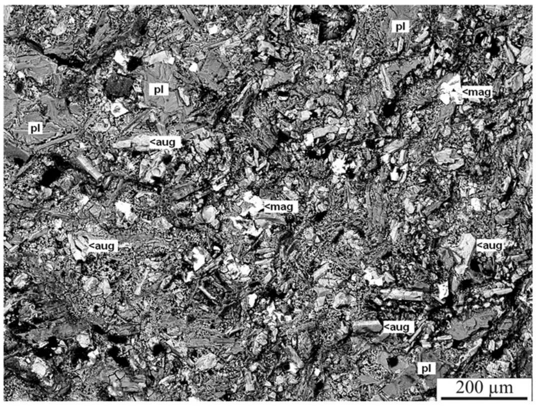

Figure II/19. Texture of the original surface of the sample VPK-1004. This is the most incomplete finding, the roughness of the original surface is very well visible on the BSE picture.

II/19. ábra. Szöveti kép a VPK-1004 jelű minta alapanyagáról. A bemutatott kőeszközök közül ennek a példánynak a felszíne a legkevésbé kidolgozott, durvasága jól látható a BSE képen.

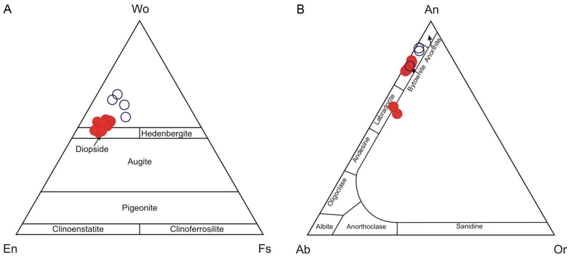

Figure II/20. Diagrams of mineral chemistry analyses of comparing results of sample VPK-1004 obtained on the original surface and thin section. A: pyroxene, B: feldspar. Here are the largest differences between the EDX data from the original surface and from the thin section. The Ca-content of minerals is higher on the original surface than the thin section.

II/20. ábra. A VPK-1004 jelű minta eredeti felszínéről és a vékonycsiszolatból származó ásványkémiai adatok összehasonlító diagramjai, A: piroxén, B: földpát. Egyedül ennél a leletnél fedezhető fel nagyobb különbség az elemzési adatok között, mindkét esetben a Ca-tartalom magasabb az eredeti felszínről származó adatokban.

Sample Bot-X5

Analysis of this sample has a particular importance because the thin section was investigated on another instrument, a JEOL Superprobe 733 electron microprobe at the Hungarian Academy of Sciences. Instrument's Oxford Instrument INCA Energy 200 energy dispersive spectrometer was used in this case (Péterdi, 2011). BSE photomicrographs were taken on this instrument also. In this way, we were able to check the correspondence of the results of two test series performed by an independent laboratory and by our laboratory.

This sample is a flat chisel with a well-polished surface made of nephrite. It is a monomineralic rock with fibroblastic texture, composed of thin needle-like tremolite fibres with occasional, unoriented larger crystals with rhombic cross-section (*Figure II/21*). The fibrous crystal groups often have radial appearance, however fan-like or completely irregular crystal groups were found also.

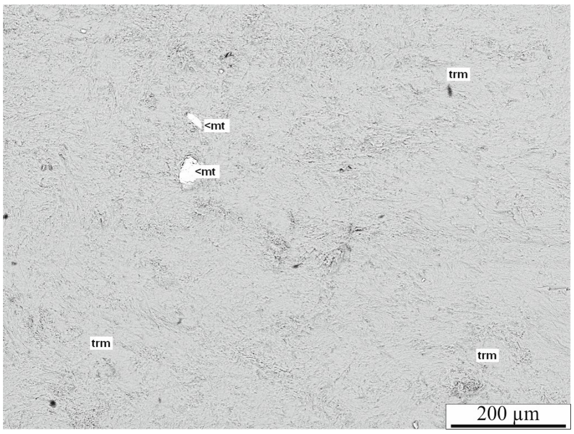

Figure II/21. Texture of the original surface of the sample BOT-X5. This is a well elaborated item, the original surface is very well polished. This sample is almost monomineralic, it consists of elongated, sometimes fan-like tremolite crystals. The only mineral beside tremolite is magnetite.

II/21. ábra. A Bot-X5 jelű minta szöveti képe. Jól látható a felszín kitűnő polírozottsága, valamint az, hogy a kőzet szinte teljesen monomineralikus. Két magnetitszemcse kivételével az egész felület tremolitból áll. Több helyen megfigyelhetők sugaras és elágazó kristálycsoportok.

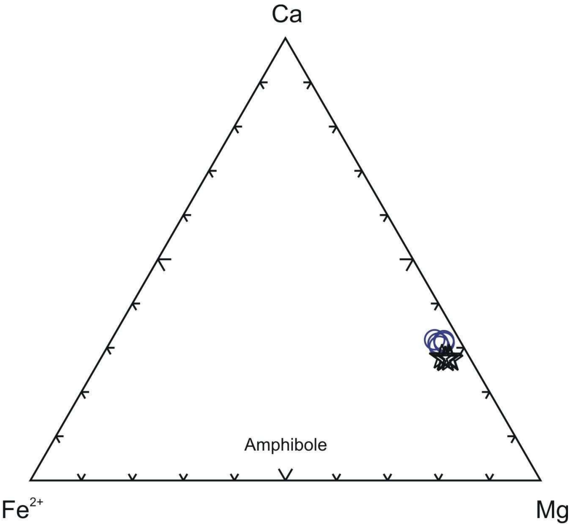

Figure II/22. Diagrams of mineral chemistry analyses of comparing results of sample BOT-X5 obtained on the original surface and thin section. The results of control analyses, which made on a JEOL 733 Superprobe are signed in black star.

II/22. ábra. A Bot-X5 jelű minta eredeti felszínéről és a vékonycsiszolatból mért amfibolok ásványkémiai adatainak összehasonlító diagramja. Ebben az esetben az eltérő jelzés (csillag) az eltérő műszeren történt mérésre utal.

Textural conformity is very good between the two different test series, and the results of mineral chemistry analyses of two different laboratories are very similar as well. This is very positive feedback on the usability of the method was developed in our lab (*Figure II/22*). In numerical terms, the largest difference between the two data series is between the Mg values, but even there is less than 2%. For other elements the difference is less than 1%. This rock can be identified properly by investigation of the original surface also.

<u>Gemstones</u>

The method presented in this article is also suitable for identifying gemstones inlaid in jewellery. For these investigations, two main advantages are the conductive metal body of the jewellery, and the surface of the gemstones had been polished to be flat.

A major disadvantage may be the shape of some objects, which can be very complex, and sometimes their size can be quite large. As a consequence, the preparation, and the installing of these objects into the sample chamber of the SEM, and finally reach the proper geometry required for measurements sometimes really difficult. The five-axis sample holder of the instrument, however, allows a very wide range of configurations, therefore the ideal position can be reached and can be changed during the measurement as required. The *Figure II/8* is showing the installation of a particularly large bow-brooch, which were very difficult to handle.

The procedure used in these cases is mainly the same as described in Section II/5. The object to be investigated have to be wrapped in aluminium foil, then Al foil have to be perforated at selected points, and then the item has to be carbon coated. The only difference is that the Al foil have to be removed after carbon coating. Finally, the object can be placed into the SEM in the planned position.

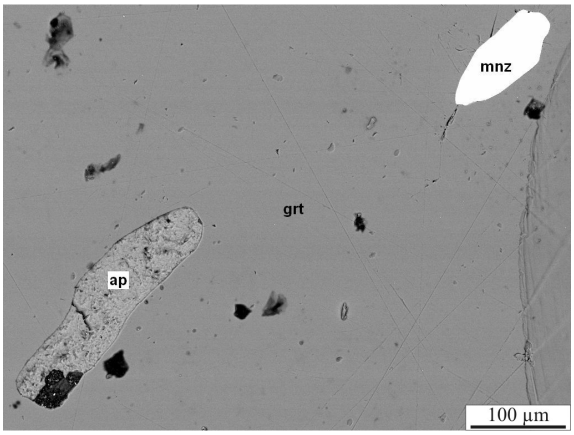

Figure II/23. One of the garnet inlays from a gold jewel from Gava with large mineral inclusions. The surface is almost perfectly polished.

II/23. ábra: Az egyik gávai aranyékszert díszítő gránátberakás nagyméretű zárványainak fotója. Érdemes megfigyelni a szinte tökéletesen polírozott felszínt.

Since the surface of gemstones is usually flat and well-polished, they have a suitable surface for investigation, as shown in *Figure II/23*. During the investigation of this assemblage, a total of 8 pieces of artefacts containing 41 pieces of garnet inlays were examined. From the 41 garnets 40 pieces are belonging to the pyralspite series and only one is belonging to the ugrandite series. In case of pyralspite garnets, their composition allows us to determinate the parameters of their formation (*Figure II/24a*) as well as the supposed geological source of the raw materials (*Figure II/24b*) (Horváth E. & Bendő, 2011 and references cited therein)[6]. Evaluation of the mineral inclusions assemblages in garnets also contributes to a better understanding of the formation conditions and through that the origin of the gems (although, these inclusions can only be identified by SEM-EDX when they are situated on the surface). Apatite, monazite, rutile and zircon inclusions were found in the studied garnets.

Consequently, our analytical protocol provides very good imaging and chemical information for garnets. Identifying the mineral chemical composition and the inclusion assemblages the method proves to be suitable for the localisation of the geological source area of the garnet raw material.

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[6] Since 2013, when this article was published, new studies have been issued about this topic, new localities have been added, and status of some known localities were changed.

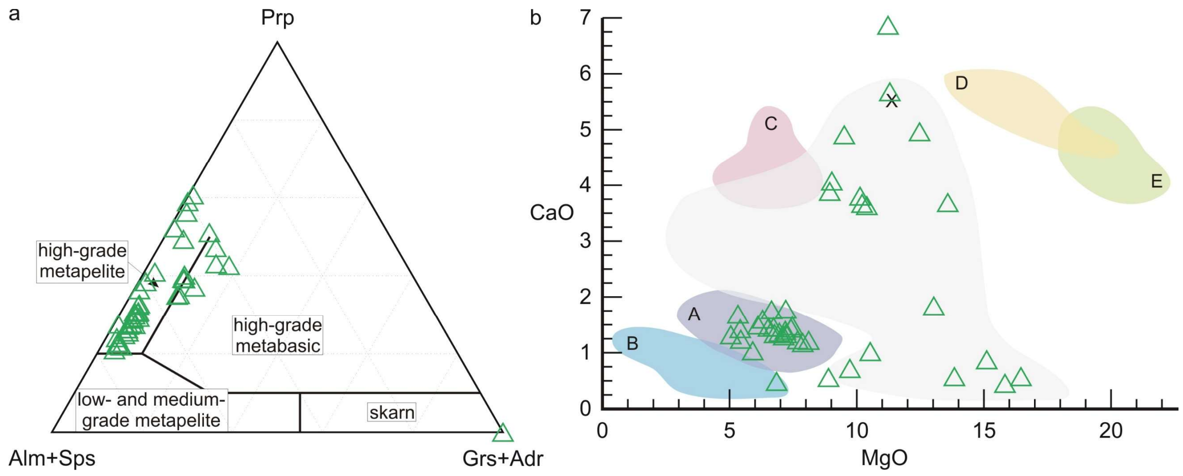

Figure II/24. a: Elemental composition of garnets provides essential information about the conditions of formation (modified after Morton et al. 2003). b: MgO – CaO diagram showing the composition of the garnets from the Gáva assemblage based on the SEM-EDX measurements. The classification of possible garnet provenances is based on Calligaro et al. 2008 and Gilg et al. 2010. Fields marked by different colours and letters correspond to the compositions of garnets form distinct localities (A: Southern India, B: Northern India, C: Scandinavia, D: Portugal, E: Bohemia, X: Sri Lanka)[6].

24. ábra. a: A gránátok összetétele a keletkezési feltételekről tanúskodik (Morton et al. 2003 után módosítva). b: A MgO – CaO diagram a gávai gránátok lehetséges származási helyét ábrázolja Calligaro et al. 2008 és Gilg et al. 2010 cikkei alapján. A különböző színű és betűjelű mezők az egyes lelőhelyekről származó gránátok összetételét jelzik (A: Dél-India, B: Észak-India, C: Skandinávia, D: Portugália, E: Csehország, X: Sri Lanka)[6].

II/7. Conclusion

The original surface investigation method presented here has been proved to be very useful tool in examination of archaeological finds and other artefacts, particularly in cases where destructive examination cannot be performed. The case studies presented above have shown that the photographic (e.g. *Figure II/15*) and mineral chemical (e.g. *Figure II/12*) data obtained from the surface are very similar to those obtained from thin sections in most cases. During our investigations, it became clear that this method cannot be applied with success to all rock types. However, lot of information were obtained even in these cases also (like texture, chemistry of the minerals that are present on the original surface, the locations of the missing phases in the texture), that provides significant additional information.

Imaging

The visual information obtained by the original surface investigation method is very similar to the visual information obtained from the thin sections. Rocks' textures were recognisable in all cases, however in cases of poorly polished surfaces, a higher magnification had to be used than in thin sections, to distinguish the different mineral phases (e.g. *Figure II/17*), especially if the sample contains fine-grained or fibrous-needle textured minerals. The same relation is true for grain boundaries: they are difficult to observe in barely polished, fine-grained rocks. In cases when well-polished stone tools or other objects are investigated, zoning can be observed also (e.g. Szakmány et al. 2013 in this volume). In most cases the original surface of the tools is not completely smooth and flat, and therefore some morphological information can be observed on BSE images on photomicrographs which can be confusing (e.g., *Figure II/11*). Due to this phenomenon the compositional changes may not visible properly in some cases. This is the reason why zonation of minerals is much less or not visible on the uneven original surface (e.g. *Figure II/9*), and more difficult to distinguish some mineral phases with close average mass number (e.g. quartz-albite) than in thin sections.

Mineral chemistry

Mineral chemistry data obtained from the surface measurements are very similar to the results from thin sections, however the standard deviation is higher in all cases. The mineral chemistry data are showing the compositional zoning within the grains even if the zonation of minerals was not observed visually. It is important to highlight that, the mineral association on the rock’s surface can be altered during the thousands of years of burial. Unstable phases may disappear or transform into new minerals under the conditions in the soil. In these cases, the original surface of the sample does not show the original mineral composition. The most important unstable phases are the feldspathoids and the glass. This means that some types of rock (e.g. the sodalitic phonolite of sample Dv-346) cannot be identified certainly by this method only. In cases when large scale alteration suspected, optical and instrumental analysis of thin section cannot be omitted. Our final conclusion is that the raw materials and, through that the source area of most stone implements can be delimited or even determined by investigating the original surface only.

II/8. Summary

Our results are showing that we can obtain useful mineral chemistry data from polished stone tools, as well as visual information on the characteristic textural properties of the rocks, mineral inclusions and sometimes zonation. These information makes easier to determine the genesis of the raw material and to narrow the possible location of its deposit. On the other hand, we can get a picture of the alteration of the surface of the stone tools, and particularly the alteration of some individual minerals.

Gemstones inlaid in jewellery can be investigated *in situ* only, in their settings, however, determining their chemical composition and inclusion assemblages allows us to identify their formation and also their raw material sources. Applying the method described here, gemstones can be investigated non-destructively and non-invasively even when inlaid in jewellery.

The aim of our analyses was to prove that this method is suitable to determine the raw materials of the best intact objects, and their possible source area, without any kind of destructive testing. Our analyses largely confirmed our expectations. Seven of the eight case studies presented in this study gave positive results, so our method is applicable to a wide range of rock types and minerals. However, results of sample Dv-346 presented in section II/6 are showing that it is not possible to determine all the rock types with the original surface method only, without investigation of a thin section. Therefore, this experience shows that, preparing thin sections is necessary in the cases where it is possible to perform destructive testing.

Chapter III

Results of non-destructive SEM-EDX and PGAA analyses of jade and eclogite polished stone tools in Hungary

Magyarországi jade és eklogit nyersanyagú csiszolt kőeszközök roncsolásmentes vizsgálatának eredményei

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III/1. Abstract

Good quality high pressure (HP) metaophiolites suitable for making stone implements, like jade and eclogite, are geologically absent in the Carpathian Basin and its surroundings. Therefore this raw material type was unknown among Hungarian findings for a long time, and henceforward this is one of the rarest type of raw material of polished stone implements in Hungary. Their investigation is very important because of their scarcity and distant origin. The nearest geological locality where these raw materials can be found is over 1000 kms away. The specific form and integrity of these stone implements indicate that they were transported as complete (finished) artefacts.

Petrological investigations of large collections (Miháldy and Ebenhöch collections) revealed their presence among Hungarian findings (Friedel et al. 2008, Szakmány et al. 2013). In 2013 and 2014, several new pieces of HP stone implements were found in museums of Hungary, most of them from known archaeological context. Most samples were found in Transdanubia, only one piece turned up in Eastern Hungary (*Figure III/3*). The 7 pieces of known archaeological context are from four localities (Zengővárkony (3 pieces), Szombathely Oladi plató (2 pieces), Alsónyék (1 piece), Gorzsa (1 piece)). Other pieces are stray finds. The localities and the main features of the tools are summarized in *Table III/1*. In addition to the 3 pieces presented in Szakmány et al. 2013, 10 pieces of stone implements made of HP metaophiolites are presented in this work (*Figure III/1*).

Only non-destructive analytical methods were used in this study. Stone implements were divided into raw material type groups based on their mineral chemical and bulk rock analytical data. Our results are corresponding to results on HP metaophiolites of North-western Italy, obtained both on geological and archaeological samples (D'Amico et al. 2003, D'Amico 2012, Pétrequin et al. 2012a). Based upon these facts, the HP metaophiolite stone implements in Hungary probably originated from the same raw material sources as Italian (and other Western European) HP metaophiolite stone tools. According to technical literature, these primary sources can be the Monviso, the Voltri Massif and secondary in the resedimented Oligocene conglomerates in Quaternary of River Po, Staffora and Curone equally (D'Amico et al. 2003, D'Amico & Starnini 2006, 2012, Pétrequin et al. 2012a).

Keywords: polished stone tool, jade, eclogite, provenance, non-destructive analysis

III/2. Kivonat

Jelenlegi ismereteink szerint a nagynyomású (HP) metaofiolit nyersanyagú eszközök igen csekély számban találhatók meg a magyarországi csiszolt kőeszközök leletegyütteseiben. Vizsgálatuk azért kiemelkedő fontosságú, mert nyersanyaguk a Kárpát-medencében, és annak közvetlen környezetében nem található meg. Legközelebbi, a neolitikumban bizonyítottan felhasznált nyersanyagforrásuk Magyarország jelenlegi területétől több, mint 1000 km távolságban található, ami, az eszközök formavilágát is figyelembe véve, arra utal, hogy ezek az eszközök kereskedelmi útvonalakon, használatra kész termékként érkeztek régészeti lelőhelyükre.

Magyarországi jelenlétükre a Mih！ldy- és az Ebenhöch-gyűjtemények kőzettani szempontú feldolgozása során derült fény (Friedel et al. 2008, Szakmány et al. 2013). 2013-ban és 2014-ben további leletek kerültek elő különböző múzeumok gyűjteményeiből, a JADE2 program keretében végzett szisztematikus kutatások eredményeképpen. A leletek legnagyobb része a Dunántúlról került elő, mindössze egy darab származik az ország keleti részéből (*III/3. ábra*). Hét darab kőeszköz került elő részletesen dokumentált régészeti ásatásból (Zengővárkony (3 db), Szombathely Oladi plató (2 db), Alsónyék (1 db), Gorzsa (1 db), a többi szórványlelet. Lelőhelyeik és legfontosabb adataik megtalálhatók a *III/1. táblázatban*. Ebben a munkánkban a Szakmány és munkatársai (2013) cikkben ismertetett 3 darab kőeszközön felül 10 további HP metaofiolit nyersanyagú kőeszközt mutatunk be részletesen (*III/1. ábra*).

Munkánk során kizárólag roncsolásmentes analitikai módszereket használtunk. Eredményeink alapján kőzetszöveti, ásvány- és teljes kőzet kémiai adatok segítségével a nemzetközi archeometriai szakirodalomban található felosztás alapján csoportosítjuk a leleteket. Eredményeink jól egyeznek az Északnyugat Olaszország területéről leírt kőeszközök adataival (D’Amico et al. 2003, D’Amico 2012, Pétrequin et al. 2012a), így az általunk vizsgált kőeszközök nyersanyagának forrásterülete feltehetőleg megegyezik azokéval. Ezek elsődleges előfordulása a Monviso, Voltri ill. az ÉNy-i Appenninek területe és másodlagosan az ezekről a területekről lepusztult, majd a negyedidőszakban áthalmozódott és a Pó síkságon, valamint a Curone és a Staffora folyók környezetében lerakódott konglomerátumok kavicsanyaga (D’Amico et al. 2003, D’Amico & Starnini 2006, 2012, Pétrequin et al. 2012a).

Kulcsszavak: csiszolt kőeszköz, jadeitit, eklogit, nyersanyag forrásterület, roncsolásmentes anyagvizsgálat

Figure III/1. Some stone implements from Hungary made from HP metaophiolite raw material. Most important form types can be seen on the picture.

III/1. ábra. Néhány magyarországi HP metaofiolit anyagú kőeszköz. A képen az összes fontosabb alaki típus látható.

III/3. Introduction

Green or greenish colour is very popular among the prehistoric polished stone tools. This colour is characteristic for several different rock types, e.g. greenschist, contact metabasite, nephrite and serpentinite; however, HP metaophiolites are outstanding among the ‘greenstones’ both by beauty and quality (*Figure III/1*). Their elaboration is unique, in most of cases they have flat, elongated, lingular or triangular shape and they are of different shades of green and their surface is especially finely polished. These types of stone implements are very widespread all over Western Europe (D’Amico et al. 2003, Pétrequin et al. 2011, Klassen 2012, Domínguez-Bella et al. 2015). Their penetration decreasing toward east, the easternmost known localities are in Bulgaria, however, they were practically unknown in the Carpathian Basin until the recent past (Pétrequin et al. 2011, Szakmány et al. 2013).

Their importance is derived from their scarcity and distant origin (*Figure III/2*). Their first recognition is connected with the study of major polished stone tool assemblages: Friedel et al. (2008) mentioned six pieces of HP metaophiolite stone implements from Ebenhöch collection without detailed description. Szakmány et al. (2013) gave detailed information on three pieces of stone implements made of HP raw material. These pieces are from the collections accumulated by F. Ebenhöch (2 pieces) and I. Mihįldy (1 piece) in the 19th century. Because of the afore mentioned article is in Hungarian, these important artefacts will be presented in this work again (see below) for a wider audience.

Figure III/2. Raw material sources of HP metaophiolites. 1 – Primary sources; 2 – secondary/tertiary sources (Oligocene conglomerates and their redeposited sediments).

III/2. ábra. A HP metaofiolit nyersanyagok előfordulási területei. 1 – elsődleges előfordulások; 2 – másodlagos/harmadlagos előfordulások (Oligocén konglomerátumokban és azok áthalmozott üledékeiben).

III/4. General characterisation of jade and eclogite raw material

HP metaophiolites can be divided into two groups based upon the garnet content of these rocks. The most widespread group (in both area and mass/amount) is the eclogite group, which contains large amount of garnets beyond the alkaline pyroxenes (at least 5 % according to D'Amico et al. 2003). Among the alkaline pyroxenes, omphacite is much more abundant than the other Na-pyroxene types, however jadeite dominated eclogites do exist as well. The group of 'alkaline-pyroxenites' or 'jades' is much smaller. Dominant mineral phases are the different alkaline-pyroxenes in this group, like jadeite and omphacite, sometimes aegirine and/or aegirine-augite. The quantity of alkaline-pyroxenes is more than 80% in these samples. In addition to the main phases, both groups contain some accessory minerals in these samples, e.g. rutile, zircon, ilmenite, apatite and titanite.

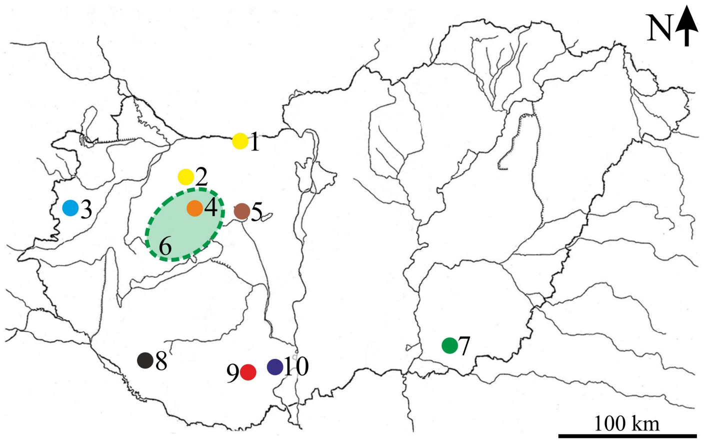
These two groups are formed under the same conditions, by high pressure (2-3 GPa) and low to medium temperature (500-600 °C) metamorphism from basaltic protoliths. Based upon their mineral and chemical composition, the HP metaophiolite raw material of these stone implements were formed by the younger, Alpean stage of orogenesis, during the Eocene epoch (Compagnoni et al. 2007; Beltrando et al. 2010).

The Alpine type HP metaophiolites suitable implements for raw material can be found both in primary, secondary (Oligocene) and tertiary (recent) positions in NW-Italy. These latter were redeposited in the Quaternary period, and prehistoric people used this as raw material (D'Amico & Starnini 2006). Primary occurrences can be found in the eastern range of the Western Alps, from Monviso till the Aosta valley, and in the Voltri Massif at the north-western end of Apennines (Monte Beigua) (*Figure III/2*). The formation of these units occurred after the subduction of the floor of Tethys-ocean. Both areas were uplifted in the Alpean orogenic stage, after the high-pressure metamorphism (Compagnoni et al. 2007). Secondary raw material sources can be found at the nearby piedmonts of the Western Alps and Voltri Massif and in the Po plain. They were formed during Oligocene by sedimentation of eroded materials from the Western Alps and Voltri Massif. These types of raw material sources were described from recent sediments of Staffora and Curone rivers (D'Amico & Starnini, 2012), and at the upper Po River, which originates from the Monviso region (Pétrequin et al. 2012a) (*Figure III/2*).

Material quality played an important role in the usage and spreading of these stone implements. Stone tools made of eclogite were used as wood-working tools by the local prehistoric people, however exceptionally shaped and finished stone implements made of jade can be found all over Europe. They are interpreted by the archaeologists as symbols of power and/or religion, and/or wealth rather than common work tools. The selection of raw material was really careful, it is indicated by the distribution of the quantity, the quality and the range of these stone implements. 'Jade' as raw material can be found at very limited area and in relatively small quantities, however, stone implements made of this raw material can be found more than 1500 km away from the source areas. On the other hand, the much more abundant eclogites were mostly locally (regionally) used as raw material for work tools (D'Amico 2005, D'Amico & Starnini 2012, Pétrequin et al. 2011).

III/5. Archaeological background

The analysed artefacts are from various localities within Hungary, some of them from archaeological excavations of prehistoric sites, others from recent field surveys or surface collections as stray finds in the old collection of various museums (*Table III/1*, *Figure III/3*). Their description here follows roughly the temporal order of their recognition among the polished stone artefacts in Hungary (Szakmány 2009, Szakmány et al. 2013).



1 – Neszmély
2 – Bakonypéterd
3 – Szombathely, Olad-plateau
4 – Zirc
5 – Iszkaszentgyörgy
6 – Bakony Mts.
7 – Hódmezővásárhely-Gorzsa
8 – Lábod
9 – Zengővárkony
10 – Alsónyék.

Figure III/3. Archeological localities of presented artefacts.

III/3. ábra. A bemutatott kőeszközök régészeti lelőhelyei.

1. Mihaldy collection

The collection accumulated by István Miháldy (1833-1901) contains 378 polished stone tools, now curated in the Laczkó Dezső Museum, Veszprém. Unfortunately, the information on the exact provenance of the pieces was lost during re-inventarisation in the 1950-ies. We know, however, that all the samples were found at different sites in the Bakony Mts. and its surroundings (Horváth, T. 2001, Füri et al. 2004). One piece of HP metaophiolite artefact was found in this collection (sample 55.1276).

2. Ebenhöch collection

The collection was accumulated by Ferenc Ebenhöch (1821-1889), prebend of Győr, NE Hungary. His collection, partly donated, partly sold to the Hungarian National Museum contains more than 700 polished stone tools and it is now part of the Prehistoric Collection of the HNM, Budapest. The artefacts were found in Western and Upper Hungary (latter is today Slovakia). The polished stone tools of this collection were studied in details by O. Friedel (Friedel et al. 2011). Two pieces of HP metaophiolite stone tools were investigated from this collection (samples 300/1876.247 and 300/1876.264). The localities involved are Bakonypéterd and Neszmély with no further archaeological context.

3. Gorzsa

Hódmezővásárhely-Gorzsa is a famous Late Neolithic (Tisza culture) tell settlement (Horváth, F. 2003, 2005). The site lies at the confluence of the Tisza and Maros rivers in the Great Hungarian Plain, north of Szeged. Approximately 1,000 square meters of the tell settlement were excavated and more than 1000 stone artefacts were collected from controlled stratigraphical context (Szakmány et al. 2008; Starnini et al. 2015). One HP metaophiolite stone implement was identified in the rich the lithic assemblage, this is the easternmost example of HP stone tools in Hungary so far (sample 99.3.1863).

4. Szombathely (Olad plateau)

Olad plateau was a Late Neolithic settlement of the early Lengyel culture between the early and the classical periods (Lengyel Ib, Ilon 2011). Two very small fragments of HP metaophiolite stone implements were found in this site (samples Olad-321 and Olad-329).

5. Zengővárkony

Classical settlement and cemetery of the Lengyel Culture, excavated and published by J. Dombay (Dombay 1939, 1960). The polished stone artefacts were investigated previously (Biró et al. 2003) and reconsidered for sourcing the HP metamorphites. Three HP metaophiolite artefacts were identified, all of them found in graves (samples N.1/81-1938, N.11/169-1938 and N.5/47-1939).

6. Alsónyék

The largest known cemetery of the Lengyel Culture, excavated in course of preventive rescue excavations. The elaboration of the site is in progress. One HP metaophiolite artefacts was found in a princely grave (Grave 3060, sample M6.2010.10B.3060.3), published separately (Zalai-Gaál et al. 2011).

#	Locality	Museum/Collection	Inv. number	L (mm)	W (mm)	H (mm)	MS (x10^{-3} SI)	shape	color	macroscopic description
1	Bakony	Laczkó Dezső Museum, Veszprém (Miháldy collection)	55.1276	95	40	15	0,17	flat, elongated, triangular adze	medium to dark green	homogenous, lighter green veins and patches on the darker green background, tiny (smaller than 1 mm), white subhedral-anhedral crystals
2	Neszmély	Hungarian National Museum, Budapest (Ebenhöch collection)	300/1876.247	40	28	7	0,47	flat adze	dark green	homogenous, pale green, greyish green, grey and locally very dark green patches and veins
3	Bakonypéterd	Hungarian National Museum, Budapest (Ebenhöch collection)	300/1876.264	56	25	8	0,10	flat, elongated, lingular adze	pale green	homogenous, medium to dark green patches, locally rounded grains with darker and brighter shade than the matrix
4	Iszkaszentgyörgy	Hungarian National Museum, Budapest (Prehistoric coll.)	39/1903	118	50	18	0,32	flat, strongly elongated, lingular adze	very dark green	homogenous, medium to dark green patches, lot of relatively large rutile (larger than 1 mm), pale green-greenish white elongated crystals (jd?) locally
5	Lábod	Rippl Rónai Museum, Kaposvár	3127	95	50	25	**ND**	thick, elongated, lingular adze	dark green	slightly inhomogeneous, dark and medium green patches
6	Zirc	Private collection of Ernő Wolf, Zirc	81/W2.5	36	29	10	0,19	flat, slightly elongated, triangular adze	pale green	slightly inhomogeneous with brighter green patches
7	Alsónyék	Wosinsky Mór Museum, Szekszárd	M6.2010.10B. 3060.3	116	50	22	0,95	thick, strongly elongated triangular adze	greenish black	roughly homogenous, sheared, bands of different shades of green changing, large (max. 2 mms) brown and green grains locally
8	Zengővárkony	Janus Pannonius Museum, Pécs	N.5/47-1939	40	30	7	0,19	flat, slightly elongated, triangular adze	bluish black	roughly homogenous, slightly foliated, tiny, white subhedral-anhedral crystals, crystal agglomerates and green veins
9	Zengővárkony	Janus Pannonius Museum, Pécs	N.1/81-1938	62	39	13	0,20	flat, elongated, triangular adze	medium green	roughly homogenous, patches with different sheds of green, some large (max. 5 mms) white patches, 1-2 mm long dark green subhedral-euhedral crystals locally
10	Zengővárkony	Janus Pannonius Museum, Pécs	N.11/169-1938	58	31	12	0,39	flat, strongly elongated, lingular adze	dark green	homogenous, medium and dark green patched, max. 2 mm long rutile crystals
11	Szombathely, Olad	Savaria Museum, Szombathely	Olad-321	18	20	6	0,03	fragment of flat axehead	medium green and red	roughly homogenous, red grains in medium green matrix
12	Szombathely, Olad	Savaria Museum, Szombathely	Olad-329	20	27	13	0,03	fragment of flat axehead	medium green	roughly homogenous, pale and medium green patches, tiny, locally white crystals
13	Hódmezővásárhely, Gorzsa	Móra Ferenc Museum, Szeged	99.3.1863	40	25	9	0,24	flat, slightly elongated, triangular adze	dark green	very dark green veins and patches in the dark green matrix, some (4-5) garnets with 1 mm of max diameter, few, elongated (max. 1 mm long) white crystals (zrn or ap)

Table III/1. Physical properties and basic petrographic descriptions of the investigated HP metaophiolite samples.

III/1. táblázat. A vizsgált HP metaofiolit anyagú kőeszközök fizikai tulajdonságai és alapszintű kőzettani leírásai.

In addition, three stray finds were investigated, their localities: Iszkaszentgyörgy, Fejér county (HNM 39/1903); Lábod (3127), RMM Somogy county; Zirc (81/W2.5), private collection, Veszprém county.

All the objects with documented archaeological context are from the Late Neolithic. Most of them belong to Lengyel culture (Zengővárkony, Olad-plateau and Alsónyék). The object from Gorzsa is assigned to the Tisza culture, coeval with the Lengyel culture.

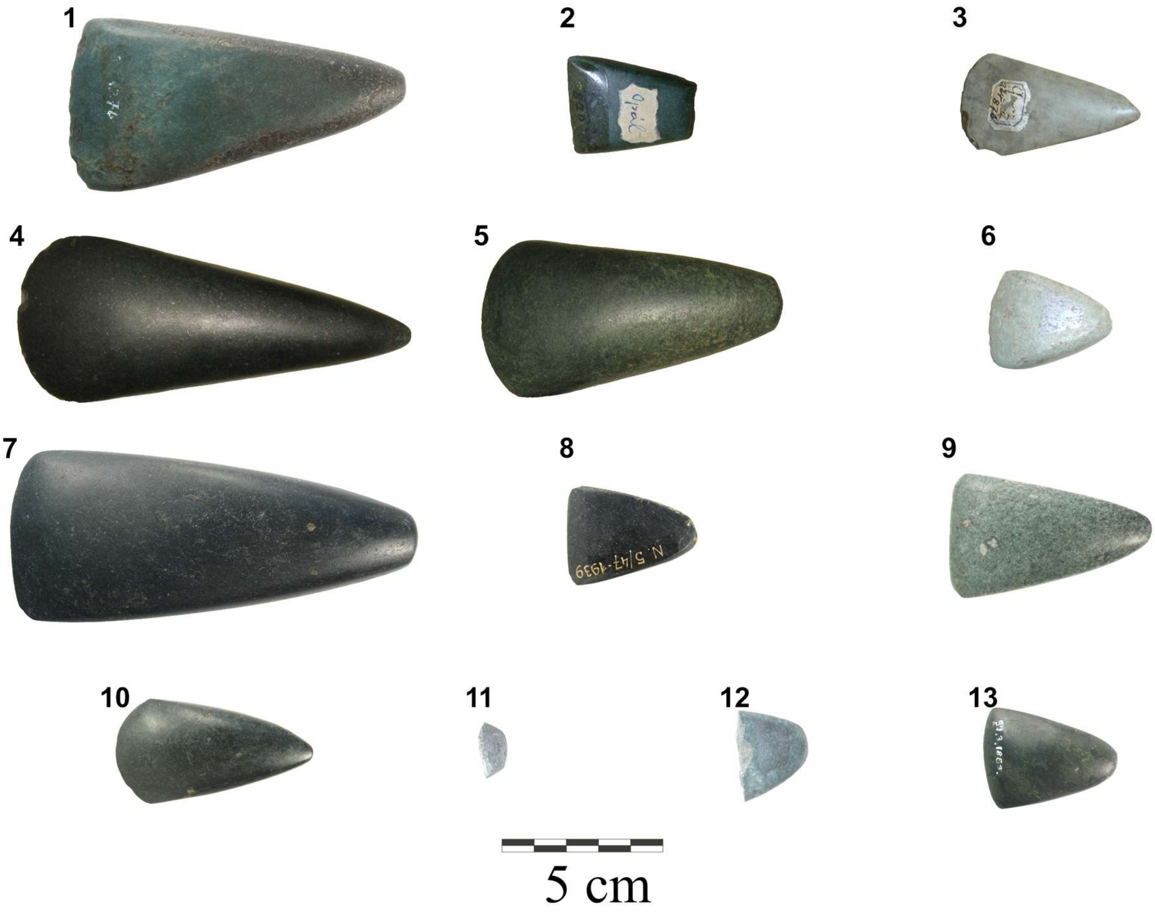


Figure III/4. Artefacts presented in this work. Numbers are referring to first column of Table III/1.

III/4. ábra. Az összes bemutatott kőeszköz. A sorszámok a III/1. táblázat 1. oszlopára vonatkoznak.

III/6. Methods

The stone implements made of jade and related rocks are generally intact, therefore only non-destructive methods can be used for their investigation. These non-destructive methods included macroscopic analyses, stereomicroscopy, magnetic susceptibility measurement, geochemical analysis by prompt gamma activation analysis, non-destructive X-ray diffractometry (performed at Miskolc University and presented in the paper by Kristály (2014) in this volume) and original surface analysis, explained in details below.

At the same time, spectroradiometrical analysis (Errera et al. 2007) was performed on the same items by M. Errera.

Loupe and stereomicroscope were used for the basic petrographic description. Magnetic susceptibility (MS) measurements were made with portable Kappameter KT-5. Real MS values were calculated by different corrections of size and thickness (Bradák et al. 2005, 2009).

All of the BSE images and EDX analyses were made by non-destructive original surface analysis method (Bendő et al. 2013) that was developed for textural and mineral chemistry analysis of stone tools. These measurements were made at the Department of Petrology and Geochemistry, Institute of Geography and Earth Sciences, Eötvös Loránd University, Budapest. The instrument was an AMRAY 1830 scanning electron microscope equipped with EDAX PV9800 energy dispersive spectrometer. Conditions of analysis: accelerating potential: 20 kV, beam current: 1 nA, beam diameter: focused electron beam (~50-100 nm), measurement time: 100 sec (livetime).

Non-destructive PGAA was performed at the Budapest Research Reactor operated by the Centre for Energy Research, Hungarian Academy of Sciences. The method is suitable for the quantitative determination of the average concentrations of the major elements (SiO_2, TiO_2, Al_2O_3, $Fe_2O_3^t$, MnO, MgO, CaO, Na_2O, K_2O and H_2O) and some trace elements (e.g. B, Cl, Sm, Gd) in a few cm^3 volume. Thermal equivalent beam intensity was $7.75*10^7$ $cm^{-2}*s^{-1}$. Calibrated Compton-suppressed HPGe detector was used to detect prompt gamma spectra, and Hypermet PC software was used for evaluation (Révay, 2009, Szentmiklósi et al. 2010, Szakmány et al. 2011).

III/7. Results

Physical properties and MS values of the stone implements are summarized in Table III/1. with short macroscopic description of the samples. According to our results, the objects can be divided into six raw material groups. The first four groups are the 'Na-pyroxenites', those HP metaophiolite raw materials which do not contain significant amounts of garnet (less than 5 %).

These groups are listed by increasing iron content. The fifth group contains the only glaucophane schist sample, and the last group comprises an iron-eclogite specimen (*Figure III/4*). Nomenclature diagram of alkaline pyroxenes (Morimoto et al. 1988) was used for the present mineral chemical grouping of samples. Garnets are presented also on a triangular diagram.

PGAA results are presented on multi-element diagrams normalized to Upper Continental Crust (UCC) data by McLennan (2001) for easier comparison. Data fields of Italian HP metaophiolite stone implements by D'Amico et al. (2003) are also presented on these diagrams for comparison.

1. Jadeitites

Two pieces of jadeitite stone implements were found until this time, both of them located in large old museum collections, one is from the Ebenhöch collection (300/1876.264), the other one is from the Mihály collection (55.1276).

In respect of mineral composition, their raw material contains much more jadeite than omphacite (*Figure III/5*). Both samples contain zircon and allanite as accessory minerals. Titanite and xenotime can also be found in them. The Na-pyroxenes are generally zoned, they have jadeite core and omphacite rim (*Figure III/6*, *Figure III/7*). Deformation textures are missing in these samples.

Jadeitic pyroxenes are similar in composition in these two samples, but the omphacitic pyroxenes of sample 300/1876.264 contain much more omphacite than pyroxenes of sample 55.1276. Jadeitic pyroxenes appear along a steep trend line toward omphacitic pyroxenes but the continuity of this trend is doubtful based on these data (*Figure III/7*).

Bulk-rock data are corresponding very well to data of D'Amico et al. (2003, grey field). According to these results these samples have fairly different calcium and magnesium content. This difference was probably caused by the higher omphacite content of sample 300/1876.264 (*Figure III/8*).

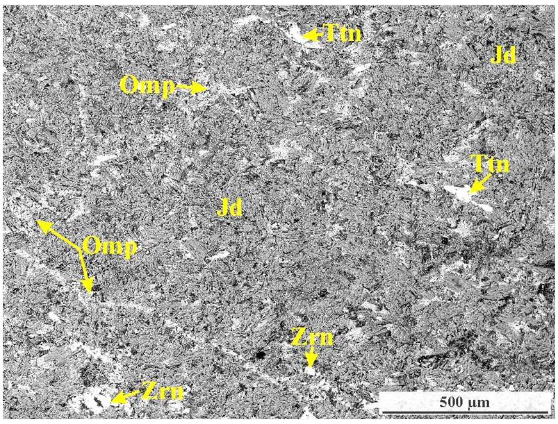


Figure III/5. Typical texture of jadeitites: small amount of omphacite is scattered among jadeite. According to the textural characteristics, omphacite was formed in the latest stage of metamorphism in this sample (300/1876.264, Bakonypéterd).

III/5. ábra. Tipikus jadeitit szövet: kevés omfacit helyezkedik el szétszórva a jadeit kristályok között. Szöveti jellegzetességei alapján az omfacit a metamorfózis legutolsó fázisában keletkezett ebben a mintában (300/1876.264, Bakonypéterd).

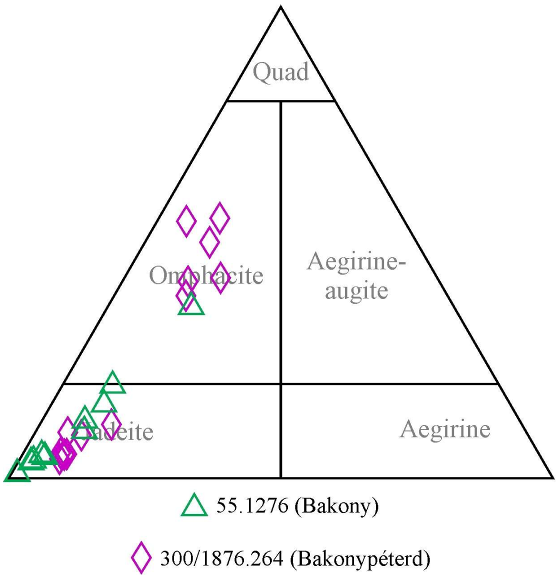


Figure III/7. Pyroxene compositions in the jadeitite samples. Discrete compositions of jadeite and omphacite are very well visible.

III/7. ábra. A jadeitit minták piroxénjeinek összetétele. A jadeit és omfacit mezőkben elhelyezkedő összetételek határozott elkülönülést mutatnak.

