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The European Cenozoic Volcanic Province: The Type Example of an Implausible Mantle Plume (IMP)?

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The links between plate tectonic processes and magmatism are less obvious in the interiors of plates than at MORs and subduction zones. This has led to simplistic suggestions that intraplate volcanism results from mantle plumes, and extreme pushing of the envelope of plausible variations of the plume model. As the limitations of the mantle plume model have been highlighted over the last few years, considerable interest has arisen in testing the model, and even questioning if mantle plumes exist at all (see http://www.mantleplumes.org/). The plume model is fundamentally a scientific idea, and thus it should make predictions for real cases. These predictions should be borne out at presently proposed plume locations, and should successfully predict what is observed at new locations.

In 1972 the plume model was first applied to the cluster of small volcanic areas that form the European Cenozoic Volcanic Province (ECVP) via the so-called Eifel plume. However, radiogenic age data do not support the predicted age progression of the volcanic fields of central Europe. In addition, the geochemical and seismic tomography data, the history of vertical movements and the tectonic evolution of the lithosphere during ECVP formation are all inconsistent with the predictions of the plume model. This proposed mantle plume is one of the most implausible in the world.

The proposal that the ECVP is the manifestation of a mantle plume is mainly based on the OIB-like (or "intraplate") geochemistry of the magmas. However, such a geochemical character can tell us nothing regarding depth of origin of the source. This is mainly because geochemical tools cannot differentiate between an in-situ lithospheric source and/or lithospheric material recycling in the sublithosphere. Plumes have often been invoked simply because the erupted basalts have an OIB signature, irrespective of whether the volumes of magma, rates of eruption, or anything else are consistent with that model.

Other evidence cited to justify the proposal that one or more plumes underlie the ECVP is from mantle tomography. Low seismic-wave-speed mantle anomalies are detected beneath some ECVP sub-areas, but not beneath another with similar geochemistry. Where the anomalies are seen they do not extend down into the lower mantle. Temperature is not the only physical property that influences seismic velocities. Composition and the presence of partial melt can also lower wave speeds, and these factors are more likely to explain the tomographic structures beneath the ECVP. The whole ECVP is far to small to be classified as a large igneous province that might correspond to a plume head. No primary high-Mg magmas (picrites) consistent with excess temperatures are reported. The He isotopic ratios are much lower that expected for a plume. Lastly, the uplift/volcanism history of the area is not as predicted for mantle plume lithospheric interactions. The ECVP contradicts essentially all the foundation predictions of the mantle plume model. ECVP volcanism is more likely linked to Alpine subduction processes that affect stress, deformation and flow in the European continental crust and underlying shallow mantle, coupled with the influence of local lithospheric conditions. RM is funded by BFR 05/133