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Provenience of polished stone artefacts raw materials from the site Bajč – Medzi kanálmi (Neolithic, Slovakia)

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Abstract: Site Bajč – Medzi kanálmi belongs to unique sites with an extremely high number of stone artefacts found there. Evaluation of a pottery assemblage dates it into the Želiezovce group and polished industry documents the period of the terminal Middle-Neolithic. From the typological point of view they are: flat axe, flat triangle shaped axe, flat shoe-last axe, flat trapezoid axe, shoe-last wedge, crusher, globular maceheads, hammer-axe, grinder, chisel and semiproduct. The polished industry from Bajč was made of following kinds of raw materials: metamorphic rocks (greenschists, amphibolites, leptynites and serpentinites), igneous rocks (basalts, andesites and volcaniclastics) and sedimentary rocks (sandstones and limestones). All described raw material types are known to occur in the Western Carpathians and adjacent geological units.

Key words: Neolithic, Bajč, Slovakia, polished stone artefacts, raw materials, provenience

Introduction

Site Bajč – Medzi kanálmi (Nové Zámky district) belongs to unique ones with an extremely high number of stone artefacts found there. Evaluation of a pottery assemblage dates it into the Želiezovce group and polished industry documents the period of the terminal Middle-Neolithic.

Bajč is situated on a sand dune between defunct meandering arms of river Žitava 200 m east of its already canalized bed (Fig. 1). The whole revealed and excavated area covered 2,7 ha. The Neolithic settlement was documented on space of 1,9 ha.

In the site from the 3rd stage of the Želiezovce group in Bajč numerous chipped and polished stone industry has been excavated together with various artefacts made of clay, bone and antler. These are representing a full spectrum of raw materials revealed at the site under archaeological investigation - the entire assemblage of the polished stone finds from Bajc contains 289 pieces. But these are only a known part of unknown bulk of polished stone production in Bajc.

From the typological point of view they are: flat axe, flat triangle shaped axe, flat shoe-last axe, flat trapezoid axe, shoe-last wedge, crusher, globular maceheads, hammer-axe, grinder, chisel and semiproduct (Fig. 2, 5, 6, 7, 8, 9, 10, 11, 12, 13).

As far as typology is concerned, two types are predominating in the polished stone industry assemblage in Bajč - a various types flat axes (trapezoid, shoe-last, triangle shaped) and shoe-last wedges (Fig. 2).

First settlement of the site with its beginning coinciding with the end of the Middle-Neolithic is at the same time connected with a climate change during the Atlantic period. The change has caused that the Želiezovce-group bearers came to this microregion without preceding settlement i.e. they got into original natural environment (only a population living on the left bank of the river Žitava was

Fig. 1 Location of the site Bajč – Medzi kanálmi.

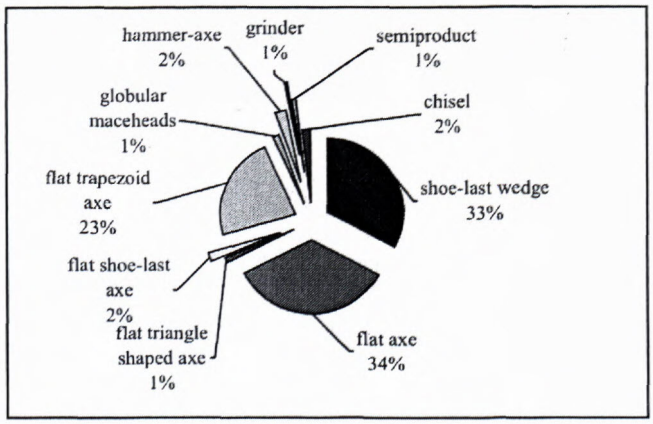

Fig. 2 Quantitative proportion of various raw material types of the polished industry from the site Bajč - Medzi kanálmi. The total number of implements studied was equal to 289 pieces.

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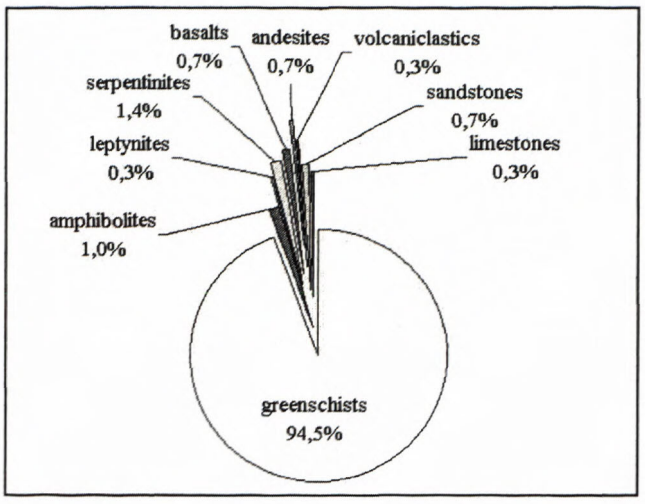


Fig. 3 Quantitative proportion (expressed in per cents) of individual rock types of the polished industry from the site Bajč - Medzi kanálmi.

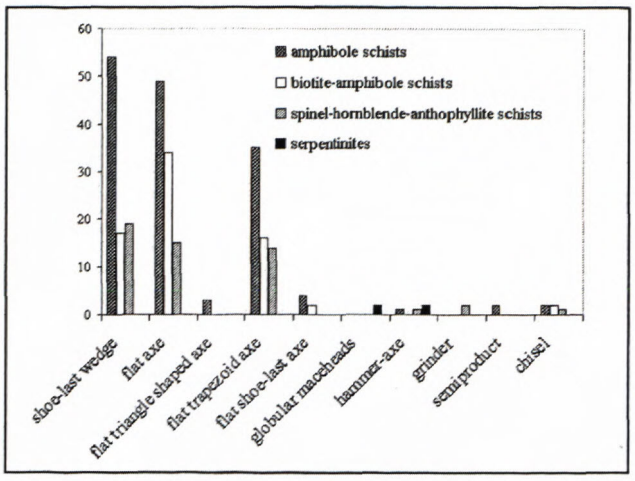


Fig. 4 Quantitative proportion (expressed in pieces) of various artefact types and proportion of metamorphic rocks of the greenschist facies from the site Bajč - Medzi kanálmi.

under investigation). In vicinity of the site an original forest, undevastated by man, spread there. Maybe some-where here lies an explanation of a great number of wood-working tools found on the area of the site under research.

Since similar situation has not been documented from other sites of the Linear culture and the Želiezovce group in Slovakia for the present, we can presume a population-group have been living in the site, activity of which was oriented on specialized production of polished industry.

Finds of this industry at the explored area were spread equally. It means that no cluster of finds was excavated indicating explicitly a possible production workshop.

Finds of rubbers usually made from damaged or broken tools represent a relatively numerous group. Mostly they are bodies of shoe-last wedge. They also provided an information about used rock type.

The great number of polished stone artefacts, namely flat axes and shoe-last chisels, had to be made of raw material from more distant regions. From the archaeological point of view the petrographic analysis can help to define regions of Bajč raw materials primary sources occurrence and by this way to confirm or extend regions with which cultural relations are documented by pottery imports.

RAW MATERIAL

The polished industry from Bajč was made of following kinds of raw materials: metamorphic rocks (greenschists, amphibolites, leptynites and serpentinites), igneous rocks (basalts, andesites and volcaniclastics) and sedimentary rocks (sandstones and limestones, Fig. 3).

