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Dušan Hovorka and Štefan Méres

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IGCP/UNESCO project 442:

"RAW MATERIALS OF THE NEOLITHIC/AENEOLITHIC POLISHED STONE ARTEFACTS: THEIR MIGRATION PATHS IN EUROPE"

Contents

Abstracts

IGCP/UNESCO 442 Project "Raw materials of the neolithic/ aeneolithic polished stone artefacts: their migration paths in Europe" in its third year

This interdisciplinary/intersectorial IGCP/UNESCO project Nr. 442 (geological sciences + historical sciences - archaeology) in the year 2001 is in its third year of being realised. Based on, it should be said, tradition, also in this year one (the 4th one) plenary session of the project corresponding members was organised. The plenary session, workshop and excursion was realised in Udine and Genova in Italy in the term 25th - 29th September 2001. Substantial part of necessary complicated organising activities have been done by Prof. Claudio D'Amico, to whom we would like to express our thank also in this way.

We have good experiences from the last year, when all oral communications presented during the Eggenburg (Austria) 3rd plenary session of the Project have been published in extenso within the 3 months limit after mentioned plenary session. Based on the last year experience also in this year we encouraged all corresponding members of the Project to submit appropriate manuscripts to be published within the 3 months limit after the realised plenary session in Udine and Genova. In spite of the last year, when papers in extenso have been published in KRYSTALINIKUM as its No. 26 in the year 2000 in the Czech republic (which journal is distributed by E. Schweizerbart´sche Verlagsbuchhandlung - Nägele und Obermiller) in this year we are thankfull to the editor and the editorial board of the scientific journal Slovak Geological Magazine, published by the Slovak Geological Survey, for acceptation of papers in extenso and extended abstracts of lectures, which have been presented in the Udine and Genova meeting, to be published. It should be mentioned, that abstracts of presented oral communications in the Eggenburg meeting in September 2000 have been published in archaeological journal Archeologické Rozhledy (LII, pp. 709-725, Praha) in 2000.

Realizing IGCP/UNESCO 442 Project also geosciences as well as archaeology try to add some new information on pre-historic human societies, namely on the level of their material life. Based on archaeological artefacts, represented by daily used tools, but also weapons and symbols of power or excelence, application of standard geoscience laboratory methods and used equipments allow to define types of the raw materials used and to characterized their provenancies. Meanwhile in the Palaeolithic leading abiotic raw material has been represented by radiolarite, flint, obsidian and limnoquartzite, resp., settled style of living ("neolithic revolution"), introduction of agriculture as the substantial way of food providing and treatment of domestic animals in the Neolithic, needed high amount of suitable stone tools. Chipped tools characteristic for the Palaeolithic have been replaced by polished tools in the Neolithic. They have been made from various kinds of rocks of all three main types: from the sedimentary, metamorphic as well as igneous categories. Their identification on one side, and definition of their provenances on the other one, together with tracing their migration paths in European continent, is the main goal of given IGCP/UNESCO interdisciplinary project.

Prof. Dušan Hovorka
leader of the project IGCP/UNESCO Nr. 442
Faculty of Natural Sciences
Comenius University, Bratislava, Slovakia
tel.: +421 2 60296 296
e-mail: Hovorka@fns.uniba.sk

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Peculiar abiotic raw material types used in the Stone Age for implements construction (territory of Slovakia)

DUŠAN HOVORKA

Faculty of Natural Sciences, Comenius University, Mlynská dolina, 84215 Bratislava, Slovak Rrepublic

Abstract. For all three main prehistorical time-periods on the territory of the Slovak Republic e. g. Palaeolithic, Neolithic and Aeneolithic, except of "common" also peculiar abiotic raw material types are characteristic. In paper their characteristics are presented. Following raw material types are considered to be peculiar in: a) Palaeolithic: silicified volcaniclastics, acid metavolcanics, b) Neolithic: jadeitite, Al-rich spinel-anthophyllite-hornblende schists, simplectite eclogite, almandine-omphacite eclogite, plagioclase-clinopyroxene hornfels, limy mudstone, terra rossa, c) Aeneolithic: soapstone/talcite, sapropelite, clays as raw material of axes.

Key words: Stone Age, peculiar abiotic raw material types, Slovak Republic

Introduction

During the very last years in the frame of national as well as international (IGCP/UNESCO 442) projects several tens of raw material types have been identified from archaeological sites on the territory of the Slovak Republic. As the objects of petroarchaeological studies we used implements from several museums collections together with the implements from the deposits of the Archaeological Institute of the Slovak Academy of Sciences in Nitra. Partial results of not yet finished studies, using standard laboratory methods of petrography and mineralogy, have been published by the author and co-authors in several scientific journals. Review of the present-day knowledge to the end of 1999 was presented in paper by Hovorka & Illášová (2000). Since the mentioned time on the territory of Slovakia several peculiar raw material types of abiotic character have been identified. In this paper peculiar raw material types will be presented according to the archaeological ranking of implements made of such raw material types.

It ought to be mentioned that peculiarity in the case of raw materials defined represent:

a) raw materials from the very distant or unknown sources,

b) raw matetrial not being standardly used for implements make, or very seldom occurring raw material types.

Peculiar abiotic raw material types are characterized according to chronological division of the pre-historic time.

PALAEOLITHIC

In accordance with the whole continental Europe trend, radiolarites, flints, cherts and acid volcanic glass (obsidian), also on the territory of the Slovak Republic mentioned raw material types have been leading ones during the Palaeolithic. But except of those there were documented several unusual/peculiar raw material types found as ready made implements on various archaeological sites.

Silicified dacitic and andesitic volcaniclastics

have been documented during excavations of cave Prepoštská jaskyňa in Bojnice (Bárta 1980). Our consequent recognition studies confirms Barta´s identification and description. Discussed stone implements are deposited in Ethnographic Museum of the Slovak National Museum in Martin and in museum at Prievidza.

Silicification in the case of discussed implements raw material is hydrothermal postvolcanic process bound to the Late Tertiary volcanic activity forming surface/subsurface geological formations of the Vtáčnik Mts. located in „one day walking distance“ of the place of implements discovery. The wealths of implements found in mentioned Palaeolithic site is due to the presence of thermal mineral springs - and consequently non freezing water in the river Nitra - which was the place of crowds of deers and other big animalts stay during cruel winters in the Last Ice (würm) Period.

Acid metavolcanics

(originally described as „porphyroids“ by Mišík 1975) have been identified as the raw material of implements found on wellknown site Moravany nad Váhom. Taking into account geological situation in the adjacent mountain ranges (e. g. the Považský Inovec Mts. and the Malé Karpaty Mts., as well) where such rock are not known, we suppose that pebble of mentioned rock was one pebble type forming so called exotic conglomerates of the Pieniny Klippen Belt in the river Váh valley.

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Acid metavolcanics and metavolcaniclastics are widespread among Early Palaeozoic complexes of the gemeric unit (inner Western Carpathians) located at least 250 km to the east of the place of implement of the given type discovery.

Following the Mišik´s (l. c.) description given raw material type has both, e. g. relic magmatic as well as the younger metamorphic fabrics. The first one are represented by magmatically corroded feldspars and quartz phenocrysts, meanwhile metamorphic features are documented by recrystallization of magmatic minerals, recrystallization of probably glassy groundmass, and well pronounced metamorphic foliation. Foliation planes have been used by implements makers as natural long sides of the given implement.

NEOLITHIC

Geological units forming continental Europe from the aspect of the rock filling are significantlz different. So also raw material types, namely those of the local provenience, differ from place to place. Based on this, among peculiar raw material types we rank those, which do not occur on the territory of the Slovak Republic, or are not part of geological sequences of neighbouring geological megaunits.

Jadeitite

belonging to the most exotic raw material type has been identified (and consequently studied in detail using electron microprobe: Hovorka et al., 1998) as the raw material of small flat non-bored axe from the western part of the Slovak Republic. The axe has been slightly demaged on the but end. Comparing mineral composition (almost monomineralic rock composed of stechiometric jadeite) as well as fabric features we are keen to joint it with the set of axes made of the just the same raw material which have been described from several Moravian (easternmost part of the Czech Republic) localites (Schmid & Štelcl, 1971). As in the whole western sector of the Carpathian Arch as well as in the Eastern Alps no jadeitite occurrences are reported to occur, the provenance of this exotic raw material type is not yet known. The nearest very small occurrences are listed from the Eastern Sudetes of the Poland territory. In the Eastern Alps there do occur such rock bodies which supplied corse detritic material for numerous implements described from the Po basin or northern Italy, generally (D´Amico et al., 1995).

Al-spinel-anthophyllite-hornblende schists

as the raw material of flat, non bored axes have been described from several sites located in the western part of the country. Their petrological character as well as the origin of the given raw material type of this peculiar character have been subject of paper by Hovorka et al. (1993). Since the time of above paper discussed raw material type have been found as the raw material of the mostly lengyel cuture flat, simple, mostly non-bored axes. Characteristic is the distribution of implements of mantioned raw material type in the western part of the country and in northwestern part of Hungary (Gy. Szákmány, personal communication, 2000).

Based on studies in detail (l. c.) and realised electron microprobe studies of the rock forming minerals the character of this raw material type should be summed up as follows.

Schists of discussed type have slightly up to well pronounced metamorphic foliation. Except of phases given in the rock-name there is also accessory amount of olivine, Mg-chlorite, magnetite, and in some cases also clinozopiste-group minerals.

Characteristric is apple-green Al-rich (60-62 % of Al_2O_3) spinel of irregular morphology concentrated in rectangular or lense-shaped parts of individual thin sections. So we suppose Al-rich spinel to be the product of breakdown of an original (magmatic?) phase rich in alumina. In mentioned rectangular, or lense-shaped portions, green spinel reach up to 40 %, in individual thin sections up to 20 % of the total mineral association

Simplectitic eclogite

has been identified as the raw material of small non-bored hammer-axe from site Nitriansky Hrádok (Hovorka & Illášová, 1996). This raw material type is not known from the Western Carpathians, as well as from the northern ridges of the Eastern Alps, which supply rivers (Danube and its tributaries) flowing to the north, by gravels. On the southward oriented Eastern Alps valleys there occur alpine-type eclogites with no significant traces of retrogressive recrystallization, which is characteristic petrological feature of the eclogite under consideration. So several geological units of the Bohemian Massif should be taken into consideration as the possible source of the simplectitic eclogite raw material type. But also in this case river pebble transport from the Bohemian Massif to the Danube river should be the most probable. Site Nitriansky Hrádok is located some 40 kms from the Danube river, which distance is traceable by the river Nitra as the communication path.

Almandine-omphacite eclogite

Also this raw material type is represented by one bored flat axe from the site Svodín, which represents one of the most typical lengyel culture sites.

For the raw material under consideration characteristic is shape of present garnets: they more-or-less all have atol-like morphology. Chemical composition of garnet and stechiometric omphacite, together with the low amount of amphibole, indicate insignificant retrogressive recrystallization of original high-pressure rock. This peculiar raw material type is described in detail (microprobe analyses of rock-forming minerals included) in paper by Spišiak & Hovorka (in print).

Also in this case we consider Bohemian Massif to be the source of this raw material type. Eclogites of similar characteristics (e. g. atol-like almandine) are known to occur namely in the Marianske Lázně metabasite complex in the southwestern part of the Massif. As this geological unit is drained by brooks and rivers of the Elbe provenance, the dry land transport is the most probable in this case.

Plagioclase-clinopyroxene hornfels

have been described in the very last time (Hovorkas et al., in print). Those very fine-grained rocks of massive diablastic pattern, composed of mentioned two main mineral phases, are the raw material of morphologically just the same 4 axes from the site Svodín. They are flat, non bored, small. Identical microscopic pattern indicates one block to be the actual raw material of which on the site of discovery, mentioned 4 axes have been made.

Though such plagioclase-clinopyroxene hornfelses are not described in the frame of Late Tertiary volcanic province, we consider contact-thermic origin of mentioned raw material. Thermal supply for thermic recrystallization has been given by a volcanic body. From it involved block should have been liberated and as appropriate raw material should has been gathered on slope formed by the products of the Late Tertiary volcanic activity, or directly as the block in the river Hron valley sediments.

Identity of the raw material of described type in the case of 4 small axes from site Svodín indicate their construction from the just one (identical) block of the source material on the site of their finding.

Limy mudstone

represents leading raw material on the lengyel culture site Šarišské Michaľany (eastern Slovakia). It represents typical local raw material. Numerous outcrops in the brook are located several hundreds meters of mentioned large settlement.

Limy mudstone is member of the Palaeogene rock seguences, which form filling of the Tertiary basin. This rock type is a member of the flysch sequence along with fine-grained sandstones, clays and conglomerates, respectivelly. Relative hardness of the give rock-type is the consequence of described raw material mineral composition (e. g. quartz of silty fraction, clay minerals and calcite) on one, and their fine-grained character on the other side. Description in detail of this raw material type is presented in paper by Banská et al. (1998).

Limy mudstone served as the raw material for axes, hammer-axes, chisels, crushers ao. construction.

Terra rossa

as the raw material used for ceramic production is known from the Domica cave, which represents one of the most typical lengyel culture site not only on the territory of Slovakia, but elsewhere. Terra rossa represents residual material after chemical weathering of carbonate complexes, which were high in iron. Iron oxids act as color (red) pigment. This pigmentation didn´t disappears after the ceramic production, its final technological stages treatment in fire included. As terra rossa shoul be classified as low quality iron ore, for a ceramic production appears to be peculiar raw material type. Except of the Domica cave similar/identical type ceramic has been found also in the other caves located in the Juhoslovenský Kras (Karst) area.

AENEOLITHIC

Daily activities of people in the Aeneolithic became more complex and in several aspects some of them start to be specialized. Patrilinear relations in human communities replaced matrilinear one, which has been leading in the past. Simultaneously "vertical" stratification inside individual tribes brought the need of new raw material types for ornamental/symbolic purposes, or as documents of power or exceptional social position. Mentioned newly developed internal social stratification needed new raw material types to express some social aspects inside individual communities. So Aeneolithic represents time-period, in which man returned to the use of raw material types known from the Palaeolithic on one side, and simultaneously use of a new raw material types on the other one.

Soapstone/talcite

has been identified as being raw material of one non-bored flat axe found on fields close to the Senica town (western Slovakia: Illášová & Hovorka, 1995).

Raw material described is pronouncedly soft. In mineral composition fine-flaky talc dominates. Except of this leading phase also Mg-chlorite, carbonate and ore minerals are present in accessory amounts. On the described implement no traces of practical use have been observed.

As in the westernmost located Western Carpathians core mountains no such rock types are listed, it is the most probable that provenance of soapstone/talcite should be geological units forming NE rim of the Bohemian Massif, wherea namely in the Merta river valley several such rock-bodies are known to occur.

Sapropelite

represents raw material of ornamental rings and the other decorative small artefacts. By its nature sapropel represents raw material of mixed (organic-anorganic) origin. This raw material type is actual mixture of organic material intimately mixed with the clay portion. They quantitative proportions change from seam to seam. It is relatively soft, well and simultaneously easy workable material which accompany the majority of coal seam in coal basin of namely Neogene in age.

Ornamental artefacts made of sapropelite have been found on the territory of the Slovakia sporadically only. They have not been studied in detail yet. Artefacts of describd type have been described on several sites in the central part of the Czech Republic. So import of this raw material type or ready made implements from mentioned province is probable.

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Clays as the raw material of axes

Are documented from several Aeneolithic sites from the western Slovakia (Točík et al., 1970). In this case clays-made axes served not for practical, but symbolical denomination. Clays-made axes bears morphology of the most widespread types of the Neolithic axes (e.g. lengyel culture axes). Actual composition of original clays, and their provenience respectivelly, has not been studied yet.

CONCLUSION

Through the whole prehistoric time-period tribes living in the territory of the nowadays Slovak Republic besides common raw materials of the abiotic nature from time-to-time and place-to-place used also peculiar raw material types. The peculiarity is expressed by: a) unusual raw material types used in given time-period (silicified volcaniclastics and acid metavolcanics in the Palaeolithic), b) in nature seldom occuring rock-types used as the raw material of individual implements (jadeitite, almandine-omphacite eclogite with atol-like garnets, plagioclase-clinopyroxene hornfelses in the Neolithic), c) raw material with unfavorable technical properties (limy siltstones in the Neolithic and soapstones in the Aeneolithic), d) raw materials which are not known in the form of geological bodies namely in the central Europe (Al-rich spinel-anthophyllite-hornblende schists in the Neolithic). For the identification of mentioned peculiar raw material types modern laboratory methods have been used.

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Lithic resources in the prehistoric societies of the III - II millenniums B.C. in the Rio Turón valley (Ardales, Malaga, Spain)

SALVADOR DOMÍNGUEZ-BELLA[1]; JOSÉ RAMOS MUÑOZ[2], PEDRO CANTALEJO DUARTE[3], MARIA DEL MAR ESPEJO HERRERÍAS[3], VICENTE CASTAÑEDA FERNÁNDEZ[2] & ANA DURANTE MACÍAS[4]

[1]Dpt. Cristalografía y Mineralogía. Universidad de Cádiz. Facultad de Ciencias. Apdo. 40 Puerto Real, Cádiz. SPAIN. e-mail: salvador.dominguez@uca.es
[2]Área de Prehistoria. Universidad de Cádiz. Facultad de Filosofía y Letras. Cádiz, SPAIN.
[3]Historical Museum. Ayuntamiento de Ardales. Málaga. SPAIN.
[4]I.E.S. Huerta del Rosario. Chiclana. Cadiz . SPAIN.

Abstract. The valley of the Rio Turón, a tributary of the Guadalhorce river, is placed at the Northwest of the Malaga province, South Spain. This has been an important area of transit, between the coast and the inland of central Andalucía, along the historic and prehistoric periods. An abundant human occupation has existed in this valley, that presents a wide and continuous archaeological register from the Palaeolithic to the Mid Age. Mineralogical and petrological characterization of polished and chipped lithic materials from the III-II nd millenniums B.C. from archaeological settlements in the Rio Turón valley, are carried out.

Mineralogical and petrological features of these materials are compared with the possible geological source areas in this area: flint materials from the limestones and dolomites of the Jurassic - Cretaceous age (Subbetic and Betic materials of the Betic Cordillera); dolerites from the outcrops in Keuper facies (Triassic Subbetic materials); ultrabasic rocks from the Ronda peridotites Massif, and other lithologies as amphibolites, limestones, sandstones, etc. that appear in the tools, with geological materials of this area.

Finally, a preliminary systematic study of the technological features of these materials show a direct relation between lithology and kinds of tools, in these agricultural societies of the III-II millenniums B.C.

Key words: Mineralogy - Petrology, Polished artefacts, Flint, Neolithic-Calcolithic, Raw materials, South Spain.

Introduction

We have developed an investigation project called „Archaeological systematic prospection in the municipal district area of Ardales" (Ramos, *et al.*, 1987; Espejo, *et al.*, 1987), with a prospection continuity in the valley of the river Turón (Espejo y Cantalejo, 1988, 1989). We have also excavated two necropolis of the II millennium B.C., Morenito I (Ramos, *et al.*, 1986, 1989) and Cerro de las Aguilillas (Espejo *et al.*, 1994; Ramos, *et al.*, 1995, 1997, 1999).

These studies have allowed us to document a register of 24 sites (centres of population, caves, lithic production workshops, burials) that belong to societies of the III and II millennium B.C. We must also remark a great number of occupied sites (villages, settings in caves) associated to tribal communitarian Neolithic societies (Espejo 1987; Ramos *et al.*, 1987, 1995) that inform us of a long historic process of sedentary life and of the beginning of the production economy of the area zone.

We are studying with petrological and mineralogical characterization techniques the different types of resources: siliceous, basic rocks, metamorphic, etc. These types of lithic resources are checked with the ones obtained in the archaeological register, by prospection or excavation, and they allow us to obtain an important approximation to their catchment and sources.

We developed a technological and typological study of the products as an approximation to the technology and the working processes. Here we carried out a contrast between the various lithologies and the archaeological types, that informed us of the possible preferences associated with the use of the available raw materials. We pretend within a medium time, to integrate the functional studies as an approximation to the working processes.

This methodological frame aspires to integrate the geological resources with the archaeological facts. The local and regional knowledge helps to understand the lithic potential resources of this zone.

Finally, we unified all the above with the spatial contexts of the products location, according to the idea of associating products with structures, in order to define activity areas (Ruiz, *et al.*, 1986).

Thereby, the archaeometric techniques overcome the „innocent and only descriptive" conceptions and they are of a great help to understand the economic, historical social problems, associated to the social formations in study (Ramos, Domínguez and Morata, 1997).

We work from a theoretical position related with the Social Archaeology. We pretend to link the development of the mineralogical and petrological techniques to solve historical problems. Our aim is, by using other studies (technological, archaeobotanic, faunistic, spatials, etc.) to examine thoroughly the knowledge of the way of production and the working process in these societies (Bate, 1998; Terradas, 1998; Pie and Vila, 1992; Ramos, 1999).

Geographical setting and territorial occupation

We study the occupation during the III and II millenniums B.C. in the geographical territory of the intersection of the Turón, Guadalhorce and Guadalteba rivers. It is a peripheric area to that of the nuclear zone located in the Depresion de Ronda (Aguayo *et al.*, 1992), Vega de Antequera (Ferrer and Marques, 1986; Fernández, 1988), and into a general frame of the Guadalquivir Valley, within what F. Nocete calls the meridional mining periphery (Nocete, 2001).

This zone is a confluence area of paths that permits to go over the Subbetic mountains barrier, that separate the inland and the Malaga coast. It is also a natural way between the Vega de Antequera, a fertile inland plain; and the upper course of the Guadalhorce river, with the Higher Andalucía area, and to Antequera with the Ronda-Cádiz lands and the Lower Andalucía (Fig. 1).

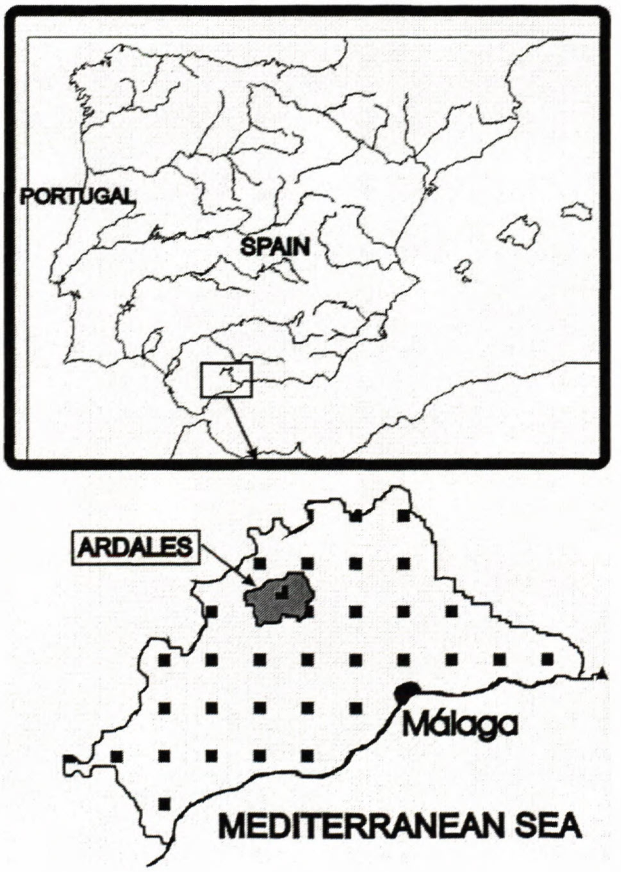

Fig. 1: Geographical setting of the Ardales municipal territory (Malaga province, Andalucía) South Spain.

This territory has a diversified landscape of a great geologic complexity (Durán and López, 1995), that offers to the different societies that occupied the zone wide possibilities for the human settlement. On the one hand, the Sierras Prieta, Alcaparain, Ortegicar, offered cynegetic resources, of mountain agriculture, forestall and siliceous resources catchment.

On the other, this zone has wide resources into the actual countryside and fertile valleys, that permitted a development of the production modes based in the agriculture and the cattle raising.

Archaeological register and lithic materials (III-II millenniums B.C.)

The transition from the IV to the III millenniums are well documented in this area, specially at the villages of Olivar de Curro and Cortijo de San Miguel, in zones with a great agricultural potentiality.

The last, with a silos field typical of the control and storage of an agricultural production. They are stable villages that have an agricultural economic base characteristic of the tribal society.

The villages of the III and II millenniums are placed (Fig. 2) in strategic height sites as Peñas de Ardales, Cerrajón and Espolón de Guadalhorce-Kontiki. Its dimensions are small, around 50x50 m. They control the routes and conform a natural belt of safety and internal control of the barns placed in the silos fields.

The most important villages are situated in the fertile valleys, as occur in Viveros, Morenito, Loma del Infierno; they occupy spaces of 50x50 m. The Mirador is an archaeological site of 100 x 100 m. placed on a fluvial terrace of Turón river.

Archaeological materials: chipped industry

The flint extraction by quarrying or mining works are linked to the obtention of siliceous materials for the elaboration of tools that will be used later in the domestic diary works, as well as in artefacts production of forest works, as axes, picks, big retouched flakes.

We have studied a selection of 65 archaeological samples of chipped stone industry from four flint workshops of the III millennium (La Galeota, Castillo de Turón, Lomas del Infierno and Morenito) and one workshop of the II millennium B.C. (La Raja del Boquerón).

Laminar products have also been documented (Fig. 3) that will later be deposited as ideological objects in the burials. This allows us to understand how the production of big laminar flint have become an strategic sector of constant demanding (Nocete, 2001). The flint extraction labours will increase during the III and II millenniums in this zone for the demand of the zone and for the countryside of the Guadalquivir valley, where these resources are practically absent (Nocete, 2001)

Lithic production areas are also located in Cucarra, Azulejo, Loma del Infierno and Morenito.

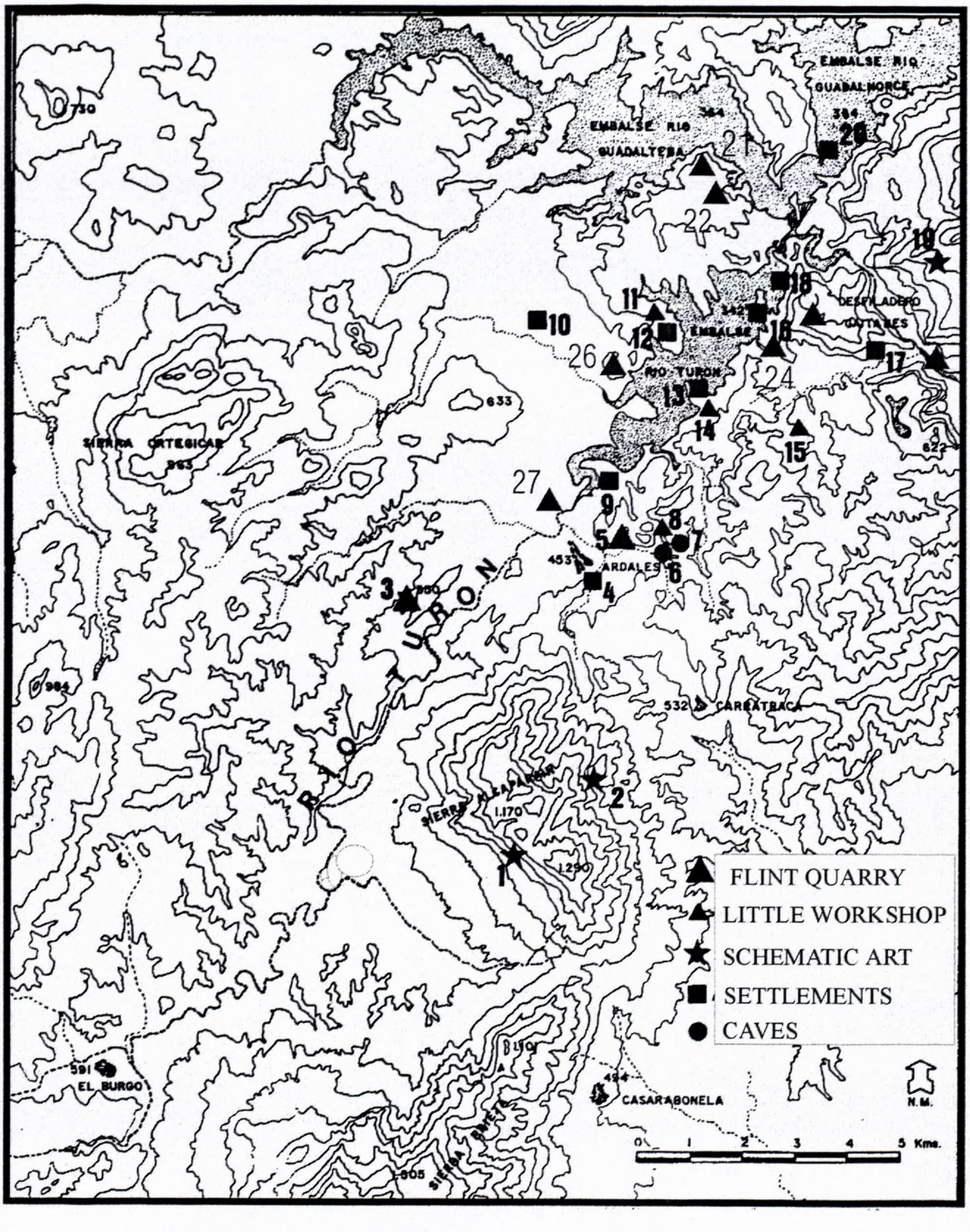

Fig. 2: Archaeological sites of the III and II millenniums B.C. in the Río Turón Valley.
III-II Millennium sites: 1: Runtuntún; 2: Los Murciélagos; 3: Castillo de Turón; 4: Peña de Ardales; 5: La Galeota; 6: La Calinoria; 7: Ardales Cave; 8: Cucarra; 9: Vivero; 10: Olivar de Curro; 11-12: Lomas de Infierno; 13-14: Morenito; 15: Azulejo; 16: Parque Ardales; 17: Villaverde; 18: El Mirador; 19:Los Gaitanes; 20: Espolón de Guadalhorce.
II Millennium sites: 21-22: Las Aguilillas; 23: Gaitanejo; 24: Las Atalayas; 25: Almorchón; 26: Raja del Boquerón; 27: Retamar.

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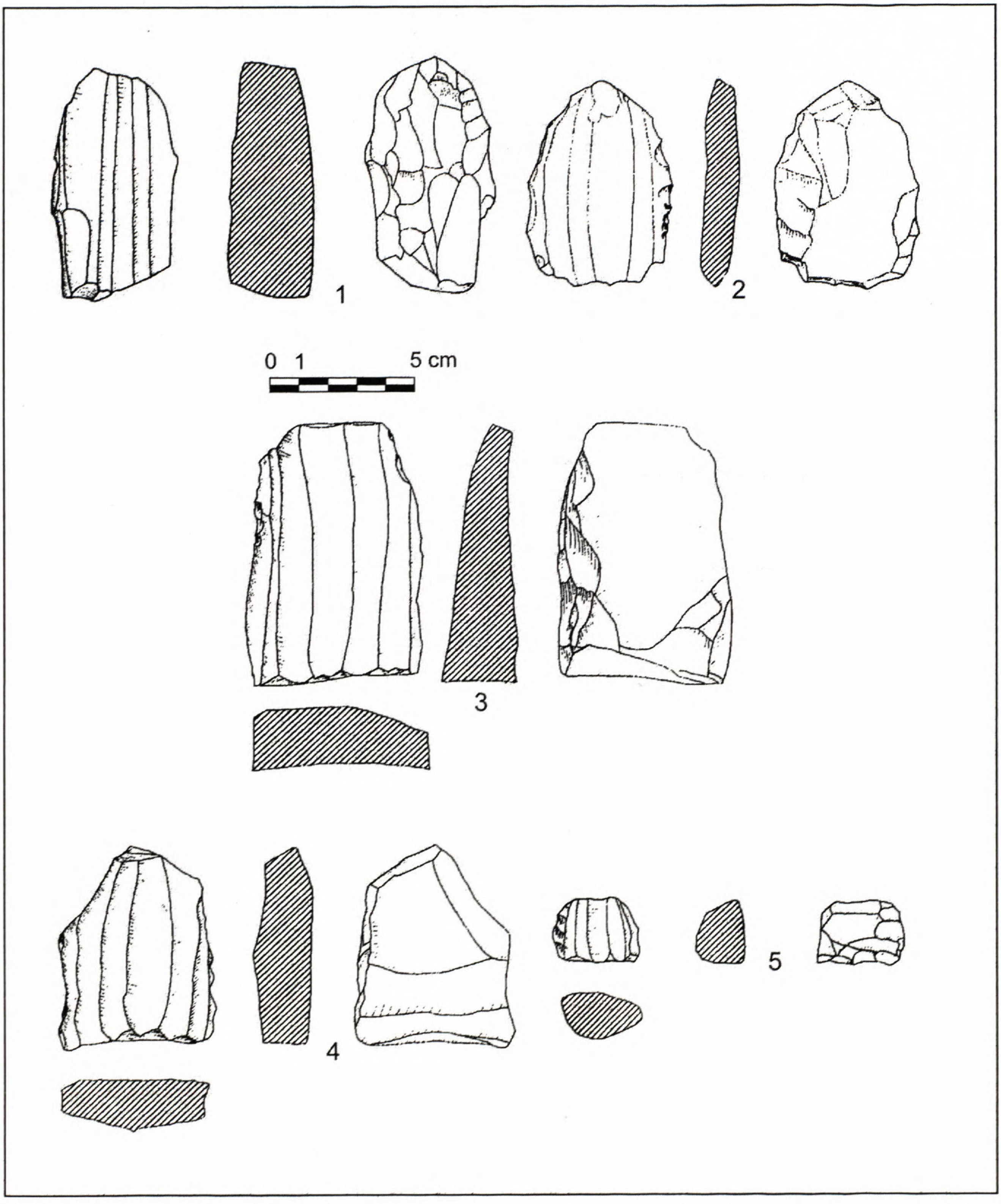

Fig. 3: Flint cores for blades obtention. (III millennium B.C.). Castillo del Turón flint workshop.

The flint working process generates cores and flakes that will support tools, that will be used in different functions and works (Figure 4).

The agricultural works are described with sickle elements, blades with lustre and products in elaboration process; linked to them are notches, denticulate and serrated flakes. There are also products related to domestic activities as scrapers and blades with continuous retouches. On the other hand the maintenance of the hunting work mode are confirmed with foliaceous points with plain retouches. These, together with the metallic objects, confirm the increase of the control on the productions.

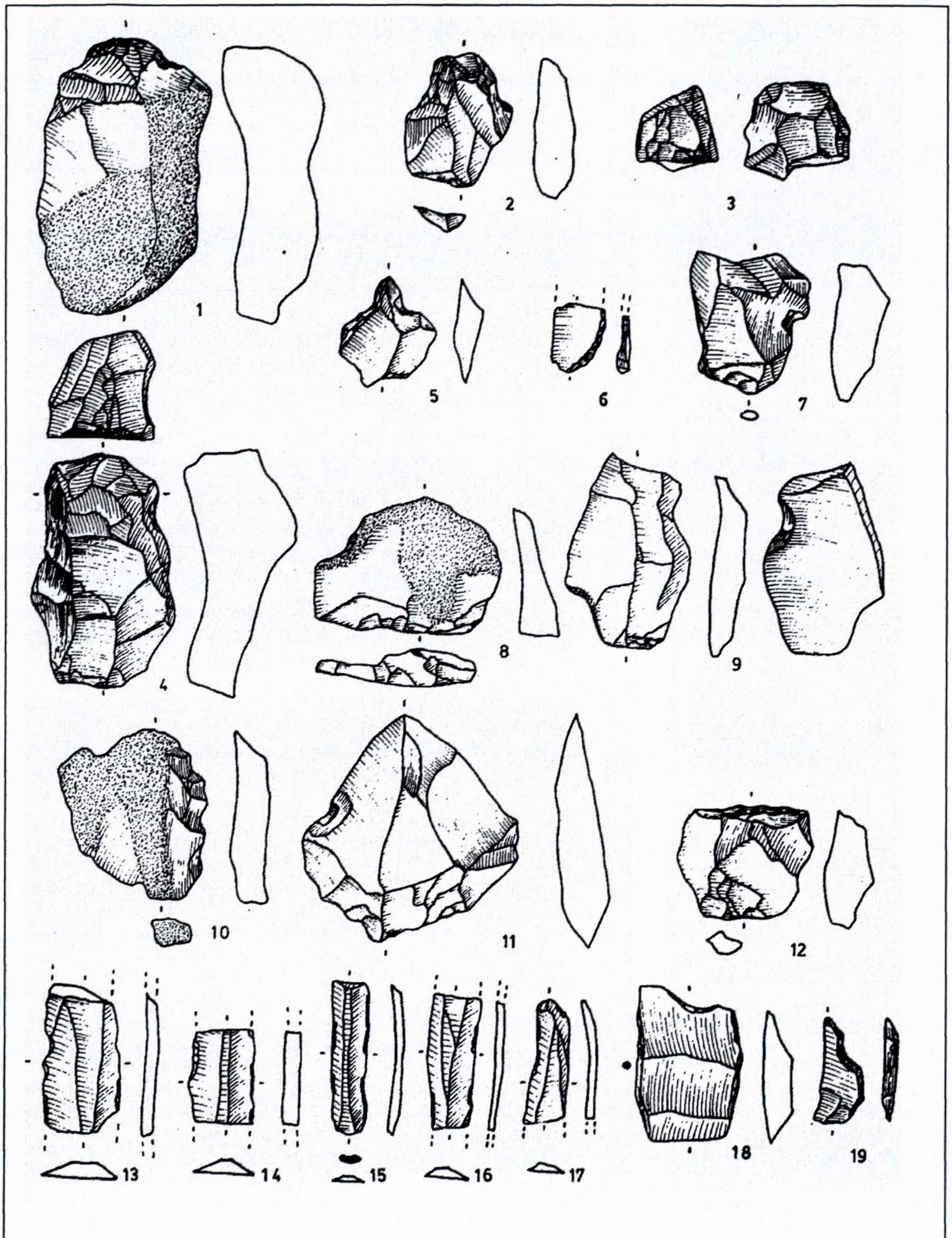

Figure 4: Different kinds of flint chipped tools (III millennium B.C.). Puerto de las Atalayas flint workshop.

Archaeological materials: Polished industry, ceramic and metals

In the settlings of the III millennium B.C., numerous polished stone products are documented. They are elaborated in dolerite and other hard rocks, as fundamental tools for the agricultural activities, as axes and adzes, mullers and mills for the vegetal product processing.

The documented ceramics of the different sites help us to explain their functionality.

There are shape evidences (jars, pots) characteristic of a storage for a direct consumption in the reduced sites. The morphological kind of ceramic for consumption, as dishes and serving dishes with thicken edges, are located in the villages of Olivar de Curro and El Mirador. The consumption bowls appeared in different sites. There are also alloctonous ceramics that are obtained in the trade relations, as the Campaniform ceramics.

During the III millennium B.C. a consolidation process of the tribal society is conformed. An agricultural intensification and an reorganization of the settlings are developed. This occurs in the surroundings of the Guadalhorce, Guadalteba and Turón rivers. We document real barns with accumulation of agricultural surplus that are organized as a real belt of places for its control (Peñón de Ardales, Parque Ardales and Espolón del Guadalhorce-Kontiki).

This situation is increased during the II millennium B.C. The settlings now occupy high, strategic places in pass ways with a good visibility and strategic position in relation with immediate productive territory.

Some villages of the III millennium are abandoned, and the number of settlings and villages are reduced. A population concentration is appreciated in the site of El Castillón, with important settlements in the Guadalhorce and the Guadalteba fluvial beach.

Places as Cerrajón and Peñón de Ardales are placed in steep hills and they seemed specialized settlings, due to its strategic situation and to the disposition of metallic products, that prove the extension of armament and the increase of the extortion of direct producers. They also control the soil used for planting cereals and the shepherding routes of the nearby mountains.

All this points out to a characteristic phenomenon of an initial classistic society. The economic structure of this society is agricultural, with a technology production, with elements of sickles, polished axes and adzes (Figures 5, 6 and 7).

In the inhabited sites, the silos are placed for pots for its storage. The cattle raising is documented by faunistic register of places as Cerro de las Aguilillas, with: *Bos taurus*, *Capra hircus*, *Sus domesticus*; and with hunting of *Cervus edaphus*, *Lepus granatensis*, *Oryctolaque coniculus* and *Vulpes vulpes*.

A certain specialized production exploitation is kept of the mines and quarries of siliceous materials, for local consumption and to supply the villages of the Guadalquivir valley countryside.

The metallic products are documented in the strategic sites and in the necropolis of Morenito, Las Granjas, Rajas del Boqueron, Lomas del Infierno, Las Aguilillas. Palmela points, punches, swords, daggers, appear. They are related with a military control. There is an interesting social hierarchization documented in the burials and artificial caves. Collective burials of the individuals, with important ceramic and lithic products and votive objects trousseaus, are found. These prestige objects denote differences of social status, this is only possible in these kind of societies with surplus products.

The burials in individual cists reflect that the local elites can acquire luxury products in periphery territories, so there was a centralization process and a posterior distribution.

Geological setting

This zone is situated in the occidental sector of the Betic Cordillera, an alpine mountain chain specially affected in the Tertiary, with the North zone of Africa, by an intense tectonic phenomenon. This valley is placed in a limit zone between the Internal and External zones of the Betic Cordillera, with the presence of some zones: the Betic zone, the Circumbetic zone, the Subbetic zone, the Tectosedimentary formations and Post-nappe materials.

In this area of the Cordillera we can differentiate many Complex: the Alpujárride complex; the Maláguide complex (Betic zone); the Campo de Gibraltar Flysch (Circumbetic zone); the Subbetic Units and the Miocene pre and postorogenic formations (Tectosedimentary formations) (Cano Medina, 1990).

In Figure 8 a synthesis of the distribution of geological materials may be observed in this zone of the valley of the Rio Turón. At the East of the village of Ardales appears a series of Jurassic mountains as the Sierra del Valle, that formed the most important relief of the zone (1191 m.), orientated in the E-W direction and is formed by oolitic limestones, marls and marly limestones, that are crossed by the Guadalhorce river in the Los Gaitanes gorge.

These mountain are limited in the South by materials of the Alpujárride and Maláguide complex, with approximate chronology of Precambrian? (migmatitic banded gneisses) and Palaeozoic (mica-schists and quartzites), and in the West, in clear discordance with them, by calcarenites and horizontal conglomerates of the Upper Miocene (Tortonian).

At the South of Ardales village appears the Serrezuela de Carratraca and the great relief Alpujárride of the zone, the Sierra de Alcaparaín (1190 m.), that is mainly formed by white saccharoid marbles of Triassic age; with Triassic and Jurassic materials, formed mainly by dolomites and limestones.

The western zone of the Ardales municipal district, that occupied the left margin of the Rio Turón valley, was dominated by materials of the Upper Cretaceous, the called „red beds", that are constituted by marly limestones and reddish marls. The right side of the river is dominated by dolomitic materials of the Triassic age and by La Nava Oligocenic breccias.

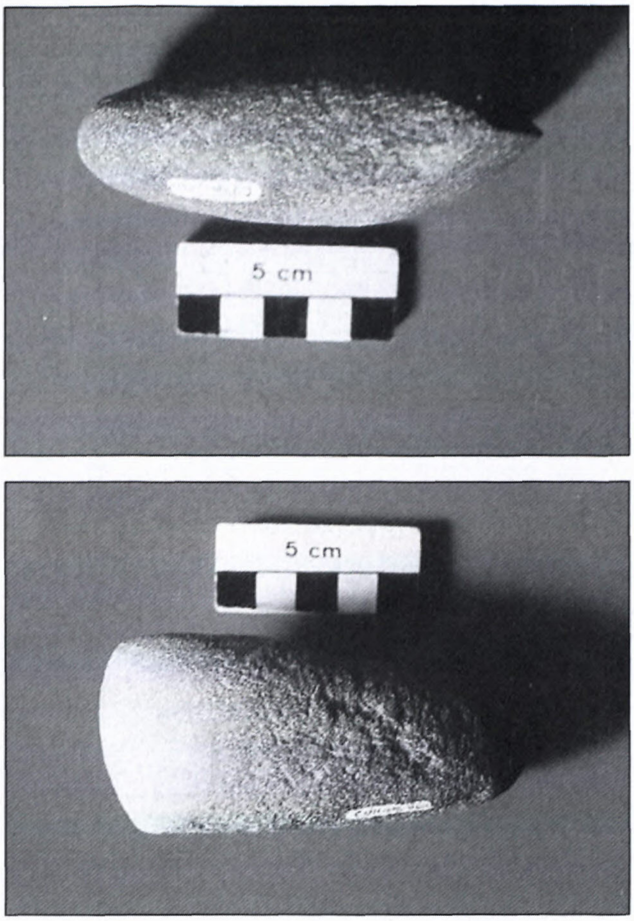

Fig. 5A–B: Amphibolite polished axe. Olivar de Curro site.

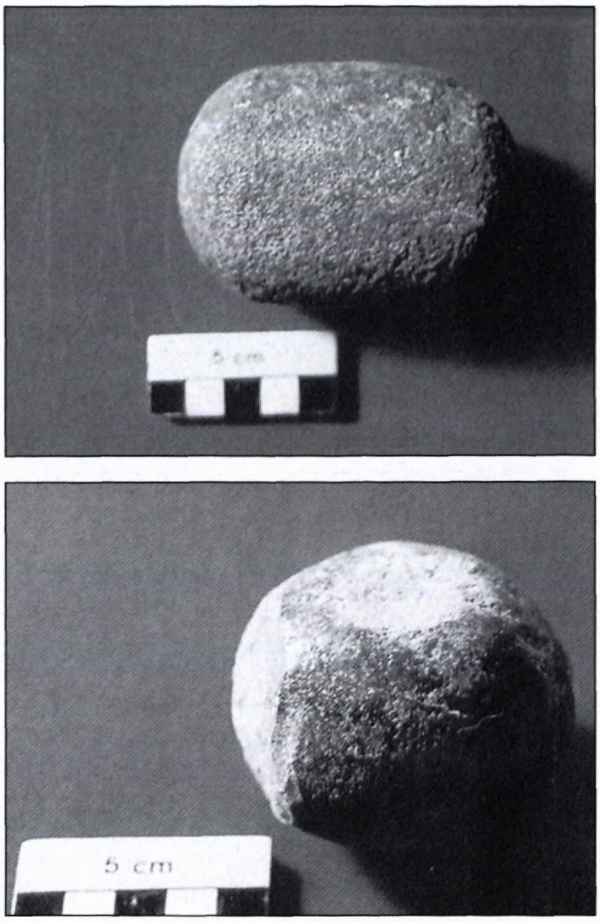

Fig. 6: Dolerite polished muller and metamorphic black quartz polished ball. Almorchón West site.

Fig. 7: Amphibolite - Dolerite polished axes. Peña de Ardales site.

All the fertile valley at the North of the river, is mainly occupied by marls and clays of the Miocene age, where we can find outcrops of Cretaceous limestones and marls.

Raw materials and possible source areas

Different lithologies appear in the archaeological register of the sites from the III-II millenniums B.C.; mineralogical and petrological features of these materials are compared with the possible geological sources in this area.

The main geological materials that appear in the area of Ardales and the valley of the river Turón are as we have described, of different origins, ages and lithologies:

– *Igneous rocks*, represented by the outcrops of the SE district area, in the Sierra de Aguas, with peridotitic materials and lithologies of dunite type, harzburgites and lherzolites. Subvolcanic rocks outcrops of dolerite type (ophite) have been as well found in the north zone of the Guadalhorce and Guadalteba dams, in the clays and marls of the Subbetic Triassic.

– *Metamorphic rocks*, specially the banded gneises, situated in the south slope of the Turón valley, at the East of Ardales, belong to the Alpujárrides units and they usually present a migmatitic character with other mineral association type: quartz, muscovite, biotite, garnet, plagioclase, with the presence in other zones of sillimanite, kyanite, andalusite and staurolite. In some zones the appear crossed by quartz veins, usually deformed.

Amphibolites have been described in this zone (Cano Medina, 1990), in intercalations with Palaeozoic materials, with associations: quartz, epidote, hornblende and quartz, biotite, garnet, epidote, hornblende, oligoclase.

– *Sedimentary rocks,* limestones and limestones with flint of the Jurassic, appear as well as a cretaceous marls

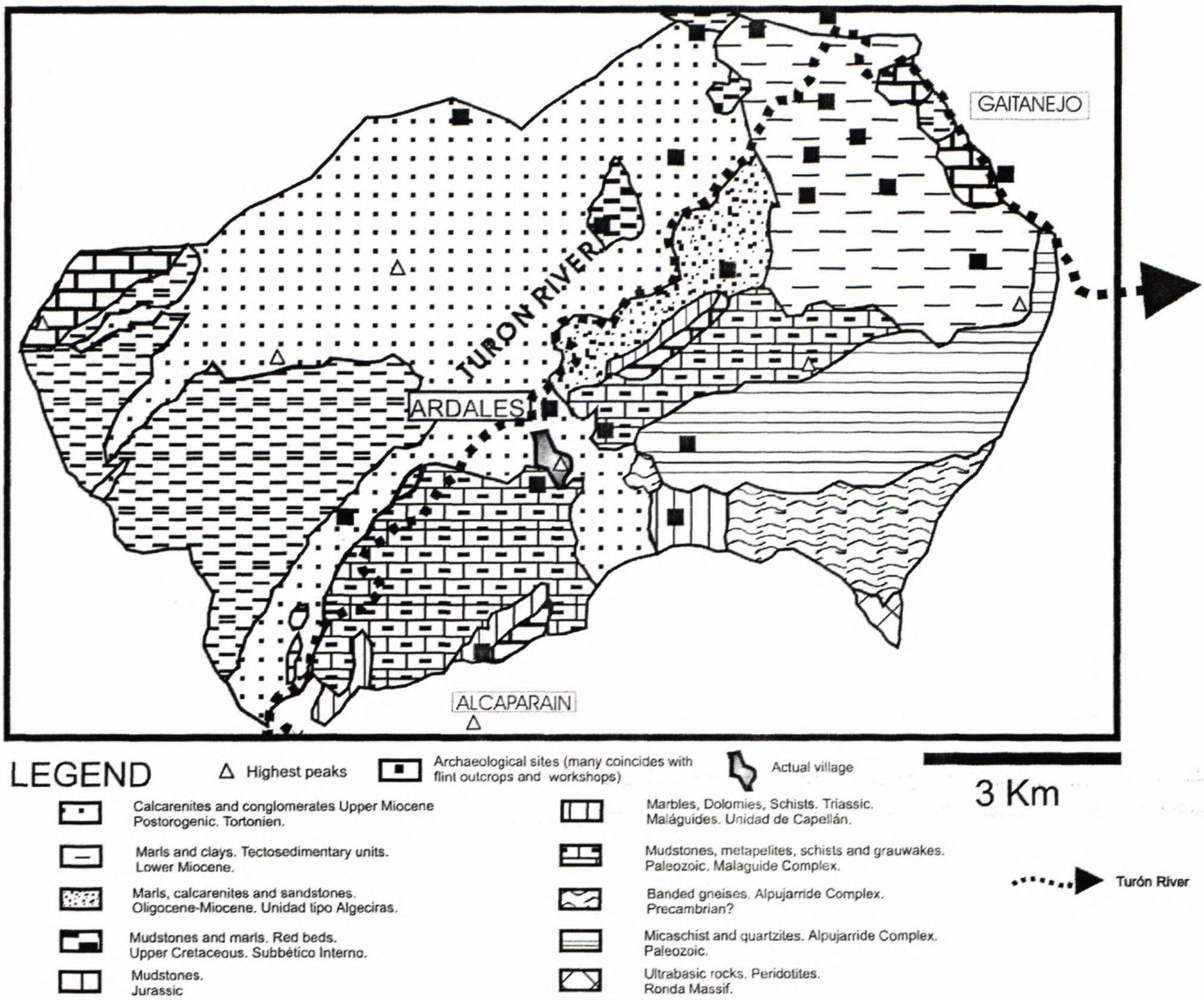

Figure 8: Synthesis map of the geological units present at the Río Turón Valley (Ardales municipal district).

and marly limestones. Carbonated lithologies of the Triassic Age are also common, as occur in the Sierra de Alcaparaín.

The Tertiary materials are based in the presence of marls and clay of the Lower Miocene, in all the North fertile valley of Turón and the calcarenites and conglomerates of the East zone of the valley, in the dam of El Chorro, Puerto de las Atalayas, the Mesa de Bobastro, etc., with a chronology of the Upper Miocene (Tortonian).

After the study of a representative selection of polished tools from the III-II millenniums archaeological sites of the Rio Turón Valley, we observe a limited variety of lithological kinds. This distribution is shown in the Figure 10. Dolerites with fine, medium and coarse grain are the dominant lithology (69.23 %), amphibolites (11.54 %), metamorphic quartz (7.69 %) and other lithologies as calcarenites, calcareous sandstones and a nodule of magnetite (all with 3.84 %) appear.

Technological Approximation

Finally, a systematic study of the technological features of these materials show a direct relation between lithology and kinds of tools, in this agricultural societies of the III-II millennium B.C.

