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Petrological and geochemical evidences of the eclogite hammer-axe from the Nitriansky Hrádok site (Neolithic, Lengyel culture, Slovakia)

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Abstract. During excavations realized in the past on site Nitriansky Hrádok (Neolithic, Lengyel culture, Slovakia) the eclogite hammer-axe has been found. For the recostruction of the source raw material we used chemical composition of garnets, pyroxenes, amphiboles and plagioclases as well as chemical composition of the hammer-axe studied. On the base of reference raw materials we suppose that eclogite (raw material of the hammer-axe) originated in the Bohemian Massif (Moldanubian, Gföhl terrane). Raw material should have been transported by the Danube river, or imported.

Key words: Nitriansky Hrádok, Neolithic, eclogite, hammer-axe, polished stone

Introduction

Polished stone industry is an important part of stone artefacts produced since the Neolithic to the Early Bronze Age. It is represented by cells, axes, axe-hammers, mace-heads and wedges. A systematic investigation of Neolithic polished industry in Slovakia has begun (Illášová 1989, Hovorka & Illášová 1995, 1996, 2000, Illášová & Hovorka 1995, Hovorka & Cheben 1997, Hovorka et al. 1997) very recently.

Some groups of appropriate raw materials recurrent during the whole Neolithic period up to the Early Bronze Age are outlined in a great amount of petrologically analysed polished stone artefacts.

High-grade metamorphic rock originated under transitional granulite/eclogite facies pT conditions used for polished artefact is represented by a unique type of raw material in the territory of the Slovak Republic. We present detailed petrological analyse of garnets, clinopyroxenes, amphiboles and feldspars of the symplectitic eclogite hammer-axe from the Nitriansky Hrádok site (Fig. 1).

The site Nitriansky Hrádok is situated on the northern foothill of the western segment of the Carpathian Arc. Several mountains ranges (the Tribeč Mts., being the closest one) are located to the north. Northern promontory of the Hungarian Plain is situated to the south, river Danube is 35 km far. Site Nitriansky Hrádok - Zámeček is located on the loess cliff surrounded by inundation plains of the Cítenka and Žitava brooks (Pavúk 1981).

The hammer-axe was found in Neolithic position of the Lengyel culture (No. 145/52, object No. 4). The site is a polycultural one. From the total number of 82 analysed polished artefacts 20 belong to Neolithic Lengyel culture, 12 to Aeneolithic Baden culture and 50 to the Early-Bronze Age Maďarovce culture.

Fig. 1 Location of the site Nitriansky Hrádok

Description of the eclogite hammer-axe

A stone hammer-axe found in the site of Nitriansky Hrádok (position Zámeček), is till now the only one made from eclogite (Hovorka & Illášová 1996). The hammer-axe (Fig. 2A) represents the most probably originally river cobble. It is of very fresh appearance without any observable products of weathering. Fragment is fine- to medium grained (2-3 mm) and by naked eyes two main components are detectable: pourple-red isometric garnets and dark-green till greenish-black columns of amphiboles. The distribution of mentioned minerals in detail is uneven: amphiboles as well as garnets are concentrated in 1 - 1,5 cm thick bands, which are observable namely in thin section. So banded fabrics (with gradual transition of individual bands) for the rock under consideration is characteristic. Except of banding caused by predominance of one of the main minerals (garnet: amphibole) bands differ by the size of phases present. Bands with prevailing

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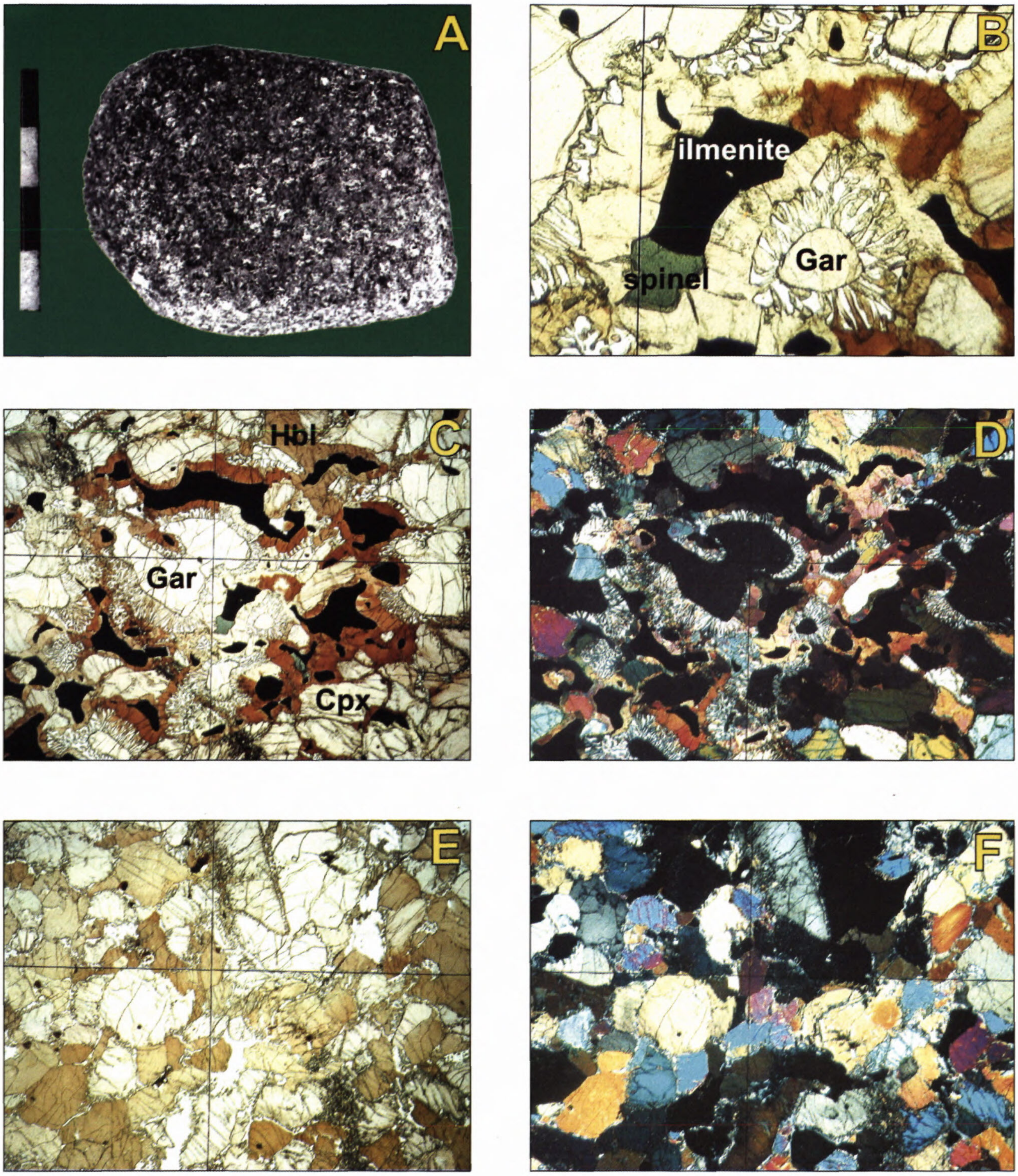