Metamorphic rocks

Metamorphic rocks represent substantial part of the raw materials of the polished industry from site Bajč. It reflect physical properties, which fundamentaly differ even within this rock group. Their basic characteristics are is as follows.

Greenschist

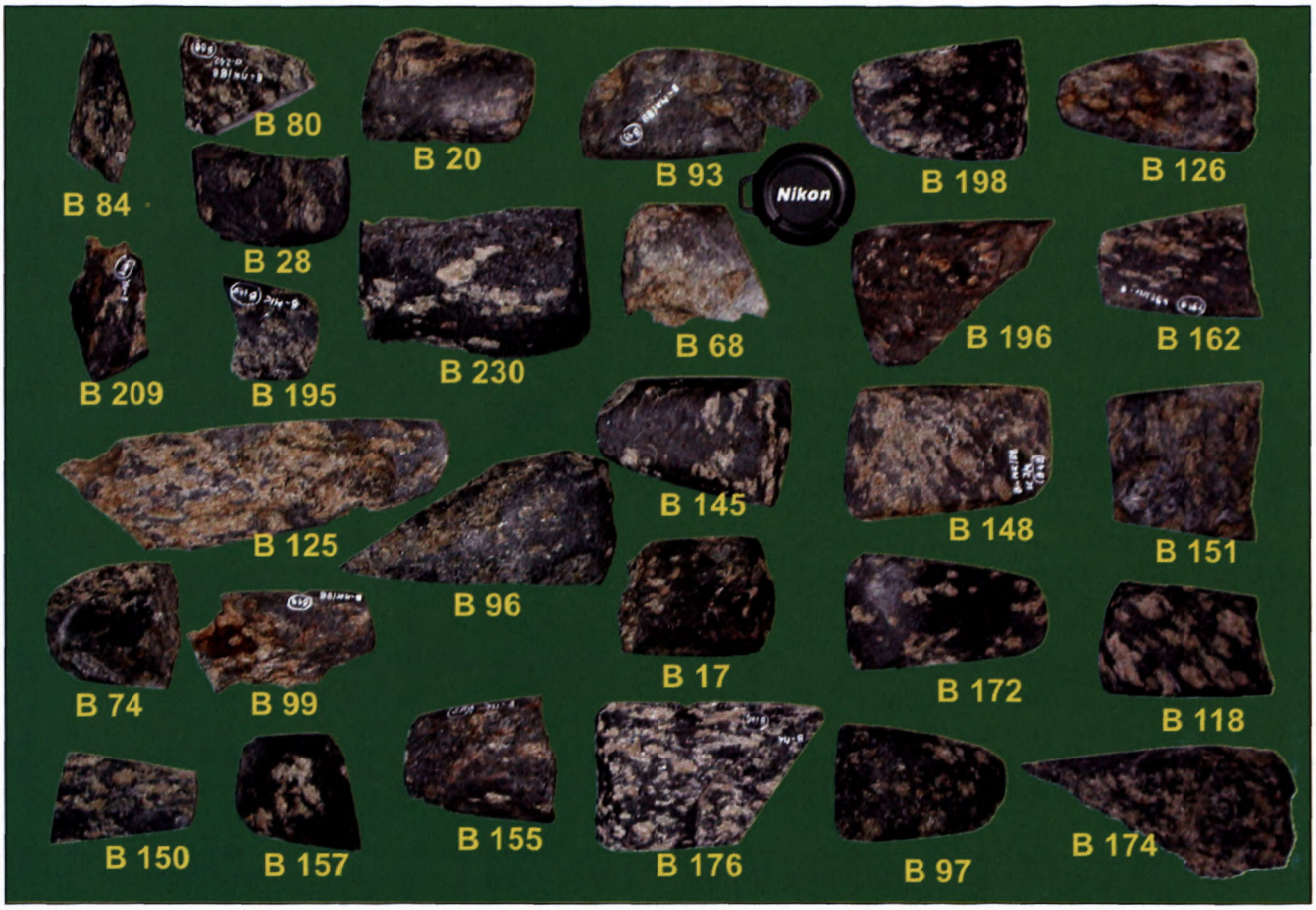
Greenschists (273 pieces, Figs. 3 and 4) are the most often used raw material type used for the polished implements construction on site Bajč. In prevailing cases the are represented by amphibole schists (150 pieces), biotite-amphibole schists (71 pieces) and spinel-hornblende-anthophyllite schists (52 pieces).

Amphibole schists are mostly very fine-grained rocks with well develloped foliation. In this type of the greenschist green pleochroic monoclinic amphibole is dominant. According to the albite morphology and size the artefacts studied they should be divided into: a) egual grained types (Fig. 15), and b) porphyroblastic types with albite porphyroblasts (Fig 16, 17). Namely types quoted ad a) gradualy pass into monomineral varieties composed mostly of amphiboles. In all thin sections studied fine-grained magnetite pigment cause dark colour of the given rock-types.

Biotite-amphibole schists are represented by fine-grained and in the majority of cases also schistose rocks (Fig 7). As the consequence of intensive periplutonic alterations feldspars are replaced by the sericite aggregates. Intensive biotitization is characteristic for the majority of them, which causes dominant immage of the given rocks - they are spotted (Fig 19).

Fig. 5 Polished stone artefacts from the site Bajč – Medzi kanálmi. Raw material for their production were amphibole (spotty) schists. Flat trapezoid axe (B - 93, 151, 150), flat shoe-last axe (B- 93, 126, 196, 96, 145, 74, 17, 172, 97), flat axe – others.

Fig. 6 Polished stone artefacts from the site Bajč – Medzi kanálmi. Raw material for their production were Al-rich spinel-hornblende-anthophyllite schists. Flat axe (B-34, 191, 43, 202, 179, 23, 228), flat shoe-last axe (B-73, 231, 231, 109, 88, 198a,b, 190,201,106) shoe-last wedge (B-44, 148, 119), chisel – B 175.


