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PROVENANCE ANALYSIS OF ROMAN MILLSTONES: MAPPING OF TRADE AREAS IN ROMAN EUROPE

Tatjana M. Gluhak, Wolfgang Hofmeister

Johannes Gutenberg-Universität, Institute of Geosciences, 55128 Mainz, Germany; gluhak@uni-mainz.de; hofmeister@uni-mainz.de

ABSTRACT. In Roman time millstones were extensively manufactured and exported in large quantities from different provinces of the Roman Empire. The Eifel with its typical basalt lava was one of the most important production places in Central Europe, the quarries of the Bellerberg volcano in Mayen were the largest Roman production sites in the Eifel region. The aim of this study is to determine the area of export by mineralogical provenance analysis of the basaltic millstone-finds, which are widespread throughout Central Europe. Special interest lies thereby in separating the Eifel trade area from the trade area of the competing production places of the Massif Central. To do that firstly the archaeologically verified Roman quarries in the Eastern and Western Eifel have to be mineralogically distinguished. By cluster- and discriminant-analysis every Eifel quarry is clearly characterized. After that the millstones of interest are sampled, analyzed and assigned to their precise production place.

Introduction

The Quaternary volcanic Eifel region in Germany has for a long time been known as an important source of basaltic raw material continually exploited from the Neolithic down to today. Archaeological research focuses on the Bellerberg quarries next to Mayen up to now, but younger field observations by Hörter Jr. (1994) over the entire region have shown that there are many more Roman basalt quarries in various sizes situated in the volcanic Eifel area. The main products of the Quaternary volcanic Eifel in Roman times were millstones. An increased production from the first century AD on, especially in the Bellerberg-quarries, implies large scale export of millstones. Archaeological finds indicate Eifel millstone export in huge quantities all over Central Europe and as far as to Britain and to free Germania. A major issue in this project is to distinguish the Eifel trade area from the neighboring trade area of the likewise exporting Massif Central in France (Fig. 1).

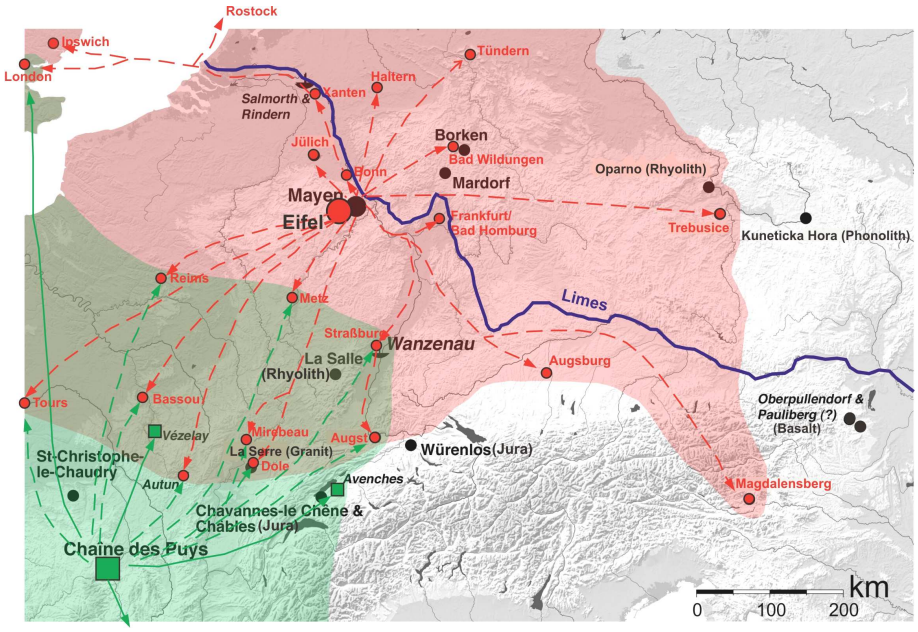

Fig. 1. Assumed millstone trade areas of Eifel and Massif Central

The basis for reliable provenance analyses of presumed Eifel millstones is a clear characterization of each possible source rock in the Eifel area. So this study wants to establish a geochemical reference data base as foundation for following millstone provenance analysis.

