Integrated Seismic and Well Log Analysis of Gas Hydrate Prospects

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Abstract

This lecture presents the findings of recent international gas hydrate exploration efforts that are using new advanced technologies to identify and characterize the properties of gas hydrate prospects. Case studies from the Alaska North Slope, Gulf of Mexico, Japan and India demonstrate how standard oilfield technologies are helping to identify and evaluate gas hydrate accumulations.

In numerous geophysical studies from around the world, high gas hydrate concentrations have been shown to be associated with increases in host-sediment acoustic velocities. Furthermore, the amplitude of the seismic response to a hydrate-bearing sand reservoir is sensitive to the range of gas hydrate saturations. Geophysical inversion techniques have been developed that use full-waveform prestack inversion processing in combination with conventional linear prestack inversions to produce P-wave and S-wave impedance 3D volumes, which are converted to "gas hydrate saturation cubes." As a result, seismic-derived maps of gas hydrate saturation can be generated with some degree of confidence in areas with suitable reference data. These types of studies have led to the discovery and characterization of highly concentrated gas hydrates in sand-rich marine reservoirs in the Nankai Trough off the southeastern coast of Japan, the Gulf of Mexico, and in the Krishna-Godavari Basin off the eastern coast of India.

In the last 25 years there have been significant advancements in the use of well logging tools to acquire detailed information on the occurrence of gas hydrate in nature. Whereas wireline electrical resistivity and acoustic logs were formerly used to only identify gas-hydrate occurrences in wells drilled in Arctic permafrost environments, more advanced wireline deployed and logging while drilling (LWD) tools are now routinely used to examine the petrophysical nature of gas-hydrate reservoirs and the distribution and concentration of gas hydrates within various complex reservoir systems. Advancements in nuclear magnetic resonance (NMR) logging and wireline formation testing has also allowed for the characterization of gas hydrate at the pore scale. Integrated NMR and formation testing studies have yielded valuable insight into how gas hydrate is physically distributed in sediments and the occurrence and nature of pore fluids in gas hydrate-bearing reservoirs. Information on the distribution of gas hydrate at the pore scale has provided invaluable insight on the mechanisms controlling the formation and occurrence of gas hydrate in nature along with data on gas hydrate reservoir properties (i.e., porosities and permeabilities) needed to accurately predict gas production rates for various gas-hydrate production concepts.