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Periodical journal of Geological Survey of Slovak Republic is a quarterly presenting the results of investigation and researches in a wide range of topics:

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Scientific Editors

Dušan Hovorka a nd Štefan Méres

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1-2/2004

IUGS UNESCO IGCP

442

IGCP/UNESCO PROJECT NO. 442:

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

IUGS UNESCO IGCP 442

IGCP No. 442 concluded

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Already in 1972 International Union of Geological Sciences (IUGS) in cooperation with the UNESCO established the International Geological Correlation Programme (IGCP). In the last International Geological Congress in Rio de Janeiro in 2000 new heading of the Programme has been accepted as International Geological Cooperation Programme. So abbreviation IGCP is still in use.

Individual projects during the first years after the programme acceptation have been concentrated on correlation of topical geological phenomena, i. e. stratigraphy, magmatism/volcanism and ore forming processes. During the last decades of the 20th century namely environmental aspects became leading ones in the frame of the IGCP. The end of the 20th century is simultaneously characterized by the recession of geosciences in the worldwide dimensions. One of possible solution is penetration of the geosciences into the other fields of human activities: into the historical sciences (archaeology), technical sciences and various technologies, and namely into the environmental problematics. So at present IUGS declared leading logo of geoscientists' activities in the 21st century as "Geoscience in Service of Society".

One of the firsts really interdisciplinary/crossectorial (archaeology and geosciences) IGCP projects has been that of No. 442 "Raw materials of the Neolithic/Aeneolithic polished stone artefacts: their migration paths in Europe" realised during time period 1999-2002. In the frame of the projects archaeologists opened their deposists and geoscientists, using standard laboratory methods, tried to identified and located raw materials of polished implements made during the Neolithic/Aeneolithic time-period. As the results of this unified geoscientists/archaeologist's effort papers on stone raw materials used in the Neolithic/Aeneolithic in various parts of Europe were published in scientific journals and as special monothematic issues of Krystalinikum 26 (2000), Slovak Geological Magazine 7, 4 (2001) as well as this issue of above journal.

Interdisciplinary collaboration of scientists of above mentioned fields of activities is expressed, among others, also by the term "petroarchaeology" (mostly used in the central Europe, or in the German speaking countries, as well), and/or "archaeometry" (used mostly in the USA). Both above terms are more-or-less synonyms, though later one has broader meaning. To this category belongs also IGCP No. 442 project.

Meanwhile during the Older Stone Age (i. e. Palaeolithic) chipped implements ("chipped industry") was made from obsidian, various cherts, radiolarites and radiolaria shales, hydroquartzites and the other silica-rich inorganic materials, during the Neolithic progresivelly more-and-more raw matetrial types were used. For all three main genetic groups of rocks (i. e. sedimentary, magmatic as well as metamorphic ones) some common physical properties are characteristic: homogeneity, hardness but simultaneously elasticity, fine-grained character, low amount, but the most often absence of sheet silicates (chlorites, micas), absence of volcanic glass and xenoliths in effusive rocks, ao.

Though systematic and the whole area covering studies of the raw material types used in the Neolithic on the Old Continent have not been realised yet, it seems that the leading raw materials types in the Neolithic/Aeneolithic were various varieties of greenschists. Locally also amphibolites, antigorite (never lizardite-chrysotile) serpentinites, (mostly) alkali basalts and in the lower amount also the other aphyric or fine-phyric effusives served as the raw materials for stone implements construction as well. Above rock types (and locally also many others) used skilfull individuals for making gradually more and more complicated (first non bored, later on bored) implements: weapons, tools of daily life use, but also ornamental and symbols representing stone made implements.

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During the Neolithic changing style of living (human tribes settled and agriculture starts to be the main type of the food provide) developed also ceramic production. So archaeologists applying results of ceramic studies are able to date also stone artefacts, occurring in just identical cultural horizons as ceramic fragments.

Studying paleoceramic fragments leading laboratory methods are those ones of geosciences as well.

Material artefacts from praehistoric period as well as from the early history, among which stone implements and ceramic wessels represent irreplaceable part of the mankind cultural heritage, offer relics of tremandeous value which ought to be studied in their complexity. The identification of raw material types used, together with their occurrences in nature, help us to understand prehistoric tribes material level, their style of living, migration paths of raw material or ready made implements used ao. Geosciences in this field of research have broad possibilities.

Slovak Geol. Mag., 10, 1-2(2004), 5-16

IUGS UNESCO IGCP 442

Main Western Carpathians rock lithologies used as the raw materials of the Stone Age

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Abstract. Among raw material types used by the Stone Age human communities all three genetic rock types were identified: igneous, sedimentary as well as various metamorphic rock types. Their quantitative proportion changes from site to site. The great majority of the inorganic raw materials used during the whole Stone Age are of the local provenience. Significantly less frequent implements have been documented, raw materials of which is of distant or even very distant proveniences. Several hundreds kms migration of raw materials, or more probably, of the ready made implements, is documented since the Late Paleolithic.

For the prevailing part of the inorganic raw material types geographical location as well as geological position is well known. But there are described raw material types whose in situ equivalents (geological bodies) are not known on the territory of the country or even on neighbouring territories.

In the Neolithic/Eneolithic, except of hard and competent raw material types, genetically different raw material - plastic clays - represent material of common use, for ceramic vessels manufacturing. Together with clays of various genetical types natural colors (namely products of ores weathering) have been used. On the very end of the Stone Age very seldom use of gold and copper is documented.

Key words: Stone Age, Western Carpathians, main rock lithologies used

Introduction

During the last decades, namely after the World War the IInd, numerous evidences dealing with human activities, from practically whole territory of the Slovak Republic, were presented. Wide river valleys (Váh, Hron, Ipeľ, Hornád and the others) filled up by loess offer suitable environment for human tribes settlements already during the Late Paleolithic. During the last period of the continental glaciation, namely caves offered temporal hidding places against cruel climatic conditions. Such places, in combination with warm mineral water springs (Piešťany, Bojnice, Gánovce and the others) offered basic type of daily food - big animals' meat. So such places have been chosen by new and new human generations as the temporal living places. Surprisingly among inhabitat areas belong also intramontagne basins, whose elevation above sea level is relatively high, for instance the Poprad basin, in the frame of which Gánovce-man cranium of the 105000 years ranking (Vlček 1995), was described.

The end of the Early Neolithic, and namely Middle Neolithic represents time period, when human tribes settled („neolithic revolution“). Hunters-gatherers gradually changed to people, whose main part of the daily food represented the products of their agricultural and pasturage activities. This process in the central Europe starts during 7th millenium before present.

New style of living and increasing number of members of individual human tribes, which reflects more suitable climatic conditions after the last continental glaciation, yielded in consumption of more and simultaneously more variable raw material types. Preparation of new fields, after the burning of forests, necessitates elaboration of great amount of stone implements, namely axes and hammer-axes for wooden houses construction and for the other purposes.

During the Paleolithic inorganic raw material types were represented, taking into account the place of their picking, namely river pebbles, in less amount also in situ geological bodies. From the point of view of their quality, they belong mostly among submicroscopically grained quartz (or its modifications) composed rocks originated by various ways. The majority of them are products of diagenetic or epigenetic processes (various cherts) in not yet consolited sediments. Characteristic are also hydroquartzites (limnoquartzites) occurring namely in the Žiarska kotlina basin. Obsidian, e. g. acid volcanic glass of the Neogene in age is another typical Paleolithic raw material type often used for manufacturing of cutting instruments. Their known occurrences in the Zemplin county (eastern Slovakia and northern Hungary) served as supplyers for the whole central and partly also western Europe. Widespread distribution, together with the western Slovakia finds of instruments made from hydroquarzites document implements/raw material exchange activities already in the Late Paleolithic. Generally, all implements made via chipping of the given raw material types are known under denomination **chipped industry**.

During the Neolithic and namely Eneolithic high demand of working tools, but also weapons and implements having ornamental/decorative aim enforced introduction of new raw material types and simultaneously introduction of new technologies of their elaboration. Smoothing and polishing of hard, mostly fine-grained rocks of all three genetic categories start to be leading process of stone elaboration. The whole colorfull set of implements made by this techniques is called **polished industry**. During the first centuries of the polished technologies use, axes and hammer-axes were fixed in wooden or antlers sticks. Later on (after several centuries) boring of the stone implements was introduced. On the Neolithic/Eneolithic stone implements two types of boring we have documented: full hole boring and core boring.

Geology of the Western Carpathians is extremely complicated. All three genetic types of rock sequences are known to occur on the present-day surface. Mountainous morphology of the most part of the country enabled the supply of variable rock debris into river valleys where from praehistoric man picked up and consequently elaborated suitable raw material types. Though local raw material types (one day walking distance) are mostly used, in individual cases long distance transport of ready made implements is supposed to act. Among the set of Neolithic/Eneolithic implements documented, there are several raw material types of unknown proveniences.

In the following there are presented rock sequences which were sources of, in the Stone Age frequently used, raw material types. The presentation of the raw material types used is based on the stratigraphic principle (e. g. Paleolithic vs. Neolithic/Eneolithic). Characterization of geological units (rock sequences) which offer given raw material types is of first ranking.

Geological units supplying raw materials used

RAW MATERIALS OF QUATERNARY

During the very end of Pleistocene, and namely during the Holocene geological processes operated in the central Europe yielded in formation of several raw material types. In the following there are presented the most important of them.

Raw materials for ceramic production

During the Neolithic (e. g. after the last continental glaciation of Europe) permantly new and new raw material types were introduced to the human communities daily life. Among them one of the most important are raw materials for ceramic production, as well. Mentioned technology was introduced gradually, so time period when ceramic vessels start to be abundand and widespread, is called **ceramic Neolithic.**

Loess

It covers huge areas of the rivers Váh and Hron valleys, Trnava plain and eastern Slovakia lowland, namely during the Neolithic was used as:

a) places very favourable for stable lodgings location (loess was used for plaster production),
b) as the raw material for ceramic production (Figs. 1-3).
c) the very fertile substratum for agricultural activities in the Middle and Late Neolithic.

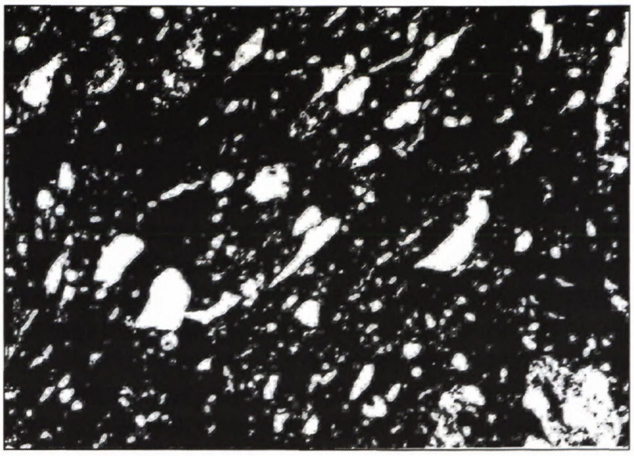

Fig. 1. The lengyel culture ceramic fragment. Preffered orientation of quartz clasts parallel to the outer rim. X polars, magn. 45x.

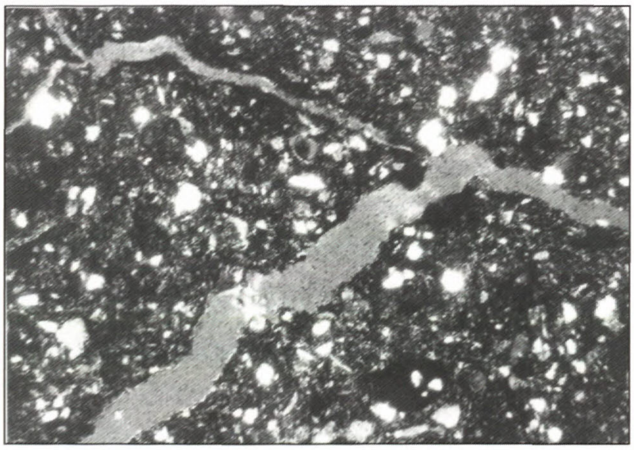

Fig. 2. The lengyel culture ceramic fragment. Hair-like veinlets in ceramic paste filled up by $SiO_2.nH_2O$ maters. X polars, magn. 45x.

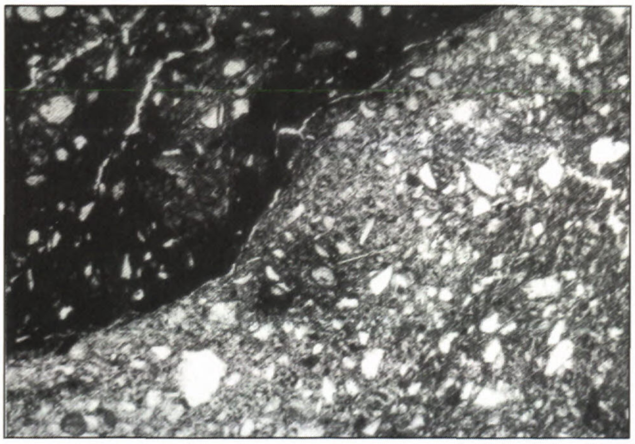

Fig. 3. Older fragment of the ceramic vessel (dark) in the lengyel culture ceramic paste. X polars, magn. 75x.

Clays

Clays of the higher quality are represented by the Neogene and Quartery strata known from several units: from the Danube and the eastern Slovakia lowlands, from the Late Tertiary intramontagne basins located among volcanic chains and the others. As laboratory identification of ceramic raw materials was not yet carried out in great amount, we haven´t arguments for clays of mentioned proveniences utilization.

Another clayey sediments are present as the rivers and brooks bottom deposits. They pass gradually to sandy deposits, so carefull selection of used parts of strata is needed. Utilization of this type of the given raw material type is traceable by clasts of minerals present in the paste of ready made ceramic, which indicate provenience of the crystalline massifs (prevailing quartz grains) vs. Late Tertiary volcanic areas (dominant are clasts of dark minerals).

Natural colors

Already in the Paleolithic man used natural colors for paintings on the caves walls, later on there are evidences of the use of natural colors for dead human bodies painting. The widespread use of natural colors is documented on ceramic fragments (Bárta 1965, Šiška 1980). Colors were used mostly before vessels burning, which technology made coloring more stable.

Natural colors are of different origin. Among widely used belong products of subrecent weathering of siderite bodies. They form so called „gossans“ composed of iron oxides and hydroxides. Downward they gradually pass into the fresh parts of Fe-carbonates. Gossans offers yellow and yellowish-brown tints of color. They are easibly dissoluble in water. Pieces of dry parts of gossans were documented from several Neolithic graves in the country.

Another genetic type of natural yellow up to brown color represent irregular clods of haematite occurring within Tertiary conglomerates of the so called Piešťany Formation. Clays of this formation are in some positions intensively colored (pinkish, yellowish and milky-white colors).

Majority of carbonate precipitates from mineralized spring waters are of yellowish to yellowish-brown colors. They are easily crushible to pulver - their use as natural colors is probable.

Various tints of grey up to black colors were obtianed by process of charcoal crushing.

LATE TERTIARY VOLCANIC PROVINCE

Products of the Late Tertiary volcanic activity are variable: they represent subvolcanic and volcanic bodies of various chemical as well as mineral composition, their volcaniclastics and products of hydrothermal silicification and hydrotherms precipitation.

Obsidian

Rapid cooling of effusive lavas yielded in volcanic glass origin. To all types of lavas correspond equivalent volcanic glasses. From practical use the most important are acid volcanic glasses being equivalents of rapidly cooling rhyolithic lavas. One type of acid volcanic glass is obsidian. It has massive compact pattern and low amount (below 2 per cents) of water. In the following we will not take into consideration volcanic glass being integral part of groundmass of more-or-less each effusive rock. We will concentrate on acid volcanic glass forming pronouncedly dominant part of the rock. Spatially obsidian represents marginal parts of lava bodies, or, in less amount the whole volcanic body is represented by volcanic glass.

Density of obsidian varies in the range 2,30-2,40 $g.cm^3$. Characteristic is its low porosity (below 1 per cent). Index of refraction is equal to 1,485. Obsidian from the discussed areas is of darkgrey up to black color. It is clear, transparent, locally low amount of silicate minerals crystallites are observable.

One of the classical areas of the obsidian occurrences in the country (except of those in the Tokaj Mts. in NE Hungary) is the area of village Viničky, in less amount also in the vicinity of the Veľká and Malá Bara villages in the Zemplin Hills (eastern Slovakia). In the area under discussion, mostly in vineyards, blocks of various size of obsidian are known to occur. The area is characteristic by various products and semiproducts of „workshops“ producing chipped industry, mostly arrow points, which can be found in high quantity on fields up to now.

In the Paleolithic on sites located in eastern Slovakia obsidian was the leading raw material type. From its occurrences in the Zemplin Hills it was distributed on long distances: eastern Slovakia obsidian implements were found on territory of the Czech Republic, southwestern Poland and in eastern part of Germany, as well. The sites with numerous obsidian industry located on eastern Slovakia are namely Kašov, Cejkov and Hrčeľ.

Obsidian made industry from eastern Slovakia archaeological sites was studied by Bánesz (1961) and Kaminská (1985). Obsidian from central Europe together with its chemical composition was presented in comprehensive paper by Bíro et al. (1986).Valuable analytical data, namely trace elements determination, is presented in paper by Killikoglou et al. (1997). Obsidian was used also in the Neolithic. Neolithic finds of the obsidian industry from the territory of Slovakia were summed up by Šiška (1999).

Hydroquartzite (limnoquartzite)

Late Tertiary rhyolitic volcanism, namely on rim of the Žiarska kotlina basin, is accompanied by intensive hydrothermal activity. Hydrotherms were saturated by the SiO_2, which in intermontagne fresh water lakes precipitated mostly in the form of chalcedony.

Hydroquartzites have various colors (milky white, grey up to redishbrown) and compact as well as porous pattern. They occur as isolated lense-like bodies forming intercalations with volcaniclastics and sediments. But they are present in the form of synform layers of several meters thickness. Characteristic are footprints of various (namely swampy) grasses, tree leaves and footprints of various insect.

On the territory of the country there are two areas of the hydroquartzite occurrences: the rim of the Žiarska kotlina basin in central Slovakia, where areally large limnoquartzite positions are known to occur. In the eastern Slovakia the Slánske vrchy and Vihorlat Mts. bear also (but smaller) hydroquartzite occurrences. Except of mentioned central Slovakia primary occurrences, river Hron gravel deposits downstream of the primary occurrences, contain also hydroquartzite gravels.

Due to its hardness and ability to split into thin and sharp partial pieces, hydroquartzite, namely in the Žiarska kotlina occurrences (Cheben and Illášová 2000), served already in the Paleolithic as one of main raw matrial types. Utilization of hydroquartzite is traceable during the whole Neolithic and Eneolithic and for some special purposes it was used till the Middle Age, or even up to now, respectivelly.

Namely in the Stone Age hydroquartzites were used for arrows sharp ends and various types of implements used for cutting. Bárta (1991) from several western Slovakia sites, namely from Brodzany, Žabokreky, Mariánsky vršok-Prievidza and from Veľké Stankovce as well, described the hydroquartzite implements of the Žiarska kotlina basin provenience. So hydroquartzites, along with the most common radiolarites and radiolaria schists, were used by the human communities living namely in the western part of the country.

Opal/chalcedony

Except of hydroquartzite also the other types of precipitates from thermal solution were used in pre-historic period as raw material for various chipped implements elaboration. Irregular nests and veins of various thickness of opal or chalcedony, are known to occur practically from all Late Tertiary volcanics subprovinces. Their maximal concentrations are known from zones of postvolcanic hydrothermal activity. Though small artefacts made from this raw material type were found on numerous sites spread over the whole country, no special attention to this raw material type have been paid in the past by archeologists or geoscientists. Opals (precious opal from the Prešovské vrchy Mts. included) were used for small implements or sharp arrow ends type as well as small cutting instruments. Patination of implements surfaces in the case of some of them make difficulties in distinguishion of individual silex-types.

Various silicified sediments

On the periphery of the central Slovakia Late Tertiary volcanic province Mišík (1975) described several types of silicified conglomerates, limestones, siltstones and vitric tuffs. Based on the archeological evaluation implements made from above mentioned non-traditional materials belong to the Paleolithic inventory. Late Tertiary postvolcanic hydrothermal activity is process responsible for appropriate technical properties (namely hardness) of originally soft, or even non consolited sediments.

Mentioned author (l. c.) listed silicified sediments from the sites in the area of Modrý Kameň town (southern Slovakia) as well as from Prievidza town and its surrounding.

Identification of various silicified sediments as the raw material of the Paleolithic implements enables to conclude that:

a) Paleolithic man was preferrently oriented on the very local or local raw material types. Exchange activities during the Paleolithic were sporadic.
b) Paleolithic „specialists" used also non-traditional or not-yet tested raw material types. It was caused by the lack (though in some time period) of traditional raw material types in the given area (site),
c) All above mentioned raw material types should be ranked among very local/local ones.

Basalt

In the frame of the Late Tertiary/Quaternary central Europe volcanic province two main basalt clans are known to occur:

a) calc-alkali basalts (Fig. 4), and
b) alkali basalts/basanites.

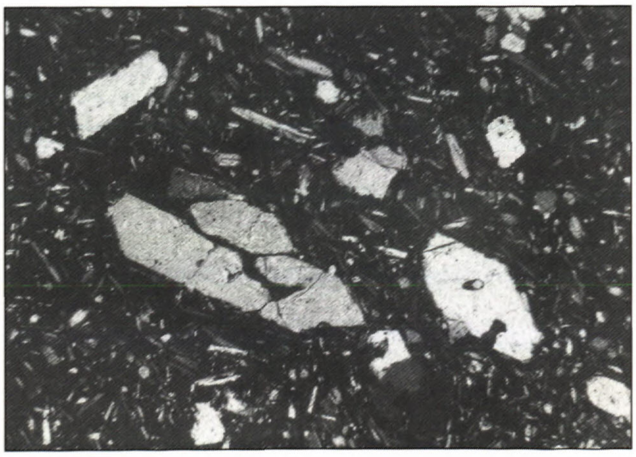

Fig. 4. Phyric (Ol, Plg) calc-alkaline basalt with fine-grained - glassy matrix . X polars, magn. 65x.

Meanwhile calc-alkali basalts (basaltic andesites) represent the most basic type of the calc-alkaline clan, alkali basalts have another magma sources. They form spatially separate occurrences and are generally younger in comparison to the previous one.The Upper mantle spinel peridotite xenoliths are characteristic for them. Alkali basaltic volcanics within the central Slovakia Late Tertiary volcanic province do occur in several individual lava flows (Banská Štiavnica, Kysihýbel, Nová Baňa, Ostrá lúka and Bacúrov). Namely last three occurrences supplyed gravels to the river Hron valley beds, where from they have been picked up and elaborated.

Except of the central Slovakia huger amount of alkali basaltic volcanics are known from the southern Slovakia.

Alkali basalts do occur also on the territory of Hungary as well as in Burgenland (Austria).

Namely in the Hungarian lowland area individual basaltic occurrences form positive morphological elevations with various sized blocks on their slopes. Such natural conditions of basaltic occurrences are in favour to be gathered and elaborated.

For utilization Neolithic/Eneolithic communities selected aphyric, or even fine-phyric types of basalts of both clans. Occurrences of calc-alkali basalts in the central Slovakia Late Tertiary volcanic province are more abundant in comparison to the alkali basalts ones. In contrats to that in the set of microscopically studied artefacts, from the alkali basalts made implements are more often. Implements made from massive and also unpronouncedly fluidal basaltic types were documented. Alkali basalts are the raw material namely of bored axes and hammer-axes (Illášová 2001) found in the form of individual pieces practically in all documented western Slovakia sites. An exception represents big (approx. 3 kg of weight) not finished hammer-axe from alkali basalt found nearby Kozárovce (central Slovakia) on secondary deposition.

Based on the fact that central and namely southern Slovakia alkali basalt occurrences are in distant areas to the western Slovakia alkali basalt implements occurrences, northwestern Hungarian and Burgenland alkali basalt bodies we suppose to be supplyers of the given raw material type.

As dealts with calc-alkali basalt use of local or semilocal raw material is more favourable. Numerous primary occurrences together with the river pebbles offer great amount of appropriate types of this raw material.

Andesite

The most abundant product of the Late Tertiary volcanic activity are just andesites. They are the most widespread among volcanic rocks of the central Slovakia volcanic mountains as well as those of the eastern Slovakia.

Among numerous andesite textural types and types distinguished on the base of their mineral (and consequently chemical) composition, Neolithic/Eneolithic man selected suitable andesitic raw materials applying namely the following criteria:

a) among andesite types for practical use those of fresh appearance (plagioclase phenocrysts of high glance and general fresh appearance of the rock) were selected. Propylitized varieties, during this process loss its original properties. Except of this in the proces of hydrothermal/pneumatolytic alteration nests or even veins filled up by secondary minerals represent places of consequent splitting of ready made implements into partial pieces.
b) Types with abundant phyric phases (dark minerals, plagioclases) were excluded from following elaboration. The presence of phyric phases namely during closing proces of smoothing or following application of ready-made tool conditioned its destruction - falling out mentioned phyric phase from the tool in its narrow parts,
c) for small tools (and weapons) construction compact raw material was used (Fig. 5). Types with porous pattern have been excluded. On contrary such types (or types with numerous phyric phases) were used as the raw material for bases and smoothers construction,
d) from elaboration Neolithic man excluded also andesite types, in which substantial part of the matrix was glassy. Such matrix has generally dark color and high lustre. Raw material types with substantial presence of glass being rock forming phase, are highly fragile.
e) The spatial distribution of centres of Late Tertary volcanic activity is highly favourable. Late Tertiary volcanics of the central Slovakia region supplies by products of volcanic activity human tribes living in the central as well as in the western part of novadays Slovakia. Volcanic mountains of the eastern Slovakia were source of raw material of discussed types over the eastern part of the country (Hovorka and Šiška 2000).

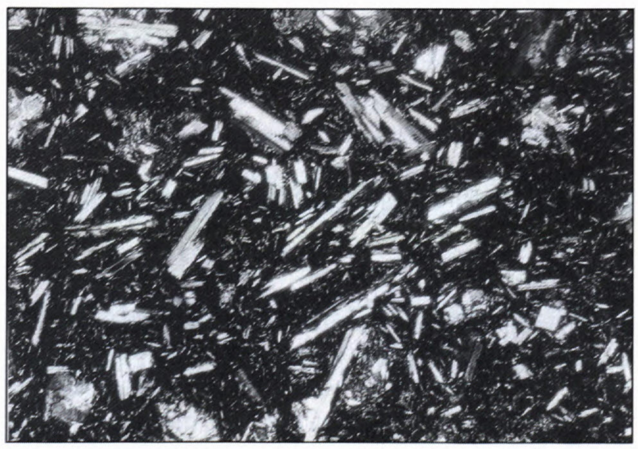

Fig. 5. Andesite with fine-grained (plagioclases laths) - glassy matrix. X polars, magn. 75x.

Contact-thermic hornfels

Among fine-grained hornfelses, which originated by contact-thermic recrystallization of various protoliths, namely the following varieties were studied by the use of polarizing microscope (Hovorka et al. 2001a):

Slovak Geol. Mag., 10, 1-2(2004), 5-16

a) amphibole-plagioclase-clinopyroxene hornfels,
b) biotite-plagioclase-clinopyroxene hornfels,
c) clinozoisite hornfels.

All mentioned raw material types represent very hard and very fine-grained types. Implements of the hammer-axe morphology of type a) and b) were found on site Svodín, meanwhile fragment of axe or hammer-axe made from the raw material ad c) was studied from site Ivanka by Nitra. It is curious that from the hornfels of the type a) 4 small non-bored axes were made. Their identical microscopic view documents their elaboration from just identical block of the raw material of the given type.

Above hornfelses we (Hovorka and Illášová 2002) locate to the province of the Late Tertiary volcanics. They originated by contact-thermic recrystallization. Needed heat was supplyed by (andesitic?) lava flows, from which surrounding individual blocks of thermic hornfelses were liberated and found the most probably on secondary deposits among river Hron blocks. So contact-thermic hornfelses represent local raw material type transported from „one day walking distance".

MESOZOIC SEDIMENTARY COMPLEXES

Mesozoic sedimentary complexes of various lithology form rock filling of various tectonic units covering the major part of the country. Their complicated geological history reflects their composition and from archeological point of view namely different physical properties as well. Though the volume of the Mesozoic rock sequences is enormous, as the raw materials in the Stone Age only selected rock types were used. They are as follows.

Radiolarite/radiolaria shale

These organogenic sedimentary rocks represent deep water accumulations of radiolaria opal-made shells. The quantitative proportion of shells vs. clay (mostly illite and smectite) matrix reflects the denomination of the given rock. Radiolaria shales (Fig. 6) contain less than 50 per cents (this limit is not accepted univocaly) of radiolaria, meanwhile radiolarites are composed of prevailing radiolaria.

Radiolaria developed since the Precambrium. Maximal extention is known from the Triassic and namely Jurassic. Their accumulations are present in the form of lenses and beds in limestones of several Mesozoic tectonic units. Among such it ought to be mentioned Meliata unit, in which radiolarites are known as interlayers in the Upper Triassic limestones up to Jurassic ones. Widely used by the Stone Age communities were radiolarites from the Kysuce and Pieniny units of the Western Carpathians Klippen belt. They have been picked up as river Váh gravels namely downstream of the Trenčín town. Radiolarites are known to occur also in other tectonic units namely of the Western Carpathians central zone. Late Cretaceous and Tertiary (Alpine) tectonic processes intensively reworked competent radiolarite beds in more

Fig. 6. Radiolaria shale of the Upper Triassic age. X polars, magn. 65x.

plastic carbonate strata, so their practical use (because of their jointing) is excluded. More information in detail on radiolarites used during the Stone Age is in paper by Mišík (1975). The only documented prehistoric place of radiolarite excavations is near Bolešov (Cheben et al. 1995) in western Slovakia.

Chert

Cherts belongs to the sedimentary rocks which originated by the local SiO_2 mobilization namely in not yet consolited limy mud. Cherts are present in the form of individual lenses or irregular bodies of various size and various colors. But they do form also synsedimentary positions (beds) in limestones of various age. Based on the stratigraphy of given cherts they have special denominations.

From cherts made small implements are rarely documented. They were used as cutting implements or sharp arrow and jevelin ends and were documented from several western Slovakia archeological sites (for informations in more datail see Hovorka and Illášová, 2002).

Flint

The most probably in the communities of archaeologists as well as geoscientists special type of chert - flint (composed mostly of chalcedony) - is the best known. It was one of the leading raw material types during Paleolithic, and its use prolongs deep to Neolithic and Eneolithic. Classical flint occurrences are bound to originally non consolited Cretaceous strata, in which it forms irregular nests and bulbs. They occur in the form of belt on the northern periphery of European continent and in Scandinavia.

Within the limit of the last continental glaciation numerous very resistent flint pebbles and blocks are member of morraines and fluvioglacial deposits, where from they were picked up by the raw material gatherers. But in many places in European countries (France, Germany, Poland), well documented and studied in detail are prehistoric flint mines (up to 10 metres deep pits etc.).

For the majority of flint made implements characteristic is the presence of milky-white rind of approx. 1 mm in thickness. It represents the product of chalcedony hydration.

Owing to the flint hardness and ability to split into thin blades which served as one of the most important cutting tools in the whole Stone Age. Also on the territory of Slovakia individual implements made from flint were documented in the past. Interesting are from flint made small axes (deposits of museums in Poprad and Zlaté Moravce).

Metamorphosed limestone (marble)

In processes of metamorphic recrystallization fine-grained even cryptocrystalline limestones of various origin and different stratigraphy change into medium- up to coarse-grained aggregates of calcite crystals (Fig. 7). Such rocks are known under denomination crystalline limestones (term used by geoscientists) or marble (term used by non in geosciences educated people).

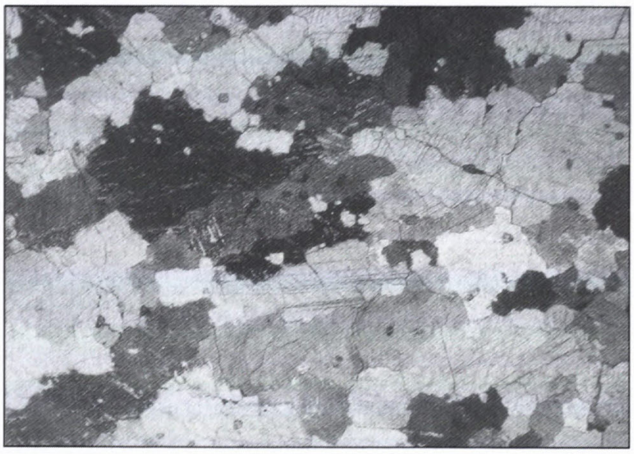

Fig. 7. Crystalline limestone. X polars, magn. 25x.

Though limestones on the territory of Slovakia belong among widespread rocks, their metamorphic equivalents are scarse. Known are namely so called Tuhár marbles of Carboniferous (?) - Triassic (?) age characterized by typical pinkish color and by the presence of darker veins and veinlets. Locally they are also of banded pattern. Another type of crystalline limestones represent those of the Meliata Unit occurring on surface in the southeastern part of the country. They belong mostly to the Middle up to Upper Triassic. Classical area of their occurrence is South Slovakia Karst (namely area of Silická Brezová village).

Ornamental implements of various shape, sometime bored, found on the country territory, are made from crystalline limestones non identical with mentioned main types. As decorative products made of discussed raw material type appear namely during Eneolithic and as they do occur on the western Slovakia sites, we suppose the Bohemian Massif (namely geological units of it eastern rim) being the raw material supplyer.

Metaquartzite

In several Western Carpathiains geological units Lower Triassic sandstones are present in the form of their metamorphosed equivalents, e. g. metaquartzites. Such are known to occur in the Slovenské rudohorie Mts. as well as in the Tribeč Mts.

Relativelly increased number of documented, from metaquartzite made implements, namely bases and crushers, appear in the Nitra river valley southward of the Tribeč Mts. Based on this we suppose that metaquartzites of this mountain range supplyed Neolithic and Eneolithic communities by this raw material type. But other raw material sources of metaquartzites, namely in the other parts of the country, are highly probable.

Metaconglomerates

Slightly metamorphosed microconglomerates (size of individual clastic constituents being of the range 1-3 mm) do occcur in the Lower Triassic as well as Permian strata. The dominant clasts are those of quartz of transparent up to violet colors. The other clastic constituents are represented by green and violet schists and seldomly also micas and feldspars. Matrix of conglomerates has composition of fine-grained sand. Metamorphosed microconglomerates of mentioned characteristic appearance are known to occur namely in the western Slovakia core mountains: the Malé Karpaty Mts. Považský Inovec Mts. and Tribeč Mts., as well.

Bases with traces of use made of microconglomerates we have documented on several western Slovakia sites, namely those in the broader vicinity of the Tribeč Mts. So heavy bases (1-5 kg) made of described raw material type have been transported on short or very short distances.

MESOZOIC ERUPTIVES

Though sedimentary sequences, belonging to different tectonic units, represent their highly prevailing part, in several Mesozoic partial basins also volcanic activity took place. Units with known volcanic activity are namely:

a) in the Middle Cretaceous of the Silezian unit of the Flych belt numerous subvolcanic and in less amount also volcanic bodies forming together alkali suite are known. They form classical area of „the teschenite-picrite province", including type localities of both, teschenite as well as picrites. In the very last years the whole volcanic province have been reclassified for lamprophyres (Dostal and Owen 1998).
b) In the Krížna nappe Middle Cretaceous occurring in various mountain ranges also alkali basalts do

Slovak Geol. Mag., 10, 1-2(2004), 5-16

occur. They form areally small occurrences of lava flows, hyaloclastites, lava breccia and the other forms (Hovorka a Sýkora 1979).

c) Characteristic are also tholeiitic basalts (Fig. 8) being part of „incomplete or tectonically dismembered ophiolites“ (Hovorka 1979) of the Meliata Unit of the Triassic-Jurassic stratigraphy. Basalts of discussed provenience are known to occur in the form of small (several decametres long) bodies cropping out between Margecany and Košice.

d) From geological point of view very important are under high pressure metamorphosed tholeiitic basalts (= blueschists) of the Meliata Unit.

Fig. 8. Paleozoic basalt (diabas). X polars, magn. 45x.

As concerns above volcanic provinces we have identified implements made of: ad a) one fragment of axe made of the teschenite found on the site Cífer-Pác (Hovorka et al., in print), ad c) several implements documented from sites in the Poprad basin (Hovorka and Soják 1997) should be derived from the Meliata Unit thleiites, and ad d) blueschists as the raw material of Neolithic/Eneolithic implements were documented (Hovorka et al. 2002) from several sites located in the Poprad basin (l. c.) as well as in the western part of the country.

PRE-CARBONIFEROUS METAMORPHIC COMPLEXES

Pre-Carboniferous metamorphic complexes, along with variscan magmatites of the granite suite, form the backbone of the individual mountain ranges. Among metamorphites those of sedimentary, as well as of the magmatic origin are known to occur. Their surface areal distribution is in individual mountain ranges very different. Also intensity of (mostly variscan) metamorphic recrystallization differ among the main tectonic megaunits. Taking into account character of the protolith, intensity of its regional metamorphic recrystallization, as well as its recrystallization in contact-thermic aureoles of the variscan magmatites, very colorfull set of metamorphic rocks is known from the Western Carpathians mountain ranges. In the following main rock categories, used as the raw material, are characterized.

Leptynite

In the very last years within pre-Carboniferous metamorphic complexes in several mountain ranges leptynite-amphibolite complex was described (Hovorka et al. 1994). The main textural pattern of the above mentioned complex is manyfold alternation of light - leptynitic, and dark - amphibolitic layers of mm-cm thickness.

Light - leptynite - portion of the above complex was identified as the raw material of several, mostly big, hammer-axes and axes. Their appropriate technical properties are based on the low content of micas and chlorites resp., in the given rock type.

As in the other raw material types with developed foliation, also in the case of leptynite made artefacts their long sides are conform to planes of rock schistosity.

Amphibolite

This rock lithology belongs among the most common ones in the pre-Carboniferous complexes of the central Western Carpathians as well as in the veporic units of the Slovenské rudohorie Mts. From genetical point of view they are : a) members of the leptynite-amphibolite complex (see above), or b) they form individual bodies located within gneisses or mica schists of the mentioned geological units.

Among amphibolites several petrographic varieties should be defined. For amphibolite varieties used as the raw material for implements construction, mostly fine-grained amphibolites s. s. or melaamphibolites, both of weak and well pronounced schistosity, were used by the Neolithic/Eneolithic tools and weapons producers. Only fresh types (no types with signs of diapthoritic recrystallization) were used. Garnet amphibolites were from sets of raw material blocks excluded.

From amphibolites/melaamphibolites namely axes, hammer-axes and chisels were made. With regard to the distance of this raw material sources, amphibolites should be classified as very local or non pronounced distant raw material. In the majority of implements made from this raw material type, river pebbles ought to be considered as the direct source of the raw material used.

Increasing amount of plagioclases in amphibolites cause their gradual alternation to amphibole gneisses, which in several cases have been also detected as the raw marerial of the Neolithic hammer-axes and axes.

Greenschist

Among Western Carpathians metamorphites greenschists belong to less occurring raw material types. Majority of them is concentrated in the Malé Karpaty Mts. crystalline core as well as in the Paleozoic of the Spišsko-gemerské rudohorie Mts. (= Gemeric Unit).

Based on appropriate technical properties greenschists in the whole Neolithic/Eneolithic represented one of the most common raw material type of polished industry (Figs. 9, 10).

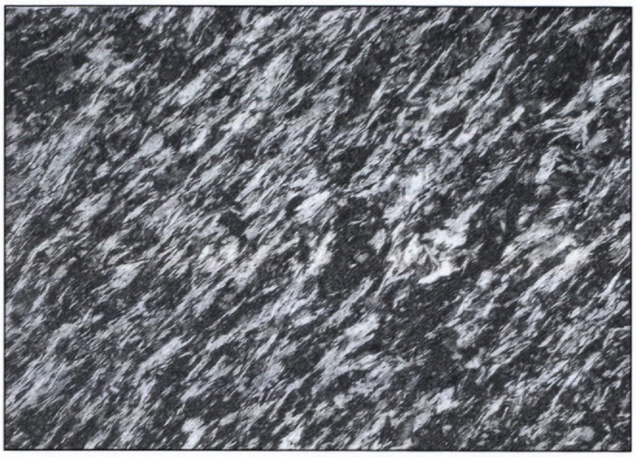

Fig. 9. Fine-grained actinolitic greenschist of planparallel pattern. X polars, magn. 45x

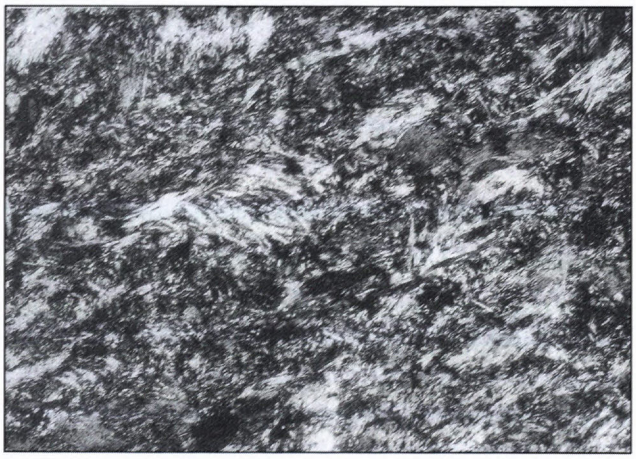

Fig. 10. Greenschis with local fan-like orientation of actinolite needles. X polars, magn. 75x.

To the category of greenschist belong rocks of various protoliths (pre-metamorphic material) which originated under limited pT conditions. Among the greenschists those composed of columnar up to hair-like amphiboles were mostly used. Felty pattern of amphibole needles make given raw material hard enough on one side, and elastic on the other one.

So various greenschist (composed of dominant amphibole needles, but not chlorites) was favourable raw material type during the Neolithic and Eneolithic in the whole central Europe.

Various types of this raw material were used for elaboration of different implements both of practical, as well as in less amount also ornamental destination. Though implements made from the greenschists are documented practically from all archaeological sites studied, their maximal concentration is known to occur on the western Slovakia sites.

Among several petrographic varieties of the greenschists described in detail by Hovorka and Illášová (2002) several of them are peculiar, or very rarely occurring types. To this category belog greenschist with green (Al-rich) spinel present in the amount of substantial category (Hovorka et al. 1997). Greenschists of this type have not been described in geological literature from the central Europe yet. So source geological bodies of this raw material type are unknown. Implements (mostly bored axes) made from this raw material type are known to occur in practically all western Slovakia archeological localities. Based on very fine-grained character of this raw material type, for its identification thin sections studies are needed.

Another characteristic variety of greenschis is that one with evidences of postmetamorphic biotitization (flogopitization). Mentioned process yielded in irregular fine-flaky nests of dark mica in the actinolite aggregates or even in origination of tiny veinlets filled up by pleochroic dark fine-flaky aggregates of mica. Veinlets are often of oblong up to perpendicular orientation to the general metamorphic foliation of the given rocks. As Early Paleozoic metamorphic complexes of the Malé Karpaty Mts. are characteristic for mentioned process, which represents the influence of late magmatic pneumatolytic-hydrothermal activity of the variscan Modra tonalite massif, we rank discussed type of the greenschist among very local/local or on short distance transported raw material type.

Antigorite serpentinite

Based on petrological aspects in the last decades two main categories of serpentinites are distinguished:

a) lizardite-chrysotile serpentinites which originate through hydration process of original peridotites. Process took part under temperature lower as 350°C.
b) The other serpentinite type is composed of prevailing antigorite with talc, tremolite, Mg-chlorite ao. present in lower amounts. Antigorite serpentinites originate under higher temperatures.
c) Both types of serpentinites are known to occur on the country territory.

Serpentinite bodies of the a) type represents members of the Triassic-Jurassic Meliata Unit, of the oceanic provenience, while b) type serpentinites are known to occur within the Tatric and Veporic metamorphic complexes.

Based on the fact that lizardite-chrysotile serpentinites have not been identified (which is the consequence of the presence of chrysotile veinlets in this rock type. They represent „weakened" zones or zones of splitting of ready made implements during their practical use), only implements made from the antigorite serpentinites were identified in thin sections.

Slovak Geol. Mag., 10, 1-2(2004), 5-16

Antigorite serpentinites are known to occur in mountainous areas of central and southeastern Slovakia. Antigorite serpentinite made implements (namely hammer-axes) are documented namely from the western Slovakia sites. Based on known occurrences of antigorite serpentinite bodies in the geological units on the eastern rim of the Bohemian Massif, and namely in the Lower Silesia (SW Poland) we suppose that the majority of implements made from the antigorite serpentinites have their sources in above mentioned units.

Metaquartzite, quartzitic gneiss

Original quartz sands or subgraywackes under high temperature greenschists or amphibolite facies pT conditions have been recrystallized to metaquartzites and quartzitic gneisses. Among limits of their practical use low till null amount of mica is basic one.

Bases made from quartzitic gneisses up to quartzites have been reported by Březinová et al. (2002) from the Neolithic/Eneolithic site Golianovo.

IMPORTED AND PECULIAR RAW MATERIAL TYPES

Among set of raw material types used during the Neolithic and Eneolithic on several archeological sites individual implements made from peculiar (imported) raw material types have been documented in the past (Hovorka and Cheben 1997, Hovorka and Illášová 2000). Such raw material types are represented mostly by one implement (or its fragment) only. Among such raw materials we rank:

soapstone/talkschist - one by morphology „ornamental" small axe, the most probably of symbolic or ornamental destination is deposited in Senica town museum,

graphitic schist - has been detected as the raw material of bracelet of the ring form (Podtatranské Museum in Poprad: Hovorka and Illášová 2002),

eclogite - two eclogite implements of genetically different raw material types, of the hammer-axes typology have been documented in the last years (Hovorka and Illášová 1996, Hovorka et al. 2001). In the both (Figs. 11 and 12) cases distant sources (the most probably from the Bohemian massif) are considered,

transparent quartz crystal - small implements of ornamental purpose have been reported (Illášová and Hovorka 2002),

melaphyre (paleobasalt) of the Permian - Lower Triassic in age due to its pronouncedly phyric pattern represents only seldomly for implements construction used raw material type (Hovorka a Illášová, 2002),

quartz porphyry - as the raw material of individual implements this rock type was used already in the Paleolithic (Mišík 1975),

limestone as the raw material for various, mostly ornamental or symbolic small implements was described from several Neolithic/Eneolithic localities (Hovorka a Illášová 2002),

Fig. 11. Symplectitic eclogite composed of Gar, Cpx, Hbl, Ab, Rtl. X polars, magn. 75x.

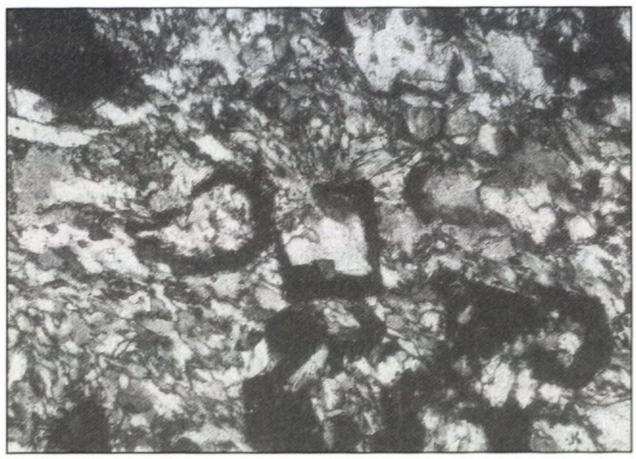

Fig. 12. Garnet-omphacite eclogite. Atoll-like garnets are of almandine composition. X polars, magn. 168x.

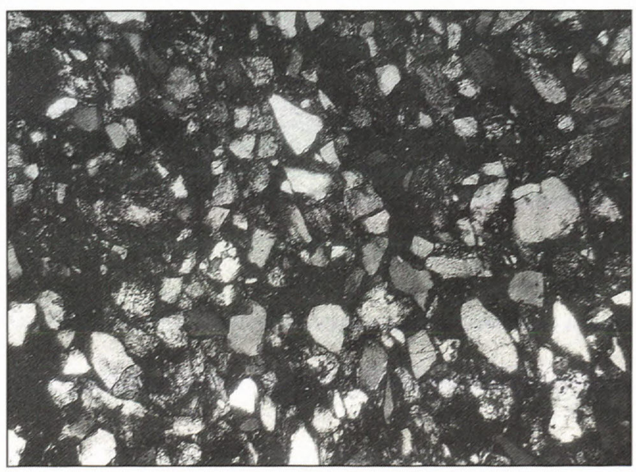

Fig. 13. Metagraywacke. X polars, magn. 45x.

metagreywacke made implements have been documented from Cífer-Pác site only. Local source (the Malé Karpaty Mts.) of this raw material type (Fig. 13) is supposed,

limy mudstone of Paleogene age represents the very local raw material type e. g. on site Šarišské Michaľany (Banská et al. 1998),

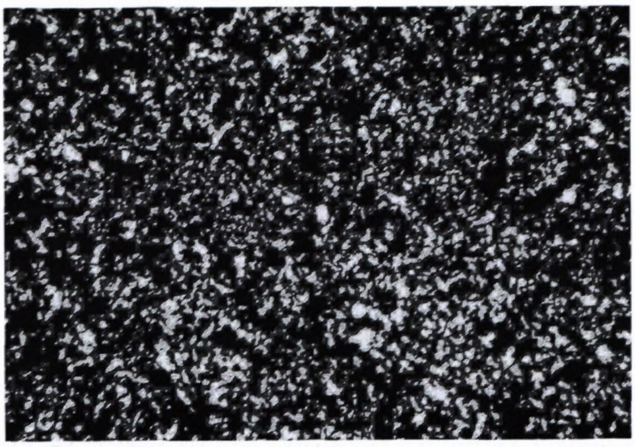

Fig. 14. Siltstone. X polars, magn. 85x.

siltstone (Fig. 14) is also one of seldomly used raw material type. Its Paleogene age is supposed. Several small implements made from this raw material type have been documented on the eastern Slovakia sites,

jadeitite was identified (by the use of electron microprobe) just in the case of one non-bored small axe found nearby the Senica town (Hovorka et al. 1998).

DISCUSSION AND CONCLUSION

Adequate quantity and quality of raw materials available substantially influenced the whole development of the mankind. In the whole Stone Age inorganic raw materials represent determinative *agens movens* for the mankind development.

Territory of the nowadays Slovakia since the Middle of the Early Paleolithic was inhabited. Evidences for it represents namely crane of the *Homo neanderthalensis* (the Gánovce man: 105000 b. p.), the Moravany Venus (made from the mamooth tusk: around 40000 years b. p), part of the Paleolithic human crane found in the river Váh depositions nearby Šala town ao.

Similarly as in the other part of the Old Continent determinative raw material types during the Paleolithic also in the territory of nowadays Slovakia were various silexes (submicroscopic quartz and its hydrous forms) together with radiolarites and obsidian. All of them have natural occurrences on the country territory. In the case of obsidian from the eastern part of Slovakia (Zemplín Hills) there exist evidences on its export to the northwest and west. For the central and western Slovakia Paleolithic as well as Neolithic sites characteristic are implements, used for cutting, made from hydroquartzite (limnoquartzite) which occurs on several places in the Žiarska kotlina basin (central Slovakia). But from several Paleolithic sites instruments made from nontraditional, we should say that for the Paleolithic progressive, raw material types were documented. Among such unexpected raw material types we rank implements made from porphyroids, from various silicified sediments of different lithology and the others. They all document that local, though nontraditional raw materials were mostly used by the Paleolithic communities.

The spectrum of raw materials used in the Neolithic/Eneolithic is much wider. All three main genetic rock clans were used, e. g. igneous, sedimentary as well as metamorphic rocks. For all of raw material types used there should be defined limits of their practical use: raw materials for implements production were mostly very fine-grained types, without substantial amount of sheet silicates, often with felty pattern. They were aphyric, or even fine-phyric types without any signs of cracks or material inhomogeneities present. In the case of effusive rocks evidently fresh types were used. Majority of raw materials documented have their sources on the country territory, or in geological units of neighbouring countries. Among them namely eastern rim of the Bohemian Massif seems to be supplyer of substantial amount of raw materials used namely in western Slovakia.

During the Neolithic there exists evident progress in technology of raw materials elaboration. For boring both nowadays known techniques were aplied: the whole hole boring and core boring. For both types of boring we have (Hovorka and Illášová, 2002t) well documented examples. But till now time succession priority of type of boring applied is not solved yet.

Characteristic inorganic raw material for so called *ceramic Neolithic* are various genetic types of clays or loesses used for ceramic pastes production. Though raw material for ceramic production offer numerous information on the raw material used, its provenience as well as ready made vessels have high informative value on the temperature of ceramic burning, use or not use of potter´s wheel and the other informations. During the whole Neolithic/Eneolithic various natural colors were used. From the material point of view they mostly represent metal oxids and hydroxids being the main constituent of ore gossans. Another type of natural colors are those of the „colored clays“ character. Colors have been used for human bodies coloring and for the decoration of the produced ceramic. During the Eneolithic also for walls painting or for expression of artistic feelings.

During the very end of Eneolithic also seldom ornamental products made of gold and copper were documented from the eastern Slovakia. They represent precursors of the coming Bronze Age.

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Slovak Geol. Mag., 10, 1-2(2004), 17-42

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Raw materials in the Neolithic-Aeneolithic of the Iberian Peninsula

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Introduction

S. Domínguez-Bella

The Iberian Peninsula, with an extension of 581.600 km^2, a great geological diversity and hundred of archaeological sites with recent prehistory chronologies, results an interesting territory for the lithic raw materials study and their use and distribution paths along the different historic periods.

This indubitable interest contrasts with the scantiness of studies about the raw materials used in the lithic industries of the prehistory, especially in the Neolithic-Aeneolithic period, where the lithological diversity is usually bigger than in the Palaeolithic.

This fact has carried out to the practical "inexistence" of this extensive territory, in a lot of the publications that has been realised over this thematic up to date in Europe, Cummins (1983).

In this chapter, we can only pretend to give first ideas of the types of raw materials that appear with a greater abundance in the Iberian Peninsula, making a balance of the published results just to date; the general characteristics of the Iberian geology and what possible trade and distribution routes have followed many of these materials at the Neolithic-Aeneolithic in this area.

It is plain that the great number of archaeological sites and chronologies known in this territory, their vast cultural, geographical and geological diversity, and the great variety of sites (caves, open air settlements, burials, villages, megaliths, etc.), make that the investigation task still outstanding is enormous and undoubtedly a challenge for the future researchers.

The Neolithic in the Iberian Peninsula has been submitted at very traditional focussing and basically dominated by the cultural change in the ceramics explanations. It was believed that their provenance from the Middle Orient and the diffusionist type explanations were reinforced, in contrast with the ligurian cave of Arene Candide (Italy). In the 60th-70th decades, Pellicer (1967) considered a tripartite scheme (Old, Medium, Recent) on the basis of the studies of caves as Carigüela de Pínar (Granada) or Nerja (Málaga).

The studies of the Valencian caves (Or, Cocina, Cendres) questioned the basis of the dual model that domains as paradigm in the functionalists explanations, recycled in explications of diffusion. A wave of advance from Middle Orient was considered, that provide the Neolithic to SW Europe and go to acculturate to the old hunter-gatherer populations. It is considered that the Neolithic arrived associated to the cardial ceramic horizon, with groups that behaved the agriculture and the cattle raising.

Other studies in caves as Fosca (Castellón) studied by Carmen Olaría and Francesc Gusi, already questioned the Levantine model and proposed chronologies previous to the Vth millennium B.C. for the first groups of producers. The excavations of Pellicer and Acosta in the caves of Dehesilla, Parralejo and Nerja in the 80th provided already previous chronologies, dated at VIth millennium for the Neolithic in the Occidental Subbetic. This fact carried to a restatement of focusing to positions more autochthonists, Pellicer (1995).

Recent studies in archaeological sites of the Cadiz and Algeciras Bays, as in Embarcadero del Rio Palmones and El Retamar, questioned the advance wave models, and confirm the specific weigh of the lithic technology with a Epipalaeolithic tradition (geometric microliths). In the VIth and even VIIth millennium B.C., it is possible to observe the wide paper of the vegetal resources, the importance of the fishing practices and a growing increase of the animals domestication (bovids, caprids), together with the hunting maintenance, Ramos and Lazarich (2002), such as reflects the Portuguese sea shell accumulations from the Bays of Lisboa, Setúbal and the Algarbe (Lagos area).

Geological context of the Iberian Peninsula

The Iberian Peninsula, formed by Spain, Portugal and Andorra and placed at the SW extreme of Europe, is a complex territory with a great variety of geological domains, ages and lithologies. Their geological materials included materials from the Precambrian or Upper Proterozoic (more that 600 million years), to the Holocene, grouped in greats units. These Units are: the Hespérico or Hercynian Massif, the Alpine cordilleras (Pyrenees, Betic Cordilleras), Cantabric Cordillera, Iberian System and Costero-Catalana Cordillera (Fig. 1).

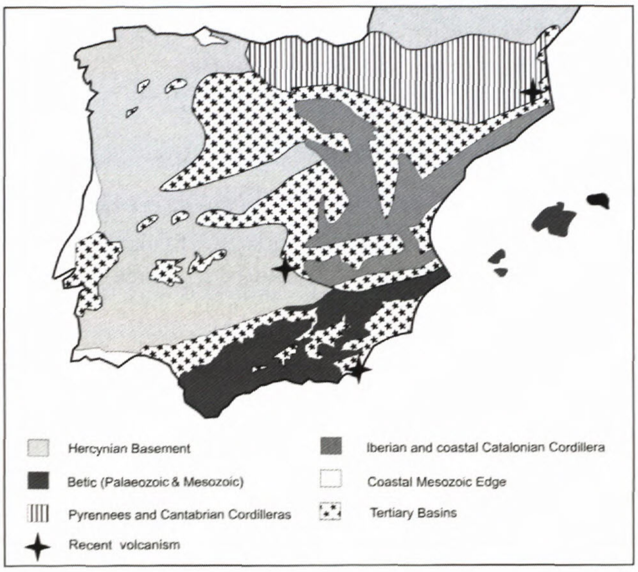


Fig. 1. Geological synthesis of Iberian Peninsula.

In these units, we can differentiate two great groups of materials: the ones that formed the Hespérico or Iberian Massif, that cover almost the west half of the Iberian Peninsula, formed fundamentally by premesozoic materials, in general metamorphic and plutonic rocks, and affected by the Hercynian or Variscan orogeny, being a basement that corresponds with an old mountain chain formed in the Upper Carboniferous and after eroded; and the ones that form a second group of materials that appear in the Peninsula and is constituted by Mesozoic and Cenozoic rocks, generally sedimentary.

The geological evolution of the Iberian Peninsula has been developed during a period of 250 m.y., and has been produced fundamentally by compressive forces, on the Iberian microplate, between the European and African tectonic plates, in general with materials of marine origin. The main characteristics of each of these great units are briefly, the following:

The Hespérico Massif was divided in 6 zones by Lotze (1945), after in 5 different zones by Julivert (1979), with limits between them subjects at controversy, Dallmeyer-Martinez, (1990). These zones are: the Central Iberian Zone and four more zones: Astur-Occidental/Leonese Zone and the Cantabrian Zone at the North, and Ossa-Morena and South Portuguese zones, at the South.

In the *Central Iberian Zone (CIZ)*, the more extended (North of Portugal, Galicia, Castilla and León, Madrid, Castilla-La Mancha, Extremadura and a portion of N. Andalusia). Present Palaeozoic and Upper Proterozoic rocks, nearly always metamorphic from lower to high grade (migmatites in Central System) and an abundance of granitic intrusions. In the North occidental area (Galicia) appears a series of allochthonous nappes or ophiolitic fragments of exotic terrains, the catazonal complexes of Cabo Ortegal, Ordenes, Lalín, Braganca, Morais and the blastomylonitic band. These units appear constituted by eclogites, metagranulites, metaperidotites, metasediments and amphibolites. Metamorphosed basaltic rocks also appear, Gil Ibarguchi & Arenas (1990). Metaperidotites are spinel-bearing harzburgites, dunites and pyroxenites. In the lower zone of the epizonal units, present in this ophiolites, appear greenschist facies. Other lithologies are metabasites and blueschist (in the Morais-Braganca area).

The *Astur-Occidental/Leonese Zone* and the *Cantabrian Cordillera* are placed between the Hercynic Massif materials of Galicia and the Pyrenees. The metamorphism grade and number of plutonic intrusions increased towards the West. Present sedimentary rocks from the Lower Palaeozoic (slates, quartzites, etc.), and Precambrian rocks in two antiforms: Narcea and Ollo de Sapo.

The Cantabrian cordillera has its origin in the folding of a Mesozoic basin, during the Alpine orogeny. The result of this process is a mountain chain parallel to the coast of the Cantabrian Sea. They present materials from the Triassic to the Tertiary; evaporites and detrital materials from the Triassic; carbonated marine sediments from the lower and middle Jurassic; fluvial and deltaic detrital materials from the upper Jurassic and Cretaceous. Reef facies are also present at the end of the lower Cretaceous and typical facies of the continental platform in the upper Cretaceous, and after a transgressive period, turbidites and abyssal deposits. In the lower Tertiary, are present limestones with organic materials and detrital sediments. In the Eocene the main orogenic folding was produced; in the Oligocene, a molasse sedimentation was produced into inner isolated basins just to the medium Miocene, with the deposit of post-orogenic sediments.

The *Ossa-Morena Metavolcanic Zone*, is characterized by materials from the Precambrian to the Upper Palaeozoic, and metamorphic and granitic rocks. Near the limit between the Central Iberian Zone and the Ossa-Morena Zone, a big batholith is placed, the Batolito de los Pedroches. Between this area and the South Portuguese Zone appears a narrow band or suture zone, with ophiolite type materials in which dunite, serpentinite, metabasalt of a Precambrian age and other rocks as granites are present, with a great nappe structure. The metamorphism of these rocks produces greenschist with chlorite and amphibolites with garnet-staurolite, Quesada & Munha (1990).

In the *South Portuguese Zone*, one zone sutured in the South, along of the Pulo do Lobo ophiolite, outcrop flysch type materials with a low metamorphism, from final Palaeozoic (Devonian and Carboniferous), intercalated with volcano-sedimentary materials of a felsic volcanism, and associated with great deposits of polymetallic sulphides (Pyritic Belt).

The Alpine Cordilleras: This orogenic belt that extends from Asia Minor to Gibraltar Strait, is present in the geological history of Iberia in the last 200 m.y., from the end of Palaeozoic to the present. The two great Alpine cordilleras in the Iberian Peninsula are:

The *Pyrenees.* (Figs. 1 and 4.B) This mountain chain, that separates Iberia from France, is constituted by a nucleus of materials that was affected by the Hercynian orogeny and later by the Alpine orogeny. In its Palaeozoic nucleus the metamorphic lithologies are dominant, deformed by the Hercynian orogeny and forming the basement and the maximal heights of these mountains. At the North and South of this nucleus, Mesozoic-Palaeogene sedimentary materials appear, that together with the basement were deformed by the Alpine orogeny and which form the marginal Sierras, in general of carbonates lithologies. This chain is basically formed during the Eocene, by a contact between the Iberian microplate and the Euro-Asiatic plate, which generates great compressive forts due to the lithosphere shortness and with a big folding and fracturation. The chain, with a WNW-ESE direction, appears divided in two, north and south zones, separated by a faulted zone. This transform fault affects to the lithosphere and has played an important role in the Iberian plate movement in front to Europe.

We can separate two zones in the Pyrenees: the Occidental or Basque-Cantabrian Pyrenees, and the Central and Oriental Pyrenees, with two zones, one southern or South-Pyrenean and other northern or North-Pyrenean, which extends up to Aquitaine. In the axial zone predominates the metamorphic rocks and granitoids, the north and south Pyrenean zones (Pre-Pyrenees) are constituted by sedimentary rocks of different lithologies, specially the Mesozoic carbonates.

The *Betic Cordillera.* (Figs. 1 and 7) This cordillera formed in the Alpine orogeny, is extended from Gibraltar to the Balearic Islands, as well as symmetrically by the North of Africa. The South of Iberia presents a Neogene sedimentary material band that constituted/formed many sedimentary basins as the Guadalquivir river basin, Vera (1988). Other band of Mesozoic and Cenozoic sediments, placed on a metamorphic plate of the Hesperico Massif. These materials can be grouped in two great groups: the Prebetic and the Subbetic-Penibetic, the first ones with shallow sedimentary marine materials and the second ones with deep marine sediments, in both cases very tectonised, with nappes and folds. At the west of the chain appear the Campo de Gibraltar Units, formed by turbiditic materials of flysch type, Gutierrez Mas *et al.*, (1991). In the central part and the east of the chain, appear the metamorphic materials of the inner zone, the Domain of Alborán. This region has been divided in many units: Malaguides, Alpujarrides and Nevado-Filabrides, Vera (1994), Martín-Algarra (1987). In these, appear premesozoic and Mesozoic metamorphosed rocks, with high pressure and low temperature facies (Nevado-Filabrides) or high grade rocks (Alpujarrides) (eclogites, amphibolites, gneiss, schist, etc.). In the central part, a great block of ultrabasic rocks (peridotites from Ronda) appears.

The *Iberian Cordillera.* (Fig. 1) This cordillera presents a basement of metamorphic rocks, that belongs to the Hercynian Massif and outcrops in many sites of the cordillera, over this appears a launching level with facies formed by marls and gypsums of Triassic age, over this appears in discordance, a group of sedimentary rocks of Mesozoic age, in general carbonates, that was extended from the Cantabrian Cordillera to the Valencia Gulf, in the Mediterranean Sea.

Many intercalated volcanic rocks occasionally appeared. In general metamorphism doesn´t exist. Finally, and due to a process of distension, along their evolution, little basins filled of Tertiary materials have been formed, as occurs in Almazan, Ateca or Teruel.

The *Catalonian Coastal Cordillera* (Fig. 1 and 4) presents two alignments parallel to the Mediterranean coast, from the Rosas Bay to the delta of the Ebro River, in the NE of Spain. It is an Alpine cordillera with Mesozoic materials in discordance over a Hercynian nucleus. In many areas of the Cordillera appear tectonic depressions (graben) filled by tertiary sediments. In the central area, a tectonic accident, the Llobregat fault, cut in two parts the mountains alignments; at the northeast area the Palaeozoic materials predominate and in the Southwest area, the Mesozoic presents a progressive development up to the Ebro River delta.

Alpine sedimentary Basins. They were formed in the process of opening of the Atlantic Ocean and the movement of the Iberian microplate to the east generating the alpine mountains, originated in the inner intracratonic basins, that quickly started to eroded, and foreland basins in the marginal zones of the continental margin. From the first group are the Duero and Tajo Basins and from the second, the Guadalquivir and Ebro Basins.

The volcanism in the Iberian Peninsula. A Cenozoic volcanic activity appears, which seems to be of the intraplate type, with activity areas between the Upper Miocene and the Quaternary, in three zones: Olot, at NE Spain, Campo de Calatrava, in the central region of Spain and Cabo de Gata, at the SE of the peninsula. Volcanic materials vary from the quaternary basalts in Olot, to the olivine basalts - olivine leucitites and olivine nephelinites from the Campo de Calatrava; with a volcanism of andesites and rhyolites, abundance of pyroclastic episodes and the presence of domes and outflows in the Cabo de Gata area (Fig.1).

Northwest of Iberian Peninsula, Galicia - W. Spain, Extremadura

In these regions, with an abundant Megalithic phenomenon and different archaeological sites of the recent prehistory, the petrological and mineralogical studies of polished industries are practically inexistent. Only many brief descriptions of the rocks in the lithic industry of many sites have been made just to this moment, Fábregas (1992), in Galicia. Mineralogical and chemical analysis of Neolithic green beads from Galicia were made by Guitián and Vazquez Varela (1975), Vazquez Varela (1975). In Extremadura region, an area with an important megalithic phenomenon, Enriquez Navascues (1995), Bueno (2000), Bueno et al. (2000), archaeometric analysis of lithic industry are not made just to date and are now in course.

North of Iberian Peninsula. Basque Country, Navarra, Aragón

Andoni Tarriño

Introduction

From the beginning, the raw materials in which are manufactured the prehistoric polished materials to attach attention, principally because they evidenced a great lithological diversity that seems evocated very different provenances.

So, from the end of the XIX[th] century and the beginning of XX[th], geologists have worked with the prehistorians in the examination of archaeological materials that composed these lithic elements to attempt the characterization of the constituent rocks and their geological and geographical origin. Among the pioneer studies in Spain, we can cite the works of Quiroga (1880) and of San Miguel de la Cámara (1918 and 1919).

But these petrographical studies were not continued for many reasons since this information could not be correlated with that one given by the geological outcrops, mainly because the basic geological works had not been done, which would have given an adjudication of the analysed rock type with a definite geological outcrop. At that time, works of geological cartography were beginning to start, with the creation of the Commission of the Geological Map of Spain. On the other hand, in those days, a great number of prehistorians still considered more important the object itself than its archaeological significance.

To these obstacles we also have to add the fact that the analysis methods were expensive and destructive. It is not till the 80 and 90 decades of the XX[th] century that more or less systematic petrographic studies will return, in this type of materials in Spain.

We found materials that generally present an external aspect different to the fresh sample of the same rock when the lithic raw materials identification of the polished implement manufactured are approached. These lithic evidences have undergone important surface modifications, that masked the mineralogical and textural criteria that usually serve for its identification due firstly to all the transformations derivate from the mechanical abrasion during the object manufacture phases (picking and polishing fundamentally) and, secondly to all the post-depositional processes that have been affected to the rock during their burial: patination, oxidations, dissolutions, recrystallizations, etc. in the rock-sediment interaction (fig. 2.B).

These circumstances have motivated that it has been necessary to recurred to physico-chemical techniques of characterization, with more or less precision for the determination of mineralogical and textural features of the rocks and minerals that composed the archaeological objects. Their classification are based in mineral percentages and also in chemical analysis, after a geochemical and a petrographic study.

Raw materials in the Basque Country, Navarra and Aragon regions

In the Basque Country, Navarra and Aragon, a great vacuum exists in relation with the raw materials determinations in which polished implements are made in the recent prehistory. A scarce number of publications exists on this line of investigation, so systematic studies have been done instead. The oldest reference that approach the nature of the prehistoric polished objects from the Pyrenean region, was realized by Mortillet in 1889: "Dans la région des Pyrénées, les haches sont en pierres de cette chaîne de montagnes, parmi lesquelles on remarque les ophites".

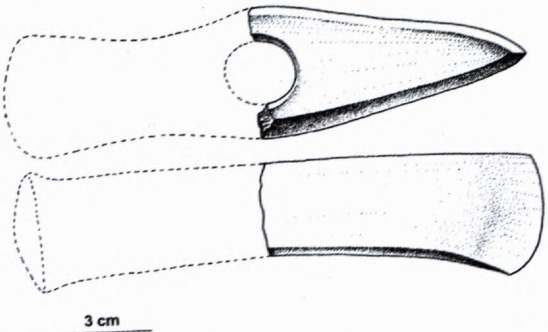
A great part of the polished artefacts proceeds from the casual discoveries or particular collections, generally without a complete information about their chronologies and context.

BASQUE COUNTRY

In the Basque country, data about the petrological features of the polished prehistoric industry are also very scarce, and sometimes, the determinations are not very reliable. One of the first works that compile polished materials from the Basque Country prehistoric cultures are the publication of Apellaniz (1973). Later, Arribas and Berganza (1984) studied 11 polished axes from different provenances in Gipúzcoa and Bizkaia, that just this moment are unpublished. These authors concluded that dolerites are the more habitual lithology in this group.

It is necessary to wait to the 90 decade to encounter an exhaustive work, that define, with certain warranties, the materials from which the implements are elaborated, in this region. This is the case of Ormazábal et al, (1994), that studied a total of 70 polished objects, collected in surface around the Urrúnaga reservoir (Álava). From this collection, 55 are identified and 15 objects and fragments are not identified. In this case, implements made

Fig. 2. A.- Perforated Axe from the Dolmen de Balenkaleku Norte (Altzania). (Barandiaran and Vallespí, 1984)



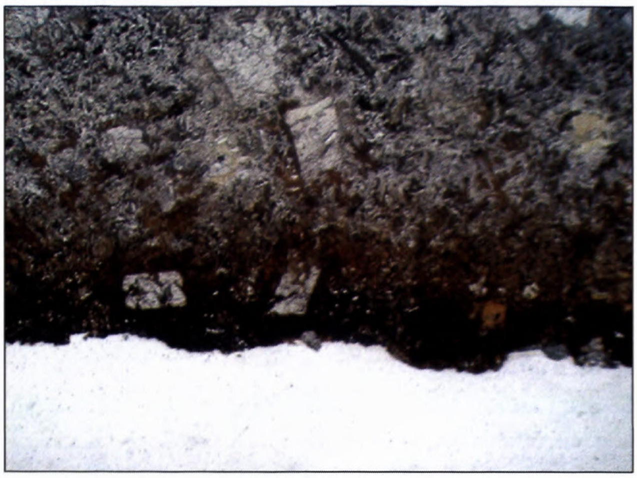


Fig. 2.B.- Micrograph of a tin section of a dolerite type object. It is possible to observe an alteration layer in the surface (in black and reddish colours) of 0,7 to 1,0 mm. Thickness. Parallel polars. Width of photo = 2,5 mm.

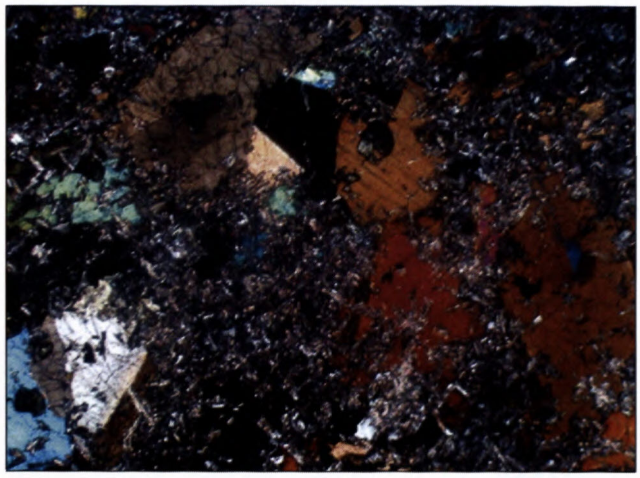


Fig. 2.C.- Dolerite type rock, with a medium to fine grain size. Crossed polars. Width of photo = 2,5 mm.

Fig. 2.D. - General view of the texture present in a vulcanite object. Crossed polars. Width of photo = 2,5 mm.

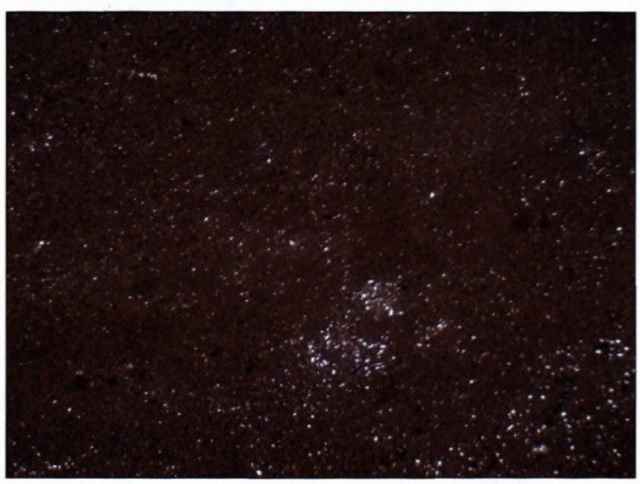


Fig. 2.E. - Siliceous mudstone with abundant and little detrital quartz fragments and micaceous minerals (5-10 microns in diameter). Parallel polars, Width of photo = 2,5 mm.

on sedimentary rocks are dominant, with a 77,12 %. Metamorphic rocks (quartzites and sillimanite-andalusite nodules) and igneous rocks (basically dolerites), with a 11,42 % in both cases, complete the register.

Another group of polished industry, has recently been studied by Fernández Eraso et al, 2003) where 34 axes and adzes, completes or fragmented, came across in 13 sites from Álava and the Condado de Trevino, in general from surface prospections.

Ten of these samples were analysed by means of petrographic microscope and their mineralogical composition and texture have been characterised. This is a group basically constituted by igneous rocks (79,4 %), with a 64,7 % of dolerites (Fig. 2.C) and volcanites - basalts (Fig. 2.D). Sedimentary rocks are the second group, with a presence of 14,7 % (shales, mudstones - Fig. 2.E - and flint). Finally, the metamorphic rocks are less represented, with only an 5,9 %, that correspond with sillimanite-andalusite samples, aluminium nesosilicates, typical from the thermal or contact metamorphism.

Most of these materials could proceed from the outcrops that exist in the alavese diapires, in short from the ophitic masses that exist in the Salinas de Anana, Maestu and/or Penacerrada diapires. As soon as, the more volcanic rocks, although their provenance is less evident, we can find very similar outcrops, both in the vizcaine Synclinorium as well as in the Palaeozoic from the Pyrenean occident (east of Gipuzkoa and north of Navarra).

Non volcanic lithologies present are the flint, that proceed from the Trevino outcrops and the mudstones that can proceed from siliceous-carbonated nodules, very abundant in the Cretaceous formations of the North of the Basque Country.

In relation with the polished implements made on sillimanite-andalusite metamorphic porphyroblasts, we can find the more neighbouring outcrops in the metamorphic aureole of the Penas de Aya Massif. Other possibility of source area, with good samples of this nature, can correspond with the contact aureoles of the granitoids from the Orient of Asturias, Fernández Eraso et al, (2003), with a farther provenance and so, their origin in these outcrops are much less probably.

NAVARRA

An important old compilation of data exist for the Navarra territory, in relation with the polished materials, realized by González Sáinz (1979) where it is summarized the collection of these materials known to the date. It is composed of a total of 257 implements and polished fragments. The petrological composition is hardly mentioned, the only identified material is the dolerite. This is a material that is abundant in this territory that appears associated to the diapiric terrains from the Keuper facies

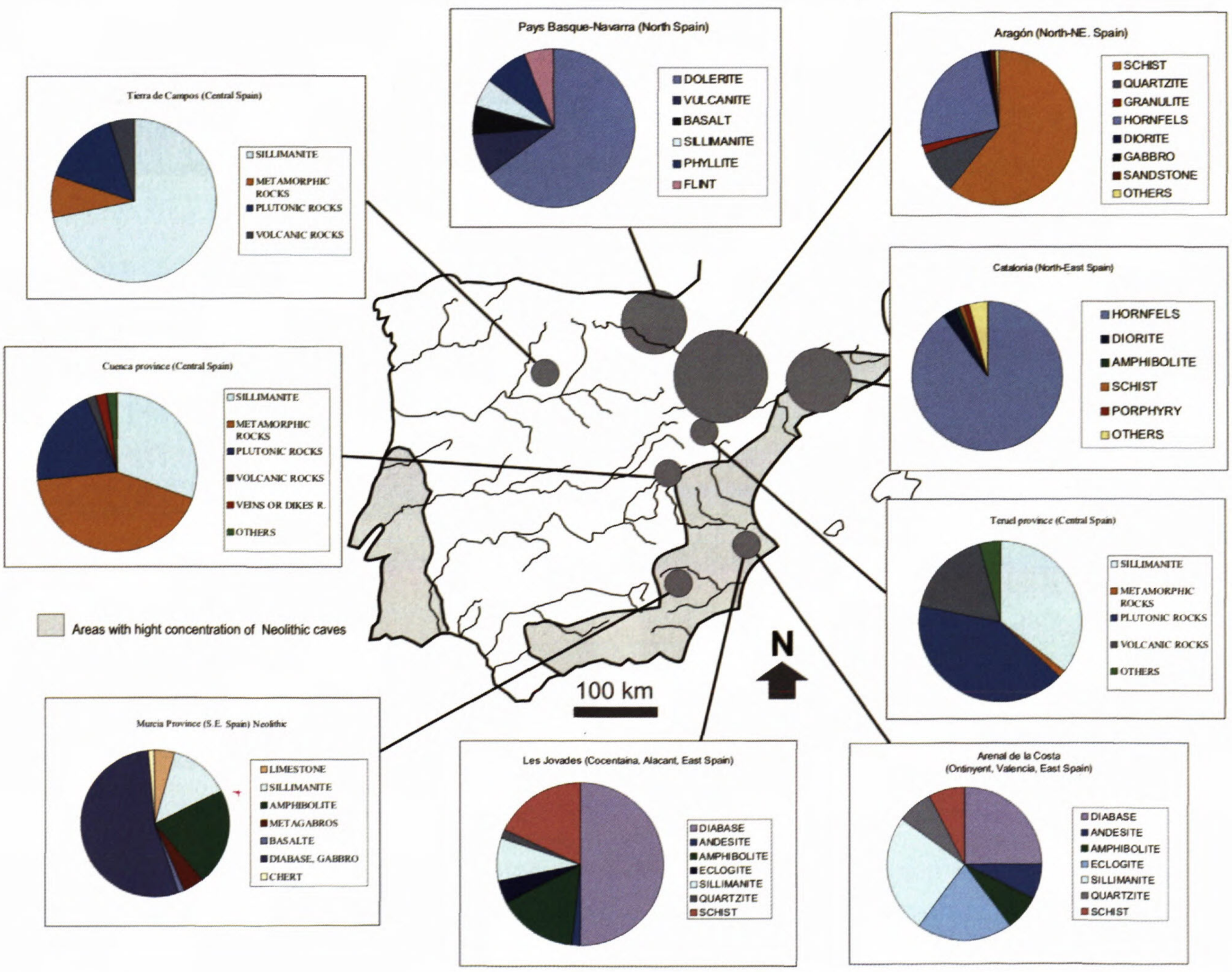


Fig. 3.- Statistical diagram (Quantitative percentages of lithologies in this polished industry) of rock groups from the polished lithic industry from Basque Country, Navarra, Aragón (North Spain); Cuenca and Teruel provinces; Catalonia, Pais Valenciano and Murcia province.(After data from Tarrino, Clop, Barrera et al., Orozco et al.), and two of the areas with a big concentration of caves with Neolithic-Aeneolithic sites.

and Triassic age that outcrop mainly in the Salinas de Oro, Larraun, Azpiroz y Ayos region.

Although the geographical distribution of the polished implements is very wide inside the Navarre territory, however, a larger density of findings can be appreciated in the medium-occidental Navarra, that is to say, in the nearest zones to the principal diapiric outcrops.

One of the more interesting examples of the polished objects from Navarra is the perforated axe (fig. 2.A) from the Balankaleku N. dolmen (Sierra de Altzania, Alsasua) which was recovered in the archaeological survey that in 1919, D. José Miguel de Barandiarán together with T. Aranzadi and E. Eguren carried out, whose data were published later (Aranzadi et al, 1921). Subsequently this finding is cited in a great number of occasions, Barandiarán (1934); Elósegui (1953); Maluquer de Motes (1962); Apellániz (1973); Vallespí (1974); Andrés Rupérez (1977); González Sainz (1979) and Barandiarán & Vallespí (1984). This type of axes are in general, frequent in Brittany and in the centre and north of Europe. Typologically it appears to have a clear relation, when it is compared with the series studied by Ch. T. Le Roux (1975) in Brittany and the Sena and Loira Basins.

A petrographic study of this axe, was realised by the Prof. San Miguel de la Cámara, which determined that it is an "ophite" (dolerite), and published a photography of the analysed sample by (Aranzadi et al, 1921). The macroscopic examination reveals that this is a basic rock with a dark green colour and a microcrystalline texture. With the summarized data it is possible to conclude that it is a rock with a doleritic composition and ophitic texture, of fine grain and compatible with the basic rocks that outcrop from the North of Iberian Peninsula to the North and centre of France and Europe (diabases and dolerites) so a far origin is not discarded.

