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Seafloor erosion at the top of the gas hydrate stability zone on Rock Garden, Hikurangi Margin – a review of possible mechanisms

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Rock Garden is an uplifted ridge on the Hikurangi Margin east of New Zealand with a flat top at about 600 m water depth. Bottom simulating reflections (BSRs) that pinch out at the edges of the plateau-like ridge crest suggest that ridge flattening coincides with the top of gas hydrate stability (TGHS) in the ocean. Several other ridges in this area display similar features. We therefore hypothesised that ridge flattening is caused by seafloor erosion at the TGHS. Several mechanisms were tested in recent years employing various modelling techniques. We present an overview of the key findings from these studies.

A purely tectonic origin of the flat ridge crests was found to be unlikely; an additional mechanism that leads to weakening of seafloor sediments at the water depth of the ridge crests is required. Pore-pressure fluctuations from repeated formation and dissociation of gas hydrates caused by meso-scale water temperature variations appear to only play a minor role in seafloor weakening, largely because the periods of meso-scale temperature fluctuations are relatively short (100s of days) and unlikely to reach significant gas hydrate deposits. Longer-period variability within the temperature signal e.g., decadal water temperature variations, are likely to penetrate to gas hydrate layers but would allow gradual dissipation of any overpressure. On the other hand, significant overpressure that may lead to hydrofracturing, and thus seafloor weakening, is predicted to build up close to the seafloor if gas hydrates cause a reduction of sediment permeability. The degree of overpressure depends significantly on the permeability contrast at the base of the gas hydrate zone, rates of fluid flow and, to a lesser degree, the buoyancy of gas columns beneath the base of gas-hydrate-bearing sediments. Weakened sediments can then be transported away with water currents or slide down the relatively steep ridge flanks. Finally, we found through modelling that submarine landslides that originate at the TGHS in the study area have tsunamogenic potential.