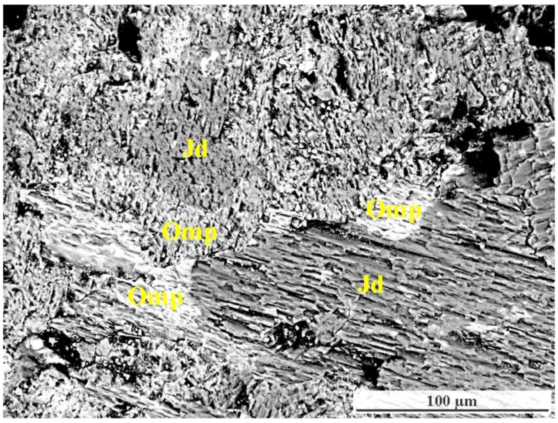


Figure III/6. Zoned pyroxenes with jadeite core and omphacite rim. Sample 55.1276 (Bakony Mts.).

III/6. ábra. Zónás piroxénkristályok jadeit maggal és omfacit peremmel az 55.1276-os mintában (Bakony).

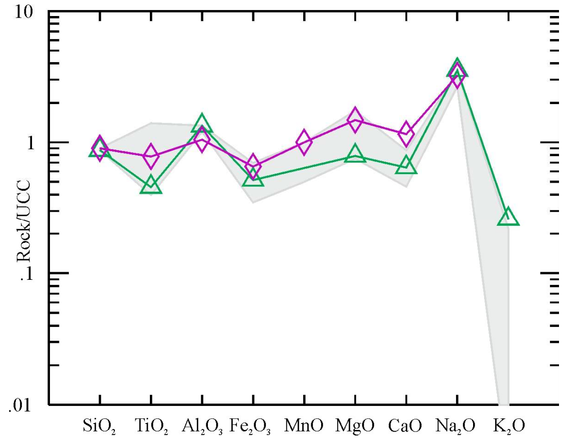


Figure III/8. Bulk-rock compositions of jadeitite samples normalized to UCC by McLennan (2001). Results showing very well correspondence to jadeitite compositions by D'Amico et al. (2003). Differences in compositions are possibly caused by varieties in omphacite content of the samples.

III/8. ábra. A jadeitit minták teljeskőzet-kémiai összetétele a kontinentális felső kéreg összetételre normálva (McLennan 2001). Az adatok nagyon jó egyezést mutatnak D'Amico et al. (2003) jadeitit adataival. A két minta közötti összetétel különbséget valószínűleg a minták különböző omfacit-tartalma okozza.

2. Mixed jades

This jade group contains two pieces of stone tools. One of them was found at the excavations of Zengővárkony (N.1/81-1938), from documented archaeological context. The other one is a stray find from Zirc (81/W2.5).

Their raw material contains more jadeite than omphacite or aegirine-augite (*Figure III/9*). Both samples contain rutile as accessory mineral. Zircon, allanite, titanite, xenotime and monazite can also be found in them. Retromorphic phases (albite, epidote) can be found in sample N.1/81-1938.

Na-pyroxenes are frequently zoned, they have jadeite core and omphacite/aegirine augite rim (*Figure III/10, Figure III/11*). Na-pyroxenes in sample 81/W2.5 have a 'radial' texture (*Figure III/10*). Deformation structures are not present in these samples.

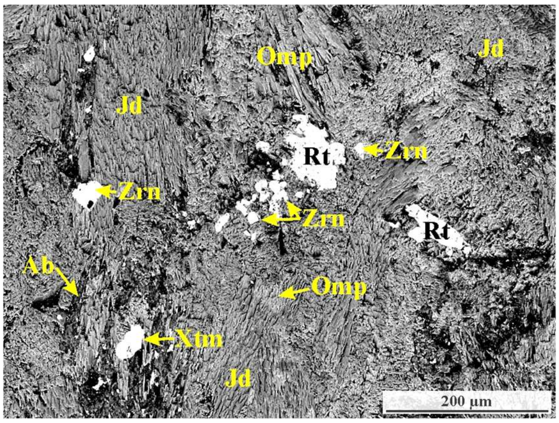


Figure III/9. Texture of mixed jades with accessory and retromorphic minerals. Sample N.1/81-1938 from Zengővárkony.

III/9. ábra. Kevert jadeitit szövete, akcesszórikus és retromorf ásványai. N.1/81-1938 minta Zengővárkonyról.

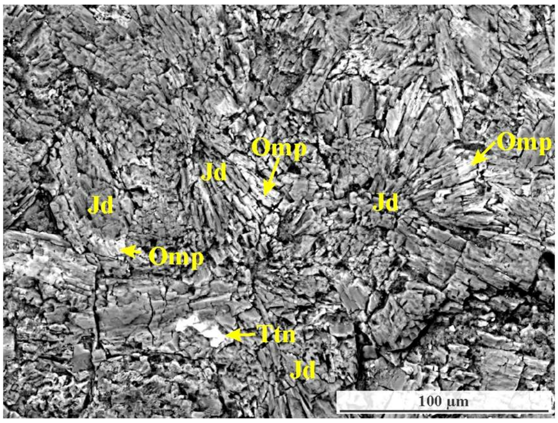


Figure III/10. 'Radial' texture of alkaline pyroxenes in sample 81/W2.5 (Zirc). Pyroxenes shows 'normal' zonation, with jadeite core and omphacite rim.

III/10. ábra. Az alkáli piroxének „sugaras" szövete a 81/W2.5 mintában (Zirc). A piroxének normál zónásságot mutatnak, jadeit maggal és omfacit peremmel.

Composition of jadeitic pyroxenes of the two samples are very similar, they appear along a relatively steep trend line. Omphacitic pyroxenes are very different, they show two distinct trends. Sample N.1/81-1938 trends towards the calcium rich omphacites, 81/W2.5 towards the iron rich aegirine-augites. The continuity of these trends is doubtful based on these data (*Figure III/11*).

Bulk-rock data are very similar to each other. Their correspondence to data of D'Amico (2003, grey field) is good, differences probably caused by the larger natural variety of the raw material of the earlier investigated samples (*Figure III/12*).

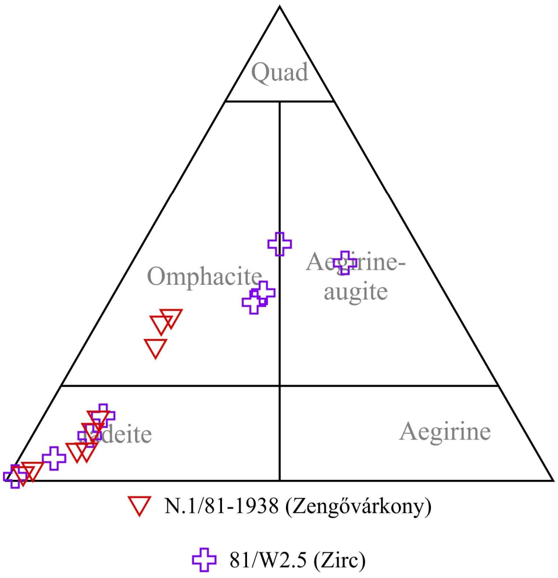


Figure III/11. Pyroxene compositions in mixed jades. Jadeites have very similar composition in both samples, however omphacite compositions are rather different, omphacites of sample 81/W2.5 are richer in iron than omphacites of sample N.1/81-1938.

III/11. ábra. Piroxén összetételek a kevert jadeititekben. A jadeiteknek nagyon hasonló az összetétele a két mintában, míg az omfacitok összetétele meglehetősen eltérő, a 81/W2.5 mintában az omfacitok sokkal vasgazdagabbak, mint az N.1/81-1938 mintában.

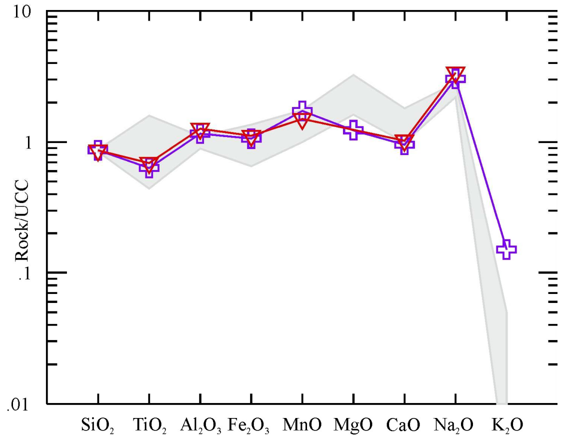


Figure III/12. Bulk-rock compositions of mixed jade samples normalized to UCC by McLennan (2001). Two datasets are very similar to each other, and their correspondence to mixed jade data of D'Amico et al. (2003) is good also.

III/12. ábra. A kevert jadeititek teljeskőzet-kémiai összetétele a kontinentális felső kéreg összetételre normálva (McLennan 2001). A két adatsor nagyon hasonló, és jó egyezést mutatnak D'Amico et al. (2003) kevert jadeitit adataival is.

3. Iron-mixed jades

This jade group contains three pieces of stone tools, all of them found at different archaeological excavations. N.11/169-1938 was found in Zengővárkony, 99.3.1863 was found in Gorzsa and Olad-329 was found at Szombathely, Olad-plateau.

Their raw material contains a lot of jadeites with large amounts of omphacite and/or Fe-jadeite and/or aegirine-augite (*Figure III/13*). Accessory minerals are zircon, allanite, rutile, apatite, ilmenite and titanite. Retromorphic phase (chlorite) can be found in one sample (Olad-329).

Na-pyroxenes are frequently zoned, in most of cases they have a jadeite core and Fe-jadeite or omphacite or aegirine-augite rim (*Figure III/14, Figure III/15*).

The pyroxenes of these samples have rather different composition. Two of the stone tools contain three different compositional groups of pyroxenes, one is near the clear jadeite composition, the second group is in the jadeite field with high iron content (iron-jadeite) and the third one has omphacitic–aegirine-augitic composition. These pyroxenes have a flat trend-like line towards aegirine-augite across the omphacite field pyroxenes. Continuity of these trend lines are doubtful based on these data, again (*Figure III/15*).

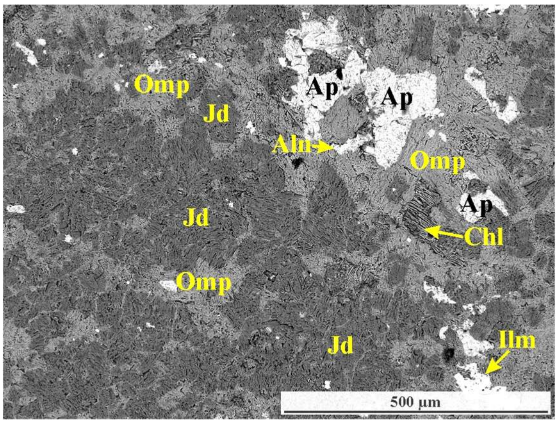


Figure III/13. Textural view of an iron-mixed jade with accessory and retromorphic minerals. Sample Olad-329

III/13. ábra. Vas-kevert jadeitit szöveti képe, akcesszórikus és retromorf ásványai. Olad-329-es minta.

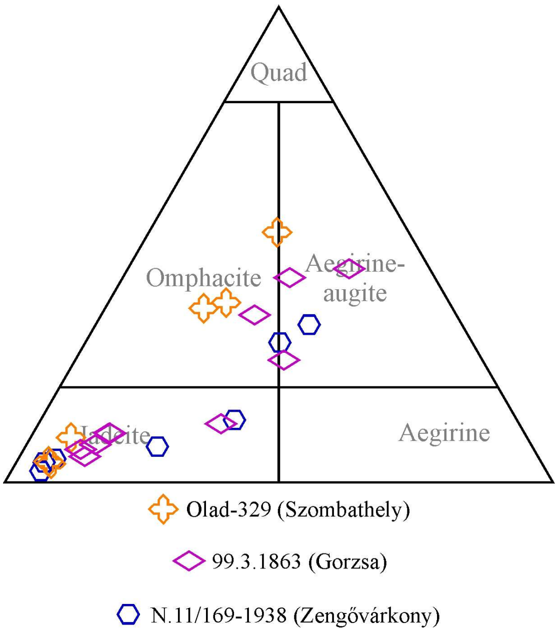


Figure III/15. Very diverse pyroxene compositions in iron-mixed jades. Sample 99.3.1863 contains four different pyroxenes: jadeite, iron-jadeite, omphacite and aegirine-augite.

III/15. ábra. A vas-kevert jadeititek erősen eltérő piroxén összetételei. A 99.3.1863-as minta négyféle piroxént tartalmaz: jadeitet, vas-jadeitet, omfacitot és egirinaugitot.

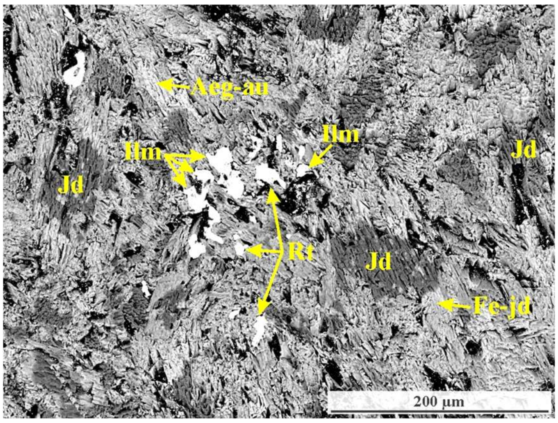


Figure III/14. Zoned pyroxenes with jadeite core and iron-jadeite/aegirine-augite rim. Sample N.11/169-1938 (Zengővárkony).

III/14. ábra. Zónás piroxénkristályok jadeit maggal és vas-jadeit/egirinaugit peremmel. N.11/169-1938 minta (Zengővárkony).

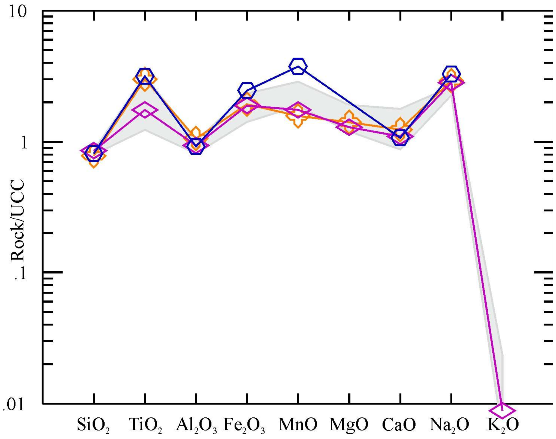


Figure III/16. Bulk-rock compositions of iron-mixed jade samples normalized to UCC by McLennan (2001). Datasets are corresponding to iron-mixed jade data of D'Amico et al. (2003).

III/16. ábra. A vas-kevert jadeititek teljeskőzet-kémiai összetétele a kontinentális felső kéreg összetételre normálva (McLennan 2001). Az eredmények jó egyezést mutatnak a D'Amico et al. (2003) által mért vas-kevert jadeititek értékeivel.

Bulk-rock data are corresponding very well to data published by D'Amico (2003, grey field). According to these results, these samples have fairly different manganese and magnesium content (*Figure III/16*).

4. Iron jadeitite

Fe-jadeitite is a frequent raw material among the Hungarian HP metaophiolite stone tools, three pieces were found. Unfortunately, all of them are stray finds without archaeological context. One piece is from the Ebenhöch Collection of the HNM (300/1876.247), the second is from Iszkaszentgyörgy (Prehistoric collection of Hungarian National Museum, Inv. nr. 39/1903), and the third is from Lábod from the collection of the Rippl-Rónai Museum, Kaposvár (Inv. nr. 3127).

Their raw material contains jadeite and Fe-jadeite; while omphacite and aegirine-augite are absent (*Figure III/17, Figure III/19*). Common accessory minerals are zircon and rutile. Titanite, allanite, ilmenite, xenotime and monazite can be found in them as well.

The Na-pyroxenes are generally zoned, they have jadeite core and Fe-jadeite rim (*Figure III/18, Figure III/19*). Deformation textures are absent from these samples.

Pyroxenes of sample 300/1876.247 contain more iron than pyroxenes of the other two samples. Pyroxenes appear along a very shallow/flat trend line towards aegirine (*Figure III/19*).

Correspondence of bulk-rock analyses to data of D'Amico (2003, grey field) is good, the variance is probably caused by the diversity of the raw material (*Figure III/20*).

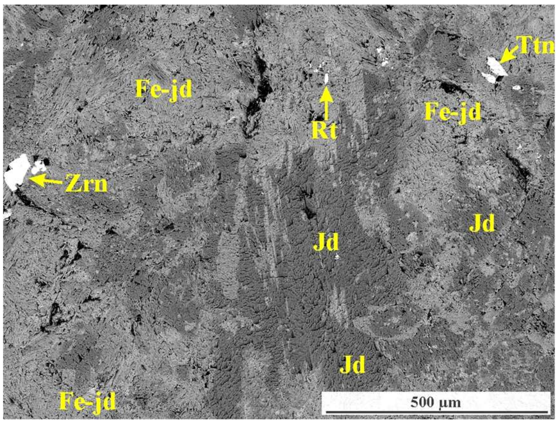


Figure III/17. Texture and accessory minerals of iron-jadeite, sample 39/1903 (Iszkaszentgyörgy).

III/17. ábra. Vas jadeitit szöveti képe és akcesszórikus ásványai, 39/1903-as minta (Iszkaszentgyörgy).

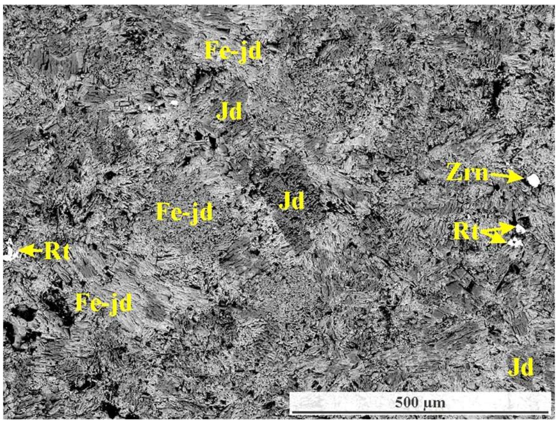


Figure III/18. Zoned pyroxenes with jadeite core and iron-jadeite rim. Sample 3127 from Lábod.

III/18. ábra. Zónás piroxének jadeit maggal és vas-jadeit peremmel. 3127 minta, Lábod.

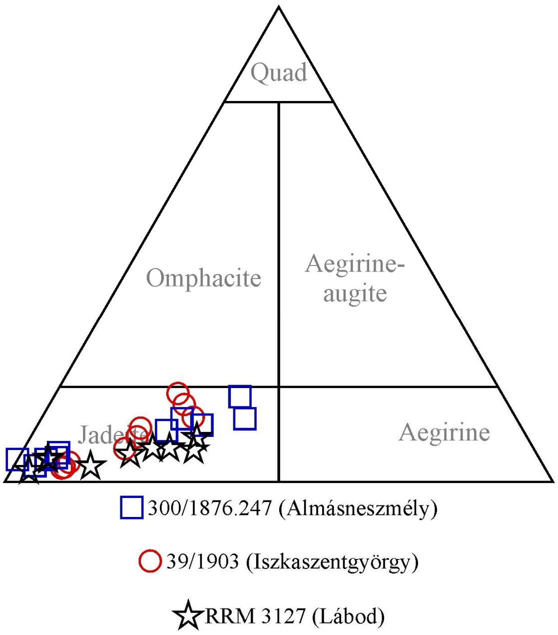


Figure III/19. Pyroxene compositions in iron jadeitites. All of results fall to the jadeite field, however compositions are varying between iron poor and iron rich jadeites.

III/19. ábra. A vas-jadeititek piroxénjeinek összetétele. Minden mért érték a jadeit mezőbe esik, de az összetételek a vasszegény és vasgazdag jadeitek között váltakoznak.

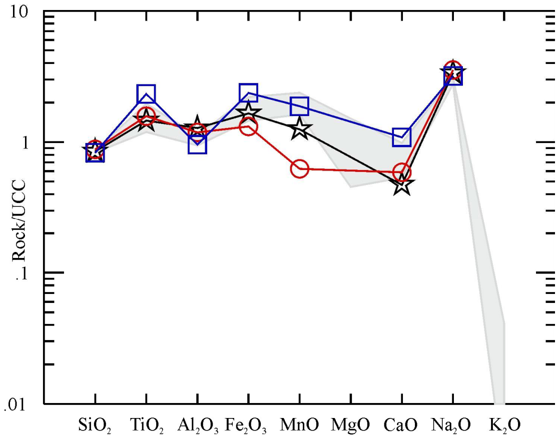


Figure III/20. Bulk-rock compositions of iron jadeite samples normalized to UCC by McLennan (2001). Correspondence to iron jadeite data of D'Amico et al. (2003) is good.

III/20. ábra. A vas jadeititek teljeskőzet-kémiai összetétele a kontinentális felső kéreg összetételre normálva (McLennan 2001). A mért adatok elég jól egyeznek D'Amico et al. (2003) vas-jadeitit adataival.

5. Glaucophane schist (retrograde omphacite schist)

This type of glaucophane schist is very rare among the Hungarian HP metaophiolite stone tools, only one piece was found until this time. This piece is from Zengővárkony archaeological site (N.5/47-1939).

Its raw material contains a lot of glaucophane and Na-pyroxenes as well. Most of the Na-pyroxenes are omphacite, jadeite occurs on the rim of omphacite crystals (*Figure III/21, Figure III/22*). Accessory minerals are ilmenite, apatite, titanite (*Figure III/21*).

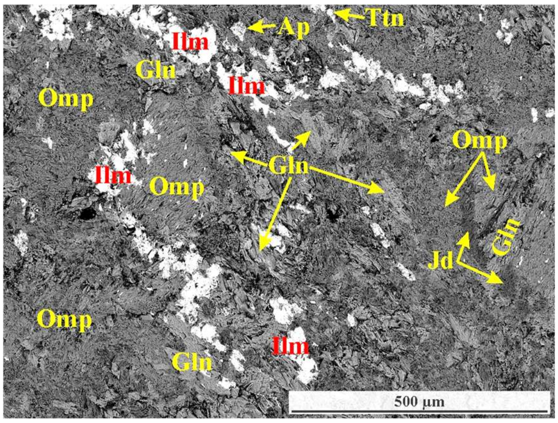


Figure III/21. Texture of glaucophane schist with accessory minerals. Sample N.5/47-1939 (Zengővárkony).

III/21. ábra. Glaukofánpala szöveti képe és akcesszórikus ásványai. N.5/47-1939 minta (Zengővárkony).

Na-pyroxenes are zoned in this sample, but they show inverse zonation against the prior samples (*Figure III/21*). According to the texture, glaucophane was formed in the latest, retrograde stage of metamorphism. N.5/47-1939 has slightly foliated texture (*Figure III/21*).

There are two compositional varieties of alkaline pyroxenes in this sample. The more abundant pyroxene is the omphacite, which has a steep trend line on the diagram. Jadeite compositions are much closer to each other, they appear in a pile and they do not form a trend line (*Figure III/22*).

Bulk-rock data fit very well to glaucophane schist data of by D'Amico et al. (2003, thick grey line). The only difference between the two compositions is the Na_2O content, probably sample N.5/47-1939 has higher alkaline pyroxene content than the reference sample. Notably, the distribution of omphacite schist and glaucophane schist are very similar to each other (thick grey line and pale grey fields in *Figure III/23*).

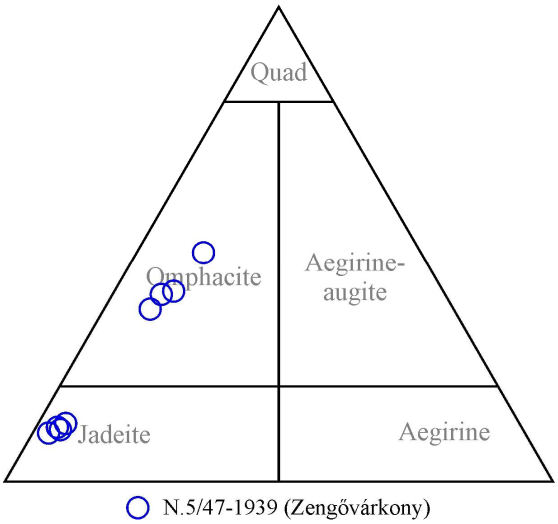


Figure III/22. Alkaline pyroxene compositions in glaucophane schist. Compositions are showing two distinct group of jadeite and omphacite.

III/22. ábra. Alkáli piroxén összetételek a glaukofánpalában. A mért eredmények két különálló halmazt képeznek, egyet a jadeit és egyet az omfacit mezőben.

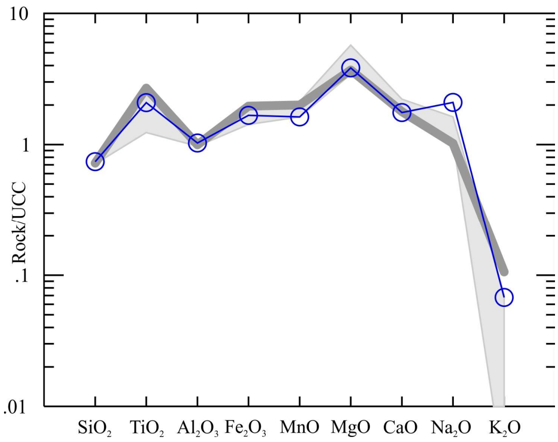


Figure III/23. Bulk-rock compositions of glaucophane schist sample normalized to UCC by McLennan (2001). Dataset are very similar to glaucophane schist (thick gray line) and omphacite schist (pale gray field) data of D'Amico et al. (2003).

III/23. ábra. A glaukofánpala teljeskőzet-kémiai összetétele a kontinentális felső kéreg összetételre normálva (McLennan 2001). Az adatsor nagyon hasonlít D'Amico et al. (2003) glaukofánpala (vastag szürke vonal) és omfacitpala (világosszürke mező) eredményeire.

6. Iron-eclogites

Eclogite is rare raw material among the investigated HP metaophiolite stone tools, only two pieces were found. Both of them were found on excavated archaeological sites, M6.2010.10B.3060.3 was found in Alsónyék, Olad-321 was found at Szombathely, Olad plateau.

Their raw material contains a high amount of garnets in addition to alkaline pyroxene which is mainly omphacite (*Figure III/24*). Accessory minerals are ilmenite, zircon, apatite and rutile. Retromorphic phase (epidote) occurs in the sample from Olad (*Figure III/25*).

Alkaline pyroxenes seem to be homogenous in most of cases, but in some cases, they have relatively jadeite-rich core (*Figure III/26*). Garnets are slightly zoned, probably, but this zonation is invisible on these rough surfaces (*Figure III/27*). M6.2010.10B.3060.3 has slightly foliated texture (*Figure III/24*).

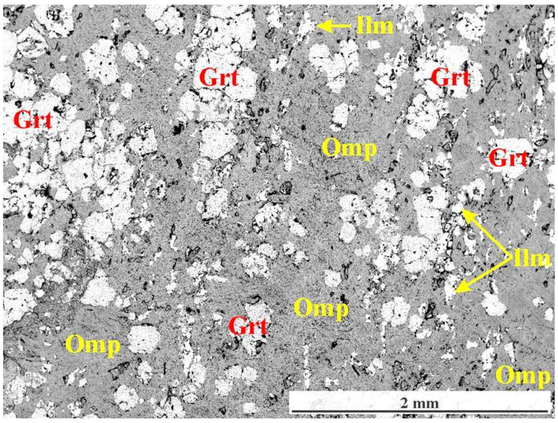


Figure III/24. Typical texture of iron-eclogites with accessory minerals and large amount of garnets. Moderate inhomogeneity of pyroxenes can be observed on this sample (M6.2010.10B.3060.3, Alsónyék). Foliation is visible on the placements of ilmenite crystals.

III/24. ábra. Tipikus vas eklogit szövet akcesszórikus ásványokkal és sok gránáttal. A piroxének összetételében enyhe inhomogenitás figyelhető meg. Az enyhe foliáció az ilmenit kristályok elhelyezkedésén látható. M6.2010.10B.3060.3 minta, Alsónyék.

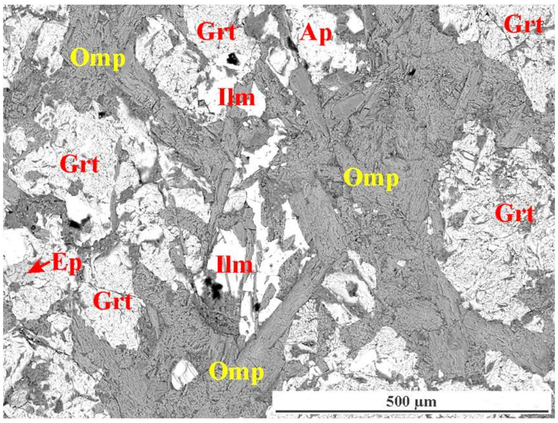


Figure III/25. Elongated, homogenous omphacite crystals among garnets and ilmenites in the sample Olad-321.

III/25. ábra. Nyúlt, homogén omfacit kristályok a gránátok és az ilmenitek között az Olad-321 mintában.

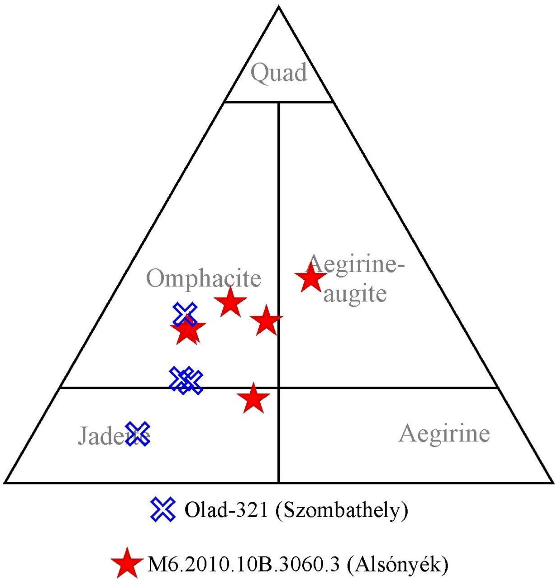


Figure III/26. Pyroxene compositions in the iron-eclogite samples. Most of the compositions fall into the omphacite field, however there are some jadeite and aegirine-augite, also.

III/26. ábra. Alkáli piroxének összetétele a vas eklogitokban. A legtöbb esetben omfacitos összetételt mértünk, de előfordulnak jadeit és egirinaugit összetételű mérések is.

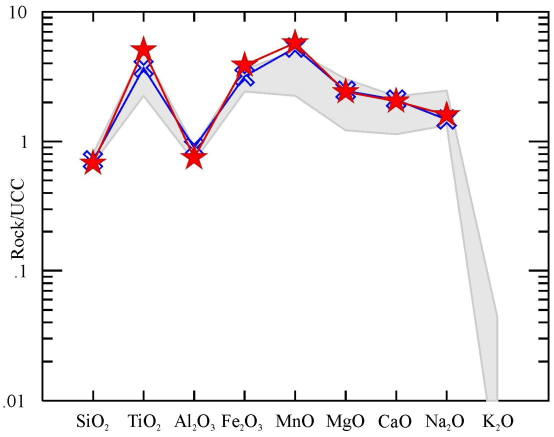


Figure III/28. Bulk-rock compositions of iron-eclogite samples normalized to UCC by McLennan (2001). The two datasets are very similar to each other, and they are corresponding very well to iron-eclogite data of D'Amico et al. (2003), also.

III/28. ábra. A vas eklogitok teljeskőzet-kémiai összetétele a kontinentális felső kéreg összetételre normálva (McLennan 2001). A két adatsor nagyon hasonló egymáshoz, és mindkettő nagyon jól egyezik D'Amico et al. 2003 vas eklogit adataival.

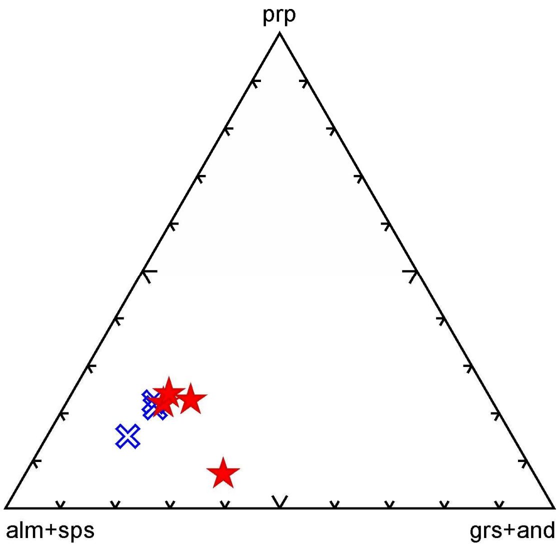


Figure III/27. Garnet compositions in iron-eclogite. Most of the compositions can be found in one narrow pile, however the distinct values are demonstrating the zonation of crystals.

III/27. ábra. Gránát összetételek a vas eklogitokban. A legtöbb érték egy szűk halmazban található, de néhány ettől eltérő összetétel is előfordul, amik a kristályok zónásságát bizonyítják.

Pyroxene composition of these samples does not show any trends or alignment. Most of them are omphacite, however there are jadeitic and aegirine-augitic parts as well (*Figure III/26*).

Most of the garnet compositions are in one pile, there are only two exceptions, and possibly they are indicating the zonation of the crystals (*Figure III/27*).

Bulk-rock data are corresponding very well to data of D'Amico et al. (2003, grey field). According to these results these samples have very similar composition (*Figure III/28*).

III/8. Discussion

Most of the investigated stone implements have characteristic, elongated, triangular or lingular shape which is similar to the stone implements described from Western Europe (D’Amico et al. 2003, D’Amico & Starnini 2006, Pétrequin et al. 2012a). Instrumental analyses allow the grouping of these stone tools. According to our results, they can be divided into 6 raw material groups. These raw material groups are jadeitites, mixed jadeitites, iron-mixed jadeitites, iron jadeitites, glaucophane schist and iron-eclogites (*Figure III/29*). Based on their inventory number, they can be grouped accordingly:

- Jadeitite: 55.1276 and 300/1876.264
- Mixed jadeitite: N.1/81-1938 and Zirc 81/W2.5
- Iron-mixed jadeitite: N.11/169-1938, 99.3.1863 and Olad-329
- Fe-jadeitite: 300/1876.247, 39/1903 and 3127
- Glaucophane schist: N.5/47-1939
- Iron-eclogite: M6.2010.10B.3060.3 and Olad-321.

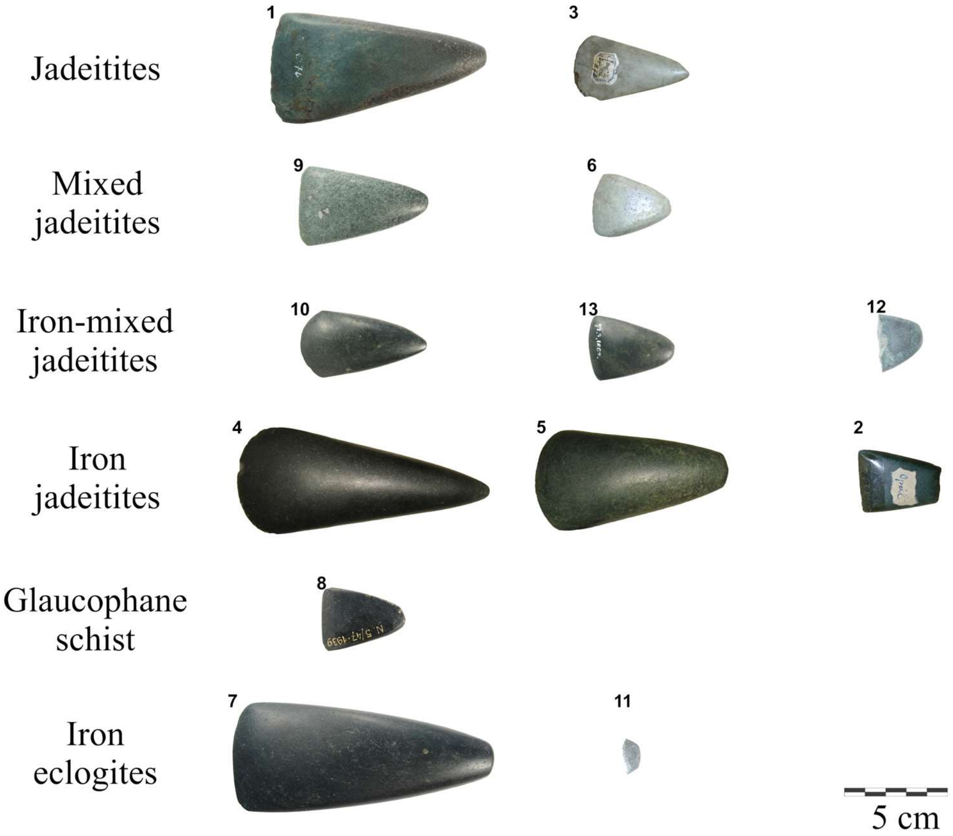
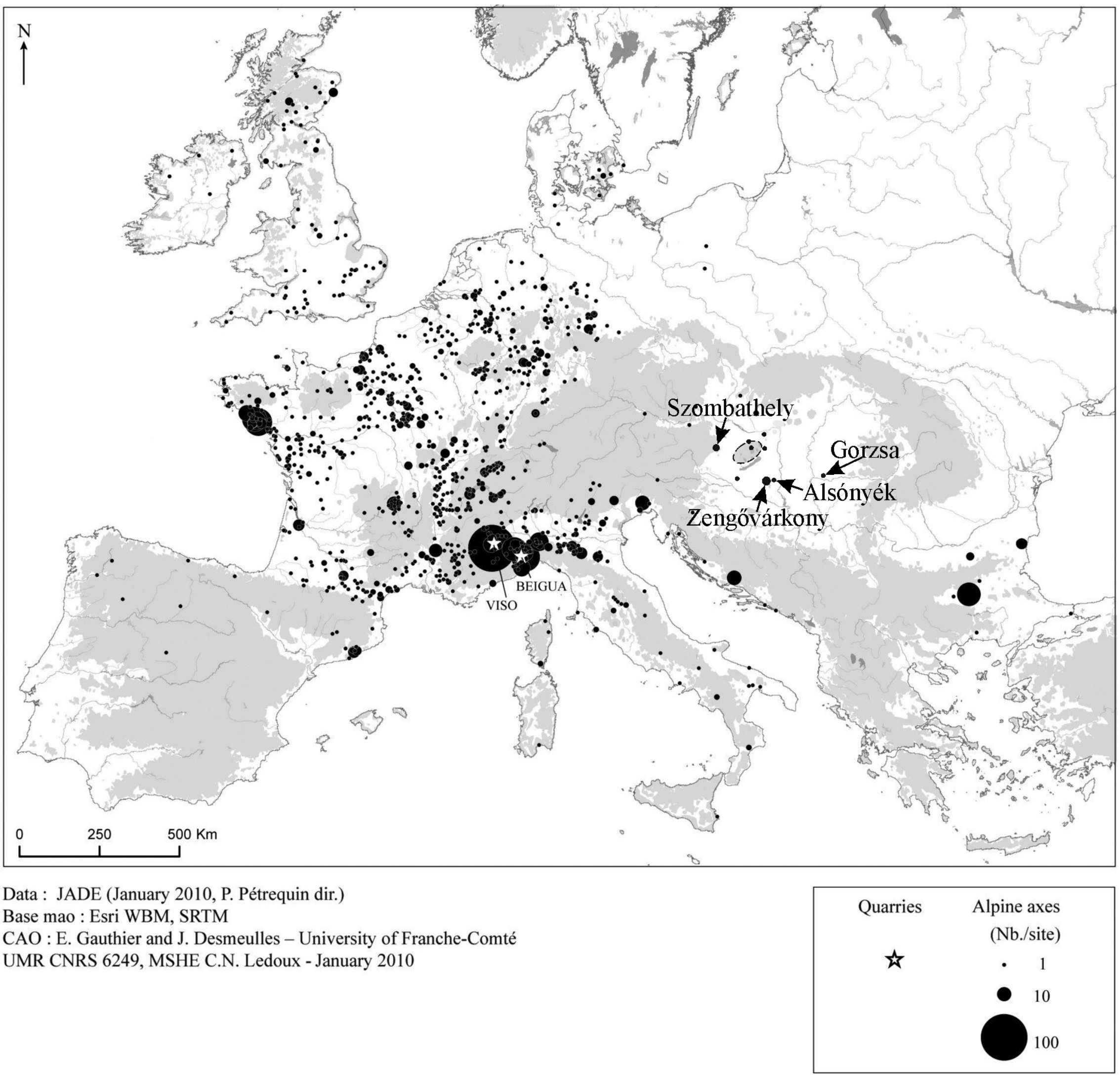


Figure III/29. All of the presented artefacts arranged by their raw material type. Numbers are referring to 1st column of Table III/1.

III/29. ábra. Az összes bemutatott kőeszköz a nyersanyag típusuk alapján elrendezve. A számok a III/1. táblázat 1. oszlopára vonatkoznak.



Data : JADE (January 2010, P. Pétrequin dir.)
Base mao : Esri WBM, SRTM
CAO : E. Gauthier and J. Desmeulles – University of Franche-Comté
UMR CNRS 6249, MSHE C.N. Ledoux - January 2010

Figure III/30. Distribution of HP metaophiolite stone implements in Europe completed with Hungarian artefacts. Modified after Pétrequin et al. 2011.

III/30. ábra. HP metaofiolit nyersanyagú kőeszközök eloszlása Európában, kiegészítve a magyarországi adatokkal. Pétrequin et al. (2011) alapján módosítva.

Based upon data from the technical literature (D'Amico et al. 2003, D'Amico & Starnini 2006, Pétrequin et al. 2012a), these raw materials, based on their mineral assemblage, chemical composition and textural properties, are identical to the North-western Italian HP metaophiolites which were formed by the Alpine orogenic stage. We do not make claims on the exact localisation of the raw material source proper because the relevant areas known from publications (see Figure III/2) are rather large, and they are all at least about 1000 km from Carpathian Basin, practically in the same direction. Therefore, from the respect of prehistoric contacts they have the same significance.

Our results essentially increased the knowledge about the distribution range of these stone implements (*Figure III/30*). Stone tools made of western Alpine HP metaophiolite raw material were formerly unknown in the Carpathian Basin, especially in Hungary. The artefacts presented here were mainly found in the Transdanubian region (West Hungary); there is one piece, however, from East Hungary as well (*Figure III/30*).

In addition, very important result is the heterogeneity of lithotypes, not all of presented stone implements were made of the most widespread “pure jade” raw material, but eclogites and glaucophane schist are also occurring. This heterogeneity is explicable with several reasons. One possible scenario is the development of manufacturing and discovery of better- and better-quality sources for these stone implements in due time. Other probability is the changes in the transportation routes and/or procurement and contact modes in the function of time and/or regions. Last but not least these very distinct materials may be transported from multiple, coexistent sources/manufactures along multiple, coexistent trading routes.

III/9. Conclusion

In the last years there was a significant growth in the number of recognized and investigated stone implements made of HP metaophiolite raw material in Hungary (*Figure III/30*). This growth is due to systematic quest for greenstones and the applied non-destructive methods (PGAA and original surface method by SEM-EDX). These methods proved their suitability to identify the raw material of stone implements and capability to provide good quality data for comparison with data in the international literature.

Artefacts from known archaeological context are from the Late Neolithic period and most of them belong to the Lengyel Culture. The only piece from East Hungary belongs to the Tisza Culture which is coeval to Lengyel Culture, and they were in regular contact with each other.

According to our results there is a large probability of finding other HP metaophiolite artefacts in Hungary, especially in the course of systematic petrologic investigations of findings of Lengyel and coeval cultures and from the old collections.

Chapter IV

High pressure metaophiolite polished stone implements found in Hungary

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IV/1. Abstract

Good quality high pressure (HP) metaophiolite rock types (e.g. Na-pyroxenite/jade, eclogite) suitable for making prehistoric polished stone implements were unknown among Hungarian findings for a long time. Nowadays they are still among the rarest types of polished stone implements known in Hungary in the respect of raw material.

After the first discovery of Neolithic stone tools made of HP metaophiolites in the records of Hungarian archaeological assemblages, detailed petrological investigations of large stone implement collections revealed their presence in a relatively large number. According to our current knowledge, 25 HP metaophiolite stone implements are known from Hungary. Unfortunately, most of them are stray finds, but 11 pieces from four localities have known archaeological context. They were mainly located in Transdanubia (except for 1 piece from Tiszántúl) and mostly attributable to the Late Neolithic Lengyel Culture and subordinately to the Late Neolithic Tisza Culture.