The hardest and highest mechanic resistance lithologies, as the dolerites and amphibolites are usually used in the elaboration of axes, adzes and chisels (Domínguez-Bella *et al*, 2000), as other more abrasive lithologies, however of less resistance, as the sandstones and calcarenites are used in the elaboration of hand muller and other instruments to the cereal milling. Other minor lithologies as the quartz pebbles (that are associated to many metamorphic rocks in this region), appear associated to cereal treatment works; and others, as an magnetite pebble, related with an artistic activity, the treatment of pigments in a cave.

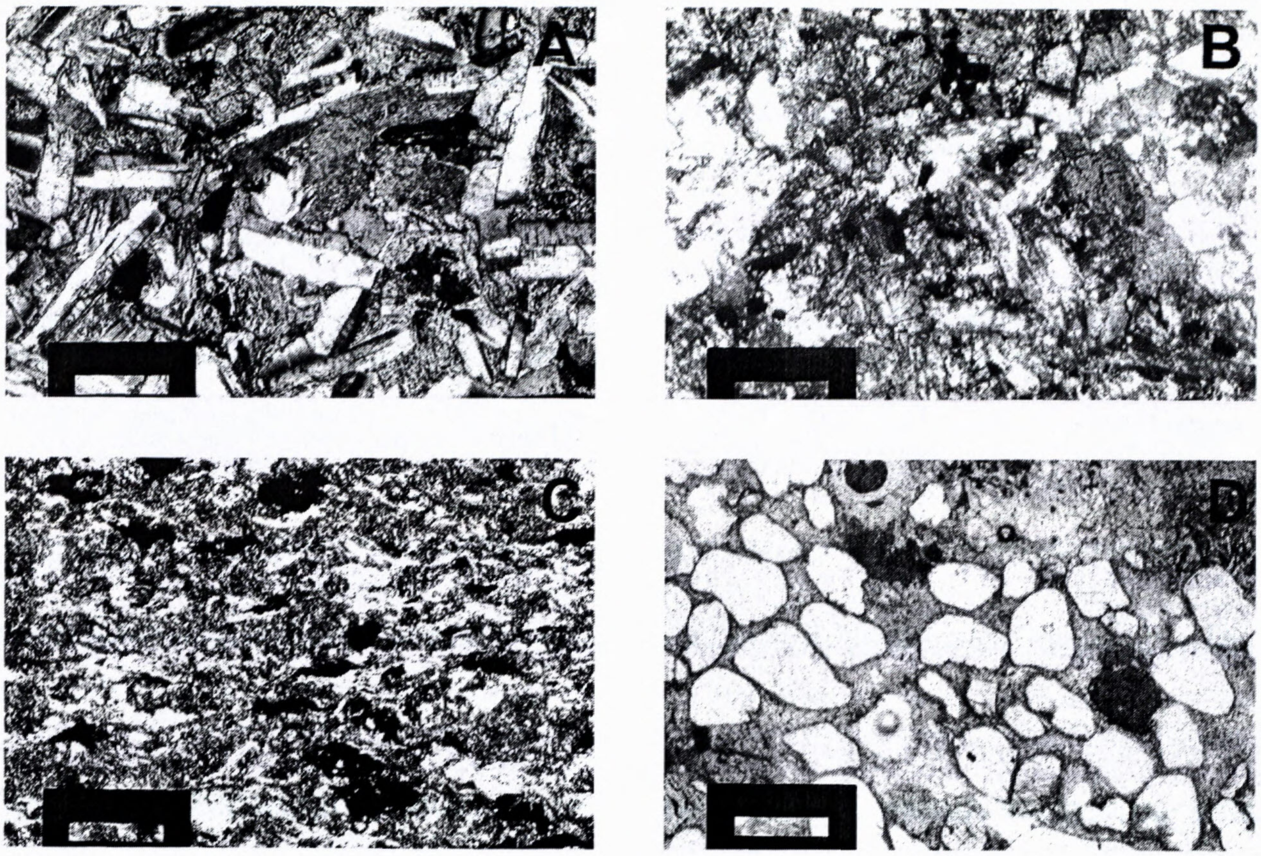

Fig. 9.A: Microscopical view (XPL). of a thin section of a polished axe made in fine grain dolerite. Lomas del Infierno site (III millennium B.C.). (scale bar = 2 mm.)
Fig. 9.B: Microscopical view (XPL). of a thin section of a polished axe made in coarse grain dolerite. El Mirador site (III millennium B.C.). (scale bar = 2 mm.)
Fig. 9.C: Microscopical view (XPL). of a thin section of a polished axe made in amphibolite. Peña de Ardales site (II millennium B.C.). (scale bar = 2 mm.)
Fig. 9.D: Microscopical view (XPL). of a thin section of a polished made in bioclastic sandstone. El Mirador site (III millennium B.C.). (scale bar = 2 mm.)

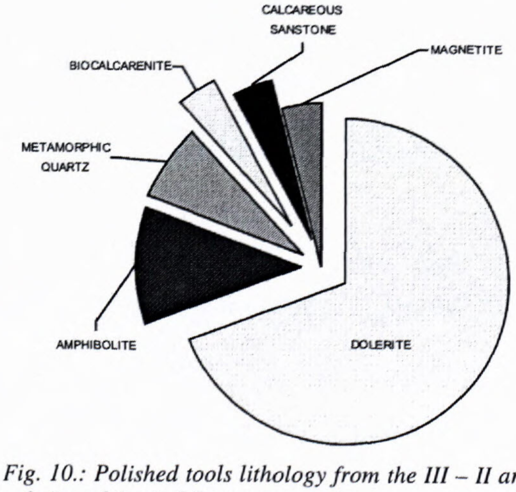

Fig. 10.: Polished tools lithology from the III – II archaeological sites of the Ardales area.

Conclussions

We can conclude that in the Río Turón Valley, during III-II millenniums B.C. a exploitation of the lithic resources is produced, mainly centred in the local raw materials or the nearby surrounding (25 km. of radius). Among the raw materials, we may mentioned the dolerites, amphibolites, sandstones and quartz in the polished lithic industry and the flint, as mainly exclusive lithology in the chipped lithic industry.

It is remarkable the specialization in the choice of the raw materials, for the polish lithic industry as well as for the chipped.

Even though there are large outcrops of rocks that could be used as raw materials, as occurs with the ultrabasic rocks of the peridotites Massif of the Sierra de Aguas or the banded gneisses, these materials are practically never used as raw material. Harder and more tenacity rocks as the dolerites and the amphibolites are preferred, although its source areas are further away from the Rio Turón valley, but in a radius of 25 km.

In the chipped industry, flint is the main raw material, being a local resource of the valley and being present in different outcrops of the zone, some of them were used as flint quarries and tools manufacture workshops (Castillo del Turón, La Galeota, etc.).

Acknowledgements:

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State of knowledges of the petrography and the diffusion ways of the metamorphic alpine rocks used for the axe blades during the Neolithic in the Rhône basin and the Western Alps.

ERIC THIRAULT

UMR 5594 du C.N.R.S., Centre d'Archéologie Préhistorique, 4, place des Ormeaux, 26000 Valence

Abstract. We present here some new results obtained by laboratory analyses as well as archaeological examinations on the neolithic polished stone axeheads of the Western Alps and the Rhône basin (France, Italie and Switzerland). The main result is the demonstration that the eclogite alpine facies are exploited and diffused strongly in the whole Rhône basin, as it has been demonstrated for the South-East of France and the North Italy. The archaeological work authorize to explain this fact in terms of exchanges networks, progressively constructed through the Western Alps during the Neolithic, with an apogee situated after 4500-4200 B.C. calib., whem the system of production includes the whole Alps, piedmontese as well as french.

Key-words: axeheads, Neolithic, Western Alps, petrography, diffusion

The knowledges on the materials in tenacious rocks used by the Neolithics (from 5500 et 2300 B.C. calib circa) in the french Alps and the Rhône valley have strongly increased during the last five years, thanks to a close collaboration between a prehistorian (E.T.), a petrographers specialised in the metamorphic rocks (Danielle Santallier, University Lyon I, France) and a crystallograph (Ruben Véra, University Lyon I). This contribution aims to present the new knowledges yet established about the stone polished axeheads, which have been fine studied, from the archaeological (Thirault, 2001[1]; Thirault, to publish) and the petroanalytical point of view (Thirault and al., 1999). We'll expound especially the problems of rock caracterization, by a presentation of the history of the researches on the alpine rocks, then our own results on the rocks analyses. After this, we'll explain briefly some significant archaeological results based on this analyses.

1. Problematic and history of the former researches

1.1 Introduction

The analyses of the rocks used by the prehistoric communities are guided by three main goals : characterize the raw materials, try to discover their origin and define the prehistoric criteria of choice. This questions are as old as the prehistoric science, and are organized in two further observation scales:

– ponctual analysis on one precise archaeological site, aimed to define the territorial lithic supplies on the place;

– main enquiries led on a various scale, from a small area to a broad region, which try to characterize on a global way the whole rocks used, to define the productions, and then to localize the supply sources and value the respective importance of wich production.

1.2 Brief history of the alpine researches

In the western Alps, the pioneer works of Franchi on the Alba (Piedmont, Italy; Franchi, 1900) and the Barcelonnette (Alpes de Haute-Provence, France Ricq-de Bouard et al., 1996) collections, and the G. Piolti analyses on the Vaie (Piedmont) artefacts (Bagolini and Biagi, 1977) have established first the importance of the eclogite rocks for the Neolithics. After this, during several decades, for lack of interest, the words "green stone/roche verte/pietra verde", "ophiolite/ofiolite" and "serpentinite" have been considered as synonyms and have been used to refer to the raw materials of the stone axeheads and the bracelets. This confusion is due to a missknowledge of the geological progresses during the 20th century, and the expression "green stone" becamed for the archaeologists a synonym for "stone of green colour" (cf. for a more precised presentation, Ricq-de Bouard et al., 1990; Santallier et al., 1998; Thirault et al., 1999). Moreover, in the South-East of France, the presence of numerous pebbles of green coloured stones in the Durance deposits and the use of some of them for the axeheads (yet identified as pebbles of glaucophanites (Ricq-de Bouard et al., 1990), has led to adopt the imprecise term of "durancian rock" ("roche durancienne").

During the seventies, some enquiries have pointed the complexity hidden by this vague words. We know three examples of them. The laboratory analysis of the stone axeheads discovered on the excavation carried on the Charavines/Les Baigneurs dwelling site (Isère, France) as demonstrated that the rocks (piedmontese ophiolites)

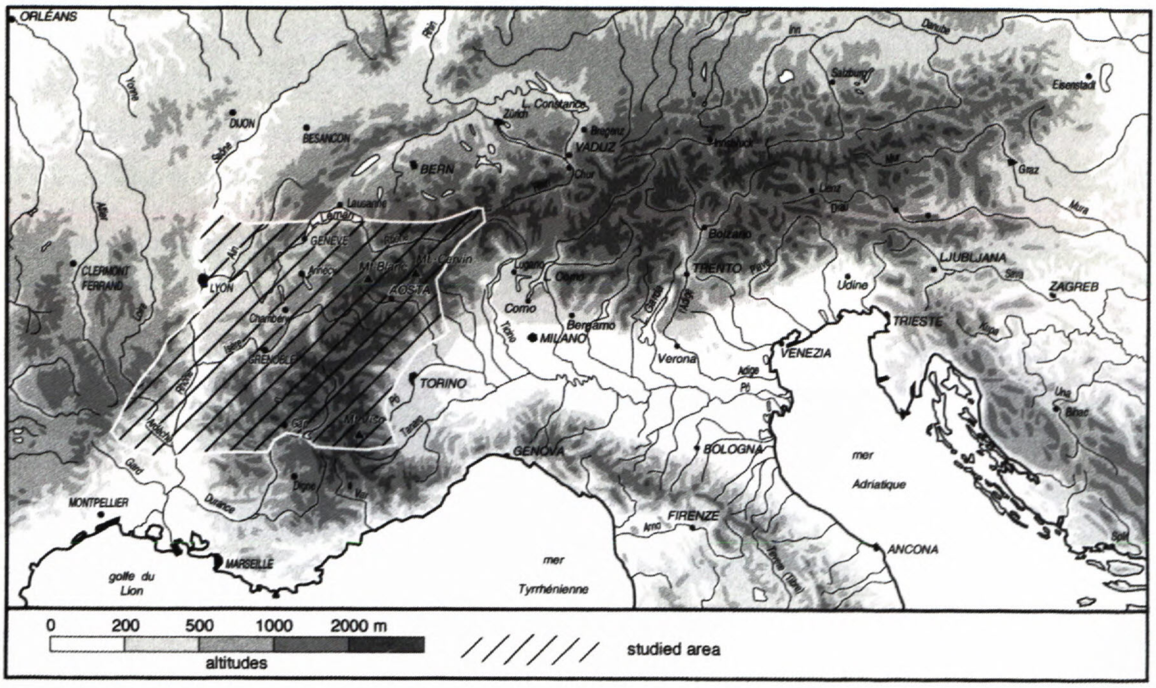

Fig. 1. The area concerned by our study.

came from the italian Alps (Bocquet, 1984). A. Masson, in a petrological study on thin sections (unpublished) about collections coming from the Forez (Loire department, France), as defined several rock groups. One of them (group n° 3) gather exogen alpine rocks (in the geological way), called by the author jadeitites and eclogites (Masson, 1977). C. Buret, in her unpublished thesis on the polished artefacts of the Auvernier excavations (Neuchâtel Lake, Switzerland), has underlined the fact that several metamorphic rocks were used, reflecting the regional morainic composition (Buret, 1983; Buret and Ricq-de Bouard, 1982).

On the same time, M. Ricq-de Bouard began her analyses on the south-eastern french series, and demonstrated quickly the reality of long-distance circulations from Liguria to Provence (Ricq-de Bouard, 1981). The progressive integration of the whole collections of the stone axeheads known in Provence and Languedoc, based on new studies at the alpine metamorphism, led this author to propose a diffusionist model (Ricq-de Bouard et al., 1990), in which the high pression/low temperature (HP/LT) metamorphic facies where mainly used. Among this rocks, the eclogites facies are preferred, coming from Liguria and/or the internal Alps. The still-known exploitation of the durancian pebbles, especially the glaucophanitic ones, has been confirmed but this appears as a regional phenomenon, linked to the western Provence and the low Rhône and Durance valleys.

In the northern part of Italy, the Ricq-de Bouard's researches have pointed the necessity of studying the regional artefacts, so new petrological investigations started under her impulse. The fundamental importance of the alpine rocks (in a geological way) of HP/LT appears clearly now, in Piedmont and Liguria (Ricq-de Bouard and Fedele, 1993; Compagnoni et al., 1995) as well as in the whole northern Italy (D'Amico et al., 1995, 1998; Venturino Gambari dir., 1996).

2. Recent works in the Rhône valley and the french Alps

In the middle Rhône Basin and the french Alps (fig. 1), the lack of precise petrographical investigations, parallel to the real need of studies about the circulation ways of goods in the rhodanian Neolithic (Beeching, 1991), led us to organize an analytical programm to caracterize the tenacious rocks used for making polished tools (axeheads, hammers, ...), weapons (arrowheads), jewels (pearls, bracelets, ...) and other enigmatic objets (marbles, ...). We expound here only the results concerning the stone axeheads. This research took part in a larger programm called "*Circulations et identités culturelles alpines á la fin de la Préhistoire*" ("Circulations and alpine cultural identities at the end of Prehistory"), coordinated by A. Beeching and financed by the Région Rhône-Alpes and the Centre National de la Recherche Scientifique (Beeching dir., 1999).

The study has been organized in three analytical scales:

– on the neolithic sites scale, a complete laboratory investigation of the artefacts coming from A. Marguet's recent propections and excavations on about ten lakeshore sites on the Annecy and Léman lakes (Marguet, 1995).

– on a regional scale, a selection of axeheads coming from well excavated sites and stray finds, choosen to cover, as well as possible, the whole regional Neolithic.

– on the western Alps scale, we've examined ourselves, during our archaeological work on the axe blades, all the objets studied, with a binocular or with naked eye (Thirault, 2001). We've estimated the fiability of this method at a rate of circa 90 %.

At last, nearly 150 axeheads and tools associated (hammers, roughouts, flakes, ...) have been determinated in laboratory, by thin section (petrography) after sampling, or by X-Ray (cf. Thirault et al., 1999, for a more detailed presentation), and nearly 2500 objets have been studied by us. The rate of laboratory analysis seems low, but we've estimated that it is a good sample of the productions. Nevertheless, extensive laboratory inquiries aren't realisable yet, due to the cost of each of them, and it seems to us that a good preliminary knowledge of the rocks used authorizes to realise a first classification and then a sampling for the laboratory. After the first laboratory determinations, we've done another sampling considering the results obtained and the new questions posed.

3. Petrographical and mineralogical laboratory results

The whole laboratory analytical results and their commentary have been recently published (Thirault et al., 1999). For this reason, we only present here the main results on a synthetical way, as we've exploited them as an archaeologist. For the polished axe blades, we introduce the rock families in their numerical importance order.

3.1 Eclogites

Under this word, we join three lithotypes clearly distinguished on the petrographical and mineralogical point of view, but which can be closely associated in the alpine metamorphic series. They are linked to the alpine high pression/low temperature (HP/LT) metamorphism, and are not or poorly retromorphosed. There are the eclogites sensu stricto, with the typical association of a sodic pyroxen and a garnet; the pyroxenic rocks type omphacite; and few cases of pyroxenites type jadeite with some garnets. This rocks are broadly identified in the ophiolitic series of the Western Alps and the Liguria (Droop et al., 1990). We don't go further in the question of the precise geographical provenances of this rocks, still debated by other authors (Ricq-de Bouard et al., 1990; D'Amico et al., 1995).

3.2 Jadeitites

We call jadeitites acid rocks metamorphized under HP/LT conditions, where the mineral jadeite is the only identified. Such pure rocks are uncommon at the alpine outcrops and can be associated with the metabasic series of the eclogitic and glaucophanitic facies (Ricq-de Bouard et al., 1990).

3.3 Glaucophanites

Well identified by M. Ricq-de Bouard, the alpine matabasites of HP/LT composed mainly by the blue amphibole glaucophane come from the eclogitic facies retromorphose. They are common in the ophiolitic alpine outcrops, but are less known in the archaeological series. The glaucophanites identified by D. Santallier in thin sections have another origin : they can be localized in the cristalline external massifs of the french Alps.

3.4 Ultrabasites

Two mineralogical types have been identified: the rocks mainly composed by antigorite, one of the two minerals of the serpentinites, and the rocks mainly composed of chloritites. The chlorite is sometimes also recognized in the serpentinites, so we can consider that the chloritites are a pure facies inside the serpentinites series. The serpentinites outcrops are numerous and ubiquist in the internal Western Alps, in the "*schistes lustrés*" zone, so the origin of the archaeological objets can't be established on a petrographical basis.

3.5 Epi- and mesozonal metabasites

We name here a list of various metamorphic rocks associated at the archaeological point of view. There are, for the low metamorphic facies, amphibolites and/or prasinites, and metadolerites. The more metamorphized facies are some hornblende amphibolites, amphibolo-pyroxenites and eclogites retromorphosed under medium pression/medium temperature conditions, i.e. non alpine facies. All this rocks can be alpine in the geographical way, or come from another metamorphic reliefs. Here, the archaeological analysis is the only way to discrimine their origin.

3.6 Various rocks

There are ubiquist rocks in the Alps or stranger to the alpine context : some cataclasites, fibrolites (sillimanites), vosgian metapelites, one cinerite from the Massif Central and some flints not coming from the South-East France formations (not analysed in thin sections). We can indicate too that a fibrous metamorphic rock, non identified yet, is common in the valesian stone axes.

4. The naked eye analyses and the map of the results

The laboratory analyses are a partial sample of the polished tools, because we've ourselves selected the objets to analyse after a first diagnosis to the naked eye. A notable exception is given by A. Marguet's excavations artefacts, which have been analysed *in extenso*. So it is necessary to integrate the whole laboratory results and the naked eye observations before a complete archaeological investigation. This have been done with the help of a spatial analysis of the whole petrographical results on our area of work (Fig. 1). The results are establish from all the archaeological series studies, coming from collections without chronological references as well as dated sites.

4.1 The eclogites supremacy

If the HP/LT metabasites are the most aboundant rocks in the polished axe blades, the alpine eclogites are

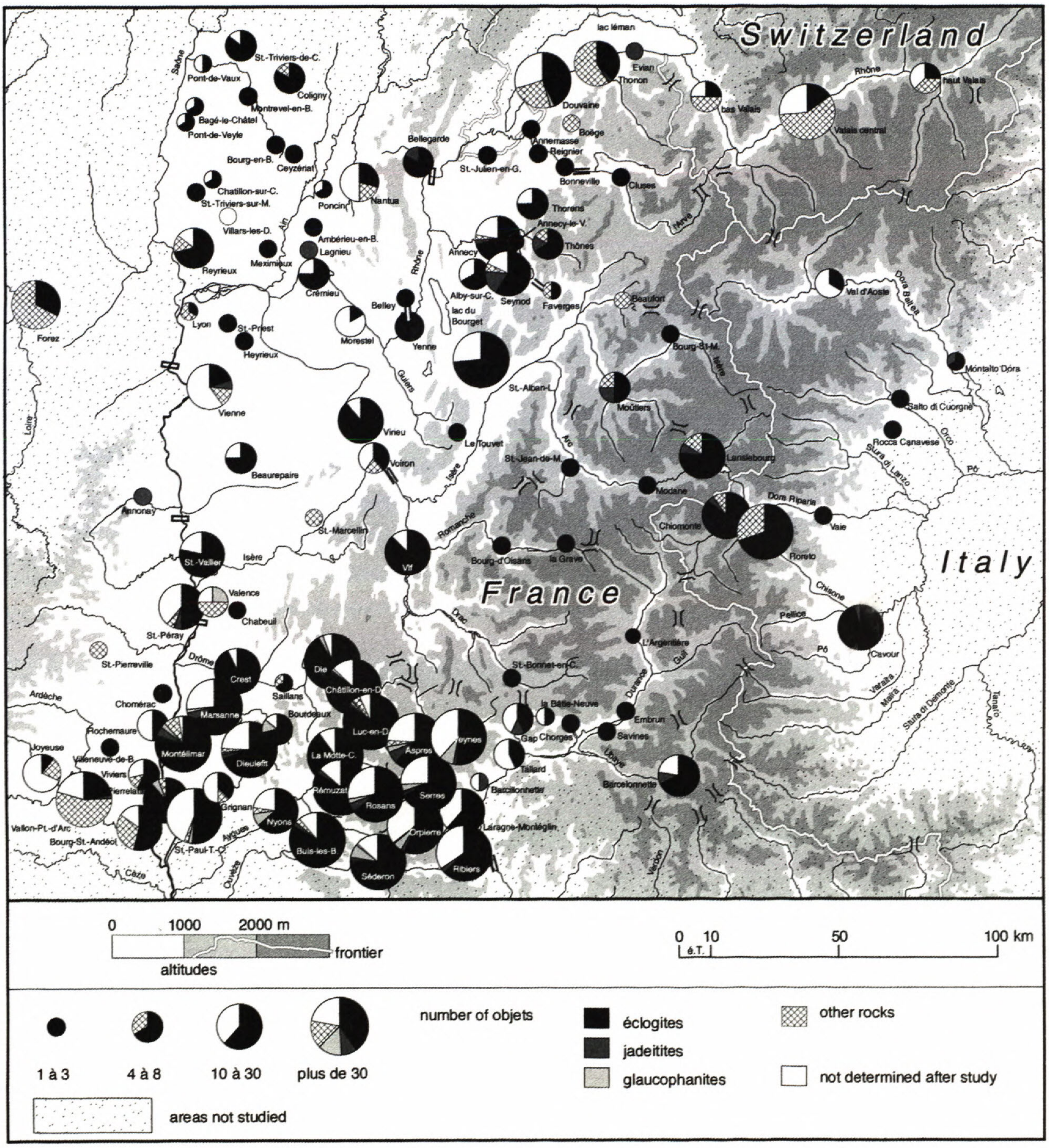

Fig. 2. Spatial distribution of the stone axeheads in HP/LT alpine metamorphic facies rocks (eclogites, jadeitites and glaucophanites). Each dot correspond to a district (in France), a geographical unity (Switzerland and Val d'Aoste) or a site (Piedmont).

dominant inside this rock group (Fig. 2). This report has still been established in Provence (Ricq-de Bouard et al., 1990) and in North Italy (D'amico et al., 1998). However, this supremacy isn't absolute, and variations can be recognized, linked to the source distance. In Piedmont (Venturino Gambari, 1996) and in the french intra-alpine valleys, the eclogites are nearly the only rocks used. This fact is linked to the exploitation of most of the alpine eclogite sources in the whole alpine dorsal. To the west, in the alpine forelands, the french Prealps and to the Rhône river, i.e. between 100 to 200 kms from the nearest stone sources, the eclogites remain dominant : the presence rate is never below 50 %, and is frequently above 75 %. Considering the spatial distribution, we propose to associate the jadeitites to the eclogites, at least for the diffusion, because there isn't any significant difference in their respective distributions.

So the eclogites and the jadeitites form the reference rock till 200 kms from their piedmontese outcrops. They remain aboundant far away, in the upper Loire valley (1/3 of the stone axe blades; Masson, 1977) and in the Ardeche Basin (Ricq-de Bouard et al., 1998). The eclo-

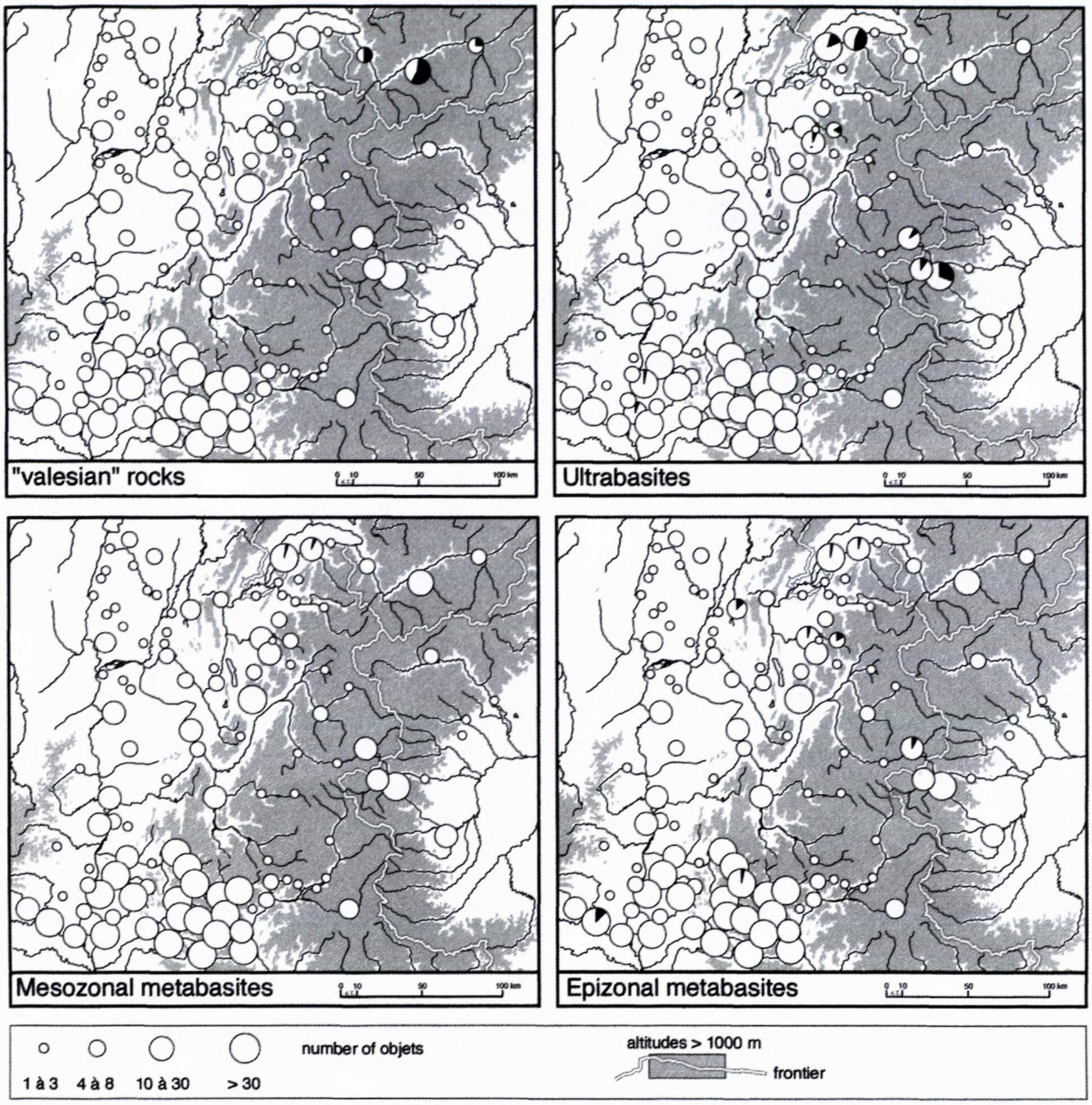

Fig. 3. Spatial distribution of the regionaly used rocks.

gites have been exploited en masse and diffused, and if we add the eastern diffusions, we can conclude that this rocks form one of the most important rock reservoir used for the axeheads in western Europe.

4.2. Regional dominant rocks

Glaucophanites are recognized in two regions : on the southern shore of the Leman lake, and on the Buëch basin (Fig. 2). The first come from the external cristalline massifs metamorphism and can be brought together, considering the neolithic supplying, with the epi- and mesozonal metabasites (see below). The others can be brought with the alpine glaucophanites used in western Provence (Ricq-de Bouard et al., 1990), thanks to two archaeological criteria: their distribution in continuity to the lower Durance and the lower Rhône valley, and the frequent use of pebbles coming from the Durance deposits. The glaucophanites pebbles are a common raw material source in western Provence (ibid.), but they are scarcely diffused more than 50 kms from the proper Durance valley.

The southern shore of the Leman lake is another region where the regional rocks are aboundant. The rocks identified are the glaucophanites still presented, several epi- and mesozonal metabasites, cataclasites and ultrabasites, which are almost known on the Annecy lake sites (Fig. 3). Some of these stone axe blades present a cortical pebble surface, which indicate that the supply is linked to the morainic or the alluvial deposits, as it is recognized on the swiss foreland, at Auvernier for instance (Buret and Ricq-de Bouard, 1982). This explains the presence of a large variety of rocks in the axe blades, partial reflexion

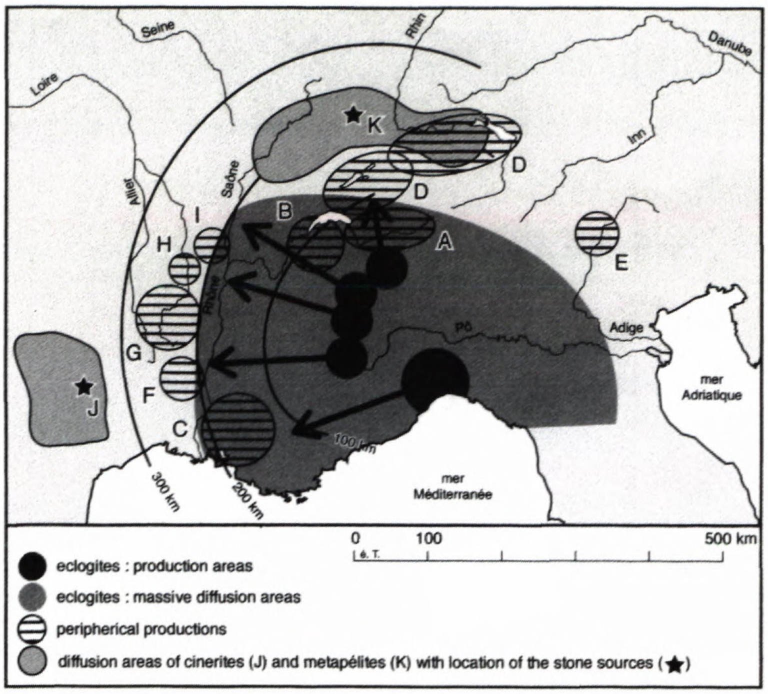

Fig. 4. Schematic distribution of the rocks used for axeheads, showing the process of peripherization around the Western Alps and the eclogite diffusions. A. "valesian rocks". B. Morainic rocks used in the Leman Basin. C. Glaucophanites (Durance pebbles). D. Serpentinites and other morainic rocks. E. Serpentinites. F. Several rocks of the Ardeche Basin (amphibolites, basalts, ...). G. Fibrolites. H. Meta-andesites. I. Amphibolites (actinolites). J. Cinerites (Requista's quarries). K. metapelites (Plancher-les-Mines' quarries).

of the moraines petrographic composition, which is opposite to the strict choice of the eclogites in the other regions. We are here face to two opposite strategies for the supply of raw materials.

In Valais, a similar choice can be recognize but with only one type of rocks, not formaly identified but probably coming from the regional metamorphic series. On the upper valleys of Susa, Chisone and Maurienne, a significant part of the stone axeheads are realised in ultrabasites (serpentinites), extracted from flaked supports.

4.3 Scarce "exotic" rocks

Among the scarce axe blades realised in non alpine rocks (in the geographical meaning), some indicate the diffusion limits of important productions outside the Alps, which cannot penetrate the mighty eclogite diffusion streams nowhere else that on their periphery. The vosgian metapelites, coming from the Plancher-les-Mines quarries (Pétrequin et al., 1996), are known in the middle Saône valley, on the Leman lakeshores, in south Jura (Bugey), in few exemplaries, but they're unknown on the Rhône south bank. On south, a lonely axe blade in cinerite coming from the Réquista quarries in the Rouergue (Servelle and Vaquer, 2000) is recognized in the Drôme valley. Lastly, the fibrolites, used in the Massif Central, are identified in scarce objets in the middle Rhône valley, the lower Dauphiné and in the Savoie forelands.

But all this rocks are only exotic curiosity among the hundreds of stone axeheads in eclogites. It is the same for the flint axe blades, polished or not, known in few exemplaries in the Rhône basin and coming from another sedimentary basin (Jura, Bassin parisien, South-West France ?).

5. Some interpretative archaeological tracks

5.1 The structuration of the diffusions (Fig. 4)

A spatial segmentation of the fabrication processes has been recognized for the eclogites and jadeitites. Indeed, numerous sites in the french Prealps and the large prealpine valleys, in the Buëch, Drôme and Drac valleys, and near by Chambéry, attest that the pecking and polishing stages, or even sometimes the flaking stages, have been realised far from the metabasites outcrops. This means that the piedmontese eclogites have been carried on 100 to 120 kms as roughouts more or less worked, before finishing on this "workshops". The strict distribution of the prealpine "workshops" in a peripherical crown in relation to the internal Alps, and their location in the key-places of the landscape (tophills, confluences, open valleys) indicates that a real control of the materials diffusions have been organized through the Western Alps and their forelands. So the great diffusions on the western side of the Alps are linked to a large spatial scale production system.

5.2 Chronological evolution

This remarkable organization has an history, summarized here under it economical aspects, without considering the important symbolic and functionnal evolutions in the polished tools status, studied otherwise (Thirault, 2001).

In the earlier Neolithic stages, the production sites are linked to the Apennines outcrops (*Groupo di Voltri*). Brignano Frascata is a good example of this sites for the *Neolitico antico*, type Vho (D'Amico et Starnini, 1996). In the Western Alps, the first production sites are related to the *Neolitico medio* (*Vasi a Bocca Quadratta*), for instance Rocca di Cavour located in front of the lower Pèllice valley (Zamagni, 1996). But we consider, on the base of indices explained otherwise (Thirault, 2001), that the recognizing of the Western Alps eclogite outcrops is earlier and could be related to the transition stages between the *Neolitico antico* and the *Neolitico medio* (Fiorano/VBQ I), maybe even before, as well as the first transalpine diffusions in the Rhône basin (Thirault, 2001). Be that as it may, during the *Neolitico medio/Néolithique moyen I*, the production sites clearly dated are all located on the eastern side of the piedmontese Alps. We propose to attribute the real implantation of the eclogites "workshops" in the french Prealps and prealpine valleys in a more recent stage (*Neolitico recente/Néolithique moyen II*). So there should be a topple over, maybe progressive, dated circa 4500-4200 B.C. calib, from the eastern to the western side of the western Alps, for the control of the most important productions in eclogites. This means that the production control forms really a stake for the alpine neolithic communities, and that a strong link is established between the production and the diffusion. We propose to interpret this fact in terms of strong transalpine exchanges networks linking the communities on several hundreds of kilometers, with a real competition for the supplying in eclogites and the axeheads fabrication. During the latest stages (*Néolithique final/Eneolitico-Calcolitico*), the diffusions remain notable in the french Rhône basin, and some of the production sites are still in activity, but the distant diffusions seems to be less developped. The definitive end of the productions, considering the topical knowledges, can be situated before the earlier Bronze Age, because we don't know any demonstrated production after the end of the second millenium B.-C. calib.

This quick chronological survey put in light the fact that, beyond the fundamental knowledges brought by the material analyses, the stake of the stone axeheads study resides in the comprehension of the technical and social processes who condition the becoming of the productions and the diffusions. The petrographical investigations are the first link in a long work chain, if we want to understand the prehistoric societies through their tools.

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Raw materials of polished artefacts from two Lengyel sites in Lower Austria

ANTONÍN PŘICHYSTAL[1] & GERHARD TRNKA[2]

[1]Department of Geology and Paleontology, Masaryk University, Kotlářská 2, CZ-61137 Brno, Czech Republic,
e-mail: prichy@sci.muni.cz
[2]Institut für Ur- und Frühgeschichte der Universität Wien, Franz-Klein-Gasse 1, A-1190 Wien, Austria,
e-mail: Gerhard.Trnka@univie.ac.at

Abstract: Lengyel sites in Lower Austria are not so rich in polished artefacts as those in southern Moravia. So far, there have been published no modern data on polished artefact rock composition from Lower Austria. The article brings petrographic determination of a few axes, hammer-axes and a whetstone based on a study of thin sections, measurement of magnetic susceptibility and a microprobe analysis. The raw material spectrum includes metamorphic rocks of the greenschist group, garnet amphibolite and jadeitite for the axes and hammer-axes, an arkose sandstone for the whetstone. Similar raw materials have been described from Lengyel localities of the adjacent part of southern Moravia and some of them give evidence on a long distance motion of stone raw material or ready-made implement in the Neolithic of Europe.

Key words: Lower Austria, Lengyel settlement, polished artefacts, petrography of raw material

Introduction

Northern Lower Austria represents besides southern Moravia, Burgenland, Pannonia and western Slovakia an important part of Central Europe with extensive Lengyel settlement in the Neolithic. Geological basement is very similar to that in southern Moravia: eastern margin of the Bohemian Massif, the Alpine - Carpathian Foredeep, the Ždánice - Waschberg Unit and the Vienna Basin. The Alpine - Carpathian Foredeep and Vienna Basin with their soft Tertiary sediments could not provide useful rocks for production of polished artefacts. Similarly, Tertiary sandstones and Mesozoic limestones of the Ždánice – Waschberg Unit were polished for Neolithic artefacts only exceptionally. The Bohemian Massif, on the other hand, is built of hard metamorphic and igneous rocks that are suitable for such production.

We have already relatively good knowledge on polished raw materials used in the Neolithic (including important Lengyel localities) in southern Moravia (Přichystal, 2000). Up-to-date information on polished raw materials used in the Lower-Austrian Neolithic is almost missing. Hence our contribution brings new petrographical data on raw materials used at two important Lengyel sites situated above the Kamp valley (Kamegg) or close to it (Strass im Strassertale), in the easternmost part of Waldviertel near its border with Weinviertel or Wienerwald.

Archaeological background

Kamegg (the district of Horn) is a settlement of early Lengyel culture (Moravian Painted Ware I a - b) dating to the first half of the fifth millennium BC. Its centre lies at 275 m above sea level and 25 m above the Kamp river. Besides remains of settlement (houses, pits) there was found a circular enclosure of two ditches. The both ditches are V-shaped and inside each of them was a palisade. The outer ditch has a diameter about 144 m, its maximal width is 4 - 6 m and depth up to 3 m. The inner ditch with a diameter 76 m has a width up to 8 m and depth 3,5 - 4 m. Excavations in 1981 – 1991 showed the inner ditch was interrupted by four entries and the same situation can be supposed for the outer ditch. The monument was not finished because the outer ditch in its southwest part was dug only as shallow segments (Trnka, 1994). After their function the both ditches had been refilled by a younger settlement of the same culture with numerous finds of pottery, stone tools, animal bones and also some female ceramic figurines ("idols").

b) Strass im Strassertale (the district of Krems-Land) is again an early Lengyel site that chronologically corresponds to the Moravian Painted Ware Ia and is situated at 312 m above sea level. Archaeological excavations unearthed remains of settlement pattern and a circular enclosure of two ditches as well. The V-shape ditches have diameters 77 and 57 m with a width of about 2 m and remaining depth approximately 2 - 2,5 m.

Petrographic investigation

Seven stone polished artefacts from both localities were investigated using a binocular microscope for preliminary determination and a kappameter to ascertain magnetic susceptibility. In addition to it, four thin sections wereprepared and studied under a polarizing microscope. It is necessary to take into account that the determination under a binocular microscope is only preliminary but we could not prepare thin sections from all artefacts.

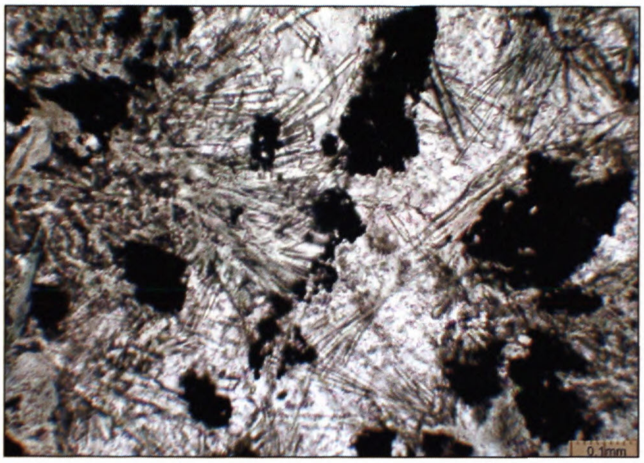

Fig. 1 Actinolite greenschist, axe-hammer, Strass 11, plane-polarized light.

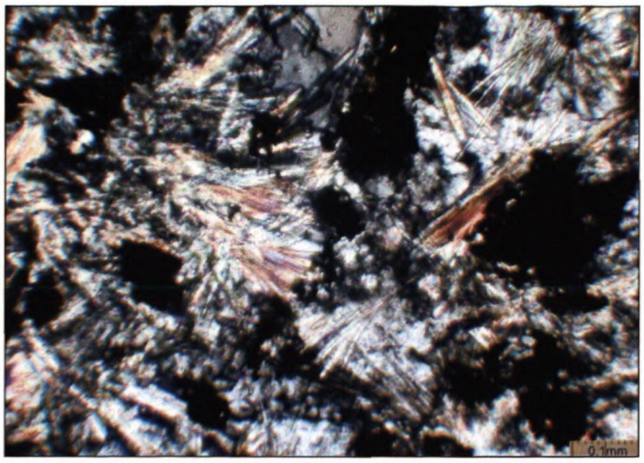

Fig. 2 Actinolite greenschist, axe hammer, Strass 11, crossed polars

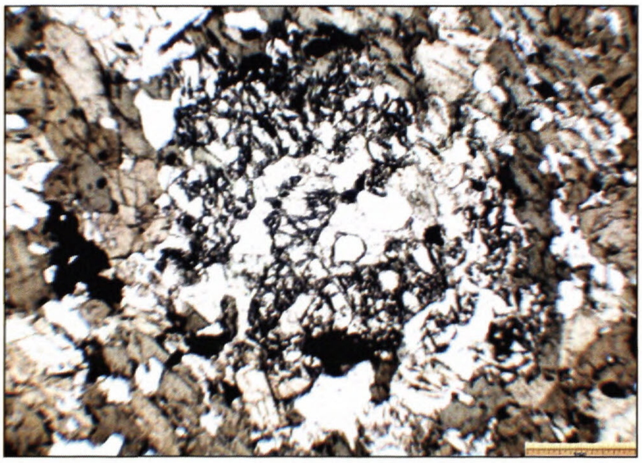

Fig. 3 Garnet amphibolite, axe-hammer, Strass 8, plane-polarized light.

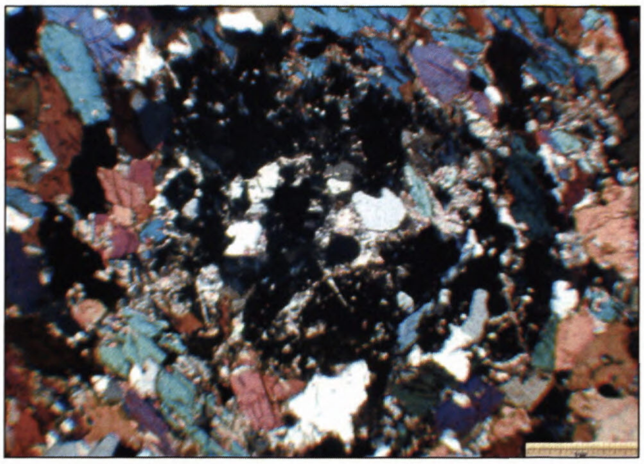

Fig. 4 Garnet amphibolite, axe-hammer, Strass á, crossed polars

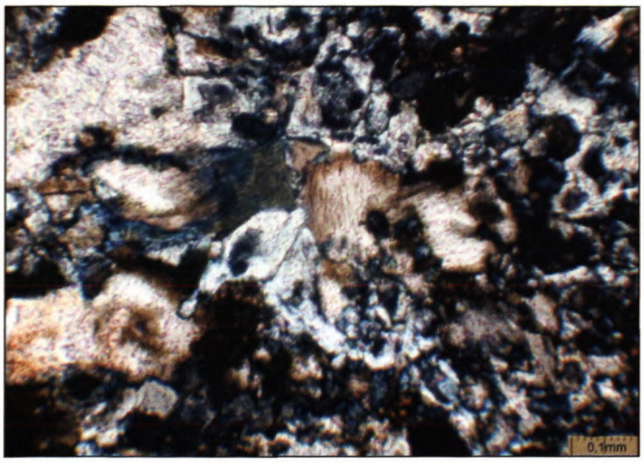

Fig. 5 Jadeitite, axe with pointed back, Kamegg 793, crossed polars.

a) Metamorphic rocks of the greenschist group represent the most distributed raw materials because they were used for 4 artefacts (Kamegg 1024, 124, 584, Strass 11). They have distinct schistosity usually with alternation of light and dark thin stripes (polyschematic structure). As is magnetic susceptibility concerned, the artefacts Kamegg 1024 and Kamegg 124 have the same values (0,27 – 0,31 x 10^{-3} SI), the axe-hammer Strass 11 has substantially higher value 3,52 – 3,56 x 10^{-3} SI and the axe Kamegg 584 is from this viewpoint totally different (21,2 – 22 x 10^{-3} SI). On the basis of thin section prepared from the axe-hammer Strass 11 we can describe the rock as an actinolite greenschist with a substantial content of opaque mineral. Similar rocks prevail at Moravian Lengyel sites with the Moravian Painted Ware of the older stage (e. g. Těšetice – Kyjovice, MPW Ia) and the question of their provenience has not been solved unambiguously till now. There are no occurrences of such rocks in two basic geological units of the eastern margin of the Bohemian Massif (the Moldanubicum and Moravicum). One of the most important sources of actinolite greenschist is supposed to be extracted in prehistoric times in NE Bohemia (the Železný Brod Crystalline Unit and its equivalents). Actinolite greenschists from the Železný Brod Crystalline Unit have magnetic susceptibility very similar to our artefacts Kamegg 1024 and Kamegg 124 excluding the axe Kamegg 584 with its very high susceptibility. We have to suppose probably another provenience for the greenschist with high magnetic susceptibility (Kamegg 584). Such magnetic susceptibility corresponds very well to the values of greenschists from the Želešice body (the southern termination of the metabazite zone of the Brno Massif in Moravia).

b) Garnet amphibolite (a part of the axe-hammer Strass 8) is a dark green coarse-grained rock with no schistosity. Porphyroblasts of rose garnet have diameter of about 2 – 3 mm. Next to it, the rock consists of pleochroic amphibole, plagioclase feldspar, chloritized biotite and opaque mineral. Magnetic susceptibility of the rock is about 0,30 – 0,34 x 10^{-3} SI. The rock has its provenience in the NW area of Strass, i. e. in the Varied Group of Moldanubicum.

c) Jadeitite. The pointed back part of axe Kamegg 793 is a dusky green (5G 3/2) aphanitic rock without foliation. Magnetic susceptibility is low (circa 0,14 x 10^{-3} SI, it is a small chip and does not cover the sheet of measuring apparatus). In thin section the rock has almost mono-mineral character. The prevalent colourless isometric grains have xenomorphic limitation, in places they form short-columnar shape with parallel cleavage and extinction angle between 32 – 36°. In some grains the characteristic pyroxenic cleavage or a zonal texture with darker core can be seen. All these signs correspond well to jadeite and this determination has been confirmed by microprobe analyses (analyst V. Vávra, microprobe CamScan 4-DV, Department of Mineralogy, Petrology and Geochemistry at Masaryk University). Clusters of small titanites, rarely epidote and opaque mineral represent accessories.

A few jadeitite axes connected also with the Lengyel cultural complex (the Moravian Painted Ware) have been described from Moravia (Schmidt & Štelcl, 1971). The source of jadeitite artefacts has not been reliably localised but there are no occurrences of such rocks in the Bohemian Massif. Hovorka et al. (1998) introduced a jadeitite axe from Sobotište (western Slovakia) that is in morphology again close to the artefacts of the Lengyel culture. According to the authors, occurrences of such raw material have not been recorded in the Western Carpathians and they suppose its import from a distant area, probably NW Italy. We believe in the same origin as well as is the axe Kamegg 793 concerned.

d) Arkose sandstone. The whetstone Kamegg 476 is made of light grey sandstone containing besides prevalent quartz also clasts of rose or brown feldspar and foils of biotite. The rock is partly porous and soft. Magnetic susceptibility is relatively higher (1,13 – 1,18 x 10^{-3} SI). Its provenience can be supposed from Permian sediments at Zöbing.

Conclusion

Our investigation has shown that the both studied Lengyel localities in northern Lower Austria have on the one hand similar raw material composition like those in southern Moravia but on the other hand they are rather poor in polished artefacts (total number from the both sites is about 20 pieces). Besides local amphibolites and Permian arkose sandstone, metamorphic rocks of the greenschist group and jadeitite had to be imported. Recently we know two important sources of greenschists in the Bohemian Massif exploited in the Neolithic: at Želešice near Brno (actinolite-chlorite and chlorite greenschists with high magnetic susceptibility) and in NE Bohemia (greenschists of the Železný Brod Crystalline Unit and its equivalents that were influenced by a contact metamorphosis of the Krkonoše-Jizera Massif). Most of raw material from Kamegg and Strass is similar to that from NE Bohemia but in the case of greenschist with high magnetic susceptibility (Kamegg 584) we can not exclude the Želešice provenience.

As is the jadeitite pointed back axe connected, we suppose their origin out of the Bohemian Massif, very probably from the Western Alps.

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Lower Bavarian Plattenhornstein flint from Baiersdorf imported into northeast Austria

GERHARD TRNKA[1], SERAFIM SAVVIDIS[2] & JOHANNES M. TUZAR [3]

[1]Institut für Ur- und Frühgeschichte der Universität Wien, Franz Klein-Gasse 1, A-1190 Wien, Austria, e-mail: GerhardTrnka@univie.ac.at

[2]TEI (Technological Education Institute) of Kozani, Koila Kozani, West Macedonia, Greece, e-mail: tok0032@teikoz.kozani.gr

[3]Krahuletz Museum Eggenburg, Krahuletz Platz 1, A-3730 Eggenburg Austria, e-mail: Tuzar@Krahuletzmuseum.at,Web: www.krahuletzmuseum.at

Abstract. Analysis of three selected late Neolithic stone artefacts, considered to be imports from the lower Bavarian area (southern Germany) into eastern Austria, again demonstrates the importance of provenance studies on raw materials and of being able to recognize the material visually. The artefacts are stray finds of so-called sickle blades made of Baiersdorf Plattenhornstein from (i) Annastift near Krummnussbaum in the lower Austrian Danube valley and, in northern Lower Austria, from (ii) Kühnring and (iii) Roggendorf . As the crow flies, the latter two objects are about 300 km away from source and, in practical terms, considerably further.

Keywords: Flint raw material, Baiersdorfer Plattenhornstein, provenance, flint sickles, late Neolithic.

Analysis and reconstruction of procurement and trade patterns in prehistoric raw materials is becoming ever more important for an understanding of relationships over wide areas and the synchronization of culture sequences. Lithics are of special importance because of their durability and because of the distinctive appearance of particular petrological types. Here we consider flint of the kind known as Baiersdorfer Plattenhornstein, named after the location in Lower Bavaria which is the sole source (for example Binsteiner, 1999 (footnote 49), 2000 and 2001). It is presumed that this material was traded in the form of finished objects along the Danube valley (e.g. to Annastift near Krummnussbaum) and then further north into the Manhartsberg region around Eggenburg. It is also possible that some travelled through Bohemia, as with Lower Bavarian Arnhofen flint (Binsteiner, 2000 and 2001). We will now describe and analyse three characteristic objects.