B 84
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B 20
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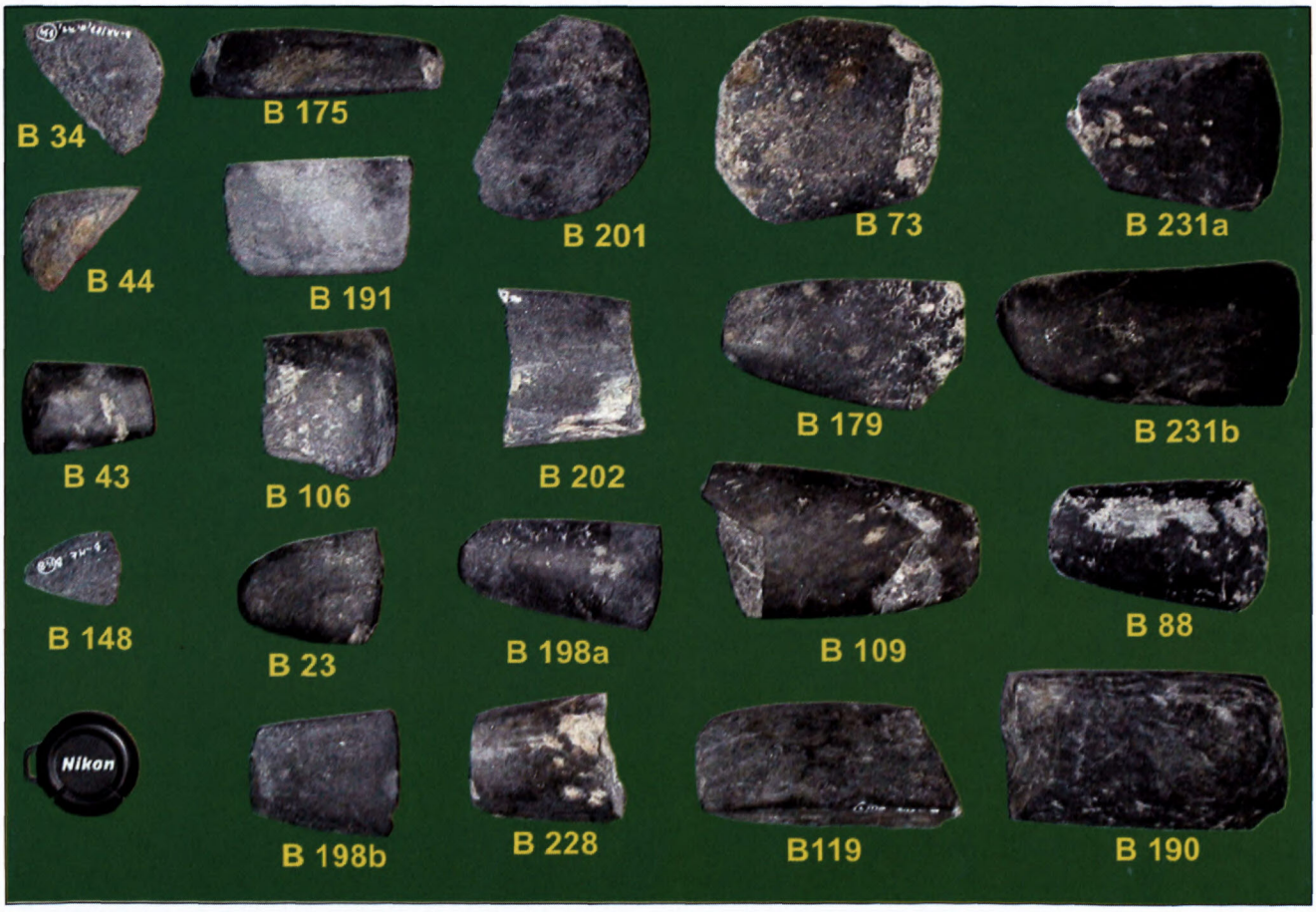
B 34
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B 73
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B 44
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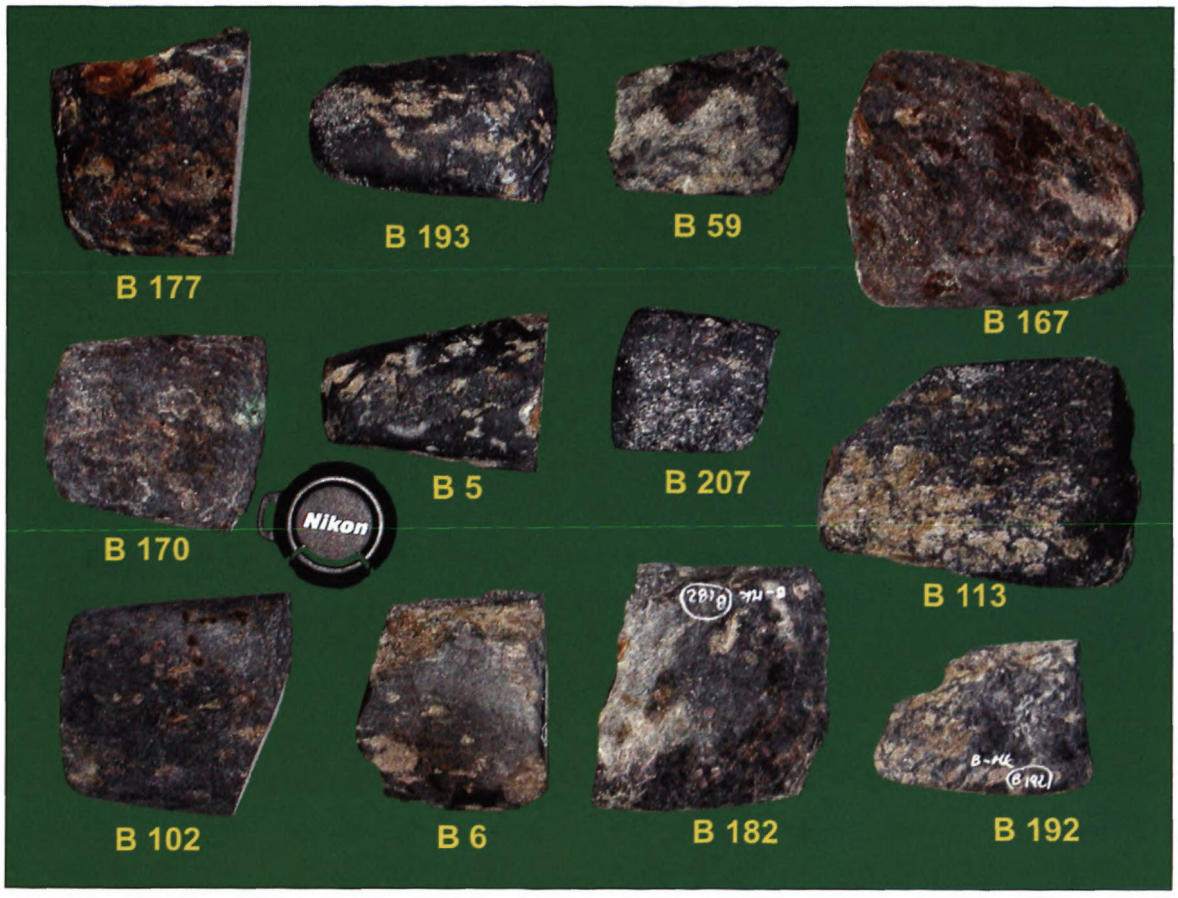
B 177
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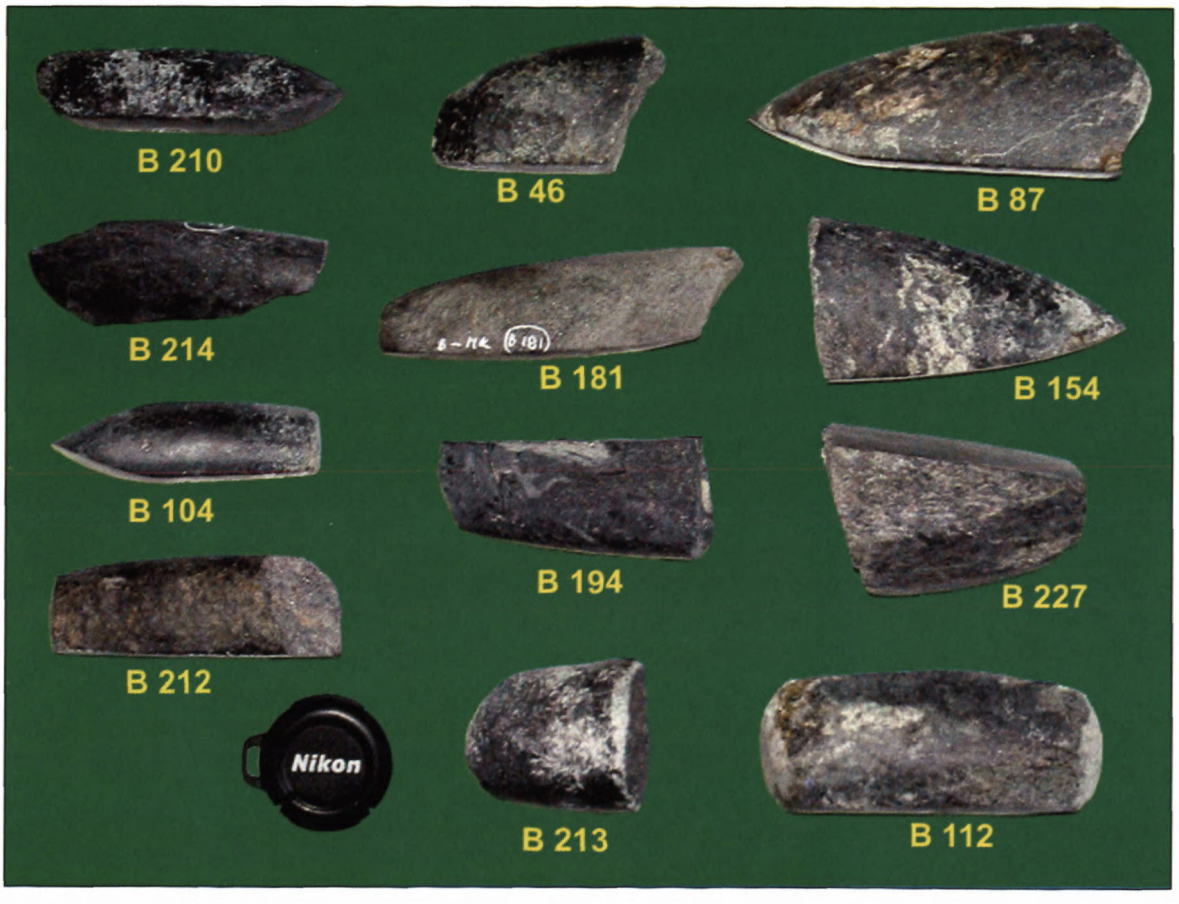
B 5
B 207
B 113
B 102
B 6
B 182
B 192


