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The shear strength of ice and methane hydrate as measured by ESTER, a ring-shear cell

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Abstract

The shear strength of methane hydrate may influence marine slope stability on continental margins, permafrost stability in the Arctic, and wellbore and reservoir stability during production. At GFZ, we built a new pressure and temperature regulated ring-shear-apparatus, ESTER, for investigating sediment, ice and hydrate samples. Currently, we are developing a new method to create solid hydrate samples in ESTER and have succeeded twice. These preliminary results indicate that solid methane hydrate has, at least, 5 to 8 times the shear strength of pure ice.

For pure ice, samples are relatively easy to manufacture and results are repeatable. Samples are frozen in the ring-shear cell in ESTER from distilled water. At an effective stress of 2.5 MPa and a shear displacement of 7.8 μm/min, we observe ice has a nearly creeping behavior and a peak shear stress of ~1 MPa. At higher shear rates, ice develops a clear shear plane.

For methane hydrate samples, we place hydrate grains created from ice seeds in the ring shear cell. We compact these hydrate grains using mallet during placement and pressurize the sample using methane gas. Then over ~10 days, we flush the sample with either water (2% KCl solution) or methane gas, building up the concentration of methane hydrate in the ring shear cell over time. After shearing, gas and water are collected to estimate hydrate volume in the ring shear cell. Two different hydrate samples have filled the ring cell: one where the hydrate sample was last saturated with gas, and one where the sample was last saturated with water. At a differential stress of 2.5 MPa and a shear displacement of 7.8 μm/min, the gas saturated sample has a peak shear stress of 8.2 MPa and the water saturated sample as a peak shear stress of 5.7 MPa. At this shear rate, both hydrate samples have clear creeping behavior.

Keywords: laboratory measurements**,** shear strength, ring shear