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Evidence for Subsurface Methane from High-Resolution Reflection and Wide-Angle Seismic Data Offshore Svalbard

Tim Minshull (1), Sudipta Sarkar (1), Anne Chabert (1), Graham Westbrook (2,1), Christian Berndt (3,1)

(1) National Oceanography Centre Southampton, University of Southampton, Southampton, United Kingdom (tmin@noc.soton.ac.uk), (2) School of Geography, Earth and Environmental Sciences, University of Birmingham, United Kingdom, (3) Leibnitz Institute of Marine Sciences at University of Kiel (IFM-GEOMAR), Kiel, Germany

Oceanographic evidence suggests that bottom waters on the continental slope west of Svalbard have warmed by about 1 degree Celsius in the last three decades due to changes in the West Spitzbergen Current. Seismic reflection profiles across the west Svalbard margin reveal evidence for widespread bottom-simulating reflectors (BSRs) associated with methane hydrate. Ongoing seabed warming may result in release into the ocean and atmosphere of methane stored within and beneath this hydrate. In August-September 2008, we collected a dense grid of high-resolution multichannel and wide-angle seismic data across the upper continental slope using a GI-gun source, a 300 m streamer with 6.25 m group spacing and 13 ocean bottom seismometer (OBS) deployments. The BSR is imaged within hemipelagic and contourite sediments, but is generally absent within glacigenic debris flows. Seismic reflection evidence for subsurface gas and fluid flow includes sub-vertical structures interpreted as fluid escape structures, chaotic high-amplitude reflectors, velocity pull-downs, and areas of reduced seismic amplitudes possibly representing dewatering/degassing structures. Some fluid-escape pathways reach the seabed and terminate at pockmark structures, while others are buried beneath shallow unconformities. These observations suggest that fluid venting was common in post-glacial times. The OBS records show clear P-wave and mode-converted S-wave reflections at short offsets. The sub-seabed variation of P- and S-wave velocity was modelled for the five sites located above and below the landward limit of hydrate stability, using a ray-trace forward modelling approach. One site at $\sim$1250 m water depth shows clear evidence for the presence of gas hydrate in a zone about 120 metres below the seabed which has a greater P-wave velocity (1.8 km/s) and S-wave velocity (0.47 km/s) than expected for unconsolidated terrigenous sediment. This high velocity zone is divided by the BSR from a zone of lower velocities (1.55 km/s and 0.40 km/s for P- and S-waves, respectively) indicating the presence of free gas. At two other sites in shallow and deep water, low-velocity zones provide evidence for the presence of free gas, but there is no unequivocal evidence for the presence of hydrate. However, the presence of gas at two sites nearly 100 km apart suggests that free gas is widespread along the west Svalbard continental margin and that hydrate may also be widespread close to the landward limit of hydrate stability. Dissociation of this hydrate may provide a source for the extensive methane venting from the seabed observed during the same experiment.