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Comparative melting dynamics of Gakkel Ridge and Lena Trough, Arctic Ocean

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Lena Trough is a 350 km highly oblique spreading center in the Arctic Ocean linking the northern Mid-Atlantic Ridge to Gakkel Ridge[1]. The two share many geodynamic characteristics of ultraslow spreading ridges: Both have deep and broad axial valleys in which basalt and peridotite outcrop are interspersed[1,2]. Both spread at a rate of 13mm/yr full rate, though Gakkel ridge drops to about 10 mm/yr near the Siberian coast.

The main distinction is their obliquity: Gakkel Ridge is nearly orthogonal, while Lena Trough describes a 55 degree angle to the orthogonal. The effective spreading rate of 7.5mm/yr is the lowest anywhere[3]. Cruises in 1999 (POLARSTERN ARK XV/2[1]) and 2001 (AMORE[2]) recovered basalt, peridotite and massive sulfide from Lena Trough.

Both ridges show unusually strong melting variation. Cr# in peridotite spinel in single dredge hauls covers in many cases the entire spectrum of abyssal peridotite compositions from very fertile to very depleted[3]. This appears to be a common characteristic of ultraslow spreading ridges. The main differences are that Lena Trough has even higher Na contents in cpx and a lower ratio of MREE to HREE, which suggests the influence of melting in the garnet stability field.

Lena Trough basalts are slightly evolved (Mg# 65) alkali basalts with 4% Na_2O ($Na_{8.0}$ of 3.5), 1.5% K_2O (K/Ti 0.54) and are LREE enriched with average (La/Sm)N of 1.6, and (Sm/Yb)N of 2.41. Their low HREE budget also agrees with the presence of garnet in the melting source.

Coherent garnet melting indicators in Lena basalt and peridotite seem to suggest a hotter thermal regime in Lena Trough juxtaposed against a cold thick lithosphere. Alternatively, deep melting may be occurring within or entraining ancient continental mantle.

A new cruise (POLARSTERN ARK XX/2) in summer 2004 will map and sample Lena Trough more thoroughly.

References

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Gakkel Ridge: Mantle and melting at ultraslow spreading rates

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Gakkel Ridge is the slowest spreading ocean ridge. Much of it consists of sparsely magmatic to amagmatic segments linked by widely spaced normal constructional volcanic segments. Mantle peridotites are abundantly exposed in the amagmatic segments. While these peridotites closely resemble those from faster spreading ridges, the proportions of dunite, harzburgite, lherzolite and plagioclase- peridotites are strikingly different. Plagioclase peridotites are relatively uncommon, amounting to only ~4% of the ultramafics recovered, compared to ~40% of abyssal peridotites dredged at slow spreading ridges. Dunite amounts to 17% compared to ~<4% at slow spreading ridges. Moreover, based on hand samples, there appears to be a nearly bimodal distribution of diopside, with near Cpx-free harzburgite and lherzolite the most abundant rock types.

Mineral compositions are highly variable, reflecting a large range in the apparent local extents of mantle melting. There are two principle pyroxene populations, with intergranular Cpx in harzburgites ranging from LREE depleted to LREE enriched, and dominantly LREE depleted Cpx in lherzolites.

Most slow spreading ridge abyssal peridotites come from transform fault zones that correspond to regions in the mantle where largely simple fractional melting occurs with the melt withdrawn and focused to beneath the midpoints of ridge segments, or simply back-impregnated into the mantle at the base of the lithosphere. Dunites are rare as little melt is transported through the lithosphere to the surface in this environment.

The large abundance of dunite and bimodal character of the Gakkel peridotites is believed to represent alternations between zones of focused melt transport through the mantle to ancient volcanic centers, and zones of simple progressive melting and melt withdrawal. In this context, regional gradients in mantle composition defined by the least-depleted peridotites likely reflect variations in the initial mantle composition as much as variations in the extent of mantle melting beneath the ridge.