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

GYÖRGY SZAKMÁNY

Eötvös Loránd University, Department of Petrology and Geochemistry, H-1117, Budapest, Pázmány Péter sétány 1/C, Hungary, Szakmany@iris.geobio.elte.hu

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

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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)

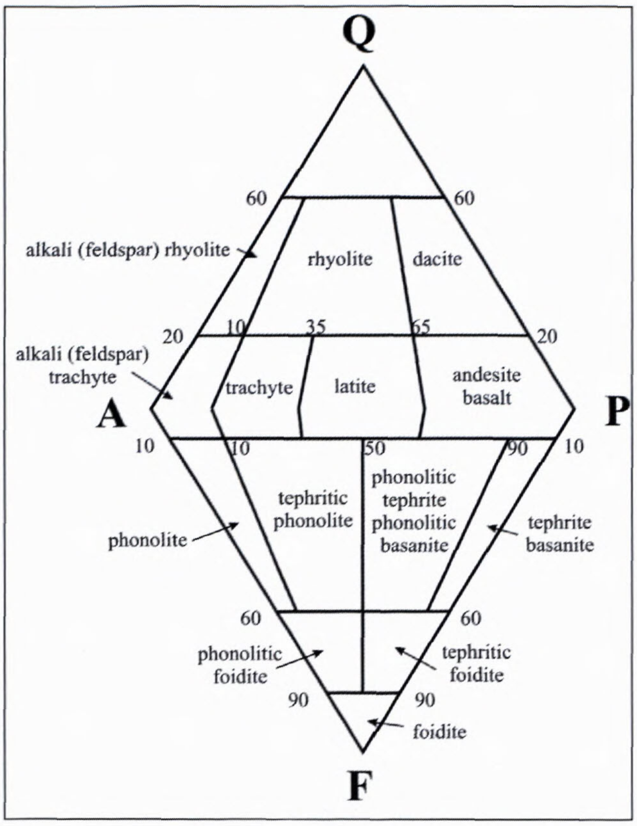

Fig. 1.: Terminology of volcanic rocks on the basis of modal (mineral) composition (simplified after Streckeisen, 1976; 1979 and Le Maître, 1989).

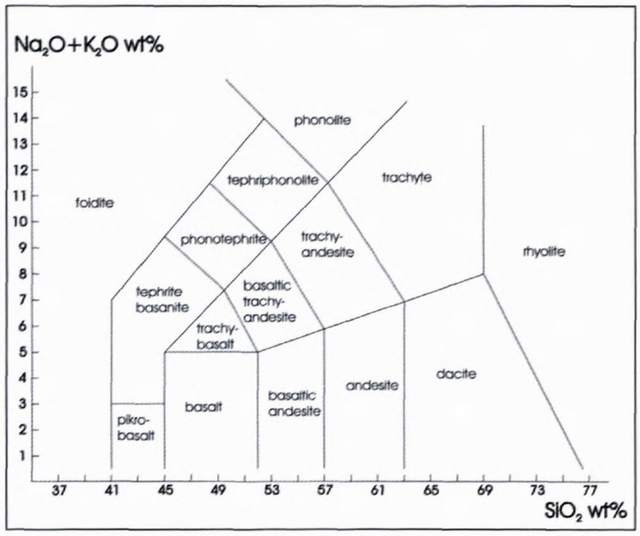

Fig. 2.: TAS (Total Alkali versus Silica) diagram for the chemical classification of volcanic rocks (Le Bas et al., 1986; Le Maître, 1989).

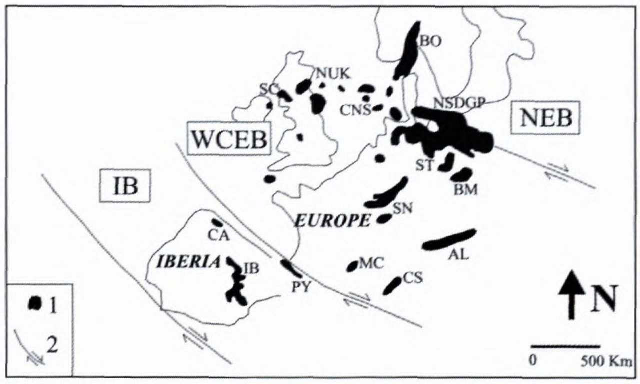

Fig. 3.: Highly schematic diagram of distribution of Permo-Carboniferous volcanic rocks in European province of the Pangean supercontinent (simplified after Doblas et al., 1998). Key to symbols and abbreviations:
1: Volcanism; 2: Continental scale dextral fracture zones;
Blocks bounded by the major dextral 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 shafthole 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.

