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Seismic evidence of methane cycling between deep and shallow fluid flow systems along the Hikurangi margin, New Zealand

A. Plaza-Faverola (1), I. Pecher (2,1), D. Klaeschen (3), and S. Henrys (1)

(1) GNS Science, New Zealand (a.plaza@gns.cri.nz), (2) University of Auckland, New Zealand, (3) IFM-GEOMAR, Kiel, Germany

Determining the source of the main natural gas, methane, forming gas hydrates, i.e. whether it is microbial or thermogenic, remains one of the main challenges in gas hydrate research. Geochemical data suggest that most of the methane that seep out from the seafloor above gas hydrate zones is microbial. However, significant volumes of free gas trapped beneath the base of the gas hydrate stability zone and the presence of faults and gas chimneys that link deep sited thermogenic gas reservoirs with the hydrate zones are evidence of fluid exchange between deep and shallow systems. We have reprocessed 10 and 12 km long surface streamer multi-channel seismic data from the Opouawe Bank and Porangahau Ridge regions along the Hikurangi Margin in order to obtain realistic geometries of fluid escape features associated with the subduction interface. Pre-stack depth migrated images of the subsurface show thrust faults linking the subduction interface with the gas hydrate zone. Anticlinal features with deeply rooted gas chimneys at their flanks and polygonal faults above the subduction interface are also evidence of fluid expulsion from the subdcuted sediments towards the gas hydrate zone. Further, anomalous low velocity zones in P-wave velocity macro models indicate preferred locations for fluid accumulations in sediments between the gas hydrate zone and the subduction interface. In order to explain the dominant microbial signature of methane sampled at the surface in spite of evident migration of fluids from well beneath the microbial zone, we present a model where microbial methane has been expelled from buried sediments together with thermogenic methane at different periods of overpressure related to the subduction system. We expect signatures for thermogenic methane to be found deeper than maximum depths of conventional coring (i.e. > 30 mbsf) in the sedimentary column. Our results complement an ongoing multidisciplinary investigation of gas hydrate systems along Hikurangi, which relies on shallow sampling and high resolution seismic data.