Geological background

The volcanic Eifel area (Western Germany) is part of the Cenozoic Central European Volcanic Province (CEVP), a belt surrounding the Alps, stretching from the French Massif Central in the West to the Pannonian Basin in the East. The Eifel can be subdivided into three volcanic fields: the Tertiary Hocheifel field and the two Quaternary volcanic fields of East- and West-Eifel. This Study focuses on the Quaternary volcanic fields, for all Roman quarries are located there.

West-Eifel magmas are predominantly foidites (mafic leucitites, nephelinites, melilite-nephelinites) and basanites, with minor olivin-nephelinites. Stronger differentiated magma only occurs in the centre of the West-Eifel field (Frechen, Thiele, 1979; Mertes, Schmincke, 1985; Thiele, Wienecke, 1980). In East Eifel basanites are predominant, primitive foidites rare. Intermediate tephrites and phonolites are widely common. It appears that the basanites and foidites are the primitive types of magma, whereas the tephrites and possibly phonolites are products of the differentiation of the basanites (Büchel et al., 1986; Duda, Schmincke, 1978; Schmincke et al., 1978).

Methods

To get a sufficient amount of reference data every Roman quarry of Eastern and Western Eifel was multiple-sampled: In the East Eifel six lava flows are known as being exploited in Roman times; three of them emerged from the Bellerberg-volcano. For two further quarries Roman exploitation is assumed. In the West Eifel traces of Roman exploitation were detected in eight lava flows (Hörter 1994).

To find a strategy to characterize the quarries exactly, different methods of sample analysis were tested. The analysis of REE-patterns by Laser-ICP-MS and of mineral content by XRD failed in showing considerable differences between the quarries (Fig. 2-3). However, major- and trace-element analysis by XRF brought adequate results for characterization. The TAS-Diagram (Fig. 4) shows that the Eifel quarry samples can be divided into three distinct groups: One group plots exclusively in the phono-tephrite field and two groups partly in the tephrite/basanite and foidite field, one of them comprising a single quarry with higher alkali- and silica-content.