B 210
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B 87
B 214
B 181
B 154
B 104
B 194
B 227
B 212
B 213
B 112

Spinel-hornblende-anthophyllite schists have pronouncedly schistose fabric (Fig 6, 8, 10, 11, 18). Greenschists under consideration are mostly of darkgrey colour. The prevailing rock-forming mineral is anthophyllite. In the given rock type variable proportion of hornblende (tremolite, anthophylite, actinolite) and grass-green spinel has been observed. Green Al-spinel forms clusters or individual xenoblastic crystals spread over oreas of rectangular shape, e. g. spinel is one of pseudomorphic phases after orthopyroxenes. Locally observed felty fabric of needle-like anthophyllite aggregates allow to classify rocks under consideration as nephritoids (Illášová & Hovorka 1995, Hovorka et al. 1997).

Serpentinite

From the serpentinite two hammer-axes and one globular macehead have been identified (Fig 13). Artefacts made from serpentinite are either light-green with black nests of ore minerals, or darkgrey with irregular nests of rusty-brown carbonates. They are of massive fabric, in thin section there is observable local foliation of antigorite flakes (Fig. 20). Rock under discussion are anchimonomineral. Except of strongly prevailing antigorite they contains magnetite pigment and Mg-Fe carbonates. Generally this rock type corresponds to antigorite serpentinite described in paper by Hovorka and Illášová (1996).

Amphibolite

Amphibolite as the raw material has been identified in the case of two polished stone artefacts: one shoe-last wedge and one flat triangle shaped axe. Amphibolite represents fine-grained rock-type mostly with well developed foliation. It is composed of two minerals: amphibole and plagioclase. Pronouncedly dominant presence of amphibole in several cases allow as to classify such types as melamaphibolites. Plagioclases of the given rock types often recrystallized into fine-grained aggregate of saussurite character.

Leptynite

From the leptynite only one hammer-axe has been identified. Leptynites represent rocks of high-grade metamorphic origin. They are light in colour, mostly foliated.

They are composed of quartz, plagioclase, and bluish-green amphibole, minerals of the epidote group and accessories (titanite, zircon).

Fig. 7 Polished stone artefacts from the site Bajč – Medzi kanálmi. Raw material for their production were biotite-amphibole schists. Flat axe (B-177, 5, 207, 113, 6, 182, 192), flat shoe-last axe (B-193, 59, 170), crusher (B- 167) chisel (B-102).

Fig. 8 Polished stone artefacts from the site Bajč – Medzi kanálmi. Raw material for their production were Al-spinel-hornblende-anthophyllite schists. Crusher (B-213, B-112), shoe-last wedge – others.

Igneous rocks

Among Neolithic/Eneolithic artefacts from various sites of the Slovak Republic territory plutonic as well as volcanic rocks are present (Hovorka & Illášová 1996, Illášová & Hovorka 1995, Hovorka & Cheben 1997). For the site studied artefacts made from intrusive as well as effusive rock types are present in subordinate amount only.

Andesites

From andesites has been made only two implements: one shoe-last wedge (pyroxene phyric andesite, Fig. 21) and one flat axe (amphibole-biotite andesite). This typical volcanic rock consists of phyric pyroxene or amphibole and biotite within submicroscopically grained matrix. It consists of very fine-grained crystals of nedle-like plagioclases and volcanic glass. Rock under consideration has locally slightly fluidal fabric.

Basalts

From basalts has ben made one shoe-last wedge and one flat axe (Fig. 12). Basalts are fresh rocks and they belong to the alkali basalt clan. They have dark-grey ap to black colour, and mostly of fine-phyric (clinopyroxene and olivine, Fig. 22) and massive patterns. Mineral composition of alkali basalts is characterised by plagioclases and clinopyroxenes, olivine, amphibole and ore minerals are also present.

Sedimentary rocks

Among sedimentary rocks as the raw material have been identified **sandstone** (one globular maceheads and one hammer-axe) and **limestone** (one globular maceheads, Fig. 13).

Provenience of polished stone artefacts raw materials – discussion

Reconstruiing the origin of raw materials used by the Neolithic population on site Bajč for stone artefacts production we used following assumptions:

- the most often used raw material type for production of stone artefacts on mentioned site have been grenschists,
- we suppose that for the choose of raw material of appropriate technical properties for the next elaboration during the Neolithic practical experiences as well as by naked eyes observations have been applied,
- the great amount of stone artefacts, grinders, and various semiproducts prove for assumption that implements were produced just on this site.

Human communities living during Neolithic/Aeneolithic on site Bajč univocaly distinguished suitable technical properties of greenschists, namely their hardness as well as elasticity. Haphazard orientation of felty long-columnar amphiboles caused their stability. Often presence of spinels caused their unusual hardness.

