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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

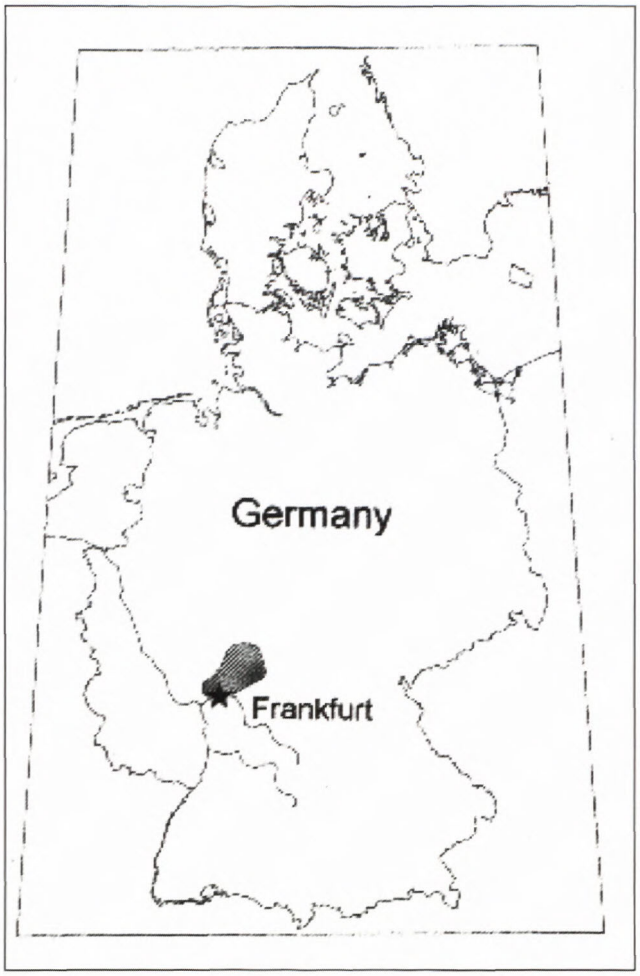


*Fig. 1: Map of Germany. Shaded area show the investigated and sampled area around Wetterau (star).*

