Tertiary Eifel volcanism – intraplate mantle plume or extension-related activity?

Zuzana Fekiacova [(1)], Dieter Mertz [(1,2,3)], Paul Renne [(3)]

(1) Institut für Geowissenschaften, Universität Mainz, Germany
(2) Max Planck-Institut für Chemie, Abteilung Geochemie, Mainz, Germany
(3) Berkeley Geochronology Center, California, U.S.A.
fekiacov@mail.uni-mainz.de / Fax: +49 6131 39 24 769

The Eifel volcanic fields are located in the Hercynian Rhenish Massif, Western Germany, and belong to the Cenozoic Central European Volcanic Province (CCEVP). About 300 Tertiary volcanic relics occur in the so-called Hocheifel (e.g., Huckenholz, 1983) a region of about 1000 km^2 in between the neighboring Quaternary West and East Eifel volcanic fields.

Seismic tomography has shown that there is a low velocity anomaly in the upper mantle underneath the Eifel (Ritter et al., 2001). This anomaly extends at least to a depth of 400 km and can be explained by a mantle plume with an excess temperature of 150-200±100 K. Whereas the activity of the Quarternary East and West Eifel volcanism appears to be related to this mantle plume, the geodynamic setting of the Tertiary Hocheifel volcanism is not clear. As alternatives, precursor activity of the intraplate Quarternary Eifel plume or magma generation related to extension are plausible models.

$^{40}Ar/^{39}Ar$ step-heating measurements by laser fusion on amphibole, feldspar and groundmass separates from 19 prominent Hocheifel volcanic occurrences yield an age range from 44 to 34 Ma (Middle and Upper Eocene). Previously published conventional K-Ar Oligocene and Miocene ages cannot be confirmed. For the Tertiary Hocheifel activity, two time intervals can be distinguished each related to a discrete geographical setting. An older phase of volcanism occurs along a central ca. 50 km long north-striking lineament with a south to north age progression from 44 to 40 Ma. A younger phase comprising an age range from 38 to 34 Ma developed ca. 10 km to the west and to the east of the central north-striking lineament.

The two age phases of the Tertiary Hocheifel volcanism form two discrete data fields in a diagram $^{87}Sr/^{86}Sr_i$ vs. $^{143}Nd/^{144}Nd_i$, where i stands for initial. In addition, these phases are also distinct from the data groups defined by the Quaternary Eifel, as well as by further Tertiary and Quaternary volcanic fields of the CCEVP. Initial Sr and Nd isotope compositions as well as trace element patterns show that the Tertiary Eifel mantle is inhomogeneous at least in the order of magnitude of 10 km and that the mantle sources tapped by Quarternary and Tertiary Eifel volcanism are different.

Based on the local geographical distribution of the Tertiary Hocheifel volcanic occurrences and their regional geographical setting as north-west prolongation of the Upper Rhine Graben, it appears that the Tertiary volcanic activity is rather related to Eocene Rhine Graben rifting than to precursor activity of the Quaternary Eifel plume. In order to test whether there is a relationship between the Eocene Eifel and the Upper Rhine Graben volcanism we are pursuing a detailed geochemical study to compare the tectonic regimes as well as the volcanic rocks from both regions in terms of ages, mantle sources and magma generation processes. However, at the moment we cannot exclude the hypothesis that the Tertiary Eifel volcanism represents precursor activity of the Quaternary Eifel plume.

References:

Huckenholz, H.G., In Fuchs et al. (eds), (1983): Plateau uplift, 121-128.
Ritter et al. (2001): A mantle plume below the Eifel volcanic fields, Germany, Earth Planet. Sci. Lett. 186, 7-14