

Contrasting spreading processes at Gakkel Ridge across the 3°E boundary shaped the Arctic Ocean lithosphere

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The Arctic mid-ocean ridge system is one of the two main representatives of the particular class of ultraslow spreading ridges with spreading rates of less than 20 mm/y full rate. The formation of new ocean lithosphere at these ridges strongly deviates from any other ocean basin. Typical properties of ultraslow spreading ridges are alternating rift sections with magmatic and amagmatic spreading. At 3°E on Gakkel Ridge, a prominent boundary exists. Here magmatic spreading in the Western Volcanic Zone with basaltic seafloor and numerous axial volcanic ridges is sharply cut off from the amagmatically generated lithosphere of the Sparsely Magmatic Zone, characterized by a deeper rift valley and seafloor made up of mantle rocks.

We analysed the teleseismic earthquake record of ultraslow spreading ridges and collected local earthquake data at various ridge locations both at Gakkel Ridge and the Southwest Indian Ridge (SWIR). We found a marked contrast in seismicity across the 3°E boundary. Magmatic spreading in the west is connected with increased seismicity and frequent strong earthquakes often organized in earthquake sequences. Amagmatic spreading, in contrast, produces less and weaker earthquakes. By analogy with an amagmatic spreading segment at the SWIR where we analysed 10 months of local earthquake data, we can show that amagmatic spreading produces a thick lithosphere whose mechanical thickness may reach 30 km. Serpentinisation down to depths of 15 km below seafloor effectively reduces the strength of the lithosphere and results in a lack of seismicity. Magmatic sections show a brittle lithosphere throughout that is dramatically thinned beneath sites of volcanic activity.

We postulate that across the 3°E boundary at Gakkel Ridge a major change in lithospheric thickness and composition occurs. This boundary has potentially been very long-lived as it can be traced off-axis in the Eurasian Basin by marine magnetic anomalies. Differences in isotopic compositions of the mantle to either side of the boundary further support this theory. We further present our plans to test this hypothesis with a dedicated field experiment.