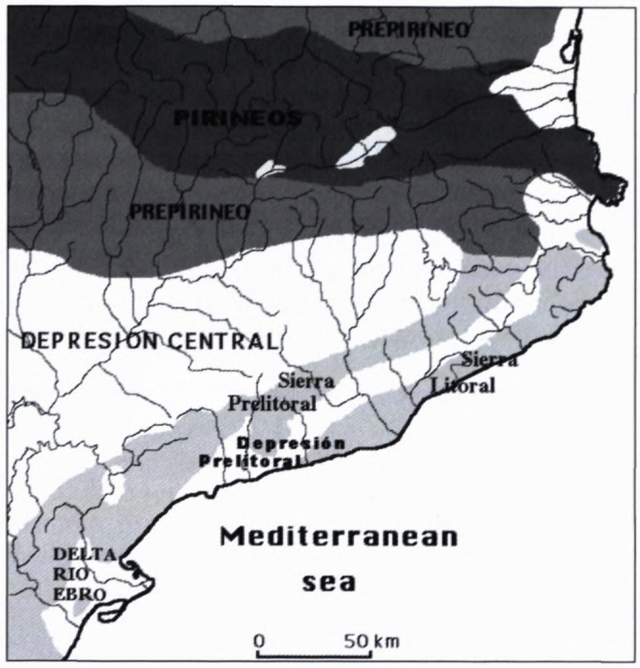


Fig. 4.A.- Geographical map of the North East area of the Iberian Peninsula

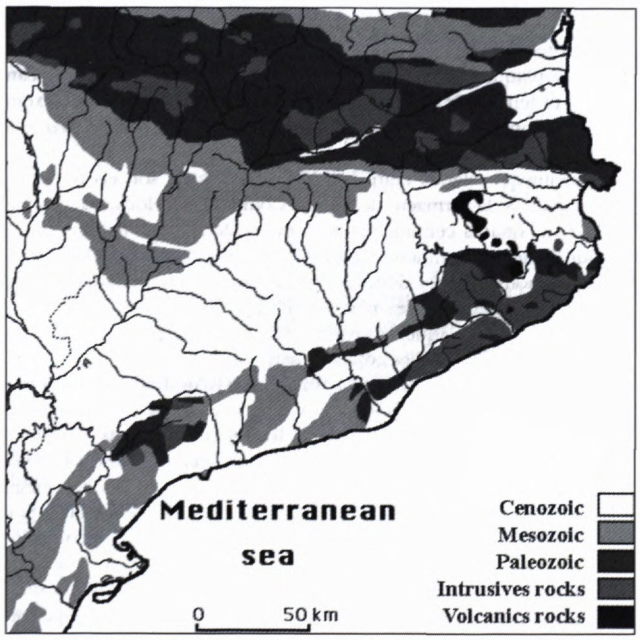


Fig. 4.B.- Geological synthesis map of the same area.

ARAGÓN

In the Prehistory and Archaeology Atlas of Aragon exist a recompilation in where are placed, in a general mode, the polished materials found in this region up to date, Utrilla (1980). At the same time, the most important general works are referenced, that contains more or less extend repertories of polished lithic products, Bosch Gimpera (1923); Ripoll (1953); Beltrán (1955) and Atrián (1960). But it is not just to the eighties when a monographic work about the polished implements of the medium course of the Cinca river (Monzón, Huesca), classifies the raw materials of the objects, in series of archaeological sites placed in this area, Mazo and Rodanés (1986).

In this collection with a total of 158 studied samples, 120 of these are classified. Practically the total (97,5%) of the samples are metamorphic rocks, from a regional metamorphism origin, in general schist and quartzites; a 25 % of hornfelses and a 3,3% of igneous (diorite and gabbro) and sedimentary rocks (sandstone). Without more definitive data about their petrological composition, these authors proposed a Pyrenean origin, compatible with the raw materials that appear in the Pleistocene gravels from the Cinca River terraces (slates, schists, hornfelses, volcanic and granitic rocks, sandstones), that were eroded and transported from the Pyrenean massifs (Fig. 2).

North east of Iberian Peninsula. Catalonia

Xavier Clop

Situation and geological context

The north-east of the Iberian Peninsula is characterised by the existence of a great diversity of terrain, landscapes and ecological units. The result of a complex geological history, the present-day relief of the north-east of the peninsula comprises three main blocks:

a) to the north there is the massif of the Pyrenees, which has a length of 450 km from the Mediterranean to the Atlantic, a maximum width of 150 km, and within which two main zones can be distinguished. First there is the main range of the Pyrenees, constituting the central axis of the mountain chain, which was in existence towards the end of the Palaeocene and which was raised and fractured during the orogenic Alpine phase. It is here that the oldest materials are to be found, largely metamorphosed and mainly Palaeozoics, such as granite, gneiss, slates, schists, marbles, etc. Then there are the Pre-Pyrenees, which comprise the relief on either side of the central Pyrenees and which were formed from the materials lain down during the Mesozoic and early Cenozoic and which were folded and raised during the orogenic Alpine phase. Limestones are clearly the predominant material, although in some sectors close to the main Pyrenean range we also find sandstones, conglomerates and red clays (Figs. 4.A and 4.B);

b) the ranges that run parallel to the coast and form a mountain system divided into two clearly defined chains: the Sierra Litoral (or Coastal Range) and the Sierra Prelitoral (or Pre-Coastal Range), which are separated by a long sunken plain, the Depresión Prelitoral (or Pre-Coastal Depression). The Sierra Prelitoral is the furthest from the coast, the longest (280-320 km) and highest (700-1700 m) of these three units. In its most northerly third we find some massifs composed of Palaeozoic and granite materials. Further to the south there are other massifs composed of conglomerates, Palaeozoic materials (slates), sandstones and limestones and Mesozoic marls. Further south still, there are a number of ranges comprising a fairly compact mountain block of quite abrupt relief, where limestones and sandstones are predominant, with a huge mass of "licorellas" (slates) and granites in the centre. Finally, as we get right down to the Ebro, we have one of the most abrupt massifs of the north-east of the peninsula, formed by limestones and Mesozoic dolerites. As for the Sierra Litoral, it forms a mountain range running along the coast itself, short in length (150-160 km) and narrow (10-15 km), with altitudes varying between 300-600 m. It is largely formed by granites and slates. South of the Llobregat, however, there are the ranges of the Garraf and the Ordal, formed by huge limestone masses. Between these, the Depresión Prelitoral forms a low-lying sunken sector some 200 km in length by 20-25 km wide, where there are principally clays and conglomerates (Figs. 4.A and 4.B);

c) the Central Depression, which lies between the Pyrenees and the Sierra Prelitoral and which is formed by series of eroded basins separated by different high plateaus and by an extensive plain that opens towards the west. Between the Pyrenees, the Iberian System and the costal ranges there is the Central Depression, an extensive area sunk in the early Tertiary era, slopping towards the west and progressively filled by materials from the neighbouring hills. Towards the centre of the depression, blue and grey marls were deposited. Towards the west large quantities of gypsum were deposited. On top of these evaporitic rocks were lain significant layers of materials brought down by rivers and streams and which constituted alternating layers of sandstone and clays (Figs. 4.A and 4.B).

The hydrological network of the north east of the peninsula has clearly defined traits. The western portion of the zone is occupied by the Ebro basin, which collects the streams of numerous tributaries to its left bank, that of the Segre -its source in the Pyrenees- being of particular importance. Of the other basins, only those of the Llobregat and the Ter are of any significant extent.

The human communities (5700- 2000 BC)

The first Neolithic communities of the north east of the peninsula have been documented to the first half of the sixth millennium BC. They are communities that, given their main material elements, fall within the set of cultural groups producing the impressed pottery of the western Mediterranean, specifically of cardial pottery. In the Early Neolithic of the north east of the Iberian Peninsula three phrases are normally distinguished, according to the changes in the decoration of pottery: the cardial Early Neolithic (cca 5700-4400 BC), the epicardial Early Neolithic (cca 5100-4000 BC) and the post-cardial Early Neolithic (cca 4900-3500 BC).

In the early stages of the Neolithic in the region, usually termed the cardial Early Neolithic, the human communities were probably formed by small groups of individuals who established themselves both in open air sites (La Draga, Plansallosa, Barranc d'en Fabra, Guixeres de Vilobí...) and in caves and shelters (Cova de Fontmajor, Cova del Frare, Cova Gran, Cova Freda, Bauma del Serrat del Pont,..). These communities, sedentary or semi-sedentary, were farmers and herders, their subsistence activities being characterised by the variety of species exploited in each case. Hunting and gathering, of progressively diminishing importance, would have complemented their diet. Although burial remains of the period are scarce, it should be noted that towards its end we find the first evidence of megalithic structures, well documented in the megalithic burial site at Tavertet.

Their material culture was largely composed of clay pots, varying in size, for cooking, storage or transporting different food products; a largely laminar stone-working industry, with which they produced arrow-heads, awls, sickle blades, etc.; a considerable number of elements that come under the term polished tools, such as axes, chisels, planes, etc.; a bone industry comprising needles, spatulas, bradawls, etc.; a significant number of ornamental objects, made from different raw materials, such as bone, shell and different minerals, etc.

The Middle Neolithic (cca 4400-3200 BC) was the real "Golden Age" in the recent prehistory of the north east of the Iberian Peninsula. For one thing, it saw the abandonment of the most mountainous areas and the concentration of population on the most fertile plains of the region. Sites such as Bobila Madurell and Ca N'Isach enable us to determine the characteristics of open-air settlements, as well as the main traits of their subsistence activities, with agriculture and herding now well-established. Significant developments in burial practices are well-documented both in open-air burial sites such as Bobila Madurell and Camí de Can Grau and in the development of megalithic barrow burials in the extreme north-east of the region and in the cysts of the central plateau.

The materials of the Middle Neolithic enable us to observe that the region was fully integrated in the major networks of the circulation of goods that existed at this time in the western Mediterranean and which permitted the distribution of different types of elements of mineral origin such as flint, obsidian and possibly certain types of rocks used in the making of polished tools, such as jades. The north-east of the peninsula was able to bring to these trade networks variscite, a mineral element used in the production of ornamental objects and which was obtained from the mines at Gava (Barcelona), undoubtedly one of the most important sites of recent prehistory, not just in the peninsula north-east by also in Western Europe.

Both the sum of burial evidence known in the whole of the region as well as the presence of its own mines allow us to argue that by this stage there was already a certain amount of development of internal social differences.

The Late Neolithic and the Chalcolithic extend from the final centuries of the sixth millennium to *circa* 2000 BC. The human communities appear to have broken down again into units of smaller size and occupy the whole of the region, including mountainous areas, again. The large number of sites documented suggests that significant demographic growth occurred. Apart from that, while it seems that there were no great changes in the architecture of living structures, which were very simple in nature and following the traditions begun in the Early Neolithic, as far as burial practices were concerned we see a spectacular increase in the number of burial structures, among which the most significant fact, apart from the extent of collective burials, is probably the diverse typology of burial sites. Different types of megalithic and para-megalithic burials were used: caves and natural shelters, structures of originally domestic use, etc.

Of particular note in the material culture is, first of all, the development of metal-working, with simple technology, for the production of sumptuary items. But we should also note the presence of a series of objects making up what has been called the Campaniform "pack", chief among which is Campaniform pottery. The Campaniform phase (circa 2800-2200 BC) shows that the region continued to be party to contemporary phenomena occurring in large areas of Europe.

Raw materials used in making polished tools

From the beginnings of prehistoric scientific research in Catalonia, researchers were aware of the importance of determining the raw material used in the making of polished tools and its possible origins. However, despite the fact that some prehistorians were fully aware of the importance that ought to be given in this sense to both petrographic analysis and the necessity of collaborating with specialist geologists, Serra-Rafols (1930), for decades the determination of raw materials, when it was carried out, was done so at macroscopic levels and invariably for a small number of polished tools. It was not until the 1980s that some researchers began to carry out studies of a certain rigour, using proper analytic methods, particularly taking thin sections, Bosch (1984); Alvarez (1986-1989). The characterisation of raw materials via the taking of thin sections has been up until now the most widely used analytic practice, Alvarez & Clop (1994) and (1998); Clop & Alvarez (1998); Clop/Alvarez/Reche (2000); Casas (2000). Only in the occasional relatively recent study, and in very specific cases, have other sorts of analysis been made, such as X-ray diffraction and microprobe analysis, Clop & Alvarez (1998); Casas (2000).

The work carried out in the last twenty years provides us with an overview that, although it still leaves many questions unanswered, allows us to put forward a number of working hypotheses based on very significant data obtained in the different studies made, often methodological practices of considerable variety.

Thus, on the one hand, we have the studies made during the 1980s of extensive collections of polished tools that made it possible to observe the possible diversity of raw materials used, as well as to clarify a number of specific questions such as the possible use of volcanic materials in the making of polished tools, an assertion that had been repeatedly made and which these studies made it possible to discard, Bosch (1984); Alvarez (1986-1989). The problem that these studies of large collections of polished tools raise is that the material elements analysed do not come from known, well-documented archaeological contexts, which places major restrictions on their use with regard to concrete historical knowledge of the human societies that produced and used them.

During the 1990s, a major change in strategy was proposed, with the study of sets coming from particular sites being tackled. We now have studies of the characteristics of the polished tools of some of the most important Neolithic sites excavated in the late 1980s, such as the lake settlement of La Draga (Girona), Clop/Alvarez/Reche (2000), Bosch et al., (2000), the open air Neolithic settlement of Plansallosa (Girona), Clop & Alvarez (1998) and the Gava mines (Barcelona), Alvarez & Clop (1994 and 1998), Bosch and Estrada (1994). It should be noted that in the case of Plansallosa a possible "workshop" for the making of polished tools was located, as appeared to be indicated by the finding of prototypes at different stages of production, Bosch et al., (1998). The study of the materials recovered from a Catalan Middle Neolithic burial structure should be added to the mentioned studies, although it is rather less significant, Casas (2000). These studies together mean that we have well-defined sets which can be situated in precise historical contexts.

All in all, although the list of studies made so far is not particularly long one, the known data mean we can establish which were the main raw materials used and which raw materials were in minority use, establish in some cases the possible zone of origin and what may have happened during certain chronological periods, such as in the final stages of the Early Neolithic and the Middle Neolithic. Apart from that, however, there are still many other aspects to be clarified, such as what happened during the Late Neolithic and during the Calcolithic, and determining with a high degree of certainty the possible origins of many particular materials, etc.

For the north-east of the Iberian Peninsula we have altogether, at this time, published data referring to a total of 409 tools which can be included under the term polished tools, with the characterisation of their raw materials based on rigorous scientific analysis.

The studies of the characteristics of all of these stone tools have permitted the identification of 16 rock types. This significant variety, however, has to be qualified when it is observed that of the 409 tools studied 365 were made from rocks of metamorphic origin, which means an almost total predominance of material of this sort as opposed to the possible use of rocks of igneous or sedimentary origin (Fig. 3, Catalonia). If the materials used are analysed in further detail, it can be seen that hornfelses are undoubtedly the characteristic material for the making of polished tools in the north-east of the Iberian Peninsula (Fig. 5.A). A 90% of the individual items analysed were made from hornfelses. The next most used rock type, diorites, account for just 3% of the total so far analysed, while the remaining rock types are present in proportions that, at most, account for 1% of the sample. The huge predominance in the use of hornfelses is reflected both in the study of large collections of materials and in some of the particular sites studied, as in the open-air settlement of Plansallosa and in the Gava mines. In the latter case, for example, hornfelses were the raw material used in the production of 90 of the 104 tools so far studied, which include both classic forms of polished tools and types more specifically related to mine-workings (mining picks, hammers,..). Hornfelses are also present, although on a very much minority scale, at the La Draga site and is absent at Bobila d'en Joca.

Hornfels is a rock of metamorphic origin formed of fine-grained detritic rocks to be found on the edge of Hercynian granite massifs. It is a very hard, non-schist rock, fine grained and of concave cleavage, composed of a mosaic of grains of more or less similar size of no particular orientation. It displays abundant biotites and opaque minerals such as ilmenite and some iron oxides. The hornfelses analysed show, in general, the typical mineralogical characteristics, with enough AlO to be able to form cordierite and andalusite crystals. In fact, the presence of these two minerals has often been considered sufficiently important to be able to defined specific subgroups in the study of the raw materials of sites like those of Minas de Gava and Plansallosa. Hornfelses often reveal porphyroblasts which give them a mottled appearance (Fig. 5A). This fact, together with the appearance that tends to have been produced by hammering during the process of manufacturing, meant that for many years researchers confused this material with basalt, "de visu" only identification having been made. This confusion, which began to be eliminated in the 1980s, Maluquer (1979-1980), Valdés (1981-1982), Álvarez (1986-1989), still persists in the imagination of some researchers who mechanically repeat erroneous conceptions that, like this, are inherited from research that was marked for a long time by the use of procedures lacking in scientific rigour.

Hornfels is a rock that is relatively frequent in the north-east of the Iberian Peninsula. It can be found irregularly distributed along the fringes of the central axis of the Pyrenees and of the mountain chains close to the coast in the region (Figs. 4.A and 4.B). It can also be found in the form of erratic pebbles in the detrital formations originating in the transport and sedimentation of materials in many beds of many rivers originating in the Pyrenees, such as the Segre and the Ter and many of their main tributaries.

It is interesting to note that hornfels seems to be the characteristic material in the making of polished tools in the peninsular north-east, when it is to be found much less in neighbouring regions in which extensive study has been made of polished tools, Ricq-De Bouard (1996), Orozco (2000). To date, however, the studies of characteristics made in the north-east of the peninsula have not permitted the location of any possible specific source or area of origin for hornfels, a task which it is to be hoped will be tackled in the not too distant future in order to clarify whether there was extensive exploitation or whether, on the contrary, it was concentrated in very precise points, as well as whether or not use was made of materials found in secondary positions or whether materials in primary positions were exploited. As regards its possible circulation, in the region of the Valencian Levant the possibility has been raised that the hornfels tools that have been identified may have been produced from raw material originating in the coastal mountain chains close

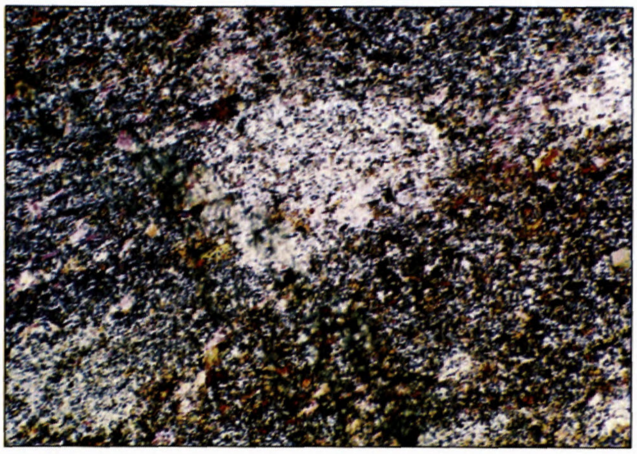


Fig. 5.A.- Micrograph of a hornfel with large andalusite crystals. Crossed polars. Width of photo = 6 mm.; Sample from a mining pick from Minas de Gava (Barcelona).

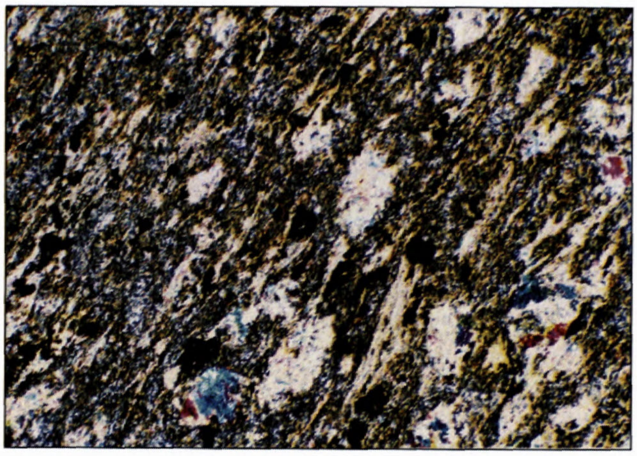


Fig. 5.B.- Micrograph of a calcitic amphibolite. Sample from a plane from Minas de Gava (Barcelona). Crossed polars. Width of photo=6 mm.

to the Ebro, a hypothesis that should also be examined in the future, Orozco (2000).

Diorites comprise, quantitatively, the second group of materials identified, although they represent just 3% of the total of the samples analysed to date. Diorite is an intrusive magmatic rock which displays plagioclases and hornblendes as its essential components. Diorites form accumulations on the margins of zones of igneous rocks, particularly granites and granodiorites or transitional facies on the edge of gabbroic masses. It is, in general terms, a very rare rock, generally originating in the hybridisation of more basic rocks. It is to be found in geological regions similar to those in which hornfelses are to be found.

In the case of the archaeological materials of the peninsular north-east it is interesting to note that diorites have been identified in the Minas de Gava, at Bobila d'en Joca and in two finds included in the collections studied during the 1980s. To date, from the data available, it seems that its presence is concentrated particularly along the Catalan coast and central pre-coastal zone. It is interesting to note that the diorites identified have been used in the production of axes but their use has not been identified so far in the production of items specifically for mining tools at the Gava mines.

The third group in importance of materials is comprised by the amphibolites. This term is used to indicate certain rocks produced by a medium grade metamorphism that display, as their principal components, amphibolites and plagioclases. Their identification as a raw material used in the making of polished tools in the north-east of the Iberian Peninsula, it should be said, is recent, since the end of the 1990s. Since their initial identification in the region, the presence of amphibolites has been shown to be recurrent in all the sites specifically studied. Thus we find items made from amphibolite at La Draga, Plansallosa, Minas de Gava and Bobila d'en Joca. To be more precise, and as seems to indicated by X-ray diffraction in the cases of Plansallosa and Bobila d'en Joca, these are generally calcite amphibolites (Fig. 5.B).

Determination of their possible origin involves, at present, great difficulties. While amphibolites have been found on the southern side of the Pyrenees in the form of radial disseminations of low-grade metaphoric rocks and retrograde metaphoric rocks, large specimens in sufficient volume for making polished tools have not been found. We know that amphibolite was a raw material used significantly during the early stages of the Neolithic in neighbouring areas in the south of France, Ricq-De Bouard (1996) where, however, despite extensive prospective work, neither primary or secondary deposits have been found from which pieces of the necessary size for the making of polished tools could have been obtained.

Particular comment should be made regarding the polished tools made from jades. In one of the first scientifically rigorous studies made in the region, Alvarez (1986-1989), attention was drawn to the use of such raw material, although the affirmation was based on "visu" determinations given the difficulties posed by carrying out analysis, however small, of archaeological pieces. The study made at Bobila d'en Joca, Casas (2000) included the analysis of two pieces made from jades of great purity and whose possible source area is still to be determined. In any case, determining more precisely the quantitative importance of the presence of items made from jades as well as establishing there possible origin, is surely one of the central issues in the development of future studies in the region.

The list of the other materials identified so far allows us to observe both their diversity as well as their apparently relatively scarce presence. The materials are as follows (in parenthesis, the number of tools identified to date):

- Metamorphic rocks: schist (5), fibrolite (2), diabase (1), calcium silicate skarn (1), slate (1), phyllite (1), calcoschists (1); quartzite (1).
- Igneous rocks: porphyry (5), dolerite (2), microtonalite (1);
- Sedimentary rocks: sandstone (3).

The materials study made from particular sites (La Draga, Plansallosa, Mines de Gava and Bobila d'en Joca) allows chronological evaluation to be made. In the first place, the absence of data on the precise timing of the earliest polished tools in the region should be noted, as well as on the characteristics of its early stages. Secondly, the studies carried out at La Draga and Plansallosa provide data on the epicardial Early Neolithic (circa 5100-4000 BC). In these sites there is a clear predominance of the use of raw materials of metamorphic origin, principally hornfelses and schists, with amphibolites also being present.

Data from the Minas de Gava and Bobila d'en Joca give us an idea of the raw materials used during the Middle Neolithic (circa 4400-3200 BC). Raw materials from metamorphic rocks continue to predominate, particularly hornfelses. However, a certain amount of difference according to the specific use of the archaeological site can be proposed, as suggested by the absence of hornfelses in a burial site like that of Bobila d'en Joca. The possible difference depending on the social use of each site is also a line of work to be developed more fully in the future. Apart from that, it should be noted that amphibolites continued to be used and we now find tools made from jades which, according to the schemes currently in use, may have reached the north-east of the peninsula within the extensive trade zones of the different types of products that have been documented during the fourth and third millennium BC in western Europe. In this sense, it is interesting to note that amphibolites were used extensively during the Early and Middle Neolithic in the south of France, Ricq-De Bouard (1996).

East of the Iberian Peninsula, Pais Valenciano

S. Dominguez-Bella

Geographical context

The País Valenciano or Levante, is a geographical region that occupies a band along the Spanish Mediterranean coast. Their geology is based in the presence of materials from the Iberian Cordillera (Fig. 1), and a predominance of sedimentary Mesozoic rocks, in general of carbonated lithologies (in many cases karstified, Fig.3), with the occasional presence of little outcrops of Palaeozoic materials and igneous rocks. These last ones are of two types: subvolcanic rocks as dolerites or diabases, related with Mesozoic episodes; and a recent volcanism, with quaternary basalts.

Archaeological sites from the Neolithic-Aeneolithic of Levante, East Spain

The archaeological register of the recent prehistory presents different levels from the Neolithic I (7000-5800 B.P. cal.); Neolithic II (5500-4000 B.P. cal.); and a Campaniform Horizon, (4000-3890 B.P. cal.); in Orozco (1998), and a great number of caves. Dolerites - diabases, with holocrystalline, fine or medium grain and inequigranular (large crystals of pyroxene enclosing, either wholly or partially, laths of plagioclase feldspar) ophitic-subophitic texture, are found in the archaeological register of this region, Orozco (1993) and (2000). The metamorphic lithologies, with much more diversity that igneous rocks, present amphibolites, eclogites, schist and objects made in sillimanite, a high metamorphic grade typical mineral, Orozco (1993 and 1998). Dolerites or diabases outcrops are present in many points of this Mediterranean band, intruded in sedimentary evaporitic sediments of Triassic age (Keuper facies). Other igneous materials present in the regional geology are the quaternary basalts, not employed as raw material in the Prehistory of this area, Orozco (1993). The local metamorphic materials outcrops, placed at the North of this region, present petrological and mineralogical features that do not correspond with those of the archaeological materials, so the origin of these raw materials can be allochthonous to this area. Materials as the schist bracelets are common in the Neolithic I phase and disappear in subsequent stages, Orozco (1998). In the Neolithic II phase, the lithological diversity is much more extend in the zone, as result not only of a catchment of local lithologies if not by interchange along trade routes, of allochthonous products as sillimanites, eclogites, amphibolites s.s. and calcium amphibolites, that the geological features of the studied materials suggest to Bernabeu & Orozco (1989-90) a great similarity with the high grade metamorphism from Southeast Spain areas, in the inner domains of the Betic Cordilleras. In the Campaniform horizon this tendency is increased. As example of the lithological abundances in this geographical region, in Orozco (1993) are published the study of two archaeological sites with a chronology of III rd millennium B.C., the villages of Jovades (Cocentaina, Alacant) and Arenal de la Costa (Ontinyent, Valencia) (Fig. 3., East Spain).

Central Iberian Peninsula, Castilla-La Mancha & Murcia

S. Domínguez-Bella.

Situation and geological context

In this geographical area, we have only information about raw materials of archaeological sites in the Cuenca, Madrid and a part of Murcia provinces, placed in the central-SE part of Iberian Peninsula. The geological substrate of these areas is constituted by the Iberian Cordillera materials, in general of carbonated character and Mesozoic age and by the Tajo Basin materials, a Tertiary basin of the central Spain (Fig. 1).

Archaeological sites from the Neolithic-Aeneolitic in Central Spain

In this area, with a great potentiality of lithological resources for the tools manufacture, as occurs with the sillimanite and other lithologies metamorphic and igneous, works about raw materials characterization in polished industry of the recent prehistory hardly exist. We only can cite the papers of Atrian (1960), Delibes (1974), Barrera and Navarrete (1980) Barrera (1984), Barrera et al. (1987), about the polished lithic industry from Teruel, the Tierra de Campos area in Castilla, sites from Cuenca, Madrid and Murcia provinces, respectively. In the Fig. 3 appears the different lithologies and percentages of these materials cited by these authors. In the sites from **Cuenca province**, attributed to a recent prehistory (Barrera & Navarrete, 1980), axes and mazes are present, in them we can observe the presence of metamorphic, plutonic, volcanic, in veins and others rocks. Among the lithologies more usually appeared: amphibolites, thermal metamorphosed or speckling slates, sillimanite, sandstone, meta-gabbro, quartz dolerite, limburgites. The limburgites, volcanic rocks formed by iddingsitized olivine phenocrystals, in a matrix of clinopyroxene, opaque minerals and interstitial zeolites and carbonates. Its origin is clearly related with the alkaline volcanism of Campo de Calatrava (Ciudad Real), 200 km. to the SW. The metagabbros, equigranular with medium and fine grain, very homogeneous, formed by very abundant amphiboles, plagioclase, garnet and residual clinopyroxene, with accessories: epidote, muscovite, chlorite, opaque, albite, clinozoisite and carbonates. A second group of metagabbros do not present garnet; in both cases they seem allochthonous lithologies that can come from the Sierra Nevada materials, placed more than 300 km at the south. Amphibolites, many times very rich in actinolite, are in this case orthoderivates of igneous basic rocks, with a great quantity of opaque minerals, their mineralogy are formed fundamentally by amphibole (hornblende-actinolite)(this one between a 50 and a 90 %) and plagioclase, with opaque minerals, sphene and rarely quartz, zircon, epidote, clinozoisite, biotite and chlorite. The possible source areas for these rocks are Sierra Nevada at the south or the Hesperico Massif at the west. Other metamorphic lithology are the chiastolitic slates, typical of the contact or thermic metamorphism, where andalusite and cordierite appear, with a quartz-micaceous matrix of fine grain, porphyritic texture, quite schistose. The most similar lithologies to these and with more geographical proximity, are the metamorphic outcrops around the granitic Batolito de los Pedroches, in the North of Andalusia (aprox. 250 km to the SW), even though they could proceed from other zones of the Hesperico Massif, in the western peninsular part. As rock in veins, only has appeared a quartz-dolerite or quartz-diabase, with clinopyroxene and plagioclase, opaque minerals and quartz as accessories; and fine grain diabase texture. Its origin could be regional, in the Iberian Cordillera. Sillimanite objects, very abundant in these sites, present whitish, greenish, bluish, yellowish and brownish colours, always with the typical fibrous aspect (fibrolite) and made from mineral nodules of relative size. These authors proposed for these axes a allochthonous origin, in the Somosierra area, Central System of Spain, even though other possible source areas can exist in the Hesperico Massif or Hercynian basement (Galicia, Portugal, Salamanca, Zamora, Pyrenees) (Fig.1).

Cueva de Juan Barbero (Tielmes, Madrid).

The petrological analysis results published by Barrera (1984), in this settlement from the early metallurgical period of Central Spain, show the presence of sillimanite, metadiabase with prismatic plagioclase aggregates and amphibole crystals, pseudomorphizing at pyroxenes, with opaque minerals. Metagabbro, of medium-fine grain, equigranular, formed by plagioclase, greenish amphibole and great opaque minerals. Quartz greywackes, with light schistosity, elongated quartz, rock fragments and tourmaline, zircon, opaque minerals, chlorite and muscovite-sericite as accessories, also appear.

Northeast of the Murcia province (Cehegín-Caravaca-Moratalla area). Central Spain.

Barrera et al., (1987), studied a group of archaeological sites, which included caves, open air villages and one dolmen, probably with Aeneolithic chronologies. The polished lithic industry is formed by axes, chisels, mazes, mill hands, ball, pendant, chisel and others. As result of petrologic analysis that these authors carried out, appears: sedimentary rocks, fossiliferous limestones and calcarenites; metamorphic rocks of sillimanite type, amphibolites and garnet metagabbros; volcanic rocks of basalt type; rocks plutonic and subvolcanic, of diabases type, quartz diabases gabbros and quartz gabbros and finally a sample of chert. (Fig. 3, Murcia).

In relation with the raw materials provenance in this area, these authors proposed an autochthonous origin for the carbonated lithologies (fossiliferous limestones and calcarenites) and the plutonic and subvolcanic rocks (dolerites "ophites", diabases), present in the local geology. Chert sample are of unknown origin. The metamorphic lithologies as sillimanite have an allochthonous origin, probably from the Central System or other western areas of Hercynian Massif. Amphibolites have also a non local origin, probably from Sierra Nevada, at the South. Finally, the unique sample of olivine basalt is also allochthonous, very similar to the volcanic materials of the Campo de Calatrava area, 190 km at the West of this region.

Portugal

David Calado and Joao Luis Cardoso

THE ALGARVE AND EXTREMADURA REGIONS

The distribution of exogenous artefacts in settlements and graves previous to the middle of the Vth millennia BC in SW Atlantic Europe seems to be limited to the exchange of some specific elements, Calado et al. (2003). The polished stone artefacts seem to follow a pattern of production over other stones existing nearby.

In the Caldeirao cave, in Estremadura, Central Portugal, Zilhao, (1992), the sole artefacts with a proven distant origin are the marine shell beads used for necklaces. The polished stone beads recovered at Caldeirao, which could be from distant origins, are made of variscite and muscovite. Variscite may perhaps be found at the Silurian strata from the Zézere river basin, some 20 km away from the cave, Real (1992) and the muscovite may also be found at a relatively short distance away, Real (1992). However, at the moment the nearest place where variscite was positively recorded is in the Carboniferous metavolcanic complex of Ossa-Morena. Also, we have no everyday use (Fig. 6), consist of axes in basanite, alkaline basalt and greywacke, all of them very common lithologies within a radius of a few km from the settlement site. Arm rings in bituminous black slate constitute the adornment artefacts. The black slate was never identified in the Algarve Palaeozoic strata, the nearest known place with this kind of rock being the Devonian carboniferous strata from the Bordeira antiform, 20 kms NW of the settlement site. The surface-polished large phallic standing stones (menhirs) with high relief symbolic decorations are a product of oolithic Jurassic limestone from the Dogger (Aalonian-Batonian), which occurs within a couple of km from the settlement site, Calado *et al.* (2001).

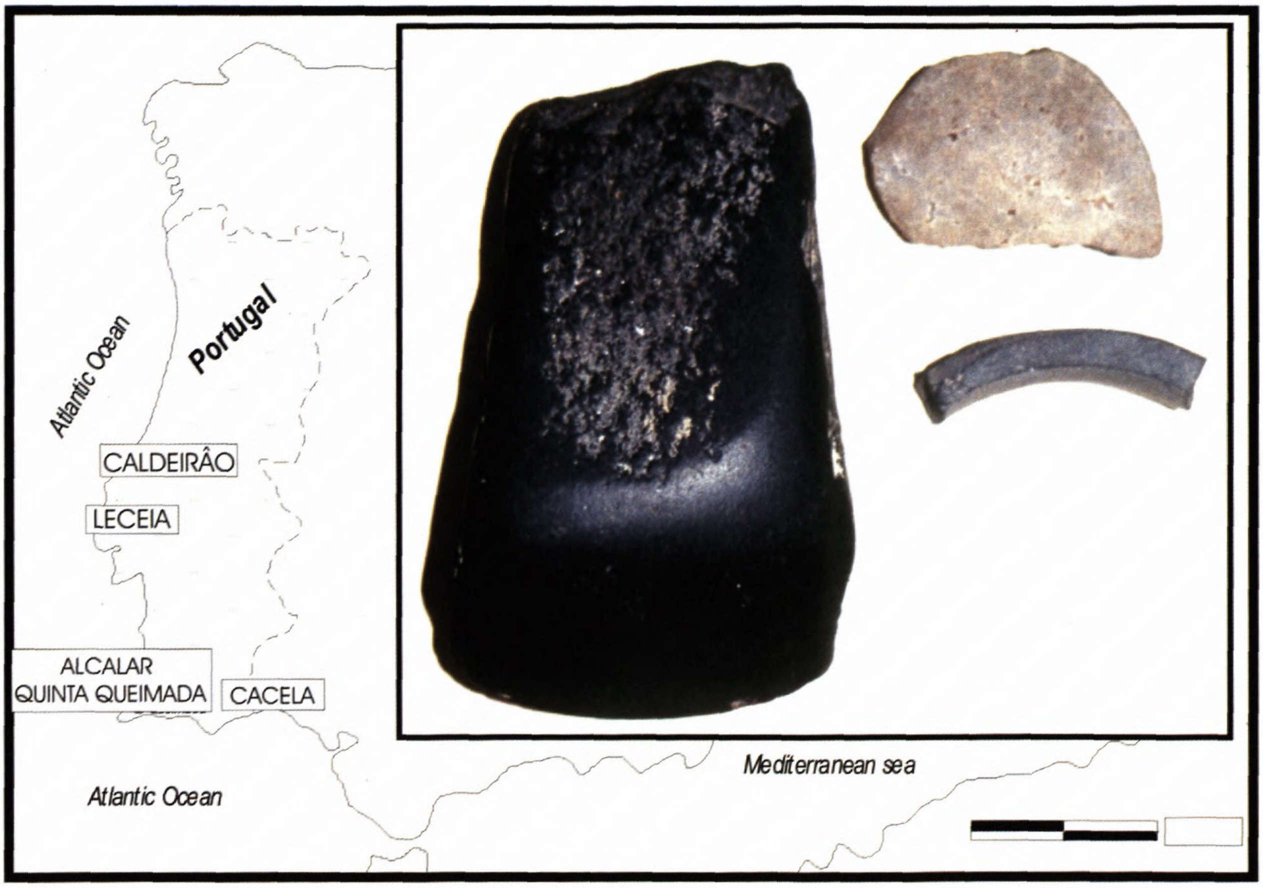


Fig. 6.- Geographical map of Portugal with the archaeological sites cited. Stone axes of basalt and limestone and arm ring of black slate from Quinta da Queimada (South Portugal), VI-V millenniums B.C.

evidence of variscite mining in SW Iberia before the last quarter of the IV millennia BC. Thus, we may assume that the artefacts in variscite and muscovite might have been produced from surface-collected small blocks of these minerals. The polished stone implements of everyday use, like axes and adzes, are made of stones common to this region.

In the Algarve, Southern Portugal, an analysis was made from all the stone implements collected at the VIth millennia BC settlement site with standing stones at the Quinta da Queimada. The polished stone artefacts of

Between the middle of the V and the middle of the IVth millennia BC, the period usually called "Middle Neolithic", there has been until now an important gap in the knowledge of SW Iberian prehistory with special emphasis to Portugal. In the Algarve, knowledge about this period is restrained to the second phase of the already destroyed settlement site of Caramujeira, Gomes et al. (1978); Calado (2000a) and (2000b). However, in La Dehesa, a settlement site from the neighbouring Spanish province of Huelva, which has similar characteristics to the second phase of Caramujeira, we observed at the surface fragments of chert and red jasper, which could only come from the Palaeozoic strata, 40 kms to the North.

From the middle of the IV[th] millennia it is regarded in the archaeological data from SW Iberia strong evidence of social stratification that culminates in the middle of the III[rd] millennia in pristine centralized political organizations in Andalusia and Algarve. Together with the increase of political centralism and social stratification, it has been verified that existed the development of a stable and complex distribution system of exogenous artefacts, embodying an exchange network that stretches, at least, over the whole of Iberia and North Africa.

The artefacts made from exogenous materials from far away regions are common in the megalithic graves in littoral Algarve (Fig. 6), like Cacela and Alcalar, Veiga (1886, 1889): black slate, amber, amphibolite, serpentine, variscite, marble, cherty oolithic limestone, gold, copper and ivory. The nearest place where black slate occurs naturally is in the Ossa-Morena complex, more than 100 km to the North, or in the Bordeira antiform. The amber, recovered in Alcalar, is very seldom found in Iberia, just occurring in the Cretaceous formations from Álava (Basque Country), Navarra, Cantabria, Asturias, Aragón, in general almost 1000 km to the NW. The amphibolite, a widely used rock in the production of polished adzes and axes during this period, seems to be nonexistent in the Algarve and its origin may have been the already described Ossa-Morena complex. The serpentine, known from polished beads, might have come from Ronda Massif or Sierra Nevada Betic Units, in Andalusia; or Ceuta, in North Africa, but it may also have existed in the Ossa-Morena complex. The variscite, widely used in the production of beads, occurs in the Ossa-Morena region, prehistoric mines being known of at Encinasola, Andalusia, Nocete and Linares (1999). The fine marble, used mainly for the production of small polished vessels is unknown in the Algarve, its possible origin being in central Portugal or in Sierra de los Filabres area, at the East of Andalusia. From the middle of the III[rd] millennium BC onwards the flint seems to be widely substituted by cherty oolithic limestone for the production of broad blades. The cherty oolithic limestone is presently known to occur only in the zone of Estepa - Morón de la Frontera, in Andalusia, Nocete et al. (1995). The gold may also have come from Andalusia (Spain), since Cala - Almadén de la Plata area, in Sierra Morena, at the North of Seville and Huelva provinces, is the closest place with mineral veins of a calibre good enough to produce artefacts by cold hammering like the ones existing in Alcalar. Other possible provenance area is the North of Extremadura region (Spain), with presence of native gold nuggets in many rivers. However, the possibility cannot be excluded that after the III[rd] millennium BC the local populations already knew the technique of gold smelting. The copper is common in the Palaeozoic strata from inland Algarve and was extensively mined. The ivory, unquestionably African in origin, is known from the megalithic graves from Cacela (Fig. 6).

In Estremadura, central Portugal, the set of artefacts from graves and settlements from the middle of the IV millennia BC onwards includes axes and adzes in amphibolites and fibrolite, beads in variscite, lignite, fluorite and calcite, micro blade cores in rock crystal and artefacts in copper and ivory. The amphibolites from the axes collected north of the Tejo River seems to come from the Montemor-o-Novo / Abrantes region, while the amphibolites from the polished axes south of the river show a basaltic-andesitic composition with a low degree of metamorphism, being similar to the rocks of the same type from the Ossa-Morena complex. However, the rock used in the adzes is composed of a fine texture, probably correspondent with basic vulcanite found within the veins of the Sines massif. The fibrolite, a mineral with a high degree of metamorphism is unknown in Portugal, Ferreira (1953), seeming, however, to exist in the Spanish part of the Ossa-Morena complex and other places in Spain, specially in Guadarrama massif. The variscite beads, Canelhas (1973), at least the ones of larger calibre, seem incompatible with the thin mineral veins identified in the metasedimentary Silurian geologic formations from Northern Portugal, Meireles et al. (1997). References exist of variscite mines in use during the Roman epoch nearby Zamora, Campano et al. (1985). However, the only registered prehistoric variscite mines in SW Iberia are in Encinasola, Andalusia, Nocete (2001); Dominguez Bella et al. (2002). The fluorite is known from two large beads found at the Lapa do Bugio, Cardoso (1992) and the Casa da Moura caves, Carreira and Cardoso, (2001/2002). This mineral not exists in the region, its probable origin being the granite - pegmatites from Panasqueira. Also the large rock crystal cores may come from the granite - pegmatites at Beira Alta. The lignite and the calcite, also used in the production of beads are common all over Estremadura. The copper is common in the fortified settlements Leceia type from the middle of the III[rd] millennium BC onwards, Cardoso et al., (1995), Cardoso and Guerra (1997-98; Fig. 6). The chemical analysis from Leceia copper confirms an origin from the metallic polysulphides pyrite belt that stretches from the Algarve to the Alto Alentejo. The territorial range enclosed in this complex system of artefact and raw materials distribution is well exemplified by the African ivory pin found at Leceia site in levels from the first half of the III[rd] millennia B.C., Cardoso (1997), Cardoso (1999-2000).

In conclusion, in Portugal, before the middle of the V millennium BC a pattern clearly emerges of extensive use of local rock types for the production of polished implements. During the second half of the V and first half of the IV[th] millennia BC it is possible to identify a pattern of use of some raw materials collected some dozens of km from the settlements. From late IV[th] millennia BC onwards an intricate exchange network of allochthonous materials stretching through Iberia and North Africa was developed. The extent of this exchange network is well exemplified by the amber found at the

Alcalar graves, in the Algarve, only evident in geological outcrops of many areas of Iberia (Basque Country, Aragón, Cantabria, Asturias) or in far away European regions; and the ivory, undoubtedly of African origin, found at Leceia, in the Estremadura and Cacela, in the Algarve (Fig. 6).

South of the Iberian Peninsula, Andalusia

S. Domínguez-Bella

Situation and geological context

The South of the Iberian Peninsula, placed at the north of Gibraltar Strait, the occidental Mediterranean Sea and the Atlantic Ocean, present three great morphologic units, practically coincident with the geological units: Sierra Morena, at the North and NE, with a medium level of 600 m and maximums just to 1323 m; the Guadalquivir Basin, along the Guadalquivir river fluvial plain, from Sierra de Cazorla to Donana salt marsh and the Betic Cordillera, a mountainous relief with the maximum altitudes of the Iberian Peninsula, in Sierra Nevada (Mulhacén, 3481 m). The geological features and materials of these zones are described before (Fig.1 and Fig. 7).

Raw materials used in making polished tools and provenance areas

Archaeological sites from the Neolithic-Aeneolithic of West Andalusia

- El **Jadramil** (Arcos de la Frontera, Cádiz), is basically an agricultural settlement Lazarich (2003), of the III-II millenniums B.C. in the Campina area of Cádiz. Between 1980 and 1998 a great number of silo type structures, silo-artificial caves and pits, have been excavated. The polished lithic industry recovered represents a total of 85 objects, with presence of axes, chisels, grooved mining stone hammers, percusor, smoothers, mullers, loom weights, idols, pendants, archer bracelets and one stone coup that have been studied by Dominguez-Bella (2003). The petrologic study of these materials reveals a great diversity of raw materials, with the presence of dolerites, sandstones, amphibolites, limestone-dolomite, biocalcarenite, marls, micaceous slate and flint (Fig. 7 El Jadramil). Dolerite, is the most common raw material in this archaeological site (55,29 %), with this material is elaborated the grooved stone hammers (Fig.8.C), the great axes (Fig. 8.A), wedges, mullets, etc. Amphibolites: (represents the 5,88 %), many types of amphiboli-

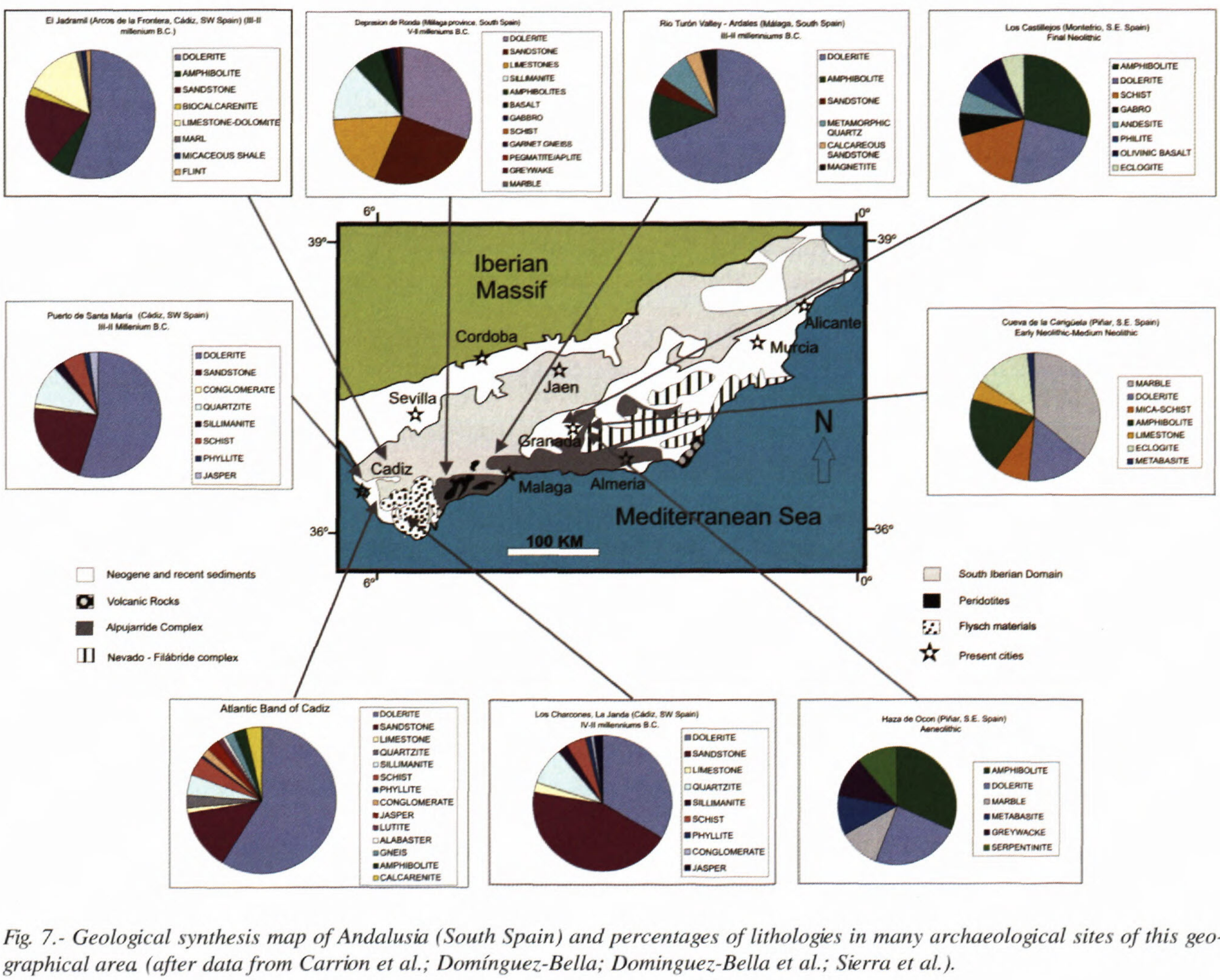


Fig. 7.- Geological synthesis map of Andalusia (South Spain) and percentages of lithologies in many archaeological sites of this geographical area (after data from Carrion et al.; Domínguez-Bella; Dominguez-Bella et al.; Sierra et al.).

Fig. 8.A.- Dolerite axe. El Jadramil. Arcos de la Frontera, Cadiz (SW Spain).

Fig. 8.B.- Group of amphibolite and dolerite adzes. El Jadramil. Arcos de la Frontera, Cadiz (SW Spain).

Fig. 8.C.-Dolerite grooved mining hammer. El Jadramil. Arcos de la Frontera, Cadiz (SW Spain)

Fig. 8.D.- Great plate of sandstone. El Jadramil. Arcos de la Frontera, Cadiz (SW Spain).(III-II millennium B.C.)

tes appears especially in the manufacture of polished axes, adzes (Fig.8.B), and chisels. Sandstone (18,82 %); they are present in palettes or great size plates (Fig.8.D), and many other objects as mullets, loom weights, pendants and idols. Limestones-dolomites (14,12 %), in this kind of materials appears elaborated objects as smoothers, idols, palettes and a stone coup made by turning. Flint: only an object, probably used as smoother, represent the 1,18 % of the total. Micaceous slate, marl - marly limestone and biocalcarenite present low percentages. Moreover of these lithologies appear pendants, bracelets, etc., made in bone or shell, as well as many metallic objects.

The utility of the grooved stone mining hammers, continue to be an incognita in this site. These hammers, habitual in mining activities in the recent prehistory of Europe, Craddock (1995), results strange in a theoretical agricultural site, so their use, in a mining activity, related with the vertical pits of this site, appears to be quite possible in relation with the extraction of a type of raw material, a compact biocalcarenite (Dominguez-Bella, 2003).

In relation with the possible source areas for the raw materials of the polished industry, we can differentiate the mentioned lithologies. Amphibolites, with greenish to blackish tones, normally are utilised in the elaboration of axes and they are rocks with a clear allochthonous character in this site, while as possible source areas we can suggest the Palaeozoic materials from the Ossa - Morena zone, at the north of the Guadalquivir valley, in the actual provinces of Huelva and Badajoz, or the centre and south of Portugal, Read et al. (1997), Lillios (1997). Dolerites, which appear as the most important lithology and constituting an important part of the axes and practically the totality of the grooves mining hammers, are rocks with a possible local origin, associated to the Mesozoic dolerites placed intro Triassic materials (Keuper facies) outcrops in this area.

Sandstones are present in the mills, mullets, palettes or great size plates, and many other objects as loom weights, pendants and idols. They are Aljibe Sandstones, materials of Miocene age that are abundant in this region. Limestones are of different types and origins; their uses are concentred in the smoothers for ceramic manufacture and in the elaboration of stone mortars or vessels, present in other zones of the SW as Huelva province, Nocete et al. (1995) with an origin probably allochthonous. Biocalcarenite, are probably a local raw material, from the Upper Miocene outcrops, frequent in the geological context of this area. Other lithologies, minority in the polished industry of this site, such as slate, phyllite, flint, etc., are Palaeozoic materials and their origin can be related with imported materials or with the catchment of a rolling stone or pebble of these, from the quaternary terraces levels, and flint related with Mesozoic carbonated outcrops in the Betic Cordillera.

- The **Atlantic Band of Cádiz** area (SSW Spain) placed between the Gibraltar Strait and the mouth of the Guadalquivir River, in the western end of Betic Cordilleras, is a limit zone with the Guadalquivir Basin, as the North limit of this. Their geology comprised three great groups of materials with different ages and lithologies (Fig. 7: Geological map). First group are constituted by the materials from the Medium Subbetic, basically clays and gypsums from the South-Iberian Triassic (Keuper facies) in which are also frequent the presence of subvolcanic rocks, dolerites (rocks commonly known as "ophites"), also intrudes Jurassic and Cretaceous materials. The second group are formed by materials from the Campo de Gibraltar Units, constituted fundamentally by the "Aljibe Sandstones", with clayey intercalations, of Miocene age, placed specially in the East area of this zone (territory of La Janda). Finally, post-orogenic materials, of Miocene-Pliocene age (basically biocalcarenites), distributed in different outcrops and which, in general, produces table relieves.

Archaeological materials (polished lithic tools) from San Fernando, Chiclana de la Frontera, Conil de la Frontera, Medina Sidonia and Vejer (surface surveys), Ramos et al., (1998) and from the stratified levels of two excavations of open air settlements: El Estanquillo (with chronologies between IVth and IInd millenniums B.C.) (Ramos, 1993), and the sites of Las Vinas and Cantarranas, in El Puerto de Santa María (Cádiz), Valverde (1993); Ruiz Fernández (1986); are studied (mineralogical, petrological and archaeological characterization) by Domínguez-Bella (1999); Domínguez-Bella et al., (2000), Domínguez-Bella et al. (2002b), Ramos et al., (1997).

The petrological study of these materials reveals that igneous, metamorphic and sedimentary rocks appear:

Igneous rocks: In the studied polished industry only fine-medium grain dolerites (ϕ < 1 mm) have been identified, as many cases of coarse grain size (ϕ > 2 mm); in general, with ophitic texture, clinopyroxene partially altered to actinolite; plagioclase, also partially transformed in epidote; titanomagnetite or leucoxene as accessory (Fig. 9.A).

Metamorphic rocks: Many types of metamorphic lithologies are present in this study. Amongst them detach the artefacts made in amphibolites, quartzites, mica-schists, metapelites (s.s.) and orthogneis. Implements made in sillimanite (var. fibrolite) are also present and relatively frequents.

Sedimentary rocks: Both detrital rocks (lutites, sandstones and conglomerates) as well as carbonated rocks (limestones s.s. and nummulitic calcarenites) are identified. Sandstones present in general quartz predominance, with the presence of feldspars, and clay minerals, oxides, zircon and tourmaline, as accessory minerals (Fig. 9.B). Furthermore, many smoothers made in green jasper and many fragments of black jasper, are documented.

- Alberite I Dolmen (Villamartín, Cádiz). Neolithic. V-IV millenniums B.C. This dolmen is a good example of the Megalithic phenomenon in the South of Iberian Peninsula. It was excavated in 1993 by Ramos-Munoz and Giles (1996) and shows a typical corridor structure, oriented E-W, and a final chamber with only two inhumations. Walls are decorated in relief and painted with red pigments. The materials recovered from this excavation consist in a necklace with 1200 beads of shell, bone, stone (130 green beads of variscite and two beads in amber). Polished axe, adze and gauge, many big flint knives (20 cm in long), one idol in stone, one big crystal of quartz, a stone palette and a mullet for pigment preparation, with presence in it of powdered hematite and cinnabar. Materials and possible provenance areas are studied by Dominguez-Bella and Morata (1995 and 1996), and they confirm the existence in this geographical area of a developed network of interchange for a great number of exotic materials, Dominguez-Bella et al. (2002a), related with a peculiar status of prestige in many individuals of the social groups that live in this area at V-IV millenniums B.C. Petrological characterization of these materials give as result the presence of dolerite in a big axe (aprox.: 50 cm long) and the palette and mullet for pigment preparation; an amphibolite axe-adze (Fig. 9.C); a gauge made in metavolcanic tuff (Fig. 9.D); variscite, limestone and amber beads, a big crystal of quartz and certain quantity of powdered red ochre (hematite and cinnabar). The raw material sources for the majority of these materials present an origin at hundred or more kilometres of distance at the North of Cádiz, Domínguez-Bella and Morata (1995, 1996).

Archaeological sites from the III-II millennium transition in Central Andalusia. Province of Jaén

In this geographical area, in the centre of **Guadalquivir Valley**, a lot of important archaeological sites exist, in

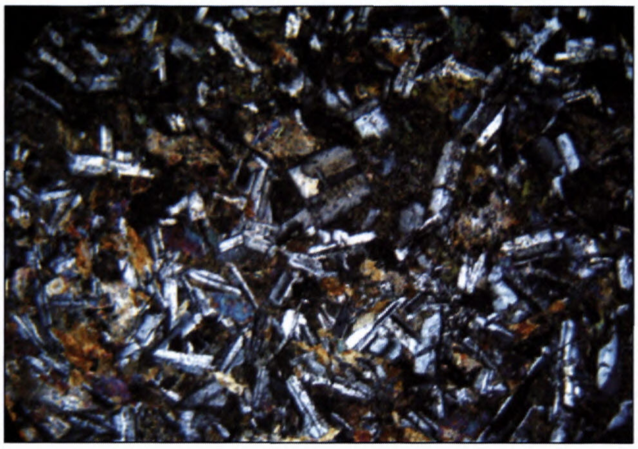


Fig. 9.A.- Micrograph of a tin section of a dolerite axe. Atlantic Band of Cádiz (SW Spain). Crossed polars. Width of photo = 6 mm.

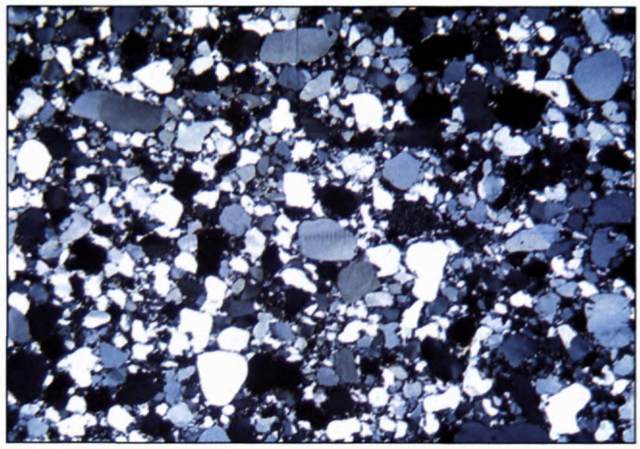
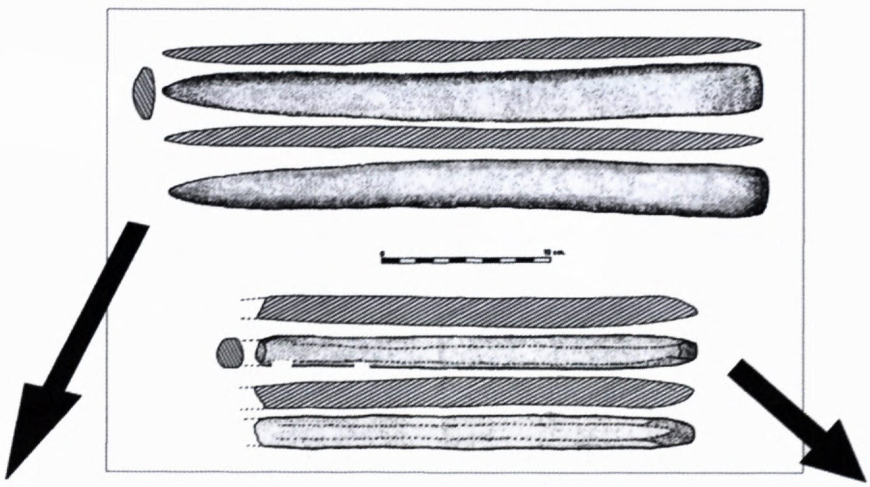


Fig. 9.B.- Micrograph of a mullet made in sandstone. Las Vinas, Cádiz (SW Spain). Crossed polars. Width of photo = 6 mm.



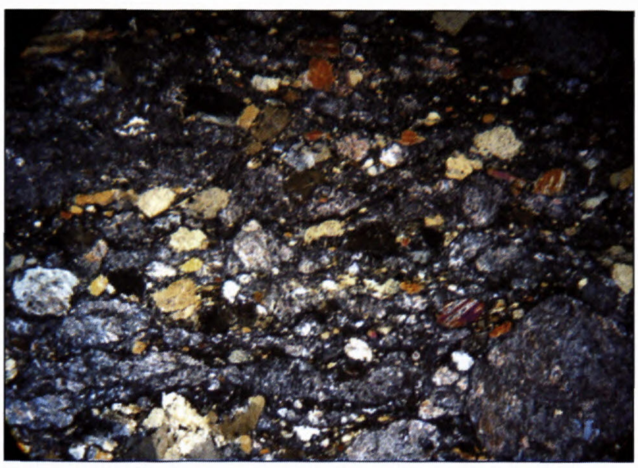


Fig. 9.C.- Micrograph of a tin section of an amphibolite axe. Alberite I Dolmen, Cádiz (SW Spain). Crossed polars. Width of photo = 6 mm.

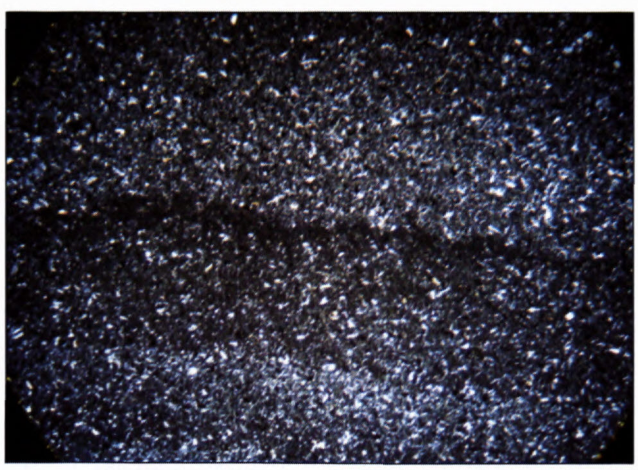


Fig. 9.D.- Micrograph of tin section of a gauge made in a volcanic tuff, ligthly metamorphized. Alberite I Dolmen. Neolithic. Crossed polars. Width of photo = 6 mm.

general open air settlements and villages, as occur in El Berral site, (Porcuna, Jaén); with the presence of sedimentary (red, brown and grey sandstones and many flint); metamorphic (quartzite) and igneous (dolerites), in general of local origin (dolerite from outcrops placed at the South of El Berral) and quartzites, sandstones and flint of local secondary origin, associated to quaternary fluvial deposits of the Salado river, near the archaeological site, Sanchez and Domínguez-Bella (2001).

Archaeological sites from the VI-II millenniums in Central Andalusia. Malaga Province

- The **Ronda Basin** area (Málaga), is slightly placed at the South of the Central Andalusia, over a postorogenic sedimentary basin, formed by molasses, generated by the fast erosion of the Betic alpine chain. The most abundant materials are the molasses of the Upper Miocene; flyschs materials, dominated by the Aljibe sandstones, limestones, dolomites and marls from the Subbetico and Penibetico, with ages from Jurassic to Cretaceous; dolomites, clays and gypsums of the Triassic (Keuper facies), with dolerite outcrops included, Palaeozoic materials (slates, greywackes, limestones, phyllites, schists, gneises and migmatites) from the Malaguide and Alpujarride and the peridotites of the Serranía de Ronda.

A study of Sierra et al. (1994), on a sample of 250 stone objects shows the presence of dolerites as predominant igneous-subvolcanic rocks, employed in the elaboration of big axes; also sedimentary rocks as sandstones, limestones (detrital limestone, limestone with microfossils); and metamorphic rocks as quartzites, gneises, schist, sillimanite, amphibolite and amphibolite gneises. Basalt, gabbro, gneiss with garnet, marble, aplite, pegmatite, and quartz-schist, occasionally appear (Fig. 7 Ronda Basin). Dolerites, sandstones, many limestones, present a clear local origin. Other lithologies have possibly an allochthonous origin.

Ardales - Rio Turón Valley. This area of the North of the Malaga province is placed at the East of the Depresión de Ronda, in a strategic path of communication between the coast and the Guadalquivir Basin, along the Guadalteba and Guadalhorce Rivers. A considerable number of open air settlements, workshops and villages from IIIrd to IInd millenniums, with silos, artificial caves, etc. are documented. The polished industry present a dominance of igneous subvolcanic rocks, with a 70 % of dolerites, with typical mineralogical and textural features of these rocks associated with Triassic materials in the Betic cordilleras. Amphibolites represent a 11,54 %. Sandstones, calcareous sandstones, milky quartz from metamorphic rocks veins and a mullet of magnetite also appear, Dominguez-Bella et al., (2001c; Fig. 7: Ardales). Other prestige materials as green micas or marble appear in collar beads and stone bracelets (Fig. 10.C-D). Peridotites are not present in the archaeological register even though there are outcrops of this material present in this area.

Archaeological sites from the Neolithic-Aeneolithic of East Andalusia. Province of Granada.

This geographical area, placed near the central part of the Betic Cordillera, is dominated by the Sierra Nevada mountains and many planar alluvial extensions in La Vega, etc. A good example of the petrological studies applied to the characterization of polished industries in the recent prehistory of this area, are the studies of Carrion and Gomez (1983). The dominant lithologies in this area, in the different periods of Neolithic and Aeneolithic, can be seen in (Fig.7 Montefrio, Cariguela and Haza de Ocon, S E. Spain), in which three examples of archaeological sites appear from three different chronologies (Early-Medium Neolithic, in Cueva de la Cariguela, Pinar); (Final Neolithic in Los Castillejos, Montefrio) and (Aeneolithic in Haza de Ocon, Pinar), all in Granada province (S E. Spain). Dolerites and amphibolites are the dominant lithologies, with a great use of metamorphic rocks as schists, eclogites, and phyllite, all with a regional origin, associated to the nucleus zone of the Betic Cordillera, in Sierra Nevada. It is remarkable the presence of serpentinite in the last periods of the recent prehistory, a material also present in the area of Sierra Nevada and of volcanic rocks as the olivine basalts, andesites, metabasites and gabbros. Finally, the presence of marble in the Early Neolithic and in the Aeneolithic of this area, and its highly relation with the bracelets and collar beads elaboration, is an interesting question.

In the archaeological register of the Cueva de la Cariguela, Carrion and Gomez (1983) estimated that two types of marbles are present; one of these with a provenance centred in the Nevado-Filabride Complex, in Sierra Nevada, a very important zone of marble outcrops, with famous localities of ancient and actual production of marbles, as Macael. The other 50 %, according to these authors, has an allochthonous origin, in the Sierra Morena area, placed at 150 km to the west. Dolerites are also materials with an allochthonous origin, placed as well in the Sierra Morena area. Amphibolites are also used in the artefact manufacture, their petrological features indicate an origin placed at Sierra Morena, with a poor quality and a bad finished, and an other group with an origin in Sierra Nevada, with best quality in the raw material.

In the Middle Neolithic, marbles, amphibolites and eclogites have a regional origin, in Sierra Nevada area, with metabasites-metagabbros from the Subbetic Units and many "ophites" from Sierra Morena.

In the Late Neolithic of the Los Castillejos village, the amphibolites are the most used lithologies, with a local origin; the rest of lithologies, have a great variety and proceed from Sierra Morena, Subbetic and Alpujarride (schists), Carrion and Gomez (1983).

In the Aeneolithic of the Haza de Ocon (open air settlement) and other sites as Pena de los Gitanos, amphibolites are abundant, with dolerites, schists and olivine basalts that proceed from the Campo de Calatrava volcanic area, in Central Spain, placed many hundreds of km at the North. Other sedimentary lithologies as limestones and greywacke are also present in these industries. This temporal continuous relation between Sierra Morena and Granada area is an interesting question to develop future investigations about the trade routes for this circulation of lithic materials along the prehistory.

Fig. 10.A.- Sillimanite little adze. Cadiz province (SW Spain). Neolithic. (4 cm. long).

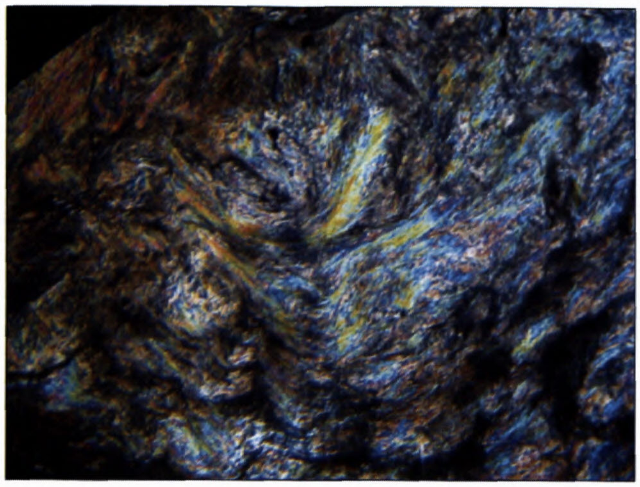


Fig. 10.B.- Micrograph of a tin section of the same object, with the typical fibrolite nodules aspect. Crossed polars. Width of photo = 1,5 mm.

Fig. 10.C.- Marble bracelet. Ardales (Málaga, SW Spain)(aprox. 9cm. diameter)

Fig. 10.D.- Micrograph of a thin section of this bracelet. Crossed polars. Width of photo = 8 mm. Neolithic.

General remarks about raw materials use in Spain

S. Dominguez-Bella

From the statistical studies made on the possible relations between the lithology and the typology of the lithic implements, we can deduce as first conclusion, the existence of a predominance of lithologies with high resistance to the wear and a good mechanical behaviour (not fragile, high or medium-high hardness, good polish, etc.), Domínguez-Bella et al. (2000).

Among this type of lithologies, igneous rocks predominate, in general dolerites (Fig. 9.A) and diabases, widely distributed by all the Iberian Peninsula and specially in the Triassic units of the External Zones of the Betic Cordilleras, Morata (1993). This type of igneous rocks are frequent practically in many zones of the Iberian Peninsula, specially in South and SE Spain, Dominguez-Bella and Morata (1998), Dominguez-Bella et al. (2002b), Carrion and Gomez (1983), Pérez Rodríguez et al, (1998), etc. However, in many geographic areas and for many temporal periods of the recent Prehistory, it is not strange the presence of olivine basalts type volcanic rocks, as the ones proceeding from the Campo de Calatrava volcanic area, Central Spain. The basalts, reported by Philips (1975), are also very abundant in the axes manufacture in the Barcelona region or the volcanic metatuffs as the one appeared in the Dolmen of Alberite I (Neolithic), surely coming from the volcano-sedimentary materials of the Ossa-Morena Zone, at the South of Hesperico Massif (Fig. 9.D).

In same cases these lithologies are used in the manufacture of objects as the grooved mining hammers, Nocete and Linares (1999), Domínguez-Bella (2003; Fig.8.C), of great resistance to the mechanical impact, generally made in dolerites or porphyry dolerites, as occurs in the copper mining activity of the recent prehistory in Sierra Morena area (North Andalusia), Domínguez-Bella et al., (2001b). Prestige objects also were made in dolerite, such as the plate or palette, for red pigments preparation, from the burial chamber of the Alberite I dolmen.

The peridotites, a high hardness lithology, as they appear in the Serranía de Ronda, in Andalusia, have hardly been utilised as raw material in the prehistory, perhaps because in the surface of the outcrops, the rocks appeared strongly serpentinized, Sierra et al., (1994).

Pegmatites and aplites have identical or similar uses to the already mentioned for the subvolcanic rocks, it is also possible to quote other materials as the massive quartz from hydrothermal veins, that are very used in the recent Prehistory, specially in the manufacture of objects related with the milling processes, as we can observe in Neolithic-Aeneolithic sites as Ardales (Málaga).

The metamorphic lithologies are also very abundant in the raw materials register of the peninsula, being dominated by the amphibolites (Fig.9.C), of different types and origins, specially in the East part of Portugal and West Spain, also in other outcrops of the inner zones of the Betic Cordillera. They appeared in the archaeological register of almost all the Iberian Peninsula, existing an important distribution phenomenon of this type of materials, Philips (1994), as was deduced from the source areas and archaeological distribution correlation, Carrion and Gomez (1983), Cardoso et al., (1995), Read et al., (1997), Risch (1995). These lithologies are very employed for the cutting tools manufacture, made by the polishing technique (axes, adzes, chisels, gauges, etc.). Other metamorphic lithologies as are the schist and slates (black slates, chiastolitic slates, etc.) appear equally very distributed, they are specially used in the manufacture of certain objects such as "archer bracelets", typical in the West and South of Iberian Peninsula or the stone bracelets, very abundant in Andalusia and Levant, having been localized areas of supply raw materials and of transformation of the same, as occurs with the slates extraction and manufacture area of Cabecicos Negros in Almería, (SE Spain), Goni et al., (1999). Eclogite appears almost exclusively in the manufacture of axes and adzes, in areas of the SE peninsular, in relation with the source areas of Sierra Nevada, in the inner of the Betic Cordillera; other possible source areas are the outcrops from the NW of the peninsula. Hornfelses are an abundant lithology in many areas, as occur in the NE of the peninsula, where they were employed in the manufacture of mining picks, etc., Alvarez and Clop (1994 and 1998).

On the other hand, many lithologies a bit less frequent, as the sillimanite, generally correspond with tools of little size and a very good finishing (Fig. 10.A-B), although in many cases were elaborated with this lithology "prestige or ceremonial" axes, as the ones that appear in the Cantabrian Cornice and in the East of France, and with a wide geographical distribution.

Quartzites, a geologically very abundant material in the Iberian Peninsula, are not very frequent in the polished lithic industry, appearing occasionally in adzes or little axes; it is more abundant their presence in tools related with the milling processes.

Marble, appears with quite frequency, specially in the south half of the Peninsula, as one of the raw materials basic in the elaboration of stone bracelets (Fig. 10.C-D), whose aesthetic change along the Neolithic and Aeneolithic, or idols and pendants.

Sedimentary rocks are widely extended in the peninsular archaeological register; they could be lithologies generally utilised in the manufacture of objects for milling works (Fig.8.D; sandstones, conglomerates, greywackes, bio-calcarenites - Fig.9.B), decorative or of personal adornment (collar beads in limestone). Also in objects associated to other activities as the loom weights (limestones, dolomites), the "archer bracelets" (sandy limestones, slates, schists), the smoothers for ceramic (limestones, flint, jasper), idols (alabaster, limestones), stone cups or mortars (marmoreal limestones) Nocete et al., (1995), Domínguez-Bella (2003), etc.

Jaspers, with different colorations and textures, appear in tools, usually of little size and with a wide and varied distribution, in general around or near the possible source areas, as the Ossa-Morena Zone, in the SW peninsular. It is very scarce in the Betic Cordillera geological materials, with a probably allochthonous origin in many archaeological sites of the South; probably in the Hercynian Massif. It is also cited in other Iberian zones as Catalonia.

Other minerals, rocks and fossil resins, as the variscite, jet or amber, appear with certain frequency in the recent Prehistory of the Iberian Peninsula. The most frequent is the variscite, Munoz-Amilibia (1971) Salvado Canëlhas (1973) Fernández and Pérez Canamares (1988) Blasco et al., (1992) Domínguez-Bella and Morata (1995 and 1996) Guerra et al., (1995) Rojo et al., (1995) Edo et al., (1997) Domínguez-Bella et al., (2002a) Pozo et al., (2002), already treated in extension in an other chapter of this book.

Amber, although not very studied in the Iberian Peninsula (Domínguez-Bella and Morata 1995), has been cited in many megalithic burials as the Dolmen of Alberite I in Andalusia, where two recovered collar beads made in amber have been identified as Simetite, an amber variety original from the Simeto river (Sicily), after their comparative study with many geologic reference materials from Europe and Iberian Peninsula, Domínguez-Bella et al., (2001a). Other collar beads are found, still in study, Domínguez-Bella (in press), proceeding from burials in tumulus of the Valle de las Higueras (Toledo, Central Spain), Bueno et al., (2000) and a great number of collar beads found in the North Spain, Portugal, Guadalquivir Valley, etc., but they have not studied up to the moment.

The same occurs with jet, which appears in many Neolithic and Aeneolithic sites, but which has not been archaeometrically characterised. Many analytic studies have been made on the collar beads, both in green stones that correspond with muscovites, chlorites, talc, etc. (Huet B. Gonçalves and Reis (1982), Fernández and Pérez (1988)) as well as with other new samples, recently recovered in archaeological surveys, with the presence of raw materials as clinochlore, idocrase, etc., Domínguez-Bella (in press), not cited till the moment in the archaeological materials of Iberian Peninsula.

In general, a great proportion of analysed lithic resources, employed for the polished lithic instruments production in the Iberian Peninsula, have a local origin.

Quarry activities for igneous and metamorphic rocks extraction are rarely documented to date in this geographical area, with many exceptions, Linares et al., (1997), Nocete and Linares (1999). The catchment of these raw materials should have been easy in many geological contexts, in which appear stone blocks formed by natural fracturation (for example, the numerous dolerite outcrops of the SSW of Andalusia and Levant) Morata (1993). The polished lithic instrumental production process, related to the catchment of raw material phase, was probably easily realised. In the dolerite and other igneous rocks outcrops, it is habitual the existence of natural blocks, originated by diaclasas or disjunction natural processes, that facilitate the obtaining of the blocks for ulterior working.

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Slovak Geol. Mag., 10, 1-2(2004), 43-64

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Axe heads productions during the Neolithic in France: a state of knowledges

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INTRODUCTION

In France, the discovery of flint mining sites in the Paris Basin begins at the end of the 19th century, and is at the origin of definition of the Campignian (Nougier 1950). However, the first archaeological excavations are not older than the 1970', with C. Guillaume's work at Saint-Mihiel (historical record *in* Bostyn & Lanchon dir. 1992, p. 23-25). Some of this mining sites are devoted to the production of flaked axe heads (intended to be polished). For the tenaceous rocks, the recognition of productions appeared during the 1950' with the creation of a programm of petrographic analyses of the axe heads discovered in Brittany under the direction of P.-R. Giot and J. Cogné (historical record in Le Roux 1999). This work took up the methods previously developped in Great Britain (Grimes 1979). Quickly, it was demonstrated that three main rock families were preferentialy used, but only one, metadolerites called at this time of the "A type", were broadly diffused out of Brittany (Le Roux 1999). The discovery then the excavations of the quarries of Plussulien (*ibid.*) authorized to precise the concept of production: a structured organization of the making of the axe heads (from extraction to final polishing), devoted to more or less important diffusions.

To schematize, since this pioneer works, two main ways of research have been developped in France, wich are seldom associated. The first one is the analysis of the modalities of production: the discovery or the excavation (mostly in emergency conditions) of the great flint mining sites of the Paris Basin and the debitage areas associated allows to understand the modalities of production; for the tenaceous rocks, the discovery of the quarries, excepted Plussulien (in 1964), occured only at the beginning of the 1990' (*cf. infra*). The second way, mostly developped for the tenaceous rocks, consisted in the caracterization of great number of objects coming from receiving sites or from stray finds (especially old collections), in order to define petrographic groups and then discuss the origin of the rocks.

This contribution would like to compere a state of knowledges on the productions of the Neolithic axe heads in France. It takes into account the two ways of research aforesaid. All the rocks identified, all the sites of production are not presented, because of the difficulty to present an exhaustive assessment in few pages, but also because of the lacks of documentation about some of the rocks used. In particular, it is difficult to know at this day if the various tenaceous rocks identified on small series of axe heads correspond to real productions, or if we are face to occasional rock use (for instance, on the eastern border of the Massif Armoricain; Le Roux 1999).

We present below the productions of polished axe heads in tenaceous rocks and flint identified in France, by the way of short notices. If the inventory isn't exhaustive at all, the most important productions are described, as well as most of the less important productions wich have nevertheless a regional significance (1). As it is, this report reflects the current researches on both questions of the productions and the diffusions. Nevertheless, it doesn't reflects the whole researches about the Neolithic axe heads, wich grow richer with the questioning about the functions, the functionning and the position of this eccentric tool within the Neolithic societies (Pétrequin & Jeunesse dir. 1995; Thirault 2001a; Pétrequin et al. 2002).

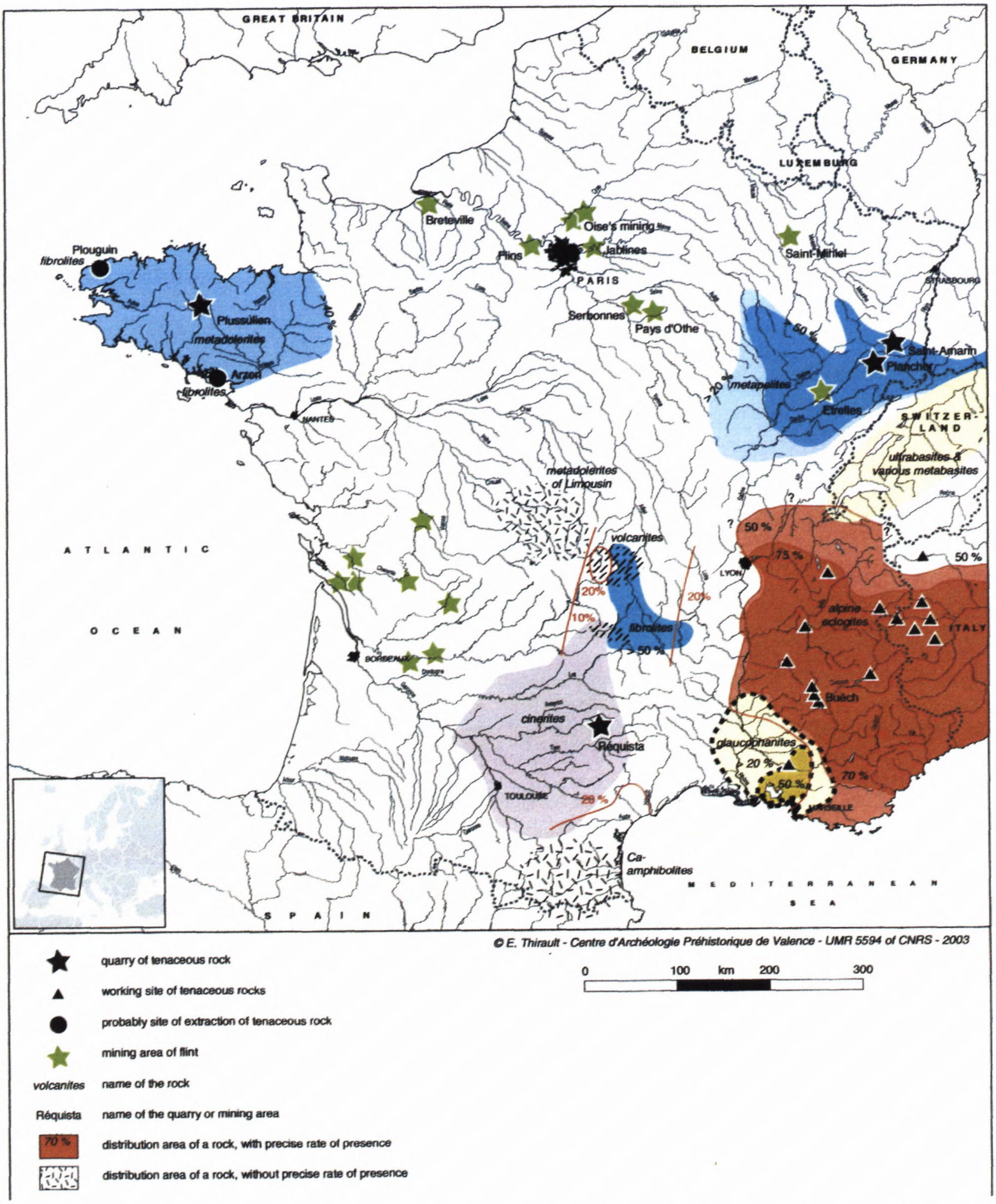

Figure 1. The main centers of productions and the broad diffusions of axe heads in France (map E. Thirault, with the help of F. Bostyn and P. Fouéré).