Annastift near Krummnussbaum (Melk district): Fig. 2

Flint blade, thin, light brown, patinated, tabular flint (Plattensilex) with light brown cortex preserved on both sides; elongated sickle-shaped form with a nearly straight cutting edge preserving distinct sickle gloss and an asymmetrically curved back; all sides carefully retouched. Length 20.8 cm, max. width 6.2 cm, thickness 0.8-1.1 cm, weight 199.54 gm.

Fig. 1 Distribution map of Altheim sickles made from Baiersdorf Plattenhornstein in Lower Austria.

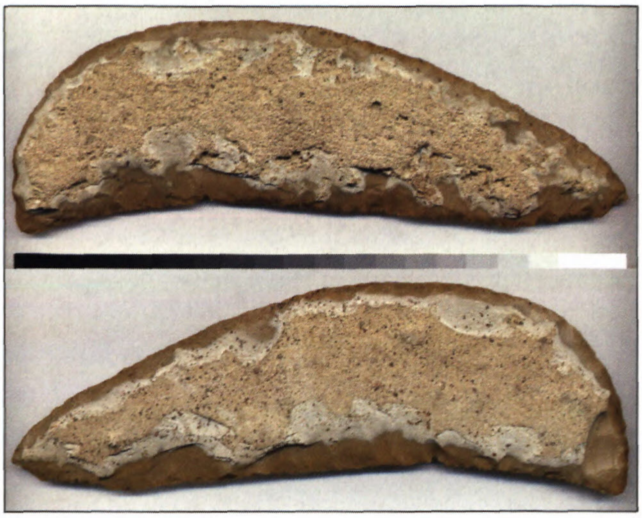

Fig. 2 Annastift near Krummnussbaum.

Fig. 3 Kühnring.

Fig. 4 Roggendorf.

Stray find from ploughing in the 1970s; now in Melk Museum.
Literature: Reitinger, 1968-70. Trnka, 2001.

Kühnring (Horn district): Fig. 3.

Flint blade, thin, light brown, patinated, tabular flint (Plattensilex); elongated form with lightly curved cutting edge displaying distinct sickle gloss and an asymmetrically curved back; all sides carefully retouched; the cortex has been almost entirely preserved on one side but polished to make it smoother both at the tip and again towards the rear; on the opposite side only a small area of cortex was left; the grip or alternatively neck, was broken (?in antiquity).
Surviving length 20.0 cm, max. width 5.5 cm, max. thickness 1.02 cm, weight 123.35 gm.
Stray find, collected by Johann Krahuletz at the turn of the 19th/20th century; now in the Krahuletz Museum, Eggenburg, Inv. No. 3104.
Literature: Bayer, 1933, 214, Tab. 10/1. Hrodegh, 1925, Fig. 35. Trnka, 2001.

Roggendorf near Eggenburg (Hollabrunn district): Fig. 4.

Tip of a sickle blade, thin, light grey, tabular flint (Plattensilex); fine retouch on cutting edge with well-developed sickle gloss, lighter retouch on blade back; one side has a light brown, relatively rough cortex, the other a paler cortex which has been polished to a point where the brighter light grey colour comes through.
Surviving length 7.0 cm, max. width 3.1 cm, thickness 0.5 cm, weight 15.36 gm.
Stray find (no details) now in the Krahuletz Museum, Eggenburg, Inv. No. 33242.

Discussion

All three of these artefacts are Altheim sickles. Typical Altheim sickles are made from sheet tabular flint and are highly sophisticated artefacts about 20 cm long with characteristic straight edge, curved back with the roughly worked base meeting the blade edge at right angles. The edges are retouched in a narrow band no deeper than 1 cm, except when the original tablet is too thick (Tillmann, 1992, 291f). The three Lower Austrian examples are made on tablets that vary between 0.5 and 1 cm in thickness. There is no question that they have been made in an Altheim culture milieu on grounds of both form and raw material. In terms of culture chronology these are early Baden or Bóleraz (c. mid-fourth millennium B.C.)

Baiersdorf Plattenhornstein comes from residual deposits in weathered limestone outcrops. The thickness of the sheets or tablets generally ranges from 1 to 2 cm with a colour that varies from blue-grey to grey-brown, with fossil remains and sometimes banding or mottling. The two sides of the cortex differ, with one being more textured than the other, but it is always the case that the inner sides of either surface have a lighter colour (Binsteiner, 1992, 332).

Baiersdorf Plattenhornstein was widely traded in the south German later Neolithic (Grillo, 1997, 162f) and has recently been shown to have been traded into the south-eastern Alpine region as well, over an estimated distance of 470 km. The best known findspots are the Styrian sites of Tesserriegel (Binsteiner, 1999) and the hoard find of Hengsberg near Schönberg (Fuchs, 1987). Finds seems to demonstrate that a large amount of Baiersdorf Plattenhornstein was utilized in the late Neolithic/early Copper Age of eastern and western Styria (Gerald Fuchs, pers. comm. 2001). It must remain an open question both how and why it was transported over such long distances, but it is obviously significant that there is no equivalent raw material in eastern Austria from which such long sickle blades could have been made.

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Neolithic Phonolite mine and workshop complex in Hungary

KATALIN T. BIRÓ[1], GYÖRGY SZAKMÁNY[2] & ZSOLT SCHLÉDER[2]

[1]Hungarian National Museum, H-1088 Bp. Múzeum krt. 14-16, Budapest, Hungary
[2]Eötvös L. University, Dept. of Petrology and Geochem., H-1117 Budapest, Pázmány Péter sétány 1/C, Hungary

Abstract. Phonolite is a very specific volcanic rock which can be spotted in the archaeological material by simple means. Recently it was found among the polished stone tools of Late Neolithic Lengyel culture. Tools were identified within a 100 km circle around the sources. Workshop activity (production of phonolite axes) was documented by a detailed study of the well-known prehistoric settlement of Zengővárkony. Detailed field survey also resulted in the localisation of the prehistoric quarry region.

Keywords: Phonolite, Prehistoric quarry, workshop, distribution, polished stone tools, Late Neolithic

Introduction

In the frame of IGCP-442, basically provenance of polished stone tool raw materials are investigated with an aim of reconstructing European trade network routes. For a number of materials, we are facing the following difficulties:

– inferior quality local staff, used for symbolic artefacts e.g. „grave axes" have really no significance for trade networks

– high quality raw materials preferentially used (e.g., greenschist, serpentinite, basalt) may occur at several places within the reach / contact zone of prehistoric communities, therefore they should be unambiguously characterised (fingerprinted) by the sources before distribution data could be interpreted in a source-to-site relation.

Recently, the study of Late Neolithic basalt artefacts by Schléder and Biró (1999) and Judik et al (1999, in press) dealt with the apparent difficulties of the second type.

It is but in rare fortunate cases that petroarchaeological characterisation studies of polished stone tools can rely on single-point or almost single-point sources, where in the possible reach of the prehistoric population there was only one source area available. Even less frequently we can say that traces of prehistoric mining and processing of polished stone tools is documented. The fortunate case we would like to present in this paper is **phonolite** – extraction, processing, provenance and distribution as seen in the light of recent research in Hungary.

Phonolite – geological, petrographical description; sources of phonolite in Hungary and wider environs

Phonolite is a volcanic rock. It was originally „Klingstein" (clinkstone; Hungarian, „csengőkő") on account of the sound emitted when it was struck by a hammer. It consists mainly of nepheline and alkali feldspar (sanidine or rarely anorthoclase). Other minerals occurring in phonolite are alkaline pyroxenes, alkaline amphiboles, leucite, analcime and sodalite-group minerals (sodalite, nosean, hauyne). It is the volcanic equivalent of nepheline syenite. Phonolite is grey to dark green, usually with a phyric texture and a greasy lustre due to the presence of nepheline. On surface conditions, the fresh broken fractured surface is getting easily weathered: typically, a yellowish-grey patina is observable on the subfossil (archaeological) specimens. The appearance of the rock resembles a poppy-seed cake with sugar in it, characteristic among the polished stone tool raw materials used for the production of prehistoric artefacts.
It is used today as building stone for interior decoration and ceramic additives.

Phonolite in Hungary occurs on the surface only in the Mecsek Mountains Lower Cretaceous formation termed „Mecsekjános Basalt Formation". The sequence include a subvolcanic and submarine volcanic rock association forming a differentiation series ranging from (alkali) basalt through trachybasalt and tephrite to phonolite. Its four members include the subvolcanic Szamárhegy Phonolite Member, the Singödör Basalt Member which has the greatest mass and contains also microbasalt, the Balázsorma Tephrite Member, and the Kisbattyán Basalt Member with no extreme differentiates but with spilite. The thickness of the formation is several hundred of metres.

Phonolite can be found specifically at two localities, Hosszúhetény-Kövestető and Kisújbánya-Szamárhegy. Petrographically, both are dominated by sanidine and some plagioclase. Nepheline is occurring in characteristic irregular spots. Analcime or other zeolites may occur in knots. As coloured constituents, they contain primarily

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aegirine of columnar habit. In the Szamárhegy phonolite (and only in this type) alkaline amphibole with reddish brown pleocroism can be observed, having a characteristic rim composed of opaque minerals as a consequence of magmatic resorbtion. The texture of the rock shows fluidal features with phyric holocrystalline texture. Both phonolite types are of subvolcanic origin. Recent mineralogical and petrological description of the Mecsek phonolite was published by Harangi, 1994 and Harangi & Árva Soós, 1993.

Approximate chemical composition data for phonolite, as well as some mechanical (mainly thermal) qualities are listed at http://english.keramost.cz/suroviny5htm.

Chemical composition data are quoted from here:

	%		%
SiO_2	52 - 55	CaO	0,8
Al_2O_3	20,5 - 23	MgO	0,2
Fe_2O_3	1,5 - 2	K_2O	3,5 - 5
TiO_2	0,3	Na_2O	10 - 10,5

Its occurrences apart from Hungary are mentioned from Central Italy (Rome environs, Bracciano-lake), Bohemia (Teplitz, Marienberg, near Aussig, Klein-Priesen);, Germany (Siebengebirge, Saurenberg, Eifel, Salzhausen), France (Auvergne, Mont-Dore, Haute-Loire) and Poland (Besquides).

From our more immediate vicinity, phonolite was described from the territory of Yugoslavia (Fruska Gora, Rakovác and Ledinc valley and Pétervárad.

The Szamárhegy phonolite mine

The study of prehistoric mines, more or less naturally, started with the investigation of „flint mines" in the large sense. Very spectacular instances like Spiennes, Grimes Graves or Krzemionky draw attention to the problem fairly early. The exhibition and thematic monograph consecrated to the problem by the Bochum Museum of Mining (Weisgerber ed.1980, published already in 3rd edition, Weisgerber ed. 1999) as well as the series of Flint Symposia set the standard of flint mine research and produced a system of cataloguing the known quarries by countries. The most recent, updated „flint mine catalogue" was published for the VIIth Flint Symposium (Lech ed. 1995). The system of registering included a reference number by country and the following standard data:

- name, county, geological co-ordinates, geographical setting
- history of research
- geology and the characterisation of the raw material mined
- mining methods and exploitation units
- mining tools and the other finds
- quantity of the output
- palaeoecological data
- processing of the raw material
- chronology and the culture implications
- references

Of course most of these data can be supplied only in case of archaeologically investigated (excavated, prospected etc.) localities. It is imperative however to supply as much details as we can for the sake of a standard description.

The number of prehistoric „flint" mines presented in 1995 (H-1-12) was completed by Biró and Dobosi by 1998. 2 new „flint" (=silex) mines (Hejce and Budapest-Farkasrét) were added and the only known Palaeolithic paint mine, Lovas added as Nr. 15. It seems reasonable to record other prehistoric quarries in the same manner, at least non-metallic raw material mines. Therefore we suggest Szamárhegy to be added as Nr. 16. on the list of prehistoric mines.

Kisújbánya-Szamárhegy: the first polished stone tool raw material mine in Hungary

While „flint" (=silex) mines of prehistoric age are relatively frequent, there are very few instances of prehistoric polished stone tool raw material mines in general.

The reason for this is rooted partly in finding very hardly dateable material in a quarry context in general and, typically, by the modern mining typical of most polished stone tool raw materials which destructed / covered traces of possible prehistoric mining activities. The so-called „pen-knife mines" known in the vicinity of almost any village with suitable raw material ourtcrops could be well originated from prehistoric periods, as well. Such was the case for the important greenschist outcrops in the vicinity of Felsőcsatár. The use of this material is adequately demonstrated both by archaeological and petrological evidence (Harcos 1997, Szakmány & Biró 1998, Kasztovszky & Szakmány 1999, Szakmány & Kasztovszky in press for IGCP 442 Udine abstracts). Modern quarrying of the material (from Roman times on, the Felsőcsatár greenschist was exploited on „industrial" scale) partly, erased possible prehistoric evidence, partly made small-scale extraction pits indistinguishable from traces of prehistoric mining.

In case of phonolite, petroarchaeological research is more fortunate. As we know, this distinctive raw material in large amount occurs within the Carpathian Basin only in the Mecsek Mts., S. Hungary, known from two outcrops (Hosszúhetény-Követető and Kisújbánya-Szamárhegy, respectively (see map). The former one is situated close to the southern slopes of the mountain, only 15 kms from the major city Pécs. Due to the superb physical qualities of the material, the outcrop was exploited on industrial scale and prehistoric chipped pieces can no longer be distinguished, even on being found, from modern (also antropogeneous but much more recent), debris.

The other locality, Kisújbánya-Szamárhegy on the other hand is situated in the very heart of the mountain, in strictly protected area for its natural endowments by the Duna-Drava National Park office. Geographical co-ordinates for the locality were determined as 46°14' N and 18° 22' E according to Greenwich co-ordinates. No modern mining was known, recorded or found here, and

Fig.1. Kisújbánya-Szamárhegy, phonolite exploitation area

thanks to the severe protection measures, probably the area will be preserved intact. In course of petrographical mapping field survey, the students of ELTE Dept. of Petrology and Geochemistry, Budapest became aware of the fact that lithic debris on the northern slopes of the mountain were essentially different in form and consistence than usual for phonolite, observable on the southern slopes. Zsolt Schléder, part of the survey team recalled artificial forms from his expertise as collaborator in flint mine excavations at Szentgál. Fortunately, he was already involved in the petroarchaeological research concerning the Baranya county polished stone tools, especially Zengővárkony where the presence of phonolite was spotted.

The surface morphological features were checked by K. Biró and J. Antoni, archaeologists with expertise on polished stone tool technology and prehistoric mining activities (Antoni 1990, Biró 1992) and the surface morphological features, extracted blocks and „axe" pre-forms identified on the spot (Fig. 1.). Some typical forms were collected for the Lithotheca collection of the Hungarian National Museum.

As a first step in more detailed studies, a geodetic survey of the area was prepared. By the help of Gy. Terei, archaeologist/surveyor of the Budapest Historical Museum, mapping and registering surface features was performed in a 1: 200 scale over an area of 190 x 100 m (1,9 ha) by a method routinely applied for earth moulds, elaborated by Gyula Nováki and György Sándorfi. The basis of the method is the detection of distance, direction and drip by the help of ultra-sonic detector and a computer elaboration of the data. The survey was realised in two measurement circles. In both cases, the starting point was set at the geodetic point (562 m a.s.l.) and thus the two circles could be collated.

On the first day, the eastern – north eastern part of the area was surveyed in 17 main measurement points. On the second day, 22 main points were taken. Total error for all measurements was within 110 cm on the first day and 171 cm on the second day, which means that direct reading can be modified some 5-6 cms for each points only. Apart from the current surface features, stone flows, possible exploitation areas were registered in a scale of 1:200.

The results were published first in the short communication for Pécsi Szemle on prehistoric an antique mining in the Mecsek Mts. (Kraft et al. 2000). The exploitation area shows traces of (in all probability, prehistoric) interference, though there is no evidence of direct dating. The known archaeological provenance data suggest a preferential use of the material in the Late Neolithic (Lengyel culture) though oncoming detailed survey may reveal more sites and wider chronological distribution in the near future.

Phonolite in the archaeological material

The possibility for finding phonolite in the archaeological material was raised not very long time ago.

Even former macroscopic classification suggested its existence among the archaeological (polished) artefacts. The certitude came with the revision of petroarchaeological data on the Zengővárkony Lengyel culture site and, mostly, after the identification of the Kisújbánya prehistoric phonolite mine and the workshop-related pieces from Zengővárkony.

The Zengővárkony polished stone producing workshop

The use of phonolite in general seems most important on the famous Late Neolithic settlement and cemetery Zengővárkony, excavated and published in two bulky monographs by János Dombay (Dombay 1939, 1960).
At Zengővárkony, the role of lithic industry in general and specially that of polished stone industry surpasses the „average" known for Hungarian prehistoric sites.

Several students of the subject stressed the importance of the lithic industry including János Dombay, excavator of the site himself.

In the 1980-es, Judit Antoni made a systematic study of the polished stone tools and the antler and bone tools of the settlement. She was aided in her work by Zoltán Almádi who made a preliminary (macroscopic) petrographical classification of the industry. Unfortunately, apart from the manuscript PhD thesis (Antoni 1990) the results of this work remained unpublished.

Also based partly on the Zengővárkony polished stone artefacts, István Zalai-Gaál made a socio-archaeological study on the material, mainly based on the evidence found in the graves. No petrographical determination of the polished stone tools was made for the support of this study.

Recently, the authors of this paper and Ms. Antoni together made a survey of the total polished stone tool inventory of the site. One of the first observations was noting the presence of phonolite, tephrite and phonotephrites in the material, formerly described by Almády mainly as „microgranite".

Our study included apart from the survey of finished polished stone tools forms which could be connected with the production of polished stone tools, in the first place, phonolite. By this time the existence of the Szamárhegy mine was already known to us.

Altogether some 200 pieces were registered. Of these, about 10 % was made of phonolite. Polishers and tools for making polished stone axes were also observed.

Pieces which might be associated with the „phonolite-workshop" were specifically selected for further studies, both archaeological and petrographical.

The typological (morphological) description of the pieces selected is given below:

1. N 2/281-1948 Imperfect axe-blade pre-form, slightly polished. Dimensions: 97 x 48 x 35 mm,
2. N 1/160-1949 Square (sawed?) pre-form with polish, broken axe pre-form ? Dimensions: 138 x 46 x 42 mm,
3. N 2/217-1948 Slightly asymmetrical axe-blade pre-form before finish. Dimensions: 121 x 68 x 36 mm,
4. N 1/79-1947 Fragment of an axe pre-form with traces of polish. Re-used piece. Dimensions: 97 x 40 x 37 mm,
5. N 2/110-1948. Bulky hammer made of axe pre-form with initial polish. Dimensions: 125 x 66 x 46 mm,
6. N 1/405-1947 Sliced large phonolite block before production of pre-form. Dimensions: 110 x 75 x 55 mm,
7. N 1/297-1947 Medium size axe pre-form with traces of polish Dimensions: 102 x 44 x 42 mm,
8. N 1/427 – 1947 Broken axe pre-form with traces of polish. Dimensions: 64 x 61 x 38 mm,
9. Smaller axe pre-form with initial polish. Dimensions: 102 x 44 x 28 mm,
10. N 2/341-1948 Rounded axe pre-form used as hammer. Dimensions: 83 x 50 x 35 mm, (Fig. 2)
11. N 1/379-1947 Large pre-form with parallel planes, broken obliquely in the middle. Dimensions: 102 x 75 x 42 mm,
12. N 12/21-1941 Raw phonolite block with traces of sawing, shaping and initial polish. Dimensions: 110 x 45 x 36 mm.

Even now, the number of pieces identified as phonolite is not too much: revision of southern Hungarian material, however, will probably extend the scope.

Macroscopically identified pieces

Apart from the workshop site of Zengővárkony, phonolite axes have been located so far at the following localities (Fig. 3.):

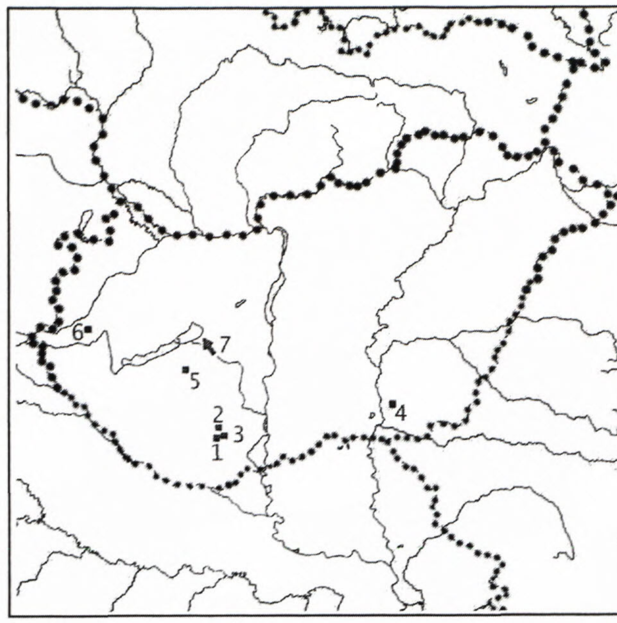

Fig. 2 Known distribution of phonolite polished stone tools on Hungarian archaeological sites.
Key: Sources – 1. Hosszúhetény-Kövestető; 2. Kisújbánya-Szamárhegy; Workshop – 3. Zengővárkony (LN Lengyel culture); Archaeological sites: 4. Hódmezővásárhely – Gorzsa (LN Gorzsa group); 5. Zics – Szűkszűr dűlő (MN, LN, CA); 6. Győrvár (unknown), 7. + further than Mezőkomárom (unknown)

Zics-Szűkszürdűlő

Surface collected material by I. Sipos.

The „suspect piece" is the edge fragment of a medium size axe in fairly corroded state. The piece was renewed and pierced at some period of its existence (Fig. 4)

The site associated with the polished stone tool contains the remains of several prehistorical cultures including Early/Middle Neolithic Oldest LBC, Classical LBC, Late Lengyel/Balaton, Baden cultures.

Győrvár

Surface collected piece by Zs. Farkas. The artefact used to be a bulky shaft-hole axe, with oval transsection, the butt half remaining to us.

Hódmezővásárhely-Gorzsa (Fig. 5)

This piece is especially valuable to us as it is coming from controlled excavation with micro-stratigraphical method. The site is one of the key settlements of the Alföld Late Neolithic, its connections with the Lengyel culture has been demonstrated by the archaeological evidence in general (Horváth F. 1986) and the chipped stone industry, specifically (Biró 1998). There are important connections shown by the regular presence of Mecsek radiolarite on this site.

The suspect piece is the broken butt end of a shaft-hole rounded axe, a type which is frequently met at Zengővárkony. The distance from the outcrop is at least

Fig. 3. Phonolite axe half-product from the Zengővárkony workshop site

Fig. 4. Zics-Szűkszűr dűlő. Fragment of polished stone tool. Phonolite (?)

Fig. 5 Hódmezővásárhely-Gorzsa. Fragment of polished stone tool. Phonolite (?)

Fig. 6 Phonolite artefacts from the Mihäldy collection (6/1) and petrographical thin section of item inv. No.55.1239. with 1 N (6/2) and X N (6/3), respectively.Courtesy of J. Füri.

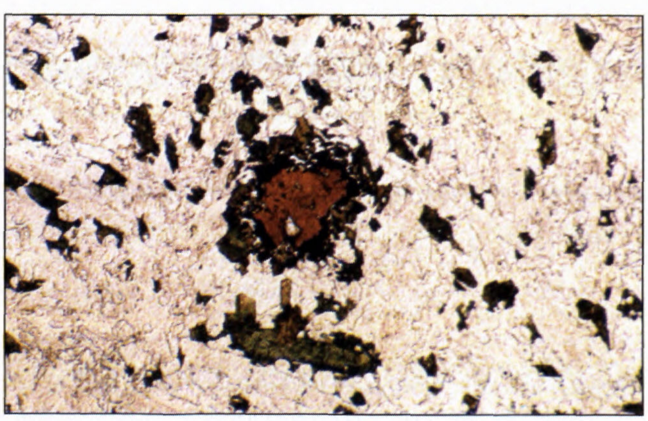

Fig. 6/2

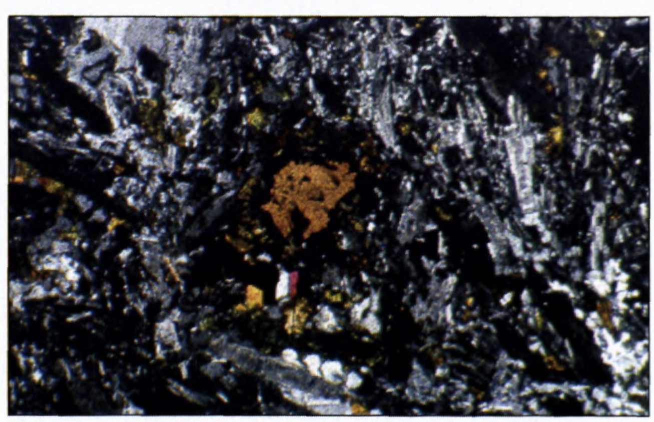

Fig. 6/3

100 km as the crow flies and the trader must have surpassed severe geographical obstacles like the course of the rivers Danube and Tisza. We are currently checking this piece; the presence of phonolite at Gorzsa indicates a wider, at least regional distribution of phonolite on Hungarian archaeological sites and chronologically supports our view that the acme of phonolite axe exploitation and production was probably in the Late Neolithic.

Mihály collection: Two samples have been determined as phonolite (Fig. 6/1). Inventory numbers: 55.1239 (Szamár-hegy type on the basis of thin section (Fig. 6/2-3.), it is sure that it is it), and 55.875 (only macroscopic data) The exact site for both pieces is unknown. The Mihály collection, stored in the Veszprém County Museum and elaborated in details by T. Horváth (1999) has unfortunately lost most of the provenance data due to hasty re-inventarisation in the early 50-is. Nearest to the quarry site we find site nr. 96 (Mezőkomárom), published by S. Mithai (1978), some 60 kms minimal distance from the outcrop. The phonolite items from the Mihály-collection were petrographically identified by the archaeometry study team of the ELTE Petrography and Geochemistry Dept. (Szakmány et al. 2000, Szakmány et al. in press)

Analytical studies on phonolite artefacts

There were so far only limited studies by analytical methods on phonolite artefacts. The specimens investigated by, at least petrographical microscopy include pieces from the Mihály collection and Zengővárkony. Several more items are currently under investigation and we hope to serve details by the Udine meeting.

Tasks and directions of research

As it is apparent from our paper, tracing phonolite in the archaeological record in Hungary (and probably the regions lying to the south of our borders) is a current field of research. The recognition of phonolite in the archaeological material started fairly recently, the study of the quarry area and the workshop is in its initial phase as yet. It is very difficult to estimate the actual significance of phonolite (as well as related rocks, phono-tephrite and tephrite) in the archaeological material. Its significance lies primarily in the fact that being a very specific raw material relatively easy to identify and rare concerning geographical / geological occurrences, it will be probably an excellent marker for ancient trade routes.

Acknowledgements

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Preliminary petrographic report on blueschists, the materials of Neolithic polished stone tools from Hungary

SÁNDOR JÓZSA [1], GYÖRGY SZAKMÁNY [1], HARGITA ORAVECZ[2] & CSENGERY PIROSKA[3]

[1]Eötvös L. University, Dept. of Petrology and Geochemistry, H-1117 Budapest, Pázmány Péter Sétany 1/C, Hungary
[2] National History Museum, H-1088 Budapest, Múzeum krt. 14-16
[3] Herman Ottó Museum, H-3529 Miskolc, Görgey A. u. 28

Abstract. Nearly 1000 Neolithic stone tool samples were looked over from the whole territory of Hungary. 26 of them showed blueish shade of colour so they may be blueschists at first sight. With the polarising microscopic investigation of 7 selected peaces beside of proving the macroscopical determinations we could devide these bluescihsts into 3 different types. This is the first report of the recognition of blueschist polished stone tools from Hungary. These blueschist stone tools are concentrated in the northeastern part of Hungary and their proportion decreases southwards. On the base of petrography and the closeness of the supposed source area it is very likely that the blueschist material of studied stone tools derived from the surroundings of Sugov valley, south Slovakia.

Key words: archaeometry, blueschist, petrography, Neolithic, axe

Introduction

Intensive microscopic petrographical investigation of Hungarian Neolithic polished stone tools started nearly 10 years ago. This work resulted an overlook of raw materials of polished stone tools from Pannonian Basin (Biró & Szakmány, 2000.). More intensive research in last few years was promoted by the IGCP-442 program, so the first blueschist tools have been found out last year from Hungary. This work is the first petrographic report of Hungarian blueschist raw material.

Archaeological background

26 blueschist stone tools out of 143 were found from 9 NE-Hungarian localities. Most of blueschist tools came to light from Felsővadász-Várdomb (14 out of 19 tools) and Borsod(Edelény)-Derekegyháza (5 out of 15 tools) localities. Other localities gave one blueschist tools from each.

Felsővadász-Várdomb locality

Felsővadász is situated in the Cserehát hills northeastern part of Hungary. The NW-SE elongated, so called "Várdomb" hill consisting of sand and sandstones extends in the SE margin of Felsővadász. The southern slope was very useful place for settle down of prehistoric man. The locality is known as a archaeological site from the end of 19th century (Lehoczky, 1883; Szendrei, 1888; Korek & Patay, 1958; Kalicz, 1968), but the first archaeological excavation was in 1978 (Hellebrandt, 1979), later there were excavated remnants of prehistoric settlements (Koós, 1986a; 1986b). There were discovered some unit and legacy of Neolithic bükkian culture, Aeneolithic hunyadhalmi group and badenian culture, moreover hatvanian and füzesabonyian culture from the Bronze Age, there were some pit and graves among them.

One part of blueschist raw material polished stone tools was found from Neolithic pits and objects, moreover a lot of them have been found from spade layer with Neolithic, Bronze Age or both mixed material. Most of blades were made of metamagmatic rocks, namely blueschist, greenschist and serpentinites moreover some macroscopically not exact determinable metamagmatic rocks. The blueschist blades are not perforated, they are axes first of all, they are 4-7 cm long, 2-5 cm wide and 1-2 cm thick. All the blades have traces of hafting and traces of use wear.

Borsod (Edelény) – Derekegyháza locality

This locality is situated 20 km north from the Bükk Mts. in the Cserehát hills close to the southward flowing Tarna river. An opened settlement from the Bükkian kulture (Middle part of Neolithic age) were recovered here in the middle of 20th century.

Most of tools were made of metamagmatic rocks which are perhaps belonging to one rock series, namely blueschist (5), actinoliteschist (5) and serpentinit (3). The row material of rest three tools (diorite, metavulcanite and sandstone) has not such a strong connection to this rock group. 4 out of 5 blueschist polished stone tools were found in a litter pit and one in a soil layer. All 5 tools are

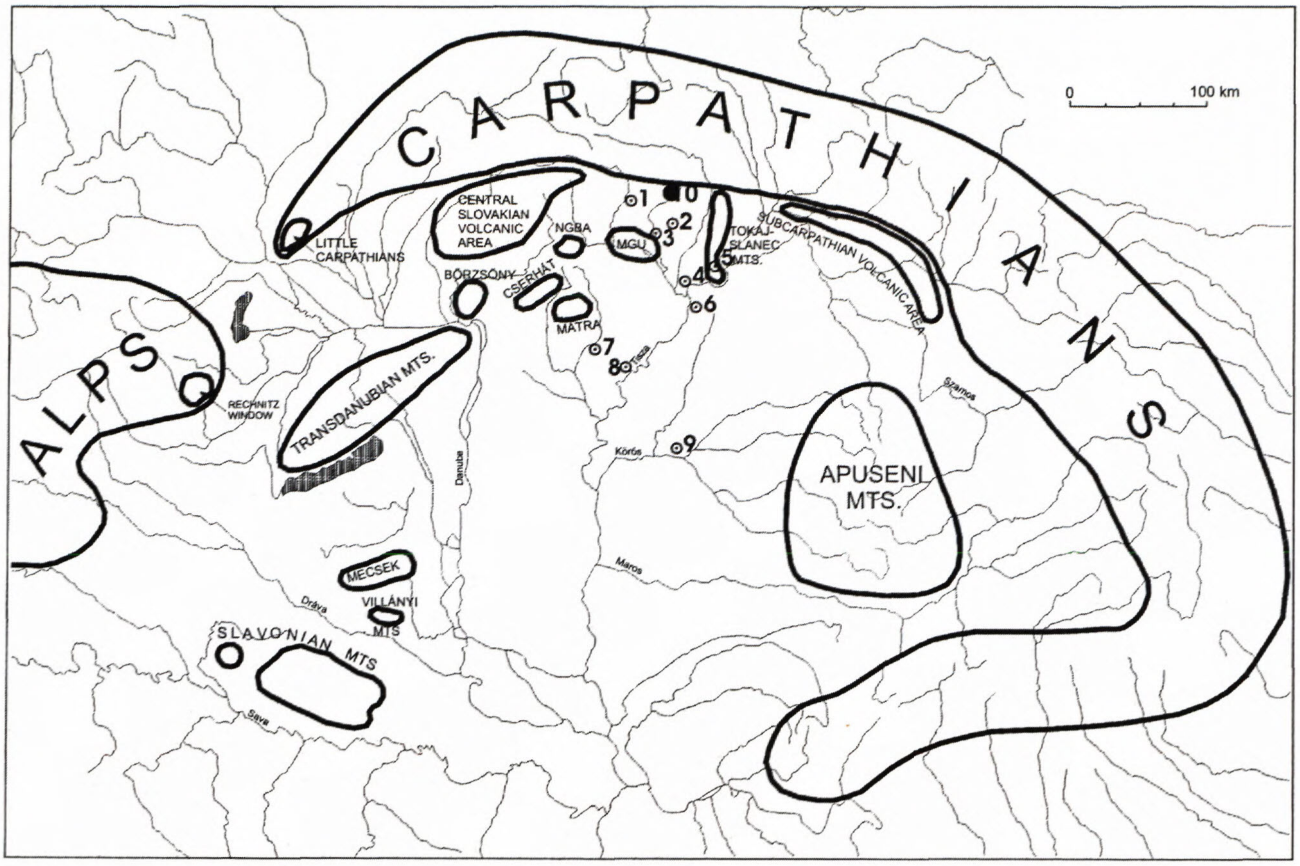


Fig. 1 The localities of blueschist polished stone tools in Hungary, and the closest blueschist outcrops
Abbreviations: MGU – Meliata-Gemeric Unit; NGBA – Nógrád-Gemeric Basaltic Area; Number of localities: 1 – Aggtelek; 2 – Felsővadász; 3 – Edelény; 4 – Tiszalúc; 5 – Bodrogkeresztúr; 6 – Polgár; 7 – Tarnabod; 8 – Kisköre; 9 – Dévaványa; 10 – Sugov-valley (blueschist outcrops)

axes, 4 of them show trapezoid form, and only one has form narrowing to the direction of its edge. Most of them appears in form of broken peaces, only one whole tool was found in this and next five localities. Traces of use wear are usually well visible and refer about chiseling and cutting functions. On the unbroken tool the traces of hatting are also become distinct.

From all the rest localities (Aggtelek, Tarnabod, Polgár-Folyás-Szilmeg, Dévaványa-Sártó, Kisköre-gát, Bodrogkeresztúr-Kutyasor, Tiszaluc-Sarkad) blueschist stone tools came out sporadically (one of each occurrences). These stone tools exept one Bronze age tool are Neolithic, they are often represented only by fragments. In many cases traces of use wear and in few cases traces of hatting are visible.

Petrography

Locally, the blueschist stone tools have a great importance in the Carpathian basin (first of all in its northeastern part). This rock type as a raw material of stone tools in our region has not been published earlier. Macroscopically the polished stone tools are made of fine-grained blueschist and very difficult to distinguish from those made of greenschist (and fine grained amphibole schists), because of the similar appearance of the two types. In many cases there are a lot of green or greenish coloured minerals in the blueschists, moreover the texture of these rocks are similar.

Macroscopic description

Nearly 1000 stone tool samples were looked over from the whole country. 26 of them showed blueish shade of colour so they may be blueschists at first sight. Macroscopically the blueschist stone tools have blueish black, dark greenish blue or in some cases dark blueish (-blackish) green colour, with or without thin white or whitish bands or in some cases lenses, parallel to the well or very well appeared foliation. The green colour is due to the large amount of green minerals (epidote, chlorite, actinolite, the latter is due to the greenschist facies overprint, which is very often in these rock types). The material of stone tools is mostly fine grained (less than 1 mm grainsize), but there are some medium grained samples too among them. Macroscopically the greenschist and the blueschist types are very similar to each other; it is almost impossible to distinguish them.

Microscopic description

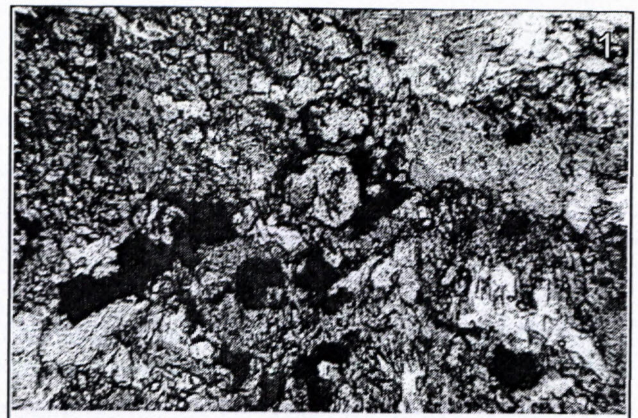
7 blueschist stone tools were selected for polarising microscopic investigation to proove the macroscopic determination and to make more precious characterisation

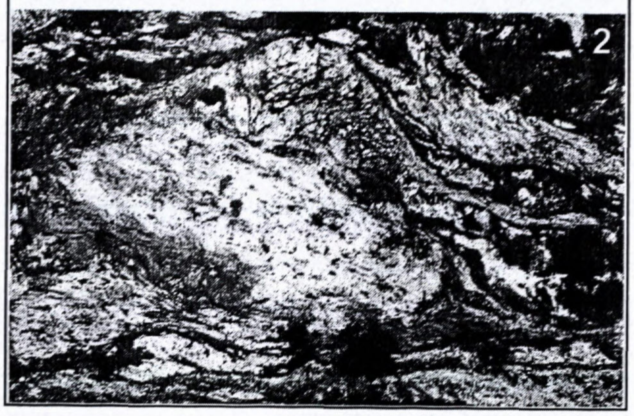
of the rocks. 30μm thin sections were made of the selected samples. Firstly we determined the mineral content and the texture of the rocks, then on this base the exact rock name were given. Special features were also detected to make comparism with each other and also with possible source material.

Selected rock materials of tools, described by naked eyes as blueschists, showed little differences in main mineral content determined in thin section. All of them proved to be real blueschists with the appearance of large amount of blue amphibole (most probably glaucophane).

3 type of blueschists could be distinguished by petrographical microscope. In two samples (one from Edelény (15/1949.224), the other from Felsővadász (FVD-11/7)) which are belonging to the first group of rocks relict clinopyroxene preserved in form of isometric or elongated, strongly deformed and more or less altered graines wich have nearly same grainsize (50-100 μm). These pyroxenes are augites and show typical pretectonical characters. Twinned chrystals are rare, but curved grains and wavy extinction are characteristic, dispersion is strong. Its original proportion in the rock was about 15-20 % with equal distribution. Alteration reached about 60 % of the whole amount of augite and produced badly chrystallised brown hornblende, small amount of very finegrained titanite, zoisite-clinozoisite and pumpellyite and few tremolite. Most of finegrained titanite has been formed from ilmenite, which originally was represented as amoeba like grains in comparably significant proportion (1-3 %) and grainsize (50-100 μm). Due to shearing process during the metamorphism beside total alteration ilmenite was strongly deformed and turned into weakly oriented, long, thin and curvy titanite aggreates. Mozaik like aggregates of slightly elongated equigranular chrystals of epidote form wavy bands and lenses aruond relict, cracked pyroxenes. Remaining places are filled with mostly wavy laths and bunches of blue amphiboles. Two other samlpes from Felsővadász (FVD-41 and FVD-51) could be ranked to this group too, but these blueschists are little bit differ from previous two samples by their finergrained appearance and smaller amount and less remained relict pyroxenes. In all four blueschist samples traces of relict magmatic texture (ophitic and intergranular) are visible.

The next two samples (also from Edelény (15/1949.233) and Felsővadász (FVD-42, see the photoplate)) form the garnetbearing group of studied blueschists. Relicts of magmatic minerals are missing, only weakly preserved pseudomorphs after pyroxene consisting of medium and finegrained mosaic crystals of chlorite, wite mica, quartz, albite and few titanite are present. Mass of titanite appears in form of aggregates as described in the previous group. Mostly large, big euhedral blue amphibole gives 30-50 % of the whole rock. Angular spaces between them are filled by medium grained isometric, mosaic chrystals of albite, quartz, white mica and epidote. Euhedral mainly medium grained garnet is scattered evenly in the rock. In the sample from Felsővadász larger, more altered garnet chrystals are also present.





Photoplate 1. Microphotos of blueschist stone tools from Felsővadász

Fig.1. Garnet, blue amphibole, titanite and chlorite in blueschist (sample FVD-42, 1N, shorter side of the photo is 0.55 mm)

Fig.2. Pretectonic and zone blue amphibole with mica and chlorite (sample FVD-B, 1N, shorter side of the photo is 1.43 mm)

The third type of selected rocks is represented by only one sample from Felsővadász (FVD-B, see phototable). This rock suffered very strong greenschist facies metamorphism and contemporary shearing which probably expunged almost all traces of previous processes. Only more or less rounded large chrystals of former plagioclase remained partly unaltered. Most of these grains transformed to actinolite, albite, chlorite, sericite and undeterminable by petrographic microscope finegrained green material. Connected to these monocrystals in the direction of stronger sheared zones policrystalline aggregates of wavy extincting quartz and albite with scattered small actinolite laths and needls in them appear in form of wavy bands and lenses. Some large pale green or almost colourless amphibole crystals with darker core and few finegrained titanite bearing grains with similar pretectonic appearance were also detected. These large lenselike aggregates and grains are surrounded by strongly oriented wavy bands of mineral assemblages rich in small euhedral and large subhedral amphibols (tremolite, actinolite, brownish hornblende and very few greenishblue-green amphibol). Thiner titanite and opaque mineral rich bands are often alternating with amphibol rich ones. Some of the almost colourless and greenishblue amphibols may have composition close to glaucophane or riebeckite, so we were describing this rock among blueschists, in spite of the present mineral content on the basis of which this rock is an actinoliteschist. Transitional character of this rock from blueshist to actinolite schist can be registered by major and certain trace element (Sc, V, Cr, Co, Sm, Eu, Gd, Dy) analysis of the whole rock, made by PGAA method (Kasztovszky-Szakmány in prep.). Microprobe analysis of amphiboles is needed for exact determination.

Discussion

Neolithic blueschist stone tools are known only from several places from Europe for example first of all in Italian part of Western-Alps (D'Amico and Starini, 2000.). In the Carpathian-Pannonian region these type of tools are rare, because there is only one occurrance at Sugov Valley and surroundings where blueschist occure on the surface in large area and in big quantity (Faryad, 1997a., Faryad and Hejnes-Kunst, 1997, Faryad, 1997b) and which could surve as source territory for this kind of row material. In this paper we give the first description of blueschist stone tools from the territory of recent Hungary.

Among 142 tools from 9 place of occurrences 25 showed macroscopically blueschist character. Our preliminary observations were supported by petrographic investigations of 7 thin sections.

Abundance of inland blueschist stone tools is limited to northeast Hungary (see the map). Within this territory the distribution shows well defined regularity: moving away from the supposed source territory i.e. to the south, the frequency of occurrance and the ratio of blueschist to other rock types decreases. Considering the localities, the blueschist tools are in good correlation with the tools made of serpentinite, gabbro-dolerite and andesite. Andesite is a wide distributed rock type in north Hungary, but serpentinite and gabbro-dolerite can be considered as members of blueschist bearing ophiolitic rocks series.

Blueschists from geological outcrops of Sugov valley and surroundings are regarded as members of just the same rock series described from neolithic localities with blueschist tools. Petrographical similarities (the same mineralogical composition, particularly the existance of pyroxene and garnet in the same textural position both in the stone toolls and the outcrops) also strengthen the identifying of the blueschists from geological outcrops of the source area with the blueschists from stone tool findings.

Conclusion

This is the first report of the recognition of blueschist polished stone tools from Hungary.

We established that the blueschist stone tools are concentrated in the northeastern part of Hungary and their proportion decreases southwards.

On the base of petrography and the closeness of the supposed source area it is very likely that the blueschist material of studied stone tools derived from the surroundings of Sugov valley, south Slovakia.

Detailed identification of tools and source rock materials is possible by further detailed isntrumental investigations.

Aknowledgements

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

DUŠAN HOVORKA[1], JÁN SPIŠIAK[2], ŠTEFAN MÉRES[1], ĽUDMILA ILLÁŠOVÁ[3] & KATARÍNA DUBÍKOVÁ[1]

[1]Faculty of Natural Sciences, Comenius University, Mlynská dol., 842 15 Bratislava, Slovak Republic
[2]Geological Institute of the Slovak Academy of Sciences, Severná 5, 97401 Banská Bystrica, Slovak Republic
[3]Archeological Institute of the Slovak Academy of Sciences, Akademická 2, 94 921 Nitra, Slovak Republic

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.

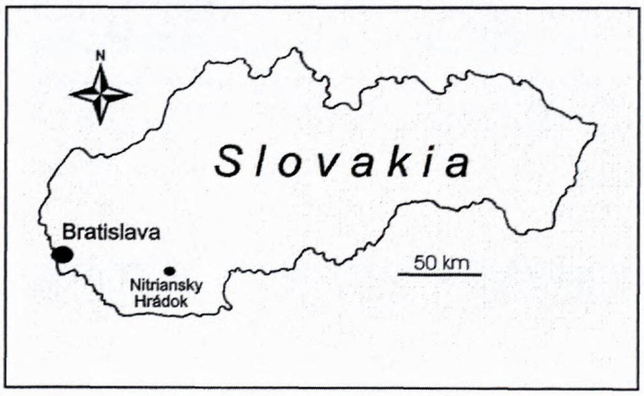

Fig. 1 Location of the site Nitriansky Hrádok

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

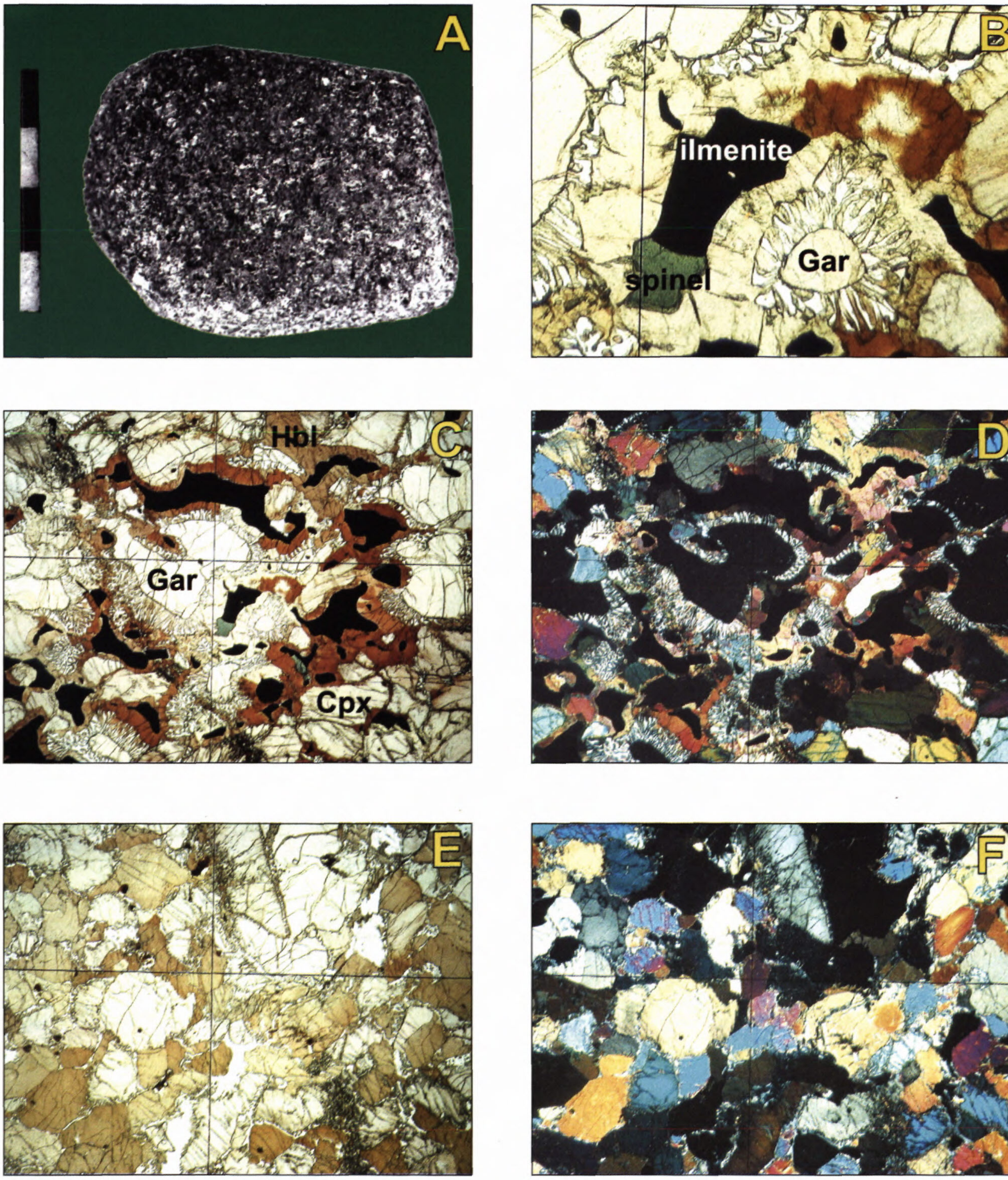

Fig. 2 Eclogite hammer-axe. A. Fragment of eclogite hammer-axe. B. Symplectite around garnet and green spinel on contact with ilmenite. Parallel polars. C. Position in eclogite composed of prevailing garnets and with kelyphitic structure. Parallel polars. D. Micrograph as C. Crossed polars. E. Position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

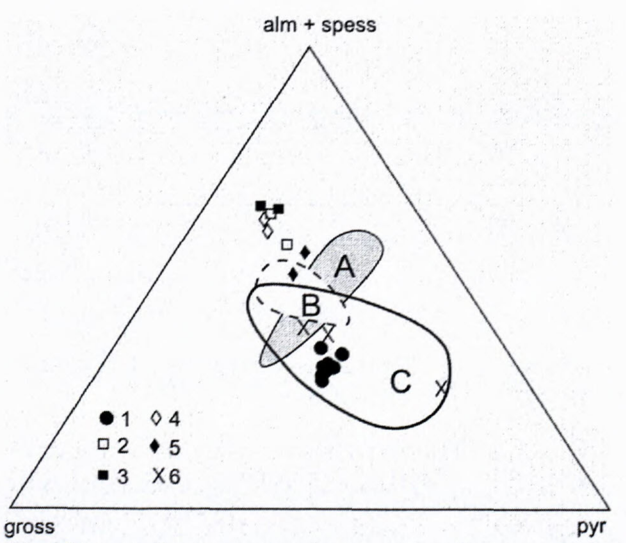

Fig. 3 Ternary diagram gross: alm+spess : pyr for study garnets. 1 = garnets from eclogite hammer-axe (Tab. 1), 2 – 5 = composition of garnets from the Western Carpathians core mountains garnet-pyroxene matabasites (Janák et al. 1997), 6 = garnets from eclogites of Gföhl terrane (data in Beard et al. 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

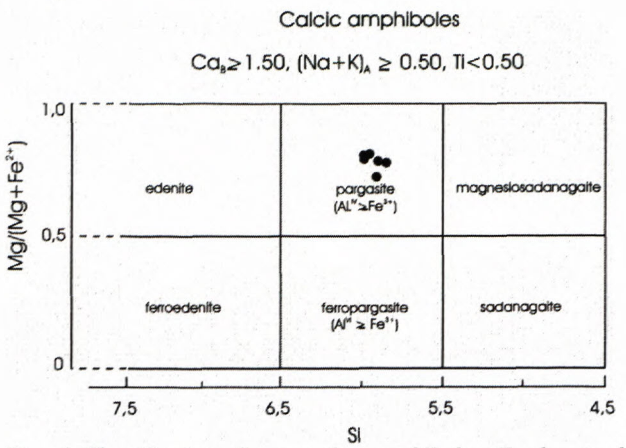

Fig. 4 Classification diagram for amphiboles (Leake et al. 1997) – dots represent projections of studied amphiboles from the eclogite-hammer-axe.

