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The origin and transportation of methane for gas hydrate formation: case study from Porangahau Ridge, Hikurangi Subduction Margin, New Zealand

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The distribution of gas hydrate in marine sediments is controlled not only by temperature and pressure conditions, but also by the supply of natural gas in excess of solubility. Methane can be generated by either thermogenic processes, requiring high pressures, high temperatures and long geological time scales, or by biogenic generation within the top few kilometres of sediments. Biogenic methane may be produced within the gas hydrate stability zone (GHSZ) and incorporated into gas hydrate in-situ, or it may be generated beneath the base of gas hydrate stability and transported along fluid conduits to the GHSZ.

Methane associated with gas hydrate on the Hikurangi subduction margin is predominantly biogenic based on geochemical findings. This is consistent with the observation that the possible source rocks for thermogenic methane terminate landwards of known gas hydrate accumulations.

Seismic sections of the southern Hikurangi Subduction Margin clearly image thrust faults splaying upwards from the subduction décollement to the seafloor. The thrust faults form imbricated thrust ridges at the surface that exhibit strong Bottom Simulating Reflections (BSRs) on seismic sections and high resistivity anomalies, inferring the presence of high concentrations of gas hydrate. The décollement overlies pore-water saturated underthrust sediments that are actively dewatering due to sediment compaction and tectonic deformation.

We suggest that the methane for hydrate formation at Porangahau Ridge is produced by biogenic methanogenesis within organic rich accreted trench-fill turbidite sediments below the base of gas hydrate stability, but above depths suitable for thermogenic production. The biogenic methane is transported upwards, together with fluids expelled from underthrust sediments, along thrust faults that splay from the décollement. When the methane and fluid reach the base of gas hydrate stability, gas hydrate is formed. This mechanism of methane generation and transportation supports the observation that zones of highly concentrated gas hydrate accumulations correlate with features that focus fluid flow.