Geophysical Research Abstracts
Vol. 12, EGU2010-3416, 2010
EGU General Assembly 2010

Active spreading processes at ultraslow-spreading ridges: Relocalization and analysis of the 1999 earthquake swarm at Gakkel Ridge, Arctic Ocean

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Gakkel Ridge is situated within the Arctic Ocean and spans from eastern Greenland to the continental Siberian shelf. It is termed an ultraslow spreading ridge (full spreading rate 6-14 mm/yr). At ultraslow spreading ridges, heat loss by conductive cooling is thought to decrease magma supply and focus magmatism in widely spaced discrete volcanic centres.

In 1999 lasting over 7 months, the largest ever earthquake swarm at a mid-ocean ridge was teleseismically registered worldwide. It originated from around 85°E which was postulated to be a volcanic complex and featured 252 recorded events, including 11 events with a magnitude mb > 5.0. The unprecedented duration, magnitude and number of events ran counter to expectations at this location. Preliminary analysis with unreviewed datasets showed changing source-mechanisms from extensional to events with a greater non-double-couple component at around March, 4th and an abrupt decrease in the number of events on the 15th of April. Also the epicentres of the larger events seemed to migrate with advancing time to the NW, farther away from the volcanic centre.

As these analyses were based on preliminary datasets it seemed indicated to relocalize the earthquakes when the reviewed bulletin of the International Seismological Centre was released. This relocalization was done with the earthquake localization programme NonLinLoc using a probabilistic approach and grid-search. The calculation of travel times used as velocity model both AK135 and IASP91 combined with a regional velocity model for recording stations with epicentral distance < 30°. We tested extensively the influence of localization algorithm, velocity model, station coverage and weighting on the localization result. The new locations of the epicentres show a clustering of events within the central rift valley and the southern rift flank.

The dataset was further reviewed with regard to the quality of the localization and reduced to 93 well located events whose epicentre locations are largely independent of the tested parameters. The 68% error in ellipse semi-major axes of the new localization is in the order of 15 km for the best events.

An analysis of the respective epicentral distance to the volcanic complex with advancing time showed diffuse activation around the volcanic complex within the rift valley before the 15th of April, to the NW migrating epicentres with additional activation of the valley walls after April 15th. We postulate that the change in seismicity rate and the following change in source mechanism might mark the onset of volcanic activity. Suspiciously, at the beginning of April three events with highly correlating waveforms were registered. They locate at the southern rift valley wall and in the vicinity of a central rift valley volcano termed Oden volcano and their source mechanism should give significant insights into the developing activity.