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Active spreading processes at ultraslow mid-ocean ridges: Unusual seismicity at the amagmatic Lena Trough, Arctic Ocean

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Lena Trough is the southern continuation of the ultraslow-spreading Gakkel Ridge and with its position in the Fram Strait between Greenland and Spitsbergen it is the only deep-sea gateway to the Arctic Ocean. DFG funded Emmy Noether group 'Mid-Ocean Volcanoes and Earthquakes' located at Alfred Wegener Institute for Polar and Marine Research is focusing on the seismicity of ultraslow spreading ridges and is especially interested in Lena Trough as an ultraslow spreading ridge in a developing stage. The southern Lena Trough shows similarities to the northern Red Sea spreading centre which is in the early stage of development from continental to oceanic rift. Cochran postulated in 2003 that the continental crust within the water-covered Red Sea is less than 10 km thick and that the northern part of the Red Sea rift spreads ultraslow as well. At Lena Trough an actively spreading mid-ocean ridge with a narrow rift valley has already developed but continental crust lies within a short distance.

Lena Trough is extending from 83°N/5°W to 80.3°N/2°W where it passes into the transform fault of the Spitsbergen Fracture Zone. The geometry of Lena Trough and certain asymmetric structures in the rift valley indicate oblique spreading and mostly tectonic and amagmatic rifting. There are several topographic highs west of the ridge axis which could be bounded by deep faults with normal faulting or detachment character exposing mantle material at the surface.

Seismicity at the Lena Trough shows apparently the same asymmetric character with epicenters of teleseismically recorded earthquakes concentrating predominantly west of the ridge axis. The most frequent focal mechanism of the earthquakes within the rift valley is normal faulting, whereas strike-slip faults occur in the Spitsbergen Fracture Zone.

We relocalized teleseismic earthquakes recorded from May 1973 to April 2009 in the region using a refined localization algorithm and could confirm systematic asymmetry in the distribution of earthquakes relative to the ridge axis. There are several high magnitude earthquakes (mb > 6) which are abnormally strong even for ultraslow spreading ridges. A major recent seismic crisis with 33 events from beginning of February 2009 until end of March 2009 peaked in a mb 6.5 earthquake occurring on March 6, 2009.

We recorded the microseismicity in the area in July 2008 and August 2009 using small-aperture seismic arrays on drifting ice floes and noted ongoing increased seismicity in the region of the southern Lena Trough in 2009. We analysed the waveforms of these swarm-like events extracting improved traveltime picks and polarities and could localize the epicentres close to the Spitsbergen Fracture Zone in a narrow cluster striking almost parallel to the Fracture Zone. The Mb 6.5 event is located at the outside-corner southern Lena Trough in the prolongation of the Spitsbergen Fracture Zone. We are currently identifying geological structures and faults that are linked to these events.