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The Mohns Ridge as a major mantle convection boundary

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We measured high-precision Pb, Hf, and some Nd isotope compositions for 70 MORB glasses from along ~1600 km of the Arctic Mid-Atlantic Ridge (MAR), covering the Kolbeinsey, Mohns, and Knipovich Ridges and the Tjörnes Transform Zone, the Spar Fracture Zone, and the Jan Mayen Platform. Together with existing Nd, Sr, and He isotope data for the same samples [1], these new data provide the first comprehensive set of isotopic properties between the latitudes of 66°N and 78°N, distinguish some unusual isotopic compositions among Arctic MORB, and place new constraints on the geodynamic significance of especially the Jan Mayen plateau and the slow-spreading Mohns Ridge. Lead isotopes reflect the presence of three components, one of them resembling normal MORB, the second a plume component (HIMU?) mostly present around Jan Mayen, while the third, also found at Jan Mayen, typifies traces of continental crust. The Ce/Pb and Nb/U ratios of basalts from the Jan Mayen plateau, however, exceed mantle canonical values in the direction away from crustal values. Together with the nearly MORB-like $^{3}He/^{4}He$ of these basalts, this excludes that continental crust and sediments beneath the Jan Mayen plateau alone can account for the unusual geochemical characteristics. The progressive poleward deepening of the Mohns and Knipovich Ridges is accompanied by increasingly radiogenic Hf up to ε_{Hf} of +24, which is strongly decoupled from the corresponding Nd isotope compositions that do not exceed N-MORB values of ε_{Nd}~10. This may reflect the presence of an ancient garnet- or plagioclase-bearing pyroxenite protolith. The MAR north of Iceland is interrupted by two major discontinuities, which appear most clearly when the geochemical properties are viewed with respect to the latitude in the Eulerian NA-EU rotation reference system. The southern edge of the Jan Mayen plateau, and, to an even greater extent, the entire Mohns Ridge then become small-circle (transform) features, which are consistent with the moment tensor solutions of the local earthquakes. These two discontinuities concentrate the remarkably strong bathymetric and isotopic gradients of the Jan Mayen and Mohns and seem to isolate mantle domains with clearly distinctive geochemical properties. The geochemical variability increases markedly north of Mohns Ridge, likely reflecting the slower upwelling rate and therefore smaller degree of melting as the spreading axis approaches its Eulerian pole.

References

[1] Schilling et al. (1999) *JGR* **104,** 10543-10569.

5.6.31

Oceanic detachments: Formation and associated deformation

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Oceanic detachments are common along slow- and intermediate-spreading ridges, but the conditions that lead to their origin, the controls on strain localization, and the causes of cessation of this mode of lithospheric deformation are still open to debate. These structures are characterized by striations parallel to spreading, a curved fault plane, high angle faults that snapping of the detachement surface due to flexure, the occurrence of fault rocks in addition to exhumed gabbro, peridotite and basalt/diabase, and the localization during extended periods of time (1-10 Ma). Sampling with the BGS BRIGE drill, geological observations and geochemical analyses of fault rocks sampled along the Mid-Atlantic Ridge detachment at 15°45'N constrain the deformation conditions at this fault zone. Fault rocks are composed mainly of talc, amphibolite and chlorite, formed in the shallow lithosphere (green-schist facies) and plastic deformation is practically absent. Deformation was coeval with magmatism (diabase clasts embedded in the fault rock; diabase with chilled margins in contact with fault rock). The parent rock of the fault material is ultrabasic, as indicated by the composition of relict spinels, and the REE concentrations. The presence of talc is also indicative of fluid flow through the detachment fault during deformation. The thickness of the deformation zone is <100 m, and as thin as 50 m [1]. Additional ODP drilling penetrated ~200 m of cataclastically deformed gabbros at the striated surface, in addition to fault schists [1]. These data are consistent with sparser geological observations at other detachments.

We propose a shallow detachment model that is applicable to other striated surfaces identified along slow- and intermediate-spreading oceanic crust. These observations do not support a detachment model rooting in melt-rich, high-T zones as documented at Atlantis Bank (SWIR). We infer that detachment faulting in the oceanic lithosphere localizes strain at shallow levels, is active during active magmatism, and roots at shallow rheological boundaries, such as a melt-rich zone or magma chamber ('hot' detachments) or an alteration front ('cold' detachments).

References

[1] P. Kelemen et al., ODP Leg 209 (Preliminary results, unpub.)