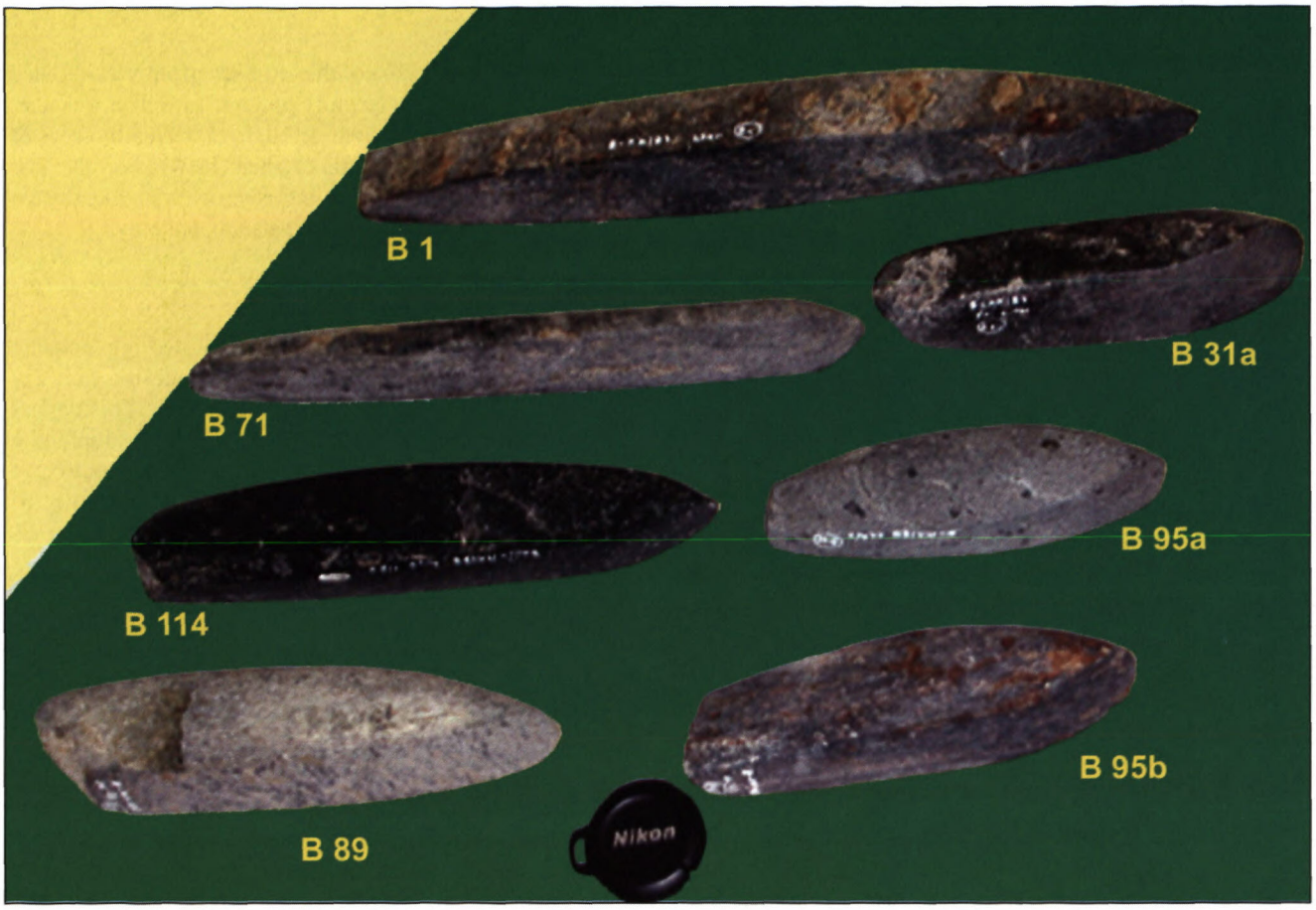

Fig. 9 Polished stone artefacts from the site Bajč – Medzi kanálmi. Shoe-last wedge made from various types of greenschists. B-1 - the buigest shoe-last wedge found on site under consideration (24,5 cm) -spotted amphibole schists, B-71 - Al-spinel-hornblende-anthophyllite schist, B- 31a - amphibole schist, B-114 amphibole schist with relic volcanic pattern (see Fig. 16), B-95a - amphibole schist with relic volcanic pattern - dark spots = feldspars (see Fig. 17), B-89 - spotted amphibole schist, B-95b - amphibole schist with relic volcanic pattern.

Fig. 10 Polished stone artefacts from the site Bajč – Medzi kanálmi. Grinders made from Al-spinel-hornblende-anthophyllite schists.

Fig. 11 Polished stone artefacts from the site Bajč – Medzi kanálmi. Shoe-last wedge with partrial borehole in basement – semiproduct. Raw material: Al-spinel-hornblende-anthophyllite schist.

Fig. 12 Polished stone artefacts from the site Bajč – Medzi kanálmi. Shoe-last wedge/semiproduct with trace of beginning of boring. Raw material: alkali basalt.

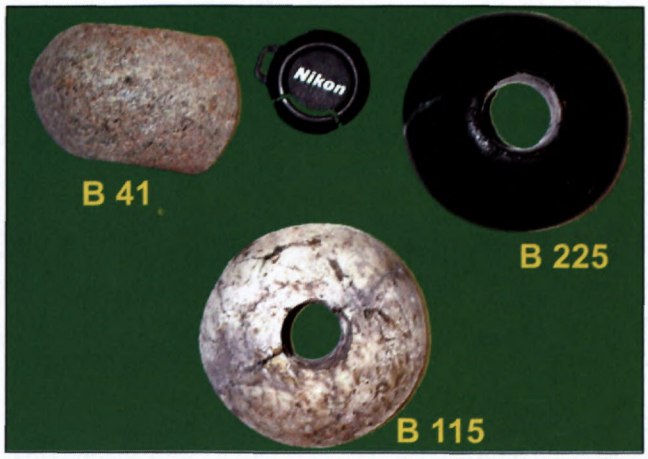

Fig. 13 Polished stone artefacts from the site Bajč – Medzi kanálmi. Globular maceheads from the leptynite (B-41), from the serpentinite (B-225) and from the limestone (B-115).

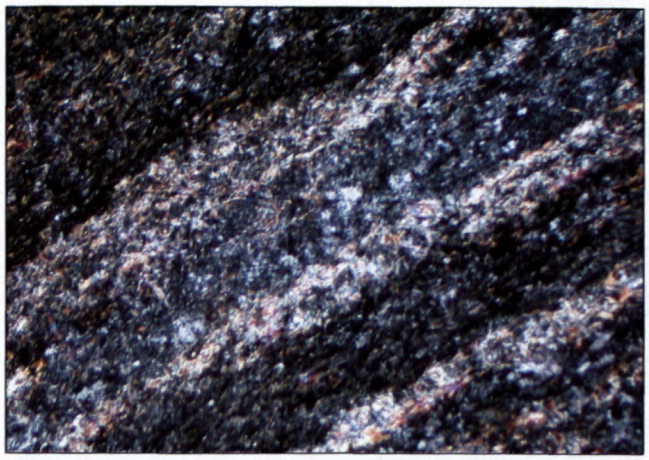

Fig. 14 Fine-grained banded amphibole schist. B-229- hammer-axe. Crossed polars.

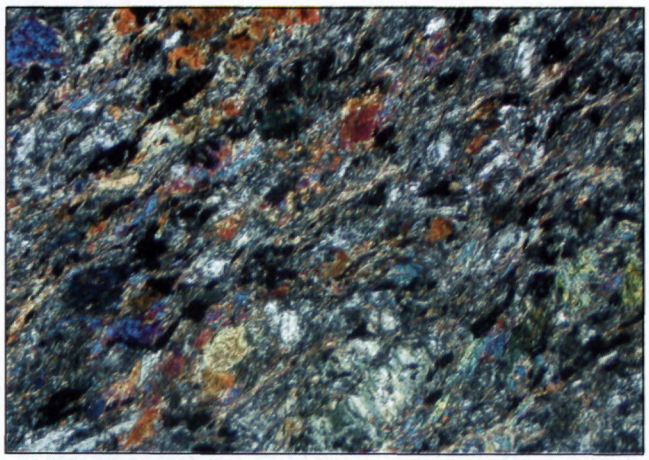

Fig. 15 Spotted schistose amphibole schist with ore pigment. B-133 - flat axe, Crossed polars.