Fig. 2 Eclogite hammer-axe. A. Fragment of eclogite hammer-axe. B. Symplectite around garnet and green spinel on contact with ilmenite. Parallel polars. C. Position in eclogite composed of prevailing garnets and with kelyphitic structure. Parallel polars. D. Micrograph as C. Crossed polars. E. Position in eclogite composed of prevailing clinopyroxenes. Parallel polars. F. Micrograph as Fig. E. Crossed polars.

idioblastic garnets are coarse-grained in comparison to those composed of amphiboles.

In thin sections of studied artefact the following mineral assemblage have been found:
garnet+clinopyroxene+amphibole+kelyphite (Qtz+Plg+Hbl).

Idioblasts of garnets are the quantitatively dominant phase. Garnets contain enclosures of Cpx and are pronouncedly tectonically crushed with well developed systems of cracks of various orientation. Around individual garnets crystals kelyphite rims (Fig. 2B,C,D) are developed. They are formed by intensively brownpleochroic hornblend together with acid plagioclase ± quartz. The second main mineral phase is brown monoclinic hornblende (amphibole). Its pleochroic colours varies between yellowish-brown (in alpha direction) to chocolate-brown (in gama direction). Hornblende/amphibole crystals are very fresh. Characteristic are sporadically present yellowish-brown monoclinic pyroxenes. Typical accessory phase is grass-green spinel. Spinel forms lobate (0,X mm) grains spatially connected with ilmenite crystals (Fig. 2B). Rutiles of submicroscopic dimensions are present in the form of inclusions in garnets. Fine-grained quartz is a component of the kelyphitic rims. Opaques dominantly belong to ilmenite.

Composition of the minerals

From the rock forming minerals present in the given raw material type by the use of electron microprobe JEOL Superprobe 733 we analysed (under standard operation conditions: Geological Survey of the Slovak Republic) garnets, amphiboles, pyroxenes and plagioclases.

Garnets. In analysed garnets substantially are present molecules of pyrop (36-44 %), grossular (25-34 %) and almandine (24-29 %). Contents of spessartite molecule is low (1-2 %). On the diagram pyr:alm+spess:gross (Fig. 3) plots of studied garnets are projected in the central part of the diagram. Garnets are weakly zonal, the content of FeO, MgO, and MnO in direction core - rim of crystals has increasing, and the content of CaO decreasing tendency.

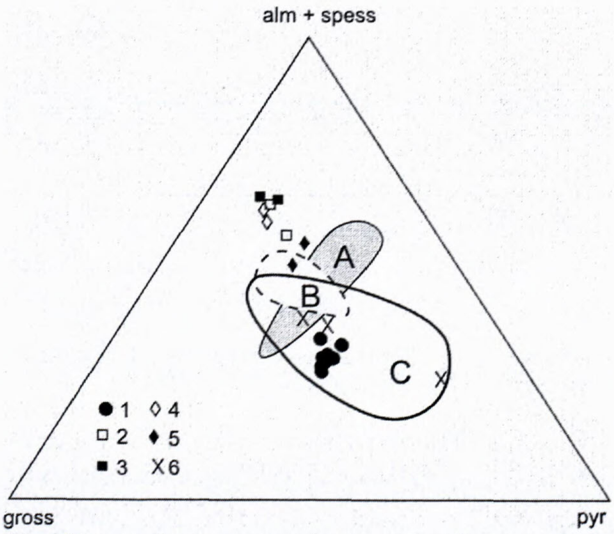

Fig. 3 Ternary diagram gross: alm+spess : pyr for study garnets. 1 = garnets from eclogite hammer-axe (Tab. 1), 2 – 5 = composition of garnets from the Western Carpathians core mountains garnet-pyroxene matabasites (Janák et al. 1997), 6 = garnets from eclogites of Gföhl terrane (data in Beard et al. 1992, Tab. 2 - garnets from sample CZ2E, CZ2G, CZ14F). A = field of garnets from Cpx-bearing granulites of the St. Leonard granulite massif, Austria (data in Cooke 2000), B = field of garnets from eclogites of the Silvretta nappe, Eastern Alps (data in Schweinehage & Massonne 1999), C = field of garnets from eclogites of the Bohemian Massif Moldanubian Zone (data in Dudek 1971; O'Brien & Vrána 1995; Beard et al. 1992; Carswell & O'Brien 1993; Medaris et al. 1995; Medaris et al. 1998).

