



## High-pressure metabasites: peculiar raw material of Neolithic/Aeneolithic stone implements (Slovakia) and their supposed sources

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Polished stone implements of Neolithic/Aeneolithic age represent an important part of the cultural heritage of mankind. They are represented by maceheads, cells, axes, hammer-axes, wedges, chisels, hoes, bases and others. Systematic laboratory studies, using standard petrographical laboratory methods, e.g. thin section studies under polarizing microscope, electron microprobe determination of rock forming mineral composition yielded in description of several tens of rock types being used as raw materials by Neolithic/Aeneolithic communities occupying the territory of the nowadays Slovak Republic. Among raw material types used in Neolithic/Aeneolithic, except of common raw material types, e.g. different varieties of greenschists, amphibolites, antigorite serpentinites, alkali basalts, but also metaconglomerates, metaquartzites, limy mudstones ao. also individual implements made from soapstone, Al-rich spinel-anthophyllite-hornblende schists, nephritoid schists and others have been documented. To this category belong implements made from jadeitite and eclogites.

### Jadeitite

Slightly damaged on the but end light green of non-expressed trapezoid shape small axe (8x2, 4-2, 7x1,5 cm) was found by an amateur collector on fields just between the villages of Kunov and Sobotišťe in the Senica county in western Slovakia. The axe has symmetrical cross section of oblongue through biconvex shape and asymmetrical edge.

During repeated surveys realised by archaeologists in the broad vicinity of Sobotišťe village rich collection of pottery proving settlement from the Early Linear Pottery to the Baden cultures was found. They document the Early Neolithic to the Middle Aeneolithic ages (Jamárik 1961, Pichlerová 1961, Pavúk 1963). The discussed axe is close in morphology to those axes of the Lengyel culture (Salaš 1986), which is represented in this area by a stage from LgCl (Lengyel culture I) to the Ludanice Group, which corresponds to 1000-1500 years of development.

The assignment of the discussed jadeitite axe to the Lengyel culture time span is supported by the data from close Moravia (the easternmost counties of the Czech Republic) where from jadeitite tools are found more often (Schmidt and Štelcl). Majority of the Moravian jadeitite and nephrite tools belong to the Moravian Painted Pottery culture, which represents a part of the Lengyel culture (Skutil 1946, Podborský 1993).

Rather slight foliation of studied raw material is caused by the presence (visible in thin sections only) of irregular, non-consistent lighter bands. The dominant part of the rock under consideration has very fine-grained (less than 0,1 mm) practically monomineralic (clinopyroxene) composition. In central parts of some clinopyroxene crystals very tiny rutile crystals are present.

Microprobe analyses of clinopyroxene crystals document their unzonal composition with stable high contents of Na (Na-pyroxenes). They correspond to stoichiometric jadeite. Jadeite represent approximately 95 volume per cent of the given rock. Besides the mentioned integral parts of light spots also epidote, zircon and xenotime were identified by microprobe. Jadeite and rutile are typical minerals of eclogite facies pT conditions. Geologically documented jadeitite occurrences in Europe are very rare (D'Amico et. al. 1995). The import of 8 ready-made jadeitite axes from distant sources described from the Moravia counties (Czech Republic) has been supposed also by Schmidt and Štelcl (1971).

### Symplectitic eclogite

The only implement made from symplectitic eclogite is described from the territory of the Slovak Republic (Hovorka and Illášová 1996). It is a fragment of hammer of very fresh appearance found on the site of Nitriansky Hrádok, position Zámeček which is characteristic for its Lengyel culture ceramics as well as by stone implements. A fragment of the hammer has fresh and fine to medium (2-3 mm) grained appearance. By naked eye two main phases are determinable in its composition: purple-red isometric garnet crystals and dark greenish black)

columns of amphibole. So banded fabric with gradual transitions of individual bands are typical of the rock under consideration. Idioblasts of garnet are quantitatively dominant rock constituent of the given type. Around individual garnets kelyphitic rims are developed. They are formed by intensively pleochroic amphibole together with acid plagioclase and quartz. They are also characteristic clinopyroxene inclusions in garnet crystals along with intensive crushing of the last mentioned mineral. The garnets are characteristic for high MgO contents (i.e. pyrope, 40 %) or low MnO contents (spessartine). They are slightly zonal. Zonality occurs with growing contents of FeO, MnO and MgO or lowering CaO content from core to rims. Another mineral phase with a considerable representation is monoclinic amphibole. On the basis of IMA classification (Leake et al. 1997) the analysed amphiboles correspond to pargasites. In the rocks there are also sporadic occurrences of yellowish light-brown crystals of monoclinic pyroxene-omphacite. This is typical mineral of eclogites.