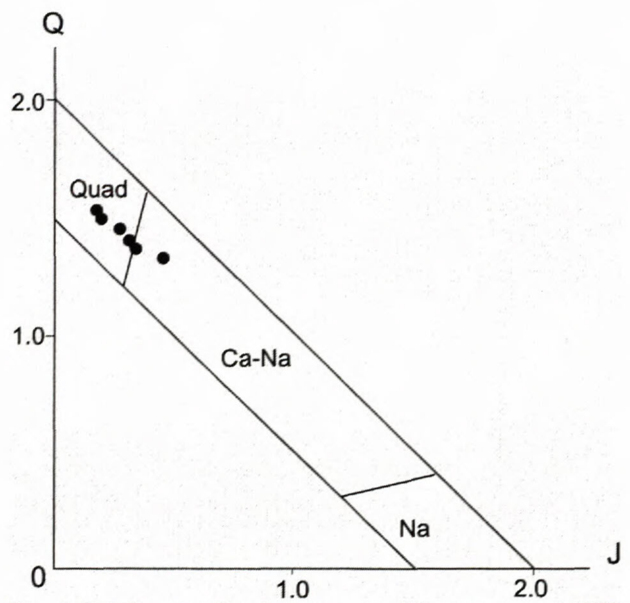

Fig. 5 Q-J diagram for the pyroxenes (Morimoto et al 1988), Quad = field of Ca-Mg-Fe pyroxenes, Ca-Na = field of Ca-Na pyroxenes, Na = field of Na pyroxenes. Dots represent projections of pyroxenes from the studied hammer-axe.

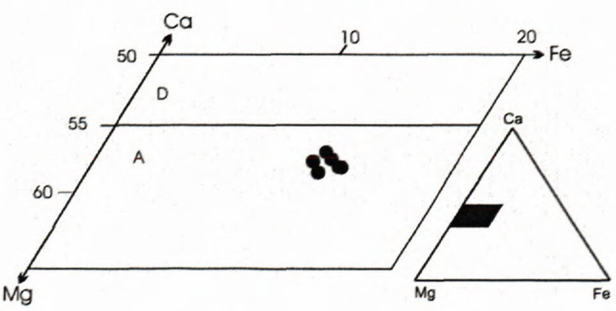

Fig. 6 Classification diagram for Ca-Mg-Fe clinopyroxenes (Morimoto et al. 1988). Dots represent projections of clinopyroxenes from the studied eclogite-hammer-axe

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.

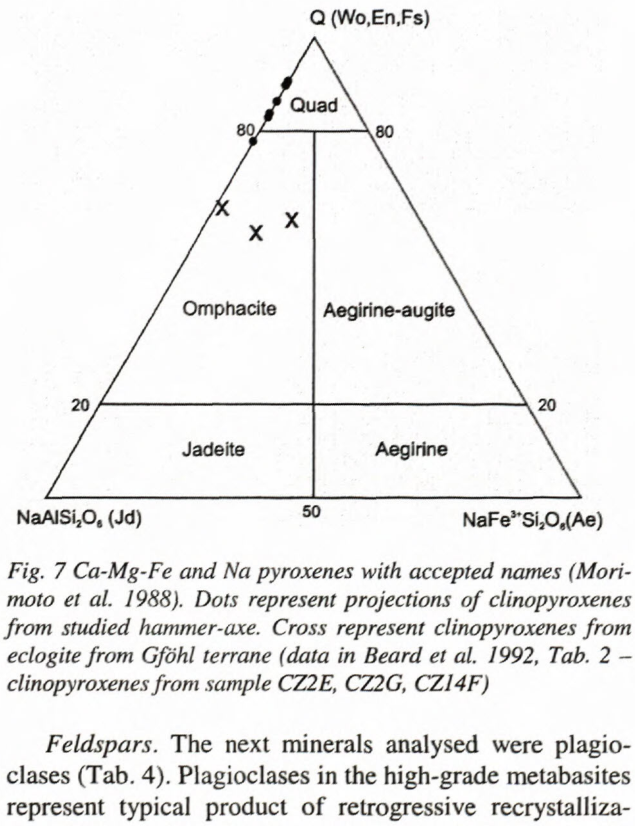

Fig. 7 Ca-Mg-Fe and Na pyroxenes with accepted names (Morimoto et al. 1988). Dots represent projections of clinopyroxenes from studied hammer-axe. Cross represent clinopyroxenes from eclogite from Gföhl terrane (data in Beard et al. 1992, Tab. 2 – clinopyroxenes from sample CZ2E, CZ2G, CZ14F)

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.

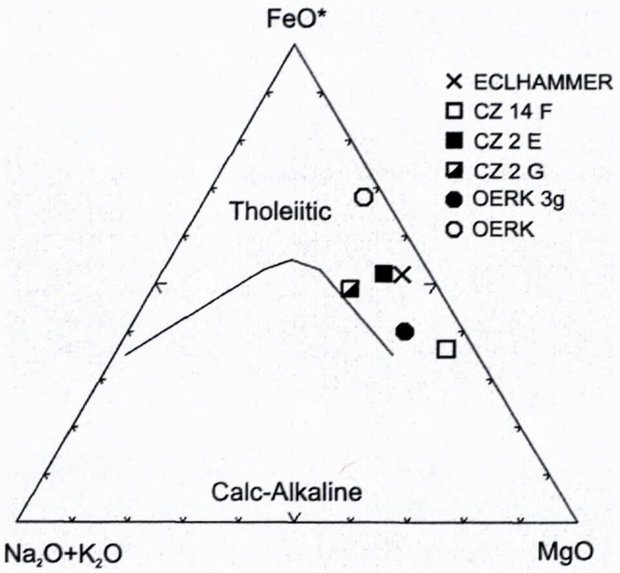

Fig. 8 Chemical composition of eclogite hammer-axe and composition of comparative eclogites of the Bohemian Massif and the Eastern Alps in Irvine and Barager's (1971) diagram. Rock analyses are in Tab. 5.

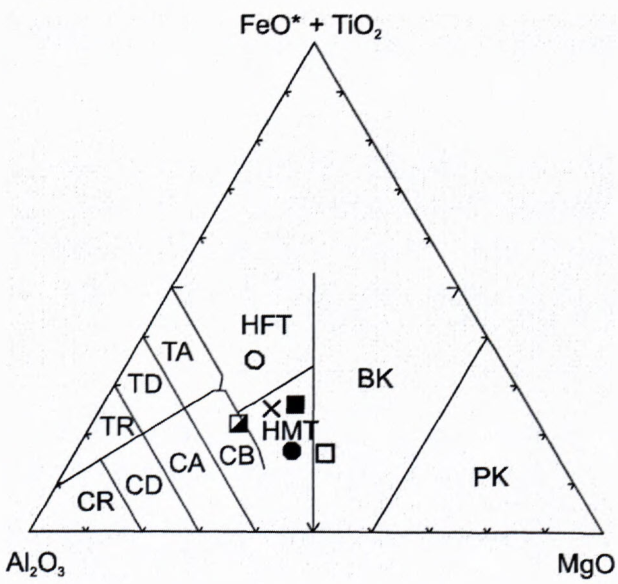

Fig. 9 Chemical composition of eclogite hammer-axe and eclogites of the Bohemian Massif and the Eastern Alps in the Jensen´s (1976) diagram. Rock analyses are in Tab. 5.
Designation of fields: TR-Tholeiitic Rhyolite, TD-Tholeiitic Dacite, TA-Tholeiitic Andesite, CR-Calc-alkaline Rhyolite, CD-Calc-alkaline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

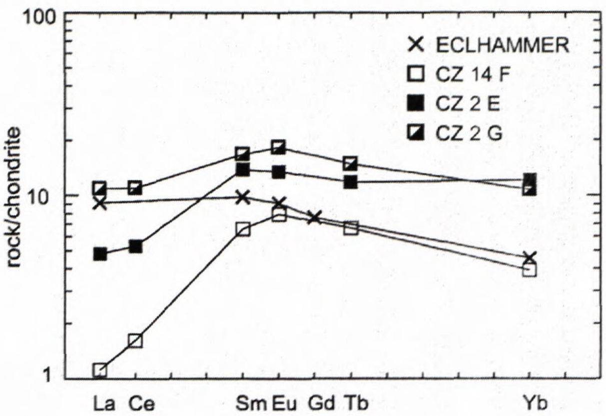

Fig. 10 REE normalized pattern from the eclogite hammer-axe and eclogites of the Bohemian Massif (Analyses in Tab. 5). Normalization on chondrite model (Sun 1982).

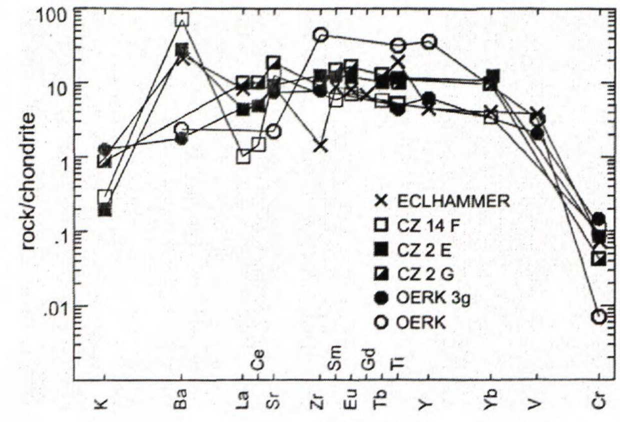

Fig. 11. Extended plots of selected elements of the eclogite hammer-axe and eclogites of the Bohemian Massif and the Eastern Alps. Normalization on chondrite model (Taylor & McLennan 1985). Analyses are in Tab. 5.

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)

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

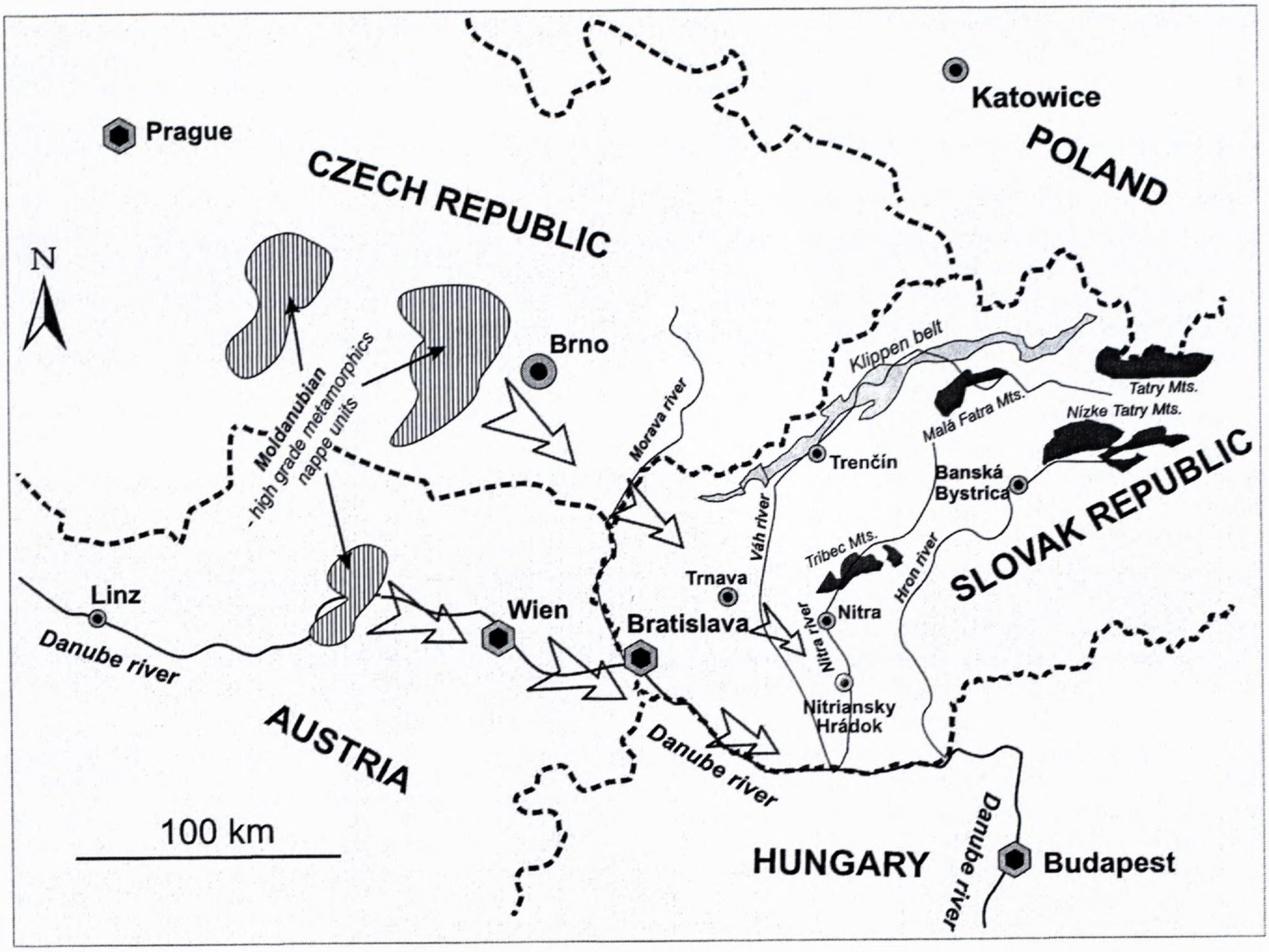

Fig. 12 Scheme with presented geological units from which eclogite should originate.

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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Alkali basalts: raw material of the Neolithic and Aeneolithic implements (Slovakia)

ĽUDMILA ILLÁŠOVÁ

Constantin the Philosopher's University in Nitra, Faculty of Natural Sciences, Tr. A. Hlinku, 949 74 Nitra, Slovak Republic

Abstract. On sites within, or adjacent, to the Late Tertiary volcanic province, artefacts of various size and shape and namely of various utilization, made from basalts, were collected in the past. In the Late Tertiary/ Quaternary volcanic province two genetical basalt clans (e.g. calc-alkali and alkali) are known to occur. Due to mostly phyric (plagioclases up to 10 mm) pattern of the calc-alkali basalts, Neolithic/Aeneolithic stone artefacts producers carefully selected alkali basalts for the subsequent elaboration. Their experience is based on the fact that alkali basalts have only fine-phyric (up to 0,5, very seldom up to 1 mm) pattern. Alkali basalts belong to the local/semilocal raw material type. Mostly secondary deposits (river gravels and slope blocks) have been used for implements construction.

Key words: alkali basalts, stone artefacts, Neolithic and Aeneolithic sites, Slovakia

Introduction

Among several raw material types alkali basalts belong to the less occurring one. For the Carpatho-Pannonian megaunit Late Cenozoic basalts are members of too genetic clans:

a) calc-alkali, and

b) alkali (Hovorka, 1978).

– Basalts of alkali series are described as basaltoid-andesites, andesitoid basalts or leucobasalts and represent the most basic members of the CA volcanic series rhyolite – dacite – andesite – andesitoid basalt. In contrast to alkali basalts they are older and their age is high as 8 million years. They have variable contens of main oxides namely SiO_2 and also variable contents of trace elements. CA basalts are poorer in alkalies.

– Alkali basic efusives in the inner side of the Carpathian Arc and in Pannonian Basin they bear character of alkali olivine basalts with typical Upper Mantle spinel peridotite xenolith and basanites with substantial presence of nepheline.

Basalts are products of the Late Tertiary and Quaternary volcanic activity (Pontian up till Pleistocene), which is known from several central European volcanic provinces.

They occur in the Lower Austria (Burgenland), in Hungary – namely in the Balaton lake area (esp. Tihany peninsula), in southern Slovakia (Novohrad Mts.) and in the Tertiary volcanice province of central Slovakia) and adjacent northern Hungary. Small occurrences in Silesia belong to the Cretaceous teschenite-picrite volcanic province in the Carpathians of the Czech Republic and as well as Poland territories.

Alkali basalts

Alkali basalts in Slovakia (Fig. 1) are known to occur in central Slovakia (Kalvária in Banská Štiavnica, Putikov vŕšok by Nová Baňa and massives Karanč and Šiator by Fiľakovo town (Hovorka and Fejdi, 1980).

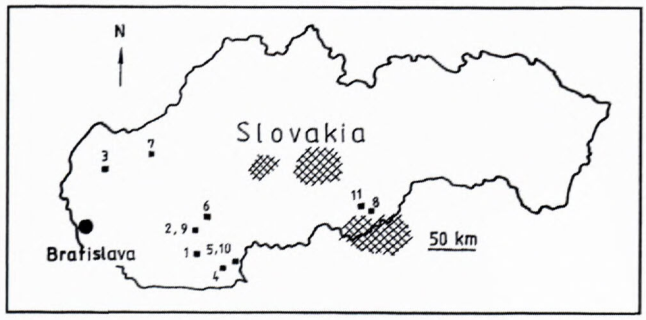

Fig. 1 Map of Slovakia. Archaeological sites (1-11) and area of alkali basalts occurrences in the Western Carpathians - in the central Slovakia and in the southeast Slovakia (by Ivan & Hovorka, 1993, simplified):
1 – Bajč, 2 – Nitriansky Hrádok, 3 – Senica, 4 – Svodín, 5 – Malé Kosihy, 6 – Zlaté Moravce, 7 – Opatovce, 8 – Stránska, 9 – Nitriansky Hrádok, 10 – Malé Kosihy, 11 – Rimavská Sobota

On the territory of Slovakia more than 30 rock types used for production of the tools, veapons and various ornamental or symbolic implements have been described (review see in Hovorka and Illášová, 2000). Artefacts like axes, hammer-axes and wedges made from alkali basalts were present mostly on the archaeological sites adjacent to the central Slovakian young volcanic area. The arte-

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Table 1 Archaeological sites with artefacts made from basalts.

Neolithic

Sites	Artefacts	Culture
Bajč[1]	1 axe	Želiezovská
Nitriansky Hrádok[2]	3 axes and 3 axe-hammers	Lengyel I a II
Senica[3]		
Svodín[4]	15 axe-hammers, 4 axes, 1 hoe, 1 semi-product, 1 base	Lengyel I a II
Malé Kosihy[5]	1 axe-hammer, 1 hammer,	Neolithic
Zlaté Moravce[6]	1 axe-hammer	Neolithic

Aeneolithic

Opatovce[7]	1 axe-hammer	Aeneolithic
Stránska[8]	1 axe	Baden
Nitriansky Hrádok[9]	1 axe, 13 axe-hammers, 1 hoe	Baden
Malé Kosihy[10]	1 axe-hammer	Aeneolith
Rimavská Sobota[11]	2 axes, 2 axe-hammers	Neolithic / Aeneolithic

Explanation to Table 1

[1]**Bajč** - Hovorka, D. & Cheben I., 1997: Raw materials of the Neolithic polished stone artefacts from the site Bajč (SW Slovakia). Min. slovaca 29, 210 – 217.

[2]**Nitriansky Hrádok** - Illášová Ľ. & Hovorka D., 1999: Typologická a patrografická analýza kamenných artefaktov z Nitrianskeho Hrádku - Zámečka. Študijné zvesti Archeol. ústavu SAV, 32, Nitra, 99-185.

[3]**Senica** - Hovorka D., Cheben I. & Husák Ľ., 2000: Raw materials of Neolithic/Aeneolithic stone implements from sites around Senica (Western Slovakia). Archeologické rozhledy 1, 11, Praha, 465-470.

[4]**Svodín** - Hovorka D. & Illášová Ľ., (in print)

[5]**Malé Kosihy** - Illášová Ľ., (unpublished): Archaeological Institute of the Slovak Academy of Sciences. Documentation centre, Nitra, Slovakia.

[6]**Zlaté Moravce,** [7]**Opatovce,** [8]**Stránska** - Illášová Ľ., (unpublished): Archaeological Institute of the Slovak Academy of Sciences. Documentation centre, Nitra, Slovakia.

[9]**Nitriansky Hrádok** - Illášová Ľ. & Hovorka D., 1999: Typologická a petrografická analýza kamenných artefaktov z Nitrianskeho Hrádku - Zámečka. Študijné zvesti Archeol. ústavu SAV, 32, Nitra, 99-185.

[10]**Malé Kosihy** - Illášová Ľ., (unpublished): Archaeological Institute of the Slovak Academy of Sciences. Documentation centre, Nitra, Slovakia.

[11]**Rimavská Sobota** - Hovorka D. & Illášová Ľ., (base analyses, unpublished)

Fig. 2 Poorly expressed fluidal pattern of an alkali basalt. In the middle of the micrograph the olivine phencryst: plagioclases have a lathy morphology. Thin section: S - 27, X polar. magn. 90x (by Hovorka et al., 2000).

facts have already been mentioned in several published papers (see Hovorka and Illášová, l.c.) however the raw material types have not been described in detail yet. Therefore the presented paper gathers and synthetises existing information and add new ones.

As it is shown at (Table 1) in the stone age from the alkali basalts made artefacts have been found up to date on several Neolithic and Aeneolithic sites.

On the territory of the Slovak Republic basalts occur as not uniform genetic types and of various stratigraphy. They are known from several geological units, forming bodies of various size, shape and intensity of metamorphic recrystallization.

Alkali basalts have dark-grey up to black colour, they are mostly of fine-phyric and massive patterns. The surface of artefacts, deposited thousands years in the soil, is characteristic by tiny pores, representing empty spots after disoluted feldspars.

For the mineral composition of alkali basalts two main phases are characteristic: plagioclases and clinopyroxenes, in several artefacts also olivine, amphibole and ore minerals have been identified (Fig. 2).

Among them clinopyroxene and olivine form fine (up to 1 mm) phyric crystals. Mentioned minerals are present in the matrix, too. For the Late Cenozoic alkali basalts characteristic is the presence of the Upper Mantle perovka xenoliths of the spinel peridotite type (Hovorka and Fejdi, 1980). They reach several centimeters diameter, but mentioned authors (l.c.) described also desintegrated xenoliths. In this case in the groundmass only individual

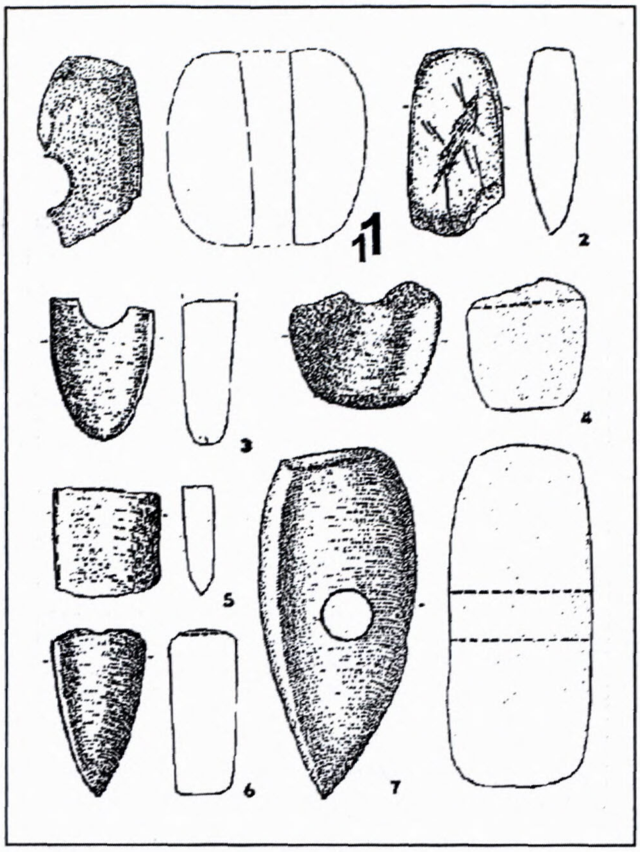

Fig. 3 Polished stone artefacts from alakali basalts from Nitriansky Hrádok site : 1, 3, 4, 6 - hammer-axes (fragments), 2 - axe, 5 - axe (fragment), 7 - hammer-axe

crystals (representing formerly constituents of xenoliths) are detectable in thin sections.

For the effusives of the calc-alkali clan the presence of phyric plagioclasses, in size up to 10 mm (but mostly 2 - 5 mm) is characteristic. Due this aspect Neolithic and Aeneolithic people left such phyric varieties, as the artefacts made from such rock type would be damaged already in the process of their completion or during first attempts of their use.

Stone implements

Alkali basalts belong to the raw material type, which has been used in the Neolithic and Aeneolithic sporadically only. Stone artefacts made from this raw material type are known from rare Neolithic and Aeneolithic sites in the country. From the Middle Neolithic - Želiezovce culture - site Bajč (Cheben, 2000) stone implement of axe to wedge morphology is known, which bears traces of beginning of boring. From the alkali basalts are made mostly axes of concave shape (Fig. 3: 2), which we know from the site Nitriansky Hrádok (Lengyel culture, phase I and II). In this case we have to do with massive big axes, of the approximate size 120 x 80 x 35 mm. Their final surface elaboration has not been perfect in comparison to artefacts made from the antigorite serpentinites and greenschists.

From the site Kozárovce stone semiproduct of wedge shape is documented. It represents the biggest semiproduct of the unique size, which has been ranked among Palaeolithic artefacts. Its size is 170 x 65 x 85 mm, and its weight is equal to 1,20 kg (Fig. 4).

More implements made from alkali basalts are known to occur in the site Svodín, which represents one of the most typical Lengyel culture site. On the site under consideration, axes, hammer-axes, hoes and semiproducts have been documented. Hammer-axes from mentioned site belong to long and narrow types such as pickaxes or mattocks.

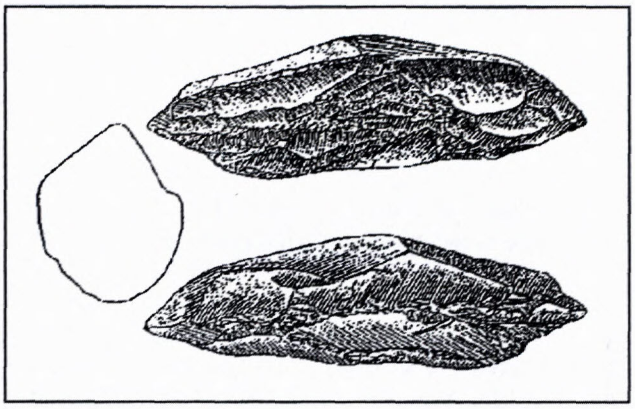

Fig. 4 Semiproduct of wedge from the Kozárovce site.

In the Baden culture from the Nitriansky Hrádok site there were find massive and large hammer-axes, in the length more than 200 mm (Fig. 3: 7). On this place there have been found also smaller hammer-axes. They have mostly angular bat-side (Fig. 3: 4).

Massive hammer-axes are known from the sites in the proximities of the Zlaté Moravce as well as Rimavská Sobota towns. They are stored in local museums of mentioned towns. They are mostly partly demaged being of the longht of 200-220 mm. Their weight is up to 2 kg.

From the presented brief survey on finds of stone artefacts made from alkali basalts it should be summed up, that mentioned implements are massive, pronouncedly bigger, in the case of hammer-axes flat and angular in the but part. On the surface patination is present as the product of weathering processes.

Neolithic and Aeneolithic communities for the production of stone implements used alkali basaltic sources from the country territory, which are presented on the map. Stone artefacts analyses from the Spiš county region (northern Slovakia) univocally prooved utilization of basalts located on the territory of southern Poland (Mts. Wzar and area south of Sztiawnicza: Hovorka and Soják, 1998).

Conclusion

In the case of the basalts as the raw material of Neolithic and Aeneolithic artefacts they are represented by less numerous set of stone artefacts. They are know to occur in individual cultures of the Neolithic till Early

Bronze Age and their number is generally low. Alkali basalts belong to firm rocks with strenght in pressure 1500-4000 kg/cm^2, they are resistive and stabile agains grinding.

The stone artefacts made from Early Paleozoic or Mesozoic basalts belong to rare occurring one. They occur on individual sites in limited numbers (1-2 per site). From the alkali basalts mostly axes and hammer-axes are made. They were documented, for example from sites of Bajč (Želiezovce group), Nitriansky Hrádok (Lengyel culture phase I and II, Fig. 3: 2, 3), Svodín (Lengyel culture phase III-IV), Stránska (Baden culture), Nitriansky Hrádok (Baden culture, Fig. 3: 1, 4, 6, 7) and the others.

From the alkali basalts mostly axes and hammer-axes are made. They were documented, for example, from sites of Bajč (Želiezovce group), Nitriansky Hrádok (Lengyel culture, phase I and II), Svodín (Lengyel culture, phase I), Stránska and Nitriansky Hrádok (Baden culture) and the others (Table 1).

The typical extent of production of stone artefacts made from alkali basalts has culmination in the Early Bronze Age. From the till now realised microscopic determinations of sets of stone artefacts from several sites of the country territory is evident that prevailing abiotic raw material type of the Neolithic and Aeneolithic cultures have been greenschists (Hovorka et al. 1997; Hovorka and Cheben, 1997; Illášová and Hovorka, 1995).

The stone artefacts made from Early Paleozoic or Mezozoic basalts belong to rare occuring ones. They occur on individual sites in limited numbers (1-2 per site). Stone artefacts made from basalts differ from the others by their surface design, higher weight, they are bigger and they have different surface final elaboration. Mentioned differences are based on properties of the raw material used - in discussed case of alkali basalts.

Acknowledgements:

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

ŠTEFAN MÉRES[1], DUŠAN HOVORKA[1] & IVAN CHEBEN[2]

[1]Faculty of Natural Sciences, Comenius University, Mlynská dol., 842 15 Bratislava, Slovak Republic
[2]Archaeological Institute of Slovak Academy of Sciences, Akademická 2, 94921 Nitra, Slovak Republic

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.

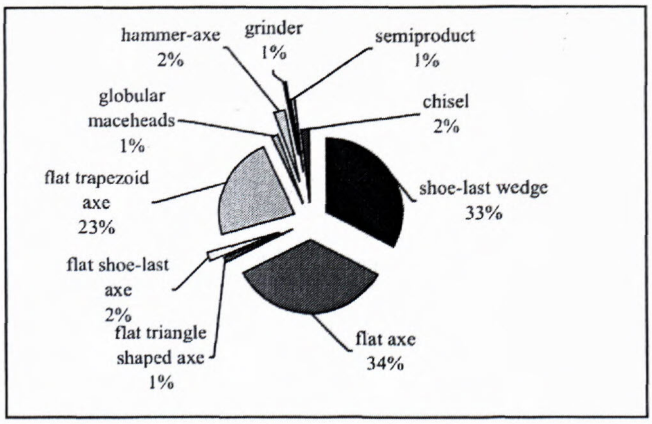

Fig. 2 Quantitative proportion of various raw material types of the polished industry from the site Bajč - Medzi kanálmi. The total number of implements studied was equal to 289 pieces.

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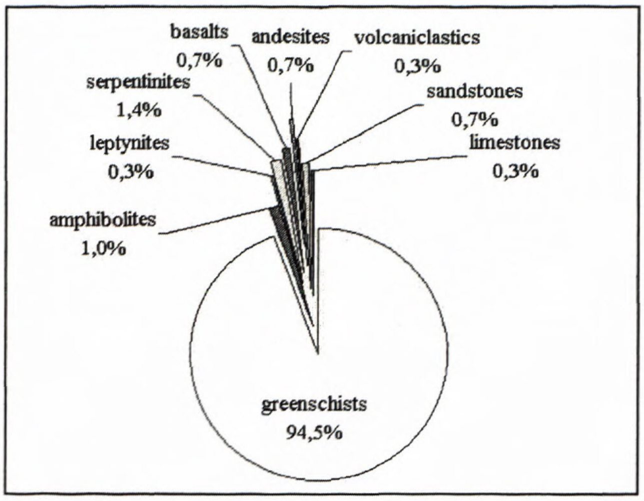


Fig. 3 Quantitative proportion (expressed in per cents) of individual rock types of the polished industry from the site Bajč - Medzi kanálmi.

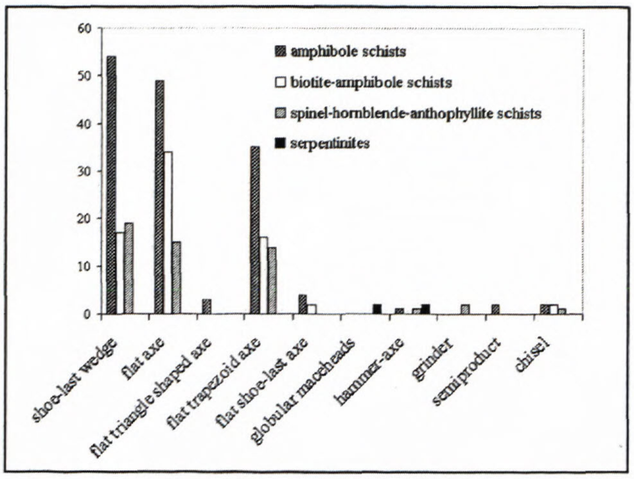


Fig. 4 Quantitative proportion (expressed in pieces) of various artefact types and proportion of metamorphic rocks of the greenschist facies from the site Bajč - Medzi kanálmi.

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

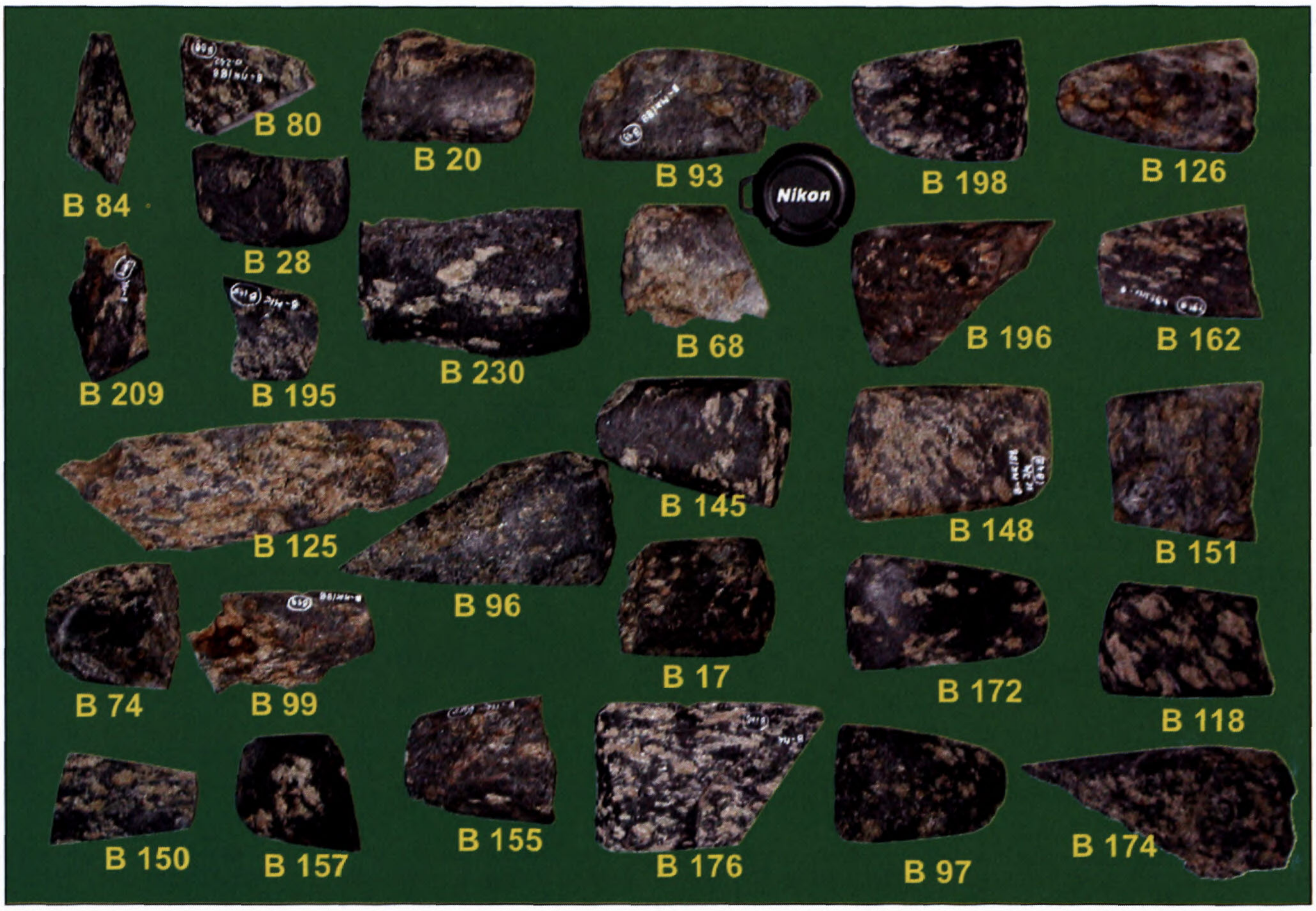
Greenschists (273 pieces, Figs. 3 and 4) are the most often used raw material type used for the polished implements construction on site Bajč. In prevailing cases the are represented by amphibole schists (150 pieces), biotite-amphibole schists (71 pieces) and spinel-hornblende-anthophyllite schists (52 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.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Nikon
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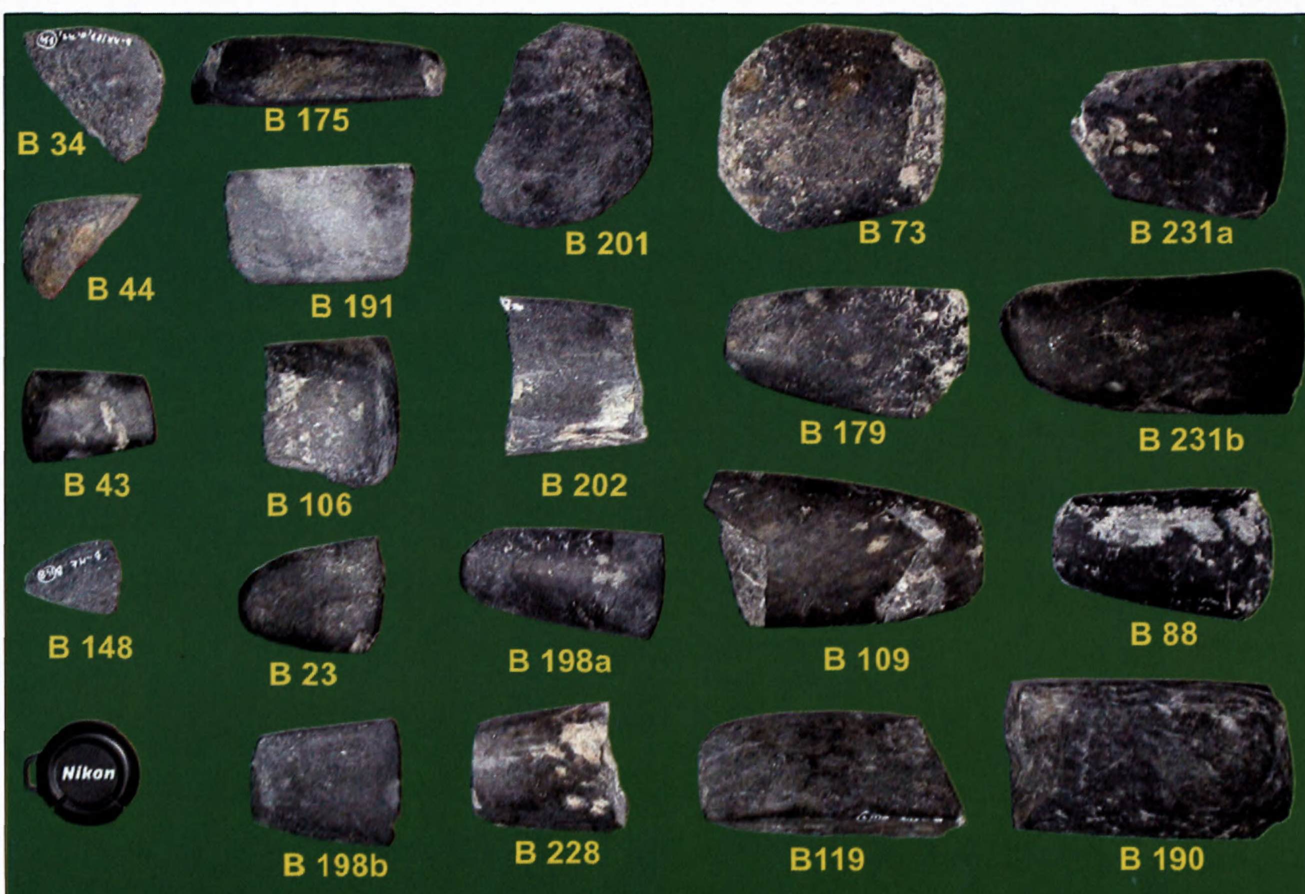
B 34
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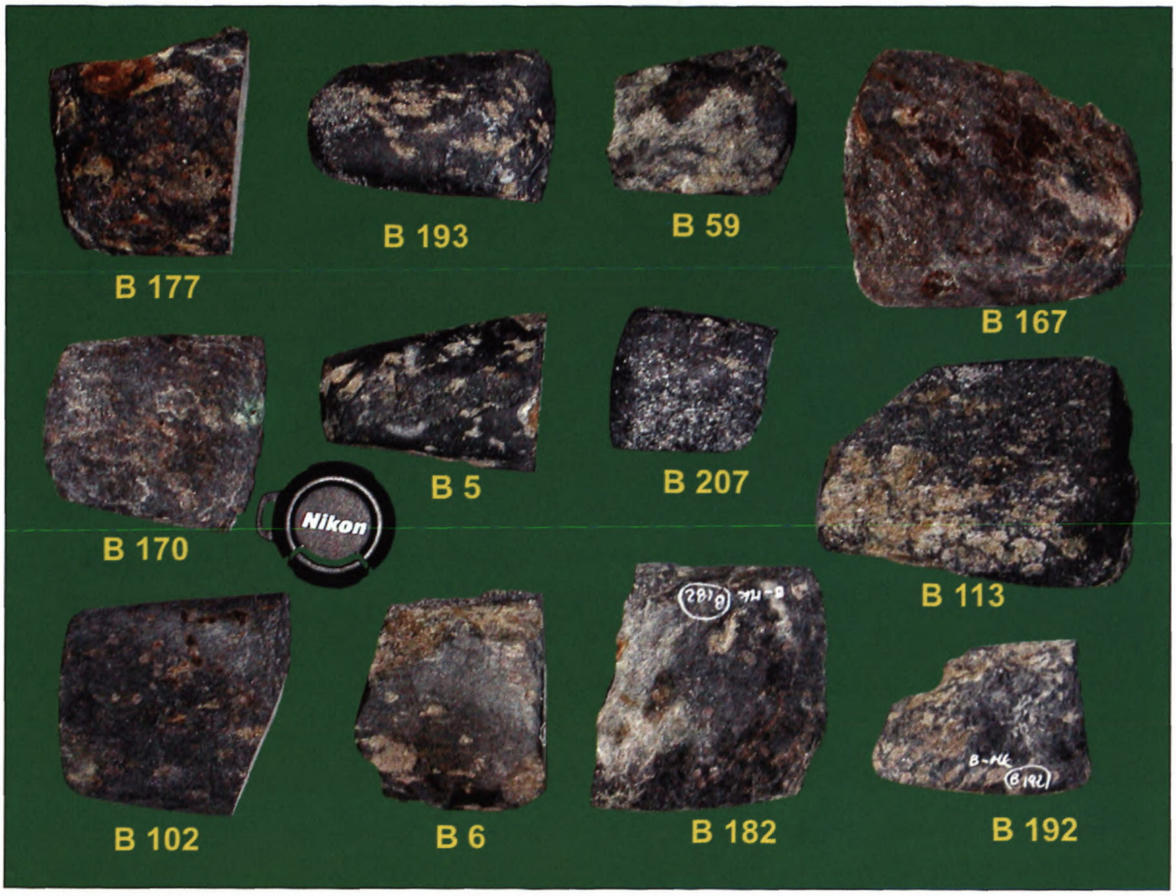
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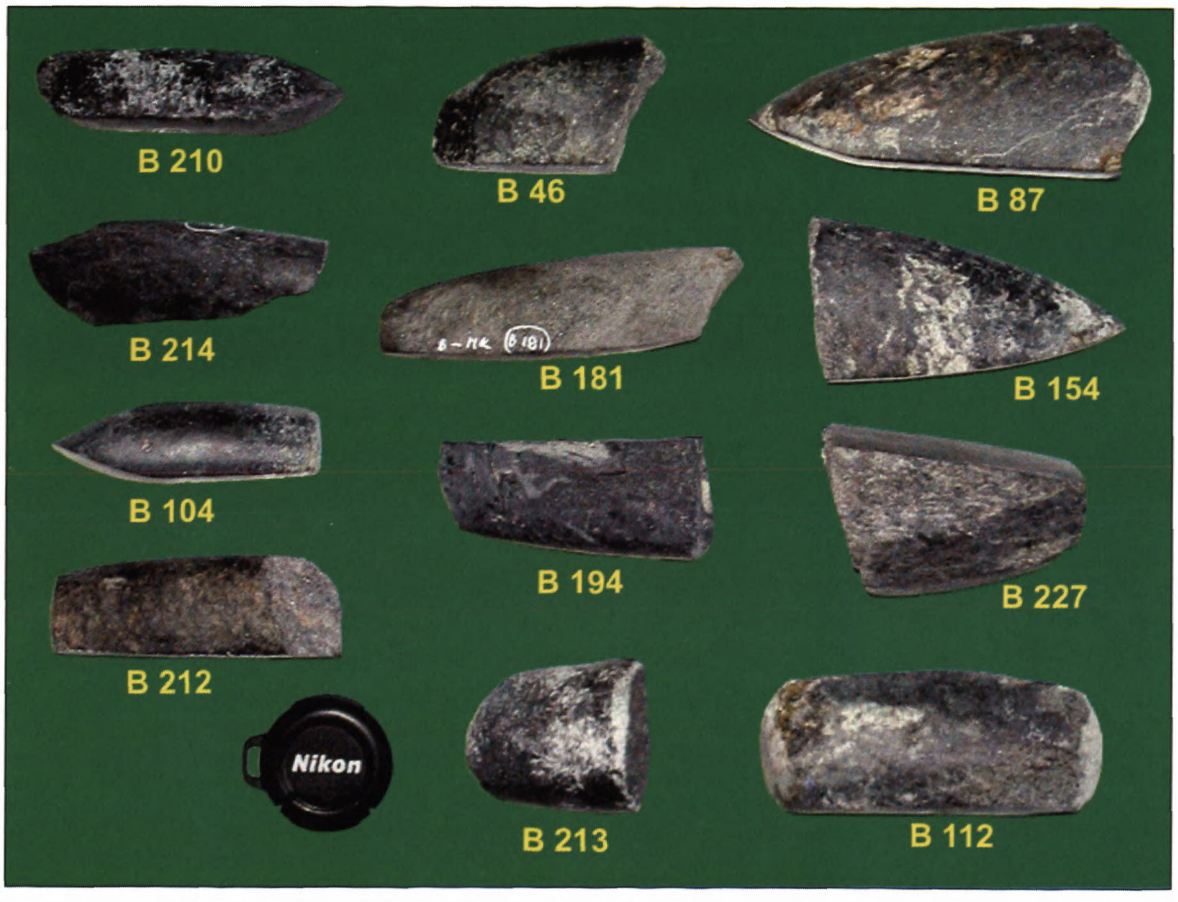
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B 87
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B 104
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B 112

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.

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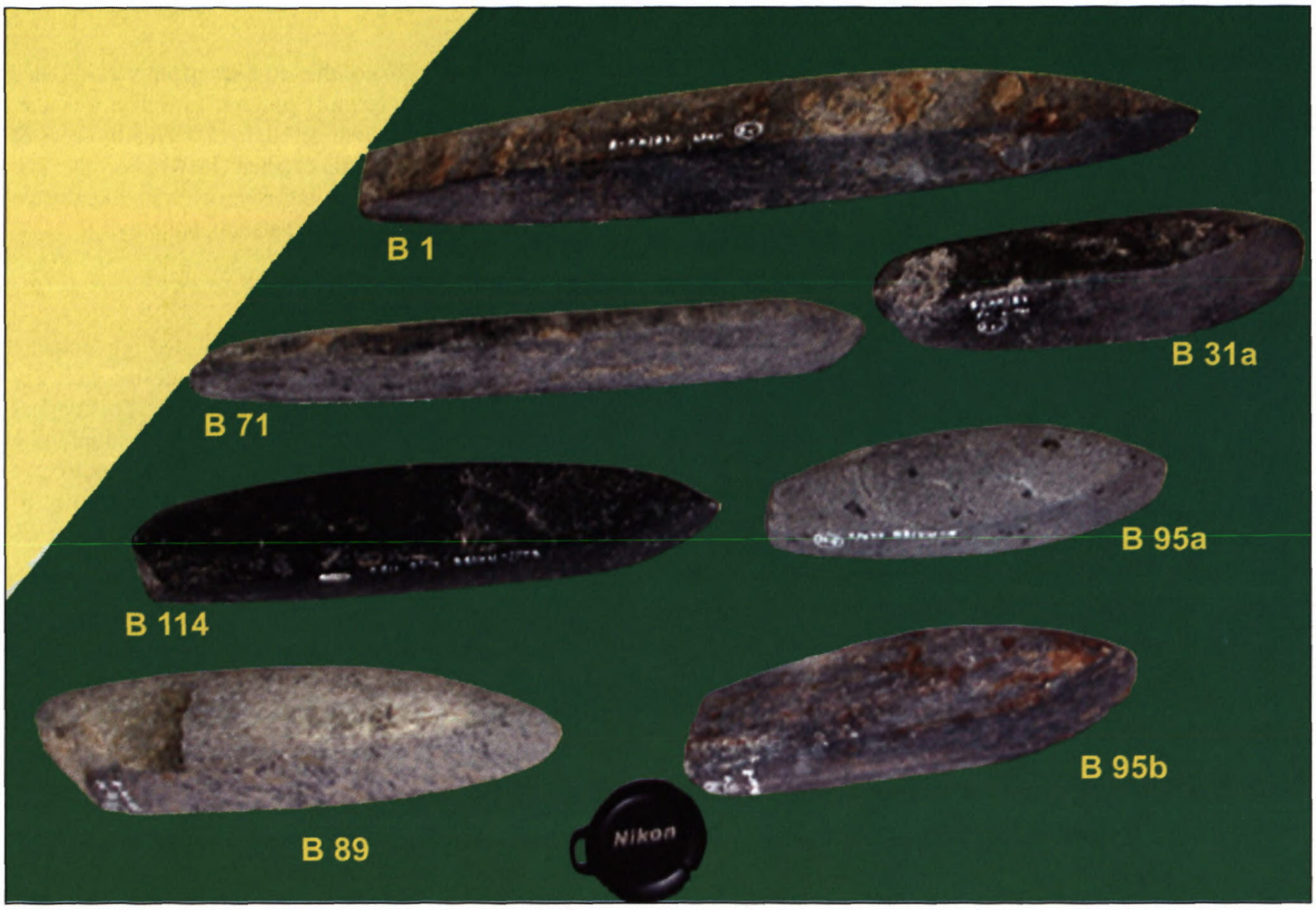

Fig. 9 Polished stone artefacts from the site Bajč – Medzi kanálmi. Shoe-last wedge made from various types of greenschists. B-1 - the buigest shoe-last wedge found on site under consideration (24,5 cm) -spotted amphibole schists, B-71 - Al-spinel-hornblende-anthophyllite schist, B- 31a - amphibole schist, 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.

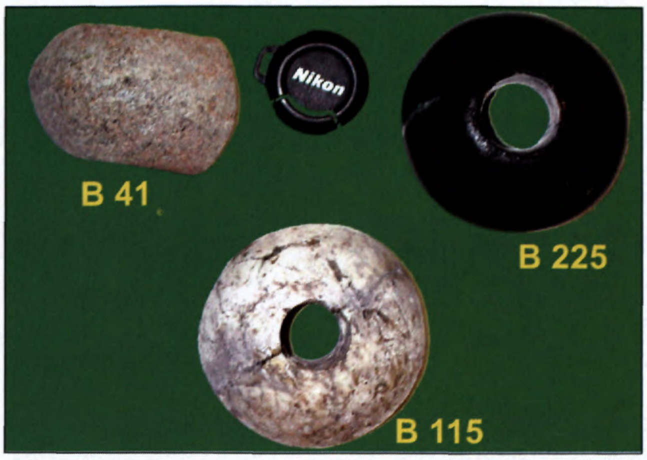

Fig. 13 Polished stone artefacts from the site Bajč – Medzi kanálmi. Globular maceheads from the leptynite (B-41), from the serpentinite (B-225) and from the limestone (B-115).

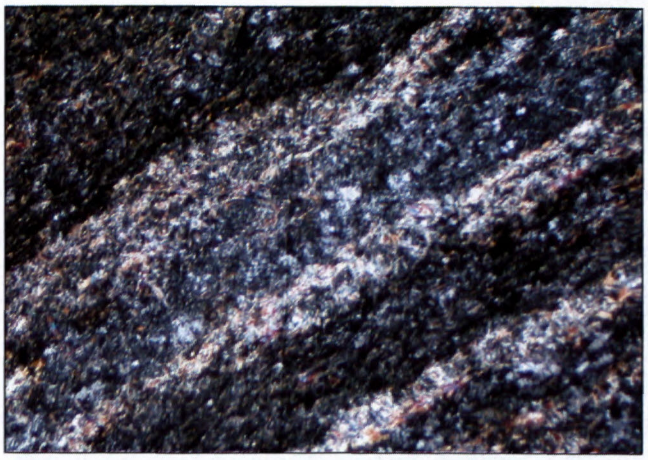

Fig. 14 Fine-grained banded amphibole schist. B-229- hammer-axe. Crossed polars.