Tab. 1 Selected analyses of garnets from eclogite hammer-axe

	1r	1r-c	1c	2	3	4r	4c
SiO_2	38,70	38,44	39,89	38,26	38,80	40,71	39,40
TiO_2	0,28	0,43	0,60	0,44	0,57	0,41	0,62
Al_2O_3	22,63	22,16	21,97	21,79	21,84	22,10	22,32
FeO_{tot}	16,26	15,15	14,16	16,53	14,77	15,56	14,07
MnO	0,46	0,41	0,37	0,69	0,31	0,54	0,29
MgO	10,49	10,69	10,26	9,40	10,19	12,08	10,36
CaO	10,90	12,04	13,27	11,89	12,49	10,15	13,05
TOTAL	99,72	99,32	100,52	99,00	98,97	101,55	100,11
X(grs)	0,30	0,33	0,36	0,33	0,34	0,26	0,35
X(alm)	0,29	0,24	0,26	0,29	0,26	0,29	0,25
X(sps)	0,01	0,01	0,01	0,02	0,01	0,01	0,01
X(prp)	0,40	0,41	0,38	0,36	0,39	0,44	0,39

c = core, r = rim

Tab. 2 Selected analyses of amphiboles from eclogite hammer-axe

	1	2	3	4	5	6
SiO_2	40,81	41,06	41,72	41,33	41,99	41,48
TiO_2	3,83	2,55	2,22	1,49	3,22	3,22
Al_2O_3	16,19	16,58	16,32	16,80	16,01	16,62
FeO_{tot}	9,76	10,39	9,35	10,05	9,81	10,27
MnO	0,16	0,15	0,15	0,08	0,21	0,12
MgO	12,37	12,25	12,88	12,98	12,25	12,32
CaO	11,21	11,79	11,16	10,66	10,95	11,03
Na_2O	3,82	3,49	3,64	3,23	3,70	3,55
K_2O	0,00	0,00	0,01	0,49	0,01	0,01
TOTAL	98,15	98,26	97,44	97,10	98,15	98,62
Formula based on calculation Schumacher´s 1997						
Si^{IV}	5,87	5,93	6,01	5,97	6,01	5,92
Al^{IV}	2,13	2,07	1,99	2,03	1,99	2,08
Sum T	8,00	8,00	8,00	8,00	8,00	8,00
Al^{VI}	0,61	0,76	0,77	0,83	0,70	0,71
Ti	0,41	0,28	0,24	0,16	0,35	0,35
Fe^{3+}	0,42	0,26	0,46	0,57	0,50	0,51
Mg	2,65	2,64	2,76	2,79	2,61	2,62
Fe^{2+}	0,75	1,00	0,65	0,56	0,67	0,69
Mn	0,02	0,02	0,01	0,01	0,03	0,01
Sum C	4,87	4,94	4,89	4,92	4,86	4,88
Mg	0,00	0,00	0,00	0,00	0,00	0,00
Fe^{2+}	0,00	0,00	0,01	0,08	0,00	0,02
Mn	0,00	0,00	0,01	0,01	0,00	0,01
Ca	1,73	1,82	1,72	1,65	1,68	1,68
Na	0,27	0,18	0,26	0,27	0,32	0,29
Sum B	2,00	2,00	2,00	2,00	2,00	2,00
Na	0,79	0,80	0,76	0,64	0,70	0,69
K	0,00	0,00	0,00	0,09	0,00	0,00
Sum A	0,79	0,80	0,76	0,73	0,70	0,70

1, 5, 6 = amphiboles from matrix; 2, 3, 4 = amphiboles from symplectites

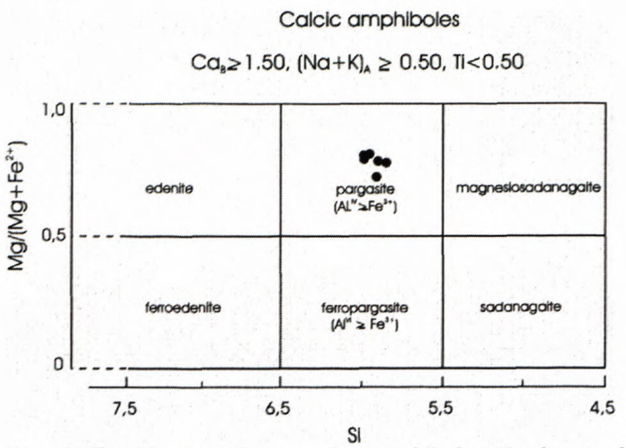

Fig. 4 Classification diagram for amphiboles (Leake et al. 1997) – dots represent projections of studied amphiboles from the eclogite-hammer-axe.