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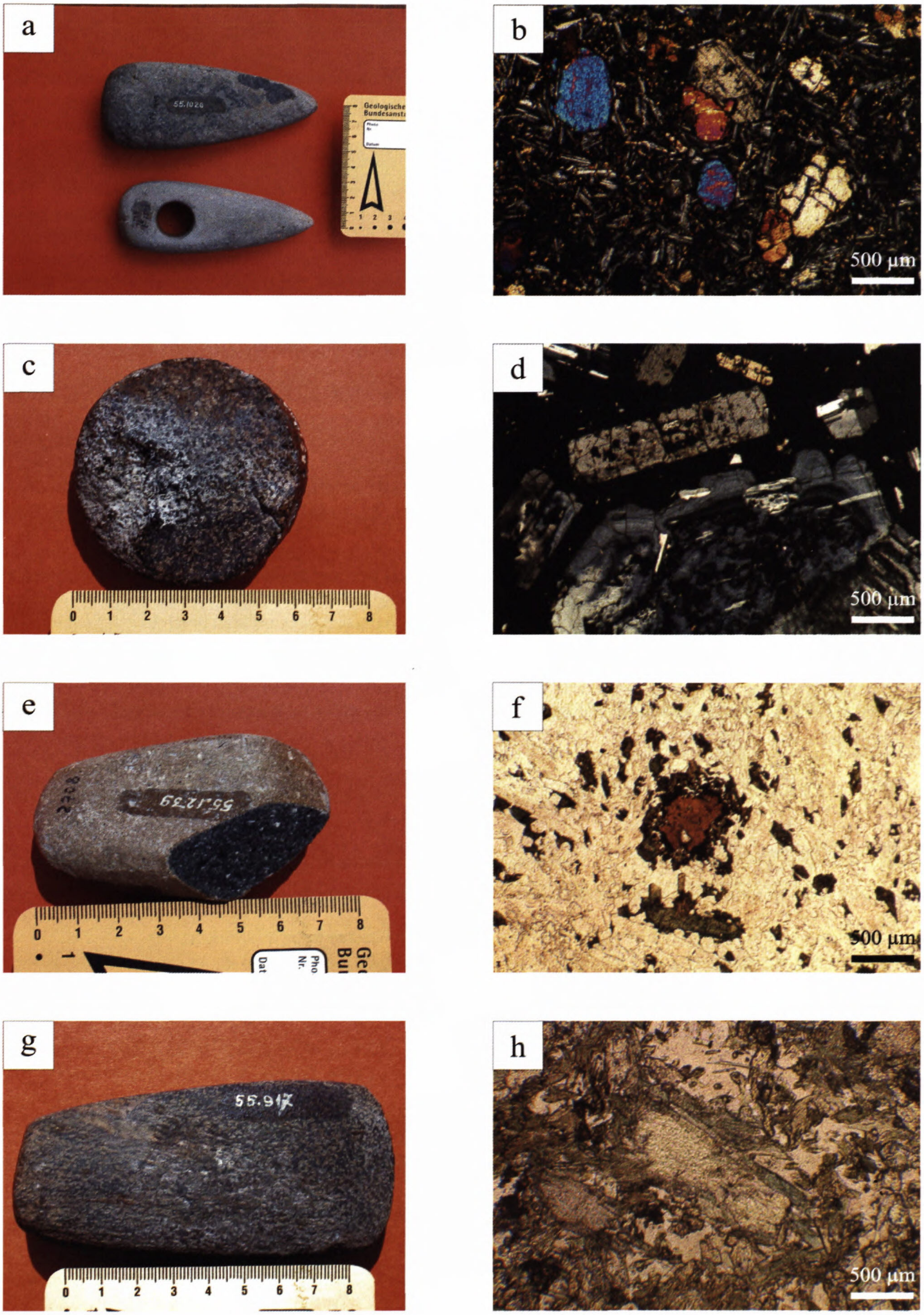

Regional distribution of volcanites and dolerite-type raw materials as archaeological implements: a state of art draft

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 19[th] 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 Mihãldy 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,

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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 Michaľany 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 Michaľany (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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