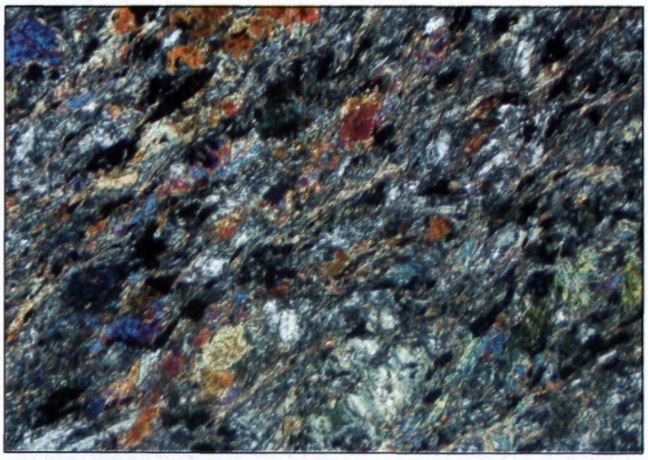

Fig. 15 Spotted schistose amphibole schist with ore pigment. B-133 - flat axe, Crossed polars.

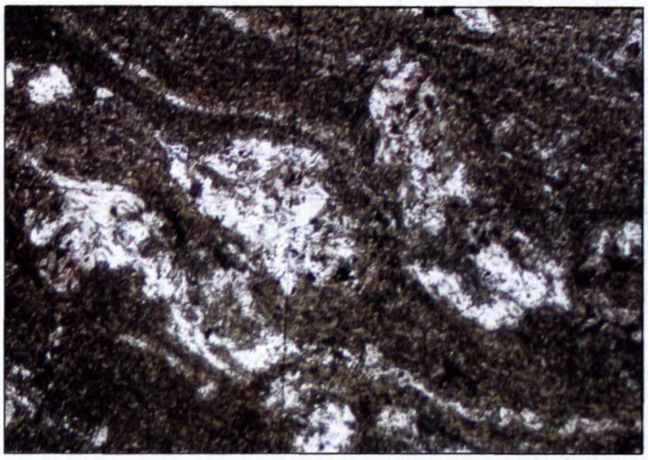

Fig. 16 Fine-grained augen amphibole schists with relic volcaniclastic pattern. In the very fine-grained matrix of the rock (around 0,1 mm) tabular/augen plagioclases are present. B-117 - flat axe. Crossed polars.

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.

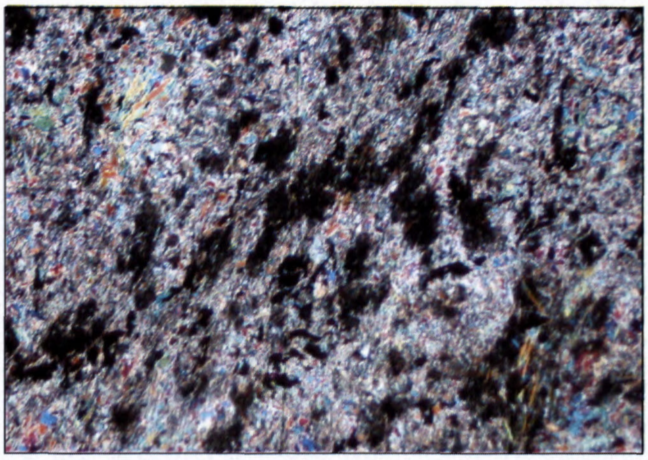

Fig. 18 Spinel-hornblende-anthophyllite schists with relic clinopyroxene. B-61 – grinder. Crossed polars.

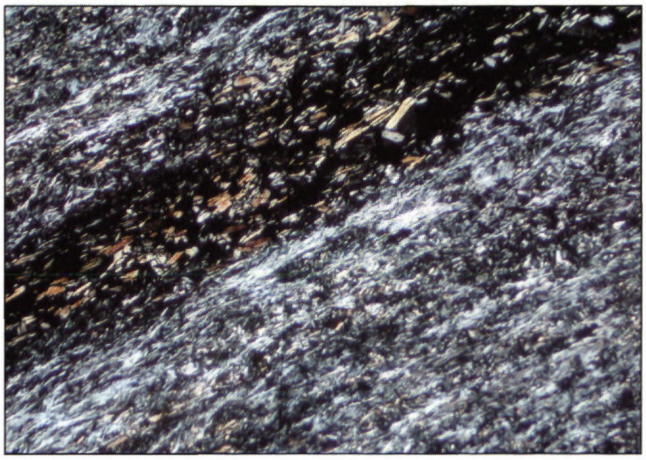

Fig. 19 Fine-grained biotite-amphibole schist. Biotitization in comparison to metamorphic recrystallization is younger process which is developed namely in direction of metamorphic foliation of the given rock. B-178- shoe-last wedge. Crossed polars.

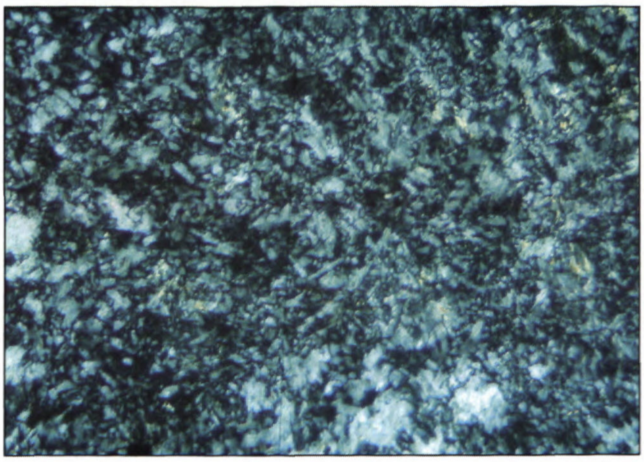

Fig. 20 Fine-grained antigorite serpentinite. B-185 - hammer-axe. Crossed polars

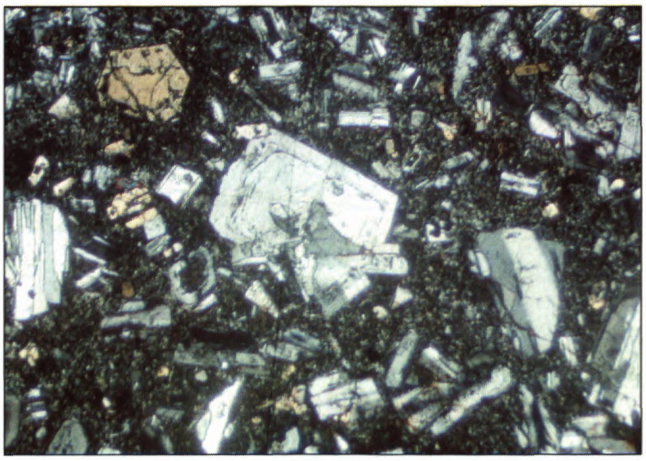

Fig. 21 Two-pyroxene andesite. Plagioclases are present in the form of glomerophyric aggregates (3 mm) deposited within hemicrystalline submicroscopic matrix. B-86 - shoe-last wedge. Crossed polars.

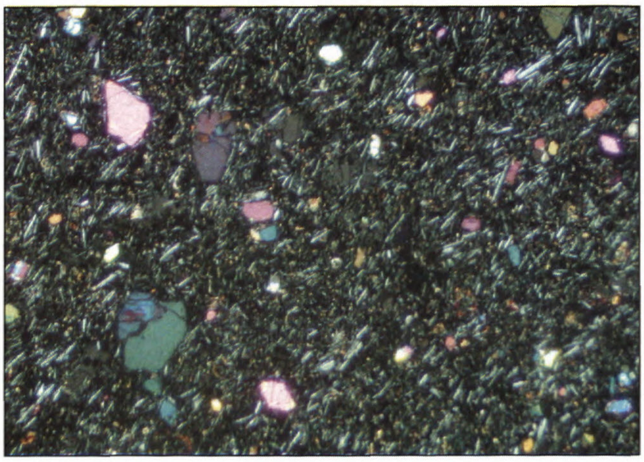

Fig. 22 Alkali basalt with porphyritic structure (dark minerals only) and non pronouncedly developed fluidal matrix. It is formed by narrow laths of fresh plagioclasesand recrystallized volcanic glass. B147 - shoe-last wedge.

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-gemerské 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).

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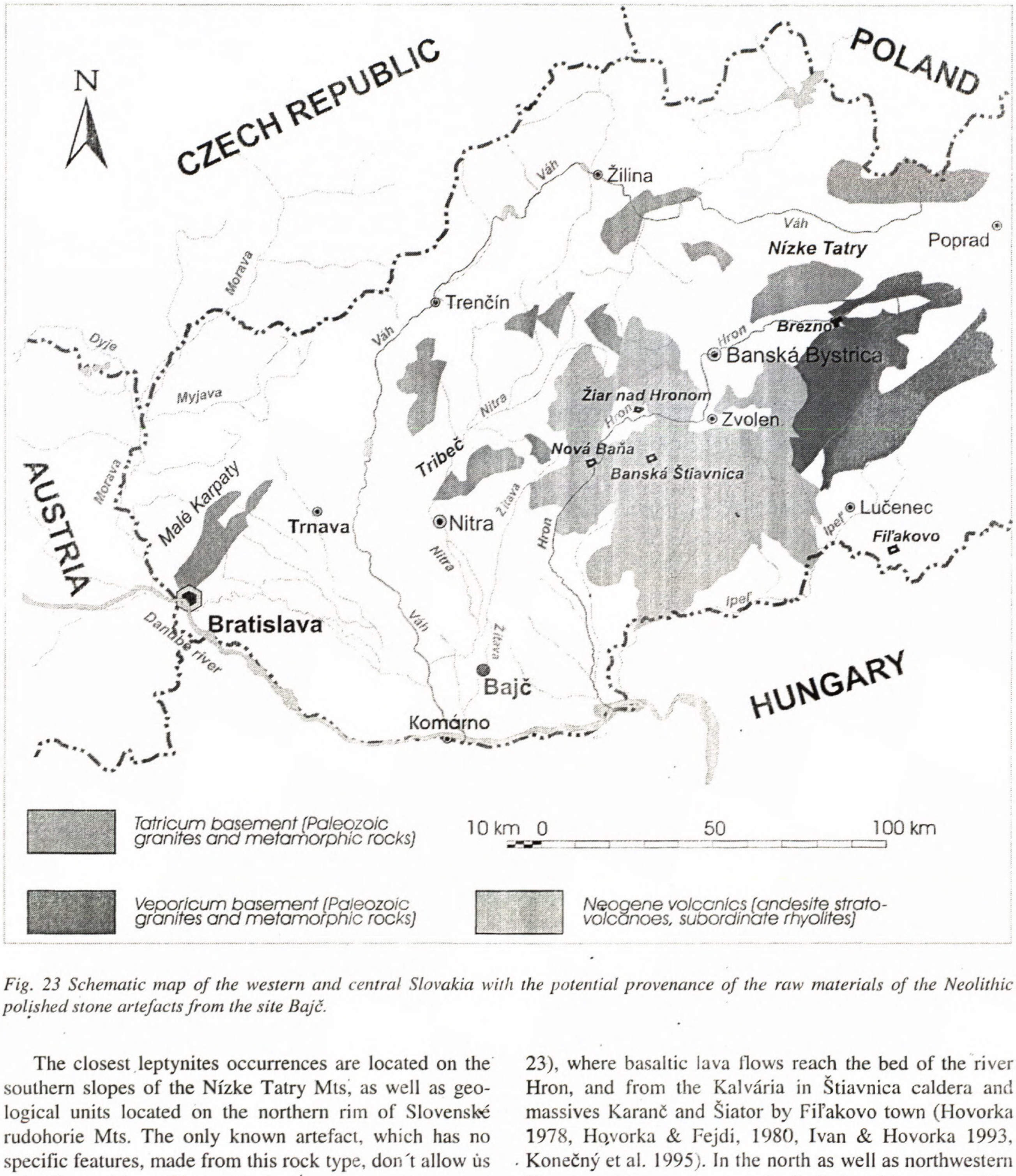

Fig. 23 Schematic map of the western and central Slovakia with the potential provenance of the raw materials of the Neolithic polished stone artefacts from the site Bajč.

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 ús 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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Neolithic rock raw materials from the Kujawy region (Polish Lowland)*

PIOTR CHACHLIKOWSKI[1] & JANUSZ SKOCZYLAS[2]

[1]Institute of Prehistory, Adam Mickiewicz University, Św. Marcin 78, 61-809 Poznań, Poland
[2]Institute of Geology, Adam Mickiewicz University, Maków Polnych 16, 61-606 Poznań, Poland

Abstract: The choice of the raw material for stone implements production among the communities was not thus accidental but intentional and depended, among other things, on physical and technical properties of individual rocks to be used. Manifestations of the selection of the most suitable raw material for a final product have been distinguished in a specific selection of raw materials. The presented relationships between the function of the choice and the type of the material used for its production fully justify the assumption that the Late Neolithic communities of the region had a high level of practical knowledge about the available rock raw material.

Key words: petroarchaeology, erratic rock raw material, utilisation, Lowland Poland, Neolithic.

Introduction

Advances and developments in pre-historical studies are nowadays, unlike other fields of science that deal with the history and culture of mankind, dependable on the possibilities and achievements in natural science as well as in physics and chemistry. The branches of science supporting studies in prehistory, especially in relation to taxonomic research, and in particular chronology establishment as well as the selected aspects of economy and some production (processing) issues have been found of the well-established usefulness.

Studies on the reconstruction of the environmental conditions of the existence of pre-historical and early-historical communities have also gathered momentum in their significance. The contribution of the relevant studies to the knowledge of manifold and complex manifestations of the activities of man and the surrounding nature in which he shaped his presence appears to be unshakeable and by no means unimportant.

Geological sciences are given the ever-increasing interest in the studies upon the economy of pre-historical and early-historical communities of the river-basin of the Vistula and Odra rivers, especially when it comes to the methods used in petrography. The co-operation between archaeologists and geologists encompasses the increasing number of joint research subjects, which illustrates well the phenomenon of pursuing new fields of interests currently taking part in the contemporary pre-history studies. This tendency is also exemplified by the scientific description of the origins and utilisation of stone raw material in the past which is labelled as petroarchaeology.

Petroarchaeology can be thus placed within the study of the phenomena characteristic for modern science, which lead to a creation of new study areas, in this case of natural science, and the sciences which deal with material remains of the past (made of rock or minerals). The research issues formulated within the interests of petroarchaeology must be then solved by way of the complementary use of research methods proper for geology, especially petrography, and archaeology.

Petroarchaeology is thus an interdisciplinary branch of science placed somewhere between the sciences whose primary interest lay upon the earth's crust and those which focus their attention on products (objects of rock or minerals) of man's activity in the pre-historical past.

A conception of the actual placement of petroarchaeologiocal studies - in terms of its formal and cognitive status and the scope and subject of its application - was presented essentially by Chachlikowski (1994a; 1994b; 1996; 1997). The presentation of the "research space" of petroarchaeology outlined in the works allows us to understand better the placement of the said studies within the "archaeology of stone and mineral raw material" as well as the complexity of its methodical and theoretical position within the sciences dealing with man's development in the past.

Rock raw material, primarily of all siliceous rocks and other non-siliceous rocks, found application in those lines of production whose source manifestations represent those which are best documented in archaeological material (ceramics, pottery, stone industry products, mortar, building materials). In the case of older epochs they form, basically, the only relics of the history of the past. Thus the range of potential petroarchaeological studies appears to be wide enough and includes a number of different economic activities of man - in relation to, primarily, pottery, flint tools production, and stone production, i.e.

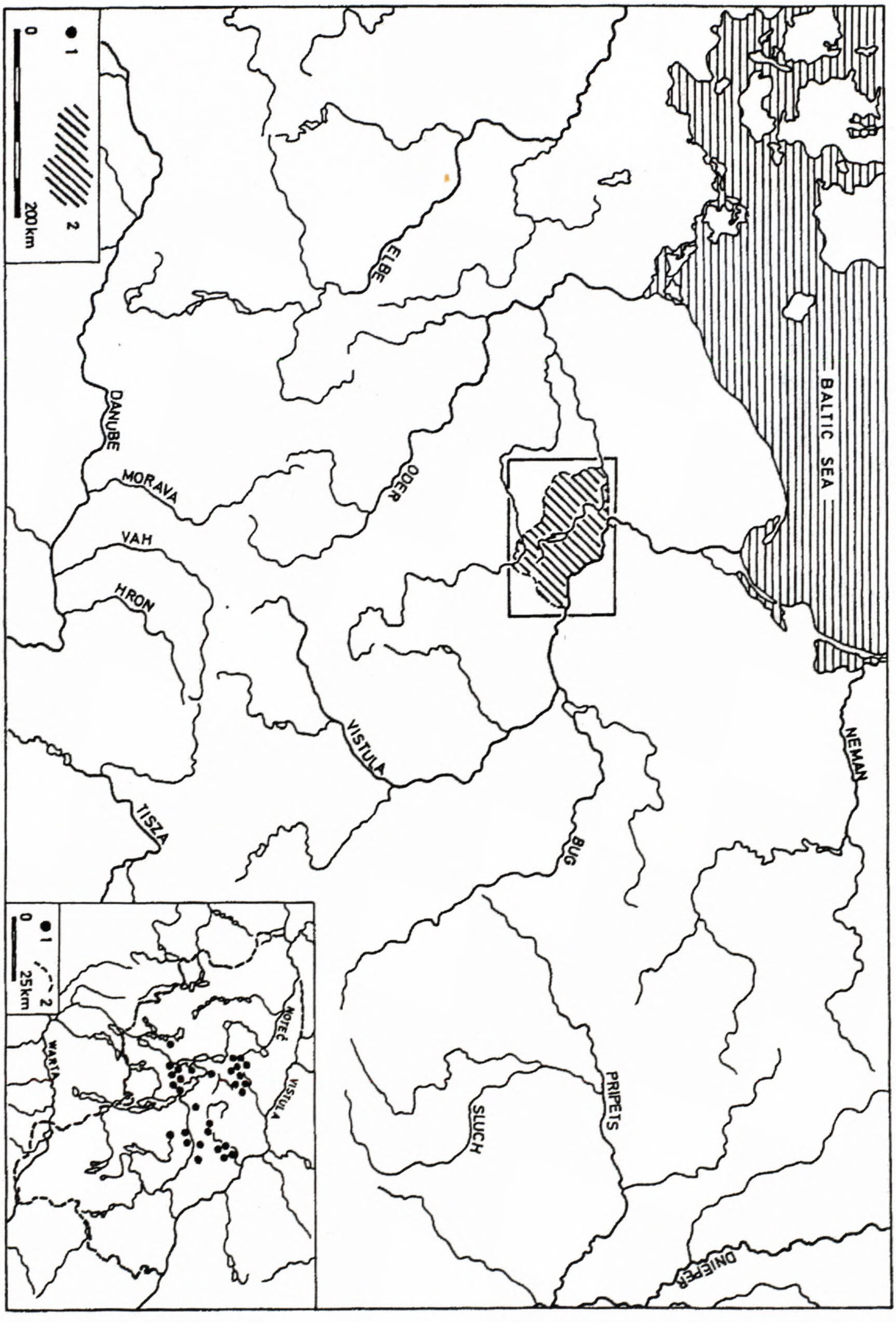

Fig. 1 Distribution of the settlements-sites of FBC and GAC populations in the Kujawy region the sources included in the present work refer to.
Legend: 1- settlement-sites; 2 – ranges of the Kujawy settlement and cultural mesoregion..

those activities which were very important to create foundations for the basic spheres of existence of the pre-historical and early-historical communities.

Rock and mineral raw-materials, along with their importance in satisfying material conditions of living, were also valuable for the production of items that indicated status, prestige or wealth of their owners, *viz.* amber-processing, glass making, jewellery, architecture and others.

An attempt at a broader application of geology in studies on stone material was made within the study project on exploration, exploitation and the use of stone raw-materials in pre-historical communities of the Kujawy region (Central Poland) (Chachlikowski 1989; 1991; 1992; 1994a; 1994b; 1996; 1997; 1998; 2000). The works presented a new approach towards the studies on rock raw material in the past both in the methodological and conceptual aspects.

The subject for the petroarchaeological studies introduced in the Kujawy project is the activity of human communities documented in the sphere of exploitation and utilisation of non-siliceous rock raw material. The stone production activity is studied here through a comprehensive analysis of the sources testifying to the whole of the manifestations of practices linked with this particular sphere of human economic activity. In the analysis, a vast array of stone findings with the established intentionality, including the sources so far left out or disregarded in the syllabuses for petroarchaeological studies, is taken into consideration. Thus, not only final products are put into investigation, as has been a normal practice so far, but also natural rock concretions, production waste, and unfinished products. All these sources are subjected to a complex analysis from the point of view of the ways of the exploration of the raw materials, differentiation in their types and kinds, used techniques in stone processing, sizes and assortments of the production and of the range of the forms of organisation of the activities in relation to exploration and processing of the stone raw material. Furthermore, additional research is done aimed at distinguishing and describing the preferences that were used in the selection of raw material in relation to the kinds of tools to be produced.

The general characteristics of stone sources of the late-Neolithic communities of the Kujawy region.

The archaeological excavations carried out in the Kujawy region have unearthed rich and varied source material, which proves the use of a series of production followed by the pre-historical inhabitants of the region (Fig. 1). They have also revealed the whole of variety and complexity of the activities connected with exploration and utilisation of stone raw-materials in the communities.

The presented selection of the results obtained in the course of the Kujawy project of petroarchaeological studies deal with stone raw-materials that were used in the stone industry of the local communities of late Stone Age, i.e. the peoples of the Funnel Beaker Culture (FBC) and the peoples of the Globular Amphorae Culture (GAC), who inhabited the region from around 4000 BC to 2500 BC. In the present approach, the establishments of the previous research conducted from the point of view of the identification of the dependencies between the function (appropriation - purpose) of a product and the kind of rock used for its production have been stressed and emphasised. The results of the research indicate preferences the Late-Neolithic inhabitants of the region had in the selection of stone raw material used in the production of the specific kinds of tools.

Base source for the present study is the stone material obtained in the course of the excavation works conducted at 31 sites (Fig.1). In sum, 66 stone inventories, including 23 that document stone production of FBC settlements and 43 of those of GAC, were put to investigation. Eventually, 1,753 items were ascribed to FBC, while 778 objects were documented as representing GAC. The total weight of 2,531 stone products under scrutiny was 800,35 kg (Chachlikowski 1997; 2000)

The majority of the studied sites is situated within eolithic forms - dunes or forms capped with a layer of covering sands of eolithic origin (Chachlikowski 1991; 1992; 1997; 2000). In terms of geology the places of the findings, can be regarded as natural sediments are highly improbable. Eolithic forms, from nature, lack rock fractions - stone macroliths - which are suitable for stone tools production in terms of their size. Moreover, the bulk of the studied material was characterised, beyond any reasonable doubt, by clearly identified intentional man's activity represented by traces of different processing techniques or by their use.

Stone production of FBC and GAC communities in the Kujawy region was primarily targeted at the production of multifunctional tools of every-day use, which were used in households. In the settlements of these communities the processing of rock raw materials in order to produce polishing plates, hammerstones and polishers, mill tools (querns and grinders) and hand axes was clearly dominant. The production of axes or hammers among the communities of FBC was done on a much smaller scale (Fig. 2).

In late Neolithic period the communities of the region used in their stone industry a variety of assortment of stone raw material (Fig. 3, see also Table 1). Among the stone raw- materials used by these communities 21 types of individual types of rocks have been recognised. Quartzite sandstone, gneiss, granite and quartzite were most frequently used for the production of weapons and tools. All in all, they constituted 78.66 per cent of the rock raw-materials collection which were used in the stone production of the FBC and GAC communities in the mentioned region (1991 articles out of the total number of 2531).

Biotite gneiss, amphibolite, gabbro, syenite, diorite, basalt, pegmatite, paleozoic basalts and porphyry were used less frequently. The processing of the remaining number of 8 kinds of rock took place on a much smaller scale (Fig. 3, see also Table 1).

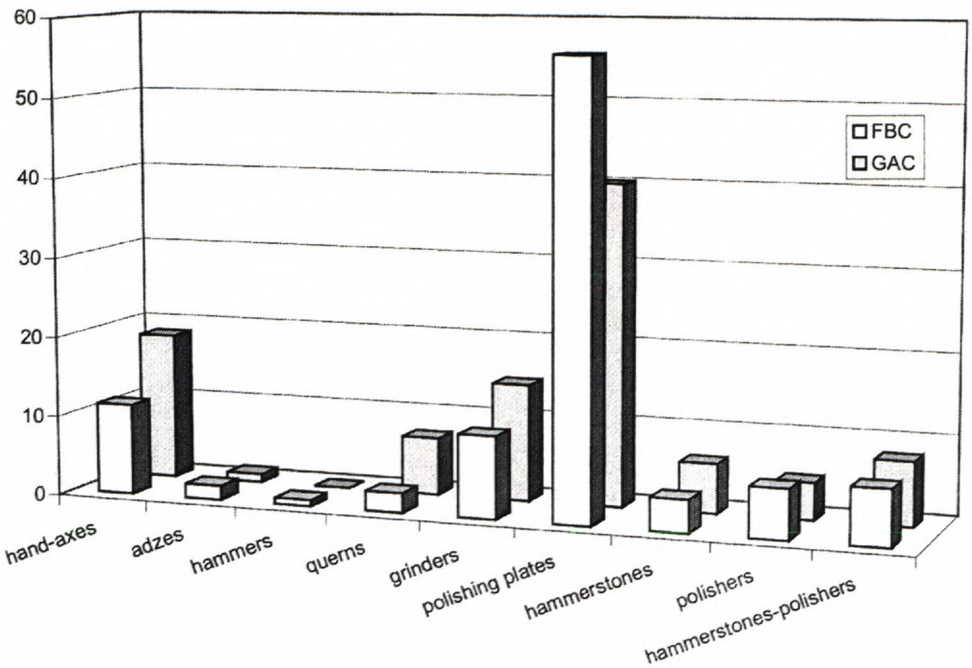

Fig. 2 Comparison of the share of the articles made from stone among the products of the stone industry of the FBC and GAC communities in the Kujawy region (expressed in percentage).

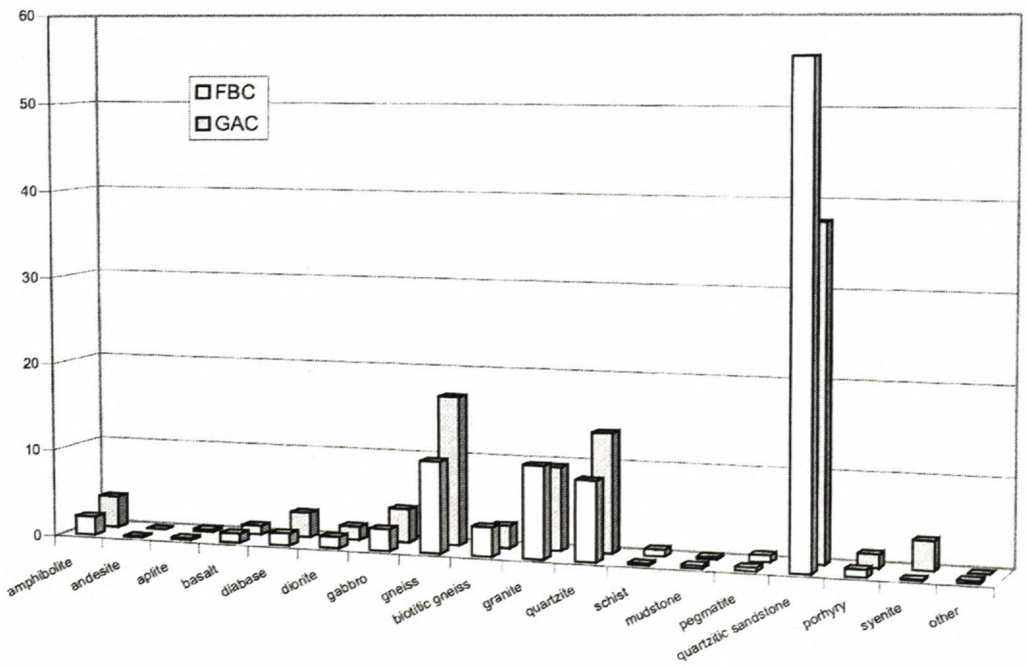

Fig. 3 Comparison of the share of stone raw-materials among the stone production of the FBC and GAC communities in the Kujawy region (in percentage).

The use of rock raw material in the Kujawy region in late Neolithic period. Their typological, functional and cultural aspects

A distinct relationship between the function (appropriation - purpose) of a product and the kind of rock used for its production has been recorded among the products of the stone production of the Late-Neolithic period. Apparently, the structure of rock raw material utilised by local FCB and GAC communities shows clear and close relationship to the tool structure (Table 1, see also Figs. 4-11).

Within the rock raw-materials utilised by the Kuiavian communities of FBC and GAC two groups with pronounced different application in the stone industry can be distinguished (see columns, Table 1).

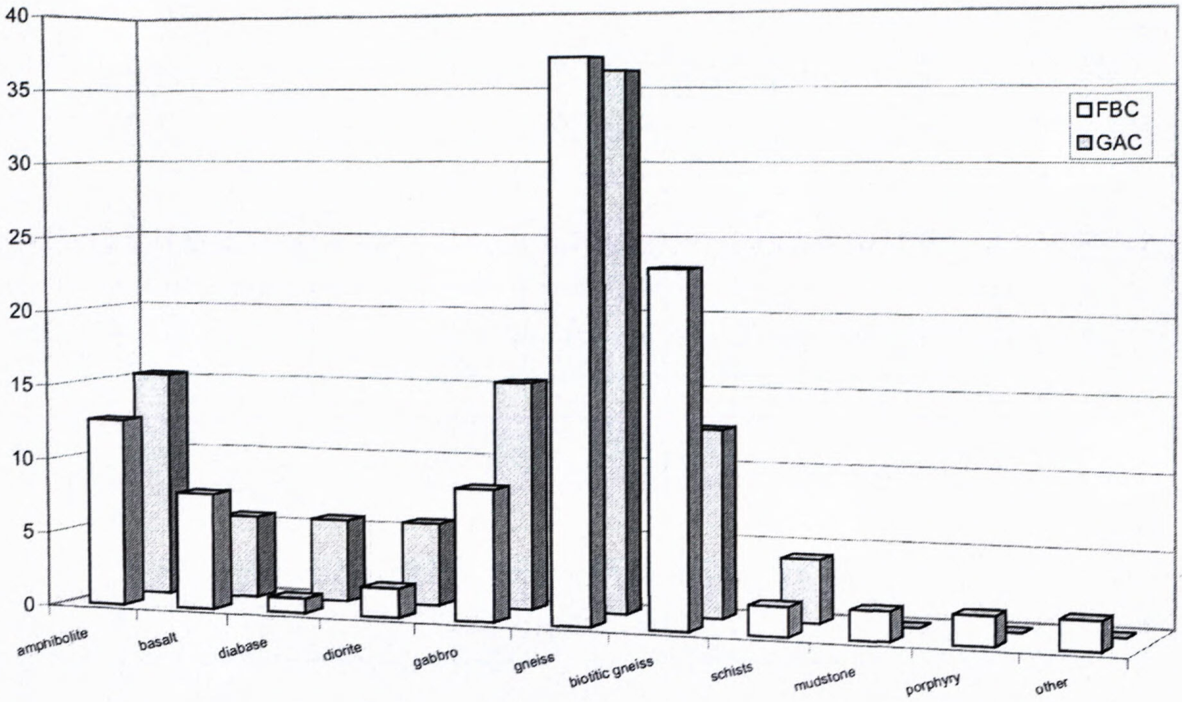

Fig. 4 Comparison of the share of stone raw-materials among hand axes of FBC and GAC communities of the region (in percentage).

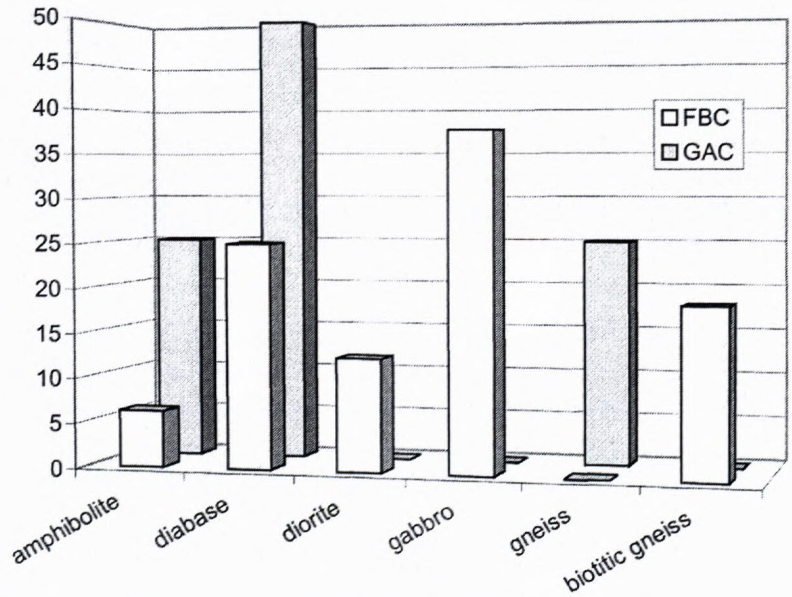

Fig. 5 Comparison of the share of stone raw-materials among adzes of FBC and GAC communities in the region (in percentage).

The first group is represented by: amphibolite, andesite, basalt, paleozoic basalts, diorite, gabbro, gneiss, biotite gneiss and schist. These raw materials were used by the local communities mainly in the production of tools with retouched blade (with secondary trimming or shaping applied to stone implements), i.e. with hand axes and adzes. Andesite, basalt, biotitic gneiss, and schist were used at the same time exclusively for the production of these types of products. However, most probably, when not only axes but also adzes were made of amphibolite, paleozoic basalts, diorite, gabbro, gneiss, biotitic gneiss and, possibly, basalt; schist was used exclusively for the production of axes. Only few tools which served as hammerstones, polishers or hammerstone-polishers were made of amphibolite, paleozoic basalts, diorite, gabbro or gneiss. Similarly, diorite and gabbro were used only on a small scale for production of grinders.

Tools made of amphibolite, hand axes predominate in the Kujavian communities of FBC and GAC (see Table 1). They were followed, though on a much smaller scale, by hammerstone-polishers, hammerstones, adzes and

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Table 1: The characteristics of the use of stone raw-materials in stone industry of the communities of the region in late Neolithic times (in percentage).

Type of raw material Type of product	Amphi-bolite	Aplite	Basalt	Diabase	Diorite	Gabbro	Gneiss	Biotitic gneiss	Granite	Quartzite	Schist	Mudstone	Pegmatite	Quartzitic sandstone	Porphyry	Syenite	Other	Total
Hand-axes	70,59 *13,71*	- -	85,71 *6,86*	20,84 *2,86*	33,34 *3,43*	52,63 *11,43*	39,26 *36,57*	80,49 *18,86*	- -	- -	100,00 *2,86*	50,00 *1,14*	- -	- -	14,29 *1,14*	- -	50,00 [a] *1,14*	*100,00*
Adzes	5,88 *10,00*	- -	- -	25,00 *30,00*	11,11 *10,00*	15,79 *30,00*	0,61 *5,00*	7,32 *15,00*	- -	- -	- -	- -	- -	- -	- -	- -	- -	*100,00*
Axes/adzes	5,88 *11,76*	- -	14,29 *11,76*	8,33 *11,76*	- -	2,63 *5,89*	3,68 *35,30*	9,75 *23,53*	- -	- -	- -	- -	- -	- -	- -	- -	- -	*100,00*
Hammers	- -	- -	- -	- -	- -	- -	0,61 *14,28*	- -	2,22 *42,86*	2,17 *42,86*	- -	- -	- -	- -	- -	- -	- -	*100,00*
Querns	- -	- -	- -	- -	- -	- -	12,89 *42,00*	- -	17,04 *46,00*	- -	- -	- -	- -	0,15 *2,00*	- -	35,72 *10,00*	- -	*100,00*
Grinders	- -	33,33 *0,67*	- -	- -	22,22 *2,67*	7,90 *2,00*	20,86 *22,67*	- -	41,48 *37,33*	7,25 *6,67*	- -	- -	71,44 *3,33*	3,90 *17,33*	21,43 2,00	57,14 *5,33*	- -	*100,00*
Querns-grinders	- -	- -	- -	- -	- -	- -	3,07 *55,56*	- -	2,96 *44,44*	- -	- -	- -	- -	- -	- -	- -	- -	*100,00*
Polishing plates	- -	- -	- -	- -	- -	- -	- -	- -	- -	63,04 *13,06*	- -	- -	- -	86,81 *86,94*	- -	- -	- -	*100,00*
Hammerstones	5,88 *3,28*	33,33 *1,64*	- -	12,50 *4,92*	22,22 *6,56*	5,26 *3,28*	5,52 [b] *14,75*	- -	14,81 *32,79*	7,97 [b] *18,03*	- -	- -	14,28 *1,64*	0,30 *3,28*	35,70 [b] *8,19*	- -	25,00 [c] *1,64*	*100,00*
Polishers	2,94 *1,35*	- -	- -	- -	- -	- -	6,14 [b] *13,51*	2,44 *1,35*	5,19 [d] *9,46*	9,42 [d] *17,57*	- -	50,00 *2,70*	- -	5,70 [b] *51,36*	14,29 [b] *2,70*	- -	- -	*100,00*
Hammerstones-polishers	8,83 *3,19*	33,33 *1,06*	- -	33,33 *8,51*	11,11 *2,13*	15,79 *6,39*	7,36 *12,77*	- -	16,30 *23,41*	10,15 *14,89*	- -	- -	14,28 *1,06*	3,14 *22,34*	14,29 *2,13*	7,14 [e] *1,06*	25,00 [c] *1,06*	*100,00*
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	

In Rows: in terms of the differentiation of the assortment of stone raw-materials within individual types of products.
In Columns: in terms of the differentiation in the assortment of products (product range) within individual types of rocks.
Note: [a] Andesite and lydite. [b] One of the products also used as a base-plate. [c] Granite-gneiss. [d] Two of the products also used as a base-plates.
[e] Product used as a base-plate.

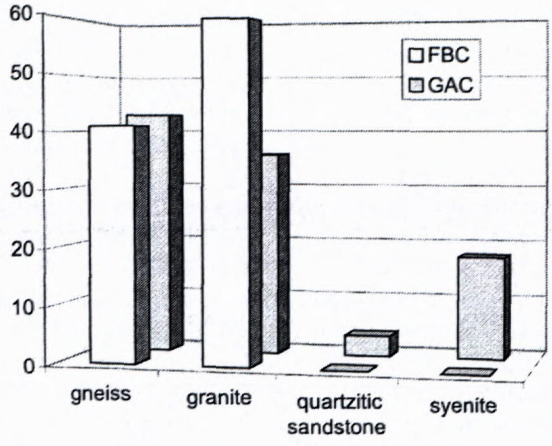


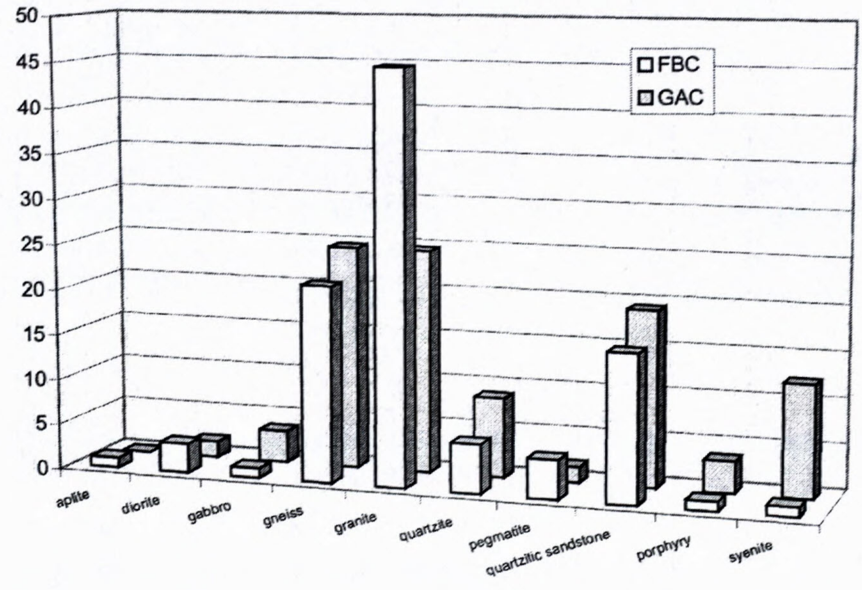
Fig. 6 Comparison of the share of stone raw-material among querns of FBC and GAC communities in the region (in percentage).

sporadically. Only among articles made of gabbro and gneiss the forms with retouched blade are in preponderance over the remaining kinds of tools, whilst the frequency of hand axes, adzes, querns and grinders as well as hammerstones and polishers among diorite and porphyry is similar.

However, among the late-Neolithic communities of the Kujawy region, the production of tools made of gneiss had the most functionally diversified range (see Table 1).

With the stone workers of FBC and GAC gneiss was commonly used in the production of all kinds of tools except polishing plates. Gneiss was most frequently used in the production of hand axes but querns, grinders, hammerstones and hammerstone-polishers. Adzes and massive hammers which were used as drop-hammers (piledrivers) were least frequent. It is worth remembering at this point, however, that this particular raw-material was, along with quartzitic sandstone, most frequently used in

Fig. 7 Comparison of the share of stone raw-material among grinders of FBC and GAC communities in the region (in percentage).



polishers. Similar assortment of tools is represented by articles made of paleozoic basalts, though the rock was used on a larger scale in the production of adzes rather than axes and, what is more, they only slightly outnumber hammerstones and hammerstone-polishers.

Among the Kujavian communities of late Neolithic period the following raw-materials were utilised on a larger scale: diorite, gabbro, gneiss and porphyry (see Table 1). These raw materials were utilised not only in the production of hand axes, adzes or hammerstones, polishers or hammerstone-polishers but also in the production of mill tools, i.e. querns (gneiss) and mainly grinders (diorite, gabbro, gneiss and porphyry). However, at the same time, diorite and gabbro were used in a more versatile way by the communities of FBC, which utilised these materials in the production of all kinds of these tools, except querns, while the GAC communities used diorite and gabbro for the production of axes, and in the production of grinders and hammerstones used them only the stone production of the region in the late Neolithic period (cf. Fig. 3).

Articles made of aplite, granite, granite-gneiss, quartzite, mudstone, pegmatite, quartzitic sandstone and syenite represent totally different functional assortment (production range) of tools (see Table 1). The inhabitants of the region did not use the aforementioned raw materials in the production of articles with retouched blades, i.e. hand axes and adzes, at all. However, these raw-materials were used in the production of large quantities of querns and grinders, polishing plates as well as tools that served as polishers, hammerstones or base-plates.

Among the products made of granite, querns and grinders were represented most frequently, while hammerstone-polishers, hammerstones, and polishers were less frequent. Hammers were least numerous within the range of products made of granite. Similarly, a wide range of utilisation in the stone production of the Kujavian communities of FBC and GAC went to quarzite

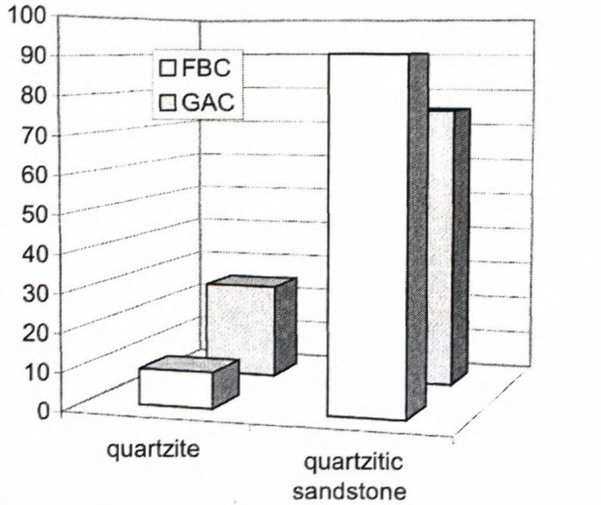


Fig. 8 Comparison of the share of stone raw-material among polishing plates of FBC and GAC communities in the region (in percentage).

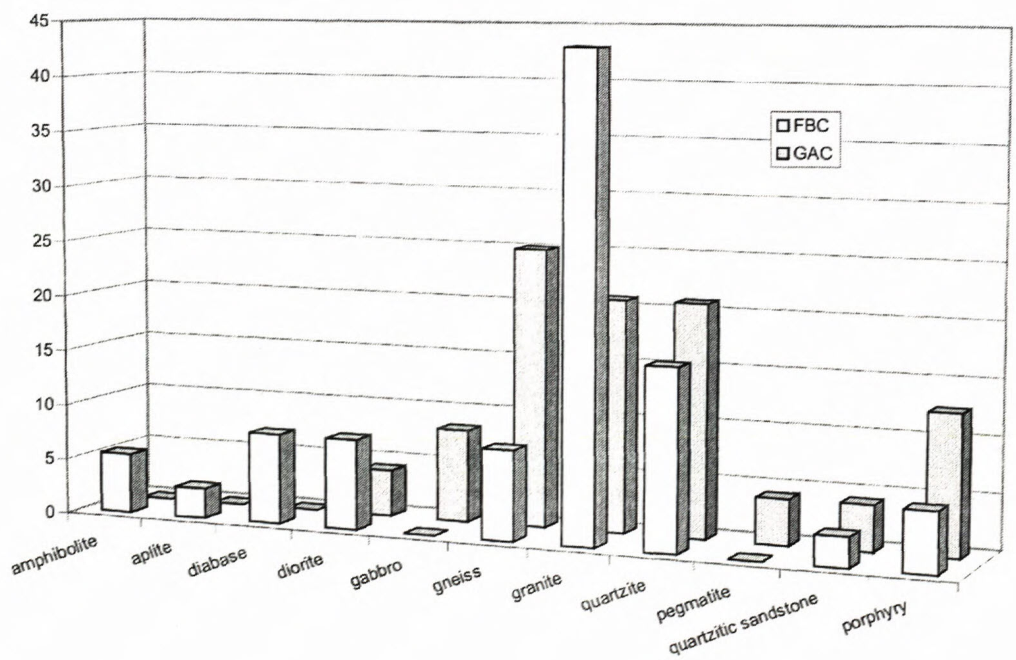
the production of hand axes in the Late-Neolithic communities of FBC (Chachlikowski 1997).

FBC and GAC communities of the region used in their stone production not only a relatively diversified but also carefully selected set of raw-materials. They were used selectively depending on the function of the final product (see rows, Table 1, Figs. 4-11).

A strong and marked preference in the selection of raw materials is to be observed in the production of polishing plates (see Table 1, Fig. 8). Only two types of stone were used for their production quartzitic sandstone, which was absolutely dominant, and quartzite, used on a much smaller scale. Similarly with hammers, we can detect a relatively limited assortment of stone raw materials, which were used for the production of the tools. The most frequent raw material was granite and quartzite, sporadically gneiss.

Narrow selection is also visible in the selection of raw-materials for the production of hand axes (see Table 1, Fig. 4). And though the tool local communities used more diversified set of rock raw-materials (eleven types of different rocks have been distinguished), still axes made of gneiss, biotitic gneiss, amphibolite, gabbro or basalt were the most frequent. Diorite, paleozoic basalts and schist were less frequently used here and porphyry, andesite and, possibly, mudstone, were used only sporadically. In the production of adzes, paleozoic basalts and gabbro were most frequently used and were followed, on a much smaller scale, by biotitic gneiss, diorite and gneiss (see Table 1, Fig. 5).

Fig. 9 Comparison of the share of stone raw-material among hammerstones of FBC and GAC communities in the region (in percentage).



and quartzitic sandstone though they were used primarily for making polishing plates scarce. Scarce products made of pegmatite and aplite, represented a relatively narrow scope for tools production. The former were represented mainly by grinders and, sporadically by hammerstones and hammerstone-polishers. The latter was used by the inhabitants of the settlements under investigation for the production of grinders, hammerstones and hammerstone-polishers alike. On the other hand, the production of tools made of syenite was very limited to the settlements of GAC communities, and it was represented virtually by querns and grinders only with one exception in the case of a single base-plate. Mudstone, on the other hand, was mainly used in the production of polishers. What still remains unanswered is the possible use of mudstone in

For the production of querns, granite and gneiss were common syenite much smaller scale and sporadically, quartzitic sandstone (see Table 1 and Fig. 6). Among grinders, a strong predominance of articles made of granite as well as gneiss and quartzitic sandstone is recorded. The remaining stone raw-materials such as quartzite, sy-

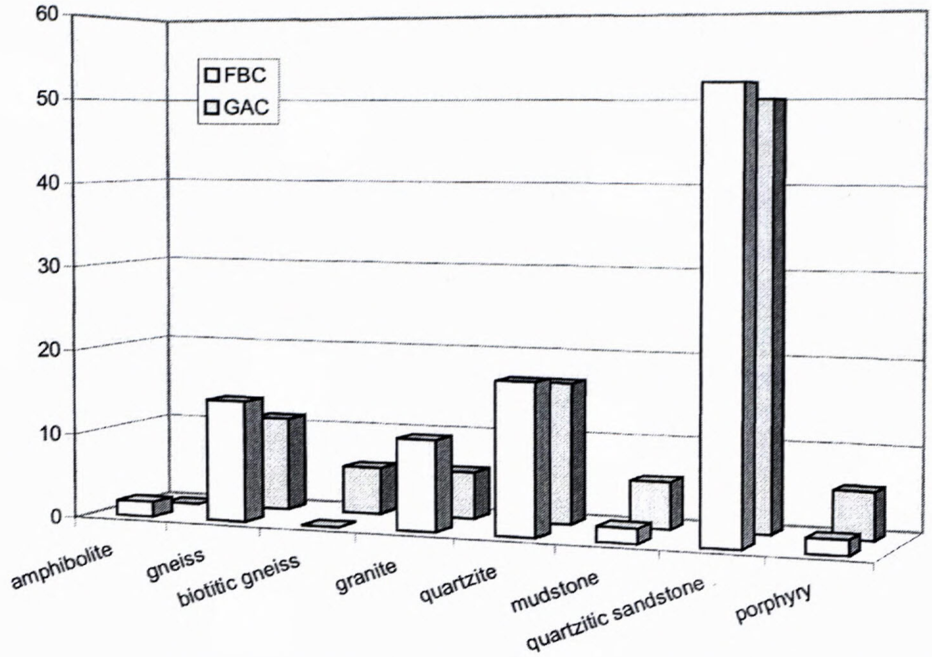


Fig. 10 Comparison of the share of stone raw-material among polishers of FBC and GAC communities in the region (in percentage).

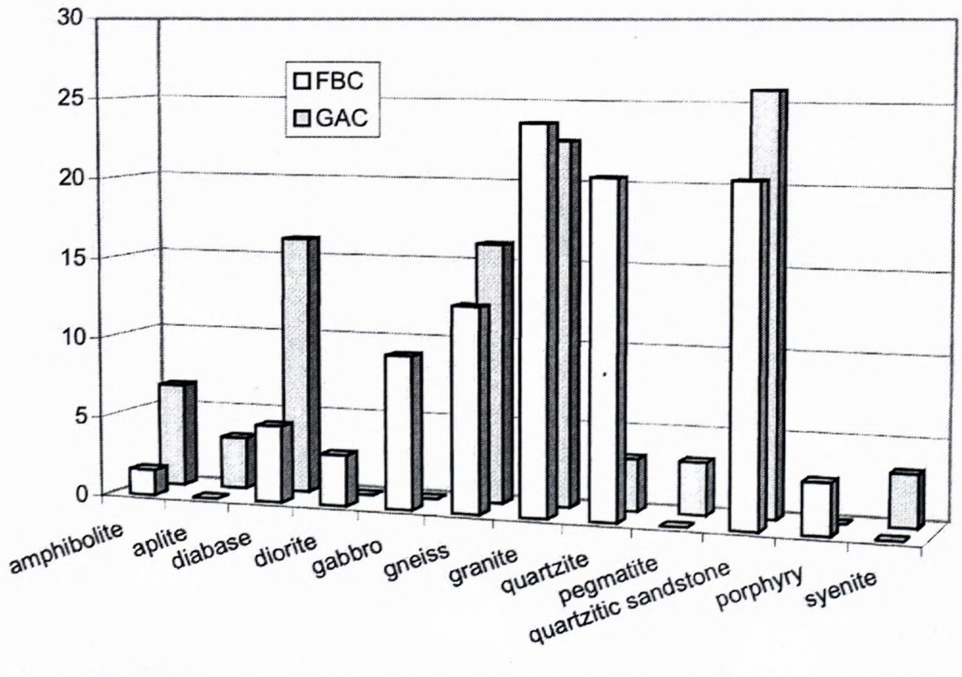


Fig. 11 Comparison of the share of stone raw-material among hammerstone-polishers of FBC and GAC communities in the region (in percentage).

enite, pegmatite, diorite, porphyry, gabbro and aplite, is easily distinguishable (see Table 1 and Fig. 7).