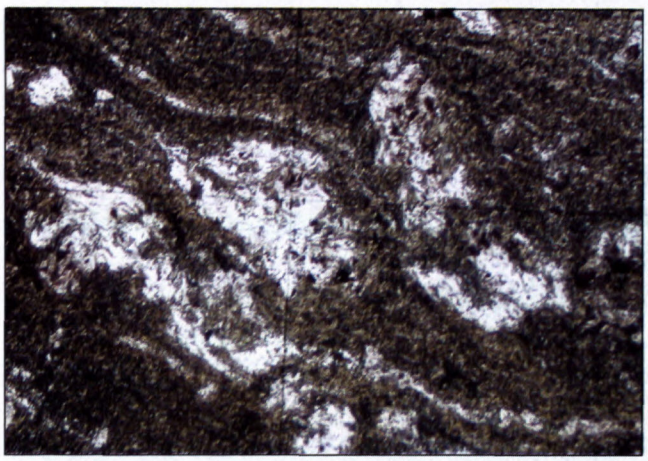

Fig. 16 Fine-grained augen amphibole schists with relic volcaniclastic pattern. In the very fine-grained matrix of the rock (around 0,1 mm) tabular/augen plagioclases are present. B-117 - flat axe. Crossed polars.

Fig. 17 Very fine-grained (0,1 mm) amphibole schist (after intermediate porfyritic volcanic rock). In the given rock sporadically plagioclases (up to 3 mm) occur. B-95a - shoe-last wedge. Crossed polars.

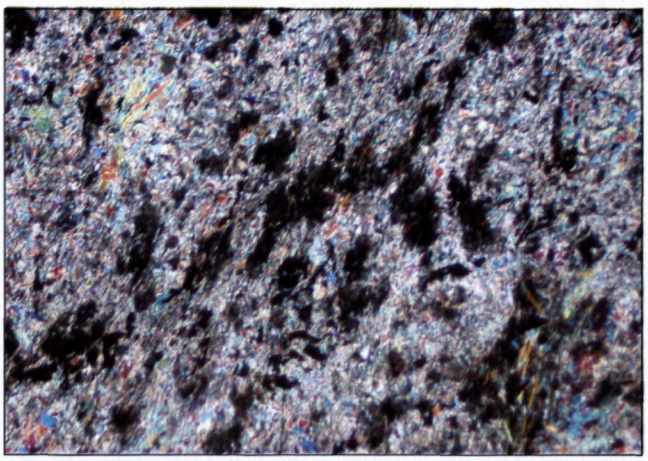

Fig. 18 Spinel-hornblende-anthophyllite schists with relic clinopyroxene. B-61 – grinder. Crossed polars.

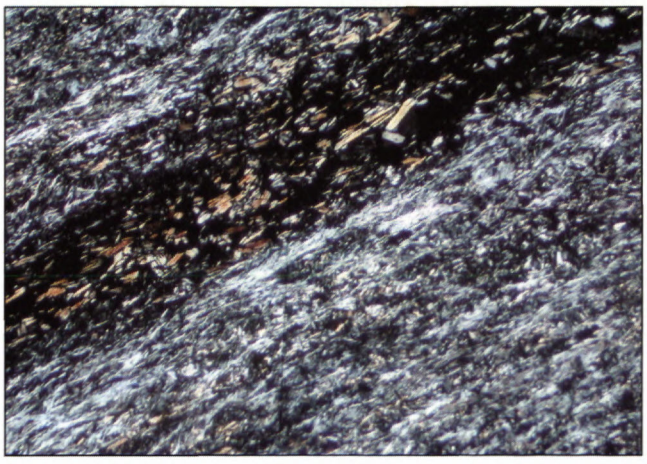

Fig. 19 Fine-grained biotite-amphibole schist. Biotitization in comparison to metamorphic recrystallization is younger process which is developed namely in direction of metamorphic foliation of the given rock. B-178- shoe-last wedge. Crossed polars.

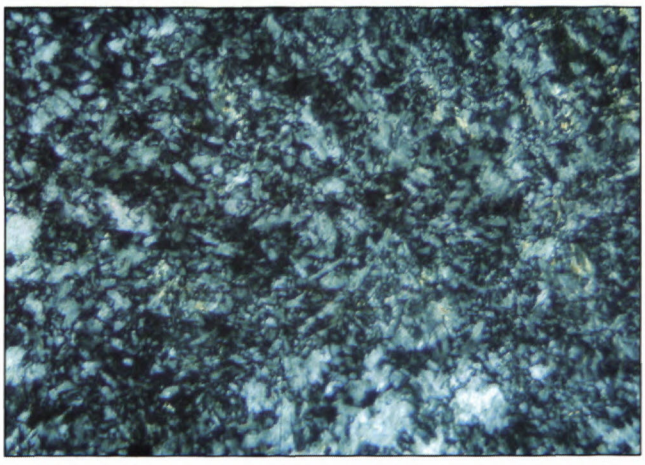

Fig. 20 Fine-grained antigorite serpentinite. B-185 - hammer-axe. Crossed polars

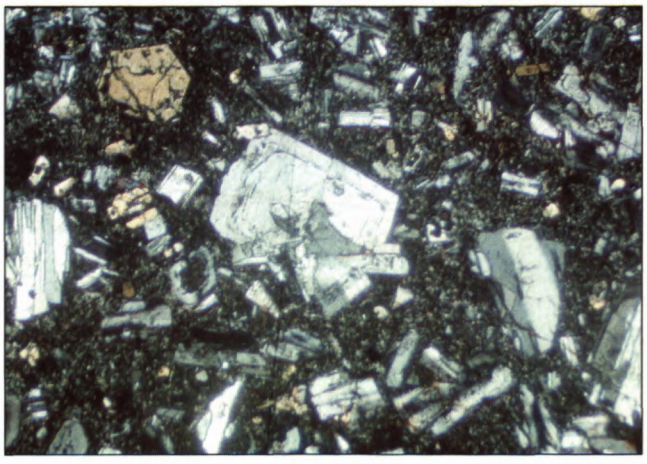

Fig. 21 Two-pyroxene andesite. Plagioclases are present in the form of glomerophyric aggregates (3 mm) deposited within hemicrystalline submicroscopic matrix. B-86 - shoe-last wedge. Crossed polars.

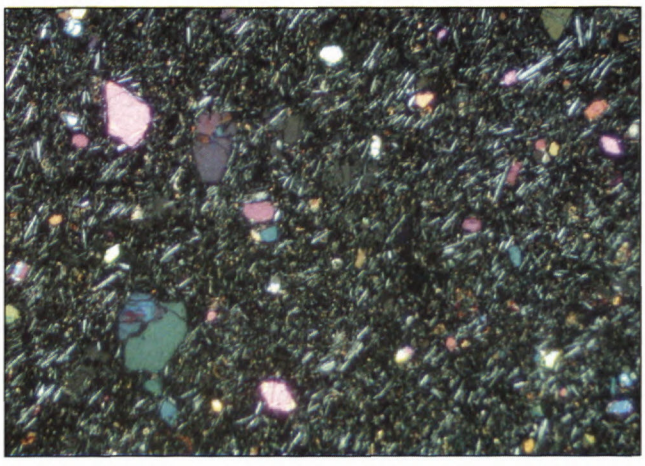

Fig. 22 Alkali basalt with porphyritic structure (dark minerals only) and non pronouncedly developed fluidal matrix. It is formed by narrow laths of fresh plagioclasesand recrystallized volcanic glass. B147 - shoe-last wedge.