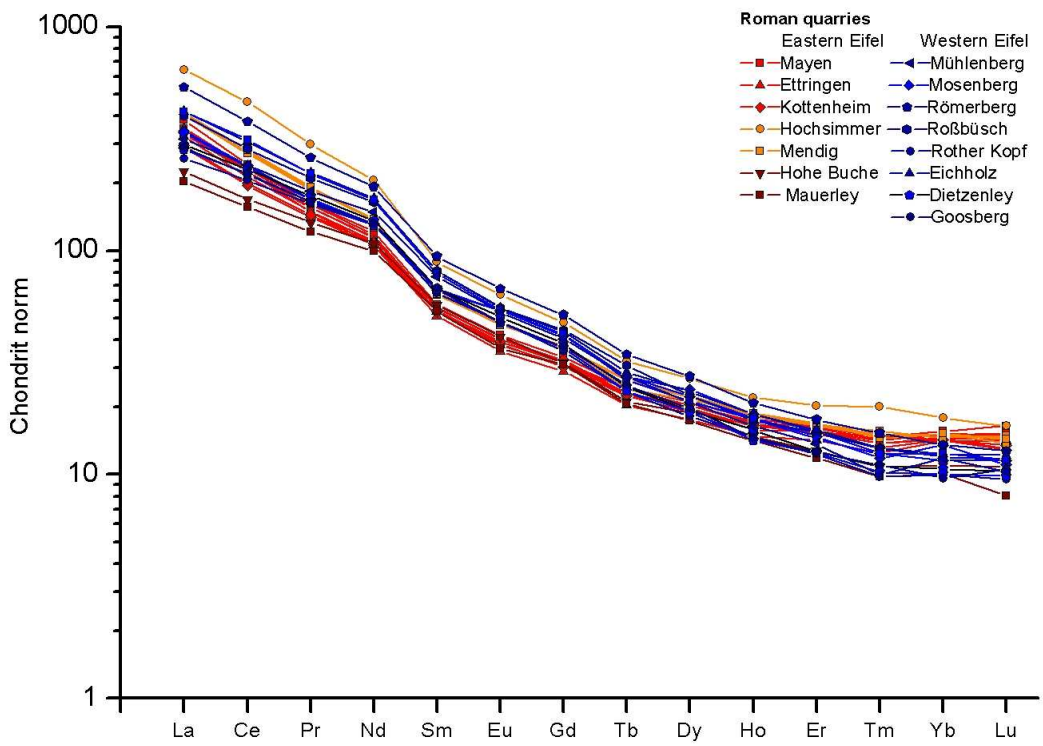

Fig. 2. REE-patterns of Roman quarries in East and West Eifel

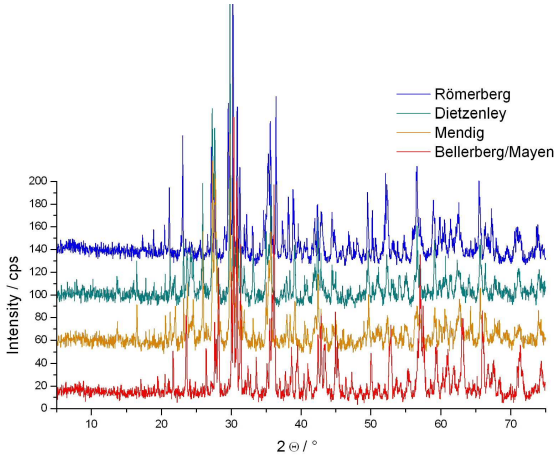

Fig. 3. XRD of East and West Eifel quarries

Furthermore it is possible to separate the lavas of the Massif Central from the quarries of the Eifel on the basis of major and trace elements.

Nevertheless, although the single Eifel lava deposits show considerable differences in their element distribution, the possibilities to achieve a clear separation of the deposits by comparing them in bi- or ternary plots are limited. More than two elements can be studied simultaneously by multivariate analysis. In this project cluster analysis and discriminant analysis are used. Having already two distinct Eifel-groups based on geological criteria according to the TAS-diagram, cluster and discriminant analysis is applied to the two subsets separately to obtain more detailed results. Cluster analysis treats the samples from the Eifel quarries as unknown and is used to check whether it is actually possible to separate the deposits into single clusters. However, discriminant analysis checks the dependence of the quarries' group memberships on the variables' values. The resulting function from discriminant analysis is able to separate the deposits in 98%. Fig. 5 and 6 show that discriminant analysis is able to distinguish the Roman Eifel quarries explicitly.