An extremely differentiated assortment of stone raw-materials was used by the inhabitants of the Kujawy region of the late-Neolithic period in the production of multifunctional tools such as hammerstones and polishers similarly as production of articles which combined the function of a hammerstone with that of a base-plate (see Table 1 and Figs. 9-11). A much broader range of raw-materials was used for production of the hammerstones and hammerstone-polishers production than in the case of polishers and base-plates. For the hammerstones 12 different kinds of individual rocks were used. Granite, quartzite, and gneiss were most widespread; diorite, porphyry, paleozoic basalts, amphibolite, gabbro and quartzite sandstone were less frequent. The remaining raw-materials, such as aplite, pegmatite, granite-gneiss were represented, in each instance, only by a single specimen of the tools. For the production of hammerstone-polishers, granite, quartzite sandstone and quartz were used and, to a lesser degree, gneiss, paleozoic basalts and gabbro. The least number of this kind of tools was made of amphibolite, diorite, porphyry and aplite. For polishers, quartzitic sandstone and quartz, followed by gneiss and granite were used. Amphibolite, mudstone and porphyry were used only sporadically for the tools that served a similar function. For base-plates, gneiss, granite, quartz, quartzitic sandstone, porphyry and syenite were most common.

It is worth noticing that for the production of the widest range of tools - hand axes, adzes, grinders, hammerstones or polishers - the FBC communities of the Kujawy region a substantially richer set of rock raw-materials than the GAC communities of the region (cf. Figs. 4, 5, 7, 9, 10 and 11). The FBC communities most of axes were made of gneiss, biotitic gneiss, amphibolite, gabbro and basalt, while in the GAC communities more axes were made of gabbro and amphibolite than of biotitic gneiss. For the production of the tools the paleozoic basalts, diorite and schist in the GAC communities were used in larger scale than it was noticed in FBC communities (cf. Fig. 4). On the other hand, for the production of adzes, gabbro, paleozoic basalts, biotitic gneiss, diorite, possibly basalt and gneiss, were the most common as raw-materials in the FBC communities, while for the production of the same type of tools among the GAC communities only paleozoic basalts, amphibolite and gneiss were utilised (cf. Fig. 5). The occurrence of syenite in the production of querns and grinders in the GAC communities is also remarkable. This raw-material was not used by the FBC communities (cf. Figs. 6 and 7). Only with the instance of the production of querns, the GAC communities used more varied in type raw-materials. Though gneiss and granite were clearly dominant, syenite and quartzitic sandstone were also distinguished, while among the FBC communities only granite and gneiss were used.

Discussion and conclusions

As it can be evidenced on the basis of obtained results the structure of the stone raw-materials used in the region in late Neolithic times was closely related to the profile of the product range of the local stone production. The manifestations of the selection of individual rocks most suitable for the production of the final product were distinguished in the selection of the raw-materials in terms of their type and grade and in their utilisation in the production of, basically, all types of products. These dependencies lead to a conclusion that for the production of specific forms of tools local stone workers deliberately preferred only a selection of the available types of raw-materials. A concurrence in preferences of local stone workers in the range of the selection of specific types of individual rocks used in the production of different tools and weaponry is also clearly visible.

The FBC stone workers used, as we pointed out earlier in the text, more varied assortment of stone raw-material for the production of the majority of tools. However, the most important differences among the communities of FBC and GAC deal only with the volume of the utilisation of some of the individual types rocks in the production of the same articles, predominantly hand axes, adzes and mill tools. But for the production of multifunctional tools of everyday use such as polishing plates, hammerstones or polishers as well as the majority of querns and grinders the said communities used basically the same assortment of stone raw-materials, making use of specific types of rocks to a similar degree, though with different intensity within every type of the tools.

The presented results may support the assumption of intentionality in the selection of stone raw-materials used by the late-Neolithic communities of FBC and GAC in the Kujawy region. The selection was based, among other things, on the future function of the of the final product to be produced.

The question of the selection of stone raw-materials in the production of the same types of tools and weapons (mostly forms with retouched blades) in Polish Lowland (Niż Polski) in the Neolithic period was formerly analysed by Prinke and Skoczylas (Prinke & Skoczylas 1978; 1980a; 1980b; Skoczylas & Prinke 1979). They believed that the most sought-after features that had decided on the selection of specific types of rocks in the production of the said articles was for the local stone workers: high tightness (minimal porosity) and low absorbability, which secured substantial resistance to physical effects of frost and weathering, and high specific weight which allowed high hitting power despite the limited size of the tool. Another important feature was good fissility, which was very helpful in processing of the raw material, and relatively high denseness and compactness for the sake of the article's durability. All of the mentioned features are to be found in basalt which makes this kind of trap rock the most suitable, almost ideal or exemplary raw material, very much in need of a Neolithic stone worker (Prinke & Skoczylas 1974, 1978; 1980b; Skoczylas & Prinke 1979; Skoczylas 1990a, 1990b; cf. also Chachlikowski 1996; 1997).

Other raw materials that were used in Polish Lowland in the production of tools with retouched blades in Neolithic times such as amphibolite, paleozoic basalts and, to a lesser degree, diorite, gabbro or gneiss possess similar physical properties to basalt (Chachlikowski 1997). It is then proper to assume that the said raw materials were carefully and accurately selected by the stone workers of FBC and GAC from among other types of rocks at their disposal in the available erratic material. The next step was to carefully choose them from the point of view of their appropriation (purpose), i.e. as regards their workmanship (depending on technical possibilities of their processing) and as regards their future use (considering the effectiveness of their application and durability of ready-made products) in application to axes, adzes and other tools with retouched blades. Similar criteria were most probably decisive in the selection of stone raw material used by the communities of FBC in the production of hammers, i.e. in the selection of granite, quartzite and gneiss (Chachlikowski 1997).

A deliberate selection in the raw materials depending on the future application of the tools to be made has also been distinguished among the remaining tools which were used as polishing plates, polishers or hammerstones (Chachlikowski 1997). These raw materials that were used in the production of the said tools possessed physical and technical properties which sufficiently met the expectations of their users. And it was polishing plates that were represented exclusively by quartzitic sandstone, less frequently by quartzite which have high grinding and polishing properties. On the other hand, for hammerstones and other tools which combined the function of a hammerstone and a polisher, raw materials were selected that were distinguished not so much by their good polishing or grinding properties but also a high degree of hardness and high compactness or in the resistance of the rock material to blows or hits.

The whole of the remarks described hitherto confirms the feasibility of the assumption that the choice of stone raw materials in the stone production of the FBC and GAC communities of the region was not accidental but intentional and depended on the function of the final product. The dependencies of this kind were distinguished in the choice of the types of raw material used by the local stone workers in the production of, basically, all types of functional tools (see Table 1 and Figs. 4-11).

In keeping with the above assumption is the reasoning that the preferences of the local stone makers in the selection of local raw materials were shaped not only by cultural factors, i.e. symbolic and communicative factors, but also by technological and utilitarian criteria. The thing is that physical and technical properties of specific raw materials were decisive in the choice made in their selection for special purposes in the production of specific tools and weapons. It was because of those specific properties of different types of rocks that a narrow selection of stone raw materials took place. The selection was targeted functionally, i.e. in relation to the available assortment.

The shown relationships between the function of a tool and the type of rock used for its production prove beyond any doubt that the late-Neolithic inhabitants of the Kujawy region had a high practical knowledge on stone raw material in the Lowland. They also prove that the knowledge on the erratic raw material of the area that the local stone workers possessed allowed them to repeat a specific choice, always the same, of a given assortment of individual rocks. Geological specificity of the Polish Lowland which lacks natural deposits of the majority of stone raw material used in the Neolithic stone industry required from the local stone workers an advanced empirical knowledge of the local resources of erratics. The exploration of stone raw materials for the production of tools and weapons by the exploitation of local erratic blocks was linked with the necessity of continual selection of certain kinds and types of stone raw-materials (believed to be of better suitability in the production of specific articles) among other available lowland erratics.

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Maces of the Neolithic and Aeneolithic periods: Slovakia

ĽUDMILA ILLÁŠOVÁ[1] & DUŠAN HOVORKA[2]

[1]Constantin the Philosopher's University in Nitra, Faculty of Natural Sciences, Tr. A. Hlinku, 949 74 Nitra, Slovak Republic
[2]Faculty of Natural Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovak Republic

Abstract: A group of polished stone industry artefacts represented by maces were analysed from typological and petrographical points of view. This group includes drilled stone artefacts that were not used for work and other similar ones characterized by absence of traces of a working activity. They are made of such raw materials which did not allow their use in working process. In general they are considered to be symbols of power, fighting force or a weapon. They were revealed in site excavations (objects) or found in testing pits on a locality. In Slovakia stone maces are known from Neolithic and Aeneolithic localities plotted on Fig. 1.

Key words: Globular, discoid, two-shoulders maces, Neolithic/Aeneolithic, Slovakia

Introduction

A group of polished stone industry artefacts represented by maces was analysed from typological and petrographical points of view. After J. Štelcl and J. Malina (1972) this group includes drilled stone artefacts that were nor used for work, and other similar ones, characterized by absence of traces of a working activity. They are of such raw materials which did not allow their use in working process, e.g. globular, discoid and two-shouldered maces. The only exception in this group are hammer-shaped maces, on which traces of working activities are observable. In this case they are known under denomination "hammers".

As their concerns functioning, maces served for various purposes. Opinions on their function, use and social sphere, are different. In general they are considered to be symbols of power, fighting force or a weapon.

Up to now no adequate attention has been paid to them, they used to be treated as a part of polished stone industry M. Berounská (1987) mentioned also maces from Slovakia supporting information published by J. Lichardus (1960). The only exception are globular maces, typology of which together with their occurrences, production and raw materials on the territory of central Europe were elaborated by M. Berounská (1987). The set of Neolithic and Aeneolithic maces from Slovakia has been completed with further finds and the results of our studies are presented here.

The Neolithic and Aeneolithic maces are relatively rare among stone artefacts. They were revealed in site excavations (objects) or found in testing pits on a locality. From typological point of view globular maces prevail, discoid macehead was found only in one case and two-shouldered ones in two cases. After J. Lichardus (1960) 30 types of axes, axe-hammers and maces (5 types are globular maces) have been known in Slovakia up to now. Their surface is glacely polished, what depends on the raw material used for their production.

Basic characteristics

1. Globular maces - are artefacts prevailingly of round cross-section (characterized by their diameter and height) with perforation in their centres. Diameter of this mace in the perpendicular cut to the perforation is only a little bigger than its height. The globular maces are known from several Neolithic and Aeneolithic sites in Slovakia (Fig. 2). Globular maces prevail among those mentioned here. To semiproducts of a globular or slightly discoid macehead also the find from Borovce (Staššíková-Štukovská, oral communication) can be added. It is a river pebble (raw material quartzite) with indicated perforation on one side. Globular maces are the most often made of the raw material different from that used for polished industry, e.g. limestone of grey or white colour with darker tones. According to the J. Lichardus´s (1960) typology globular maces found in Slovakia belong to the type 28, according to the M. Berounská´ s (1987) typology (morphology) to the type 1. The perforation is slightly conical, drilled from one side. Globular maces that were found in central Europe are made of various raw materials. After M. Berounská (1987) the most often used raw material is limestone, followed by serpentinite, sandstone, limonite, amphibolite, rarely granite, basalt, marble and jadeitite.

2. Discoid maces - are artefacts of discoid shape, plan-convex or biconvex cut, with a perforation approximately in their centre. Their size is characterized by diameter and height, with the diameter several times higher that its height. In Slovakia we know the discoid maces semiproduct from Abrahám (B. Novotný 1958) a half of

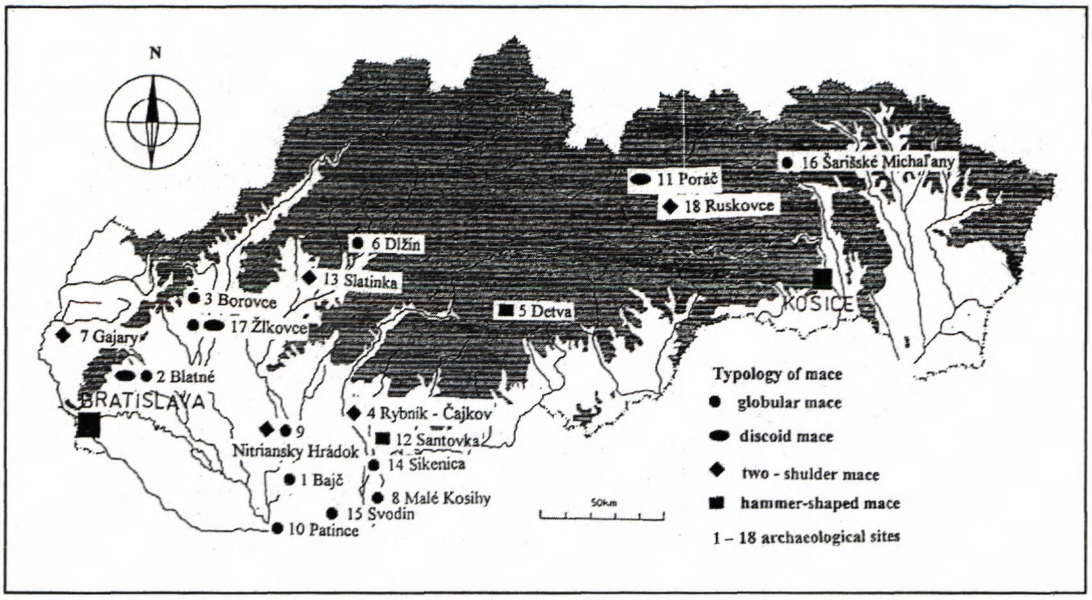

Fig. 1 Occurrences of maces in Slovakia

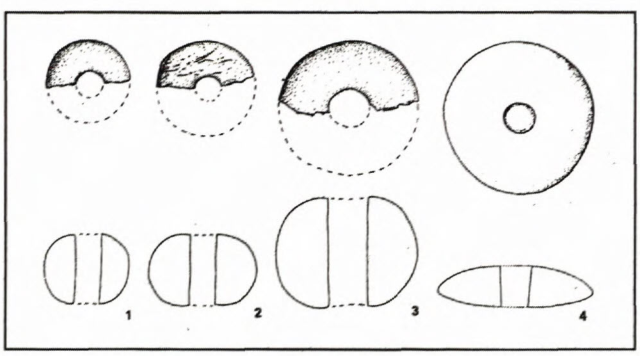

Fig. 2 Fragments of globular maces in Slovakia and their raw materials: 1 – Svodín, marble, 2 – Nitriansky Hrádok-Zámeček, marble, 3 – Malé Kosihy, amphibole schist, 4 – Poráč, discoid mace, antigorite serpentinite

discoid mace from Žlkovce (J. Pavúk, unpublished written report), semiproduct of discoid mace from Blatné. They were made of metamorphic schists of dark grey colour and Lower-Triassic quartzite of the same colour. According to the J. Lichardus's (1960) typology the discoid maces from Žlkovce, Abrahám and Poráč belongs to the type 27.

3. Two-shoulders maces - are artefacts with equal shoulders and perforation in its centre. They used to be of plan-convex to biconvex shape, with rectangular profile sometimes narrowing to the edge (Štelcl & Malina 1972). The height maximum is in the middle of the mace, where the perforation is drilled. The back is convex, sometimes widened, the lower side is levell, sometimes slightly raising to the edge. Its length ranges between 170-320 mm. The most often they were made of amphibole schist. By their morphology J. Lichardus (1960) classifies them as shoe-last chisels and attaches exclusive position and importance to them. In Slovakia two-shoulders maces are known from some localities, e. g. Rybník - Čajkov (Janšák, 1938), Gajary (Eisner, 1933), Nitriansky Hrádok - Zámeček

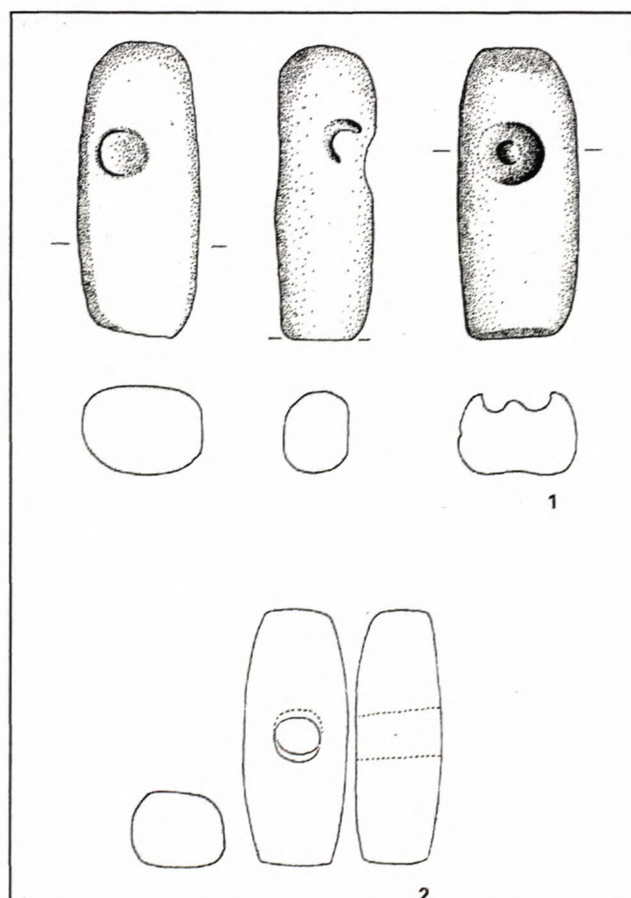

Fig. 3 1 - hammer-shaped mace with traces of drilling, site in Detva, 2 – reconstruction (by Vencl, 1960)

(Illášová & Hovorka, 1999 - fragment of a two-shoudered mace with partially preserved perforation, secondary used) and Ruskovce (Hovorka & Soják, 1997).

4. Hammer-shaped maces - are drilled implements; they are, on both ends, rounded. Conical perforation is in

Table 1

Archaeological sites	1	2	3	4	5	6
Bajč	X					
Blatné	X	X				
Borovce					X	
Detva				X		
Dlžín	X					
Gajary			X			
Malé Kosihy	X					
Nitriansky Hrádok	X			X	X	X
Patince	X					
Poráč		X				
Ruskovce			X			
Rybník			X			
Santovka				X		
Sikenica	X					
Slatinka n. Bebravou					X	
Svodín	X					
Šarišské Michaľany	X					
Žlkovce	X	X				
Spolu:	10	3	3	3	3	1

Notes: 1 - globular, 2 - discoid, 3 - two-shoulder mace, 4 - hammer-shaped, 5 - rough-worked pebbles, 6 - other type

the middle of the artefact. The mace cross-section is rectangular or square. Width and height are sometimes equal, length is remarkably prevailing. In Slovakia several fragments of these maces were found, some of them with perforation. They are of angular shapes. Their ends bear traces of working activities. An not entirely drilled up hammer-shaped mace was found in the site of Detva, position Kalamárka (Fig. 3 : 1 and reconstruction Fig. 3 : 2, by Vencl 1960). It is made of fine-grained andesite, with traces of fire on its surface. The perforation is partially drilled but unfinished in several points (Šalkovský, 1994).

5. Other types of maces - In is group are included various maces in general: a) with perforation without detailed identification, b) without perforation. To the first group belong unidentified fragments or partially halves of maces broken in perforation. They are presupposed to be hammer-shaped ones. To the other group an egg-shaped mace with cutings from Nitriansky Hrádok-Zámeček (the Baden culture) can be included together with maces of angular and cuboidal shapes with deformations after working activities.

6. Rough-worked pebbles of elliptical and angular cross-section with a perforation indicated on one side. Such finds are known e. g. from Slatinka nad Bebravou (Bárta, 1983).

Conclusion

The find of not entirely drilled globular mace (Ožďani, 1983, unknown locality) shows that perforations were made with hollow driller, on the core (from one side). Also pebbles are presupposed to be used for production of globular mace. It is evidenced by the mace from Borovce, too (Staššíková-Štukovská, unpublished report).

In Slovakia stone maces are known from Neolithic and Aeneolithic localities plotted on Fig. 1. Globular maces were excavated in Bajč (Cheben, 2000), Blatné (Illášová, 1988), Dlžín (Archives of the Archaeological Institute SAS), Malé Kosihy (Točík, 1969), Nitriansky Hrádok (Illášová & Hovorka, 1999), Patince (Cheben, 1987), Poráč (Hovorka & Soják, 1997), Sikenica-Trhyňa (Archives of the Archaeolical Institute SAS), Svodín (Illášová, 2000), Šarišské Michaľany (Šiška, unpublished report), Žlkovce (Pavúk, unpublished). Discoid maces were excavated in Blatné, Žlkovce and Ruskovce, two-shoulders maces were excavated in Rybník-Čajkov (Janšák, 1938), Gajary (Eisner, 1933), hammer-shaped in Detva (Šalkovský, 1994), Santovka (Pavúk, 1986, unpublished report), Nitriansky Hrádok. Rough-worked pebbles - semiproducts were excavated in Borovce (Staššíková-Štukovská, unpublished report), Slatinka nad Bebravou (Bárta, 1983) and Nitriansky Hrádok. Other types maces (hammered of form) were excavated in Nitriansky Hrádok (Table 1).

Stone maces of non-working character represented a symbol of fight and chieftain's power, weapon, ruler's sceptre, etc. This is evidenced mainly by finds from grave inventories of central Europe, published by M. Berounská (1987).

At the end it is neccessary to such up that maces found in Slovakia were collected from site excavations and field surveys. We presuppose that the list of localities with their occurrence is not finished and further evaluation of problematic material is needed.

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Die Felssteingeräte aus der neolithischen Tellsiedlung in Gălăbnik, Westbulgarien

ELKA CHRISTOVA ANASTASOVA[1] & JURAJ PAVÚK[2]

Universität Sofia, Bul.Ovcha kupel No. 71, 1618 Sofia, Bulgarien
[2]Archeologický ústav SAV, Akademická 2, 949 21 Nitra, Slovak Republic

Abstrakt: Der Beitrag ist den geschliffenen Felssteingeräten aus der neolithischen Tellsiedlung der Gălăbnik-Gruppe und der klassischen Stračevo-Kultur (6000/5980 bis 5620/5580 BC) gewidmet. Aufgrund der makroskopischen Analyse wurden 218 Artefakte petrographisch bestimmt. Die Geräte wurden als zwei kulturelle und zeitliche Fundverbände (Gălăbnik I und II-III) behandelt. In beiden Fundverbänden wurden neben Geräten zur Holzbearbeitung (Dechsel, Beile, Meissel, Meissel-Keile) zahlreiche Stößel als Bestandteil der Steinmörser und Schleifsteine vetreten.

Key words: Bulgarien, Neolithikum, Felsteingeräte, Petrographie, Typologie

Die Frühneolithische Tellsiedlung in Gălăbnik befindet sich im oberen Strumatal in SW-Bulgarien, etwa 70 km SW von der Hauptstadt Sofia. Die Siedlung liegt im Radomir-Becken, das von alluvialen und kolluvialen Sedimenten in der Überseehöhe um 750 m eingeebnet wurde. Der fünf Meter hohe Tell ragt nur etwa 1,5 m aus der Ebene empor, sein größter Teil wurde von Sedimenten übergedeckt und die unteren drei Wohnhorizonte liegen im Grundwasser. Während der bulgarisch-slowakischen Ausgrabung in den Jahren 1979 bis 1993 wurden 10 Bau- und Wohnhorizonte festgestellt. Die untere sieben Horizonten gehören der Gălăbnik-Gruppe der Protostarčevo-Periode an und die oberen drei Horizonte stammen aus der Zeit der klassischen Starčevo-Kultur (Pavúk/Čochadžiev 1984; Pavúk/Bakamska 1989). Kalibrierte Radiokarbondaten geben für die Tellsiedlung in Gălăbnik die Zeitspanne von 6000/5980 bis 5620/5580 BC an (Bojadžiev). Die Gălăbnik-Gruppe stellt mit den gleichzeitigen Kulturgruppen mit charakteristischer weiß bemalter Keramik zweite Etappe der frühneolithischen Entwicklung auf dem östlichen und zentralen Balkan dar, welcher die Etape der Kulturgruppen mit der spezifischen monochromen Keramik vom Typus Krajinici voranging und die den Anfang des Neolithikums kennzeichnet. Der vorgelegte Bericht stellt eigentlich die erste Information über die Felssteinindustrie dieser Periode dar.

Die geschliffenen Felsteingeräte aus Gălăbnik lassen sich in zwei Gruppen einteilen, die den erwähnten zwei kulturchronologischen Einheiten angehören. Die kleinere Fundgruppe von 65 Exemplaren stammt aus den Wohnhorizonten I bis VII, die der Besiedlung der frühneolithischen Gălăbnik-Gruppe entsprechen und die zahlreichen 153 Geräte wurden in den oberen Wohnhorizonten VIII bis X aus der Zeit der Starčevo-Kultur gewonnen.

1. Die Methodik der Fundaufnahme

1.1. Typologische Klassifikation

Der Problematik der Typologie der geschliffenen Steinindustrie wurde in der bulgarischen Literatur bis jetzt nur wenig Aufmerksamkeit gewidmet. Als Hilfsmittel könnte man nur die Arbeiten von P. Detev (1960) sowie von K. Kănčev und N. Ja. Merpert (1979) ausnutzen, wobei die zweite Arbeit, die der späteren Periode gewidmet ist, nur teilweise anwendbar wäre. Die Arbeit über Beile von P. Detev war damals bedeutend, doch ist sie unvollkommen und wurde von den bulgarischen Spezialisten nicht erweitert. Eine bessere Definition des Beiles findet man bei J.-L. Piere-Desruisseaux (1992).

Die vorgelegte Liste der Typen beruht auf reicheren Kenntnissen, entspricht unseren jetzigen Bedürfnissen und läßt sich als offenes System leicht erweitern.

1. Die Stößel

1.1. Die Stößel von unregelmäßiger oder ovaler Form (wobei die Gestaltung nicht absichtlich geformt wurde, man hat die natürliche Form des Steines benutzt).

1.2. Die Stößel von unregelmäßiger zylindrischer Form oder in der Form eines geschnittenen Konus mit Gebrauchsspuren auf beiden Enden entstanden durch die teilweise zugeschliffene Oberfläche. Bei diesen Stücken ist die Anfertigung weniger präzis und das Gerät weist im Querschnitt mehr als einen Durchmesser auf.

1.3. Reutilisierte Formen aus schon beschädigten oder zerbrochenen Dechsel und Beilen.

2. Schleifsteine wurden aus den für diese Zwecke geeigneten Rohstoffen hergestellt oder wurden anderen schon beschädigten Geräten angepasst.

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3. Dechsel sind Formen, deren Schneide beim länglichen Querschnitt asymmetrisch ist.
3.1. Trapezförmige Dechsel
3.1.1. Trapezförmige Dechsel mit ellipsoidem bis fast kreisförmigem Querschnitt
3.1.2. Trapezförmige Dechsel mit plankovexem Querschnitt - die Ventralseite des Gerätes ist fast gerade gerade und die Dorsalseite ist unterschiedlich gewölbt.
3.1.3. Trapezförmige Dechsel mit viereckigem Querschnitt.
3.2. Dechsel von rechteckiger Form.
3.2.1. Rechteckiger Dechsel mit elipsoidem bis kreisförmigem Querschnitt.
3.2.2. Rechteckiger Dechsel mit plankonvexem Querschnitt.
3.2.3. Rechteckiger Dechsel mit viereckigem Querschnitt.
3.3. Dechsel von dreieckiger Form.
3.3.1. Dreieckiger Dechsel mit ellipsoiden bis fast kreisförmigem Querschnitt.
3.3.2. Dreieckiger Dechsel mit plankonvexem Qeurschnitt.
3.3.3. Dreieckiger Dechsel mit viereckigem Querschnitt
4. Die Meissel. Geräte von länglicher Form deren Höhe beinahe der halben Breite gleicht.
4.1. Meissel mit ovalem Querschnitt - von einer Ellipse bis zum Kreis.
4.2. Meissel mit plankonvexem Querschnitt
4.3. Meisel mit viereckigem Querschnitt
5. Meissel-Keil. Geräte des Typus Meissel, deren Höhe der Gesamtbreite gleicht.
5.1. Meissel-Keil mit ovalem Querschnitt
5.2. Meissel-Keil mit viereckigem Querschnitt
5.3. Meisel-Keil mit plankonvexem Querschnitt
6. Die Beile. Geräte deren Schneide im länglichen Querschnitt symmetrisch ist
6.1. Trapezförmige Beile
6.1.1. Trapezförmige Beile mit ovalem Querschnitt
6.1.2. Trapezförmige Beile mit elipsoidem Querschnitt
6.1.3. Trapezförmige Beile mit dem viereckigem Querschnitt
6.2. Rechteckige Beile
6.2.1. Rechteckige Beile mit ovalem Querschnitt
6.2.2. Rechteckige Beile mit elipsoidem Querschnitt
6.2.3. Rechteckige Beile mit viereckigem Querschnitt
6.3. Dreieckige Beile
6.3.1. Dreieckige Beile mit ovalem Querschnitt
6.3.2. Dreieckige Beile mit elipsoidem Querschnitt
6.3.3. Dreieckige Beile mit viereckigem Querschnitt
7. Halbfabrikate
8. Fragmente
8.1. Fragmente von Dechseln, Beilen oder Meisseln
8.2. Fragmente von Stößeln oder Schleifsteinen

1.2. Morphometrische Analyse

1.2.1. Metrische Analyse. Berücksichtigt wurden die grundlegenden Maße des Gerätes: die maximale Länge, Breite und Höhe
1.2.2. Die Form der Arbeitskante. Bei der Analyse der Artefakte der beiden kulturchronologischen Fundgruppen wurden fünf Formen der Arbeitskante registriert:
0. Beschädigt
1. Gerade
2. Schräg
3. Konvex
4. Andere Form. Dieser Kategorie wurden Artefakten von Typus der Stößel und Schleifsteine zugewiesen. Die ersten vier Formen der Arbeitskante beziehen sich auf die Dechsel, Beile und Meissel.

1.2.3. Der Winkel zwischen den Ebenen der dorsalen und ventralen Seite der Arbeitskante. Dieses Kriterium bietet die Möglichkeit zur Untersuchung, ob bei der Herstellung der Dechsel, Beile und Messiel der bestimmte Winkel, der die optimale Arbeitsleistung bewirken konnte, gesucht wurde. In dieser Hinsicht wurden alle Varianten der Geräte untersucht.
0. unbestimmbar
1. von 10° bis 15°
2. von 15° bis 20°
3. von 20° bis 25°
4. von 25° bis 30°
5. von 30° bis 35°
6. von 35°

1.3. Funktionelle Analyse

1.3.1. Gebrauchsspuren. Diese Untersuchung beruht auf der makroskopischen Beobachtung der Arbeitskante. Bei der Charakteristik der Spuren sowie bei der Bestimmung der wahrscheinlichen Funktion der Geräte berufen wir uns auf die Information von Frau Dr. Maria Gjurova. Natürlich, ohne Untersuchung eines spezialisierten Trasologen kann man mit einem kleinen Prozentsatz von Fehlbestimmungen rechnen. Auf den Geräten beider Fundverbände wurden folgende Gebrauchsspuren beobachtet.
0. Ohne Gebrauchsspuren
1. Gebrauchsspuren, die parallel mit der Arbeitskante verlaufen
2. Gebrauchsspuren senkrecht auf die Arbeitskante
3. Gebrauchsspuren angeordnete unter verschiedenen Winkel gegen Arbeitskante
4. Unbestimmbare Gebrauchsspuren
5. Gebrauchsspuren nach dem Schleifen
6. Gebrauchsspuren, typisch für die Geräte vom Typus der Stößel

Untersucht wurden auch die Gebrauchsspuren auf dem Nacken der Geräte. Der polierte Nacken ist auf die feine Bewegung in der Schäftung des Gerätes zurückzuführen und nicht als echte Arbeitsspuren zu deuten.

1.4. Petrographische Analyse

Die petrographische Bestimmung des Rohstoffes der Geräte aus der Siedlung in Gălăbnik erfolgte aufgrund der makroskopischen Analyse vom Geologen Johnson Fish, wofür wir ihm unseren Dank aussprechen.

1. Sedimentierte Gesteine
1.1. Amorphe Silikate
1.1.1. Nephrit
1.1.2. Mannifaltige Nephrite
1.1.3. Feine amorphe Silikate
1.2. Echte sedimentierte Gesteine
1.2.1. Festige Lehme
1.2.2. Silifizierter Tuff
1.2.3. Feiner Sandstein
1.2.4. Sandstein
1.2.5. Sandiger Psammit
1.3. Karbonate
1.3.1. Kalkstein
2. Plutonische Gesteine
2.1. Gabro
2.2. Basalt
2.3 Diorit
2.4. Trachyt
2.5. Dolorit
2.6. Granit
2.7. Rhyolith
2.8. Porphyr
2.9. Andesit
3. Metamorphische Gesteine
3.1. Serpentinit
3.2. Quarz
3.3. Schwach metamorphierte Sedimente
3.4. Kristalliner Schiefer
4. Auf dem makroskopischen Niveau unbestimmbar
5. Knochen

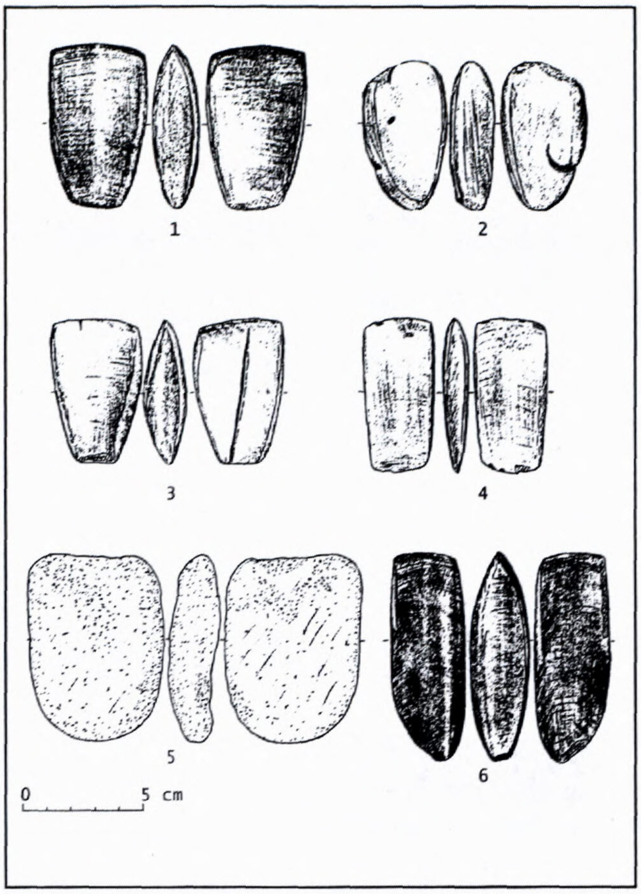

Abb. 1. Gălăbnik I. Hortfund. 1 – Dechsel; 2 – Schleifstein; 3 – Beil; 4 – Meissel; 5 – Halbfabrikat; 6 – Meissel-Keil.

2. Gălăbnik I

2.1. Typologische Analyse

Der Fundverband Gălăbnik I stellt 65 geschliffene Steingeräte aus den ersten sieben Wohnhorizonten dar, die der Protostarčevo-Periode mit der weiß bemalten Keramik angehören. Verglichen mit dem Fundverband Gălăbnik II aus den oberen drei Wohnhorizonten lieferte er wesentlich weniger Geräte. In diesem älteren Fundverband dominieren gleich mit 21 Stück die Dechsel und Beile, gefolgt von Meisseln und Meissel-Keilen vetreten mit insgesamt 10 Stück (Tab. 1).

Auf der Tab. 2 sind die einzelnen Subtypen ausführlicher dargestellt.

Aus der ausführlichen Unterteilung geht hervor, daß unter den Dechsel mit 9,2% trapezförmige Exemplare mit elipsoiden bis kreisförmigem Querschnitt (3.1.1) überwiegen. Trapezförmige Dechsel mit plankovexem Querschnitt (3.1.2) stellen 7,7% dar. Die trapezförmigen Beile mit viereckigem Querschnitt (6.1.3) sind mit 9,2% sind gleich vertreten wie die trapezförmigen Dechsel mit ellipsoidem bis kreisförmigem Querschnitt, also die verschiedentliche Gestaltung der Seiten beider Geräte zur Holzbearbeitung könnte als weiteres typologisches Merkmal betrachtet werden. Ziemlich hoch ist der Prozentsatz (7,7%) der Stößel, die als zerbrochene Dechsel und Beile sekundäre Verwendung fanden.

2.2. Morphometrische Analyse des Fundverbandes Gălăbnik I

2.2.1. Metrische Analyse

Beim Messen der drei grundlegenden Ausmasse - Länge, Breite und Höhe, auf allen Artefakten, eventuell nur aus vollkommen erhaltenen Stücken mit allen drei Maßangaben wurde festgestellt, daß bei manchen Geräten (Typus 1, 2, 4 und 8) keine bestimmte Beziehung zwischen den Ausmaßen gesucht wurde. Eine solche Abhängigkeit erscheint jedoch bei den Dechseln, Beilen und Meisseln. Bei den Meisseln-Keilen läßt sich eine ähnliche Abhängigkeit nicht beurteilen, weil nur ein ein- ziges Exemplar vorliegt. Bei den Dechseln (Diagramm 1) beobachtet man die Proportionen 1-2/3 (1/2)- 1/3 (1/4). Die Meissel mit den Proportionen 1- 1/2- 1/4 (1/5) zeigen die Tendenz zur Verkleinerung der Höhe. Die Beile haben die gleichen Proportionen wie die Dechsel (Diagramm 2).

2.2.2. Die Form der Arbeitskante

Die Arbeitskante der Dechsel und Beile ist konvex (27,7%), schräg (24,6%) sowie gerade (23,1%), wobei

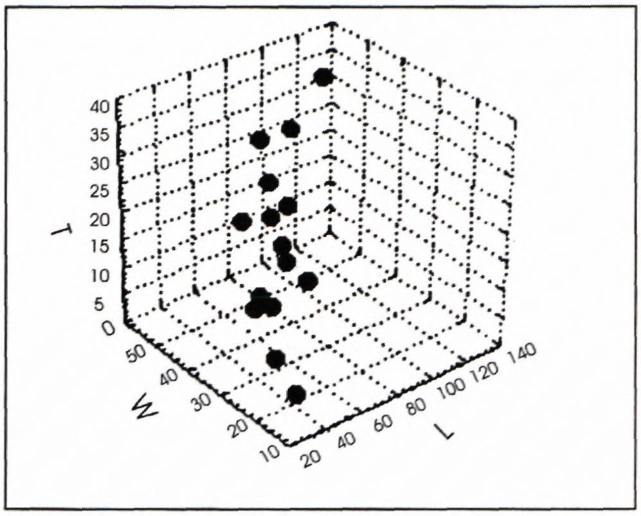

Diagramm 1. Die Parameter der Dechsel aus dem Gălăbnik I.

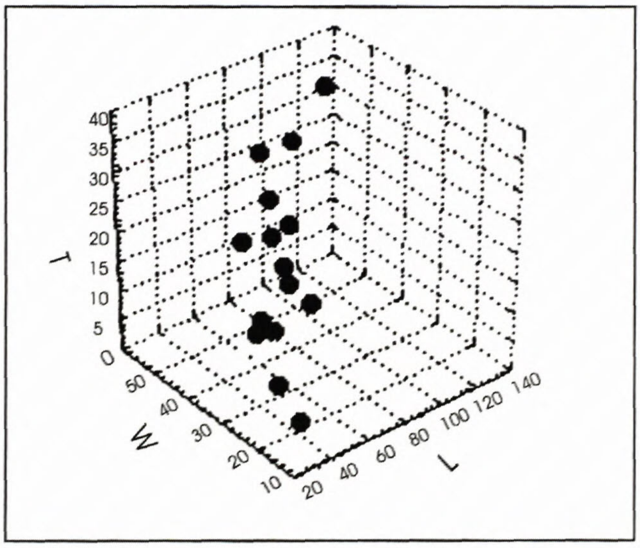

Diagramm 2. Die Parameter der Beilen aus dem Gălăbnik I.

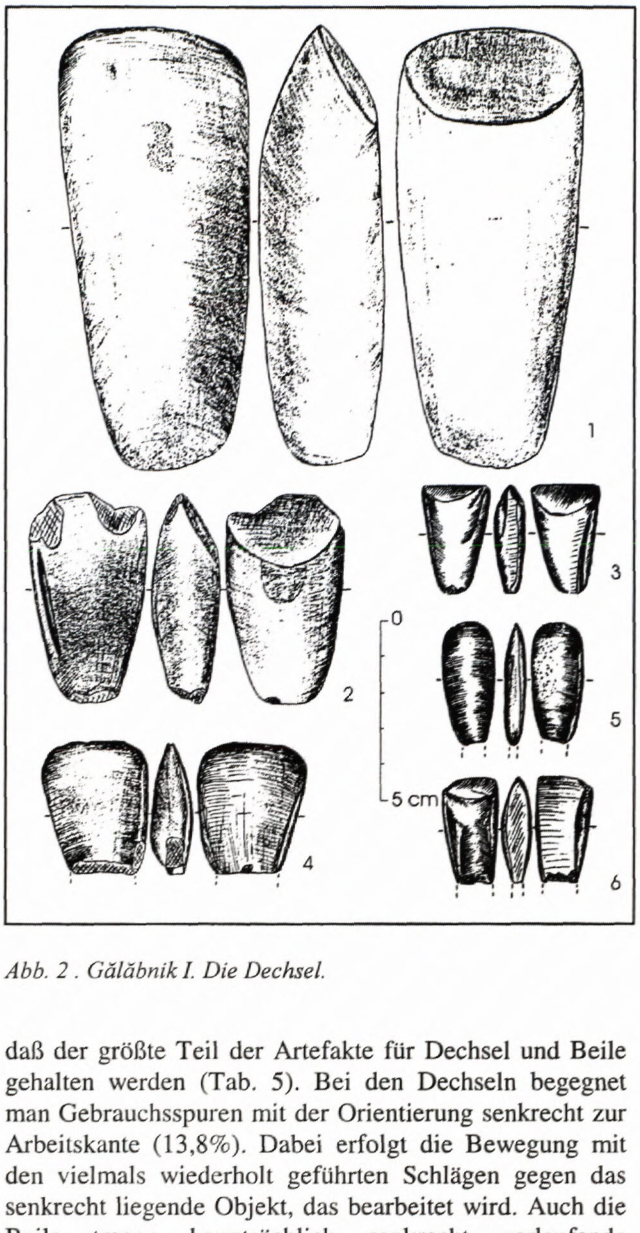

Abb. 2 . Gălăbnik I. Die Dechsel.

bei Dechseln die Schneide hauptsächlich konvex und bei Beilen meistens schräg ist (Tabelle 3).

2.2.3. Der Winkel zwischen der Dorsal- und Ventralseite, gemessen auf der Schneide

Das Ergebnis der Analyse zeigt, daß die Werte der Winkel auf der Arbeitskante gewöhnlich zwischen 45° bis 50°, 30° bis 35° und 50° bis 55° schwanken. Bei den Dechseln bewegt sich der Winkel zwischen 30° und 35° und bei den Beilen zwischen 45° bis 50°.

2.3. Funktionelle Analyse der Felssteingeräte des Fundverbandes Gălăbnik I

2.3.1. Die Gebrauchsspuren

Im Fundverband überwiegen die Gebrauchsspuren laufend senkrecht zur Arbeitskante (27%), die Gebrauchsspuren unter anderem Winkel zur Arbeitskante (24,6%) und solche, die parallel mit der Arbeitskante verlaufen (15,4%). Diese Ergebnisse sind logisch, weil damit gerechnet wird, daß der größte Teil der Artefakte für Dechsel und Beile gehalten werden (Tab. 5). Bei den Dechseln begegnet man Gebrauchsspuren mit der Orientierung senkrecht zur Arbeitskante (13,8%). Dabei erfolgt die Bewegung mit den vielmals wiederholt geführten Schlägen gegen das senkrecht liegende Objekt, das bearbeitet wird. Auch die Beile tragen hauptsächlich senkrecht verlaufende Gebrauchsspuren gegen die Arbeitskante wie auch unter einem anderen Winkel (7,7%). Auch diese Ergebnisse werden von der Kinematik der Bewegungsrichtung, bei der die Schneide des Gerätes parallel schwach unter dem Winkel gegen den bearbeiteten Gegenstand geführt wird, unterstützt. Bei der Bearbeitung wurden auch Benutzungspuren auf dem Nacken von Beilen und Dechseln beobachtet. 19,0% der Dechsel und 52,4% der Beile tragen auf dem Nacken Spuren der Verwendung als Stößel. Der hohe Prozentsatz von Beilen (7,7%) mit senkrechten Benutzungsspuren auf der Arbeitskante zeugt von einer größeren Universalität dieser Geräte.

2.4. Petrographische Zusammensetzung des Fundverbandes Gălăbnik I

Dieser Fundverband wurde der petrographischen Analyse unterzogen um festzustellen, aus welchen Rohstofftypen die Geräte hergestellt wurden. Die meisten der Artefakte waren aus folgenden Rohstoffen hergestellt:

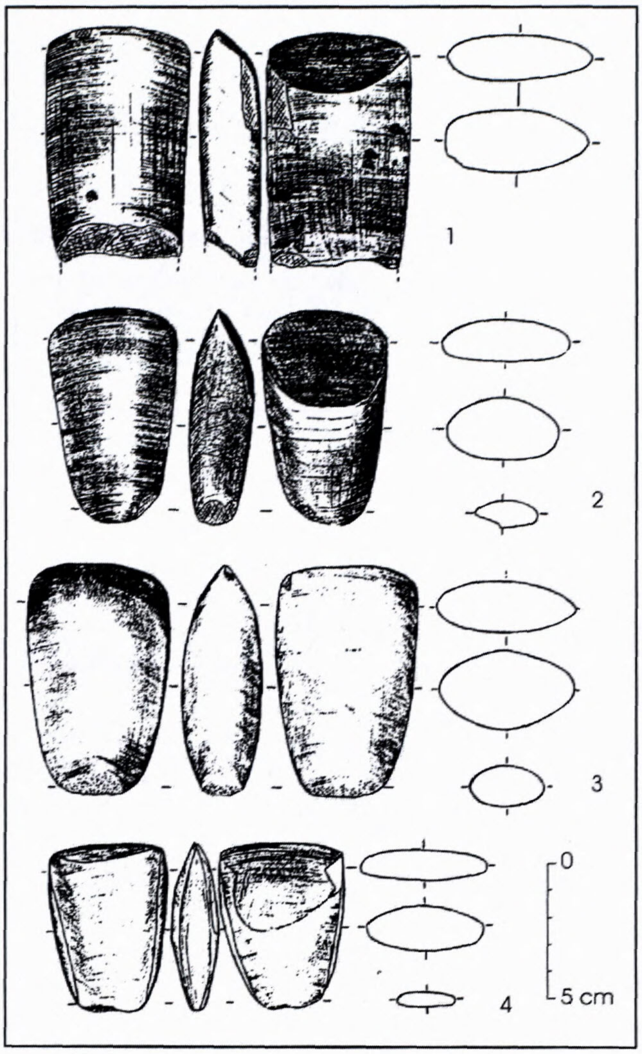

Abb. 3. Gălăbnik I. 1-2 – Dechsel; 3-4 – Beile.

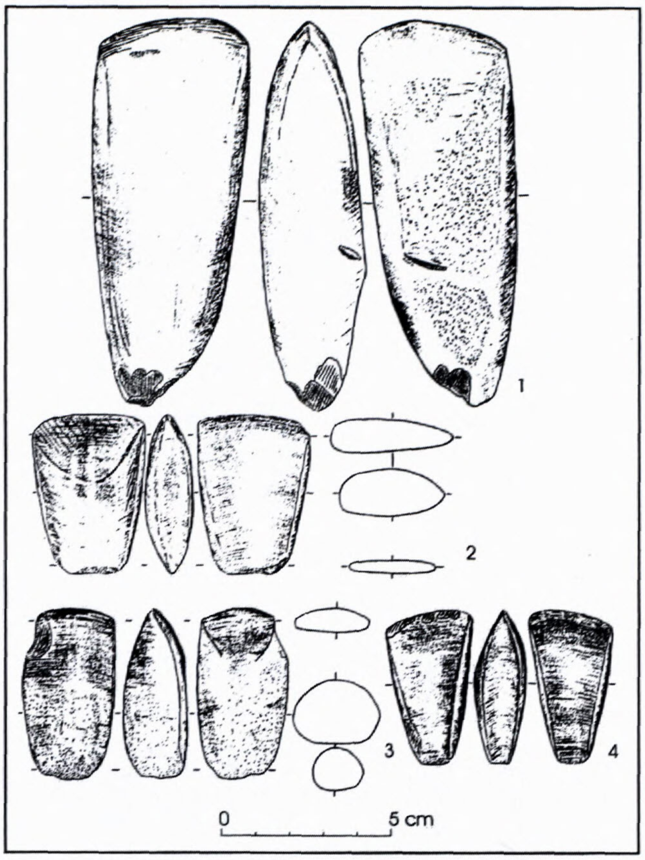

Abb. 4. Gălăbnik I. Die Beile.

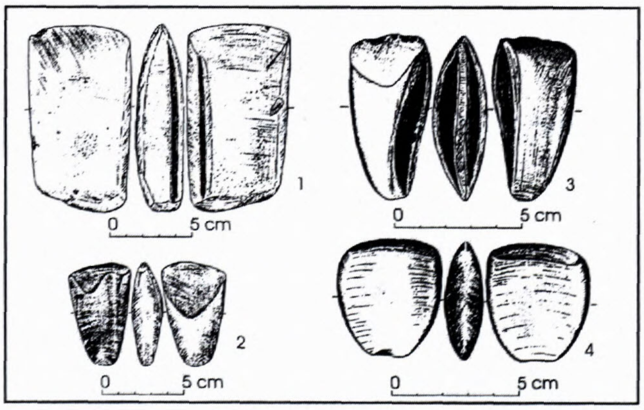

Abb. 5. Gălăbnik I. Die Beile.

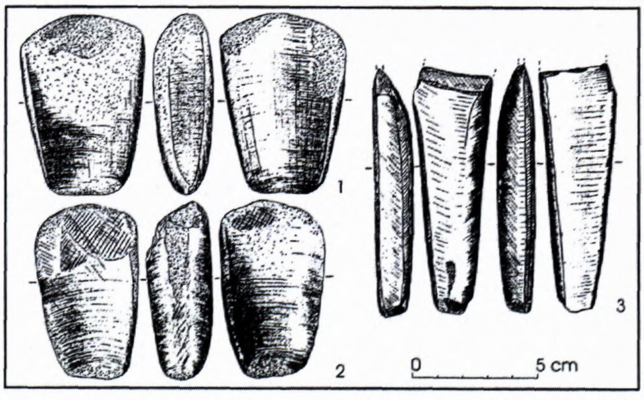

Abb. 6. Gălăbnik I. 1-2 – Reutilisierte Stößel; 3 – Meissel.

Basalt (18, 5%), Quarzit (13, 8%), silifizierter Lehm (12,3%). Oft benutzt wurde auch Gabbro und Serpentinit (je 7,7%9). Für kleinere Artefakte wurden auch manche Abarten von Nephrit (6,2%) verwendet.

Diesem Fundverband gehört auch ein Depot aus dem VI. Wohnhorizont an, das in einem Haus gefunden wurde. Das Depot besteht aus einem Dechsel, Beil, Meissel, Meissel-Keil, Schleifstein und aus einem Halbfabrikat. Der Meissel wurde aus einem fossilisiertem Knochen hergestellt. Das Artefakt wurde von den französischen Spezialisten Jean-Luc Guadeli und Francois Deppech von Universität Bordeaux I untersucht. Das Gerät mit zwei Arbeitsenden wurde aus der Tibia eines großen Tiers hergestellt. Die Ventralseite an beiden Enden wurde durch die Verwendung wurde geglättet (Abb. 1: 4).

