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Distribution of gas within a Black Sea submarine landslide from AUV sub-bottom profiler data

Ford, J. and Zolezzi, F. and Camerlenghi, A.

A submarine canyon in the Black Sea has recently been surveyed by an autonomous underwater vehicle (AUV) to assess geohazard to seafloor infrastructure from repeated mass-wasting events. A large, well-preserved submarine landslide (approximate total length 20 km, maximum width 1.5 km and maximum thickness 30 m) is observed in the centre of the canyon. Within the slide deposit several fluid-flow and free gas indicators are seen, implying that in some places the slide is acting as a seal, and in other places as a reservoir. This study aims to characterise the presence and distribution of gas by forward modelling the amplitude of the sub-bottom profiler reflections under varying porosity and pore fluid composition scenarios.

Geophysical data acquired from the AUV platform include high-resolution multi-beam bathymetry (approximate resolution 2 m) and a dense grid of Chirp sub-bottom profiles. In addition, the slide deposit has been sampled by several piston cores and cone-penetration tests.

For this study, the sub-bottom profiles were re-processed to preserve relative amplitudes between traces. Migration, static corrections and depth conversion were performed to properly image the sediments in depth. Interpretation of the slide morphology was made using the envelope of the image. The basal shear surface of the slide appears to be strongly erosive, with an irregular, ramped topography. The slide is frontally confined but with an overrunning distal component which runs out for approximately 15 km past the point of maximum thickness. Little internal structure is discernable in the sub-bottom profiles, however mud volcanoes and acoustic blanking are observed inside and around the slide, indicating widespread fluid-flow and free gas. Mapping of the slide deposit and fluid-flow features forms the first part of this study.

The second part of the study aims to explain the seismic response of the top and basal reflectors, with respect to the changing porosity and pore fluid composition (percentage gas). A petrophysical model of the slide deposit is constructed with a two-phase brine/gas pore fluid and variable porosity to represent compaction from sliding. Modelling of the seismic response is performed by simple convolution of the Chirp wavelet with a 1-D reflectivity series derived from acoustic impedance logs. Intrinsic P-wave attenuation is modelled using a Q-dependent time-varying bandpass filter. P-wave and density are constrained from multi-sensor core logger (MSCL) analysis performed on piston cores both within the slide deposit and within the unfailed sediment outside the slide.

The results of this study allow for better interpretation of amplitude variation in terms of changing compaction or percentage gas above and below the basal reflector. In addition, the forward modelling results allow for better discrimination between low-reflectivity zones due to gas blanking versus that due to stratal disruption from sliding. Any link between fluid-flow and sediment failure is still speculative, but understanding the distribution of gas could be important to understanding the trigger mechanisms for submarine landslides in this submarine canyon.