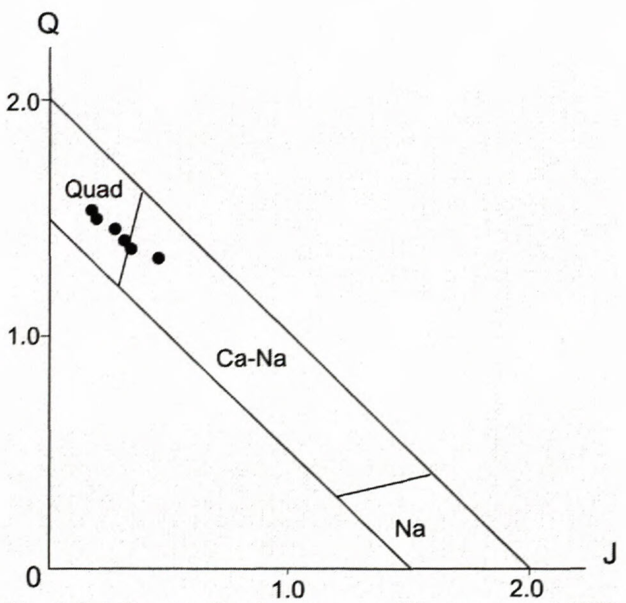

Fig. 5 Q-J diagram for the pyroxenes (Morimoto et al 1988), Quad = field of Ca-Mg-Fe pyroxenes, Ca-Na = field of Ca-Na pyroxenes, Na = field of Na pyroxenes. Dots represent projections of pyroxenes from the studied hammer-axe.

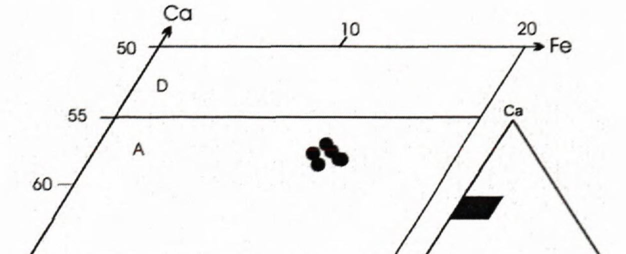

Fig. 6 Classification diagram for Ca-Mg-Fe clinopyroxenes (Morimoto et al. 1988). Dots represent projections of clinopyroxenes from the studied eclogite-hammer-axe

Amphiboles. Analysed amphiboles (Tab. 2) in the IMA amphibole classification (Leake et al. 1997) correspond to pargasites (Fig. 4). For analysed amphiboles relativelly high contents of Ti and Na are characteristic. Amphiboles forming symplectites and those of the groundmass have identical composition. No significant differences are in the Ti content. Pargasites are known to occur in retrogressively rectrystallized eclogites.

Clinopyroxenes. For the studied clinopyroxenes relativelly high content of Na is characteristic. Following Cpx classification (IMA, Morimoto et al. 1988) clinopyroxenes studied belong to the group of Ca-Mg-Fe pyroxenes. In the Q-J diagram only one analyse is plotted in the field of Ca-Na pyroxenes (Fig. 5). In the classification diagram Ca-Mg-Fe pyroxenes (Fig. 6) plots of realised analyses form coherent field in the augite portion of the diagram. Based on the transitional character of analysed Cpx which is conditioned by relativelly high Na content, we have used diagam Q-Jd-Ae (Fig. 7). Plot of the majority of studied clinopyroxenes is in the Quad (Ca-Mg-Fe pyroxenes) field, the plot of the only one analyse is projected in the field of omphacite. This mineral is characteristic for eclogites. Composition of analysed clinopyroxenes shows that given rock represent retrogresivelly recrystallized eclogite.

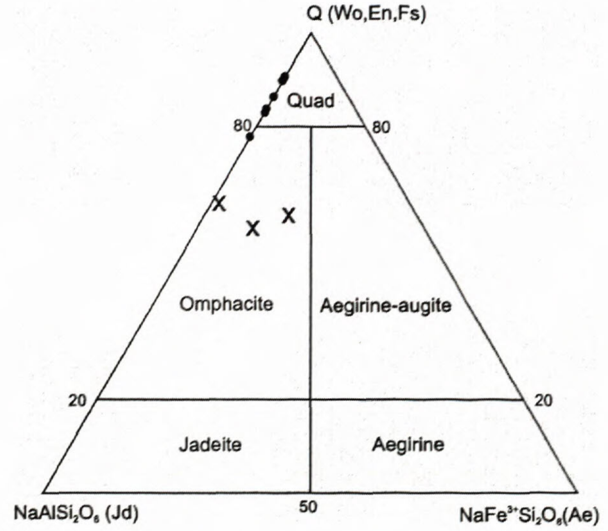

Fig. 7 Ca-Mg-Fe and Na pyroxenes with accepted names (Morimoto et al. 1988). Dots represent projections of clinopyroxenes from studied hammer-axe. Cross represent clinopyroxenes from eclogite from Gföhl terrane (data in Beard et al. 1992, Tab. 2 – clinopyroxenes from sample CZ2E, CZ2G, CZ14F)

Feldspars. The next minerals analysed were plagioclases (Tab. 4). Plagioclases in the high-grade metabasites represent typical product of retrogressive recrystallization. They originate by the breakdown of Ca-Na pyroxenes, or Na pyroxenes respectivelly. Reaction of this proccess is as follows: omphacite › diopsidic clinopyroxene + plagioclase, or Ca-amphibole + plagioclase. Analysed plagioclases are present in symplectites only. The Ca contents in plagioclases is stabile and is equal to An_{60}.

Composition of the rocks

From the hammer-axe studied we have at our disposal chemical analyse (determined main oxides as well as selected trace elements, Tab. 5) by the use of AES-ICP in Ecological Laboratories in Spišská Nová Ves.