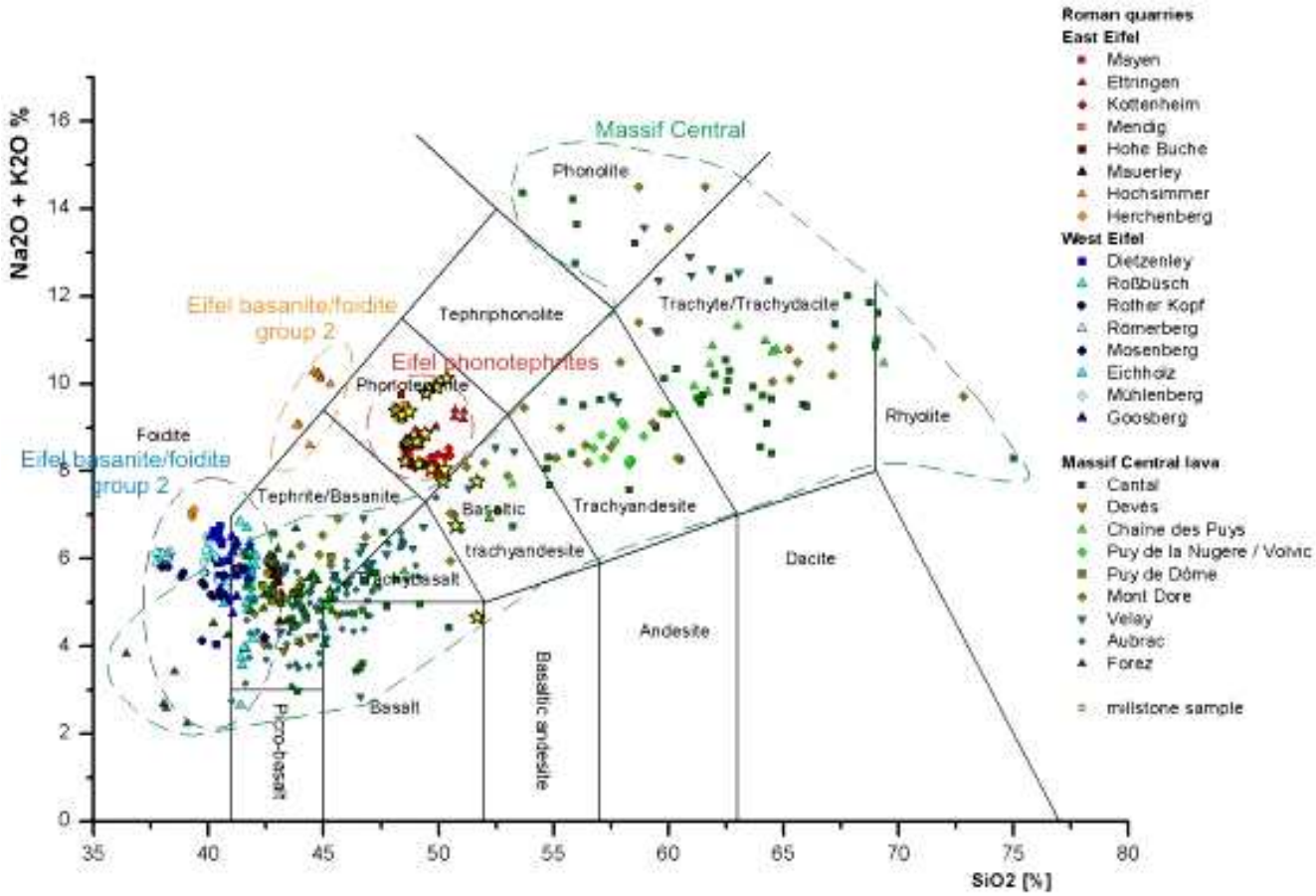

Fig. 4. TAS-Diagram. Data East- and West Eifel: Gluhak (unpublished). Data Cantal: Vatin-Perignon et al. (1980), Wilson et al. (1995), Caroff et al. (1997), Legendre et al. (2001). Data Devès: Liotard et al. (1988), Liotard et al. (1983). Data Chaîne des Puys, Puy de la Nugère / Volvic: Maury et al. (1980), Maury, Brousse (1978), Gourgaud, Camus (1984), Liotard et al. (1988), Williams-Thorpe (1988), Williams-Thorpe, Thorpe (1988), Miallier et al. (2004). Data Puy de Dome: Magonthier (1975). Data Mont Dore : Maury, Brousse (1978), Gourgaud, Villemant (1992). Data Velay: Villemant, Treuil (1983), Liotard et al. (1988). Data Forez: Hernandez (1973), Lenoir et al. (2000)