Neolithic people had good experiences namely with spinel bearing greenschists. Majority of greenschist varieties, which have been used by Neolithic population, have mostly darkgreen color and in the majority of cases fine-grained pattern. All varieties of greenschists have similar properties observable by naked eyes. Among common features belong namely dark drey and dark green colors. Dark tint of implements is caused by the substantial presence of fine-grained magnetite pigment (up to 20 vol. per cents). It is evident that mentioned types of greenshist have been favorable raw material types. People´s experiences with the greenschists is documented by the prevalence of this raw material types among ready made artefacts. If the matrix of the greenschist raw material types is lighter, in such cases green spots and augens of amphiboles and dark-brown spots of biotites are characteristic. On weathered surfaces such (namely biotitic) spots form negative relief.

Neolithic implement-makers evidently have been searching for mentioned raw material types. Their good experiences are documented by frequent use of this raw material types on one side, and their use as whetstones which have been used for elaboration of stone implements, on the other one.

Very similar greenschists are known to occur in the Malé Karpaty Mts. (Cambel 1962, Ivan et al. 2001). Up to now no spinel is described among their rock-forming minerals, as well. It is possible that in the case of the occurrence of small rock-body Neolithic people should have exploited it. Such consideration is based on extent area in which such raw material type is documented around Malé Karpaty Mts. (see Fig. 1 occurrences in paper by Hovorka et al. 1997).

Greenschists represent relatively widespred rock-type in numerous central European geological units. They are known to occur in the Malé Karpaty Mts., Spišsko-gemer-

ské rudohorie Ore Mts. to the east of described localities, as well as in geological units being part of eastern rim of the Bohemian Massif. Malé Karpaty Mts. geographically are closest to the archeological sites in western Slovakia, and rock complexes forming the Pezinok-Pernek Formation ought to be taken into consideration.

The Malé Karpaty Mts. (Fig. 23) experienced a multi-staged metamorphic alteration. Cambel (1962) described them as a combination of the regional pre-granite metamorphic episode, deep contact (periplutonic) and contact metamorphism. Korikovskij et al. (1984) suppose that during the intrusion of the Bratislava massif, metamorphic zones were created around it, from the thermally lowest biotite, through garnet and staurolite-chlorite, to the highest temperature staurolite-sillimanite zone. Contact metamorphism occurred mainly at the contact between the Modra granitoids and the overlying rocks. Overlapping of contact metamorphism and zones of regional metamorphism led to various types of contact hornfelses (Korikovskij et al., 1985).

Detailed petrography of the metabasalts from the Malé Karpaty Mts. showed variability in petrographic rock types, which was correctly ascribed to the diferences in protolith and metamorphic evolution (Cambel 1962, Ivan et al. 2001). No primary magmatic minerals have been found in the metabasites and original magmatic textures are only sporadically preserved. Based on these textural relics, grain-size and pseudomorphs after magmatic plagioclase crystals and phenocrysts, various types of gabbros, dolerites, basalts and basaltic volcaniclastics have been identified.

Basaltic rocks were transformed by metamorphism to the rocks with petrographic characteristics ranging from greenstones (greenschists) to amphibolites. Badly preserved relics of doleritic, ophitic, intersertal, porphyric, amygdaloidal and hyaloclastite textures were locally found. Differences in metamorphic evolution resulted in variable chemical composition (and color) of amphibole and also small changes of the mineral association and textures. Based on these petrographic features the metabasalts of the Malé Karpaty Mts. can be tentatively divided into following petrographic types: (1) greenschists, (2) lower temperature amphibolites, (3) higher temperature amphibolites and (4) hornfelsed amphibolites (Ivan et al. 2001).

Greenschists are light green massive or foliated rocks composed mainly of actinolite, albitic plagioclase, prehnite or in its place forming clinozoisite or less frequently epidote. They also contain accessory carbonate, titanite and pyrite. All other petrographic types originated as a result of further progresive greenstone transformation.

Lower temperature amphibolites contain blue-green amphibole (mostly magnesiohornblende or tschermakite) and albitic plagioclase. Actinolite is locally preserved in the form of relic cores in some amphibole porphyroblasts. Small relics of prehnite or clinozoisite and epidote are also sporadically preserved. Disseminated small crystals of magnetite or pyrite rimmed by magnetite are common. Textural patterns are almost identical to greenstones.

Higher temperature amphibolites are composed of brown-green amphibole (magnesiohornblende or pargasite) and albitic plagioclase. In some larger amphibole - grains blue-green amphibole cores are preserved. Original thin epigenetic carbonate veins have been transformed to metamorphic diopside. Textures originally inherited from greenstone stage have been modified by metamorphic recrystallization, which led to a grain coarsening and also to more perfect evolution of amphibole crystals.

Hornfelsed amphibolites are grey-brown in color as a result of the presence of light brown amphibole and a small amount of Mg-biotite. They occur only occasionally in pelitic metasedimentary rocks of the Harmónia-Dubová area and display well preserved textures of original greenstone with typical prismatic amphibole. A partial recrystallization, colour changes in amphibole and locally also formation of small amount of Mg-biotite are the only results of the thermal effect of the Modra granitoid massif.

All mentioned properties of the Malé Karpaty Mts. metabasites are very close to the propereties of greenschists, being raw material of the majority of implements described from the Bajč site. Therefore we suppose the Malé Karpaty Mts. as the most probably province of the given raw matrial types identified among the Neolithic stone implements on site Bajč.

Antigorite serpentinite is spite of its relatively seldom occurrence in nature, artefacts made from this raw material are one of frequently used raw material in the Western Slovakia (Hovorka and Illášová 1996). The cloasest antigorite sepentinite occurrences are known from the Slovenské rudohorie Mts. (area of Brezno - Fig. 23, Hovorka 1967, 1994, Hovorka et al. 1985). Antigorite serpentites are known from the area of city Brno as well from the area of Austrian-Hungarian boundary. They are known from the river Danube pebbles. As artefacts studied made from antigorite serpentinites have not any specific features, the problem of original rock sources is not yet solved.

Amphibolite represents sporadicaly present raw material type of the given site. Amphibolites of very similar mineral composition, fabric and degree of preservation occur in Hlboká and Dahožická valleys in the Tribeč Mts. (Hovorka et al. 1994, 1997), in the Malé Karpaty Mts. as well as in other mountain ranges of central Slovakia (Spišiak & Pitoňák 1992, Janák et al. 1993) Bohemian Massif and the Eastern/Northern Alps. It is wellknown that amphibolites represent common rock-type within middle till high grade metamorphic complexes. Our knowledge of this problematic allow us to consider the following sources of this type raw material: primary occurrences in the Tribeč and Malé Karpaty Mts (Fig. 23).