Tab. 3 Selected analyses of clinopyroxenes from eclogite hammer-axe

	1	2	3	4	5	6
SiO_2	51,24	50,33	50,57	50,26	50,09	51,92
TiO_2	1,35	1,46	1,38	1,45	1,36	1,10
Al_2O_3	9,48	9,84	8,91	8,41	9,65	9,91
Cr_2O_3	0,00	0,00	0,00	0,00	0,00	0,00
FeO_{tot}	6,15	6,49	6,12	6,48	6,54	5,40
MnO	0,08	0,14	0,19	0,17	0,17	0,12
MgO	11,19	10,76	11,67	12,15	10,62	10,60
CaO	19,75	18,83	20,92	20,21	18,50	17,95
Na_2O	1,97	2,32	1,47	1,32	2,41	3,21
K_2O	0,00	0,00	0,01	0,00	0,00	0,00
TOTAL	101,21	100,17	101,24	100,45	99,34	100,21
Formula based on 6 oxygens						
Si	1,86	1,84	1,84	1,84	1,85	1,88
Al^{IV}	0,14	0,16	0,16	0,16	0,15	0,02
Al^{VI}	0,26	0,27	0,22	0,21	0,27	0,31
Ti	0,04	0,04	0,04	0,04	0,04	0,03
Cr	0,00	0,00	0,00	0,00	0,00	0,00
Fe^{3+}	0,00	0,00	0,00	0,00	0,00	0,00
Fe^{2+}	0,19	0,20	0,19	0,20	0,20	0,16
Mn	0,00	0,00	0,01	0,01	0,01	0,00
Mg	0,60	0,59	0,63	0,66	0,58	0,57
Ca	0,77	0,74	0,81	0,79	0,73	0,70
Na	0,14	0,16	0,10	0,09	0,17	0,23
K	0,00	0,00	0,00	0,00	0,00	0,00
Calculation after R.G.Cawthorn and K.D.Collerson, 1974						
Jd	13,65	16,35	10,32	9,30	17,15	22,42
Ac	0,00	0,00	0,00	0,00	0,00	0,00
Aug	86,35	83,65	89,68	90,70	82,85	77,58

Tab. 4 Selected analyses of feldspars from eclogite hammer-axe

	1	2	3	4	5	6
SiO_2	51,95	53,17	53,78	54,95	53,71	54,43
Al_2O_3	30,70	30,05	29,58	28,95	29,56	28,96
FeO_{tot}	0,11	0,00	0,01	0,00	0,00	0,00
CaO	13,31	13,55	12,48	12,22	11,91	11,85
Na_2O	3,90	3,85	4,02	4,52	4,71	4,92
K_2O	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL	99,97	100,62	99,87	100,64	99,89	100,16
Formula based on 8 oxygens						
Si	2,36	2,39	2,43	2,46	2,43	2,45
Al	1,64	1,59	1,57	1,53	1,57	1,54
Ca	0,65	0,65	0,60	0,59	0,58	0,57
Na	0,34	0,34	0,35	0,39	0,41	0,41
K	0,00	0,00	0,00	0,00	0,00	0,00
or	0,00	0,00	0,00	0,00	0,00	0,00
alb	34,66	33,97	36,83	40,01	41,72	42,91
an	65,34	66,03	63,17	59,90	58,28	57,09

In the plot FeO_{tot} : Na_2O+K_2O : MgO (Fig 8, Irvine & Baragar 1971) raw material of the implement studied (x) is plotted in the field of tholeiites. In the diagram $FeO_{tot}+TiO_2$: Al_2O_3 : MgO (Fig 9, Jensen 1976) plot is located in the field tholeiites (HMT - high-Mg tholeiites).

Normalised (Sun 1982) pattern of the REE of the hammer-axe studied has relativelly flat (around the value of 10) position without Eu anomaly (Fig. 10), which is characteristic for the N-MORB basalts.

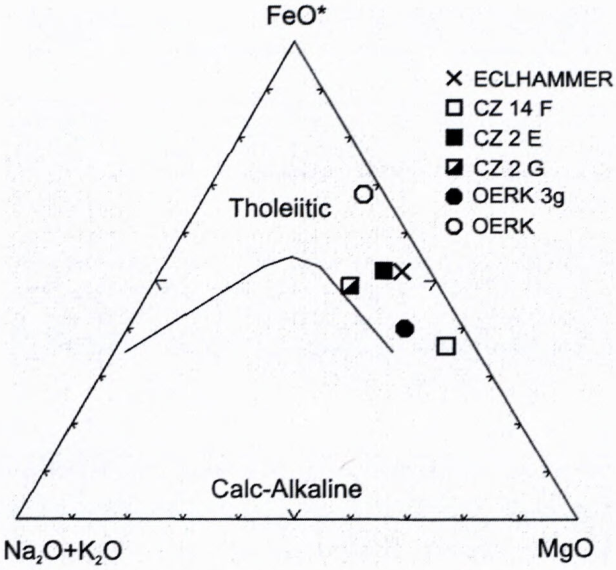

Fig. 8 Chemical composition of eclogite hammer-axe and composition of comparative eclogites of the Bohemian Massif and the Eastern Alps in Irvine and Barager's (1971) diagram. Rock analyses are in Tab. 5.

