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A joint seismic/electrical approach to quantification of methane hydrate in porous media

Michelle H. Ellis, Timothy A. Minshull, Angus I. Best, Martin C. Sinha and Jeremy Sothcott

Southampton Oceanography Centre, Southampton, UK (mhe1@soc.soton.ac.uk)

Methane beneath the deep seafloor is commonly stored in the form of clathrate hydrates, which are stable at low ambient temperatures and high pressures. Hydrates are associated with the upper few hundred meters of continental margin sediments. Estimates of the distribution and volume of the large amounts of hydrate trapped in sediments vary widely. This is unfortunately due to our inability to quantify accurately hydrates in situ. To improve these estimates, a technique that can accurately assess the amount of hydrate in sediments is needed. Destabilization of continental slopes by methane hydrate dissociation (a geohazard itself) can potentially introduce significant amounts of methane into the water column and the atmosphere.

It is known that the presence of hydrate in sediments can increase the seismic velocity of P- and S-waves due to cementation of grains, and can increase the electrical resistivity as hydrate is a good insulator. We seek to develop a joint seismic/electrical effective medium model of hydrate in marine sediments, and to validate the model through laboratory measurements on test samples. The elastic effective medium technique uses a combination of the self-consistent approximation (SCA) and differential effective medium theory (DEM), which are linked through the probability of interconnection of the fluid phase. This approach is combined with an electric effective medium model which also uses the probability of interconnection and can describe the microstructure and relative proportion of each phase. A joint seismic and electrical approach offers several advantages as each method gives different, but complementary, information on the nature of the hydrate/sediment. The model is tested against measurements from artificial sediments created in the laboratory. These sediments consist of Balotini glass beads and brine which are pluvated into a sediment cell. Resistivity measurements are taken along the length of the cell at 2-cm intervals. P-wave and porosity measurements are made using a core logger at 0.5-cm intervals. Predicting the bulk physical properties of hydrate in sediment at the scales detected by marine seismic and electomagnetic methods remains a challenge because of unknowns such as pore size, distribution and mineralogy of the sediment. Our ultimate goal is to invert joint seismic/electromagnetic datasets for hydrate content, and thus provide a means to better estimate global hydrate volumes.