Geophysical Research Abstracts, Vol. 8, 06655, 2006
SRef-ID: 1607-7962/gra/EGU06-A-06655

Heat-, fluid flow, and geological variations controlling gas hydrate systems on the western Svalbard continental shear margin

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The western Svalbard continental shear margin represents one of the worlds's shortest distances from shelf edges to mid-ocean ridges and holds sediments of relatively young depositional age ($<$ 0.78 Ma). Consequently, the margin is a prominent area for studying heat- and fluid flow variations, and how they control the gas hydrate system from the continental slope to the deep-sea basin in different geological settings. Multi-channel 2D-seismic profiles from the continental slope to the deep-sea basin indicate two different characteristics of a 'bottom-simulating reflector' (BSR), the base of the gas hydrate stabiliy zone (BGHS). On the continental slope from 1200 to 1900 m water depth a BSR appears in contouritic sediments as a continuous reflector-event at approx 200 mbsf. Cross-section images of the lateral and vertical distribution of P-wave interval velocities indicate a gradual velocity increase towards deeper levels, which is in agreement with the expected interval velocity of normal-consolidated marine sediments (e.g. the Hamilton curve). A 40-90 m thick zone above the BSR shows an anomalous and distinct increase in interval velocities (1850 m/s on average). Beneath the 'base of gas hydrate stability' (BGHS) a significant drop in interval velocities occurs (to ˜1450 m/s), showing a thickness of 75 m on average. The anomalously high and low P-wave interval velocities generally mimic the bathymetry, cross-cuts the stratigraphic layering, deviate the Hamilton curve, and are attributed to the presence of gas hydrates and free gas in the sediments, respectively. Using the subsurface depth to the BSR as an in-situ temperature proxy, we derive geothermal gradients along the margin, where a BSR is present. The shallowest BSR present occurs in water depth of 1200 mbsl inferring a geothermal gradient of approx 80 žC/km, steadily increasing to 100 žC/km down slope. Tectonically-induced faults pierce the gas hy-

drate stability zone causing near-vertical zones of focused fluid flow and a shoaling of the BSR. Elevated heat flow and in-situ hydrate dissociation occurs on a local scale. In the deep-sea basin at 2700 m water depth no contouritic sediments but sub-horizontal layered turbidity and hemipelagic deposits exists. Here, the BSR is recognized as an abrupt termination of high negative amplitude reflections in a tectonically controlled trough located on the eastern side of the Molloy Transform fault complex. Interval velocities are high above the BSR and low in a zone below the BSR. The low velocity zone continues eastward but without a visible BSR, yet, we interpret the remarkable drop in velocities to reflect gas-charged sediments. In contrast to the continental slope, gas-enriched layers or pockets are layer-bound within the turbidity deposits making it difficult to observe a BSR where strata parallel the bathymetry. A BSR is located at approx. 230 mbsf, inferring a high geothermal gradient of 120 žC/km. Considering the water depth and bottom water temperature in the deep-sea basin, the BSR is shoaling in areas of high heat flow. Tectonic-controlled faults and fractures occur on the middle part of the continental slope acting as preferential migration pathways for anomalous hot fluids, consequently interrupting the BGHS.