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Insights into an ultraslow volcanic spreading centre by an unusual LET: Seismometers mounted on ice floes

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In 1999 an unusually strong, teleseismically registered earthquake swarm at the volcanic complex at 85°E/85°N marked the onset of a spreading episode at Gakkel ridge with exceptional, deep submarine explosive volcanism. At this site, the rift valley centre hosts several distinctive volcanic features which cluster on ridge-parallel faults or fissures. The rift valley itself is well-defined by 1-2 km high bounding walls. To gain a better understanding of the seismological characteristics of the region, we investigate here three-dimensional P- and S-wave velocity structure in the crust and upper mantle.
Three arrays of four seismometers each which were mounted on ice floes, drifted 21 days with a drift speed of up to 1 km/h over a total region of 60 km x 70 km. We recorded over 300 local earthquakes. Of these, we used 128 earthquakes which were recorded by more than two arrays and yielded more than 1200 P- and S-phases for a local tomography. Because of the unusual set up of seismometers on drifting ice floes, each earthquake is recorded by a set of unique station coordinates. Additionally, the highly variable bathymetry in the survey region had to be taken into account. We therefore defined a water layer with vp=1500 m/s. Its thickness varies by more than 1100 m in 3D.
Due to the remote location and the perennial ice cover of the Arctic ocean, no previous information on crustal structure were available. We adressed the lack of prior information on the velocity structure by localizing a set of well recorded events with HYPOSAT, using a suite of more than 90 randomly selected velocity models. The respective traveltimes were corrected for the varying thickness of the water layer by compensating to a depth of 3900 m. The overall best performing velocity model was then chosen as our 1D starting background model, and was also used to relocate our whole dataset for input source locations.
Here we present the results of this seismic tomography, inverting for sources and velocity: Most of the earthquakes cluster at varying depths beneath and around the volcanic complex, with the deepest events underneath the volcanic centre. They yield a dense ray coverage outward from the volcanic cones, covering the centre of the rift valley extensively. We plotted several velocity-slices in varying depths, as well as along- and cross axis. The velocity variations along axis indicate a thin crust, cross axis we find that the rift valley walls are underlain by material with slower seismic velocities.