Gas Hydrate Detection Using VSP Data and its Correlation with Dell Log Data

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Borehole reflection seismology can provide very high-resolution subsurface images around the borehole. The change in sediment physical properties due to the presence of hydrate and of underlying free gas allows detection and semi-quantitative concentration estimates in field studies, and in exploration and research wells. The two primary properties are seismic velocity and electrical resistivity. Both properties can be measured in field surveys and in down-hole logs.

Sediment velocities are strongly increased by the inclusion of high-velocity hydrate. As is well known, even a very small concentration of gas can decrease velocity substantially. Partial replacement of pore fluid by hydrate does not change the density much, so the impedance contrasts that produce hydrate related reflections are primarily due to velocity. The effect of hydrate on seismic properties of natural sediments largely depends, however, on the distribution of hydrate in the sediment. Hydrate disseminated within the pore space is believed to only moderately increase and to have almost no effect on Vs, since Vs is controlled mainly by sediment matrix properties. If hydrate acts as a cementing agent between grains, the effect on Vp is assumed to be larger, and Vs may increase significantly due to stiffening of the matrix. Hydrates being distributed macroscopically, i.e. as bodies considerably larger than the pore size, would yield a time-averaged velocity of methane hydrate and the rest of the sediment column. Because the formation of hydrate excludes salinity, inclusion of hydrate increases sediment electrical resistivity. Small amounts of gas have only a small effect on resistivity.

For marine occurrences, the bottom-simulating reflector (BSR) is the most obvious indicator of gas hydrate. The BSR occurs at the base of the P-T stability field for hydrate. It marks the bottom of the hydrate "ice", and the top of underlying free gas .BSRs are produced by the negative impedance contrast between high velocity sediments containing hydrate and low velocity sediments containing free gas. Vertical seismic profiles (VSPs) can be collected to determine seismic velocities in the hydrate-bearing sediments and relate them to hydrate concentration. Well log data and VSP processed data collectively can be used for detection of gas hydrate bearing zones.