In this study we applied exclusively non-destructive analytical methods (macroscopic observation, magnetic susceptibility measurements, a new non-destructive ‘original surface method’ by SEM-EDX, Prompt Gamma Activation Analysis). As a result, the prehistoric stone implements were classified into raw material types. Based on our data, the high pressure-low temperature (HP-LT) metaophiolite stone implements from Hungary probably originated from the same raw material sources as the Italian HP metaophiolite stone tools (sourcing from North-western Italy). According to literature on the topic, both primary (Western Alps in the surroundings of the Monviso in Piedmont or the Voltri Massif in Liguria) and secondary occurrences (in Quaternary deposits of the rivers Po, Staffora and Curone) are potential sources. These analyses confirmed the existence of long-distance trade routes connecting the Po Valley with the Carpathian Basin during the V Millennium BC.

Keywords: Neolithic polished stone tools, Na-pyroxenite, jade, eclogite, provenance, non-destructive PGAA and ‘original surface method’ by SEM-EDX

IV/2. Kivonat

A jó minőségű, csiszolt kőeszközök készítésére alkalmas, nagynyomású (HP) metaofiolit kőzettípusok (pl. Na-piroxenit/jade, eklogit) sokáig ismeretlenek voltak a magyar leletek között, és ma is a Magyarországon ismert csiszolt kőeszközök ritkább típusai közé tartoznak.

Az első HP metaofiolitból készült neolitikus kőeszközök előkerülése után a nagy kőeszközgyűjtemények részletes petrológiai vizsgálata során viszonylag nagy számban kerültek elő ezek a leletek. Jelenlegi ismereteink szerint Magyarországról 25 HP metaofiolit kőeszköz ismert. Sajnos többségük szórványlelet, de négy lelőhelyről 11 darabnak ismert a régészeti kontextusa. Ezek főként a Dunántúlról kerültek elő (1 tiszántúli darab kivételével), és többnyire a késő neolit Lengyel-kultúrához köthetők az egyedüli tiszántúli darab kivételével, amely a késő neolitikus Tisza-kultúrához köthető.

A vizsgálat során kizárólag roncsolásmentes analitikai módszereket alkalmaztunk (makroszkópos megfigyelés, mágneses szuszceptibilitás mérés, új roncsolásmentes „eredeti felszín módszer” SEM-EDX, Prompt Gamma Aktivációs Analízis). Ezeknek a eredményeknek az alapján az őskori kőeszközöket nyersanyagtípusuk szerint csoportosítottuk. Adataink alapján a Magyarországon fellelt magas nyomás-alacsony hőmérsékletű (HP-LT) metaofiolit kőeszközök valószínűleg ugyanabból a nyersanyagforrásból származnak, mint az olaszországi HP metaofiolit kőeszközök, vagyis a nyersanyagforrás a mai ÉNY Olaszország területén helyezkedett el. A témával foglalkozó szakirodalom szerint mind az elsődleges (Nyugati-Alpok a piemonti Monviso környékén vagy a liguriai Voltri-masszívum), mind a másodlagos előfordulások (a Po, Staffora és Curone folyók negyedidőszaki lerakódásaiban) potenciális nyersanyagforrások. Vizsgálataink eredményei megerősítették a Pó-síkságot a Kárpát-medencével összekötő hosszú távú kereskedelmi útvonalak létezését a Kr. e. V. évezredben.

Kulcsszavak: Neolitikus csiszolt kőszerszámok, Na-piroxenit, jade, eklogit, származási hely, roncsolásmentes PGAA és „eredeti felszín módszer” SEM-EDX-szel.

IV/3. Introduction

Finely elaborated, large sized polished stone artefacts (axes and adzes, blades, chisels) made of Alpine-origin high pressure (HP) metaophiolite rocks are distributed over a large territory of Western Europe (Pétrequin et al. 2012a, 2017c). Best quality jade implements are present from Scotland (Pétrequin et al. 2012a) through South Scandinavia (Klassen 2012) to Spain (Domínguez-Bella et al. 2015). Good quality HP metaophiolite rock types suitable for making polished stone implements, like jade and eclogite, are absent from the geological formations of the Carpathian Basin and its surroundings. This raw material type was unknown among Hungarian findings until 2008 (Friedel et al. 2008) and still this is one of the rarest raw material types for polished stone implements in Hungary. The archaeometric investigation of this raw material is very important because of its scarcity and distant origin. The nearest geological locality where these raw materials can be found is over 1000 kms away. The specific form and integrity of these stone implements imply that presumably they were transported as complete artefacts.

Before its first publication by Friedel et al. (2008) the HP metaophiolite stone tools were hidden in large and old (even dated back to the 19th century) museum collections, without recognition of their special raw material and importance. After the first mention of these finds detailed petrological investigations of large stone implement collections (Miháldy and Ebenhöch collections; see below in details) revealed their presence in relatively large number. The research was also stimulated by the results of international collaborations (JADE1-2 (2007-2010, 2013-2017), IGCP-442 (1999-2002))[7] focusing on the systematic investigation of Alpine raw materials essential in Neolithic stone tool manufacturing networks. Szakmány et al. (2013) published the first detailed information (in Hungarian) on three pieces of stone implements made of HP raw material, belonging to the collections accumulated by F. Ebenhöch and I. Miháldy. In 2014, several further pieces of HP stone implements were found in the Ebenhöch collection and other museums of Hungary, moreover at new excavations. Bendő et al. (2014) published the petro-mineralogical and geochemical investigations of the initial 3 and further 10 stone findings with sample-by-sample description.

According to our current knowledge, a total of 25 HP metaophiolite stone implements are known from Hungary and in Hungarian museum collections for the neighbouring area (*Figure IV/1*). Unfortunately, most of these objects are stray finds, but 11 pieces have a known

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[7] JADE: Jade. Grandes haches alpines du Néolithique européen (2007-2010)
JADE2: Objets-signes et interprétations sociales des jades alpins dans l'Europe néolithique (2013-2017)
IGCP 442 International Geological Collaboration Project, Raw materials of the Neolithic/ Aeneolithic polished stone artefacts (1999-2002)

Legend/Jelmagyarázat:
Archaeological sites are marked with numbers:
Számmal jelölt régészeti lelőhelyek:
1: Szombathely-Olad
2: Zengővárkony
3: Alsónyék
4: Hódmezővásárhely-Gorzsa
Localities of stray finds are indicated with open symbols:
A szórványleletek lelőhelyei nyitott szimbólumokkal jelölve
Pentagon/Ötszög: Zirc
Circle/Kör: Lábod
Triangle/Háromszög: Iszkaszentgyörgy
Source areas of archaeological collections are outlined with grey hues:
A nagy archeológiai gyűjtemények forrásterületei szürkével jelölve:
Dots/Pöttyök: Ebenhöch collection
Dashed field/Szaggatott vonallal jelölt terület: Miháldy collection

Figure IV/1. Localities of high pressure metaophiolite stone tools in Hungary and in Hungarian museum collections for the neighboring area.

IV/1. ábra. A nagynyomású metaofilit nyersanyagú kőeszközök magyarországi lelőhelyei. Külön jelölve a nevesített múzeumi gyűjtemények lelőhelyei.

archaeological context from four localities, namely Alsónyék (5 pcs.), Zengővárkony (3 pcs.), Szombathely-Olad plateau (2 pcs.), Hódmezővásárhely-Gorzsa (1 piece). Most of these artefacts were found in Transdanubia and connected to the Late Neolithic Lengyel Culture (5000/4900-4500/4400 BC, Regenye 2001; Zalai-Gaál 2001; Visy ed. 2003; Diaconescu 2014), only one piece turned up in South-Eastern Hungary in the Great Hungarian Plain (Hódmezővásárhely-Gorzsa) from the Late Neolithic Tisza Culture (Horváth 1987, 2005).

IV/4. Previous studies on HP greenstones

The raw material of greenish coloured prehistoric polished stone implements includes several different rock types (e.g. contact metabasite, greenschist, serpentinite, nephrite, HP-LT metaophiolites). HP-LT metaophiolites are divided into two basic groups according to their garnet content: eclogite (garnet-bearing) and Na-pyroxenite (without or almost without garnet).

The first comprehensive classification and nomenclature of HP metaophiolite rocks significant in the European Prehistoric polished stone implement production was proposed by D'Amico et al. (2003). They investigated the major mineralogical constituents and the bulk chemical composition (emphasizing the Fe/Mg ratio) but the classification is mainly based on the chemistry. The studied rocks have been categorized as eclogites (Fe-eclogite, intermediate eclogite, Mg-eclogite), omphacite(-jadeite) schist, and jades (jadeitite, Fe-jadeitite, omphacitite, Fe-omphacitite, Mg-mixed jade, Fe-mixed jade). Most recently, Giustetto and Compagnoni (2014) proposed a new classification consistent with the recommendations of the Subcommission on the Systematics of Metamorphic Rocks (SCMR) of the International Union of Geological Sciences (IUGS). This grouping is based solely upon the quantification of the major mineral phases and neglects the consideration of the bulk chemical composition. It differentiates Na-pyroxenites (jadeitite, mixed pyroxenite (Omp-Jd pyroxenite, Jd-Omp pyroxenite), omphacitite) and Na-pyroxene + garnet rocks (grt-omphacitite, eclogite, omp-garnetite, garnetite).

The reason for ignoring the bulk rock chemistry by Giustetto and Compagnoni (2014) was explained with the inappropriate aspect of chemical analyses (e.g. scanning electron microscopy with energy dispersive spectrometry (SEM-EDS) or X-ray fluorescence analysis (XRF)) for archaeological implements. However, in this study we applied the completely non-destructive Prompt Gamma Activation Analysis (PGAA) which provides the average chemical composition of a few cm^3 irradiated heterogeneous sample volume. Hence, we decided to primarily apply the chemistry-sensitive grouping of D’Amico et al. (2003), though the classification into the newer nomenclature of Giustetto and Compagnoni (2014) is also done.

Eclogites contain a large amount of garnets in addition to the Na-pyroxenes (at least 5 wt% according to D’Amico et al. 2003; at least 25 wt% according to Giustetto and Compagnoni 2014). The predominant Na-pyroxene is omphacite, but jadeite dominated eclogites do exist as well. These rocks can contain some accessory minerals, like rutile, zircon, ilmenite, apatite and titanite. Stone tools made of eclogite were used as woodworking tools by the prehistoric people of northern Italy starting from the beginning of the Neolithic period. As a raw material, the eclogite group is more widespread. However as material for stone tools they have only a local (regional) predominance (D’Amico 2005; D’Amico & Starnini 2012; Pétrequin et al. 2012a).

Na-pyroxenites consist predominantly (more than 80 wt%) of different Na-pyroxenes (e.g. jadeite and omphacite, sometimes aegirine and/or aegirine-augite). Garnet is present in less than 5 wt% concentration or only occasionally. These rocks have some accessory minerals (e.g. rutile, zircon, ilmenite, apatite and titanite). The exceptionally shaped and finished stone implements made of jade can be found all over North-Western Europe (Pétrequin et al. 2012a, 2017a). They are interpreted by the archaeologists as symbols of power and/or religion and/or wealth rather than as common working tools. Na-pyroxenites as a raw material can be found only in very limited areas and in relatively small quantities. However, stone implements made of this raw material can be found more than 1500 km away from the source areas (D’Amico 2005; D’Amico & Starnini 2012; Pétrequin et al. 2012a).

Table IV/1 Schematic comparative chronological, metamorphic P-T conditions, pro- and retrograde mineralogical and textural characteristics of European Na-pyroxenite and eclogite localities, with references

IV/1. Táblázat: Az európai Na-piroxenitek és eklogitok vázlatos összehasonlító táblázata, kronológiai, nyomás-hőmérsékleti, metamorf ásványtani és szöveti jellegzetességek alapján.

Locality	Age and conditions of peak metamorphism	Texture and mineralogy	Retrograde overprint	References
Na-pyroxenites				
Western Alps (Monviso, Voltri Massif)	Alpine, lawsonite-eclogite facies	isotropic microstructure, (saccharoidal texture); Jd-rich px (Fe-Jd, Omp)(relict cloudy core with Ttn) + Lws (pseudomorphs in omphacitites) + Grt (atoll structured) + small-sized Zrn (a few micrometers, blocky prismatic or tiny single crystals or crystal aggregates) + Ap + Aln + Mnz + Rt + Spn ± Ilm ± Pg ± Ph	only submicroscopic dusted aggregates of Ab, Anl (Chl, Gln, Act, Ep, Zo)	Tsujimuri & Harlow 2012, Harlow et al. 2015, Castelli et al. 2002, Groppo & Castelli 2010, Angiboust et al. 2011, 2012, Compagnoni et al. 2007, 2012
Aegean Sea (Syros, Tinos)	Alpine; Syros: T=270–500 °C, P=0.8–1.8 GPa Tinos: T=450–550 °C, P=1.2–2.0 Gpa	Jd, Zrn + Ttn (white mica, Rt inclusions)	extended, Ab, Chl, Anl	Dixon & Ridley 1987; Bröcker et al. 1993, Bröcker & Enders 1999; Bröcker & Keasling 2006; Bulle et al. 2010, Fu et al. 2012, Pétrequin et al. 2017b
Eclogites				
Rhodope	Pre-Cambrian, P=0.9–1.2 GPa, T=450–550 °C	stripped structure; Grt + En + Di + Ol + Spl + Srp	extended	Kozhoukharova 1980, 1996, 2010
Bohemian Massif	Variscan, P=2 GPa, T=600–650 °C, Moldanubicum: eclogite (T=710 °C, P> 1.5 GPa) to MP-HP granulite facies (T=700–800 °C, P=0.7–1.2 GPa)	coronitic texture; Münchberg: Omp + Grt + Qz + Rt + Hbl/Ky/Ph/Zo, Erbendorf: Grt (inclusions of Qz, Rt, Opq) + Cpx + Opx (exsolution lamellae of Cpx) + Po (with lamellae of Pn, intergrown with Ccp), Moldanubicum: Grt (rimmed by a radial, kelyphite-like symplectite of Mg-Hst + Pl ± Spl) + symplectitic Px + Amp + Omp + Rt (groundmass Rt replaced by Ilm + Spn) ± Qz ± Ky (replaced by symplectitic Hc + An) ± Zo	MP amphibolite-facies metamorphism: Grt (Hc, acicular Amp, Chl inclusions) + Cpx replaced by Hbl coronas + Cpx + Pl; Cpx > symplectite of Cpx + Hbl; Opx > Bt, Rt > Ilm	Busch 1970, O'Brien, 1989 Dudek & Fediuková 1974, Okrusch et al. 1991, Beard et al. 1992
Western Carpathians (Veporic Unit)	Variscan, P=2.5 GPa, T=700 °C	rarely preserved primary mineral composition (Omp + Grt + Ph + Rt + Zo + Qz ± Amp	amphibolite to greenschist facies: Omp > symplectites of Cpx (lower Na-Al content) + Na-Pl, Amp (Prg, Hbl, Act)	Janák et al. 2007, Hovorka et al. 1994

Table IV/1 – continued

IV/1. Táblázat – folytatás

Locality	**Age and conditions of peak metamorphism**	**Texture and mineralogy**	**Retrograde overprint**	**References**
Ligurian Alps (Savona Crystalline Massif)	Variscan, P=1.7 GPa, T=650–750 °C	Grt (euhedral porphyroblasts, Alm 49–62% + Grs 19–29% Prp 13–27% + Sps <3%; zoned decrease in Mn and Ca, and increase in Mg/(Mg+Fe) from core to rim) + Omp (Jd 32–41%) + Zo + Rt + Ky (rimmed by Ms + Qz) + Ph + Qz	Di-Andesine symplectites, Grt rimmed by kelyphites of green Amp + Pl	Giacomini et al. 2007, Messiga et al. 1992
Western Alps (Monviso, Voltri Massif)	Alpine, P=up to 2.6–2.7 GPa, T=480–550 °C	Grt (atoll-like texture, many inclusions, Alm-rich, if zoned then Sps varied) + Omp-rich Px (less Jd, Fe-Jd)(cloudy core crowded with very fine-grained, oriented inclusions of Ttn) + Rt + Ilm + Spn ± Zo ± Pg ± Zrn ± Ap (Mnz, Aln), mylonite may occur, sometimes late neoblastic Omp needles	blueschist to greenschist facies: Gln, Tr-Act, Ep, Chl, Ab, zero to moderate deformation	Castelli et al. 2002, Beltrando et al. 2010, Angiboust et al. 2012, Pétrequin et al. 2017b
Sivrihisar Massif (Turkey)	Alpine, P=2.6 GPa, T=500°C (lawsonite eclogite); P=1.8 GPa, T=600°C (epidote eclogite)	Omp + Grt + Lws + Ph + Rt ± Gln ± Qz ± Ep + Ttn, pristine (Omp + Grt + Ph)	partially retrogressed (still Omp + Grt, partly replaced by Chl, Ep, white mica, Gln) to completely retrogressed (Chl + Ep)	Carpenter 1979, Davis & Whitney 2006
Aegean Sea (Syros, Sifnos, Tinos)	Alpine, epidote-blueschist to the eclogite facies, P= 1.2–2 GPa, T= 450–500 °C	non-schistose matrix; Omp + Grt (porphyroblasts up to 5 mm, inclusions of Rt + Omp) + Rt + Spn ± Ph ± Pg + Qz + Ap	Gln, Ep, Chl, Ab	Okrusch & Bröcker 1990, Seck et al. 1996, Bulle et al. 2010, Fu et al. 2012, Dixon & Ridley 1987, Putlitz et al. 2005
Betic Cordillera (Iberian Peninsula)	Alpine, LT	porphyroblastic, coronitic texture (large, diversely oriented Omp crystal aggregates in a matrix of intergrown Ab + Ep); aggregate of Omp + Amp rimmed by Grt (former Ol) , fine-grained aggregate of Ab + Czo (former Ca-Pl), Ilm > Rt (needle-like inclusions in Omp)	Grt + Omp > Na-Ca Amp + Na-Pl, strong textural deformation	Puga et al. 1989, 2013, Lozano et al. 2017

These two groups of HP metaophiolites are formed under the same conditions, of high pressure (dominantly 0.6-2 GPa) and generally low (<550 °C) to medium temperature (>550 °C), mainly subduction related metamorphism from basaltic protoliths (Tsujimori & Harlow 2012). HP-LT metaophiolites can be found in Palaeozoic to Cenozoic orogens around the world, in the Caribbean, the circum-Pacific, the Alpine-Himalayan and the Caledonian belt, and also as xenoliths in kimberlitic pipes in the Colorado Plateau (USA) (see Tsujimori & Harlow 2012 for details).

Considering the archaeological context, only the European HP-LT metaophiolite localities belonging to the Alpine-Himalayan belt have been taken into account as potential sources in this study. The European jadeitite sources are the Monviso and the Voltri Massif (in Italy, Western Alps), and Syros and Tinos Islands (in Greece, Cyclades, Aegean Sea) (Tsujimori & Harlow 2012, Harlow et al. 2015). The European eclogite sources are widely distributed. Pre-Alpine (Variscan) eclogites are known from the Bohemian Massif in Germany and the Czech Republic (Okrusch et al. 1991, Beard et al. 1992), the Veporic Unit of the Western Carpathians in Slovakia (Janák et al. 2007, Hovorka et al. 1994), the Ligurian Alps in Italy (Giacomini et al. 2007), and the Rhodope Massif in Bulgaria (Kozhoukharova 1980, 1996, 2010). In addition, eclogite pebbles deriving from the Bohemian source are also described from the alluvial gravel of the Danube in Hungary (Horváth et al. 2005) and Slovakia (Hovorka & Illášová 2002). The Alpine-type eclogites are distributed in the Western Alps (Castelli et al. 2002, Beltrando et al. 2010), Turkey (Carpenter 1979, Davis & Whitney 2006), the Aegean Islands (Syros, Sifnos, Tinos) (Okrusch & Bröcker 1990, Seck et al. 1996, Bulle et al. 2010, Fu et al. 2012) and the Betic Cordillera in the Iberian Peninsula (Puga et al. 1989, 2013). Characterization of the metamorphism (age and conditions), the pro- and retrograde mineralogical compositions and textures found in the above listed localities are summarized in *Table IV/1*.

IV/5. Methods

Due to the predominance of valuable complete artefacts in the studied assemblages, only non-destructive analytical methods were used in this study. Firstly, macroscopic and stereomicroscopic observations have been made, coupled with magnetic susceptibility measurements. The basic petrographical descriptions and the first grouping were made by means of hand lens and stereomicroscope (magnification range 10–100X). Magnetic susceptibility (MS) measurements were made with a portable Kappameter KT-5. Real MS values were calculated with different corrections of size and thickness (Williams-Thorpe et al. 2000; Bradák et al. 2005, 2009). After these basic investigations scanning electron microscopy with energy dispersive spectrometry (SEM-EDX) in a non-destructive mode (Bendő et al. 2012,

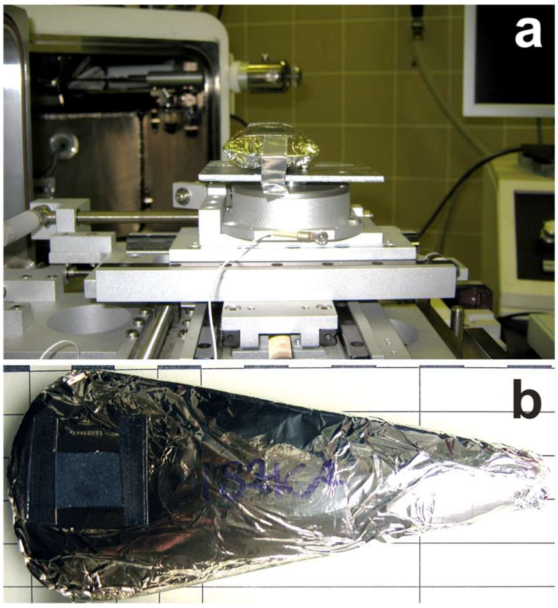


Figure IV/2. Sample preparation for non-destructive SEM-EDX analysis on the original surface of the artefacts. (a) Sample 3127 mounted to sample holder of SEM. (b) Sample 39/1903 prepared for investigation by wrapping in aluminium foil. The foil has a window and the sample was carbon-coated for the investigation only on the small area of interest.

IV/2. ábra. Mintaelőkészítés a kőeszköz eredeti felszínének roncsolásmentes SEM-EDX vizsgálata számára. (a) 3127-es minta bekészítve vizsgálatra a SEM mintatartójára. (b) 39/1903 minta előkészítve vizsgálatra. A minta alufóliába van csomagolva, a fólia a vizsgálat tervezett helyén ki van vágva és a vizsgálandó felület be van szenezve.

2013) was used to perform detailed mineral chemical analyses and textural investigation. Prompt Gamma Activation Analysis (PGAA) was used to determine the average bulk concentrations of major and some trace elements on a few cm^3 volume of each sample.

The non-destructive version of SEM-EDX allows in situ textural and mineral chemical studies on the original surface of the archaeological artefacts without any damage (Bendő et al. 2012, 2013). Due to the lack of the traditional detailed textural descriptions by petrographic microscope (which is a destructive method), textural characterization of the samples is restricted to a more general standard (which is based on the observation of the back scattered electron (BSE) images and hence has limits concerning the visibility of e.g. grain boundaries, phases of similar grey values). All of the BSE images and EDX analyses of this study were made by this non-destructive method at the Department of Petrology and Geochemistry, Institute of Geography and Earth Sciences, Eötvös L. University, Budapest. The instrument is an AMRAY 1830 scanning electron microscope equipped with EDAX PV9800 energy dispersive spectrometer. The conditions of analysis were 20 kV accelerating potential, 1 nA beam current, ~50–100 nm focused electron beam diameter, and 100 sec measurement time (livetime). Our SEM, equipped with a quite large sample chamber, allows examining samples up to 300x200x55 mm (*Figure IV/2a*). The sample chamber has a manual five-axial (X, Y, Z, R, T) moving system which helps to approach a horizontal state of the irregular surface for the most precise measurements. Since the investigations were done in vacuum (10^{-3} Pa), producing a conducting layer on the sample surface was necessary. The cleaned samples were wrapped into aluminium foil (to conduct electric charge), with a window in the foil, and the sample was carbon-coated (by a JEOL JEE-4B type vacuum evaporator) for the investigation of only the small area of interest (1–2 cm^2) (*Figure IV/2b*). The carbon coating can be easily removed by water or organic solvent (e.g. mineral spirit *aka petroleum ether*) after the investigation without any damage or surface change to the valuable archaeological artefacts. For the quantitative mineral chemical measurements, ZAF corrections and standardizations were applied. The following international mineral standards were used: albite (Amelia # AS5010-AB), orthoclase (MAD-10), augite (ENM-augite), chromite (Australia, C. M. Taylor Company), titanite (C. M. Taylor Company), kaersutite (Glen Innes, Australia, C. M. Taylor Company), biotite (LP-6), apatite (Wilberforce apatite # AS1040-AB), Ba-, Zn-, U-containing artificial glass (K-378F. G.), olivine (AS5200-AB), spessartine (garnet No.3d.) (Bendő et al. 2013), jadeite (SPI #AS1195-AB), omphacite (Smithsonian Microbeam Standard, SMS, NMNH 110607), garnet (SMS, NMNH 87375) and pyrope (SMS, NMNH 143968) (Bendő et al. 2014).

Non-destructive PGAA was performed at the Budapest Research Reactor operated by the Centre for Energy Research, HAS. The method (see for details in Révay 2009; Szentmiklósi et al. 2010) is suitable for the quantitative determination of the average concentrations of the major components (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, and as a specialty of the method, precise detection of H; e.g. Lindstrom et al. 1994, Anderson & Kasztovszky 2004, Paul & Lindstrom 2012, Turkoglu et al. 2017) and of some trace elements (B, Cl, Nd, Sm, Gd) in a few cm^3 volume. Concentrations of major elements are calculated in wt% and, as a convention in geochemistry, are given in oxide forms, calculated according to the oxidation numbers. The thermal equivalent beam intensity was $7.75*10^7$ $cm^{-2}*s^{-1}$. A calibrated Compton-suppressed HPGe detector was used to detect prompt gamma spectra, and Hypermet PC software was used for evaluation (Molnár et al. 2002, Révay et al. 2005). In the case of the measurements made in this study, the typical acquisition time was between 1600 and 7000 seconds. The collimation size of the neutron beam was between 5 mm^2 and 2 cm^2.

IV/6. Materials

The 25 artefacts analysed are from various localities within Hungary, some of them derived from archaeological excavations of prehistoric sites. Others from specific collections and some stray finds came from old collections of various museums (*Table IV/2*).

The Mihály collection was accumulated by István Miháldy (1833–1901), the vicar of Bakonyszentlászló, it contains 378 polished stone tools, now curated in the Laczkó Dezső Museum in Veszprém. Unfortunately, the exact provenance of the pieces was lost: However, it is known that all the samples were found in different sites in the Bakony Mts. and its surroundings (Horváth 2001; Füri et al. 2004). One piece of HP metaophiolite artefact (No. 55.1276.) was found in this collection.

The Ebenhöch collection was piled up by Ferenc Ebenhöch (1821–1889), and it contains more than 700 polished stone tools. It is now a part of the Prehistoric Collection of the Hungarian National Museum in Budapest. The artefacts were found in Western Hungary and in the territory of Upper Hungary (todays Slovakia) (Ebenhöch 1876; Friedel et al. 2011). Ten pieces of HP metaophiolite stone tools have been found in this collection so far (see in *Table IV/2*). Another polished artefact belonging to the Prehistoric Collection of the Hungarian National Museum, Budapest is also made of HP metaophiolite and was collected from Iszkaszentgyörgy (No. 39/1903) (Biró et al. 2017).

Szombathely-Olad plateau was a Late Neolithic settlement and ritual center. Almost 100 pieces of anthropomorphic clay idols were found there (Ilon 2007). Chronologically, the site represents a transitional stage of the Lengyel culture between the early and the classical periods (Lengyel Ib, Kalicz 2007). Two very small fragments of HP metaophiolite stone implements were found there (No. Olad-321, Olad-329).

The polished stone artefacts from Zengővárkony settlement and cemetery of the Lengyel Culture were investigated previously (Biró et al. 2003) but are now reconsidered for provenancing HP metamorphites. Three HP metaophiolite artefacts (No. n5/47-1939, n1/81-1938, n11/169-1938) were located, all of them found in graves.

Alsónyék is the largest known cemetery and settlement of the Lengyel Culture, excavated during preventive archaeological operations. The evaluation of the site data is in progress (Zalai-Gaál et al. 2011). Five HP metaophiolite artefacts (No. M6-2010.10B.792.2., M6-2010.10B.3060.1., M6-2010.10B.6348.1., M6-2010.10B.6380.1., M6-TO.10/B.6320.) have been identified, all of them found in graves.

Hódmezővásárhely-Gorzsa is a well-known Late Neolithic (Tisza culture) tell settlement. The site lies at the confluence of the Tisza and Maros rivers in the Great Hungarian Plain, north of Szeged. Approximately 1000 square meters of the tell settlement were excavated so far and more than 1000 stone artefacts were collected in a controlled stratigraphical context (Horváth F. 1987, 2005; Szakmány et al. 2008; Starnini et al. 2015). One HP metaophiolite small polished adze blade (No. 99.3.1863.) represents the easternmost example (the only one to the East of the river Danube) of HP stone tools in Hungary so far.

A single axe/adze of HP metaophiolite (No. 3127 RRM) was found at Lábod and registered in the Rippl-Rónai Museum at Kaposvár. The artefact is on long-time loan for exhibition at Balatonboglár (Somogy county, Hungary). A unique sample (No. Zirc 81/W2 5) belonging to a private collection owned by Ernő Wolf was found at Zirc and was also included into this study.

Table IV/2 General information of the investigated 25 HP metaophiolite stone tools identified in the Hungarian archaeological record. Inventory information and archaeological description (typology after Pétrequin et al. 2017a), colour, Munsell colour (codes of the Munsell colour chart indicate the colours of the base rock; –>: hues in the order of frequency, v: veins, p: patches), magnetic susceptibility data, and macroscopic description of the raw material (typology after D'Amico et al. 2003).*

IV/2. táblázat: Általános információk a Magyarországon azonosított és megvizsgált 25 db HP metaofiolit anyagú kőeszközről. Leltári információk, régészeti leírás, tipologizálás (Petrequin et al. 2017a alapján), szín, Munsell színek (színkód jelzi a kőzet alapszínét; -> színárnyalatok a gyakoriság sorrendjében, v: ér, p: folt), mágneses szuszceptibilitás adatok, rövid makroszkópos leírás és a nyersanyag tipologizálása (D'Amico et al 2003 alapján).

Inventory No.	**Location**	**Context**	**Museum/Owner**	**Type (after Pétrequin et al. 2017a)**	**Dimensions (l x w x h, mm)**	**Colour**	**Munsell colour***	**MS value (x10^{-3} SI)**	**Texture/ Macroscopic description**	**Raw material type (after the system of D'Amico et al. 2003)**
55.1276	Bakony (Veszprém environs)	stray	Mihály Collection, LDM, Veszprém	flat, elongated, triangular adze, cross section: oval, Chelles type	95 x 50 x 19	medium-dark green	5G 2.5/1 –> 5G 3/2; v: 5G 4/2	0.17	homogeneous, dark green matrix with lighter veins/patches, small (<1 mm) white sub-anhedral crystals	jadeitite
66/1883.41	Farnád Farna (Sk)	stray	Ebenhöch Collection, HNM, Budapest	flat, elongated, lingular adze, cross section: lense, Durrington type	89 x 50 x 14	dark green	5G 3/1 –> 5G 5/2	0.35	inhomogeneous, strongly foliated, alternating medium and dark green bands, some 1-2 mm light green grains	Mg-eclogite
66/1883.147	(Komárom) Szentpéter Svaty Peter (Sk)	stray	Ebenhöch Collection, HNM, Budapest	flat, strongly elongated, triangular adze, cross section: rectangular	90 x 42 x 14	medium-dark green	5G 3/1 –> 5G 5/1	0.11	homogeneous, weakly oriented, medium green matrix with large dark green patches, some 1-2 mm light green grains, dark-light green veins	jadeitite
66/1883.173	Szőgyén Svodín (Sk)	stray	Ebenhöch Collection, HNM, Budapest	flat, elongated, lingular adze, cross section: D shaped, Durrington type	91 x 49 x 14	light-medium green	5G 8/1 –> 5G 2.5/1	0.58	inhomogeneous, slightly oriented/foliated, light green matrix with many dark green veins and patches, <1 mm dark green-black grains (omphacitic garnet), one side is dark green	Mg-eclogite
106/1882.58	Mogyoród?/ Mogyorós?	stray	Ebenhöch Collection, HNM, Budapest	flat, elongated, lingular adze (broken butt), cross section: oval, Durrington type	53 x 47 x 14	medium-dark green	5G 2.5/2 –> 10GY 5/1	0.27	inhomogeneous, foliated, dark green matrix with lighter veins and irregular patches, some light green subhedral crystals	omphacitite
117/1884.130	Lekér Hronovce (Sk)?	stray	Ebenhöch Collection, HNM, Budapest	flat, strongly elongated, triangular adze, cross section: oval	78 x 32 x 15	medium green	5G 4/2 –> 5G 2.5/1	0.10	homogeneous, slightly oriented/foliated, medium green matrix with lighter vein network and other green patches, some light green 1-2 mm grains, some 3-4 mm dark green grains	jadeitite

Table IV/2 – continued

IV/2. táblázat - folytatás

Inventory No.	**Location**	**Context**	**Museum/Owner**	**Type (after Pétrequin et al. 2017a)**	**Dimensions (l x w x h, mm)**	**Colour**	**Munsell colour***	**MS value (x10^{-3} SI)**	**Texture and macroscopic description**	**Raw material type (after the system of D'Amico et al. 2003)**
117/1884.213	Vámosladány Mýtne Ludany (Sk)	stray	Ebenhöch Collection, HNM, Budapest	flat, triangular adze (broken butt), cross section: oval	24 x 28 x 7	dark green, black	5G 2.5/1 –> 5G 3/2	0.22	slightly inhomogeneous, dark green matrix with lighter patches, brown 0.5-2 mm garnet crystals, sometimes in bands (foliated?)	Fe-eclogite
141/1882.44	(Garam)Kövesd Kamenica nad Hronom (Sk)	stray	Ebenhöch Collection, HNM, Budapest	flat, weakly elongated, lingular adze, cross section: thin lense, thin Durrington type	65 x 43 x 11	light green	5G 7/2; e: 5G 2.5/2; p: 5G 4/2	0.13	slightly inhomogeneous, light green matrix with dark green veins, medium green and white patches, <1 mm dark green-black grains	jadeitite
177/1872.I/2.	unknown (Vét (Sk)?)	stray	Ebenhöch Collection, HNM, Budapest	flat, weakly elongated, lingular adze, cross section: oval, Durrington type	83 x 49 x 20	medium green	5G 5/1 –> 5G 4/2	2.02	homogeneous, slightly oriented/foliated?, medium green matrix with dark green patches, dark green-black grains, mm sized garnets	Fe-eclogite
300/1876.247	Almásneszmély	stray	Ebenhöch Collection, HNM, Budapest	flat, triangular adze, cross section: lense, Varna type	40 x 28 x 7	medium-dark green	10 GY 3/2-5G 3/2	0.47	homogeneous, dense, massive, some dark green patches, few garnets	Fe-jadeitite
300/1876.264	Bakonypéterd	stray	Ebenhöch Collection, HNM, Budapest	flat, elongated, triangular adze, cross section: oval	57 x 34 x 12	light green	5G 6/1-10G 6/2	0.10	homogeneous, dense, massive, some white patches	jadeitite
39/1903	Iszkaszentgyörgy	stray	Prehistoric Collection, HNM, Budapest	flat, strongly elongated, lingular adze, cross section: lense, Greenlaw type	118 x 50 x 18	medium green-greenish black	5G 3/2-5GY 2/1	0.27	homogeneous, alternating white and dark green (black) patches, elongated dark green crystals, few garnets	Fe-jadeitite
3127 RRM	Lábod	stray	Rippl-Rónai Museum, Kaposvár	elongated, lingular adze, cross section: oval, Chelles type	90 x 48 x 23	medium green	5GY 3/2	0.37	homogeneous, medium green matrix with light green veins, dark green patches	Fe-jadeitite
Zirc 81/W2 5	Zirc	field survey	private collection, Wolf Ernő	flat, weakly elongated, triangular adze, cross section: oval	37 x 30 x 10	light greyish green	5G 6/1	0.19	slightly inhomogeneous, light green patches	mixed jade

Table IV/2 – continued

IV/2. táblázat - folytatás

Inventory No.	Location	Context	Museum/Owner	Type (after Pétrequin et al. 2017a)	Dimensions (l x w x h, mm)	Colour	Munsell colour*	MS value (x10^{-3} SI)	Texture/ Macroscopic description	Raw material type (after the system of D'Amico et al. 2003)
M6-2010-10B.792.2	Alsónyék	Lengyel Culture, grave	Institute of Archaeology, Research Centre for Humanities, HAS	flat, triangular adze, cross section: D shape	64 x 40 x 12	medium green	5G 4/1; p: 5G 6/1	0.44	inhomogeneous, banded, foliated, medium green matrix with light green bands and dark green patches, 1-2 mm black sub-anhedral crystals	Fe-jadeitite
M6-2010-10B.6348.1	Alsónyék	Lengyel Culture, grave	Institute of Archaeology, Research Centre for Humanities, HAS	flat, elongated, triangular adze, cross section: D shape	45 x 31 x 10	medium green	5G 5/2; p: 5GY 7/1	0.15	homogeneous, slightly foliated, alternating light and medium green bands, black, max. 1mm eu-subhedral crystals, 2 large-sized (9 and 5 mm) white-light green patches, 2 large-sized (3 and 4 mm) inhomogeneous dark grey patches	jadeitite
M6-2010-10B.6380.1	Alsónyék	Lengyel Culture, grave	Institute of Archaeology, Research Centre for Humanities, HAS	flat, elongated, triangular adze, cross section: lense	103 x 49 x 17	medium-dark green	5G 2.5/2; bands: 5G 4/1	0.21	homogeneous, fine-grained, translucent matrix with light or dark green patches, 3 light green paralel bands on its butt	jadeitite
M6-TO.10/B.6320	Alsónyék	Lengyel Culture, grave	Institute of Archaeology, Research Centre for Humanities, HAS	flat, elongated, lingular adze (broken butt), cross section: oval, Durrington type	71 x 60 x 18	medium green	5G 6/1 –> 5G 2.5/1	0.34	homogeneous, strongly foliated, alternating medium and light green bands, some 1-2 mm white grains, and brown grains (rutile crystals, strained)	mixed jade
M6-2010-10B.3060.3	Alsónyék	Lengyel Culture, grave	Institute of Archaeology, Research Centre for Humanities, HAS	thick, strongly elongated, triangular adze, cross section: oval, Chelles type	116 x 50 x 22	dark green-black	10BG 2.5/1	0.95	homogeneous, foliated, alternating different green bands, some max. 2 mm brown and green grains (garnet), 2-3 mm pyrite	Fe-eclogite
N5/47-1939	Zengővárkony	Lengyel Culture, grave	JPM, Pécs	flat, weakly elongated, triangular adze, cross section: oval	40 x 30 x 8	dark green-black	10B 2.5/1; p,v: 5G 2.5/1	0.19	homogeneous, slightly oriented, black matrix with green veins, small white sub-anhedral crystals-aggregates, red garnets?	glaucophane schist
N1/81-1938	Zengővárkony	Lengyel Culture, grave	JPM, Pécs	flat, elongated, triangular adze, cross section: flat D shape	62 x 39 x 12	light-medium green	5G 4/2 –> 5G 3/1; p: 10Y 7/1	0.20	homogeneous, alternating different green bands, many white <0.5 mm nodules (altered garnets?), some 1-2 mm eu-subhedral dark green crystals	mixed jade

Table IV/2 – continued

IV/2. táblázat - folytatás

Inventory No.	Location	Context	Museum/Owner	Type (after Pétrequin et al. 2017a)	Dimensions (l x w x h, mm)	Colour	Munsell colour*	MS value (x10^{-3} SI)	Texture/ Macroscopic description	Raw material type (after the system of D'Amico et al. 2003)
N11/169-1938	Zengővárkony	Lengyel Culture, grave	JPM, Pécs	flat, strongly elongated, triangular adze, cross section: lense, Durrington type	58 x 31 x 11	dark green	5G 4/2 –> 5G 2.5/1	0.39	homogeneous, alternating medium and dark green patches, garnets, some max. 2 mm rutile crystals	Fe-mixed jade
Olad-321	Szombathely, Olad	Lengyel Culture, settlement	Savaria Museum, Szombathely	butt fragment of flat adze, cross section: rectangular	17 x 9 x 6	medium green, red	5G 5/2	0.03	homogeneous, medium green matrix with red garnet crystals	Fe-eclogite
Olad-329	Szombathely, Olad	Lengyel Culture, settlement	Savaria Museum, Szombathely	butt fragment of flat adze, cross section: oval	20 x 27 x 10	medium green, blueish	5G 5/2	0.03	homogeneous, alternating light and medium green patches, some small white crystals, 0.5 mm garnets	Fe-mixed-jade
99.3.1863	Hódmezővásárhely-Gorzsa	Lengyel Culture, settlement	Móra Ferenc Museum, Szeged	flat, weakly elongated, triangular adze, cross section: oval, Varna type	43 x 31 x 10	medium-dark green	5GY 3/1 –> 5G 2.5/1	0.24	inhomogeneous (brecchiated), medium-dark green matrix with white and dark green-black patches and veins, some max. 1 mm garnet crystals (4-5 pcs.), few white, elongated (~ 1 mm) crystals (zircon or apatite)	Fe-mixed jade

Abbreviations: LDM: Laczkó Dezső Museum, HNM: Hungarian National Museum, HAS: Hungarian Academy of Sciences, JPM- Janus Pannonius Museum

Most of the objects have a flat, elongated, triangular or tongue-like shape. The sizes are variable; the length is between 18 and 124 mm, the width spans between 20 and 53 mm, while the height varies between 6 and 22 mm. Their colours are of different shades varying from light through dark green, even to black (see details in *Table IV/2*).

The typology of polished stone artefacts is universally less established than that of chipped stone tools. While there is a more-or-less accepted consensus for chipped stone tool nomenclature, especially for the older phases of the Palaeolithic (Bordes 1961, Brezillon 1971) there is a wide difference in opinion for the typeability of polished stone tools. As an extremely simplified system we can mention the opinion of J. Antoni (2012b) who distinguished polished stone artefacts without shaft-hole („blades”) and items with shaft-hole, perpendicular („hoe”) or parallel to the working edge („axe”). The other extreme opinion expressed in this matter is that of I. Zalai-Gaál (2001), who made a minute classification of polished stone axes to be used in serial dating of large Late Neolithic cemeteries.

For the classification of greenstone (notably, jadeitite and eclogite) polished stone tools, we will use the system presented by P. Pétrequin (Pétrequin et al. 2012c, Fig. 20). They are universally referred to as „axe-heads”. Our work is supported by the classification given by Pétrequin on the Hungarian axes in the JADE2 project monographs (Pétrequin et al. 2017c, Biró et al. 2017, *Figure IV/3*). Many of the pieces reported here were subjected to resharpening and re-use and some of them are fragmented. Using the classification by Pétrequin, we can say that the most popular form was the Durrington type (7 pieces) followed by Chelles (4 pieces) and Greenlaw type (1 piece). It is not mentioned specifically in the above cited work, but, on the basis of published drawings we think that the Varna type is also present here (items from Almásneszmély and Hódmezővásárhely-Gorzsa) (see *Table IV/2*).

IV/7. Results

Figures IV/4–8 presents the essential part of the results of the present study, with samples divided into groups based on the classification of D’Amico et al. (2003), as listed in *Table IV/3*. The detailed macroscopic observations (using naked eye and hand lens) showed that these rocks are fine-grained (sometimes very fine-grained), though some larger sized grains/blasts can be present. The macroscopic texture can be homogeneous or inhomogeneous with usually 1–2 mm sized (green/white/black/red/brown, sometimes sub- and anhedral) crystals, crystal aggregates, veins or (white, grey, light to dark green) patches. The garnet content – which is a discriminative feature concerning Na-pyroxenites vs. Na-pyroxene+garnet rocks – can be determined with high probability due to the reddish coloured crystals. Deformation of the texture (e.g. orientation of constituents into bands, weak to strong foliation) can be observed in many cases.

