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Impact of ice or gas hydrates on the maximum and residual shear strength of sandy sediments using a new External ring Shear TEst Rig, ESTER

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With an increasing usage of the continental slopes, there is an increasing demand for knowledge on sediment stabilities and a better understanding of natural slope movements. Gas hydrates are common in the slope sediments and influence their strength behavior. Since they are also considered as a possible source for methane production it is essential, to determine the geo-mechanical properties of hydrate-bearing sediments and investigate their strength behavior once they are subjected to stress.
Within the SUGAR III project, we designed and constructed an external shear test rig (ESTER) to determine friction angle and cohesion of gas hydrate-bearing sediments in relation to hydrate saturation, effective stress, shear rates, and grain size distribution. ESTER is a stand-alone shear cell allowing for the formation of ice or pore-filling, load-bearing, and cementing gas hydrates in porous sediments under simulated in situ conditions. The maximum load is 25 MPa and the temperature range is -30 to 100°C. The sample compartment allows for the flow through of fluids and has a volume 40 cm3. A strong servomotor can be throttled to the shear velocities of approx. 0.001 ° / min, which is equivalent to shear rates of commercial cells not suited for enhanced pore pressure. The maximum torque is 1 kNm. For cross calibration purposes we work with colleagues from the Bergakademie Freiberg, Germany.
Gas-free samples of ice or hydrate-bearing sediments can be formed in ESTER, representing marine and permafrost type samples. To start with, we have been running several test series with different ice saturations in a well-sorted coarse sand to determine maximum and residual shear strength in relation to saturations and confining pressure as well as look into the creep behavior of the sediment given changing shear rates. Currently, these data are being compared with shear tests on a sand containing pore-filling gas hydrates of similar saturations. Whereas ice dispersed in sediment pores has proven to be a good model to estimate geophysical properties of hydrate-bearing sands, the first experiments in ESTER using hydrate-bearing sediments show the differences in shear strength behavior. Compared to ice-bearing sand, the gas hydrate-bearing sand withstands higher torque, whereas creeping is much stronger in ice- bearing samples.