Leptynites represent rare rock type in nature as well as rare raw material of the Neolithic/Aeneolithic artefacts known from the central European sites. The only one fragment of axe made from leptynite confirm such rare occurrences of leptynites. Leptynites are member of leptyno-amphibolite complexes which are typical rock-sequences of middle European Variscides (the Bohemian Massif, the Eastern Alps as well as the Western Carpathians (Hovorka et al. 1994, 1996, 1997, Hovorka & Méres 1993).

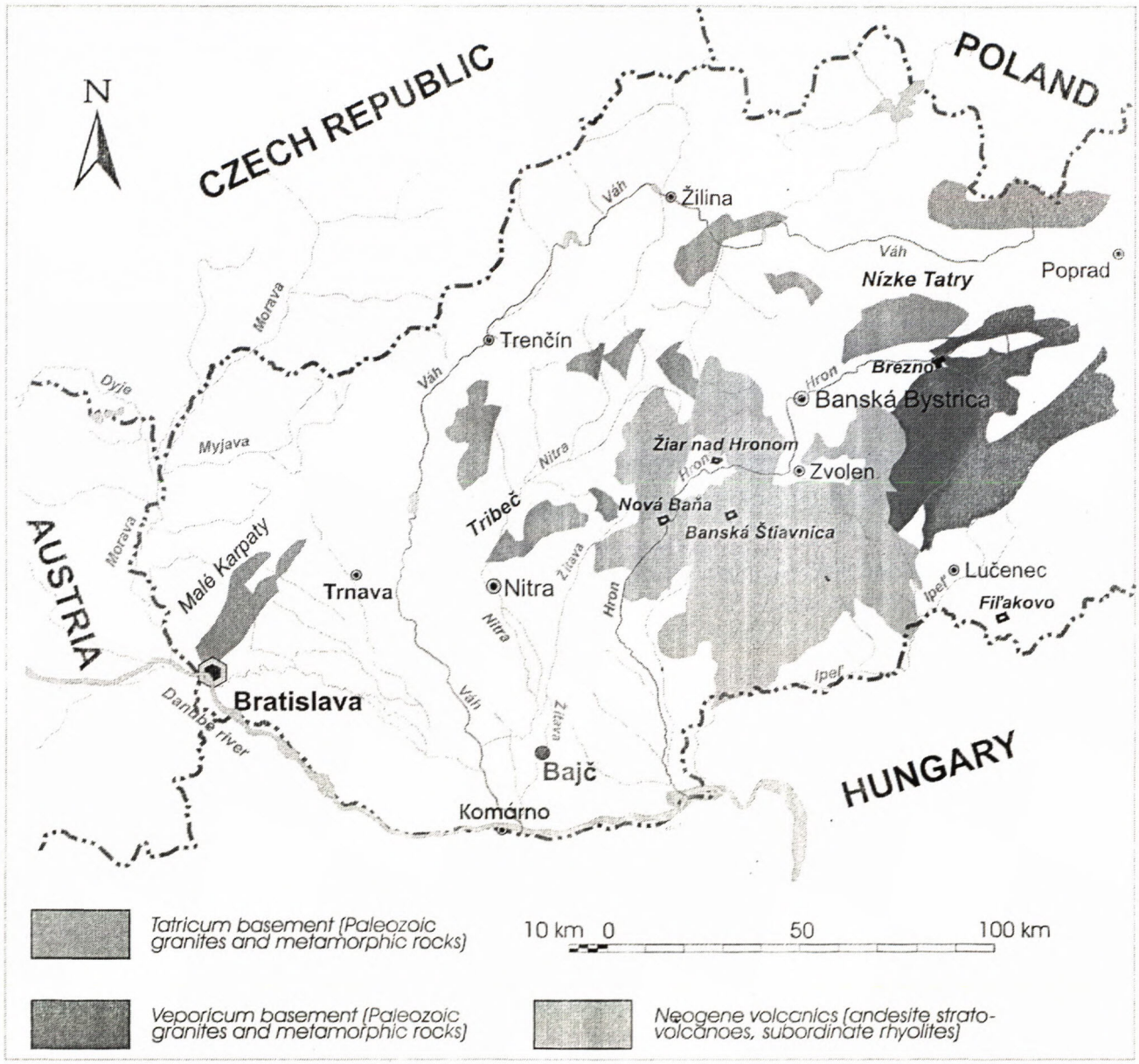

Fig. 23 Schematic map of the western and central Slovakia with the potential provenance of the raw materials of the Neolithic polished stone artefacts from the site Bajč.

The closest leptynites occurrences are located on the southern slopes of the Nízke Tatry Mts, as well as geological units located on the northern rim of Slovenské rudohorie Mts. The only known artefact, which has no specific features, made from this rock type, don´t allow us solve the problem of its provenience.

Andesites represent one of the main products of Late Tertiary volcanic activity. The closest volcanic fields are those of the Pohronský Inovec and Vtáčnik Mts. to the north and Börszony Mts. on Hungarian territory to the south. Southern perifery zones of the Štiavnica stratovolcano are composed of volcaniclastics of fine-gained braccia and sandy types (Fig. 23, Konečný & Lexa 1984). Based on this these areas should be excluded as possible source areas of this type of raw material.

In central Slovakia occurrences of *alkali basalts* are known from site Nová Baňa and Žiar nad Hronom (Fig. 23), where basaltic lava flows reach the bed of the river Hron, and from the Kalvária in Štiavnica caldera and massives Karanč and Šiator by Fiľakovo town (Hovorka 1978, Hovorka & Fejdi, 1980, Ivan & Hovorka 1993, Konečný et al. 1995). In the north as well as northwestern Hungary ther occur several alkali basaltic cones. The most probably gravels of the river Hron have been raw material types for above mentioned implements.

Sandstones being raw material of some implements are the most probably of the Permian stratigraphy, meanwhile *limestones* belong to the Mesozoic formations.

Conclusion

Site Bajč – Medzi kanálmi belongs to unique sites with an extremely high number of stone artefacts found there. Evaluation of a pottery assemblage dates it into the

Želiezovce group and polished industry documents the period of the terminal Middle-Neolithic.

From the typological point of view they are: flat axe, flat triangle shaped axe, flat shoe-last axe, flat trapezoid axe, shoe-last wedge, crusher, globular maceheads, hammer-axe, grinder, chisel and semiproduct. As far as typology is concerned, two types are predominating in the polished stone industry assemblage in Bajč - various types flat axes (trapezoid, shoe-last, triangle shaped) and shoe-last wedges.

The polished industry from Bajč was made of following kinds of raw materials: metamorphic rocks (greenschists, amphibolites, leptynites and serpentinites), igneous rocks (basalts, andesites and volcaniclastics) and sedimentary rocks (sandstones and limestones). The greenschist are evidently prevailing raw material type.

All described raw material types (except of spinel bearing greenschists) are known to occur in the Western Carpathians and adjacent geological units. On the base of grinders occurrences we suppose the workshop for stone artefact elaboration was located just on discussed place.

We suppose that this raw material primary occurrences have been located in adjacent areas:

- greenschists – in the Malé Karpaty Mts,
- amphibolites and leptynites – in the Tribeč Mts,
- serpentinites in the Slovenské rudohorie Mts. (area of Brezno) or in the Bohemian Massif geological units occurring in its eastern rim,
- andesites are products of central Slovakia Late Tertiary volcanic activity,
- alkali basalts are known from site Nová Baňa and Žiar nad Hronom,
- sandstones being raw material of some implements are the most probably of the Permian stratigraphy, meanwhile limestones belon to the Mesozoic formations.

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