1. PRODUCTIONS IN TENACEOUS ROCKS

1.1. THE ALPINE WORLD (E. Thirault)

1.1.1. ALPINE ÉCLOGITES WITHIN SOUTH-EASTERN FRANCE

Alpine eclogites gather the metabasites of high pressure and low temperature (eclogitic facies) few of not retrogressed. They include eclogites *stricto sensu* (garnet + omphacite associated) and omphacitites (where omphacite is the only dominant mineral) without or poor garnets (Ricq-de Bouard et al. 1990; Compagnoni et al. 1995; D'Amico et al. 1995; Thirault et al. 1999).

Location of the exploited deposits

None deposit is known within the French Alps. Autochthonous deposits are known in Italy within the Voltri Group (Apennines of Liguria and Piedmont) and within the valleys and alpine reliefs of Piedmont and Val d'Aosta (Mont-Viso's Massif, Sesia-Lanzo Zone, Gran Paradiso). In Switzerland, deposits exists in Valais within the Zermatt's and Saas's valleys (Mont-Rose's Massif). The main allochthonous deposits are the Tertiary conglomerates of the Pô basin in Italy, and the morainic and alluvial deposits of Valais and Swiss Plateau up to the Léman Lake.

Production sites

In Italy, production sites are known:
- within the Apennines of Liguria and Piedmont (Voltri Group): near by the outcrops (Sassello: Garibaldi et al. 1996b) and near by the Tertiary conglomerates (Brignano Frascata: D'Amico & Starnini 1996; D'Amico et al. 1995; Zamagni 1996b; Rivanazzano: Mannoni et al. 1996).
- Alba's sites alongside the Tanaro river (Piedmont): Venturino Gambari & Zamagni 1996; D'Amico et al. 2000.
- within the piedmontese alpine valleys and in the foothills: Rocca di Cavour (Zamagni 1996a), Balm'Chanto at Roreto (Biagi & Isetti 1987), La Maddalena at Chiomonte (Delcaro 2002).

In France, production sites testifying the pecking and the polishing of preformed roughouts are identified:
- within the " Sillon alpin " (Isere valley, Isere): Saint-Loup at Vif (Thirault 2001a et c).
- in the Buëch valley (Hautes-Alpes): at least 16 sites on the communes of Aspres-sur-Buëch, Le Bersac, Chabestan, Lagrand, Orpierre, Sainte-Colombe, Saléon, Savournon and Sigottier (Thirault 2001a et c).
- within the Diois (Drôme valley, Drôme): sites of Les Terres Blanches at Menglon, Les Clapiers and Vallieu at Recoubeau (Thirault 2001a et c).

Diffusion of the products

Alpine eclogites are predominant for the polished tools in a radius of 200 kms at least to the East and the West of the alpine and apennines deposits (D'Amico 2000; Thirault 2001a). They usually form more than the three quarters of the axe heads on the french Rhône right bank, from the Léman Lake (excluded) to the Mediterranean See (Ricq-de Bouard 1996; Thirault et al. 1999; Thirault 2001a et b).

Chronology

The first productions are identified within the Early Neolithic (*Neolitico antico*) of Liguria (*Impressa* of Arene Candide and La Pollera: Garibaldi et al. 1996a) and of Piedmont (Brignano Frascata and maybe Alba). They are scarcely diffused in Provence and within the French Préalpes. During the Middle Neolithic (*Neolitico medio*, Culture of *Vasi a Bocca Quadratta*), production sites appear within the piedmontese alpine foothills (Rocca di Cavour). Then, during the *Chasséen récent* (Néolithique moyen II in France, *Neolitico recente* in Italy), they appear within the Western Alps both of the piedmontese (Chiomonte) and dauphinois side (Sillon alpin, Buëch valley, Diois), i.e. at 100-120 km far from the closest natural deposits. At this time, the diffusions are broad within the South-Eastern part of France. During the end of the Neolithic period (Néolithique final/*Eneolitico/Calcolitico*), some alpine production sites remain active (Balm'Chanto, Dauphiné's sites).

1.1.2. ULTRABASITES, METABASITES AND CATACLASITES WITHIN THE LÉMAN LAKE BASIN

Definition & location of the exploited deposits

This productions are realised on pebbles and rolled blanks of various petrography, coming from moraines. Ultrabasites gather the serpentinites (constituted by antigorite) and the chloritites (constituted by chlorite). Metabasites are metamorphozed under conditions of low to middle pressure and temperature: amphibolites, metadolerites epi- and mesozonals, pyroxenites of middle pressure and temperature and retrogressed eclogites are identified by thin section and X-ray analysis. Cataclasites are formed by grinding of the aforesaid rocks in geological faults, then resilification (Thirault et al. 1999).

According to the location of the sites where the axe heads have been discovered, the used deposits are the moraines of the south bank of the Léman Lake.

Production sites, diffusion of the products and chronology

Roughouts are common on the lakeshore dwellings of the south bank of Léman Lake: Séchex at Anthy-sur-Léman, Beauregard and Tougues at Chens-sur-Léman, Bel-

Slovak Geol. Mag., 10, 1-2(2004), 43-64

levue and Eaux Vives at Geneve, Crozette at Messery and Corzent at Thonon-les-Bains (Thirault 2001a). None diffusion can be demonstrated away from the Léman bank.

The lakeshore dwellings of the Léman Lake are occuped from the Middle Neolithic (*Néolithique moyen II Cortaillod*) until the *Néolithique final*, i.e. during the IV° and III° millenium BC calib. (Marguet 1995). The manufacture of the axe heads isn't preciselly dated.

1.1.3. GLAUCOPHANITES IN WESTERN PROVENCE

The glaucophanites and the glaucophanitic metabasites belong to the alpine metamorphism of high pressure and low temperature. They are metabasites of the external piedmontese zone, recrystallized under the blue schist facies, and caracterized by the glaucophane (a sodic amphibole). To the naked eye, the glaucophanites offer a green to blue color, and often whitish veins. The grain of the rock is fine or very fine (Ricq-de Bouard et al. 1990; Ricq-de Bouard 1996).

Location of the exploited deposits

None indication of exploitation as been recognized at this day on the french outcrops within the Queyras and the upper valley of the river Ubaye. In fact, the axe heads are realized on pebbles used entire or flaked. This pebbles comes from the middle and lower valley of the Durance, in western Provence, from the conglomerates of the Plateau de Valensole, et maybe from the Crau and the Côtiere de Nîmes (Lazard 1993; Ricq-de Bouard et al. 1990; Ricq-de Bouard 1996; Thirault 2001a).

Production sites

In the valley of the Durance, two dwellings have given the proof of the fabrication of axe heads in glaucophanites (flakes, roughouts, whetstones). They are located at Forcalquier "La Fare" and at Lourmarin "Les Lauzieres" (Lazard 1993). Both are dated from the end of the Neolithic period.

Diffusion of the products and chronology

During the Neolithic, the distribution of the glaucophanites never passed about fifty kms around the alluvial natural deposits (Ricq-de Bouard 1996). During the Early Neolithic, the glaucophanites are used in western Provence and near by the littoral of the eastern Languedoc, until the valley of the Aude river, on both banks of the Rhône delta. During the Middle Neolithic, the use of the glaucophanites is poorly developped, but always on the same area. During the final Neolithic, the glaucophanites are abundant but on an area more important westward, until the valleys of Ardeche and Hérault. On the left bank of the Rhône, they are well attested in western Provence until the Mont-Ventoux northward, and until the Mediterranean sea southward.

1.2. THE MASSIF CENTRAL

1.2.1. ECLOGITES AND JADÉITITES IN AUVERGNE (F. Surmely)

Definition

Cf. § Alps.

Location of the deposits

From a geological point of view, the eclogites exist in Auvergne, especially in Haute-Loire, between Brioude and Langeac (Lasnier 1977; Lasnier & Marchand 1982), but also in the zone of Saint-Flour (Cantal; Goër & Tempier 1990), Ardes-sur-Couze (Chaillou 1967) and Dore-l'Eglise (Puy-de-Dôme). They can be find also on the limit between the *départements* of Cantal and Lozere, near by the viaduct of Garabit (Colin 1960; Lapadu-Hargues 1948). The eclogites are also well present in the nearby Limousin (Santallier et al. 1986).

But, generally speaking, the eclogites of Auvergne and Limousin are formed under conditions of high pressure, then more or less retrogressed under the amphibolite facies. Consequently, they are rich in amphiboles and plagioclases, and they are caracterized by a weaker density than the "fresh" alpine eclogites (density of 3 to 3,2). Nevertheless, in Auvergne and Limousin, exist real eclogites not retrogressed and " fresh ", that can be find at the heart of the biggest masses. However, those rocks are rare (Goër de Herve & Surmely 2001).

Nevertheless, in opposite of what some former researchers have written, our own researches, based on petrographic examination under thin sections, tend to prove that almost all the eclogites used for the axe heads found in Auvergne are coming from the Alps (Surmely et al. 2001). The same result can be applied at the jadeitites, which are totally unknown in Auvergne as natural deposits.

Production sites

They have to be searched within the alpine massif (cf. § Alps). The axe heads seem to have been introduced in Auvergne as finished products. They could have been resharped during their use.

Diffusion of the products

In Auvergne as a whole, the eclogites are the most used rocks after the fibrolites (*cf.* § below ; about 20 % of the axe heads inventoried). In opposite, the jadeitites are rare (4 %). Both materials have been used for the fabrication of a broad range of axe heads, which testify varied uses (functional and "prestige" pieces). Notable variations are observed from case to case. The *département* of Haute-Loire, which forms the eastern part of Auvergne, attracts attention by the notable importance of the rate of the alpine metamorphic rocks (35 % of eclogites and 9 % of jadeitites). The axe heads in jadeitites are absent on the both sides of the *département* of Cantal, south-westward of Auvergne, where the eclogites are well present. In return, they are numerous on the big hilltop site of Corent (Puy-de-Dôme).

1.2.2. FIBROLITES IN THE MASSIF CENTRAL
(F. Surmely)

This metamorphic rock is essentially composed by sillimanite, which gives a great tenacity to it (due to it's texture formed by bunches of fibres), as well as a great hardness (7 to 7,5) and a weak rugosity (which make the polishing easier). The fibrolite exists mostly as centimetrical nodules, easy to extract from their gneissic context. During the Neolithic, this nodules have been simply regularised. According to it's mechanical qualities, this material appears as really suitable for the fabrication of polished axe heads. Nevertheless, the size of the nodules forbidds the fabrication of long axe heads (Surmely et al. 2001). The colour of the fibrolite is very variable: milky white, sometimes with grey-blue, red or black veins.

Location of the deposits

Sometimes called *« jade »*, *« jade gris »* or *« jade néphritique »* by the naturalists of the XIXth century (Gonnard 1870, 1883), the fibrolite is abundant in Auvergne, especially into the metamorphic series of the upper valley of the river Allier (Haute-Loire; Gonnard 1883; Lasnier & Marchand 1992) and of the lower valley of the river Alagnon (Cantal; Gonnard 1883; Pagès-Allary 1908). Consequently, the fibrolite is used in aboundance in the axe heads of this area (western part of Haute-Loire, eastern side of Cantal). Piles of fibrolite have been pointed out in Puy-de-Dôme, in the zone of Saint-Ours (Gonnard 1870, 1883) and of Pontgibaud (Hottin & Camus 1989). But they can also be found, as pebbles, in the alluvial deposits of the upper terraces of the river Allier as far as in Bourbonnais. F. Gonnard pointed out their aboundance in the zone of Issoire-Perrier (Puy-de-Dôme), with pebbles of 400 g, indeed 1000 g in some exceptional cases (Gonnard 1883).

Because of the multiplicity of the deposits (outcrops and alluvial deposits), and the great diversity of this rocks, the precise determination of the sources(s) of supplying remains difficult.

Production sites

In numerous cases, the axe heads seem to have been shaped on the dwelling sites, from pebbles taken in the alluvial deposits, with a shaping out often partial (cutting edge). It is the case for numerous small pieces used in the middle part of Val d'Allier (site of Corent, Puy-de-Dôme; Goër de Herve & Surmely 2000).

A shaping worshop as been signaled on the commune of Beaulieu in Puy-de-Dôme (Balsan 1956). The site gave hundreds of worked or rough nodules. Some roughouts had more or less wide grooves, realised in the aim to divide the nodules. Nevertheless, this collection has disappeared, and had not been examined by us. Another similar workshop is known in Haute-Loire (Gonnard 1883), but the objects stored at the Museum of Le Puy-en-Velay consist mostly in raw nodules. Above all, the fibrolite seems to have been sawed, wich gives an explanation for the frequent traces of sawing on the axe heads, notably in the *département* of Haute-Loire.

Diffusion of the products

Because of the multiplicity of the potential sources of supplying, it is difficult to precise the ways of distribution of the products. In Auvergne as a whole, the fibrolite is, from far, the most employed material (44 % of the axe heads). They are mostly small to very small pieces (5 cm in average), with a great variability of forms. Most of them are triangular and flat, but some of them are some kind of small and elongated cisels. The reason of this variability, functional or depending of the natural shape of the pebble, is difficult to understand.

Generally speaking, the axe heads in fibrolites are numerous in the sectors where this material is naturally abundant: Haute-Loire, Puy-de-Dôme, eastern Cantal (Surmely et al. 2001). The size of the axe heads of Haute-Loire is more important than the size of the ones of Puy-de-Dôme. That could be explained by the supplying modalities. In opposite, the axe heads in fibrolite are almost totally unknown on the western side of Cantal, where this material is totally away (2).

The diffusion of the fibrolite seems to be limited to a small scale, not morer than some tens of kilometers. But some rare axe heads in fibrolites are noted in the neighbouring regions: Lyonnais (Masson 1977), middle valley of Rhône (Thirault 2001a), Limousin (Santallier et al. 1986), Berry (Le Roux & Cordier 1974; Le Roux et al. 1980), indeed Charentes or Périgord (Surmely & Santallier 2002). In some cases, a coming from Auvergne can be supposed, but, especially for the western regions, this pieces could come aswell from Brittany or from Vendée (*cf.* below).

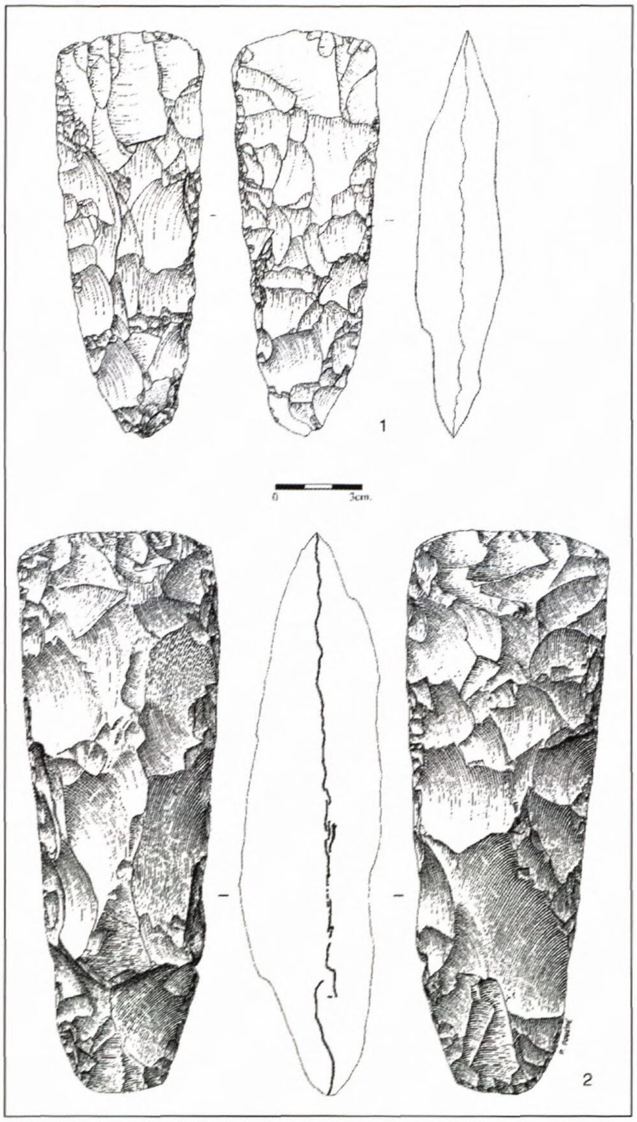

Figure 2.
1. Axe head in Bartonian flint coming from Flins (Yvelines; drawing A. Lo Carmine).
2. Axe head in Turonian flint coming from Ozillac (Charente-Maritime), collection Musée des Carmes of Jonzac (drawing P. Fouéré).

Chronology

Because of the lack of chronological context for most of the pieces, and of their morphological specificity, it is yet impossible to realise a seriation of this axe heads productions in fibrolites. Nevertheless, the fibrolite is known in sites attributed to the Middle Neolithic and to the Final Neolithic. In the middle Rhône valley, some pieces in fibrolite, which seem to come from Auvergne, have been discovered in Chassey sites contexts (Thirault 2001a).

1.2.3. AXE HEADS IN SERPENTINITE IN AUVERGNE (F. Surmely)

The serpentinites are metamorphosed peridotites (olivine → serpentine). This material is not very hard, which cannot resist to the most violent shocks. Nevertheless, this poor hardness is compensated by a much more important tenacity, due to the engaged texture of the rock. Experimentations should be realised to test it's real efficiency on such materials as wood. The serpentinite is often marbled or moiré, it's colour is real green or dark, indeed almost black, and it's rock is a very decorative one. The density varied between 2,5 to 2,7, depending to the variety.

Regional deposits and production sites

The serpentinites are common inside the ancient massifs. In Auvergne, they are present in the metamorphic series, mostly like enclaves of several square meters, principally in the upper valley of the river Allier (*département* of Haute-Loire; Lasnier & Marchand 1982; Marchand et al. 1989), in northern Margeride (Goër & Tempier 1990) and in the region of Riom-es-Montagnes (Cantal). One of the biggest outcrop (more than 200 m of diameter), forms the hill of Rocheneyre, nearby Bouchet, under the pass of Fageole. They are also present on the *départements* of Puy-de-Dôme and Allier, especially in the Cézalier and the Combrailles (Gonnard 1870; Chaillou 1967). A detailed and descriptive inventory as been realised by F.-H. Forestier in the upper valley of the river Allier (Forestier 1964), completed for the realisation of the geological maps (Lasnier & Marchand 1982 ; Goër & Tempier 1990). The serpentinites exist in the north of the *département* of Allier and are also abundant in the adjacent *départements*, Aveyron for instance (Couturier 1996). At this day, no study has been realised to precise the geographical origin of the serpentinites.

At this day, no site of extraction as been identified in the Massif Central as a whole.

Diffusion of the products & chronology

Some authors thought that the serpentinite composed a lot of axe heads. In fact, it was a confusion with the eclogites, and the axe heads in serpentinite remain scarce. The explanation is certainly linked to the poor hardness of the rock. The serpentinite seems to have been reserved to some « ceremonial » pieces.

In the corpus studied in Auvergne (more than 1200 axe heads; Surmely et al. 2001), 3 pieces only are composed by serpentinite. One of them is an exceptionnal piece, a bipenne and boat-shape axe head, which offers a great quality of finishing, and wich had certainly no utilitarian fonction. It comes from nearby Davayat (Puy-de-Dôme).

The serpentinite has been used to realise bracelets too. One of them, entire, comes from the great site of Corent (Puy-de-Dôme; Grange 1857; Marchant 1865; Mortillet 1907; Goër & Surmely 2000).

In any cases, the serpentinite used as got very beautifull colours, unknown at this day in Auvergne, and it could be materials originated from the Alps or other regions.

All the objects in serpentinite have been discovered without any archaeological context.

1.2.4. THE USE OF THE VOLCANIC ROCKS IN AUVERGNE (F. Surmely)

Two categories exist within the volcanic rocks: the recent lavas from the Tertiary and Quaternary periods, and the paleolavas from the Primary period, which are often metamorphosed. This distinctions are often impossible to establish, because of the patina of polishing and alteration. For this reason, it is often difficult to distinguish a recent lava from a paleolava or a metalava, which gives an imprecision in the determinations at the naked eye. This problem disappears with the realisation of analysis under thin sections.

During the Neolithic period, the most hard and resistant lavas have been choiced. The studies realised for the nowaday industrial exploitation demonstrate that this materials are particulary shocks-resistant, especially the paleolavas (Surmely & Murat 2003). The less tenaceous rocks, especially some lavas with a vacuolary texture of the Quaternary period, have been neglected.

Location of the exploited deposits

The volcanic rocks are abundant everywhere in Auvergne. The recent lavas are omnipresent in the three *départements* studied, and only absent in the *département* of Allier. They are also abundant in the abjacent *départements* southward: Ardeche, Lozere and Aveyron. Most of them form lava flows, put on top relief by the erosion and then, easy to access. So the supplying is easy, guided by the prismation of some stages and by the alteration zones.

The paleolavas and the metalavas are scattered on the whole region, everywhere the hercynian basement offers formations not or few metamorphised. They often form veins. Their age is comprised between the Devonian and the Permian, including the Visean and the Stephanian.

The undoubtfull axe heads in paleolavas or metalavas appear essentially in two regions: the western Cantal and the northern part of the *département* of Puy-de-Dôme. This is due to the proximity of potential deposits, which correspond, for the Cantal, to the Sillon Houiller (paleolavas coming from the stage of the « tufs anthraciferes »): region of Ayrens, Maurs or Saint-Céré (Brousse et al. 1980 ; Bogdanoff et al. 1989 ; Muratet 1981 ; Guillot et al. 1992) and for the Combrailles, to the Visean deposits (regions of Pontgibaud and Volvic: Hottin & Camus 1989). Although a regional origin seems probable, a coming of metalavas from other regions can't be excluded, for instance from the Forez, where they have been abundantly used (Masson 1977 ; study in course by V. Georges).

The determination of the origin of this rocks remains difficult because of the extreme variability of them: ignimbritic tufs, basanites, trachytes, more or less alterated and metamorphosed. The research of the geographical origin remains impossible by examination in thin section and naked eye, and set a geochemical study (Vuaillat et al. 1995).

Production sites

No site of extraction has been recognized at this day. For the recent volcanic rocks, the probability of discovery of such sites is nil, considering their topographic position, which authorize a supplying on the side of a flow, which is quickly masqued by the natural and later collapses. The probability is higher for the paleolavas, but the regional research did not really cared of the question.

Diffusion of the products & chronology

The diffusion ways of these rocks are impossible to restitute because of the problems of geographic characterization and of the broad distribution of them. The volcanic rocks, easy to find in Auvergne and available in nodules of all sizes, have been few used (more or less 7 % of the whole regional axe heads). Notable differences exist between the regions. They are numerous in westward Cantal (17 % of the whole) and northward Puy-de-Dôme, and they are almost absent in Haute-Loire (1 %). The distribution between recent and old lavas remains difficult to do without systematic analyses.

This rocks seem to have been reserved for the realization of great and heavy pieces. In fact, the most imposing axe heads of Auvergne are realised in lavas. The longest piece discovered at this day, at Dore-l'Église (Puy-de-Dôme), which is more than 31 cm long, is probably a paleolava (but a microscopic examination is required).

The lack of archaeological contexts for the most important part of the studied pieces, forbid to examine the chronological variations in the productions.

1.2.5. THE CINÉRITES OF THE ROUERGUE (E. Thirault)

Définition

Formely named « silexites », the cinerites of the Rouergue are volcano-sedimentary rocks comprised within the permo-carboniferian basin of Brousse-Broquies (Aveyron), nearby the river Tarn. The formation, 100 to 150 m thick, includes two series: the lower series, 60 m of thickness, offers quick alternations of cinerites and sandstones, which facilitates the extraction ; the upper series offers massive beds of cinerites (Servelle 1993). The raw material allows a delitage of great slabs, to 1 m of length and few centimeters of thickness. The cinerites offer a good availability for the knapping, are easy to polish and offer real attractive qualities due to their microstratification.

Location of the exploited deposits and production sites

The only exploited outcrop have been discovered by C. Servelle near by Réquista (Aveyron). The whole series outcrops on abrupts sides, where the quarries, the mines and the knapping workshops are located. The extraction consists in delitage of thin slabs with a lever, following the beds and the cracks of the rocks. The choice of the extracted beds depends on the technical (thickness, morphology, cohesion of the rock) and attractive qualities required. The knapping allows to obtain roughouts ready to be polished, wich have an average length of 8 to 12 cm, but sometimes more than 20 cm (Servelle 1993; Servelle & Vaquer 2000).

In a radius of 20 km around the Réquista quarries exist knapping and probably polishing workshops, for instance Juéris at Martrin and Prat-Sarrat at Cassagnes-Begonhes. Their datation is centered on the Chassey Middle Neolithic, but may also be more recent (Servelle & Vaquer 2000; Dausse 1996).

Diffusion of the products & chronology

The roughouts realised on slabs are not diffused more than 50 kms around Réquista, excepted for the long ones discovered as intentional deposits. The roughouts realised on pebbles coming from the Tarn deposits, wich reveal a low technical investment, are not diffused and the polished blades are used on a local scale (Servelle & Vaquer 2000).

The finished axe blades on slabs are diffused till around 280 kms from Réquista, preferentially southward, westward and northward. They appear in the Chassey Middle Neolithic of the Aveyron, the Quercy, the valleys of Garonne and Aude (Servelle & Vaquer 2000), and also nordward in Auvergne and notably in the Cantal (Surmely et al. 2001; Goër de Herve et al. 2002; Surmely et al. to publish). The cinerites are unknown before the middle phase of the Chassey Culture, around 4000 BC calib., and they are well known in the first half of the fourth millenium BC calib. Then, the diffusions decrease till the end of the Neolithic, around 2300 BC calib. (Servelle & Vaquer 2000).

1.3. THE MASSIF ARMORICAIN (E. Thirault)

Coordinated researches in Brittany and it's eastern side have been realised since more than 50 years. The first one have been initiated by P.R. Giot and J. Cogné, then by C.-T. Le Roux (historical record *in* Le Roux 1990, 1999). In proper Brittany, three main petrographic groups have been identified, and in the eastern part of the Massif, several petrographic groups which are poorly diffused are recognized by Le Roux (ibid.).

1.3.1. MÉTADOLERITES OF PLUSSULIEN (CÔTES-D'ARMOR)

Numerous doleritic veins occur in the Massif Armoricain, but only one outcrop has been surely exploited during the Neolithic period, at Plussulien. The metadolerites of the Plussulien's outcrops, formely called « metadolerites of A type », which are metamorphosed during the Hercynian orogenesis, offer exceptionnal qualities. The grain of the rock is very fine, the texture of recrystallization is very tangled, which strengthen the tenacity of the rock (Le Roux 1999).

Location of the exploited deposits, production sites and chronology

Only one outcrop has been exploited during the Neolithic, on a hill located nearby Sélédin and Quelfenec, on the commune of Plussulien, at the geographical heart of Brittany near by the upper valleys of the Blavet and the Oust (Giot et al. 1998; Le Roux 1999). The prospections and the sondages realised from 1963 to 1966 after the agricultural reallocation conducted to delimit the main sectors where the neolithic exloitations were, on a superficy of cca one hundred ha. The excavations realised from 1969 to 1976 on 300 m^2 on the foot of an still visible outcrop has permitted to study the chronology and the modalities of the exploitation, from the extraction to the pecking of the roughouts. Four phases of extraction are identified: first from the alterated upper rock, then from the massive rock pulled down by firing, lastly the exploitation of old blocks coming from the former extractions. The activity of the excavated quarry has been dated by C^{14} from the beginning of the Vth millenium BC calib to about 2500 BC calib.

Around Plussulien, production sites are attested by surveys in a radius below 15 kms, whith the proof of flaking (Le Roux 1999). This workshops are late (Néolithique récent, Campaniforme, i.e. IIIrd millenium BC).

Diffusion of the products & chronology

The petrographic studies lead westward of France have precised the importance of the diffusion of the metadolerites coming from Brittany (Le Roux 1990, 1999). Several facies of dolerites have been identified, but only one, which was exploited at Plussulien, is broadly diffused: in Brittany, this rock represents most commonly more than 50 % of the axe heads, and two main preferential ways of diffusion are identified in the lower Loire basin, and in direction of Normandie. But geochemical studies lead on the metadolerites of Limousin, which are identical to the metadolerites of Plussulien, considering a petrographic point of view, indicate that the metadolerites of Limousin have been used during the Neolithic. This fact questions the reality of the diffusion of Plussulien in the Loire basin (Santallier et al. 1986; Vuaillat et al. 1995).

The available datations on the receiving sites indicate that the metadolerites of Plussulien are diffused since the end of the V° millenium BC calib northward of France, and up to the end of the Neolithic, at the end of the III° millenium BC calib (Le Roux 1999).

1.3.2. THE FIBROLITES OF BRITTANY

Definition

Cf. fibrolites of Massif Central. The fibrolites form nodules or pebbles detached from their matrix and then, directly suitable for the exploitation.

Location of the exploited deposits & production sites

In the Massif Armoricain, two coastal regions offer suitable deposits of fibrolites (Le Roux 1990). At the western part, northward Brest around Plouguin (Finistere), the exploitation is suspected thanks to the discovery of technical indices (roughouts, hammerstones) in a sector where the nodules of fibrolite outcrop. Southward, in the Morbihan gulf southward Vannes (Morbihan), the fibrolite outcrops in the peninsula of Rhuys, but no indice attests a production. Nevertheless, the fibrolites are well known on the near neolithic sites. According to the concentrations of axe heads in fibrolite, other exploitations have to be researched in the south part of the *département* of Finistere, the north-eastern part of Brittany (region of Saint-Malo, Ille-et-Vilaine) and the estuary of the Loire (region of Saint-Nazaire, Loire-Atlantique).

Diffusion of the products & chronology

Axe heads in fibrolite are very scarce outwards the aforesaid regions, wich indicates very restricted diffusions (Le Roux 1999). But it seems that the use of this rock occurs mainly during the old phases of the Neolithic of Brittany (V° millenium BC): it appears in domestic and funeral contexts of the early Neolithic (Villeneuve-Saint-Germain group), then inside the funeral chests under low mounds and inside the giant barrows of the south part of Morbihan (Cassen et al. 1998 ; Cassen 2000, p. 530-532). The use of the fibrolite is so prior to the beginning of the exploitations of Plussulien.

1.4. THE VOSGES (E. Thirault)

The use of the tenaceous rocks coming from the vosgian deposits has been recognized since the XIXth century, but the first elaborated work on this subject is much more recent (Piningre 1974). Then, the diffusion and the petrography of those formerly called « aphanites » have been precised (Willms 1980 ; Diethelm 1989). Nevertheless, the questionning and the field informations have been deeply renewed since 15 years within the framework of a pluridisciplinary programm not yet finished (Jeudy et al. 1995; Pétrequin et al. 1993, 1996; Pétrequin & Jeunesse dir. 1995). We present here the two main productions identified, the pelites-quartz (the most importand) and the nodulosy schists, but more than ten exploited deposits have been identified in the Vosges.

1.4.1. THE PELITES-QUARTZ
(quarries of Plancher-les-Mines, Haute-Saône)

The rocks exploited at Plancher-les-Mines are dark coloured, sometimes with white veins, with a very fine grain, generally homogenous. They are volcano-sedimentary and detritic rocks (pelites), dated to the Visean, composed by grains of quartz, felspar and sometimes mica, with a variable proportion of organic material. The very siliceous cement, coming from an acid volcanism, gives a very great consistency to those rocks, which are real curiosity within the sedimentary series of the vosgian Visean. The fine and homogenous grain, allied to the hardness given by the silica, explain the good ability of this rocks for knapping (Rossy in Pétrequin & Jeunesse dir. 1995).

Location of the exploited deposits

The existence of quarries devoted to the extraction of the pelites-quartz has been recognized by P. Pétrequin and it's collaborators in 1989 (Jeudy et al. 1995; Pétrequin et al. 1993, 1996; Pétrequin & Jeunesse dir. 1995). It is a quarrying area composed by two distinct groups on the steep sides of a small valley near by Plancher-les-Mines. Within the main group, the quarries are formed on 6 ha by numerous working faces up to 15 m high, and by the screes formed by the wastes of the exploitation which form cones lower down each forking face. The layout of the quarries, partially recovered by the later cones, autorize to propose a chronology of the exploitations, from the lower part to the upper part of the side, and a chronology of the tecnical schemes of extraction and debitage.

Production sites

Two groups of neolithic sites with the proof of fabrication are known (Jeudy et al. 1995; Pétrequin & Jeunesse dir. 1995; Séara 1995): southward and southwestward of Plancher-les-Mines, at about 20 kms maximum (i.e. one day of walk), in the region of Lure, Belfort and Montbéliard; eastward of the quarries, at about 30-40 kms (i.e. two days of walk), between Altkirch and Thann in upper Alsace. On those sites, the knapping flakes are numerous, but also the roughouts in course of pecking.

Diffusion of the products

The pelites-quartz are diffused essentially westward, southward and eastward from the Trouée de Belfort, between the *département* of Haute-Saône and the Bodensee for the most intensive diffusions (at least 50 % of the axe heads), i.e. maximum distances of more or less 200 kms. Sporadic diffusions are recognized eastward the Paris Basin, northward the Vosges, in the region of the upper Rhine valley around the Federsee and in the region of Ulm (South-West part of Germany), and up to the Léman Lake and the Valais at some distances exceptionnally upper than 300 km (Piningre 1974; Willms 1980; Pétrequin & Jeunesse dir. 1995).

Chronology

The collective work directed by P. Pétrequin correlates the exploitation of the quarries, the production sites on the dwellings, the fabrication schemes, the diffusions and the uses of the axe heads in pelite-quartz, and then proposes a network of global understanding of this phenomenon. Briefly, the good fortune of the pelites-quartz is linked to the cultural mouvements and of the social transformations identified at a bigger scale (Pétrequin & Jeunesse dir. 1995; Jeunesse & Pétrequin 1997). After a first phase of recognizing of the vosgian rocks, during the early Neolithic (*Rubané i.e. LinearBandkeramik*), where the pelite-quartz are not in the majority in the polished tools, the quarries and the diffusions become more and more important in course of the Vth millenium BC calib.: the sites of production are located in upper Alsace up to around 4200 BC calib. (groups of Roessen III and of Bruebach-Oberbergen) and the diffusions extend westward and eastward. At around 4000-3800 BC calib., the exploitations of Plancher-les-Mines attain their apogee, the sites of production are closer to the quarries (Trouée de Belfort) and they are controlled by the *Néolithique Moyen Bourguignon* Culture ; the diffusions are the most intensive throught several cultural frontiers. After 3600 BC calib., the long-distance diffusions collapse, but the productions of Plancher-les-Mines remain notable at a regional scale up to the extreme end of the Neolithic, around 2200 BC calib.

1.4.2. THE NODULOSY SCHISTS
(quarries of Saint-Amarin, Haut-Rhin)

The *schistes noduleux* exploited in the Vosges, in fact *cornéennes*, are sedimentary rock of the Visean period (pelites and grauwackes), constituted by quartz, feldspars and phyllitean minerals (micas, chlorites). This *cornéennes* are metamorphosed by thermal contact with a granitic magma, which as caused the recrystallization of the cement. The rocks obtained are hard and consistent, they are sometimes bedded, and they can contain millimetric or more smaller nodules. Their availability to the knapping is proved (Rossy *in* Pétrequin & Jeunesse dir. 1995).

Location of the exploited deposits

After numerous prospections realised under P. Pétrequin's leadership, only one outcrop of *schistes noduleux* suitable for the neolithic use as been discovered at Saint-Amarin/Finsterbach on the side of the Markstein (Pétrequin & Jeunesse dir. 1995). On a square of one hectare are preserved the wasted of the exploitation and of the knapping: a depression resulting of the extraction of the rock, the tested blocks, the knapping wastes and the rejected cores allow to understand *in situ* the organization of the work, from the extraction to the preparation of the knapped roughouts.

Production sites & diffusion of the products

As well as for the pelites-quartz, the shaping out is realised outside the quarries, on the dwelling sites located south-eastward Saint-Amarin, in the plain of the Rhine between Thann and Altkirch, a dozen kms far from the quarries.

The *schistes* noduleux are diffused close together with the pelites-quartz, but they represent only a small part of the total of the axe heads.

Chronology

The chronology of both productions and diffusions is parallel to the one of the pelites-quartz (Pétrequin & Jeunesse dir. 1995). The axe heads in *schistes noduleux* are known as soon as the Early Neolithic (*Rubané i.e. LinearBandkeramik*), but the first important activities are not older than the second half of the Vth millenium BC calib. at Saint-Amarin and on the sites of production of the Rhine plain. The apogee is also dated around 4000-3800 BC calib.

2. FLINT PRODUCTIONS

2.1. FLINT PRODUCTIONS OF AXE HEADS IN AUVERGNE (F. Surmely)

Beside the axe heads in blond flint of the upper Cretaceous, probably imported from the edge of the Paris Basin, in Auvergne can be find pieces realised in Tertiary flint of the upper Oligocene, which seem to be regional materials. These flint have a texture sometimes heterogeneous, with an aspect frequently zoned, and colours from light grey to black. Their aspect is very variable, with nodules sometimes important (flagstones of more than one meter of diameter). Some experimentations realised by C. Sestier have demonstrated the good quality of those modules for the shaping out of the axe heads.

Location of the regional deposits

Numerous sedimentary Tertiary basins exist in Auvergne and in the nearby fringes, which offer silicifications (Surmely 1998). These basins may have constitute the potential areas of supplying. The most important of them are the basin of Aurillac/Mur-de-Barrez in the *département* of Cantal, and the basin of the Comté d'Auvergne in the *département* of Puy-de-Dôme (Surmely 1998; Surmely et al. to pubblish). Most of them are dated of the upper Oligocene. The best materials are located in the basin of Aurillac/Mur-de-Barrez (Pasty et al. 1999).

Production sites

For the regional flints, a mining site has been formerly signaled in the locality of « La Côte blanche » at Mur-de-Barrez (Aveyron), which would have been linked with the axe heads production (Balsan 1957; Boule 1884 et 1887). A new examination of the archives, joined to the periodic supervision of the working face of the current quarry on the site, show that this mining site wasn't really important. Moreover, no indice demonstrates that the production was linked to the axe heads (Santallier & Surmely 2003). During the ancient excavations, no roughout has been discovered.

So it is easier to suppose that the axe heads realised in the regional Tertiary flint have been shaped from blocks revealed by the erosion on the sedimentary deposits. Some indices of this have been signaled, for instance roughouts or knapped axe heads discovered around Aurillac (keeped in the Museum of Archaeology of Aurillac). Considering the superficy of the outcrops and their partial reworking by the volcanic phenomenons, it is almost impossible to discover the traces of the human removal.

Diffusion of the products & chronology

The axe heads in Tertiary flint are numerous in the areas where the material is naturally present (middle of the *département* of Puy-de-Dôme and especially the western part of the département of Cantal). Elsewhere, they are scarce or even almost absent (for instance, in the *département* of Haute-Loire; Surmely et al. 2001). Even in the privileged regions, the local flint seems to have been competed by over siliceous materials: cinerite of Réquista (*cf. § supra*) or allochthonous Tertiary flints (Surmely et al. 2001; Surmely et al. to publish; Surmely & Murat 2003; Surmely & Pasty 2003). So the diffusion seems to have been quite local, even if there is a lack of informations about a potential traffic on the direction of the Quercy or the Rouergue.

Lastly, the caracterization of the geographic origin of the Tertiary flints remains hypothetical. It is very possible, but unprobable at this day, that the flint axe heads discovered in Auvergne may have come from the significant mining sites of the Paris Basin (*cf. § infra*).

As always concerning the axe heads of Auvergne, the corpus is almost composed by objects devoided of stratigraphic context, which forbidd to give chronological arguments.

2.2. AXE HEADS PRODUCTIONS IN FLINT AND OTHER SILICEOUS ROCKS IN THE NORTHERN PART OF THE AQUITAINE BASIN (P. Fouéré & C. Chevillot)

The materials

The silifications of the northern part of the Aquitaine Basin, from the Poitou to the Périgord and the Atlantic coast, are well known thanks of the interest of several generations of researchers, around the famous regional prehistoric sites.

The flint of the layers of the Jurassic and of the upper Cretaceous, but also the millstones (*meulières*) of the Tertiary and the epigenetic formations derived from it, are all potential sources for the neolithic supplying in axe heads. Nervertheless, all the varieties haven't been used. Several criterions are probably be retain for the selection, such as the abundance of the raw material, the facilities of extraction, the dimensions of the matrices. But we can notice that in fact, the most resistant materials have been used first, in relation with the constraints of the use of this kind of tool. So, the black or brown flints of the Senonian used for the current tools have been neglected for the axe heads, because they are two or four times less resistant to the crushing than the other flints (Fouéré 1994). As we know today, the most exploited flints are ones of the decalcification clays of the upper Turonian of Saintonge (region of Taillebourg-Ecoyeux, Saint-André de Lidon and Pons) and of Angoumois (La Couronne, Vallée de la Boëme), the flints of the middle Jurassic of Poitou (Sommieres-du-Clain), and also the flints of the end of the Senonian of the region of Bergerac. Locally, we can add the millstones of the Tertiary (Saint-André-et-Appelles) or the silico-ferruginous flagstones of the valley of the Dronne. The main articles given in references, most of them old, give a glimpse of this exploitations.

Modalities of extraction

The documentation is really unequal for the different areas of production. The excavations on the mining sites and workshops in the Aquitaine Basin remain almost non-existent, and in most of the cases, we have to deal with the surface gatherings.

The modalities of extraction are almost unknown, but they are probably pits or working faces in the decalcification clays of the changed covering of the underlying limestones dated to the Tertiary. The higher concentrations in nodules, the higher quality of the flints and the facilities of exploitation of this geological deposits justify their exclusive exploitation.

Some examples of the structures of extraction are known: pits have been signaled on the workshop of La Petite Garenne at Angouleme (Favraud 1911) and most recently on the neighbouring site of La Couronne (Charente) where exist also some small working faces open in the clays covering the upper Turonian (Fouéré et al. 2001). At Saint-André-de-Lidon (Charente-Maritime), a small pit has been discovered during a poll on the workshop of La Merletterie (Fouéré 1994). Lastly, the same kind of exploitation has been observed for the silico-ferruginous flagstones in Dordogne, at Sauclaud where pits digged in the clay allowed to touch, two meters deeper, a diaclasis dug in the Turonian limestone, filled with silico-ferruginous flagstones (Chevillot et al. 1999, 2000, 2001, 2003).

The strategies of exploitation are yet poorly described. At La Couronne, the quarriers looked for the concentations stratified within the clays, with more or less success. For this they made working faces or sporadic diggings, from the outcroping layers. Curiously, the best part of the deposit, burried at less than one meter in the clays, has not been exploited. Most of the extracted blocks have been tested, freezed or not. The pit of La Merletterie has been dug on more than one meter deep in the silts to reach a level with stones and flints of various qualities.

Shaping out the preforms

In all the regions considered, the shaping out of the preforms seems to be realised for the most important part on the sites of extraction, revealed by the areas of high concentration in raw materials. The numerous knapping wastes and the faulty abandoned roughouts allow to discuss the conduct of the debitage.

The first transformations are probably realised immediately after the extraction: quality test of the material, then preparation of the preform following the methods appropriate to the morphology of the raw material. For the nodules or the polyedric blocks of suitable dimensions, the direct shaping out of the roughouts is used; when the blocks are too much important or when the aim is to realise small axe heads, the debitage of big blank-flakes is privileged. At La Couronne, a first stage is to cleave the lens-shaped nodule in two parts, because of the frequent presence of a geode in the equatorial plane of the block. Those works on the extraction sites are realised almost in any cases by direct percussion with a hard hammer ; actually, the stigmatas of the soft percussion (lip, lack of impact point, ...) appear on few scarce flakes. Once never find (or very few) roughouts ready to be polished on the natural deposits, the best preform being taken out by the knappers.

Sometimes, all or part of the shaping out chain is realised on the dwelling sites, after importation of the raw material or the preform sometimes on several kms. It is the case on the site dated at the *Néolithique récent* type Peu-Richard and of the site at Diconche in Saintonge dated at the *Néolithique final* (Artenac group; Fouéré 1994; Burnez & Fouéré dir. 2000). Once find the cortex removal flakes and up to the "peelings" of finition. Some small workshops, corresponding only to the ultimate phase of the shaping out of the preform, are known too for the *Néolithique récent* of Bergeracois, at Les Gillets (Fouéré et al 1998) or at Les Réclaussoux (Fouéré et al. 2003). Unlike the extraction sites, the shaping out of the preforms on the dwelling sites seeks most commonly a soft hammer.

Polishing

This ultimate stage of the fabrication of the axe heads is probably the most difficult to understand. The unpolished roughouts may sometimes diffuse on long distances. Then, the preform ready to be polished of axe heads realised in flint of Saintonge can be find on numerous regional dwelling sites, as far as the Vendée. It is also the case for the axe heads in flint of Bergeracois recovered on the Atlantic coast of Médoc. Some megalithic whetstones are known in Dordogne and in the basin of the river Charente, but they are too much scarce to prove the existence of workshops devoted to the polishing. The finishing of most of the axe heads has probably been realised mainly on the dwelling sites, where small whetstones are frequently discovered.

Typology

Define a type or a standard for the axe heads isn't easy, because most of the available pieces are broken, reknapped, or even repolished and resharpened. Then, the dimension of the nodules used is very variable. According to the roughouts abandoned on the workshops or the scarce intact axe heads, some specific criterias may appear in the regions of production. The axe heads of the Poitou, seen on four workshops of the valley of the Clain, are small sized, rarely longer than 15 cm, with sometimes plano-convex sections caracteristic of the adzes. The axe heads of the Saintonge, where the adzes are scarce, are frequently 15 to 20 cm long, or even more according to the size of some fragments. This is also a maximum for the productions of the Angoumois and of the Bergeracois, even if we know some long roughouts ready to be polished of 26 and 28 cm on this region and for the millstones of Saint-André-et-Appelles in the *département* of Gironde (Cauvin 1971). Numerous axe heads of the Bergeracois have particular squared sides and an invasive and blading (« *laminaire* ») retouch on the proximal part, retouch realised after polishing. Nevertheless, those lateral ledges aren't an exclusivity and may exist on the productions of the Saintonge.

Datation

The scarcity of datations is linked to the lack of excavations on the mining sites of the Aquitaine Basin. No date is available for the sites of production of Saintonge, Poitou and Périgord. One of the pits of La Couronne is attributed to the *Néolithique récent* by the radiocarbone. In return, the products discovered on the dwelling sites autorize to suppose the beginning of the exportations at least at the *Néolithique moyen* for the productions of the Bergeracois (cave of Les Perrats at Agris, Charente, Roquefort at Lugasson, ...) of the Saintonge (Les Châtelliers at Auzay, Vendée). The full growth of the regions of production corresponds probably to the *Néolithique récent* and *final*, linked to a probable demographic growth illustrated by the abundance of sites.

Extent of the exportations

The precise study of the exportation of axe heads in the Aquitaine Basin and their spatial and temporal variations is a long work which, for the main part, still have to be realised. Each region of production had probably it's own area of influence which may have evolved according to economic, social or cultural criterions (which remain unknown). Considering the Neolithic period as a whole, the productions of the Bergeracois are probably the one which have the most circulated. Axe heads are known as far as the Saintonge and the Angoumois, near by the centers of production of the axe heads in turonian flint, and the exportations go probably broadly southward, up to the foothills of the Pyrénées (Vaquer 1990; Delage 1993; Fouéré 1994). The axe heads of the Saintonge have rather a littoral diffusion, known from Brittany up to the Gironde (Fouéré, *op. cit.*). Except for the local use, once doesn't known the scale of the exportations of the axe heads of the Augoumois. Those later are probably in competition with the crystalline rocks of the Limousin, the Bergeracois and the Saintonge. The same observation can be realised for the axe heads of the Poitou: the scarce known workshops did probably not give the same mass production as the other regions.

Numerous points have to be developped concerning the axe heads productions of the Aquitaine Basin. Some elements of answers would probably be given by the works in course, especially the excavations on the mining sites of Sauclaud (Villars, Dordogne) and the researches programms on the Bergeracois.

2.3. THE PARIS BASIN

2.3.1. THE MINING SITES IN THE TERTIARY FLINT OF THE PARIS BASIN (F. Bostyn & F. Giligny)

The Tertiary flint of the Paris Basin is coming from the marly-limestone levels of the middle Bartonian (limestones of Saint-Ouen), which is a lacustrine limestone in which the silicification isn't always complete. The presence of numerous microfossils, sometimes bad recrystallized, may cause irregularities in the raw material.

Location of the exploited deposits

The strata of the Bartonian outcrop in the whole Paris Basin, between the valleys of the rivers Aisne and Oise northward, the valley of the river Marne and of it's main tributaries southward. Eastward, the Île-de-France cuesta forms a natural and sharp limit in an arc of a circle form. Westward, the concerned strata are limited by the river Epte on the right bank of the river Seine, and by the river Vaucouleurs on the left bank. In fact, the levels are accessible only on the sides of the main rivers and of their tributaries, and also in the outliers which subsist in some areas.

Production sites

At this day, three sites of extraction are certified:
- Jablines « le Haut-Château » (Seine-et-Marne), mining site recognized by aerial photograph and excavated on a strip of 500 m long and 60 m wide on average (Bulard et al. 1986 ; Bostyn & Lanchon 1991, 1992, 1995, 1997). On this area, more than 750 shaft holes have been recognized. From this sample, it is possible to estimate at more than 5000 the number of shafts on this mining site (Bostyn & Lanchon dir. 1992).
- Coupvray « Les Chauds Soleils » (Seine-et-Marne), mining site formerly recognized by surface gatherings (Giraux & Reynier 1911) and identified as a mine during the widening of the railway at the end of the 1970'. Some shafts have been also repeared by aerial photograph in 1989. No recent excavation has been realised.
- Flins (Yvelines), mining site formerly recognized by surface gatherings (Silvestre de Sacy & Baudouin 1926, 1927). Aerial photographs realised in 2000 by the *Service Archéologique Départemental* of the Yvelines have permitted to locate several areas of high concentrations of shafts. A pedestrial and fine prospecting linked to a geophysical prospecting (realised by the Society Terra Nova), complete the knowledges about the extension of the mining site, which remain still partial at this day (Bostyn et al. 2002, 2003).

Chronology

At present, the mining site of Jablines is the only one which gives precise data about the chronology of the exploitation and so, of the production of the axe heads which is intimately linked. The radiocarbone datations realised on 16 different shafts demonstrate that the exploitation is lasting from 4060 BC cal to 3050 BC cal, i.e. during the *Néolithique moyen* and the beginning of the *Néolithique récent*.

Diffusion of the products

Considering the great likeness between the small plates coming from the several outcroups of the bartonian flint, we are not able yet to precise the exact coming of the finished products discovered on the dwelling sites localized outside the Tertiary Basin (Bostyn 2003). During the *Néolithique moyen*, axe heads in Tertiary flint are known eastward on the site of Mairy (Ardennes; Hamard 1993), westward on the site of Louviers « la Villette » (Giligny dir. to publish) and northward in the *département* of Oise (Hamard 1993, Verret 1987). At the opposite, south-eastward the Paris Basin, no product as been signaled at this day on the dwelling sites (Augereau 1993).

2.3.2. FLINT EXTRACTION AND AXE HEADS PRODUCTION, THE EXAMPLE OF THE MINING COMPLEX OF THE PAYS D'OTHE
(Aube & Yonne; P.-A. de Labriffe)

Upon the construction of the motorway A5 between Paris and Troyes (Aube), four flint mines and their workshops have been observed (3). Those interventions have also permitted to locate or to rediscover a ten of mines, knapping worshops and polishings.

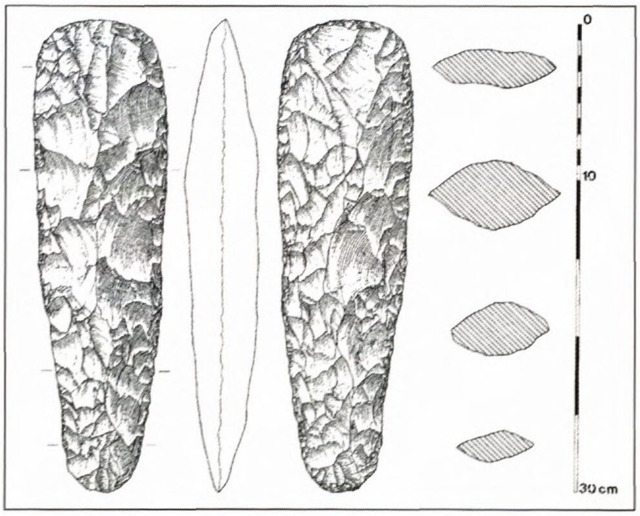

Figure 3. Axe head in Bartonian flint coming from Jablines " Le Haut Château " (Seine-et-Marne, drawing S. Vacher).

Geographical and geological context

The Pays d'Othe, located between 100 and 150 km south-eastward Paris, belongs to the Paris Basin, from a geological point of view. The substratum is mainly constituted by chalky deposits of the Senonian abundantly provided in flint. They are sometimes surmounted by Tertiary remains which contain numerous blocks of sandstone.

In spite of a common geological frame, each of the excavated sites had it's own conditions of geological deposit. All the extraction sites are established on Secondary aged deposits (Campanian or Coniacian). At Villemaur « Grand Bois Marot » and Serbonnes, the Senonian layers are recovered by Quaternary deposits, resulting from the alteration of the underlying chalky deposits.

The beds or nodules of exploited flint are either in primary position within the chalk, or in secondary position within the Quaternary sediments. Generally speaking, there are small and irregular nodules, with numerous excrescences. Within the chalk, they form sub-horizontal beds. But the neolithic miners have also exploited the nodules present within the Quaternary deposits, which are formed by the demolishing of the beds of flint. The miners have often exploited several beds in the same time.

Organisation of the sites

Each of the excavated sites covers a surface of several hectares, in which only a very tiny percentage has been specifically studied. The both mines of Villemaur could have a extent comprised between 15 and 40 ha. Some sites have a considerable density of structures per hectare. Actually, we estimate that on the site of les Orlets at Villemaur there are more than 800 structures of extraction per hectare. The numerous crosses between structures tend to demonstrate a long duration of the occupation.

No dwelling vestiges nor domestic wastes have been discovered on the four excavated sites. Nevertheless, a child burial as been discovered at Villemaur « Les Orlets ». It was settled in the upper filling of an extraction shaft. Considering the layout of the body, it is a real burial and not an accidental death.

The structures of extraction

Three types of structures have been identified.
- *The pits*: they are not deeply dug (several tens of cm), generally sub-circular shaped in surface, with a basin shape in profile. They are rare and localized on the margins of the mining sites, where the banks of flint outcrop on the surface.
- *The shafts*: this word gathers all the deep structures. Their size and morphology are very variable. The location and the layout of the raw material govern their shape. The depth vary from 1,50 to more than 6,50 m. They have a circular opening, which is prolonged by a chimney or access shaft. This vertical chimney is open at the level of the bank(s) of flint, by chambers of extraction disposed in radius. They are small sized, go not far from the shaft (2 or 3 m maximum) and are only 80 cm high in average, which forbid the miner to stand up.
- *The trenches*: this system of exploitation, revealed on other european mining sites, as been used at Pâlis, where one of the exploited bank outcroped. This trenches are narrow, sinuous and not very deep.

The tools used for the extraction

The antlers have been preferentially used on the four mining sites. Several hundred of objects, representing all the stages of fabrication, use and surrender, have been collected during the excavations on these sites (4). The form and the functions of the tools are varied: picks or pickaxes, rams or loosers for the nodules, rakes, etc. The falled antlers are the most frequent, but some slaughter antlers are also present. On the site of Le Grand Bois

Marot at Villemaur, we have also discovered some picks in flint, but they are much less abundant than their equivalent in antlers.

Technics of extraction

In the Pays d'Othe, the technics used for the digging are particular. The neolithic miners adopted a system aimed to reduce to the minimum the efforts for a optimal result in spite of the random distribution of the raw material.

In most cases, a first pipe has been dug to recognize the raw material. This hole, a cylindrical shaft with a small diameter, permitted to observe the nature of the flint on it's faces. If the conditions were good, then the exploitation begun, with the digging of small chambers of extraction disposed in radius from the shaft. If several beds of flint are present in the same shaft, the first to be exploited is always the lowest. Then, the neolithic miners always tried to let the most as possible of sterile sediments inside the spaces freed by the advancing of the work.

On several of the excavated mining sites, we fund examples of test-shafts abandoned without being used for the exploitation, because they didn't reached any suitable flint. These test-shafts are perfectly cylindrical pipes without any chamber of extraction. They are generally located at the margins of the mining sites.

Production

The conditions of preserving of the four sites are very different. At Villemaur « Le Grand Bois Marot », the workshops of debitage located at the exit of the shafts were perfectly preserved. In opposite, on the other sites the production is known only by the wastes of debitage trapped inside the upper fillings of some of the structures of extraction.

On the three sites excavated in the *département* of Aube, the dominant production is the axe head. But there is also, marginally, a production of short and wide blades, and also flakes. All the stages of the fabrication of the axe heads are represented on the sites, excepted the polishing which should have realised near by the mines, on one of the numerous whetstones of the region.

Datations

The objects suitable for answer directly to the question of the chrono-cultural assigning of these mining sites are extremely rare. Nevertheless, we have to signale the discovery of a tulip-shaped vase in the upper filling of one of the shafts of the mining site of Les Orlets at Villemaur-sur-Vanne. From a cultural point of view, this vase could be related to the Michelsberg Culture, to the Group of Noyen or to the Néolithique Moyen Bourguignon.

On the site of Le Grand Bois Marot, inside the debitage piles, few notched scrapers have been found, tools belonging to the *Néolithique récent* or *Néolithique final* (Seine-Oise-Marne Culture or Group of Gord).

On both sites of Villemaur, these impressions are confirmed by the radiocarbone dates realised on charcoals discovered inside the fillings of the shafts. At Les Orlets the dates rise in tiers from 6510 ± 50 BP to 5100 ± 130 BP. Most of the dates are around 5300 BP. At Le Bois Marot the dates are more recent and are comprised between 4320 ± 80 BP and 3980 ± 30 BP.

Conclusion

The sites excavated thanks to the opportunity of the building of the motorway A5 have also permitted to rediscover other probable sites of extraction. Added with the sites excavated, it forms in this small region one of the important centers of extraction of flint and of fabrication of axe heads. Despite the lack of precise informations on this subject, we can assume that the axe heads of the Pays d'Othe have not only supplied the populations located immediately near these deposits, but also the communities located at several tens of kms eastward in sectors where the flint is totally absent.

2.3.3. THE AXE HEADS IN CRETACEOUS FLINT OF PICARDIE (F. Bostyn)

In Picardie, most of the chalky layers of the Cretaceous (Campanian, Santonian, etc.) comprise beds of flint more or less dense and continuous. All of them may have been potentially exploited, but at this date, the extraction of the beds of flint is known on several broad sites. Nevertheless, the production of axe heads is studied or mentionned only on few of these sites. Only those sites are presented here.

Location of the exploited deposits

- The mining complex of Hardivilliers-Troussencourt (Oise): the neolithic exploitations affect a bed of white shalk of the Campanian (Agache 1959, 1960). The knapping workshops installed immediately near by the shafts for flint have given an abundant documentation on the making of the axe heads.
- Hallencourt (Somme; Fabre 2001)
- Nointel (Oise; Fouju 1891)
- Champignoles (Oise; Fouju 1891)
- Margny-les-Compiegne (Oise; Quenel 1913).

Diffusion of the products

Few studies have been realised on this aspect in so far as the fine work of recognizing of the possible differences between the deposits of raw material is hardly roughed out. In other respects, on numerous sites, the researches are very old and the datas remain sporadic.

Considering the abundance of the raw material in the region, it is probable that the diffusion of the axe heads remained at a regional scale.

Chronology

No C^{14} date has been realised on the mining sites of flint previously quoted. For this, the datation of the extraction and of the fabrication of the axe heads realised on the very place of the acquisition remains indirect, by the presence of products on the dwelling sites. Since the Middle Neolithic, the presence of numerous axe heads is signaled on the dwelling sites (fortified or not) and this production continue during the *Néolithique récent* and *final*.

2.3.4. THE MINING SITE OF HALLENCOURT (SOMME) AND ITS APPROACHES (J. Fabre)

Location of the exploited deposits

The mining site of Hallencourt is located on a shalky outlier of the Campanian belonging to the plateau of the Vimeu, on the left bank of the river Somme (Fabre 2002, 2003). It is constituted by 17 separated *loci*, scattered on an area of 200 x 600 m. Each *locus* presents structures of extraction and knapping workshops accompagned by their suite of rejected pieces which reflect the whole fabrication schemes. All these *loci* give also shaped tools, on blocks and on shaping out flakes, which are associated to the exploitation: picks, edged hammer stones, backed knives, thick scrapers and scarce large scrapers, but very few domestic material. So the conduct of this mining site, a small-scale production because of the scattering of the *loci*, is different of the conduct of Jablines, where the exploitation is intensive. Hallencourt functionned mostly from extraction shafts, and the surface cartography shows structures of various dimensions (on 15 *loci*), but also probably, according to the geological study, two annex exploitations in the open air, on the outcrop. The Campanian flint of the mining site is found on several peripheral sites, especially the site of the Group of Gord (*Néolithique final*) of Bettencourt Saint-Ouen, located at 19 kms, which gives for a part a datation for the mining exploitation of the flint. Another C^{14} datation has given, on antlers found in a excavated shaft, an age of the Old Chassey Culture for the mining site, which so functionned in continuity or not at least from the Chassey Culture to the Group of Gord.

Diffusion of the products and chronology

The relations with the peripheral sites (Fontaine sur Somme, Liercourt, Allery, Bettencourt), were not limited to the diffusion of bifacial pieces but also to domestic material (scrapers, notched srcapers, backed knives, etc.) from Campanian flint previously shaped. The knappers of the villages shaped also axe heads in Coniacian flint. The proportion of this domestic material decrease from the mining site till Allery (4 kms; 66 %), Fontaine (6 kms; 40 %) and Bettencourt (19 kms; 8 %), which implicates social relations in a context of micro-regional finage. Endly and at this day, there is no testified communication between this mining site and some sites excavated attributed to the Middle Neolithic (Longpré-les-Corps- saints, enclosure of L'Etoile). On the other hand, there is less than 1 % of Campanian material at Pont-Remy, a surface site also attributed to the Middle Neolithic. So the mining site initiates shyly its activity during this time and is at its full power during the period of the Group of Gord.

Generally speaking, the sites located on the edges of the plateau give indications about the presence of neolithic people on the outcrops of flint of the Coniacian c, b and scarcely Coniacian a. On the sites located in the bottom of the valleys, the situation is reversed. The most used flint for the axe heads is the Campanian one of the mining site of Hallencourt, but the Coniacian flint b/c and exceptionally the Coniacian a are also used.

2.3.5. SYSTEMS OF PRODUCTION OF AXE HEADS IN THE MIDDLE NEOLITHIC IN THE PARIS BASIN (A. Augereau & F. Bostyn)

The different productions of axe heads

Since the Middle Neolithic (*Néolithique moyen*), the two main resources of flint of the Paris Basin, the flint of the Tertiary (Bartonian) and the flint of the Cretaceous (Coniacian, Santonian, Campanian), are widely exploited for the making of axe heads on the sites of extraction. The production of axe heads in Tertiary flint is realised on plates of big dimensions, which give products relatively standardized (the longest are 30 cm long). The forms of the rare roughouts ready to be polished studied at Jablines « Le Haut-Château » and also the polished tools coming from the Yvelines are slightly trapezoidal, the sharps are regular and convex and the sections are oval and regular. The stage of competence required for the shaping of these pieces is necessary high (Bostyn 1992).

The axe heads realised in the flint of the Cretaceous are less long (less than 20 cm), but differences within the quality of production are perceptible between the South-East of the Paris Basin and the Picardie. In the Pays d'Othe and the Sénonais, the pieces ready to be polished are often irregular and not really long (often around 15 cm). The failures of production are particularly abundants and testify the relatively low degree of competence (Augereau 1995). In opposite, the knappers of the mining area of Hallencourt (Somme) owned a sufficient degree of know-how to product roughouts of axe heads more regular, even if the accidents remain frequent on the studied rejects (Fabre 2001). The axe heads of the mining site of Hardivilliers-Troussencourt (Oise) precisely described enough by R. Agache (1959 & 1960) present very close characteristics to the axes of Hallencourt.

Once observe a bifacial and bilateral shaping, ended by a stage of regularizing of the edges and of the sharp. There is also a similarity in the dimensions: the lenght of the roughouts vary between 12 and 15 cm in majority.

The impact of the raw material

The quality of the finished products is greatly linked to the initial morphology of the blocks and to the quality of the raw material. Actually, the Tertiary flint of the Bartonian looks like small plates more or less thick, with a morphology adapted to this production. The silicification is mostly homogenous, and the possible crackings are easy to locate on the surface of the plates, which avoid numerous accidents during the knapping (or during the shaping). This qualitative selection of the raw material has a reflect on the organization of the underground exploitation of the flint, because the upper bed of flint (of lower quality) has been almost neglected during the extraction. The differences of thickness observed on the plates coming from the different zones of the mining sites have also an impact on the finished products, because for the thinest blanks, some cortical surfaces are often preserved on the central part of the tools, on one or both faces.

At Villemaur (Pays d'Othe), the raw material of the Cretaceous is globaly of mediocre quality, and some bad silicified zones can frequently be observed. The nodules have random morphologies and dimensions, and they form discontinuous beds. The two upper beds are constituted by nodules of small dimensions, and they have been few exploited. The third bed comprises mostly faulted small plates. The last bed, which is the most researched, contains nodules of better quality, but they have various forms and dimensions.

On the mining sites which exploit the Campanian flint of Picardie, the choice for the making of the axe heads was realised preferentially at the advantage of the biconvex nodules, sometimes almost table-shaped. These nodules have a form closest as possible as wanted for the roughout ; the more irregular nodules are devoted to the production of flakes. At Hardivilliers, the miners have also neglected the nodules coming from the silts containing flints, which are almost all frost-broken.

The production of axe heads as a reflect of various social organizations

Only the situations of Jablines and of the Pays d'Othe have been studied enough to allow the discussion about such aspects of the socio-economical organization of the productions of axe heads. In the Pays d'Othe and the Sénonais, the very random quality of the raw material, the relatively low degree of competence (translated by the production of short pieces and of mediocre quality) and the abundance of sites of extraction in the valleys occupied during the Neolithic, all these facts are convergent elements for an hypothesis of the fortuitous exploitation of the deposits of flint for the satisfaction of local needs. If the products have been diffused, it has probably been a limited one.

In the case of the productions of axe heads in Tertiary flint, the situation is very different. The extremely structured extraction of the lower bed of flint suppose that the conduct of the deposit was strict, and it requires a precise know-how. These facts suggest a speciallized activity of craft. In other respects, the technical quality of the long axe heads is the matter of specialized knappers which own a high degree of know-how to carry out this production. The quantity of flint extracted on the single mining site of Jablines probably passed the needs of a single village and the long axe heads have probably been included in the exchange networks which were functionning during the Middle Neolithic. Actually, some axe heads in Tertiary flint have been diffused eastward till the Ardennes (Mairy) and westward till the valley of the Eure (Louviers), which represents each time several tens of kilometers.

2.5. THE LORRAINE: THE FLINTS OF THE OXFORDIAN AND THE MINING SITE OF SAINT-MIHIEL (E. Thirault)

Definition & location of the exploited deposits

The white oolithic and lithographic limestones of the upper Jurassic (Oxfordian), which outcrop in the valley of the river Meuse are the only one in Lorraine to contain flints of good quality (Guillaume 1987; Georges 1995). The are chalcedony-flints and limo-siliceous cherts wich form nodules often ovoidal, mostly grey coloured with a white and shalky cortex. At Saint-Mihiel, three beds of flint have been exploited between 2 and 4 m of deepness in average. The deeper bed is the most suitable for the knapping and is associated to blocks of quartzites which have been extracted and used to make tools.

The mining site of Saint-Mihiel

In the zone of the Oxfordian outcrop, 6 mining sites and 3 zones of concentrations of knapping workshops have been discovered. The mining site of Saint-Mihiel, known since 1878 is the only one to have been partially excavated under the direction of C. Guillaume from 1972 to 1979 and in 1986-1987. The mining site is located on the left bank of the Meuse on a hill shelf. 18 surveys and areas of excavation permitted to understand the extension and the organization of the mining site. Four zones of extraction are located on two ha. Within the excavations, 65 structures have been identified: 47 shafts, 18 galleries and one trench, for a total estimated about 1000.

Two types of units of extraction are identified:

- a shaft associated to a gallery,
- several shafts associated to a long gallery; the seconds are the extend of the firsts.

In average, from a shaft of 1,5-2 m of diameter, the galleries are dug on 2-3 m wide, and 4 to 7 m long. The extraction begins by the removal of the lower bed of flint, the best, then the upper beds are extracted and the spoil hearth is set down on the bottom of the gallery. The study of the filling and the organization of the shafts allows to imagine an exploitation by successive units gradually agglomerated. This kind of exploitation requires a team of 2 to 6 miners during the bad season (outwards the agricultural works).

Diffusion of the products and chronology

According to the available dates, the exploitations of Saint-Mihiel are in activity during the IIIth millenium BC calib., i.e. the regional Néolithique final. The products (polished axe heads, tranchets, arrowheads, products of debitage) are known on the sites of the « Mosellan Group », subsequent of the Group of Gord and of the Seine-Oise-Marne Culture, which indicates a preferential diffusion eastward in direction of the Rhine valley and none diffusion in the direction of the Paris Basin nor the Champagne. So maybe the mining site of Saint-Mihiel was exploited by only one community for it's own benefit.

2.6. THE LACUSTRINE FLINTS OF HAUTE-SAÔNE AND THE MINING SITE OF THE REGION OF ETRELLES (E. Thirault)

Definition & location of the exploited deposits

The lacustrine flints of the Tertiary (Oligocene) of the *département* of Haute-Saône occupy a basin of around 30 x 15 km between the rivers Saône and Ognon. The flints are included within the marls and the limestones, forming discontinuous beds of variable forms: plates, flagstones and nodules. The dimensions can attain 80 cm and the masses can exceed a tens of kg. Among the varieties of flint identified, only the « type 207 » defined by J. Affolter has been intensively exploited.

The neolithic exploitations are known since 1878 in the region of Etrelles (Piningre 1974). Surface prospecting led since 1960 confirmed the presence of the Paleolithic and the Neolithic, and, from 1986 to 1991, a global study has been conducted about the Tertiary basin and the workshops of Etrelles under the direction of C. Cupillard (Cupillard & Affolter 1995).

Production sites

Around 20 open-air sites are count, including 7 mining sites of 2-3 to 7-10 ha; one group is located at Etrelles and at Mont-les-Etrelles. The whole forms a complex of 20 to 30 ha. The excavations of 1986-1991 concerned a sector of 360 m^2 excavated on the mining site of Blanc-Saule at Etrelles-et-la-Montbleuse, for a total superficy estimated to 3 ha. Apart form the knapping piles, 10 dug structures (pits and shafts) have been excavated. They are dug up to the substratum, i.e. a deepness of 2,4 m maximum.

Diffusion of the products and chronology

On the mining site of Blanc-Saule, a group of C^{14} dates indicates the presence of exploitations at the end of the *Néolithique moyen II* and at the beginning of the *Néolithique récent* (4000-3000 BC calib.), i.e. at the end of the *Néolithique Moyen Bourguignon* and the late *Cortaillod.* Some younger dates indicate exploitations around 3000-2600 BC calib.

The distribution of the knapped axe heads is linked to the Tertiary lacustrine basin, i.e. the sector close to the mining sites. In opposite, the polished axe heads realised in flint « type 207 », are broadly distributed in the *département* of Haute-Saône, but they are hardly kwown upwards.

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Notes

(1) The writing of the notices as been entrusted to the authors indicated at the head of each notice. Besides, E. Thirault assumed the coordination of the whole.
(2) Fibrolite could exist in some areas north-eastern of the Cantal.
(3) Serbonnes « Le Revers de Brossard » (Yonne), excavation leaded by Manuel Mendoza,
  - Pâlis « Le Buisson Gendre » (Aube), excavation leaded by Jacqueline Hascoët,
  - Villemaur-sur-Vanne « Le Grand Bois Marot » (Aube), excavation leaded by Pierre-Arnaud de Labriffe,
  - Villemaur-sur-Vanne « Les Orlets » (Aube), excavation leaded by Pierre-Arnaud de Labriffe.
(4) They have been studied by Isabelle Sidéra (UMR 7041 of CNRS).

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Raw Material for Making Chipped Stone Artefacts in Early and Middle Neolithic of Serbia

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Abstract: The artefact analysis of material from 20 Early and Middle Neolithic localities in Serbia pointed at a neccessity to check and verify past interpretations dealing with origin and primary deposits of so called "Balkan flint" and obsidian. In addition, time and space related to a greater use of so-called "white stones of different origin" are definied.

Key words: raw material, chipped stone artefacts, Neolithic, Starčevo Culture

Introduction

The central Balkan area, together with its all concurrent influences, has an extraordinary importance for development of Neolithization. Period of the earliest village communities on the territory of Serbia today is represented by artefacts related to Proto-Starčevo or Gura Bacului and Starčevo culture. These cultures denoted Early and Middle Neolithic and in the frame of absolute chronology on the basis of relatively small number of C^{14} analyses they start at the end of the VIII Millennium and beginning of VII Millennium before present. The end of the period of domination of representatives of these cultures is believed to be the boundary between the VII and VI Millennium before present (Tasić, 1988, 45-47).

This study is aimed to offer a more consistent answer to one of many questions related to chipped stone artefacts - in this case particularly to the question if all the chipped stone artefacts made of obsidian and so-called "Balkan flint", which were documented from some Early Neolithic localities in Serbia, are imported as a result of contacts between remote communities or, alternatively, they could have been of autochthonous origin, as well.

The chipped stone artefacts that were subjected to the analysis of raw material and its provenance arrived from 20 localities (Figure 1)[1]. Although the finding conditions were not identical, most material came from the localities at which systematic excavations had been carried out i.e. from Padina, Lepenski Vir, Ušće Kameničkog potoka, Knjepište, Donja strana-Velesnica, Blagotin, Vinogradi-Grabovac, Livade, Šalitrena pećina, Donja Branjevina, Golokut and Vojlovica.

Rock types

The oldest traces of, conditionally speaking, mining activities or exploitations of rocks suitable for making chipped stone artefacts are related to the locality of Kremenac, near the Rujnik village, close to Niš. The first data suggest that certain exploitation works on that locality were even in the Early Paleolithic (Kaluđerović, 1996, 289-290). The opal samples from the line Glavica-Krivo Polje, near Ramaća and close to Kragujevac, as well as traces of small open pits indicate that these deposits of raw material were used by inhabitants of Starčevo settlements, which were situated in the close vicinity during the Early and Middle Neolithic (Jovanović and Bogdanović, 1990, 82-84). Except at Lepenski Vir, where basalt and analogous igneous rocks are believed to have been used for chipped stone artefacts (Kozlowski and Kozlowski, 1984, 271), the raw material from all other localities may be classified as follows: *chert, quartzite, quartz, "white rocks of different origin" and obsidian.*

Abundances of all types of raw material reported in this study are presented in table 1 according to given archaeological localities.

In table 2 is given average contribution of five characteristic types of raw material from the localities that had undergone systematic excavations or recognizing and complete sampling without a selection. Hence, there exist unequivocal indications that these localities were in fact settlements at which no mixture of material from later cultures had occurred.

Chert is a siliceous sedimentary rock composed of chalcedony and quartz. It may also contain remnants of radiolarian (microorganisms with siliceous shells) and

[1] During the writing of this paper material from the locality of Padina was inaccessible for study. Namely it had been earlier transferred from the Center for Archaeological Research of the Faculty of Philosophy in Belgrade to the National Museum in Kladovo. All data used here were taken from the M.Sc. Thesis of Radovanović. However, the main topic of the mentioned Thesis were Mesolithic chipped stone artefacts while the artefacts of the Starčevo provenance were only partly investigated. Therefore, a direct comparison with other localities on the basis of raw material and principal types of tools was not possible.

silicified foraminifers (microorganisms with, most frequently, carbonate shells) and others[2].

Chert is very hard and brittle. It gives a characteristic conchoidal fracturing and is characterized by weakly to highly lustre surfaces and when thin it can be more or less transparent. It appears variously coloured depending on type and quantity of impurities. The impurities of Fe-oxides and hydroxides give rise to yellow colour, manganese gives greenish or blue greenish, clay minerals grey and traces of organic matter produces black colour of chert (Protić, 1984, 171).

It is inevitably clear that cherts of identical macroscopic characteristics may originate from a single, but also from two or more very remote deposits, and that, on the other hand, cherts of different macroscopic features can originate from considerably remote deposits but also from a single locality. This fact discredits classifications of raw material based on rocks colour as a decisive criterion. Concretion cherts (mostly originated by silicification of limestone) appear as concretion interlayers, lenses or nodules in a lithological column (Protić, 1975, 139). Such chert can be macroscopically very different both laterally and vertically. Petrological studies (e.g. x-ray diffraction, differential-thermic analysis, microscopic analysis), if they are not accompanied by control samples from the exactly located areas, in archaeological sense, do not give comparable results. A reliable petrological definition may determine geological units, which contain particular chert occurrences suggesting directions of further investigation of potentially primary appearances (Hodges, 1981).

Although there are different conceptions in the geological literature (Pettijohn, 1957, 431-444; Tomkeieff, 1983, 97) and the terms *flint, chert, silex, silexite, novaculite, jasper, hornstone* all are being used as synonyms, in this study only the name chert is exclusively used. It is because that incorporates all those rock types, which, according to the given definition, belong to the group of siliceous sedimentary rocks, irrespectively to colour, lustre or transparency.

Chert is the most abundant raw material and it dominates at all the localities except at Blagotin and Velesnica.

The problem of localization of so called "Balkan flint"

This chert may be variously coloured, from honey yellow to honey grey or milky grey, or may show lighter circular lines of greyish colour. For the last type Kozlowski and Kozlowski discuss: "*This raw-material did not appear in Iron Gate and was imported from Pre-Balkan Plateau, east of Iron Gates. Its exact localization, however, is not known*" (Kozlowski and Kozlowski, 1984, 267), a afterwards add: "*A peculiar thing is, that all analogies concerning certain types of artefacts like end-scrapers, retouched blades and flakes concern the whole region supplied with Balkan flint which also includes finds of Körös culture in Great Hungarian Plain*" (Kozlowski and Kozlowski, 1984, 275).

In her PhD Thesis Voytek noted: "*In addition, in Lepenski Vir IIIb, yellow spotted chert was used for the first time by the inhabitants. This material was found in blades and large flakes which were also located inside pots" (Voytek, 1985, 69), and: "Outcrops of Balkan flint are known from Dobrogea and the pre-balkan platform in northern Bulgaria (Tringham 1971, 153; Načev and Kančev 1984). In addition, it can be found in blocks along the river gravels on the left bank of the Danube, e.g., at Greaca and Suhaia (Comşa, 1976, 240)*" (Voytek, 1985, 129, 130).

In contrast to Kozlowski and Kozlowski, Voytek located the areas with primary occurrences of so called "Balkan flint" and related them to the "Pre-Balkan Plateau" i.e. to the area in North Bulgaria, westward from Varna and to the territory on the left banks of the Prut river in Dobrogea in Romania.

In her PhD Thesis Voytek presents the chert zone in Bulgaria (Figure 2 according to Voytek, 1985, Map IIIA.2). This zone is easy to follow along an E-W line, from the Black Sea coast to East Serbia. Comparing this sketch with the geological map in figure 3 (according to Dimitrijević, 1992) one should observe an absolute conformity to the zone denoted as Pre-Balkan.

Using the term "Pre-Balkan *Plateau*" is, from geological point of view, very problematic. This zone, which Kozlowski and Kozlowski, as well as Voytek, are referring to *Pre-Balkan Plateau*, according to geological data (Dimitrijević, 1992), in fact, belongs to a specific tectonic unit - *Pre-Balkan terrane* (not terrain!). This unit was recognized in the territory of Bulgaria, and further to the West it continues as the Vrška Čuka-Miroč terrane (East Serbia).

These are particular geological terms and their equalizing leads to misunderstandings both when using literature data or during consultations with specialists in geology.

The analysis of average contribution of so called "Balkan flint" to the material under this study shows that the number of these artefacts decreases going downstream the Danube river, from Lepenski Vir to Knjepište, which contradicts to the hypothesis for the location of primary deposits suggested by Kozlowski and Kozlowski and Voytek (Figure 4).

Accepting the concept of Voytek that those who first used "Balkan flint" were inhabitants of settlements of Lepenski Vir the Phase IIb, it remains unclear what is the provenance of the chipped stone artefacts made of identical raw material, which were found at localities more to the west from the Đerdap area, such as Toplik (Malo Crnuće), Orašje (Dubravica) and Blagotin (Poljna) all dated as earlier phases of the Starčevo culture.

On the other hand, at Blagotin, this type of chert amounts 14.34 %, whereas at considerably remote locali-

[2] In case that the radiolarian content is high (above 20%) the rock may be classified as radiolarite, i.e. an organic sedimentary rock that, according to general characteristics, could not be distinguished from chert.

