The role of free gas in a subaqueous landslide setting – insights from 3D modelling and seismic interpretation

M. Wiebe[1], F. Gross[2], S. Krastel[2], M. Daszinnies[3], J. Mountjoy[4], K. Huhn[1]

1. MARUM, Bremen, 2. Christian-Albrechts-Universität zu Kiel, Institut für Geowissenschaften, Kiel, 3. Migris AS, Trondheim, Norway, 4. NIWA - National Institute of Water and Atmospheric Research, Wellington, New Zealand

Subaqueous landslides pose a global threat to coastal and submarine infrastructure, as well as human life. One factor influencing slope stability is the presence of free gas. This could trigger subaqueous landslides in a two-stage process: (1) Gas migrates along stratigraphic layers and accumulates at permeability interfaces where it builds up pore overpressure. (2) The amount of generated overpressure suffices to reduce sediment shear strength enough to initiate failure. This conceptual model, however, has yet to be numerically tested in a realistic landslide setting.
We use 3D finite element modelling to study gas migration and accumulation, and compare the results with seismic interpretation. This allows us to address: (1) Where does gas accumulate depending on slope stratigraphy? (2) What are the spatial dimensions of gas traps? (3) How do permeability interfaces and gas source volume control gas accumulations?
The Tuaheni landslide complex offshore New Zealand is an ideal case study for such a modelling approach, as comprehensive data is available. This includes sediment cores and heat flow measurements as input for model parameters, as well as high-resolution 3D seismic data. The latter gives information about the slope stratigraphy as input for the model geometry. Seismic analysis also indicates occurrences of gas hydrate in the central to distal parts of the landslide, which could provide a source of free gas. Furthermore, high seismic amplitudes are interpreted to show locations of free gas accumulations, which are used for comparison with model results. Recent reactivation has been proposed for this landslide, meaning it enables in situ investigation of the influence of free gas on slope stability in geological real-time.
Modelling results show that gas accumulates locally in morphological traps along permeability interfaces. The modelled gas column heights amount to several metres and are controlled by permeability, trap morphology, and injected gas volume. Both modelling and seismic interpretation suggest that free gas accumulations occur in the proximal to central parts of the landslide upslope of the gas hydrate stability zone, and cover localised rather than wide-spread areas.