Cross correlation of 27 geochemical and geophysical parameters suggests shallow lithospheric contamination of mantle plumes

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The thermochemical structure, dynamics, and history of the Earth's mantle is best addressed with constraints from a wide variety of fields. Although qualitative agreements between geochemical and geophysical parameters have been pointed out before, a statistical treatment is not usually applied. Furthermore, a vertical connection between deep mantle geophysical parameters and surface volcanism is often assumed. Plume locations at the surface tend to cluster around the Large Low Shear Velocity Provinces (LLSVPs) when projected down. Consequently, it has been suggested that plumes may originate from the edges of LLSVPs, thereby potentially sampling two distinct geochemical compositions. However, statistically it is the correlations between convection-affected (distorted) plume conduits and seismic tomography that are significant. The convection-affected conduits seem to trace to within the LLSVPs, instead of the edge, in which case all plume components may originate in the LLSVPs. We expand on these ideas with correlations between geophysical and geochemical data to further our understanding of mantle structure and dynamics.

We cross-correlated 27 different geophysical and geological parameters to examine whether the geochemistry of the convection-affected plume conduits correlates significantly with any geophysical parameters in order to further constrain the chemical structure of the mantle. We report a significant correlation between extreme geochemical compositions of lavas with both shallow seismic velocities and the depth extent to which a hotspot source can be traced with seismic tomography. The simplest explanation for these correlations is that buoyantly rising mantle plumes (large depth extent) are contaminated with thermally eroded continental material in the upper mantle (slowest shallow seismic velocities). These results thus contribute to our general understanding of mantle dynamics, and to the ongoing debate on the origin of the enriched EM1 mantle component.