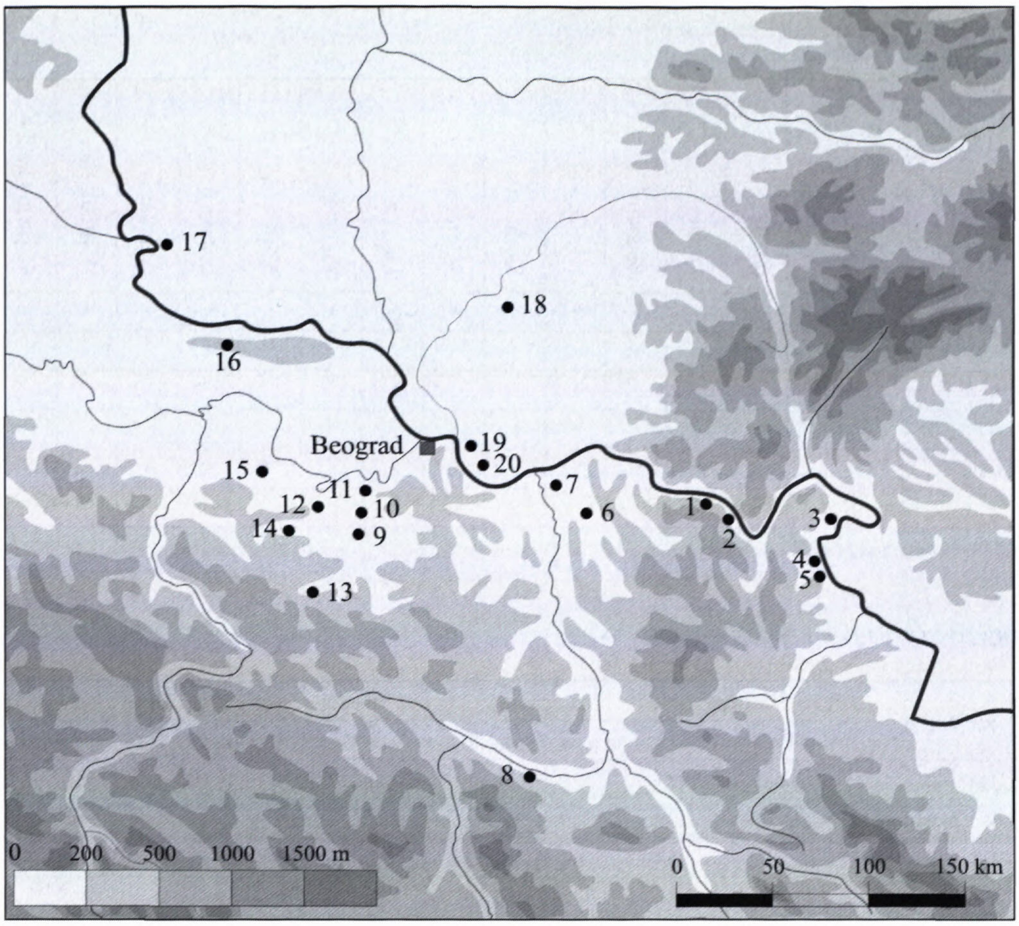

Fig. 1 Geographic position of the studied localities: 1. Padina (Donji Milanovac); 2. Lepenski Vir (Donji Milanovac); 3. Donja strana (Velesnica) ; 4. Ušće Kameničkog potoka (Novi Mihajlovac); 5. Knjepište (Mihajlovac); 6. Toplik (Malo Crniće); 7. Orašje (Dubravica); 8. Blagotin (Poljna); 9. Livade (Kalenić); 10. Novo Selo (Stubline); 11. Lug (Zvečka); 12. Vinogradi (Grabovac); 13. Šalitrena pećina (Brežđe); 14. Simića strana (Čučuge); 15. Popovića brdo (Zablaće); 16. Golokut (Vizić); 17. Donja Branjevina (Deronje); 18. Stari vinogradi (Banatska Dubica); 19. Rafinerija (Vojlovica); 20. Sedlar (Pančevo).

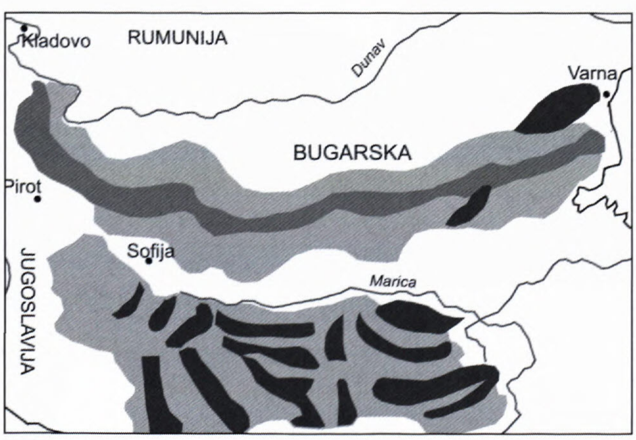

Fig. 2 Chert zone in Bulgaria according to Voytek

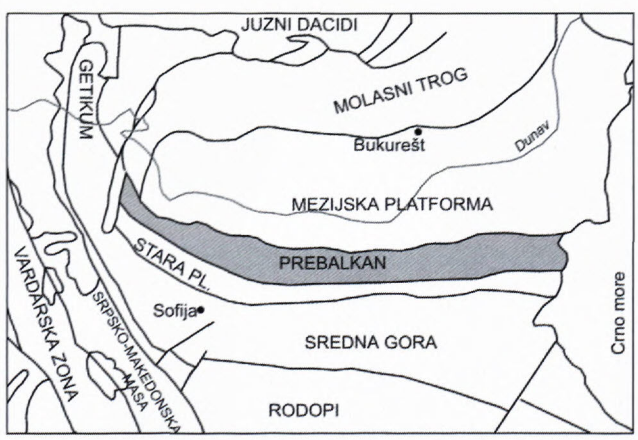

Fig. 3 The zone denoted as Prebalkan, according Dimitrijević

ty of Simića strana the abundance increases to 21.05 %, while at Popovića Brdo, a locality very close to the latter, chert is presented with only 0.88 %. At the locality of Donja Branjevina, which is most distant from the Đerdap area, this percentage increases to 11.05 %, reaching even 18.51 % at the locality of Golokut. It is noteworthy that between Golokut and Donja Branjevina a distance of around 35 km exist.

A disproportion in abundance of some types of raw material could be a result of chronological hiatus among

Table 1 - Abundances of basic raw material at given localities

	Lepenski Vir	Velesnica	U. Kam. potoka	Knjepište	Orašje	Toplik	Blagotin	Popovića brdo	Simića strana	Šalitrena pećina	Lug	Vinogradi	Novo selo	Livade	Golokut	D. Branjevina	Stari vinogradi	Rafinerija	Sedlar
chert	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
quartzite	•	•	•	•			•	•						•		•			
quartz	•						•	•											
WSDO						•	•	•	•	•				•					
obsidian	•					•	•	•	•					•	•	•	•		
other rocks	•																		

Abbreviation: WSDO - white stone of different origin

Table 2 - Percentage contribution of basic raw material

	chert		quartzite		quartz		WSDO		obsidian	
Localities:	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%
Lepenski Vir IIIa-b	319	89.85	3	0.83	23	6.74	0	0	?	
U. Kamen. potoka, N.Mihajlovac	203	77.48	59	22.51	0	0	0	0	0	0
Knjepište, Mihajlovac	313	87.67	44	12.32	0	0	0	0	0	0
Donja strana, Velesnica	104	19.84	420	80.15	0	0	0	0	0	0
Blagotin, Trstenik	1004	42.47	1311	55.81	29	1.23	3	0.12	2	0.08
Livade, Kalenić	17	54.83	1	3.22	0	0	11	35.48	2	6.45
Šalitrena pećina, Brežđe	92	76.66	0	0	0	0	28	23.33	0	0
Simića strana, Čučuge	38	84.44	0	0	0	0	6	13.33	1	2.22
Popovića brdo, Zablaće	903	96.78	17	1.82	3	0.32	7	0.75	3	0.32
Golokut, Vizić	22	81.48	0	0	0	0	0	0	5	18.51
Donja Branjevina, Deronje	823	98.21	11	1.31	0	0	0	0	4	0.47

Abbreviation: WSDO - white stone of different origin

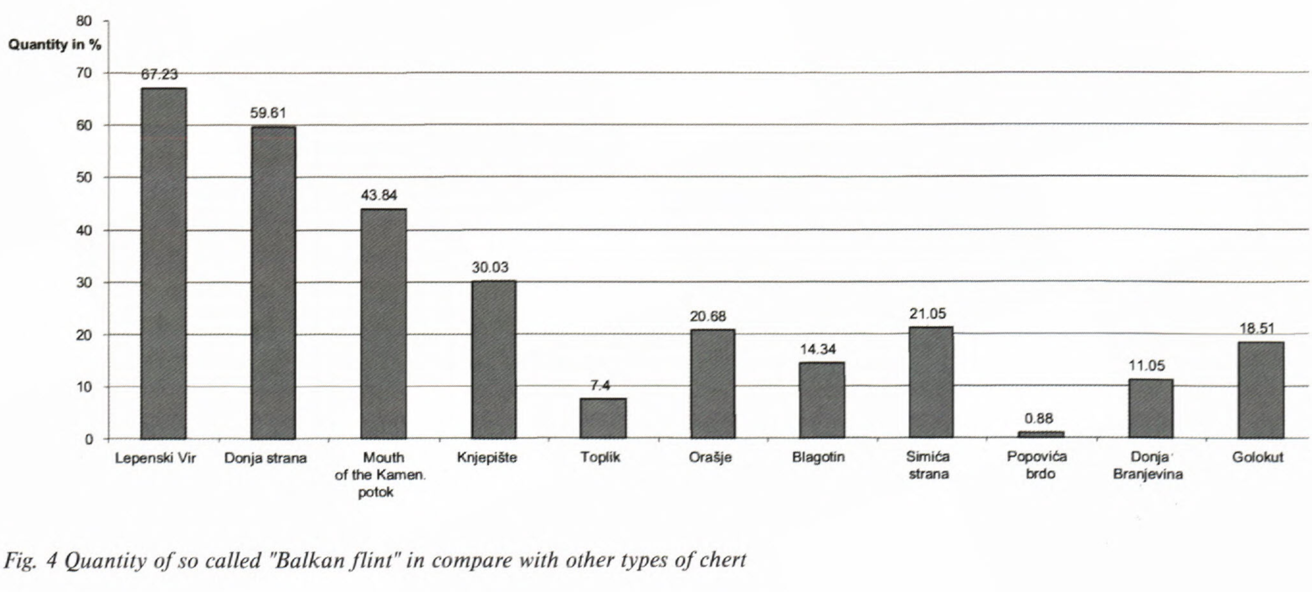

Fig. 4 Quantity of so called "Balkan flint" in compare with other types of chert

given deposits. It is logical that during longer time periods some deposits were exhausted and that simultaneously others were discovered. However, the chronological frames, inferred from dating of the localities of studied raw material, bear some characteristics that exclude their primary role in causing different abundance of so-called "Balkan flint".

In the area of Ključ, more precisely in the district of the Korbova village, is situated Zbradila, as a very important locality of the Vinča culture (Babović, 1984, 93-100; 1986, 95-98). The collection of chipped stone artefacts from this locality has a total of 1896 samples, among which the artefacts made of "Balkan flint" make 85.44 %. At certain artefacts made of this raw material a cortex of river pebble is preserved suggesting that the rocks were collected from secondary deposits - alluvions (Šarić, 2002). In case of this Late Neolithic locality chronological differences could have produced difference in abundances of artefacts made of so-called "Balkan flint", but the appearance of artefacts showing a cortex of river pebble are indeed very significant, because they indicate a local origin of the mentioned type of raw material.

The finding of three artefacts with a cortex of river pebble in Velesnica and Blagotin, along with numerous similar artefacts from the Late Neolithic locality of Zbradila, set some questions important for analysis of the origin of this type of chert:

Is it probable that such common and widespread raw material as chert could have been an object of barter and market even at such long distances as 700 km? In case of obsidian that distant market is, however, known given its tightly located deposits (in geographical sense) and quality that usually draws extraordinary attention of possible users.

Is it likely that the objects of the market and barter from the primary deposits were small river pebbles instead of large chert pieces of high quality?

Is the finding of artefacts with a cortex of river pebble indicates a collection of this raw material from redeposited primary deposits very close to Velesnica and Blagotin?

As it was underlined before, conditions of chert formation allow generation of cherts characterized by identical petrographical characteristics even formed at completely different places and this fact should be taken into account when attempting to locate primary deposits of so called "Balkan flint". Hence, even if we accept the concept about the location of primary deposits of this raw material in the area of non-precisely defined "Pre-Balkan Plateau", according to the mentioned authors, it is by no means certain that it was the only district where rocks of petrographic characteristics similar to "Balkan flint" could have been found.

Quartzite is a common metamorphic rock and when in form suitable for making chipped stone artefacts it was most frequently collected from alluvions. It is the fact that quartzite is commonly used for making tools and difficulties in recognition of such tools and their neglecting during excavations are main reasons that this industry is still poorly known. Therefore, I suppose that that the large differences in percentages of quartzites at certain localities did not cause by more or less expressed heritage of earlier periods, but in great extent they exist due to incomplete collections of artefacts. If we speak about locations characterized by inevitably complete inventory of chipped artefacts, then the difference of quartzite abundances may result from differences in accessibility of this raw material within a given environment. The best indicator for that is the fact that almost all samples with preserved cortexes, have cortexes of river pebble implying that they were collected from alluvions. The only exception is the locality of Blagotin, characterized by extraordinarily developed quartzite industry, where a majority of samples bears a cortex that suggests the exploitation from a primary deposit. Considering that at Blagotin do not exist traces of settlements of cultures older than Proto-Starčevo, it appears that the usage of quartzite was not influenced by possible Mesolithic traditions, but by the fact that in the close vicinity, within the rocky mountain massifs, easily accessible quartzite strata occurred.

Quartz - euhedral quartz crystals are often to be found in porous rocks as geodes and most famous varieties are citrine - yellow, amethyst - violet, morion - black, smoky quartz- dark brown. Beside single crystals, quartz appears also in monocrystalline and more often in polycrystalline granular aggregates (Ilić and Karamata, 1978). According to the Mohs' scale its hardness is 7, it shows conchoidal fracturing characterized by sharp edges on flakes. Therefore, colour is the only criteria for distinguishing between quartz and flakes of volcanic glass, especially when the artefacts are very thin and transparent.

Rock crystal is a colourless variety of low-temperature quartz that forms rombohedral prisms with pyramidal crystal faces at one or both sides. It seems that larger samples of quartz crystals suitable for chipping were relatively rarely found and therefore the artefacts of this raw material are exceptionally rare at our Early Neolithic localities. In the material under the study only at Popovića Brdo and Blagotin rare artefacts made of quartz were found.

Quartz is less abundant then chert and quartzite and this is the major reason that it was not being greatly used, while a small number of quartz artefacts found is due to the lack of enough large crystals suitable for handling. Quartz still remains as one of the most quality raw material and it is quite obvious from the quality of quartz artefacts from Blagotin. The presence of quartz at Blagotin (29 samples) could be related to the spatial position of this settlement, which is situated in the Zapadna Morava valley and rounded by mountains of Kotlenik, Jelica, Čemerno, Kopaonik, Požar Jastrebac, Ozren, Rtanj, Kučaj, Juhor and Gledići. More to the North is situated Rudnik Mt. where, along the line Prljuša-Mali Šturac, many traces of copper and quartz exploitation from the Iron Age are documented (Jovanović, 1988, 5-12). Amphibolite implements containing a characteristic ore paragenesis have been found in the dugout No. 07. Considerable weight and well-polished surfaces of the amphibolite samples indicate that they most likely were brought as raw material for decorative objects. Generally, amphibolite is readily accompanied by quartz and it may be expected that at Blagotin quartz appeared due to the interest for different types of raw material and arrived there after subsequent organization of certain exploration campaigns.

"White stone of different origin" - this, unfortunately inadequate term, should denote artefacts made of silicified limestone, magnesite, porcelanite, tuff and diatomaceous earth (Antonović, 1988, 26)[3], at least if we speak about tools made by polishing (Antonović, 1997, 33-39, 1998, 24-28). Antonović pointed out that they predominantly correspond to silicified magnesite. Although magnesite should not be named a "light white stone", due to rather high density of 3 g/cm^3, the author suggested this term to be retained arguing that "....it has been far accepted in the literature.....". Bogosavljević-Petrović proposed the phrase "soft white stone" (Bogosavljević-Petrović, 1991, 5-36, 1998, 155-166). Once accepted, such formulations for a group of stones of various origin and different physical properties, among which neither light nor soft stone dominates, i.e. silicified magnesite, may produce a line of confusion and bewilderment that are later not easy to eradicate. In this study, though not entirely suitable, the term "white stone of different origin", mainly in order to mitigate the inconsistency, which emphasized even the authors who proposed the other two expressions are being used.

Raw material that is comprised by this study and that correspond to "white stone of different origin", occur, albeit very rarely, at the localities of Livade (Kalenić), Simića strana (Čučuge), Toplik (Malo Crniće), Šalitrena pećina (Brežđe), Popovića brdo (Zablaće) and Blagotin (Poljna). Based on thin section studies exclusively it may be concluded, although not unequivocally, that in most cases the raw material is silicified tuff, while there are some samples of silicified marl and wood (at Blagotin). Taking into account the type of activity that chipped stone artefacts were assigned to and assuming that tuff is less hard then chert, i.e. more liable to failures even in contact with weaker material, it seems surprising to have this raw material used for chipped artefacts. The possibility that chipped artefacts made of "white stone of different origin" are, in fact, by-products in processes of polishing, as it was the case at Divostin could not be excluded (Tringham et al., 1988, 202-253).

"White stone of different origin", like quartz, represent subsidiary raw material for making chipped stone artefacts. Such artefacts are represented by rare samples and usually they are non-retouched and low-quality flakes and blades. It is apparent that four localities (Popovića brdo, Simića strana, Šalitrena pećina and Livade) are situated in a narrow geographical area between the Sava river in the North, Drina in the West, Kolubara in the East and Ribnica in the South, whereas Blagotin and Toplik are located in central and East Serbia, on the banks of the Zapadna Morava and Mlava rivers, respectively. Toplik is dated as Proto-Starčevo, Livade, without close determination, as Starčevo, while for Popovića brdo, Simića strana, Šalitrena pećina and Blagotin the phase Starčevo II is suggested. Geographical position of all the places and appropriate periods of the last four localities could indicate the time and space of first usage of "white stone of different origin", which culminated during Early Neolithic in the frame of the Vinča Culture.

Obsidian is amorphous mass, i.e. volcanic glass that originates by quenching of lava during some volcanic eruptions. It can be often found as interstitial groundmass in some volcanic rocks (Tomkeieff, 1983). There are different volcanic glasses according to their chemical composition (especially water content) and textural/structural characteristics. On the basis of these criteria we may distinguish following varieties: obsidian, pitchstone, perlite and pumice (Đorđević et al., 1991). Obsidian and pitchstone cannot be distinguished by naked eyes observation, whereas perlite and pumice are easy to recognize due to their characteristic perlitic cracks and porous structure, respectively.

Obsidian is a volcanic glass with composition varying from rhyolite to andesite and with a water content up to 1 % (Huang, 1967, 148). Flat and shiny surfaces and conchoidal fracturing as well as grey, grey black and totally black colour are characteristic (Protić, 1984, 108). Sometimes finely dispersed hematite can give dark red or brown colour to obsidian (Huang, 1967, 147). This rock shows hardness of around 6.5 according to the Mohs' scale, hence traces of usage on obsidian surfaces are much easily formed then in case of cherts.

Examples of distribution of obsidian are very interesting especially if we regard this rock as specific raw material, which primary deposits are regionally located within narrow areas.

For central and Southeastern Europe the Tokaj-Prešov (Slovakia) district and Hedalya Mt. in Hungary are characteristic. There appears obsidian mainly in green and light green colour but grey, black, brown and rarely red obsidian may be found, too (Titov, 1980, 220). Occurrences of obsidian in Romania are also documented but they were regarded as not suitable for making chipped stone artefacts (Nandris, 1975, 71-94), whereas Williams and Nandris give evidence of primary deposits of obsidian in Northeast Hungary, in the area of Zemplen Mt. and in Southeast Slovakia (Williams and Nandris, 1977, 207-219)[4].

[3] In her thesis Antonović as raw material mentioned diatomaceous earth, which as a loose (unconsolidated) sedimentary rock could not have had any usable value. It is highly probable that the author was thinking of diatomite chert.

[4] This obsidian is also non suitable for making chipped stone artefacts but it is still important as an example of the primary occurrence that is today observable in the field.

According to the conclusions of Renfrew, mainly on the basis of etnoarchaeological investigations of recent primitive communities, the ware objects of obsidian probably acted as presents among friends and merchants and on the basis of reciprocity, what would exclude the existence of an open market (Renfrew, 1973). Renfrew and Bahn came to the same conclusion for distribution of Anatolian and Jermenian obsidian, distinguishing a supplying zone, which covers primary deposits in a circle of up to 320 km in diameter, and its contact zone (Renfrew and Bahn, 1991, 325-326). In such supplying zone inhabitants of some settlements alone provide themselves with raw material, while in the contact zone there is barter for given ware, without participation of specialized merchants. In the contact zone there is a regularity - the more distant settlement from the supplying zone, the smaller the number of obsidian artefacts.

Accepting this model, the Tokaj-Prešov district can be regarded as a supplying zone, whereas archaeological localities in the territory of Serbia would represent part of a contact zone. Unfortunately, incomplete study of the material found up to recently makes no clear picture about decreasing of the number of chipped obsidian artefacts with increasing the distance between an archaeological locality and supplying zone. Williams and Nandris argue that, during the field work in 1975 in the area of Zemplen Mt., in the great quantity of archaeological and geological material they did not find samples of green, red or red yellow obsidian (Williams and Nandris, 1977), which, on the other hand, were mentioned by Roska (Roska, 1925, 168-170 and Janšák, 1935). More recent investigation shows that obsidian from the Tokaj-Prešov district and Mt. Hedalya is mostly characterized by green and light green colour, and that it much rarely appears as grey, black, brown or red (Titov, 1980, 220). If all the obsidian from the archaeological localities in Serbia has its provenance from the supplying zone, and all the samples found are black or grey, it is a logical question why none green sample was found although this colour dominates in the territory of primary deposits or why any sample of brown or red colour does not exist?

Williams and Nandris (Williams and Nandris, 1977) reported findings of black obsidian with the largest dimensions of 3,3 cm from Hungary (Tolcsva) and 7,5 cm from Slovakia (Malá Toroňa), while Titov (Titov, 1980, 220) mentioned findings of obsidian cores as long as 15 cm from the locality of the Bükk culture in Hungary. Differences in these data inevitably show that the areas of primary occurrences of obsidian were not geologically studied, what subsequently causes further negative implications during archaeological research. Only a detail knowledge of primary deposits and thorough analyses of their samples will enable formation of control series that may help in interpretation of the provenance of obsidian artefacts from Neolithic localities of Southeast Europe, as well as from the Proto-Starčevo and Starčevo localities in Serbia. Before reaching this level of knowledge, the existence of primary deposits in the territory of Serbia has to be considered as possible, implying that all the obsidian in archaeological sense should not be interpreted as exclusively imported material. During the Tertiary the territory of Serbia was place of very strong volcanism, predominantly acid to intermediate in character and some of these activities were related to the formation of various types of volcanic glass (Cvetković, 1997). Local obsidian occurrences of presumed importance for exploitation in the Neolithic could have been rather small and mined out at that time and later on, during the last millenniums, and subsequently buried by Quaternary sediments and therefore inaccessible and unknown. The finds of a black obsidian pebble in the valley of the Onjeg potok on the northern slopes of Rudnik Mt. argue in favour of this hypothesis (Jež, 1998)[5].

Obsidian is raw material without much importance for making chipped stone artefacts in Early and Middle Neolithic in the territory of Serbia. Only quartz is less abundant than obsidian. The earliest appearances are related to Lepenski Vir and Toplik, both dated as Proto-Starčevo and Blagotin that is considered to be Proto-Starčevo II. All other finds correspond to the Starčevo phases II and III, whereas the artefacts from Donja Branjevina, Golokut and Stari Vinogradi, with a great probability, can be regarded as imported material. For all other localities the problem of provenance of obsidian remains an open question.

Given the data from the Explanatory Sheets of the Basic Geological Map SFRY 1:100.000 the following regions may be distinguished as potential primary deposits of volcanic glass: Timok Eruptive Complex (Bogdanović and Rakić, 1980), Turonian-Senonian volcanics in the close Bor area (Kalenić et al., 1976), volcaniclastic rocks in the Ibar valley (Urošević et al., 1973), Tertiary lacustrine basin Čačak-Kraljevo (Marković et al., 1968) and volcanic area Barajevo-Ripanj (Filipović and Rodin, 1980). The appearances of obsidian pebbles in the Onjeg potok, on the Northern slopes of Rudnik Mt., and occurrences of hyaloclastic rocks with obsidian within the Borač Eruptive Complex (Cvetković, 1997) should be emphasized.

Conclusion

This level of knowledge compels that many possible conclusions have to remain in a hypothetical sphere. They are mostly controlled by number of investigated archaeological localities, quantity of found chipped stone artefacts, extent of technical documentation about excavations, number and type of undertaken petrological analyses, but also by inconsistencies in using of specific terms and by inadequately argumented hypothesis that can be later traced from author to author.

[5] Although the mention of obsidian pebbles is lacking in the paper, I was personally told about the finds by Jež who had previously been informed by Ing. Geol. Čitaković.

Slovak Geol. Mag., 10, 1-2(2004), 65-72

Locating of potential primary deposits of raw material used in manufacturing of chipped artefacts may and should be a basis for a detailed field prospection in cooperation with experts in geology. With respect to real hypotheses about the local origin for at least a part of used obsidian and so called "Balkan flint" the acquired results could be very interesting and indicative. They may provide a partial correction of nowadays opinions about the processes and directions of communication among representatives of the Neolithic culture in the territory of Serbia.

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A General Review of the Neolithic in the Old Continent. A Review of the Raw Materials Used: Regional Aspects. Poland

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Abstract: The paper emphasizes that the rock material used in the Neolithic has not been properly studied yet, and that most authors discuss flint tools as a category separate from those made of non-silicic rock; only in very few monographs are the two types of finds approached as a single group. While there is already a substantial literature on the subject of the usage of rock material in the Neolithic, further investigations would be in order. The research project summarized in the paper has established that non-silicic rock was imported from distant locations (up to 700 km away from the sites of certain finds), although it was of mediocre practical value, and that local postglacial stone was the most common type of material throughout the territory of Poland, and particularly in the lowland areas: postglacial erratic boulders were preferred in the Lowlands of Poland, and weathering formations encountered at the outcrops of rock, in the mountains and highlands.

Key words: rock material, silic rock, Polish Lowland, Neolithic

In terms of geology and geography, the most important natural conditions affecting the development of human settlements in the territory of Poland during the Neolithic, and indirectly also the prospecting for, excavation, cutting, transportation and use of rock, included:

1. The arrangement of the morphological areas in transverse stripes, closed up by the barrier of the mountains in the south;
2. Varied geological characteristics, determined by geomorphological features (mountains, highlands and superglacial plains);
3. The considerable size of the Polish territory along the North-South" axis, amounting to 650 km and resulting in a diversity of the climate.

Human settlements appeared principally in highlands and at the foot of the mountains, or in the southern areas of Poland; due to this fact, as well as to the perseverance of the customs of the Paleolithic period, the rock material quarried and used during the Neolithic was mainly flint and other types of silicic rock, including hornstone, radiolarite, jasper, obsidian, quartzite etc., all of them fairly hard, cleavable and homogeneous, and quite easy to cut.

Because of the warming of the climate and other reasons, humans subsequently migrated to the north, into typical superglacial lowland areas, where rock is hardly available in situ, but loose postglacial material abounds; accordingly, the people of that time adapted to the new circumstances by learning to collect erratic boulders.

The postglacial erratic boulders were seldom made of flint, or the type of rock which humans had known and preferred previously; therefore Neolithic people attempted to identify flint among the local material, imported it from the south (mainly from the Holy Cross Mountains), or tried to replace it with other material, and principally with crystalline magmatic and metamorphic rock.

The Usage of Flint Material

The matter of the usage of silicic rock in the territory of Poland during the Neolithic has already been discussed in detail, particularly by Balcer (1983), Lech (1983), Ginter & Kozlowski (1990) and Kruk & Milisauskas (1999).

The subject of the excavation of flint has been investigated the most extensively in the Holy Cross Mountains, where two areas of quarrying have been identified: the northern area of the range of the Lysogory, extending at a length of 30 km, with deposits of chocolate flint, and the eastern area of the range of the Lysogory, extending at a length of 25 km, with outcrops of striped, Ozarow and Swieciechow flint. Striped and Swieciechow flint were the most commonly used materials in the Neolithic. Balcer (1983) also mentions the highlands of the Jura of Krakow and Czestochowa, the region of Glubczyce, and Western Pomerania including the region of the Lower Warta (Fig. 1).

A petrological and geological classification of flint related to the various archeological classifications is a complex subject requiring a separate monograph. For the purposes of the present paper, we will merely list after Cyrek (1983), the types of flint known from the basins of the Vistula and the upper Warta:

1. Baltic flint: Cretaceous, easily available;
2. north-eastern flint: Cretaceous;
3. Mielnik flint: Cretaceous, exposed in the terraces of the central Bug;

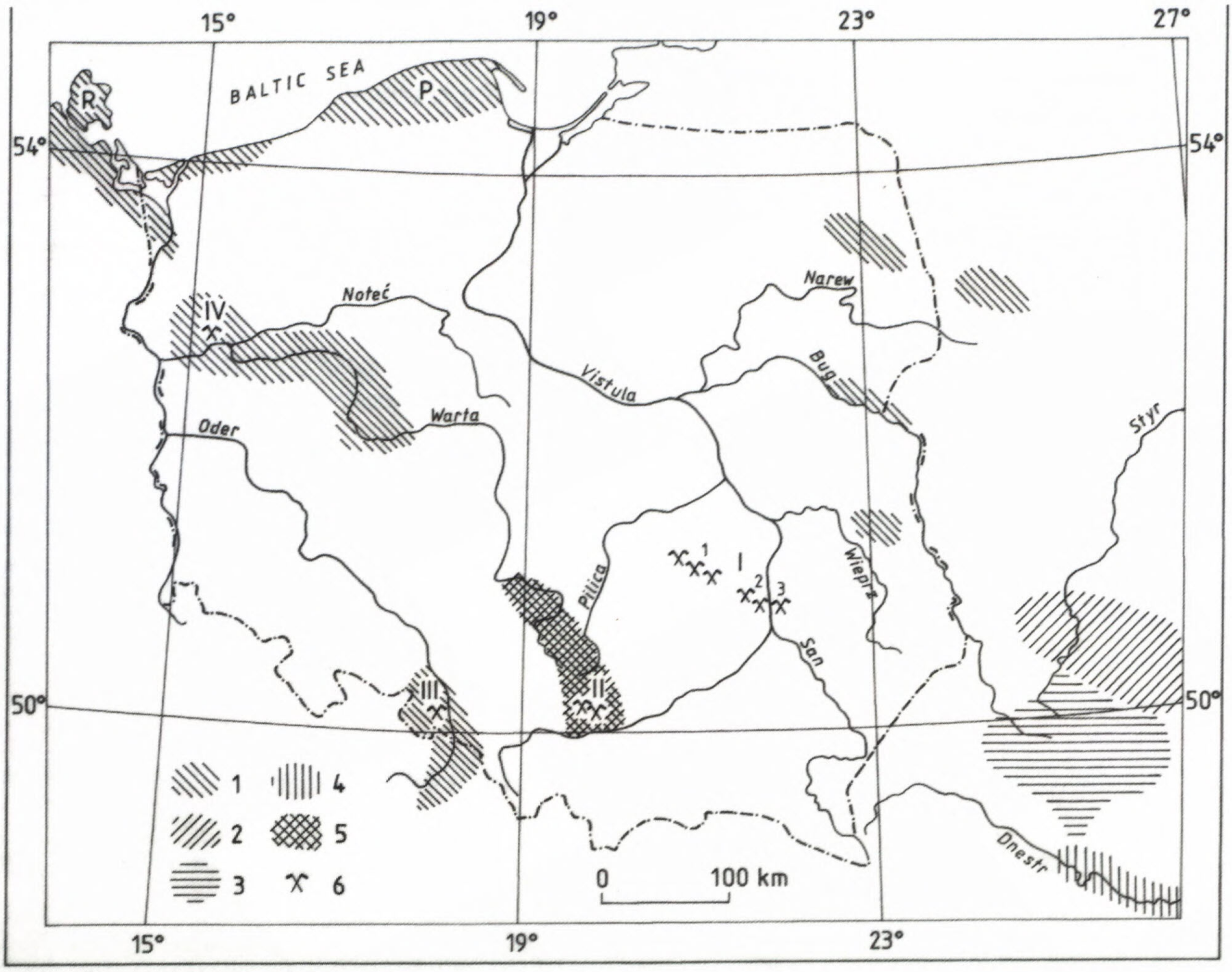

Fig. 1. The locations of the principal deposits and areas of the excavation of the flint used in the territory of Poland in the Neolithic (after Balcer, 1983, p. 46). 1. Baltic flint: R: Rugen, P: Pomeranian; 2. Volhynian flint; 3. Podolian flint; 4. Dnestr flint; 5. Jurassic flint; 6. areas of excavation: I. the Holy Cross Mountains: 1. the northern Lysogory, Lysogory flint, 2. the eastern Lysogory, striped flint, 3. Sieciechow; II. the Jurassic region (the Jura of Krakow and Czestochowa); III. the region of Glubczyce; IV. the Warta.

4. Volhynian flint: Cretaceous, of great value for human applications;
5. Pomeranian flint: Cretaceous, honey-colored;
6. Swieciechow flint: in the Holy Cross Mountains;
7. chocolate flint: in the Holy Cross Mountains;
8. other types of Jurassic flint.

Other types of silicic rock were used as well, including hornstone, obsidian, radiolarite etc.

In Lech's view (1983), Jurassic and Cretaceous flint, which was of primary importance for the Neolithic human communities, was quarried from three types of deposits:

1. Jurassic parent limestone, e.g. in Krzemionki;
2. Tertiary rock-weathering formations of Jurassic limestone and Cretaceous marl, e.g. in Swieciechow;
3. Quaternary till, sand and postglacial gravel, e.g. in the regions of Gorzow Wielkopolski and Poznan-Staroleka.

Lech (1983) emphasizes that excavation was conducted mainly from rock-weathering formations, at the outcrops. Such sites were preferred not only because of the good quality of the material, but also because of its availability.

According to Ginter & Kozlowski (1990), the criteria of the classification of flint must include its age, which may determine its appearance and physical characteristics, as well as the size of the concretions. A possible reconstruction of the age of the quarried flint is outlined in Table 1 (Ginter & Kozlowski, 1990, p. 18). The authors remark that their list does not include many type of rock, e.g. the radiolarite from the mountain ranges of the Tatra, the Holy Cross and the Pieniny.

Less significant material from the territory of the neighboring states includes the Senonian flint of Rugen, the deposits of Turonian flint from the upper Dnestr and Prut, and the hornstone and quartzite of middle and northern Moravia (Fig. 2).

The distribution of the various types of flint is probably the most relevant indicative of their importance and practical value. Chocolate flint is encountered in an area of the radius of app. 450 km, in the archeological

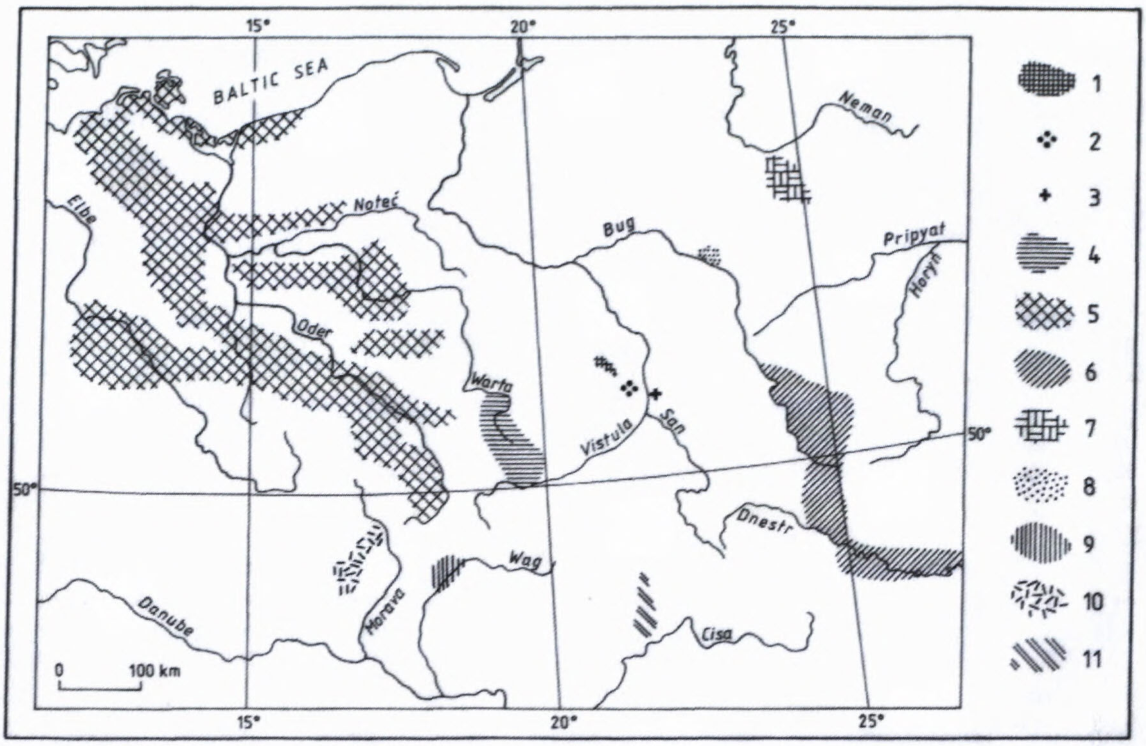

Fig. 2. The principal types of silicic rock (after Ginter & Kozlowski, 1990, p. 29, somehow simplified). 1. chocolate flint; 2. striped flint; 3. Swieciechow flint; 4. Jurassic flint; 5. Baltic flint; 6. Volhynian and Dnestr flint; 7. flint from the river Ros; 8. Mielnik flint; 9. radiolarite; 10. Moravian quartzite and hornstone; 11. obsidian; 1-4. The areas of the excavation of: 1. Jurassic and Krakow flint; 2. chocolate flint; 3. Volhynian flint 4. Dnestr flint; I-IX. regions of settlement: I. Krakow; II. Rzeszow and Przemysl; III. Zamosc; IV. Sandomierz; V. West Lublin; VI. Kuiavian; VII. Glubczyce; VIII. Lower Silesia; IX. Pyrzyce. The arrows mark the routes of transportation.

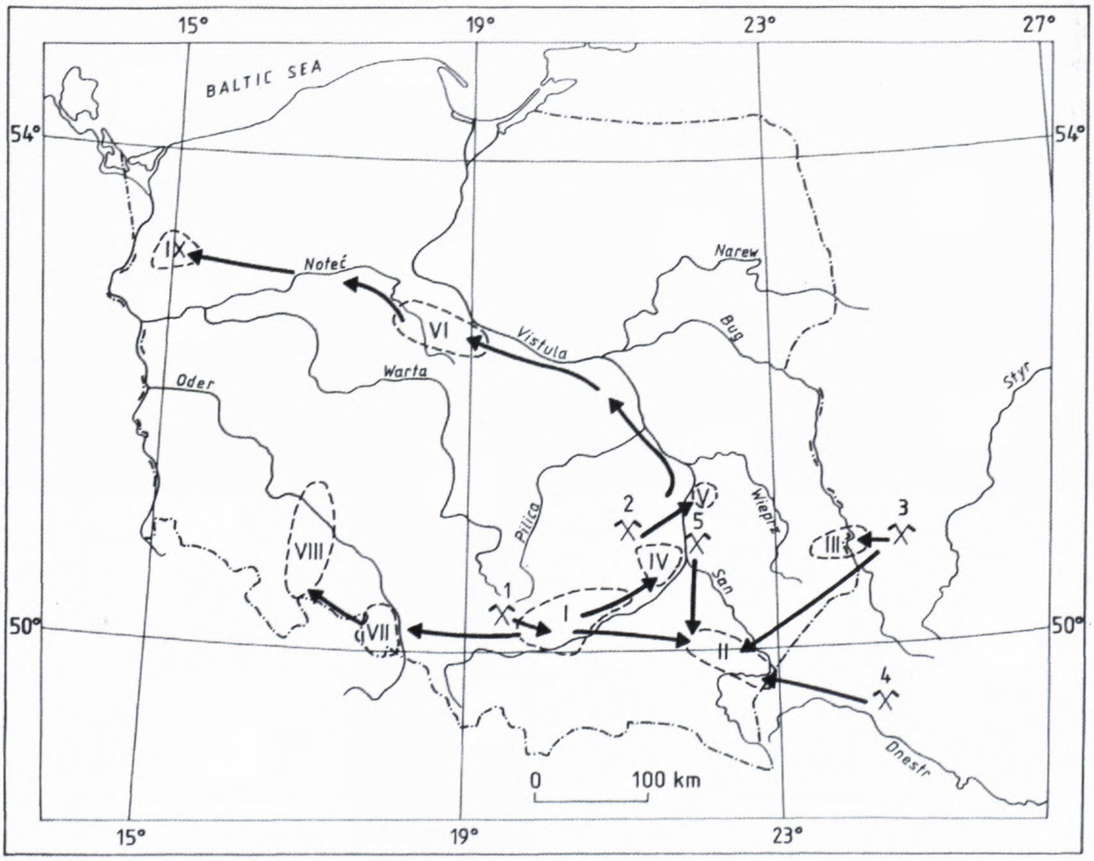

Fig. 3. The principal routes of the transportation of flint in the territory of Poland at the time of the BPC (after Balcer, 1983, p. 78).

sites of the Band Pottery culture (BPC, Fig. 3). The area of the occurrence of Jurassic, Volhynian and Dnestr flint and of obsidian is much smaller, enclosed within a radius of a mere 250 km. The artifacts of the communities of the Funnel Beaker culture (FBC) made of Volhynian flint have been encountered 600 km away from the outcrops of the rock, and made of Swieciechow flint, 570 km away from the deposits. Objects ascribed to the Globular Amphorae culture (GAC) appear 500 km away from the deposits; interestingly, the number of the sites featuring tools made of this material does not decrease with the distance from its source. Conversely, products of the Corded Ware culture (CWC) made of Swieciechow flint have been found only within the radius of 150 km. The geographical distance of the material from the original quarries diminished even further in the early Bronze Age.

Balcer (1983) states that in the 1st stage of the early Neolithic, stone cutters depended largely on local material, and long-distance trade in rock was of minor economic importance. As specialization developed in the 2nd stage, the expansion of trade may have been caused by an increase in the plant production. Finally, the exchange of flint material decreased again in the 3rd stage.

Obviously, flint cutting was only one of the many aspects of the archeological culture of the Neolithic, and accordingly any studies of the use of this material must take the broad context of this period of the prehistory. Investigations of the use of flint in the Neolithic confirm that southern and south-eastern influences were profound at that time, and particularly in the BPC, the FBC, the Striped Pottery culture (SPC) and the CWC.

Kruk & Milisauskas (1999, p. 157) offer interesting insights into the use and exchange of flint material, in particular in the FBC settlement in Bronocice, located at a distance of 25-60 km from the nearest areas of the excavation of Jurassic flint, and of more than 270 km from the farthest ones on the Bug. The same authors establish that the importation of flint object in the periods 2900-2500 BC and 3640-3060 BC was not higher than, respectively, 15 and 47 items, which amounts to one imported artifact per, respectively, 13 and 11 persons. These tentative estimates are illustrative of the scope and extent of the developments under discussion.

The migration of the Neolithic human settlements into the lowlands took place at a time of significant technological and ecological breakthroughs and of a major expansion of the agricultural economy. This process took place in numerous areas in an independent manner. A symptom of it is the increasing share of non-silicic rock material in the production of stone artifacts.

In the Lowlands of Poland, very distant from the mountains and the highlands, there was a certain demand for imported flint and silicic rock of uniform visual and physical properties. With time, the predominant rock material used for the making of tools became postglacial pieces of rock and boulders of varying petrographical composition, accidental shapes and sizes, and diversified physical and technical characteristics, colors, luster and frequency of appearance.

The usage of non-silicic rock material in the Lowlands of Poland during the Neolithic has been studied in detail in Great Poland and Kuiavia under a long-term project of petrographical research.

The Usage of Non-Silicic Rock Material during the Neolithic

The results of the studies of the usage of non-silicic rock material in mid-western Poland during the Neolithic were already published on several occasions (Prinke & Skoczylas, 1978, 1979, 1980, 1986). A complete catalog of the material used for the making of tools in this part of the country has been compiled, covering both the entire period of the Neolithic and the individual chronological-and-cultural groups. This is a list of 109 types of rock, including 25 most frequent ones. The essential material used for the making of axes, hammers, adzes, hoes, chisels and clubs was crystalline rock, e.g. amphibolite, basalt, diabase, gabbro and gneiss.

We now proceed to discuss the results of a study of non-silicic Neolithic tools from the Kuiavian settlement-and-cultural mesoregion. The chronological scope of the study are the periods of middle- and late-Neolithic groups of the Funnel Beaker culture (FBC) and of the Globular Amphorae culture (GAC) in the late Neolithic and at the end of that age, or between app. 4000 BC and 2350 BC (Chachlikowski, 1997; Chachlikowski & Skoczylas, 2001 a, b, c).

In the late Neolithic, the people of Kuiavia used a wide assortment of rock material for their stonecutting activity, selecting the types suitable for the specific final products. Twenty-one essential types of rock in many varieties have been identified as used by these communities.

The populations in question showed a marked preference for quartzitic sandstone and quartzite, as well as for gneiss and granitoid rock. Other types of rock were of much less importance. While the choice of stone material had become very standardized among the communities of the FBC and GAC, their artifacts differ considerably both in terms of their sizes and of the usage of the various types of non-silicic rock.

The available material proves that the communities of the FBC used quartzitic sandstone as their most common material; it accounts for 37.74% of the corpus of archeological finds. Quartzitic sandstone and the various types of quartzite provided the material for almost a half (46.24%) of all non-silicic artifacts of the late Neolithic in Kuiavia (Table 2). While gneiss was less popular, almost every fourth stone item (23.36%) was made of this material. About one eighth (13.21%) of the corpus of archeological finds are objects made of granite. A small percentage (3.85%) of the tools of the FBC were produced of amphibolite. Table 2 breaks down the rock material used by the communities of the FBC and the GAC.

Table 1

The Mesozoic			Type of flint
Period	**Epoch**	**Floor**	
Cretaceous	Upper	Senonian	Cretaceous Baltic flint
		Turonian	Volhynian flint Gray white-spotted (Swieciechow) flint
	Lower		
Jurassic	Upper	Kimmeridgian	Lysogory "chocolate" flint
		Lower Astartian	Krzemionki striped flint
		Rauracian	Various types of "Jurassic" flint from the limestone of the Jura of Krakow and Czestochowa
		Oxford	
	Middle	Dogger	Flint and hornstone at the western edge of the Jura of Krakow and Czestochowa
	Lower		
Triassic	Upper		
	Middle	*Muschelkalk*	Flint in the dolomite beds of the Silesian Highland
	Lower		

Table 2. The breakdown of the material of Neolithic rock artifacts

	Rock	FBC		GAC		Total	
		Number	%	Number	%	Number	%
1.	Amphibolite	67	3.85	15	2.19	82	3.40
2.	Aplite	–	–	1	0.15	1	0.04
3.	Basalt	30	1.72	4	0.59	34	1.40
4.	Biotite gneiss	76	4.37	17	2.48	93	3.83
5.	Diabase	20	1.15	9	1.31	29	1.20
6.	Diorite	28	1.61	9	1.31	37	1.50
7.	Gabbro	54	3.10	16	2.34	70	2.90
8.	Gneiss	348	19.99	196	28.61	544	22.36
9.	Granite	230	13.21	90	13.14	320	13.20
10.	Mudstone	20	1.15	–	–	20	0.82
11.	Pegmatite	16	0.92	18	2.63	34	1.44
12.	Porphyry	18	1.04	12	1.75	30	1.23
13.	Quartzite	148	8.50	85	12.91	233	9.60
14.	Quartzitic sandstone	657	37.74	172	25.11	829	34.17
15.	Schist	7	0.40	7	1.02	14	0.57
16.	Syenite	–	–	34	4.96	34	1.44
17.	Other	22	1.25	–	–	22	0.90
	Total	1741	100.00	685	100.00	2426	100.00

Slovak Geol. Mag., 10, 1-2(2004), 73-80

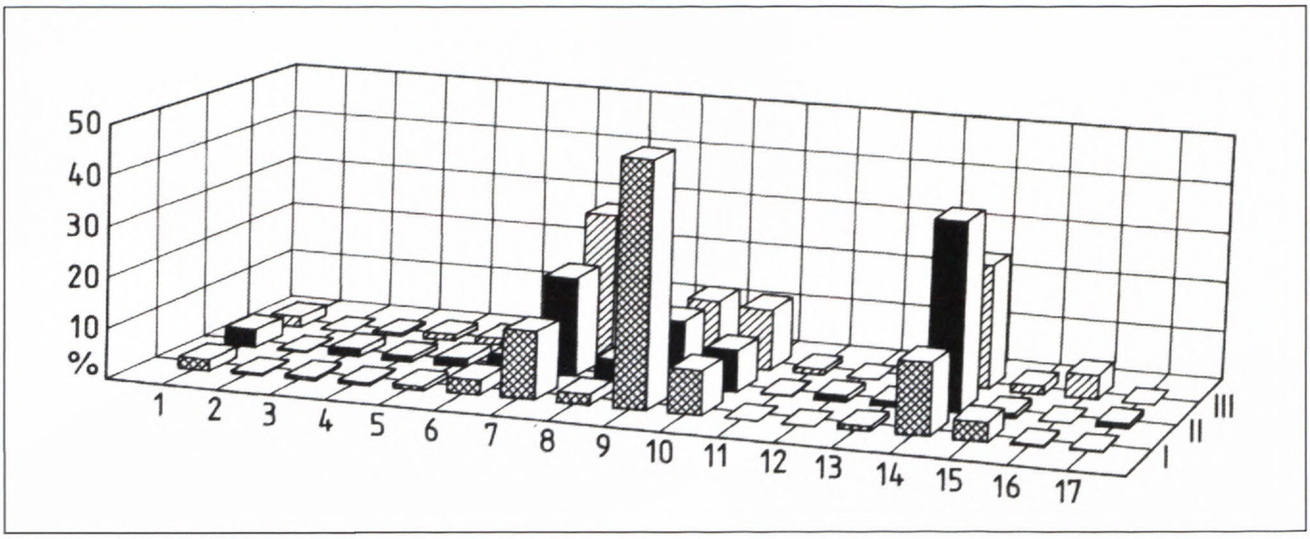

Fig. 4. A comparison of the breakdown of the material of erratic boulders and of the Neolithic stone tools of the FBC and the GAC from Kuiavia (Chachlikowski, 1997). I. the breakdown of the material of erratic boulders; II. the breakdown of the material of the stone tools of the FBC; III. the breakdown of the material of the stone tools of the GAC; rock: 1. amphibolite; 2. aplite; 3. basalt; 4. diabase; 5. diorite; 6. gabbro; 7. gneiss; 8. biotite gneiss; 9. granite; 10. quartzite; 11. crystalline schist; 12. mudstone; 13. pegmatite; 14. quartzitic sandstone; 15. porphyry; 16. syenite; 17. other.

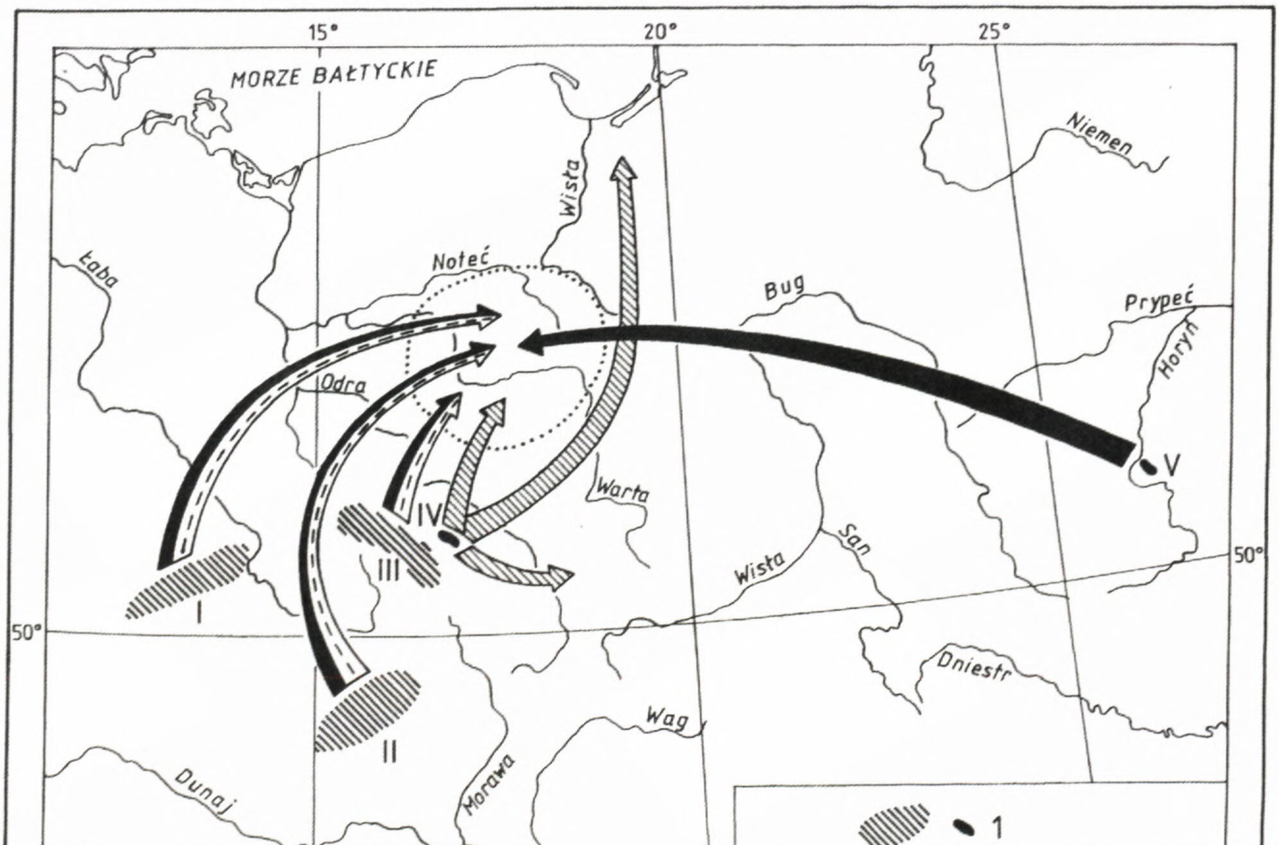

Fig. 5. The routes of the transportation of non-silicic rock into north-western Poland in the Neolithic. 1. outcrops and other areas of the occurrence of the imported rock; 2. the routes of the transportation of serpentinite and jade; 3. the routes of the transportation of basalt and amphibolite; 4. the routes of the transportation of non-olivine basalt; I. northern Bohemia; II. Moravia; III. western Sudetes (the Kaczawa Mountains); IV. the Gogolow-Jordanow massif; V. basalt quarries in Volhynia (Berestovec, Janova Dolina etc.)

Similar tendencies are observed in the corpus of the artifacts of the GAC, where quartzitic sandstone is again the predominant material, although it was used less frequently (25.11%); combined with quartzite (12.91%), it accounts for 38.02% of the entire rock material of this culture identified by archeological studies. The share of gneiss (31.09%) was visibly larger. Granitoid rock provided the material for app. 13.11% of the rock products of the GAC, which figure is very similar to that for the FBC.

A most general account of the usage of rock material in Kuiavia in the late Neolithic emphasizes the decided preference for quartzitic sandstone and quartzite, which provided some 43.77% of the total rock material in the corpus of archeological finds from that area and period. Tools and weapons were also fairly commonly made of gneiss, which constitutes the material of 36.19% of the finds. The third most popular type of stone was granitoid rock, accounting for 13.2% of the total number of finds (Table 2).

The four essential types of rock (quartzitic sandstone, quartzite, gneiss and granite) provided the material of app. 93.16% of the total number of late-Neolithic stone artifacts in Kuiavia.

Incidentally, the stonecutters of the FBC used andesite and mudstone, too, while a conspicuous amount of chipped-off syenite is noticed in the archeological finds of the GAC; the latter rock was hardly used by the communities of the FBC. The people of the FBC were also much more interested in basalt, biotite gneiss and quartzitic sandstone as the material of their tools, that those of the GAC. Conversely, the cultural layers of the communities of the GAC contain significant quantities of gneiss, quartzite, schist and pegmatite, which are less noticeable in the sources from the time of the FBC.

The increasing share of cut quartzite sandstone in the settlements of the FBC was obviously accompanied by a decline in the use of gneiss. The GAC showed the opposite tendency, for superseding quartzitic sandstone with gneiss, quartzite, and particularly syenite.

It is also known what tools the studied communities made of the various types of rock. The principal classes of tools which both cultures produced of quartzitic sandstone, gneiss and quartzite (although in various numbers), were querns and polishing plates (the latter made exclusively of quartzitic sandstone and quartzite). Among the cutting tools, the FBC preferred basalt and biotite gneiss as the material for its axes, and the GAC used diabase, diorite and schist for this purpose, and additionally amphibolite to produce adzes.

The quantitative usage of the less popular types of stone, including gabbro, granite, diabase, diorite and porphyry, was very similar in both the FBC and the GAC.

Having determined the categories of the stone artifacts made in certain areas of Poland, we will now attempt to establish from where that rock material came, how it was prospected for, identified and excavated.

The Neolithic people of the Mid-European Lowlands supplied themselves with rock material from at least three sources:

1. erratic boulders brought by the continental ice sheet: these abounded throughout the Lowlands of Poland, and appeared in more concentrated deposits in moraine formations and in river valleys;
2. areas south of the lowlands, mainly at the foot of mountains and in the mountains of southern Poland, south-eastern Germany, Bohemia and western Ukraine;
3. a few types of rock encountered in the direct deposits in the lowlands: Poznan silicified variegated clay, mudstone and Tertiary quartzitic sandstone.

A simple comparison of the material of the Neolithic stone tools from Kuiavia with the erratic boulders encountered in this area suffices to establish that the populations in question preferred local postglacial rock.

Because of the geological conditions in Kuiavia, local erratic boulders, found in postglacial deposits, constituted the essential source of non-silicic rock used by the prehistoric stonecutters. This was the most common material of all types of stone artifacts, both in the FBC and in the GAC.

The two cultures used the easily available local postglacial material to make such essential household tools as grindstones and querns, polishing plates, hammerstones or polishers. The material provided by the Kuiavian erratic boulders included quartzitic sandstone, gneiss, granite and quartzite. The most common types of erratic boulders were made of granite, accounting for almost 49% of the corpus of the studied rock material, or nearly four times more than its share among the rock artifacts (13.2%). Less popular materials were quartzitic sandstone, gneiss and quartzite, represented in the corpora of rock products of the two cultures in higher amounts than among erratic boulders (Fig. 4).

When making tools and weapons more specific of their cultures (typically with a blade or a point), the people of the communities in question showed a marked preference for gneiss, but also used amphibolite, basalt, diabase, diorite, gabbro and schist, mainly supplied by erratic boulders. A petrographical study of both the erratic boulders of Kuiavia and the late-Neolithic stone artifacts of this region suggests that the available rock material from erratic boulders were more than sufficient for stonecutting activity, in terms of both the amounts and the quality.

While the erratic boulders of Kuiavia are seldom made of diabase, basalt, diorite or crystalline schist, this rock material appears fairly frequently in the corpora of the artifacts of the FBC and the GAC. The stonecutters of the FBC were particularly fond of these types of rock. Thus, the small content of erratic boulders made of basalt, diabase, diorite, schist and syenite in the overall composition of ice pavement, e.g. in Goszczewo, may be construed as due to either the low percentage of such types of rock among the erratic boulders of Kuiavia in general, or possibly the peculiarity of the area from which the more than 1500 erratic boulders have been collected for the petrographical study.

The FBC and GAC communities in Kuiavia probably attempted to replace certain types of rock which they imported from the south, with their local substitutes. We emphasize that imported rock used the most commonly in the early- and mid-Neolithic Kuiavian settlements belonging to the Danubian cultures, included-beside amphibolite - basalt, serpentinite, jade and crystalline schist (Chachlikowski, 1997; Majerowicz, Prinke & Skoczylas, 1981, 1987; Prinke & Skoczylas, 1978, 1979, 1980). In turn, the late-Neolithic communities of the same region managed to identify stone of high quality in the local postglacial material. Thence, their demand for and use of imported stone was apparently a result of religious rather than technical or economic considerations.

Certain material which was encountered locally, e.g. mudstone, most probably did not appear in erratic boulders.

The above conclusion challenges the traditional view that some types of rock were imported from distant locations. In fact, the discussed data indicate that the extent of the importation from the south decreased with time during the Neolithic, as the nature of stonecutting activity evolved, and customs and the economic necessity of the importation of suitable rock material were replaced by experience and a growing awareness of the potential of the local deposits of rock, which could easily substitute the material brought from other areas.

While basalt has been identified in 314 locations in Lower Silesia, microscopic studies suggest that the basalt used for making tools in the Lowlands of Poland was excavated in the area of Luban Slaski, and particularly at the quarry in Lesna. A few tools have been found, produced of non-olivine basalt which apparently comes from Volhynia (Berestovec and Janova Dolina). The material of the equally scarce items made of serpentinite probably originates from the Gogolow-Jordanow massif, and more specifically from the areas of the heights of Winna Gora and the heights of Naslawice and Tomice, as petrographical and archeological studies have established: Sites of prehistoric excavation of serpentinite have been identified on the slopes of Janska Gora (Wojciechowski, 1988).

Jade, in turn, was quarried near Jordanow (Skoczylas et al., 1992, 2000; Foltyn et al., 2000; Fig. 5). It has been suggested that certain tools discovered in Great Poland, were made of amphibolite and diabase brought from the Kaczawa Mountains.

Quartzitic sandstone, quartzite, gneiss and granite from erratic boulders account for 93,16% of the material used by the stonecutters in the late-Neolithic communities of Kuiavia, while erratic boulders themselves constituted up to 99% of the available rock material. Nevertheless, it has been evidenced that non-olivine basalt was imported from Volhynia to Great Poland (over a distance of 600-700 km as the crow flies), and that the people of Kuiavia also acquired foreign Sudetes basalt (200-300 km), serpentinite and jade (100-400 km), and amphibolite from the Kaczawa Mountains (200-300 km). Certain tools made of basalt, diabase and amphibolite might have been produced of material imported from the territory of Slovakia and Moravia (Fig. 5).

Contrary to the general opinion, stone was seldom excavated in the proper sense of the term, or by being chipped off a face of solid rock; much more often loose blocks and pieces of rock were picked up near outcrops. Large and unweathered blocks of rock had as much practical value as pieces excavated in situ from a face (Kulczycka-Leciejowiczowa, 2002).

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Slovak Geol. Mag., 10, 1-2(2004), 81-95

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Volcanic rocks as possible raw material for Neolithic stone artefacts in Europe - an overview

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Abstract: Volcanites are used everywhere as raw material for polished stone tools but they are less common and less widely distributed than eclogite in Western Europe and greenschist in Central and East-Central Europe. Typically they covered smaller distances from the sources with the exception of places with no suitable local materials. Volcanites occur at several localities within Europe and the quality of the rock is fairly even.

For the production of polished stone tools (axes s.l.), basalt was used in most cases because it has no large phenocrysts and the matrix is only sligtly glassy. Fine grained dyke rocks (in the first place, dolerite) were also suitable for the production of polished stone tools Andesite, dacite and sometimes rhyolite was used less frequently for this purpose and only some local fine grained varieties occurred in significant quantities among the polished stone tools. Coarse grained andesite and volcanites containing essential amount of glass were used more for other stone utensils, typically for grinders and polishers.

The level of petroarchaeological elaboration of stone tools made of volcanites is fairly uneven, complex and adequate in some countries while sporadic in some others. At the same, though essential effort was devoted to collecting the available literature, it is still not complete: there can be essential gaps in our knowledge

Introduction and definition

Volcanic rocks are important and widely used raw materials for polished stone tools in the Neolithic/Aeneolithic (and later) period. Due to their wide geological distribution in the Old Continent, polished stone tools made of volcanite occur almost all cultures and regions. Unfortunately, the state of archaeometrical research and publishing is not of the same level in the individual countries. Due to the very active participation of the Central European countries in the IGCP-442 project the archaeometrical studies and reports on stone tools made of these rock types are better represented than publications of the western European countries.

Volcanism produce two important classes of material, lava and pyroclastic rocks. From the archaeometric point of view the lava rocks are more widely used and therefore more important than volcaniclastics, at least for the study of polished stone tools. Lavas formed by the eruption of molten silicate material, so called magma, that flows out of a vent or fissure over the surface and solidified to form crystalline, partly glassy and sometimes completely glassy rock. Pyroclastic rocks produced during explosive types of eruption and therefore they are composed of fragmental materials mainly. Material of lava flows may have a relatively uniform composition but pyroclastic rocks are more heterogenous. The less silicic, less viscous magma, from which basic igneous rocks crystallize more often erupts as lavas, while the acidic rocks tend to favour the pyroclastic mode of eruption.

Many lavas and pyroclastic rocks have a porphyritic texture, in which large crystals (phenocrysts or porphyres) are set in a fine grained or partly/completely glassy groundmass (matrix). The amount of glassy material depends on the composition of the magma. The more acidic is the composition of the magma, the more glassy the forming volcanic rocks will be and by the increasing rate (speed) of cooling, the more fine-grained or glassy groundmass is formed.

During the textural analysis of the volcanic rocks, by petrographic microscopic analysis, the determination of the mineral constitution of the rocks is also possible, having very important consequences on the classification and nomenclature of these rocks.

The main mineral constituents we may divide into two groups, felsic and mafic minerals. Quartz, feldspars (K-feldspar and plagioclase) and feldspathoids (nepheline, leucite, sodalite group and analcime) belong to the first group. The mafic minerals are olivine, pyroxene, amphibole and biotite. Beside the essential mineral constituents volcanites contain accessories in small amounts, the most important ones are opaque minerals (magnetite, ilmenite) as well as apatite, zircon and tourmaline.

The products of volcanic activity can be varied in mineral and chemical composition in some cases even within one volcanic complex. The chemical composition (main-, trace and REE elements moreover isotopic composition) gave further, more precise information than those based only on microscopic studies and about the forms and origin of the given volcanic rocks. Important main chemical variables are SiO_2, Al_2O_3, FeO^t, MgO, CaO, Na_2O, K_2O and in addition minor constituents as H_2O, TiO_2, MnO and P_2O_5. Beside the main- and minor constituents there are very important the trace and REE elements moreover isotopic composition of given elements which help us to determinate more precise the origin of the raw material of the stone artefacts. The chemical variations are expressed in the mineral composition with the chemical composition of the common rock-forming minerals enabling certain generalization to be made about the mineralogy of different rock types. We can distinguish the following four main types of volcanic rocks.

1. The more alkaline rich (Na_2O+K_2O) rocks contain first of all significant amount of K-feldspar (sanidine), feldspathoids and/or Na-rich plagioclase. Also the mafic minerals are predominantly alkaline rich (alkaline rhyolite and alkaline trachyte). These rocks however were not found in archaeological context as yet. The alkaline rocks with high SiO_2 content comprise quartz, while if there is relatively low SiO_2 present feldspathoids instead of quartz. In the latter case the most common rock types are tephrite, basanite and phonolite.

2. If the SiO_2 content is higher than 65%, and the rocks contain less alkaline components, quartz is present in the rock (acidic rocks, rhyolite and dacite). The predominant mafic contituents are biotite and sometimes amphibole. In some types the amourphous non-crystalline part (glass content) is very high or the rock can be composed of glass almost completely (e.g. obsidian).

3. The term "intermediate volcanic rock" is used if the SiO_2 content is between 52-65%. The most widespread and common volcanic rock type belonging to this group is andesite. The amount of trachyte and latite significantly less. This group characterize by feldspar phenocrysts (neutral plagioclase in andesite, sanidine or albite in trachyte and both in latite). The mafic minerals present may be amphibole, biotite and pyroxene.

4. In the mafic rock types both the SiO_2 and alkalines are low. The most representative rock type is basalt. The ferromagnesian minerals pyroxene and in most case olivine are important and frequently appear in this rock as phenocryst. Plagioclase generally remains in the groundmass. Rocks, containing more alkaline components are named alkaline basalt.

The Systematics of Igneous Rocks Subcomission of the International Union of Geological Sciences (IUGS) has made a recommendation in order to make the exact nomenclature of all igneous rocks consistent, including the volcanites on the basis of modal (mineral) composition (Streckeisen, 1976; 1979; Le Maître, 1989) (Fig.1.). The other used classification of volcanic rocks based on their normative (chemical) composition (Total Alkali Silica, TAS diagram Le Bas et al., 1986, Le Maître 1989) (Fig.2.).

Volcanic rocks have been formed widely throughout the geological time. Among all of the volcanic rocks, basalts, andesites and rhyolites (+dacites) are the most common rock types. Basalts are the most abundant type among the volcanites, and are found in different geological environments (mid ocean-ridges, island arcs, oceanic islands, cordillerran arcs, and continental rifts). Andesites are also common but not so much as basalts. They are formed along destructive plate margins, both in cordillerran arcs and island arcs. The amounts of rhyolites (and dacites) are less than basalts and andesites but they are widespread in many igneous environments like destructive plate margins, and rare in oceanic islands, in mid-oceanic ridges and in continental rift territories. Obsidian is the most important glassy varietite of rhyolites in archaeometrical point of view. Further volcanic rock types often used as raw material include trachyte, particularly those associated with basalt (alkali basalt) provinences. Tephrite and phonolite were formed particularly in oceanic islands and in continental rift territories.

Occurrences

Different types of volcanic rocks have wide distribution in Europe which have been formed during all the time from the Archean until recently. The older the volcanites mainly altered to other rock types (e.g. metamorphite), therefore the most fresh volcanite material originate from the youngest, Tertiary-Pleistocene(-Holocene) period. In this part we deal with only the volcanites s.s., the totally metamorphosed metamagmatite occurrences are not mentioned. This summary is based on the data by Moores and Fairbridge (1997), with some addition of other works (see below).

The oldest, ***Precambrian-Early Paleozoic*** volcanites are scattered mainly in Eo- and Paleo-Europe[1]. Intermediate and acidic rocks of *Precambrian age* occur in the Ukrainian (Podoliana) shield, basalt and rhyolite in S Norway and spilite in Barrandian and Thuringian Forest. *Cambrian-Ordovician(-Silurian)* mainly ophiolitic origin, basalt-rhyolite volcanites connected to the Caledonian orogenic belt occur in the NW British Isles, in London-Brabant Massif, in Scandinavia, in the Harz Mountains and mainly rhyolitic rocks crop out in the Ardennes. The initial *Devonian-Lower Carboniferous* only slightly metamorphosed basic magmatism occurs in Rhenohercynian zone (e.g. Germany). Devonian basic volcanics are in Bohemian Massif. Small occurrences of old palaeozoic basalt and dolerite are found in the Iberian Peninsula.

Widespread extrusion magmatism took place in Pangea during the Late Variscan period. *The Permo-Carboniferous* volcanism was observed in Europa in three major blocks (the fourth, south-easternmost block belongs nowadays to the African continent) (Doblas et al., 1998) (Fig 3.).

1. In the nothern zone (NEB) tholeiitic dyke rocks, tholeiitic and alkali olivine basalts occur in the southern

[1] The territories consolidated until the end of the Early Paleozoic (Moores and Fairbridge, 1997)

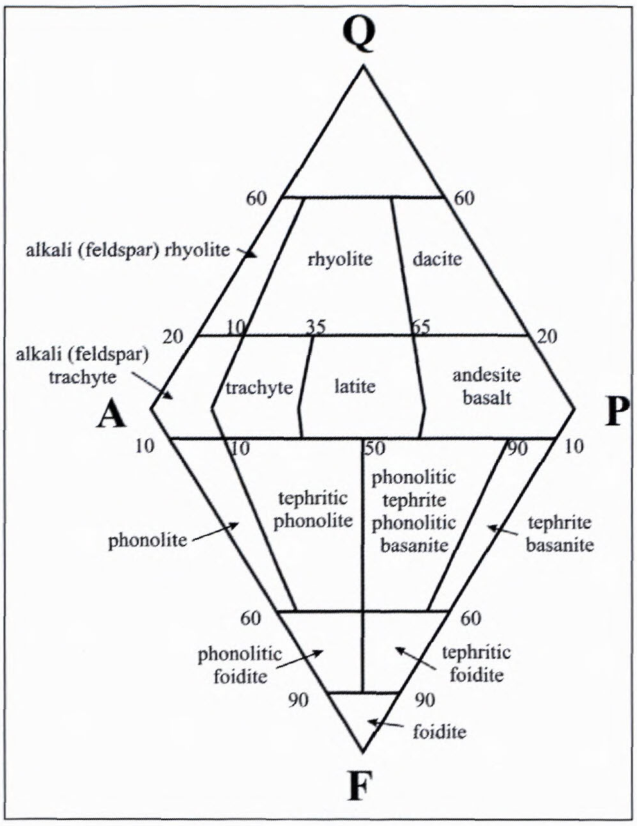


Fig. 1.: Terminology of volcanic rocks on the basis of modal (mineral) composition (simplified after Streckeisen, 1976; 1979 and Le Maître, 1989).

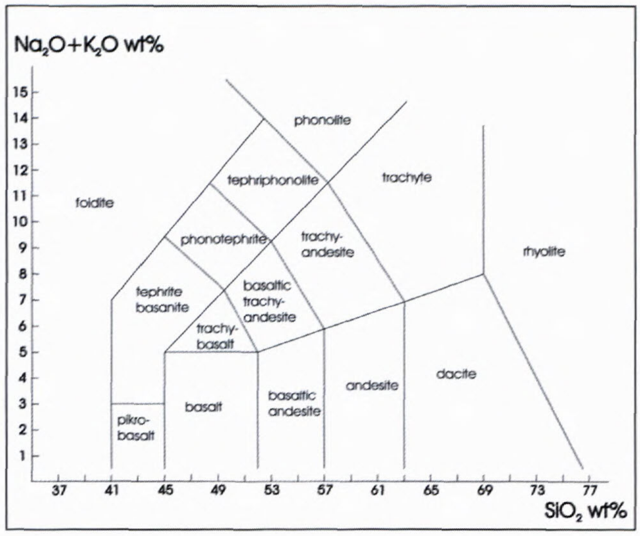


Fig. 2.: TAS (Total Alkali versus Silica) diagram for the chemical classification of volcanic rocks (Le Bas et al., 1986; Le Maître, 1989).

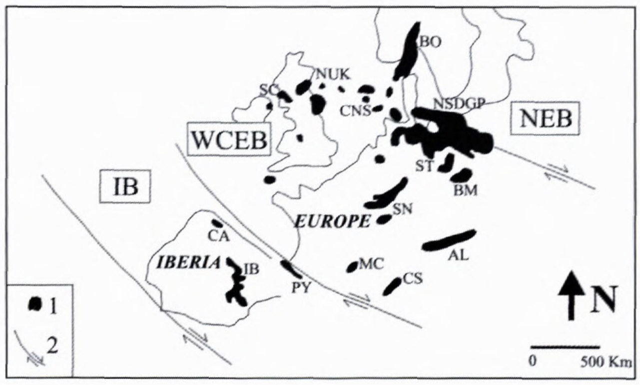


Fig. 3.: Highly schematic diagram of distribution of Permo-Carboniferous volcanic rocks in European province of the Pangean supercontinent (simplified after Doblas et al., 1998). Key to symbols and abbreviations:
1: Volcanism; 2: Continental scale dextral fracture zones;
Blocks bounded by the major dextral fracture zones: IB: Iberian; WCEB: west/central European; NEB: north European
Terrytories of volcanism: IB: Iberian Ranges and Spanish Central System; AL: Alps; BM: Bohemian Massif; BO: Bamble/Oslo; CA: Cantabria; CNS: central North-Sea; CS: Corsica/Sardinia; MC: Massif Central; NSDGP: North-Sea/Dutch/German/Polish province; NUK: Northern United Kingdom; PY: Pyrenees; SC: Scotland; ST: Saar/Nahe Trough.

part of Sweden and basalt, latite, trachyte and rhyolite in the Oslo graben (S Norway).

2. The second zone comprise the west/central European blocks (WCEB). They are located between the Tornquist-Teisseryre Fault Zone and Bay of Biscay Fault Zone. The most important volcanites occur in the British Islands (Scotland and northern United Kingdom tholeiitic dyke), in the central North Sea province, in the southern North Sea province (Vosges, German and Polish lowlands, the Saale. Trough calc-alkaline volcanics, the Bohemian Massif and NE environs (Czech Republic and SW Poland) with three main volcanic stages, the Saar-Nahe Trough, the western and Central Alps region, the Ligurian-Corsica-Sardinia sector, and the French Massif Central region. Both calc-alkaline (basalt and rhyolite) and later alkaline volcanics occur almost at all localities.

3. Permo-Carboniferous volcanites of the Iberian block in south European zone (IB) are in the Pyrenees with calc-alkaline later alkaline character, the central Iberian sector (rhyolites, aluminous basalts, andesites, dacites, and the Cantabrian region displaying acid and basic volcanics.

Besides the above mentioned zones there are more local occurrences of these rocks inside the Alpine systems, for example in the Apuseni Mts.

There are several localities in Europe with significant amount of volcanites formed during the ***Mesozoic age.*** Among them the most important ones are those which can be connected with the development of the European Alpides. Rift volcanism and formed of ophiolites took place during opening of the Tethys ocean from the *Triassic to the Early Cretaceous*. The volcanites appear in several places. The *Triassic* volcanites connecting the rifting are basalts, diabases and dolerites in the Pyrenees, in the Dolomites, in Slovenija, and dacite, keratophyr quartzkerátophyr in Bosnia and Albania, moreover in the Carpathian foreland (E Romania). The main ophiolite territories are in Troodos (Cyprus, which is the most fully documented ophiolite sequence in the world), in the Dinarides, in the Hellenides and in the Vardar-zone in the Balkan area. Basalts, dolerites are the main rock types, with small amounts of basaltic andesite and rarely andesite. Several small bodies of ophiolites with basic rock types appear in other territories (e.g. Betic chains in the Iberian Peninsula, Meliata Unit in S-Slovakia and N-Hungary, Maros valley in the S-Apuseni Mts, in E. Carpathians, in Zagorje and Medvednica in NW Croatia) One of the largest ophiolitic complex in the Alps suffered a serious metamorphism, therefore altered to basic metamorphite rock types (eclogite, blueschist, greenschist). The alkaline basic rock remnants (tephrite, basanite, phonolite) of the Early Cretaceous continental rift volcanism crop out in the Silesian nappe (S Poland-N Czech Republic) and the Mecsek Mts. (S Hungary). Late Cretaceous - Early Paleogene rift related basalts and related volcanics and subvolcanic bodies are distributed in the inner Hebrides and NE Ireland.

In southernmost Sweden Jurassic and Cretaceous volcanic plugs of basalt are the youngest episode of the earlier magmatism in S Scandinavia.

Connecting to the closure period of the Tethys there were volcanic activities in several part of Europe in the *Paleogene-Neogene and Holocene* during the last 40 Million years. The volcanism proceeded in three main volcanic provinces in four main territories (Harangi, 2002) (Fig. 4.)

1. In the foreland of the Alps (Calatrava in the Iberian Peninsula, Massif Central in France, the Rhine-graben and the Egerian rift valley in Germany, Ohře rift valley in the Czech Republic between Saxothuringicum and Bohemicum) (ECRIS) with mainly alkaline mafic rocks types and its differentiates (alkaline basalt, basanite, tephrite, tephriphonolite, phonolite, nephelinite, trachyte, rhyolite and subordinate leucite-bearing rocks). One of the most important and large volcanic territories among them is the late Cretaceous to Quaternary alkaline volcanism occurring in a broad, poorly defined belt which traverses Germany in a E-W direction at about 300 km distance from the Alps.

2. The Alpine region (along the Periadriatic lineamens) (PILMS) with dominantly Paleogene pluton and dyke rock with subordinate calc alkaline andesite and ultrapotassic rocks.

3. The Mediterraneum with very different and variable calc-alkaline, alkaline and ultrapotassic volcanite rocks in the next blocks.

a. SE Spain, Valencia valley with calc-alkaline, potassic and ultrapotassic rocks which followed alkaline basalt.

b. Middle part of Appennine Peninsula, Sardinia, Aeolian Islands, Toscana, Vesuv, Sicily have various rock types:

Fig. 4.: Main Tertiary-Quaternary volcanic territories in Alpean and Mediterranean region (Harangi, 2002). Key to abbreviations: ECRIS: European Cenozoic Rift System; PILMS: Periadriatic-Insubrian Lineament magmatic series; CPT: Carpathian-Pannonian region

calc-alkaline rocks, high-K calc-alkaline rocks, rhyolite, shoshonite, alkaline basic rocks, ultrapotassic rocks and tholeiitic rocks.
c. Macedonia, Rhodope (Bulgaria), Aegean Islands and Western Turkey with calc-alkaline andesite, dacite, subordinate rhyolite, moreover basalt only in Santorini.

4. Carpathian-Pannonian region (Styrian Basin, Little Hungarian Plain, Bakony-Balaton Highland, Mid- and East-Slovakian neovolcanic area, Štiavnica-Nógrád-Gemer territory, Börzsöny, Cserhát, Mátra, Tokaj in N Hungary, Banat, Persany moreover in the Sudetes outside of the Carpathians) (CPR) with Miocene-to Pliocene calc-alkaline (mainly andesite, dacite, rhyolite and its pyroclastic) rock types moreover late Miocene to Quaternary alkaline basaltic rocks and subordinate Miocene to Pliocene potassic-ultrapotassic rocks.

Redeposited volcanites are occurring as pebbles and cobbles in fluviatile coarse siliciclastic sequences almost the all territory in Europe, and as a constituent of the glacial boulders connecting the Pleistocene glacial period. The most important territory where the glacial boulders are wide-spread in the German-Polish plain and the British Islands.

Polished stone tools from volcanite raw material

Among the volcanites **basalt** (and its subvolcanic variety, **dolerite**) are the most frequently used raw materials for polished stone tools due to its very good quality (see the Typology chapter). Geological occurrences of basalt are known from several countries in Europe therefore basalt polished stone tools are widespread and play an important role among the raw materials in several European prehistoric collection. They are typically used in a region together with other rock types, unlike eclogite (and other high pressure origin rocks) in Western Europe and greenschists in East-Central European territories, which are, if available, the predominant raw materials for making polished stone tools around their sources. Therefore basalt implements generally did not cover such vast distances like eclogite, serpentinite or greenschist. On certain areas where high quality local eclogite or greenschist were not available, even the basalt implements could "cover" several hundred kilometres like on the Polish Plains.

The importance and quantity of **andesite** and **rhyolite** as raw material is significantly less than that of basalt, due to the lesser quality raw material, altough especially andesite is a rock type widely spread on the large part of Europe. Mainly due to the large size crystals (andesite) and the rigid glassy matrix (rhyolite), these rocks were less suitable for the production of chipped stone artefacts. Volcanites which are less widespread on geological sources than basalt, andesite or rhyolite can have local importance and some which are exceptionally suitable to make polished stone tools (e.g. phonolite in S.Hungary) can be traced regionally.