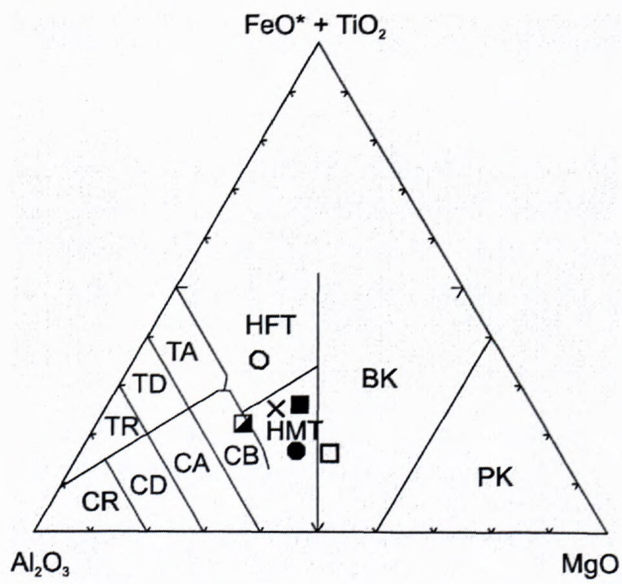

Fig. 9 Chemical composition of eclogite hammer-axe and eclogites of the Bohemian Massif and the Eastern Alps in the Jensen's (1976) diagram. Rock analyses are in Tab. 5.
Designation of fields: TR-Tholeiitic Rhyolite, TD-Tholeiitic Dacite, TA-Tholeiitic Andesite, CR-Calc-alkaline Rhyolite, CD-Calc-alkaline Dacite, CA-Calc-alkaline Andesite, CB-Calc-alkaline Basalt, HFT-High-Fe Tholeiite, HMT-High-Mg Tholeiite, BK-Basaltic Komatiite, PK-Peridotitic Komatiite.

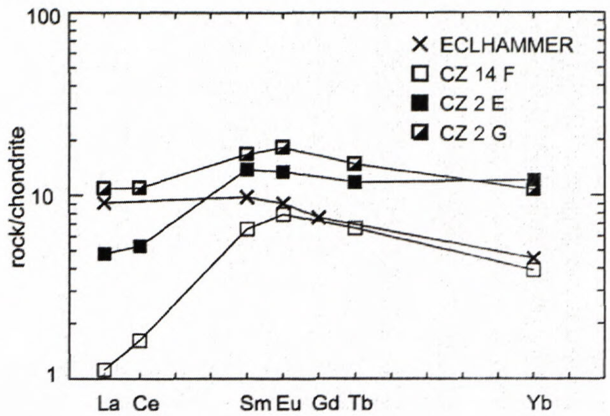

Fig. 10 REE normalized pattern from the eclogite hammer-axe and eclogites of the Bohemian Massif (Analyses in Tab. 5). Normalization on chondrite model (Sun 1982).

Tab. 5 Chemical composition of eclogite hammer-axe (ECLHAMMER), eclogites from Silvretta nappe (Eastern Alps, sample OERK and OERK 3g - Schweinehage & Massonne 1999) and eclogites from the Gföhl Unit (Moldanubian zone of the Bohemian Massif – sample CZ 2 E, CZ 2 G, CZ 14 F - Beard et al. 1992, Medaris et al. 1995).

Sample	ECLHAMMER	OERK	OERK 3g	CZ 2 E	CZ 2 G	CZ 14 F
Rock type	eclogite	eclogite	eclogite	eclogite	eclogite	eclogite
SiO_2	42,56	41,53	47,63	44,00	48,78	45,20
TiO_2	2,10	3,47	0,53	1,26	1,22	0,56
Al_2O_3	17,59	17,57	15,72	16,54	18,08	17,58
Fe_2O_3	13,19	0,24	1,82	13,87	10,88	10,61
FeO	0,00	17,14	6,86	0,00	0,00	0,00
MnO	0,23	0,36	0,15	0,22	0,19	0,17
MgO	9,48	7,19	10,51	10,23	7,10	15,38
CaO	13,76	9,91	12,49	12,58	10,58	11,12
Na_2O	1,25	0,94	2,09	1,55	3,03	1,27
K_2O	0,10	0,00	0,13	0,02	0,09	0,03
P_2O_5	0,01	0,95	0,02	0,03	0,16	0,03
H_2O	0,08	0,49	1,24	0,00	0,00	0,00
CO_2	0,29	0,07	0,08	0,00	0,00	0,00
LOI	0,14	0,00	0,00	0,29	0,00	0,03
TOTAL	100,78	99,86	99,27	100,59	100,11	101,98
Cr	318	28	457	332	168	386
V	322	275	176	nd	nd	nd
K	830	0	1079	166	747	249
Ba	81	8	6	97	nd	246
Sr	103	26	87	110	220	148
Ta	1,0	3,0	5,0	0,23	0,12	0,02
Hf	1,0	3,0	3,0	1,0	1,81	0,55
Zr	8	248	43	70	50	nd
Ti	12589	20803	3177	7554	7320	3357
Y	10	81	14	nd	nd	nd
La	3,00	nd	nd	1,59	3,59	0,37
Ce	nd	nd	nd	4,60	9,50	1,40
Sm	2,0	nd	nd	2,82	3,41	1,34
Eu	0,70	nd	nd	1,04	1,41	0,61
Gd	2,10	nd	nd	nd	nd	nd
Tb	nd	nd	nd	0,59	0,74	0,33
Yb	1,00	nd	nd	2,67	2,37	0,86

(main oxides in wt %, trace elements in ppm)

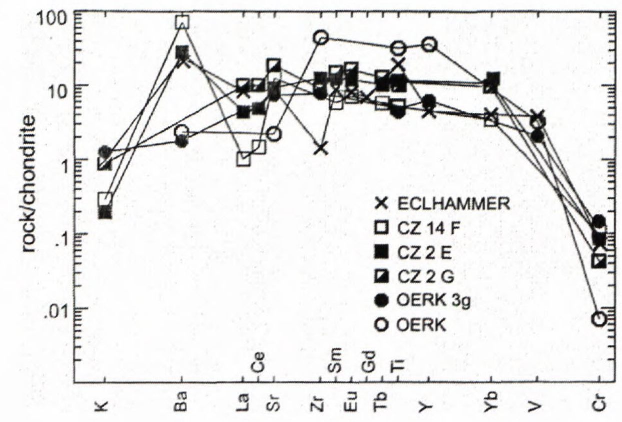

Fig. 11. Extended plots of selected elements of the eclogite hammer-axe and eclogites of the Bohemian Massif and the Eastern Alps. Normalization on chondrite model (Taylor & McLennan 1985). Analyses are in Tab. 5.