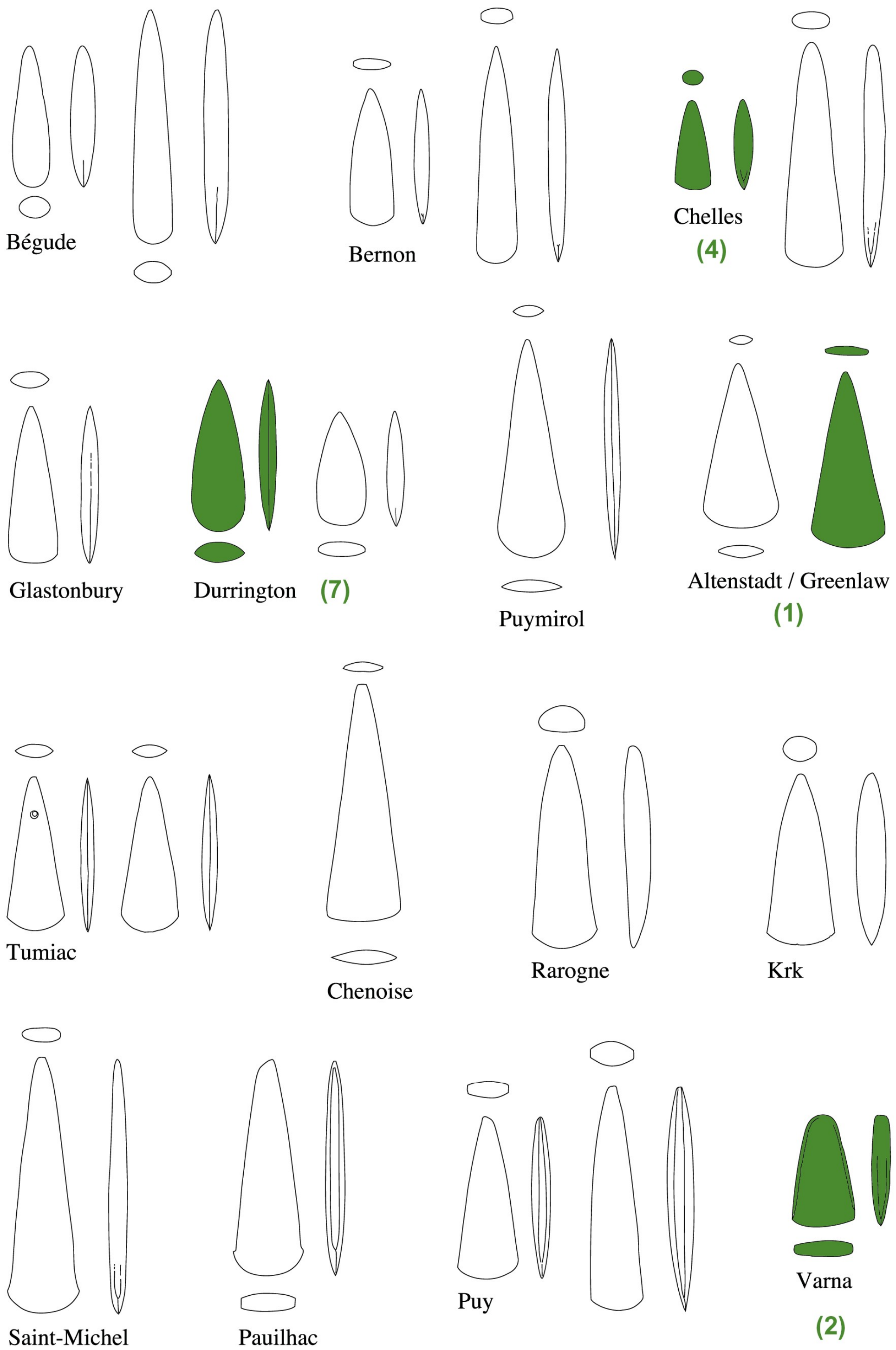


Figure IV/3. Classification of greenstone axe-heads by Pétrequin et al. 2012c and determination by the same author in the JADE2 monograph (modified after Pétrequin et al. 2017c; Biró et al. 2017). Green colour indicates the axe-head types represented in the Hungarian archaeological record, numbers refer to pieces of artefacts in each type.

IV/3. ábra: A zöldkő kőbalták osztályozása Pétrequin et al. 2012c alapján, és a Magyarországon talált kőeszközök beosztása a JADE 2 kötetben ugyanazon szerző által (Pétrequin et al. 2017c után módosítva; Biró et al. 2017). A zöld szín jelzi, hogy a magyarországi leletek között milyen alaki típusok fordulnak elő, a zöld szám pedig azt, hogy az adott típusból hány darab található.

Magnetic susceptibility measurements provided a data set which partly can correlate with the macroscopic colour of the samples (see in *Table IV/2*). In most of the Na-pyroxenites the higher MS data is coupled with the darker colours (dark green to black), though contradicting examples are also present.

Major element concentrations of the bulk samples have been determined by PGAA. In *Table IV/3* we summarize the results. Although, concentrations of some trace elements were also detected by PGAA, those data were not considered during this study because they could not provide a sufficiently wide range of rare earth or other trace elements. It was found in previous research (Szakmány et al. 2011) that trace element spectra by PGAA is not detailed enough for the appropriate geochemical interpretation in the case of polished stone tools. This is different case of chipped stone tools, especially obsidians, where mobile trace elements (B, Cl) detected by PGAA can play a fundamental role in characterization and provenancing (e.g. Kasztovszky et al. 2017).

According to our results, the presently identified 25 HP metaophiolite stone adzes can be classified into 8 raw material types (see *Table IV/ 3* and *IV/ 4*). The raw material classes of the first column in Table 4 were introduced by D'Amico et al. (2003) on the basis of micro-invasive petrographic analysis of archaeological finds from Northern Italy (by micro-coring sampling method). The raw material classes of the second column in *Table IV/4* were proposed by Giustetto and Compagnoni (2014). As can be seen, there are overlapping groups of the two classification systems. Since in this study bulk rock chemical data were available, we followed the classification of D'Amico et al. (2003) during the description of the raw material types.

As was explained above, lacking thin section data, the traditional petrographic description is not possible. However, appropriate textural characterization can be done based on the BSE images. Apart from the average mineralogical composition, the most significant microstructural features of HP rocks (grain size of minerals, presence/absence of metamorphic veins, degree of deformation), which were suggested by Giustetto and Compagnoni (2014), can be well determined. In addition, individual characteristics of mineral blasts (e.g. shape, zonation or other compositional varieties, retromorphic changes), and the contact of mineral phases can also be observed. Pyroxene compositions are presented using the conventional alkaline pyroxene terminology diagram of Morimoto et al. (1988) (see 'c' sections of *Figures IV/4-8*). Garnet composition of eclogites (*Figure IV/8d*) is presented on the conventional garnet terminology diagram first introduced by Wright (1938). Our mineral chemical data, recalculated to 100 wt%, are published in the Electronic Supplementary Material (ESM1.xlsx and ESM2.xlsx files).

Table IV/3: Major element bulk composition of the 25 HP metaophiolite stone implements found in Hungary determined by PGAA, given in wt%

IV/3 táblázat: A Magyarországon fellelt 25 HP metaofiolit nyersanyagú kőeszköz PGAA-val meghatározott teljes kőzet főelem adatai wt%-ban megadva.

Inventory No.	Raw material class after D'Amico et al. 2003	SiO_2	TiO_2	Al_2O_3	Fe_2O_{3t}	MnO	MgO	CaO	Na_2O	K_2O	H_2O	SUM
66/1883.147	jadeitite	56.6	0.705	20.7	2.02	0.060	4.2	2.1	13.51	<QL	0.09	99.98
117/1884.130	jadeitite	54.6	0.970	20.1	2.32	0.077	6.1	1.9	13.83	<QL	0.12	99.98
141/1882.44	jadeitite	54.1	0.722	18.1	2.85	0.070	8.1	4.1	11.79	<QL	0.21	99.98
300/1876.264	jadeitite	59.5	0.531	15.9	3.27	0.077	3.3	4.9	12.59	<QL	0.04	100.00
55.1276	jadeitite	57.5	0.313	20.3	2.58	<QL	1.7	2.7	13.79	0.88	0.13	99.95
M6-2010-10B.6348.1	jadeitite	58.5	0.391	21.2	2.90	0.048	1.2	2.0	13.66	<QL	0.12	99.99
M6-2010-10B.6380.1	jadeitite	57.5	0.292	19.3	3.26	0.061	2.2	3.6	12.82	0.87	0.04	99.99
39/1903	Fe-jadeitite	58.0	1.073	18.0	6.57	0.055	<QL	2.5	13.80	<QL	0.05	100.00
300/1876.247	Fe-jadeitite	54.7	1.584	14.5	11.83	0.152	<QL	4.6	12.45	<QL	0.17	99.95
M6-2010-10B.792.2	Fe-jadeitite	56.6	0.976	19.2	5.67	0.092	0.9	2.9	13.38	0.01	0.25	99.98
3127 RRM	Fe-jadeitite	56.0	0.994	19.5	8.27	0.101	<QL	2.0	13.11	<QL	0.11	99.98
M6-TO.10/B.6320	mixed jade	55.5	0.505	17.7	6.14	0.132	3.1	3.4	12.81	<QL	0.03	99.28
N1/81-1938	mixed jade	57.0	0.470	19.2	5.58	0.120	<QL	4.3	13.18	<QL	0.16	99.97
Zirc 81/W2 5	mixed jade	57.2	0.431	17.6	5.31	0.138	2.7	4.0	11.80	0.51	0.31	99.97
N11/169-1938	Fe-mixed jade	53.8	2.148	14.0	12.3	0.300	<QL	4.5	12.81	<QL	0.18	99.99
99.3.1863	Fe-mixed jade	56.5	1.193	14.3	9.44	0.140	2.8	4.6	11.00	0.03	<QL	100.00
Olad-329	Fe-mixed jade	51.6	2.041	16.1	9.66	0.126	3.1	5.2	11.40	<QL	0.78	99.97
106/1882.58	omphacitite	49.5	0.601	15.0	7.20	0.152	8.4	9.2	7.15	0.21	2.32	99.74
N5/47-1939	glaucophane schist	48.9	1.422	15.6	8.35	0.130	8.5	7.4	8.17	0.23	0.88	99.51
66/1883.41	Mg-eclogite	49.5	1.476	15.3	7.95	0.179	6.6	10.9	6.33	0.14	1.67	99.91
66/1883.173	Mg-eclogite	50.6	1.071	15.9	10.67	0.240	6.7	4.0	10.75	<QL	0.07	99.98
177/1872.I/2.	Fe-eclogite	48.7	2.352	12.7	15.24	0.463	4.8	8.1	7.46	<QL	0.13	99.91
117/1884.213	Fe-eclogite	50.9	1.551	12.5	15.18	0.541	4.6	5.3	9.34	<QL	0.06	99.99
M6-2010-10B.3060.3	Fe-eclogite	44.8	3.464	11.4	19.35	0.459	5.3	8.6	6.25	<QL	0.37	99.99
Olad-321	Fe-eclogite	47.2	2.508	13.6	15.94	0.423	5.4	8.8	5.75	<QL	0.32	99.93
Quantification limit		2.5	0.050	2.0	0.20	0.020	0.7	0.5	0.05	0.01	0.02	

Jadeitite is the most abundant raw material among the investigated HP metaophiolite stone tools, 7 pieces were in the measured sample set. Mixed jades (with 3 pieces), Fe-jadeitites (with 4 pieces), Fe-mixed jades (with 3 pieces) and Fe-eclogite (with 4 pieces) proved to be relatively frequent raw materials among the present collection of Hungarian HP stone implements, while Mg-eclogite is less common (2 pieces). Omphacitite and Alpine-type glaucophane schist are the rarest identified raw materials among the Hungarian HP metaophiolite stone tools studied, represented by only 1 piece of each type.

In order to obtain a better comparison, the major element distribution is plotted after normalization to the Upper Continental Crust (UCC) composition published by McLennan (2001) (see 'd' sections of *Figures IV/4-8*). As it is comparable to the grey or green shaded fields in *Figures IV/4d-8d*, the major element compositions of the investigated metaophiolites are in good agreement with the published data of different HP metaophiolite types of Italian tools (D'Amico et al. 2003). This comparison allows us to classify the investigated Hungarian artefacts into the basic raw material classes. Variations in the concentrations of TiO_2 and CaO, and deviation of MgO measured in jadeitites (*Figure IV/4d*) can be explained with variable amounts of omphacite and titanite in the samples. Small deviations in concentrations of MnO and Fe_2O_3 in Fe-jadeitites (*Figure IV/5d*) can be observed. In agreement with the chemical characterization by D'Amico (2003), jadeitites have the lowest Fe_2O_3 and TiO_2 content and the highest (though varied) MgO content compared to the Fe-jadeitites (highest Fe_2O_3 and TiO_2, lowest MgO content), and mixed- and Fe-mixed-jadeitites (medium Fe_2O_3, TiO_2, MgO content). In all the observed 25 samples, the Na-pyroxenites show the highest concentrations of Na_2O.

The major element distribution of the glaucophane schist sample (*Figure IV/7d*) differs from the data of D'Amico et al. (2003) only in the Na_2O content. It is probable that sample N.5/47-1939 has higher alkaline pyroxene content than the reference sample. Thus, the glaucophane schist sample is rather similar to the omphacitite sample and the omphacitite reference published by D'Amico et al. (2003). It is worth noting that the reference distributions of glaucophane schist and omphacitite are very similar to each other (thick grey line and pale grey fields in *Figure IV/7d*) except for Na_2O. The Mg- and Fe-eclogite samples show some smaller differences in their major element chemistry (*Figure IV/8e*) than those expected on the basis of D'Amico et al. (2003). Though, Fe and Mn content are significantly lower in Mg-eclogites, those are not accompanied with significantly higher Mg content.

Jadeitite samples (7 pieces) are homogeneous rocks consisting predominantly of jadeite and variable amounts of omphacite. Zoned Na-pyroxene blasts are fine- to medium-grained, with

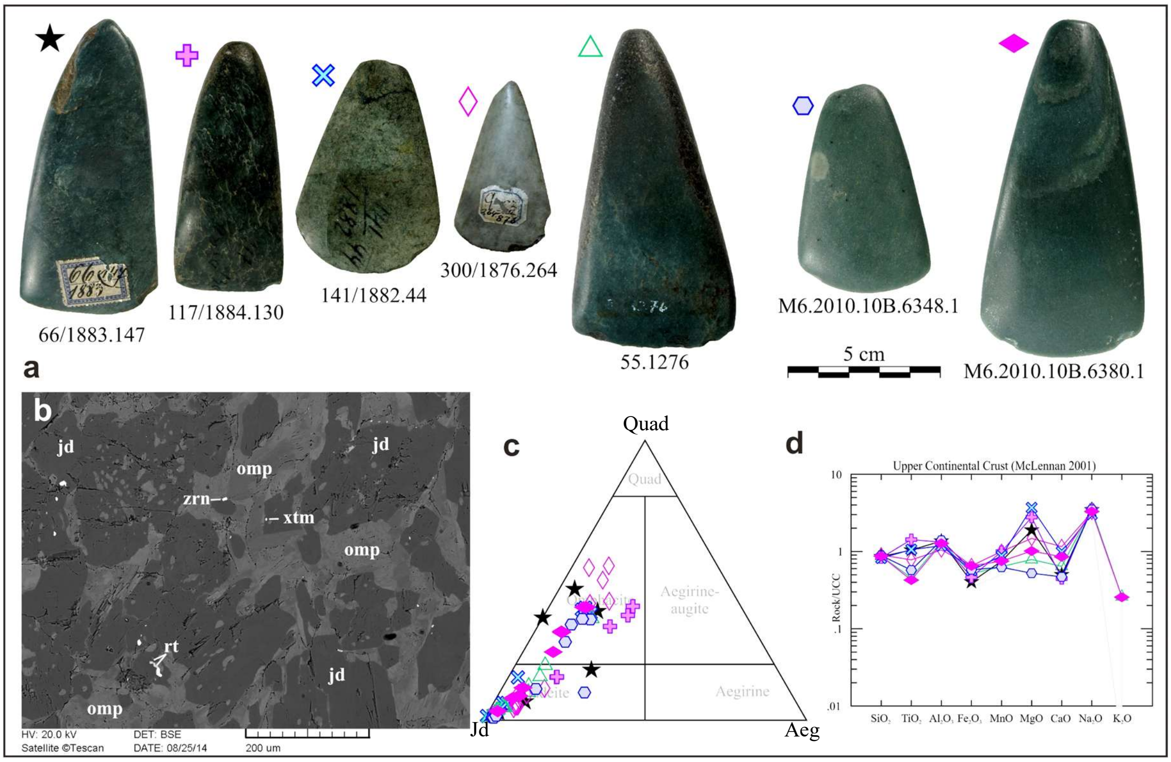


Figure IV/4. Jadeitite samples. (a) First four pieces are from the Ebenhöch collection, localities: 66/1883.147: Komáromszentpéter; 117/1884.130: Lekér; 141/1882.44: Garamkövesd; 300/1876.264: Bakonypéterd. Sample 55.1276 turned up in Bakony Mts. and belongs to the Miháldy collection. Samples labelled with M6.2010.10B are from the Alsónyék archaeological site. (b) Typical texture of jadeitites, their pyroxenes are showing more or less regular zonation. Backscattered electron image of sample M6.2010.10B.6348.1 from Alsónyék. (c) Pyroxene chemistry diagram. (d) Major elements distribution. Comparison data (grey field) are from D'Amico et al. (2003).

IV/4. ábra. Jadeitit minták. (a) Az első négy darab az Ebenhöch-gyűjteményből van, lelőhelyeik: 66/1883.147: Komáromszentpéter; 117/1884.130: Lekér; 141/1882.44: Garamkövesd; 300/1876.264: Bakonypéterd. Az 55.1276 minta a Bakony hegységből került elő és a Miháldy gyűjtemény része. Az M6.2010.10B jellel kezdődő kőeszközök az alsónyéki régészeti lelőhelyről kerültek elő. (b) Tipikus jadeitit szövet. A piroxének többé-kevésbé szabályosan zónásak. M6.2010.10B.6348.1 (Alsónyék) minta visszaszórt elektronkép. (c) Piroxén összetételi diagram. (d) Főelem-eloszlási diagram. Az összehasonlító adatok (szürke mező) D'Amico et al. 2003 alapján.

weakly variable dimensions in the same specimen, and form homoblastic texture. Jadeitites contain much more jadeite than omphacite and the Na-pyroxenes are generally zoned with jadeite core and omphacite rim (*Figure IV/4b-c*). In addition, omphacite crystallized in a later phase can be also present. In the core of the jadeite blasts small 'blebs' of exsolved omphacite can occur. Accessories are moderate (see mineral species in *Table IV/4*).

Fe-jadeitites (4 pieces), mixed jades (3 pieces) and Fe-mixed jades (3 pieces) contain coexisting jadeite and other Na-pyroxene(s) in variable amounts. Na-pyroxenes are frequently zoned, they have a jadeite core and usually a Fe-jadeite or omphacite rim. In the Fe-jadeitites the zoned Na-pyroxenes have a jadeite core and a Fe-jadeite rim (*Figure IV/5b*), omphacite is absent (*Figure IV/5c*). In sample M6-2010-10B.792.2 aegirine could be also detected.

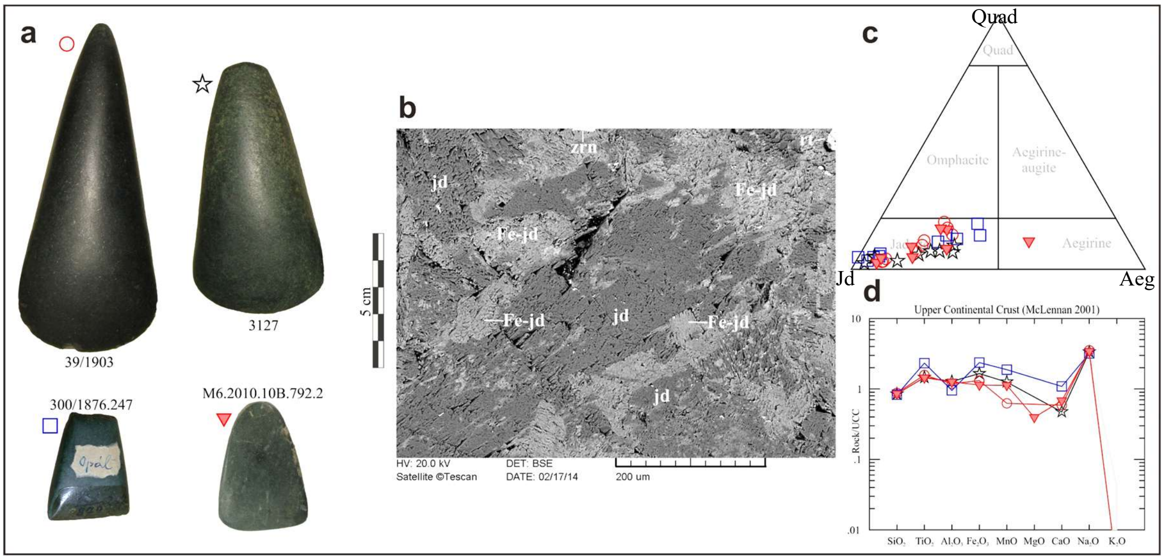


Figure IV/5. Fe-jadeitite samples. (a) First three pieces are from the Ebenhöch collection, localities: 39/1903: Iszkaszentgyörgy; 3127: Lábod; 300/1876.247: Almásneszmély. Sample M6.2010.10B.792.2 is from Alsónyék. (b) Typical texture of Fe-jadeitites, their pyroxenes are showing more or less regular zonation. Backscattered electron image of sample 39/1903. (c) Pyroxene chemistry diagram. (d) Major elements distribution. Comparison data (grey field) after D'Amico et al. (2003).

IV/5. ábra. Fe-jadeitit anyagú eszközök. (a) Egy darab az Ebenhöch-gyűjteményből van, i.sz. 300/1876.247, lelőhelye: Almásneszmély. A 39/1903 leltári számú darab lelőhelye Iszkaszentgyörgy; a 3127 sz. darab lelőhelye Lábod. Az M6.2010.10B.792.2 számú darab Alsónyékről származik. (b) A Fe-jadeititek tipikus szövete. A piroxének többé-kevésbé szabályosan zónásak. 39/1903 minta visszaszórt elektronkép. (c) Piroxén összetételi diagram. (d) Főelem-eloszlási diagram. Az összehasonlító adatok (szürke mező) D'Amico et al. 2003-as cikkéből származnak.

Mixed jades contain more jadeite than omphacite and the Na-pyroxenes have a jadeite core and an omphacite rim (the transition is sharp) (in sample M6-TO.10B.6320 Fe-jadeite was also detected) (*Figure IV/6b*). In Fe-mixed jades, the pyroxene composition varies among jadeite (core), omphacite, Fe-jadeite and aegirine-augite (rim) (*Figure IV/6b-c*). In the case of Fe-jadeitites, the average blast size is variable creating a moderately heteroblastic texture without foliation, but in the mixed and Fe-mixed jadeitites fine- to medium-grained homoblastic texture is usual with varied foliation. In one case (99.3.1863. from Hódmezővásárhely-Gorzsa), Fe-mixed jadeitite contains garnet (<5 wt%) with a composition similar to the studied eclogites (see comparable data in *Figure IV/8d*). These garnets are 200–250 µm sized, idioblastic blasts with jadeitite inclusions. In some cases (e.g. M6-2010-10B.792.2., n1/81-1938, Olad-329) diverse and significant amounts of accessories are present, sometimes filling the pores and forming skeletal crystals. Retromorphic overprint can be rarely observed in Fe-jadeitites and mixed jadeitites (in one sample of each group) and more frequently in Fe-mixed jadeitites (see the specific retromorphic mineral phases in *Table IV/4*).

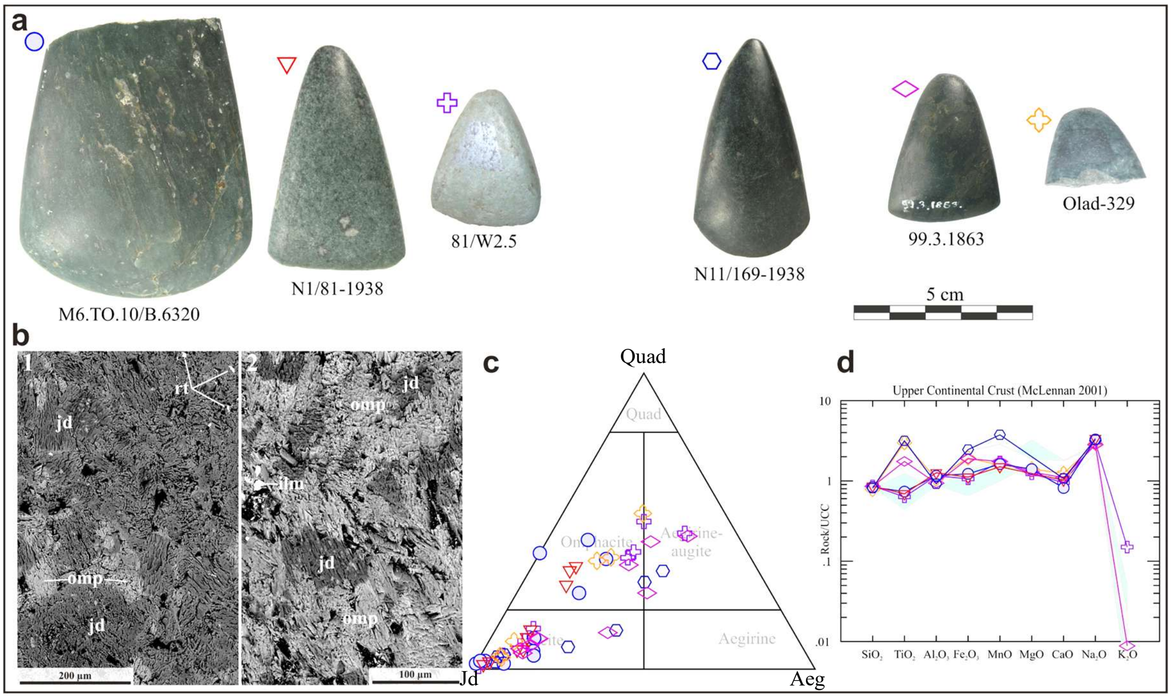


Figure IV/6. Mixed jadeitite and Fe-mixed jadeitite samples. (a) First three samples are mixed jadeitites, localities: M6.TO.10B.6320: Alsónyék; N1/81-1938: Zengővárkony; 81/W2.5: Zirc. Last three samples are Fe-mixed jadeitites, localities: N11/169-1938: Zengővárkony; 99.3.1863: Hódmezővásárhely-Gorzsa; Olad-329: Szombathely, Olad-plateau. (b) Typical texture of mixed jadeitite (1) (M6.2010.10B.6320, Alsónyék) and Fe-mixed jadeitite (2)(N11/169-1938 Zengővárkony). Pyroxenes are showing more or less regular zonation. (c) Pyroxene chemistry diagram. (d) Major elements distribution. Comparison data after D'Amico et al. (2003) (light grey field: Fe-mixed jades, light green field: mixed jades).

IV/6. ábra. Kevert jadeitit és Fe-kevert jadeitit anyagú eszközök. (a) Az első három eszköz anyaga kevert jadeitit, lelőhelyeik: M6.TO.10B.6320: Alsónyék; N1/81-1938: Zengővárkony; 81/W2.5: Zirc. Az utolsó három eszköz anyaga Fe kevert jadeitit, lelőhelyeik: N11/169-1938: Zengővárkony; 99.3.1863: Gorzsa; Olad-329: Szombathely, Olad-plató. (b) (b) A kevert jadeititek (1)(M6.2010.10B.6320, Alsónyék) és a Fe kevert jadeititek tipikus szövete (2)(N11/169-1938 Zengővárkony). A piroxének többé-kevésbé szabályosan zónásak. (c) Piroxén összetételi diagram. (d) Főelem-eloszlási diagram. Az összehasonlító adatok (világoszöld mező: kevert jadeititek, világosszürke mező: Fe kevert jadititek) D'Amico et al. 2003-as cikkéből származnak.

The sole omphacitite sample (106/1882.58) is strongly affected by retromorphic processes (see the specific retromorphic mineral phases in *Table IV/4*) which overprinted the original texture. It is difficult to determine the average grain size or the homogeneity of the texture. Predominant omphacite and subordinated jadeite blasts (*Figure IV/7c*) are usually not zoned but inhomogeneous in patches in many places (*Figure IV/7b1*).

Glaucophane schist (N5/47-1939), being a retromorphic rock which originally consisted of pyroxenes, contains glaucophane and much more omphacite than jadeite (*Figure IV/7b2*). Na-pyroxenes are inverse zoned with omphacite core and jadeite rim. The zonation can be regular or patchy (jadeite patches in omphacite crystals) (*Figure IV/7b2*). The blue glaucophane amphibole is a final retrograde rim around the Na-pyroxene blasts, usually accompanied by epidote and accessory minerals (see the specific retromorphic mineral phases in *Table IV/4*). Due to the retrograde foliation, monomineralic bands of glaucophane or epidote can be also observed.

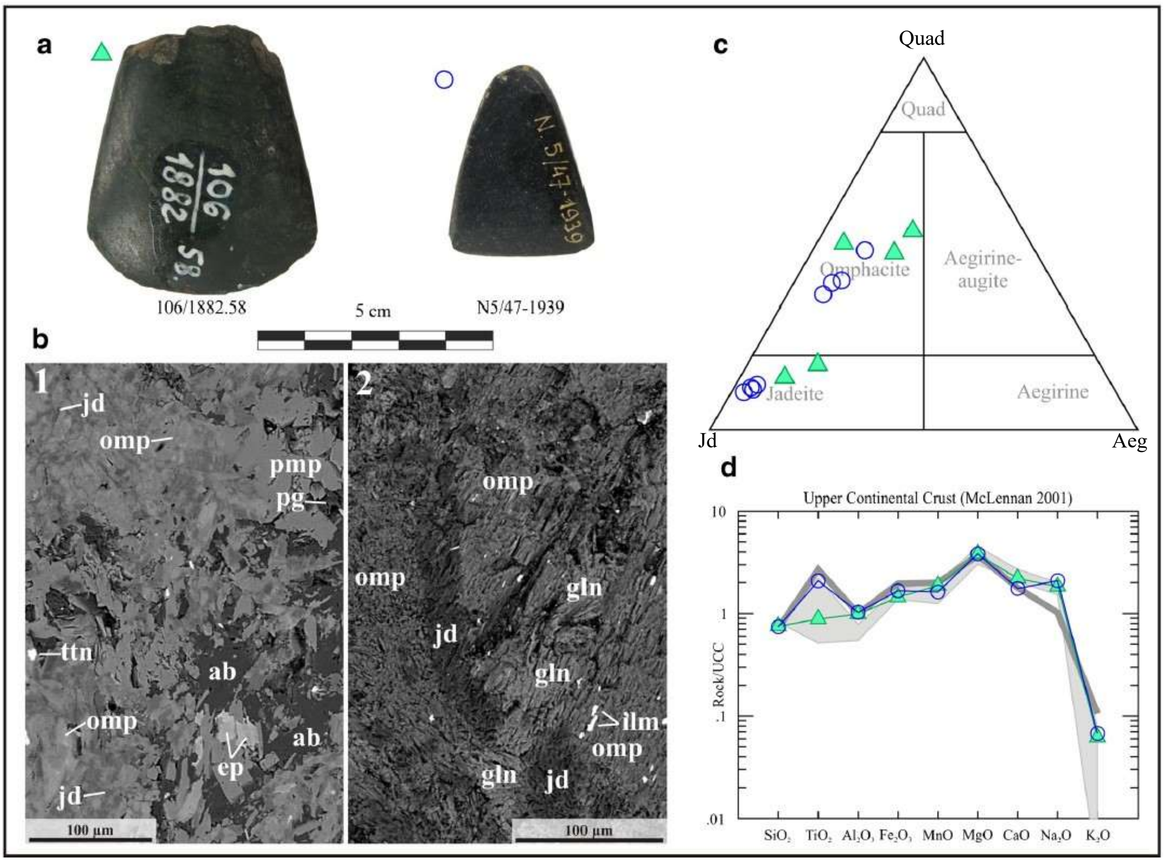


Figure IV/7. Omphacitite and glaucophane schist samples. (a) 106/1882.58: omphacitite sample from Mogyorós (todays Mogyorósbánya) (Ebenhöch collection). N5/47-1939: glaucophane schist sample from Zengővárkony archaeological site. (b) Backscattered electron images, (1) patchy texture of Na-pyroxenes in the sample 106/1882.58 and (2) reverse zonation of Na-pyroxenes in the sample N5/47-1939. (c) Pyroxene chemistry diagram. (d) Major elements distribution. Comparison data (grey field) after D'Amico et al. (2003) (grey field: omphacitite, thick grey line: glaucophane schist).

IV/7. ábra. Omfacitit és glaukofánpala anyagú kőeszközök. (a) 106/1882.58: omfacitit anyagú lőeszköz Mogyorós (ma Mogyorósbánya) lelőhelyről (Ebenhöch gyűjtemény). N5/47-1939: Glaukofánpala a zengővárkonyi régészeti lelőhelyről. (b) Visszaszórt elektronképek: (1) Na piroxének foltos szövete az omfacitit mintában (106/1882.58), (2) reverz zónás Na-piroxének a N5/47-1939 jelű mintában. (c) Piroxén összetételi diagram. (d) Főelem-eloszlási diagram. Az összehasonlító adatok D'Amico et al. 2003-as cikkéből származnak (szürke mező: omfacitit, vastag szürke vonal: glaukofánpala).

Eclogites (2+4 pieces) are heteroblastic rocks with variable mylonitic foliation, often highlighted by the preferential orientation of tiny Na-pyroxene crystals, garnet aggregates and accessory phases (see the specific mineral phases in *Table IV/4*). In Mg-eclogites, Na-pyroxenes form a fine-grained, strongly foliated matrix with idio-hipidioblastic (50–100 µm in sample 66/1883.41) or atoll-like structured (100–200 µm in sample 66/1883.173) garnet poikiloblasts.

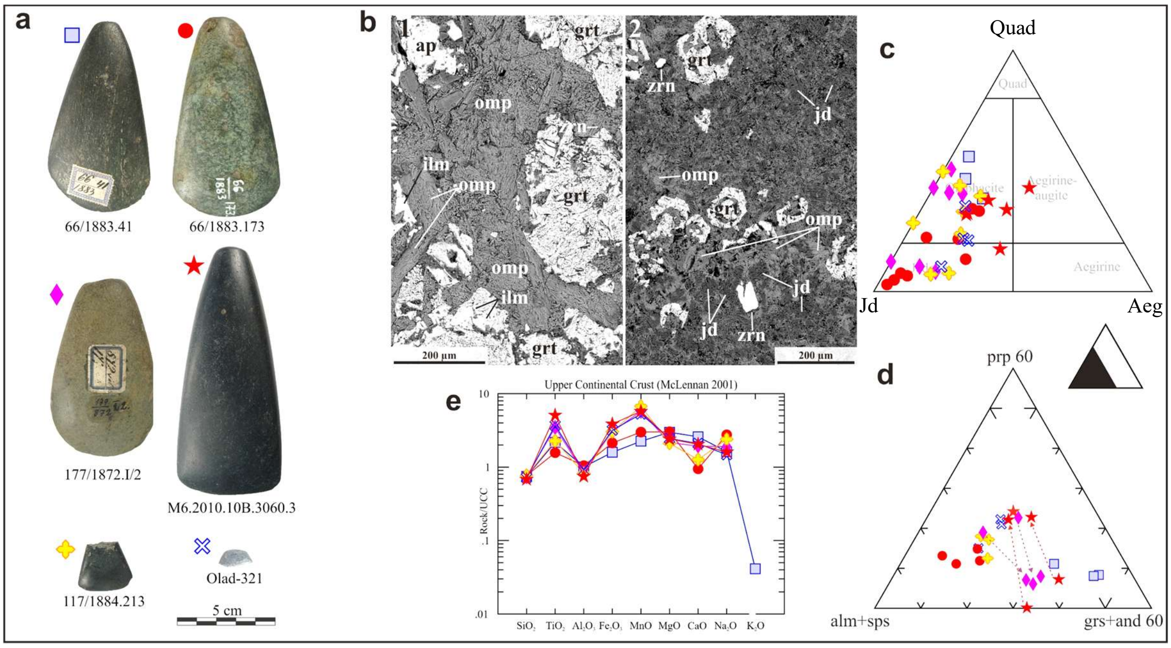


Figure IV/8. Eclogite samples. (a) First two samples (66/1883.41 and 66/1883.173) are Mg-eclogites, the other four samples are Fe-eclogites. Four pieces are from Ebenhöch collection, their localities: 66/1883.41: Farnad; 66/1883.173: Szőgyén; 177/1872.I/2: unknown; 117/1884.213: Vámosladány. Sample M6.2010.10B.3060.3 is from Alsónyék. Olad-321 was found at Szombathely, Olad-plateau. (b) Backscattered electron images, (1) texture of Fe-eclogite in sample Olad-321 (Szombathely) with omphacites as the only Na-pyroxene, (2) texture of Mg-eclogite in sample 66/1883.173 (Szőgyén) with atoll-garnet and zoned Na-pyroxene. (c) Pyroxene chemistry diagram. (d) Garnet chemistry diagram (arrows indicate the from-core-to-rim compositional change). (e) Major elements distribution. Comparison data after D'Amico et al. (2003) (gray field: Mg-eclogite, green field: Fe-eclogite).

IV/8. ábra. Eklogit anyagú kőeszközök. (a) A felső két kőeszköz (66/1882.41 és 66/1883.173) Mg-eklogit anyagú, az alsó négy kőeszköz (177/1872.I/2, 117/1884.213, M6.2010.10B3060.3 és Olad-321) Fe-eklogit. Négy darab az Ebenhöch-gyűjtemény része, lelőhelyeik: 66/1883.41: Farnád; 66/1883.173: Szőgyén; 177/1872.I/2: ismeretlen; 117/1884.213: Vámosladány. Az M6.2010.10B.3060.3 jelű kőeszköz az alsónyéki, míg az Olad-321 jelű a Szombathely, Olad-platón végzett régészeti feltárások során került elő. (b) Visszaszórt elektronképek: (1) Fe-eklogit szövete az Olad-321 mintában (Szombathely), amiben az omfacit az egyedüli Na piroxén. (2) Mg-eklogit szövet a 66/1883.173 (Szőgyén) mintában atoll gránáttal és zónás Na-piroxénnel. (c) Piroxén összetételi diagram. (d) Gránát összetételi diagram (a nyilak az összetétel változását mutatják a magtól a perem felé). (e) Főelem-eloszlási diagram. Az összehasonlító adatok D'Amico et al. 2003-as cikkéből származnak (szürke mező: Mg-eklogit, zöld mező: Fe-eklogit).

Mg-eclogites consist of omphacite and subordinate jadeite, but the two samples differ: sample 66/1883.173 has zoned Na-pyroxene crystals with jadeite core and omphacite rim (*Figure IV/8b2-8c*), while sample 66/1883.41 has homogeneous, fine-grained omphacitic pyroxenes. Garnet poikiloblasts are rather homogeneous and their composition values in Mg-eclogites (*Figure IV/8d*) plot to the almandine-spessartine corner of the triangle, being enriched in almandine/spessartine (Alm 43–75, Sps 0.8–4.1), with moderate grossular (Grs 10–50) and scarce pyrope (Prp 0–20). Accessories of Mg-eclogites are specified in *Table IV/4*.

Fe-eclogites consist of foliated, fine-grained Na-pyroxene matrix with idio-hipidioblastic (100–500 µm garnet poikiloblasts. Fe-eclogites contain omphacite (*Figure IV/8b1-8c*), in two samples (M6.2010.10B.3060.3, 177/1872.I.2) they are zoned (jadeite-rich core and omphacite-rich rim). There is no significant difference between the garnet compositions of the Mg- and the Fe-eclogite samples. Garnet composition values of Fe-eclogites (*Figure IV/8d*) plot to the almandine-spessartine corner of the triangle, being enriched in almandine/spessartine (Alm 39–70, Sps 0.6–27), with moderate grossular (Grs 15–40) and scarce pyrope (Prp 0–30). Though in two samples the garnets are moderately zoned, due to the analyses by non-destructive SEM-EDX, the results are relatively informative (elimination of the sample preparation and analysis on the original surface imply that we observe a naturally eroded surface which can provide fewer grains appropriate for the investigation than in a conventional thin section). In sample M6.2010.10B.3060.3 (marked with red stars and arrows in *Figure IV/8d*) the core of the garnet blasts is pyrope free while the rim has pyrope content. On the contrary, in sample 177/1872.I.2 (marked with lilac diamonds and arrows in *Figure IV/8d*) the core of the garnet blasts is enriched in pyrope compared to the rim. Accessories of Fe-eclogites are specified in *Table IV/4*.

To conclude, based on the results of SEM-EDX and PGAA analyses, the presently known Hungarian HP stone implements were divided by our data into 8 groups which are in very good agreement with data of D'Amico et al. (2003). Our results show that jade implements are more frequent than eclogites. The most common components are jadeite-Fe-jadeite and/or omphacite, these appear in variable proportions in both rock types. Accessory minerals (e.g. rutile, zircon, allanite) are generally present in large quantity, and eclogites contain large amounts of garnet.

IV/8. Discussion

In the last two years there was a significant growth in the number of recognized and investigated polished stone implements made of HP metaophiolite raw material in the Hungarian archaeological record. All of the 25 presently identified HP metaophiolite stone implements are presented with detailed description in this study. Compared to the situation in 2013 (three HP stone tools published in Szakmány et al. 2013), this significant increase is due to a systematic quest for greenstones and the applied non-destructive methods (PGAA and SEM-EDX on the original surface of the samples). These methods proved their effectiveness in identifying the raw material of stone implements and have the capability to provide good quality data for comparison with results in the international literature.

Table IV/4. Jade raw material types identified in the Hungarian archaeological record and their main distinctive characteristics

IV/4. táblázat: A magyarországi régészeti leletek között azonosított jadeitit nyersanyagtípusok és főbb jellemzőik.

Raw material class after D'Amico et al. (2003)	**Raw material class after Guistetto and Compagnoni (2014)**	**Samples**	**Major minerals**	**Pyroxene zoning**	**Accessories**	**Retromorphic minerals**	**Deformation**	**Dominant grain size (µm)**	**Fabric homogeneity**
Jadeitite	Jadeitite / Omphacite-jadeite pyroxenite	66/1883.147 117/1884.130 141/1882.44 300/1876.264 55.1276 M6.2010.10B.6348.1 M6.2010.10B.6380.1	Jd>>Omp	Jd core, Omp rim	Zrn, Rt, Ttn (Aln, Xtm, Mnz, Ilm, Ap)	Ab (in sample M6.2010.10B. 6348.1)	no	50-200	homoblastic
Fe-jadeitite	Jadeitite	39/1903 300/1876.247 M6.2010.10B.792.2 3127	Jd, Fe-Jd	Jd core, Fe-Jd rim	Zrn, Rt (Ttn, Aln, Ap, Ilm, Xtm, Mnz, Mag)	Ab, Ep (in M6.2010.10B. 792.2)	no	50-200 and 200-400	heteroblastic (homoblastic)
Mixed jades	Omphacite-jadeite pyroxenite	M6.TO.10/B.6320 N1/81-1938 81/W2.5	Jd>Omp	Jd core, Omp rim	Rt, Zrn, Aln (Ttn, Xtm, Mnz)	Ab, Ep (in N1/81-1938)	variable, strongly foliated (in M6.TO.10/B. 6320)	50-200	homoblastic
Fe-mixed jade	Omphacite-jadeite pyroxenite	N11/169-1938 Olad-329	Jd, Omp, Fe-Jd, Aeg-Aug	Jd core, Omp/Fe-Jd rim	Zrn, Rt, Ap, Aln, Ilm, Ttn	Chl (in Olad-329)	foliated (Olad-329)	50-200	homoblastic
	Garnet-omphacitite	99.3.1863	Jd, Omp, Fe-Jd, Aeg-Aug	Jd core, Omp/Fe-Jd rim	Grt, Zrn, Ap, Aln, Ilm/Rt	no	no	px 50-200 grt 200-250	homoblastic
Omphacitite	Jadeite-Omphacite pyroxenite	106/1882.58	Omp>Jd	rarely zoned	Ttn	Ab, Pg, Ep, Chl, Pmp	no	cannot be determined	cannot be determined
Glaucophane schist		N5/47-1939	Gln, Omp>>Jd	Omp core, Jd rim (regular or patchy)	Ilm, Ap, Ttn	Gln, Ep	foliated	<100	homoblastic

Table IV/4. – continued

IV/4. táblázat – folytatás

Raw material class after D'Amico et al. (2003)	**Raw material class after Guistetto and Compagnoni (2014)**	**Samples**	**Major minerals**	**Pyroxene zoning**	**Accessories**	**Retromorphic minerals**	**Deformation**	**Dominant grain size (µm)**	**Fabric homogeneity**
Mg-eclogite	Eclogite	66/1883.41 66/1883.173	Omp, (Jd), Grt	Jd core, Omp rim (in 66/ 1883.173)	Ttn, Ilm, Rt, Zrn	Ab, Pg, Ep (in 66/1883.41)	variable, strongly foliated (in 66/1883.41)	px<100 grt<200	heteroblastic
Fe-eclogite	Eclogite	177/1872.I/2 117/1884.213 M6.2010.10B.3060.3 Olad-321	Omp, Grt	Jd core, Omp rim (in M6.2010.10B .3060.3, 177/1872.I.2)	Ilm, Zrn, Rt, Aln, Ap	Bt, Ep (in Olad-321)	variable, weakly foliated (in M6.2010.10B. 2060.3)	px<200 grt 100-500	heteroblastic

See the abbreviations at the end of this work.

