Petrogenesis of the oceanic crust from trace elements in basalt glasses

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Laser-ablation ICP-MS gives precise trace-element analyses on small areas of basaltic glasses, not only for the traditionally analysed trace elements (REE, HFSE, LILE and first-row transition elements), but also elements such as Be, Ga, Ge, As, Se, Ag, Cd, In, Sn, Sb, W, Tl and Bi. We have analysed >350 Ocean Floor Basaltic (OFB) glass samples from the Smithsonian collection [1] covering a global range in OFB from the Atlantic, Pacific and Indian oceans, for 53 trace elements, plus sulfur by electron microprobe. EMP analyses of the major elements are given in [1]. Principal Component Analysis of a set of 29 precisely determined (±2%) highly incompatible trace elements (HICE: here, all 26 Refractory Lithophile trace elements plus P, K and Pb) shows that 96% of their variance is contained in the first two PCs (93% with PCA on the correlation matrix). The further statistical treatment of this large data set uncovers a highly systematic variation of HICE with degree of low pressure evolution from beneath the variability due to source heterogeneity and melting processes. This cannot be explained by simple fractional crystallization but reflects magma eruption/discharge processes [2, 3], not evident from major elements, which are buffered along the olivine-plagioclase-clinopyroxene cotectic. This evolution systematically fractionates the HICE among themselves in a way that is not consistent with simple fractional crystallization, e.g. mean Th/U increses from 2.3 at 9.5% MgO to 3.3 at 5.5% MgO. Inverting the parental OFB composition allows average mantle source composition and degree of melting to be calculated independently of assumptions about ocean crust recycling. The result shows that OFBs are a product of a high degree of melting (20 to 25 %), from a source that is too depleted to be balanced by estimates of the composition of the continental crust. This seems to require a non-chondritic Earth [4].

[1] Melson WG, O'Hearn TJ & Jarosewich E (2002) *Geochem Geophys Geosyst* **3**, #1023. [2] Albarede F (1985) *Nature* **318**, 256–258. [3] O'Hara MJ & Herzberg C (2002) *Geochim Cosmochim Acta* **66**, 2167–2191. [4] O'Neill HStC & Palme H (2008) *Phil Trans Royal Soc A* **366**, 4205–4238.

Coupling, decoupling and metasomatism: A saga of crust-mantle relationships beneath NW Spitsbergen (Arctic Norway)

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Recent studies integrating mantle and lower crustal geochronology on xenolith samples, isotopic information from crustal zircons worldwide, and seismic tomographic imaging of deep lithosphere domains, suggest that over 70% of the present deep lithosphere formed by about 3 Ga. Subsequent tectonism has modified the lithospheric mantle and caused crustal reworking. The Bockfjord area of NW Spitsbergen (Norwegian Arctic) provides an ideal natural laboratory to track crust/mantle evolution and tectonism over >3.2Ga. Quaternary alkali-basalt volcanism provides abundant xenoliths of mantle and crustal rocks from both sides of a major translithospheric N-S fault. Zircons from lower-crustal xenoliths (from both sides of the fault) have mainly Neoarchean/ Paleoproterozoic or Paleozoic U-Pb ages; several show ages and/or Hf model ages >3.2 Ga. Mantle-derived peridotite xenoliths east of the fault contain common metasomatic minerals rare in those west of the fault. Re-Os analysis of sulfides in xenoliths west of the fault show T_{RD} model ages to 3.3 Ga; major populations are 2.4-2.6 Ga, 1.6-1.8 Ga and 1.2-1.3 Ga, with rare Caledonian ages. However, sulfides in xenoliths east of the fault show maximum T_{RD} of 2.3 Ga with major peaks at 900-1100 and 400-500 Ma, identical to the spectrum of zircon ages of protoliths for exposed gneisses and schists east of the fault

These data demonstrate a major disjunct, on both sides of the B-B fault, between the Archean lower crust and a Proterozoic-Paleozoic upper crust; this suggests that the original Archean upper (and middle?) crust was detached from the lower crust and replaced by thrust sheets of younger material, probably during the major overthrusting of the Caledonian orogeny. The striking differences in the SCLM on either side of the B-B fault suggest major transcurrent movement, juxtaposing lithospheric sections that evolved discretely at some distance from one another. West of the B-B fault, the presence of Archean lower crust overlying Archean SCLM suggests coupling of the crust and mantle for ≥3 Ga