Discussion and conclusion

Eclogites are the raw material of many polished axes of the Neolithic to Bronze Age. These tools are very abundant in northern Italy and southern and eastern France, and are more sporadically present in a great part of the rest of Europe. Provenance of this eclogitic rocks is the Piemonte zone of the Western Alps (D'Amico et al. 1995, D'Amico & Starnini 2000). Single eclogite/jade finds are know in many European countries. Numerous eclogitic artefacts (tools) have been described from the eastern part of the Czech Republic (Schmidt & Štelcl 1971, Štelcl & Malina 1972).

From the territory of the Slovak Republic till now only two occurrences of implements (axe and axe-hammer) made from eclogitic rocks are known:

(1) axe/axe-hammer made from symplectitic eclogite (Nitriansky Hrádok: Hovorka & Illášová 1996), and

(2) small axe made from almandine-omphacite eclogite (Nitriansky Hrádok: Spišiak & Hovorka, 2001, Spišiak et al. 2001)

Raw material for production of the first mentioned implement according to Hovorka and Illášová (1996) was river cobble eclogite transported by the river Morava and consequently by the river Danube from the eastern rim of the Bohemian Massif. Mentioned authors in the case of axe from site Svodín they consider transport of already ready made implement from the Marianske Lázne complex located on the southwestern part of the Bohemian Massif. Theoretically eclogite made from the symplectitic eclogite should have originated:

1. from the crystalline complexes of the Western Carpathians,
2. from the cobbles of the Cretaceous conglomerates from the Western Carpathians Klippen belt,
3. from the Eastern Alps,
4. from the Bohemian Massif.

Ad 1) In the Western Carpathians within the pre-Carboniferous complexes there occur small enclaves of

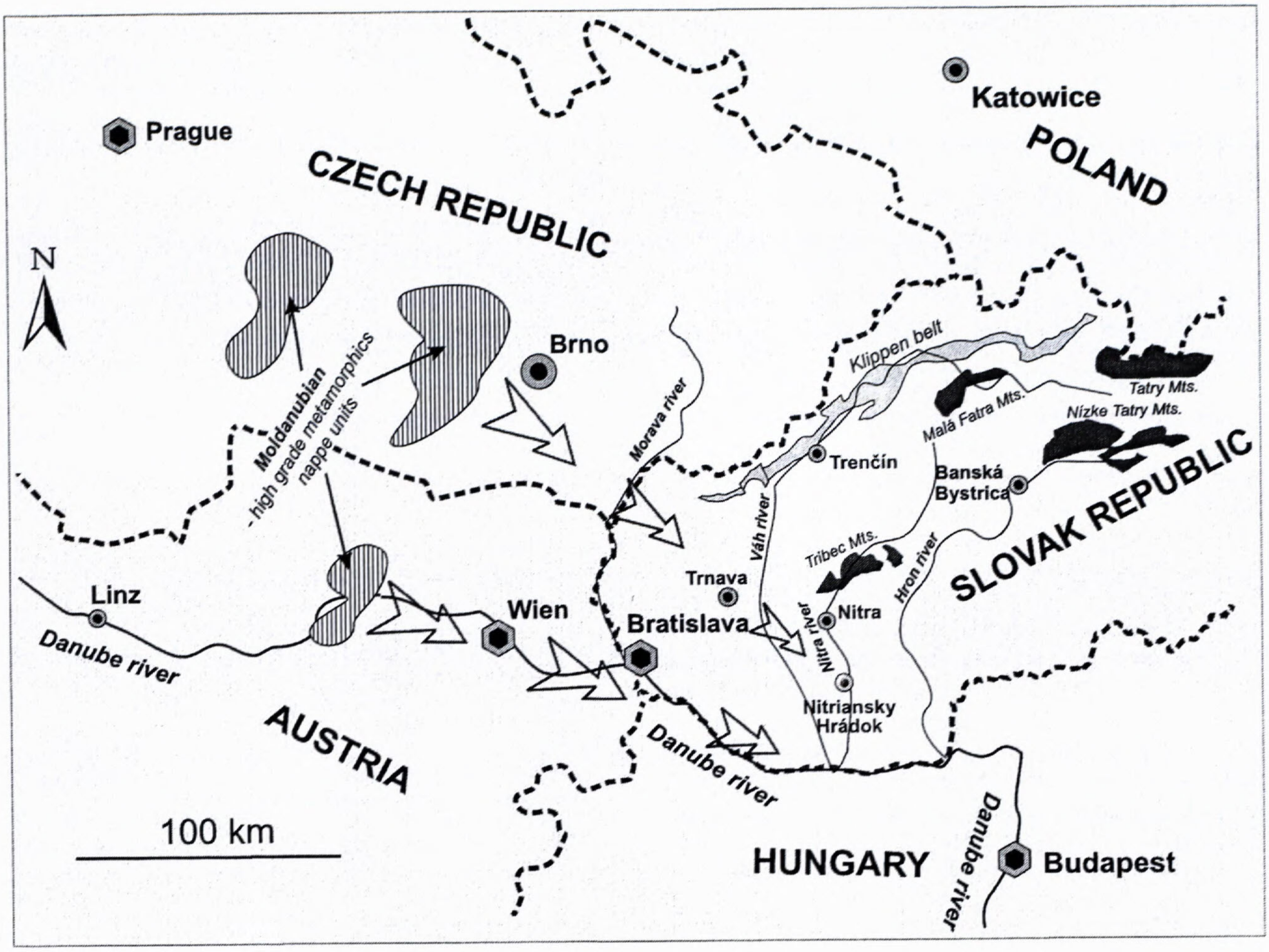

Fig. 12 Scheme with presented geological units from which eclogite should originate.

