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Petrological characterization of the seismic low-velocity anomaly beneath the Eifel volcanic field (West Germany) using major and trace element compositions of olivine macrocrysts

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The Eifel volcanic field is part of the Central European Cenozoic Magmatic Province and was periodically active from the mid-Cretaceous until the latest Pleistocene. Two contrasting models are used to explain sources and magma generation mechanisms of the Pleistocene Eifel volcanism: i) decompressional partial melting at the base of the subcontinental lithosphere as a consequence of extension caused by lithospheric flexuring from emplacement of Alpine nappes (Wilson & Downes, 1991); ii) plume-type thermal upwelling in the asthenosphere on the basis of seismic tomography indicating a low-velocity anomaly beneath the Eifel probably caused by temperatures higher than the normal asthenosphere adiabat (e.g., Ritter et al. 2001).

We present high-precision electron microprobe data for major and minor elements as well as laser ablation ICP-MS data for trace elements of olivine from the Eifel in order to put new constraints on the origin of Pleistocene Eifel volcanism. Being an early liquidus phase in the crystallization of basaltic melts, olivine composition may be used to characterize the composition of primary mantle melts and their source region in terms of major and trace elements. Moreover, it is useful for T estimation providing a snapshot of the liquid equilibria at early magmatic stage. In addition, important petrological parameters can be constrained, like the extent of prior melt extraction of their mantle source, the presence of different geochemical components in the source, olivine residence times etc.

Olivine macrocrysts occur in most of the Eifel Mg-rich lavas, forming up to 10 vol% of the rocks. We studied olivines from 10 representative lava flows of basanitic composition. Based on compositional and textural differences, three genetic groups are recognized: i) volumetrically dominant igneous olivines or phenocrysts (melt related); they are equilibrated with their host melt showing normal zonation (core-rim Fo89-80) and NiO contents up to 0.3 wt%, whereas $Cr2O_3$ and CaO are around 0.18 wt% and 0.20 wt%, respectively; ii) mantle xenocrysts are typically mantled by olivine of phenocrystal composition, with the plateau-like core compositions typically with Fo91.5 and NiO contents around 0.4 wt%; a number of features supports their mantle origin, namely CaO contents lower than 0.1 wt%, homogeneous compositions within the grain (typical for mantle olivine, resulting from long equilibration times), anhedral shapes showing deformation features such as kink bands etc; iii) a genetic group also demonstrating xenocrystic features (e.g., compositional disequilibration with the host melt, the mantling by olivine of phenocrystal composition); however, it differs from the mantle olivine by having higher CaO (> 0.3 wt%), slightly lower Mg# (up to 90), and considerably lower NiO contents (< 0.1 wt%); we interpret these grains to originate from wherlitic assemblages within the lithospheric mantle.

Our preliminary estimation of the olivine-liquid equilibria using compositions of the phenocrysts indicates temperatures not considerably higher than 1300 oC. The trace element composition of olivine phenocrysts and two types of xenocrysts show several important characteristics. Relative to mantle xenocrystal olivine that is depleted in the most trace elements, phenocrysts are considerably enriched in Li and Zn, and depleted in Ti. Low NiO xenocrysts have high Ti with slightly elevated Li concentration. There is a certain overlap between the phenocrysts from Eifel lavas and those from orogenic Mediterranean volcanics, indicating compositional similarities in their mantle sources that may imply the presence of common metasomatizing agent(s).

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Ritter, J. R. R., Jordan, M., Christensen, U. R. & Achauer, U. (2001). Earth and Planetary Science Letters 186, 7-14.