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NE Atlantic mantle geochemistry: New insights from volcanic flank zones in Iceland and Jan Mayen

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Basalts from Icelandic rift zones and nearby MOR segments have high ε_{Sr} and ε_{Hf} for a given ε_{Nd}, negative Δ^{207}Pb and positive ΔNb. Most of these features are also found in low-degree, alkaline or transitional basalts from Icelandic volcanic flank zones and Jan Mayen, although published ε_{Hf} data are not yet avaiable. Tertiary continental margin basalts have similar chemical features, indicating wide lateral dispersion of the ancestral Iceland plume head. A mantle source dominated by recycled ocean lithosphere of Paleozoic age explains the Sr-Nd-Pb-isotopic compositions. The fertile and refractory source components may originate mainly from the upper and lower parts of the subducted lithosphere, respectively. They may also be partly related by early low-degree melting and short-scale melt segregation, followed by radioactive decay.

The low-degree melts erupted in the volcanic flank zones have generally higher VICE/MICE, ε_{Sr}, ^{206}Pb/^{204}Pb and δ^{18}O and lower ε_{Nd}, γ_{Os} and ^{3}He/^{4}He than rift zone tholeiites. In contrast, weak positive correlation between δ^{18}O and γ_{Os} has been reported from a more restricted compositional range of rift zone tholeiites. The different δ^{18}O in flank and rift zone basalts are consistent with seafloor hydrothermal alteration of the upper and lower parts of recycled oceanic lithosphere, respectively. Olivine-melt fractionation (0.5‰) may also contribute to this difference. Lower γ_{Os} of fertile Snæfellsnes basalts compared to nearby rift zone tholeiites may indicate efficient Re-loss from the upper part of the subducted and recycled slab. The Öræfajökull volcanic system in the eastern flank zone has anomalously high ε_{Sr} and positive Δ^{207}Pb and Δ^{208}Pb, possibly related to an EM2-like component.

Lateral deflection and variable melting and sampling of the complex mantle source upwelling beneath central Iceland are goverened by crustal structure and geometry of local rift zones and regional oceanic ridges. The lateral mantle flow extends beyond Jan Mayen (V-shaped ridge pattern). Our ongoing Sr-Nd-Hf-Pb-Os-O-He-isotope study of alkaline basalts from Jan Mayen and the Icelandic flank zones may further resolve the range of fertile mantle components.

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Evolution of the mantle source beneath Macquarie Ridge revealed by Macquarie Island glasses

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The ~11 Ma Macquarie Island ophiolite represents oceanic crust generated within the slow-spreading, waning Macquarie Ridge (Australia-Pacific plate boundary, Southern Ocean). A unique feature of the Macquarie Island MORB glasses is the occurrence of very primitive, weekly fractionated compositions (Mg# 63-69 mol%, olivine Fo 87-90) which show extreme diversity in abundances and ratios of incompatible major, trace and volatile elements [1, 2]. These glasses: 1) exhibit clear parent-daughter relationships with less primitive glass compositions; 2) allow simple reconstruction of primary melt compositions; 3) show exceptional compositional diversity (e.g., K_2O/TiO_2 0.09-0.9; H_2O 0.25-1.5 wt%; Cl 130-1500 ppm; La/Yb 1.5-22; ^{206}Pb/^{204}Pb 18.70-19.52); and 4) preserve changes in major element and isotope compositions which are correlated with the degree of trace element enrichment (e.g., La/Sm). The glasses with highest abundances of incompatible elements and lowest FeO and CaO represent a new ultra-enriched endmember in the spectrum of MORB melts. The trend from this endmember to common E- and N-MORB glasses is extended further to strongly depleted compositions (K 150 ppm; Cl 50 ppm; La/Yb 0.45) by melt inclusions in Cr-spinel (Cr# 31-60 mol%) from picrites.

The entire trend of near-primary melt compositions is thought to result from continuous melting of a garnet-free mantle peridotite. The dominance of primitive enriched varieties - a unique feature of Macquarie Island MORBs – provides evidence that early magma batches erupted with little or no mixing and fractionation, possibly because the slow-speading ridge environment produced only transient, if any, magma chambers. The magma source is considered to be “dynamic”, i.e. changing its bulk chemical and isotopic composition with progressive melting and melt extraction [2]. The concept of a “dynamic source” (i.e. assemblage of locally equilibrated mantle solids and related melt fraction) combines the models of small-scale mantle heterogeneities and fractional melting, and can substitute for conventional multi-component mixing.

References

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