All of the 11 stone tools with known context found in Hungary are chronologically attributable to the Late Neolithic period, mostly to the Lengyel Culture and one piece, east of the river Tisza, to the contemporary Tisza Culture. The 14 stray finds are also connected with high probability to Late Neolithic localities on the basis of other proxies co-occurring in the archaeological record (e.g. characteristic potsherds collected in the same area). From the geographical point of view, almost all of them (except for one piece) are located on the western side of the Danube (Dunántúl or Transdanubia). The exceptional sample from the locality of Hódmezővásárhely-Gorzsa is in South-Eastern Hungary, in the eastern part of the Great Hungarian Plain (Tiszántúl or Trans-Tisza). The Danube is seen to be a very important boundary concerning the distribution of Neolithic stone implements in the Carpathian Basin (Szakmány 2009; Szakmány et al. 2011). According to the results of this former research, there is a significant difference in the Neolithic period between the stone tool raw material origins of three main regions: Transdanubia, Trans-Tisza and the Northern highlands. The polished stone tool raw material of these three major provinces are different in the predominant rock types, i.e. the Transdanubian and N-NE regions are dominated by basic-metabasic rocks (basalt, greenish schistose rocks: contact metabasite and greenschist, etc.) and metadolerite, while the Trans-Tisza region is dominated by hornfels, metadolerite and basalt (Szakmány 2009; Szakmány et al. 2011). However, it is worth mentioning that the over representation of the HP metaophiolite stone implements in Transdanubia can also be the result of the recent purposeful searching for samples in the Transdanubian archaeological collections.

An interesting question is the spreading and provenance of raw material of the HP metaophiolite stone tools. Based on the petrological and geochemical data, all the investigated 25 HP metaophiolite stone tools are made of HP-LT rocks with various compositions which imply the possibility of multiple raw material sources. HP-LT metaophiolite rocks are known from many regions in Europe, as was mentioned in the ‘Previous studies on HP greenstones’ section. Na-pyroxenite raw materials are found in the Western Alps and Voltri Massif, as well as on Syros and Tinos Islands (Cyclades, Greece). Based on the references (Castelli et al. 2002, Groppo & Castelli 2010, Angiboust et al. 2011, 2012, Compagnoni 2007, 2012, Dixon & Ridley 1987, Bröcker et al. 1993, Bröcker & Enders 1999, Bröcker & Keasling 2006, Bulle et al. 2010, Pétrequin et al. 2017b), it is our supposition that major element composition and mineral chemistry of the Na-pyroxenes are not characteristically different in the two Na-pyroxenite sources. The average mineralogical composition and the textural features are more typical for the particular jadeitite localities. Petrographic characteristics of the Western Alpine Na-pyroxenites (limited or no glaucophane content, moderate or no retrograde overprint on the texture) can be well compared with our observations on the artefacts found in Hungary. Based on field observations, Pétrequin and coauthors (2017b) could eliminate Tinos and Sifnos as provenance of the Na-pyroxenites applicable for manufacturing polished stone tools. According to the published petrographic and geochemical data (Pétrequin et al. 2017b) about the Syros jadeitite source, extended retrograde albitization, chloritization and formation of analcime are characteristic features. In addition, a small but significant amount of zircon, and titanite with white mica and rutile inclusions is also characteristic. Based on their comparative studies, Pétrequin et al. (2017b) concluded that the Syros jadeitite source and the production of tools on the island could be limited or negligible. In addition, their investigations proved that the few HP metaophiolite axes found in SE Europe (Romania, Bulgaria) are made from the W-Alpine raw material (Tsonchev 1946; Errera et al. 2006; Pétrequin et al. 2012b). Due to spectroradiometric analysis, the two European Na-pyroxenite sources can be differentiated with high probability (above 80%). Considering the differences in the mineralogy of the retrograde metamorphism and the statements of Pétrequin et al. (2017b) as well as the similarity to other tools already attributed (D’Amico et al. 2003), it is our suggestion that the raw materials of the Na-pyroxenite polished stone implements found in Hungary originated from the W-Alpine (Monviso or Voltri Massif) source.

Eclogite localities are more common in Europe than Na-pyroxenites. Pre-Alpine (mostly Variscan) eclogites are known from the Bohemian Massif, the Veporic Unit of the Western Carpathians, the Ligurian Alps, and the Rhodope Massif. The Alpine-type eclogites are distributed in the Western Alps, Turkey, the Aegean Islands (Syros, Sifnos, Tinos) and the Betic Cordillera. There is a fundamental difference in the mineralogical composition and the textural features of the Pre-Alpine and the Alpine-type eclogites. Variscan eclogites are MT-HT/HP metamorphites with related mineral assemblage (garnet enriched in pyrope component, pyroxene depleted in jadeite component, and often they have kyanite content) and expressed retrogressed characteristics due to the retrograde amphibolite facies recrystallization (e.g. pyroxene-feldspar symplectites after Na-pyroxenes, kelyphitic garnets). Alpine-type eclogites were formed at lower temperature metamorphism with related mineral assemblage (garnet depleted in pyrope component, pyroxene enriched in jadeite component) and often with moderate retrogression characteristics.

Based on the above discussed textural and mineralogical evidence, Pre-Alpine eclogites can be excluded as the raw materials for the HP metaophiolite polished stone tools found in Hungary. It is more probable that the Alpine-type eclogites with lower temperature mineral assemblage are the sources of the observed artifacts. the best fit with the mineralogical and textural features of the observed archaeological eclogite artefacts found in Hungary has been the Western Alpine sources (Monviso and Voltri Massif) due to the similar chemical composition of the Na-pyroxenes and garnets, and the zero to moderate retrograde metamorphic overprint. A similar peak phase assemblage but with a significant amount of glaucophane is typical at the Aegean Sea localities of eclogite. In addition, Na-pyroxenes of Syros eclogite contain more calcium (CaO>20 wt% on the basis of Fig. 16b in Okrusch & Bröcker 1990) than the Hungarian eclogite artefacts (CaO=0.83–14.54 wt%, see in the Electronic Supplementary Material, ESM1.xlsx file). (However, it is worth noting that the Syros source can contain glaucophane schists identical with the composition of the sole glaucophane schist sample, No. N5/47-1939 identified in this study.) In the case of the Na-pyroxenes of the Turkish eclogites (Davis & Whitney 2006) the decreased sodium content (Na_2O=5.44–7.49 wt%) also does not agree with that of the Hungarian archaeological eclogite finds (Na_2O= 6.34–15.29 wt%, see in the Electronic Supplementary Material, ESM1.xlsx file). The Betic Cordillera represents the farthest locality (more than 2000 kms) considered in this study and there is evidence of use of those eclogites as polished stone tool raw materials on a regional scale rather than in long-distance trade (e.g. Lozano et al. 2017). Furthermore, Domínguez-Bella et al. (2015) identified a polished green stone Neolithic axehead (from Aroche, Andalucía, SW Spain) as manufactured from jadeitite deriving from Monviso. This fact also decreases the importance of the Betic Cordilleran source in the long-distance trade network of Europe. In addition, presence of extended deformation of the texture and its coronatic feature (Puga et al. 1989, 2013) does not support the originating of the Hungarian archaeological eclogite objects from this far source.

Based on the above discussed evidence, it is our hypothesis that Na-pyroxenite and eclogite polished stone artefacts found in Hungary are most similar to the equivalent rocks of the Western Alpine HP-LT metaophiolite source. The idea of their deriving from the Monviso or Voltri Massif is also supported by the general opinion of the society of experts in petroarchaeology that the raw materials of the Western Alps played a predominant role in the production of the symbolic (and a moderate role in the production of the woodworking) green stone polished stone tool in the Neolithic long-distance trade network in Western, Southern and Central Europe (D'Amico et al. 2003, Pétrequin et al. 2011).

HP-LT metaophiolite rocks are characteristic of the Western-Alps and the Voltri Massif. The Alpine type HP-LT metaophiolites suitable for polished stone tool production can be found both in primary, secondary (Oligocene) and tertiary (recent) deposits in North-western-Italy. These latter were redeposited in the Quaternary period, and prehistoric people used them as a raw material source (D'Amico & Starnini 2006). Primary occurrences are in the eastern range of

Figure IV/9. Supposed source regions (A: Western-Alps; B: Voltri Massif; C: secondary/tertiary sources of redeposited gravels and pebbles in Oligocene Conglomerate series in the foothills of the North-Western-Apennines and in the recent alluvium in river valleys, e.g. Po, Curone and Staffora) of HP metaophiolite stone implements found in Hungary and in Hungarian museum collections for the neighboring area (marked with transparent ellipsoid)

IV/9. ábra. A magyarországi régészeti feltárások során, ill. a múzeumi gyűjteményekben talált HP metaofiolit anyagú kőeszközök feltételezett forrásrégiói (A: Nyugat-Alpok; B: Voltri Masszívum; C: Az Északnyugati Appenninek hegylábainál lerakódott Oligocén konglomerátumok (másodlagos) és ezek átmozgatott kavicsanyagából kialakult harmadlagos nyersanyag források, mint pl. a Po, Curone és Staffora folyók recens üledékei).

the Western Alps, from Monviso in Piedmont till the Aosta Valley, and in the Voltri Massif at the north-western end of Apennines (Monte Beigua, Liguria). Secondary raw material sources are at the nearby piedmonts of the Western Alps and Voltri Massif. Tertiary raw material sources can be found in recent sediments of the Staffora and Curone rivers (D'Amico & Starnini 2012, Giustetto et al. 2017), and at the upper Po-river, which originates from the Monviso region (Pétrequin et al. 2012a). They were formed during the Oligocene by sedimentation of eroded materials from the Western Alps and Voltri Massif. Differentiation of these types of Western Alpine sources is difficult. In our study we cannot solve the problem of deriving of the artefacts found in Hungary from the primary, secondary or tertiary locations. These sources could equally provide raw material for the stone tools observed in this study (*Figure IV/9*). The Alpine-type Na-pyroxenite (jadeitite) implements are widespread in Western Europe (to the west-northwest to the Alps, in United Kingdom, Denmark), but their penetration to the East is seemingly very low (D'Amico et al. 2003; Pétrequin et al. 2012a). Only some artefacts from Varna (Bulgaria) were known in the past, identified by means of spectroradiometry (Tsonchev 1946; Errera et al. 2006; Pétrequin et al. 2012b). Also, HP metaophiolite axe-heads were found in Croatia (Milošević 1999; Petrić 1995, 2004), in the Czech Republic (Schmidt and Štelcl 1971; Přichystal 2009; Přichystal et al. 2011), Romania (Pétrequin et al. 2017b) and two pieces in Slovakia (Hovorka et al. 1998, 2008; Pétrequin et al. 2011, 2012c). This paucity of finds can be affected by the incomplete and regionally focused research knowledge of the single countries. However, some geographic reasons can also be taken into account. This situation is partly due to natural down-the-line distribution pattern but also due to research aspects. This idea is also supported by the observation that the typical large sized artefacts are absent in Central and Eastern Europe. Medium to small sized stone implements are characteristic (max. 16–18 cm length in the Carpathian Basin).

IV/9. Conclusion

It was postulated in the first JADE program that Chalcolithic jadeitite stone implements and the earliest copper artefacts and gold finds were of complementary distribution. In the Carpathian Basin, however, all the HP metaophiolites of known archaeological context were found, so far, at the turn of the Late Neolithic and Early Copper Age, in the second half of the Vth Millennium (approx. 4800–4500 BC): in the Lengyel Culture and the Gorzsa group of the Tisza Culture (Visy ed. 2003; Diaconescu 2014; see *Table IV/2*). The really very early Copper Age gold horizon and the first bulky copper artefacts (tools, weapons) can be dated to a younger phase, typically to the Middle Copper Age (Virág 2003).

During our study, we basically applied the HP metaophiolite nomenclature of D’Amico et al. (2003). However, we also tried to simultaneously use the nomenclature of Giustetto and Compagnoni (2014) on the basis of the presence and ratios of the main mineral phases (i.e. jadeite, omphacite, garnet) (see in *Table IV/4*). At this state of the research it can be concluded that the two nomenclature systems cannot be perfectly correlated with each other.

Our results correspond well with results on HP metaophiolites of North-western Italy (D’Amico et al. 2003), obtained both on geological and archaeological samples (D’Amico 2012; D’Amico and Starnini 2012). It implies that the HP metaophiolite stone implements found in Hungary probably originated from the same raw material sources as the Italian (and other Western European) HP metaophiolite stone tools. According to the literature on the topic, these primary sources can be the metamorphic formations of Monviso in Piedmont or of the Voltri Massif in Liguria. Secondary occurrences of jades and eclogites are similarly present in the resedimented Oligocene conglomerates in the Quaternary alluvium of rivers Po, Staffora and Curone (D’Amico et al. 2003; D’Amico and Starnini 2006, 2012; Pétrequin et al. 2012a).

However, the petrological variability of HP metaophiolite implements found in Hungary highlights the possibility of multiple raw material sources.

Regarding the distance of the HP metaophiolite sources from the Carpathian Basin, the above-mentioned secondary sources can have some relevance. Based on the results of D'Amico and Starnini (2006) and D'Amico et al. (2013), a Northern Italian atelier-site, Rivanazzano (bank of river Staffora, South-Western-Lombardy/South-Eastern-Piedmonte border) seems to be an important and relevant source for Central and Eastern Europe. This site can be interpreted as a border region in the HP metaophiolite supply system. Firstly, Neolithic sites settled to the west of Rivanazzano show lithological parameters different from the Rivanazzano model, suggesting that those sites were supplied from other sources (Western-Alps). Secondly, to eastward from Rivanazzano (northeast to Lombardy and the Venetian region, southeast along the Emilia Region) Neolithic archaeological sites have polished stone implement collections with petrographic characteristics compatible with the Rivanazzano model. This eastward distribution of the HP metaophiolite raw materials thus supports the idea of the utilization of resedimented raw materials, i.e. the North-Western-Apenninian Oligocene conglomerates and their clastic deposits as sources of raw material. The investigation of the HP metaophiolite stone tool assemblage from two Italian Neolithic sites, San Lazzaro (D'Amico et al. 2013) and Castello di Annone (Giustetto et al. 2016), provided examples of supply from a Rivanazzano type source. Comparing our results with that of D'Amico et al. (2013) and Giustetto et al. (2016), a good agreement can be identified (especially concerning the mineral chemical data). To understand the importance of the role of Rivanazzano on a larger scale, i.e. in Central and Eastern Europe, investigation of the small sized adzes found in that region of Europe can be fundamental and perhaps decisive. Our further research and results can also provide new information on this aspect.

Though, the raw materials of the Hungarian artefacts are very similar to HP metaophiolite rocks of the Western Alps, the Voltri Massif and the northern piedmont of the Apennines (North-western Italy) (D'Amico et al. 2003; Pétrequin et al. 2012d), we do not make statements on the exact provenance. These three areas are rather large, are about 1000 km distant from the Carpathian Basin but practically in the same direction, and therefore from the aspect of prehistoric contacts they have the same significance.

As a final note, showing the direction of future research, D'Amico and Starnini (2012) proposed a more detailed distinction of lithotypes on the base of the textural details, alteration products and accessories. They also tested the differentiation of possible primary, secondary or even tertiary sources. Giustetto and Compagnoni (2014) call our attention to the more detailed mineral chemistry studies (of both Na-pyroxenes and garnets) suggesting using them as potential clues to determine the supply sources. These researches emphasize the role played by detailed petrographic investigation in the precise identification of HP metaophiolite polished stone tools and show a first step for future studies.

The authors declare that they have no conflict of interest.

Chapter V: Conclusion and summary

V/1. Problem & solution

Non-destructive or micro-invasive methods are crucial during the investigation of cultural heritage; however, the necessary instrumentation is hardly or not available in Hungary, especially from point of view (POV) of budgets of projects, which are running on these topics.

Our project was begun with gemstones inlaid in jewellery, and their special sample preparation method for SEM-EDX investigation (e.g. Horváth et al. 2013).

Later, this method was extended to polished stone tools, at first, to have more detailed information on three stone tools from Mihály- and Ebenhöch collections. Their unique, HP raw material was confirmed earlier with another method, PGAA (Friedel et al. 2008, Szakmány et al. 2011), however, further details were necessary to collect more specific data about texture and mineral chemistry. Since these three items are completely intact axes carved from HP metaophiolite, from a raw material group, which was unknown among Hungarian stone implements, there was no possibility to perform destructive investigations. Then, for these investigations, the original sample preparation method for jewellery was adapted to the new challenges, according to this list:

Revealing lot of useful data about these three items (Szakmány et al. 2013a-b) was the lead to extend the method to other stone tool raw material types, in fields of both metamorphic and volcanic rocks, like contact metabasite, nephrite, hornfels; basalt and foidite; however, detailed presentation of all investigated raw material types is not among the goals of this study, they can be found among the enlisted publications of the author.

V/2. Analytical methods

Due to the sensitive nature of the most investigated objects, main method was the SEM-EDX investigation combined with the original surface investigation method described in Chapter II; however, there were a few fractured axes where was possible to make polished thin sections. This was especially important during the demonstration of original surface investigation method, where results from polished thin sections were directly compared with results from the original surfaces of the exactly the same stone implements. An interlaboratory test was performed also during these comparisons, where the results from thin section were measured in another laboratory. Other methods were used during the investigation series:

- Two polarizers petrographic microscope for thin sections (Chapter II. only);
- PGAA for bulk rock chemistry;
- Magnetic susceptibility measurement to perform a very basic grouping on the investigated pieces;
- Stereomicroscope was used for choosing the areas to be investigated.

Main instrument during the investigations was the AMRAY 1830 SEM at the Department of Petrology and Geochemistry, Eötvös Loránd University, Budapest, Hungary. This SEM is equipped with a quite large sample chamber to have enough room for even a 30 cm long and even 5 cm thick stone implements. Detailed description of the instrument and the used method can be found in Chapter II. All measurement were standardized, the applied microanalytical standards are international standards with well-known compositions, their details can be found in the related chapters.

For SEM-EDX investigations, a special preparation and investigation method were used, their detailed presentation can be found in Chapter II. This method is the original surface investigation method, which allowed to investigate these objects without invasive sample preparation.

During this special preparation process, a layer of conductive carbon has to be applied on the surface of the objects to be measured. This layer can be easily removed immediately after the investigation (Chapter II.).

V/3. New results of this study

New results of this study are presented in short thesis points below.

Thesis 1:

Original surface investigation method requires a special sample preparation method to be a completely non-destructive investigation.

Original surface investigation method was developed for non-destructive investigation of cultural heritage artefacts, especially with geological origin, like gemstones and stone implements with well-polished surfaces. This method allows to investigate these objects without any invasive preparation process, like cutting, mounting, grinding and polishing which are the essential parts of the normal petrographic or metallographic sample preparation methods.

Steps of sample preparation process for stone implement investigations:

- Step 0: Though it is not the part of “real” sample preparation, it is a crucial one: prior to any other preparation step, it is essential to decide the final setup of the object during the investigation. For this, it is necessary to make trials on the SEMs sample holder to reveal the suitable surfaces for EDX measurements. Important criteria during this test:
    - The investigated item has to be in stable position;
    - The investigated surface has to be perpendicular to the e^- beam;
    - Ideal working distance must be achieved.
- Step 1: If all the above-mentioned criteria are fulfilled, select an area on the chosen surface to investigate. It is recommended to use stereomicroscope for the best results.
- Step 2: Cover the surface of the object with aluminium foil, except the area which was chosen for investigation. Another working method is to cut out the aluminium foil at the desired location prior the carbon coating.
- Step 3: Perform a carbon coating process on the object. Proper positioning of the object is very important because carbon coating is a “line of sight” process, so area to be coated has to be positioned towards the source of carbon.
- Step 4: After the carbon coating, aluminium foil has to be left on the object to be investigated, because this will be the conductive media to make possible the investigation.

After these steps, the investigation can be performed with the setup of the object defined during the step 0. After the investigations, carbon layer can be removed easily with a soft cloth, a small amount of organic solvent, or water and a gentle rubbing of coated surfaces. For the best results, it is recommended to perform this step immediately after the investigation.

Thesis 2:

Usability of chemical and textural results of original surface investigation method have been proved by a test series performed on stone implement samples were investigated by destructive and non-destructive ways.

This method originally was developed to investigate inlaid gemstones, and later was adapted for non-destructive testing of the two identified HP metaophiolite polished stone axes from Bakony Mts, and a third one from Almásneszmély, Hungary. After the success of first trial, a question was arisen: is this method good for other raw material types also? As a kind of good luck, a group of stone implements from Diósviszló (Baranya County, Southern Hungary) were allowed to be cut for thin section showed up at the very same time. During the testing of method, this set of stone implements was extended with two other stone tools. These two stone implements already had polished thin sections from earlier investigations. One of them, from Veszprém-Kádárta, was investigated by our lab (Oláh et al. 2012), other one is from Balatonőszöd, and it was investigated by the lab of Geological and Geochemical Institute of Hungarian Academy of Sciences (Péterdi 2011, Horváth T. & Péterdi 2012) made us to perform an interlaboratory comparison also. During this test series, it is turned out the original surface investigation methods is working well from POV of both imaging and mineral chemistry. BSE images are able to reveal the basic texture of rocks, zoning of individual minerals and chemical composition of most rock forming minerals, including feldspars, amphiboles, pyroxenes, epidote, muscovite, opaque minerals, like ilmenite and other accessories, e.g. zircon, monazite and apatite. Based on the results discussed in Chapter II. in most cases mineral compositions from the original surfaces are very similar to their thin section counterpart. This determination is valid in the case of interlaboratory test also. Practically it means that stone implements with raw materials built up these stable phases are determinable with this method.

Thesis 3:

Limitations of original surface investigation method were determined by the very same test series.

During the comparison tests, some limitations of this method were revealed also from both imaging and chemical measurement POV-s. On roughly polished specimens, mineral zoning may not observable (however it is measurable by mineral chemistry). Other problem can be the alteration of some minerals, like sericitization, however it can be solved with use of higher magnification during the investigation.

Phase alteration affects the original surface investigation method much deeper: while cutting of a rock sample with weathered surfaces will reveal the intact core of the specimen, a stone tool with non-stable phases on its surfaces can cause confusion during the evaluation of results and it may lead to false interpretation. Fortunately, there is not much mineral phases tends to be disappeared during the burial time, at least in stone implements. Most affected phases are foids, like analcite, nepheline and sodalite; and the volcanic glass. All of them can be altered to clay minerals during the few thousand years of burial in the soil makes the identification of raw material impossible by the original surface method.

This kind of alteration is affecting the texture of the original surface of these rocks also; disappeared phases are leaving holes, pits on the surfaces, and most of the filled up with clay minerals. Large amount of clay minerals on the surface is the only evident that the results are not suitable to step forward. In these cases, application of destructive methods is cannot be omitted if it is possible.

Another limitation of this method is a consequence of the lack of the sample preparation. Unpolished surfaces are affecting both the imaging – where the unevenness of the surface may mask of the chemical differences inside the minerals – and the chemical measurements also. During microanalysis, grain surfaces may not horizontal perfectly and their positions can change one-by-one, so results measured in this way may not suitable for sophistic geochemical calculations, like thermobarometry or age determination.

Thesis 4:

Original surface investigation method is working on inlaid gemstones also.

From the other hand, this method is able to provide data on inlaid gemstones where the most basic and traditional gemmological investigation method, refractometry fails due to the lack of direct connection between the inlaid gemstone and the refractometer. Sample preparation is very similar to the stone implements' preparation, however there are a few differences. First thing is that the investigation of inlaid gems requires a much more precise positioning, because some artefacts has inlaid gemstones on more than one surfaces (e.g. a ring or a bracelet). In these cases, objects have to be tilted, rotated and replaced during the investigation to check all the inlayed gems.

Another important difference is the covering process: The whole item must be covered carefully to avoid the contamination of the metal framework of the inlaid gemstones, and aluminium foil must be punched through only over the gemstones to be investigated. Other difference that the covering foil better be removed after the carbon coating, as the metal framework is conductive, and maybe it has to be investigated also. Last but not least, removing the carbon layer has to be performed in the gentlest way, under stereomicroscope, with use of organic solvents like alcohol. Fortunately, very smooth, well-polished surfaces of gemstones make the removing process easier.

As it can be seen below, the preparation steps are very similar for the gemstones than the stone implements:

- Important criteria are the same:
    - The investigated item has to be in stable position. If one items needs to be investigated in different positions, all positions have to be planned prior the investigation;
    - All investigated surfaces have to be perpendicular to the e^- beam;
    - Ideal working distance must be achieved for all positions.
- Step 1: If all the above-mentioned criteria are fulfilled, select the inlaid gemstones to be investigated. In case of small jewellery, may all inlaid stones can be investigated in one setup. If necessary, multiple positions have to be determined prior the investigation. For gem selecting it is recommended to use stereomicroscope.
- Step 2: Cover the surface of the object with aluminium foil, and cut out the foil over the gemstones to be investigated prior the carbon coating.
- Step 3: Perform a carbon coating process on the object. Proper positioning of the object is very important because carbon coating is a “line of sight” process, so area to be coated has to be positioned towards the source of carbon.
- Step 4: After the carbon coating, aluminium foil has to be removed from the item, because metal framework will be the conductive media in this case. Removing the foil is allowing the investigation of the metal part of the jewellery also, so it is the better option in this case.
- Step 5: Put conductive tape on to the gemstones to connect the carbon layer to the metal framework of the jewellery. This step is necessary for avoid the charging during the investigation.

Gemstones have a large advantage over the polished stone implements: their surface is completely plane, and it has much better quality as most of them had been polished until their surface are shining like a mirror. That makes them better subject of investigation, since their surface is met the requirements of microanalyses. Other advantage of gemstones is the stability of these minerals: in general, hard and stable stones were chosen for gems – beyond their beautiful appearance of course.

Gemstones frequently have inclusions on their surface. This method allows the investigation of inclusion assemblages uncovered during the polishing of the gemstones, from point of view of both chemical composition and texture. These information with the chemical composition of gemstones may lead to the determination of the source area of the gemstone, and may help to reveal commercial connections between the source area and the finding area of the investigated item.

Thesis 5:

Original surface investigation method was a powerful tool to prove that stone tool carved from HP metaophiolite raw material are present in Hungary in a relatively large number.

Investigation of stone implements is a current topic all over Europe, to uncover the connection among the ancient people. High pressure metaophiolites, like jadeitites, are not widespread raw material, and this makes them a perfect tool to track down commercial connections and routes across over the prehistoric Europe.

During our work on these stone implements, an interesting difference from Western Europe attracted our attention: the low penetrations of HP stone implements towards East. Beside the few artefacts from Varna, they were practically unknown for a long time at the eastern region of Europe, including the Carpathian Basin and its environs. Altogether a few pieces were known from Croatia (Milošević 1999; Petrić 1995, 2004), in the Czech Republic (Schmidt and Štelcl 1971; Přichystal 2009; Přichystal et al. 2011) and two pieces from Slovakia (Hovorka et al. 1998, 2008; Pétrequin et al. 2011, 2012c). These numbers were increased during this work to 25 proven HP artefacts finds from the Carpathian Basin, with a very wide range covering practically the whole Transdanubian region incorporated an area located North from Danube River in today's Slovakia; and appears also in Eastern Hungary with a single location in Hódmezővásárhely-Gorzsa (*Figure V/3*).

Before 2008 HP metaophiolite raw material there were practically unknown among the stone implements found in Hungary. Friedel and colleagues (2008) mentioned this raw material type among the pieces of Ebenhöch collection without any detail, just mentioning that the group was determined based on PGAA analysis and magnetic susceptibility measurements, and other (destructive) investigations were not allowed since the tools were completely intact. The endeavour to step forward and collect more (textural and mineral-chemical) details about these items without involving destructive analytical methods was led to the development of original surface method. All the first three stone implements investigated by the original surface method was HP metaophiolite and was published by Szakmány and colleagues (2013). During the next few years, collection of HP metaophiolite stone implements was grown from 3 pieces to 13 in the first step (Bendő et al. 2014), and later to 25 (Bendő et al. 2018). Since the first tree pieces were all stray finds, during the next years, it turned out that some of the archaeological excavations uncovered HP metaophiolite stone implements also. According to the actual situation, there are 14 stray finds among the Hungarian HP metaophiolite tools, and 11 pieces were found during archaeological excavations from different localities (Figure V/3):

- Alsónyék: 5 pieces;
- Zengővárkony: 3 pieces;
- Szombathely-Olad: 2 pieces;
- Hódmezővásárhely-Gorzsa: 1 piece

The first three localities are belonging to the Lengyel culture which was widespread in Transdanubia, while Hódmezővásárhely-Gorzsa is belonging to the Tisza culture which was a contemporary culture with lot of commercial connections with the Lengyel culture.

Another interesting difference from the Western European findings that, the really large sized artefacts (up to 46 cm), which are characteristic for there, are completely missing from the above-mentioned artefact assem-blages, where small and medium sized pieces can be found with a maximum length of 16-18 cm (*Figure V/1*).

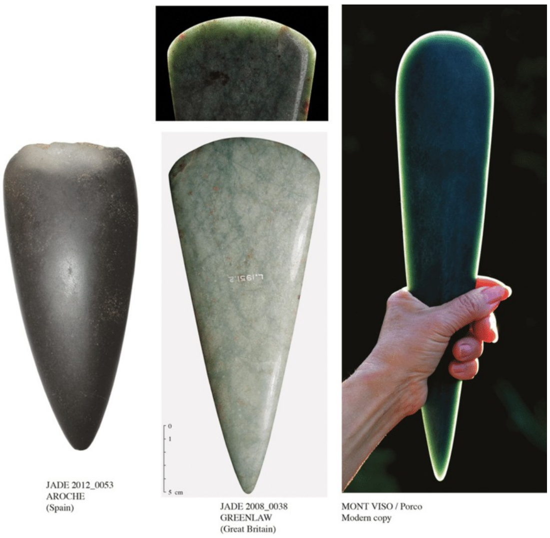


Figure V/1. Large sized jadeitite implements and a modern copy. Pétrequin et al. 2017a.

V/1. ábra. Nagyméretű jadeitit kőeszközök és egy modern másolat. Pétrequin et al. 2017a.

Thesis 6:

Based on the textural and mineral chemical results acquired by the original surface investigation method from HP metaophiolite stone implements, it has been proven that multiple HP metaophiolite types are represented among the Hungarian stone implements.

For grouping of raw materials, classification was presented in D’Amico et al. 2003 was used in this work also. Based on textural and mineral chemistry data by SEM-EDX, and bulk chemistry data by PGAA, five groups were distinguished: jadeitites, mixed jadeitites, Fe-jadeitites, omphacite/glaucophane schist and eclogite (*Table V/1*).

Table V/1: Grouping of the investigated 25 HP metaophiolite stone tools identified in the Hungarian archaeological record based on their texture, mineral composition and bulk rock chemistry information.

V/1 táblázat: A Magyarországon azonosított és megvizsgált 25 HP metaofiolit nyersanyagú kőeszköz csoportosítása a szöveti jellegeik, ásványos összetételük és a teljeskőzet összetételük alapján.

#	Group	Short description of group	Inventory number of related stone tools	Localities	Context
1	**Jadeitite**	Contains much more jadeite than omphacite and/or Fe-jadeite. Na-pyroxenes are generally zoned, they have large jadeite core and thin omphacite rim. Accessory minerals are zircon, allanite, titanite and xenotim. Texture can be slightly oriented.	66/1883.147	Szentpéter (Svaty Peter, SK)	Stray
2			117/1884.130	Lekér (Hronovce? SK)	Stray
3			141/1882.44	Kövesd (Kamenica nad Hronom, SK)	Stray
4			300/1876.264	Bakonypéterd	Stray
5			55.1276	Bakony	Stray
6			M6.2010.10B.6348.1	Alsónyék	Lengyel culture, grave
7			M6.2010.10B.6380.1	Alsónyék	Lengyel culture, grave
8	**Fe-jadeitite**	Contains zoned Na-pyroxenes, they have jadeite core and Fe-jadeite rim. Omphacite and aegirine-augite are missing. Accessory minerals are zircon, rutile, titanite, allanite, ilmenite, xenotime and monazite. Texture can be slightly foliated.	39/1903	Iszkaszentgyörgy	Stray
9			3127	Lábod	Stray
10			300/1876.247	Almásneszmély	Stray
11			M6.2010.10B.792.2	Alsónyék	Lengyel culture, grave
12	**Mixed jadeitite and iron mixed jadeitite**	Contains zoned Na-pyroxenes, they have jadeite core and Fe-jadeite or omphacite or aegirine-augite rim. Accessory minerals are zircon, allanite, rutile, apatite, ilmenite and titanite. Chlorite can be found as retromorphic phase. Texture is homogeneous in general.	M6.TO.10/B.6320	Alsónyék	Lengyel culture, grave
13			N1/81-1938	Zengővárkony	Lengyel culture, grave
14			81/W2.5	Zirc	Field survey
15			N11/169-1938	Zengővárkony	Lengyel culture, grave
16			99.3.1863	Hódmezővásárhely-Gorzsa	Tisza culture, settlement
17			Olad-329	Szombathely, Olad	Lengyel culture, settlement

Table V/1 – continued

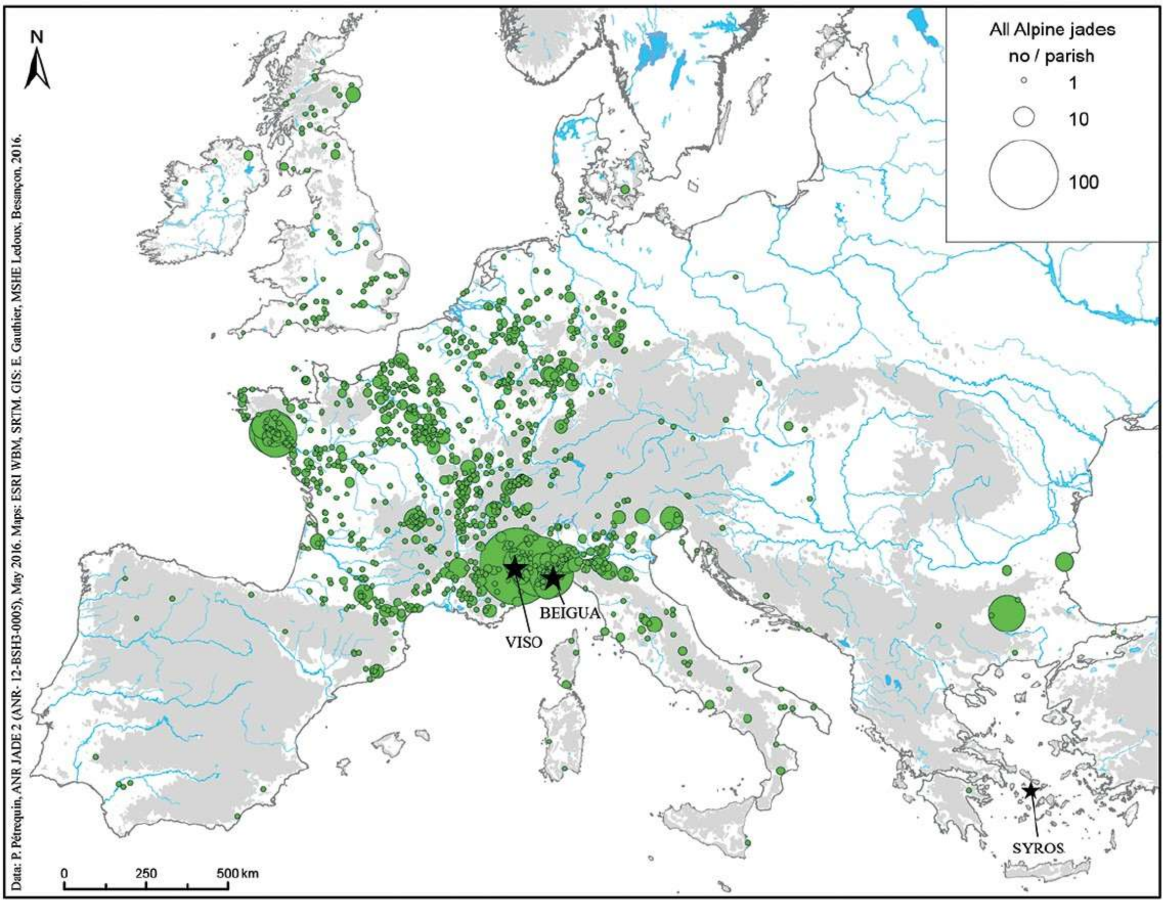
V/1 táblázat – folytatás

#	Group	Short description of group	Inventory number of related stone tools	Localities	Context
18	**Omphacite/ glaucophane schist**	Contains zoned Na-pyroxenes with omphacite core, and jadeite rim. Accessory minerals are ilmenite, apatite, titanite. According to the texture, glaucophane was formed in the latest, retrograde stage of metamorphism. Slightly foliated/oriented texture.	106/1882.58	Mogyoród? Mogyorós?	Stray
19			N5/47-1939	Zengővárkony	Lengyel culture, grave
20	**Eclogite**	Contains high amount of garnets in addition to Na-pyroxenes. Omphacites seem to be homogenous, but in according to the data their core is slightly enriched in jadeite. Accessory minerals are ilmenite, zircon, apatite and rutile. Retromorphic phase (epidote) occurs rarely. Garnets are slightly zoned, but this zonation is invisible on the rough surfaces. They have foliated/oriented texture.	66/1883.41	Farnád (Farna, SK)	Stray
21			66/1883.173	Szőgyén (Svodín, SK)	Stray
22			177/1872.I/2	Unknown (Vét?)	Stray
23			M6.2010.10B.3060.3	Alsónyék	Lengyel culture, grave
24			117/1884.213	Vámosladány (Mýtne Ludany, SK)	Stray
25			Olad-321	Szombathely, Olad	Lengyel culture, settlement

Thesis 7:

Based on the previously presented data, the origin of the HP metaophiolite polished stone artefacts found in Hungary is most likely the Western Alpine HP-LT metaophiolite source.

Products of this source were widely sought-after stone tools in the Neolithic Europe with a long-distance trade network from the Western Alps to Scotland, to Scandinavian peninsula, to Iberian Peninsula and towards East, to the nowadays Bulgaria (*Figure V/2*) (Pétrequin et al. 2011). Their origin from Monviso or Voltri Massif is a widely proven fact by the group of experts are working on this topic since a long time (JADE & JADE 2 projects). According to their results these raw materials of the Western Alps were used as very important symbolic items (D'Amico et al. 2003; Pétrequin et al. 2011). This kind of HP-LT metaophiolitic rocks are characteristic rocks of the Western Alps, where they can be found from Aosta valley area at



Data: P. Pétrequin, ANR JADE 2 (ANR- 12-BSH3-0005), May 2016. Maps: ESRI WBM, SRTM. GIS: E. Gauthier, MSHE Ledoux, Besançon, 2016.

Figure V/2. Alpine jades in Europe, 6th-4th millennia BC. Axeheads longer than 13.5 cm. Pétrequin et al., 2017a.

V/2. ábra. Alpi jadeitit anyagú kőeszközök Európában, az i. e. 6. – 4. évezredben. Csak a 13.5 cm-nél nagyobb méretű eszközök vannak feltüntetve. Pétrequin et al., 2017a.

North till Monviso at South and in the Voltri Massif at the north-western end of Apennines (Monte Beigua, Liguria) (Figure V/3).

Figure V/3. Map of provenance and locality range in Carpathian Basin based on this work.

Possible provenances of HP raw materials are marked with different colours:
Western Alps, Voltri Massif, secondary/tertiary deposits
Most important localities of artefacts:
- Transdanubian region with Southern Slovakia (all investigated collections and archaeological localities) covered with a green area, except:
- Hódmezővásárhely-Gorzsa – the single point in Southeastern Hungary.

V/3. ábra. A forrásterületek és a Kárpát-medencében található lelőhelyek térképe.

A különböző forrásterületek különböző színekkel vannak jelölve:
Nyugati Alpok, Voltri Masszívum, másodlagos/harmadlagos üledékek
A kőeszközök legfontosabb lelőhely területei:
- Dunántúl és Dél-Szlovákia zölddel lefedett területe (minden megvizsgált gyűjtemény és régészeti lelőhely), kivéve:
- Hódmezővásárhely-Gorzsa – az egyetlen lelőhelye Délkelet-Magyarországon.

Map source / Térkép forrása:
http://upload.wikimedia.org/wikipedia/commons/7/79/Europe_relief_laea_location_map.jpg

The other possible provenances are secondary and tertiary raw material sources. Secondary sources are conglomerates which are positioned at the piedmonts of the Western Alps and Voltri Massif (D'Amico and Starnini 2006) and deposited during the Oligocene epoch. These Oligocene conglomerate deposits resedimented after the last Ice Age into tertiary raw material sources can be found in recent conglomerates of the Staffora and Curone rivers in area of NW Apennines (D'Amico and Starnini 2012). Sediments of upper Po River also contains this kind of HP metaophiolitic rocks, which most probably were originated from the Monviso area (Pétrequin et al. 2012d) (Figure V/2).

Differentiation of these Western Alpine sources is difficult, and exact source determination of the investigated stone implements exceeds the aims of this work, however, their variable materials and compositions suggest that, they are not originated from a single source; the most probable scenario is that they were transported from different areas of Western Alps and or Voltri Massif.

V/4. Conclusion

During the two years, when the investigations of these artefacts were performed, number of identified HP metaophiolite stone implements was grown from 3 to 25 pieces. In our first article about this subject (Szakmány et al. 2013) we gave detailed description about three axe heads, while in this work 25 pieces of HP metaophiolite stone implements are presented divided into groups according to their rock type, and all groups are introduced with detailed description of main and accessory minerals, textural characteristics, and phases alterations if they were present. This significant increment was the result of systematic searching for greenstone artefacts in different collections (mainly in museums, however one HP metaophiolite tool was identified in a private collection also) and application of non-destructive analysis methods (PGAA and original surface method presented in this work) on artefacts which are not allowed to be a subject of destructive analysis. These methods proved their applicability to identify the raw materials of different stone artefacts, and proficiency to provide good quality data for comparison with data in the international literature. Based on the results, the origin of this raw material type is the Western Alps and/or the Voltri Massif, and/or secondary/tertiary sources sedimented from the erosion of the above-mentioned primary locations. Exact locations of these raw materials were not determined since all the above-mentioned locations are close to each other in the same direction and distance from Carpathian Basin, which means that practically they have the same significance from POV of contacts among the folks of prehistoric Europe.

With this work, proven range of HP metaophiolite stone implements now is covering the Transdanubian region, and one piece appears at Eastern Hungary also (*Figure V/3*). For the different distribution, there was a widespread explanation, that the jadeitite and the copper and gold items were in complementary distribution in Europe (Klassen et al. 2012) (*Figure V/4*), however, according to the Hungarian archaeological record, they did not appear in the same archaeological periods: all the HP metaophiolites from known archaeological context are belonging to the Late Neolithic and Early Copper Age Lengyel Culture and Tisza Culture which were flourished in the second half of the Vth Millennium (approx. 4800–4500 BC) (Visy 2003; Diaconescu 2014); while the very early Copper Age first gold and copper artefacts can be dated to the younger Middle Copper Age (Virág 2003).