From among other minerals there were detected grass-green spinels in the rocks. Spinel is lobate shape and spatially are connected to ilmenite. Rutile in submicroscopic dimensions is present as inclusions in garnets.

One of the basic rock characteristics is chemical composition. We have managed to analyse a fragment of a hammer for main and trace elements. On the basis of different discriminant diagrams (Pearce & Cann 1973, Pearce & Norry 1979, Mullen 1983 etc.) the projection points fall with the field of MORB. Similarly, the normalized REE curve shows a flattened horizontal course (value around 10) without Eu anomaly. The observed banded fabric and the results of geochemical study point that the likely protolith of the studied eclogite hammer were primary banded rocks (banded gabbro). This magmatic rock has been subducted to pT conditions equivalent to those of the eclogite facies transition.

#### Eclogite with atoll-like garnets

Rich collection of chipped as well as polished stone implements found during systematic excavation of site Svodín in the past (Němejcová-Pavúková, 1971-1983) brought several unexpected implements made from very rarely occurring rock types. The other one is eclogite with atoll-like garnets.

Studied implement is homogeneous in colour, which is ash-grey with brownish tint. Axe is represented by small, flat (4x4x1,5 cm), non-bored type of perfectly preserved shape. On axe surface no products of weathering and precipitation are seen. Rock (raw material of the axe) is extremely hard. The rock under consideration has simple composition. It is composed of two main phases: garnet and pyroxene. In accessory amount also allanite and zircon are present. Very rarely occurring plagioclase (labradorite An<sub>65</sub>) crystals (till 2,5 mm in length) belong to rock peculiarities.

Approximately 90% of garnet crystals have distinctly developed atoll morphology. In thin sections also various stages of garnet crystal homogenisation can be docu-

mented. Based on numerous garnet crystals nuclei in the process of original rock mineral association blastesis, we consider rapid increase but simultaneously short lasting high-pressure pT conditions, which represent the "background" of metamorphic mineral association origin. In general garnet crystals have composition of almandine with substantial portion of pyrope molecule. Atoll garnets have homogeneous composition, in more-or-less homogeneous garnet crystals compositional zonality was detected. Rectangular shape is in favour of idea that such garnet crystals blasted in the rim of plagioclases or even pyroxene crystals. Blastesis of garnets continued inward precursor crystal. The results of this process are more-or-less idioblastic garnet crystals. The total amount of garnets in the given rock is estimated to be 33 volume per cents.

Pyroxene based in its amount is dominant mineral in the rock under discussion. It is present in the form of irregular, but in general in equidimensional small (0,2 mm) crystals. In some crystals compositional zonality, expressed by the presence of two different pyroxene phases in single crystal are detected. Lighter type of pyroxene is enriched in Ca and Mg and depleted in Al and Na. Based on the IMA pyroxene classification (Morimoto et al. 1988) pyroxene studied are plotted in the diagram Q-J to Na-Ca pyroxenes field and in detailed classification of this pyroxene group they are plotted in omphacite field. Generally for pyroxenes studied low to null content of Ti and high content of Na are characteristic.

#### Conclusion

- In the set of more than 300 Neolithic/Aeneolithic implements studied in thin section till now we have identified 3 made from high-pressure metabasites. They have been found on different archaeological sites.
- Symplectite eclogite hammer-axe though its man's adaptation is observable, has been picked up among river Danube cobbles. From the site of its find Danube is approx. 60-70 km far.
- Taking into account geological reality southern slopes of the Bohemian Massif we suppose to be the source area of raw material for the given axe.
- For the almandine-omphacite eclogite made axe, for which raw material atoll-like almandines (composition determined by microprobe) are characteristic geological bodies known in the Mariánské Lázně complex (south-western Bohemian massif) should be raw material provenience.
- Jadeite axe found in western part of the country should have source-raw material in numerous jadeite occurrences in the Western Alps. The distance is around 1000 km.

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