IDEA 230

IPY 2007/2008

Seismic arrays on drifting sea-ice and icebergs – research on the origin of seismicity of the polar oceans and on ice/water interactions

V. Schlindwein (1) vschlindwein@awi-bremerhaven.de
C. Müller (2) mueller@fielax.de
W. Jokat (1) wjokat@awi-bremerhaven.de
A. Eckstaller (1) aeckstaller@awi-bremerhaven.de

1) Alfred Wegener Institute for Polar and Marine Research, Columbusstr., 27568 Bremerhaven, Germany
2) Fielax GmbH, Schifferstr. 10-14, 27568 Bremerhaven, Germany

Ice floes and icebergs offer a unique platform for seismological recordings in polar regions. Little is known about the microseismicity in the central Arctic, since only few permanent seismological stations are operational around the Arctic Ocean. Furthermore, permanent ice cover in these areas prevents the use of ocean bottom instruments for seismological studies. However, what appears to be a severe draw-back, is indeed a challenge for future polar research: recording earthquakes on drifting and creaking ice floes and icebergs.

Pilot studies with conventional seismological stations on ice floes have shown that it is possible to record artificial and natural seismic waves on ice floes and to distinguish these signals from the signals caused by the ice floe itself. Furthermore, the ice-water system produces interesting seismic signals, especially long-lasting tremor-like signals with a sequence of harmonic spectral peaks resembling volcanic tremor. Similarly, strong amplitude signals lasting for several days were also recorded from large Antarctic icebergs.

However, the special recording site requires adapted methods for the analysis of any seismic signals as the water column underneath only propagates P-waves. Whereas accurate positioning of ocean bottom instruments is difficult, seismic arrays consisting of several seismometers in a fixed geometry can easily be installed on ice floes. Arrays serve as sensitive seismological antennae allowing to determine the direction of approach of a seismic wave.

To our knowledge, the concept of small aperture arrays deployed on drifting ice floes was first applied in a pilot study during RV Polarstern cruise AMORE2001 to the Gakkel Ridge. We were not sure if this innovative method would provide reasonable results. But ongoing examinations of the recordings are promising regarding monitoring and locating capabilities of microseismicity. Thus, similar future experiments will strongly benefit from our newly acquired experience and will lead to an improved array design and analysis technique.

We propose to undertake in the framework of the IPY comprehensive seismological measurements on ice with two main goals:

1) During the expedition AMORE2001 of RV Polarstern, seismological mini-arrays were

deployed on three locations along the Gakkel ridge to test the capability of the method and to get a first impression of the microseismicity of the Gakkel ridge. As ultra-slow rifting spreading centre the Gakkel ridge is a major focus of mid-ocean ridge research, but very little is known about its seismicity. This pilot study successfully revealed microearthquakes in the central rift valley and along the flanks as well as a swarm of small earthquakes in an area of major earthquake and volcanic activity in 1999.

We propose to undertake a systematic investigation of the seismicity of the Gakkel ridge during the IPY2007/2008. For a localisation of earthquakes with unprecedented accuracy along a mid-oceanic ridge, 3 simultaneously deployed arrays each consisting of 7 seismometers on 2 concentric circles have to be positioned on both sides of the rift valley and record earthquakes of a period of 2-4 weeks. Additional hydrophones underneath the ice floe will give the array a three-dimensional component and allow to more easily distinguish earthquakes from icequakes. Automated identification of earthquakes in the highly noisy records will be a major methodological challenge of the project. The experiment should be conducted at three or more differing rift segments. This will greatly help to understand the activity of the individual rift segments and offer a framework for interpretation of other data for example from petrological, heat flow, and hydrothermal studies.

The experiment requires a presence in the Gakkel Ridge area over a long time span of at least 8 weeks but no special logistics. Helicopter time is necessary to carry the seismometers from the ship to the recording sites and to recollect them. Extended multidisciplinary expeditions to the high Arctic during IPY2007/2008 therefore offer a unique opportunity to realise this project.

2) From July until December 2000 sustained seismic signals of several hours duration were recorded by the seismographs of the Neumayer seismological network stations/Antarctica. These strong amplitude signals were characterised by spectral features very similar to volcanic tremor as narrow spectral peaks with a fundamental frequency varying between 0.5 and 4 Hz and up to more then 20 harmonic overtones. As the source of these unusual signals, the iceberg B09a could be recognised drifting in the coastal current offshore Dronning Maud Land. The signals could be recorded up to a distance of more then 1000 km. Due to the similarity to volcanic tremor a better understanding of the source processes might also give new ideas to explain volcanic tremor generating mechanisms, which are far from being understood.

Thus, in the frame of IPY we propose to deploy a seismic array on a large Antarctic iceberg to answer the question if similar signals usually occur in such ice/water systems and to better understand originating mechanisms. Similar to the Arctic sea-ice arrays, these iceberg seismic recordings can also be used to monitor tectonic seismic activity of the oceanic Antarctic plate.

The data of our proposed projects will be useful for a larger science community: Intensive hydroacoustic monitoring of the polar oceans not only reveals tectonic and volcanic processes on the sea floor, but also supplies data for research on marine mammals and artificial noise in the polar oceans.