3. Fundverband Gălăbnik II-III

3.1. Typologische Analyse des Fundverbandes

Dieser Fundverband besteht aus 153 Felssteingeräten (Tab. 7). Aus den oberen drei Wohnhorizonten stammen recht viele Stößel, die in diesem Fundverband dominieren, was gut verständlich ist, weil in den Wohnhorizonten

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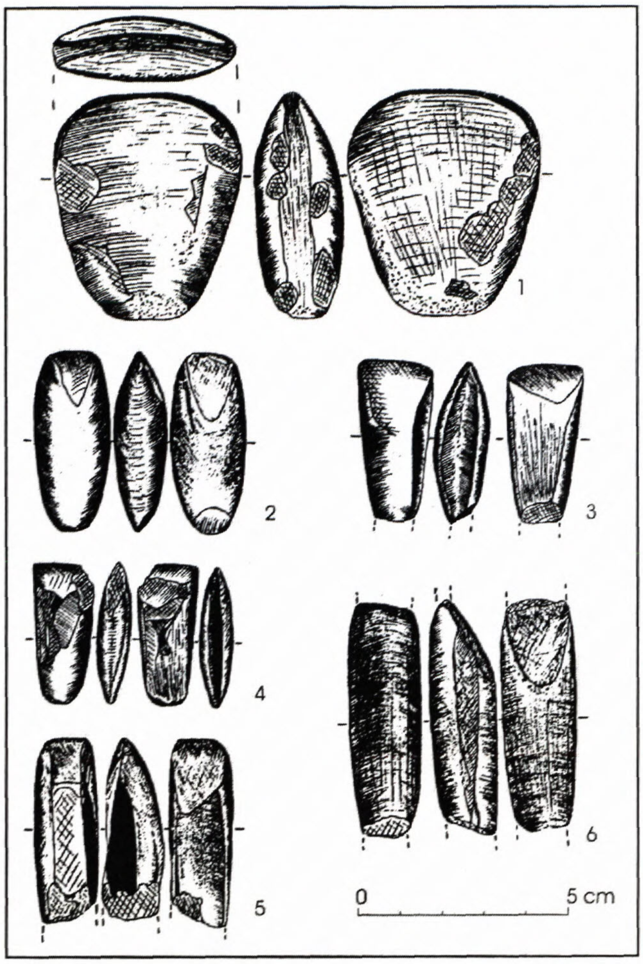

Abb. 7. Gălăbnik I. 1 – Schleifstein; 2-4 – Meissel; 5-6 – Meissel-Keil.

der Starčevo-Kultur sehr viele Felssteinmörser gefunden wurden und die Stößel dienten gerade zum Zerschlagen verschiedener Materialien. Nur kürzere stößelartige Artefakte konnten als Schlägel und auch anders benutzt werden.

Auf dem Niveau von Subtypen (Tab. 8) überwiegen Stößel der unregelmäßigen zylindrischen Form oder der konischen Form mit zwei Arbeitsenden mit polierter Oberfläche bei den Enden (17,6%). Hoch ist auch der Anteil von Meisseln mit plankonvexer Querschneide (7,2%) sowie Dechsel mit rechteckigem Querschnit und mit einer Querschneide (6,5%).

3.2. Morphometrische Analyse des Fundverbandes Gălăbnik II-III

3.2.1. Metrische Analyse

Bei dieser Analyse wurden dieselben Kriterien wie bei dem Fundverband Gălăbnik I angewandt. Die Abhängigkeit in den Proportionen wurde wieder bei den Dechseln gesucht: 1- 1/3(2/3)- 1/4 (Diagramm 3), bei den Meisseln 1- 1/3 (1)- 1/3(1/4)- 1/3(1/4) und bei den Beilen 1- 1/2 (2/3)- 1/3(1/4) (Diagramm 4).

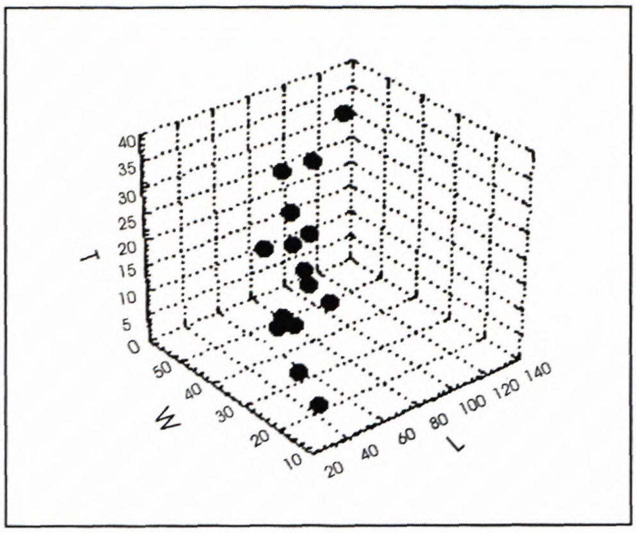

Diagramm 3. Die Parameter der Dechseln aus dem Fundverband Gălăbnik II-III

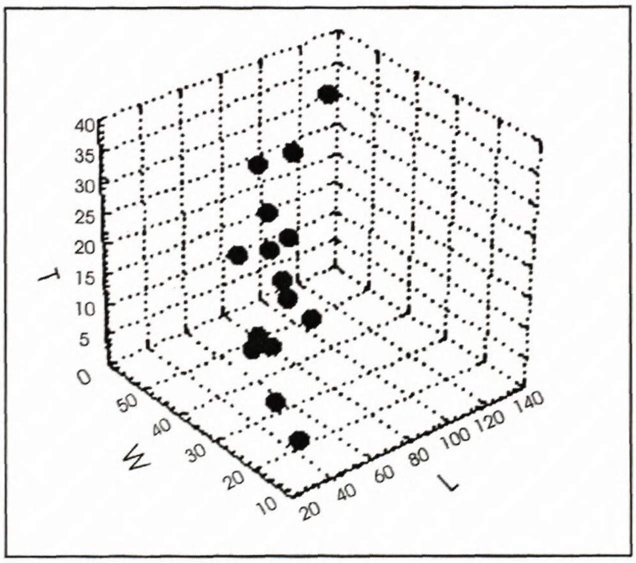

Diagramm 4. Die Paramenter der Beilen aus dem Fundverband Gălăbnik I-III

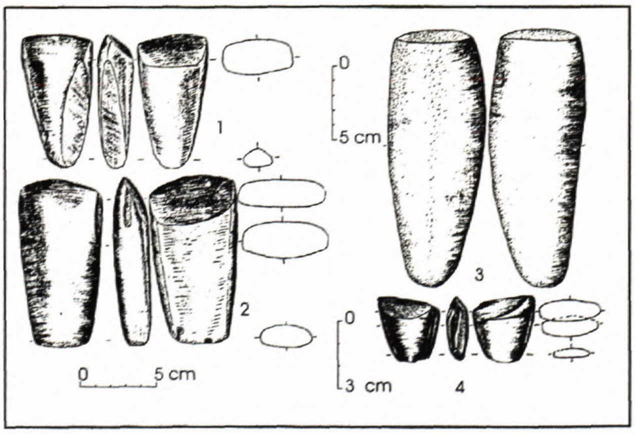

Abb. 8. Gălăbnik II-III. 1, 2, 4 – Dechsel; 3 – Stößel.

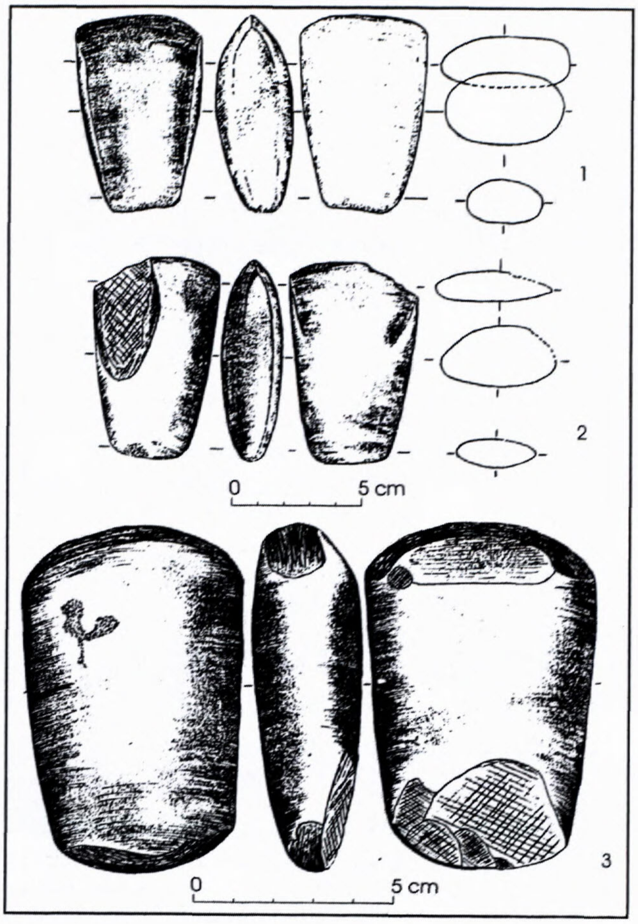

Abb. 9. Gălăbnik II-III. 1, 2 – Beile; 3 – Schleifstein.

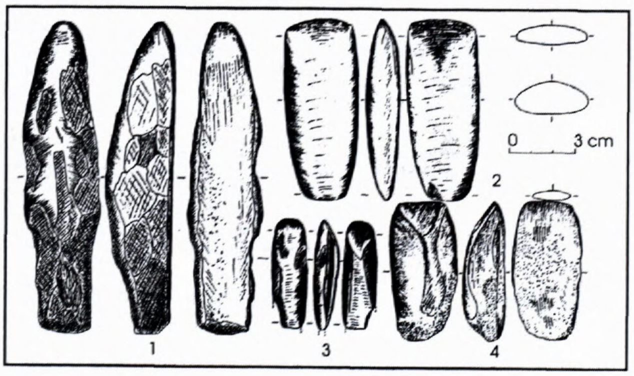

Abb. 10. Gălăbnik II-III. 1 – Schleifstein; 2 – Meissel; 3 – Meissel-Keil; 4 – Halbfabrikat.

Tab. 1

Typus	Zahl	%
Stößel	5	7.7
Schleifsteine	4	6.6
Dechsel	21	32
Meissel	7	11
Meisel-Keil	3	4.6
Beile	21	32
Halbfabrikate	1	1.5
Fragmente	3	4.6
Zusammen	3	4.6

3.2.2. Die Form der Arbeitskante

Die untersuchten Artefakte dieses Fundverbandes aus der Siedlung der Starčevo-Kultur zeigen eine große Ähnlichkeit mit den Geräten aus den Siedlungshorizonten der Siedlung der vorangehenden Protostarčevo-Periode (Gălăbnik I). In dem jüngeren Fundverband Gălăbnik II-III überwiegen die Geräte mit schräger Schneide (25,5%) gefolgt von jenen, die als Schleifsteine und Stößel verwendet wurden (20,3%). Hoch ist der Anteil der Dechsel und Beile mit einer stark beschädigten Schneide (20,3%). Die konvexe Arbeitskante findet man bei 18,3% der Geräte (Tab. 9).

3.2.3. Der Winkel zwischen Dorsal- und Ventralseite, gemessen auf der Arbeitskante

In diesem Fundverband haben die Artefakte den Winkel der Schneide grundsätzlich zwischen 40 und 55 Grad (Tab. 10). Bei den Geräten des Typus Dechsel, Beil und Meissel bewegte sich der am öftesten gesuchte Winkel auf der Schneide zwischen 45 bis 50 und 50 bis 55 Grad.

3.3. Funktionelle Analyse der Artefakte des Fundverbandes Gălăbnik II-III

3.3.1 Die Gebrauchsspuren

Charakteristisch für diesen Fundverband der Felssteingeräte ist der schon erwähnte hoher Anteil von Stößeln (24,2%). Häufig sind auch Geräte mit den senkrecht zur Arbeitskante verlaufenden Gebrauchspuren, die für Dechsel als spezifisch gelten (18,3%) sowie die Geräte mit den Benutzunsspuren unter irgendeinem Winkel zur Arbeitskante (18,3%). Der Großteil der Geräte ist schlecht erhalten oder stark abgenutzt, weshalb die Benutzungsspuren nur schwer bestimmbar sind (18,3%).

Bei den Geräten, die typologisch zu Dechseln gehören, gibt es viele Artefakte mit Benutzungsspuren unter einem schrägen Winkel zur Arbeitskante (6,5%). Anderseits findet man bei den Beilen eine bestimmte Menge von Stücken (3,9%) mit länglichen Arbeitsspuren, die senkrecht zur Gerätschneide verlaufen, was wieder eine stärkere Unifizierung der Geräteverwendung andeutet, die der typologischen Klassifikation nicht einwandfrei entspricht. Das ist gut verständlich, weil sowohl die Dechsel als auch die Beile hauptsächlich zur Holzbearbeitung dienten, und bei manchen Arbeitsvorgängen konnten sie beide Arten der Arbeitsspuren hinterlassen haben.

3.4. Petrographische Zusammensetzung der Geräte des Fundverbandes Gălăbnik II-III

In diesem Fundverband sind folgenden Arten des Felsgestein dominierend: Basalt (15,7%), feiner Sandstein (13,1%) und Dolorit (9,2%). Wenn man zur Herstellung von Stößel sandsteinartige Abarten verwendete, wurden für die Dechsel, Meissel und Beile hauptsächlich härtere Arten von

Tab. 2

Typus	Subtypus	Variante	Zahl	% von Typus	% von Subtypus	% von Fundverband
	1.1					
1	1.2					
	1.3		5	100%	100%	7,70%
2	2.1		4	100%	100%	6,50%
		3.1.1	6	28,60%	54,50%	9,20%
	3.1	3.1.2	5	23,80%	45,50%	7,70%
		3.1.3				
		3.2.1	1	4,80%	20%	1,50%
3	3.2	3.2.2	2	9,50%	40%	3,10%
		3.2.3	2	9,50%	40%	3,10%
		3.3.1	1	4,80%	20%	1,50%
	3.3	3.3.2	3	14,30%	60%	4,50%
		3.3.3	1	480%	20%	1,50%
	4.1		1	14,30%	100%	1,50%
4	4.2		4	57,10%	100%	6,20%
	4.3		2	28,60%	100%	3,10%
	5.1		1	33,30%	100%	1,50%
5	5.2		2	66,70%	100%	3,10%
	5.3					
		6.1.1	2	9,50%	22,20%	3,10%
	6.1	6.1.2	1	4,80%	11,10%	1,50%
		6.1.3	6	28,60%	66,70%	9,20%
		6.2.1	2	9,50%	40%	3,10%
	6.2	6.2.2	2	9,50%	40%	3,10%
		6.2.3	1	4,80%	20%	1,50%
		6.3.1	4	19%	57,10%	6,20%
	6.3	6.3.2	2	9,50%	28,60%	3,10%
		6.3.3	1	4,80%	14,30%	1,50%
7			1	100%	100%	1,50%
8	8.1		3	100%	100%	4,50%
	8.2					
Zusammen			65			100,00%

Tab. 3

Typus	Form der Arbeitskante				
	0	1	2	3	4
1	1	1		1	2
2				1	2
3	5	4	3	9	
4	2	4	3	1	
5	1	1	1		
6	1	5	9	6	
7					
8	1				
Zahl	11	15	16	18	4
%	16,9	23,1	24,6	27,7	6,6

Basalt, Dolorit und andere Abarten der plutonischen und metamorphischen Felsgesteinen ausgenützt (Tab. 12).

Aus dem Vergleich der beiden Fundverbände der Felsteingeräte resultieren manche interessante Ergebnisse. Die fast dreifache Menge der Felssteingeräte in den drei oberen Wohnhorizonten der Starčevo-Kultur gegen über der Zahl dieser Fundgattung aus den unteren sieben Wohnhorizonten der Protostarčvo-Periode ist auch darauf zurückzuführen, daß alle Steinfunde von einem Bauhorizont in den nachfolgenden von den Bewohnern mitgenommen wurden. Man hat sogar die größeren Geröllsteine aus den Unterlagen der Öfen herausgenommen und in den neu gebauten Häusern wiederverwendet. Die steinerne Mörser wurden regelmäßig in die neuen Häuser mitgenommen. Die recht kurzen Dechsel und Beile sind als Folge der wiederholten Nachschärfung der beschädigten oder stumpfen Schneide zu betrachten. Die geschliffenen Felssteingeräte wurden also eine lange Zeit benutzt und ihre größere Menge in den oberen drei Horizonten ist auch darauf zurückzuführen, daß fast alle Häuser in diesen Wohnhorizonten verbrannten und ein Teil der Geräte konnte beim Verlassen der Tellsiedlung nicht mehr mitgenommen werden. Die langfristige Verwendung der Geräte und die sehr wahrscheinliche Möglichkeit, daß viele Geräte aus den unteren Wohnhorizonten in die oberen jüngeren überliefert wurden,

Tab. 4.

Typus	Winkel der Schneide											
	0	1	2	3	4	5	6	7	8	9	10	11
1									1			
2												
3			1			7		2	5	5	1	
4					1	3	1					
5									3			
6						4	3		10	3	1	
7												
8									1			
Zahl			1		1	14	4	2	20	8	2	1
%			1,5		1,5	21,4	6,2	3,1	30,8	12,3	3,1	1,5

Tab. 5

Typus	Gebrauchsspuren auf dem Arbeitsteil						
	0	1	2	3	4	5	6
1							5
2						3	
3		5	9	5	2		
4			2	4	1		
5			1	2			
6		5	5	5	6		
7							
8							
Zahl		10	18	16	9	3	5
%		15,4	27,7	24,6	13,8	4,6	7,7

Tab. 7

Typus	Zahl	%
Stößel	36	23,5
Schleifsteine	3	1,96
Dechsel	33	21,6
Meissel	18	11,8
Meissel-Keil	2	1,3
Beile	26	16,99
Halbfabrikate	4	2,6
Fragmente	29	18,95

Tab. 6

Kode	Rohstoffe	Zahl	%
1.1	Amorphe Silikate	2	3,1
1.1.1	Nephrit	3	4,6
1.1.2	Nephritabarten	4	6,2
1.1.3	Feine amorphe Silikate	2	3,1
1.2.1	Festigte Lehme	3	4,6
1.2.2	Silifizierte Sedimente	8	12,3
1.2.5	Sandiger Psammit	1	1,5
2	Plutonische Felssteine	1	1,5
2.1	Gabbro	5	7,7
2.2	Basalt	12	18,5
2.3	Diorit	3	4,6
2.4	Trachyt	1	1,5
3.1	Serpentinit	5	7,7
3.2	Quarz	9	13,8
3.3	Schwach metamorphierte Ablagerungen	2	3,1
3.4	Kristalliner Schiefer	1	1,5
4	Unbestimmbar	2	3,1
5	Fossilisierter Knochen	1	1,5

verursachen eine gewisse Unsicherheit bei der näheren Spezifizierung der Gesteingeräte aus beiden Funverbänden. In den oberen Tellschichten war es auch eine spätneolithische Besiedlung und manche Felssteingeräte könnten auch aus diesen unstratifizierten Schichten stammen. Es ist interessant, daß neben den recht zahlreichen Dechseln, Beilen und Meisseln nur wenige Fragmente und Absplisse gefunden wurden.

Auf den mehreren Dechseln und Beilen sind eindeutige Spuren nach dem Segen (Abb. 5: 1; 8: 4) erhalten. Klare Segenspuren sind auch auf dem beilenartigen Gegenstand, der aus dem oberen Teil des großen Nephritstückes abgesägt wurde.

Typologisch, technologisch, petrographisch und funktionell läßt sich der gesamte Fundverband in zwei Gruppen unterteilen: zahlreicher sind jene Geräte, die hauptsächlich zur Holzbearbeitung dienten, wie Dechsel, Beile und Meissel; zur zweiten Gruppe gehören vor allem die Stößel, die primär zum Zerkleinern der Materialien und Produkte in den Steinmörsern benutzt wurden. Abgesehen von den kleineren Stößeln aus reutilisierten Dechseln und Beilen für die Herstellung der echten Stößel wurden ganz andere Gesteine genommen als für die Dechsel und Beile. Die Stößel wurden aus gleichartigen Gesteine wie die Mahlsteine und Reibesteine sowie die Steinmörser hergestellt und sind als Bestandteil dieser Fundgruppe zu betrachten. Die Stößel aus der mit der Besiedlung in Gălăbnik gleichzeitigen Siedlung in Čavdar östlich von Sofia hat K. Kănchev (1981) in diese Fundgruppe aufgenommen.

Interessant ist der Vergleich der petrographischen Zusammensetzung der beiden Fundverbände von Gălăbnik. In der älteren Fundgruppe waren zahlreicher als in der jüngeren Artefakte aus Nephrit, silifizierten

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Tab. 8

Typus	Subtypus	Variante	Zahl	% von Typus	% von Subtypus	% von Fundverband
1	1.1					
	1.2		27	75%	100%	17,60%
	1.3		9	25%	100%	5,90%
2	2.1		3	100%	100%	2,00%
3	3.1	3.1.1	3	9,10%	27,30%	2,00%
		3.1.2	7	21,20%	58,30%	4,60%
		3.1.3	1	3,00%	9,10%	0,70%
	3.2	3.2.1	4	12,10%	23,50%	2,60%
		3.2.2	10	30,30%	58,80%	6,50%
		3.2.3	3	9,10%	17,60%	2,00%
	3.3	3.3.1	1	3,00%	25%	0,70%
		3.3.2	2	6,10%	50%	1,30%
		3.3.3	1	3,00%	25%	0,70%
4	4.1		2	11,10%	100%	1,30%
	4.2		11	61,10%	100%	7,20%
	4.3		4	22,20%	100%	2,60%
5	5.1		2	100%	100%	1,30%
	5.2			%	%	%
	5.3			%	%	%
6	6.1	6.1.1	4	15,40%	30,80%	2,60%
		6.1.2	2	7,70%	15,40%	1,30%
		6.1.3	7	26,90%	53,80%	4,60%
	6.2	6.2.1	8	30,80%	72,70%	5,20%
		6.2.2		%	%	%
		6.2.3	3	11,50%	27,30%	2,00%
	6.3	6.3.1	2	7,70%	100%	1,30%
		6.3.2		%	%	%
		6.3.3		%	%	%
7			4	100%	100%	2,60%
8	8.1		23	79%	100%	15,00%
	8.2		6	20,70%	100%	3,90%
Zusammen			153			98,94%

Tab. 9

Typus	Form der Arbeitskante				
	0	1	2	3	4
1	9				27
2					3
3	7	2	19	6	
4	4	1	5	8	
5				2	
6	6	1	14	5	
7					
8	5	2	1	7	1
Zahl	31	6	39	28	31
%	20,3	3,9	25,5	18,3	20,3

Sedimenten und aus Quarzit vertreten. In dem älteren Fundverband fand man 16 Arten von Gesteinen und in den jüngeren 22 Arten. Aus Nephrit wurde auch ein dreifacher Verteiler für eine lange Halskette aus Muscheln und Steinperlen gefunden. Eine Besonderheit stellt ein flacher beilartiger Gegenstand von fast 30cm Länge aus Nephrit dar. Erzeugnisse aus Nephrit und Jadeit, besonders die Beile und Dechsel werden auch aus den gleichzeitigen und verwandten Kulturgruppen in Makedonien als typisch erwähnt (Garašanin 1979, 99). Die neuen Rohstoffarten im Funverband Gălăbnik II-III bilden 41,3%. Auffallend hoch (9,2%) war der Zuwachs von Dechseln und Beilen aus Dolorit, der als neuer Rohstoff erst während der Starčevo-Kultur eingeführt wurde. Zugunsten von Dolorit ist der Basalt in dem jüngeren Fundverband um 3% zurückgegangen. Artefakte aus Quarzit sanken auf 2% gegenüber von 13,5%. Wesentlich angestiegen ist die Zahl der Erzeugnisse aus feinem Sandstein (13,1%). Als neu sind Artefakte aus Granit, Rhyolit, Porphyr und Andesit in der Menge von 1,3 bis 3,3%. Aus den letzt genannten Gesteine wurden hauptsächlich die Stößel hergestellt.

Beim Vorlegen der Felssteingeräte aus der neolithischen Tellsiedlung in Gălăbnik verzichten wir aus verschiedenen Ursachen auf den Versuch einer komplizierten Suche nach dem Ursprung der einzelnen Gesteinsarten. Wir möchten nur vermerken, daß in diesem Fundverband

Tab. 10

Typus	Winkel der Arbeitskante											
	0	1	2	3	4	5	6	7	8	9	10	11
1												
2												
3	1					1		6	11	8	6	1
4	2							2	6	5	1	2
5								1	1			
6	1						1	4	11	7	1	1
7												
8	15							3	6	1	2	2
Zahl	19					1	1	16	35	21	10	6
%	12,4					0,7	0,7	10,5	22,9	13,7	6,5	3,9

Tab. 11

Typus	Gebrauchsspuren						
	0	1	2	3	4	5	6
1							36
2						3	
3		6	4	10	14		
4		2	9	3	4		
5			1	1			
6		3	6	12	5		
7							
8		1	7	2	5	2	1
Zahl		12	27	28	28	5	37
%		7,8	17,6	18,3	18,3	3,3	24,2

Tab. 12

Kode	Rohstoffe	Zahl	%
1.1.2	Mannifaltige Nephrie	3	2
1.1.3	Feine amorphe Silikate	2	1,3
1.2	Echte sedimentierte Gesteine	5	3,3
1.2.1	Festigte Lehme	2	1,3
1.2.2	Silifizierter Tuff	7	4,6
1.2.3	Feiner Sandstein	20	13,1
1.2.4	Sandsteine	8	5,2
1.2.5	Sandiger Psammit	9	5,9
1.3.1	Kalkstein	1	0,7
2	Plutonische Gesteine	1	0,7
2.1	Gabbro	6	3,9
2.2	Basalt	24	15,7
2.3	Diorit	6	3,9
2.4	Trachyt	3	2
2.5	Dolorit	14	9,2
2.6	Granit	2	1,3
2.7	Rhyolith	5	3,3
2.8	Porphyr	4	2,6
2.9	Andesit	4	2,6
3.2	Quarz	3	2
3.3	Schwach metamorphierte Sedimenete	9	5,9
3.4	Kristalliner Schiefer	6	3,9
4	Unbestimmbar	2	1,3

keine Geräte aus amphibolithischen Schiefern, die in Mitteleuropa hauptsächlich für die Herstellung von Beilen und Dechseln Verwendung fanden, nicht einwandfrei festgestellt wurden. Es wäre auch interessant zu wissen, wasfür Gesteine für die Beile und Dechsel in der Poststarčevo-Periode auf dem Balkan ausgenützt wurden. Erst nach der Veröffentlichung von Funden der geschliffenen Felsteingeräte - samt ihrer petrographischen Bestimmung - aus den anderen frühneolithischen Siedlungen in Südosteuropa wird es möglich sein, über die Gewinnung und Verteilung der geeigneten Gesteinarten zu überlegen.

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Raw material types of groundstones from Çatalhöyük Neolithic site in Turkey

Asuman G. Türkmenoğlu[1], Adnan Baysal[2], Vedat Toprak[1] & M. Cemal Göncüoğlu[1]

[1]Middle East Technical University, Department of Geological Engineering, Ankara, Turkey
[2]University of Cambridge, Department of Archaeology, London, United Kingdom

Introduction

Çatalhöyük Neolithic Site is located near Çumra Village at the large Konya Plain of Interior Turkey (Fig.1). Since its discovery in 1950s, the excavations revealed its uniqueness as being the first urban center in the world at 7000BC which was occupied by thousands of people, in addition to the wealth of information coming from the findings on wall paintings, sculptures, textiles, ceramic artifacts, mud balls, stone artefacts and houses of a Neolithic village (Mellaard, 1975). So it has importance for the understanding of the development of Mediterranean societies. An international team, lead by Dr. Ian Hodder, from the University of Cambridge has been continuing excavations at the site in order to shed more light on the origin of site and its social and economic development (Catal News 6, 2000).

The surroundings of the Çatalhöyük site are drained by the Çarşamba River and its tributaries. The river forms meandering channels in the widespread alluvial deposits in Konya plain leaving some small remnant hills. The mountain slopes rises slowly at long distances away from the site. The Çatalhöyük site is divided into east and west mounds which are easily recognizable from distance since they rise from a low lying topographic surface.

During the excavations a lot of stone material and artefacts are collected, especially at the west mound. Among these groundstones indicate agricultural activities and food processing, and thus their presence and mobility/immobility may give valuable information about the social and economic life styles of the Çatalhöyük people. So, one of the major concerns is to find the geological sources of stone materials although the raw material sources seem to be scarce based to the geomorphological observations.

This study aims to investigate the provenance of the Çatalhöyük groundstones. Their petrographical properties are compared with the rock samples collected from the area surrounding the site in order to find their possible sources.

Geological Framework

Konya basin is a closed lacustrine basin surrounded by high mountains at the west, south and the east. It is separated from Tuz lake drainage area by a pass only 50 m. high at the north. It has a tectonic origin and appeared during Miocene times during the uplift of Taurus Mountains composing the southern drainage area of the basin. Rivers like the Çarşamba river, originate from a lake, flows downslope towards the Konya Plain. The sediment fill of the Konya plain is lime rich marls, enriched in clastic material importaed by rivers from the Taurus Mountains, and by slope processes from the limestone and volcanic reliefs. At present, the Konya Plain is a flat lying palaeolake bottom (Fig. 2), with the altitude of around 1000 m. Surrounding heights reach up to 1500 m. like Bozdağ (a limestone palaeorelief). Two stratovolcanoes, Karadağ and Karacadağ, are higher than 2000 m.

The oldest rocks in the area are slightly recrytallized limestones of Mesozoic age and ophiolithic rocks structurally overlying them. Calc-alkaline volcanic rocks of differing compositions and ages are more common and some of them are erosional remnants of volcanic necks. Karadađ Volcano of Pleistocene age is the major volcanic feature nearest to Çatalhöyük site. Karacadađ volcano has Pliocene age and is mainly andesitic. Near Karapinar, Upper Pleistocene strombolian basaltic cones and maar form a plateau. Most of the area is covered by limestones of Miocene age that expose at the northern slope of the Taurus Mountains forming the southern boundary of the Konya Plain (Karabiyikoğlu and Kuzucuoğlu, 1998).

Methods of Study

Geological investigations were carried out in a wide area around the Çatalhöyük site in order to collect samples from possible source rocks in the field. Samples were collected from igneous rocks and limestone outcrops. The Çarşamba river gravels were also sampled from the exposures of river deposits such as alluvial fans, stream ter-

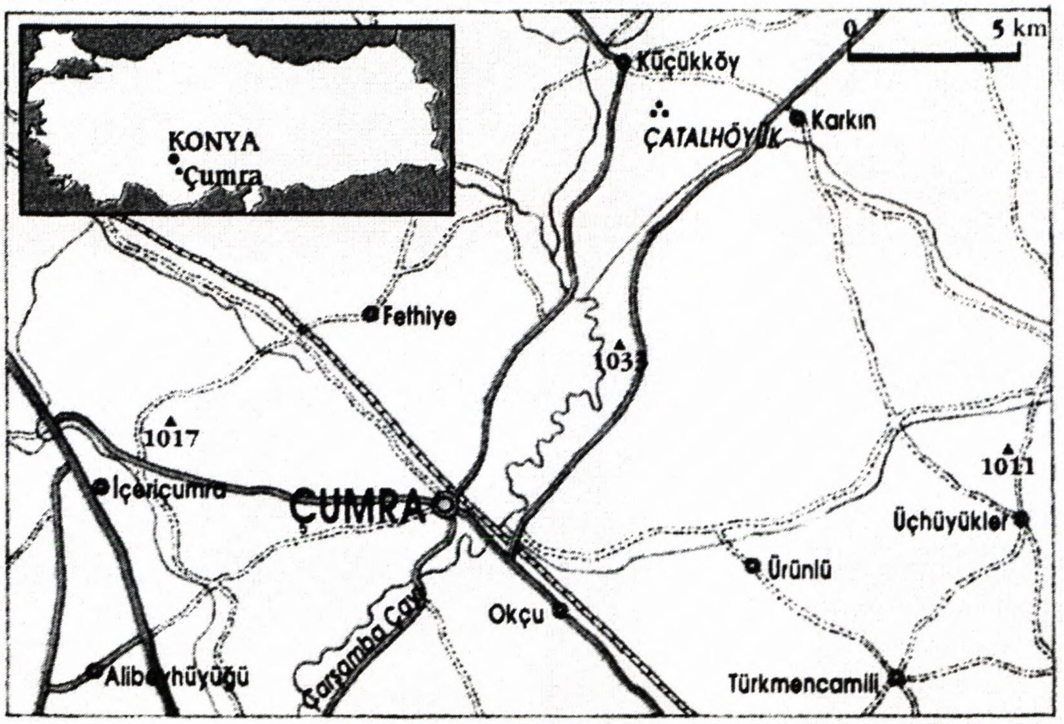

Fig. 1 Location map of the Çatalhöyük archaeological site

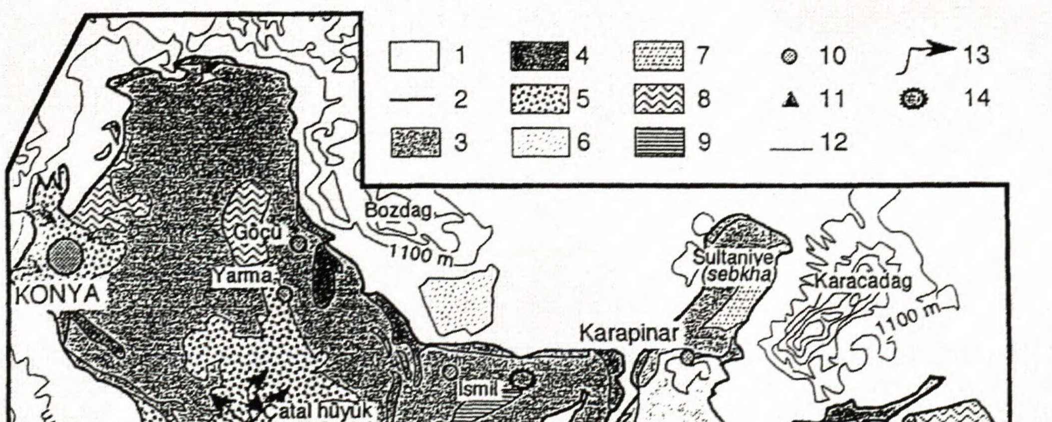

Fig. 2 Regional geologic map of the study area. 1. Prequaternary and Pleistocene limestones and volcanics, 2. Limit of the palaeolake Konya bottom, 3. Pleistocene palaeolake Konya, 4. Sand and gravel shore deposits, 5. Coarse material alluvial fans, 6. Dune systems, 7. Sabkha, 8. Marshes, 9. Lakes, 10. Towns and villages, 11. Neolithic site, 12. 400 m contour intervals, 13. Main river imput to the plain, 14. Swallow hole (Adapted from de Meester, 1970; and Roberts, 1983)

races and channel beds in order to detect the possible varieties of rock types transported by the river from far distances.

In addition to field samples 34 groundstones from the excavation site were selected for petrographic investigations in order to compare their petrographic characteristics for the provenance analysis. The thin sections of 49 samples were prepared and examined with a polarizing microscope to study their mineralogical compositions, textures and alteration products.

Results

The studied groundstones can be classified into volcanic, sedimentary and metamorphic rock types based on petrographic analysis. In comparison with the field samples correlations are done for provenance studies.

Among the volcanic varieties three subgroups are recognized as:

1) hornblende-andezite and hornblende-biotite andesite,
2) pyroxene basalt, and
3) dacite and dacitic andesite.

The groundstones of the first subgroup can be correlated with the field samples collected from Karadađ-Kaletepe location. They exhibit porphyritic texture with hornblende and plagioclase as the common phenocrysts. Hornblende crystals show brown and green pleochroism and they have opaque rims. Plagioclase crystals show zoning and twinning. In the groundmass plagioclase microliths are common and may be aligned. Calcitization and argillization are detected in plagioclase phenocrysts.

The groundstones of the second subgroup includes pyroxene and are defined as basalt or basaltic andesite. They have porphyritic texture with plagioclase and pyroxene phenocrysts. These minerals are also abundant in the groundmass as microliths. No matching is observed between these groundstones and field samples collected from volcanic outcrops.

In the third subgroup there is only one groundstone which is petrographically similar to those field samples obtained from Karadağ-Necktepe location at the faulted contact of volcanics with limestone. The volcanic rock is defined as dacitic andesite with quartz, hornblende and plagioclase phenocrysts. It is intensely altered to clay, hematite and calcite which is also typical for the groundstone belonging to this petrographic subgroup.

Groundstones from sedimentary raw material are also present in the Çatalhöyük site. They are white colored, massive looking micritic limestones which have similar petrographic features with the field samples collected at two locations. Chert is another variety of sedimentary groundstones. In the field , at two locations at the alluvial plain chert is also collected which is correlated with the groundstone. In the sediments of Çarşamba River gravels of siltstone, sandstone and conglomerate are present. However, no groundstones with equivalent pertographic characteristics of such gravels are identified.

Only nine of the groundstone samples belong to metamorphic group. Their raw material is low- grade metamorhic rocks which contains greenstones, metagranites and metasandstone and marble. No exposures of metamorphic rocks are present in close vicinity of the site. These type of groundstones are most probably collected from river sediments.

In conclusion, the groundstones from the Çatalhöyük Neolithic site have mainly volcanic sources of andesitic-basaltic nature. They may be locally collected from nearby outcrops close to the site. On the other hand, sedimentary and metamorphic varieties are less common, and are suggested to be obtained from the fluvial deposits of the Çarşamba river. They are very probably transported by the river from the Taurus mountainous.

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The distribution of axes in alpine metamorphic rocks (eclogites and jadeitites), in the central and southwest part of France

Frédéric Surmely[1], Alain de Goër de Herve[2], Danielle Santallier[3] & Claudio D' Amico[4]

[1]Service régional de l'archéologie – UMR 60424, rue Blaise Pascal 63000 Clermont-Ferrand –France
[2]UMR 6042 – France
[3]Université Claude Bernard, 27-43, Bd du 11 novembre – 69622 Villeurbanne cedex -France
[4]Dip. Scienze della Terra, Piazza San Donato, 1 40126 Bologna – Italy

Numerous studies, led for some years, have shown the very wide distribution of axes in alpine metamorphic stones in a big part of Europe. Attention was especially focused, in France, on the big axes, exceeding 15 cms in size. Most of them had a prestigious role for the populations.

We chose to study this phenomenon in a detailed way by means of an exhaustive inventory of all the artifacts of all sizes coming from several „counties" of the central and southwest part of France. The Charente and Charente-Maritime are two „counties" of the southwest of France, whereas the other places are mentioned in the centre of the country.

We set an exhaustive list of all the axes kept in public and private collections from the various „counties" involved. For some of them (Haute-Loire, Puy-de-Dôme), this task is almost finished, at least as far as public collections are concerned. Because of a large number of small private collections, it is very difficult to have a real idea of their importance. On the contrary, we still have axes to be inventoried in the museums of the other departments. So the present list of artifacts (1564 axes) we can give now is not a final one and will be completed after further studies.

The very big majority of axes were picked up on the ground, without precise archaeological context. So, a chronological study of imports is impossible.

Together with studies by simple visual exam, petrographical analysis in thin blades were made, as well as a study by spectroradiometry (M. Errera) for the „counties" of the Centre of France.

Our study is focused on eclogites and jadeitites. We voluntarily put aside the case of serpentinites, because it is so difficult to tell serpentinites of alpine origin from those of the French Central Massif.

The alpine metamorphic stones form a variable proportion within the groups of axes. Generally speaking the regions of the centre are richer in imported cliffs, maximum being reached(affected) in the Haute-Loire (23 % of axes are there eclogite alpine, 6 % in jadeitite) (Fig. 1). Going away eastward, proportions decrease quickly, but eclogite and jadeitite remain very present, in spite of the estrangement (more than 600 km separate Charente-Maritime of the potential shelters). One notices the important differences which can set is it and the West of the same county (Cantal) cut in two by a mountain massif.

Results

The alpine metamorphic cliffs form a variable proportion within the groups of axes. Generally speaking, the regions of the Centre are richer in imported rocks, the highest purcentage is reached in the Haute-Loire (there, 23 % of axes are alpine eclogite, 6 % jadeitite) (Fig. 1). When moving eastward, proportions decrease quickly but eclogites and jadeitites remain very present, although the Charente-Maritime is more than 600 km away from the potential deposits. One notices important differences between the West and the East of the same „county" (Cantal) cut in two by a mountain massif.

It looks as if axes must have bben carried away as finished tools. It is quite certain for some big ones with a typical shape that can be found in other regions of France (Fig. 2). It gives evidence of a standardized production on the very place where tools were made. Some small axes result from the transformation of initially bigger axes. It is difficult to know where this reshaping was made.

In the Centre of France, notably in the Haute-Loire, these alpine rocks were used, even when the same kind of rocks (eclogites of Velay) were present on the spot and could have been used. This phenomenon is another proof of the dynamism of the export of the alpine metamorphic rocks.

Generally speaking eclogites are more frequent than jadeitites. The geographic origin of eclogites is not quite clear yet, the eclogites forming the major part of the axes of the Centre of France would might come from Ligurie (Italy, Fig. 3).

Conclusion

The wide distribution of Italian metamorphic rocks shaped as axes illustrates the importance of the flows of traffic of raw materials all though the Neolithic. The quantity of products even leads us to think of the existence of real commercial currents. Of course, we have no idea of the products which may have been given in exchange by the populations receiving these axes. Ethnographical researchs made by P. Pétrequin in Papua-New Guinea show that they may can be of very different nature, including perishable or even immaterial products.

With the cooperation of Michel Errera.

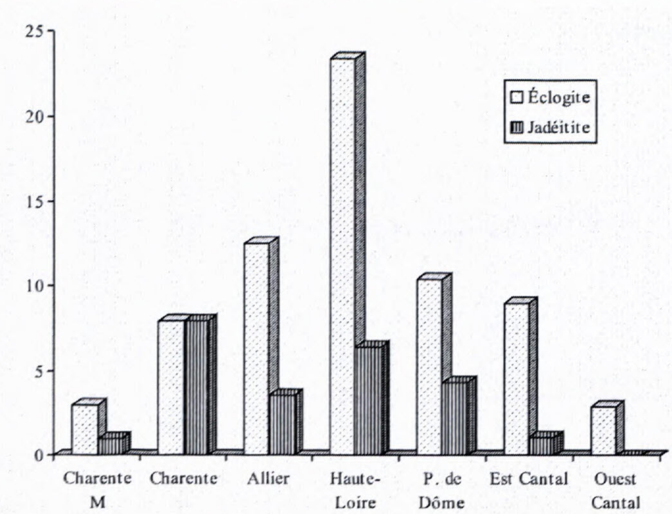

Fig. 1 Proportion of axes in alpine metamorphic stones (in % for every geographic sector)

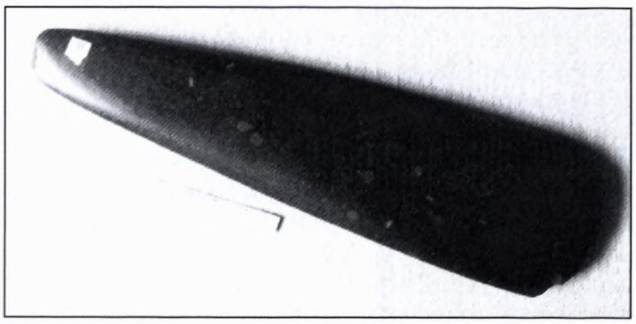

Fig. 2 Axe made of eclogite stone, 19 cm size, discovered on the site of Corent (Puy-de-Dôme). The polishing is remarkable.

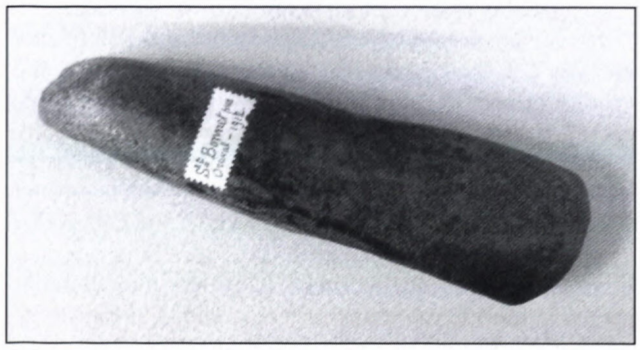

Fig. 3 Axe polished in éclogite alpine discovered(found) to Saint-Bonnet-Près-Orcival (Puy de Dôme, France). Collections of the Bargoin museum of Clermont-Ferrand. Photo F. Surmely

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Origin and sources of the neolithic raw materials in Croatia

MAJA PAUNOVIC

Croatian Academy of Sciences and Arts, Institute of Quaternary Paleontology and Geology,
HR-10000 ZAGREB, A. Kovacica 5/II, Croatia, e-mail: zpgk@hazu.hr

In studying the Neolithic of Croatia one should keep in mind that its territory is characterized by variety of composition: 1. about 1/3 of Croatia is of a striking plain character surrounded and interrupted by a belt of small hills and hills which separate them from the mountainous regions of the Alps in the west and Dinarides in the south-west; 2. the Dinarides are characterized by chain mountains of steep slopes with karst phenomena and deeply incised river valleys; 3. all stream waters belong to the catchment areas of the Black Sea (79 %) and Adriatic Sea (21 %), but the density of the river net is the smallest in karst regions. The stream waters in mountainous regions are of the greatest fall and energy, especially upper and middle parts of their catchment areas. Closely to the Pannonian basin, the falls suddenly decrease and rivers assume appearance of plain rivers.

Also, to understand the reasons of Neolithic raw material exploatation, the geology of Croatia must be considered in the context of wider area which is, thanks to its position in European part of the Alpine orogen, i.e. Mesozoic carbonate platform, characterized by a complicated geological composition. Paleogeographically and geotectonically, this area can be divided into two main parts: the External Dinarides (Adriaticum, Epiadriaticum and Dinaricum) composed of Mesozoic limestones and dolomites and the Internal Dinarides (Supradinaricum) consisting mainly of Mesozoic ophiolites and formations of the Tethyan active and continental margins (Herak 1986, Drobne & Trutin 1997). Its earliest evolutionary phases during the Alpine cycle were probably related to rifting processes which started in the Late Permian/Early Triassic (Pamić 1984).

Because Late Permian and Triassic magmatism produced basalts, andesites and dacites in extrusive level, and gabbro, diorite, granosyenite and granite in intrusive level, and because of the great diversity within the Dinarides (Jurkovic and Pamic 1999) the following magmatic groups are defined by different rock types (Fig. 1):

I - the dacite-quartz keratophyre (with subordinate andesite and basalt) magmatic group of Slovenia mainly included within the Sava nappe,

II - the basalt-spilite-andesite magmatic group of Gorski Kotar, Lika and Dalmatia,

III - the basalt-spilite magmatic group of Hrvatsko Zagorje and SE Slovenia: small group composed of basalts, largely transformed into spilites with some andesites associated with pyroclastic rocks,

IV - the basalt-spilite-andesite-keratophyre-quartz keratophyre magmatic group associated with gabbro, diorite and granosyenite of SW Middle Dinarides. The volcanics are accompanied by larger plutonic bodies in some places in association with numerous swarms of diabases. Middle Triassic volcanic-sedimentary formation is in this area represented with tuff, tuffite, tuffitic sandstone, iron-manganese schist, shale, chert, and volcanic rocks,

V - the andesite-keratophyre-quartz keratophyre magmatic group with subordinate diorite and granosyenite of SE Bosnia and N Montenegro,

VI - the basalt-spilite magmatic group of SE and Central Bosnia.

At the same time, metamorphic rocks of this area (Central Dinaride Ophiolite Belt = CDOB) are represented by low-grade metamorphism, or by lower part of greenschist facies and by higher or high-pressure metamorphism: phyllites, chloritoid schists, chlorite schists, greenschists, calcschists, metapsamites, quartz micaschists, eclogites etc (Majer et al. 1993). The ophiolite belt contains also the greatest masses of spinel lherzolites known by now in the world (Garašić & Majer, 1993), while alkali amphibole bearing metamorphic rocks (blueschists) are mostly encountered in the collision area between Dinarides and bordered geotectonic units of the Pannonian basin, and only a few occurences are connected with the ophiolite belt (Majer & Lugović 1991).

Thus, because among neolithic tools found at Croatian sites most common are diabases, gabbros, amphibolites, quarz, quarzite, chert, etc., sporadically nephrite, obsidian, jasper, jadeite and opal (Benac 1979), with exception of obsidian (origin: ?Italy) and jadeite (origin: ?Italy or ?Macedonia), the raw materials are autochtonous and not imported. Namely, regarding the mentioned geological and geographical but also archaeological characteristics of the area, the sources of raw materials in Croatia are prevailingly formations which occur as raised eroded cores of megastructures represented by high christalline schists (two-mica gneisses, amphibolites and micaschists) encountered below a thick cover of the Tertiary and Quaternary sediments in Pannonian basin as well as the magmatic group of Hrvatsko Zagorje. Also the raw materials are brought by water courses rich in pebbles and rocks (Soča, Sava, Drava, Una, Bosna, Neretva etc.) directly from outcorps of volcanic and metamorphic rocks partly of Slovenia and partly of Bosnia, or maybe Serbia and Montenegro. Namely, the main

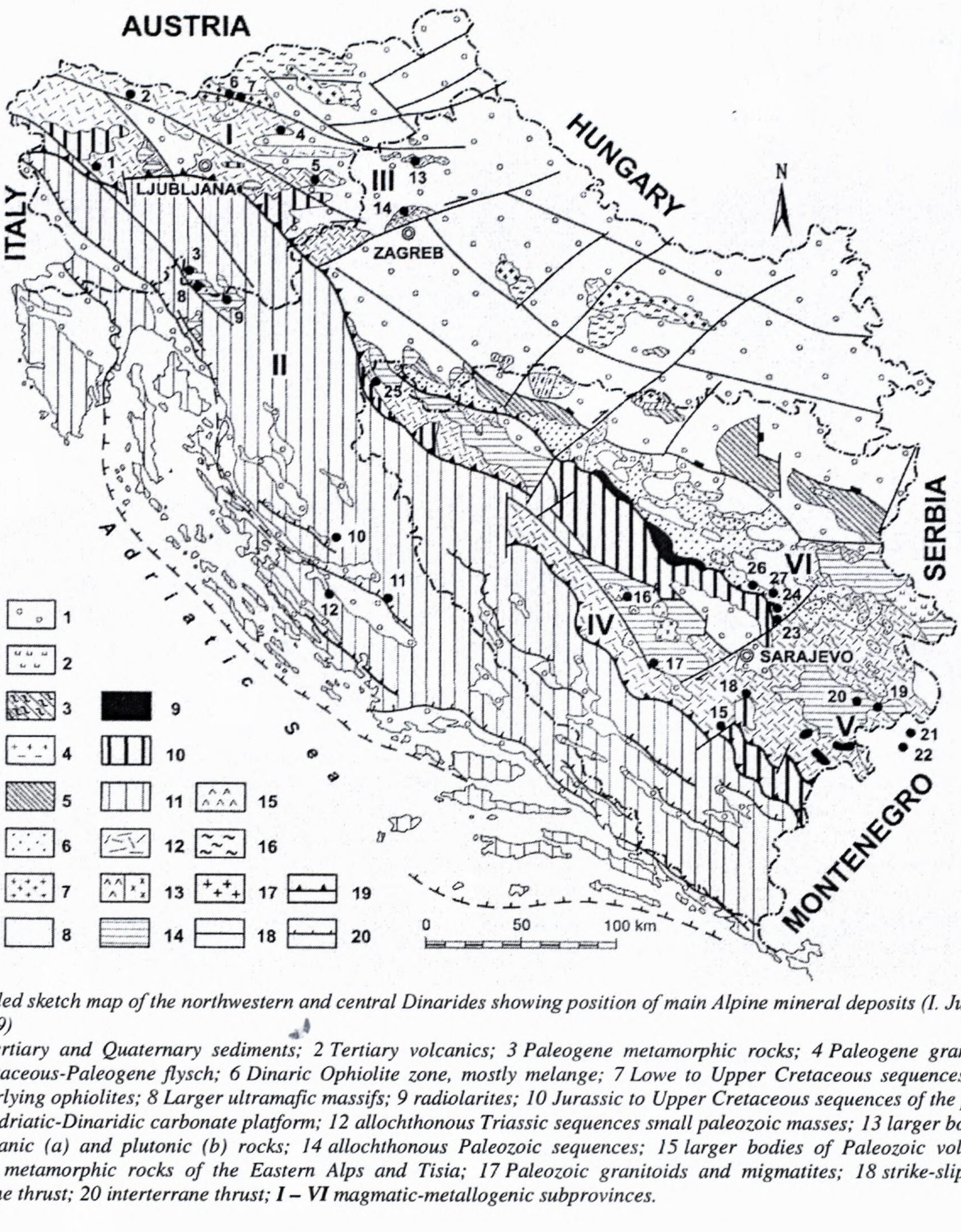

Fig. 1 Compiled sketch map of the northwestern and central Dinarides showing position of main Alpine mineral deposits (I. Jurković, J. Pamić 1999)

Legend: 1 Tertiary and Quaternary sediments; 2 Tertiary volcanics; 3 Paleogene metamorphic rocks; 4 Paleogene granitoids; 5 Upper Cretaceous-Paleogene flysch; 6 Dinaric Ophiolite zone, mostly melange; 7 Lowe to Upper Cretaceous sequences uncoformably overlying ophiolites; 8 Larger ultramafic massifs; 9 radiolarites; 10 Jurassic to Upper Cretaceous sequences of the passive massifs; 11 Adriatic-Dinaridic carbonate platform; 12 allochthonous Triassic sequences small paleozoic masses; 13 larger bodies of Triassic volcanic (a) and plutonic (b) rocks; 14 allochthonous Paleozoic sequences; 15 larger bodies of Paleozoic volcanics; 16 Paleozoic metamorphic rocks of the Eastern Alps and Tisia; 17 Paleozoic granitoids and migmatites; 18 strike-slip fault; 19 interterrane thrust; 20 interterrane thrust; ***I – VI*** *magmatic-metallogenic subprovinces.*

characteristic of the neolithic settlements in Croatia is its position along the interfluvial regions on elevated river banks or on natural rises near streams, small rivers and marshes. Thus, depending on all natural sources, the neolithic population in each specific region used the raw material found in vicinity of the settlement without long distance search. At the same time, the tools made from the rare raw materials, such as obsidian or jadeite, probably represent luxury items or presents occasionally imported in limited quantity along the trading or migrating routes.