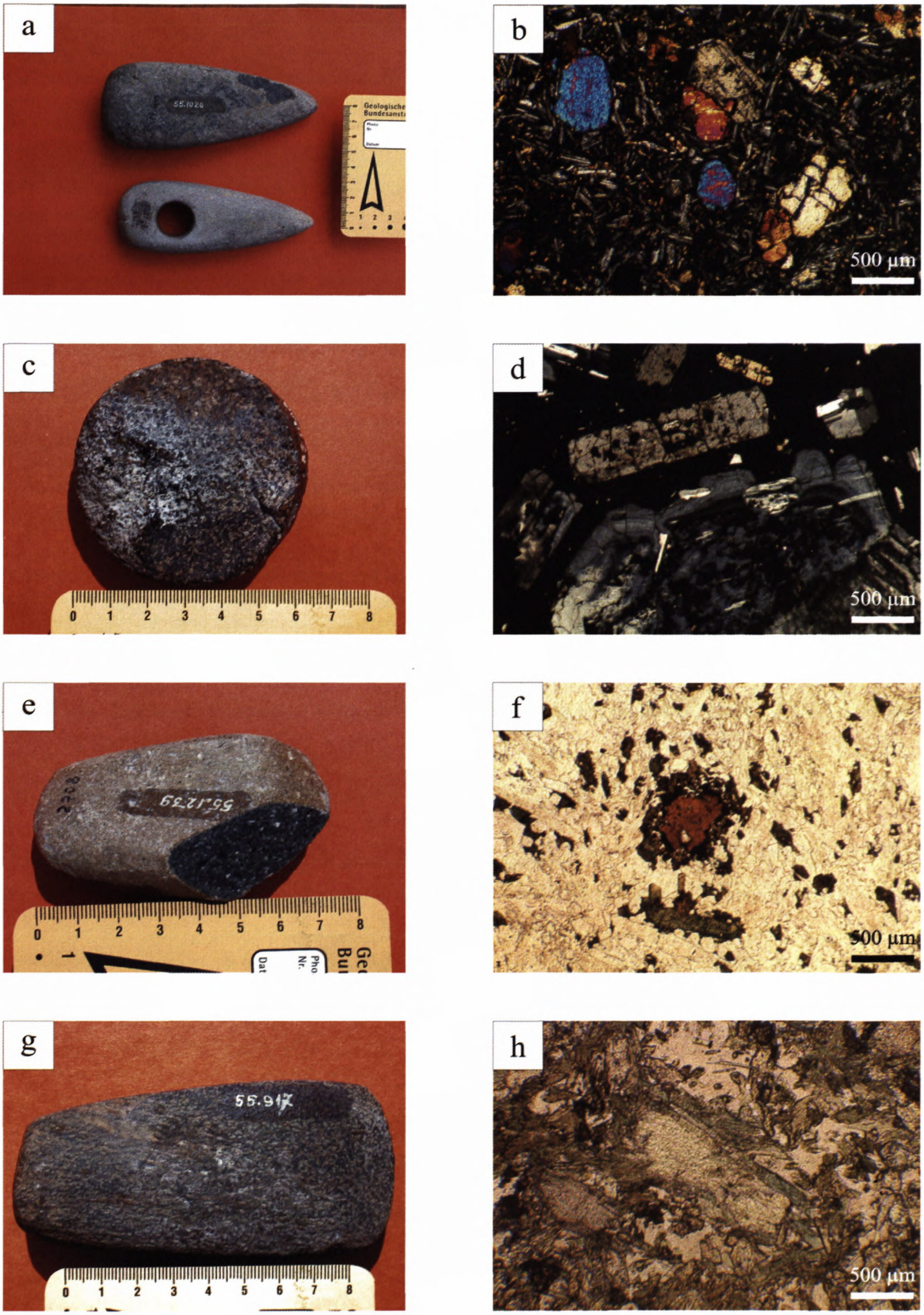
Typology

Seemingly, the best raw material for polished stone tools among the volcanites is basalt used almost exclusively as implements of daily practical use, in contrast with, for example, serpentinite and eclogite which were used frequently as decorative/ornamental implements and symbols of rank and prestige. Basalt stone tools have very good qualities (hardness and high mechanic resistance, strength, elasticity, compactness), because basalt is a fine grained rock and there is not too large difference of measure of the phenocrysts and groundmass crystals. Generally the glassy material is scanty in the basalt, the matrix consists of thin, lath-shaped plagioclase, small sized pyroxene and oxide minerals, the interlocking of which resulted in a strong, lasting connection as well as elasticity for the rock. Tools typically made of basalt are, first of all, axe, adze, hammer axe but flat chisels also often occur. Tools with shaft hole and without shaft hole are equally occurring though pieces with shaft-hole come forth less frequently, being fragile and typical for the younger prehistoric periods (Late Neolithic/Aeneolithic and Bronze Age). Macehead is speciality made of basalt in Slovakia (Illášová and Hovorka, 2001). Cryptocrystalline and fluidal basalts were also used for the production of chipped stone tools, e.g., projectile points.As regards the other volcanic rock types, volcanites with textural characteristics similar to basalt (see above) are used as implements for similar aims. For example tephrites, basanites, phonolites, trachytes and fine grained and well crystallized andesites and dacites are in this group. Volcanites which have large pheno- or xenocrysts in their texture can not be used well for polished implements, because in the course of utilisation (especially blows) the artefacts tend to get broken along the margin of the large crystals. Rhyolites and other volcanites which have a large amount of volcanic glass in the matrix are rigid, therefore the implements made of these raw materials were ill suited for the production of tools exposed to strong mechanical effects. On the other hand, the latter rocks can be useful for grinding and polishing stones, millstones due to their hardness.

Subvolcanic and dyke rocks have uniform fine to medium grained (0,X-2 mm) size texture. Dolerite is the most commonly used raw material among them. The lath-shaped plagioclase and the pyroxene (sometimes olivine) and oxid minerals are in very strong connection with each other (similar to the basalt groundmass), therefore implements made of this rock types are very useful for utilisation with great mechanical stress. Predominantly, axes, adzes and hammer axes are made of dolerite.

Different types of polished stone tools and its polarising microscope appear made of most widespread raw material are shown in Fig 5.

Slovak Geol. Mag., 10, 1-2(2004), 81-95



Regional distribution of volcanites and dolerite-type raw materials as archaeological implements: a state of art draft

Western Europe and adjacent areas

British Islands

As the current IGCP-442 program had no British contribution, this survey was made on the basis of available references.

From the end of 19th century, there were intensive petrographic studies on stone implements on the territory of the **British Islands** (Briggs 2001). The Council of British Archaeology (CBA) organised this work. According to the detailed studies, the most often occurring raw material of stone implements in the British Islands divide into 25 groups (e.g. Cummins, 1979). The most abundant raw material type (about 25% of all implements) consists of low grade metamorphosed volcanic tuff (greenstone), called "Group VI". Mainly polished stone axes were made of this material (Cummins, 1979). This group was identified first by Keller et al. (1941) among the raw material of archaeological implements. This rock was found to be coming from the Ordovician Borrowdale Volcanic Series, which dominates the upland English Lake District in Western part of Britain (Briggs, 1989). Moreover this rock type is widespread in the form of glacial erratic blocks in the British Islands. Unfortunately there is no technique which could distinguish between implements made directly of country rock or the ones deriving from erratics (Briggs 2001). Group VI implements are exceptional in having their distribution patterns centred several hundred kilometres from the source area (Cummins, 1979).

Further raw material of volcanic origin among the 25 established categories is silicified tuff (Group VIII), which served mainly for the production of stone axes. The source of this widely and locally distributed raw material is in south-west Wales. Group X., i.e., dolerite is occurring rarely in Britain, because its source is near Sélédin, in Brittany (see below in the chapter on France). The source of group XI (fine silicified tuff) is in Great Langdale are of the Lake District. This raw material is also rare in Britain. Axe hammers and battle axes made of ultramafic volcanite rocks, picrite constitute Group XII. The source of the raw material is near Hyssington on the Shropshire-Montgomeryshire border. Group XIII (spotted dolerite) and group XVIII (quartz dolerite) represent further dyke rocks. Spotted dolerite is rare, but important as the famous "Blue Stone" of Stonehenge. Its source is in the Preselau hills, Pembrokeshire. Mainly axe hammers were made from Group XVIII (quartz dolerite) which is widespread locally and abundant around its source in the Whin Sill in North England (Cummins, 1979).

Fig. 5.: Different types of volcanic raw materials of polished stone tools and their characteristic microscopic appearance on the sample of Mihály collection, Veszprém Museum, W-Hungary.
***a**: basalt chisel and axe with hole; **b**: olivine and pyroxene phenocrysts in fine grained matrix consists of lath-shaped plagioclase and volcanic glass in basalt. Crossed nicols; **c**: polished andesite disc; **d**: zoned plagioclase and orthopyroxene phenocryst in glassy matrix in andesite; **e**: phonolite chisel; **f**: alkaline amphibole with aegirine and opaque minerals rim, sanidine, nepheline and aegirine in phonolite; **g**: dolerite chisel blade; **h**: pyroxene relict with amphibole and chlorite alteration rim, and albite in metadolerite.*

Stone axes are recognised to be one of the characteristic elements of the material culture in theNeolithic period (4000-2500 B.C.) in **Ireland** (Cooney and Mandal 2000).The Irish stone Axe Project started in 1990 to make a database of Irish stone axes and incorporate contextual, morphological and petrological information on all known polished stone tools. Until this time more than 20000 stone axeheads are in the database. Petrological work was based on macroscopic description and identification of all stone axes, which followed a selected polarising microscopic analysis in thin section supplemented by XRD analysis of the fine grained rocks and geochemical analysis by XRF method.

Over 18000 stone axes were grouped by lithology based on macroscopical identification of . The dominant rock types were porcellanite (in their use of the term, special high temperature origin metamorphic rock types), which is very characteristic raw material of the Irish axes. Igneous rocktypes account for a minor, but significant proportion of the total material (9%). Rocks of volcanic origin used comprise porphyrite, **basalt, andesite, rhyolite, tuffs and dolerite**. Thin section analysis showed that large amount of the igneous rocks suffered a degree of low grade metamorphism generally to lower greenschist facies. The raw material data plotted on the map of Ireland by Cooney and Mandal (2000) show three regional zones where different axe lithologies are dominant. Dolerite and porphyry are the dominant rock types on the southeastern part of the country. The provenance of the raw material of these rocks are considered to be within the Lower Palaeozoic rocks of this area. The source of the porphyritic andesite exploited for the manufacture of stone tools in the Neolithic has been identified on Lambay island (NE of the Dublin).

The detailed studies on Irish stone axes showed, that part of the artefacts originated from Britain or further afield. Macroscopic and polarising microscopic studies show that more than 100 tuff axes from Irish localities were imported from the Great Langdale and Scafell areas of Cumbria in northwest England (Cooney and Mandal 1998). Some dolerite axes could be imported from Breton sources (territory of France: Le Roux 1979, 1998), but this origin have not been confirmed in Ireland yet.

Twelve axes or axe fragments from vicinity of the Eaver Hills, in north Staffordshire were studied by 'total' (transmitted and reflected light) petrography moreover using a non-destructive field-portable X-ray fluorescence spectrometer by Ixer et al., (2000). Thin section petrography shows, that the raw materials are fine- to medium grained perhaps calc-alkaline intermediate igneous rocks which suffered low grade metamorphism. The authors distinguished four groups of volcanic origin among the raw materials, i.e., **epidotized tuff, microdiorite, porphyritic andesitic lava and coarse-grained pyroclastics**. The epidotized tuffs petrographically and geochemically are assigned by Ixer et al. (in press) to axe-group Group VI (see above), the microdiorites are assigned to axe-group Group VII in the same system. The raw materials of porphyritic andesites and coarse-grained andesitic tuff are perhaps from the Lake District source, but these axe types did not belong to any established axe-group (McK Clough-Cummings 1979:127). Finally Ixer et al. (l.c.) demonstrated that 'total petrography' is certanly the better of the two methods for identifying rock types but requires destructive sampling.

Germany and adjacent territories

Though published results are not numerous, it seems that volcanic rocks seemingly played an inferior role in the production of polished stone artefacts in Germany. Polished stone tools made of (quarried) flint (Weiner, 1986) and various amphibolites (Christensen et al., 2003) must have played a more important role. Within Central-South Germany amphibolites (s.s.) comprise the most important raw material for polished stone tools, followed by basalt as second important raw material (Christensen et al., 2003).

Rehn (2002) studied in thin section under polarising microscope late Neolithic stone tools made of basalts near village Kottenheim and Mayen (W Germany). Two types of raw material were distuinguished by the author. The Quaternary local, porous basalt occurs between villages of Kottenheim and Mayen in southern part of Eifel Mountains at about 6 km^2 territory, was not suitable for the production of axe blades since it is too porous, but it was most suitable for production of millstones. Among the axe blades and adze blades only three basalt artefacts were produced a little bit farer probably from Rieden.

From the Netherlands, basalt adzes were reported by Bakels and Arps (1979) from the Linear Pottery sites in Elsoo, Stein asn Sittard (SE Netherlands). Excavations and petrographic analysis in the South-eastern Netherlands revealed that the second largest group of the raw materials of implements are basalt. Petrographically, basalt was divided into 3 groups on the basis of grain size, textural and structural variety. The main constituents are olivine, pyroxene (Ti-augite), plagioclase, titanomagnetite and altered basaltic hornblende. Rarely, basalts contain foids (leucite), therefore the rock name is turned out to be basanite, but the basanite was probably less attractive for making implements. On the petrographic characteristics of the raw materials and the close occurrence the source area of the basalt seems to be coming from Siebengebirge and High and Western Eifel Mts. moreover Laacher See environs.

France

Eclogites and other high pressure metamorphites of Alpine origin are the dominant raw materials of polished stone tools **in France**. The volcanic rocks used for Neolithic stone tools are in background and restricted predominantly to the Massif Central and its environs.

920 polished stone tools (axes) were surveyed by Surmely et al. (2001) from three departments (Cantal, Haute-Loire, Puy-de Dôme) in the Auvergne region (S part of Massif Central). They studied 90 items in thin section from the broken implements by polarising microscope, performed density measurement and applied spectroradiometric method using electromagnetic radiation from the intact pieces. The proportion of lava and paleo-lava rocks wase between 1 to 17%, the least was in the Haut-Loire and the highest in Cantal Ouest departments, and generally they are large size (up to 31 cm) artefacts. The lava rocks have two types, the first one is young, Tertiary and Quaternary (basalt, basanite, trachyte, etc.) comprising in some cases ignimbrites as well, the second type is represented by paleovolcanites, predominantly from dykes formed in the Palaeozoic period (from Late Devonian to Early Permian). The paleolava rocks were often metamorphosed. In many cases they could distuinguish the two types from each other macroscopically. All over the region, Tertiary and Qaternary volcanic rocks were widespread except for Allier department. The distribution of Paleozoic volcanites were sporadic in the territory. Tertiary lava rocks, particularly basalt was used the most. The Quaternary rocks are strongly porous therefore they were not popular to make stone tools from by the prehistoric man. Paleozoic rocks were used predominantly in W Cantal and N Puy-de Dôme localities due to the close source region but the use of import materials cannot be excluded. The determination of the origin is difficult due to the great variety in this rock.

Dolerite raw material of polished stone tools is mentioned to occur in Brittanny (France). It has very great importance: it was popular as raw material for polished stone tools in the Neolithic period. The rock described by Cogné and Giot (1952) as a very fine grained and strongly epidotized dolerite, forms a very important group, accounting for nearly 50% of the axes in Brittany, and 30-40% in the rest of the Armorican massif. Axes of this raw material are still abundant throughout north-western France along the Loire valley up to Orleans. Their distribution extends as far as the Pyrenees, the lower Rhone valley, Burgundy, Alsace and Belgium. In southern England, this rock is equivalent with the British Group X (see earlier) (Le Roux, 1979). The workshop-site, discovered in 1964 at Sélédin, near Plussulien, in the south of Côtes-du-Nord is situated on a particularly fine-grained outcrop among the large doleritic sills of lower Carboniferous age in the south east of the Chateaulin basin (Le

Roux, 1979). Typologically the production consist of every day utilisation axes of various sizes and shapes.

Iberian Peninsula

Dolerite is one of the most important raw materials for polished stone tools in Cadiz province, in the southern part of the Iberian Peninsula. Several Neolithic/Aeneolithic localities (2-6 millennium B.C.) were studied by petrographic microscopy and X-ray diffraction methods, (Pérez et al., 1998; Ramos et al. 1998; Dominguez-Bella et al., 2000; 2001; 2002). At all of the localities with dolerite polished stone tools, it is the dominant rock type: its percentage can reach 35-40% among the used rock types but in several localities its quantity significantly exceeded 50%. The tool types made of dolerite are dominantly axes, adzes, hammers, chisels and other cutting tool fragments with finely elaborated smooth surface. Moreover, there are some balls of dolerite (4-5 cm in diameter) that occur in some localities with a rough or picketed surface in the Atlantic zone. Dolerite is of coarse-medium (>2mm) to fine (1-2mm) grained size constitued by plagioclase and pyroxenes and developped ophitic or subophitic texture. As regards the provenance, dolerite is probably of local origin here, from the eastern external part of Betic Cordilleras, associated with ten to hundred meter large outcrops included in the Triassic sediments that cross the southern part of Iberian Peninsula. from the SW to the NE.

Though not in the circle of polished stone tools, another coeval application of volcanite can be raised here. Mineralogical and petrological studies of the dolmen of Albertie (Villamartin) in Cádiz Province at 5th millenium B.C. show slightly metamorphosed **tufite** raw material which the provenance of which was probably the Ossa-Morena Units in SW Spain (Dominguez-Bella and Morata-Céspedes, 1995).

Italy

In **Northern Italy**, eclogites and other high-pressure metaophiolitic rocks dominate the raw materials of Neolithic and Aeneolithic polished stone implements, often suprassing 90% of stone materials at single sites (D'Amico and Stranini 2000). In most of the studied collection volcanic rocks are absolute missing, except for Ancient to Medium Neolithic in **Sammardenchia** (Friule, Udine pprovince, NE Italy), where volcanics and volcanic origin rocks are more than 5% (D'Amico and Stranini 2000), and Aeneolithic stone tools of **S Lazzarro di Savena** (near Bologna), where basaltic rocks are absolutely dominant (94%: D'Amico et al., 1996). Different types of axes (s.l.) which are mainly fragments are dominant implements.

The basaltic raw material of S Lazzarro di Savena is local, from the N part of Appennines (D'Amico et al., 1999) Cinerites(tuffic rocks) and basalts are of local origin among the volcanic origin implements in Sammardenchia, but some silexites, vitric cinerites and quartz andesite-dacite interpreted as imported, could have been exchanged objects from the Danubian domain (D'Amico and Stranini 2000). The presence of eastern lithotypes in Sammardenchia is a unique case in Northern Italy (D'Amico et al., 2002).

Carpathian-Pannonian-Dinarid (-Balkan) territories

Czech Republic

Several types of volcanic rocks from different geological periods were widely used raw material for polished stone tools by prehistoric people in the territory of Czech Republic. **Basaltoid**, particularly Cenozoic basalt was the most common and important raw material among volcanics in this territory, but there were also paleovolcanites used such **Proterozoic spilite, Cambrian andesite, rhyolite, Paleozoic diabase, Permian metabasalt and rhyolite, Cretaceous teschenite** and **Miocene andesite** in several localities (Přichystal, 2000).

Local high quality greenschist was the predominant raw material for polished stone tools in the **Linear Pottery culture**. The volcanic rocks are very scarce. Four semifinished shoe-last celts from Bezměrov occurred from fine grained metabasalt or its tuff. Olivine basalt was determined in Bohušice (Třebič District).

Tertiary volcanites (augitite, limburgite, trachyte), acid volcanics and their low grade metamorphic equivalents (quartz keratophyres, porphyroids) and acid tuffs of the **Stroke-ornamented ware culture** were studied at Mšeno near Mělnik in Central Bohemia. Porphyric igneous rocks were recognised in Bíly Kámen hill (near river Sázava) by Karel Žebera (Přichystal, 2000). It seems the tools were made mostly from local material in this territory, the imported material was unlikely used in Central Bohemia (Šreinová et al. 2000).

There is evidence on the use of Proterozoic local spilitic raw material for stone artefacts in the younger Aeneolithic **Řivnáč culture** in central Bohemia.

There are a lot of data about the use of volcanic raw materials by the people of the **Corded Ware culture** in Moravia and adjacent parts of Silesia. The main rock types of the stone tools are greenschist and amphibolite, but Plio-Pleistocene olivine basalt, olivine nephelinite and nepheline basanite were important raw materials too. The polished stone tools made of basalt are different types of battle-axes. The localities of this basalt have been identified in the area around Opava and Krnov (NE Czech Republic), because of large amount (12% of the studied material) of perforated battle-axes is concentrated (Přichystal, 1999; 2000). Other volcanites, andesite, dacite and their pre-mesozoic equivalents comprise 7% of the above mentioned set, but the provenance of the raw material is not known yet, similarly to tuffs and tuffites present in small quantities among the stone tools. Cambrian paleoandesite originated from Křivoklát-Rokycany belt; it was used as raw material in Central-Bohemia, moreover Tertiary volcanic rocks (basalt, olivine basalt, tephrites and other alkaline rocks) occurred in České středohoři Mts. in the same culture. The raw material (diabase, metadiabase, diabase porphyries, diorite, diorite porphyries) of metabasite zone of Brno Massif was also used in this culture for polished stone tools (Přichystal, 1999).

In the **Bell-beaker culture**, Tertiary olivine basalt and rhyolite tuff occurred as raw material of stone tools in Liptice (NW Bohemia: Přichystal, 2000).

Carboniferous and Permian age quartz porphyry and its tuffs were commonly used for millstones and whetstones in N Bohemia (Bukovanská, 1992)

Poland

Volcanites, particularly basalts are widespread but constitute a moderately amount (about 1-15 %) of raw materials among Neolithic polished stone tools in Poland (predominantly in the Polish Lowland, moreover in Sudetes and Upper Silesia (Foltyn et al., 2000; Chachlikowski and Skoczylas 2001). The volcanic implements were formed to make multifunctional tools for every day use in the housholds. The collections comprise instruments for the processing of rock raw materials in order to produce polishing plates, hammerstones, polishers, mill stones (querns and grinders) moreover large amount of hand-axes, and small quantities of adzes. Basalt and andesite were the best rock types to make hand axes and axes in this territory, while porphyry and diabase were used also as grinders, polishers and hammerstones.

Basalt raw material originated from primary (from outcrops) and secondary (glacial erratics) sources. The primary provenance regions are the Western Sudetes, the foreground of Eastern Sudetes (Nowa Cerekiew-Kiertz, Annaberg-Chelm and environs of Otice and Bruntál). The age of basalt is Tertiary and the localities belong to the eastern part of the Rhein valley volcanic field. There are 510 known basalt outcrops in the Sudeten belt. On the basis of its mineral composition the following rock types occurred: basalt, basanite, tephrite, tephritoid, nephelinite, limburgite and ankaramite. The dominant types are olivine basalt, olivine nephelinite, nephelinebasanite and limburgite. Furthermore there is Precambrian age primary basalt locality in the Wolhynian Upland (territory of Horyn river, Ukraine). These basalts were metamorphosed, have columnar structure, and very often there are amygdaloides in it. It has different mineralogical components: there is no olivine in it, and has larger amount of plagioclase and pyroxene than the Sudeten basalts.

Large amount of fluvioglacial, alluvial and morainic origin erratic blocks of volcanic origin can be found in the county of Oder and Vistula, moreover in the territory of Weichsel which could be also utilised for the production of stone tools.

Secondary and primary origin, local and import basalts were equally used in Middle Poland, particularly in its western part. The imported pieces were both from the Sudetes and from Wolhynia. In contrast, only local basalt material was used in Upper Silesia: there is no evidence for using import basalts here (Foltyn et al 2000).

Slovakia

There are different types of volcanites widespread in the Carpathian-Pannonian region are. They are known best as raw materials for polished stone tools in Slovakia and Hungary, investigated also by petrographic microscope.

Among volcanic rock types, basalt was the most popular raw material to make implements from by prehistoric man in territory of Slovakia. Other volcanics or volcanic origin rocks (andesite, dacite and vitroclastic tuffs) moreover dyke or subvolcanic rocks (dolerite, diabase, teschenite) were also used (Hovorka and Illášová, 2000; 2002). The amount of volcanic raw material for polished stone tools was not significant in the Neolithic but they were more often used in the Aeneolithic and Early Bronze Age period. Axes, hammer axes, adzes, buts and wedges were made first from different types of basalt and secondly from andesite, dacite and other volcanics (Hovorka and Illášová, 2000; Hovorka et al., 2000; Illášová, 2001).

Basalt implements from Neolithic period occurred in around Senica, in Malé Kosihy, in Zlaté Moravce, in the Želiezovce-culture from Bajč in Lengyel culture, from Nitriansky Hrádok and Svodín, moreover from the Aeneolithic period in Opatovce, in Malé Kosihy, in Rimavská Sobota and from the Baden culture in Nitriansky Hrádok and Stránska (Hovorka et al., 2000; Hovorka et al., 2001; Illášová, 2001). As a typical example, a large number of semiproduct basalt axes found near Kozárovce along the river Horn (Garam) can be mentioned. Maces made of basalt or andesite were also found (Illášová and Hovorka, 2001).

Two main types of **basalt** were used as raw material for polished stone tools in Slovakia, alkaline and calc-alkaline types, coming from different geological periods (Hovorka and Illášová, 2000; Illášová, 2001). Late Cenozoic alkaline basalt, which was used frequently, is a fresh, fine grained volcanic type, with olivine and pyroxene phenocrysts and matrix composed of very fine grained lamellar plagioclase, often showing fluidal texture and opaque minerals. No glassy or amygdaloidal types were used. Late Cenozoic alkaline basalt-formation activity is known from several volcanic provinces in Central Europe (see earlier). In southern Slovakia the area of Novohrad county and adjacent part of northern Hungary is the closest territory to the archaelogical localities, but the Little Hungarian Plain and Balaton Highland region in Hungary is also not far. There are small occurrences of alkaline basalt in Silesia connected to the Cretaceous teschenite-picrite series, but this latter was excluded by Hovorka and Illášová (2000) as raw material source for Slovakian implements.

Basalts belonging to the calc-alkaline suite are rather **basaltic andesite** than real basalts on the basis of their petrology. The rock consists of plagioclase and pyroxene as well probably as olivine phenocrysts. This rock type is known from several localities especially from Late Tertiary volcanic province in Central Slovakia, in the Carpathian flysh zone in Moravia, moreover in some terrirories of North Hungary (Cserhát, Tokaj Mts). Basaltic andesite implements occur for example around Senica (Hovorka et al., 2000) and Svodín (Hovorka et al., 2001).

The raw material of Pre-Tertiary **paleobasalt (diabase)** artefacts are altered with a lot of secondary minerals (chlorite, epidote, quartz etc.). This type of raw material is not so widespread as Cenozoic basalt. Paleobasalt artefacts occur in Eastern Linear Pottery culture Šariške Michalany in Eastern Slovakia. The source of the raw material is not known yet (Hovorka and Šiška, 2000).

Several fragments of axes and hammer axes from **andesite** and **trachyandesite** were described from Neolithic-Aeneolithic or Early Bronze Age period in the Poprad basin and the Spišská Vrchovina Highland (Hovorka and Soják 1997), garnet andesites of the Lengyel culture from Nitriansky Hrádok, **pyroxene andesite** and **amphibole-biotite andesite** with fine grained needle like plagioclase and partly glassy matrix of Želiezovce group of Middle Neolithic from Bajč (Hovorka and Cheben, 1997, Méres et al., 2001). **Andesites** from Eastern Linear Pottery culture from Šariške Michalany (Hovorka and Šiška, 2000), **hornblende-pyroxene-biotite andesite** from Lengyel culture in Svodín (Hovorka et al. 2001) moreover from the Aeneolithic site at Stránska (Hovorka and Illášová, 2000).

Provenance of the raw material of **andesite** may be partly in Mt. Wzar in the Polish part of the outer West Carpathians Klippen Belt based on typical mineral composition and partly the areas of Late Tertiary volcanites of central Slovakia (Hovorka and Illášová, 2000), Other Late Tertiary volcanic territories of the inner side of the Carpathian arc in North Hungary (Börzsöny, Csehát, Mátra, Tokaj Mts. etc.) cannot be excluded as source area.

Fine-grained, holocrystalline **dolerite** was identified in only few cases as raw material for making axes of Lengyel culture from Nitriansky Hrádok, at Neolithic site in Žlkovce, Aeneolithic site in Stránska and Neolithic/ Aeneolithic site around Senica (Hovorka and Illášová, 2000; Hovorka et al., 2000)

For **other stone utensils** (crushers, grinders, dressed cobbles and whetstones) andesite is widespread, basalt is rarely used compared to other rock types (quartzite, sandstone, granite and different metamorphites) in the territory of Slovakia. Particularly large amounts of andesite and alkaline basalt were described by Hovorka and Illášová (2001) from Nitriansky Hrádok.

Hungary

Volcanic rock types, particularly basalt was very popular as raw material for Neolithic-Aeneolithic-Bronze Age implements in the Hungary, central part of Carpathian Basin (Biró and Szakmány, 2000). Basalt is the second most common raw material after greenschist-amphibolite schist used for raw material of polished stone tools. Among the other types of volcanic rocks, different types of andesite including basaltic andesite, moreover phonolite, tephrite, dacite, dolerite (diabase) were found and studied macroscopically and under petrographic microscope from several archaeological localities and collections (Biró and Szakmány 2000). Beside the detailed petrographic analyses the main basaltic raw material types were submitted to chemical analyses by absolutely non-destructive prompt gamma activation analyses (PGAA), both archaeological implements and samples from outcrops of the possible source regions (Füri, 2003, Füri et al., 2003; Füri et al. in press).

Three main types of **basalt** raw material occurred among the Neolithic/Aeneolithic polished stone tools investigated so far from Hungary:

Late Cenozoic alkaline basalt is widespread in the northern-middle part of the country (Aszód, Bicske, Mihaldy collection belonging to Laczkó Dezső Museum Veszprém, and the collection of National Museum) (Szakmány 1996; Starnini and Szakmány, 1998, Judik et al., 2001; Szakmány et al., 2001; Szakmány and Starnini, 2002; Oravecz and Józsa, in press), and occurs less frequently in the southern localities of the country (Schléder and Biró, 1999, Nikl et al, 2002, Schléder at al, 2002). The source of the raw material is identified as the Nógrád-Gömör Region (NGR) in case of Aszód (Judik et al, 2001) and the Little Hungarian Plain - Balaton Highland (LHP-BH) region in the case of the polished stone tools of the Mihaldy collection (Szakmány et al., 2001; Füri 2003). The two subtypes of alkaline basalt may not be distinguished by chemical analysis because of their very similar chemical composition due to the same age and process of formation. Petrographical investigation by polarising microscopy, however, can frequently distinguish between the two great regions. The LHP-BH basalts contain olivine and pyroxene phenocrysts and there are fine grained plaigoclase laths, opaque minerals and more or less glass in the matrix. The NGR basalts are more alkaline, as LHP-BH, their pyroxene often has green, alkaline rich core, moreover some nepheline and small sized phlogopite are in the groundmass. The late Cenozoic alkaline basalt type is the same which is occurs in Slovakia (see above).

Polished stone tools of basaltic raw material originating from the Lower Cretaceous rift related basalts of the Mecsek Mts. occurred on the archeological localities in the SW part of the country (Füri et al in press, Füri 2003). This type has large sized, predominantly pyroxene phenocrysts, olivine is rare and generally completely altered. The matrix consists of plagioclase laths and two types of opaque minerals (magnetite and ilmenite). The matrix often shows fluidal structure.

The third type of basalt observed occurs mainly in the SE localities of Hungary (Tápé-Lebő, Szarvas, Endrőd). The raw material has no or only sporadical pyroxene phenocrysts. The mineralogy and fluidal structure of matrix is very similar to the Lower Cretaceous basalts of Mecsek Mts. The chemical composition is only partly similar to this type. Preliminary electron microprobe studies shows, that this third type basalts may belong to the Mecsek type basalts (Füri, 2003).

Andesites are common raw materials, sometimes also used for polished stone tools but more typical among other stone utensils (grinders, polishers etc.). The raw material is known in several varieties. Tertiary calc-alkaline andesites are widespread in the northern part of the country forming the Inner Carpathian volcanic arc (Visegrád Mts, Börzsöny, Cserhát, Mátra, Tokaj Mts., together with the Central Slovakian volcanic territory and the Transcarpathian volcanic territory of Ukraine). Generally, andesite types occurring on prehistoric localities are similar to the andesite types of the closest mountains, but detailed studies have not been carried on as yet. One of the most important raw material for polished stone tools is the fine grained basaltic andesite, known in the form of workshop material and half-products from Aszód Late Neolithic settlement (T. Biró, 1992, Judik et al., 2001). On the base of preliminary field and petrographic studies the exact source of the raw materials is supposed to be in the E-Cserhát Mts. Basaltic andesite raw materials are known from artefacts found in NE Hungary as well, but their raw material is petrographically more similar to the Tokaj geological occurrences (Oravecz and Józsa in press).

Fine grained andesite types (Cserhát, Tokaj source area) were generally used as axes and chisels, but coarser grained andesite types (e.g. Börzsöny and Visegrád Mts. Source area) were generally used as grinding stones.

One of the most specific rock types used by prehistoric man for polished tools was **phonolite**. Phonolite is a highly differentiated rock variety of the Lower Cretaceous rift related magmatism in the Mecsek Mts., and there are only two outcrops in the Carpathian-Pannonian Region, in the Eastern Mecsek Mts. (Szamárhegy and Kövestető). This rock type is fairly common for stone implements in the environs of the Mecsek Mts.The traces of exploitation remained visible around the source at Szamár-hegy because this area was not subjected to modern quarrying activities like most of the potential sources for polished stone implements (T. Biró et al, 2001). **Tephrite** is another differentiated type of this Lower Cretaceous basic magmatic rock series, also widespread in South Hungary as implements (Schléder and Biró, 1999; Schléder et al, 2002; Nikl et al., 2002).

Dolerite (and metadolerite) and **diabase** also occur in some percent among the polished stone tool raw materials in the larger polished stone tool assemblages but detailed study have not been performed on them as yet.

Croatia

Only sporadically occurrences of volcanic raw materials for polished stone tools are known from Croatia. Basalt, andesite and diabase shaft-hole axes are mentioned from the Sopot culture site Samatovci (Slavonia, NE Croatia) in small amount by Balen et al. (2001; 2002). Their investigations were based on the macroscopic analysis of 232 items and petrographic microscopy of 26 items including a few volcanites.. In the opinion of the authors the potential sources of materials perhaps originate from gravel deposits of the Sava river. On the basis of petrographic features this basalt is very similar to the raw material of several polished stone tools occurring in South Hungarian Neolithic localities. This raw material may originate from lower Cretaceous basalt of the Mecsek Mts. (see in Hungarian basalts chapter).

Basalt, diabase and andesite are the most widespread raw materials for polished stone tools in the Aeneolithic Age in Cave Vindija in Hrvatsko Zagorja, NW Croatia. The raw material used is regarded as of local origin, because these rocks are widespread in the area, moreover the volcanic rocks could be found as pebbles and cobbles in alluvial beds of the river Drava (Šimek et al., 2002).

The author had the possibility to study polished stone tools macroscopically in Zagreb. Though the volcanic raw material seems to be present in subordinate quantities, other volcanites of South-Hungarian origin were also spotted like phonolite and tephrite.

Bulgaria

784 worked stonne tools, 205 polished stone tools among them were studied from Neolithic Karanovo culture from the tell site of Kazanluk along the Tundža river, central Bulgaria by Stojanova and Kunchev (1984). The most widespread raw materials were crystalline schist, but diabase, diabase tuff, and rarely basalt were used for polished stone tools (axes, adzes and chisels) while andesite was rarely used for hammers and polishers. The source of the raw material was supposed to be not far from the locality, the diabase originating from "diabase-phyllitic formation" in the Sredna Gora and Stara Planina, andesite masses found to the northwest of the site near the village Ruda and the Stara Zagora mineral areas.

218 artefacts were studied from Early Neolithic Starčevo Culture (6000-5600 BC) in Gălăbnik, W Bulgaria by Anastasova and Pavúk (2001). The petrographic analyses were based on macroscopic determination only. Among the different rock types volcanic rocks were represented by basalt (18.5%) and trachyte (1.5%) in Gălăbnik I level and Basalt (15.7%) rhyolite (3.3%), andesite (2.6%), porphyre (2.6%) and trachyte (2.0%) in Gălăbnik II-III levels. The tools are predominantly chisels and axes, moreover smaller amount of knives and polishing stones also occur.

Romania

Detailed petrological treatment is only sporadically available for the Neolithic localities in Romania Kalmar and Stoicoviciu (1990) made petrographic analyses of

Neolithic settlement belonging to Iclod-group in the are a Somesul Mic river and in the Transylvanian Plain (Cluj county), moreover Bobos and Avram (1990) dealt with mineralogical and petrographical studies on siliceous Neolithic artefacts in western Romania.

Southeast Europe

Greece

Moundrea-Agrafioti (1996) mentioned that most polished stone tools in Greece were made of metamorphic rocks. There are some data however on the utilisation of volcanites for Neolithic - Bronze Age saddle querns in mainland Greece that were made of Aegina andesite.

Many stone objects of everyday use (millstones, stone tools, etc.) mostly made of **rhyolite** and limestone were mentioned from Kos island (SE Aegean) by Poupaki and Chatzikonstantinou (2001).

Appendix: *a glossary of specific rock types mentioned in the text, which are not explained on Figs. 1 and 2*

Alkali basalt: Basalts containing accessory foids. Alkali basalt is chemically a basalt which contains normative nepheline.

Augitite: A volcanic rock composed predominantly of augite and opaque phenocrysts in an intermediate dark coloured matrix which may be analcime.

Diabase: (metabasalt, metadolerite): Medium grained rock of basaltic composition. Generally strongly altered. The rock belongs to the basalt group.

Dolerite: A rock intermediate in grain-size between basalt and gabbro and composed essentially of plagioclase, pyroxene and opaque minerals often with ophitic texture. It may present olivine and in some cases quartz in it. The rock belongs to the basalt group

Keratophyre: Albitised felsic extrusive rocks consisting essentially Na rich plagioclase (albite) with minor mafic minerals ofte altered to chlorite. The rock belongs to the trachyte group.

Limburgite: A basic volcanic rock containing pyroxene, olivine and opaque minerals phenocrysts in a glassy matrix containing the same minerals. No feldspar are present. The rock is a glassy basanite.

Nephelinite: The term is a variety of foidite in which nepheline is the dominant felsic phenocryst.

Quartzkeratophyre: Similar appear and composition to keratophyre, but also contains quartz phenocrysts. The rock belongs to the rhyolite group.

Picrite: Ultramafic volcanic rock type, extremely rich in olivine and pyroxene, may contain plagioclase in small amount.

Shoshonite: Basaltic trachyandesite with high amount of Potassium.

Ultrapotassic rocks: Basaltic rocks with extremely high potassium content $K_2O/Na_2O>2$ and $K_2O>3$ wt%)

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Slovak Geol. Mag., 10, 1-2(2004), 97-104

442

The origin of the raw material of basalt polished stone tools in Hungary

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Abstract: Basalt is a very common rock type among the Hungarian archaeological polished stone tools. The popularity of this raw material is due to, on the one hand, the good mechanical qualities and, on the other hand, the common occurrence of the raw material in the Carpathian Basin. The appearance, size and finish of these stone tools can be very different. The main aim of our study was to determine and characterise the different types of polished stone tools and localise the source region of the different types of basalt in Hungary. Macroscopical, petrographic microscopical and geochemical studies were made on archaeological as well as geological samples. Geochemical studies were made by Prompt Gamma Activation Analysis (PGAA) which is a relatively new, sensitive non-destructive analytical method; therefore it may be useful on archaeological finds. Apart from possibly determining the source of basalt raw material, the application of this relatively new technique on basalt was one of the main objectives of the current studies.
Basalt samples from the outcrops and polished stone tools macroscopically identified as basalt were compared. We could separate three groups according to the PGAA and the macroscopical and microscopical investigation. First and second(?) type is similar to the basalt from Mecsek; the third type is similar to the late Miocene to Quaternary alkaline basalt type.

Key words: polished stone tools; basalt; PGAA method; raw materials

Introduction

Basalt is a very popular raw material of polished stone tools in the Neolithic-Late Bronze age period in Hungary. It is a massive, hard and resistant rock type occurring fairly common in the Carpathian Basin. In the framework of the current study, 14 basalt polished stone tools and basalt rock types from different geological sources from Hungary were investigated. The archaeological age of the finds is ranging from the Neolithic to the Early Iron Age. 13 samples from basaltic occurrences were collected for study and we compared the material of the archaeological implements with the samples from the outcrops. Our aim was to identify the source of the raw materials with traditional petrographic methods and a relatively new, non-destructive method geochemical, prompt gamma activation analysis (PGAA).

Basalt polished stone tools from the Carpathian-Pannonian area

On the NW-side of Hungary, the Little Hungarian Plain and the Balaton Highlands, there are important source areas of basalt raw materials. Therefore in this part of Hungary in the archaeological collections it is very often used as raw material for polished stone tools (Nikl 1998, Schléder, Biró 1999, Szakmány et al. 2001). Schléder and Biró studied polished stone tools from Baranya County, from 18 finds had 5 basaltic raw material, which were grouped to 3 part. One of the all groups was measured by neutron activation analysis (NAA). According to NAA he supposed the source of the basalt is the Hungarian Little Plain, but didn't preclude the possibility of the origin from Balaton Highlands, Nógrád-Gömör Unit or Bánát region. Nikl (1998), in her thesis studied 7 basalt stone tools from Tolna County and she found similar origin than Schléder, only 1 is from the Mecsek Mts. The Mihály collection, collected basically from Northern Transdanubia in the 19th century, comprised 378 polished stone tools; from these, more than 30 % have basaltic raw material. The exact origin of the individual pieces in this collection is unknown, but we know, that the bulk of the pieces were collected in the Bakony Mountains and its environs (Horváth, T. 2001). Most of the material was studied macroscopically but some thin section were prepared already for our former studies (Szakmány et al. 2001). According to the big size of the tools, the large quantity of pieces, the texture and mineral composition, these are possibly from local raw material sources (Balaton Highlands and/or Little Hungarian Plain). In the basalt polished stone tools from Bicske-Galagonyás, clinopyroxene with aegirine-augite core and Ti-augite rim was observed (Szakmány 1996), which is characteristic for the basalt of Nógrád-Gömör unit (Dobosi 1989, Dobosi, Fodor 1992).

On the East Side of the country, Biró studied a Late Neolithic axe workshop from Aszód, Papi földek (Biró 1992) and Judik et al. (2001) defined some rock types from this site exactly. In this collection the most frequent raw material type is basalt and dark glassy andesite. Basalt samples containing phlogopite could be related in respect of origin to Medves-Karancs (Nógrád-Gömör

Unit) by the microscopical observation. At the Szarvas-Endrőd archaeological site, only one basaltic stone tool was identified, and the source of the raw material is unknown yet (Starnini et al. 1998).

In Slovakia, basaltic raw material is relatively rare among the polished stone tools, probably due to frequency of competing greenschist. It is rather connected to some cultures, 1 or 2 pieces in an assemblage, for instance in Bajč (Méres et al. 2001). The basalt stone tools belong mostly to the group of alkali basalt, which were supposed to originate from Central Slovakian young volcanic area (Illášová 2001).

The origin of the studied polished stone tools

In this study, basalt stone tools from several Hungarian archaeological collections were selected from the different parts of the country. Some of them were treated in other studies as well using other methods, mainly traditional petrographic investigation. One part of the examined samples originated from the Mihály collection of the Laczkó Dezső Museum (Veszprém). We examined 2 pieces from Wosinszky Museum (Tolna County) and 1 piece from private collection from Mórágy (Tolna County), which were treated by other analytical methods by Nikl in her MSc thesis (Nikl 1998). We got some samples for non-destructive measurements from the Hungarian National Museum. 2 polished stone tools originated from the site Tápé-Lebő, which were studied by Hargita Oravecz and Sándor Józsa and 2 samples from Late Neolithic settlements around Szentgál (Bakony Mts.) (Fig. 1., Table 1.).

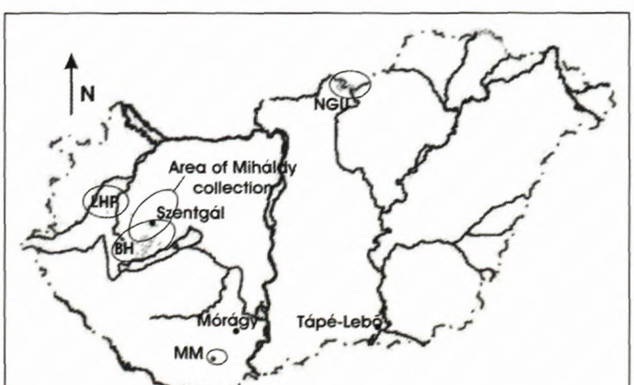


Fig. 1. The localities of studied samples and main basalt occurrences in Hungary: Balaton Highlands (BH), Little Hungarian Plain (LHP) Nógrád-Gömör Unit (NGU), Mecsek Mts (MM).

Basalt occurrences in Hungary and in the Carpathian-Pannonian Region

In Hungary there are 4 main areas, where significant basalt occurrences suitable for tool-making can be found: notably, in the Mecsek Mts (MM)., the Balaton Highlands (BH), the Little Hungarian Plain (LHP) and in the Nógrád-Gömör Unit (NGU) (see Fig. 1.).

The most typical basalt formation period comprises Late Miocene to Quaternary alkaline volcanism in Hungary apparent in several isolated volcanic fields in the Carpathian-Pannonian Region. The outcrops of these volcanic fields can be found extending from Burgenland in Austria, trough the Little Hungarian Plain, the Balaton Highlands and the Nógrád-Gömör Unit to the Persany Mts. This volcanic activity produced almost exclusively basaltic rocks. The alkaline mafic volcanism began at the western (Burgenland) and central Pannonian Basin in the Late Miocene (10-12 Ma), culminating at 3-5 Ma at each volcanic field. The last eruptions occurred only a few hundreds of thousands years ago at Brehy (Sk) and in the Persany Mts. (Balogh et al.1986, Harangi 2001). The general mineral composition of these basalt types is olivine, clinopyroxene as phenocryst, in the groundmass with plagioclase, clinopyroxene, olivine, ilmenite, Ti-magnetite and apatite as accessories. 60 eruption centres are known in the Balaton Highlands. The area of the basalt outcrops in Nógrád-Gömör Unit is smaller, but the volume is similar to the former. The differences in the mineral composition are the occurrence of phlogopite, nepheline and the green-core in the clinopyroxene, which is caused by high pressure (Embey-Isztin et al. 1998).

In the Mecsek Mountains, another type of basalt is occurring in Hungary, originating from the Early Cretaceous period. The Cretaceous volcanic activity produced extensional-related magmatism along the southern margin of the European continental plate. K/Ar radiometric age data indicate that the paroxysm of the volcanic activity occurred between 135 and 100 Ma. Two volcanic series have been recognised in the Mecsek Mts.: the more important series for our studies is the ankaramite-alkali basalt-trachybasalt effusive series, the other one is a Na-basanite-phonotephrite-tephriphonolite-phonolite subvolcanic suite (Harangi et al. 1993). The magma was flown partly below the seawater, it is proved by pillow lava structure and lava breccias, other part of the lava became solid than subvolcanic body or dyke (Viczián 1966, Harangi et al. 1993). The large thickness of the basaltic lava flows (somewhere over 1000 m) reflects the intensity of the volcanic activity (Bilik 1974). The load structure basalt connects to the Na-rich series. The phenocrystals of the alkali basalt are about 5-15-volume %. The quantity of basic plagioclase is more than that of clinopyroxene. The quantity of olivine is few or it is missing. The groundmass is composed of neutral plagioclase, clinopyroxene and Fe-Ti-oxides, mostly ilmenite (Harangi et al. 1993). We can also find these volcanic rocks in the Upper Cretaceous conglomerate in the Mecsek Mts. The gravel size is up to 10-15 cm, which could be good for stone implement preparation.

Analytical methods

Petrographical investigation

We made groups on base of the macroscopical features and we selected some of them for further analyses.

Microscopical thin sections were made of each group and thin sections from previous studies were also studied. All of the samples, which were studied microscopically were measured by PGAA.

Prompt gamma activation analysis

Chemical composition was investigated by prompt gamma activation analysis (PGAA), carried out at the Budapest Research Reactor, Hungary. This measurement technique is based on the detection of prompt gamma rays originating from neutron radiative capture or (n, ?) reaction. The output of the reactor is 10 MW. The emitted gamma rays (prompt gamma rays) are recorded simultaneously in a spectrum. The detection of the gamma rays is made by HPGe-BGO detect system. The spectrums are evaluated by Hypermet-PC program. Elements are detected according to their energies and intensities (Molnár et al. 1997). The intensity is proportional to the concentration of the element and the energies are characteristic to the elements. The method is suitable for determination of all the elements, however with different sensitivities. PGAA measurements give reliable data for main components of basalt (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, and K_2O) and some trace elements (B, Sc, V, Cr, Sm, Eu, Gd and Dy) moreover we can detect Cl too. Since the neutron beam come through on the material of samples, we can get average chemical composition from the full thickness, about from 1×1 cm or 2×2 cm area. The time of measurements depends on the size of the samples, the long of our measurements are about 1000 sec-24000 sec. The advantages of method are absolutely non-destructive and the measurement not required preparations, therefore same identical sample can be used for other chemical analysis later. This method was applied on greenschist and blueschist polished stone tools, and gave good results on the different type of greenschist, which are from several places in the Carpathian-Pannonian region (Szakmány-Kasztovszky 2001).

Results of petrographical analysis

Macroscopically, the archaeological basalt samples have grey or dark-grey, black colour, the cut surface is usually darker, almost black. They are massive fine-grained, homogenous rocks. The surface is sometimes heavily altered; therefore it has a lot of tiny holes because of the dissolution of olivines and pyroxenes. We can see small black (pyroxene) and dark green (olivine) phenocrystals in the grey matrix. In general, the smaller finds have more elaborate surface than the larger pieces.

Mineral composition of alkali basalt is characterised by plagioclases and clinopyroxenes, olivine, amphibole, and ore minerals are also present. We can distinguish three groups of basalt on the basis of microscopical features. The first group has fluidal texture (Fig. 2.). The phenocrysts are clinopyroxenes and sometimes a few olivines, too (Fig. 3). The second group is similar to the first group, but it has smaller pyroxene phenocrystals. The third group includes a lot of olivine phenocrysts, but

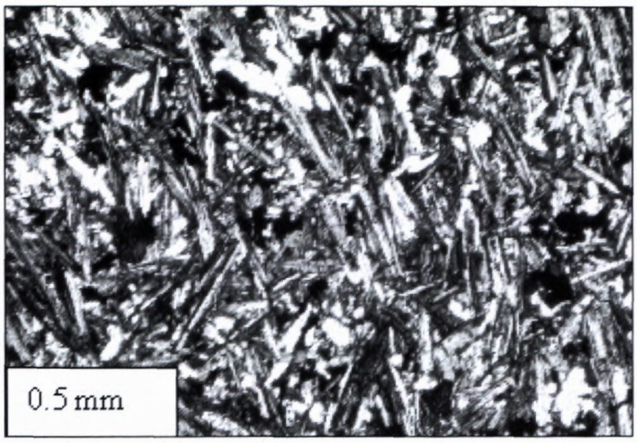


Fig 2. Fluidal texture of the basalt polished stone tools. Characteristic to the first and second group of basaltic polished stone tools.

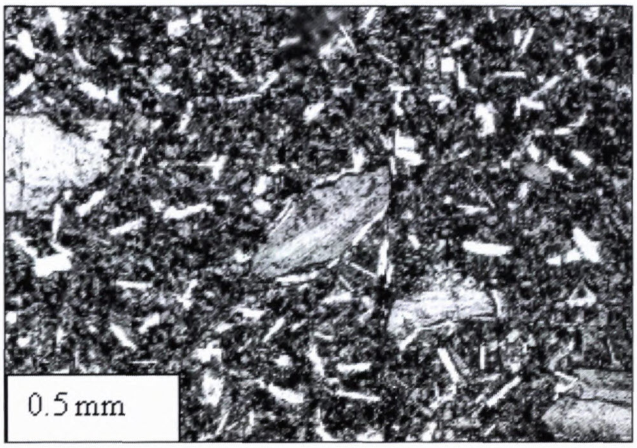


Fig. 3. Clinopyroxene phenocrysts in fine grained matrix of first group of basaltic polished stone tools.

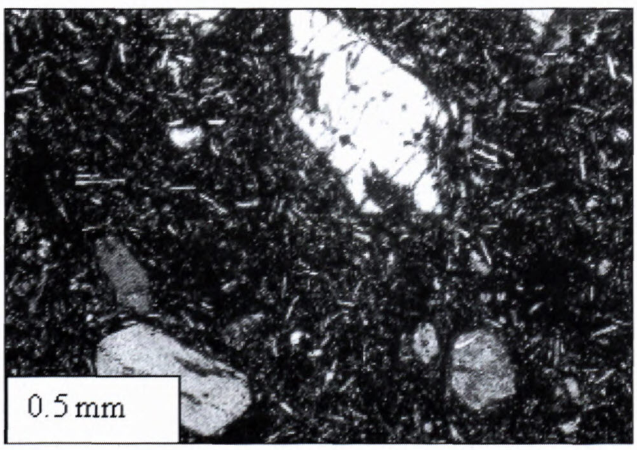


Fig. 4. Large olivine and small sized clinopyroxene phenocrysts in fine grained and glassy matrix of the third group of basaltic polished stone tools.

their size and quantity are smaller than clinopyroxenes (Fig 4.). In the groundmass, the plagioclase forms the skeleton in all three cases, and there are small-size opaque minerals, clinopyroxenes, apatites, chlorites and variable quantity of glass among the plagioclase laths.

We studied some samples from geological outcrops from Balaton Highlands, Little Hungarian Plain, Nógrád-Gömör Unit and Mecsek Mts. The average mineral composition is plagioclases, clinopyroxenes, olivine, amphibole, ore minerals, apatite and glass. The basalt from Nógrád-Gömör Unit differs from the other young basalts in the green-core of the clinopyroxene and it has nepheline and phlogopite. The samples from Mecsek have fluidal texture and the quantity of olivine is low or it is missing.

Result of chemical analysis

The chemical composition of polished stone tools and the samples from outcrops were measured by PGAA, altogether on 27 samples (Table 2.). We made different diagrams from the results of PGAA. As a result of the measurements we got two groups of data by some types of diagrams. The two groups are separated by the TiO_2-Fe_2O_3, Sm-Gd, TiO_2/Al_2O_3-Na_2O/K_2O, TiO_2/Al_2O_3-Sm diagrams (fig. 5, 6, 7, 8). From the 14 archaeological samples 2 belong to different group by trace elements (fig. 6., Sm-Gd) and by major elements (fig. 5, 7).

Discussion

We could formulate three groups among the measured rock samples on bases of the different investigations.

Macroscopical investigation did not show a significant difference between the samples. Moreover, the archaeological implements are typically heavily altered on the surface, because of being buried for a long time. The differences in texture and minaral composition observed in the microscopical studies did not show any connection with the previous macroscopical grouping. Seemingly meaningful groups could be made on the basis of microscopical observation and PGAA.

Comparing the microscopical observation with PGAA results, we can define three groups among the basalt polished stone tools and samples from geological occurrences. Two groups were quite clear and they were observed both in the geological and archaeological sample set. Group 1 correspond to Mecsek, group 3 correspond to young volcanites from the Carpathian-Pannonian unit. Group 2 was only present in the archaeological set and from a site in SE Hungary: its unique features can be explained several ways

1. they belong to a so far not investigated source (Transylvania(?), Southern territories(?))
2. they belong to a variety of the groups established, i.e. Mecsek, the textural features of which are very similar to this group.

The first and second group have similar microscopical features, but in the second group there are no phenocrysts. Maybe this is the reason of the difference observed in the rare earth elements results of PGAA. The second group has two pieces from the archaeological finds, which are similar to the samples from Mecsek in major elements, but different in rare earth elements on bases of PGAA. The first group is comparable to samples from Mecsek in chemical composition and in microscopical features, too, therefore we think this group is from the Mecsek. The third group is similar to the young basalt types in results of PGAA, but we could not make further dissection within group. The mineralogical distintive features of Nógrád-Gömör basalts were not observable in our archaeological sample set. Further chemical differentiation within the young volcanites may need further studies, for example the mineral chemistry of the rock-forming minerals by electron-microprobe analysis. Though chemical analysis did not differentiate regions within the young volcanic range, we suppose that the "third group" is from the Balaton Highlands or Little Hungarian Plain, because the archaeological sites investigated are nearest to former raw material sources.

Among the basalt tools, the young basalt is typical on the North part of Transdanubia and North-Eastern Hungary. Lower Cretaceous basalt is typically occurring in

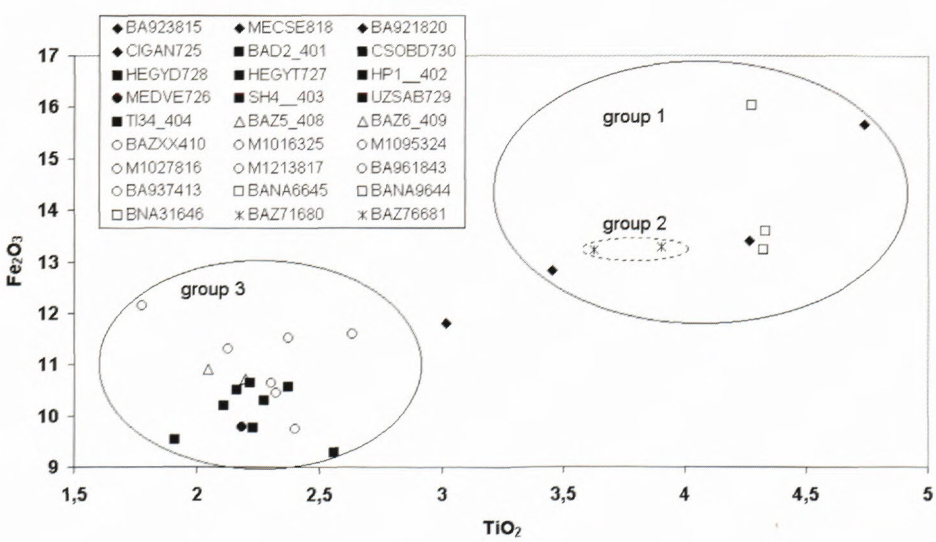
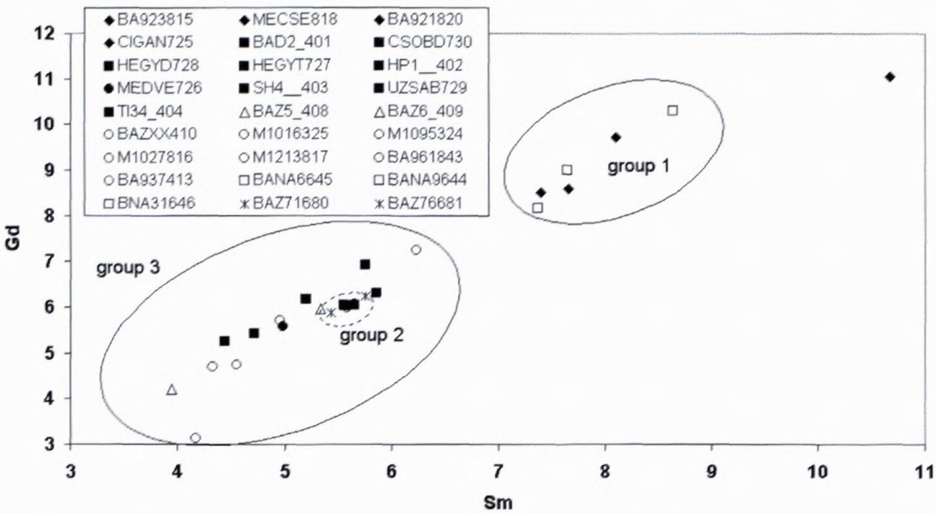


Fig. 5.
Fe_2O_3 versus TiO_2 diagram of analysed basaltic polished stone tools (open and X signs) and samples from outcrops (fill signs). The origin and legend of the individual sample signs see the table 1.

Fig. 6.
Gd versus Sm diagram of analysed basaltic polished stone tools (open and X signs) and samples from outcrops (fill signs). The origin and legend of the individual sample signs see the table 1.



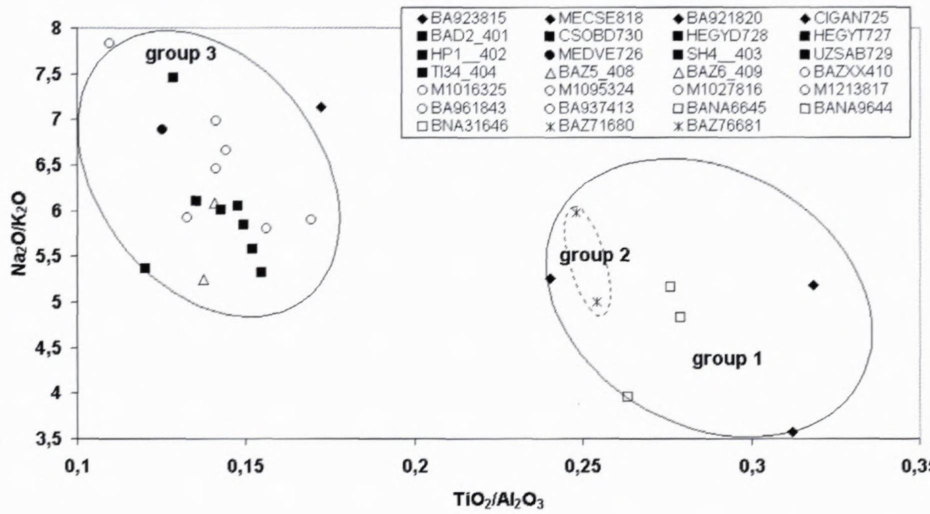
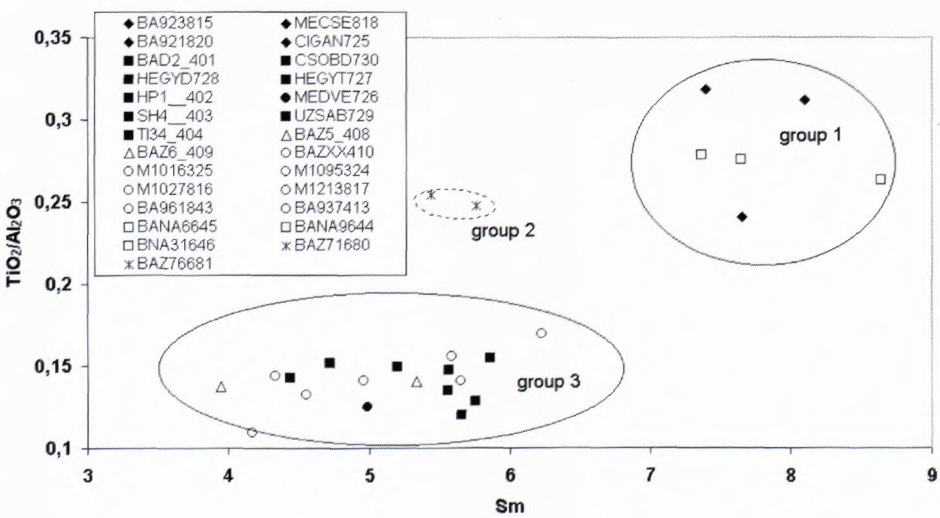


Fig. 7.
Na_2O/K_2O versus TiO_2/Al_2O_3 diagram of analysed basaltic polished stone tools (open and X signs) and samples from outcrops (fill signs). The origin and legend of the individual sample signs see the table 1.

Fig. 8.
TiO_2/Al_2O_3 versus Sm diagram of analysed basaltic polished stone tools (open and X signs) and samples from outcrops (fill signs). The origin and legend of the individual sample signs see the table 1.



the Southern part of Transdanubia. Here we can find two basalt raw material types (groups 1 and 2, respectively).

Conclusion

1. 27 samples were investigated (14 from polished stone tools, 13 from outcrops). The samples are from different geological/archaeological age and locality.

2. We get three groups by geochemistry and petrography. Two of them are clearly distinct and correspond to, on one hand, to Mecsek Cretaceous basalt (Group 1), on the other hand, to young alkaline basalt (Group 3). Group 2 shares more features of the former, its interpretation, however, needs further studies.

3. The distance of transport between the archaeological sites and the raw material sources was relatively short, except in the Great Hungarian Plain, where raw material from all basalt raw materials sources could be observed.

4. Within the groups established, no further (regional) differences could be observed by the methodology applied. This can be due to the homogeneity of the specific quality of basalt used for tool making or the homogeneity of the chemical composition of the Late Cenozoic volcanic event as well.

Acknowledgements

The authors thank to Judit Regenye, Hargita Oravecz, Sándor Józsa, Szabolcs Harangi for lending the archaeological and geological samples investigated. The work has been supported by Grant of the National Scientific Research Fund (OTKA) No. T-025086, and by Pro Renovanda "Student for Science" Foundation.

Table 1. The signs, localities and origin of the studied samples.

Sign of samples	Origin	Locality
BA921820	outcrop	Mecsek
BA923815	outcrop	Mecsek
BA937413	55.937	Mihaldy-collection
BA961843	55.961	Mihaldy-collection
BAD2_401	outcrop	Badacsony
BANA6645	Nikl A 6.s.	Tolna County
BANA9644	Nikl A 9.s.	Tolna County
BAZ5_408	Szentgál 2/2	Hungarian National Museum (Szentgál)
BAZ6_409	Szentgál 2/1	Hungarian National Museum (Szentgál)
BAZ71680	7.1951.363	Hungarian National Museum (Tápé-Lebő)
BAZ76681	7.1951.276	Hungarian National Museum (Tápé-Lebő)
BAZXX410	55.1xx1	Mihaldy-collection
BNA31646	Nikl A. 31.s.	Tolna County
CIGAN725	outcrop	Cigányhegy (Mecsek)
CSOBD730	outcrop	Csobánc
HEGYD728	outcrop	Hegyesd
HEGYT727	outcrop	Hegyestű
HP1__402	outcrop	Haláp
M1016325	55.1016	Mihaldy-collection
M1027816	55.1027	Mihaldy-collection
M1095324	55.1095	Mihaldy-collection
M1213817	55.1213	Mihaldy-collection
MECSE818	outcrop	Mecsek
MEDVE726	outcrop	Medves (Nógrád)
SH4__403	outcrop	Ság-hegy
Ti34_404	outcrop	Tihany
UZSAB729	outcrop	Uzsabánya

wt %	BA921820	BA923815	BA937413	BA961843	BAD2_401	BANA6645	BANA9644	BAZ5_408	BAZ6_409	BAZ71680	BAZ76681	BAZXX410	BNA31646	CIGAN725
SiO_2	42,20	44,75	45,39	44,74	45,08	46,65	45,31	47,60	43,43	46,08	47,37	44,57	41,96	43,54
TiO_2	4,74	4,27	2,13	2,63	2,22	4,33	4,32	2,05	2,20	3,63	3,90	2,32	4,27	3,45
Al_2O_3	15,20	13,40	16,04	15,54	17,24	15,54	15,67	14,90	15,63	14,63	15,37	16,46	16,24	14,37
Fe_2O_3	15,67	13,39	11,30	11,60	10,64	13,58	13,23	10,92	10,73	13,22	13,27	10,45	16,02	12,82
MnO	0,25	0,41	0,14	0,22	0,20	0,20	0,23	0,18	0,18	0,19	0,13	0,19	0,15	0,19
MgO	4,26	6,34	8,43	7,85	7,33	4,45	4,81	9,15	10,64	7,11	5,04	8,45	4,69	6,45
CaO	9,84	9,15	9,56	10,45	8,75	7,87	8,63	8,86	10,01	8,14	7,93	10,00	9,86	10,79
Na_2O	2,99	3,15	3,04	3,46	4,79	3,26	3,39	3,44	3,40	3,62	3,14	3,77	2,29	3,32
K_2O	0,58	2,04	2,88	2,43	2,66	1,57	1,77	1,80	2,68	2,35	1,86	2,68	1,67	1,94
H_2O	4,13	3,02	0,90	0,84	0,81	2,40	2,57	0,87	0,96	0,87	1,85	0,88	2,77	2,90
ppm														
B	11,3	7,6	5,7	10,8	6,1	4,5	7,1	4,7	4,3	11,1	6,1	6,1	3,7	6,9
Cl	70	35	651	960	1042	88	49	553	581	178	94	749	101	707
Sc	29,2	25,0	1,0	34,4	30,8	24,6	22,1	39,2	25,3	39,5	1,0	36,5	26,9	24,0
V	<100	<100	<100	<100	234	316	330	340	<100	419	355	332	362	374
Cr	<200	<200	656	<200	561	524	<200	715	562	424	381	672	<200	620
Sm	8,1	7,4	4,5	6,2	5,8	7,4	7,6	3,9	5,3	5,8	5,4	5,6	8,6	7,7
Eu	3,0	2,3	3,6	5,2	3,3	0,1	4,5	3,4	0,1	0,5	0,7	3,2	1,5	4,1
Gd	9,7	8,5	4,7	7,2	6,9	8,2	9,0	4,2	6,0	6,2	5,9	6,1	10,3	8,6
Dy	<1	<1	<1	<1	<1	<1	<1	12,0	<1	<1	<1	<1	<1	<1

wt %	CSOBD730	HEGYD728	HEGYT727	HP1__402	M1016325	M1027816	M1095324	M1113326	M1213817	MECSE818	MEDVE726	SH4__403	TI34_404	UZSAB729
SiO_2	46,65	46,41	44,15	48,83	48,02	44,64	43,61	50,55	46,88	44,69	44,80	48,85	41,19	45,94
TiO_2	2,11	2,56	2,37	2,17	1,78	2,40	2,37	0,94	2,30	3,02	2,19	2,23	2,27	1,91
Al_2O_3	15,61	16,55	16,07	15,18	16,19	15,36	16,46	19,27	16,31	17,49	17,45	14,66	15,23	15,87
Fe_2O_3	10,20	9,28	10,57	10,52	12,14	9,75	11,52	8,11	10,64	11,80	9,79	9,76	10,30	9,53
MnO	0,17	0,15	0,20	0,19	0,24	0,19	0,20	0,11	0,19	0,20	0,20	0,18	0,24	0,19
MgO	8,46	6,47	8,59	7,11	5,84	11,08	8,37	6,90	6,68	3,92	7,06	9,11	5,54	9,61
CaO	8,16	9,32	10,20	7,94	7,33	9,76	9,72	7,80	8,63	6,42	9,16	8,63	17,30	7,77
Na_2O	3,69	2,88	3,42	3,89	5,05	3,42	3,94	2,85	4,62	5,50	4,62	3,61	3,50	3,49
K_2O	2,41	2,43	2,64	2,12	2,78	2,38	2,71	1,06	2,36	1,63	2,26	1,97	2,34	1,87
H_2O	2,32	3,72	1,59	1,87	0,51	0,88	0,89	2,27	1,12	5,27	2,23	0,76	1,85	3,67
ppm														
B	5,0	2,6	5,1	3,5	1,1	6,2	2,7	8,1	5,5	7,2	2,9	10,0	3,0	5,5
Cl	778	822	378	89	1130	659	742	325	954	123	856	482	792	153
Sc	26,6	32,5	25,4	27,1	0,0	28,4	21,0	30,9	20,5	11,3	27,6	35,5	31,1	26,1
V	216	294	350	303	<100	<100	260	<100	<100	<100	283	291	372	222
Cr	601	498	655	762	<200	<200	569	602	<200	<200	657	882	632	643
Sm	5,6	5,9	5,6	4,4	4,2	5,6	4,3	1,5	5,0	10,7	5,0	4,7	5,2	5,7
Eu	1,6	2,2	1,6	9,2	0,0	1,3	0,0	2,9	1,5	4,5	2,4	0,1	6,5	7,4
Gd	6,0	6,3	6,0	5,2	3,1	6,0	4,7	1,8	5,7	11,1	5,6	5,4	6,2	6,0
Dy	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	9,2	<1	<1	<1

Table 2. Major and trace elements results of studied samples.

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Archaeological and petrographic investigation of polished stone tools of the Neolithic and Copper Age period from the collection of the Hungarian National Museum

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Abstract: 605 pieces of Middle Neolithic to Copper age stone tools from authentic excavations in Hungary were studied, of which 255 pieces were selected for detailed archaeological and petrographical analyses. 175 pieces came from the Eastern part of the country, 81 from the territory to the West of the Danube. During morphological classification we noticed, that the traditional nomenclature do not reflect the actual function of the tools in the majority of cases, in fact the tools were used for several purposes. In these instances, we suggest the name multi-functional plano-convex tool for the tools. Different traces of use observed in natural light by naked eye and by the help of a magnifying glass were encountered on the tools denoting their way of use and hafting. All selected tools were petrographically determined, 33 of which was observed and precised by petrographic microscope. 17 main rock types were distinguished. The majority of stone tools were made of three large group of rocks, the andesite-basalt and meta-volcanites, the ophiolitic originated diorite-dolerite-gabbro and serpentinite-greenschist-blueschist and the sandstone-quartzite groups. Raw material provenance area was grouped on 7 regions according to geographical distribution of the archaeological site and that of the possible source of the rock type.

Key words: petrography, traces of use, polished stone tools, Neolithic and Copper Age, Hungary

Introduction

A research program was started by the financial support of the Hungarian National Science Foundation[1)] in 1997 for the study of polished stone tools in the Hungarian National Museum. The aims of the project were to investigate both archaeological and petrological issues important for the study of polished stone tools. The rich collection of the Hungarian National Museum comprising several thousand stone tools offered an ideal background for these studies. Mainly, evidences of the earliest farming communities found on settlements or burial sites were selected from the period between VIth-IIIth Millennium BC With the exception of the Earliest Neolithic, almost all cultures of these periods were investigated. Due to the research history of the HNM collection, sites from the Eastern, north-eastern parts of Hungary were better represented in this study (Fig. 1).

Opposed to traditional typological investigations, the tools were analysed in a complex way. Emphasis was given to the objective description of the probable function of the tools, traces of utilisation, raw material of the tools and their possible provenance.

Altogether 605 pieces of stone tools were studied, of which 255 pieces were selected for detailed archaeological and petrographical analysis. 175 pieces came from the Eastern part of the country, 81 from the territory to the West of the Danube. All of them came from authentic excavations, their archaeological age could be clearly identified and, at the same time, they represented a characteristic and varied sample of the polished stone tool kit.

Archaeological investigations

Evidences of previous documentation (1850-1999) were revised and organised into a computerised database. All the tools were newly assigned. Aspects of morphological and functional elements were systematically described with special concern on utilised parts (working edge, butt, traces of fixing in handle) and types of use-wear (fracture, wear, polish, abrasion etc.). Dimensions and weight were also recorded. Probable use of the pieces were indicated.

Morphological classification of the tool types was considered essential mainly for their possible chronological implications. Hungarian museums own a large number of polished stone tools of unknown age and (archaeological) provenance the assignment of which can be made possible by comparison with pieces of known context. This method helped us to give possible temporal dimensions to 449 pieces of artefacts from unknown age within the collection of the Museum. Typological classification was made with an eye on the finish of the functional

1) OTKA T-023784, "A MNM újkőkori és rézkori csiszolt kőszerszámainak régészeti és kőzettani vizsgálata" (Archaeological and petrographical investigation of polished stone tools of the Neolithic and Copper Age period from the collection of the Hungarian National Museum).

Slovak Geol. Mag., 10, 1-2(2004), 105-134

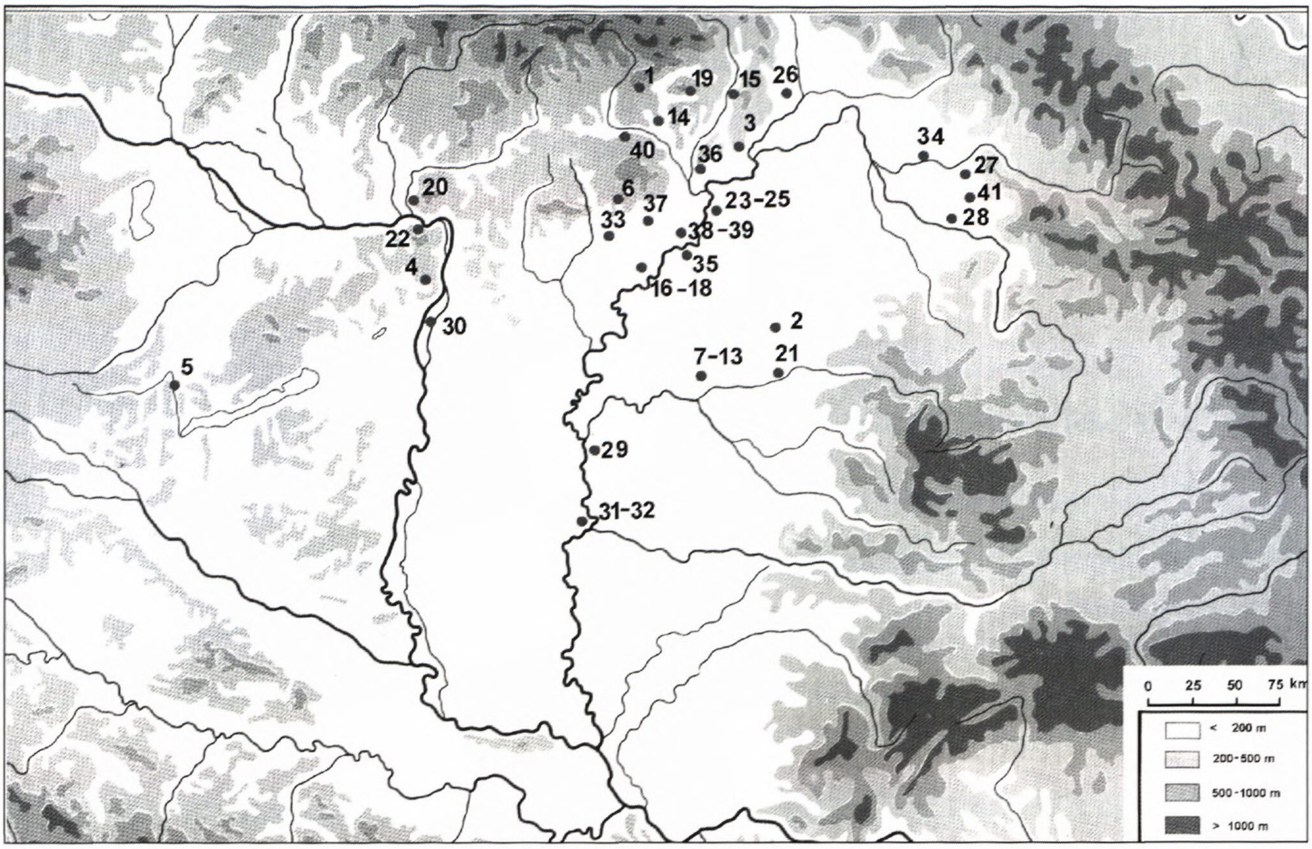

Fig. 1. Archaeological sites investigated (See also Table 1.)

Key: 1 Aggtelek-Baradla barlang;2 Berettyószentmárton;3 Bodrogkeresztúr-Kutyasor ;4 Budakeszi ;5 Csáford;6 Demjén-Hegyeskőbérc;7-13 Dévaványa -Sártó, -Réhelyi gát, -Simasziget;14 Edelény (Borsod)-Derekegyháza;15 Hejce-Püspöktábla;16-18 Kisköre-Gát;19 Krasznokvajda-Kőtelek dűlő;20 Letkés-Vízfogó;21 Magyarhomorog-Kónyadomb;22 Pilismarót-Szobi rév;23-25 Polgár-Csőszhalom, -Folyás-Szilmeg, -Basa-tanya;26 Sátoraljaújhely-Ronyva part;27 Sonkád;28 Szamossályi;29 Szegvár-Tűzköves;30 Szigetcsép-Tangazdaság;31-32 Tápé-Lebő Alsóhalom, -Lebő Felsőhalom;33 Tarnabod;34 Tarpa-Márki tanya;35 Tiszafüred;36 Tiszalúc-Sarkad;37 Tiszanána;38-39 Tiszavalk-Tetes, -Négyesi határ;40 Uppony-Malom ág;41 Zajta

parts (edge, butt, sides). Among the tools, "traditional" forms were separated the form of which underwent no or very little changes during the Neolithic and the Copper Age period. An essential portion of the tools could be classified to this group like plano-convex items. At the same time, types typical of certain periods were also found, e.g. among the axes, more typical for the Late Neolithic / Copper Age cultures.

In course of the typological classification we were facing the inadequacy of traditional nomenclature in most of the cases. Names applied for the tools according to the traditional nomenclature do not reflect the actual function of the tools in the majority of cases. Partly, the terms do not meet the actual function; partly, the tools could be (in fact, were) used for several purposes. E.g., the tool type generally referred to as "flat axe" could not be used as axes proper but served for several, at least three functions, i.e., carving, planing and fine cutting. In these instances, the suggested name for the tools was multi-functional plano-convex tool. In a number of cases we have observed differences in the use of tools seemingly of identical form, not reflected in the name. Such evident differences could be seen in the so-called trapezeform chisels having large (3-400 g) and small (15-20 g) versions. As a consequence it was deduced that while naming the tool, basically the aspects of function should be considered.

Different traces of use were encountered on the tools denoting their way of use and hafting. Most of these signs could be observed in natural light and by the help of a magnifying glass. Fractures, abrasion, polish were observable on the polished surface to the naked eye as well.

Most of the traces observed relate to the way of use of the item (grooving, cutting, planing etc.). Part of the features observed related to way of application and hafting. The handles attached to the stone blades caused characteristic traces of wear: grooves, bright spots, fray. Typical traces of abrasion could be observed for instances of hafting (into a socket or amidst wooden chops), inserting into a handle or pinching the piece out to a sort of handle.

In the following some characteristic types of tools will be presented the function of which could be identified on the basis of traces of characteristic abrasion (Plate I.).

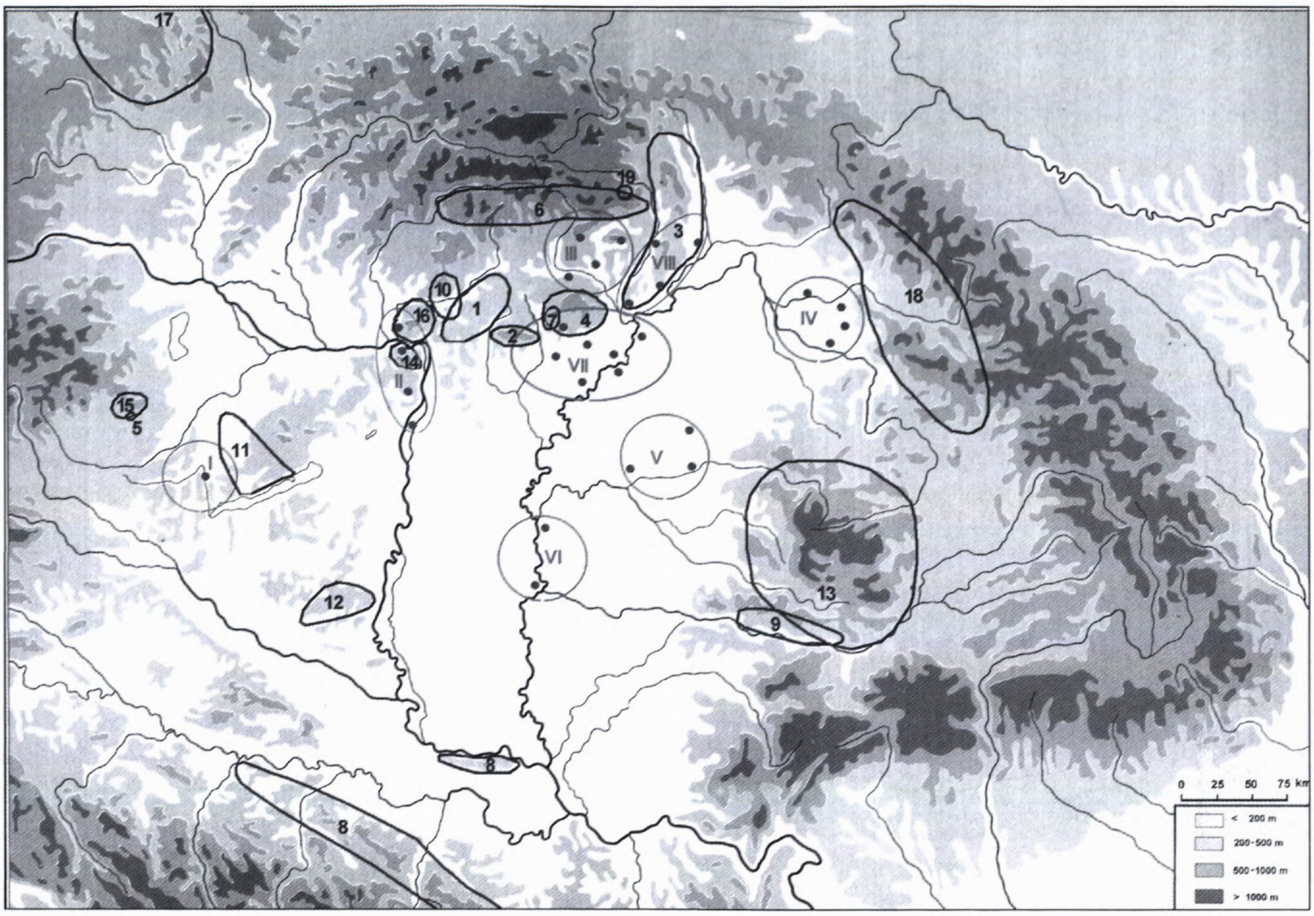

Fig. 2. Connection of the archaeological sites investigated, based on petrographical observations
Key: Roman numbers: archaeological districts I: Zala county region, II: Pilis Mts. region, III: Borsod region, IV: Szamos region, V: Körös region, VI: Szeged environs, VII: Tisza region, VIII; Tokaj Mts. Arabic numbers: raw material source regions 1:Cserhát Mts. , 2: Mátra Mts., 3: Tokaj-Prešov Mts., 4: Bükk Mts., 5: Felsőcsatár environs, 6: Gömör-Szepes Ore Mts., 7: Szarvaskő environs, 8: Vardar zone, 9: Maros (Mureş) valley, 10: Nógrád-Gömör region, 11: Balaton-Highlands, 12: Mecsek Mts., 13: Transylvanian Ore Mts., 14: Visegrád Mts., 15: Penninicum, 16: Börzsöny Mts., 17: Bohemian Massive, 18: Subcarpathian volcanites, 19: Sugov Valley

Petrographic investigations

The aim of the petrographic investigations was to define the raw material of the tools. As a first step, groups of rocks coming possibly of the same geological setting were separated. Analysis was performed macroscopically for the complete set (255 items) and by petrographic microscopy on a selected set of characteristic types, in 33 instances (12,5 % of the total number studied, Table 1). More elaborate analytical studies, necessary for the exact characterisation of the source, could not be accomplished due to high costs of the suitable analyses.

