The origin of the mantle "species": Five decades of debate

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This year marks the 50th anniversary of a groundbreaking paper that used lavas erupted at hotspots to probe the geochemical composition of the mantle. Gast, Tilton and Hedge [1] found that lead and strontium isotopes are heterogeneous in lavas from Tristan and Gough Islands, thus sparking a 50-year campaign to characterize the degree to which the mantle is heterogeneous and to understand how the mantle came to be heterogeneous.

Five decades later, and armed with a much larger geochemical dataset, the origin and diversity of geochemical components identified in the mantle continues to defy explanation. While some mantle components identified in hotspot lavas are likely linked to the return of ancient subducted materials, including continental crust and oceanic crust, the origins of other mantle components are not easily explained and no clear consensus has emerged. For example, the enriched mantle 1 (EMI) endmember has been linked to a host of possible formation mechanisms, including metasomatic processes, recycled sediments, recycled lower continental crust, recycled subcontinental lithospheric mantle, and recycled large igneous plateau. A community effort to narrow the range of possible origins for this controversial mantle component is warranted.

In order to trace the geochemical evolution of the various mantle reservoirs through time, it is important to define the intial composition of the mantle. Over the past decade, a body work has emerged that suggests the composition of the Bulk Silicate Earth (BSE) may not be tied to the ratios of the refractory lithophile elements in chondrites. If this is the case, the mantle reservoir hosting primordial noble gases may be the best candidate for defining the BSE.

The distribution of the geochemical reservoirs in the mantle continues to be the source of debate. It is becoming apparent that the surface expression of geochemical components in hotspots volcanoes relates to their spatial distribution withing upwelling mantle plumes, which may in turn reflect the geometry of large-scale enriched domains in the deepest mantle. Collaboration among seismologists, dynamicists and geochemists will be critical for resolving the spatial relationships of the various mantle domains.

[1] Gast, P.W., Tilton, G.R., Hedge, C. (1965). Isotopic composition of lead and strontium from Ascension and Gough Islands. *Science* **145**, 1181-1185