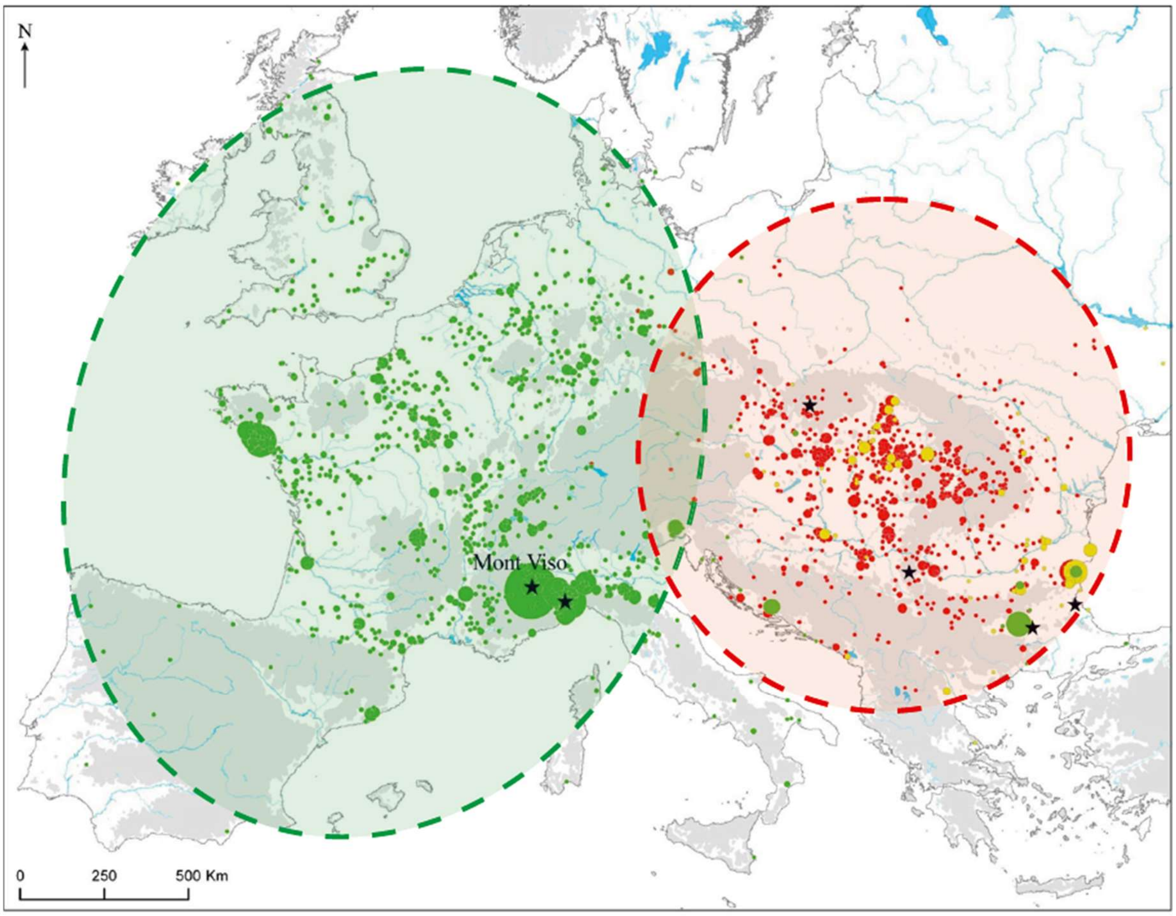


Figure V/4. Distribution of alpine jades and early metal (gold and copper) artefacts in Europe, 6th – 4th millenia BC. (Modified after Klassen et al. 2012).

V/4. ábra. Az alpi jadeitit nyersanyagú kőeszközök és korai fémtárgyak (arany és réz) területi eloszlása Európában az i. e. 6. – 4. évezredben (Klassen et al. 2012 alapján módosítva.)

V/5. Other results with using the original surface investigation method

Based on results about HP metaophiolite stone implements, our research was extended to stone implements made of nephrite, serpentinite and hornfels raw materials. However, these researches are not finished yet, some important articles and conference papers were published. Some important results are listed below, along with the results of the inlaid gemstones.

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V/7. Abbreviations

ab – albite, aeg-au – aegirine-augite, aln – allanite, ap – apatite, chl – chlorite, ep – epidote, Fe-jd – iron-jadeite, gln – glaucophane, grt – garnet, ilm – ilmenite, jd – jadeite, omp – omphacite, pg – paragonite, pmp – pumpellyite, rt – rutile, ttn – titanite, xtm – xenotime, zrn – zircon

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Declaration of the Supervisor

I hereby confirm that the content of the dissertation is based on the independent work of the doctoral candidate and that he has contributed decisively to the results through his independent creative activity. I consider the entire dissertation to be eligible for support from a professional and academic point of view and recommend its acceptance.

Szeged, 10.02.2026

Tivadar M. Tóth DSc
supervisor

Supplements

Magyar nyelvű összefoglalás

Összefoglalás

A probléma ismertetése

A geológiai minták előkészítése során teljesen megszokott a minták összetörése, elvágása, porítása, egyszóval roncsolása. Ilyen vizsgálati módszereket viszont nem alkalmazhatunk kulturális örökségünk ásvány vagy kőzet anyagú tárgyainál, például ékszerek drágakőberakásainál, szobrok, vagy festmények pigmentjeinek vizsgálata során. Ilyen esetekben a roncsolásmentes (esetleg mikroroncsolásos) módszerek alkalmazása kiemelten fontos ezeknek az egyedülálló és megismételhetetlen tárgyaknak a megőrzése szempontjából. Ez különösen igaz akkor, ha azok sértetlenek, jó minőségűek és részletes régészeti vagy történelmi dokumentációval rendelkeznek. Az archeometria kezdetei óta mindig nagy probléma volt, hogyan lehet a lehető legtöbb információt kinyerni, anélkül, hogy károsítanák vagy megsemmisítenék ezeket a hihetetlen történelmi háttérrel rendelkező tárgyakat. A kőkorszaki eszközök vizsgálatánál is célszerű roncsolásmentes vizsgálatokkal kezdeni, és csak erősen sérült, töredékes darabok esetén roncsolni a mintákat.

Az elemzési technikák fejlődése több részleges választ is adott a fenti problémára különböző elemzési módszerek formájában. Ezek a módszerek egymás eredményeit kölcsönösen alátámasztják, azonban egyik sem képes önmagában minden szükséges választ megadni. Sajnos azonban a leggyakrabban használt roncsolásmentes módszerek (XRF, Raman) egyike sem tud képi információt adni a kőzetszövetről.

Anyagvizsgálati módszerek

A minták teljesen roncsolásmentes vizsgálatának igénye és a vizuális információk szükségessége egy speciális mintakészítési módszer kidolgozásához vezetett, amely lehetővé teszi olyan minták vizsgálatát, amelyekről e módszer nélkül nem lehetett volna részletes információkat szerezni. Ezt a módszert „eredeti felszín vizsgálat”-nak neveztük el, mivel a vizsgált tárgyak eredeti (habár alaposan megtisztított) felületére összpontosít. Ennek a módszernek fő előnye a hagyományos, széles körben használt és elérhető elektronnyalábos anyagvizsgálat, amely mind szöveti, mind (ásvány)kémiai adatokat szolgáltat a mintákról. Mivel az „eredeti felületi módszer” nem igényel vágást, csiszolást vagy egyéb roncsolásos előkészítést, ez a módszer roncsolásmentesnek tekinthető (Bendő et al. 2013).

A vizsgálathoz az ELTE Kőzettan-Geokémiai Tanszékén lévő nagyméretű mintakamrával felszerelt pásztázó elektronmikroszkópot használtuk, melyben akár 30 cm hosszú mintákat is megvizsgálhatunk. A minták egy speciális mintaelőkészítési eljáráson mennek keresztül, melynek főbb lépései a tisztítás, a vizsgálandó felület kijelölése, a felület beburkolása alufóliával, legvégül pedig az előző lépések során kialakított felület vezetővé tétele vékony szénréteg rágőzölésével, mely a vizsgálat után nyomtalanul eltávolítható. Ezek után kerülnek be a leletek a pásztázó elektronmikroszkóp mintakamrájába, ahol a korábban előkészített területről készíthetünk fotókat és méréseket (Bendő et al. 2013).

A disszertációban bemutatott minták egy része töredékes volt, ami lehetővé tette, hogy roncsolásmentes vizsgálataink eredményeit a kőeszközökből készített vékonycsiszolatokon elvégzett „hagyományos" SEM-EDX vizsgálatok eredményeivel hasonlítsuk össze, ezzel tesztelve módszerünket. Eredményeink megmutatták, hogy az általunk alkalmazott teljesen roncsolásmentes módszer az archeometriai vizsgálatok során az esetek többségében jól használható, megfelelő képi és kémiai információt ad több kőzettípus esetén, azonban az is kiderült, hogy néhány kőzettípus esetén az eredeti felszín vizsgálati módszer csak részeredményeket szolgáltat. Ezekben az esetekben pontosabb eredményeket csak további – roncsolásos – vizsgálatokkal kaphatunk (Bendő et al. 2013).

Az „eredeti felszín vizsgálat"-on kívül hagyományos petrográfiai mikroszkópot, sztereomikroszkópot és mágneses szuszceptibilitás méréseket végeztünk, ill. a HP metaofiolit anyagú kőeszközök mindegyikéről teljeskőzet kémiai elemzés készült PGAA-val a KFKI-ban.

A vizsgált leletek eredete

A referenciaként (tehát eredeti felszínén és vékonycsiszolatban is megvizsgált kőeszközök) Diósviszlóról (Baranya megye), Veszprém-Kádártáról (Veszprém megye) és Balatonőszödről (Somogy megye) kerültek elő. A leletek egy része ásatásból került elő, más része szórványlelet volt (Oláh et al. 2012b, Oláh et al. 2013, Péterdi 2011).

HP-LT metaofiolit anyagú kőeszközök sokáig nem voltak ismertek Magyarország területéről, elsőként Friedel et al. 2008 és 2011 említi őket részletes vizsgálat nélkül. Következő lépésben Szakmány et al. 2013 ír 3 HP-LT metaofiolit kőeszköz részletes vizsgálatáról, melyek eredmények ezen disszertációnak is szerves részét képezik. Sajnos ezen kőeszközök többsége szórványlelet, de négy lelőhelyről 11 darabnak ismert a régészeti kontextusa. Ezek főként a Dunántúlról kerültek elő (1 tiszántúli darab kivételével), és többnyire a késő neolit Lengyel-kultúrához köthetők az egyedüli tiszántúli darab kivételével, amely a késő neolitikus Tisza-kultúrához köthető (Bendő et al. 2014, 2018).

A dolgozat eredményei

A disszertációban bemutatott eredeti felszín vizsgálati módszerről bebizonyosodott, hogy nagyon hasznos lehet a régészeti leletek és más műtárgyak vizsgálata során, különösen azokban az esetekben, ahol roncsolásos vizsgálatra nem kerülhet sor. A bemutatott esettanulmányokból kiderült, hogy a felszínről kapott képi és ásványkémiai adatok a legtöbb esetben nagyon hasonlók a vékonycsiszolatból mért adatokkal. Vizsgálataink során az is nyilvánvalóvá vált, hogy a módszer nem alkalmazható egyértelmű sikerrel minden kőzettípusnál. Ugyanakkor ezekben az esetekben is kapunk olyan információkat (szövet, az eredeti felszínen megjelenő ásványok kémiája, és a hiányzó fázisok helye, a szövetben), melyek a többi roncsolásmentes vizsgálati eljáráshoz hasonlóan jelentős többlet információt tartalmaznak (Bendő et al. 2013).

A jó minőségű, csiszolt kőeszközök készítésére alkalmas, magas nyomású-alacsony hőmérsékletű (HP-LT) metaofiolit kőzettípusok (pl. Na-piroxenit/jade, eklogit) sokáig ismeretlenek voltak a magyar leletek között, és ma is a ritkább típusok közé tartoznak.

Az első HP-LT metaofiolitból készült újkőkori kőeszközök előkerülése után a nagy kőeszközgyűjtemények részletes petrológiai vizsgálata során viszonylag nagy számban kerültek elő ezek a leletek. Jelenlegi ismereteink szerint Magyarországról 25 HP metaofiolit kőeszköz ismert. A disszertációban bemutatott leletekkel a HP-LT metaofiolit kőeszközök bizonyított elterjedési területe immár a Dunántúli régiót, valamint a mai Szlovákia déli részét is lefedi (Bendő et al. 2014, 2018).

A vizsgálatok során használt roncsolásmentes módszerek eredményei alapján a kőeszközöket 8 különböző csoportba tudtuk sorolni nyersanyaguk szerint D’Amico et al. 2003 alapján: jadeitit, kevert jadeitit, vas-kevert jadeitit, vas jadeitit, omfacitit- és glaukofánpalák, magnézium- és vas-eklogitok.

Adataink alapján a Magyarországon fellelt HP-LT metaofiolit kőeszközök valószínűleg ugyanabból a nyersanyagforrásból származnak, mint az olaszországi HP metaofiolit kőeszközök (D’Amico and Starnini 2006), vagyis a nyersanyagforrás a mai ÉNY Olaszország területén helyezkedett el. A témával foglalkozó szakirodalom szerint mind az elsődleges (Nyugati-Alpok a piemonti Monviso környékén vagy a liguriai Voltri-masszívum), mind a másodlagos előfordulások (a Po, Staffora és Curone folyók negyedidőszaki lerakódásaiban) potenciális nyersanyagforrások (Pétrequin et al. 2012a, 2012d, D’Amico and Starnini 2006, 2012). Vizsgálataink eredményei megerősítették a Pó-síkságot a Kárpát-medencével összekötő hosszú távú kereskedelmi útvonalak létezését a Kr. e. V. évezredben.

Supplements

Co-authors declarations

Társszerzői nyilatkozat

Alulírott Szakmány György nyilatkozom, hogy a *Results of non-destructive SEM-EDX and PGAA analyses of jade and eclogite polished stone tools in Hungary. (Archeometriai Műhely 2014 XI/4:187-206)* és a *High pressure metaophiolite polished stone implements found in Hungary. (Archaeological and Anthropological Sciences 2018 11: 1643–1667)* publikációkban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Kerepes, 2026 február 6.

…………………

(társszerző)

Társszerzői nyilatkozat

Alulírott T. Biró Katalin nyilatkozom, hogy a *Results of non-destructive SEM-EDX and PGAA analyses of jade and eclogite polished stone tools in Hungary. (Archeometriai Műhely2014 XI/4:187-206)* és a *High pressure metaophiolite polished stone implements found in Hungary. (Archaeological and Anthropological Sciences 2018 11: 1643–1667)* publikációkban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026 február 6. ……………………….

T. Biró Katalin

T. Biró Katalin

Társszerzői nyilatkozat

Alulírott Kasztovszky Zsolt nyilatkozom, hogy a *Results of non-destructive SEM-EDX and PGAA analyses of jade and eclogite polished stone tools in Hungary. (Archeometriai Műhely 2014 XI/4:187-206)* és a *High pressure metaophiolite polished stone implements found in Hungary. (Archaeological and Anthropological Sciences 2018 11: 1643–1667)* publikációkban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026 február 6.

....

Kasztovszky Zsolt

Társszerzői nyilatkozat

Alulírott Oláh István nyilatkozom, hogy a *Csiszolt kőeszközök és ékkövek roncsolásmentes SEM-EDX vizsgálata: lehetőségek és korlátok. Non-destructive SEM-EDX analytical method for polished stone tools and gems: opportunities and limitations. (Archeometriai Műhely 2013 X/1: 51–66)* és a *High pressure metaophiolite polished stone implements found in Hungary. (Archaeological and Anthropological Sciences 2018 11: 1643–1667)* publikációkban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Szada, 2026 február 6.

Oláh István
....
(társszerző)

Társszerzői nyilatkozat

Alulírott Szilágyi Veronika nyilatkozom, hogy a *Results of non-destructive SEM-EDX and PGAA analyses of jade and eclogite polished stone tools in Hungary. (Archeometriai Műhely 2014 XI/4:187-206)* és a *High pressure metaophiolite polished stone implements found in Hungary. (Archaeological and Anthropological Sciences 2018 11: 1643–1667)* publikációkban a doktorjelölt szerepe meghatározó fontosságú, a publikációk eredményeit nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026. február 6.

…………………………
Szilágyi Veronika

Társszerzői nyilatkozat

Alulírott Dr. Péterdi Bálint nyilatkozom, hogy a *Csiszolt kőeszközök és ékkövek roncsolásmentes SEM-EDX vizsgálata: lehetőségek és korlátok. Non-destructive SEM-EDX analytical method for polished stone tools and gems: opportunities and limitations. (Archeometriai Műhely 2013 X/1: 51–66)* publikációban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026. február 6.

Dr Péterdi Bálint

Dr. Péterdi Bálint

Társszerzői nyilatkozat

Alulírott Horváth Eszter nyilatkozom, hogy a *Csiszolt kőeszközök és ékkövek roncsolásmentes SEM-EDX vizsgálata: lehetőségek és korlátok. Non-destructive SEM-EDX analytical method for polished stone tools and gems: opportunities and limitations. (Archeometriai Műhely 2013 X/1: 51–66)* publikációban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026 február 6.

....
Horváth Eszter

Társszerzői nyilatkozat

Alulírott Osztás Anett nyilatkozom, hogy a *High pressure metaophiolite polished stone implements found in Hungary. (Archaeological and Anthropological Sciences 2018 11: 1643–1667)* publikációban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026 február 6.

Osztás Anett

Társszerzői nyilatkozat

Alulírott Maróti Boglárka nyilatkozom, hogy a *Results of non-destructive SEM-EDX and PGAA analyses of jade and eclogite polished stone tools in Hungary*. *(Archeometriai Műhely 2014 XI/4:187-206)* publikációban a doktorjelölt szerepe meghatározó fontosságú, a publikáció eredményeit nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026. február 6.

Maróti

………………………………

Maróti Boglárka

Társszerzői nyilatkozat

Alulírott Harsányi Ildikó nyilatkozom, hogy a *High pressure metaophiolite polished stone implements found in Hungary. (Archaeological and Anthropological Sciences 2018 11: 1643–1667)* publikációban a doktorjelölt szerepe meghatározó fontosságú, a publikáció eredményeit nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026. február 6.

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Harsányi Ildikó

Társszerzői nyilatkozat

Alulírott Szilágyi Szandra nyilatkozom, hogy a *Results of non-destructive SEM-EDX and PGAA analyses of jade and eclogite polished stone tools in Hungary. (Archeometriai Műhely 2014 XI/4:187-206)* publikációban a doktorjelölt szerepe meghatározó fontosságú, nem használtam fel tudományos fokozat megszerzésekor, és ezt a jövőben sem teszem.

Budapest, 2026 február 6.

………………………….
Szilágyi Szandra

Supplements

Mineral chemistry raw data

Sample DV-346

Korinek Collection, Hungarian National Museum, Budapest
Stray found from Diósviszló, Hungary
Raw material: sodalitic phonolite

Results measured on the original surface

Feldspar mineral chemistry measured on the original surface

ID	ab1		ab2		ab3		ab4		ab5		kfs1		kfs2		kfs3		kfs4		kfs5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	67.70	0.88	68.63	0.72	66.07	0.85	68.08	0.80	69.99	0.81	66.27	0.77	65.89	0.72	65.41	0.77	66.51	0.76	65.65	0.72
Al_2O_3	21.35	0.53	18.89	0.38	22.29	0.53	20.13	0.45	19.99	0.44	19.04	0.42	18.87	0.39	18.77	0.41	18.80	0.41	18.86	0.39
CaO	n.d.	-	0.26	0.01	0.70	0.03	0.52	0.02	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-
Na_2O	10.80	0.78	11.92	0.61	10.36	0.71	10.64	0.66	9.20	0.58	n.d.	-	n.d.	-	n.d.	-	3.02	0.22	n.d.	-
K_2O	0.16	0.01	0.29	0.01	0.57	0.03	0.62	0.03	0.82	0.03	14.69	0.22	15.24	0.22	15.82	0.23	11.67	0.19	15.49	0.22
Total	100.01	1.29	99.99	1.02	99.99	1.23	99.99	1.13	100.00	1.09	100.00	0.90	100.00	0.85	100.00	0.90	100.00	0.91	100.00	0.85

Pyroxene mineral chemistry measured on the original surface

ID	aeg1		aeg2		aeg3		aeg4		aeg5		cpx1	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	53.60	0.64	51.32	0.65	50.57	0.66	50.13	0.69	49.48	0.68	50.76	0.75
TiO_2	1.24	0.05	0.97	0.04	0.44	0.02	0.49	0.02	0.49	0.02	0.97	0.05
Al_2O_3	2.91	0.11	4.70	0.17	2.59	0.10	2.75	0.12	2.13	0.09	5.52	0.21
Fe_2O_3(T)	24.92	0.39	26.13	0.42	28.10	0.45	32.98	0.51	31.98	0.50	-	-
FeO(T)	-	-	-	-	-	-	-	-	-	-	12.68	0.32
MnO	1.00	0.04	0.95	0.04	2.20	0.09	1.09	0.05	0.96	0.04	0.40	0.02
MgO	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	10.45	0.48
CaO	3.04	0.08	3.54	0.10	7.31	0.15	6.03	0.14	6.74	0.15	19.23	0.31
Na_2O	13.30	0.77	12.41	0.80	8.79	0.61	6.52	0.50	8.22	0.62	n.d.	-
Total	100.01	1.09	100.02	1.13	100.00	1.02	99.99	1.01	100.00	1.06	100.01	1.01
FeO(Tc)	22.42	n.a.	23.51	n.a.	25.28	n.a.	29.68	n.a.	28.78	n.a.	-	-
Fe_2O_3(Tc)	-	-	-	-	-	-	-	-	-	-	14.09	n.a.

Results measured on thin section

Feldspar mineral chemistry measured on the thin section

ID	ab1		ab2		ab3		ab4		ab5		afs1		afs2		afs3		afs4		afs5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	68.81	0.71	68.82	0.71	68.61	0.75	67.97	0.73	68.65	0.74	67.86	0.70	66.44	0.68	65.70	0.68	65.84	0.71	67.79	0.73
Al_2O_3	19.44	0.39	19.53	0.39	19.38	0.40	20.25	0.42	19.48	0.41	20.21	0.39	19.99	0.39	21.07	0.41	19.85	0.40	19.48	0.40
Na_2O	11.45	0.63	11.41	0.64	12.01	0.68	11.47	0.66	11.58	0.66	8.47	0.50	6.75	0.41	6.97	0.42	2.29	0.17	7.02	0.44
K_2O	0.30	0.01	0.23	0.01	n.d.	-	0.30	0.01	0.30	0.01	3.46	0.08	6.82	0.12	6.26	0.12	12.02	0.18	5.71	0.12
Total	100.00	1.03	99.99	1.03	100.00	1.09	99.99	1.08	100.01	1.08	100.00	0.95	100.00	0.90	100.00	0.91	100.00	0.85	100.00	0.95

Feldspar mineral chemistry measured on the thin section - continued

ID	afs6		afs7		afs8		afs9		afs10		kfs1		kfs2		kfs3		kfs4		kfs5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	67.80	0.73	67.56	0.73	68.20	0.74	66.21	0.71	68.46	0.74	65.84	0.67	66.59	0.71	65.32	0.70	65.50	0.70	65.80	0.71
Al_2O_3	19.40	0.39	19.26	0.39	19.10	0.39	18.82	0.38	19.38	0.39	18.77	0.36	19.13	0.39	18.54	0.37	18.44	0.37	18.78	0.38
Na_2O	7.46	0.46	4.74	0.32	7.38	0.46	3.01	0.21	8.30	0.51	1.04	0.07	0.52	0.04	0.55	0.04	n.d.	-	n.d.	-
K_2O	5.35	0.12	8.43	0.15	5.33	0.12	11.96	0.18	3.86	0.10	14.35	0.19	13.76	0.20	15.58	0.21	16.06	0.22	15.42	0.21
Total	100.01	0.96	99.99	0.89	100.01	0.96	100.00	0.85	100.00	0.98	100.00	0.79	100.00	0.83	99.99	0.82	100.00	0.82	100.00	0.83

Pyroxene mineral chemistry measured on the thin section

ID	aeg1		aeg2		aeg3		aeg4		aeg5		aeg6		aeg7		aeg8		aeg9		aeg10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	50.82	0.63	52.02	0.65	51.28	0.64	51.84	0.64	50.69	0.63	51.84	0.64	50.31	0.63	49.42	0.62	52.36	0.65	50.89	0.63
TiO_2	0.79	0.03	1.31	0.05	0.86	0.03	0.56	0.02	n.d.	-	0.56	0.02	0.46	0.02	0.38	0.02	1.18	0.04	0.42	0.02
Al_2O_3	1.75	0.07	n.d.	-	1.35	0.06	n.d.	-	1.74	0.07	n.d.	-	1.46	0.06	1.42	0.06	1.78	0.07	1.62	0.06
Fe_2O_3(T)	29.36	0.43	29.85	0.44	29.62	0.44	29.79	0.44	29.37	0.43	29.79	0.44	29.46	0.43	29.90	0.43	29.29	0.43	28.61	0.43
MnO	0.96	0.04	1.22	0.05	0.97	0.04	1.14	0.05	1.56	0.06	1.14	0.05	1.15	0.05	1.42	0.06	0.99	0.04	1.72	0.07
CaO	4.78	0.11	4.75	0.11	5.67	0.13	6.41	0.13	8.63	0.16	6.41	0.13	7.14	0.14	8.92	0.16	4.34	0.10	8.50	0.16
Na_2O	11.55	0.74	10.85	0.71	10.24	0.68	10.25	0.68	8.01	0.55	10.25	0.68	10.02	0.66	8.55	0.58	10.06	0.67	8.25	0.56
Total	100.01	1.07	100.00	1.07	99.99	1.04	99.99	1.04	100.00	0.96	99.99	1.04	100.00	1.02	100.01	0.97	100.00	1.03	100.01	0.96
FeO(Tc)	26.42	n.a.	26.86	n.a.	26.65	n.a.	26.81	n.a.	26.43	n.a.	26.81	n.a.	26.51	n.a.	26.90	n.a.	26.36	n.a.	25.74	n.a.

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
n.a.:	not available
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions

ab:	albite	aeg:	aegirine	afs:	alkaline feldspar	kfs:	potassium feldspar	cpx:	clinopyroxene

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample DV-347
Korinek Collection, Hungarian National Museum, Budapest
Stray found from Diósviszló, Hungary
Raw material: greenschist

Results measured on the original surface

Feldspar mineral chemistry measured on the original surface

ID	ab1		ab2		ab3		ab4		ab5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	67.65	0.73	67.14	0.75	67.16	0.69	67.62	0.72	66.99	0.72
Al_2O_3	21.10	0.44	20.81	0.44	21.04	0.41	21.40	0.43	21.08	0.43
CaO	n.d.	-	0.25	0.01	0.20	0.01	0.18	0.01	0.23	0.01
Na_2O	11.25	0.66	11.80	0.72	11.44	0.63	10.80	0.64	11.57	0.66
K_2O	n.d.	-	n.d.	-	0.17	0.01	n.d.	-	0.14	0.01
Total	100.00	1.08	100.00	1.13	100.01	1.02	100.00	1.06	100.01	1.07

Amphibole mineral chemistry measured on the original surface

ID	amp1		amp2		amp3		amp4		amp5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.43	0.65	55.67	0.66	55.67	0.66	55.85	0.65	56.23	0.63
Al_2O_3	3.03	0.11	3.61	0.13	3.61	0.13	3.00	0.11	3.50	0.12
FeO	9.18	0.22	9.41	0.23	9.41	0.23	9.74	0.23	8.62	0.20
MnO	n.d.	-	0.20	0.01	0.20	0.01	0.11	0.01	n.d.	-
MgO	16.33	0.49	16.59	0.54	16.59	0.54	17.32	0.54	18.03	0.53
CaO	12.93	0.20	12.53	0.20	12.53	0.20	11.97	0.20	11.63	0.18
K_2O	0.10	0.00	n.d.	-	n.d.	-	n.d.	-	n.d.	-
Total	98.00	0.87	98.01	0.92	98.01	0.92	97.99	0.91	98.01	0.87

Pyroxene mineral chemistry measured on the original surface

ID	cpx1		cpx2		cpx3		cpx4		cpx5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	51.57	0.59	51.66	0.56	50.63	0.60	51.05	0.62	48.19	0.67
TiO_2	0.83	0.03	0.80	0.03	0.61	0.03	0.79	0.03	1.10	0.05
Al_2O_3	5.55	0.17	5.03	0.15	5.28	0.17	4.64	0.15	3.89	0.15
Cr_2O_3	0.54	0.03	0.15	0.01	0.41	0.02	0.15	0.01	n.d.	-
FeO	5.69	0.16	6.16	0.16	6.26	0.17	6.90	0.19	10.86	0.26
MnO	n.d.	-	0.18	0.01	0.18	0.01	0.16	0.01	n.d.	-
MgO	15.67	0.47	19.24	0.51	17.42	0.54	16.83	0.55	14.85	0.58
CaO	20.14	0.25	16.79	0.21	19.22	0.24	19.46	0.25	21.11	0.29
Total	99.99	0.83	100.01	0.82	100.01	0.87	99.98	0.90	100.00	0.98

Results measured on thin section

Pyroxene mineral chemistry measured on thin section

ID	cpx1		cpx2		cpx3		cpx4		cpx5		cpx6		cpx7		cpx8		cpx9		cpx10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	51.37	0.66	49.26	0.63	50.93	0.65	51.22	0.65	50.96	0.65	52.52	0.65	50.26	0.64	51.28	0.65	50.91	0.65	50.73	0.65
TiO_2	0.96	0.04	1.57	0.06	1.01	0.04	0.80	0.04	1.05	0.04	0.54	0.03	1.27	0.05	0.88	0.04	0.82	0.04	1.13	0.05
Al_2O_3	3.24	0.12	3.41	0.13	3.98	0.14	3.52	0.13	3.35	0.12	2.81	0.11	3.24	0.12	3.81	0.14	3.83	0.14	3.55	0.13
Cr_2O_3	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	0.24	0.01	n.d.	-	n.d.	-	n.d.	-	n.d.	-
FeO	9.82	0.24	13.23	0.28	6.47	0.19	8.09	0.22	9.51	0.23	6.13	0.18	12.27	0.27	7.07	0.20	7.53	0.20	11.23	0.26
MnO	0.17	0.01	0.43	0.02	0.19	0.01	0.21	0.01	0.26	0.01	0.21	0.01	0.26	0.01	0.21	0.01	0.22	0.01	0.27	0.01
MgO	14.54	0.52	13.35	0.50	16.90	0.56	16.15	0.55	15.20	0.53	17.33	0.57	13.79	0.50	16.27	0.54	16.36	0.55	13.79	0.51
CaO	19.91	0.27	18.76	0.26	20.51	0.27	20.02	0.27	19.67	0.27	20.21	0.27	18.90	0.26	20.47	0.27	20.33	0.27	19.31	0.27
Total	100.01	0.92	100.01	0.91	99.99	0.93	100.01	0.93	100.00	0.92	99.99	0.93	99.99	0.91	99.99	0.92	100.00	0.93	100.01	0.92

Amphibole mineral chemistry measured on thin section

ID	amp1		amp2		amp3		amp4		amp5		amp6		amp7		amp8		amp9		amp10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.67	0.69	55.76	0.69	55.72	0.69	56.16	0.69	56.26	0.69	56.69	0.69	56.17	0.69	56.43	0.69	56.08	0.69	55.97	0.69
Al_2O_3	2.49	0.10	2.91	0.11	3.19	0.12	2.83	0.11	3.28	0.13	2.34	0.09	2.57	0.10	2.28	0.09	2.75	0.11	3.37	0.13
FeO	9.37	0.23	11.03	0.26	9.51	0.24	9.85	0.24	9.62	0.24	9.29	0.23	9.50	0.23	9.69	0.24	9.55	0.23	9.84	0.24
MgO	16.35	0.53	15.63	0.52	16.11	0.54	16.13	0.54	16.19	0.54	16.73	0.55	16.74	0.54	16.72	0.55	16.61	0.54	15.87	0.52
CaO	13.12	0.22	12.68	0.21	13.47	0.22	13.03	0.22	12.65	0.21	12.95	0.22	13.02	0.22	12.89	0.21	13.01	0.22	12.95	0.22
Total	98.00	0.94	98.01	0.93	98.00	0.94	98.00	0.94	98.00	0.94	98.00	0.94	98.00	0.94	98.01	0.94	98.00	0.94	98.00	0.93

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
ab:	albite
amp:	amphibole
cpx:	clinopyroxene

Sample DV-349
Korinek Collection, Hungarian National Museum, Budapest
Stray found from Diósviszló, Hungary
Raw material: alkaline dolerite

Results measured on the original surface

Feldspar mineral chemistry measured on the original surface

ID	ab1		ab2		ab3		ab4		ab5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	69.19	0.63	69.42	0.62	70.40	0.66	69.90	0.63	70.30	0.62
Al_2O_3	20.59	0.33	19.48	0.33	19.44	0.34	19.30	0.32	19.69	0.32
CaO	0.49	0.02	0.50	0.02	1.04	0.03	1.39	0.04	0.65	0.02
Na_2O	8.10	0.38	10.39	0.48	8.87	0.44	9.09	0.43	9.16	0.43
K_2O	1.65	0.05	0.22	0.01	0.25	0.01	0.33	0.01	0.20	0.01
Total	100.02	0.81	100.01	0.85	100.00	0.86	100.01	0.83	100.00	0.82

Pyroxene mineral chemistry measured on the original surface

ID	cpx1a		cpx1b		cpx2		cpx3		cpx4 zone a		cpx4 zone b		cpx5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	51.84	0.54	52.92	0.52	51.89	0.53	52.51	0.54	52.42	0.52	52.30	0.52	51.01	0.54
TiO_2	0.78	0.03	0.78	0.03	0.79	0.03	0.83	0.03	0.69	0.03	0.82	0.03	0.69	0.03
Al_2O_3	4.11	0.12	2.71	0.08	4.68	0.13	3.02	0.09	3.97	0.11	2.98	0.09	3.47	0.11
Cr_2O_3	0.76	0.03	0.18	0.01	0.52	0.02	n.d.	-	0.82	0.03	n.d.	-	0.20	0.01
FeO	5.35	0.14	6.65	0.15	5.68	0.14	7.68	0.17	5.09	0.13	9.98	0.19	7.06	0.17
MnO	n.d.	-	0.23	0.01	n.d.	-	0.22	0.01	n.d.	-	0.32	0.01	0.16	0.01
MgO	14.57	0.40	15.03	0.39	14.93	0.40	14.85	0.41	14.98	0.39	13.73	0.37	14.50	0.42
CaO	22.59	0.24	21.49	0.23	21.51	0.23	20.89	0.23	22.04	0.23	19.87	0.22	22.92	0.25
Total	100.00	0.74	99.99	0.72	100.00	0.73	100.00	0.75	100.01	0.72	100.00	0.70	100.01	0.75

Results measured on thin section

Feldspar mineral chemistry measured on thin section

ID	ab1		ab2		ab3		ab4		ab5		ab6		ab7		ab8	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	68.62	0.74	68.84	0.75	68.73	0.76	67.74	0.74	67.60	0.74	68.09	0.74	68.41	0.74	68.47	0.76
Al_2O_3	19.37	0.40	19.50	0.40	19.55	0.41	20.35	0.42	20.85	0.43	19.97	0.41	19.61	0.40	19.51	0.41
CaO	0.28	0.01	0.28	0.01	0.39	0.02	0.34	0.01	0.45	0.02	0.31	0.01	0.24	0.01	0.42	0.02
Na_2O	11.74	0.65	11.38	0.65	11.33	0.67	11.57	0.66	11.10	0.65	11.63	0.67	11.42	0.63	11.59	0.68
K_2O	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	0.31	0.01	n.d.	-
Total	100.01	1.06	100.00	1.07	100.00	1.09	100.00	1.08	100.00	1.07	100.00	1.08	99.99	1.05	99.99	1.10

Pyroxene mineral chemistry measured on thin section

ID	cpx1		cpx2		cpx3		cpx4		cpx5		cpx6		cpx7		cpx8		cpx9		cpx10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	51.79	0.65	51.42	0.65	51.84	0.66	51.78	0.66	51.37	0.66	52.62	0.69	52.22	0.70	51.67	0.67	51.58	0.68	52.17	0.68
TiO_2	0.75	0.03	0.78	0.03	0.88	0.04	0.71	0.03	0.70	0.03	0.70	0.03	0.93	0.04	0.67	0.03	0.98	0.04	0.58	0.03
Al_2O_3	3.57	0.13	2.67	0.10	3.01	0.12	2.45	0.09	3.27	0.12	2.86	0.12	2.60	0.10	3.72	0.15	2.82	0.11	2.95	0.12
Cr_2O_3	0.59	0.03	n.d.	-	n.d.	-	n.d.	-	0.54	0.03	n.d.	-	n.d.	-	0.26	0.01	n.d.	-	n.d.	-
FeO	5.47	0.17	10.48	0.25	7.75	0.21	7.38	0.21	6.08	0.18	6.77	0.20	8.44	0.23	6.14	0.19	8.79	0.23	5.81	0.18
MnO	n.d.	-	0.35	0.02	0.27	0.02	0.18	0.01	0.21	0.01	0.23	0.01	n.d.	-	n.d.	-	0.24	0.01	n.d.	-
MgO	16.38	0.55	15.14	0.53	16.09	0.56	16.92	0.58	16.82	0.57	16.02	0.57	15.91	0.58	17.16	0.60	15.79	0.57	17.29	0.61
CaO	21.45	0.28	19.15	0.26	20.17	0.27	20.58	0.28	21.02	0.28	20.80	0.29	19.89	0.28	20.38	0.28	19.80	0.28	21.19	0.29
Total	100.00	0.93	99.99	0.92	100.01	0.94	100.00	0.95	100.01	0.95	100.00	0.97	99.99	0.99	100.00	0.98	100.00	0.97	99.99	0.99

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
ab:	albite
cpx:	clinopyroxene

Sample DV-q
Korinek Collection, Hungarian National Museum, Budapest
Stray found from Diósviszló, Hungary
Raw material: Greenschist

Results measured on the original surface

Feldspar mineral chemistry measured on the original surface

ID	ab1		ab2		ab3		ab4		ab5		ab6		ab7		ab8	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	66.50	0.85	66.30	0.81	67.36	0.86	68.06	0.78	67.75	0.84	68.84	0.78	69.61	0.78	68.29	0.82
Al_2O_3	21.53	0.52	21.99	0.49	20.59	0.49	20.29	0.44	20.56	0.49	19.88	0.42	19.47	0.42	19.84	0.46
CaO	0.23	0.01	0.22	0.01	0.39	0.02	n.d.	-	0.27	0.01	n.d.	-	n.d.	-	n.d.	-
Na_2O	11.42	0.79	10.75	0.71	11.65	0.81	11.65	0.69	11.42	0.78	10.94	0.66	10.81	0.64	11.87	0.76
K_2O	0.32	0.02	0.74	0.03	n.d.	-	n.d.	-	n.d.	-	0.34	0.02	0.11	0.01	n.d.	-
Total	100.00	1.27	100.00	1.18	99.99	1.28	100.00	1.13	100.00	1.25	100.00	1.10	100.00	1.09	100.00	1.21

Amphibole mineral chemistry measured on the original surface

ID	amp1		amp2		amp3		amp4		amp5		amp6		amp7		amp8	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	54.48	0.78	55.98	0.73	54.47	0.69	55.59	0.74	55.49	0.72	54.04	0.71	56.36	0.73	55.38	0.75
Al_2O_3	3.47	0.16	3.33	0.13	5.77	0.2	4	0.16	3.99	0.15	4.93	0.18	3.56	0.14	3.3	0.14
FeO	12.21	0.31	9.59	0.25	9.53	0.24	10.26	0.26	9.86	0.26	10.3	0.26	9.99	0.25	10.42	0.27
MnO	0.23	0.01	0.16	0.01	0.21	0.01	0.15	0.01	0.23	0.01	0.26	0.01	0.18	0.01	0.27	0.02
MgO	14.35	0.59	16.98	0.59	16.94	0.55	16.03	0.58	17.13	0.58	15.21	0.55	15.51	0.54	15.61	0.58
CaO	13.25	0.24	11.96	0.22	11.08	0.2	11.98	0.22	11.3	0.21	13.07	0.23	12.14	0.22	13.02	0.24
K_2O	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	0.18	0.01	0.27	0.01	n.d.	-
Total	97.99	1.06	98.00	1.00	98.00	0.95	98.01	1.01	98.00	1.00	97.99	0.98	98.01	0.98	98.00	1.03

Amphibole mineral chemistry measured on the original surface - cont.