For a preliminary evaluation of the rocks several groups could be distinguished. Some of them, like quartzite or sandstone, can be identified also macroscopically but have a wide geological distribution and the different sources can yield exemplars of very similar appearance. The provenancing of these rock types would require further analytical studies.

There are also some rocks which are relatively easy to identify like serpentinite and actinolite schist or andesite and some plutonic magmatic rocks (e.g., dolerite, gabbro) which are not too frequent therefore even their macroscopical identification can serve as an enlightened guess for the identification of the place of origin. In the case of several interacting source regions, however, their further study is inevitably necessary.

The fastest result can be expected from the identification of rare and characteristic rock types like blueschist due to their unambiguous identification.

The macroscopical identification of certain fine grained rocks is very uncertain therefor they can be effectively separated using petrographical microscope only. The preparation of a thin section made of these rocks is necessary even for the simple identification of the rock.

Identification of the rocks, and mainly, the provenance of the pieces can be helped by the characteristic pattern of occurrence and distribution, i.e., the rocks will often appear as parts of a series. The joint occurrence of these rock types or their appearance in certain district can be of distinctive character. In the case of large areas and a representatively large number of sites the regional distribution of the rock types can also indicate direction and distance of transport.

The characteristic rock types were encountered in the following percentage distribution (Table 2).

Petrographic evaluation and microscopic description[2)] of the rock types of raw material presented in Table 2.

Concerning the whole material investigated we can establish, that the majority of stone tools were made of three large group of rocks. The first group of raw material is given by andesite, basalt and volcanite-metavolcanite (60 pieces). Most of these kind of rocks appear as members of Miocene-Pliocene volcanic series in the Inner Carpathians. The second group contains rock types of ophiolitic origin. This group can be divided to non-, or less metamorphosed (diorite-dolerite-gabbro, (35 pieces)), and metamorphosed (serpentinite, greenschist and blueschist (64 pieces)) subgroups which can be found in four main localities in the surroundings - Penninicum (in Eastern Alps), Szarvaskő-Meliata (in Bükk and Gemericum), Maros Valley (in Transylvanian Mid-Mts.) and Vardar zone (in Dinaric Mts.) - and one a bit further in Bohemian Massive. The third group is given by sandstones and quartzites (63 pieces) which have a wide geological distribution.

Andesite is one of the more frequent rock types in this collection. Different varieties of (mela-, pyroxene-, amphibole-, propylitised-, hydro-, basaltic-) **andesites** (35) were macroscopically determined. All of the six thin section analyses proved the macroscopically determined names, so this is the easiest determinable rock type among the raw materials. 6 andesites from only two localities, all on the margin of Tokaj Mts. were **microscopically** analysed: Five of them turned out to be pyroxene andesite (see microphotos II/4, II/6, III/2) with or without orthopyroxene and olivine phenocrysts and considerable glass content in the groundmass. The sixth sample proved to be strongly weathered mela- andesite (83.35.537, see microphoto II/2.). Andesite tools appeared in the Pilis region and the surroundings of Tokaj and Mátra Mts. These mountains could serve as source regions for andesitic raw materials. Polished stone tools made of andesite are generally known from the material examined so far from Hungary, but with the exception of Aszód-Papi földek (Kalicz 1985, T. Biró 1992, Judik et al. 2001) it was not found frequently in the museum collections. They also represent several types originating from, similar to the collection of the HNM, the Tertiary volcanic regions of the nearby regions. The situation seems similar in Slovakia as well (Hovorka and Soják, 1997; Hovorka and Illášová 2000).

The category of **tuff** is represented by 4 samples of andesite tuff, metamorphosed tuffs and metatufite. There were no thin section analysis made to resolve the small degree of uncertainty of macroscopic determinations. In spite of this, we have allocated two pieces of metamorphosed tuff from Uppony, and the andesitic tuff from Letkés unambigously as derived from the nearest Bükk-Uppony, and Börzsöny Mts., respectively.

In the group of **basalts** (9) 1 metabasalt and 1 questionable quartz-basalt also occurred. Moreover, four basalts of five, determined by petrographic microscope, were described by naked eye as eclogite-hornfels, amphibolite, metamicrogabbro and andesite. The **microscopically** analysed (5) basalts show different character. The sample from Szigetcsép (77.7.25.) is very fresh, and contains a lot of olivine and augite phenocrysts in medium grained plagioclase-augite bearing intergranular groundmass with few rock-glass (see microphoto IV/2.) This is a clearly Neogenic feature. One tool from Tápé (1951.7.66.) has similar character to the Mecsek type basalt. This rock has fine-grained intergranular texture with plagioclase, augite, iddingzitised or fresh olivine, opaque mineral and minor glass (see microphoto III/6) and with only one phenocryst (see microphoto III/4). The sample found in Kisköre is microscopically finer grained, but close to the ophiolitic originated metadolerite (58.35.4, see microphoto IV/6.), so the most probably source region for it is the close lying Szarvaskő area. Because of very fine-grained appearance, more thin section and chemical analyses are needed to distinguish four different possible source of raw materials for stone tools. Perhaps it is more frequent in this collection as presented. At some places in other Hungarian assemblages it was found dominant like in the Mihaldy-collection (Szakmány et al. 2001), comprising almost exclusively Neogene basalts while in the South-Hungarian material, the Mecsek Lower Cretaceous basalt is found together with (lesser amount of) Neogene basalts (Schléder and T Biró 1999, Schléder et al. 2002, Nikl et al. 2002, Füri et al. in this volume). In the neighbouring countries, also several versions were described from Slovakia (Hovorka and Soják, 1997; Hovorka and Illášová 2000, Illášová 2001) and their presence was also noted in Croatia (Balen et al. 2001).

Rhyolite (3) and **volcanites-metavolcanites** (12) were determined only by naked eye. Macroscopic naming in some cases would be necessary to be proved by thin section analysis. Source area for rhyolite is not clearly detected, but the volcanite-metavolcanitic tools are concentrated around and south of Tokaj Mts. where rhyolite is frequent.

In the third largest category of rocks different varieties (meta-, micro- and/or quartz-) of **gabbros, dolerites** and **diorites** (36) were sorted. These rocks are macroscopically very well determinable, only one, the finest grained of 11 **microscopically** analysed samples was determined first, by naked eye, as hornfels. For determining the exact rock name thin section analysis is needed,

[2)] Micrsoscopic description is given only if thin section was made.

and to clear up the source rock, further petrochemical analyses are necessary. On the basis of 12 thin section analyses from 4 localities it is concluded that all of these intrusives could be ranged into one group showing ophiolitic origin character (see for example microphotos IV/6, V/2, V/4, V/6) They have intergranular to ophitic texture and contain magmatic plagioclase and augite, and considerable amount of metamorphic minerals as brown hornblende, actinolite, albite, tremolite, epidote, chlorite, quartz, calcite, and in one case bluish amphibole (1973.13.7.). Rocks of this group are also fairly frequent in other Hungarian polished stone tool assemblages. Their detailed analysis is one of the great debts of petroarchaeological research. They have a variable appearance and composition which is the result of their varied grain size and degree of metamorphosis. Comparable pieces to the HNM collection were found at Aszód (Judik et al. 2001), as well as Szarvas and Endrőd (Starnini and Szakmány 1998). It was also frequently found in Slovakia (Hovorka and Soják, 1997; Hovorka and Illášová 2000).

In the **serpentinite** (26) group 14 pieces of serpentinite (1 of them was established by thin section analysis), 6 different types of metaperidotites (1 was proved microscopically), and 6 uncertainly determined serpentinite (-chlorite schist, -greenschist, -limnoquartzite) was collected. For raw material distinction chemical analyses are necessary. The **microscopically** investigated serpentinite in some places has relict ophitic texture with relict augite and laths of albite (89.2.1063, see microphoto VI/4.). The two metaperidotites investigated by microscope also kept relict texture with considerable amount of pseudomorphs after olivine (see microphoto VI/2.). This group is spread all over the Carpathian Basin both in Hungary and the neighbouring regions in minor quantities but always present (Hovorka and Illášová 1995; Szakmány 1996, Szakmány and Starnini 1998, Schléder and T. Biró 1999; Hovorka and Illášová 2000; Szakmány et al 2001, Nikl et al. 2002., Schléder et al. 2002, Szakmány and Starnini, 2002), more in the Western, south-western territories (T Biró and Szakmány 2000)

7 pieces of chlorite schist were ranked into greenschist group (25), 5 **greenschist** items were proved by microscopic determinations. These rocks are easy to determine macroscopically, but at least thin section analyses are needed for the determination of possible source area of raw material. In four fine-grained rocks, albite, tremolite, epidote, chlorite and fine grained sphene can be distinguished **microscopically**. Schistosity is not very strong (see microphoto VII/2.). These rocks are originated perhaps from Felsőcsatár. In the fifth thin section (70.9.19) beside previous minerals finer grained patches of fibrous zoizite, elongated opaque minerals and thin non-oriented laths of tremolite regulated in lenses are characteristic with strongly developed schistosity (see microphoto VI/6.). This feature is characteristic for certain Bohemian greenschists (Szakmány and Kasztovszky 2001, in prep.). Greenschist is one of the most widely used raw material for polished stone tools in the Carpathian Basin which is even more frequent at the western parts of the basin (Szakmány and Kasztovszky 2001) and the north-eastern territories adjacent to the Carpathian Basin (e.g., Slovakia: Hovorka and Illášová 2000, and the territory of the Bohemian Massiv: Přichystal 2000). Several types could be established by petrography and chemical fingerprinting, part of them probably originating from the Eastern Alps (Penninicum), but a large portion of them originate most probably the Bohemian Massiv (Szakmány and Kasztovszky 2001, in prep).

In the **blueschist** group (13) 10 surely determined (two was ascertained by microscope) and three uncertainly determined (-metagabbro, -amphibolite, -chlorite schist) blueschist was sorted. These tools are mainly concentrated to North Hungary, close to the possible source area in the Gemer Mts. Majority of rock determinations are unambiguous even without thin section analysis. The two microscopically investigated blueschist stone tool contain glaucophane, albite, epidote, titanite and opaque mineral. In the courser grained sample garnet and chlorite also exist (1949.15.233, see microphoto VII/4.). The closest source area is the Gemer Mts. in South Slovakia. A detailed elaboration of blueschist tools found so far in Hungary was performed by Józsa et al. (2001), and further specimens were pointed out by Hovorka et al. (2000) in the adjacent regions.

Hornfels (8) is difficult to determined by naked eye, half of the amount surveyed (4) were similar to quartzite, sandstone and siliceous limestone, two more samples macroscopically determined as hornfels microscopically turned out to be siliceous limestone and basalt. Identification of possible source is difficult even with the help of polarising microscope and needs further specific research. This raw material is also widely distributed in the Carpathian Basin (Hovorka et al. 2001) and the Hungarian polished stone tool kit specifically, more frequent in the SE parts (e.g., Szarvas and Endrőd: Starnini-Szakmány, 1998),

Medium-grained meta-sedimentary rocks rich in quartz (metasandstone, quartzite schist, quartz, quartzite and the transitional types between them) were described as **quartzite** (24). Detailed determination is impossible without thin section analysis, but even this method do not help much in the searching of the source rock. In our collection this rock type is comparatively frequent. It appeared also in other collections, but not in a large quantity.

Jasper (2) and **lydite** (4) was not investigated by microscope, but the few number of samples do not allow considerable conclusions for the raw material. These rock types appear very rarely as raw materials for polished stone tools.

Under the name **sandstone** (39) we collected 34 sandstones, one siliceous and one tuffitic sandstone and three questionable rocks between sandstone, siltstone and chert. Comparatively well determinable, but less informative rock type. One of the main rock groups in this collection. It was found mainly as grinding stone (e.g., Szakmány 1996, Judik et al, 2001 etc.). The fine grained varieties may occur as polished stone tools, as well, though rarely used. (Szakmány et al 2001).

Claystone (4), **limestone** (7), and **diatom schist** (1) in this collection are not very frequent rock types. Valuable information on possible source is not possible without thin section analysis.

Raw material provenance area was grouped according to geographical distribution of the archaeological site and that of the possible source of the rock type.

Zala county region: The only locality from this region studied was Csáford. The two implements analysed from this site cannot reflect the overall features of the area. One of the stone tools found here, made of serpentinite, probably originated from the nearby Kőszeg-Rohonc Mts., because further localities of serpentinite occurrence seem to be very far off (e.g., Gömör-Szepes Ore Mts. or Transylvanian Mid-Mts.)

Pilis Mts. region: There were 6 sites with 27 stone tool items belonging to this group. Of the two rock groups which could be evaluated in respect of provenance, andesites (12 pieces) probably originate from the Börzsöny or Visegrád Mts. Their exact origin could be more precisely defined by thin-section studies. It is interesting to note that they were not found in the material of three sites close to Budapest and further off from the source area and the Danube but were found on the site lying more distant from the source but along the Danube at Szigetcsép. Chlorite schist-actinolite schist appeared here in relatively large quantities (10 pieces). It can be postulated to occur here, at most, in the Danube pebbles. Most of these were found in the material of Budakeszi and Békásmegyer. The provenance of this rock could not be ascertained so far.

Borsod region: 5 sites were assigned to this group with 21 pieces of stone tools. The most abundant rock type here was serpentinite and actinolite schist-blueschist (13) which could be procured from the close-lying Gemer-Szepes Ore Mts. in the so-called Meliata unit. Meta-volcanites and metatuffites here could have originated from the eastern Bükk volcanites. On the northernmost exposed settlements lying further off from the Bükk Mts. (Borsodedelény and Krasznokvajda), these rocks were not present. The dolerite-diorite group of rocks could have come equally from Szarvaskő environs in the Bükk Mts. and the Meliata unit of the Gemer-Szepes Ore Mts. Sandstone implements in this region occurred mainly on the eastern parts (Borsodedelény and Krasznokvajda) and could be connected to the Szamos region.

Archaeological sites of the **Szamos region** can be mainly characterised by the sandstones. There were four sites investigated from here with one item on each site. The more precise location of sandstone could only be realised by expensive analytical techniques, with sampling for comparative material over large areas.

On the sites of the **Körös region** (5 sites with 35 pieces of artefacts investigated), stone tools made of two groups of rocks were found mainly, partly serpentinite and in minor ratio, chlorite and actinolite schist and blueschist. Such rocks are known to occur, nearest, in the Maros valley, a bit further off, also in the Gömör-Szepes Ore Mts. More exact analyses are needed to decide on provenance, which is still in progress. The same can be said about the group of rocks diorite-dolerite-gabbro as well.

Among the rock types of the 48 pieces of artefacts from **Szeged environs** region comprised mainly sandstone (12) which is difficult to attribute for specific sources being widespread and not easily separable. The rock group comprising quartzite (9) is similarly difficult to locate. Rocks comprising serpentinite and actinolite (5) as well as diorite-dolerite-gabbro (10) can be connected to those of the Körös region and an origin from the Maros valley can be postulated for both. The evaluation of further rock types need more analyses.

The most complex region within the study areas was the **Tisza region** (110 pieces analysed). Sites of this region, with one exception only (Tiszavalk), are characterised by the presence of andesite tools (26 items) which could have come from the Tokaj, Mátra or Cserhát Mts. as well but more distant origin (Selmec Mts. or N-Transylvanian outcrops) could be equally considered. By a simple petrographical thin section a more exact sourcing could be realised in this set of samples. Rocks of the serpentinite, chlorite- actinolite- and blueschist group (23 items) appear here not on all of the sites. The considerations made in the case of the Szeged region could be acknowledged here, i.e., they could have come from two directions. The same relates to the group diorite-dolerite-gabbro appearing only on two sites, however, on these two sites in considerable quantities (12 pieces).

A separate **sub-region** is formed by the sites lying **close to the Tokaj Mts**. A small shift in the ratio of rocks can be observed here in favour of andesite which can be explained by the vicinity of the Tokaj Mts. Moreover, apart from the previously mentioned rocks, further characteristic rocks could be observed here. Such is sandstone (21 pieces), with a seemingly characteristic area of distribution but no definite clue on provenance. The most characteristic rock type of the region is quartzite (5 pieces), which is also difficult to locate. At the northernmost lying site of the Tisza group, at Polgár, sandstone and quartzite could be also observed which fits well into our observation made on the distribution of these rocks.

Summary

Analysing the raw material of the tools it is apparent that the people of the Neolithic period used the raw material sources lying close to their settlement, surface outcrops and river pebbles (for example andesite). Copper Age people were less bound to their immediate vicinity. Some raw materials from more distant localities were also in demand like greenschist, blueschist, hornfels and diorite-dolerite-gabbro. For obtaining these raw materials, "expeditions" for several days might have been organised or exchange relations could have been established with the neighbouring cultures.

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Table 1. Description of the polished stone tools investigated by archaeological and petrographical criteria

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Csáford[1)]	axe	1960.15.6.	Copper Age		green quartzite with white weathered crust	
Csáford	symbolic tool	1960.15.7.	Copper Age		serpentinite	Penninic Unit (E-Alps)?
Letkés-Vízfogó[2)]	plane	49.1948.17.	Middle Neolithic		black, fine grained slightly slaty quartzite	
Letkés-Vízfogó	chisel-plane-cutting tool	49.1948.18.	Middle Neolithic		fine grained, homogeneous quartzite(?)	
Letkés-Vízfogó	chisel	49.1948.19.	Middle Neolithic		dark grey very fine grained amphibole andesite	Tokaj Mts.?
Letkés-Vízfogó	symbolic tool	1985.2.161.	Middle Neolithic		medium-dark grey, fine grained andesite tuff	Tokaj Mts.? Mátra Mts.?
Letkés-Vízfogó	chisel-plane-cutting tool	1985.2.162.	Middle Neolithic		black - dark green, strongly foliated quartzite schist	
Letkés-Vízfogó	plane	1985.2.188.	Middle Neolithic		dark grey andesite, rich in plagioclase phenocrysts (max. 0.5 mm)	Visegrádi Mts.? Velence Mts.? Mátra Mts.?
Letkés-Vízfogó	chisel-plane-cutting tool	1985.2.520.	Middle Neolithic		strongly foliated quartzite schist or metasandstone	
Szigetcsép-Tangazdaság[3)]	grinder	1977.7.25.	Copper Age, Baden Culture	TS	gray fine grained basalt with olivine	Balaton Highland or Little Hungarian Plain or Nógrád
Szigetcsép-Tangazdaság	undetermined	1977.7.333.	Copper Age, Baden Culture		dark green, fine grained homogeneous greenschist (actinolite schist)	Felsőcsatár? Bohemian Massive?
Pilismarót-Szobi rév[4)]	chisel-plane-cutting tool	1984.1.60.	Copper Age, Baden Culture		gray andesite	Visegrádi Mts.
Pilismarót-Szobi rév	chisel	1987.21.395.	Copper Age, Baden Culture		medium grained well crystallized fresh andesite	Visegrádi Mts.

1) Korek (1960).
2) Papp (1973).
3) Korek (1984).
4) Unpublished finds. With kind permission of M. Bondár.

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Pilismarót-Szobi rév	symbolic tool	1988.1.2343.	Copper Age, Baden Culture		dark gray, fine grained andesite, rich in oriented plagioclase phenocrysts	Visegrádi Mts.
Pilismarót-Szobi rév	other stone utensil	1988.1.2258.	Copper Age, Baden Culture		Silicified andesite (jasper-like)	Visegrádi Mts.? Börzsöny?, Mátra Mts.?
Pilismarót-Szobi rév	chisel-plane-cutting tool	1988.1.3077.	Copper Age, Baden Culture		fine grained greyish black andesite(?)	Visegrádi Mts.? Börzsöny? Cserhát? Mátra Mts.?
Pilismarót-Szobi rév	chisel-plane-cutting tool	1988.1.3078.	Copper Age, Baden Culture		chlorite schist rich in quartz	
Pilismarót-Szobi rév	cutting axe	1988.1.3079.	Copper Age, Baden Culture		very fine grained, dark grey andesite	Visegrádi Mts.? Börzsöny? Cserhát? Mátra Mts.?
Pilismarót-Szobi rév	cutting axe	1989.1.200.	Copper Age, Baden Culture		gray, fine grained and porous andesite (weathered)	Visegrádi Mts.? Börzsöny? Cserhát? Mátra Mts.?
Pilismarót-Szobi rév	other stone utensil	1989.1.318.	Copper Age, Baden Culture		hornfels (pebble)	Apuseni Mts.?
Pilismarót-Szobi rév	undetermined	1989.1.363.	Copper Age		dark grey amafitic andesite	Mátra Mts.? Cserhát? Visegrádi Mts.?
Pilismarót-Szobi rév	grinder	1989.1.363	Copper Age		amafitic andesite	Mátra Mts.? Cserhát? Visegrádi Mts.?
Budakeszi[5)]	chisel	1969.17.1.	Middle Neolithic		dark green, fine grained strongly schistosed chlorite schist	
Budakeszi	chisel-plane-cutting tool	1969.17.2	Middle Neolithic		finely schistosed green chlorite schist	
Pomáz[6)]	symbolic tool	1957.34.40.	Middle Neolithic		strongly schistosed chlorite schist	
Békásmegyer[7)]	chisel-plane-cutting tool	9.1937.2.	Middle Neolithic		dark green, schistosed chlorite schist	
Békásmegyer	chisel-plane-cutting tool	9.1937.1.	Middle Neolithic		dark green chlorite schist	
Demjén-Hegyeskõbérc[8)]	chisel-plane-cutting tool	1975.2.274.	Middle Neolithic		light green and white metavolcanite(?)	Bükk Mts.?
Uppony-Malom ág[9)]	chisel	1962.68.12.	Middle Neolithic		slightly metamorphosed tuff	Bükk Mts.?
Uppony-Malom ág	symbolic chisel	1962.68.26.	Middle Neolithic		light greenish grey slightly metamorphosed tuff	Bükk Mts.?

5) Excavation of A. Mozsolics and J. Korek. Unpublished finds.
6) Excavation of I. Bognár-Kutzián and S. Sashegyi. Unpublished finds.
7) Excavation of F. Tompa in 1932. Unpublished finds.
8) Dobosi(1976).
9) Korek (1971).

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Aggtelek-Baradla barlang[10]	chisel	37.1948. 37.	Middle Neolithic		medium size grained, slightly lineated blueschist	Gemericum
Aggtelek-Baradla barlang[11]	paint crusher made of symbolic tool	64.1929.63.	Middle Neolithic		dolerite	Szarvaskõ? Vardar zone? Maros-valley?
Krasznokvajda-Kõtelek dûlõ[12]	plane	1980.1.104.	Middle Neolithic		very fine grained laminated siliceous sandstone - clayey siltstone	
Tarnabotörölnid[13] ***	fragment of polished tool	1980.1.155.	Middle Neolithic		actinolitised blueschist	Gemericum
Edelény (Borsod)-Derekegyháza[14]	chisel	15.1949.69.	Middle Neolithic		greenschist (actinolite schist)	Felsõcsatár? Bohemian Massive?
Edelény (Borsod)-Derekegyháza	chisel-plane-cutt ing tool	15.1949.70.	Middle Neolithic		fine grained, slightly bluish grey metavolcanite	Bükk Mts.?
Edelény (Borsod)-Derekegyháza	chisel-plane-cutting tool	15.1949.71.	Middle Neolithic		serpentinite	
Edelény (Borsod)-Derekegyháza	undetermined plano-convex tool	15.1949.72.	Middle Neolithic	TS	dark green greenschist (actinolite schist)	Felsõcsatár
Edelény (Borsod)-Derekegyháza	chisel	15.1949.73.	Middle Neolithic	TS	greenschist (actinolite schist)	Felsõcsatár
Edelény (Borsod)-Derekegyháza	undetermined plano-convex tool	15.1949.74.	Middle Neolithic		white microholocrystalline diorite	
Edelény (Borsod)-Derekegyháza	chisel-plane-cutt ing tool	15.1949.125.	Middle Neolithic	TS	greenschist or contact metamorphite	
Edelény (Borsod)-Derekegyháza	chisel-cutting tool	15.1949.155a.	Middle Neolithic		blueschist with epidote and actinolite.	Gemericum
Edelény (Borsod)-Derekegyháza	chisel-plane-cutting tool	15.1949.181.	Middle Neolithic		blueschist, with vein of epidote-quartz-albite.	Gemericum
Edelény (Borsod)-Derekegyháza	undetermined tool	15.1949.192.	Middle Neolithic		serpentinite.	
Edelény (Borsod)-Derekegyháza	chisel-plane-cutting tool	15.1949.224.	Middle Neolithic	TS	blueschist	Gemericum
Edelény (Borsod)-Derekegyháza	chisel-plane-cutting tool	15.1949.233.	Middle Neolithic	TS	blueschist with garnet	Gemericum
Edelény (Borsod)-Derekegyháza	chisel	15.1949.234.	Middle Neolithic	TS	greenschist (actinolite schist) with epidote	Felsõcsatár
Edelény (Borsod)-Derekegyháza	other stone utensil	15.1949.235.	Middle Neolithic		sandstone	

10) Korek (1970).
11) Excavation of F. Tompa in 1929. Unpublished.
12) Losits (1980)
13) Unpublished surface find from the neolithic settlement.
14) Korek-Patay (1958).

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Edelény (Borsod)-Derekegyháza	chisel-plane-cutting tool	15.1949.287.	Middle Neolithic		actinolitised blueschist	Gemericum
Sátoraljaújhely-Ronyva part[15)]	plane	27.1912.34.	Middle Neolithic		green coloured siliceous fine grained volcanite	Tokaj Mts. ?
Sátoraljaújhely-Ronyva part	cutting axe	27.1912.35.	Middle Neolithic	TS	pyroxene andesite	Tokaj Mts.? Cserhát? Mátra Mts.?
Sátoraljaújhely-Ronyva part	chisel	27.1912.36.	Middle Neolithic		light grey amphibole bearing andesite	Tokaj Mts. ?
Sátoraljaújhely-Ronyva part	chisel-cutting tool	27.1912.37.	Middle Neolithic		translucent, red-greenish-bluish grey, quartzite, resembling jasper	
Sátoraljaújhely-Ronyva part	chisel-plane-cutting tool	27.1912.38.	Middle Neolithic		green metavolcanite with lilac pebble	Tokaj Mts.? Bükk Mts.?
Sátoraljaújhely-Ronyva part	chisel-plane-cutting tool	27.1912.39.	Middle Neolithic		striped, greyish-yellow siliceous sandstone	
Sátoraljaújhely-Ronyva part	symbolic tool	27.1912.40.	Middle Neolithic		siliceous siltstone-fine grained sandstone	
Sátoraljaújhely-Ronyva part	chisel-plane-cutting tool	27.1912.41.	Middle Neolithic		fine grained greenish metavolcanite (keratophyre?)	Bükk Mts.?
Sátoraljaújhely-Ronyva part[16)]	symbolic tool / paint crusher	50.1929.7.	Middle Neolithic		siliceous, kaolinitic sandstone.	
Sátoraljaújhely-Ronyva part	symbolic tool	50.1929.8.	Middle Neolithic		clayey slightly limonitic sandstone	
Sátoraljaújhely-Ronyva part	chisel-plane-cutting tool	50.1929.9.	Middle Neolithic		fine grained, siliceous sandstone	
Sátoraljaújhely-Ronyva part	symbolic tool	50.1929.10.	Middle Neolithic	TS	basaltic andesite with olivine	Cserhát?
Sátoraljaújhely-Ronyva part	symbolic tool	50.1929.11.	Middle Neolithic		striped, slightly siliceous sandstone.	
Sátoraljaújhely-Ronyva part	symbolic tool	50.1929.12.	Middle Neolithic	TS	slightly altered greenish grey glassy pyroxene andesite	Tokaj Mts.
Hejce-Püspöktábla[17)]	symbolic tool	1984.2.1142.	Middle Neolithic		dark grey pyroxene andesite	Tokaj Mts? Mátra? Cserhát?
Hejce-Püspöktábla	chisel-plane-cutting tool	1984.2.1672.	Middle Neolithic		propilitised andesite	Tokaj Mts.? Mátra Mts.?
Hejce-Püspöktábla	other stone utensil	1984.2.1942.	Middle Neolithic		metamorphic quartz	
Tarnabod[18)]	chisel-cutting-grooving tool	1953.7.28.	Middle Neolithic		fine grained medium grey amphibole andesite	Tokaj Mts?
Tarnabod	symbolic chisel	1953.7.62.	Late Copper Age		black spotted schist	

15) Visegrádi (1912).
16) Visegrádi (1937).
17) Losits (1981)
18) Kalicz-Makkay (1977).

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Bodrogkeresztúr-Kutyasor[19)]	chisel-plane-cutting tool	1953.38.81.	Late Neolithic		very fine grained, layered quartzite or quartzarenite	
Bodrogkeresztúr-Kutyasor	chisel-plane-cutting tool	1953.38.82.	Late Neolithic		blueschist	Gemericum
Bodrogkeresztúr-Kutyasor	symbolic chisel	1953.38.83	Middle Neolithic		striped serpentinite	
Bodrogkeresztúr-Kutyasor	symbolic chisel	1953.38.84	Middle Neolithic		fine grained andesite	Tokaj Mts.? Mátra Mts? Cserhát Mts?
Tiszalúc-Sarkad[20)]	adze	1976.2.1.	Copper Age, Hunyadihalom Culture		dolerite	Maros-valley? Szarvaskő? Vardar-zone?
Tiszalúc-Sarkad	undetermined	1977.8. 197.	Copper Age, Hunyadihalom Culture		Coarse grained micaceous sandstone	
Tiszalúc-Sarkad	adze	1977.9. 230.	Copper Age, Hunyadihalom Culture		Fine grained tuffy sandstone or sandy tuff	
Tiszalúc-Sarkad	grinder-polisher	1980.3. 71.	Copper Age, Hunyadihalom Culture		Fine grained hard micaceous (meta)sandstone slightly foliated, rich in muscovite.	
Tiszalúc-Sarkad	undetermined	1980.3. 137.	Copper Age, Hunyadihalom Culture		lydite (black quartzite)	
Tiszalúc-Sarkad	chisel-plane-cutting tool	1980.30.221.	Copper Age, Hunyadihalom Culture		green banded quartzite	
Tiszalúc-Sarkad	chisel	1980.3. 341.	Copper Age, Hunyadihalom Culture		fine grained, grey andesite	Tokaj Mts.? Mátra? Cserhát?
Tiszalúc-Sarkad	chisel	1982.3.251.	Copper Age, Hunyadihalom Culture		massive, slightly oriented metavolcanite with rare small cavities	Bükk Mts.?
Tiszalúc-Sarkad	symbolic axe	1982.3. 425.	Copper Age, Hunyadihalom Culture	TS	dark grey, medium grained basaltic andesite with cavities	Cserhát
Tiszalúc-Sarkad	axe	1983.35.379.	Copper Age, Hunyadihalom Culture		lydite (black quartzite)	
Tiszalúc-Sarkad	chisel	1983.35.537.	Copper Age, Hunyadihalom Culture	TS	gray, fine grained sericitized amaphitic andesite with small cavities	Cserhát? Tokaj Mts.? Mátra?
Tiszalúc-Sarkad	axe	1983.35.589.	Copper Age, Hunyadihalom Culture		black very fine grained quartzite (Lydite?)	

19) Korek-Patay (1958).
20) Excavation of P. Patay. Examination of polished and grinding stone made by H. Oravecz and S. Józsa.

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Tiszalúc-Sarkad	adze	1983.35.590.	Copper Age, Hunyadihalom Culture	TS	fine grained metadolerite (diabase)	Maros-valley? Szarvaskõ? Vardar-zone?
Tiszalúc-Sarkad	chisel	1986.30.130.	Copper Age, Hunyadihalom Culture		green, slightly slaty metavolcanite	Bükk Mts.?
Tiszalúc-Sarkad	symbolic tool	1986.30.531.	Copper Age?	TS	fine grained strongly sheared metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Tiszalúc-Sarkad	symbolic chisel	1986.11.216.	Copper Age, Hunyadihalom Culture		light green, slightly mottled fine grained siliceous sandstone	
Tiszalúc-Sarkad	adze	1986.12.497.	Copper Age, Hunyadihalom Culture	TS	pyroxene andesite	Tokaj Mts.
Tiszalúc-Sarkad	cutting axe	1987.5. 252.	Copper Age, Hunyadihalom Culture		blueschist or chlorite schist	
Tiszalúc-Sarkad	chisel	1987.5. 536.	Copper Age, Hunyadihalom Culture		green metavolcanite	Bükk Mts.?
Tiszalúc-Sarkad	chisel	1987.6. 309.	Copper Age, Hunyadihalom Culture		metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Tiszalúc-Sarkad	chisel	1987.6. 397.	Copper Age, Hunyadihalom Culture		basaltic andesite	Cserhát?
Tiszalúc-Sarkad	other stone utensil	1987.6. 730.	Copper Age, Hunyadihalom Culture		quartzite or fine grained metasandstone	
Tiszalúc-Sarkad	other stone utensil	1988.7 82.	Copper Age, Hunyadihalom Culture		Fine grained micaceous sandstone	
Tiszalúc-Sarkad	other stone utensil	1988.7. 131.	Copper Age, Hunyadihalom Culture		diorite or sienite	
Tiszalúc-Sarkad	symbolic chisel	1988.7. 195.	Copper Age, Hunyadihalom Culture		slightly foliated metamorphic quartzite with ore minerals	
Tiszalúc-Sarkad	chisel	1988.7. 379.	Copper Age, Hunyadihalom Culture		coarse grained siliceous sandstone (quartzarenite)	
Tiszalúc-Sarkad	chisel	1988.7. 866.	Copper Age, Hunyadihalom Culture		dark grey, argillaceous, bituminous limestone	Bükk Mts.?
Tiszalúc-Sarkad	symbolic chisel	1988.7. 1011.	Copper Age, Hunyadihalom Culture		reddish grey, medium grained micaceous sandstone	

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Tiszalúc-Sarkad	symbolic tool	1988.7. 1244.	Copper Age, Hunyadihalom Culture		propilitised andesite	Tokaj Mts.? Mátra? Börzsöny?
Tiszalúc-Sarkad	chisel-plane-cutting tool	1988.7. 1245	Copper Age, Hunyadihalom Culture		dark grey micaceous quartzite or hornfels	
Tiszalúc-Sarkad	chisel	1988.7. 1381.	Copper Age, Hunyadihalom Culture		light-medium green strongly altered andesite	Tokaj Mts.? Mátra? Visegrádi Mts? Börzsöny?
Tiszalúc-Sarkad	adze	1988.7. 1464.	Copper Age, Hunyadihalom Culture		andesite	Tokaj Mts.? Mátra Mts.? Cserhát? Visegrádi Mts.?
Tiszalúc-Sarkad	chisel	1988.7. 1599.	Copper Age, Hunyadihalom Culture		fine grained andesite	Tokaj Mts.?
Tiszalúc-Sarkad	chisel	1988.8. 16.	Copper Age, Hunyadihalom Culture		green, propilitised andesite	Tokaj Mts.? Mátra? Börzsöny?
Tiszalúc-Sarkad	grinder	1989.2.120.	Copper Age, Hunyadihalom Culture		white quartzarenite	
Tiszalúc-Sarkad	other stone utensil	1989.2.164.	Copper Age, Hunyadihalom Culture		sandstone	
Tiszalúc-Sarkad	other stone utensil	1989.2.1063.	Copper Age, Hunyadihalom Culture	TS	serpentinite	
Tiszalúc-Sarkad	other stone utensil	1989.4.512.	Copper Age, Hunyadihalom Culture		greenish-black slightly mottled hornfels	Apuseni Mts.?
Tiszalúc-Sarkad	chisel-plane-cutting tool	1989.4.458.	Copper Age, Hunyadihalom Culture		dark red, fine grained micaceous sandstone	
Tiszalúc-Sarkad	chisel-plane-cutting tool	1989.4.459.	Copper Age, Hunyadihalom Culture		red, medium grained micaceous sandstone	
Tiszalúc-Sarkad	other stone utensil	1992.1.902.	Copper Age, Hunyadihalom Culture		quartzite schist	
Tiszalúc-Sarkad	other stone utensil	1992.1. 746.	Copper Age, Hunyadihalom Culture		dark grey, clayey, bituminous limestone	Bükk Mts.?
Tiszalúc-Sarkad	other stone utensil	1990.1.42.	Copper Age, Hunyadihalom Culture		greenschist	Felsőcsatár? Bohemian Massive?
Tiszalúc-Sarkad	grinder	1993.1.78.	Copper Age, Hunyadihalom Culture		andesite with large amount of phenocrysts	Tokaj Mts.? Mátra? Börzsöny?

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Tiszalúc-Sarkad	chisel-plane-cutting tool	1994.10.4.	Copper Age, Hunyadihalom Culture		medium-dark green, siliceous metavolcanite (keratophyr)	Bükk Mts.?
Tiszalúc-Sarkad	symbolic tool	1995.11. 377.	Copper Age, Hunyadihalom Culture		volcanogenic sandstone(?) with muscovite	
Tiszalúc-Sarkad	chisel-plane-cutting tool	1995.2.117.	Copper Age, Hunyadihalom Culture		pink and yellow diatomic schist	Tokaj Mts. or Mátra Mts.
Tiszalúc-Sarkad	chisel	1996.1.44.	Copper Age, Hunyadihalom Culture		chloritised dolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Tiszalúc-Sarkad	grinder	1996.1.90.	Copper Age, Hunyadihalom Culture		dark grey andesite with large amount of amphibole phenocrysts	Tokaj Mts.
Tiszalúc-Sarkad	chisel	1996.1.141.	Copper Age, Hunyadihalom Culture		dark grey, medium grained micaceous sandstone	
Tiszalúc-Sarkad	chisel	1996.1.170.	Copper Age, Hunyadihalom Culture		dolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Tiszalúc-Sarkad	plane	1996.1.207.	Copper Age, Hunyadihalom Culture		yellowish grey, medium grained micaceous sandstone	
Tiszalúc-Sarkad	symbolic chisel	1996.1.281.	Copper Age, Hunyadihalom Culture		greenish-red quartzarenite	
Tiszavalk-Négyesi határ[21)]	grooving axe	1970.9.19.	Copper Agei	TS	greenschist (actinolite-schist)	Bohemian Massiv
Tiszavalk-Négyesi határ	symbolic cutting axe	1970.9.325.	Copper Age		basalt(?)	Nógrád? Balaton-highland? Mecsek?
Tiszavalk Tetes[22)]	other stone utensil	1962.67.46.	Middle Copper Age		green metavolcanite with light pink grains	Bükk Mts.?
Kisköre-Gát[23)]	symbolic tool	1967.2.162.	Middle Neolithic		fine grained grey porphyritic (feldspars, piroxene) andesite	Tokaj Mts.? Mátra? Cserhát?
Kisköre-Gát	chisel-plane-cutting tool	1963.27.1.	Late Neolithic, Tisza Culture		serpentinite or greenschist	
Kisköre-Gát	chisel-plane-cutting tool	1963.27.21.	Late Neolithic, Tisza Culture		dark-light striped serpentinite or greenschist	
Kisköre-Gát	cutting axe	1963.27.39.	Late Neolithic, Tisza Culture	TS	weathered metaperidotite	Maros-valley? Szarvaskõ? Vardar-zone?

21) Excavation of P. Patay. Unpublished finds.
22) Patay (1978), (1979).
23) Korek (1977a).

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Kisköre-Gát	grooving axe	1963.27.74.	Late Neolithic, Tisza Culture	TS	weathered microquartzdiorite (banatite?)	Apuseni Mts.?
Kisköre-Gát	axe	1965.16.7.	Late Neolithic, Tisza Culture		dolerite or microquartzdiorite	
Kisköre-Gát	chisel	1965.16.82.	Late Neolithic, Tisza Culture		fine grained, homogeneous, chromitic serpentinite	Maros-valley? Vardar-zone?
Kisköre-Gát	symbolic chisel	1966.4.1.	Late Neolithic, Tisza Culture		blueschist or amphibolite	
Kisköre-Gát	cutting axe	1966.4.2.	Late Neolithic, Tisza Culture	TS	metasomatized basalt	Szarvaskõ? Maros-valley? Vardar-zone?
Kisköre-Gát	chisel	1966.4.157.	Late Neolithic, Tisza Culture		serpentinite (metaperidotite) with relict texture	
Kisköre-Gát	chisel	1966.4.203.	Late Neolithic, Tisza Culture		serpentinite (metaultramafite) with chromite	
Kisköre-Gát	chisel-plane-cutting tool	1966.4.204.	Late Neolithic, Tisza Culture		dark green metavolcanite(?) with small sized porphyrytic feldspar	Bükk Mts.?
Kisköre-Gát	chisel-plane-cutting tool	1966.4.205.	Late Neolithic, Tisza Culture		hornfels with white mica	Apuseni Mts.?
Kisköre-Gát	chisel-plane-cutting tool	1966.4.206.	Late Neolithic, Tisza Culture		serpentinite	
Kisköre-Gát	chisel	1967.8.3.	Late Neolithic		metabasalt	
Kisköre-Gát	chisel-plane-cutting tool	1967.8.4.	Late Neolithic		meta-microgabbro	Maros-valley? Szarvaskõ? Vardar-zone?
Kisköre-Gát	chisel-plane-cutting tool	1967.8.347.	Late Neolithic		dark grey limestone with calcite veins	Bükk Mts.?
Kisköre-Gát	chisel-plane-cutting tool	1967.8.417.	Late Neolithic		dolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Tiszanána[24)]	chisel-plane-cutting tool	1969.19.1.	Middle Neolithic		dark grey andesite	Tokaj Mts.? Mátra? Cserhát?
Tiszafüred[25)]	chisel-plane-cutting tool	1973.31.134.	Copper Age		metavolcanite	Bükk Mts.?
Polgár-Basatanya[26)]	chisel	1952.95.86.	Copper Age, Bodrogkeresztúr Culture		slightly translucent serpentinite	
Polgár-Basatanya	chisel-plane-cutting tool	1952.95.104.	Copper Age, Bodrogkeresztúr Culture		greenschist (actinolite schist)	Felsõcsatár? Bohemian Massiv?

24) Excavation of J. Korek. Unpublished find.
25) Excavation of T. Kovács. Unpublished find.
26) Bognár-Kutzián (1963).

Slovak Geol. Mag., 10, 1–2(2004), 105-134

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Polgár-Basatanya	mace-head	1953.1.29.	Copper Age, Bodrogkeresztúr Culture		white marl or limestone, with oolithes	
Polgár-Basatanya	plane	1953.1.183a	Copper Age, Bodrogkeresztúr Culture		greenschist (actinolite schist)	Felsõcsatár? Bohemian Massiv?
Polgár-Basatanya	symbolic tool	1953.1.84.	Copper Age, Bodrogkeresztúr Culture		fine grained quartzarenite	
Polgár-Basatanya	symbolic tool	1953.1.192.	Copper Age, Bodrogkeresztúr Culture		light green/dark green serpentinised metaperidotite or retrograde eclogite, with garnet and lilac grains	
Polgár-Basatanya	symbolic tool	1953.7.36.	Copper Age, Bodrogkeresztúr Culture		dark gray hidroandesite	Tokaj Mts.? Mátra Mts.?
Polgár Folyás-Szilmeg[27)]	symbolic chisel	1952.77.45.	Middle Neolithic		eclogite(?)	W-Alps? Bohemian-Massiv?
Polgár Folyás-Szilmeg	chisel-plane-cutting tool	1952.77.283.	Middle Neolithic		eclogite(?)	W-Alps? Bohemian-Massiv?
Polgár Folyás-Szilmeg	chisel-plane-cutting tool	1952.77.284.	Middle Neolithic		very fine grained dark grey quartzite	
Polgár Folyás-Szilmeg	plane	1952.77.285.	Middle Neolithic		slightly reddish-brown, dark grey quartzite	
Polgár Folyás-Szilmeg	chisel-plane-cutting tool	1952.77.286.	Middle Neolithic		dark green siliceous porphyric (feldspar) andesite with slightly fluidal texture	Tokaj Mts.? Mátra? Cserhát?
Polgár Folyás-Szilmeg	chisel-plane-cutting tool	1952.77.572.	Middle Neolithic		blueschist with stripes of epidote	Gemericum
Polgár Csõszhalom[28)]	chisel-cutting tool	1951.125.2.	Late Neolithic		sandstone	
Polgár Csõszhalom	chisel-cutting tool	1951.125.3a.	Late Neolithic		fine grained gray andesite	Tokaj Mts.? Mátra? Cserhát?
Polgár Csõszhalom	chisel-cutting tool	1951.125.3b.	Late Neolithic		banded greenschist (actinolite schist)	Felsõcsatár? Bohemian Massiv?
Polgár Csõszhalom	chisel-cutting tool	1951.125.3c.	Late Neolithic		greenschist (actinolite schist)	Felsõcsatár? Bohemian Massiv?
Zajta[29)]	plane	1975..32.1.	Middle Neolithic		clayey sandstone.	
Sonkád[30)]	symbolic tool	1975.37.136.	Middle Neolithic		dark grey clayey sandstone	

27) Bognár-Kutzián (1966).
28) Collection of T. Bender.
29) Korek (1977b).
30) Korek (1977b)

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Tarpa-Márki tanya[31)]	symbolic tool	1980.7.31.	Middle Neolithic		clayey sandstone	
Szamossályi[32)]	symbolic chisel	1964.1.34.	Middle Neolithic		slightly yellowish light grey, very fine grained claystone	
Dévaványa-Sártó[33)]	symbolic tool	14.1936.1.	Middle Neolithic	TS	metaquartzgabbro, with thin greenish laths of feldspar	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Sártó	chisel-plane-cutting tool	25.1936.1.	Middle Neolithic		greenschist (actinolite schist) with small feldspar lenses	Felsõcsatár? Bohemian Massiv?
Dévaványa-Sártó	chisel	25.1936.2.	Middle Neolithic		strongly siliceous dark green actinolitised blueschist with epidote bands	Gemericum
Dévaványa-Sártó[34)]	chisel-plane tool	1958.35.1.	Middle Neolithic		epidote rich chlorite schist	
Dévaványa-Sártó	chisel-plane-cutting tool	1958.35.2.	Middle Neolithic		siliceous meta-tuffite	
Dévaványa-Sártó	chisel	1958.35.3.	Middle Neolithic		metagabbro or blueschist	
Dévaványa-Sártó	cutting axe	1958.35.4.	Middle Neolithic	TS	(meta)dolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Sártó	symbolic tool	1958.35.5.	Middle neolitium		sandy muscovitic claystone	
Dévaványa-Sártó[35]	paint crusher	1960.35.25.	Middle Neolithic		amphibolite or metadolerite with feldspars and quartz veins	
Dévaványa-Sártó	other stone utensil	1960.35.27.	Middle neolitkum		fine grained white limestone	
Dévaványa-Sártó	mace-head	1960.35.34.	Middle Neolithic		dark grey gabbro(?)	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Sártó	symbolic tool	1960.35.45.	Middle neolitikum		metadolerite with dark green actinolite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Sártó	chisel-plane-cutting tool	1960.35.104.	Middle Neolithic		green metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Sártó	chisel-plane-cutting tool	1960.35.105.	Middle Neolithic		bluish wavy banded greenschist (actinolite schist)	Felsõcsatár? Bohemian Massiv?
Dévaványa-Sártó	chisel	1960.35.106.	Middle Neolithic		gereenschist (actinolite schist)	Felsõcsatár? Bohemian Massiv?

31) Dobosi (1983).
32) Korek (1977).
33) Oravecz-Józsa (2001).
34) Oravecz-Józsa (2001).
35) Korek (1960); Oravecz-Józsa (2001).

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Dévaványa-Sártó	symbolic axe	1960.35.107.	Middle Neolithic	TS	metaperidotite	Maros-valley? Vardar-zone?
Dévaványa-Sártó	other stone utensil	1960.35.108.	Middle Neolithic		jasper	Tokaj Mts.? Mátra Mts.?
Dévaványa-Sártó[36)]	chisel	1973.19.5.	Middle Neolithic		dolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Sártó	chisel-plane-cutting tool	1973.19.6.	Middle Neolithic		basalt(?)	Nógrád? Balaton-highland? Mecsek?
Dévaványa-Sártó	symbolic tool	1973.19.7.	Middle Neolithic		metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Simasziget[37)]	chisel	1963.26.1.	End of Middle Neolithic, beginning of Late Neolithic		serpentinite.	
Dévaványa-Simasziget	chisel	1963.26.2.	Middle Neolithic		chlorite schist or serpentinite with white stripes	
Dévaványa-Simasziget	chisel-plane-cutting tool	1963.26.3.	Middle Neolithic		dark green serpentinite.	
Dévaványa-Simasziget	chisel	1963.26.4.	Middle Neolithic		serpentinised metagabbro	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Simasziget	chisel	1963.26.5.	Middle Neolithic		metagabbro-metadoler ite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Simasziget	plane	1963.26.6.	Middle Neolithic		metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Simasziget	symbolic tool	1963.26.7.	Middle Neolithic		metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Simasziget	chisel	1963.26.8.	Middle Neolithic		metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Réhelyi gát[38)]	chisel	1973.21.6.	Middle Neolithic?	TS	(meta)dolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Dévaványa-Réhelyi gát	chisel	1973.21.7.	Middle Neolithic		metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Berettyószentmár-ton[39)]	chisel	1956.10.1469.	Middle Neolithic		Very fine grained sandstone (similar to hornfels)	

36) Oravecz-Józsa (2001).
37) Kalicz-Makkay (1977); Oravecz-Józsa (2001).
38) Ecsedy (1982); Oravecz-Józsa (2001).
39) Bognár-Kutzián (1972).

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Berettyószentmárton	undetermined	1956.10.1718.	Middle Neolithic		fine grained, dark green serpentinite or greenschist	
Berettyószentmárton	chisel-plane-cutting tool	1956.10.1766.	Middle Neolithic		dark-medium green, finely striped, massive serpentinite or greenschist	
Berettyószentmárton	chisel	1956.10.1787.	Middle Neolithic		very fine grained, microcrystalline basalt	Mecsek? Nógrád? Balaton-highland?
Magyarhomorog-Kónyadomb[40)]	macehead	1964.12.25.	Copper Age, Bodrogkeresztúr Culture		metaultramafite with bronze coloured serpentinised orthopyroxene crystals	Maros-valley? Szarvaskõ? Vardar-zone?
Magyarhomorog-Kónyadomb	symbolic axe	1965.20.124.	Copper Age, Bodrogkeresztúr Culture		green, propilitised andesite with pyrite crystals	Tokaj Mts.? Mátra Mts?
Magyarhomorog-Kónyadomb	symbolic axe	1965.20.133.	Copper Age, Bodrogkeresztúr Culture		light green serpentinite	
Tápé-Lebõ, Alsóhalom[41)]	other stone utensil	7.1951.7.	Late Neolithic, Tisza culture		lydite (black laminated quartzite)	
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.50.	Late Neolithic, Tisza culture		sandstone, with very fine grained limonitic psudomorphoses	
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.65.	Late Neolithic, Tisza culture		hard, greenish black-light green banded-mottled massive quartzite	
Tápé-Lebõ, Alsóhalom	paint crusher made of a grooving axe	7.1951.66.	Late Neolithic, Tisza culture	TS	basalt	Mecsek?
Tápé-Lebõ, Alsóhalom	paint crusher made of a symbolic chisel	7.1951.67.	Late Neolithic, Tisza culture		light reddish grey, medium grained, not very hard sandstone	
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.68.	Late Neolithic, Tisza culture		Grey siliceous rhyolite(?) with amoeba-shape dark patches and with porose scattered small cavities and small columnar dark minerals	Tokaj Mts.? Mátra Mts.?
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.108.	Late Neolithic, Tisza culture		medium grey banded rhyolite with micro-cavities	Tokaj Mts.? Mátra Mts.?
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.109.	Late Neolithic, Tisza culture		light grey fine grained metasandstone	

40) Patay (1976); Oravecz-Józsa (2001).
41) Korek (1958).

Slovak Geol. Mag., 10, 1–2(2004), 105-134

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Tápé-Lebõ, Alsóhalom	grooving axe	7.1951.110.	Late Neolithic, Tisza culture		grey clayey marl(?) with limonitic knots surrounded light narrow faded zone	
Tápé-Lebõ, Alsóhalom	other stone utensil	1951.7.127.	Late Neolithic, Tisza culture		reddish black striped compact jasper	Tokaj Mts.? Mátra Mts.?
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.128.	Late Neolithic, Tisza culture		rhyolite(?)	Tokaj Mts.? Mátra Mts.?
Tápé-Lebõ, Alsóhalom	chisel	7.1951.129.	Late Neolithic, Tisza culture		bluish grey, fine grained quartzite or siliceous sandstone (maybe volcanite)	
Tápé-Lebõ, Alsóhalom	chisel	7.1951.140.	Late Neolithic, Tisza culture		light grey, fine grained, slightly clayey sandstone	
Tápé-Lebõ, Alsóhalom	chisel	7.1951.156a.	Late Neolithic, Tisza culture		banded calc-schist with slightly gneissose structure and coarse surface	
Tápé-Lebõ, Alsóhalom	chisel	7.1951.156b.	Late Neolithic, Tisza culture		light-medium grey (with yellow tint), very fine grained sandstone	
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.157.	Late Neolithic, Tisza culture		magnesitic(?) sandstone	
Tápé-Lebõ, Alsóhalom	cutting axe	7.1951.158.	Late Neolithic, Tisza culture	TS	green metagabbro with minor relict blue amphibole	Maros-valley? Szarvaskõ? Vardar-zone?
Tápé-Lebõ, Alsóhalom	paint crusher made of a symbolic tool	7.1951.207.	Late Neolithic, Tisza culture		sandstone	
Tápé-Lebõ, Alsóhalom	chisel-plane-cutt ing tool	7.1951.208.	Late Neolithic, Tisza culture		light greyish green serpentinite with small white micas	
Tápé-Lebõ, Alsóhalom	cutting axe	7.1951.209.	Late Neolithic, Tisza culture	TS	fine grained metadolerite with small amount of quartz	Maros-valley? Szarvaskõ? Vardar-zone?
Tápé-Lebõ, Alsóhalom	chisel	7.1951.236.	Late Neolithic, Tisza culture		medium grey basalt	Mecsek? Nógrád? Balaton-highland?
Tápé-Lebõ, Alsóhalom	chisel	7.1951.262.	Late Neolithic, Tisza culture		very fine grained, light grey, slightly slaty quartzite	
Tápé-Lebõ, Alsóhalom	symbolic cutting axe	7.1951.274.	Late Neolithic, Tisza culture		quartz pebble	
Tápé-Lebõ, Alsóhalom	symbolic chisel	7.1951.275.	Late Neolithic, Tisza culture		fine grained sandstone, with alternating green-red colours	
Tápé-Lebõ, Alsóhalom	grooving axe	7.1951.276.	Late Neolithic, Tisza culture	TS	greenish gray basalt	Mecsek?

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Tápé-Lebõ, Alsóhalom	grooving axe	7.1951.277.	Late Neolithic, Tisza culture	TS	gray basalt-dolerite	Mecsek? Szarvaskõ? Maros-valley? Vardar-zone?
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.303.	Late Neolithic, Tisza culture		striped magnesitic serpentinite or limnoquartzite.	
Tápé-Lebõ, Alsóhalom	chisel	7.1951.304.	Late Neolithic, Tisza culture		greenish-pink grey, fine grained quartzite or siliceous sandstone	
Tápé-Lebõ, Alsóhalom	symbolic chisel	7.1951.305.	Late Neolithic, Tisza culture		yellowish grey, fine grained sandstone with muscovite	
Tápé-Lebõ, Alsóhalom	chisel	7.1951.306.	Late Neolithic, Tisza culture		quartzite or fine grained sandstone	
Tápé-Lebõ, Alsóhalom	cutting axe	7.1951.307.	Late Neolithic, Tisza culture	TS	fine grained metadolerite with small amount of quartz	Maros-valley? Szarvaskõ? Vardar-zone?
Tápé-Lebõ, Alsóhalom	grooving axe	7.1951.308.	Late Neolithic, Tisza culture		diabase (metadolerite)	Maros-valley? Szarvaskõ? Vardar-zone?
Tápé-Lebõ, Alsóhalom	paint crusher made of symbolic tool	7.1951.343.	Late Neolithic, Tisza culture		Very fine grained sandstone or quartzite (or hornfels(?))	
Tápé-Lebõ, Alsóhalom	symbolic tool	7.1951.344a.	Late Neolithic, Tisza culture		grey quartzite or fine grained metasandstone	
Tápé-Lebõ, Alsóhalom	chisel-plane-cutting tool	7.1951.344b.	Late Neolithic, Tisza culture		dark grey sandstone with angular grains and with argillaceous matrix	
Tápé-Lebõ, Alsóhalom	chisel	7.1951.362a.	Late Neolithic, Tisza culture		greenish black greenschist (actinolite schist)	Felsõcsatár? Bohemian Massive?
Tápé-Lebõ, Alsóhalom	cutting axe	7.1951.362.	Late Neolithic, Tisza culture		bone-coloured very fine grained sandstone or silex(?)	
Tápé-Lebõ, Alsóhalom	chisel	7.1951.363.	Late Neolithic, Tisza culture	TS	basalt with mafic porphyric grains	Mecsek?
Tápé-Lebõ, Alsóhalom	chisel	7.1951.364.	Late Neolithic, Tisza culture		black hornfels(?) or siliceous limestone	Apuseni Mts.? or Bükk Mts.?
Tápé-Lebõ, Alsóhalom	symbolic cutting axe	7.1951.381.	Late Neolithic, Tisza culture	TS	siliceous crinoidal limestone	Bükk Mts.?
Tápé-Lebõ, Alsóhalom	grooving axe	7.1951.382.	Late Neolithic, Tisza culture		dark grey hornfels(?) or quartzite(?)	
Tápé-Lebõ, Alsóhalom	other stone utensil	7.1951.383.	Late Neolithic, Tisza culture		reddish brown medium grained sandstone (pebble origin)	

Site	Type of tool	Inv. Nr. Hungarian National Museum (HNM)	Archaeological age	TS	Rock name and short macroscopic features	Possible origin of the rock
Tápé-Lebõ, Alsóhalom	symbolic chisel	8.1951.29.	Early Copper Age		dark green strongly banded greenschist (actinolite schist)	Bohemian Massive? Felsõcsatár?
Tápé-Lebõ, Felsõhalom	paint crusher made of symbolic tool	9.1951.1.	Late Neolithic		very fine grained quartzarenite or quartzite	
Tápé-Lebõ, Felsõhalom	undetermined	9.1951.2.	Late Neolithic		greenschist (actinolite schist)	Felsõcsatár? Bohemian Massiv?
Szegvár-Tûzköves[42)]	chisel-plane-cutting tool	1971.9.2.	Late Neolithic		metadolerite	Maros-valley? Szarvaskõ? Vardar-zone?
Szegvár-Tûzköves	symbolic shoe-last form chisel	1971.9.3.	Late Neolithic		Medium grey metadolerite(?)	Maros-valley? Szarvaskõ? Vardar-zone?
Szegvár-Tûzköves	chisel-plane-cutting tool	1971.9.24.	Late Neolithic		medium green hornfels	Apuseni Mts.?
Szegvár-Tûzköves	chisel-plane-cutting tool	1971.9.25.	Late Neolithic		grey quartzite(?) or microcrystalline basalt(?)	

Table 2. Overview of main rock types

Rock type	Pieces	(Thin S.)	Percentage
andesite	37	(6)	14,49
tuff	4	(0)	1,57
basalt	11	(5)	4,31
rhyolite	3	(0)	1,18
volcanite- metavolcanite	12	(0)	4,70
diorite-dolerite-gabbro	35	(12)	13,72
serpentinite	26	(2)	10,20
greenschist	25	(5)	9,80
blueschist	13	(2)	5,10
hornfels	8	(0)	3,14
quartzite	24	(0)	9,41
jasper	2	(0)	0,78
lydite	4	(0)	1,57
sandstone	39	(0)	15,28
claystone	4	(0)	1,57
limestone	7	(1)	2,74
diatome schist	1	(0)	0,39
Total	255	(33)	100,00

42) Korek (1987).

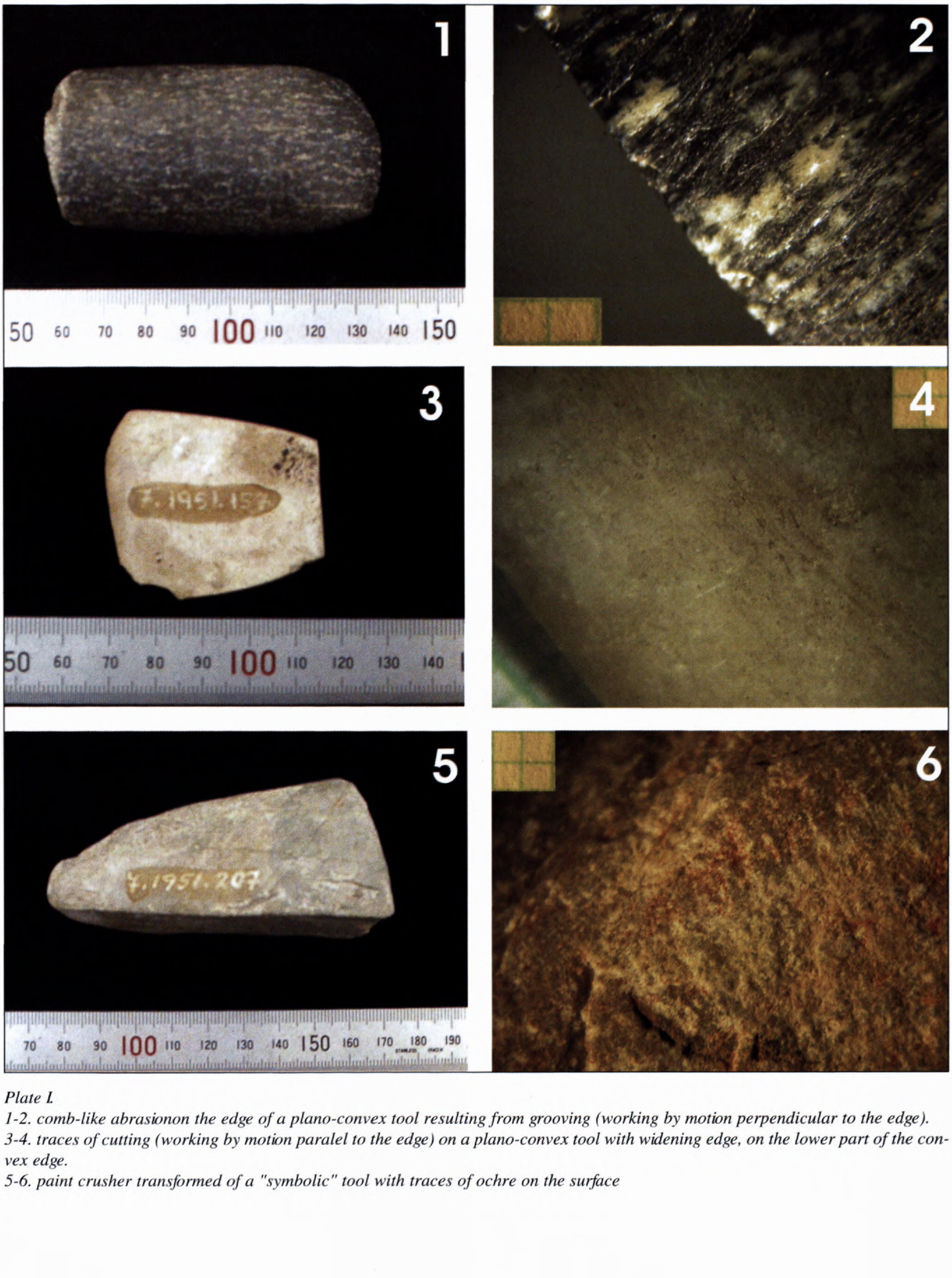

Plate I.

1-2. comb-like abrasionon the edge of a plano-convex tool resulting from grooving (working by motion perpendicular to the edge).

3-4. traces of cutting (working by motion paralel to the edge) on a plano-convex tool with widening edge, on the lower part of the convex edge.

5-6. paint crusher transformed of a "symbolic" tool with traces of ochre on the surface

Slovak Geol. Mag., 10, 1-2(2004), 105-134

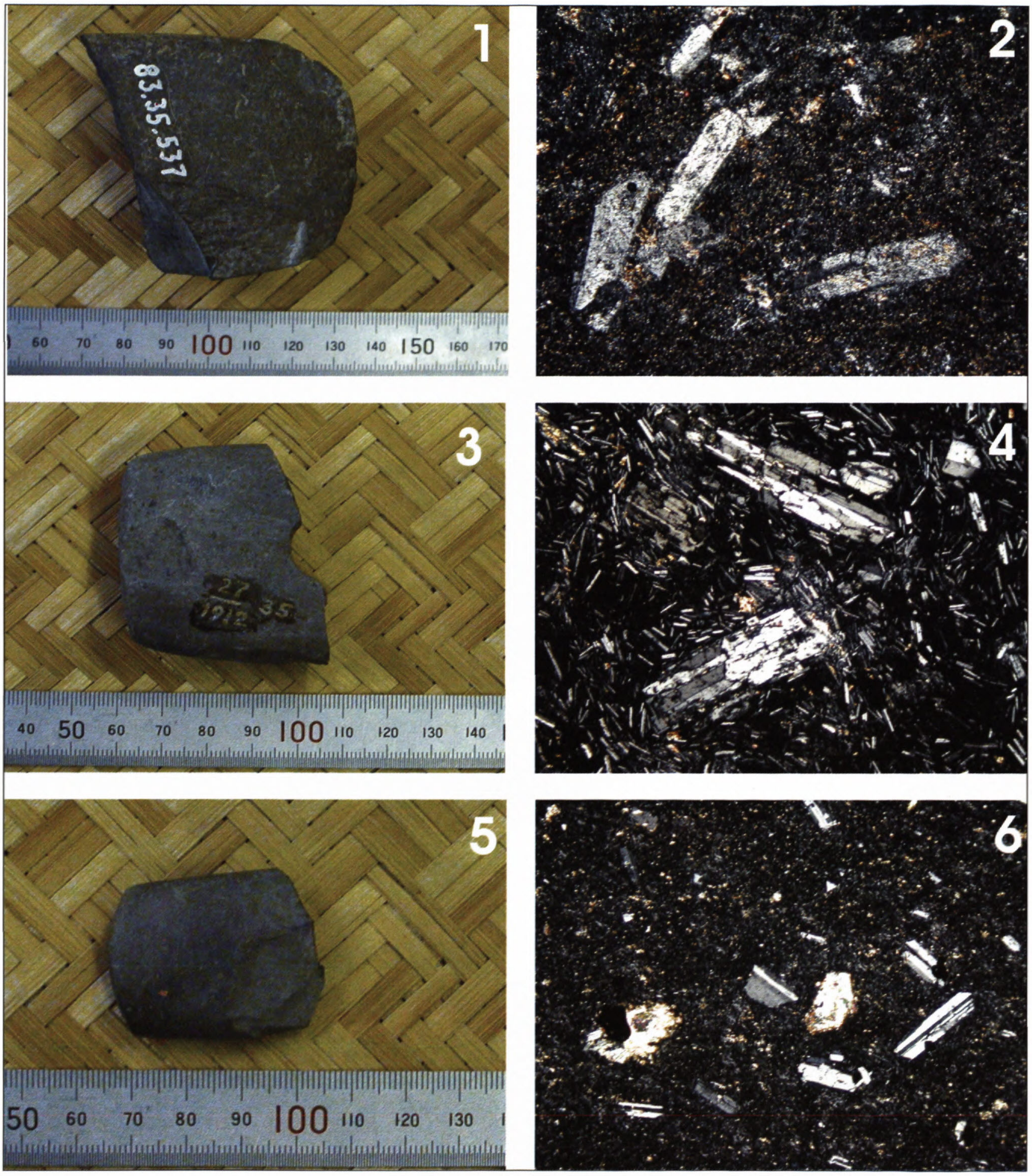

Plate II.
1-2 andesite (83-35-537),
3-4 pyroxene andesite (1912-27-35),
5-6 pyroxene andesite (29-50-12)

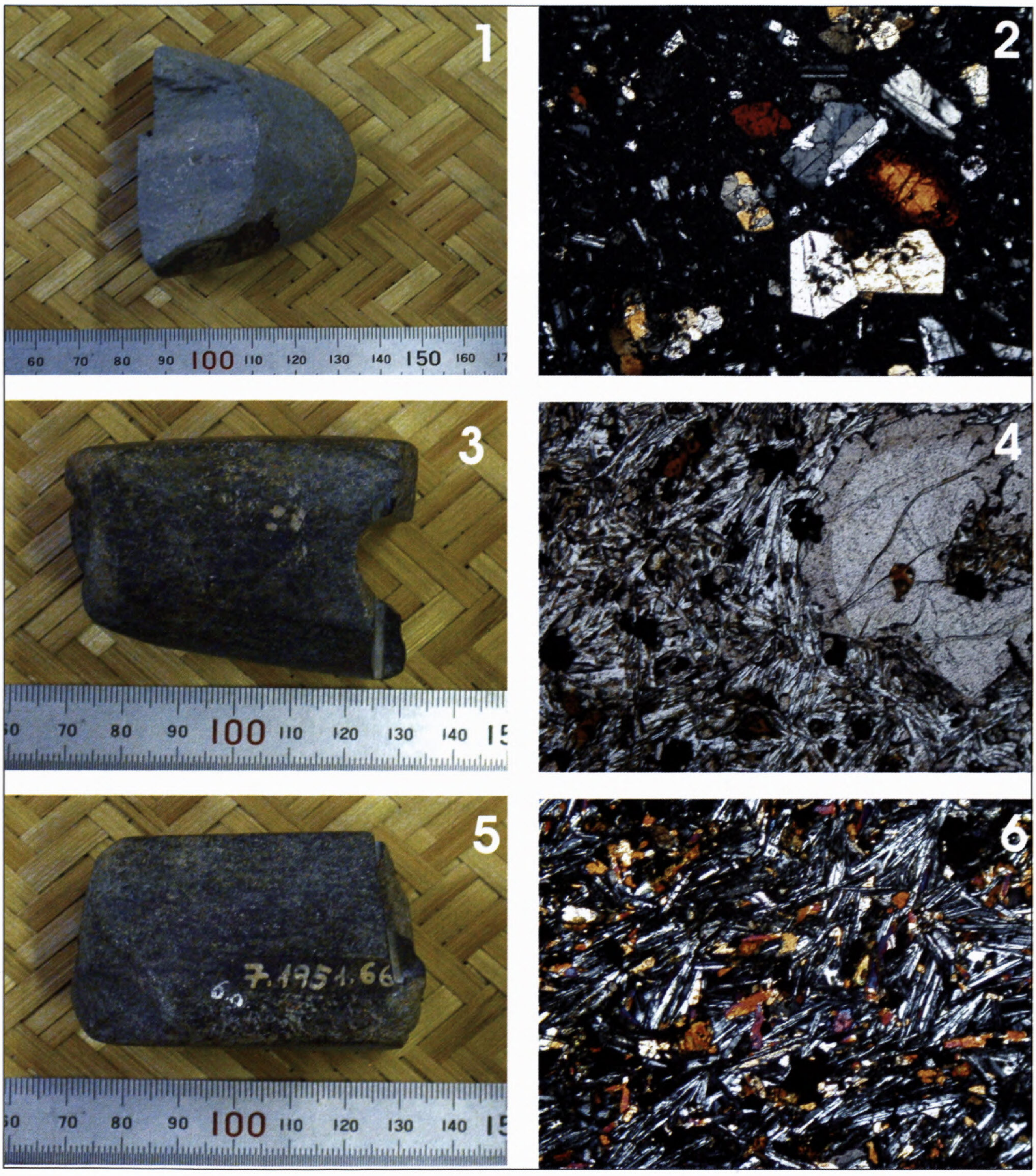

Plate III.
1-2 basaltic andesite with olivine (29-50-10),
3-4 basalt with pyroxene phenocryst (1951-7-66 Mecsek?),
5-6 basalt (1951-7-66 - Mecsek?).

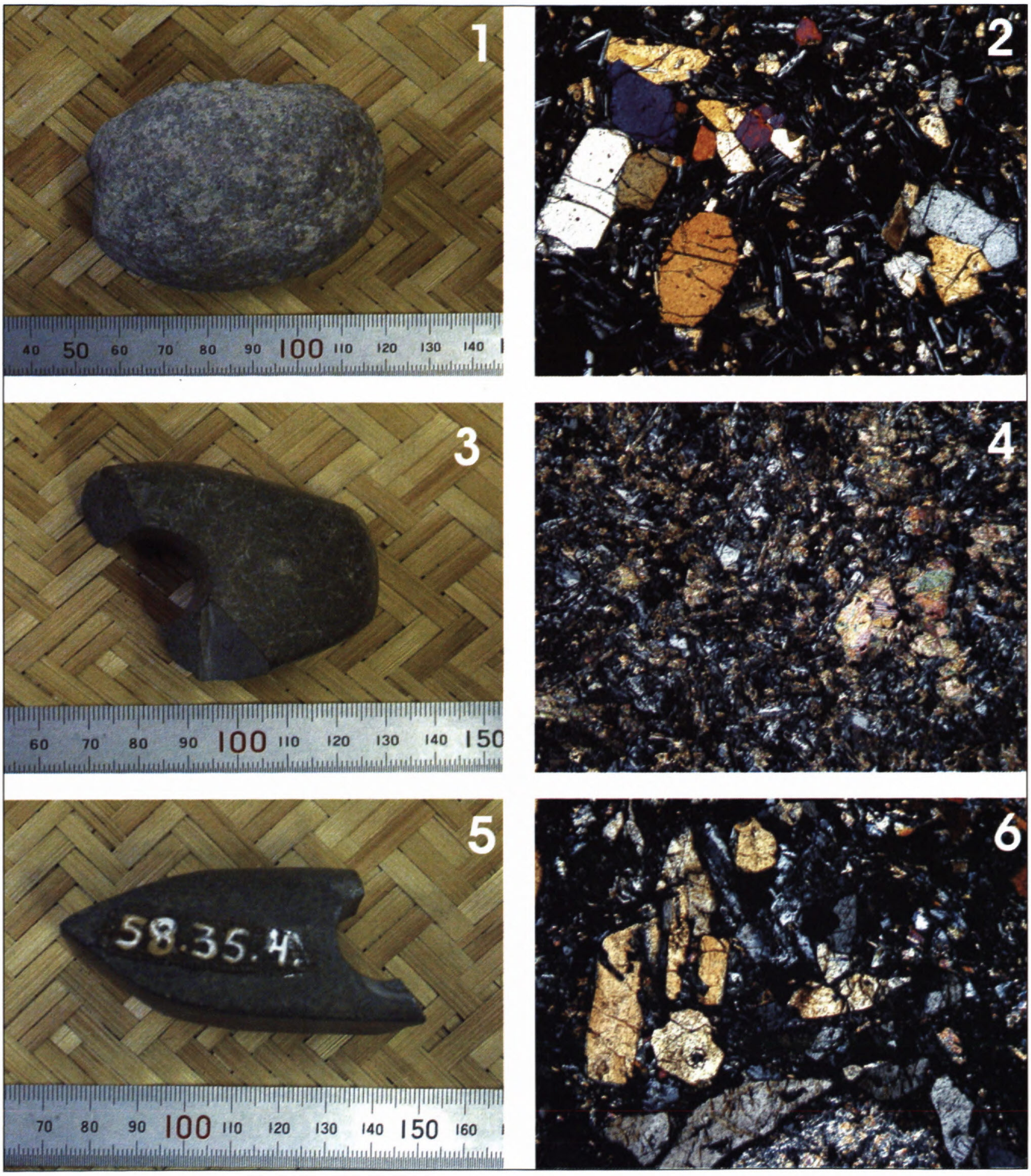

Plate IV.
1-2 basalt (77-7-25 - Neogene),
3-4 carbonatic basalt (83-35-590),
5-6 (meta)dolerite (58-35-4).

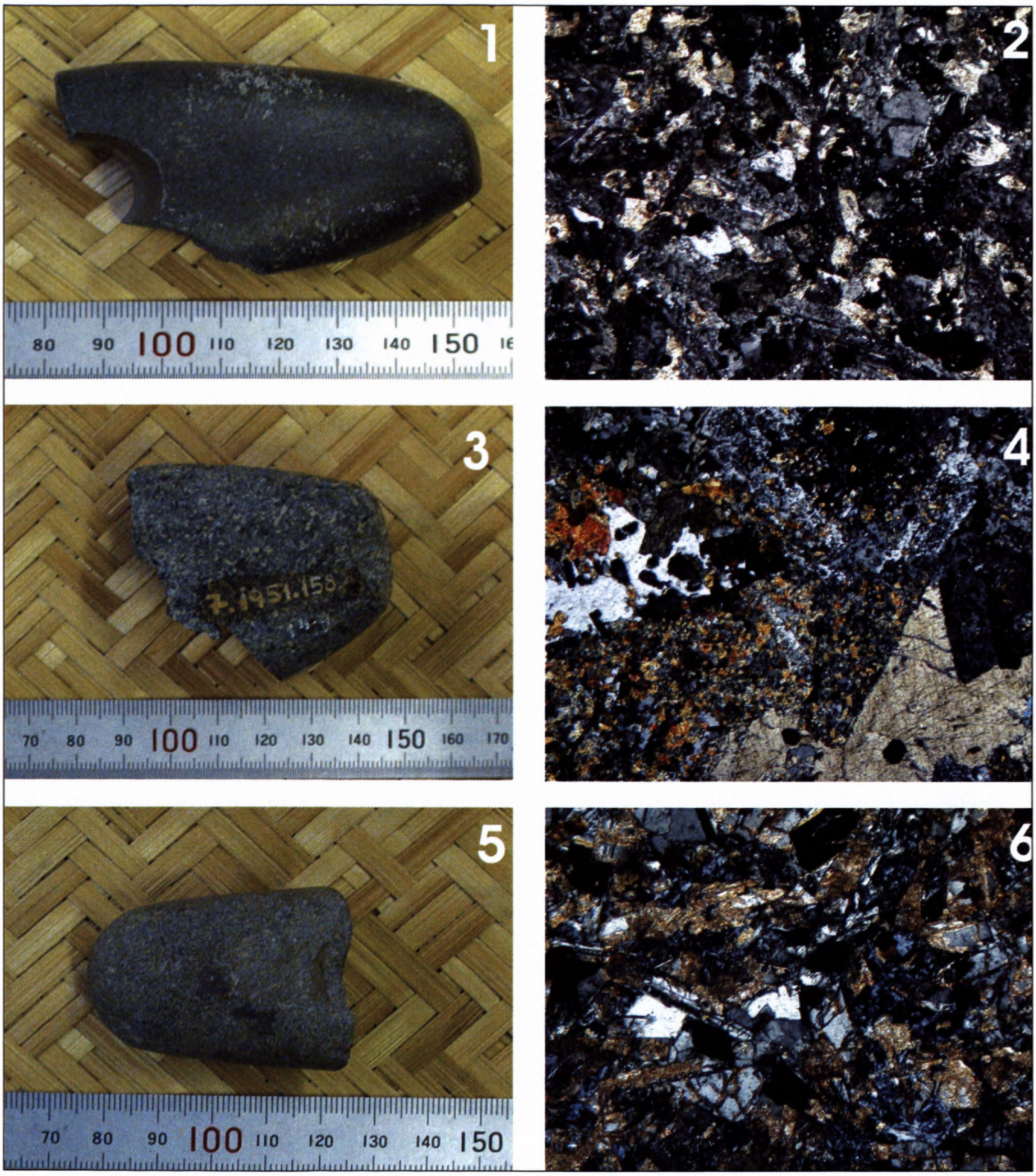

Plate V.
1-2 metadolerite with some quartz (1951-7-307),
3-4 metagabbro (1951-7-158),
5- 6 micro-quartzdiorite (63-27-74b - banatite?)

Slovak Geol. Mag., 10, 1-2(2004), 105-134

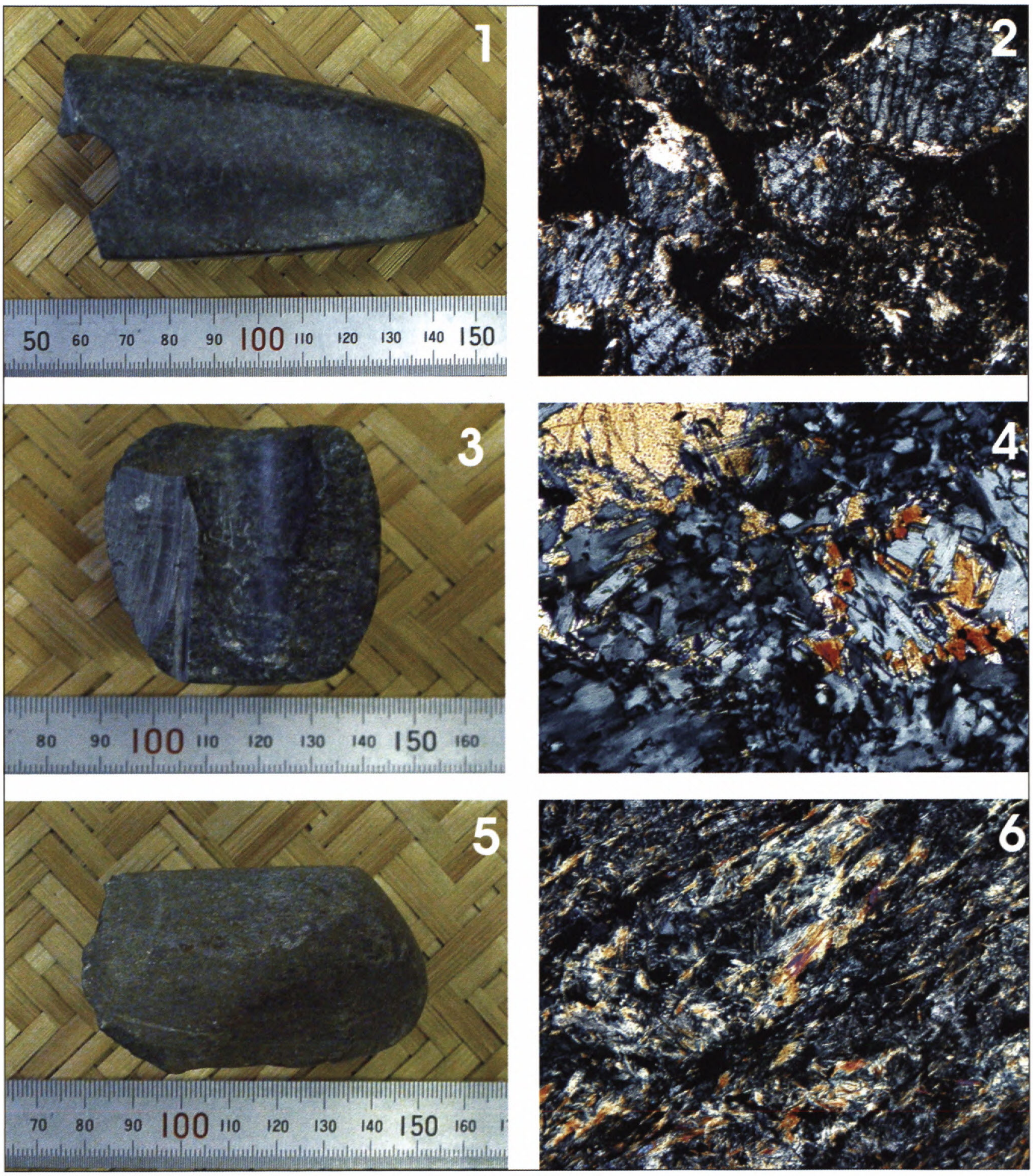

Plate VI.
1-2 metaperidotite(60-35-107),
3-4 serpentinite (89-2-1063),
5-6 greenschist (70-9-19).

