SO226 CHRIMP – Chatham Rise (Methane) Pockmarks

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A large number of seabed depressions has been mapped on the southern slope of the Chatham Rise, east of South Island, New Zealand [Davy et al., 2010]. Smaller sub-circular depressions (~150 m diameter and 4-8 m deep) exist in 500-700 m water depths whereas medium (~1-5 km diameter and 50-150 m deep) and giant circular depressions (8-11 km diameter, 80-100 m deep) are found in water depths of 800-1100 m. [Davy et al., 2010] propose gas hydrate (GH) dissociation during glacial-interglacial cycles and related release of gas as a cause of the formation of the depressions. Depressurization triggered by a sea-level drop during last glaciation could have caused shoaling of the base of gas hydrate stability (BGHS) with corresponding hydrate dissociation. Seismically triggered slumping along such over-pressured BGHS and subsequent influences by ocean currents may have given rise to the circular shape of the depressions. Another possible mechanism in triggering gas hydrate dissociation is the role of ocean warming in recent times (between 35 and 21 ka) by about 1 degree C.

Gas hydrate is present on active continental margins of New Zealand [Pecher et al., 2005,Townend, 1997]. On Parasound data from the Canterbury basin, west of the Chatham Rise, a gas hydrate BSR was suspected [Davy et al., 2010]. Modelling results indicate that GHs can exist in shallow sediments of the Canterbury basin [Gorman and Senger, 2010]. However, both seismic and physical evidence of GHs is still not known from the southern flank of the Chatham Rise. The CHRIMP project and cruise SO226 [Bialas et al., 2013] aimed to study whether a GH system exists in the shallow marine sediments below the observed seafloor depressions, if there are clues on hydrate dissociation and gas release, and to identify a mechanism explaining the formation and preservation of the depressions.

During the first leg of cruise SO226 multibeam bathymetry was acquired together with 2D multichannel seismic data (MCS) (Fig. 1) to image the lateral extent of the small medium and giant sized depressions. High resolution 3D P-cable and ocean bottom seismometer (OBS) data were acquired over a large and a medium sized depression (Fig. 1). Additional sediment echsounder data were acquired on all lines. Only a few 2D MCS profiles were acquired in the field of smaller depressions (Fig. 1). In the second leg of the cruise, we acquired additional multibeam bathymetry data, which extended the earlier coverage, along with backscatter images, and shallow cores (Fig. 1).

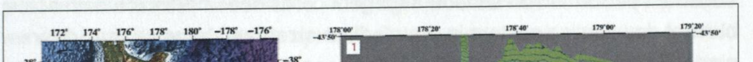

Figure 1: Map of the workings areas investigated during Leg-1 and Leg-2 of cruise SO226

Black lines: 2D seismic profiles, pink boxes: 3D seismic areas, pink dots: OBS, yellow dots: coring stations, yellow lines: OFOS tracks, black boxes: sidescan

Commercial and scientific boreholes (such as ODP 594 from Deep Sea Drilling Project, Leg 90) and previously acquired seismic data helped to establish a seismic stratigraphic model for our seismic sections. The sedimentary succession imaged in our seismic data provides more insight into the depositional environment and post-depositional sedimentary processes within the Cenozoic carbonate platform type sedimentary system of the southern flank of the Chatham Rise.

Erosional interfaces within the depressions of area 1 and area 2 argue for a complete evacuation of sediments prior to partial refill by contouritic drift type sediments. Although several negative polarity events were found in the seismic data there are no indications of gas hydrates could not be revealed as a bottom simulating reflector is absent. However, the seismic images reveal ample evidence for amplitude anomalies below the depressions, such as laterally extensive strong amplitude reflections ~115 ms below the seabed, extensive zones of seismic reflection amplitude blanking caused by fluid migration through polygonal faults, and erosional surfaces. Geologic sampling and geochemical assessment of pore water and sediment performed on shallow sediment cores does not indicate an active current day venting system in the medium-sized and large seabed depressions. Sediment cores are being further analysed for palaeo gas venting.

Two major structural anomalies have been imaged underneath the medium-sized depressions in area 2, one of which has been imaged by a 3D P-Cable survey. This conical mound in Cretaceous mud-bearing strata shows a circular outline in a 3-D timeslice and internal chaotic reflection pattern. Bending of overlying sediments indicates uprising of the mound until Late Oligocene. P-wave velocity analysis based on OBS data revealed reduced velocities in the central mound. Therefore we interpret the conical structure as mobilized mud with a mud source from the Cretaceous sediments. Mound uprising could have been initiated by localized overpressure development inside the structure caused by gas injection from the deeper basin.

Although there is no evidence for active gas escape structures close to the depressions, there are evidences for singular paleo pockmarks, such as depressions overlying the conical mound in deeper water (~ 1000 m). These pockmarks on the interface overlying the mound indicate past fluid release [Waghorn, 2014]. Development of a polygonal fault system is limited to the Eocene-Oligocene sediment package as well. Such paleo-structures were subsequently buried under Miocene sediments. Current scouring and localized mass transport deposition took place subsequently. Beneath the medium-sized depressions small scale mass transport deposits are found.

Conical mounds were not found in the shallower water depth of area 1. Here prominent structural anomalies are found as lens shaped reflection events in Early Eocene strata. The negative polarity reflection from the upper boundary of the structures could be caused by presence of gas. Their overall lens-shape could be a result of differential compaction in channel-levee type of depositional units Evidences for deeper fluid venting such as seismic chimneys are seldom observed, not only below the depressions but also in the areas adjacent to the depressions. It appears that the polygonal fault system played a role behind fluid migration as features like amplitude blanking are commonly observed associated with the faults in the echo-sounder data. Despite the absence of any geophysical evidence of gas hydrate system, the region could have in the past served as a potential site for gas accumulation and if conditions were favourable, hydrates would have accumulated close to the seabed. As most of the shallow sections are strongly influenced by current-controlled erosion and post-erosional infill, subsurface imaging alone cannot conclusively determine the existence of such system. Future geochemical analyses could provide more insight into the possibility of hydrate reservoir and past release of gas.

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