ID	amp9		amp10		amp11		amp12	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	54.43	0.71	55.54	0.75	56.55	0.71	55.21	0.78
Al_2O_3	5.64	0.2	4.7	0.19	4.28	0.16	3.89	0.16
FeO	10.13	0.25	10.12	0.27	8.88	0.24	10.35	0.28
MnO	0.27	0.02	0.09	0.01	0.12	0.01	0.32	0.02
MgO	16.39	0.56	15.44	0.57	16.61	0.55	15.18	0.6
CaO	11.03	0.21	12	0.22	11.42	0.21	13.05	0.24
K_2O	0.12	0.01	0.12	0.01	0.15	0.01	n.d.	-
Total	98.01	0.99	98.01	1.03	98.01	0.96	98.00	1.06

Results measured on thin section

Feldspar mineral chemistry measured on thin section

ID	ab1		ab2		ab3		ab4		ab5		ab6		ab7		ab8	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	68.66	0.76	68.37	0.76	68.46	0.76	68.59	0.77	68.81	0.77	68.13	0.76	68.09	0.76	68.23	0.76
Al_2O_3	19.74	0.42	19.91	0.42	19.59	0.42	19.61	0.42	19.55	0.42	20.14	0.43	20.15	0.43	20.00	0.43
CaO	n.d.	-	n.d.	-	0.24	0.01	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-
Na_2O	11.60	0.68	11.72	0.70	11.72	0.68	11.80	0.70	11.64	0.68	11.74	0.70	11.76	0.70	11.77	0.69
Total	100.00	1.11	100.00	1.12	100.01	1.11	100.00	1.12	100.00	1.12	100.01	1.12	100.00	1.12	100.00	1.12

Amphibole mineral chemistry measured on thin section

ID	amp1		amp2		amp3		amp4		amp5		amp6		amp7		amp8		amp9		amp10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.96	0.69	56.23	0.69	55.25	0.68	56.46	0.69	56.00	0.69	55.99	0.69	56.25	0.69	56.28	0.68	55.69	0.68	55.87	0.68
Al_2O_3	2.42	0.10	2.32	0.09	3.52	0.14	2.62	0.10	2.14	0.09	2.21	0.09	2.16	0.09	2.13	0.09	3.08	0.12	2.46	0.10
FeO	10.41	0.25	10.30	0.25	10.05	0.24	10.30	0.25	10.19	0.25	10.36	0.25	10.78	0.25	10.24	0.24	10.37	0.24	10.33	0.24
MnO	0.33	0.02	0.24	0.01	0.17	0.01	0.14	0.01	0.14	0.01	0.12	0.01	0.13	0.01	0.25	0.01	0.17	0.01	0.22	0.01
MgO	16.02	0.53	15.80	0.53	16.30	0.54	15.88	0.53	16.36	0.54	16.09	0.53	15.64	0.52	15.97	0.53	16.00	0.53	16.31	0.54
CaO	12.87	0.21	13.11	0.22	12.70	0.21	12.62	0.21	13.17	0.22	13.22	0.22	13.05	0.22	13.12	0.22	12.69	0.21	12.81	0.21
Total	98.01	0.93	98.00	0.93	97.99	0.94	98.02	0.93	98.00	0.94	97.99	0.93	98.01	0.93	97.99	0.93	98.00	0.93	98.00	0.93

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
ab:	albite
amp:	amphibole

Sample DV-zz
Korinek Collection, Hungarian National Museum, Budapest
Stray found from Diósviszló, Hungary
Raw material: contact metabasite with biotite

Results measured on the original surface

Amphibole (hornblende) mineral chemistry measured on the original surface

ID	amp1-1		amp1-2		amp1-3		amp1-4		amp1-5		amp1-6		amp1-7		amp1-8		amp1-8a		amp1-9		amp1-10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	51.80	0.61	53.66	0.58	54.62	0.58	55.14	0.58	50.92	0.58	54.26	0.63	52.73	0.63	55.20	0.60	46.04	0.67	54.36	0.64	52.30	0.65
TiO_2	0.40	0.02	0.52	0.02	0.20	0.01	0.31	0.01	0.84	0.03	0.39	0.02	0.70	0.03	0.25	0.01	1.00	0.04	0.36	0.02	0.61	0.03
Al_2O_3	6.24	0.19	5.49	0.16	5.64	0.16	5.20	0.15	8.21	0.22	6.20	0.19	8.39	0.24	7.65	0.20	12.19	0.36	6.96	0.21	7.27	0.22
FeO	13.20	0.25	13.07	0.24	11.29	0.22	11.31	0.22	12.24	0.24	10.08	0.22	9.77	0.22	8.74	0.20	13.61	0.30	9.78	0.22	10.85	0.25
MnO	0.24	0.01	0.29	0.01	0.27	0.01	0.12	0.01	0.17	0.01	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-
MgO	13.07	0.42	14.64	0.42	14.40	0.40	15.50	0.42	13.06	0.40	15.20	0.46	15.11	0.45	15.92	0.43	12.12	0.46	15.48	0.47	15.03	0.49
CaO	12.81	0.19	10.17	0.16	11.57	0.17	10.41	0.16	12.46	0.18	11.75	0.19	11.15	0.18	10.24	0.17	12.78	0.22	10.90	0.18	11.93	0.20
K_2O	0.23	0.01	0.16	0.01	n.d.	-	n.d.	-	0.10	0.00	0.11	0.00	0.16	0.01	n.d.	-	0.25	0.01	0.17	0.01	n.d.	-
Total	97.99	0.83	98.00	0.78	97.99	0.78	97.99	0.78	98.00	0.79	97.99	0.86	98.01	0.86	98.00	0.81	97.99	0.96	98.01	0.87	97.99	0.90

Amphibole (cummingtionite) mineral chemistry measured on the original surface

ID	amp2-1		amp2-2		amp2-3		amp2-4		amp2-5		amp2-6		amp2-7		amp2-8		amp2-8 zone a		amp2-9		amp2-10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.65	0.6	56.57	0.61	55.76	0.62	56.53	0.61	55.8	0.62	56.34	0.68	56.65	0.66	56.05	0.66	55.16	0.68	55.76	0.68	54.56	0.71
Al_2O_3	2.47	0.09	3.52	0.11	2.5	0.09	2.27	0.08	2.32	0.09	2.13	0.08	2.27	0.09	2.61	0.10	3.85	0.14	2.41	0.10	2.62	0.11
FeO	20.49	0.3	20.53	0.3	21.5	0.32	20.64	0.3	21.8	0.32	19.92	0.33	19.28	0.32	19.41	0.33	17.71	0.32	20.28	0.34	22.53	0.38
MnO	0.43	0.02	0.48	0.02	0.64	0.03	0.47	0.02	0.37	0.02	0.33	0.02	0.30	0.01	0.43	0.02	0.32	0.02	0.32	0.02	0.40	0.02
MgO	16.65	0.47	15.37	0.45	16.29	0.48	16.68	0.48	16.41	0.49	17.75	0.55	18.09	0.54	18.15	0.56	17.34	0.55	17.97	0.57	16.63	0.58
CaO	1.31	0.04	1.37	0.04	1.32	0.04	1.41	0.04	1.31	0.04	1.53	0.05	1.41	0.05	1.34	0.05	3.61	0.10	1.27	0.04	1.26	0.04
K_2O	n.d.	-	0.16	0.01	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-
Total	98.00	0.82	98.00	0.82	98.01	0.85	98.00	0.84	98.01	0.85	98.00	0.94	98.00	0.91	97.99	0.93	97.99	0.94	98.01	0.96	98.00	1.00

Amphibole (actinolite) mineral chemistry measured on the original surface

ID	amp3-1		amp3-2		amp3-3		amp3-4		amp3-5		amp3-6		amp3-7		amp3-8		amp3-9		amp3-10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.58	0.57	56.74	0.60	56.82	0.59	57.03	0.59	56.79	0.60	57.07	0.68	54.48	0.68	55.97	0.67	56.37	0.66	56.09	0.69
Al_2O_3	2.18	0.07	2.83	0.09	2.93	0.10	2.37	0.08	3.10	0.10	1.65	0.07	4.00	0.15	2.50	0.10	3.00	0.11	3.05	0.12
FeO	9.80	0.20	10.56	0.22	10.58	0.21	9.65	0.20	10.87	0.22	9.27	0.23	11.53	0.26	10.04	0.24	9.43	0.23	9.63	0.24
MnO	0.22	0.01	0.10	0.00	0.10	0.00	0.11	0.01	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-
MgO	16.79	0.43	15.25	0.42	15.37	0.42	15.55	0.43	15.23	0.44	17.49	0.56	15.58	0.52	16.60	0.53	17.23	0.53	16.17	0.53
CaO	11.43	0.17	12.52	0.18	12.20	0.18	13.28	0.19	12.01	0.18	12.52	0.21	12.42	0.21	12.88	0.21	11.98	0.20	13.06	0.22
Total	98.00	0.76	98.00	0.79	98.00	0.78	98.00	0.79	98.00	0.80	98.00	0.94	98.00	0.93	98.00	0.92	98.00	0.91	98.00	0.94

Results measured on thin section

Amphibole (hornblende) mineral chemistry measured on thin section

ID	amp1-1		amp1-2		amp1-3		amp1-4		amp1-5		amp1-6		amp1-7		amp1-8		amp1-9		amp1-10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	51.59	0.68	51.24	0.67	52.70	0.68	50.85	0.67	50.72	0.67	50.88	0.67	52.40	0.68	50.40	0.67	51.57	0.68	51.08	0.68
TiO_2	0.35	0.02	0.40	0.02	0.38	0.02	0.40	0.02	0.63	0.03	0.32	0.02	0.60	0.03	0.61	0.03	0.60	0.03	0.58	0.03
Al_2O_3	8.03	0.26	7.87	0.25	7.30	0.24	8.15	0.25	8.53	0.27	8.57	0.27	6.67	0.22	8.46	0.26	7.69	0.25	7.83	0.25
FeO	11.59	0.27	11.69	0.27	10.95	0.26	11.66	0.27	11.37	0.26	11.53	0.27	11.33	0.26	11.77	0.27	11.36	0.26	11.29	0.26
MnO	n.d.	-	0.27	0.02	n.d.	-	0.22	0.01	0.12	0.01	0.18	0.01	0.18	0.01	0.15	0.01	0.15	0.01	0.17	0.01
MgO	14.79	0.51	15.12	0.51	15.25	0.51	14.92	0.51	14.84	0.51	14.54	0.51	15.34	0.52	15.20	0.52	14.87	0.52	15.31	0.53
CaO	11.66	0.20	11.41	0.20	11.26	0.20	11.64	0.20	11.60	0.20	11.83	0.21	11.37	0.20	11.40	0.20	11.65	0.21	11.60	0.20
K_2O	n.d.	-	n.d.	-	0.15	0.01	0.16	0.01	0.19	0.01	0.15	0.01	0.11	0.00	n.d.	-	0.12	0.00	0.13	0.01
Total	98.01	0.95	98.00	0.94	97.99	0.94	98.00	0.94	98.00	0.95	98.00	0.95	98.00	0.95	97.99	0.95	98.01	0.95	97.99	0.95

Amphibole (cummingtonite) mineral chemistry measured on thin section

ID	amp2-1		amp2-2		amp2-3		amp2-4		amp2-5		amp2-6		amp2-7		amp2-8		amp2-9		amp2-10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.87	0.66	55.61	0.67	56.28	0.69	56.72	0.70	55.70	0.70	56.24	0.72	56.07	0.71	55.94	0.71	56.33	0.71	54.33	0.70
Al_2O_3	2.19	0.09	1.99	0.08	2.12	0.09	2.21	0.09	2.21	0.09	2.13	0.09	2.08	0.09	2.36	0.10	2.09	0.09	3.40	0.14
FeO	20.23	0.33	20.10	0.34	20.11	0.35	20.27	0.35	19.78	0.35	20.38	0.36	20.71	0.36	20.17	0.36	20.00	0.35	20.21	0.36
MnO	0.38	0.02	0.47	0.02	0.35	0.02	0.29	0.01	0.47	0.03	0.35	0.02	0.39	0.02	0.43	0.02	0.47	0.02	0.46	0.02
MgO	18.26	0.56	18.65	0.58	18.12	0.58	17.51	0.57	18.40	0.60	17.87	0.60	17.63	0.60	17.97	0.60	18.04	0.60	18.31	0.60
CaO	1.08	0.04	1.19	0.04	1.03	0.04	1.00	0.04	1.43	0.05	1.04	0.04	1.12	0.04	1.12	0.04	1.07	0.04	1.29	0.05
Total	98.01	0.93	98.01	0.95	98.01	0.97	98.00	0.97	97.99	0.99	98.01	1.01	98.00	1.00	97.99	1.01	98.00	1.00	98.00	1.00

Amphibole (actinolite) mineral chemistry measured on thin section

ID	amp3-1		amp3-2		amp3-3		amp3-4		amp3-5		amp3-6		amp3-7		amp3-8		amp3-9		amp3-10	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.62	0.69	56.58	0.69	57.05	0.70	57.11	0.69	56.40	0.69	56.99	0.70	57.08	0.70	55.95	0.69	56.23	0.70	56.89	0.70
Al_2O_3	2.96	0.11	2.04	0.09	1.62	0.07	1.96	0.08	1.93	0.08	2.22	0.09	1.69	0.07	1.83	0.08	2.03	0.08	1.92	0.08
FeO	10.43	0.25	9.51	0.24	9.47	0.24	9.60	0.24	9.56	0.24	9.41	0.23	9.61	0.24	9.55	0.24	9.87	0.24	9.81	0.24
MnO	0.24	0.01	0.16	0.01	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-
MgO	17.48	0.56	17.58	0.57	17.88	0.58	16.88	0.54	18.31	0.58	17.56	0.57	17.06	0.56	18.34	0.58	18.31	0.58	16.61	0.55
CaO	11.27	0.20	12.13	0.21	11.97	0.21	12.44	0.21	11.80	0.20	11.82	0.20	12.55	0.21	12.33	0.21	11.56	0.20	12.78	0.22
Total	98.00	0.95	98.00	0.95	97.99	0.96	97.99	0.94	98.00	0.95	98.00	0.95	97.99	0.95	98.00	0.96	98.00	0.96	98.01	0.95

List of abbreviations in the tables:
ID: measurement position identification
+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
ab: albite amp: amphibole

Sample BOT-X5

Baden culture settlement, Balatonőszöd, Temetői-dűlő, Hungary
Raw material: nephrite

Results measured on the original surface

Amphibole mineral chemistry measured on the original surface										
ID	trm1		trm2		trm3		trm4		trm5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	60.28	0.57	60.12	0.58	59.43	0.58	59.78	0.59	60.07	0.58
Al_2O_3	2.07	0.07	2.24	0.07	2.26	0.07	2.01	0.07	1.98	0.07
FeO	3.11	0.10	3.33	0.10	3.52	0.11	3.58	0.11	3.67	0.11
MgO	18.61	0.42	18.11	0.43	18.98	0.45	18.73	0.44	18.62	0.44
CaO	13.93	0.19	14.21	0.19	13.80	0.19	13.90	0.19	13.65	0.19
Total	98.00	0.74	98.01	0.76	97.99	0.77	98.00	0.77	97.99	0.76

Results measured on thin section by an external laboratory

Amphibole mineral chemistry measured on thin section										
ID	trm1		trm2		trm3		trm4		trm5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.76	n.a.	59.32	n.a.	58.54	n.a.	59.25	n.a.	58.69	n.a.
FeO	3.69	n.a.	3.30	n.a.	2.98	n.a.	3.27	n.a.	3.21	n.a.
MgO	22.51	n.a.	22.77	n.a.	23.40	n.a.	22.64	n.a.	23.07	n.a.
CaO	13.04	n.a.	12.61	n.a.	13.08	n.a.	12.83	n.a.	13.02	n.a.
Total	98.00	n.a.	98.00	n.a.	98.00	n.a.	97.99	n.a.	97.99	n.a.

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
n.a.:	not available
trm	tremolite

Sample VPK-1004

Archeological excavation, Veszprém-Kádárta, Hungary
Raw material: basalt

Results measured on the original surface

Pyroxene mineral chemistry measured on the original surface

ID	cpx1		cpx2		cpx3		cpx4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	40.40	0.43	42.49	0.47	43.47	0.47	45.67	0.48
TiO_2	5.53	0.13	4.27	0.12	4.38	0.12	3.91	0.11
Al_2O_3	9.43	0.20	8.37	0.19	8.26	0.19	8.06	0.18
FeO	9.74	0.21	9.15	0.22	9.54	0.22	9.68	0.22
MgO	7.96	0.23	9.18	0.27	8.24	0.25	9.00	0.26
CaO	26.93	0.28	26.54	0.29	26.12	0.29	23.68	0.27
Total	99.99	0.64	100.00	0.69	100.01	0.69	100.00	0.68

Plagioclase mineral chemistry measured on the original surface

ID	pl1		pl2		pl3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	46.30	0.48	47.28	0.51	47.49	0.48
Al_2O_3	31.39	0.42	31.12	0.44	31.07	0.41
CaO	20.44	0.25	19.56	0.26	18.44	0.24
Na_2O	1.51	0.08	1.53	0.09	2.54	0.14
K_2O	0.37	0.01	0.51	0.02	0.46	0.02
Total	100.01	0.69	100.00	0.73	100.00	0.69

Glass chemistry measured on the original surface

ID	gl1		gl2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	77.59	0.64	76.36	0.68
TiO_2	1.01	0.04	1.13	0.05
Al_2O_3	7.00	0.16	6.63	0.17
FeO	6.30	0.18	7.92	0.21
MgO	0.77	0.03	0.88	0.04
CaO	0.57	0.02	0.98	0.03
Na_2O	2.08	0.11	1.46	0.09
K_2O	4.68	0.10	4.65	0.11
Total	100.00	0.70	100.01	0.75

Olivine mineral chemistry measured on the original surface

ID	ol1		ol2		ol3		ol4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	37.83	0.48	39.36	0.49	35.86	0.55	39.39	0.51
FeO	25.48	0.38	17.73	0.32	35.36	0.54	18.04	0.34
MgO	36.68	0.67	42.92	0.73	28.78	0.73	42.57	0.76
Total	99.99	0.90	100.01	0.94	100.00	1.06	100.00	0.98

Magnetite mineral chemistry measured on the original surface

ID	ti-mt1		ti-mt2		ti-mt3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
TiO_2	25.55	0.31	26.43	0.31	25.23	0.30
Al_2O_3	2.88	0.10	2.63	0.09	2.90	0.10
FeO	70.27	0.61	69.72	0.60	70.74	0.61
MgO	1.30	0.06	1.22	0.06	1.13	0.06
Total	100.00	0.69	100.00	0.68	100.00	0.69

Results measured on thin section

Pyroxene mineral chemistry measured on thin section

ID	aug_1_core		aug_1_rim_1		aug_1_rim_2		aug_1_zone		aug_2_core		aug_2_rim_1		aug_2_rim_2		aug_2_zone_1		aug_2_zone_2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	47.23	0.55	44.85	0.53	45.39	0.54	50.10	0.56	44.08	0.53	47.13	0.54	45.39	0.54	49.63	0.56	50.09	0.56
TiO_2	2.08	0.07	3.65	0.11	3.62	0.11	1.40	0.05	3.66	0.11	3.04	0.09	3.62	0.11	1.83	0.07	1.40	0.05
Al_2O_3	7.46	0.20	8.54	0.22	8.42	0.22	5.07	0.15	9.77	0.24	6.38	0.18	8.42	0.22	5.78	0.16	5.39	0.16
Cr_2O_3	0.89	0.04	0.13	0.01	n.d.	-	0.63	0.03	0.66	0.03	0.22	0.01	n.d.	-	0.27	0.01	0.47	0.02
FeO	5.55	0.16	7.50	0.19	7.38	0.19	5.07	0.15	6.22	0.17	6.92	0.18	7.38	0.19	5.95	0.16	4.78	0.14
MgO	13.51	0.41	11.87	0.38	12.08	0.38	14.90	0.43	12.93	0.39	12.88	0.40	12.08	0.38	14.53	0.42	15.12	0.44
CaO	23.28	0.27	23.45	0.27	23.11	0.27	22.83	0.26	22.69	0.26	23.42	0.27	23.11	0.27	22.00	0.26	22.75	0.26
Total	100.00	0.78	99.99	0.77	100.00	0.77	100.00	0.78	100.01	0.78	99.99	0.77	100.00	0.77	99.99	0.79	100.00	0.79

Oxides mineral chemistry measured on thin section

ID	mt1		mt2		mt3		ilm?	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	0.84	0.03	0.62	0.03	n.d.	-	n.d.	-
TiO_2	19.40	0.29	24.66	0.33	10.53	0.20	23.47	0.34
Al_2O_3	8.09	0.27	5.23	0.20	17.21	0.44	n.d.	-
Cr_2O_3	4.21	0.12	0.29	0.01	13.01	0.23	n.d.	-
FeO	60.99	0.61	66.08	0.63	52.12	0.56	75.14	0.72
MnO	n.d.	-	n.d.	-	n.d.	-	1.38	0.05
MgO	5.48	0.27	2.89	0.16	7.12	0.32	n.d.	-
CaO	0.99	0.03	0.23	0.01	n.d.	-	n.d.	-
Total	100.00	0.79	100.00	0.76	99.99	0.84	99.99	0.80

Plagioclase mineral chemistry measured on thin section

ID	pl1		pl2 core		pl2 rim	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	51.47	0.63	51.01	0.62	55.34	0.64
Al_2O_3	30.78	0.48	30.66	0.48	28.06	0.46
CaO	15.50	0.23	15.50	0.23	11.23	0.19
Na_2O	1.89	0.13	2.52	0.16	3.96	0.25
K_2O	0.36	0.01	0.30	0.01	1.42	0.05
Total	100.00	0.83	99.99	0.84	100.01	0.85

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions

aug:	augite	cpx:	clinopyroxene	gl:	glass in the matrix	(ti-)mt:	(Ti-bearing) magnetite	ilm?:	maybe ilmenite
ol:	olivine	pl:	plagioclase						

Sample 55-1276
Miháldy Collection, Laczkó Dezső Museum, Veszprém
Stray found from Bakony, Hungary
Raw material: jadetite

Pyroxene mineral chemistry

ID	Jd1		Jd2		Jd3		Jd4		Jd5		Jd6		Jd7		Jd8	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.74	0.63	58.26	0.62	58.62	0.59	59.61	0.61	55.03	0.57	58.21	0.56	59.04	0.63	58.54	0.64
TiO_2	0.29	0.01	0.30	0.01	0.91	0.04	0.57	0.03	0.20	0.01	0.44	0.02	0.31	0.01	0.23	0.01
Al_2O_3	23.03	0.42	19.81	0.38	23.74	0.40	24.92	0.42	11.90	0.27	20.78	0.33	22.69	0.39	21.50	0.39
FeO (T)	2.48	0.11	4.71	0.16	2.00	0.09	1.03	0.05	6.56	0.19	1.34	0.05	0.42	0.02	1.02	0.05
MgO	2.58	0.11	3.26	0.14	1.93	0.08	2.11	0.09	6.57	0.24	2.44	0.10	1.48	0.07	2.22	0.10
CaO	2.40	0.08	4.62	0.12	1.78	0.06	0.79	0.03	14.00	0.22	1.44	0.04	0.26	0.01	1.07	0.04
Na_2O	10.49	0.48	9.04	0.44	11.02	0.47	10.97	0.47	5.74	0.29	15.35	0.65	15.81	0.75	15.41	0.73
Total	100.01	0.92	100.00	0.88	100.00	0.87	100.00	0.88	100.00	0.79	100.00	0.92	100.01	1.05	99.99	1.05
Fe_2O_3 (Tc)	2.76	n.a.	5.23	n.a.	2.22	n.a.	1.14	n.a.	7.29	n.a.	1.49	n.a.	0.47	n.a.	1.13	n.a.

Pyroxene mineral chemistry

ID	Jd9		Jd10		omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.59	0.65	58.67	0.65	56.17	0.64	57.70	0.65	57.21	0.62	57.33	0.63
TiO_2	0.07	0.00	0.77	0.03	0.29	0.01	0.23	0.01	0.14	0.01	0.41	0.02
Al_2O_3	21.39	0.40	21.32	0.40	11.63	0.29	18.10	0.37	15.70	0.33	17.65	0.35
FeO (T)	1.62	0.07	0.87	0.04	5.34	0.16	3.27	0.11	3.37	0.11	3.00	0.10
MgO	1.92	0.09	2.24	0.11	7.24	0.30	3.64	0.17	5.47	0.22	3.68	0.16
CaO	1.30	0.05	0.97	0.04	9.81	0.17	2.85	0.08	5.54	0.12	3.60	0.09
Na_2O	15.11	0.77	15.15	0.74	9.52	0.53	14.21	0.74	12.57	0.64	14.33	0.72
Total	100.00	1.09	99.99	1.07	100.00	0.95	100.00	1.07	100.00	0.99	100.00	1.04
Fe_2O_3 (Tc)	1.80	n.a.	0.97	n.a.	5.93	n.a.	3.63	n.a.	3.75	n.a.	3.33	n.a.

Allanite mineral chemistry (non std)

ID	aln1	
Oxide	w/w%	+/- 2 σ
SiO_2	32.58	0.51
Al_2O_3	19.70	0.44
FeO	8.42	0.20
MgO	2.83	0.13
CaO	10.80	0.18
La_2O_3	4.63	0.12
Ce_2O_3	12.84	0.30
Nd_2O_3	6.09	0.15
Sm_2O_3	2.10	0.06
Total	99.99	0.82

Xenotime-(Y) mineral chemistry (non std)

ID	xtm1	
Oxide	w/w%	+/- 2 σ
P_2O_5	40.05	0.36
Y_2O_3	35.95	0.33
Gd_2O_3	2.14	0.07
Dy_2O_3	9.08	0.27
Er_2O_3	6.62	0.20
Yb_2O_3	6.17	0.18
Total	100.01	0.62

List of abbreviations in the tables:

ID: measurement position identification
+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
jd: jadeite omp: omphacite aln: allanite xtm: xenotime

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 66/1883.41
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Farnad (today: Farná, Slovakia)
Raw material: Mg-eclogite

Garnet mineral chemistry						
ID	grt1		grt2		grt3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	38.36	0.36	37.59	0.38	37.87	0.37
Al_2O_3	21.93	0.28	19.44	0.27	20.71	0.28
FeO	22.18	0.27	23.84	0.30	26.31	0.31
MnO	1.52	0.05	1.86	0.06	0.35	0.01
MgO	2.26	0.07	2.11	0.07	2.80	0.09
CaO	13.76	0.15	15.15	0.17	11.96	0.15
Total	100.01	0.56	99.99	0.59	100.00	0.58

Pyroxene mineral chemistry						
ID	omp1		omp2		omp3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.19	0.45	56.44	0.44	56.44	0.45
Al_2O_3	8.95	0.16	10.90	0.18	9.72	0.17
FeO (T)	4.72	0.12	4.24	0.11	7.92	0.17
MgO	9.26	0.21	8.54	0.20	7.28	0.18
CaO	14.54	0.17	12.19	0.15	9.92	0.14
Na_2O	6.34	0.22	7.68	0.25	8.72	0.28
Total	100.00	0.60	99.99	0.60	100.00	0.62
Fe_2O_3 (Tc)	5.25	n.a.	4.71	n.a.	8.80	n.a.

Paragonite mineral chemistry		
ID	pg1	
Oxide	w/w%	+/- 2 σ
SiO_2	47.78	0.40
Al_2O_3	39.49	0.41
FeO	1.40	0.05
Na_2O	6.84	0.25
K_2O	2.48	0.05
Total	97.99	0.63

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	30.66	0.30
TiO_2	38.69	0.35
Al_2O_3	1.56	0.04
FeO	0.72	0.03
CaO	28.36	0.23
Total	99.99	0.52

Albite mineral chemistry		
ID	ab1	
Oxide	w/w%	+/- 2 σ
SiO_2	68.64	0.48
Al_2O_3	19.50	0.25
CaO	0.15	0.00
Na_2O	11.71	0.33
Total	100.00	0.64

Epidote mineral chemistry						
ID	ep1		ep2		ep3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	38.92	0.38	39.02	0.38	38.99	0.37
Al_2O_3	28.52	0.33	28.70	0.33	28.84	0.33
Fe_2O_3	7.75	0.17	7.57	0.17	6.74	0.15
MnO	0.76	0.03	0.58	0.02	0.82	0.03
CaO	23.04	0.22	23.13	0.22	23.60	0.22
Total	99.00	0.57	99.00	0.58	99.00	0.57

List of abbreviations in the tables:

ID: measurement position identification
+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
ab: albite ep: epidote grt: garnet omp: omphacite pg: paragonite ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 66/1883.147
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Komáromszentpéter (today: Svätý Peter, Slovakia)
Raw material: jadeitite

Pyroxene mineral chemistry								
ID	Jd1		Jd2		Jd3		Jd4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	59.17	0.50	59.30	0.52	58.37	0.49	59.60	0.51
TiO_2	0.10	0.00	0.13	0.01	n.d.	-	0.93	0.03
Al_2O_3	21.87	0.29	21.76	0.30	18.95	0.26	22.31	0.30
FeO (T)	0.99	0.04	1.21	0.05	3.49	0.11	0.90	0.04
MgO	1.72	0.06	1.42	0.05	2.50	0.08	n.d.	-
CaO	0.85	0.03	0.84	0.03	1.92	0.05	0.77	0.03
Na_2O	15.30	0.44	15.35	0.46	14.77	0.42	15.49	0.45
Total	100.00	0.73	100.01	0.76	100.00	0.71	100.00	0.75
Fe_2O_3 (Tc)	1.10	n.a.	1.34	n.a.	3.88	n.a.	1.00	n.a.

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	63.34	0.49	56.40	0.52	57.01	0.50	56.62	0.49
TiO_2	1.20	0.04	0.45	0.02	0.51	0.02	0.42	0.02
Al_2O_3	8.98	0.16	10.01	0.20	12.63	0.22	10.19	0.19
FeO (T)	4.41	0.12	6.49	0.17	9.57	0.20	5.42	0.14
MnO	0.14	0.01	n.d.	-	n.d.	-	0.16	0.01
MgO	6.70	0.17	7.14	0.21	3.98	0.13	7.72	0.20
CaO	7.80	0.13	11.98	0.18	4.63	0.10	10.43	0.15
Na_2O	7.43	0.25	7.52	0.29	11.66	0.39	9.02	0.31
Total	100.00	0.63	99.99	0.71	99.99	0.72	99.98	0.67
Fe_2O_3 (Tc)	4.90	n.a.	7.21	n.a.	10.64	n.a.	6.02	n.a.

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	31.07	0.33
TiO_2	40.43	0.40
Al_2O_3	1.88	0.05
FeO	0.19	0.01
CaO	26.42	0.25
Total	99.99	0.58

List of abbreviations in the tables:

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n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
jd: jadeite omp: omphacite ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 66/1883.173
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Szőgyén (today: Svodín, Slovakia)
Raw material: Mg-eclogite

Garnet mineral chemistry								
ID	grt1 core		grt1 rim		grt2 core		grt2 rim	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	37.56	0.40	37.64	0.41	37.30	0.40	37.35	0.40
Al_2O_3	21.13	0.31	20.81	0.31	20.97	0.31	20.89	0.31
FeO	30.79	0.36	31.45	0.37	33.33	0.38	34.12	0.38
MnO	1.73	0.06	1.20	0.04	1.53	0.05	1.51	0.05
MgO	2.98	0.10	3.68	0.12	2.80	0.10	3.15	0.10
CaO	5.81	0.10	5.22	0.10	4.07	0.08	2.99	0.06
Total	100.00	0.64	100.00	0.66	100.00	0.65	100.01	0.65

Pyroxene mineral chemistry								
ID	Jd1		Jd2		Jd3		Jd4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	59.08	0.42	58.78	0.47	58.74	0.50	59.20	0.49
Al_2O_3	22.39	0.25	20.87	0.27	21.35	0.28	21.95	0.28
FeO(T)	1.84	0.06	3.32	0.10	2.08	0.07	1.20	0.05
MgO	n.d.	-	n.d.	-	1.79	0.06	1.41	0.05
CaO	1.39	0.03	1.91	0.05	2.08	0.05	0.83	0.03
Na_2O	15.29	0.37	15.13	0.42	13.95	0.41	15.42	0.41
Total	99.99	0.62	100.01	0.69	99.99	0.71	100.01	0.70
Fe_2O_3 (Tc)	2.04	n.a.	3.69	n.a.	2.31	n.a.	1.33	n.a.

Pyroxene mineral chemistry										
ID	omp1		omp2		omp3		omp4		omp5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.95	0.42	56.46	0.45	57.49	0.49	56.09	0.46	57.19	0.48
TiO_2	0.22	0.01	0.22	0.01	n.d.	-	0.16	0.01	n.d.	-
Al_2O_3	11.39	0.17	9.67	0.17	14.05	0.22	8.51	0.15	14.34	0.22
FeO(T)	12.10	0.19	10.33	0.19	8.67	0.19	13.37	0.23	9.01	0.19
MgO	3.27	0.09	5.66	0.15	3.79	0.12	4.82	0.13	3.09	0.10
CaO	5.37	0.09	8.57	0.13	5.50	0.10	8.10	0.12	3.58	0.08
Na_2O	10.71	0.30	9.09	0.29	10.50	0.34	8.94	0.29	12.80	0.39
Total	100.01	0.58	100.00	0.63	100.00	0.68	99.99	0.63	100.01	0.69
Fe_2O_3 (Tc)	13.45	n.a.	11.48	n.a.	9.64	n.a.	14.86	n.a.	10.01	n.a.

Ilmenite and magnetite mineral chemistry				
ID	ilm1		mt1	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
TiO_2	53.45	0.34	11.81	0.15
Al_2O_3	n.d.	-	1.25	0.04
FeO	45.66	0.38	86.20	0.53
MnO	0.90	0.03	0.55	0.02
MgO	n.d.	-	0.18	0.01
Total	100.01	0.51	99.99	0.55

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n.d.:	not detected
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available

grt:	garnet	ilm:	ilmenite	jd:	jadeite	mt:	magnetite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 106/1882.58
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found, uncertain, Mogyoród/Mogyorós, multiple possibilities available
Raw material: omphacitite

Pyroxene mineral chemistry										
ID	omp zone a		omp zone b		omp1		omp2		omp3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.05	0.48	55.70	0.47	55.75	0.46	56.63	0.47	57.88	0.48
Al_2O_3	17.99	0.25	7.87	0.16	6.11	0.13	9.77	0.17	15.65	0.23
FeO(T)	3.70	0.11	8.94	0.19	8.14	0.18	4.94	0.13	5.77	0.14
MnO	n.d.	-	0.24	0.01	0.28	0.01	0.24	0.01	n.d.	-
MgO	3.34	0.10	7.63	0.20	9.26	0.22	8.29	0.20	4.00	0.12
CaO	3.88	0.08	12.14	0.16	13.77	0.17	12.94	0.17	4.63	0.09
Na_2O	13.05	0.39	7.48	0.27	6.68	0.23	7.18	0.24	12.07	0.37
Total	100.01	0.69	100.00	0.65	99.99	0.63	99.99	0.63	100.00	0.68
Fe_2O_3 (Tc)	4.11	n.a.	9.94	n.a.	9.05	n.a.	5.49	n.a.	6.41	n.a.

Albite mineral chemistry				
ID	ab1		ab2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	68.22	0.51	68.78	0.51
Al_2O_3	19.81	0.27	19.21	0.26
CaO	0.37	0.01	0.37	0.01
Na_2O	11.60	0.36	11.65	0.34
Total	100.00	0.68	100.01	0.67

Epidote mineral chemistry						
ID	ep1		ep2		ep3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	41.12	0.39	39.75	0.39	39.61	0.37
Al_2O_3	29.32	0.33	32.35	0.36	31.22	0.36
Fe_2O_3	5.77	0.14	3.59	0.11	7.03	0.17
CaO	22.80	0.22	23.32	0.23	21.14	0.21
Total	99.01	0.58	99.01	0.59	99.00	0.58

Paragonite mineral chemistry				
ID	Pg1		Pg2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	48.20	0.47	46.93	0.44
Al_2O_3	40.57	0.45	38.94	0.39
FeO	0.87	0.04	0.50	0.02
MgO	n.d.	-	2.25	0.07
Na_2O	7.60	0.30	8.94	0.30
K_2O	0.75	0.02	0.44	0.01
Total	97.99	0.72	98.00	0.67

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	30.93	0.32
TiO_2	38.88	0.38
Al_2O_3	2.17	0.06
CaO	28.02	0.25
Total	100.00	0.55

Chlorite mineral chemistry		
ID	chl1	
Oxide	w/w%	+/- 2 σ
SiO_2	31.11	0.38
Al_2O_3	20.36	0.32
FeO	14.84	0.26
MgO	23.35	0.40
CaO	0.34	0.01
Total	90.00	0.68

Pumpellyite mineral chemistry		
ID	pmp1	
Oxide	w/w%	+/- 2 σ
SiO_2	38.16	0.39
Al_2O_3	31.11	0.38
Fe_2O_3	2.42	0.09
MgO	5.56	0.15
CaO	21.75	0.22
Total	99.00	0.61

Pyrrhotite mineral chemistry		
ID	po1	
Elemen	w/w%	+/- 2 σ
Fe	61.26	0.86
Ni	0.68	0.05
S	38.06	0.45
Total	100.00	0.97

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(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
ab: albite chl: chlorite ep: epidote omp: omphactie pg: paragonite
pmp: pumpellyite po: pyrrhotite ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 117/1884.130
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Lekér (today: Hronovce, Slovakia)
Raw material: jadeite

Pyroxene mineral chemistry

ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	59.29	0.53	59.95	0.53	59.04	0.48
TiO_2	0.32	0.01	0.25	0.01	n.d.	-
Al_2O_3	23.77	0.33	22.75	0.31	22.16	0.28
FeO(T)	0.74	0.03	0.89	0.04	0.94	0.04
MgO	n.d.	-	n.d.	-	1.48	0.05
CaO	0.56	0.02	0.89	0.03	1.17	0.03
Na_2O	15.32	0.48	15.28	0.47	15.21	0.41
Total	100.00	0.79	100.01	0.78	100.00	0.69
Fe_2O_3 (Tc)	0.82	n.a.	0.99	n.a.	1.04	n.a.

Pyroxene mineral chemistry

ID	omp1a		omp1b		omp2a		omp2b		omp3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.22	0.47	57.61	0.49	56.01	0.47	57.79	0.50	55.63	0.46
TiO_2	0.45	0.02	0.18	0.01	0.26	0.01	0.20	0.01	0.29	0.01
Al_2O_3	8.57	0.16	16.78	0.25	7.78	0.15	16.39	0.25	7.04	0.14
FeO(T)	11.27	0.21	5.26	0.14	10.95	0.21	5.19	0.14	11.46	0.21
MnO	0.17	0.01	0.11	0.01	0.15	0.01	0.16	0.01	0.17	0.01
MgO	6.02	0.17	2.97	0.09	6.62	0.18	3.43	0.11	7.24	0.19
CaO	8.24	0.13	4.23	0.09	9.49	0.14	4.20	0.09	10.06	0.14
Na_2O	9.05	0.30	12.86	0.39	8.75	0.29	12.63	0.40	8.10	0.27
Total	99.99	0.66	100.00	0.70	100.01	0.65	99.99	0.71	99.99	0.63
Fe_2O_3 (Tc)	12.52	n.a.	5.85	n.a.	12.17	n.a.	5.77	n.a.	12.74	n.a.

Titanite mineral chemistry

ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	31.68	0.33
TiO_2	41.57	0.40
Al_2O_3	1.56	0.04
FeO	0.19	0.01
CaO	25.00	0.23
Total	100.00	0.56
Y_2O_3	1.80	stdless

List of abbreviations in the tables:

ID: measurement position identification

+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.

n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
jd: jadeite omp: omphactie ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 117/1884.213
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Vámosladány (today: Mýtne Ludany, Slovakia)
Raw material: Fe-eclogite

Garnet mineral chemistry						
ID	grt1 core		grt1 rim		grt2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	37.16	0.45	37.41	0.44	37.90	0.37
Al_2O_3	19.23	0.32	19.69	0.31	22.19	0.30
FeO	31.84	0.39	30.99	0.38	31.61	0.34
MnO	1.96	0.06	2.51	0.08	1.00	0.03
MgO	4.17	0.15	4.47	0.15	3.26	0.10
CaO	5.64	0.11	4.92	0.10	4.04	0.07
Total	100.00	0.70	99.99	0.69	100.00	0.60

Pyroxene mineral chemistry				
ID	Fe-jd1		Fe-jd2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.30	0.49	57.61	0.48
TiO_2	0.31	0.01	0.40	0.01
Al_2O_3	16.72	0.25	16.22	0.24
FeO(T)	7.89	0.18	9.01	0.19
MnO	0.20	0.01	0.28	0.01
MgO	2.04	0.07	1.74	0.06
CaO	2.01	0.05	1.80	0.05
Na_2O	13.53	0.42	12.94	0.38
Total	100.00	0.72	100.00	0.68
Fe_2O_3 (Tc)	8.77	n.a.	10.01	n.a.

Pyroxene mineral chemistry												
ID	omp1		omp2		omp3		omp4		omp5		omp6	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.14	0.48	55.61	0.51	57.14	0.48	54.28	0.49	56.56	0.49	55.68	0.50
TiO_2	0.96	0.03	n.d.	-	n.d.	-	0.21	0.01	1.06	0.04	0.21	0.01
Al_2O_3	8.55	0.17	10.72	0.21	12.28	0.20	10.53	0.20	8.66	0.17	10.75	0.20
FeO(T)	16.23	0.27	8.36	0.20	5.21	0.14	13.77	0.25	16.87	0.26	7.93	0.18
MnO	n.d.	-	n.d.	-	n.d.	-	n.d.	-	0.19	0.01	0.15	0.01
MgO	2.67	0.09	6.96	0.21	7.04	0.18	3.40	0.11	2.68	0.09	6.66	0.19
CaO	5.60	0.10	9.96	0.16	8.65	0.13	11.41	0.16	5.85	0.11	10.91	0.16
Na_2O	9.84	0.33	8.40	0.32	9.68	0.31	6.39	0.26	8.14	0.29	7.70	0.29
Total	99.99	0.68	100.01	0.72	100.00	0.66	99.99	0.67	100.01	0.67	99.99	0.68
Fe_2O_3 (Tc)	18.04	n.a.	9.29	n.a.	5.79	n.a.	15.30	n.a.	18.75	n.a.	8.81	n.a.

Ilmenite mineral chemistry	
ID	ilm1
Oxide	w/w%	+/- 2 σ
TiO_2	52.79	0.42
FeO	44.86	0.45
MnO	2.36	0.07
Total	100.01	0.61

List of abbreviations in the tables:

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+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
Fe-jd: iron-bearing jadeite grt: garnet ilm: ilmenite omp: omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 141/1882.44
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Garamkövesd (today: Kamenica nad Hronom, Slovakia)
Raw material: Jadeitite

Pyroxene mineral chemistry						
ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	60.85	0.44	58.81	0.42	59.09	0.44
Al_2O_3	22.71	0.25	20.86	0.23	21.60	0.25
FeO(T)	0.54	0.02	1.08	0.04	1.41	0.05
MgO	n.d.	-	2.28	0.06	2.26	0.06
CaO	0.42	0.01	1.81	0.04	1.67	0.04
Na_2O	15.48	0.35	15.17	0.35	13.96	0.36
Total	100.00	0.62	100.01	0.60	99.99	0.63
Fe_2O_3 (Tc)	0.60	n.a.	1.20	n.a.	1.57	n.a.

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.17	0.42	56.84	0.40	57.11	0.41	59.08	0.43
TiO_2	n.d.	-	0.16	0.01	0.10	0.00	n.d.	-
Al_2O_3	11.42	0.17	11.61	0.16	11.45	0.17	17.44	0.22
FeO(T)	4.81	0.11	4.84	0.11	4.11	0.10	3.89	0.10
MgO	7.55	0.17	7.39	0.16	7.93	0.17	3.39	0.09
CaO	10.31	0.13	10.12	0.12	10.59	0.13	3.99	0.08
Na_2O	8.73	0.25	9.04	0.25	8.72	0.24	12.21	0.32
Total	100.00	0.57	100.00	0.55	100.00	0.56	100.00	0.60
Fe_2O_3 (Tc)	5.35	n.a.	5.38	n.a.	4.57	n.a.	4.32	n.a.

List of abbreviations in the tables:

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+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
jd: jadeite omp: omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 177/1872.I/2
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found, uncertain, Vét or Vék (possibly a settlement Vékpuszta, part of Ógyalla, today: Vék, Hurbanovo, Slovakia)
Raw material: Fe-eclogite

Garnet mineral chemistry										
ID	grt1c		grt1 rim		grt2 core		grt2r		grt3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	38.62	0.37	37.39	0.38	37.73	0.39	37.17	0.43	37.71	0.44
Al_2O_3	22.27	0.29	20.41	0.29	20.52	0.29	19.76	0.31	20.56	0.32
FeO	26.64	0.30	29.74	0.34	30.44	0.34	29.76	0.34	26.32	0.32
MnO	1.46	0.05	0.28	0.01	1.83	0.06	0.77	0.03	2.16	0.06
MgO	6.18	0.16	1.82	0.06	4.79	0.14	1.43	0.06	2.08	0.08
CaO	4.83	0.08	10.36	0.14	4.69	0.08	11.12	0.15	11.16	0.15
Total	100.00	0.59	100.00	0.60	100.00	0.62	100.01	0.65	99.99	0.66

Pyroxene mineral chemistry						
ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.77	0.49	57.73	0.46	57.71	0.49
Al_2O_3	15.44	0.24	16.74	0.23	16.85	0.25
FeO(T)	11.89	0.22	8.80	0.18	9.01	0.19
MgO	1.31	0.05	1.50	0.05	1.33	0.05
CaO	2.77	0.06	2.11	0.05	2.62	0.06
Na_2O	10.83	0.35	13.12	0.38	12.49	0.39
Total	100.01	0.69	100.00	0.67	100.01	0.70
Fe_2O_3 (Tc)	13.21	n.a.	9.78	n.a.	10.01	n.a.

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.56	0.45	56.55	0.48	56.60	0.44	54.22	0.44
TiO_2	0.18	0.01	0.49	0.02	n.d.	-	n.d.	-
Al_2O_3	10.92	0.18	10.68	0.19	10.23	0.16	10.53	0.17
FeO(T)	7.68	0.16	8.90	0.19	8.21	0.16	12.44	0.21
MnO	n.d.	-	n.d.	-	n.d.	-	0.29	0.01
MgO	6.08	0.15	5.87	0.16	6.20	0.15	3.63	0.11
CaO	10.34	0.14	10.10	0.15	10.35	0.14	12.29	0.15
Na_2O	8.23	0.26	7.40	0.26	8.40	0.25	6.61	0.23
Total	99.99	0.61	99.99	0.65	99.99	0.59	100.01	0.60
Fe_2O_3 (Tc)	8.54	n.a.	9.89	n.a.	9.12	n.a.	13.83	n.a.

Ilmenite mineral chemistry						
ID	ilm1		ilm2		ilm3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
TiO_2	53.97	0.40	53.00	0.39	55.14	0.39
FeO	44.83	0.43	45.12	0.43	42.83	0.42
MnO	1.20	0.04	1.88	0.05	2.03	0.06
Total	100.00	0.59	100.00	0.59	100.00	0.58

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(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available

grt:	garnet	ilm:	ilmenite	jd:	jadeite	omp:	omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 300/1876.247
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Almásneszmély, Hungary
Raw material: Fe-Jadeitite

Pyroxene mineral chemistry										
ID	jd1		jd2		jd3		jd4		jd5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.74	0.59	58.46	0.59	58.11	0.61	58.62	0.60	58.54	0.61
Al_2O_3	22.91	0.38	21.40	0.36	21.46	0.38	22.13	0.37	22.12	0.38
FeO(T)	1.76	0.07	2.38	0.08	2.47	0.09	1.36	0.06	1.82	0.07
MgO	1.67	0.08	1.70	0.08	1.88	0.09	1.62	0.07	1.54	0.07
CaO	1.21	0.04	1.68	0.05	1.43	0.04	0.95	0.03	1.30	0.04
Na_2O	13.70	0.65	14.25	0.66	14.65	0.68	15.11	0.68	14.45	0.71
K_2O	n.d.	-	0.12	0.00	n.d.	-	0.22	0.01	0.23	0.01
Total	99.99	0.97	99.99	0.96	100.00	1.00	100.01	0.99	100.00	1.02
Fe_2O_3 (Tc)	1.96	n.a.	2.65	n.a.	2.75	n.a.	1.51	n.a.	2.02	n.a.

Pyroxene mineral chemistry										
ID	omp1		omp2		omp3		omp4		omp5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.23	0.58	55.14	0.57	54.41	0.59	54.33	0.61	55.09	0.55
TiO_2	0.26	0.01	0.29	0.01	0.40	0.02	0.45	0.02	0.31	0.01
Al_2O_3	13.53	0.29	13.19	0.29	11.87	0.28	11.83	0.29	13.55	0.28
FeO(T)	9.71	0.20	10.79	0.21	12.38	0.24	13.07	0.25	9.37	0.19
MnO	0.15	0.01	0.21	0.01	0.23	0.01	0.28	0.01	0.11	0.01
MgO	3.07	0.13	3.36	0.15	2.72	0.13	3.25	0.16	3.29	0.14
CaO	3.91	0.09	3.34	0.08	5.10	0.11	3.65	0.09	3.29	0.07
Na_2O	14.13	0.72	13.67	0.71	12.89	0.70	13.14	0.74	14.98	0.70
Total	99.99	1.00	99.99	1.00	100.00	1.00	100.00	1.04	99.99	0.97
Fe_2O_3 (Tc)	10.79	n.a.	11.99	n.a.	13.76	n.a.	14.53	n.a.	10.41	n.a.