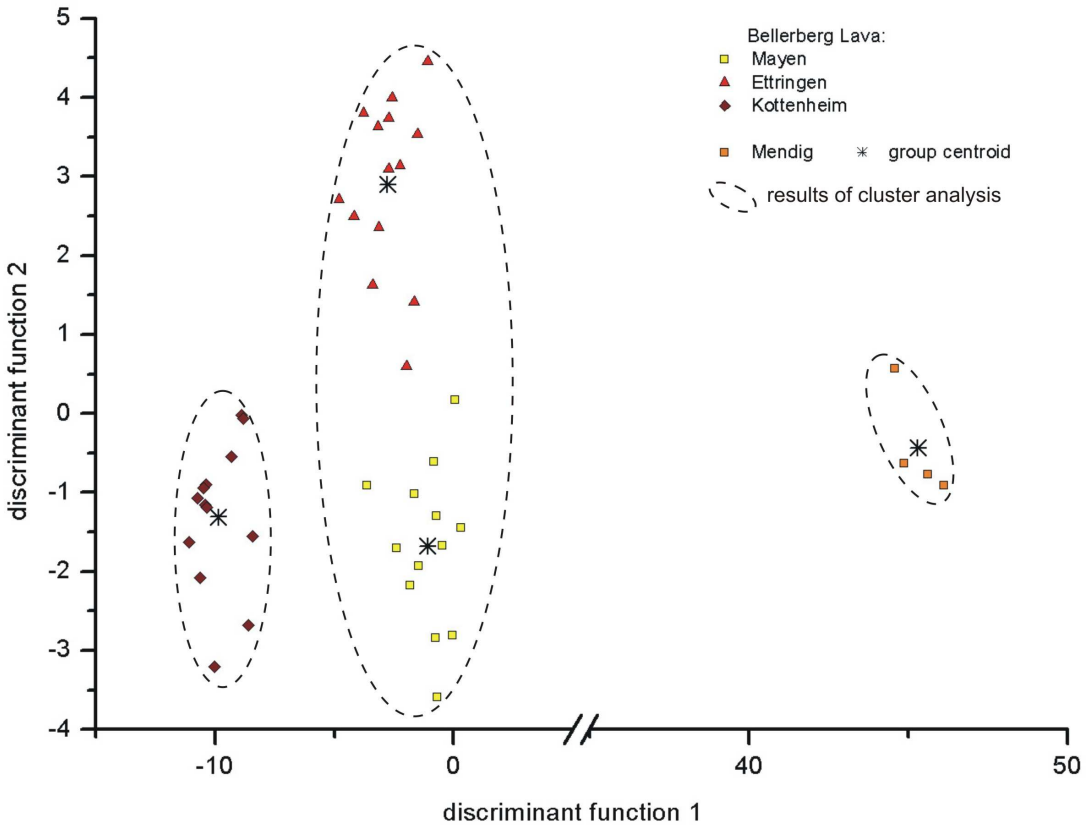

Fig. 5. Discrimination of the phono-tephrite quarries

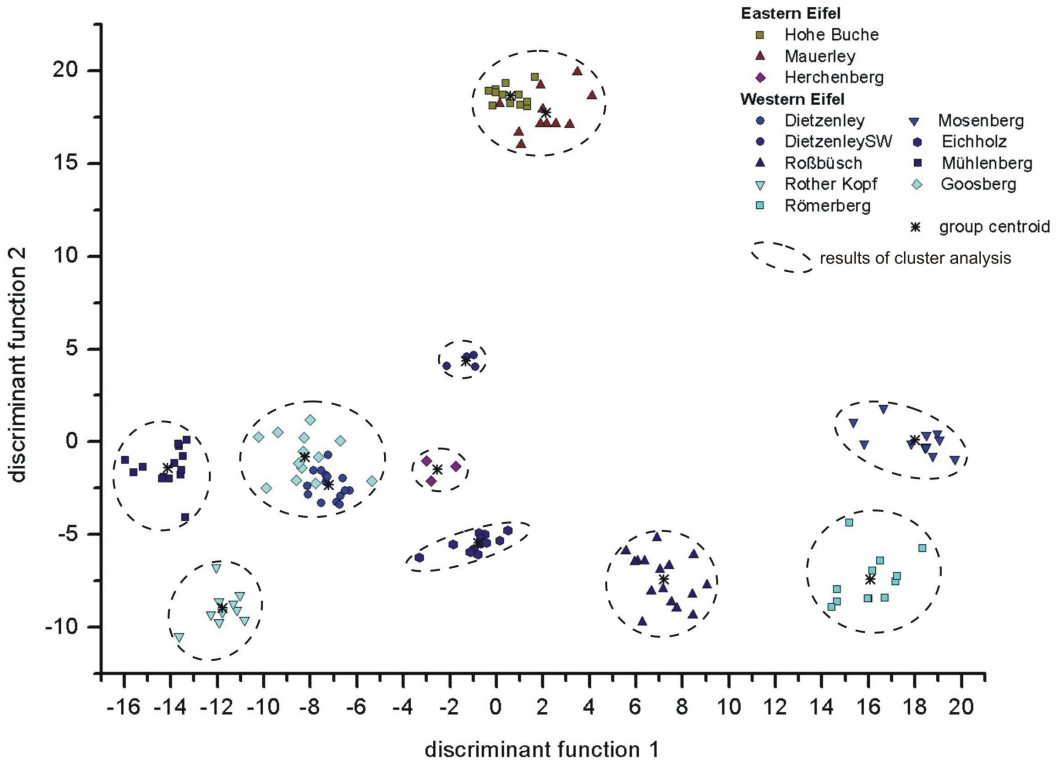

Fig. 6. Discrimination of the foidite/basanite quarries

After this the millstone samples are clustered together with the quarry samples to get a first impression whether they are derived from the Eifel and if so, from which deposit. Precise assignment is then done by discriminant analysis. The values of the unknown millstone samples are inserted into the discriminant function, and by calculating the distance to the quarries' group-centroids the millstone can be assigned to its production place.

On this basis the following questions can be answered:

- To what extent do the Eifel millstones compete with the millstones from the Chaîne des Puys as the adjacent production place?
- Where are the limits of the Eifel trade area?
- Did the small Roman quarries in the Western Eifel trade their millstones only regionally? Were, as presumed so far, only millstones from Mayen traded supra regionally?

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