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How sediment properties influence soft sediment mobilization processes – insights from scaled analogue experiments

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Pockmarks and mud volcanoes are well-known surface expressions of soft sediment mobilization and transport, which can be relatively easily traced over a certain area e.g. through swath bathymetry. However, seismic reflection data have revealed that often pipe structures or sand intrusions are buried and therefore are not connected to any structure detectable on the sea floor. Such structures are usually caused by excessive pore fluid pressure, which leads to hydro-fractures in sealing layers of overpressured reservoirs or to fluidisation of sediments. Due to their typically high permeability, sand intrusions and pipe structures can serve as pathways for fluid migration through otherwise low-permeable sediments. Therefore, they have to be considered in risk assessments or modelling of caprock integrity in particular of submarine reservoir.

Scaled laboratory experiments employing various granular materials representing different sediment types are suitable to study under which conditions structures resulting from soft sediment mobilization can reach the surface. In a series of such experiments in which sediment mobilization is triggered through fluid overpressure realized by injecting pressurized air in layered sections consisting of different granular materials and powders we tested how sediment mobilizations processes evolve in e.g. cohesive and non-cohesive materials. A comparison of experiments with different types of materials and with different layer thicknesses reveals pressure conditions and structural evolutions of hydrofractures and fluidization structures. The structural evolution observed in the experiments suggests that in highly cohesive cap rocks anticlinal uplifts and hydrofractures at the flanks of the anticlines form followed by an intrusion of granulate of the reservoir layer into the fractures as soon as the hydrofractures reach the surface. In less cohesive materials, the cover layer is entirely fluidized and forms a cone-shaped pipe structure. The breakthrough of the fractures at the surface in the first case and the beginning of the fluidisation in the second case is accompanied by a significant drop of air pressure in the materials. The results of our test-experiments highlight the importance to know about sediment mechanical properties and their fluctuations in regions which potentially may be considered for subsurface storage.