garnet-clinopyroxene metabasites, which are supposed to be retrogresivelly recrystallized eclogites (Hovorka & Méres, 1989, 1990, Hovorka et al. 1992, 1994, 1997, Janák et al. 1996, 1997, Janák & Lupták 1997). From the mountan ranges in which Gar-Cpx metabasites occur closest to the Nitriansky Hrádok site are those of the Tribeč Mts., Malá Fatra Mts., Nízke Tatry Mts. and Tatry Mts. (Fig. 12) as well. From the territory of the Western Carpathians no primary outcrop of symplectitic eclogite, which should be considered identical with the raw material of the studied implement is known.

We compared composition of garnets from the studied axe and garnets from the garnet-clinopyroxene metabasites of the Western Carpathians core mountains (Janák et al. 1997). Garnets from the symplectitic eclogite have significantly higher contents of pyrope molecule (Fig. 3) and lower of those of almandine and spessartite molecules. In the majority of the Western Carpathians core mountains symplectitic eclogites oposite zonality of garnets is detected.

In the clinopyroxenes from the Western Carpathians Gar-Cpx metabasites lower contents of jadeite molecule has been detected in comparison to that of implement studied (= max. 8 % Jd). So very low probability exists that symplectitic eclogite being raw material of studied implement has its origin in the Western Carpathians metamorphic complexes.

Ad 2) In the past there exists mention on the eclogite pebble presence in the Cretaceous conglomerates of the Pieniny Klippen Belt (Šímová & Šamajová 1981, Šímová 1982).

Theoretically it is possible to consider that mentioned comglomerates should have been potencial source of eclogite raw material for the implement studied. Eclogite raw material should have been transported to the close vicinity of the Nitriansky Hrádok site by the river Váh (Fig. 12).

Ad 3) The next geological megaunit with in situ eclogite bodies occurrences are the Eastern Alps. Within the Eastern Alps several geological units bears eclogite bodies.

In retrogressed eclogites of the Silvretta nappe (Eastern Alps) in garnets similar zonality as in the studied implement have been described (Schweinehage & Massonne 1999). As it is seen on Fig. 3 garnets from the implement studied have higher pyrope molecule content as those minerals from the Silvretta nappe eclogites.

Observed banded texture, chemical composition of minerals and the rock indicate that protolith of the imple-

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ment studied has been banded intrusive rock (of a gabbro family) geochemically bound to the ocean ridge basalts (MORB) which has been consequently metamorphosed in the eclogite facies pT conditions. Similar results dealing with the protolith of eclogites present from the Silvretta nappe Schweinehage and Massonne (1999). Compared samples of the Silvretta nappe eclogites have different content of some main elements oxids (FeO, MgO -Fig 8, 9) and several trace elements (Ba, Sr, - Fig 11). Based on analytical data compared we exclude the Eastern Alps eclogites to be the source raw material of implement studied.

Ad 4) Geological unit to the west - the Bohemian Massif - is wellknown for its eclogite occurrences. They are spread over huge areas being an integral part of the following geological units (Medaris et al. 1995): the Teplá terrane, Monotonous and Varied terranes, Gföhl terrane (all mentioned units being units of lower order of the Moldanubian zone). In the Gföhl terrane retrograde eclogite occurs as lenses or layers in garnet peridotite in Gföhl gneiss, but is rare in granulite. Gföhl gneiss contains numerous garnet peridotite bodies that enclose retrograde HT group P retrograde eclogite (=eclogite boudins or layers surrounded by peridotite or serpentinite). Kelyphitic textures around garnet demonstrate that they were formed by retrogresion of eclogites. Czech eclogite are massive to slinghtly foliated and fine- to medium grained, although garnet up to one cm in diameter occurs locally. Layering due to modal variation in garnet and clinopyroxene occurs in some HT Group P eclogites on a mm, cm or dm scale. Retrograde recrystallization to granulite and amphibolite facies assemblages is widespread, the most common effects of which are symplectitization of omphacite, development of amphibole-plagioclase kelyphite around garnet, replacement of rutile by titanite, and growth of matrix amphibole Garnets have retrograde and prograde zoning. Garnet consistents essentially of almandine (14-41%)-pyrope (28-67%)-grossularite (12-31%) solid solutions, with spessartite component always being less than 5 mol % and commonly less than 1 mol %. The majority of amphibole are ferroan pargasite to pargasitic hornblende. Clinopyroxene from the eclogites varies in jadeite from 5 to 40 mol%. (Medaris et al. 1995).

Eclogite in the Gföhl terrane is product of simple fractional crystallization from basaltic magmas. The source of melts from which eclogite and garnet pyroxenite crystallized was subducted, hydrotermally altered oceanic crust (Medaris et al. 1995).

From the plot in Fig. 3 it follows that garnet of Gföhl terrane eclogites are by their composition very close to the composition of garnets from the axe studied. From the chemical analyses of Gfohl terrane eclogites and implement studied it results that namely samples CZ 2 E and CZ 2 G have very similar contents of main elements and trace elements REE included (Figs. 8, 9, 10 and 11).

From all theoretically provenances of studied eclogite axe-hammer after comparing all available information the most probable is its origin in the Bohemian Massif - the moldanubian megaunit. Namely eclogites of the Gföhl tarrane are, by their mineral composition, retrogressive alternations and have chemical composition very similar to the exlogite axe-hammner studied. Raw material should have been transported by the river Danube, or it should have been imported (Fig. 12).

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