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The Lena Trough ocean-continent transition: melts form, migrate, stagnate and freeze

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During cruise ARK XX/2 of RV Polarstern in summer 2004, nearly 2400 kg of basement rocks were recovered by 23 dredge hauls along the ultraslow spreading Lena Trough (13mm/yr full rate, 7.5 mm/yr effective). This 350 km long linear deep, which links the orthogonal spreading Gakkel Ridge in the north to the Molloy Deep in the South, was until now barely explored.

Lena Trough can be divided into three clearly defined segments: (1) a northern basalt-dominated segment, (2) a central basalt-free segment, and (3) a southern basalt-bearing segment. In northern Lena Trough, there is robust volcanism, since the four northernmost axial dredge hauls yielded more than 98 % basalt or diabase. The sudden change in spreading geometry from magmatically robust orthogonal spreading at the Western Gakkel Volcanic Province to oblique near-continental spreading at Lena Trough, did not lead to an abrupt cessation in partial melting underneath the northernmost part of Lena Trough. However, this eruptive magmatism in northern Lena Trough may not have been active for a long time, since the off-axis dredge haul on the western flank at 82.8˚N contained only peridotites.

The central part of Lena Trough is completely devoid of basalts, and is therefore the longest (conventionally defined) amagmatic section along the global mid-ocean ridge system. In the conventional sense, the lack of basalt and the exclusive presence of mantle rocks exposed on the ocean floor directly translate to amagmatic extension. It is likely, however, that some partial melting occurred. This melt was not extracted from the mantle, and is now present in the form of disseminated plagioclase and veins. Our studies on mantle rocks from Gakkel Ridge, SWIR and CIR suggest that a nearly a quarter of all abyssal peridotites there are not the product of partial melting alone. Instead, the mineral composition of such plagioclase-bearing peridotites as well as their

textures can only be explained by significant melt entrapment. Furthermore, the extreme chemical disequilibrium between the minerals in almost all plagioclase-bearing abyssal peridotites worldwide suggests rapid cooling rates, supporting a very low-pressure origin of the melt injection.

The weight fraction of plagioclase-bearing peridotites per total amount of peridotite recovered per dredge behaves systematically. Plagioclase is virtually absent in the southernmost and northernmost dredge hauls and increases towards the center of Lena Trough, where nearly all collected peridotites contained plagioclase. For the residual peridotites along Lucky Ridge, the baseline spinel Cr# is 0.15-0.19 and is observed in every dredge haul. Local variations in the degree of melting occur as indicated by Cr# of up to 0.52 in some modally depleted harzburgites.

Melt generation thus occurred along the entire length of Lena Trough. In the northermost part, these melts were extracted from the mantle and formed a basaltic layer, possibly a very thin one. In the central part of Lena Trough, melts were formed in the mantle, but never managed to focus, pool and erupt. The reason for this may be an increase in lithospheric thickness from the Gakkel Ridge/Lena Trough intersection towards the south. In the central part of Lena Trough, the lithosphere may be exceptionally thick resulting from the conductively cooling influences of the extreme obliquity, the ultraslow spreading and the vicinity to the continental margin of Greenland and Svalbard.