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n.d.:	not detected
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available
jd:	jadeite
omp:	omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 300/1876.264
Ebenhöch Collection, Hungarian National Museum, Budapest
Stray found from Almásneszmély, Hungary
Raw material: Jadeitite

Pyroxene mineral chemistry														
ID	jd1		jd2		jd3		jd4		jd5		jd6		jd7	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.07	0.63	57.88	0.69	57.29	0.69	57.87	0.63	57.82	0.62	57.84	0.64	57.96	0.63
Al_2O_3	19.52	0.37	20.36	0.43	18.48	0.41	20.51	0.38	20.13	0.37	19.96	0.39	20.67	0.39
FeO(T)	2.24	0.08	3.82	0.13	4.76	0.15	2.79	0.10	2.89	0.10	3.07	0.11	2.57	0.09
MgO	2.89	0.14	2.37	0.13	2.45	0.13	1.83	0.09	2.31	0.11	2.06	0.10	1.93	0.09
CaO	2.80	0.07	2.39	0.07	3.21	0.09	1.21	0.04	1.47	0.05	1.52	0.05	1.54	0.05
Na_2O	14.48	0.75	13.17	0.76	13.82	0.83	15.78	0.77	15.38	0.75	15.56	0.82	15.21	0.77
K_2O	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	n.d.	-	0.12	0.01
Total	100.00	1.06	99.99	1.13	100.01	1.17	99.99	1.07	100.00	1.06	100.01	1.12	100.00	1.08
Fe_2O_3 (Tc)	2.49	n.a.	4.25	n.a.	5.29	n.a.	3.10	n.a.	3.21	n.a.	3.41	n.a.	2.86	n.a.

Pyroxene mineral chemistry												
ID	omp1		omp2		omp3		omp4		omp5		omp6	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.38	0.64	55.45	0.61	56.78	0.62	56.01	0.62	55.96	0.63	55.84	0.64
TiO_2	n.d.	-	0.24	0.01	n.d.	-	0.22	0.01	n.d.	-	n.d.	-
Al_2O_3	9.64	0.25	9.21	0.24	9.05	0.23	11.14	0.27	11.03	0.27	8.91	0.24
FeO(T)	4.55	0.14	6.32	0.16	4.06	0.13	4.80	0.14	4.43	0.13	3.95	0.13
MnO	n.d.	-	0.12	0.01	n.d.	-	n.d.	-	0.12	0.01	n.d.	-
MgO	7.21	0.29	7.95	0.31	8.51	0.32	7.23	0.28	7.42	0.30	9.33	0.36
CaO	14.97	0.22	11.85	0.18	14.79	0.21	10.99	0.17	11.86	0.19	15.15	0.22
Na_2O	8.25	0.49	8.85	0.49	6.81	0.38	9.61	0.53	9.18	0.53	6.81	0.41
Total	100.00	0.93	100.00	0.91	100.00	0.86	100.00	0.93	100.00	0.95	100.00	0.91
Fe_2O_3 (Tc)	5.06	n.a.	7.02	n.a.	4.51	n.a.	5.33	n.a.	4.92	n.a.	4.39	n.a.

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	30.25	0.42
TiO_2	38.27	0.41
Fe_2O_3	2.16	0.08
CaO	29.32	0.29
Total	100.00	0.66

List of abbreviations in the tables:

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+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available

jd: jadeite omp: omphactie ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 39/1903
Prehistoric Collection, Hungarian National Museum, Budapest
Stray found from Iszkaszentgyörgy, Hungary
Raw material: Fe-Jadeitite

Pyroxene mineral chemistry						
ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.44	0.52	58.52	0.52	58.06	0.48
Al_2O_3	19.46	0.28	19.65	0.28	18.87	0.25
Fe_2O_3(T)	3.72	0.11	3.95	0.12	4.02	0.12
MgO	1.85	0.06	1.61	0.06	1.87	0.06
CaO	0.86	0.03	1.17	0.04	0.93	0.03
Na_2O	15.67	0.48	15.09	0.48	16.25	0.45
Total	100.00	0.77	99.99	0.78	100.00	0.71
FeO(Tc)	3.35	n.a.	3.55	n.a.	3.62	n.a.

Pyroxene mineral chemistry												
ID	omp1		omp2		omp3		omp4		omp5		omp6	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.18	0.48	57.00	0.49	56.43	0.48	56.83	0.47	57.15	0.49	57.79	0.48
TiO_2	0.61	0.02	0.51	0.02	0.64	0.02	0.42	0.02	0.28	0.01	0.24	0.01
Al_2O_3	11.51	0.20	15.03	0.23	11.37	0.19	11.79	0.19	14.59	0.22	15.53	0.23
Fe_2O_3(T)	11.02	0.22	7.79	0.18	9.87	0.20	8.87	0.18	8.07	0.18	7.52	0.17
MnO	n.d.	-	n.d.	-	0.15	0.01	n.d.	-	n.d.	-	n.d.	-
MgO	3.46	0.11	2.39	0.08	3.95	0.12	4.31	0.12	2.51	0.08	2.13	0.07
CaO	3.81	0.08	3.24	0.07	4.58	0.09	5.21	0.10	2.77	0.07	2.02	0.05
Na_2O	13.42	0.43	14.03	0.44	13.01	0.41	12.58	0.39	14.64	0.45	14.77	0.43
Total	100.01	0.72	99.99	0.73	100.00	0.70	100.01	0.68	100.01	0.73	100.00	0.71
FeO(Tc)	9.92	n.a.	7.01	n.a.	8.88	n.a.	7.98	n.a.	7.26	n.a.	6.77	n.a.

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	33.49	0.33
TiO_2	38.54	0.36
Al_2O_3	1.35	0.03
FeO	0.43	0.02
CaO	26.20	0.23
Total	100.01	0.54
Y_2O_3	0.90	stdless

List of abbreviations in the tables:

ID: measurement position identification
+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
jd: jadeite omp: omphactie ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 3127
Rippl-Rónai Museum, Kaposvár
Stray found from Lábod, Hungary
Raw material: Fe-Jadeitite

Pyroxene mineral chemistry						
ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	59.26	0.46	59.83	0.47	60.36	0.46
Al_2O_3	19.51	0.24	20.31	0.25	19.72	0.23
Fe_2O_3(T)	2.34	0.08	1.39	0.05	2.26	0.08
MgO	1.55	0.05	1.49	0.05	1.30	0.04
CaO	1.50	0.04	0.72	0.02	1.34	0.04
Na_2O	15.85	0.40	16.26	0.41	15.02	0.38
Total	100.01	0.66	100.00	0.68	100.00	0.65
FeO(Tc)	2.11	n.a.	1.25	n.a.	2.03	n.a.

Pyroxene mineral chemistry												
ID	omp1		omp2		omp3		omp4		omp5		omp6	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.22	0.45	58.24	0.44	56.19	0.46	57.18	0.43	57.21	0.44	59.06	0.45
TiO_2	0.66	0.02	0.42	0.02	0.98	0.03	n.d.	-	0.47	0.02	0.27	0.01
Al_2O_3	13.25	0.19	14.30	0.20	11.12	0.18	11.07	0.17	12.45	0.18	16.77	0.21
Fe_2O_3(T)	9.58	0.18	8.29	0.16	12.16	0.21	12.81	0.21	10.89	0.20	5.85	0.13
MnO	0.15	0.01	n.d.	-	0.14	0.01	0.22	0.01	n.d.	-	n.d.	-
MgO	2.36	0.07	1.88	0.05	2.71	0.08	1.87	0.06	2.11	0.06	1.43	0.04
CaO	2.05	0.05	1.69	0.04	2.62	0.06	1.92	0.05	2.06	0.05	0.95	0.03
Na_2O	14.73	0.40	15.17	0.38	14.08	0.41	14.92	0.39	14.81	0.39	15.67	0.39
Total	100.00	0.67	99.99	0.64	100.00	0.68	99.99	0.64	100.00	0.66	100.00	0.64
FeO(Tc)	8.62	n.a.	7.46	n.a.	10.94	n.a.	11.53	n.a.	9.80	n.a.	5.26	n.a.

allanite (non std)		
ID	aln1	
Oxide	w/w%	+/- 2 σ
SiO_2	39.22	0.42
Al_2O_3	21.51	0.32
FeO	9.49	0.16
MgO	2.61	0.08
CaO	8.28	0.11
La_2O_3	2.09	0.04
Ce_2O_3	10.83	0.19
Nd_2O_3	5.97	0.11
Total	100.00	0.61

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available
aln:	allanite
jd:	jadeite
omp:	omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample 81-W2.5
Privet collection of Ernő Wolf, Zirc
Stray found from Zirc, Hungary
Raw material: Mixed jadeitite

Pyroxene mineral chemistry								
ID	jd1		jd2		jd3		jd4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.15	0.50	61.40	0.45	58.19	0.48	59.39	0.48
TiO_2	n.d.	-	n.d.	-	n.d.	-	0.56	0.02
Fe_2O_3(T)	17.77	0.25	21.27	0.23	17.05	0.24	19.32	0.25
Fe_2O_3	4.43	0.12	0.53	0.02	4.48	0.12	2.58	0.08
MnO	n.d.	-	0.10	0.01	0.21	0.01	n.d.	-
MgO	2.11	0.07	n.d.	-	2.27	0.07	1.80	0.06
CaO	2.80	0.07	0.27	0.01	3.96	0.08	1.34	0.04
Na_2O	14.75	0.45	16.43	0.37	13.84	0.42	15.01	0.41
Total	100.01	0.74	100.00	0.63	100.00	0.70	100.00	0.69
FeO(Tc)	15.99	n.a.	19.14	n.a.	15.34	n.a.	17.38	n.a.

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.06	0.43	53.76	0.44	52.72	0.47	54.14	0.47
TiO_2	0.24	0.01	n.d.	-	n.d.	-	0.20	0.01
Al_2O_3	8.27	0.14	6.76	0.13	6.15	0.13	9.06	0.17
Fe_2O_3(T)	10.64	0.19	13.18	0.23	14.97	0.26	10.95	0.21
MnO	0.24	0.01	0.37	0.01	0.43	0.02	0.36	0.02
MgO	5.26	0.14	5.38	0.15	5.29	0.16	4.63	0.14
CaO	10.58	0.14	13.21	0.16	12.37	0.17	11.21	0.16
Na_2O	9.72	0.30	7.34	0.26	8.07	0.31	9.45	0.34
Total	100.01	0.61	100.00	0.62	100.00	0.67	100.00	0.67
FeO(Tc)	9.57	n.a.	11.86	n.a.	13.47	n.a.	9.85	n.a.

allanite (non std)		
ID	aln1	
Oxide	w/w%	+/- 2 σ
SiO_2	39.47	0.42
Al_2O_3	21.48	0.32
FeO	10.60	0.18
MgO	1.26	0.04
CaO	8.78	0.12
La_2O_3	3.63	0.07
Ce_2O_3	10.44	0.19
Nd_2O_3	4.34	0.08
Total	100.00	0.61

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	29.94	0.32
TiO_2	37.22	0.36
Al_2O_3	2.18	0.06
FeO	1.91	0.07
CaO	28.76	0.24
Total	100.01	0.54

List of abbreviations in the tables:

ID: measurement position identification
+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
aln: allanite jd: jadeite omp: omphactie ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample M6-2010-10B.792.2
Institute of Archaeology, Research Centre for Humanities, HAS, Budapest
Lengyel Culture, grave, Alsónyék, Hungary
Raw material: Fe-Jadeitite

Pyroxene mineral chemistry

ID	Fe-jd1		Fe-jd2		Fe-jd3		aeg1	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	59.11	0.53	57.36	0.51	57.90	0.52	55.87	0.51
Al_2O_3	16.35	0.25	12.93	0.21	16.02	0.24	7.98	0.16
FeO(T)	7.15	0.16	10.65	0.20	6.19	0.15	18.74	0.27
MnO	n.d.	-	n.d.	-	n.d.	-	0.13	0.01
MgO	n.d.	-	1.84	0.06	1.97	0.07	1.30	0.05
CaO	1.44	0.04	2.37	0.06	2.69	0.07	2.91	0.07
Na_2O	15.95	0.50	14.84	0.49	15.23	0.48	13.07	0.47
Total	100.00	0.78	99.99	0.77	100.00	0.77	100.00	0.77
Fe_2O_3 (Tc)	7.95	n.a.	11.84	n.a.	6.88	n.a.	20.83	n.a.

Pyroxene mineral chemistry

ID	Jd1		Jd2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	60.22	0.53	59.23	0.53
TiO_2	n.d.	-	0.40	0.02
Al_2O_3	19.62	0.27	18.63	0.26
FeO(T)	2.87	0.09	3.03	0.09
MgO	n.d.	-	1.52	0.05
CaO	0.80	0.03	1.33	0.04
Na_2O	16.48	0.49	15.87	0.48
Total	99.99	0.77	100.01	0.77
Fe_2O_3 (Tc)	3.19	n.a.	3.37	n.a.

Pyroxene mineral chemistry

ID	omp1		omp2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.38	0.51	57.06	0.50
TiO_2	0.17	0.01	0.19	0.01
Al_2O_3	12.58	0.21	12.40	0.21
FeO(T)	9.07	0.18	8.44	0.17
MnO	0.14	0.01	0.30	0.01
MgO	2.79	0.09	3.20	0.10
CaO	4.49	0.09	4.73	0.10
Na_2O	13.37	0.44	13.67	0.45
Total	99.99	0.75	99.99	0.74
Fe_2O_3 (Tc)	10.08	n.a.	9.38	n.a.

Albite mineral chemistry

ID	ab1	
Oxide	w/w%	+/- 2 σ
SiO_2	68.77	0.55
Al_2O_3	19.14	0.27
Na_2O	12.08	0.39
Total	99.99	0.73

Magnetite mineral chemistry

ID	mt1	
Oxide	w/w%	+/- 2 σ
SiO_2	0.69	0.02
Al_2O_3	1.04	0.04
FeO	97.73	0.65
MnO	0.54	0.02
Total	100.00	0.65

Titanite mineral chemistry

ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	30.63	0.34
TiO_2	39.40	0.39
Al_2O_3	0.71	0.02
FeO	0.74	0.03
CaO	28.52	0.26
Total	100.00	0.58

Bornite mineral chemistry (non std)

ID	bn1	
Elem.	w/w%	+/- 2 σ
Fe	18.68	0.23
Cu	55.17	0.52
S	26.15	0.23
Total	100.00	0.62

Epidote mineral chemistry

ID	ep1	
Oxide	w/w%	+/- 2 σ
SiO_2	38.61	0.41
Al_2O_3	25.70	0.34
Fe_2O_3	10.24	0.21
MnO	0.20	0.01
CaO	24.25	0.24
Total	99.00	0.62

allanite (non std)

ID	aln1		aln2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	41.80	0.46	41.09	0.46
Al_2O_3	25.59	0.37	25.96	0.38
FeO	8.03	0.16	7.86	0.16
CaO	14.15	0.17	13.93	0.17
La_2O_3	2.25	0.06	1.49	0.04
Ce_2O_3	5.78	0.14	6.25	0.14
Nd_2O_3	2.41	0.06	3.43	0.09
Total	100.01	0.66	100.01	0.67

List of abbreviations in the tables:

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+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
ab: albite aeg: aegirine aln: allanite bn: bornite ep: epidote
Fe-jd: iron-bearing jadeite jd: jadeite mt: magnetite omp: omphactie ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Sample M6-2010-10B.6348.1
Institute of Archaeology, Research Centre for Humanities, HAS, Budapest
Lengyel Culture, grave, Alsónyék, Hungary
Raw material: Jadeitite

Pyroxene mineral chemistry				
ID	Fe-jd1		Fe-jd2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.99	0.52	58.07	0.52
TiO_2	n.d.	-	1.38	0.05
Al_2O_3	16.03	0.23	10.86	0.18
FeO(T)	4.20	0.12	9.91	0.19
MgO	2.23	0.07	2.24	0.07
CaO	3.44	0.08	2.91	0.07
Na_2O	15.11	0.47	14.63	0.46
Total	100.00	0.75	100.00	0.75
Fe_2O_3 (Tc)	4.67	n.a.	11.01	n.a.

Pyroxene mineral chemistry						
ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	60.04	0.51	60.17	0.52	60.07	0.53
Al_2O_3	21.07	0.27	21.21	0.27	20.69	0.27
FeO(T)	0.90	0.04	1.10	0.05	1.28	0.05
CaO	0.33	0.01	0.28	0.01	0.52	0.02
Na_2O	17.67	0.49	17.23	0.49	17.44	0.50
Total	100.01	0.76	99.99	0.77	100.00	0.78
Fe_2O_3 (Tc)	1.00	n.a.	1.22	n.a.	1.42	n.a.

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.37	0.50	57.33	0.51	57.36	0.50	56.47	0.49
TiO_2	n.d.	-	0.36	0.01	0.35	0.01	n.d.	-
Al_2O_3	9.38	0.16	9.39	0.16	11.41	0.19	10.07	0.17
Fe_2O_3(T)	5.57	0.14	4.68	0.12	4.33	0.12	3.96	0.11
MnO	n.d.	-	n.d.	-	0.14	0.01	n.d.	-
MgO	7.18	0.18	7.35	0.19	6.05	0.16	7.88	0.20
CaO	10.33	0.15	10.58	0.16	8.41	0.14	10.48	0.15
Na_2O	10.16	0.33	10.30	0.34	11.94	0.38	11.14	0.36
Total	99.99	0.68	99.99	0.69	99.99	0.70	100.00	0.69
FeO(Tc)	5.01	n.a.	4.21	n.a.	3.90	n.a.	3.56	n.a.

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	33.79	0.36
TiO_2	35.99	0.38
Al_2O_3	3.34	0.08
FeO	0.57	0.02
CaO	26.32	0.25
Total	100.01	0.58

Albite mineral chemistry		
ID	ab1	
Oxide	w/w%	+/- 2 σ
SiO_2	66.54	0.56
Al_2O_3	20.31	0.28
CaO	1.53	0.05
Na_2O	11.62	0.39
Total	100.00	0.74

List of abbreviations in the tables:
ID: measurement position identification
+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
ab: albite
Fe-jd: iron-bearing jadeite
jd: jadeite
omp: omphactie
ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

M6-2010-10B.6380.1
Institute of Archaeology, Research Centre for Humanities, HAS, Budapest
Lengyel Culture, grave, Alsónyék, Hungary
Raw material: Jadeitite

Pyroxene mineral chemistry								
ID	jd1		jd2		jd3		jd4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	59.08	0.50	58.44	0.49	58.71	0.51	57.91	0.51
Al_2O_3	20.20	0.26	17.92	0.25	18.81	0.26	17.40	0.25
FeO(T)	1.15	0.05	2.62	0.08	2.02	0.07	2.55	0.08
MgO	1.62	0.05	2.67	0.08	2.11	0.07	3.19	0.10
CaO	1.02	0.03	2.69	0.06	2.45	0.06	3.65	0.08
Na_2O	16.94	0.47	15.65	0.45	15.89	0.47	15.30	0.47
Total	100.01	0.74	99.99	0.72	99.99	0.75	100.00	0.75
Fe_2O_3 (Tc)	1.28	n.a.	2.91	n.a.	2.24	n.a.	2.83	n.a.

Pyroxene mineral chemistry										
ID	omp1		omp2		omp3		omp4		omp5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.54	0.49	56.86	0.49	56.35	0.48	56.43	0.49	56.81	0.49
TiO_2	n.d.	-	n.d.	-	n.d.	-	0.21	0.01	0.22	0.01
Al_2O_3	11.05	0.19	11.67	0.19	9.47	0.17	9.41	0.17	12.74	0.21
FeO(T)	3.25	0.10	3.24	0.10	4.01	0.11	4.20	0.11	3.76	0.10
MnO	n.d.	-	n.d.	-	0.16	0.01	0.15	0.01	n.d.	-
MgO	7.86	0.20	7.56	0.19	8.83	0.22	8.85	0.22	5.85	0.16
CaO	9.73	0.15	9.36	0.14	11.66	0.16	11.43	0.16	7.59	0.13
Na_2O	11.57	0.37	11.30	0.36	9.52	0.32	9.31	0.31	13.03	0.41
Total	100.00	0.69	99.99	0.68	100.00	0.67	99.99	0.67	100.00	0.71
Fe_2O_3 (Tc)	3.61	n.a.	3.60	n.a.	4.46	n.a.	4.67	n.a.	4.18	n.a.

List of abbreviations in the tables:

ID:	measurement position identification
+/- 2 σ:	+/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.:	not detected
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available
jd:	jadeite
omp:	omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

M6-2010-10B.6320
Institute of Archaeology, Research Centre for Humanities, HAS, Budapest
Lengyel Culture, grave, Alsónyék, Hungary
Raw material: Mixed jadeitite

Pyroxene mineral chemistry						
ID	Fe-jd1		Fe-jd2		Fe-jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.43	0.50	58.16	0.49	58.21	0.51
Al_2O_3	19.06	0.27	17.99	0.26	19.12	0.28
FeO(T)	5.08	0.14	5.32	0.14	5.39	0.14
MgO	1.71	0.06	2.90	0.09	1.68	0.06
CaO	1.66	0.05	2.73	0.07	1.26	0.04
Na_2O	14.06	0.42	12.90	0.39	14.34	0.43
Total	100.00	0.73	100.00	0.70	100.00	0.74
Fe_2O_3 (Tc)	5.65	n.a.	5.91	n.a.	5.99	n.a.

Pyroxene mineral chemistry								
ID	jd1		jd2		jd3		jd4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	59.75	0.51	60.09	0.52	59.38	0.53	60.23	0.52
Al_2O_3	21.49	0.29	22.67	0.31	21.68	0.31	21.71	0.30
FeO(T)	3.36	0.11	1.83	0.07	3.34	0.11	2.42	0.09
CaO	0.75	0.02	0.52	0.02	0.53	0.02	0.77	0.03
Na_2O	14.64	0.44	14.88	0.44	15.07	0.46	14.86	0.43
Total	99.99	0.74	99.99	0.76	100.00	0.77	99.99	0.74
Fe_2O_3 (Tc)	3.73	n.a.	2.03	n.a.	3.71	n.a.	2.69	n.a.

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.49	0.48	56.76	0.49	56.64	0.47	57.15	0.50
Al_2O_3	9.27	0.17	10.50	0.19	9.60	0.17	12.42	0.22
FeO(T)	8.12	0.18	9.97	0.20	7.93	0.17	8.18	0.19
MnO	0.27	0.01	0.28	0.01	0.21	0.01	0.32	0.01
MgO	7.00	0.18	5.77	0.16	7.15	0.18	4.82	0.14
CaO	11.00	0.15	9.00	0.14	9.56	0.14	6.59	0.12
Na_2O	7.85	0.27	7.71	0.26	8.90	0.28	10.52	0.36
Total	100.00	0.65	99.99	0.66	99.99	0.64	100.00	0.70
Fe_2O_3 (Tc)	9.02	n.a.	11.08	n.a.	8.81	n.a.	9.09	n.a.

List of abbreviations in the tables:

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n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
jd: jadeite Fe-jd: iron-bearing jadeite omp: omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

M6-2010-10-B.3060.3
Institute of Archaeology, Research Centre for Humanities, HAS, Budapest
Lengyel Culture, grave, Alsónyék, Hungary
Raw material: Fe-eclogite

Garnet mineral chemistry										
ID	grt1		grt2		grt3 core		grt3 rim		grt3 zone	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	37.94	0.40	39.40	0.39	37.40	0.40	38.42	0.41	36.82	0.43
Al_2O_3	19.92	0.29	22.04	0.30	21.15	0.31	21.42	0.31	18.53	0.30
FeO	29.34	0.33	25.72	0.31	17.87	0.26	26.82	0.33	27.90	0.35
MnO	0.73	0.03	0.78	0.03	n.d.	-	0.81	0.03	2.51	0.08
MgO	5.64	0.16	6.29	0.17	11.88	0.20	6.24	0.18	1.86	0.07
CaO	6.43	0.11	5.77	0.10	11.69	0.16	6.29	0.11	12.37	0.18
Total	100.00	0.62	100.00	0.62	99.99	0.63	100.00	0.65	99.99	0.67

Pyroxene mineral chemistry												
ID	omp1		omp2		omp3		omp4		omp5		omp6	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	54.65	0.43	55.64	0.44	53.18	0.45	54.06	0.49	54.25	0.49	54.74	0.48
Al_2O_3	8.98	0.15	11.59	0.19	7.64	0.15	10.06	0.19	11.36	0.21	10.80	0.20
Fe_2O_3(T)	11.95	0.21	6.86	0.15	14.40	0.24	9.08	0.20	14.31	0.26	7.28	0.17
MgO	5.24	0.14	6.36	0.16	4.98	0.14	6.13	0.18	2.74	0.09	6.83	0.18
CaO	9.23	0.13	8.99	0.13	11.44	0.15	10.83	0.16	4.82	0.10	9.45	0.14
Na_2O	9.95	0.31	10.56	0.33	8.37	0.30	9.84	0.36	12.51	0.43	10.89	0.37
Total	100.00	0.62	100.00	0.64	100.01	0.65	100.00	0.71	99.99	0.74	99.99	0.70
FeO(Tc)	10.75	n.a.	6.17	n.a.	12.96	n.a.	8.17	n.a.	12.88	n.a.	6.55	n.a.

Ilmenite mineral chemistry		
ID	ilm1	
Oxide	w/w%	+/- 2 σ
TiO_2	53.19	0.43
FeO	45.47	0.46
MnO	1.34	0.04
Total	100.00	0.63

List of abbreviations in the tables:

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n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
grt: garnet ilm: ilmenite omp: omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

N5/47-1939
Janus Pannonius Museum, Pécs
Lengyel Culture, grave, Zengővárkony, Hungary
Raw material: Glaucophane schist

Amphibole mineral chemistry						
ID	amp1		amp2		amp3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	45.23	0.42	42.98	0.42	43.17	0.44
TiO_2	0.22	0.01	0.29	0.01	0.31	0.01
Al_2O_3	17.25	0.25	17.72	0.27	17.54	0.28
FeO	10.31	0.19	10.92	0.20	10.81	0.21
MgO	9.83	0.21	9.72	0.23	10.03	0.24
CaO	5.87	0.10	6.36	0.11	6.39	0.11
Na_2O	8.69	0.28	9.38	0.33	9.07	0.33
K_2O	0.59	0.02	0.63	0.02	0.68	0.02
Total	97.99	0.64	98.00	0.68	98.00	0.70

Pyroxene mineral chemistry								
ID	jd1		jd2		jd3		jd4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.02	0.50	57.14	0.50	57.25	0.49	56.49	0.48
TiO_2	0.15	0.01	0.16	0.01	n.d.	-	n.d.	-
Al_2O_3	19.75	0.28	19.97	0.29	20.09	0.28	19.48	0.27
FeO(T)	2.14	0.08	2.03	0.08	1.31	0.05	1.75	0.07
MgO	2.53	0.08	2.43	0.08	2.47	0.08	3.26	0.10
CaO	3.70	0.08	3.32	0.08	3.21	0.08	3.59	0.08
Na_2O	14.72	0.46	14.96	0.46	15.67	0.45	15.44	0.45
Total	100.01	0.75	100.01	0.76	100.00	0.73	100.01	0.73
Fe_2O_3 (Tc)	2.38	n.a.	2.26	n.a.	1.46	n.a.	1.94	n.a.

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.31	0.48	54.10	0.49	54.91	0.47	55.61	0.46
TiO_2	0.16	0.01	0.33	0.01	n.d.	-	n.d.	-
Al_2O_3	12.15	0.21	9.92	0.19	11.73	0.20	11.82	0.20
FeO(T)	4.44	0.12	4.99	0.14	3.73	0.11	3.56	0.10
MgO	6.81	0.18	8.52	0.22	8.11	0.20	7.81	0.19
CaO	11.56	0.16	13.88	0.18	11.62	0.16	10.75	0.15
Na_2O	9.58	0.34	8.26	0.31	9.91	0.33	10.45	0.34
Total	100.01	0.69	100.00	0.69	100.01	0.67	100.00	0.66
Fe_2O_3 (Tc)	4.93	n.a.	5.55	n.a.	4.15	n.a.	3.96	n.a.

Epidote mineral chemistry				
ID	ep1		ep2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	38.48	0.39	39.42	0.41
Al_2O_3	20.11	0.28	20.78	0.29
Fe_2O_3	11.38	0.21	10.79	0.22
MnO	1.81	0.06	1.76	0.06
MgO	1.45	0.05	1.54	0.06
CaO	25.76	0.24	24.72	0.25
Total	98.99	0.58	99.01	0.61

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(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available
amp:	amphibole
ep:	epidote
jd:	jadeite
omp:	omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

N1/81-1938
Janus Pannonius Museum, Pécs
Lengyel Culture, grave, Zengővárkony, Hungary
Raw material: Mixed jadeitite

Pyroxene mineral chemistry								
ID	jd1		jd2		jd3		jd4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.35	0.50	57.19	0.48	58.67	0.56	58.51	0.48
TiO_2	0.51	0.02	0.38	0.02	n.d.	-	n.d.	-
Al_2O_3	17.02	0.25	17.24	0.24	22.52	0.32	20.61	0.26
Fe_2O_3(T)	4.81	0.13	4.37	0.12	1.05	0.05	1.62	0.06
MgO	2.08	0.07	2.43	0.08	n.d.	-	1.62	0.05
CaO	1.95	0.05	2.04	0.05	0.51	0.02	0.79	0.03
Na_2O	15.28	0.45	16.35	0.46	17.25	0.56	16.85	0.45
Total	100.00	0.73	100.00	0.73	100.00	0.86	100.00	0.72
FeO(Tc)	4.33	n.a.	3.93	n.a.	0.94	n.a.	1.46	n.a.

Pyroxene mineral chemistry										
ID	omp1		omp2		omp3		omp4		omp5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	57.26	0.45	55.95	0.46	55.75	0.46	57.67	0.49	55.83	0.45
TiO_2	n.d.	-	0.28	0.01	0.22	0.01	0.17	0.01	0.29	0.01
Al_2O_3	15.33	0.21	9.76	0.17	9.17	0.16	15.22	0.23	10.05	0.17
Fe_2O_3(T)	4.79	0.13	4.98	0.13	5.37	0.14	4.42	0.13	5.69	0.14
MnO	n.d.	-	n.d.	-	0.13	0.01	n.d.	-	0.14	0.01
MgO	3.47	0.10	8.09	0.19	8.45	0.20	3.78	0.11	7.25	0.17
CaO	3.41	0.07	9.93	0.14	10.26	0.14	4.06	0.09	8.67	0.13
Na_2O	15.74	0.41	11.02	0.34	10.65	0.33	14.67	0.44	12.07	0.35
Total	100.00	0.67	100.01	0.66	100.00	0.65	99.99	0.72	99.99	0.65
FeO(Tc)	4.31	n.a.	4.48	n.a.	4.83	n.a.	3.98	n.a.	5.12	n.a.

Albite mineral chemistry				
ID	ab1		ab2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	68.64	0.49	66.66	0.53
Al_2O_3	18.96	0.24	19.77	0.27
FeO	n.d.	-	0.47	0.02
CaO	0.24	0.01	1.74	0.05
Na_2O	12.17	0.33	11.36	0.35
Total	100.01	0.64	100.00	0.69

Allanite mineral chemistry (non std)		
ID	aln1	
Oxide	w/w%	+/- 2 σ
SiO_2	37.59	0.43
Al_2O_3	21.95	0.35
FeO	9.38	0.17
MgO	2.46	0.08
CaO	8.35	0.12
La_2O_3	3.60	0.08
Ce_2O_3	11.28	0.22
Nd_2O_3	5.38	0.11
Total	99.99	0.65

Epidote mineral chemistry				
ID	ep1		ep2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	40.86	0.41	39.99	0.39
Al_2O_3	31.54	0.36	27.61	0.33
Fe_2O_3	2.52	0.09	8.74	0.19
MnO	n.d.	-	0.21	0.01
CaO	24.08	0.25	22.45	0.23
Total	99.00	0.60	99.00	0.60

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n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
ab: albite aln: allanite ep: epidote jd: jadeite omp: omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

N11/169-1938
Janus Pannonius Museum, Pécs
Lengyel Culture, grave, Zengővárkony, Hungary
Raw material: Fe-mixed jadeitite

Pyroxene mineral chemistry						
ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.24	0.48	58.26	0.46	58.74	0.45
Al_2O_3	20.95	0.27	20.95	0.26	20.56	0.25
Fe_2O_3(T)	2.78	0.09	2.35	0.08	2.16	0.07
MgO	1.37	0.04	1.12	0.04	1.55	0.05
CaO	1.42	0.04	0.73	0.02	1.25	0.04
Na_2O	15.24	0.43	16.58	0.43	15.73	0.39
Total	100.00	0.71	99.99	0.69	99.99	0.66
FeO(Tc)	2.50	n.a.	2.11	n.a.	1.94	n.a.

Pyroxene mineral chemistry										
ID	omp1		omp2		omp3		omp4		omp5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	54.19	0.45	53.70	0.44	53.09	0.43	55.78	0.45	55.93	0.46
TiO_2	0.43	0.02	0.31	0.01	0.46	0.02	0.39	0.01	0.15	0.01
Al_2O_3	11.29	0.19	9.29	0.16	8.78	0.16	14.44	0.22	13.78	0.21
Fe_2O_3(T)	14.36	0.24	14.05	0.24	14.87	0.24	9.97	0.19	10.57	0.20
MnO	0.27	0.01	0.49	0.02	0.35	0.01	n.d.	-	n.d.	-
MgO	2.03	0.07	3.14	0.10	3.66	0.11	2.35	0.07	2.61	0.08
CaO	3.73	0.08	8.18	0.12	8.88	0.13	2.16	0.05	2.88	0.06
Na_2O	13.70	0.42	10.84	0.36	9.90	0.33	14.90	0.43	14.08	0.41
Total	100.00	0.70	100.00	0.65	99.99	0.64	99.99	0.69	100.00	0.69
FeO(Tc)	12.92	n.a.	12.64	n.a.	13.38	n.a.	8.97	n.a.	9.51	n.a.

Allanite mineral chemistry (non std)		
ID	aln1	
Oxide	w/w%	+/- 2 σ
SiO_2	37.52	0.44
Al_2O_3	20.90	0.35
FeO	11.95	0.20
MgO	1.62	0.06
CaO	9.94	0.14
La_2O_3	2.95	0.07
Ce_2O_3	9.44	0.19
Nd_2O_3	5.67	0.12
Total	99.99	0.65

Ilmenite mineral chemistry		
ID	ilm1	
Oxide	w/w%	+/- 2 σ
TiO_2	51.99	0.41
FeO	46.12	0.44
MnO	1.56	0.05
MgO	0.33	0.01
Total	100.00	0.60

List of abbreviations in the tables:

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n.d.:	not detected
(T):	measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc):	calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.:	not available
aln:	allanite
ilm:	ilmenite
jd:	jadeite
omp:	omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Olad-321
Savaria Museum, Szombathely
Lengyel Culture, settlement, Szombathely-Olad, Hungary
Raw material: Fe-eclogite

Garnet mineral chemistry						
ID	grt1		grt2		grt3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	37.43	0.39	38.06	0.43	38.65	0.39
Al_2O_3	20.34	0.30	21.00	0.32	22.56	0.31
FeO	31.68	0.35	28.81	0.35	26.27	0.32
MnO	1.84	0.06	0.74	0.03	1.96	0.06
MgO	3.68	0.12	5.30	0.16	5.76	0.15
CaO	5.02	0.09	6.08	0.11	4.81	0.09
Total	99.99	0.63	99.99	0.67	100.01	0.62

Pyroxene mineral chemistry								
ID	omp1		omp2		omp3		omp4	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	56.60	0.45	55.61	0.49	56.14	0.48	56.04	0.48
TiO_2	0.19	0.01	n.d.	-	n.d.	-	0.19	0.01
Al_2O_3	11.26	0.18	10.33	0.19	14.58	0.22	11.94	0.20
Fe_2O_3(T)	9.32	0.18	6.39	0.16	8.29	0.18	8.49	0.19
MgO	4.56	0.12	6.66	0.18	2.76	0.09	5.11	0.15
CaO	5.88	0.10	10.46	0.16	3.12	0.07	6.14	0.11
Na_2O	12.19	0.36	10.55	0.37	15.10	0.45	12.09	0.39
Total	100.00	0.65	100.00	0.70	99.99	0.73	100.00	0.70
FeO(Tc)	8.39	n.a.	5.75	n.a.	7.46	n.a.	7.64	n.a.

Allanite mineral chemistry (non std)		
ID	aln1	
Oxide	w/w%	+/- 2 σ
SiO_2	36.48	0.43
Al_2O_3	20.68	0.34
FeO	12.01	0.20
MgO	1.93	0.07
CaO	8.49	0.12
La_2O_3	3.14	0.07
Ce_2O_3	10.98	0.21
Nd_2O_3	6.29	0.12
Total	100.00	0.65

Biotite mineral chemistry				
ID	bt1		bt2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	36.01	0.40	31.80	0.38
Al_2O_3	20.63	0.30	17.87	0.29
FeO	19.96	0.29	24.98	0.34
MgO	15.11	0.30	16.61	0.33
K_2O	5.29	0.09	5.75	0.10
Total	97.00	0.66	97.01	0.68

Epidote mineral chemistry				
ID	ep1		ep2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	39.46	0.41	40.89	0.40
Al_2O_3	25.70	0.33	26.34	0.32
Fe_2O_3	10.46	0.22	8.70	0.19
MnO	0.47	0.02	0.07	0.00
CaO	22.91	0.24	23.00	0.24
Total	99.00	0.62	99.00	0.60

Ilmenite mineral chemistry		
ID	ilm1	
Oxide	w/w%	+/- 2 σ
TiO_2	55.12	0.42
FeO	39.87	0.41
MnO	5.00	0.12
Total	99.99	0.60

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n.d.: not detected
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(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
aln: allanite bt: biotite ep: epidote grt: garnet ilm: ilmenite omp: omphactie

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

Olad-329
Savaria Museum, Szombathely
Lengyel Culture, settlement, Szombathely-Olad, Hungary
Raw material: Fe-mixed jadeitite

Pyroxene mineral chemistry						
ID	Jd1		Jd2		Jd3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.88	0.46	59.35	0.48	58.62	0.48
TiO_2	0.22	0.01	n.d.	-	0.38	0.01
Al_2O_3	19.30	0.24	19.55	0.25	18.03	0.24
Fe_2O_3(T)	2.48	0.08	2.71	0.09	3.10	0.10
MgO	1.79	0.05	1.78	0.06	2.29	0.07
CaO	1.33	0.04	1.13	0.03	2.77	0.07
Na_2O	16.00	0.40	15.49	0.42	14.81	0.42
Total	100.00	0.67	100.01	0.69	100.00	0.70
FeO(Tc)	2.23	n.a.	2.44	n.a.	2.79	n.a.

Pyroxene mineral chemistry						
ID	omp1		omp2		omp3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	55.71	0.45	55.52	0.44	54.52	0.45
Al_2O_3	10.80	0.18	9.59	0.16	6.58	0.13
Fe_2O_3(T)	7.23	0.16	8.45	0.17	9.06	0.19
MgO	6.05	0.15	6.53	0.16	8.41	0.20
CaO	10.31	0.14	10.42	0.14	14.30	0.17
Na_2O	9.89	0.31	9.49	0.29	7.12	0.25
Total	99.99	0.63	100.00	0.61	99.99	0.62
FeO(Tc)	6.51	n.a.	7.60	n.a.	8.15	n.a.

Titanite mineral chemistry		
ID	ttn1	
Oxide	w/w%	+/- 2 σ
SiO_2	34.65	0.34
TiO_2	35.34	0.36
Al_2O_3	3.05	0.07
FeO	1.11	0.04
CaO	25.86	0.24
Total	100.01	0.54
Y_2O_3	2.10	stdless

Allanite mineral chemistry (non std)		
ID	aln1	
Oxide	w/w%	+/- 2 σ
SiO_2	39.14	0.44
Al_2O_3	23.60	0.36
FeO	11.20	0.20
MgO	1.31	0.04
CaO	13.74	0.17
La_2O_3	0.99	0.03
Ce_2O_3	5.31	0.13
Nd_2O_3	4.70	0.11
Total	99.99	0.65

Ilmenite mineral chemistry		
ID	ilm1	
Oxide	w/w%	+/- 2 σ
TiO_2	54.40	0.42
FeO	42.99	0.43
MnO	2.61	0.07
Total	100.00	0.61

Chlorite mineral chemistry						
ID	chl1		chl2		chl3	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	33.94	0.37	37.06	0.38	35.79	0.39
Al_2O_3	19.32	0.29	18.62	0.27	17.20	0.27
FeO	17.35	0.26	15.97	0.25	16.76	0.26
MgO	18.69	0.32	16.30	0.30	18.69	0.33
CaO	0.55	0.02	0.48	0.02	0.66	0.02
K_2O	0.14	0.00	1.58	0.04	0.90	0.03
Total	89.99	0.63	90.01	0.61	90.00	0.64

List of abbreviations in the tables:

ID: measurement position identification
+/- 2 σ: +/- 2 sigma values: calculated error of measurements, measured data fall within this range with confidence of approximately 95.45%.
n.d.: not detected
(T): measured total value of an iron-oxide in Na-pyroxenes which can contains bot 2+ and 3+ iron ions
(Tc): calculated total value of the other iron-oxide in Na pyroxenes which can contains bot 2+ and 3+ iron ions
n.a.: not available
aln: allanite chl: chlorite ilm: ilmenite jd: jadeite omp: omphactie ttn: titanite

Note: Since the data were measured during multiple sessions, some differences can be found in the original dataset, especially in FeO vs. Fe_2O_3 assessments of Na-pyroxenes. This issue have been solved with both FeO and Fe_2O_3 values are indicated in the dataset.

99.3.1863
Móra Ferenc Museum, Szeged
Tisza Culture, settlement, Hódmezővásárhely-Gorzsa, Hungary
Raw material: Fe-mixed jadeitite

Garnet mineral chemistry				
ID	grt1		grt2	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	38.02	0.50	37.18	0.52
Al_2O_3	20.22	0.37	19.32	0.37
FeO	26.87	0.40	24.44	0.38
MnO	2.24	0.08	9.50	0.22
MgO	6.26	0.23	3.70	0.16
CaO	6.40	0.14	5.87	0.13
Total	100.01	0.79	100.01	0.80

Pyroxene mineral chemistry										
ID	jd1		jd2		jd3		jd4		jd5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	58.03	0.56	58.10	0.57	58.30	0.60	57.75	0.59	57.78	0.56
TiO_2	0.18	0.01	0.13	0.01	0.10	0.00	0.13	0.01	0.12	0.01
Al_2O_3	18.50	0.30	17.38	0.29	19.51	0.32	17.42	0.30	17.97	0.29
FeO(T)	3.88	0.13	4.89	0.15	4.27	0.15	5.14	0.16	4.68	0.15
MgO	2.39	0.09	3.01	0.11	1.73	0.07	2.52	0.10	2.35	0.09
CaO	2.02	0.06	2.86	0.08	1.51	0.05	2.93	0.08	2.29	0.07
Na_2O	15.00	0.49	13.62	0.46	14.58	0.52	14.10	0.51	14.81	0.49
Total	100.00	0.82	100.00	0.82	100.00	0.87	100.00	0.86	100.00	0.83
Fe_2O_3 (Tc)	4.31	n.a.	5.43	n.a.	4.75	n.a.	5.71	n.a.	5.20	n.a.

Pyroxene mineral chemistry										
ID	omp1		omp2		omp3		omp4		omp5	
Oxide	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ	w/w%	+/- 2 σ
SiO_2	53.36	0.61	54.86	0.54	53.49	0.55	55.88	0.56	55.26	0.56
Al_2O_3	7.66	0.21	9.56	0.20	5.92	0.15	11.03	0.23	8.49	0.20
FeO(T)	15.83	0.33	10.05	0.23	14.41	0.29	12.22	0.26	13.16	0.27
MnO	0.48	0.03	0.32	0.02	0.52	0.03	0.23	0.01	n.d.	-
MgO	4.62	0.19	5.33	0.17	6.02	0.20	3.26	0.12	5.08	0.18
CaO	10.43	0.20	9.84	0.17	11.71	0.19	3.51	0.09	6.94	0.14
Na_2O	7.63	0.40	10.03	0.40	7.93	0.34	13.87	0.51	11.08	0.45
Total	100.00	0.87	100.00	0.78	100.00	0.77	100.00	0.85	100.00	0.82
Fe_2O_3 (Tc)	17.59	n.a.	11.17	n.a.	16.01	n.a.	13.58	n.a.	14.63	n.a.

List of abbreviations in the tables:

ID: measurement position identification
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grt: garnet jd: jadeite omp: omphactie

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