Regional scale heterogeneities in the mineralogy of the magma source region: examples from mantle xenoliths from the West Eifel Volcanic Field, Germany

Cliff S.J. Shaw
Department of Geology, University of New Brunswick, Fredericton, NB, E3B 5A3. <cshaw@unb.ca>

Our general view of the source of mantle-derived magmas is of homogeneous moderately depleted peridotite. This viewpoint has been reinforced by experimental studies that model the mantle as a simple mixture of olivine, clinopyroxene and orthopyroxene with one or other of the aluminous phases. The real nature of the mantle belies this simple view and indicates heterogeneity from the hand sample scale upward!

The Quaternary West Eifel volcanic field in Germany provides an opportunity to examine mantle heterogeneity since many of the alkaline, monogenetic volcanoes have carried samples of the lithospheric mantle to surface. Volcanism is thought to be related to melting in the asthenosphere associated with a small-scale mantle plume. Variations in the composition of the lavas within the field indicate two distinct sources one enriched in amphibole, the other in phlogopite.

Xenoliths contained in the lavas are from the lithospheric mantle rather than the asthenospheric source and isotopic and trace element data indicate that the xenoliths are not low pressure analogues of the magma source region. Nevertheless, their distribution reveals considerable heterogeneity in the mantle below the Eifel.

There are a number of distinct events that can be identified from the xenoliths. First, there was a widespread melting event that resulted in depletion of incompatible trace elements. This was followed, during the Hercynian orogeny, by metasomatism that led to widespread formation of secondary, Ti-poor amphibole, clinopyroxene and phlogopite. The third event, related to Quaternary volcanism, resulted in the development of hand sample to regional scale heterogeneities. In the central Eifel this event is characterized by the presence of 1–10 cm thick, amphibole–phlogopite–clinopyroxene veins, in lherzolite and harzburgite xenoliths hosted in olivine nephelinite–bassanite suite lavas. These veins crystallised from sodic magma that flowed along fractures in the mantle. In the west central Eifel, the Quaternary event is characterized in wehrlite xenoliths, many of which have 0.1 –0.5 cm thick veins of phlogopite and clinopyroxene that were transported by potassic foid suite lavas. Wehrlite formed by reaction of lherzolite/harzburgite with potassic magma that infiltrated along grain boundaries, with veins being formed only during periodic overpressure events.

In the Eifel we see evidence of heterogeneity in the asthenospheric source region from lava compositions and extreme heterogeneity that developed over a long period of time in the lithospheric mantle. These observations suggest that we should exercise caution in viewing the mantle as a simple, homogeneous body.