

Semantimetasomatism

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“When I use a word,” Humpty Dumpty said, “it means just what I choose it to mean ...” Many geochemists use “metasomatism” in this way. Like dark energy and magic, the main evidence in support of trace element metasomatism is often that data don’t conform to quantitative theory. In this talk I will expand on why this can be a problem, and suggest partial solutions.

“Metasomatism” refers to geochemical fractionation resulting from open-system interactions between a moving fluid or melt and an assemblage of minerals. Metasomatic processes involve *input* of fluid or melt, with or without output. They include hydrothermal alteration, flux melting, impregnation, assimilation, zone refining and chromatography. What is gained by calling all “metasomatic”? And, “equilibrium porous flow” (metasomatism) can be chemically identical to batch melting (not metasomatism). Similarly, melt extraction followed by “metasomatic enrichment” can look just like flux melting, Fluid fluxed, or melt fluxed? Supercritical goo? Who cares?

We can parse metasomatism into clearly defined processes. However, while causality may be clear in numerical or experimental models, “similarity” between rock data and models may not be unique. Many high temperature processes closely approximate grain scale equilibrium, but this is coupled with fractional distillation or other kinetic effects on a larger scale. Equilibrium is path independent and reversible, but disequilibrium is not. We can document “reaction progress” in the field or within samples, finding correlated chemical and spatial data. This reduces the number of models consistent with data. We can conceptually discriminate between processes in which fluid or melt mass increases, is constant, or decreases. Local effects may be identical, but their progressive evolution in time and space should be distinct. Multi-scale spatial studies will be increasingly valuable in studying melt transport in the mantle, for example.

Metasomatism above subduction zones is crucial for global geochemical cycles. Despite the recognition of supercritical melts in subduction zone conditions, we can document the “direction” of mass transfer in high P and UHP terranes, and interpret data within theoretical bounds defined by dilute aqueous fluids versus hydrous melts, just as we use fictive end-members, batch and fractional melting, as benchmarks in studying residual peridotites.

In summary, spatial studies will relate metasomatism to the geotherm, geochemical cycling, and geodynamics.

Regionally extensive light lithium in mantle lithosphere of far east Russia

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Lithium isotopes are increasingly employed to understand crustal recycling within the Earth, but the composition of lithium recycled from crust to mantle is uncertain. Because altered oceanic crust takes up isotopically heavy lithium from sea water, the subducted slab is generally expected to deliver heavy lithium to the mantle, yet, eclogites, considered analogs to subducted oceanic crust, have $\delta^7\text{Li}$ values that are generally lighter than MORB (down to -12‰). These light values may reflect loss of heavy lithium via low-T dehydration reactions in the down-going slab (Zack et al., 2003). Recently, Nishio et al. (2004) reported unusually low $\delta^7\text{Li}$ values for clinopyroxenes from mantle xenoliths from far east Russia and southern Japan. They interpreted these light values to reflect influx of lithium from a subducted slab and argued that acid leaching, applied to all samples, did not affect the lithium isotopic composition of the cpx. We have analysed cpx separates from well-characterized peridotite xenoliths from Far East Russia: six from the Tok volcanic field (400-1000 km to the north of the sites sampled by Nishio et al.) and one from the Barhatny volcano (near the Ennokentiev site of Nishio et al.). The xenoliths range from fertile to highly refractory in terms of modal and major element compositions (1.1 to 4 wt.% Al_2O_3), reflecting variable amounts of melt extraction at shallow levels (Ionov et al., 2005). All the xenoliths are metasomatized to various degrees (e.g., most are LREE-enriched). The cpx have variable, but mainly high lithium contents (ranging up to 16 ppm), and all show unusually light $\delta^7\text{Li}$ values (-6 to -14‰), irrespective of whether the minerals were mildly acid leached or simply washed in milli-Q water. Moreover, the enrichments in lithium and the low $\delta^7\text{Li}$ values do not appear to be correlated with Al contents, enrichments in highly incompatible trace elements or Sr and Nd isotope compositions. Although we cannot directly link the metasomatism of these samples with modern or ancient subduction zone fluids, a region of unusually low $\delta^7\text{Li}$ exists within the lithospheric mantle, stretching for over 1000 km, adjacent to the Pacific rim.

References

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Zack, T., et al. (2003) EPSL 208: 279.