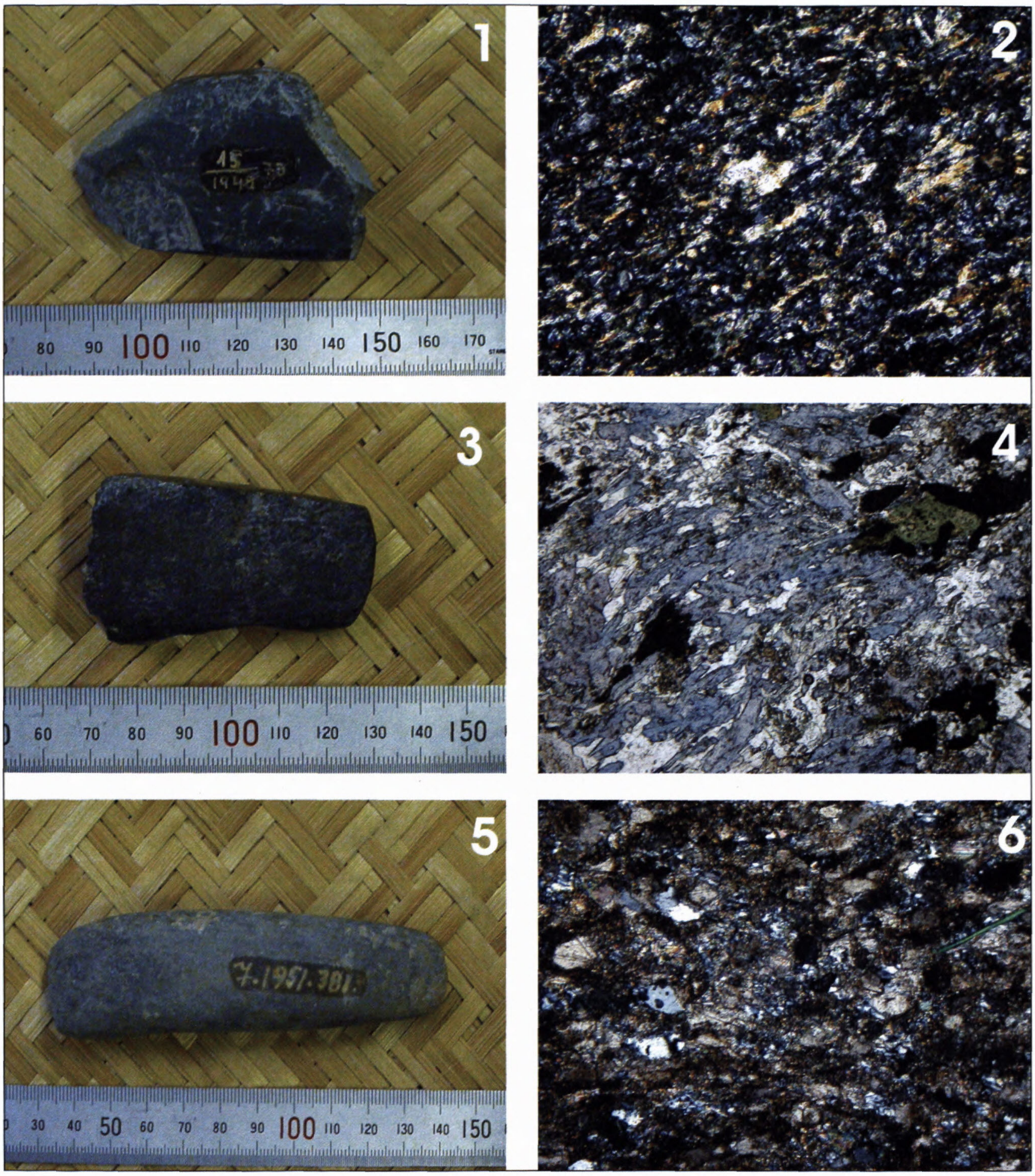

Plate VII.
1-2 greenschist (49-15-73 - Felsőcsatár-type),
3-4 blueschist (949-15-233),
5-6 siliceous limestone with Crinoidea (1951-7-381).

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On the provenance of Neolithic amphibolitic axe blades from the Wetterau (Hessen, Germany)

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Abstract: Early and middle Neolithic stone artefacts from the Wetterau area (Central Germany) show a dominance of metamorphic rocks as the preferred raw material. Within the large group of amphibolites, two groups were petrograhically and geochemically identified: a texturally heterogeneous group of amphibolites with a MORB and island arc signature, and a homogeneous group of so-called "actinolite-hornblende schist" with a distinct geochemically OIB signature. The latter group is a common and widely used material in Early Neolithic settlements, and this study undertake a comparative analysis of possible provenance areas.

Key words: Neolithic, polished artefacts, raw material, archaeometry, petrography, geochemistry, amphibolite, actinolite-hornblende schist, Central Germany

Introduction

The application of petrographic methods on Neolithic stone artefacts has previously been applied in order to clarify fundamental questions regarding provenance areas, distribution of raw material and thus cultural interactions in Neolithic time (e.g., Schwarz-Mackensen & Schneider 1983; 1986). Petrographic techniques alone have, however, shown not to be sufficient for a precise and detailed analysis. This paper presents a preliminary result of a current archaeometric research program applying both petrographic and geochemical methods to Neolithic polished artefacts from the Hessen area, Germany. The project arose in 2001 at the "Graduiertenkolleg für Archäologische Analytik", Johann Wolfgang Goethe-University, Frankfurt (superviced by J. Lüning, Seminar für Vor- und Frühgeschichte, and G. Brey, Institut für Mineralogie), with collaboration of the Institut für Mineralogie at the Bayerische Julius-Maximilians-University, Würzburg (M. Okrusch and U. Schüssler).

The central part of the investigation area is the Wetterau (Fig. 1), a typical loess-region in Central Germany. The area is to the West bordered by the Taunus highland, a foothill of the Rheinische Schiefergebirge, and to the East and Northeast by the Vogelsberg, the largest outcrop of basalt in Europe. To the South the Wetterau reaches to the lower Main plain. The different geological outcrops include a variety of useable materials like e.g., amphibolite in the Spessart, basalt in the Vogelsberg, quartzite and greenschist in the Taunus and miscellaneous sedimentary rocks in the Buntsandstein and Rotliegenden of the Wetterau and neighbouring areas.

Archaeological investigations over the last decades have produced a large number of polished artefacts. Six representative microregions, where several field surveys occurred in the last years, comprise sets of culturally related Neolithic settlements. Within each region, sedimentary, magmatic and metamorphic rocks were used as raw material. For early to middle Neolithic settlements, miscellaneous metamorphic rocks and, somewhat less important, basalt were the preferred materials. For Late Neolithic settlements the distribution of material types is more varied. Examination of the prevalent metamorphic rock types from the earlier settlements distinguished two major groups: 1) various amphibolites, and 2) a homogeneous amphibolitic rock-type, which share familiar features with the large group of amphibolites. The latter group was also recognized as the preferred material in an investigation of stone axes from the Harzvorland (Schwarz-Mackensen & Schneider 1983; 1986), and the name "actinolite-hornblende schist" was proposed for this group. Recent studies show, that the material is common throughout Bandkeramik settlements in South Germany, and thus appear to have an over-regional importance (Christensen et al., in prep.). The study of Schwarz-Mackensen & Schneider presumed the group to be imported from a provenance area in the Balkan or the West Carpathian.

Archaeological background

In the Wetterau we have a good number of polished artefacts collected already in the nineteenth century. These collections, now in various museums, along with finds from several excavations and field surveys, have revealed a dense Neolithic settlement pattern in the Wetterau area. The older museum collections show a wide range of axes, adzes, chisels, hammer-axes, globular maceheads used during the different Neolithic periods up to the Bronze Age. Most of the artefacts found during

Slovak Geol. Mag., 10, 1-2(2004), 135-138

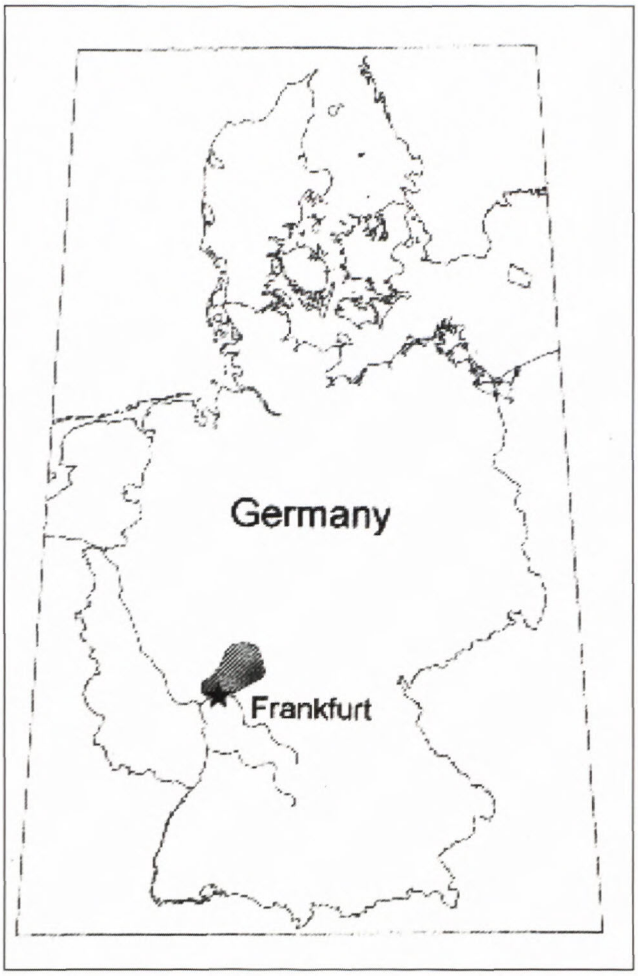


Fig. 1: Map of Germany. Shaded area show the investigated and sampled area around Wetterau (star).

the recent field surveys belong to the early Neolithic Linearbandkeramik culture, but the middle Neolithic period (Großgartach and Rössen culture) is also well represented in the collections. The younger Neolithic (Michelsberg culture) up to the final Neolithic (Corded Ware and Bell Beaker) show a less dense settlement pattern, as witnessed by fewer recovered artefacts.

Typologically, the polished artefacts of the Wetterau are predominated by various flat axes and shoe-last wedges with the characteristic D-shaped cross-section, whereas the axes with ovaloid cross-section and pointed neck along with trapezoid or rectangular axes with rectangular cross-section are rare. Beside the common end-products with different use-wear traces, several semi-products and a large number of artefacts with traces of secondary work occur.

Methods of Study

At present a number of 1078 polished artefacts from 373 sites are under investigation. The early and middle Neolithic artefacts have a strong and characteristic predominance of metamorphic rocks like amphibolite and actinolite-hornblende schist as raw material, followed by basalt and minor sedimentary material. Other rock types are rare. From the young Neolithic onwards, we find a more scattered distribution of raw materials.

A computerised data based management system has been designed to record details of the axes including archaeological (typological, metrical and use-wear datas), petrographical and geographical informations. The study initially concentrated on the survey collections of the micro-regions, with a later extension to the museum collections. After the macroscopical investigation of colour, texture, granularity, hardness and surface constitution, amphibolites and actinolite-hornblende schists could be distinguished from other rock types like basalt, different sedimentary rocks, siliceous materials like flint, quartzite and lydite, the characteristic greenstones generally called jadeite or nephrite, metamorphic rocks like gneiss, mica-schist and greenschist and magmatic rocks like andesite and gabbro.

Amphibolites and actinolite-hornblende-schists macroscopically are of greyish-green to black-green colour and have a generally schistose texture, i.e. parallel orientation of the dark minerals. Some of them are very fine grained with thin and often irregular layering. Other, more coarse grained pieces show minerals and mineral clusters visible with the naked eye. In comparison to basalt or other rocks, amphibolites and actino-lite-hornblende schists are generally less affected by weathering, and most of the artefacts still have a fine polished surface.

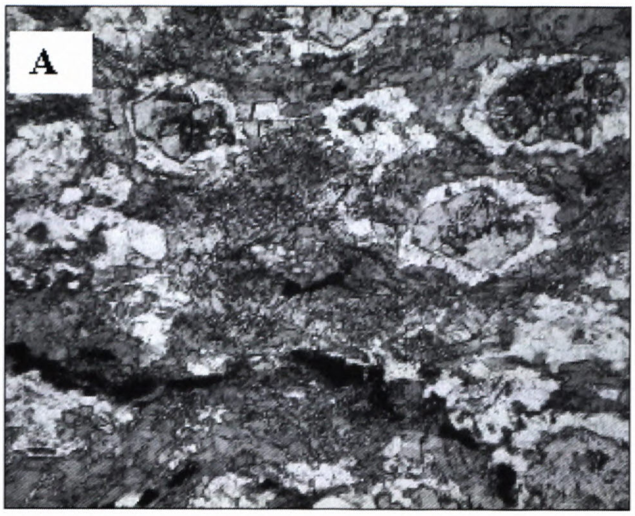
Analytical Technique

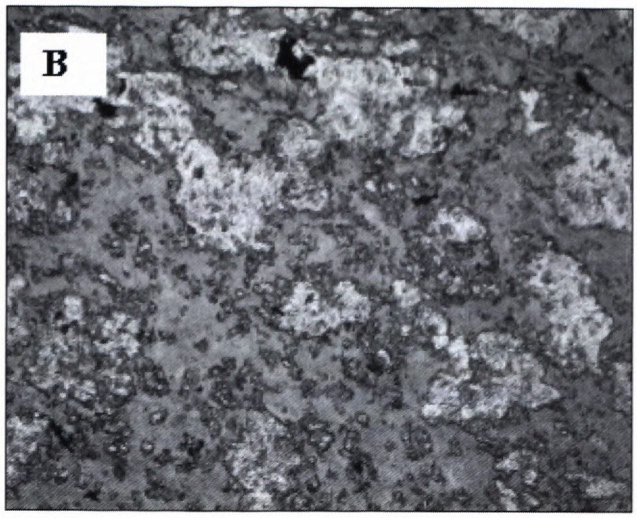
For petrographic and geochemical characterisation, a number of thin sections were produced from a representative selection of samples, and a range of major- and trace elements were performed on selected artefacts. The geochemical analyses were obtained from melted glass-discs by use of a Philips XRF PW1480 at the Institut für Mineralogie in Würzburg.

Petrography

The petrographic examination of the two major metamorphic groups found the group of amphibolites to be texturally very heterogeneous, and a subdivision was mainly based on the various grain sizes. In contrary, the actinolite-hornblende schists form a very homogeneous group. The defined groups are constituted by the following characteristics:

1) Amphibolite (Fig. 2a and b): a texturally heterogeneous group ranging from fine to coarse grained compositions of mainly amphibole, feldspar and some quartz along with minor opaque phases. Amphibole is light to dark green hornblende which occurs around small domains of felsic miner-als. Plagioclase is often strongly seritizised. Garnet has been found in some samples as larger, well developed grains. Opaque phases are rare and occur evenly distributed. Accessories are apatite, biotite, epido-





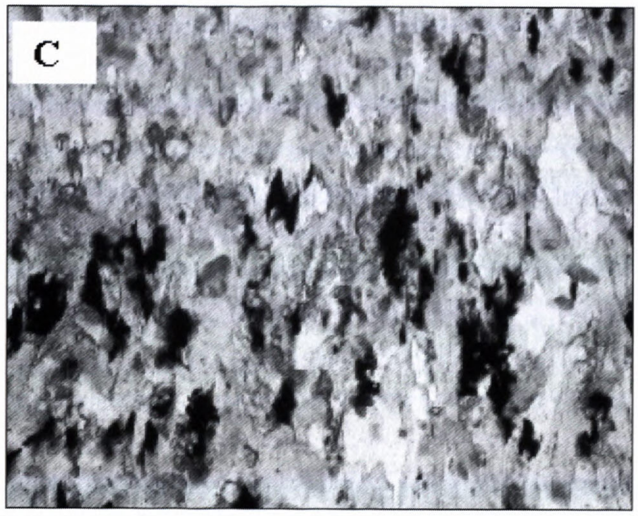


Fig. 2
*A: Coarse grained amphibolite. Garnet (light grey) surrounded by hornblende (dark grey) and plagioclase (white). Sample FaB1-a48-2 *10 magnification.*
*B: Fine grained amphibolite. Hornblende (dark grey) and plagioclase (white). Sample Wal1-2 *20 magnification.*
*C: Actinolite-hornblende-schist. Needle-shaped actinolite (light gray), opaque phases (black) and plagioclase (white). Sample WöH1-9 *20 magnification.*

te and chlorite. The material group is further subdivided by grain size into fine and coarse-grained subgroups.

2) Actinolite-hornblende schist (Fig. 2c): a markedly distinctive homogeneous group of most commonly fine grained amphibolite compositions. Actinolite is colourless to light green with a characteristic needle shape which is bushy interwoven in the matrix between the felsic minerals. Single larger grains of dark green hornblende are present within the actinolite framework, along with blades of colourless chlorite. Brown pleochroitic biotite is present in some samples. Subordinate plagioclase (often seritizised) and some quartz are present in the interwoven amphibolite matrix. A large amount of opaque phases is present as a characteristic feature. They either appear with a homogeneous distribution throughout the sample or as layers within the amphibole-rich parts. Accessories are apatite, epidote and biotite. The material group is subdivided into 3 subgroups only by means of texturally differences: (a) massive, with a non-preferred orientation of the constituting minerals, (b) textured, with a strongly developed linear or crenulation cleavage imposed upon layers of amphibole and felsic minerals, and (c) similar to (a), but containing coarser domains of enlarged amphibole, biotite and felsic minerals. This group tends to be more enriched in quartz than the others do.

Geochemistry

Major elements for the amphibolites and the actinolite-hornblende schists display a common basaltic composition for all samples, with an SiO_2 range of 47 to 51 wt%, Fe_2O_3: 12-15 wt% Al_2O_3 12-15 wt%, CaO 6-13 wt%, and a MgO range of 4 to 10 wt%. Total alkali is generally low, and constitute < 3 wt%. Chemical composition and mineral assemblages testify to a pre-metamorphic basaltic origin. Therefore both groups are normalised to two common basalt types in Fig. 3. The actinolite-hornblende schist group shows an overall enrichment in the elements Sr to Y as compared to MORB (Fig. 3a). This is typical for OIB basalts (Fig. 3d). Ba, K and Sr show a large compositional range which reflects the modal variance of feldspar in the rocks. A similar variance in the biotite content of the rocks is shown by the scatter of Rb.

On the contrary, the amphibolite group shows an overall overlap to slight depletion of the elements Sr to Y as compared to MORB (Fig. 3b), and are orders of magnitudes depleted when compared to OIB values (Fig. 3d). The heterogeneous modal composition of the group is mirrored by a strong chemical scatter of most elements.

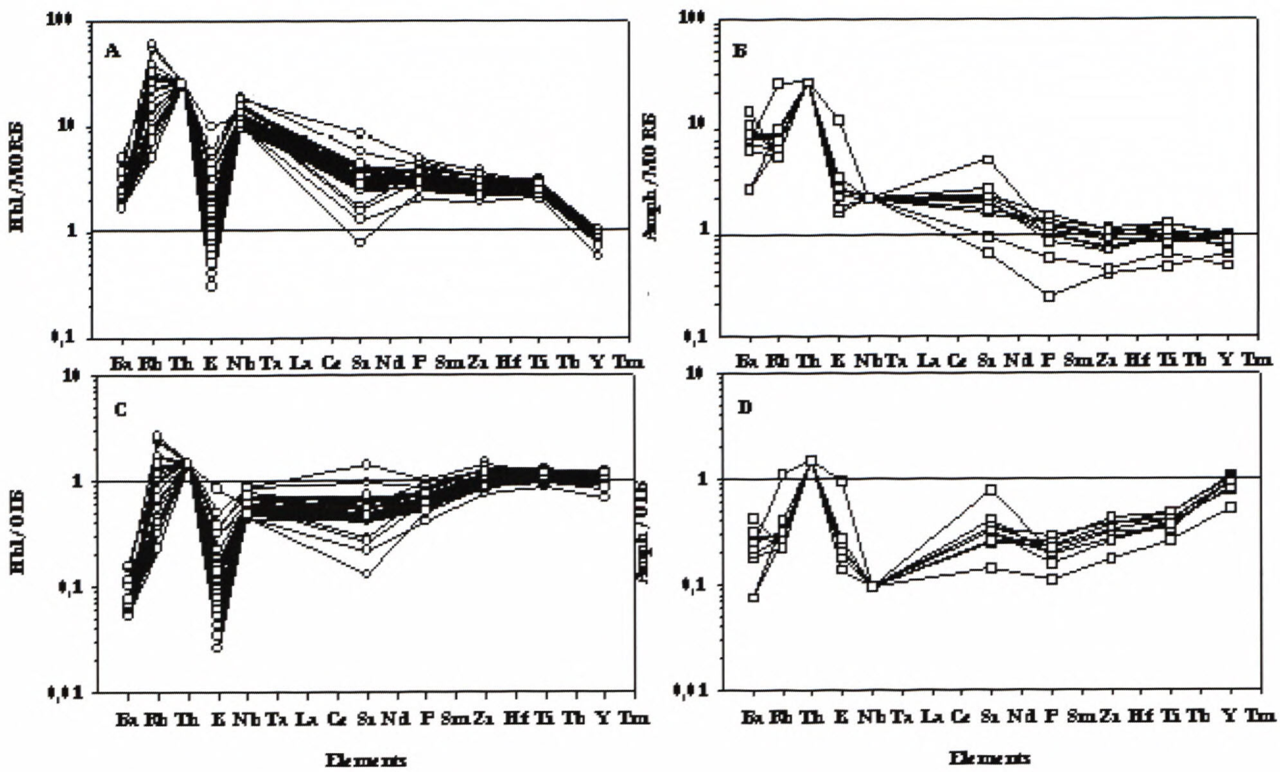


Fig. 3
A: Actinolite-hornblende schist normalised to MORB (Mid Ocean Ridge Basalt) values.
B: Amphi-bolite-group normalised to MORB values.
C: Actinolite-hornblende schist normalised to OIB (Ocean Is-land Basalt) values.
D: Amphibolite group normalised to OIB values. Normalization values taken from Sun (1980) and Saunders and Tarney (1984).

Further geochemical discrimination of the two groups (e.g., Pearce and Cann, 1973; Pearce and Norry, 1979) testify the actinolite-hornblende schists as belonging to a group with a characteristic within-plate signature, whereas the amphibolite group shows characteristics of island arc tholeiite or MORB.

The large petrographic (and in part geochemical) heterogeneity of the amphibolite group affirm the material as being "randomly" found in the surroundings, whereas the homogeneity of the actinolite-hornblende schists supports the idea of this material having been imported.

Conclusions

The petrographic and geochemically investigations undertaken in this study show a predominance of amphibolitic material in early and middle Neolithic settlements from the Wetterau area (South Germany). The material were grouped into a texturally heterogeneous group of amphibolites with a MORB and island arc signature, and a homogeneous group of so-called "actinolite-hornblende schist" with a characteristic geochemically OIB signature. Our investigation shows the amphibolite group as likely local material, whereas the actinolite-hornblende schists most probably are a regionally imported product. Petrographical and geochemical comparison with feasible provenance areas are in progress. Microprobe analyses on selected mineral phases along with isotope techniques are hoped to confine the area of provenance further (Christensen and Ramminger, in prep.).

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Slovak Geol. Mag., 10, 1-2(2004), 139-146

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Long distance exchanges versus regional rocks use: datas and interpretations for the Neolithic of the Northern French Alps

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We would like to introduce here some aspects of the complexity of the production, the diffusion and the use of stone implements hafted as axeheads during the Neolithic. For this, we have chosen to develop the problem of the prehistoric choices face to the natural availability of tenaceous rocks, in a symptomatic area which is rich in several metamorphic lithologies. Inside the Western Alps, the case of the northern french part of it, i.e. the Haute-Savoie district, takes a good example of this human choices, which can be fully understood only if we replace it in the larger frame of the Western Alps. Four parts will be necessary to explain this human choices: first, the description of the natural availability in tenaceous rocks; then, the presentation of the archaeological implements studied and the methods of characterization; the results of it, i.e. the tenaceous rocks really used in Haute-Savoie to realise polished axe blades; endly, the discussion on the part of the human choices face to the natural resources, which can be clearly revealed by the chronological study of the kind of stones used during each subdivision of the Neolithic.

1. The natural availability in tenaceous rocks in Haute-Savoie

1.1. Geographic introduction

The Haute-Savoie district forms a smal part of the French Alps, the northern of it (fig. 1, 2). It is less than 100 km from west to east and quite 70 km from north to south. From east to west, it includes a part of the internal Alps, the higher of it with the Mont-Blanc (4807 m, top of Europe) and the Aiguilles Rouges massifs, which are prolonged in the south by the Belledonne mountain range. Then several depressions drained by rivers form the Val d'Arly and the Faucigny. Then the prealpine reliefs of the Bornes and the Chablais massifs take place. West of it, the hilly forelands can sometimes forms some isolated massifs, like the Mont Saleve near Geneve. The river Rhône forms the western boundary of the Haute-Savoie district. Two notable lakes have to be introduce, because of their particular importance for the neolithic communities: the bow of the Léman lake forms the Haute-Savoie limits on the north; it develops on more than 70 km from Geneve to the upper Rhône valley (lower Valais). The Annecy's lake, less than 15 km long, forms a natural way of communication between the Val d'Arly and the forelands.

1.2. Regional resources: the tenaceous rocks

If we considere that the more important quality of a stone axeblade is it's resistance to the shocks, then the first quality required for the stone used can be defined as the tenacity (Ricq-de Bouard 1987, Thirault et al. 1999). For it, the rock have to be hard enough (but this quality can be highly variable), to have a fine grain and a great coherence between the different types of mineral. So the metamorphic rocks appear as very good materials, especially if they come from volcanic or magmatic protolites. In Haute-Savoie, three main kind of sources have to be distingued, for a general review: the cristalline massifs, the Chablais' Flysch and the morainic and alluvials deposits (fig. 2).

In the cristalline areas, the high reliefs domin strongly the landscapes: they are formed essentially by granites and gneiss, but inside the gneiss formations, can be find "layers" of amphibolites, which sometimes forms some great outcrops (Desmons and al. 1980, Broquet and al. 1985). The most important of them are located in the Belledonne mountain range, on the southern part of the map and outside the Haute-Savoie limits, but then can be find also in the Mont-Blanc and the Aiguilles Rouges reliefs. Generally speaking, the rocks of this part of the Alps belongs to the Medium Pression/Medium Temperature metamorphic facies (MP/MT).

The Chablais' Flysch is a part of the internal Alps transported on the external sedimentary layers. A part of this Flysch, called *"Flysch des Gets"* or former *"nappe ophiolitifere"*, dated of the lower and upper Cretaceous, is interesting for us. It consists of a flysch with a sandstony and schisty texture, containing olistolites of several rocks: diabases, serpentinites, sometimes radiolarites or granites (Broquet et al. 1985).

The morainic deposits form the most important part of the tenacous rocks sources. They are broadly developped in the forelands, the shores of the Léman and partly of the Annecy's lake, but they still exist in the alpine val-

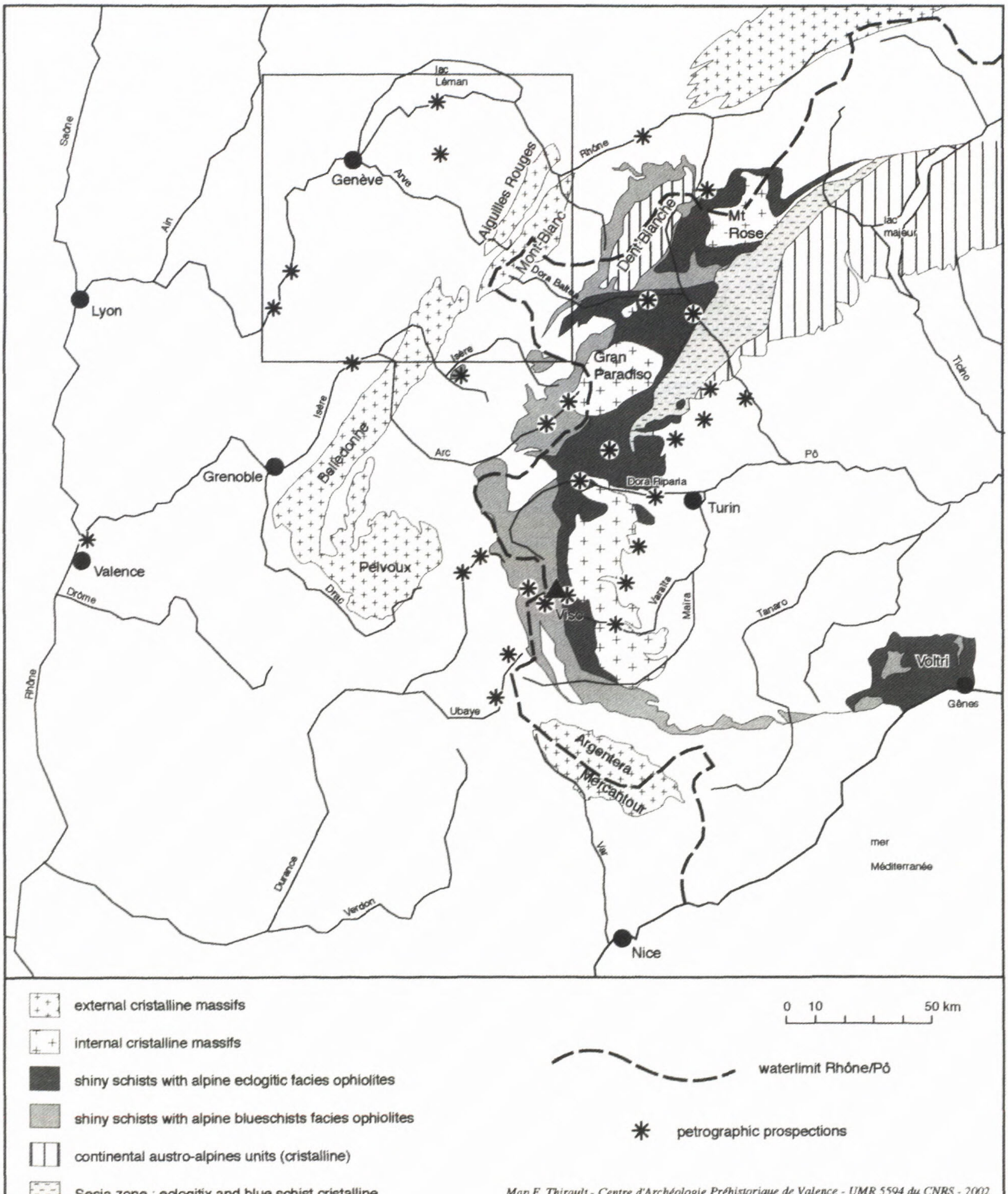


Figure 1. Simplified map of the Western Alps, showing the main tenaceous rocks outcrops.

leys and in high altitudes. The morains date from the Riss and above all the Würm Ice Ages, and are partly revisted by the former rivers. This phenomenon is still active. We have realised some petrographic sampling inside the morains and the alluvial deposits: the choice in tenaceous rocks pebbles is great, and we have find quite all the lithologies used for the axe blades, excepted the jadeitites (see below; Thirault 2001a). But, one important point is that the alpine eclogitic rocks are really scarce, not more aboundant that the over metamorphic lithologies, and they disappear downstream the Léman deposits: we have find some really small pebbles along the Rhône, but we considere that the dimensions of them and their scarcity forbid to imagine that they could have been used for the axe blades. Instead, around the Léman lake, the eclogitic pebbles could be used for this purpose, as the other tenaceous pebbles.

2. Corpus and methods of determination

We have still introduced the principles and the methods used for this broad enquiries (Thirault and al. 1999; Thirault 2001a, b). The work in Haute-Savoie took place in a broad petrographical and archaeological study concerning the whole French Alps and connected with the researches leaded in Southern France and Northern Italy (Ricq-de Bouard and al. 1990, Ricq-de Bouard 1996, D'Amico and al. 1998, D'Amico 2000). The results obtained have been completely published for the laboratory determinations (Thirault and al. 1999, Thirault 2001b) and are to be exhaustively published for the archaeological investigations (Thirault 2001a).

In the Haute-Savoie district, 149 stone axeheads have been studied, both archaeological and petrographical point of view (fig. 3). This represents quite all the artefacts known in the district (155 registred in 2000); 72 of them have been examined in laboratory by thin section and/or by XR, under the responsability of D. Santallier (University of Lyon I), the other are determinated by us, and sometimes remains unspecified. Most of this axe blades come from Neolithic sites (fig. 2): 11 sites are documented, most of them are lakeshore dwellings, yet under water: 7 sites are located on the Léman, 3 on the Annecy's lake, and one is a "dry" site, the shelter of La Vieille Eglise at La Balme-de-Thuy. This sites are documented by old excavations and collections, and for some of them, by recent works: the prospections and excavations under water directed by A. Bocquet then A. Marguet, DRASSM Annecy; Marguet 1995), and J.-P. Ginestet's excavations at La Vieille Eglise (Ginestet 1984). The other axe blades are stray finds or hoards, in which the original context is today unknown. The fig. 3 gives the list of the discoveries documented and detailes the petrographic numbers of each.

The number of axe blades documented in Haute-Savoie is not so high, even if we consider the large parts of the territory belonging to the highlands. Two other problems limit the present study: the geographic dispersion of this axe blades is greatly heterogeneous, with quite no discoveries in the Alps itself and some local concentrations on the lake shores (fig. 2) and most of them are not dated. Nevertheless the results obtained are significant, are give some good ways of researches and questions for the future enquiries.

3. The rocks used for the polished axe blades in Haute-Savoie

We won't give here a fine description of the lithotypes used for the axeheads in Haute-Savoie; this has still been done in former publications (Thirault and al. 1999, Thirault 2001b). However, we would like to precise, from an archaeological point of view, the significance of each rock family determined, and the sources that can be identified. For this, we will introduce each family in order of it's sources, from the more distant to the nearest. This review is based on the 149 implements examined (fig. 3). All the stones determined are metamorphic rocks. Nevertheless, we must add two cases of flint axeheads, one polished, the other only flacked. But we did not see this objects, which should be examined in details to certificate their state.

3.1. The non-alpine rocks

Only one lithotype can be related to another origin than the alpine regions. Two black metapelites related to the Vosges, north to the Jura massif, are surely determinated on the site of Anthy-sur-Léman/Séchex. With another scarce discoveries on the Léman lakeshore sites, this objects are located at the southern limit of diffusion of the axe blades productions of the Plancher-les-Mines' quarries (Pétrequin and al. 1996). The southern Léman shore is quite at 200 km of the quarries: that means that this implements where really exotic beside the other axe blades. They were also axe blades of good value: one is 18,2 cm long, which is still great, the other is 9,4 cm and both are intact.

3.2. The eclogites and the jadeitites

The eclogites and the jadeitites are the most common rocks used: both represent 62 % of the stone axe blades studied in Haute-Savoie, but the jadeites are really scarce (4 % of the total). Eclogites are high pression/low temperature metabasites, metamorphised during the alpine orogene and not or quite not retromorphosed. Under this word, we group real eclogites, i.e. rocks associating a pyroxene type omphacite and garnet, and pyroxenites without garnets, i.e. omphacitites. Jadeitites are pyroxenites rich in jadeite, and without garnet.

The primary outcrops of this rocks are located inside the internal Alps, in the blue schists (for the jadéitites) and the eclogites (for all of them) alpine metamorphic facies (Droop and al. 1990). If the jadeitites are extremely scarce as a raw material, the alpine eclogites are common from the Apennines to the Zermatt-Saas region in Valais (fig. 1). The use of the eclogites for the stone axe blades is general in the Western Alpes, as in the Rhône basin and Northern Italy (Ricq-de Bouard and al. 1990, D'Amico and al. 1998, D'Amico 2000, Thirault and al. 1999). On more than 200 km around the outcrops or the secondary deposits, this rock family dominates generally the other rocks used. We have demonstrated that this great diffusions are allowed by a real network of production, with the recognition of wokshops near by the natural deposits, and "production sites" far from the sources, in the French Prealps (Thirault 2001a, c).

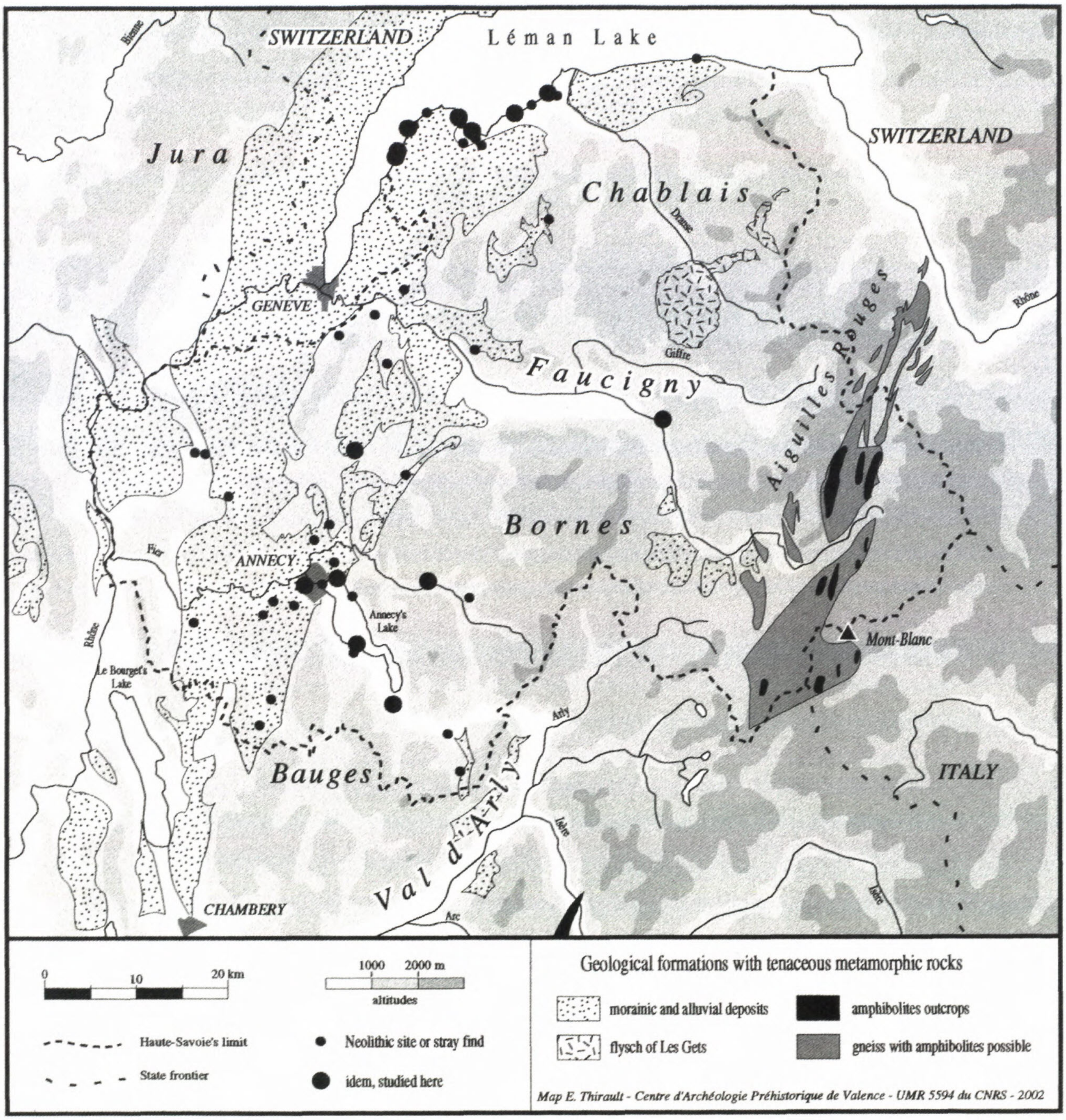


Figure 2.
Simplified map of the Haute-savoie district, showing the main tenaceous rocks outcrops and the sites and stray finds documented for the neolithic axe blades. List of discoveries studied here (see also fig. 3): 1. Annecy; 2. Doussard; 3. Vétraz-Monthoud; 4. La Balme-de-Thuy/shelter of La Vieille Eglise; 5. Saint-Jorioz/Les Marais; 6. Magland; 7. Annecy/Le Port; 8. Annecy-le-Vieux/Le Petit Port; 9. Messery/Crozette; 10. Anthy-sur-Léman/Séchex; 11. Chens-sur-Léman/Beauregard; 12. Chens-sur-Léman/Tougues; 13. Excenevez; 14. Sciez/Coudrée; 15. Thonon-les-Bains/A Corzent.

In the case of the Haute-Savoie, the closer outcrops are located in Val d'Aoste, at quite 100 km if we considere the western part of the district. But we know very little about the rock supplies in this valley, and we can't assume that the eclogites outcrops could have been exploited during the Neolithic. So it is possible that the eclogites used for the polished implements of Haute-Savoie come in fact from a farther valley. Anyway, it is demonstrated that this rocks have been carried through the alpine passes: the role of the eclogites pebbles recognized in the lemanic morains have to be questionned, but at this day very few indications can allow us to imagine an intensive use of them. No pebble surfaces can be recognized on the stone axeheads studied, and no roughouts are known. The only exception could be, close to the Haute-Savoie, in the lakeshore dwellings of the Geneve's bay where plenty of polished implements have been collected in the XIXth century. But a more detailed study should be done on this sites before any conclusion.

3.3. The morainic pebbles: ultrabasites, metabasites and cataclasites

We group here all the rocks identified by detailed examination, with a geological origin in the alpine metamorphism or not. The stone axeheads concerned often got clearly the marks of the pebble surfaces and so, the morainic origine can be surely assumed. Anyway, the alpine origin can't be demonstrated from a geological point of view and we can only precise that they come from secondary deposits when the pebbles surfaces are visible. We don't exclude that for some implements, another farther origin could be proposed. Three main families have been identified. All this rocks represent 23 % of the polished axeheads examined.

The ultrabasite rocks represent 15 % of the total. Most of them are chloritites and serpentinites (antigorites). The metabasites are very diversified: in laboratory, epizonal metabasites (amphibolites and/or prasinites), mesozonal metabasites (amphibolites, metadolerites) and MP/MT retromorphosed eclogites (amphibolo-pyroxenites) have been identified. Lastly, few cataclasites are former grinded metabasites silicified (Thirault and al. 1999).

If we consider the distribution of the morainic deposits in Haute-Savoie (fig. 2), we realise that most of the sites and the stray finds documented are located on them or quite near. Especially those where the axeheads are realised in pebbles. So, in that case, the rock supplies are quite local, maybe not always on the site itself, but never farther than few kilometers. The amphibolites located in the cristalline external mountain ranges (aiguilles Rouges, Mont-Blanc, Belledonne) could have been used, but we've got absolutly no evidence for the exploitation of such rocks on their outcrops or near by. In fact, the neolithic population of this regions remains unknown and this lack of knowledges stops the thought.

3.4. Conclusion

This short overview of the tenaceous rocks used by the Neolithics allows us to underline two main attitudes for the supplies in polished implements: whether this people get their implements directly from the local sources, i.e. the morainic deposits, with a broad rock spectrum; whether they get them by long distance diffusions, coming from the the South-East accross the alpine passes (eclogites and jadeitites), or sometimes from the North (metapelites). This second choice imply the connection with strong diffusion networks, which are better known on the south (Thirault 2001a, c). If we consider that most of the axeheads in Haute-Savoie are in the second case, we can assume that the rock supplies in this district were strongly organised. The chronological review of the facts gives a comprehensive key for it.

4. The human choices

The chronological datas for the axeheads are given by to ways: the classical archaeological attributions on the sites, by physical (C14 ou dendrochronology) or chrono-cultural datation; and the axeheads typology, based on the technological processes of manufacturing and the morphology (Thirault 2001a). In Haute-Savoie, few sites have given both fine chronological datas and axe blades. For the present study, we can considere three main phases (fig. 4): the first part of the Middle Neolithic (*Neolithique moyen I*, circa 4800-4300 B.C. calibrated ?); the second part of it (*Néolithique moyen II*, circa 4000-3400 B.C. calibrated) and the end of the Neolithic (*Néolithique final*, circa 3400-2500 B.C. calibrated).

4.1. The *Néolithique moyen I*

At this date, no site as given a sure information about this phase. But our typological seriations and the broad review of the alpine and western european contexts allow us to attribute at this old phase of the Neolithic a very specific type of axe blade, the *Bégude type* (Cordier and Bocquet 1973, Pétrequin et al. 1998, Thirault 1999, 2001a). The *Bégude type* axes are long to very long objects (to 35 cm long), very well realised and perfectly polished. They were probably not used as tools but had a non utilitarian function, probably related to social exhibitions. The important point for us is that they are always realised in alpine eclogites. So the *Bégude type* demonstrates that the transalpine networks or eclogites diffusions were still established at this time. Considering the non-utilitarian function of this long axe blades, we can assume that this diffusions have been realised as exchange networks.

In Haute-Savoie, we have identified three stray finds of the *Bégude type*, all in alpine eclogite: Annecy (fig. 2 no 1), Doussard (no 2) and Vétraz-Monthoud (no 3). The last discovery was probably an intentional hoard: two *Bégude type* axe blades have been discovered together. If we rely on this datas, the eclogite were the only rocks used during this phase in Haute-Savoie. But the number of objets is too low for a real demonstration, and it is also possible that this beautiful long axe blades represent a special part of the whole ground stone implements of the *Néolithique moyen I.*

4.2. The *Néolithique moyen II*

Three sites can be related to this period (fig. 2). Two of them have provided precised informations by archaeological excavation: Les Marais at Saint-Jorioz (no 5) and the La Vieille Eglise shelter at La Balme-de-Thuy (no 4). At Saint-Jorioz, dated by dendrochronology at 3783-82 B.C. (treefelling dates), 11 axeheads have been studied (fig. 3). All of them, excepted one (an ultrabasite), are in eclogite or in jadeitite. At La Balme-de-Thuy, not so well dated but belonging to the Middle Neolithic, 3 of the 4 axeheads are in eclogite. So on both sites, the dominant rocks come from the Val d'Aoste or the Piemont sources. The scarce over rocks belong to the ultrabasic sequence, but it isn't certain that they have a regional origin. In fact, this two axe blades haven't got any pebble surface and their precise origin remains unknown.

The third site isn't directly dated, but some stone implements of it can be attributed to the recent phases of the Middle Neolithic. At Anthy-sur-Léman/Séchex, the typology of the two axeheads realised in metapelites is clearly related to the vosgian productions, and especially those dated from the Middle Neolithic (Pétrequin et al. 1996). This time is the most important phase of diffusion for this implements, and their presence at Anthy-sur-Léman gives a good clue to suggest that this site could be occuped at this time (were is no absolute or cultural dating on it; the objects come from underwater prospections).

So the recent part of the Middle Neolithic is caracterized by a ground rock supplies quite exclusively structured by long distance exchanges with the north and the south-east. Even if the datas are not so plentiful, they suggest strongly that the morainic resources were not used for the axe blades.

4.3. The *Néolithique final*

Three lakeshore sites can be related to the end of the Neolithic, in a general meaning (fig. 2): Le Port at Annecy (no 7) and Le Petit-Port at Annecy-le-Vieux (no 8), both on the lake of Annecy, and Crozette at Messery on the Léman Lake (no 9). The first one isn't precisely dated; Le Petit-Port is dated by dendrochronology at 3058-3025 B.C. (treefelling dates), and Crozette at 2900-2300 B.C. by C14. On the three sites, the eclogites and jadeitites rate is lower as for the former periods: less than 2/3, that remains however high. The other rocks identified are some epizonal metabasites and serpentinites. On each site, a part of the axeheads are not determined because of the lack of petrographic analyses, but we can assume that this unknown rocks are quite not eclogites nor jadeitites. They have to be associated with the other metabasites or ultrabasites from regional sources.

Another informations are given by some stray finds which can be related to the *Néolithique final* by the technology of manufacturing. We have listed six of them in Haute-Savoie, and all are in alpine eclogite and in jadeitite (one case). One of them is a long polished axe blade, probably coming from an hoard (Magland, no 6). This objects demonstrate that the use of the transalpine rocks is still well developped during the end of the Neolithic, even if the local resources are worked.

4.4. The Léman Lake problem

In this chronological review, less has been said about the sites located at the Léman shore. Nevertheless, the neolithic sites have given good samples of the axeheads productions, many of them studied in laboratory. The six sites studied have provided 68 polished axe blades, but unfortunately, only one, Corzette at Messery, is dated from the *Néolithique final*. On the other sites, we've got no clear information. At Anthy-sur-Léman/Séchex only, we have suggested that the two pieces in metapelites could be dated from the Middle Neolithic. But for all of them, we can assume that they have been occupied during the Middle and/or the Final Neolithic.

Anyway, the laboratory's results are quite interesting (fig. 5). On all the sites, the eclogites and jadeitites rate is low, always below half of the total, and is very different between the sites. The ultrabasites (serpentinites and chloritites) are almost always used, and the other rocks are less common. For all this rocks and the unspecified, the sources can be related in the lemanic morains; that is indicated also by that pebbles surfaces on some of the objects. The only problem concerns the eclogites and the jadeitites: if we can assume, for the eclogites, that the raw material can be found in the morainic deposits, we haven't got the proof that this source was really used. And the problem of the jadeitites remains unsolved. So we have to assume that the eclogites and the jadeitites used on the Léman's sites came partly or entirely from the Italian Alps.

This results are in opposition with the facts established for all the dated sites in Haute-Savoie. The explanation can follow two hypotheses: it could be a opposition in the choice of the raw materials between the Léman shore sites and the neolithic sites located in the forelands and inlands of Haute-Savoie; or it could be a chronological variation, if we consider that we've got only few informations about the chronology in this regions. We don't exclude the second hypothesis, but we think that the chronological informations are still enough to give reliable informations. The first hypothesis seems better, and this interpretation can be replaced in the general knowledges about the tenaceous rocks supplies in the Western Alps and the Swiss Forelands. In the Western Alps, in Northern Italy and South-Eastern France, the alpine eclogites and, in a much less part, the jadeitites, are the dominant rocks, and they are broadly diffused accross the Alps. On the opposite, on the Swiss Forelands, in the lakeshore sites dated from the Middle Neolithic to the end of the Neolithic, the axe blades are essentially manufactured from local morainic pebbles, i.e. ultrabasites (with the serpentinites first) and metabasites (Buret and Ricq-de Bouard 1982; Thirault and al. 1999). Moreover, the metapelites from the Plancher-les-Mines' quarries in the Vosges are well diffused in the Swiss Forelands during the Middle Neolithic, and this kind of objects reachs the southern lemanic lakeshore.

If this interpretation is true, the Haute-Savoie district would be a frontier territory with two separated areas for the tenaceous rocks supplies: on the Léman, the exploitation of the morainic pebbles, as in the lakeshore sites located on north to the Léman Lake; on the inland, the

	n°	site or stray find	rocks: metapelites	eclogites	jadeitites	ultrabasites	various metabasites	cataclasites	unspecified	TOTAL
Middle Neolithic I	1	Annecy		1						**1**
	2	Doussard		1						**1**
	3	Vétraz-Monthoud		2						**2**
Middle Neolithic II	4	La Balme-de-Thuy/La Vieille Eglise		3		1				**4**
	5	Saint-Jorioz/Les Marais		9	1	1				**11**
Final Neolithic	6	Magland		1						**1**
		stray finds NF		4	1					**5**
	7	Annecy/Le Port		12	1		1		6	**20**
	8	Annecy-le-Vieux/Le Petit Port		4					2	**6**
	9	Messery/Crozette		1		1				**2**
undated	10	Anthy-sur-Léman/Séchex	2	6		6	2			**16**
	11	Chens-sur-Léman/Beauregard				1	3	2		**6**
	12	Chens-sur-Léman/Tougues		12		1	1		13	**27**
	13	Excenevez		1		3		1	1	**6**
	14	Sciez/Coudrée				2			1	**3**
	15	Thonon-les-Bains/A Corzent		3	1	4				**8**
		TOTAL sites and/or dated	**2**	**60**	**4**	**20**	**7**	**3**	**23**	**119**
		other discoveries undated		19	2	1	1		7	**30**
		TOTAL all discoveries	**2**	**79**	**6**	**21**	**8**	**3**	**30**	**149**

Figure 3. Petrographic datas for the Neolithic sites and stray finds of the Haute-Savoie axe blades.

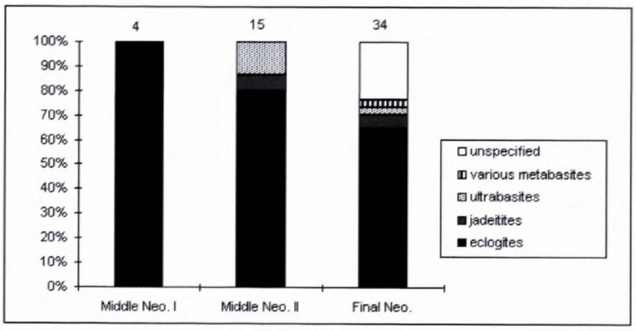
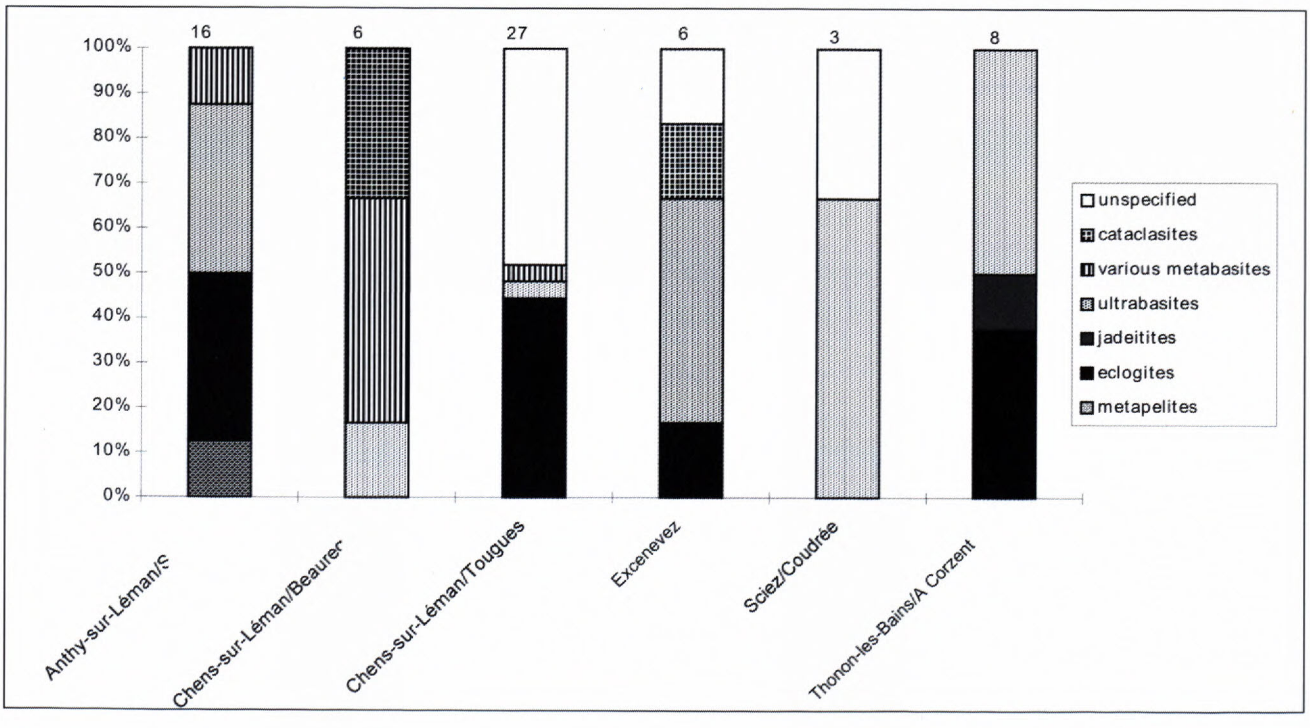


Figure 4. Chronological evolution of the rocks used for the neolithic axe blades in Haute-Savoie.

Figure 5. Petrographic composition of the axe blades coming from the Léman neolithic sites.



connection with the transalpine exchanges networks during all the Middle and Final Neolithic, with an evolution during the end of the Neolithic, with the use of some morainic pebbles. Unfortunately, we can't know if this opposition is valid during the whole Neolithic or not: we can imagine that the evolution on the Léman is similar (but stronger) to the inland evolution, with a decrease of the eclogite use at the end of the Neolithic.

5. Conclusion

This short introduction to the complexity of the tenaceous rocks use authorise us to propose some general conclusions about the neolithic behaviours. In Haute-Savoie, the availibity in good qualities tenaceous rocks is great, especially in the morainic deposits broadly developped in the Rhône valley, the Léman basin and the alpine forelands. But this availibity was not always used by the neolithic communities. For the main part of the territory considered, the rocks supplies was linked to the long distance exchanges coming from the Italian Alps. This mighty networks were active during the Middle Neolithic and decreased partly during the end of the Neolithic. This observation, valid for the whole Western Alps, suggest that at least, the human choice was directed by the network of social relations between the communities. This network was linked to the cultural geography of the communities, which should have strongly changed during the Neolithic. Even if our cultural knowledges remain scarce in this region, we can imagine that the variations in the rocks supplies reflect more the modalities of peopling that the regional geology.

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IUGS UNESCO IGCP 442

Variscite, a prestige mineral in the Neolithic-Aeneolithic Europe. Raw material sources and possible distribution routes

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Abstract: In all cases, we have new and interesting data about the possible trade routes of distribution of this mineral, in a broad period of the European prehistory, with the verification that a wide geographical distribution phenomenon of this has existed, with distances of many hundred of kilometres from the extraction site. Raw material areas for this mineral exploitation, at least in specific periods of the European prehistory, not only are placed in the well know mines of Gavá, NE Spain, exploited in a period about 5000-6000 years ago; but we have constancy of the existence of other prehistoric exploitations in the Encinasola area (Huelva, SW Spain) and other mining activity areas, probably prehistoric and reworked in Roman and Muslim times, in Palazuelos de las Cuevas and other sites of the Aliste area, in Zamora (NW Spain). There are no evidences up to the moment, of the existence of other localities with variscite mining activities, in the other geological outcrops cited in the Iberian Peninsula and in the rest of Europe.

Key words: variscite, raw material, Neolithic-Aeneolithic, Spain

Introduction

Variscite ($AlPO_4 . 2H_2O$) is a green mineral that has a great importance and diffusion, as prestige objects, in the South Western European Neolithic-Aeneolithic societies.

Archaeological objects made in this mineral, generally collar beads, appear with relatively frequency. Their size and morphology are variable, within a range between 3 and 50 mm long and plate cylinders, elongated cylinders, barrel or drop shapes; in all cases with orifices made in general by double perforation and 1-3 mm in diameter (Fig. 1).

Mineralogy and geological context of variscite

The colour of these objects are variable, they may vary between a pale green, bluish green to an intense emerald green, and in many cases brownish green or pale green with black veins. Variscite is an hydrated mineral of the phosphate group ($Al PO_4 . 2H_2O$), orthorhombic system, Kniep et al., (1977); with a chemical composition of 32,26 % in Al_2O_3, 44,94 % in P_2O_5 and a 22,80 % of H_2O, approximately; and impurities basically of iron, Rosell et al. (1993). It can present two polymorph varieties; the Messbach type variscite and the Lucin variscite, that only differ in their unit cell dimensions. Other minerals of this group as Strengite $Fe_3+ PO_4 . 2H_2O$, and the monoclinic variables metavariscite and metastrengite, can be present in their paragenesis; furthermore turquoise Cu $Al_6 (PO_4)_4 (OH)_8 . 4H_2O$), can appear, as it occurs in the Gavá-Montcada i Reixac area outcrops, in Barcelona (NE Spain) and in many outcrops of the NW of Spain and North of Portugal. Phosphate mineralization generally appears as nodules of variscite (Fig. 2) associated to primary stratiform deposits, in association with Silurian - Devonian metasediments and silexites from the Hesperico Massif, as occurs in the West of Iberian Peninsula. In general, a secondary mineralization as veins of variscite and other phosphates also appear (Fig. 3A and 3B), that proceed from the remobilisation of the primary deposits, Moro et al., (1992a).

Archaeological remarks

The description of these materials from this historical context, in the archaeological literature, has conduced to a great confusion about the real mineralogy of each object, describing all the beads and pendants with the generic nomenclature of "callaite", term given by Pliny (*Natural History, XXXVIII*) and which has subsisted up to the nineties in the European archaeological literature, Damour (1864); Munoz Amilibia (1971); Edo et al., (1995). Edo et al. (1997). This term has nowadays almost been left out, since in many cases the variscite beads appear associated in the archaeological contexts, with other green beads, but made in other minerals as muscovite, steatite, jade, or rocks as serpentinite, Munoz Amilibia (1971); Salvado Canelas (1973); Vázquez Varela (1975); Fernández and Pérez (1988).

The fact that these mineral associations appear in the European archaeological register, with a great variability of mineral compositions, geological and geographical provenances, but with the green colour as common feature, suggests that the colour of these beads or pendants is the main characteristic search by these communities, independently of its composition, hardness, etc. This intense green colour must constitute a prestige signal or

Fig. 1. Green and pale bluish green beads of variscite (1,5 to 1,7 cm. long). Alberite Dolmen, Cádiz, SW Spain.

Fig. 2. Variscite nodule of a intense green colour. Silurian meta-sediments from Palazuelos de las Cuevas (Zamora, NW Spain).

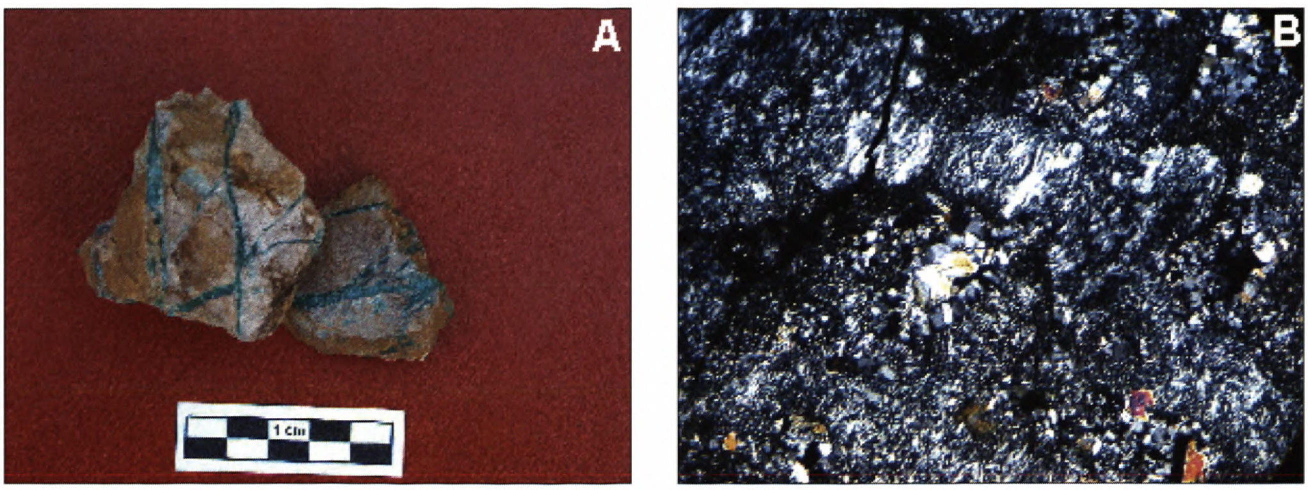

Fig. 3.
A: variscite vein in Silurian shale from Palazuelos de las Cuevas (Aliste area, Zamora province, NW Spain). B: Micrograph of the same variscite sample. Cross polars. Diameter = 1,2 mm.

has been a certain ritual significance, much esteemed by the dominant members of the communities or the power elites in these. This idea confirms the fact that in general, the big collars of these green minerals only appeared in the burials of the members of the elites, as occurs specially in a 2500 years period, in the west of France, specially in Bretagne, Damour (1864); Forestier et al. (1973); Querré et al. (2001); Sherrat (1990); also in Le Midi (SE France), Arnal (1970), and in the Iberian Peninsula in Galicia (NW Spain), Vázquez-Varela (1975); Portugal, Huet B. Gonçalves (1980); Extremadura and Andalucía, Ramos Munoz and Giles (1996); Martínez and Pereda (1991), Nocete et al. (1999); or in the culture of "sepulturas en fosa" in Catalonia, Munoz Amilibia (1965). This phenomenon remain just the early Bronze Age, green beads can appear in Campaniform contexts, Pozo et al. (2002). In the nineteenth century, green beads are also cited in the Neolithic burials from Brittany. Therefore, variscite and turquoise at these funerary environments between the Neolithic and the beginning of the Bronze Age, appear associated with other minerals and materials, that should have had a prestige or ritual significance, as the cinnabar, amber, quartz crystals, ivory and jet, Domínguez-Bella and Morata (1995). Big knifes made in flint, are also present in these trousseaus; and axes, chisels and gouges, in polished stones, as occur in Alberite (V th and IV th millennia B.C.) Ramos-Munoz & Giles (1996) and Tomillo dolmens (IV-III th millennia B.C.), Martínez and Pereda, (1991); from Cádiz province (SW Spain) and at a great number of archaeological sites in west Europe.

The appearance and extension of the variscite collars and pendants are present in the Neolithic of the west and south-west of Europe, starting from the VI millennia B.C. and their use were extended at least until the II millennia B.C. After, in the Roman Empire, their mining exploitation in many mineral outcrops at the west of Spain continues, Campano et al. (1985).

Geological source areas of variscite in Europe.

The geological features of the variscite bearing rocks outcrops that are located specially in the Iberian Peninsula present in general two types of deposits, primary stratiform deposits and secondary vein deposits, in both cases associated to metasediments (shales with black cherts and quartzites) of Silurian-Devonian age.

These types of outcrops are cited in the Palaeozoic of the Transmontana region at the North of Portugal, Meirelles et al., (1987); provinces of Zamora and Huelva (Moro et al., 1992a; Moro et al., 1992b; Moro et al., 1995b) at the West of Spain; Galicia at the NW Spain (Moro et al., 1995a) and the Coastal Cordillera of Catalonia, in Barcelona area, NE Spain, Mata et al. (1983) (Fig. 4). Others geological outcrops with variscite presence are cited in Pannecé, Loire-Atlantique (France), Forestier et al. (1973) and in Cerdena, Gimeno (1988). This mineral receives its name from the region of Variscia (Vogtland), in Germany, where it appears as nodules in little outcrops of aluminous shales in Messbach and Dornsdorf; is cited also in Brandberg, Leoben, Austria and in Trénice (Czech Republic).

According to the studies that were made up to the moment, it seems that the unique variscite and turquoise outcrops, mined in the prehistory of Europe, are located in the Iberian Peninsula. The prehistoric mines of variscite and turquoise with black flint, are well known in Can Tintorer, Gavá (Barcelona, NE Spain), Rosell et al. (1993), although they are clear signs of the existence of a prehistoric mining of variscite in Encinasola (Huelva, SW Spain), Nocete and Linares (1999: Fig. 5). In Palazuelos de las Cuevas (Zamora, West Spain), the manufacture of collar beads in Roman and Muslim periods have been documented, and also the presence of many beads that present different technology, that appear to be oldest, Campano et al. (1985). At the hill of Teso

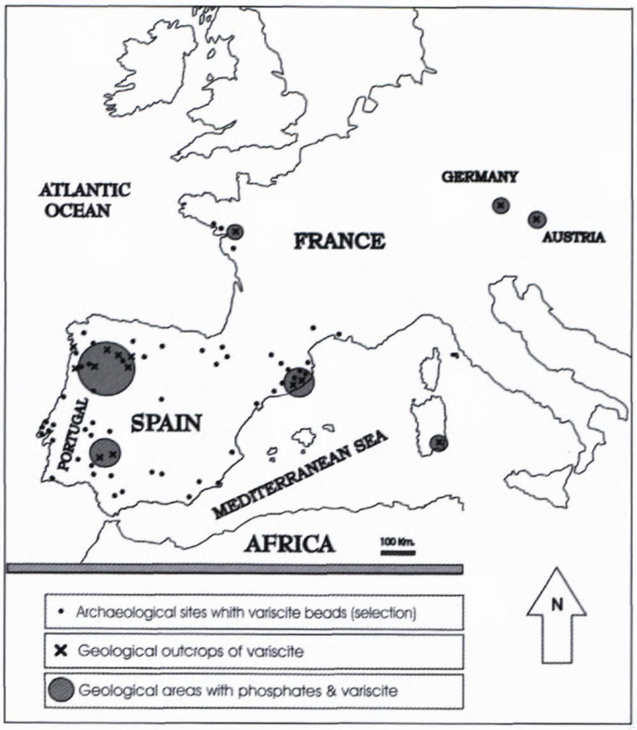

Fig. 4. Geographical emplacement of many of the most important archaeological founds of variscite and geological outcrops in Europe

del Diablo, in Palazuelos area, we can observe clear vestiges of mining, specially by the open air trench method (Fig. 6), with use of stone tools to work the variscite veins (Fig. 7), that were signalled also by other authors as Arribas et al. (1971) and Campano et al. (1985), and that have, for the early steps of the exploitation development, a chronology probably pre-Roman.

Possible distribution routes of variscite in Europe during the Prehistory.

Mineralogical characterization of samples from different outcrops in the Iberian Peninsula were made by different authors (Huet B. Gonçalves (1980); Huet B. Gonçalves et al. (1982); Meirelles et al. (1987); Edo et al. (1998), Moro et al. (1992b); Moro et al. (1995 a); Moro et al. (1995b); Salvado Canelas, (1973) and geochemical analysis (Rosell et al. (1993), Domínguez-Bella et al. (2002) and (2003); Rojo et al.(1995); Querré et al. (2001); Blanco et al. (1995) so we can realize comparative studies with archaeological materials (Table I) and establish the possible trade routes and the mobility of this material during the European prehistory, Whittle (1996). In this line, different authors have studied collar beads from the culture of the "sepulcros en fosa" in Catalonia, Edo et al. (1995 and 1998); from the Spanish Pyrenees, Utrilla et al. (1998); Domínguez Bella et al. (2002); from the Midi in SE France, Chantret et al. (1970); from the Bretagne (West of France), Querré et al. (2001); from the North of Spain, Rojo et al. (1995); Edo et al. (1997); from the Southwest of Spain (Domínguez-Bella et al. 2002) and from the Southeast of Spain (Pozo et al. 2002).

The mineralogical, petrological and geochemical characterization of the different outcrops with variscite

Slovak Geol. Mag., 10, 1-2(2004), 147-152

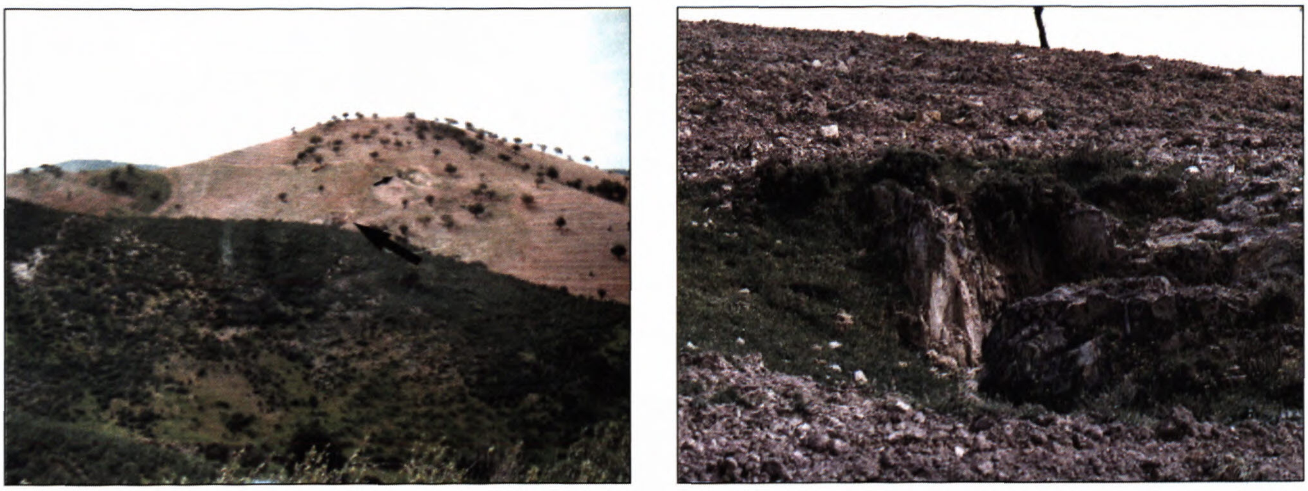

Fig. 5. Prehistoric open air mining activity for the variscite extraction remains, in Pico Centeno, Encinasola area (Huelva, SW Spain).

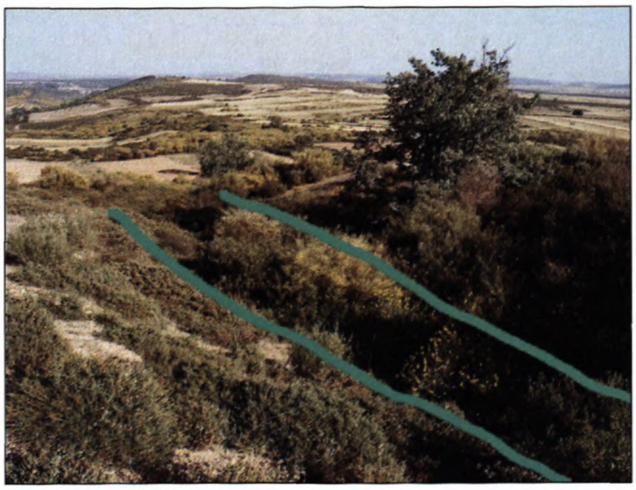

Fig. 6. Open air trench for variscita mining, probably pre-roman, in Palazuelos de las Cuevas area (Zamora, NW Spain). Trench excavations allows the verticals veins of phosphate minerals.

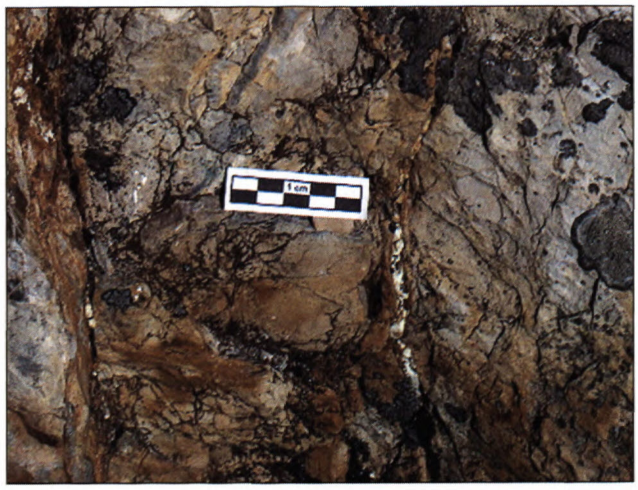

Fig. 7. Vertical vein (1,5 cms wide) of variscite in the open air trench. Palazuelos de las Cuevas, Zamora, Spain.

show, in general, quite paragenetic and geochemical similitude between them, at least in the outcrops from the west of Iberian Peninsula.

The obtained results up to this moment (Fig. 8) show the existence of different production and distribution areas for these lithic products. The variscite mining in Catalonia (Gavá Mines) seems to supply the North zone, Guerra et al., (1995), Edo et. al. (1997) and at least, a part of the northeast of Spain (Blasco et al. 1992) and the south and southeast of France.

Variscite outcrops from the west of Iberian Peninsula, seem to distribute materials to the south west and the west half of Iberian Peninsula, Domínguez-Bella and Morata (1996), Domínguez-Bella et al. (2002); Blanco et al. (1995); Nocete and Linares (1999), even also at the north zone of Spain and maybe at the north of the Pyrenees, in the west coast of France, Querré et al. (2001).

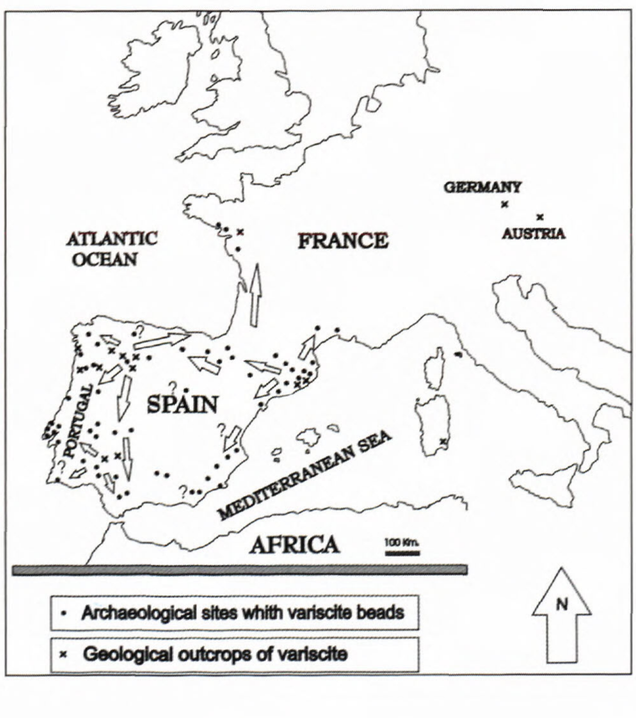

Fig. 8. Geographical distribution of a selection of most important archaeological sites with presence of variscite, the known geological outcrops and the possible trade routes along SW Europe.

Tab. 1. Geochemical analysis of geological variscites in Europe. (after Edo et al., 1998 and others; and Domínguez-Bella).*

ELEMENTS	PALAZUELOS AREA (NW Spain)	ENCINASOLA AREA (SW Spain)	CAN TINTORER MINE (Catalonia, NE Spain)*	VARISCITE ARCHAEOL. BEADS (Catalonia)*	PANNECE (France)*	SARRABÚS (Sardinia)*
P_2O_5	43,32 %	46,20	42,47	42,65	45,63	39,26
AL_2O_3	30,20	30,40	26,73	28	30,91	35,18
Fe_2O_3	1,09	1,64	6,03	4,23	0,08	1,97
SiO_2	1,90	0,74	1,07	1,20	Tr.	-
CaO	-	-	1,77	1,16	-	-
K_2O	0,02	0,02	0,21	0,27	Tr.	-
MnO	-	-	<0,01	<0,01	Tr.	-
TiO_2	0,14	0,09	0,03-0,42	-	-	-
MgO	-	-	<0,14	0,14	Tr.	-
CuO	0,03	0,02	0,02	0,31	-	1,52
Cr	0,54	0,13	0,07	0,13	0,01	0,01
As	-	-	0,34	0,21	-	-
Ni	0,005	-	<0,003	0,0026	Tr.	-
V	-	0,25	0,047	0,12	-	-
Na_2O	-	-	-	-	0,14	-
H_2O	21,50	21,90	21,51	21,63	23,28	21,89

Forestier et al. (1973), did not discard a local origin for the variscite from the Neolithic sites of the west of France, specially after the discovering of the phosphate ore outcrop at Pannecé (Loire-Atlantique, France); however, after the study of Querré et al. (2001), a allochtonous provenance for these beads of variscite appears clear, in short, with an origin in the Iberian Peninsula, which implies distribution routes of many hundred of kilometres for the variscite beads.

Different studies about the geochemistry of mayor, minor and trace elements have been carried out, with a classification matrix after the Discriminant Function Analysis of complete analysed samples by ICPMS-LA, MEB-EDX, FTIR spectroscopy, optical microscopy (Domínguez-Bella et al. 2002), with a model of 13 geochemical variables (SiO_2 , Al_2O_3 , P_2O_5, FeO, CaO, Cr_2O_3, Cr, Ti, Sm, Eu, Dy, Tm, Yb), both of geological representative from all Iberian Peninsula as well as, archaeological samples, specially from the South half of this, Domínguez-Bella et al. (2002). New analysis, with ICP-MS, XRF and isotopic analysis are nowadays in course, Domínguez-Bella et al. (2003). Similar works with the use of PIXE techniques were made by Querré et al. 2001, on french archaeological samples and many geological outcrops in france and Spain.

Final Remarks

In all cases, we have new and interesting data about the possible trade routes of distribution of this mineral, in a broad period of the European prehistory, with the verification that a wide geographical distribution phenomenon of this has existed, with distances of many hundred of kilometres from the extraction site.

Raw material areas for this mineral exploitation, at least in specific periods of the European prehistory, not only are placed in the well know mines of Gavá, NE Spain, exploited in a period about 5000-6000 years ago; but we have constancy of the existence of other prehistoric exploitations in the Encinasola area (Huelva, SW Spain)(excavated by F. Nocete), Nocete and Linares (1999); and other mining activity areas, probably prehistoric and reworked in Roman and Muslim times, in Palazuelos de las Cuevas and other sites of the Aliste area, in Zamora (NW Spain).

There are no evidences up to the moment, of the existence of other localities with variscite mining activities, in the other geological outcrops cited in the Iberian Peninsula and in the rest of Europe.

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Slovak Geol. Mag., 10, 1-2(2004), 153-162

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Rock-forming minerals in contact-metamorphosed greenschists of the polished stone artefacts (Neolithic, Slovakia, site Bajč-Medzi kanálmi)

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Abstract: On the Bajč-Medzi kanálmi site during the Middle Neolithic among stone raw materials used are repredsented namely by amphibole schists, amphibole schists with anthophyllite, phlogopite-anthophyllite schists and anthophyllite schists with Al-rich green spinel and corundum. Mineral assemblages of the greenschists and namely discriminant minerals (cordierite, Al-rich green spinel, corundum, anorthite, anthophyllite and orthopyroxene) are characteristic for rocks originated in contact-thermic aureoles developed in metabasites. Presence of grinders and saws made from the hardest occurring rocks (anthophyllite schists with Al-rich spinel and corundum) is in favour of idea that stone implements were made on the given site. Appropriate raw material has been transported, the most probably, from the crystalline complex of the Malé Karpaty Mts. Neolithic men based on, by naked eyes evaluated raw materials, choosed the most convenient (hard but simultaneously elastic) rock varieties characterized below.

Key words: Neolithic, Slovakia, site Bajč-Medzi kanálmi, polished stone artefacts, raw material, greenschists, rock-forming minerals

Introduction

The beginning of inhabitation on the site Bajč-Medzi kanálmi (Fig. 1) corresponds to 3rd stage of the Želiezovce group ranked to the the final period of the Middle Neolithic (around 4000 years B.C.). During the systematic survey in the past numerous fragments of chipped as well as polished industries together with artefacts made from clays, bones and antlers were uncovered.