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The neolithic axe workshops of eclogites and jadeitites in the french Alps and Prealps and their role in the network of exchanges in the Rhône basin

ERIC THIRAULT

Associated Member UMR 5594 du CNRS, Centre d'Archéologie Préhistorique de Valence, 4, place des Ormeaux, 26000 Valence-sur-Rhône, France, e-mail : cap.valence@wanadoo.fr

Presentation

Most of the studies loaded on the axe blades in western Europe consist esentially in petrographic caracterizations and the research of the stone sources; but the social consequences of the diffusions revealed by this methods are still poorly studied (Ricq-de Bouard 1996 ; Le Roux 1999). With an archaeological point of view, this basic stage of work (petrography) have to be overtaken if we want to understand the relationships between the diffusions of goods (i.e. axe blades) and the social operations of the neolithic communities. For this, we have to integrate the whole archaeological informations, from the production processes to the contextual facts (Bradley et Edmonds 1993 ; Jeudy *et al.* 1995). We've done such a work in a doctoral thesis just finished at the University of Lyon II in France, with the case of the western Alps and the Rhône basin[1] (Thirault 2001).

The alpine (in the geological meaning) metamorphic stones, wich are shown to the surface in the western Alps and in the Voltri Group in Liguria, present a very important stock of tenacious rocks broadly used during the Neolithic. This has been demonstrated by the studies realised in Provence, Languedoc and Piedmont by M. Ricq-de Bouard (Compagnoni *et al.* 1995; Ricq-de Bouard 1996), and in North Italy by Cl. D'Amico (D'Amico *et al.* 1995, 1998). The highly used stones are the high metamorphic metabasites (high pression/low temperature) and not or not much retromorphosed: glaucophanites, jadeitites and most frequent, the eclogites and other pyroxenites. The eclogites are broadly diffused in North Italy and in Provence but the production modalities are still not well known.

In the french Alps and in the Rhône basin, the first researches have been drived by us since 1996, in close collaboration with Danielle Santallier, pétrograph et Ruben Véra, cristallograph (University Lyon I). The main result is the demonstration of the supremacy of the alpine eclogites until the river Rhône : 75 % minimum of the axe blades (Thirault *et al.* 1999). Here, we'll gather together under the single word of "alpine eclogites" not only the true eclogites (sodic pyroxene + garnet) but also the pyroxenites (onfacitites and jadeitites) wich sometimes contain few garnets (Thirault *et al.* 1999; Thirault to publish).

The eclogite axe blades are manufactured and diffused from precise workshops. Inside and arround the ligurian and piedmontese Appenines, important productions are known on the sites of Monte Savino at Sasselo (Garibaldi *et al.* 1996b), Brignano Frascata (D'Amico et Starnini 1996; Zamagni 1996b), Rivanazzano (Mannoni *et al.* 1996) and Alba (Venturino Gambari et Zamagni 1996). In the western Alps, workshops are known in Piedmont (Rocca di Cavour near the Val Pellice; Zamagni 1996a), and other are still unpublished at this date. We would like to present here the whole list of this particuliar sites and then try to explain shortly their role in the diffusion system of the eclogite axe blades on the west side of the Alps.

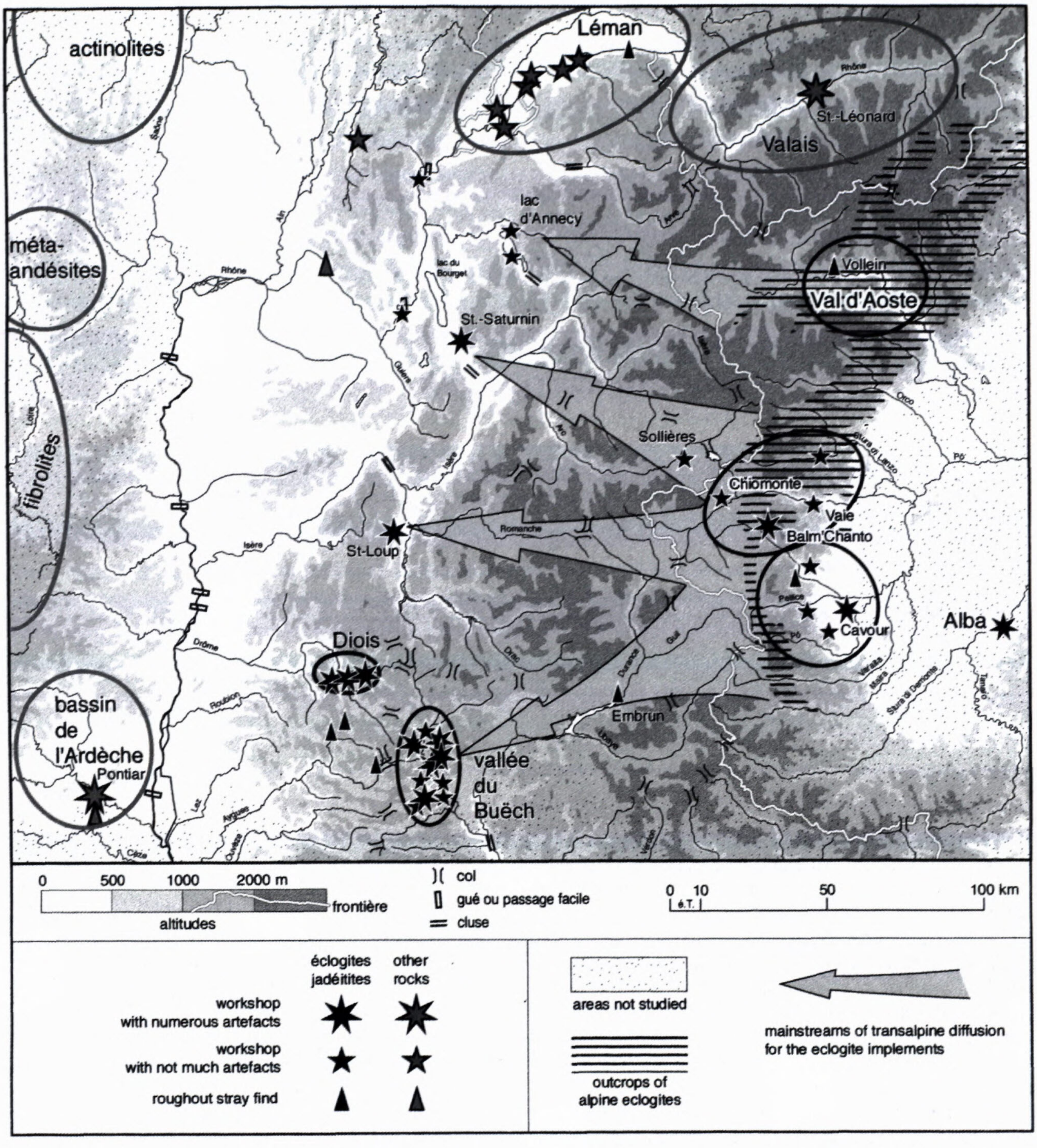
The eclogites axe blades workshops in the western Alps

For the archaeological caracterization of this sites, we have taken care to all the technical artefacts linked to the production of an axe blade: roughouts more or less elaborated, broken or not during flaking, pecking or polishing ; flakes, whetstones, hammers. Then we've mapped the sites and the stray finds where this artefacts are attested, with care to the petrography of the implements. Then a strong spatial structuration of the production appears (map).

Our subject, the alpine eclogites, are manufactured on several sites, but the production areas are concentrated in three regions.

• In the westen Alps, a number of neolithic sites and stray finds more or less known, are established in front of the valleys (Rocca di Cavour: Zamagni 1996a), in the lower valleys (riparo Rumiano at Vaie: Bertone and Fozzati 1998) or in the mountains (Balm'Chanto at Roreto: Nisbet and Biagi dir. 1987), where the eclogites are worked. But all this sites are not immediately located on the outcrops. There is then a rock carrying on variable distances, not more than 30 km from the outcrops. The extraction sites are still unknown at this date, as we know, but the location of some old-known sites near by the outcrops permit to think that the raw materials are taken on the outcrops or on great morainic blocks.

• In the internal french Alps, the general documentation about the Neolithic remains poor but the few sites



excavated in Savoie show that eclogite roughouts circulate through the mountains: Les Balmes at Sollieres in Haute-Maurienne, and Les Moulins-Chenęts de Pierre at Bozel in Tarentaise (excavation and study in progress).

• In the Prealps, we have revealed the existence of numerous eclogite workshops located as far as 100 to 140 km from the piedmontese stone sources. This fact seems to be unique. The artefacts yet preserved in the old collections or collected by private people demonstrates on the sites the manufacturing of the alpine eclogites: sometimes flaking but essentially pecking and polishing. This sites are located in precise areas and form sometimes groups. From south to north, we have recognized:

- an important group in the Bu'ch valley (river tributary to the Durance) and in the next lower small valleys (département des Hautes-Alpes). There is yet 16 sites and 12 points of stray finds identified with sometimes numerous polished artefacts, and anyway, proof the the manufacturing, on the districts of Sigottier (Le Forest, La Plaine), Le Bersac (Serre-Muret), Savournon, Orpierre (Tarrin, Ladrech), Sainte-Colombe and Tresclėoux. The main rocks worked are the eclogites but some roughouts on glaucophanite pebbles coming from the Durance deposits are also identified.

- the confluence plain between the rivers Drôme and Bez, near by Die (département de la Drôme). Three main

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sites can be distinguished: Les Terres Blanches at Menglon, known from the beginning of the XXth century, and two others recently discovered on Recoubeau: Les Clapiers and Vallieu.

- at the south of Grenoble (Isère), the site of Saint-Loup at Vif on a top-mountain is also an eclogite wokshop.

- near by Chambéry and the Bourget lake, the great site of Saint-Saturnin at Saint-Alban-Leysse as given numerous polished artefacts in eclogites. Some of them are certainly roughouts and hammers.

Datation and interpretation

We have seen that the manufacturing of the axe blades in eclogites is realised only on precise areas, without respect with the outcrops. In Piedmont as well as in Liguria, the location of workshops near by the eclogites sources isn't a surprise. But in the french internal Alps and in the Prealps, the presence of numerous workshops is more surprising, and demonstrate that roughouts sometimes not much elaborated are diffused. The concentrations of sites, especially in the Diois and the Buëch valley, indicates that this roughouts diffusions and generally speaking the whole axe production in eclogite is strongly controlled and cannot be realised anywhere. The precise location of them, on visual or physical controll position of the striking points of the landscape (top-hills, confluences between rivers, passages between high reliefs, ...), indicate also the importance of the long-way itineraries through the western Alps. There is really, for the alpine eclogites, a wish of structuration of the production and the diffusion of the roughouts and the axe blades. This structuration is developped on more than 150 km through the mountains and the valleys.

The datation of this workshops isn't always easy, especially for the old collections and the surface gatherings. We have partially resolved this problem by seriations and by technological examination on the artefacts. At least, the oldest worshops are not located in the Alps but linked to the Voltri Group. The oldest sites for the western Alps could be dated from the initial phases of the *Neolitico medio*, linked to the *Vasi a Bocca Quadratta Culture* establishments in the piedmontese valleys and in Val d'Aoste. At this time, we don't have yet the proof of eclogites axe productions on the french Alps, although the diffusions of eclogite axes are known. On the opposite, during the more recent stages of the Neolithic (*Néolithique moyen II/Neolitico recente*), many sites linked to the *Chasséen Culture* are occupied in the Bu'ch valley and the Diois. Some of this prealpine workshops are still active during the *Néolithique final/Chalcolithique*.

If we oversimplify the problem, we can recognize a break between the old and recent stages of the *Néolithique moyen*, according to the french terminology. During the *Néolithique moyen II*, the areas of eclogite manufacturing extend broadly in the western side of the Alps. This expansion is still hard to explain, but is in continuity with the long-time transalpine exchanges. Anyway, it is also linked to the great diffusions of eclogite axe blades west to the Rhône basin: the departure point of the finished artefacts, during the *Néolithique moyen II*, isn't the Piedmont or Liguria but the french Prealps. At this time, the western Alps in the whole are concerned by the manufacturing of the eclogite axe blades. The long-distances diffusions identified in Burgondy, Central Massif and Languedoc are linked to this topple of the workshops from the east to the west side of the western Alps.

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The polished stone axes workshop of Rivanazzano (PV-Northern Italy): analyses of the lithological diversities in comparison with other Italian Neolithic sites

CLAUDIO D'AMICO[1] & ELISABETTA STARNINI[2]

[1]Dipartimento di Scienze della Terra e Geologico – Ambientali, Università di Bologna, Piazza San Donato 1, I 40126 Bologna, e-mail: damico@geomin.unibo.it
[2]Dipartimento di Archeologia e Filologia Classica, Sezione di Archeologia, Università di Genova, Via Balbi 4, 16126 – Genova, e-mail: starnini@lettere.unige.it

The authors present the results of archaeometrical analyses conducted on a large sample (182 specimens) of stone artefacts collected in the polished stone tools workshop of Rivanazzano, near Pavia (North-western Italy). The site lies on the foothills of the northern side of the Ligurian Apennine, on a terrace along the river Staffora. Here, more then 400 artefacts have been collected on the surface, consisting of hammerstones, and by- products, fragmentary wastes, flakes and rough-outs resulting from the manufacture of adzes, axes and chisels, proving the existence of one important production site of polished, cutting edged tools which can be dated to the Neolithic period. Petrographical investigations were carried out with the aim of understanding the pattern of exploitation of the stone resources and their possible provenance (D'Amico et alii, in press). The sample for the petrographical analyses was selected according to two methods. The first consists of a random sampling of 90 artefacts, the second of 92 samples collected according to macroscopical differences noticed in the rocks. The cumulative result shows a predominance of eclogites, followed, in order of importance, by glaucophane schists, jades and others HP metaophiolites. The occurrence of jades is surprisingly low, in comparison to the usual pattern observed in other sites of Northern Italy (D'Amico-Starnini, 2000), whilst that of glaucophane schists is, on the contrary, very high. This can be perhaps explained because of the different character of the site, which is a workshop of primary production, where the finished tools are lacking, contrary to settlements, from which only finished and used tools have been usually analysed.

Finally, all the lithotypes present at the site can be considered of local provenance, collected as pebbles among the alluvial deposits of the Oligocene period, naturally enriched of such rocks, which are the results of the erosion of the primary formations of the Voltri Group.

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Magnetic properties of Lower Silesian serpentinites and some serpentinite artefacts from SW Poland and Moravia

ANTONÍN PŘICHYSTAL[1] & PIOTR GUNIA[2]

[1]Department of Geology and Paleontology, Faculty of Science, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic, e-mail: prichy@sci.muni.cz
[2]University of Wroclaw, Institute of Geological Sciences, Mineralogy and Petrology Dept., Pl. M. Borna 9, PL – 50 204 Wroclaw, Poland, e-mail: guniap@ing.uni.wroc.pl

Serpentinites represented very popular stone raw materials for perforated polished artefacts in the Aeneolithic. According to investigation of Přichystal – Šebela (1992), they prevail among battle-axes of the Corded Ware Culture in Moravia and the Czech part of Upper Silesia (113 artefacts out of 416 pieces, i. e. 27 %). A detailed petrographical description of the used serpentinites was performed by Přichystal (1999). Almost always the battle-axes are conspicuously patinated, so that their surface has a greenish white-grey colour (more rarely there appears a pinkish or bluish shade). On a fresh fracture, the rock is dark green, rarely with a watery green transparent layer on the edges. On the patinated surface, secondary brownish spots can be observed and dark discontinuous veins, schliers and spots. The structure is prevailingly massive, the arrangement of dark schliers and spots sometimes indicates a preferable orientation. In several cases the occurrence of chrysotile veins was found whose thickness did not exceed 1-2 mm. In thin sections, usually aphanitic rocks have a lepidoblastic texture with predominance of colourless to yellowish or greenish tegular antigorite. Further significant mineral of this mineralogical group, chrysotile occurs on thin veins usually together with carbonate that sometimes completely represents it. In addition to them it is possible to observe relics of dark minerals, probably pyroxenes, on which the original cleavage faces are followed by opaque magnetite. These relics are often filled with carbonate. Also large xenomorphic crystals were found or aggregates of magnetite in whose central parts crimson-brown isotropic granules with a rough surface appear, chrome spinels. The rocks were petrographically marked as antigorite serpentinites with carbonate.

A comparison with serpentinite occurrences in geological units at the eastern margin of the Bohemian Massif (the Brno Pluton, Moldanubicum, Moravicum, Silesicum) has shown there are no such serpentinites there. On the other hand, an accumulation of serpentinite battle-axes of the Ślęża type linked with the Corded Ware Culture has been described from SW Poland, between the town of Wrocław and Czech/Poland state frontier. The raw material of perforated battle-axes of the Ślęża type in Lower Silesia is believed to have its source in the Gogolów - Jordanów Massif near the Ślęża Mts. (Majerowicz in Wojciechowski 1983, Majerowicz et al. 2000). This assumption is also supported by archaeological investigation of Wojciechowski (1988) who described an Aeneolithic mining of serpentinites at Jańska Gora (eastern part of the Gogolów - Jordanów Massif). On the basis of all macroscopic and microscopic properties, the raw material of serpentinite battle-axes in Moravia and the Czech part of Silesia comes predominantly from the Gogolów - Jordanów Massif as well. Hence, frequent finds of the serpentinite Corded Ware battle-axes in central Moravia were transported very probably along the Odra river and than through the valley of Moravian Gate at a distance of about 200 km.

Besides the Gogolów – Jordanów Massif there are further two massifs of serpentinites (the Braszowice – Brzeźnica Massif, the Szklary Massif) and a few small lentil-shaped serpentinite bodies at the NE part of the Bohemian Massif in Poland. Some of them are believed to be possible sources for Neolithic – Aeneolithic artefacts as well (Majerowicz et al. 2000). Using portable kappameter KT-5 we studied magnetic susceptibility of serpentinite artefacts in Poland and we compared them with magnetic susceptibility of serpentinites at some important outcrops. The following table shows results of measurement at outcrops.

Magnetic susceptibility measurement of serpentinite polished artefacts connected with the Lengyel cultural complex (LgCC, samples deposited at the Department of Archaeology, University of Wroclaw) or with the Corded Ware Culture (CWC, Museum in Sobótka) have shown two basic groups of values:

a) 44,7 - 53,7 x 10^{-3} SI (Ksiegienica, the Lubin District, LgCC), 53,8 - 59,4 x 10^{-3} SI (Lukowice Brzeskie, the Brzeg District, LgCC), 56,6 - 58,8 x 10^{-3} SI (Okulice, CWC), 49 - 60,1 x 10^{-3} SI (Ksiegienia Wielkie, CWC) - these data can be well compared with the serpentinite from Jordanów quarry (eastern part of the Gogolów - Jordanów Massif).

b) 33 - 36 x 10^{-3} SI (Gniechowice, the Wroclaw District, LgCC), 32,4 - 39,6 x 10^{-3} SI (Psary, the Trebnica District, LgCC), 31,5 - 41,2 x 10^{-3} SI (Polska Cerekiew, the Kozle District, LgCC) - they correspond partly to the

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Tab. 1 Magnetic susceptibility of Lower Silesian serpentinites.

Locality	Number of measure-ments	Average value (x 10^{-3} SI units)	Dispersion (x 10^{-3} SI units)
Jordanów	6	54,7	40,3 - 64,9
Trzebnik	7	25	17,4 - 28,7
Gilów	13	109,4	82,7 - 114
Szklary A	8	19,9	11,6 - 36,7
Szklary B	7	21,1	14 - 29,1
Szklary C	6	28,3	21,2 - 33,9
Braszowice A	8	42,7	24,5 - 65,3
Braszowice B	5	42,6	30,9 - 50,8
Braszowice C	6	41,9	33,4 - 51,3
Bystrzyca Górna A	7	61,3	38 - 92
Bystrzyca Górna B	6	68,2	57 - 74,6

The Gogolów – Jordanów Massif: Jordanów, Trzebnik. Gilów – mylonitized serpentinite in the Niemcza Zone. The Szklary Massif : A – Kozmicky hill, B – Tomicky hill, C – Siodlowa hill. The Braszowice – Brzeźnica Massif: A – north of Grochowice hill, B – between Grochowice and Mnich hill, C – Mikolajevo. Bystrzyca Górna - serpentinite body in the Sowie Góry Block.

Braszowice Massif but we can not exclude another locality in the Gogolów - Jordanów Massif (hand specimens from Jańska Góra have magnetic susceptibility around 30 x 10^{-3} SI).

Our results show the determination of magnetic susceptibility as a non-destructive method can help significantly together with study of thin sections for solution of serpentinite polished artefact provenance.

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Contact-thermic hornfelses: seldom stone raw material type of the lengyel culture implements (site Svodín, central Slovakia)

DUŠAN HOVORKA[1], ĽUDMILA ILLÁŠOVÁ[2] & JÁN SPIŠIAK[3]

[1]Faculty of Natural Sciences, Comenius University, 842 15 Bratislava, Mlynská dolina-G, Slovak Republic
[2]Faculty of Natural Sciences, University of Konstantin the Philosopher, Nitra, Slovak Republic
[3]Geological Institute, Slovak Academy of Sciences, Severná 5, 974 01 Banská Bystrica, Slovak Republic

During last several years the number of characterized raw material types used in the Neolithic/Aeneolithic on the territory of the Slovak Republic for tools/weapons and decorative/ornamental/symbolic stone implements as well as the bases, crushers ao. construction has significantly increased. It is the result of concentrated effort of several authors. The present-day knowledge is synthetised in paper by Hovorka and Illášová (2000), which represents some of results of the national scientific projects.

Among the raw material types used for the above mentioned main categories of implements construction, those of very local, distant and very distant and/or unknown occurrences of given sources were described as well (l. c.). The use of the raw material of described type used ny the Neolithic/Aeneolithic communities, has not been known till now in the central European room.

Contact-thermic hornfelses we have documented from the site Svodín (approx. 30 kms to the SE of town Nitra), which represents one of the hugest settlements of the lengyel culture people. Systematic archaelogical excavations of the given site were carried out by Němejcová-Pavúková in the past (1971-1983). Mentioned author published (1995) problematic of roundels and determined there four cultural-typological horizons. In more than 150 skeletal graves rich inventory namely of polished stone implements have been collected. Implements of chipped type from the discussed site were studied and publishefd (with contribution by Němejcová-Pavúková) by Kaczanowska and Kozlowski (1991).

In the set of polished stone implements we have found four small (up to 6 cms long) completely preserved, flat, non bored axes of ash-gray color of identical morphology (shape) made of just the same raw material type. On polishesd surfaces of axes slightly developed lighter irregular "fields" are observable. By naked eyes observation the raw material type used generally appears as submicroscopically grained, generally aphanitic, extremely hard. On surfaces none products of weathering are observable. Surfaces are fresh-looking, shiny.

For identification of the raw material under consideration we used thin sections for polarizing microscope study as well as polished thin sections studied by means of electron microprobe. Composition of substantial phases of individual axes is presented in paper by Hovorka et al. (in print).

Thin sections image of the discussed stone raw material type is simple. Given rock is composed of two main phases: clinopyroxenes and plagioclases. Characteristic is their very fine-grained (less than 0,1 mm diameter) nature. In detail spatial distribution of the Cpx and Plg is uneven - the rock under consideration has spotty character. Individual spots have no sharp delimitations. In thin sections studied generally clinopyroxenes prevail over plagioclases (60 vs. 40 per cents). Except of clinopyroxenes and plagioclases in accessory amount we have identified apatite, titanite and pyrite.

Thin sections and microprobe studies should be summed up in the following. The dominant mineral in given rock type is clinopyroxene of diopsidic composition (following classification of pyroxenes proposed by Morimoto et al. 1988). They bear of nonzonal, or in places slightly zonal chemical composition. In studied set of thin sections in few of them we have found two generations of clinopyroxenes: the first generation forms even grained massive matrix (together with plagioclases) of the studied rock. The younger one is present in the form of thin (0,X mm) veinlets filled up by clinopyroxene of the younger generation. Clinopyroxene aggregates filling up mentioned veilets represent product of mobilization of the given rock mineral association due to latemagmatic/postmagmatic fluid activity. Cpx II is significantly greater (up to 0,3 mm) in places forming fan-like aggregates. The limits of such clinopyroxene veinlets are not sharp. Optical properties of Cpx I and Cpx II are comparable.

Plagioclase crystals are distributed within prevailing clinopyroxene aggregate, or they are present in the form of of irregular nests. They are mostly of fresh, nonzonal and non twinned appearance. Their anorthite content is high, reaching An 85. In association with An high plagioclases, clinopyroxenes with highest Mg content are documented.

After realisation of above specified laboratory studies we conclude the problematic as follows:

a) all 4 aves has more-or-less identical shape, size, and are made from the just same raw material type, the most probably from one rock-block,

b) the raw material of the given axes originated by metamorphic recrystallization, the most probably of volcaniclastic rocks of basic volcanics with an admixture of carbonate material (increased CaO content),

c) based on above statement we suppose elaboration of discussed axes just on the place of their discovery, e. g. in site Svodín,

d) raw material of discussed 4 axes from the petrological point of view belongs to the category of contact-thermic hornfelses originating in the internal part of the contact-thermic aureole (or within xenolith) of rock of appropriate composition within lava flow (or subvolcanic body),

e) huge complexes of Late Tertiary volcanics of the central Slovakian province we consider to be the geological unit of the contact-thermic hornfelses origin,

f) mentioned rock type has not been described yet in geological literature in the country,

g) keeping in mind possible way of origin of the raw material type it is possible to consider a block of contact thermic hornfels as block to be fallen out of the surrounding volcanic rock environment. The river Hron valley seems to be the most probable place of the raw material find by the lengyel culture people occupying site Svodín,

h) based on above aspects we consider transport of raw material block on "a distance of one or several days walk".

Taking into account the presence of lengyel culture axe found on the site Svodín made from the atol-like almandine + clinopyroxene eclogitic rock the given site also from the point of raw materials used in the Neolithic belongs to the unique ones. Such characterization is based on occurrences of axes made from two contrast raw material types: high pressure eclogitic rocks on one side and high-temperature contact-thermic hornfelses on the other one.

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Towards a comprehensive project webpage for IGCP-442

KATALIN T. BIRÓ

Hungarian National Museum, H-1088 Bp. Múzeum krt. 14-16, Budapest, Hungary

IGCP-442, as you all know, was put forward by D. Hovorka on the Budapest Archaeometry meeting in 1998. Soon after the idea raised, the project was accepted by UNESCO as a Europe-wide international collaboration project between geologists, archaeologists, mineralogists etc. After launching the project in June 1999, a dedicated web-page was set and by the time of the 2nd workshop at Veszprém, the web-paged (http://www.ace.hu/igcp442) was functioning.

It is difficult to get an estimate how much a project web page is used by members and non-members, and how much impact it has on the subject in general.

At the same time I am convinced that we are far beyond the potentials for using a project web page to the advantage of the subject.

This opinion was corroborated when, doing some research on the special subject of radiolarite research I hit against some other most informative and useful web-pages that can serve as models. I was, in fact, trying to locate Jurassic Thetian sediments which, as generally known have abundant radiolarite excessively used for the production of chipped stone tools is prehistory. It may be noted that some polished stone tools were also made of this material though more an exception than a rule (e.g., Mecsek radiolarite – Zengővárkony, Transdanubian radiolarite, porcelanite phase – Városlőd, Szentgál Lengyel sites). This way I came across http://www-sst.unil.ch/igcp_369/igcp 369_areas.htm, where I could get direct and on-line help on the subject[1].

In preparing the text of this paper, I did some websurfing to find out about IGCP project related web pages, their availability and contents. For a fast reference, the main titles are enclosed here (Table 1.) and also available as „links" on our project web page.

It was also raised on the Eggenburg meeting that our project could also produce a fast reference material for all participants and people interested in general in polished stone artefact research. To tell the truth, I did not receive so far any applicable material from project participants, so I decided to go ahead with an example, to be criticised and completed by all of us.

I am aware of certain aversions to electronical publication which may be founded to some extent:

– IPR problems
– ephemeral character
– „impact factor"- centrical judgement on project output evaluation

At the same time, my convinction is that arguments ***for*** a good and informative project web page are more strong than the ones against it and most problems can be easily solved.

IPR problems can be best overcome by using published data with consent of author clearly indicated. That is why I started our new test-web pages with data where I am personally among the authors and I could get (naturally) the consent of my colleagues to use the published evidence.

The ephemeral character of publication on the web can be best surpassed by quality: once a source of information is really useful and wanted, it can be mirrored, printed on CD's or published in traditional printed format. These solutions also help to overcome difficulties marked by the „impact factor" centred approach.

New additions to IGCP-442 project web page

As most of these novelties are under construction in the time of writing up the text of the paper, the completed new webpage will be functioning by the time of the Udine meeting.

The project webpage was naturally complemented with organisation information.

The database application frame of Lithotheca, presented in Eggenburg will be put on the website in a download version (bilingual and english versions). On the basis of last year experience, protection/menu system was disengaged. If protection is needed, individual users could supply it for themselves.

The most important new development is a map based interactive database. This enterprise is part of a major project by Hungarian National Science Foundation theme T-025086 „Prehistoric raw material atlas of the Carpathian Basin". When completed, the Atlas will have layers on various kinds of raw materials (sources, mines/ quarries, workshops, distribution) used in prehistoric Hungary, with a view on the Carpathian Basin. Whereas the parent project aims at presenting a series of maps non-metallic raw materials used in prehistoric Hungary, the IGCP-442 webpage goes further in depth and geo-

[1] IGCP 369 PeriTethyan Rift Basins - Maps - Plate Tectonic Reconstruction

graphical scope: the region of interest extending over Europe and the data depth including the presentation of the individual raw materials as well.

As a basis for information, existing Hungarian publications were used. The information is organised into an easily retrievable form. I hope by the time of our Udine meeting we can already use a quick reference of existing Hungarian polished stone raw materials.

Conclusion

What I need on your part to develop our project webpage into a useful, informative platform of related research on the subject?

In fact, not too much. List of publications (completed), list of sources with raw materials suitable for the production of chipped stone tools with good macro- and microphotos, same from stone tools actually investigated.

The preferred format would be a table/sheet with reference on literature and image files (example).

With your consent, existing published information can be also turned into a similar electronic reference material. One of the project outcomes can be, if complete enough to be published, a CD showing all related information.

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

JÁN SPIŠIAK[1], DUŠAN HOVORKA[2] & ŠTEFAN MÉRES[2]

[1]Geological Institute of the Slovak Academy of Sciences, Severná 5, 97401 Banská Bystrica, Slovak Republic, e-mail: spisiak@savbb.sk
[2]Faculty of Natural Sciences, Comenius University, Mlynská dolina 84215 Bratislava, Slovak Republic, e-mail: hovorka@fns.uniba.sk, meres@fns.uniba.sk

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 Sobotište 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 Sobotište 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 l) 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 stechiometric 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 simplectitic 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: purpure-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. Spinels are 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_{65}) 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 documented. Based on numerous garnet crystals nuclei in the process of original rock mineral association blasthesis, 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. Blasthesis 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 ecglogite 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 Marianske Lázně complex (south-western Bohemian massif) should be raw material provenience.
- Jadeitite axe found in western part of the country should have source-raw material in numerous jadeitite occurrences in the Western Alps The distance is around 1000 km.

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Greenschist – amphibole schist Neolithic polished stone tools in Hungary

GYÖRGY SZAKMÁNY[1] & ZSOLT KASZTOVSZKY[2]

[1]Eötvös L. University, Dept. of Petrology and Geochemistry, H-1117 Budapest, Pázmány Péter Sétany 1/C, Hungary
[2]Institute of Isotope and Surface Chemistry, CRC, H-1525 Budapest, P.O.Box 77, Hungary

Introduction

Among the Neolithic-Aeneolithic polished stone tools the metabasic rock types (greenschist and greenschist facies fine grained amphibole schist, blueschist, metadolerite, metagabbro) are widespread raw materials in the Carpathian-Pannonian region and its surroundings, included the polished stone tools have been found in Hungary. The stone tools made of these rock types were very popular among prehistoric people, particularly most common rocks are the greenschist (and fine grained amphibole schist) varieties. Up to now have been found greenschist in a lot of Neolithic settlements (Bicske, Mucsfa, Györe, Aszód, Felsővadász, Endrőd etc.) moreover some collections are known (*e.g.* the Miháldy collection in Veszprém, Ebenhöch collection in Hungarian National Museum, Budapest), in which the greenschists-amphibole schist stone tools have a great importance. On the other hand, in the western and northern part of the Carpathian-Pannonian region and in its northwestern surroundings this rock type is more widespread among the Neolithic stone tools than in the southern and eastern part as a raw material of polished stone tools.

Macroscopically determinable greenschist (and fine grained amphibole schist) similar to the raw material of polished stone tools are not widespread rock types on the surface in the Alp-Carpathian region and its surrounding. The most important localities are situated in the Alps (Penninic Unit). The outcrops closest to the Carpathian Basin are located in the easternmost part of the Alps, the Bernstein-, Rechnitz- and Eisenberg-windows (Burg, Rechnitz, Felsőcsatár, Bozsok etc.). There are important localities in the southern part of the Western Carpathian Mountains (Pezinok), and a little bit further in Moravia (the most important locality is Želešice).

Method

During our work more than 200 stone tools pieces and rock samples from the above mentioned outcrops were studied petrographically (macroscopic and polarizing microscopic method) first of all. Moreover we have analyzed chemically 17 samples by PGAA (Prompt Gamma Activation Analyses) method. 12 samples of them were greenschists (fine grained amphibole schists) Neolithic polished stone tools of different archaeological localities and 5 were rock samples collected from greenschist outcrops from different territories and tectonic units (Felsőcsatár, Burg, Pezinok and Želešice)

Petrography and the greenschist types

The main microscopic (and also the macroscopic) features of greenschist and fine grained amphibole schist samples are very similar. Though based on small differences in mineral composition, crystallinity and textures we were able to distinguish the same three main groups of the raw material of polished stone tools which we established on the basis of the macroscopic description, but there are more differences among the samples belonging to the same groups.

Macroscopically the greenschist stone tools are fine or very fine grained massive rocks. Most of them have dark or medium green grayish green colour and very good and very thin (order of 0.1-1 mm) foliation. Black bands occur along the foliation planes (type 1). Some greenschist stone tools macroscopically have medium-green colour and are well foliated too, but this type has white elongated bands or lenses, generally 2-4 cm long and 0.2-0.5 cm thick, parallel to the foliation (type 2). Most of the above mentioned greenschist samples generally contains black local spots, with diameter of 2-3 mm. Moreover, there are green-grayish green, well-foliated samples, which have comparatively larger (up to 1 cm) darker and closely rounded spots on its surface (type 3).

Although on the basis of the polarizing microscopic study we were able to distinguish the above mentioned three types of rock, some mixing of the features are possible, as in case of macroscopic investigations. The main types of greenschist stone tools show the following polarizing microscopic features:

Type 1. The mineralogical composition of this rock type is acicular-fibrous tremolite-actinolite (its amount often more than 50% in the rock), which has radial or a sheaf shape inside the foliation plain, fine grained (generally 50-70 μm) albite (in a few cases very poorly crystallized saussurite). In some samples, the albite aggregates rarely occur in larger nodules, perhaps replacing of the former magmatic plagioclase. Relatively large amount of opaque minerals (mostly ilmenite, in some samples altered to leucoxene), and in some cases a few magnetite can be observed. The aggregates or scattered grains of opaque minerals and titanite are parallel to the foliation.

Neolithic stone tools occurs in the western and southwestern part of Carpathian basin belong to this group first of all. There are little bit differences between the stone tools occurring in the western and in eastern part of the Carpathian basin. Its mineral composition is very similar but there are some differences: either there is not radially actinolite, and the amount of opaque minerals are few or there are textural differences.

Type 2. In this type the predominant mineral component is the lath shaped, acicular or rare fibrous actinolite-tremolite too. The actinolite needles occur more or less parallel with the foliation plane, therefore this rock type is lineated, besides foliation. It is very important, that in this greenschist type there are comparatively large amounts of fine grained, well crystallized elongated clinozoisite (in some cases epidote too) together with actinolite-tremolite crystals. The fine grained, well-crystallized albite occurs either among the amphibole and clinozoisite crystals in few amounts, or in small-elongated lenses or bands parallel to the foliation, in large amounts. In these albite-rich bands, there is only few amount of actinolite-tremolite and clinozoisite. Namely the pale bands (predominantly albite with small amount of quartz) alternate with dark, actinolite (-clinozoisite) rich bands in the rock. Mostly there are well-crystallized fine-grained titanites and only a few (or none) opaque minerals in this type of rocks. The rocks may contain some green chlorite too. These rock types are widespread in the Carpathian basin too, but they are more widespread in the western part of the territory and there is only few amount in the northeastern part.

Type 3. The rock essentially consists of very small sized, acicular or fibrous, radial and sheaf shaped colourless tremolite, but green actinolite rarely occurs too. In some cases the amphibole crystals are more or less parallel to the foliation. The saussurite (very poorly crystallized pseudomorphoses after primary plagioclase) occurs in large quantities in the rocks and its bands alternate with the amphibole-rich bands. Albites are very rare and only a few amount appears in well crystallized nodules or bands. The opaque mineral is probably ilmenite, fresh or altered to titanite (leucoxene), and its aggregates and scattered grains are parallel to the foliation. There are few chlorites in these rock types. In some cases the tremolite schist has late (perhaps metasomatic) biotite or phlogopite bands.

This third rock type we found only in the Mihåldy collection (belong to Veszprém, Laczkó Dezső Museum, Western Hungary) among the Hungarian greenschist-amphibole schist stone tools until this time.

Remark: The type 1 and type 3 are similar to each other under polarizing microscope, the only difference is that the crystallinity of the albite is better in the type 1, while there are very badly or not crystallized saussurite in the type 3. On the basis of the PGAA results, the chemical composition is very similar of the two groups, perhaps they are originate from the same geological unit.

Discussion and conclusion

As regards the rock samples originating from different outcrops, the samples originate from the easternmost tectonic window of the Penninicum especially from Felsőcsatár are the same under the polarising microscope as the type 2 polished stone tools.

The Želešice sample petrographically very similar to the type1 group, it has same mineralogical composition and predominantly similar texture but in some places there are relict coarse magmatic textures, and few thin veins crossed the rocks, contain same greenschist facies minerals as the rock. For the exact identification we have to study more samples from the outcrops in S-Moravia.

The rock sample from Pezinok originated from a geological outcrop of Little Carpathians is different from all the other samples, both from the stone tools and from the outcrops. It has well foliation with large albite rich lenses, but the albite is finer grained than in the Felsőcsatár samples. There are a lot of badly crystallized titanites in it, among the actinolites in the foliation plane and as pseudomorphoses after primary ilmenite in the albite rich lenses. There are also sericite pseudomorphoses after primary minerals in the albite rich lenses. The chemistry of the sample from Pezinok is different from the other samples. Therefore we do not think that the rocks from Pezinok were used for making Neolithic stone tools in territory of Hungary.

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Petrography of blueschist stone tools in Hungary

SÁNDOR JÓZSA[1], GYÖRGY SZAKMÁNY[1], HARGITA ORAVECZ[2] & PIROSKA CSENGERY[3]

[1]Eötvös L. University, Dept. of Petrology and Geochemistry, H-1117 Budapest, Pázmány Péter Sétany 1/C, Hungary
[2]National History Museum, H-1088 Budapest, Múzeum krt. 14-16
[3]Herman Ottó Museum, H-3529 Miskolc, Görgey A. u. 28

Intensive microscopic petrographical investigation of Hungarian Neolithic polished stone tools started nearly 10 years ago. The first blueschist tools have been found out last year from Hungary. This the first mention of blueschist stone tools from the territory of recent Hungary.

Nearly 1000 stone tool samples were looked over from the whole country. 26 of them from 13 localities (all from NE-Hungary) showed blueish shade of colour so they may be blueschists at first sight. Macroscopically the polished stone tools are made of fine-grained blueschist and very difficult to distinguish from those made of greenschist (and fine grained amphibole schists). In many cases there are a lot of green or greenish coloured minerals in the blueschists, moreover the texture of these rocks are similar. Macroscopically the blueschist stone tools have blueish black, dark greenish blue or in some cases dark blueish (-blackish) green colour, with or without thin white or whitish bands or in some cases lenses, parallel to the well or very well appeared foliation.

7 blueschist stone tools were selected for polarising microscopic investigation to proove the macroscopic determination and to make more precious characterisation of the rocks.

Selected rock materials showed little differences in main mineral content determined in thin section.

3 type of blueschists could be distinguished by petrographical microscope.

In the first group of rocks relict clinopyroxene preserved. These pyroxenes are augites and show typical pretectonical characters. Alteration reached about 60 % of the whole amount of augite and produced badly crystallised brown hornblende, small amount of very finegrained titanite, zoisite-clinozoisite and pumpellyite and few tremolite. Most of finegrained titanite has been formed from ilmenite. Mozaic like aggregates of slightly elongated equigranular crystals of epidote form wavy bands and lenses around relict, cracked pyroxenes. Remaining places are filled with mostly wavy laths and bunches of blue amphiboles. Two other little bit different samlpes from Felsővadász could be ranked to this group too. In all four blueschist samples traces of relict magmatic texture (ophitic and intergranular) are visible.

In the samples of second group garnetbearing blueschists are present. Relicts of magmatic minerals are missing, only weakly preserved pseudomorphs after pyroxene consisting of medium and finegrained mosaic crystals of chlorite, wite mica, quartz, albite and few titanite are visible. Mostly large, big euhedral blue amphibole gives 30-50 % of the whole rock. Angular spaces between them are filled by medium grained isometric, mosaic chrystals of albite, quartz, white mica and epidote. Euhedral mainly medium grained garnet is scattered evenly in the rock.

The third type of selected rocks is represented by only one sample. This rock suffered very strong greenschist facies metamorphism. Only more or less rounded large crystals of former plagioclase remained partly unaltered. Most of these grains transformed mainly to actinolite, albite, chlorite and sericite. Polycrystalline aggregates of wavy extincting quartz and albite with scattered small actinolite laths and needls in them appear in form of wavy bands and lenses. Some large pale green or almost colourless amphibole crystals with darker core were also detected. These large lenselike aggregates and grains are surrounded by strongly oriented wavy bands of mineral assemblages rich in amphibols (tremolite, actinolite, brownish hornblende and very few greenishblue-green amphibol). Some of the almost colourless and greenishblue amphibols may have composition close to glaucophane or riebeckite, so we were describing this rock among blueschists, in spite of the present mineral content on the basis of which this rock is an actinolite schist.

In the Carpathian-Pannonian region blueschist stone tools are rare, because there is only one occurrance (Sugov Valley and surroundings) where blueschist occure on the surface in large area and in big quantity.

Distribution blueschist stone tools within NE-Hungary shows well defined regularity: moving away from the supposed source territory i.e. to the south, the frequency of occurrence and the ratio of blueschist to other rock types decreases.

Petrographical similarities (the same mineralogical composition, particularly the presence of pyroxene and garnet in the same textural position both in the stone toolls and the outcrops) and the closeness of the supposed source area strengthen the identifying of the blueschists from geological outcrops of the source area (Sugov Valley and surroundings) with the blueschists from stone tool findings.

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The polished stone implements of the neolithic Starčevo culture in Northern Croatia

TIHOMILA TEŽAK-GREGL & MARCEL BURIĆ

Department of Archaeology, Faculty of Philosophy, University of Zagreb, Ivana Lučića 3, HR 10 000 Zagreb

The Starčevo Culture, the first agricultural community in northern Croatia, begining in 7[th] Millenium B.C., has been archaeologically documented by more then 60 permanent settlements (Minichreiter 1997). They are mostly located in the southern Pannonian basin of the river Sava. Favourable natural conditions of the region enabled high population density during the early and middle neolithic and so far a great number of archaeological traces. Various aspects of the Starčevo Culture have often been discussed in archaeological literature but it's stone production has been neglected although the new technology of producing stone artifacts, the techniques of abrading and polishing were usually emphasized as one of the important neolithic features. In the monograph on the Starčevo Culture in Northern Croatia, K. Minichreiter only states that stone products were numerous in the domestic inventory of Starčevo settlements, especially in early and classic phases but declining in the later phases. She considers this logical, given that the late phase was more distant from the Mesolithic basis which she considered to have held a decisive role in the production of stone artifacts in the early Starčevo Culture. This however refers to chipped stone implements, represented at the site of Zadubravlje with over five thousand artifacts. Polished stone implements are not mentioned specifically in the monograph, but the presence of last-shaped wedges, flat axes and chisels has generally been noted by other authors in all areas of the Starčevo Culture distribution. (Dimitrijević 1979, Garašanin 1979). Having a chance to view almost all the stone implements of several Starčevo settlements, such as Vinkovci-Hotel, Zadubravlje, Slavonski Brod-Galovo, Pepelana, we decided to pay more attention to that neglected neolithic production. We shall concentrate to the polished stone axes and related tools although stone querns, grinders, pestles, and various grinding surfaces were also objects that required the knowledge of polishing and abrading techniques. Three main types of polished tools are noted at all the mentioned sites: last-shaped wedges, flat axes and chisels. The last-shaped wedges are still considered by some authors to be agricultural tools for working the land. But even a deficient petrografic analysis showed that many of them were made of sandstone or siltstone and thus could not have had any practical function of an axe let alone to dig with them. But they could have been used as whetstones for abrading and polishing other types of stones or as tools for polishing and burnishing of pottery vessels. So a thorough petroarchaeological analysis of the Starčevo Culture polished stone artifacts become a necessity not only to solve the problem of their function, but also to investigate and determine the possible sources of the exploited raw material and the way of it's circulation among the Starčevo settlements. The most common opinion was that the nearest resources were lying in the mountains of the Northern Bosnia but there are some other solutions to be considered. Many of the Starčevo settlements are situated in the bottom of Mount Dilj and Požeška gora which could also be potential sources. Further, we have to take into account the fact that many artifacts were made of river-pebbles and the most of North-Bosnian rivers join the river Sava, the main economic and cultural artery of the mentioned region.

In the article we shall analize polished stone artifacts from the Starčevo sites of Vinkovci, Slavonski Brod-Galovo and Zadubravlje because they were properly excavated and the artifacts are accompanied by essential archaeological context. In that sense the most interesting will be the site of Galovo in Slavonski Brod, where systematic excavation is still being carried out. The majority of stone axes e.i. wedges had been found in context of two burial pits. Five of them were placed next to the entrance section of the pit in which a contracted skeleton had been buried. Minichreiter, the leader of the excavation, suggested *„the possibility of a ritual placement of stone axes during visitation of the deceased“* (Minichreiter 1999).

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Polished stone artefacts from Sopot culture site Samatovci in Slavonia region

JACQUELINE BALEN[1], DRAŽEN KURTANJEK[2] & DRAŽEN BALEN[3]

[1]Archaeological Museum in Zagreb, Zrinski Square 19, 10000 Zagreb, Croatia
[2]Department of Mineralogy and Petrology, Faculty of Sciences, Horvatovac 3, 10000 Zagreb, Croatia
[3]Department of Geology, Faculty of Sciences, Horvatovac 3, 10000 Zagreb, Croatia

The site of Samatovci is located 15 km west of Osijek in Eastern Slavonia. The finds kept in Archaeological Museum in Zagreb were uncovered during the vineyard cultivation between 1895 and 1906. The circumstances of discovery suggest the artefacts were collected from the topsoil. At the same occasion a limited trench excavation took place. However, it was done by people lacking professional archaeological skills, which left us with no preserved documentation. It is rather difficult to give any reliable information concerning the layout of the settlement because most of it had been destroyed through land cultivation and house building. The terrain configuration indicates a hillfort surrounded by a ditch, with a nearby stream whose dried up bed is still visible today. The collected pottery can be attributed to the I-B, II and III phase of Sopot culture. Furthermore, there are several sherds belonging to the Copper Age cultures of Kostolac and Vučedol.

Apart from large quantity of pottery, Samatovci also produced numerous stone artefacts. Although the lack of stratigraphic relations poses grave limits to the scope of scientifically obtainable inferences, Samatovci remains the site with the greatest number of stone artefacts belonging to the Sopot culture in Croatia. Unfortunately, in Croatia so far there have been no systematic studies of lithic material that would, on the basis of the raw materials analyses, typology and functional analyses, produce any significant results regarding this aspect of production of Neolithic people.

Stone tools from Samatovci can basically be divided into the following categories: chipped, ground and polished stone tools. The chipped stone artefacts number several thousands in total but as we already mentioned, without reference to their stratigraphic position. Many cores were found, flakes and a high number of blades and end-scrapers. Side scrapers and borers are represented in small numbers. Approximately forty arrowheads have been identified. It deserves mention that the site produced high quantities of obsidian artefacts, e.g. flakes, bladelets and cores for bladelets.

There were many examples of ground tools among the stone assemblage. Depending on their possible function, we divided them into pestles/hammerstones, handstones and quern-stones. Conspicuous within the assemblage are pieces resembling ordinary pebbles but which were purposefully brought to the site, although their function remains unknown.

The polished tools consist of worn, re-cycled or broken pieces of cutting-edged tools, namely small adzes or axes – shoe-last and trapezoidal flat types. Most common type is also shaft-hole axe. There are few fragments of cylindrical cores, the by-products of shaft-holes drilling, which together with numerous unfinished tools indicates that the tool production was carried out within the settlement.

Samples of polished stone artefacts were analyzed mainly as a whole rock by non-destructive optical methods using binocular microscope combined with various tests (solubility, hardness, and specific gravity). Some broken artifact tools are analyzed as thin sections with polarizing microscope.

Altogether 39 whole or damaged shaft-hole axes have been identified. The preferred rock types were amphibolite (16 examples), gabbro (5 pieces) and basalt (3). Andesite, metagabbro, metabasalt, sandstone and serpentinite served as a material for two axes each.

Small adzes and axes are mostly made of sandstone and chert, common are tuff, alunite, amphibolite, diorite and serpentinite.

Potential sources of materials could be found in the vicinity of Samatovci as gravel deposits of the Drava and Sava rivers, which may have been transported from the Alps.

The high quantity of lithic assemblage from Samatovci, ranging from pebbles, cores and finished tools to waste material, gives strong indication that the prehistoric settlement also served the function of a production center for lithic industry.

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Site Bajč (Slovakia) – bonanza of the Neolithic polished stone artefacts

DUŠAN HOVORKA[1], ŠTEFAN MÉRES[1] & IVAN CHEBEN[2]

[1]Faculty of Natural Sciences, Comenius University, Mlynská dol., 842 15 Bratislava, Slovak Republic
[2]Archaeological Institute of Slovak Academy of Sciences, Akademická 2, 949 21 Nitra, Slovak Republic

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.

In the site from the 3[nd] 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 Bajč contains 289 pieces. But these are only a known part of unknown bulk of polished stone production in Bajč.

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 - a various types flat axes (trapezoid, shoe-last, triangle shaped) and shoe-last wedges.

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 Bajc 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).

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) 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, biotite-amphibole schists and spinel-hornblende-anthophyllite schists.

Amphibole schists (150 pieces) 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, and b) porphyroblastic types with albite porphyroblasts. 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 (71 pieces) are represented by fine-grained and in the majority of cases also schistose rocks. 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.

Spinel-hornblende-anthophyllite schists (52 pieces) have pronouncedly schistose fabric. 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 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 clasify rocks under considerationm as nephritoids (Illášová and Hovorka 1995, Hovorka et al. 1997).

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Serpentinite

From the serpentinite two hammer-axes and one globular macehead have been identified. Artefacts made from serpentite 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. Rock under discusion 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-types mostly with well develloped 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 bluishgreen amphibole, minerals of the epidote group and accesories (titanite, zircone).

Igneous rocks

Among neolithic/eneolithic artefacts from various sites of the Slovak republic territory plutonic as well as volcanic rocks are present (Hovorka and Illášová 1996, Illášová and Hovorka 1995, Hovorka and 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 (clynopyroxene phyric andesite) and one flat axe (amphibole-biotite andesite). This typical volcanic rock consists of phyric clinopyroxene or amphibole and biotite_within submicroscopically grained matrix. It consists of very fine-grained crystals of needle-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. 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) 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).

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Beránek, B., Leško, B. & Mayerová, M., 1979: Interpretation of seismic measurements along the trans-Carpathian profile K III. In: Babuška, V. & Plančár, J. (Eds.): *Geodynamic investigations in Czecho-Slovakia.* Bratislava: VEDA, p. 201-205.

Lucido, O., 1993: A new theory of the Earth's continental crust: The colloidal origin. *Geol. Carpathica,* vol. 44, no. 2, p. 67-74.

Pitoňák, P. & Spišiak, J., 1989: Mineralogy, petrology and geochemistry of the main rock types of the crystalline complex of the Nízke Tatry Mts. MS – Archiv GS SR, Bratislava, 232 p. (in Slovak).

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