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-

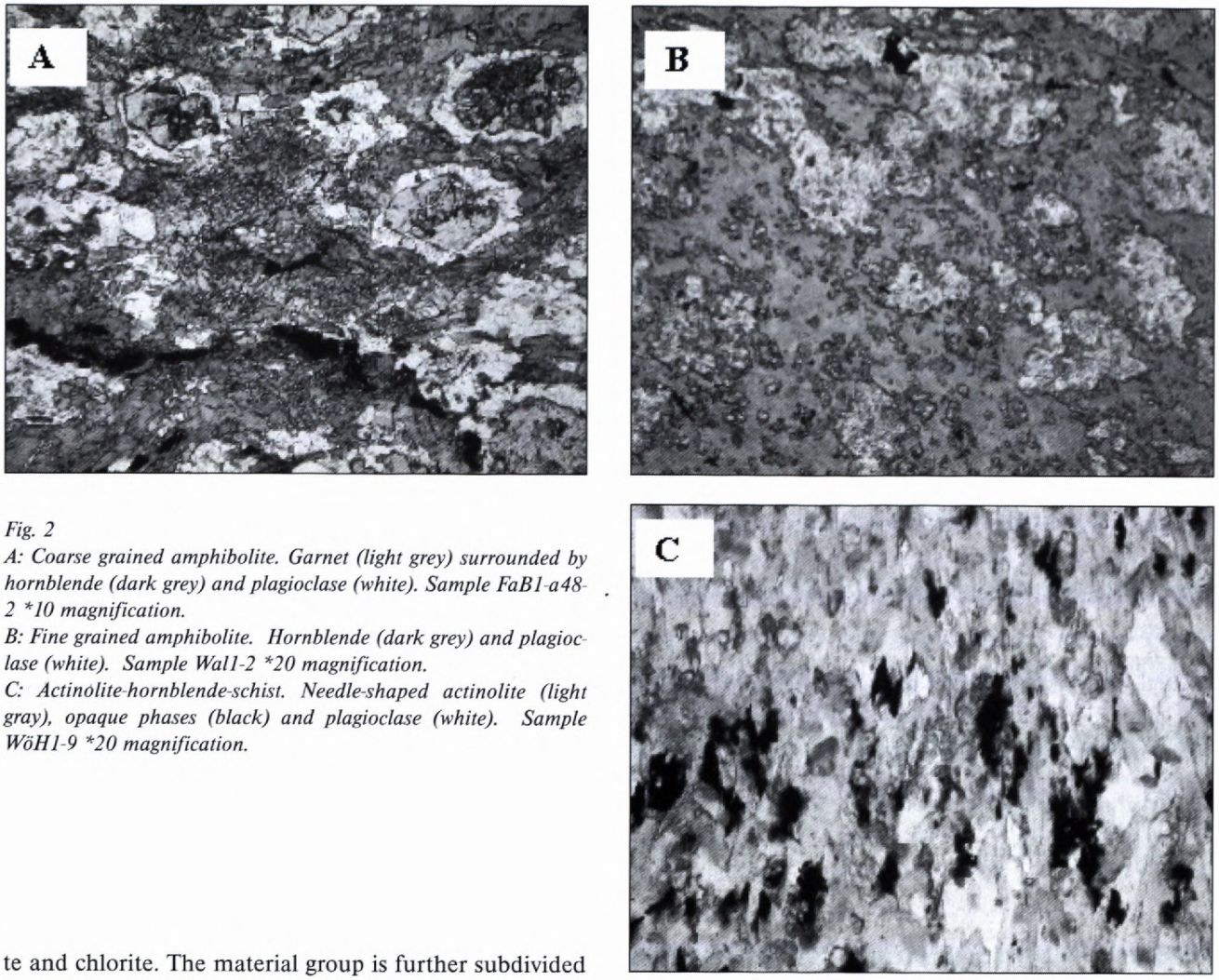


*Fig. 2*
*A: Coarse grained amphibolite. Garnet (light grey) surrounded by hornblende (dark grey) and plagioclase (white). Sample FaB1-a48-2 *10 magnification.*
*B: Fine grained amphibolite. Hornblende (dark grey) and plagioclase (white). Sample Wal1-2 *20 magnification.*
*C: Actinolite-hornblende-schist. 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.

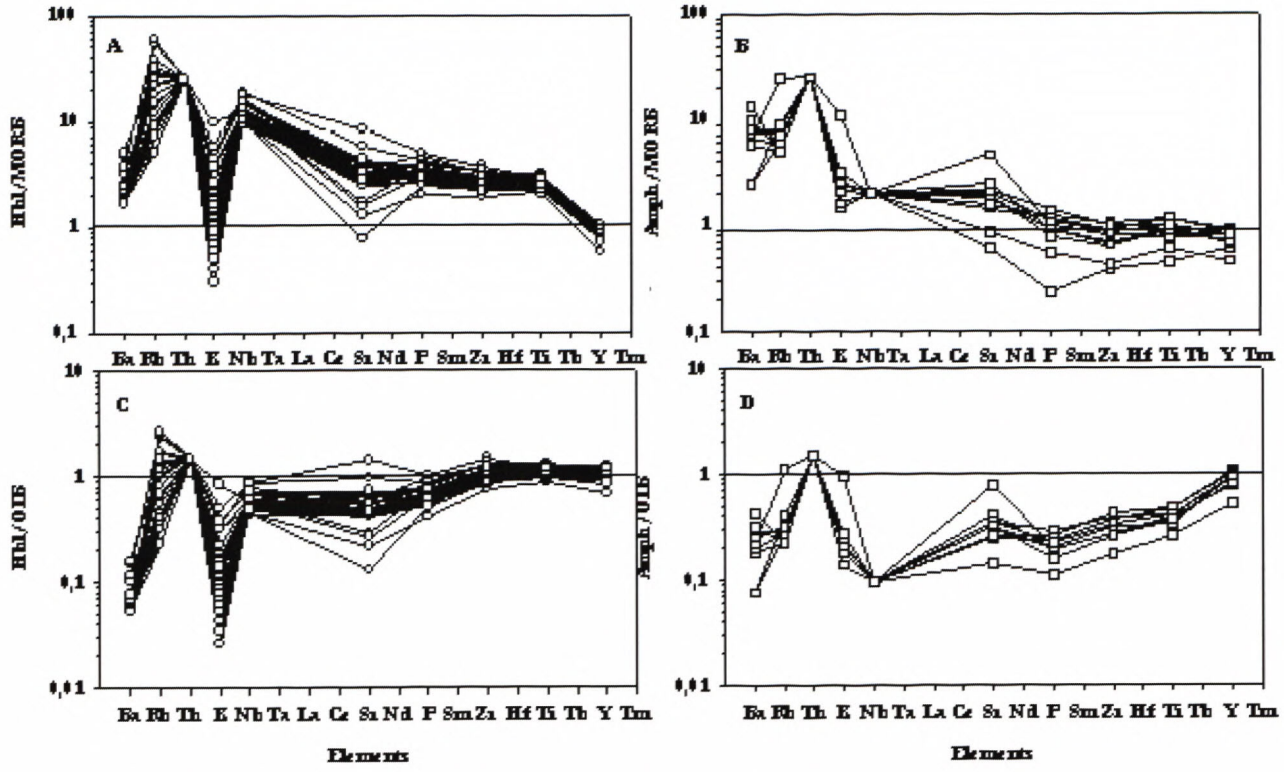


*Fig. 3*
*A: Actinolite-hornblende schist normalised to MORB (Mid Ocean Ridge Basalt) values.*
*B: Amphi-bolite-group normalised to MORB values.*
*C: Actinolite-hornblende schist normalised to OIB (Ocean Is-land Basalt) values.*
*D: Amphibolite group normalised to OIB values. Normalization values taken 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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