Estimation of Gas Hydrate Daturation using Geostatistical Inversion

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Summary

Gas hydrates are solid, crystalline and ice-like substances. These clathrate structures where guest gas molecules are enclosed within the host water molecule cages are found in permafrost areas and deep water basins around the world. Gas hydrates are a potential non-conventional energy resource, but also a potential geo-hazard. Acoustic and electric properties of gas hydrates differ strongly from the hosting sedimentary rocks. Two major diagnostic properties used in the identification and concentration estimation of naturally occurring gas hydrates from geophysical tool data are their acoustic and electrical properties. Because seismic data contains no information regarding electric properties, it is still a challenge to infer the concentration of gas hydrate employing seismic derived velocities alone, in part due to insufficient velocity reference data from laboratory studies.

In a recent study of the regional occurrence of gas hydrate in the Beaufort-Mackenzie Basin, efforts have been made to characterize gas hydrate occurrence using industrial well logs and seismic data. In this paper, we present an integrated approach for identifying possible gas hydrate locations and inferring the likely concentration of gas hydrate in permafrost setting using a geostatistical seismic inversion. First, the integrated approach establishes a petrophysical model of gas hydrate based on well data collected from Mallik gas hydrate research wells. Then the petrophysical model is used to evaluate gas hydrate concentration of the wells in vicinity of available seismic lines. Calibrated by the well results, seismic attributes in frequency and time domains are extracted from seismic data and used to infer the gas hydrate concentration using the Support Vector Machine (SVM) based geostatistical inversion.

The workflow for estimating gas hydrate concentration is tested using nine wells and six seismic lines in the offshore Beaufort-Mackenzie Basin. The estimated bulk concentration of gas hydrate varies from 0 to 10% of pore space. The seismically inferred locations and depths of gas hydrate bearing intervals are geologically sound and consistent with the inferred gas hydrate stability zones. Study results suggest that there is a potential to use geostatistical seismic inversion as a method of regional gas hydrate concentration estimation. From the examples we conclude that the geostatistically inferred volume and spatial variations of gas hydrates can provide additional information which improves our understanding of the regional occurrence of the gas hydrate resource in this basin.