Together around 300 pieces of stone artefacts were documented from the site. Based on their typology the most abundant are flat axes and shoe-last wedges, in lesser amount also grinders, globular maces, axe hammers, crushers, chisels and various semiproducts were described (Hovorka and Cheben 1997, Méres et al. 2001). Polished stone artefacts known from the discussed site were made from eruptive, sedimentary as well as metamorphic rock types.

The most commonly used were metamorphic rocks, among which greenschists were dominant (94 % of the stone artefacts documented).

In presented paper we dealt with the characteristic features of greenschist, which should offers information on the raw material source area and in such way to precise communication paths of communities living in the given area during the Middle Neolithic. We studied metamorphic mineral assemblages in detail and based on the chemical composition (electron microprobe determination) we present classification of amphiboles present.

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

Characterization of the raw material types

Based on mineral composition among the studied set of stone artefacts we distinguished the following varieties of the used greenschists: amphibole schists, amphibole schists with anthophyllite, phlogopite-anthophyllite schists and anthophyllite schists with Al-rich green spinel and corundum.

Amphibole schists have mostly augen appearance, very fine-grained granularity and dark greyish-green color. Chracteristic is their volcaniclastic texture. In the rock matrix very fine-grained (less than 50 μm) needlelike amphiboles prevails. By naked eyes observable light spots are composed of plagioclase, more sporadically also by quartz (Fig. 2/A, /B, /C). In accessory amount Mg-chlorite, clinozoisite, quartz, carbonates and ore minerals were identified.

Plagioclases in the amphibole schists, based on their composition, are zonal (Tab. 3). Their anorthite molecule contents is increased from the cores (An38) to the rims (An56). Also Ca-amphiboles present have zonal composition. Their cores are represented by actinolite and rims by Mg-hornblende and tschermakite (Fig. 2/C, 9, Tab. 1). In core of zonal amphiboles often clinozoisites occur. magnesiohornblendes and tschermakites do

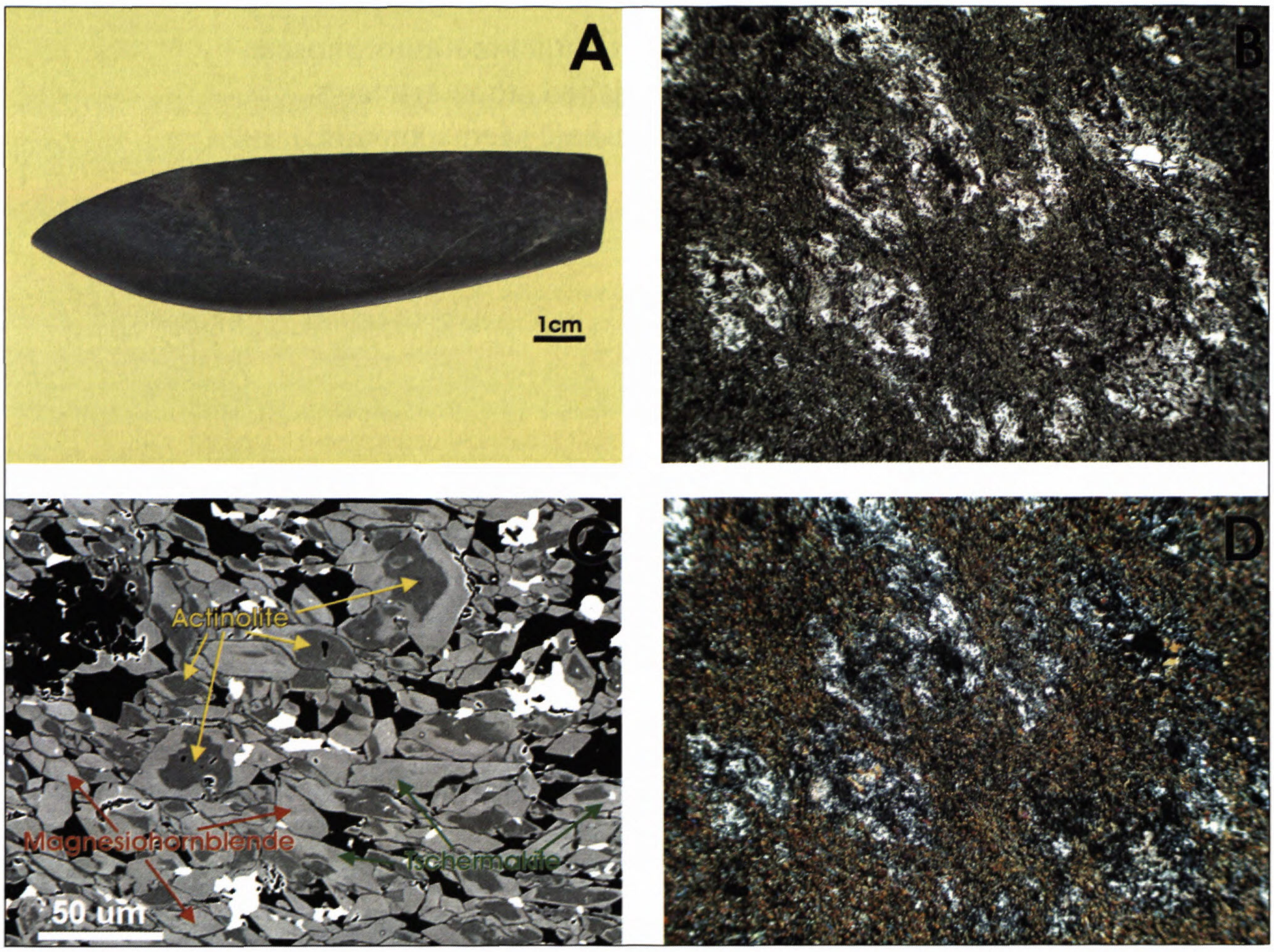

Fig. 2. A - Shoe-last wedge made from the amphibole schist. Samle B-18. Site: Bajč-Medzi kanálmi. B - Fine-flaky matrix of the amphibole schist is composed of amphiboles and light plagioclase plates/augens (sporadically also quartz). Parallel polars, C - Composition of zonal amphiboles (in cores actinolite, in rims magnesiohornblende and tschermakite) in scattered electrons, D - Identical with B: crossed polars.

occur also in the form of individual needles in the rock matrix.

Amphibole schists with anthophyllite represent very fine-grained light greyish-green up to dark-grey rocks. In some of them dark spots formed by the quartz aggregates (Fig. 4) are present. In the rock matrix dominant are tiny amphibole needles (Fig. 3/b, /c, /d, 4/b, /c). In this rock variety in accessory amont also Mg-chlorite, clinozoisite, quartz, phlogopite and ore minerals are present. In some artefacts high amount of ore minerals cause their dark color.

Also in this rock variety amphiboles are compositionally zonal. Following their chemical composition group of Ca-amhiboles (actinolite and magnesiohornblende) and Mg-Fe-Mn-Li amphibole group is represented by anthophyllite (following the Leake´ et al. classification, 1997, Fig. 9, Tab. 1). Cores of zonal amphiboles are formed by actinolites and the rims by magnesiohornblende and anthophyllite (Fig. 3/C). Actinolite and magnesiohornblende are the most abundant, anthophyllite is present in lesser amount. The last one we identified also in the form of individual very fine needles (below 5 μm) in the rock matrix. The anorthite molecule in plagioclases varies in wide range (An2 - An98, Tab. 3).

Phlogopite-anthophyllite schists are represented by fine-grained greyish-green rocks. Characteristic is spotty appearance observable namely in foliation planes. Spots are formed by aggregates of phlogopites (Fig. 5/A). In mineral composition dominant is fine-grained amphibole of needle-like morphology. In accessory amount clinozoiste, Mg-chlorite, ilmenite, plagioclase, quartz and muscovite are present. In this rock variety also cordierite was identified. (Tab. 2). In contrast to previously characterized rock varieties in this one only anthophyllite from the group of Mg-Fe-Mn-Li amphiboles (Leake et al. 1997) was identified. Plagioclase is represented by anorthite (Tab. 3).

Anthophyllite schists with spinel and corundum also represent very fine-grained dark-green rock variety. In their mineral composition amphibole prevails. Presence of green, Al-rich spinel and corundum located often in the space of probably orthopyroxene ancestors was documented. In described variety, except of mentioned phases, also orthopyroxene, clinozoisite, phlogopite,

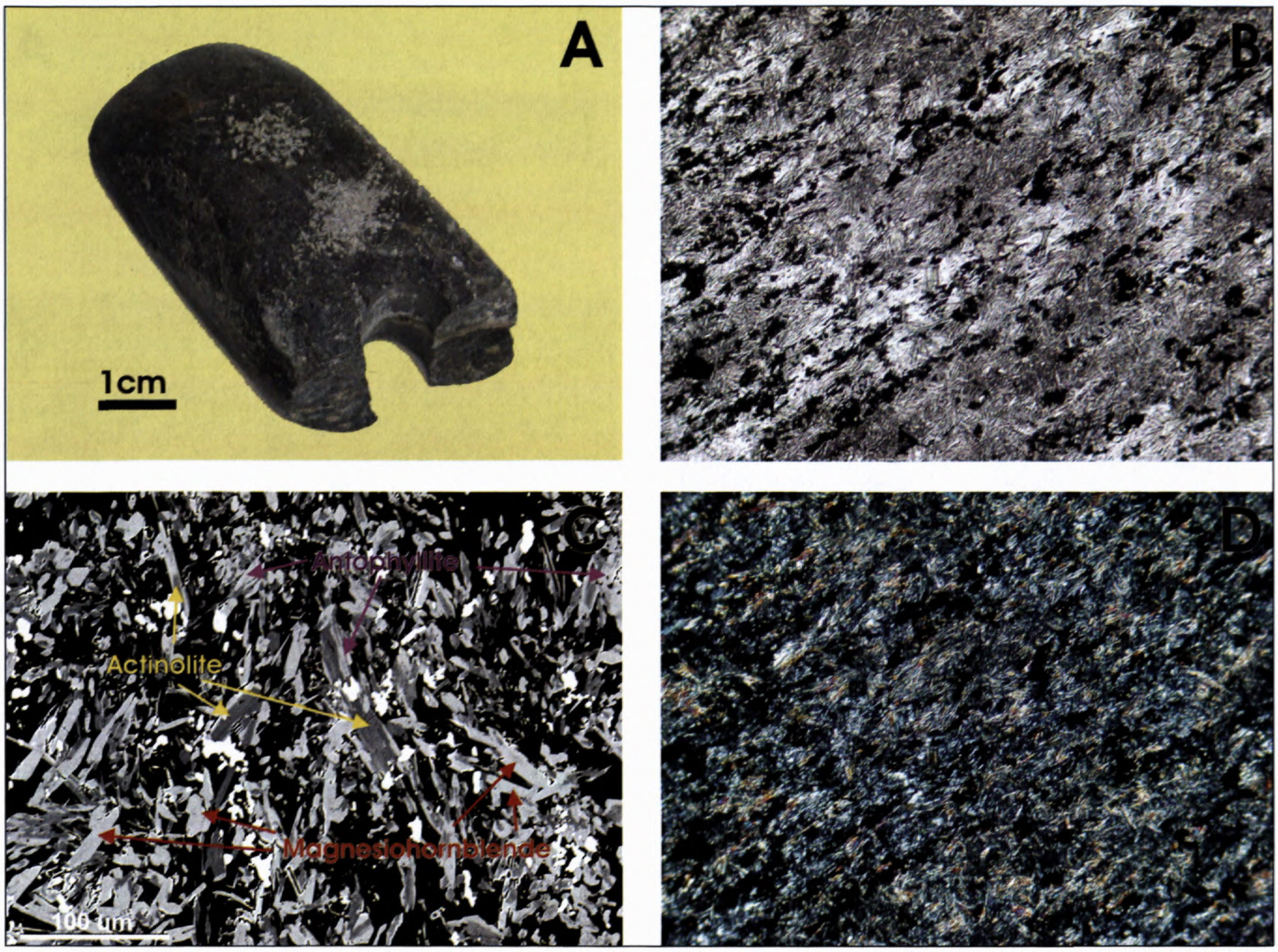

Fig. 3. A - Double-armed axe hammer made from amphibole schist with anthophyllite. Sample B-229. Site: Bajč-Medzi kanálmi. B - Fine-platy matrix composed of amphiboles and ore minerals (black). Parallel polars. C - Composition of zonal amphiboles (in cores actinolite, on rims Mg-hornblende or anthophyllite (in scattered electrons). D - Identical with B: crossed polars.

Mg-chlorite, plagioclase, muscovite, quartz and ore minerals are present (Tab. 2).

In several thin sections also magnesiohornblende and anthophyllite were identified (Fig. 9, Tab. 1). Plagioclase (Tab. 3) is represented by practically pure anorthite (An99).

Discussion

Our laboratory study was concentrated on the composition of rock-forming minerals of the most abundant raw material type - various varieties of greenschists. Special attention was paid to amphiboles.

Following the classification of amphiboles by Leake et al. (1997, Tab. 1, Fig. 9) in studied stone artefacts we identified two main groups of amphiboles: 1) Ca- amphiboles (actinolite, magnesiohornblende and tschermakite) and 2) Mg-Fe-Mn-Li amphiboles represented by anthophyllite. In studied artefacts also the following minerals were identified: phlogopite, anorthite, cordierite, spinel and corundum. Mentioned asemblage is present mostly in contact-thermic aureoles developed in metabasites. Preliminary identification of greenschists varieties, as it was presented above, was consequently proved on the base of their mineral composition and the intensity of their metamorphic recrystallization, as well.

In amphibole schists characteristic is presence of zonal amphiboles. In their cores actinolite do occur, while in the rims magnesiohornblende and tschermakite were identified. This rock variety corresponds the most probably to the regionally metamorphosed greenschists occuring in the source area. Amphibole schists with anthophyllite differ from the amphibole schists by the presence of anthophyllite located on the rims of zonal amphibole crystals, but occurring also in the rock matrix. Increase of anthophyllite content documents the increased grade of metamorphic recrystallization. Anthophyllite schists respresent rock variety originated in the outermost part of contact-thermic aureole. Phlogopite-anthophyllite schists on the other side represent totally thermally recrystalized original amphibole schists. Anthophyllite schists with corundum and Al-rich green spinel represent the most intensively thermally recrystallized original amphibole schists which originated just on, or near the contact between the greenschists and granite magma. Identification of different mineral

Slovak Geol. Mag., 10, 1-2(2004), 153-162

Fig. 4. A - Shoe-last wedge made from amphibole schist with anthophyllite. Sample B-95a. Site: Bajč-Medzi kanálmi. B - In fine grained matrix composed mostly of amphiboles sporadically present are also guartz grains. Parallel polars. C - Identical B: crossed polars.

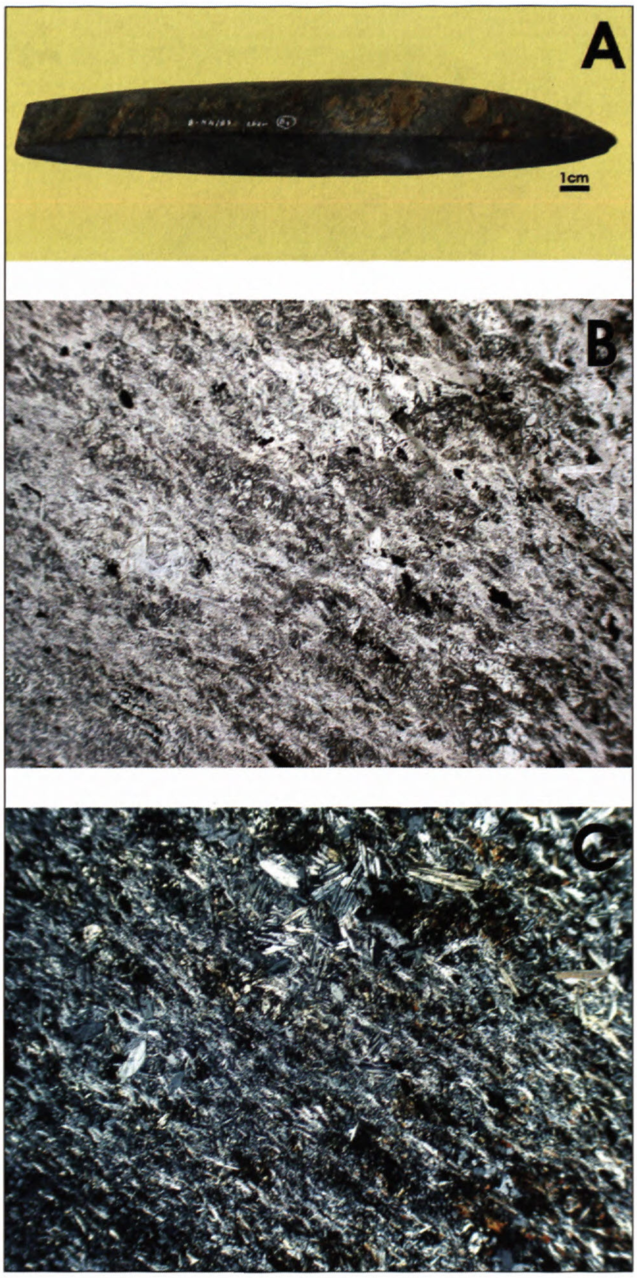

Fig. 5. A - Shoe-last wedge made from spotty phlogopite-anthophyllite schist. Sample B-1. Site: Bajč-Medzi kanálmi. B - Fine-platy matrix is composed of anthophyllite, spots of phlogopite and ore minerals (black). Paralel polars. C - Identical with B: crossed polars.

assemblages in various varieties of greenschist leads us to suppose their formation within one contact-thermic aureaole.

During the Neolithic/Aeneolithic time spane greenschists in the frame of the Bohemian Massif (Přichystal 2000) and Carpathian Basin together with the southern slopes of the Carpathian mountain chain (Hovorka and Illášová 2000, Szakmány and Kasztowszky 2001, Biró and Szakmány 2000) were the most frequently used raw material type for the stone implements construction. Based on the greenschists technical properties (hardnes, but simultaneously appropriate elasticity and chemical stability) were also frequently used in the praehistoric site Bajč-Medzi kanálmi (Hovorka and Cheben 1997, Méres et al. 2001). The favorable technical properties of greenschists used for the stone implements construction have increasing trend in accordance with gradually increasing amount of anthophyllite (increasing durability) and simultaneously with increasing amount of green spinel and corundum (elevated hardnes of the raw material). The fact that among various greenschists varieties just those of the most favourable technical properties have been chosen by the Neolithic/Aeneolithic populations for the following treatment, prove their high skillful-

Tab. 1 Representative amphibole analyses of greenschist of the Neolithic polished stone artefacts. Site: Bajč-Medzi kanálmi.

Sample	amphibole schists									amphibole schists with anthophyllite						Phl-Ath schists	
	B18/2	B18/5	B18/7	B18/8	B18/9	B117/3	B117/4	B117/5	B117/6	B229/1	B229/2	B229/4	B95/1	B95/2	B31A/1	B1/2	B1/5
	Ts	*Mho*	*Act*	*Mho*	*Mho*	*Act*	*Mho*	*Act*	*Ts*	*Ath*	*Act*	*Mho*	*Ath*	*Act*	*Ath*	*Ath*	*Ath*
SiO_2	41,72	44,19	53,94	52,90	52,45	55,34	45,11	55,17	41,75	53,61	52,18	51,14	56,55	53,90	56,57	55,11	55,96
TiO_2	0,41	0,51	0,14	0,25	0,34	0,08	0,46	0,06	0,45	0,03	0,13	0,31	0,05	0,05	0,10	0,07	0,03
Al_2O_3	14,90	12,04	2,72.	4,25	5,35	1,04	11,41	0,89	14,22	0,39	3,96	5,66	0,90	2,79	0,67	0,81	0,49
FeO	16,62	16,27	12,34	8,95	9,47	12,76	16,34	12,54	17,28	25,27	14,73	17,19	15,74	9,27	17,85	18,85	19,12
MnO	0,24	0,20	0,17	0,13	0,16	0,27	0,20	0,23	0,25	1,18	0,30	0,52	0,34	0,10	0,27	0,30	0,35
MgO	8,90	10,30	15,59	18,67	17,82	16,11	10,28	16,24	8,67	15,54	14,40	13,67	22,37	18,13	21,82	21,45	21,49
CaO	12,17	12,31	12,75	11,76	12,00	12,83	12,26	12,83	12,06	0,96	11,82	9,10	1,82	11,81	1,31	0,87	0,64
Na_2O	1,89	1,57	0,36	0,58	0,66	0,09	1,48	0,11	1,81	0,04	0,28	0,36	0,12	0,36	0,04	0,03	0,00
K_2O	0,36	0,25	0,06	0,06	0,08	0,03	0,16	0,02	0,38	0,00	0,06	0,11	0,01	0,04	0,01	0,00	0,02
Total	97,21	97,64	98,07	97,55	98,33	98,56	97,70	98,08	96,88	97,01	97,87	98,07	97,89	96,46	98,63	97,48	98,09

Tab. 1 continuation

Sample	phlogopite anthophyllite schists								anthophyllite schists with Spl and Crn									
	B1/7	B24/1	B24/2	B177/2	B177/4	B177/5	B177/6	B177/9	B61/1	B61/3	B61/4	B61/7	B61/8	B61/12	B61/13	B70A/3	B70A/8	B70A/9
	Ath	*Ath*	*Ath*	*Ath*	*Ath*	*Ath*	*Ath*	*Ath*	*Ath*	*Ath*	*Mho*	*Mho*	*Ath*	*Mho*	*Ath*	*Ath*	*Ath*	*Ath*
SiO_2	56,09	55,77	55,79	54,41	55,51	56,41	56,42	56,27	56,13	55,76	48,98	51,03	55,75	50,68	55,80	54,36	55,56	56,46
TiO_2	0,02	0,07	0,02	0,17	0,13	0,05	0,13	0,05	0,53	0,03	0,55	0,33	0,02	0,48	0,53	0,10	0,04	0,05
Al_2O_3	0,42	1,48	1,49	3,97	2,15	1,17	1,01	1,57	1,16	1,18	9,93	7,67	0,78	8,56	1,13	4,53	2,52	1,24
FeO	18,41	16,80	17,11	15,25	17,26	17,49	17,53	15,74	17,53	17,43	9,91	8,99	17,63	9,45	17,90	16,24	16,85	16,70
MnO	0,34	0,22	0,22	0,17	0,18	0,19	0,17	0,31	0,29	0,27	0,05	0,10	0,30	0,09	0,30	0,17	0,17	0,19
MgO	21,57	23,06	22,83	22,95	22,47	22,73	22,76	23,28	21,97	22,05	16,02	17,12	22,20	16,86	21,73	22,57	23,00	23,16
CaO	0,66	0,33	0,36	0,50	0,36	0,35	0,33	0,54	1,00	1,05	11,76	12,07	0,81	11,62	1,66	0,57	0,69	0,64
Na_2O	0,03	0,06	0,06	0,40	0,11	0,05	0,07	0,10	0,05	0,04	0,35	0,24	0,04	0,27	0,04	0,31	0,14	0,06
K_2O	0,01	0,01	0,00	0,02	0,00	0,00	0,01	0,01	0,01	0,01	0,28	0,17	0,00	0,24	0,00	0,00	0,01	0,00
Total	97,55	97,81	97,88	97,84	98,16	98,43	98,43	97,86	98,66	97,81	97,84	97,73	97,54	98,25	99,10	98,85	98,97	98,50

All analyses presented in this paper were realised in electron microprobe under standard condition in geological Survey of Slovak Republic. Explanation: Mho = magnesiohornblende, Ath = anthophyllite, Act = actinolite, Ts = tschermakite,

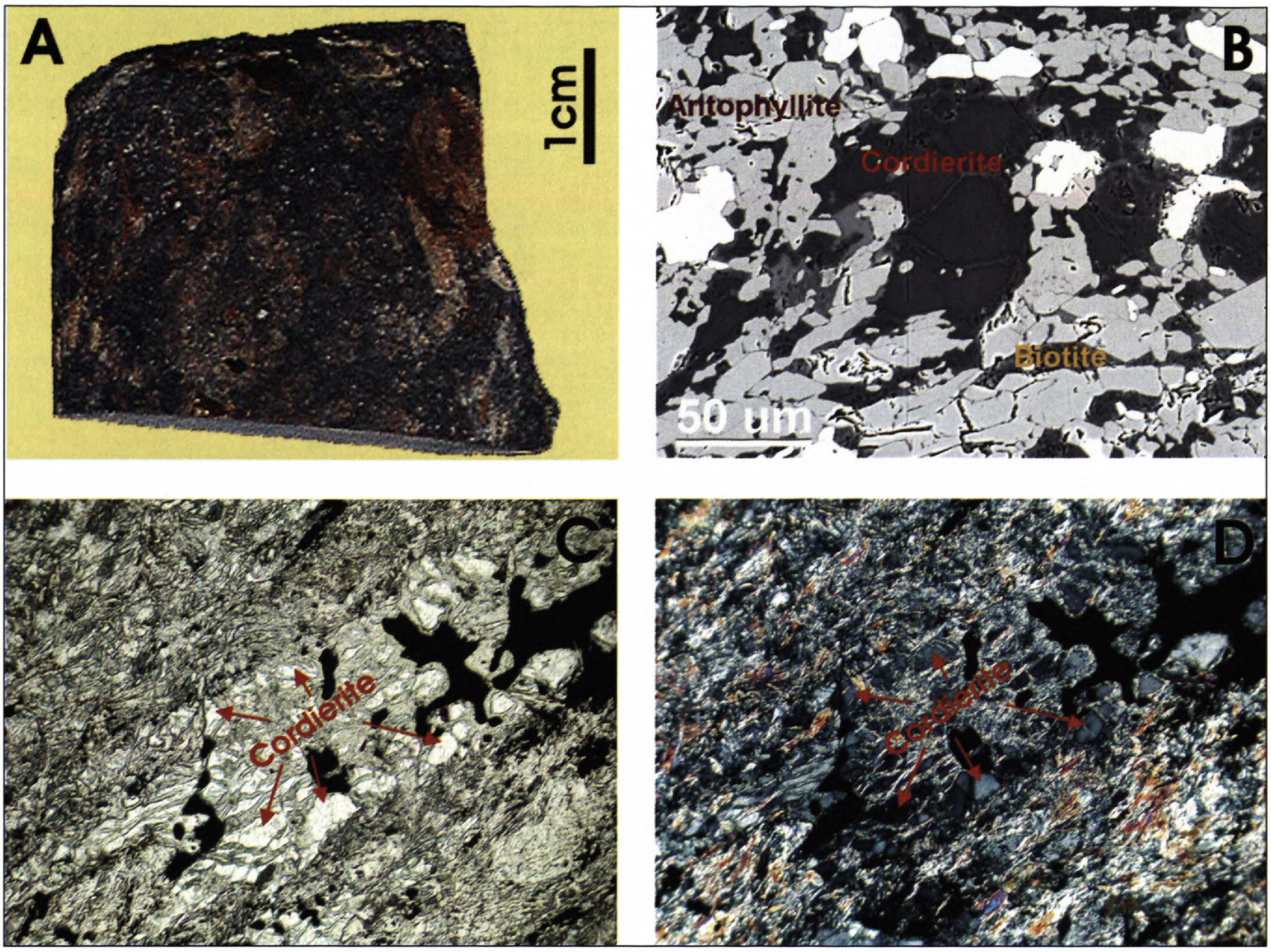

Fig. 6. A - Flat axe made from spotty phlogopite-anthophyllite schist with cordierite. Sample B-177. Site: Bajč-Medzi kanálmi. B - Anthophyllite, phlogopite, cordierite and ilmenite composition in scattered electrons. C - Fine-grained matrix is composed namely of anthophyllite, spots of cordierite and ore minerals (black). Paralel polars. D - Identical with C: crossed polars.

Tab. 2 Representative analyses of selected minerals from greenschists of polished stone artefacts from the site Bajč-Medzi kanálmi.

	phlogopite anthophyllite schists					anthophyllite schists with Spl and Crn				
Sample	B177/1	B177/7	B177/3	B177/8	B1/3	B61/5	B61/6	B61/10	B61/11	B70A/2
Mineral	*Phl*	*Ms*	*Crd*	*Crd*	*Ms*	*Opx*	*Opx*	*Spl*	*Spl*	*Spl*
SiO_2	39,92	47,67	50,28	49,93	47,69	53,47	52,86	0,02	0,03	0,00
TiO_2	1,68	0,00	0,00	0,00	0,00	0,19	0,08	0,04	0,12	0,04
Al_2O_3	16,75	36,22	32,96	33,12	39,30	1,77	1,64	58,10	58,43	62,86
Cr_2O_3	0,41	0,00	0,04	0,00	0,01	0,02	0,00	1,85	1,52	0,15
MgO	20,11	0,90	11,35	10,80	0,00	23,33	23,59	9,11	9,50	11,78
CaO	0,00	0,15	0,00	0,03	0,18	0,36	0,32	0,03	0,03	0,02
MnO	0,02	0,00	0,01	0,02	0,00	0,29	0,33	0,14	0,12	0,03
FeO	8,21	0,76	3,68	3,56	0,14	21,34	21,44	26,49	25,71	23,60
Fe_2O_3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,34	1,99	0,60
Na_2O	0,67	0,80	0,40	0,92	0,05	0,00	0,00	0,00	0,00	0,00
K_2O	7,79	9,59	0,00	0,00	10,15	0,00	0,00	0,00	0,00	0,00
Total	95,56	96,09	98,72	98,38	97,52	100,77	100,26	98,12	97,45	99,08

Explanation:
Crd - cordierite, Crn - corundum, Opx - orhopyroxene, Phl - phlogopite, Ms - muscovite, Spl - spinel

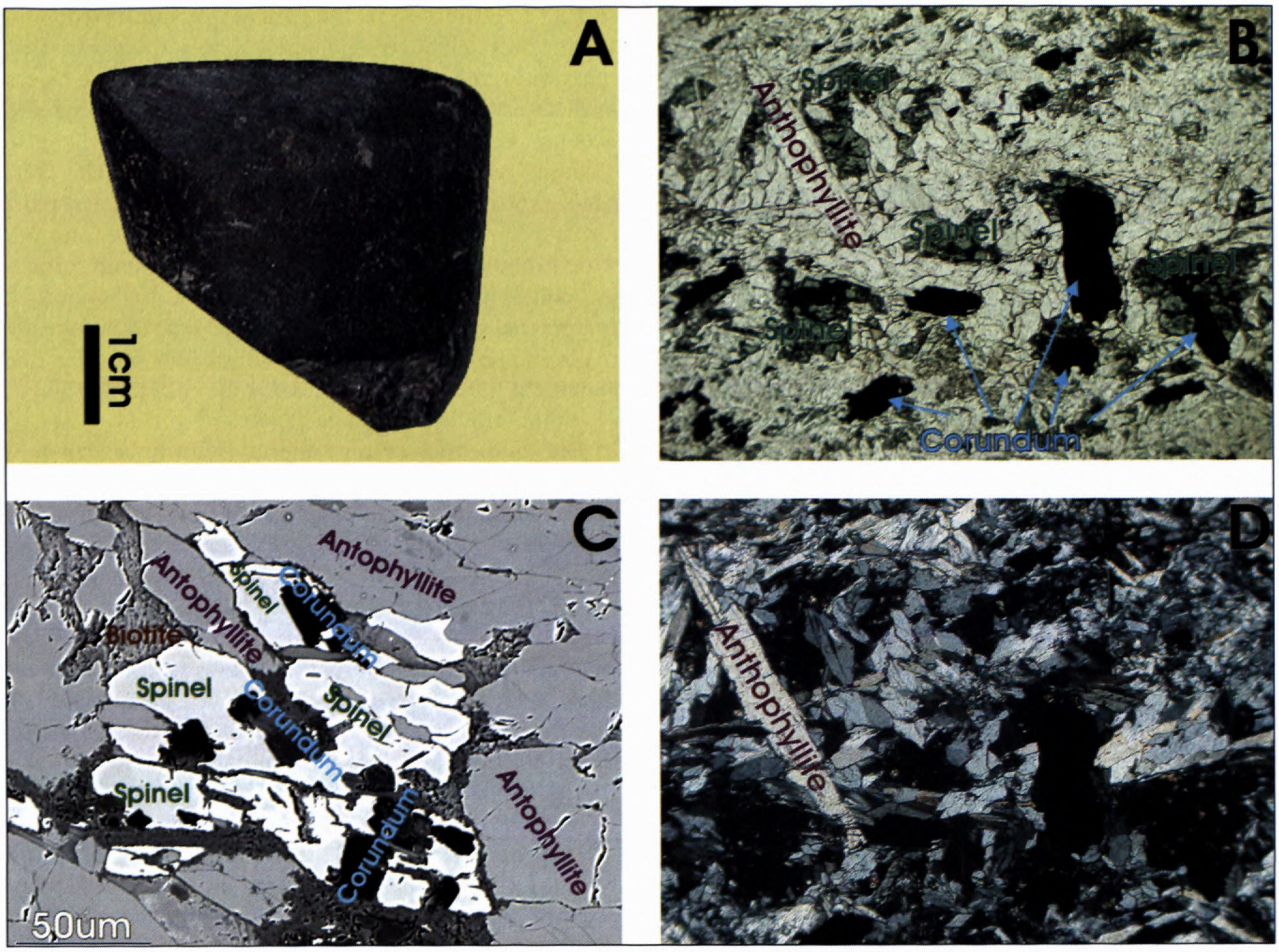

Fig. 7. A - Flat shoe-last axe made from anthophyllite schist with spinel and corundum. Sample B-70A. Site: Bajč-Medzi kanálmi. B - In fine-grained matrix green Al-rich spinels are present. Parallel polars. C - Composition of antophyllite, spinel, corundum and phlogopite in scattered electrons. D - identical with B: crossed polars.

Tab. 3 Representative analyses of plagioclase from greenschists of polished stone artefacts from the site Bajč-Medzi kanálmi.

Sample	amphibole schists			phlogopite anthophyllite schists			phlogopite anthophyllite schists			
	B18/4	B117/1	B117/2	B31/2	B95/3	B229/3	B61/14	B61/9	B70/11	B70/6
	Plg	*Plg*	*Plg*	*Plg*	*Plg*	*Plg*	*Plg*	*Plg*	*Plg*	*Plg*
SiO_2	54,13	59,09	54,05	69,14	47,83	45,73	43,50	43,06	43,31	43,40
Al_2O_3	29,11	26,45	29,19	19,39	33,42	34,72	36,52	36,19	35,38	35,64
CaO	11,53	7,99	11,78	0,36	16,87	18,26	20,29	20,16	20,10	20,08
Na_2O	5,11	7,24	5,12	11,44	2,07	1,26	0,07	0,05	0,06	0,08
K_2O	0,04	0,03	0,02	0,07	0,01	0,00	0,00	0,01	0,05	0,01
Total	99,92	100,80	100,16	100,4	100,2	99,97	100,38	99,47	98,90	99,21
Ab	44,38	62,01	43,97	97,93	18,16	11,10	0,63	0,48	0,57	0,70
Or	0,25	0,15	0,15	0,38	0,07	0,02	0,01	0,03	0,30	0,08
An	55,37	37,84	55,88	1,70	81,77	88,88	99,36	99,49	99,13	99,21

Explanation: Pl - plagioclase, An - anorthite, Or - orthoclase, Ab - albite.

Slovak Geol. Mag., 10, 1-2(2004), 153-162

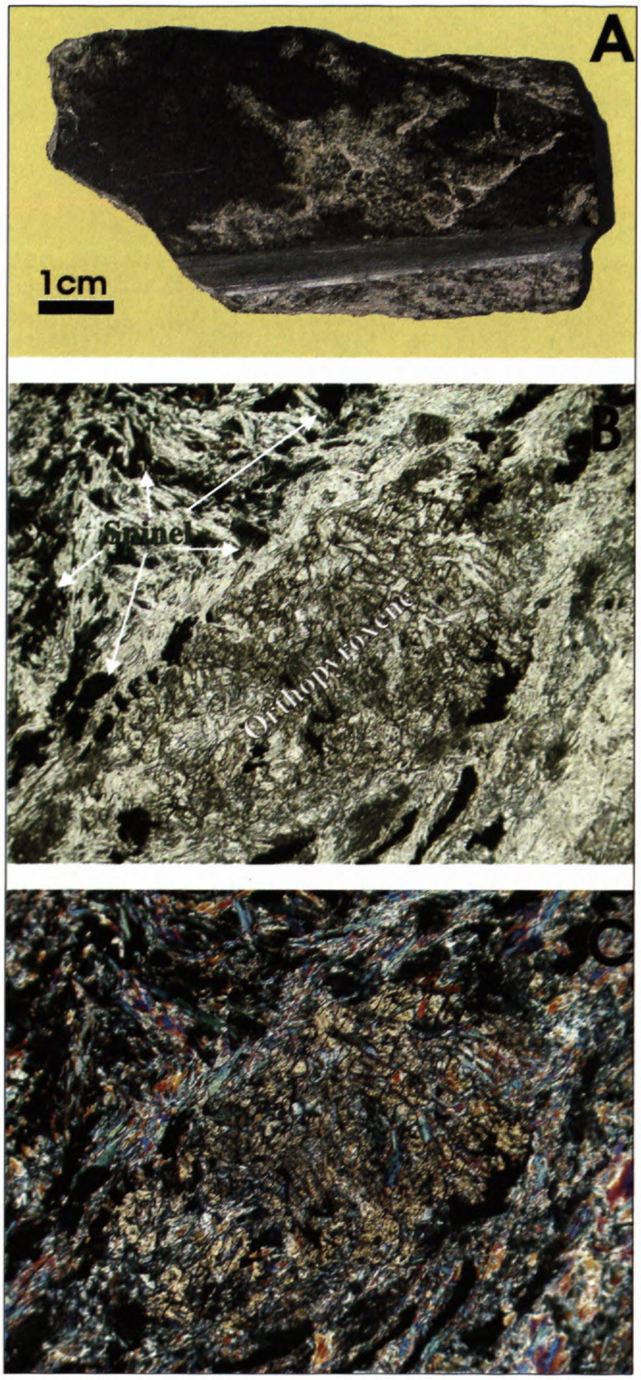

Fig. 8. Grinder made from anthophyllite schist with spinel and corundum. Sample B-61. Site: Bajč-Medzi kanálmi. B - In fine-grained matrix green Al-rich spinels and porphyritic orthopyroxene are present. Parallel polars. C - Identical with B: crossed polars.

ness in chosing the best inorganic raw material types. Neolithic men based on practical knowledge distinguished that some of the raw material types can be used as grinders or saws, meanwhile other are polisheable. This fact is just on the discussed site documented by the find of saws, which have been used for the other stone implement production (Fig. 8). Mentioned saws and grinders are made from the hardest raw material types - from the anthophyllite schists with corundum and Al-rich green spinel. Neolithic stone implements producers choosed for the next elaboration namely fine-grained varieties, meanwhile spots of phlogopite consequently were places of the most intensive destruction (weathering) processes, acted on the ready made implements.

Based on the fact that in the vicinity of the site Bajč-Medzi kanálmi neither do occur rock of the greenschist facies provenience nor their contact-thermic varieties which should be compared with the raw material varieties being raw material of stone Neolithic implements, it follows that raw materials of discussed type (but no ready made implements) were imported on the site. For this statement the leading argument is the occurrence just of saws and grinders on the given site.

The source area of raw material is not yet solved definitelly. Origin of the raw material identified varieties described above as a part of alluvial deposits is of low probability. Among raw matrial type evidently prevail various varieties of the greenschists, among which namely those, consequently influenced by the contact-thermic recrystallization, are characteristic. So we suppose that "specialists" chosed appropriate raw materials just on their in situ occurrences. The nearest occurrences of rock from the contact-thermic aureoles is known to occur in the Malé Karpaty Mts., namely in the zone between Bratislava and Modra (Cambel 1962, Korikovskij et al. 1994, 1995). Mentioned support occurrences of implements made from identical rock-types in the Neolithic/Aeneolithic sites located aroud the Malé Karpaty Mts. (Hovorka et al. 1997). Taking into account high skillfulnes of the Neolithic/Aeneolithic men, even identical roc-types are not known on nowadays surface in the mentioned mountain range, as realistic seems supposition, that mentioned extremely hard rocks (with corundum and Al-rich spinels) were selectively exploited. Changes of morphology (urbanization of the area) should "cover" given rock varieties. So our repeatedly realised field survey in the mentioned area was unsuccesfull til now.

Conclusions

By the use of electron microprobe we studied composition of rock-forming minerals of the most frequrently used raw material varieties of stone implements on the Neolithic site Bajč-Medzi kanálmi. From identified set of minerals present it follows:

a) mineral associations and discriminant minerals (cordierite, Al-rich green spinel, corundum, anorthite, anthophyllite, orthopyroxene) do occurs in rocks, which originated in contact-thermic aureoles in metabasites/greenschists,

b) members of the Middle Neolithic human community occupying site Bajč-Medzi kanálmi based on, by naked eyes observed properties, were abble selectively choose and consequently elaborate rock (raw material) types, which were the most suitable,

c) described raw material (rocks) varieties have the

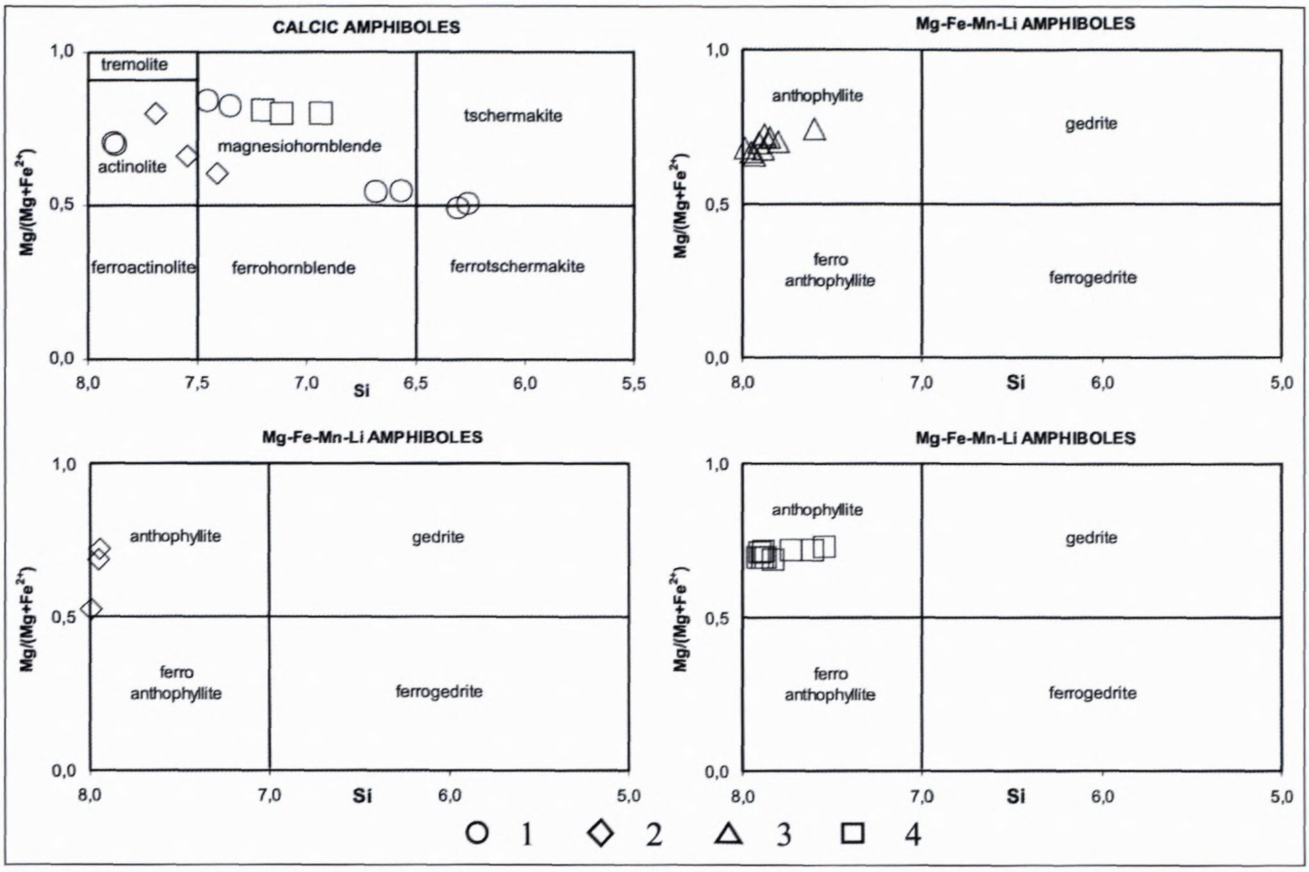

Fig. 9. Amphiboles from the greenschist raw material varieties classification (site: Bajč-Medzi kanálmi) in the Leakes´ et al. (1997) scheme. Analyses are presented in Table 1. Calculation used according to Schumacher (in Leake et al. 1997). Explanation: 1 - amphibole schists, 2 - amphibole schists with anthophyllite, 3 - phlogopite-anthophyllite schists, 4 - anthophyllite schists with spinel and corundum.

most probably their in situ occurrences in the Malé Karpaty Mts, which moumtain chain is of approximately 80-100 kms distance from the site,

d) based on the observed presence of the Neolithic implements made just from identical rock varieties which do occur in the area of the Malé Karpaty Mts. (Hovorka et al. 1997) it shoud be expected that given rock varieties were totally exploited in the past.

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ABSTRACTS

Slovak Geol. Mag., 10, 1-2(2004), 165-166

IUGS UNESCO IGCP 442

Petrography and chemical composition of groundstones from Çatalhöyük Neolithic site

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Introduction

Çatalhöyük Neolitic 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 complex in the world at 7500 BC 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 (http://catal.arch.cam.ac.uk).

During the excavations a lot of stone material and artefacts are collected, especially at the Neolithic East 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.

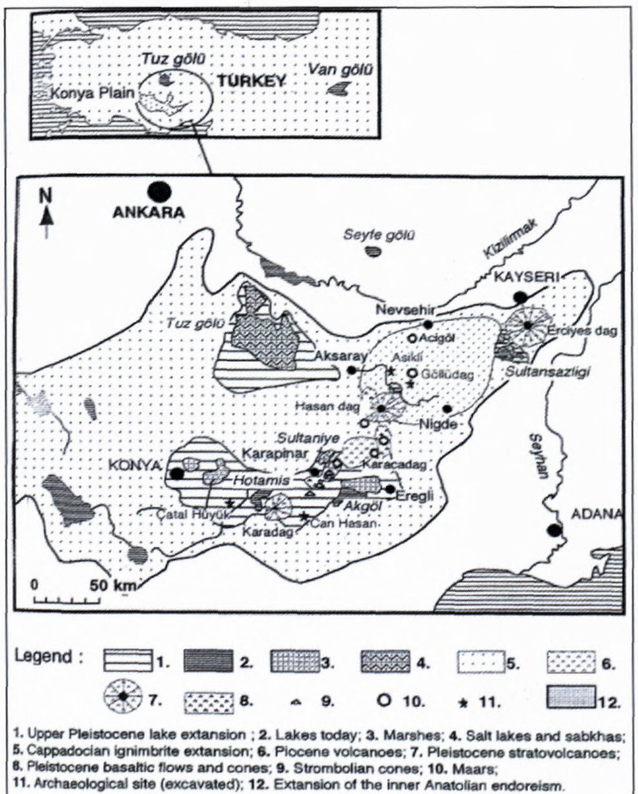

Fig. 1. Location map of the Çatalhöyük archaeological site (adopted from Karabiyikoglu and Kuzucuoglu; 1998)

This study aims to establish the links between the raw material sources of the Çatalhöyük groundstones based on their chemical and petrographic analyses.

Sampling and Methods of Study

Groundstone samples are collected from the East mound which is Neolithic in age, together with only one sample (Sample/Unit No: 2910) from the West mound, which belongs to Chalcolithic age (Table 1). Field samples were collected from igneous rocks including a volcanic neck and from the limestone outcrops in the region. River gravels were also sampled from the exposures of river deposits.

Thin sections of all samples were prepared and examined with a polarizing microscope to study their mineralogical compositions, textures and alteration products. XRF analyses were carried using the facilities at Turkish Atomic Energy Autorithy Laboratories, Ankara. The chemical data obtained were statistically analysed.

Results and Conclusion

The studied groundstones and field samples are classified into volcanic, sedimentary and metamorphic rock types based on petrographic analysis. In each rock type subgroups were also identified. The groundstones of the first subgroup can be correlated with the field samples collected from Karadag-Kaletepe location (Table 2). The groundstones of the second subgroup are correlated with the field samples collected from Karadag location. For the third subgroup there is no matching groundstone. Groundstones of sedimentary raw material have similar petrographic features with the field samples collected from certain locations. Only a few of the groundstone samples belong to metamorphic group without any match with the studied field outcrops.

The geological formations are proposed for the raw materials based on their petrographic characteristics and geological observations (Table 2).

Slovak Geol. Mag., 10, 1-2(2004), 165-166

Table 1. Description of the Samples Studied

Analysis No	Sample/Unit	Sample No	Area/Location	Material	Description	Attributed Level
1	2519	Stn/S3	North 97	Groundstone	Metamorphic	VI-V
2	3049	Stn/S3	North 98	Groundstone	Volcanic	VII- VI
3	1092-1	Stn/S4	Mell 96	Groundstone	Sedimentary	VII
4	3115-2	Stn/S8	Mell 98	Groundstone	Sedimentary	VIII
5	3314	Stn/S8	Mell 98	Groundstone	Sedimentary	VIII
6	4121	Sample 2	South 99	Groundstone	Sedimentary	VIII
7	5308	Sample 28	South 99	Groundstone	Sedimentary	prelevel XII/C
8	4186	Sample 11	South 99	Groundstone	Metamorphic	VIII
9	4194	Sample 25	South 99	Groundstone	Metamorphic	
10	4246	Sample 13	South 99	Groundstone	Metamorphic	VII
11	3501x5		Bach 98	Groundstone	Volcanic	VI?
12	2910	Stn/S22	West 98	Groundstone	Volcanic	
13	6010	Sample 17	Kopal 99	Groundstone	Metamorphic	
14		Sample 1	Karadađ/Kaletepe	Outcrop	Volcanic	
15		Sample 2	Karadađ/ Kaletepe	Outcrop	Volcanic	
16		Sample 3	Karadađ/ Kaletepe	Outcrop	Volcanic	
17		Sample 4	Karadađ/ Necktepe	Outcrop	Volcanic	
18		Sample 7	Karadađ/ Necktepe	Outcrop	Sedimentary	
19		Sample 1	Kanal taksim mahalli	Outcrop	Sedimentary	
20		Sample 2	Kanal taksim mahalli	Outcrop	Sedimentary	Fosillifeous
21		Sample 1	Belkuyu	Outcrope/stone	Sedimentary	

Table 2. Provenance Analysis of Groundstones

Field Outcrop	Rock Type .	Matching Groundstones
	I. Volcanic Sources/Pleistocene Age	
Karadađ/Kaletepe	Ho-andesite, Ho-Bi-andesite	3049, 3501, 1242
Karadađ	Px-basalt	2910, 3501x5, 3506
Karadađ/Necktepe	Dacitic andesite	*No match*
	II. Sedimentary Sources/Possible Geological Formation-Age	
Kaletepe/Necktepe7, K.T.Mahalli	Lake limestone-marl/Karahisarlý Lst-Neogene	3115-2, 3314, 5308, F160
Dineksaray, Belkuyu	Radiolarian Chert/Ophiolithic melange-Cretaceous age	1092-1, 6010
Dineksaray	Conglomerate,Sandstone, Siltstone/alluvial deposits of Çarşamba River/Quaternary	3315-1, 4121, 4796
	III. Metamorphic Sources/Possible Geologic Formation-Age	
No match	Recrstallized limestone/Taurus Belt –Permian age	6010
No match	Metadiabase/Hatip Melange at the south of Konya plain	4194
No match	Quartz-mica schist/metagranite of basement rocks-Precambrian age	4186, 4246, 2518, 1015
No match	Meta-sandstone/?	1344, 3743

Ho: Hornblende Bi: biotite Px: Pyroxene

These findings are also supported by major and trace element analyses.

Acknowledgement

The authors are grateful to Adnan Baysal (Cambridge University) for providing the groundstone samples.

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IUGS UNESCO IGCP 442

Raw materials and posible provenance areas of the variscite green beads from some Neolithic dolmens in the Cádiz province (SW Spain)

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Key words: raw materials, variscite, Neolithic, Iberian Península, Cádiz.

Green beads are an usual constituent in the Neolithic and Mesolithic burial materials and funerary trousseaus in Southwest Europe (particularly in the Iberian Peninsula and France). An interesting question in the European Neolithic studies has been during long time, the mineralogical, geochemical and typological characterization of these "green beads".

The description and characterization of these archaeological materials continue to be an interesting problem in the European prehistory, since the XIX th century in which Damour began with the study of some green beads found in the Celtic graves in France.

The record of Neolithic and Chalcolithic sites is very extended from north to the south of the Iberian Peninsula, with various examples in Spain and Portugal.

Different archaeological samples of green beads (mainly constituted by Variscite: $Al(PO4)\cdot 2H2O$) belonging to the Alberite and Tomillo dolmens (V th and IV th millenniums B.C.), from Cádiz province (SW Spain) have been studied.

The prehistoric communities that built these dolmens had a clear agropecuaric character. Our investigations confirm the existence of communities that were related with tribal economic and social formations, having productive capacity to generate agricultural and cattle excedents, in sedentary habitats of fertile countryside.

The presence of "exotic" products in this region, as the variscite beads, cinnabar or great quartz monocrystals, with a geological origin related with remote production areas, reflects a big value of them as prestige or ritual objects, and introduces the question of the distribution nets phenomenon.

Geochemical, mineralogical and petrological techniques (XRF, ICP-MS, optical and electronic microscopy, XRD, FT-IR) are used to characterise the green beads from these archaeological sites. In this study, samples from the most important geological localities for variscite and related minerals in Spain and Portugal, placed at the northeast and west of the Spain and north of Portugal, have also been studied.

The obtained results of the geochemistry, mineralogy and petrology of both the archaeological and geological samples were compared by means of factorial analysis. This comparison allows us to discriminate the probably source areas for these Neolithic materials and, in consequence, establish the transport and the possible trade ways of these beads at the V th millennium BP in the SW of Iberian Peninsula. These results are also in relation with the recent discoveries of extraction areas of these raw materials and the vestiges of ancient mining activities in Zamora and Huelva provinces (west of Spain).

All these data are interesting in order to obtain conclusions about the interchange phenomenon and social features of these human social groups.

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The stone tools of Sopot culture in Croatia

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The Sopot Culture is a representative of the typical Neolithic agriculture based on land cultivation. It developed on the basis of the late Starčevo Culture with strong influence of the Vinča Cultural Circle. During the Middle and Late Neolithic it was present throughout the northern Croatia. The population of the Sopot Culture lived in settlements located in lowlands, frequently in marsh areas, but always in the immediate vicinity of a river or creek. These settlements were surrounded by ditches or palisades (Dimitrijević 1968;1979).

This paper is based on an analysis of the lithic material from three sites of the Sopot Culture. These are Samatovci near Osijek, Bapska near Ilok, and Novoselci in the vicinity of Požega. The three sites are located in different areas that were covered by the Sopot Culture.

There is an exceptionally high number of lithic finds on the sites of the Sopot Culture; nonetheless no systematic analysis - typological, technological or functional - has ever been carried out. Chipped stone products are mostly blades, scrapers, flakes and cores. Arrowheads with thorns have also been found on the sites of that culture. The material for these products mostly belonged to the local types of primary and secondary chert. Although the presence of radiolarit of the Metzek type has also been noticed on some sites.[1] In the range of chipped stone products, a special place is kept by those made of obsidian. The leading center of the obsidian production was undoubtedly in Samatovci near Osijek, where large amount of cores, flakes and small plates were discovered. The Samatovci obsidian is of Carpathian I type.

The polished stone tools were rather similar throughout the three phases of the Sopot Culture. There were various types of small flat trapezoid axes and chisels with noticeable wearmarks on the heads rather then on their blades, which indicates that they were used for wood processing. Both kinds of tools are also present in very small sizes ranging from 4 to 10 cm. These small items sometimes have no visible wearmarks, so that they could have been used for polishing. However, no certain claims can be made given that a wearmark analysis has never been carried out on the Croatian finds. These types of tools were mostly made of chert, tuff and sandstone.

Shafted axes are also present in the Sopot Culture, although not in high numbers. They were mostly made of amphibolite and basalt.

Among the polished tools there is also a group of items with parallel sides, with no blade and with two blunt ends, that is, with two slightly rounded sides. On both sides there area visible wearmarks that indicate that they were used as pestles/hammers. This type of tools were mostly made of sandstone. Some axes, chisels and wedges that were damaged or broken while serving their original purpose were later also used as pestles.

Tools with rough, unpolished surface were mostly made of sandstone. There were several types of these tools: grinding stones, whetstones and grindstones. The most frequent type is grinding stone: a round, or almost rectangular tool, 3.5 to 5.5 cm long.

All the above mentioned types of stone that were used to make polished axes can be found in the Dinaride Ophiolite Zone and some of them are also available in the Slavonian Mountains where they can be found in primary layers and in creek sediments. Given the vicinity of primary and secondary sources it is highly probable that the stone used for the tools production is of local provenance. However, given that no detailed and systematic research has been carried out in the territory of Croatia and that there is no database regarding the primary rocks, the origin of the material, unfortunately still remains unconfirmed.

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Dimitrijević S., 1979: Sjeverna zona, Praistorija jugoslavenskih zemalja II, Neolitsko doba, Sarajevo, 229-360.

[1] The flaked tools from Samatovci were analysed by our colleagues from Hungary: Katalin T. Biró, György Szakmány and Zsolt Schleder

Slovak Geol. Mag., 10, 1-2(2004), 169-171

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Modeling and firing technology - reflected in the textural features and the mineralogy of the ceramics from Neolithic sites in Transylvania (Romania)

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Coarse, semifine and fine ceramic pottery found in Early, Middle and Late Neolithic archaeological sites from Transylvania (Romania) were analyzed.
The fabric of the ceramics depends on raw materials, modeling technology, and firing conditions. The mineralogical changes of the compounds, the X-ray spectra and DTA curves reflect the temperature of the firing. Different pre-wheel modeling techniques were used, mirrored by the arrangement of the lamellar minerals inside the ceramic wall.

Key words: Geoarchaeology, Neolithic ceramics, clay minerals.

Introduction

The study was performed on coarse, semifine and fine ceramic artifacts (pottery) found in different archaeological sites from Romania (Fig. 1), being as follows:

1. Early Neolithic age (around 6,500 b.Chr., acc. to Lazarovici et al., 1995): Baciu site, Cluj county. The ceramics belong to the Starcevo-Cris Culture. The mineralogy of the ceramics as well as some preliminary considerations on the firing temperature and modeling techniques were already made by Lazarovici et al. (1995).

2. Middle Neolithic age (around 6,000 b.Chr., acc. to Lazarovici et al., 1996): Zau site, Mures County. The studied ceramics belong to the great cultural complex called CCTLNI (Cluj-Cheile Turzii-Lumea Noua-Iclod), which began at the end of the Early Neolithic, developed mainly in the Middle Neolithic and finished in the Late Neolithic. The data on the Middle Neolithic ceramic from Zau were presented by Ghergari et al. (2001).

3. Late Neolithic age (around 5,500-5,000 b.Chr., acc. to Lazarovici et al., 1996): Cheile Turzii site (Cluj county). The ceramics belong to the Petresti Culture. The mineralogical data as well as the results of X-ray diffractometry and SEM analyses are new and for the first time presented in this paper.

The main targets of the study were the identification of:

- the mineralogical compounds of the ceramics as support for a correct classification as well as for data base;
- the mineralogical elements which allow the finding of the geological sources used for raw materials;
- the fabric features - as mirroring the different pre-wheel modeling techniques used by ancient man;
- the transformation of mineralogical compounds during the firing as reflecting mainly the temperature, i.e. the level of the Stone-Age technology;

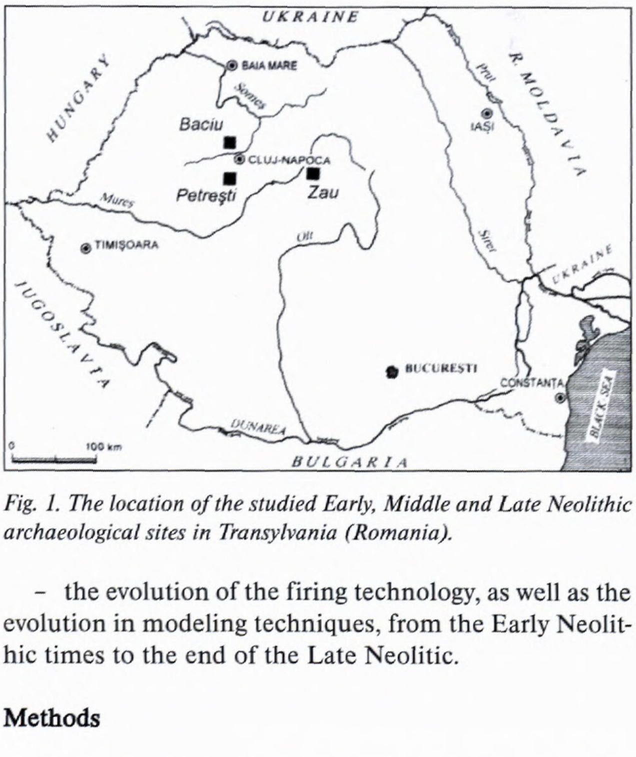

Fig. 1. The location of the studied Early, Middle and Late Neolithic archaeological sites in Transylvania (Romania).

- the evolution of the firing technology, as well as the evolution in modeling techniques, from the Early Neolithic times to the end of the Late Neolitic.

Methods

For this study, a DRON 3 - type X-ray diffractometer (Cu anticathode; Ka radiation, with la = 1,54051 A), a polarizing petrographic microscope Nikon and a BF 450 - TESLA Brno type Scanning Electron Microscope (surface of the samples covered with gold or copper) were used, as well as.

Sample description

A number of 42 Neolithic ceramic samples (9 of Early Neolithic, 13 of Middle Neolithic and 20 of Late Neolithic age) were studied. The pottery has mainly smoothed, seldom polished surfaces. Macroscopically, the firing is either good or poor, of reducing or oxidizing character.

About 20-30% of Early Neolithic ceramics is painted, proving the presence of the local pottery workshops. The quantity of painted ceramics increases in the Middle and Late Neolithic times, reaching up to 50%. The base colours of the ceramics are variable, from gray and grayish-black to brick-red, brown, red, orange or reddish-brown. For the decoration, incisions as well as red, brown and black paintings were used.

The fabric and the mineralogical features of the Neolithic ceramics

Texturally, the Neolithic ceramic pottery belongs mainly to the coarse (lutito-arenito-siltic) and semifine (lutito-silto-arenitic) categories, and subordinately to the fine (lutito-siltic) one. The prevalence of semifine ceramics is increasing in the Middle and Late Neolithic times.

The four types of the arrangement of some of the phase compounds (mainly lamellar minerals as micas, clay minerals) noticed in cross section to the ceramic wall, allow us to figure the modeling techniques used by the Neolithic man:

a) Slight orientation in the outer parts of the ceramic wall and changes in the direction (in oblique rows or chaotically arranged) in the center of the ceramic wall: modeling from clay lumps pressed on a wooden form; this technique is common for all Neolithic times;

b) Parallel to the wall: modeling by repeated beating-and-pressing of already flattened clay slabs, on a wooden form or an anvil; this technique is common for all Neolithic times;

c) Short changes of the direction (loosely circular): modeling by pressing of clay rolls coiled on a wooden form; this style of modeling is found in the Middle Neolithic ceramics from Zau;

d) Variable arrangements: in the core of the ceramic wall loosely circular orientation; in the outer parts of the wall, the lamellae are oblique to the wall surface; modeling from an almost sphaerical clay lump, in which a hollow is made by striking it with the right fist; afterwards the walls are thinned by pressing-modeling with both hands. This technique is specific only for the Late Neolithic ceramics from Cheile Turzii site.

One has to notice that the Neolithic times knew various styles of pottery pre-wheel modeling, each of it being specific for a certain period of time.

The Neolithic ceramics is constituted from a paste (matrix) in which lithoclasts, crystalloclasts, bioclasts and ceramoclasts occur (Ghergari et al., 1999).

Formed by thermally altered clay minerals, the matrix has a sintered, microcrystalline-amorphous to microcrystalline-vitreous, low-porous character. Mainly illite, kaolinite and montmorillonite occur, in variable percents, defining in general polymictic clays.

The lithoclasts, crystalloclasts, bioclasts and ceramoclasts have a variable composition, depending mainly on the raw clay materials as well as on the temper (non-plastic material[1]) added in order to lower the plasticity of the ceramic mixture, respectively to reduce excessive shrinkage). The lithoclasts are represented by sedimentary, magmatic and metamorphic rocks. As crystalloclasts, quartz, plagioclase and potassic feldspars, biotite, muscovite occur.

As characteristic features for the Early Neolithic ceramics, the presence of the chaff as well as the high amount of the bioclasts, both specially added as temper, are prevailing. In the Middle Neolithic ceramics, the bioclasts are very rare. The ceramoclasts (tiny fragments of shards) are frequent and obviously were added as temper. The Late Neolithic ceramics reveals rare ceramoclasts but the presence of bioclasts, as foraminifera remnants, is a characteristic feature.

The firing temperatures as deduced from mineralogical, X-ray diffraction and DTA data

Comparing the experimental data[2] and reference sources (Shepard, 1976; Velde and Druc, 1999) and changes (as partial or total irreversible destroying of the crystalline structure) of some minerals (carbonates, clay minerals) noticed by polarized light microscopy and scanning electron microscopy observations, as well as the modifications of the X-ray diffraction spectra and DTA curves[3], the average temperature ranges were estimated as presented in table 1.

The temperatures of firing are almost at the same level in Early and Middle Neolithic, being in general between 600 and 850°C, only ocasionally reaching the level of 900°C. During the Late Neolithic, the temperatures of firing are significantly higher (700-900°C, with some values around 1000°C and over.

Conclusions

As inferred from ceramic characteristics (composition, fabric, thermal transformations), the technology used for the Neolithic ceramics involves:

- mixing of clay + temper ± chaff + water;
- modeling by pressing flattened slabs or lumps on a wooden form or on an anvil or by coiling rings or spirals;
- firing at various temperatures, ranging between

[1] Sands, volcanic ash, chaff as well as crushed ceramics, shells, bones.

[2] Unpublished.

[3] The lowest-temperature thermal effect that appears on the DTA diagram corresponds to the highest temperature reached during the pottery firing; the thermal effects produced during firing are not any more present in DTA analysis.

Table 1. The main firing temperatures for the Neolithic ceramic as inferred from mineralogical changes (seen in polarized light and in SEM) and from X-ray powder diffraction.

Estimated temperature	Mineralogical changes (seen in polarized light and in SEM)	Features of X-ray powder diffraction spectra
Early Neolithic		
600-700°C	Beginning of sintering of clay minerals: >500°C Siderite transformed in hematite: 550-650°C Not decomposed dolomite: <700-750°C	Absence of 7Å line of kaolinite: >600°C Presence of 4.5Å line of clay minerals: <900-950°C Presence of 3.03Å calcite line: < 900°C
650-750°C	Partly decomposed dolomite: ~700-750°C Not decomposed calcite: <850-900°C	
750-850°C	Decomposed dolomite: >750-800°C Decomposed calcite: >900°C	
Middle Neolithic		
600-700°C	Beginning of sintering of clay minerals: >500°C Not decomposed calcite: <850-900°C Not decomposed dolomite: <700-750°C	Absence of 7Å line of kaolinite: >600°C Presence of 4.5Å line of clay minerals: <900-950°C Presence of 3.03Å calcite line: < 900°C
700-800°C	Decomposed dolomite: >750-800°C Not decomposed calcite: <850-900°C	
800-900°C	Decomposed dolomite: >750-800°C Partly decomposed calcite: ~850-900°C	Absence of 7Å line of kaolinite: >600°C The 14Å line of chlorites intensifies: 650-850°C Presence of 4.5Å line of clay minerals: <900-950°C Presence of 3.03Å calcite line: < 900°
Late Neolithic		
700-800°C	Beginning of sintering of clay minerals: >500°C Partly decomposed dolomite: ~700-750°C Not decomposed calcite: <850-900°C	Absence of 7Å line of kaolinite: >600°C The 14Å line of chlorites intensifies: 650-850°C Presence of 3.03Å calcite line: <900°C Presence of 4.5Å line of clay minerals: <900-950°C
800-900°C	Decomposed dolomite: >750-800°C Partly decomposed calcite: ~850-900°C	Absence of 7Å line of kaolinite: >600°C Presence of 3.03Å calcite line: <900°C Presence of 4.5Å line of clay minerals: <900-950°C
900-1000°C	Decomposed dolomite: >750-800°C Decomposed calcite: >900°C Partly melted (vitrified) clay minerals: ~950°C	Absence of 7Å line of kaolinite: >600°C Absence of 10Å and 5Å lines of illite: >900°C Absence of 3.03Å calcite line: >950°C Absence of 4.5Å line of clay minerals: >950°C
1000-1050°C	Decomposed dolomite: >750-800°C Decomposed calcite: >900°C Melted (vitrified) clay minerals: >950°C Kaolinite transformed in mullite: >1000°C	Absence of 7Å line of kaolinite: >600°C Absence 10Å and 5Å lines of illite: >900°C Absence of 3.03Å calcite line: >950°C Absence of 4.5Å line of clay minerals: >950°C Presence of 3.39Å and 3.43Å lines of mullite: >1000°C Absence of all lines of clay minerals: >1000°C

600-850°C for Early Neolithic, 600-900°C for Middle Neolithic, and 700-1000°C for Late Neolithic ceramics. Higher temperature, as 1050°C, for Late Neolitic ceramics, was also estimated.

Most probably, the firing was performed in open fires for Early and Middle Neolithic ceramics. Semiclosed structures, the lower part being excavated in the ground, allowed the firing of the Late Neolithic ceramics at high temperature.

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Slovak Geol. Mag., 10, 1-2(2004), 172-173

Utilization of siliceous weathering products during the Neolithic and Aeneolithic of the Czech Republic

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Siliceous weathering products originated during the geological history on different rock types of the Bohemian Massif. Two main groups of siliceous weathering products have been divided. To the first group belong opal and plasma (green coloured), which are formed as a part of the lateritic profiles mostly on ultrabasic rocks. Trnka (1981) studied opal from weathering cover of another metamorphic rocks (e.g. gneisses). According to Plusnina and, Szpila (1990), in special cases, they may generate recently under low temperature conditions as well. Together with described siliceous masses there are many varieties of silicificated lateritic residues and "siliciophites". The second group consists of clastic siliceous sediments including silcretes, i.e. products of surface and subsurface silicification. On the Bohemian Massif two major types of silcrete have been recognized: chert breccia and silica-cemented sandstones - quartzites (isolated blocks of quartzites called "sarsens, sluňáky "), which could represent different silicification mechanisms. Both silcrete types are preserved mainly as denudation relicts. Siliceous weathering products could be used as indicators of paleogeographical and paleoclimatical changes in geological past, but in the event of silcretes, only if their mode of origin is known.

Siliceous weathering products represented significant raw material for chipped industry during the Paleolithic and also the Neolithic/Aeneolithic of the Czech Republic.

Opal and plasma

From southern Bohemia, Žebera (1952) published the findings of artefacts made from brown variety of opal in the Epipaleolithic site near Křemže. Besides, there are many sources of opal and plasma also in southwest Moravia in area of Jevišovice and Náměšť nad Oslavou, which utilization were first mentioned by Přichystal (1979) and Kovárník (1980). Přichystal (1980, 1984) described plasma as a raw material on several Neolithic settlements (e.g. site at Těšetice - Kyjovice (the Znojmo district) with the Moravian Painted Ware culture). According to Kovárník (1992), in Czech- Moravian Highlands, there are a lot of localities where these kinds of raw material can be found, but only a few of them were used in the primeval period. This author informes of mining and primary processing of plasma in vicinity of Jevišovice, its distribution on the Neolithic / Aeneolithic sites, in which could represent the prevalent raw material. Similar data were given by Přichystal (1999). Kovárník (1992) also described several sources of opal (Mešovice, Čížov- the Znojmo district; opals from area of Nová Ves near Oslavany, Třebíč etc.) and findings of opal artefacts from the Upper Paleolithic site Lhánice II (the Třebíč district), the Late Neolithic site Příštpo (the Třebíč district) with the Moravian Painted Ware culture and the Middle Neolithic site near Čížov with the Linear Pottery culture - Šárka stage. Mrázek and Holá (1978) studied plasma (localities around Oslavany: Biskoupky, Hrubšice and Nová Ves near Oslavany) from gemological point of view.

Relicts of silcrete: quarzites and chert breccia

Both silcrete varieties represented significant raw material for production of chipped implements during the Paleolithic and younger ages as well.

Quartzites are distributed in regions of the Czech Republic largely as scattered solitary blocks ("sluňáky"), except ones from the Late Cretaceous and the Early Tertiary of north-west Bohemia (the Kadaň and Most areas).

Quartzites are potencially analogous to silcretes occuring elsewhere in the world (e.g. in the Tertiary Paris Basin in France (Thiry, Simon-Coinçon 1996); siliceous boulders ("sarsens, puddingstones") laying on various Cenozoic formations in southern England, where were used for parts of megalithic monuments such as the Avebury Stone Circle (Hepworth 1998, Ullyot et al. 1998) etc.).

Knowledge about quartzites from north- west Bohemia were summarized by Malkovský and Vencl (1995). They discussed genesis, division with characteristic features and exploitation during prehistory. Neústupný (1966) described mining of Tušimice type during the Neolithic/Aeneolithic. According to Friedrich (1972), Bečov type was mined in surface pits and in open shafts till the Middle Bronze age. In addition, several types of described quartzites (Skršín, Bečov, Tušimice) are known from the Paleolithic to the Neolithic / Aeneolithic in Moravia as well.

Chipped artefacts made from quartzites "sluňáky" were described from the Late Paleolithic settlements situated on southern slopes of Drahanská vrchovina Highland (central Moravia) by Absolon (1935), Štelcl and

Malina (1973) and others. Quartzite blocks are possible to find also at Nízký Jeseník Highland and Maleník block, which were used on the Aurignacien sites around Přerov (Přichystal 1999).

Sources of chert breccia are known from the Krumlovský les Highland, Brno agglomeration and central part of the Moravian Karst. Chert breccia from the Krumlovský les Highland were studied by Jaroš (1965) and Přichystal (1998). There is evidence for its utilization on several Paleolithic and Neolithic/Aeneolithic sites in the vicinity of Moravský Krumlov (Vedrovice). Artefacts made from chert breccia are known also from the Early Bronze age site Kubšice.

The author studied the collection of siliceous weathering products, which utilization (exploitation) is expected or proved. Studying siliceous weathering products of serpentinites is based on thin sections observation, determination of SiO_2 modifications by X-ray diffraction and analyses of trace elements by ICP (Inductively Coupled Plasma). In conformity with X-ray powder diffraction, several SiO_2 modifications were indicated. Opals (milk-white opals from localities Bohouškovice near Křemže and Smrček near Nedvědice) included disordered crystalline low temperature a - cristobalite (lussatite) and a - tridymite, so it is possible to used the term opal-CT. Some kinds of opal reveal the transformation to chalcedony (including minor content of quartz). Almost all studied plasma and silicified lateritic residues consist of microcrystalline quartz (chalcedony). In siliceous matrix of last described material could be observed relict structures (often emphasized by mixture of ferrous compounds) and remnants of minerals (e.g. amphiboles, chlorites, magnetite etc.). Among investigated siliceous masses there are considerable differences at trace elements contents, especially Ni and Co, which could be caused by position within weathering profiles or by origin during different stages of weathering.

As regards of silcretes, the most important is determination of their origin. On the Bohemian Massif, two genetic categories have been recognized: pedogenic ("complex" or "weathering") and groundwater ("simple") silcrete. Their division is based on detailed description of micromorphological features under polarizing microscopy and analyses of individual features (titanium and iron contents) by electron microprobe. Thin sections (chert breccia, Moravian quartzites) were made only from scattered blocks, because there are no profiles preserved. Pedogenic silicification (which results in origin of almost all quartzites) took place on former land surface, so it is the most useful paleoenvironmental indicator. Groundwater silcretes (Bečov type of quartzite) could form in different depths and they are related to former groundwater phenomenon. It is possible to observe also multiphase silicification in some chert breccia. Recognition of silcrete genetic types, their mineralogy and chemistry may be useful for identification of source area as well.

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Slovak Geol. Mag., 10, 1-2(2004), 174-175

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Raw materials of the Aeneolithic polished tools from the cave Vindija (NW Croatia)

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Despite the fact that the Neolithic, Bronze-age, Roman and Middle-age remains were found at the site, the cave Vindija (Hrvatsko Zagorje, NW Croatia) is well known mostly because of Neandertals, their culture and associated Upper Pleistocene faunal assemblages. Thus, while in the frame of previous project (101711 "Paleolithic and Mesolithic of Croatia") the analysis of the Paleolithic industry from the cave Vindija was made, the investigation is recently focused to the analysis of the industry deriving from geologically youngest deposits of the cave.

The cave Vindija is situated on the slopes of the peak Križnjakov vrh (Mt. Ravna Gora) in semimountainous region of northwestern Croatia (46 18'12"N, 16 14'38"E), 20 km from the town Varaždin and approximately 55 km from Zagreb. Its semicirculary vaulted entrance opens at 275m/sl. The cave consists of a single large chambre measuring 50 meters in length, 28 meters in breadth, and over 20 meters in height.

The genesis of the cave is connected with the Middle Pliocene tectonic pattern of the area, when the north-south movements generated the NW-SE transcurrent dextral fault, as well as with the Upper Pliocene and Pleistocene rising of Mt. Ravna Gora that caused formation of a brook valley, as well as the recent morphology of the cave. The sedimentation of Quaternary deposits has started in the Middle Pleistocene.

Approximatelly 15 meters of investigated deposits were divided into 13 distinct stratigraphic units and designed with letters from M (oldest) to A (youngest). The levels M and L appear to date to the Riss Glacial (OIS 6), unit K is correlated with the Eemian (OIS 5e), while the levels J - D encompass the Last Glacial (OIS 5d - 2).The uppermost levels A, B, C, and partly D were dated to the Holocene (OIS 1), and their lithostratigraphy is defined as follows:

level A - black humus - 15 cm - subrecent
level B - brown humus-like soil - 60 cm - Subboreal-Subatlantic
level C - speleothem - 20-50 cm - Atlantic
level D - greyish silty sediment - 50-150 cm - Early Holocene-Early Dryas

Only the speleothem, i.e. level C, was dated radiometrically. The estimated radiocarbon age of the sample Z-1856 is 1.7 +/- 0.6 pMC, i.e. 4.929 years B.P.

The Lasinja and Retz-Gajary Culture (Aeneolithic), as well as Litzen-type ceramic (Bronze-age), and probably Kisapostag-culture were found in the described levels.

The polished stone artifacts from the cave Vindija are stored as separate collection at the Archaeological department of the Museum of the town Varaždin. The collection consists of 20 polished tools/weapons and 2 plugs found in the uppermost levels of the cave interior or in the sediments excavated in front of the cave (levels A, B) together with the mentioned Aeneolithic and Bronze-age cultural remains. The excavations were performed by teacher and curator at the Museum Stjepan Vuković in the period from 1934 till 1949 and documented in attendant protocols.

Following the method of typological analysis established for the stone industry of northeastern Slovenia the stone tools from the cave Vindija are divided into two main categories: perforated polished tools (14 specimens) and polished tools/weapons without perforation (6 specimens).

In the category of tools without perforation, to the type D 2 i.e. to the cylindrical axes belong the specimens Inv. Nr. 379, 512 and 381. The artifact Inv. Nr. 513 is ascribed to the type G2 i.e. in the group of maces and grinders. Peculiar are two stone tools which resemble the so called foreign-shaped axes registerd also on the territory of Slovenia and in Koprivnica region. One of them, i.e.specimen nr. 6277 is extremely well formed, with well polished lower part and with a cross-like incission in the middle of upper elongated part. Similar characteristics could be seen on the the specimen Inv. Nr. 394. Most probably they belong to the new subcategory of the type B. The fragmentary axe Inv.Nr. 378 found in the level with a ceramics of Litzen-type belongs to the type B 2.

Perforated stone artifacts belong to the variants of the types A, B, and C: specimens 501 and 514 to the variant A4, tool 1335 as well as specimens 384 and 382 to the variant A3. One fragment of axe-hammer Inv. Nr. 370 belongs probably to the same variant. The fragment 391 is probably one axe of the variant A 9. The perforated hoes are ascribed to the type C: the specimen 392 to the variant C1, the fragment 374 to the variant C2. The fragments 504 and 503 are typologically not defined.

The miniature axe Inv.Nr. 377 is exceptional because of its fine chiseling and decoration in the shape of double-cross incision on both sides and probably with cult assignment.

Two plugs in collection indicate a local tool production and possibly greater quantity of perforated tools.

The performed petrographical analysis showed that among the raw materials used for production of above described tools, basalt is represented wiht 36%, diabase with 23%, serpentinite with 23%, andesite wiht 9% and sandstone with 9 %. These raw materials possessed physical and technical properties which met the expectations of their users, and the choice of stone raw materials was not accidental but intentional and depended on the function of the final product.

From above 22 described stone artifacts from the cave Vindija, 14 were determined only macroscopically with binocular lens by using non-destructive optical methods: with exception of 4 specimens (Inv.Nr. 514, 380, 382, 513), they have been made from andesite (2 specimens), serpentinite (5 specimens) and sandstone (2 specimens).

The thin sections were made of 8 broken or fragmented specimens (Inv.Nr.: 370, 384, 391, 503, 374, 379, 501, 504) and determined by polarizing microscope. While the determined diabase samples represent a hypabyssal rocks of basaltic composition consisting mainly of pyroxene and feldspar and with larger crystals of clinopyroxene enclosing the lath-shaped crystals of plagioclase feldspars, the fine-grained rocks with phenochrysts of pyroxene in a groundmass of plagioclasse together with some crystals of opaque minerals (probably magnetite) were determined as basalt.

Only one specimen (Inv.Nr. 374) comprises patches of rhomboedral calcite crystals in a microcrystaline matrix. Also, on the surface of some artifacts, the calcite could be found as a thin micritic crust.

Tectonic pattern of the area of Hrvatsko Zagorje is one of the most complicated in north Croatia, and the result of tectonic activities is Middle Triassic basalt-spilite magmatic group of Hrvatsko Zagorje and Cretaceous volcanogenic-sedimentary complex. Petrologically, the magmatic group is composed of basalts, largely transformed into spilites with some andesites and pyroclastic rocks, while the volcanogenic-sedimentary complex consists of the tuffs, tuffits, spilitized diabases, and gabbros.

Thus, considering the results of recently analysed Vindija's polished stone tools, it is obvious that the used raw material is of local origin, because the following rocks were registered in the area: basalts, andesitic basalts and spilitized basalts (Mts. Ivanšćica and Strahinšćica), spilites (Mt. Kalnik), gabbros (Mt. Kalnik), andesites (Mt. Ravna Gora) diabases (Mts. Ivanšćica and Kalnik), and serpentinite (Mt. Kalnik).

It must be noted that some of the bigger outcrops of mentioned volcanic rocks were used from the Roman times untill today in the quarries of technical stone in Lepoglava (Mt. Ivanšćica), Ljubešćica (Mt. Kalnik), etc. At the same time, the volcanic rocks could be found as pebbles (or cobbles) of Alpine provenience in alluvial beds of the river Drava. Thus, the selection of raw material was made functionally in relation to the available assortment showing that the Aeneolithic inhabitants of Vindija cave had a practical knowledge of raw material in the area of NW Croatia. But, to find out the exact origin (i.e. locality = quarry) of different raw materials used at Vindija, the analyses of the tool samples must be extended to the stone samples originating directly from the outcrops of volcanic and/or metamorphic rocks of the investigated area.

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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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