

Rock Physics of Methane Hydrate Reservoirs

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Sponsors: The Stanford Rock Physics Consortium, Rock Solid Images.

Description: Gas hydrates are solids comprised of a hydrogen-bonded water lattice with entrapped guest molecules of gas. There are convincing arguments that vast amounts of methane gas hydrate are present in sediments under the world's oceans as well as in on-shore sediments in the Arctic. This hydrate is possibly the largest carbon and methane pool on earth. As such, methane hydrate may be the principal factor in global climate balancing. One may also treat this methane pool as a potential energy source. These considerations ignite the scientific and business community's interest in quantifying the amount of methane hydrate in the subsurface. Gas hydrate reservoir characterization is, in principle, no different from the traditional hydrocarbon reservoir characterization. Similar and well-developed remote sensing techniques can be used, seismic reflection profiling being the dominant among them.

Seismic response of the subsurface is determined by the spatial distribution of the elastic properties. By mapping the elastic contrast, the geophysicist can illuminate tectonic features and geobodies, hydrocarbon reservoirs included. To accurately translate elastic-property images into images of lithology, porosity, and the pore-filling phase, quantitative knowledge is needed that relates rock's elastic properties to its bulk properties and conditions. Specifically, to quantitatively characterize a natural gas hydrate reservoir, we must be able to relate the elastic properties of the sediment to the volume of gas hydrate present and, if at all possible, the permeability. One way of achieving this goal is through rock physics effective-medium modeling. The use of a first-principle-based rock physics model is crucial for gas hydrate reservoir characterization because only within a physics-based framework can one systematically perturb reservoir properties to estimate the elastic response with the ultimate goal of characterizing the reservoir from field elastic data. Rock physics relations have to be upscaled to become applicable to seismic reservoir characterization.

We have developed a number of rock physics models that can be used for inferring the location and quantities of methane hydrate from seismic. These models have been successfully used by us as well as by the industry (Japex, JNOC, Schlumberger) in Nankai Trough offshore Japan; the Gulf of Mexico; and on-shore in Canada to quantify natural methane hydrate reservoirs.

Status: This work continues, sponsored by the Stanford Rock Physics Project.

Publications:

Dvorkin, J., and Nur, A., Rock physics for characterization of gas hydrates, in *The Future of Energy Gases*, USGS Publications, 293-298, 1993.

Helgerud, M., Dvorkin, J., Nur, A., Sakai, A., and Collett, T., Elastic-wave velocity in marine sediments with gas hydrates: Effective medium modeling, *GRL*, 26, 2021-2024, 1999.

Dvorkin, J., Nur, A., Uden, R., and Taner, T., Rock physics of gas hydrate reservoir, *The Leading Edge*, 22, 842-847, 2003.

Dvorkin, J., and Uden, R., Seismic wave attenuation in a methane hydrate reservoir, *The Leading Edge*, 23, 8, 2004.

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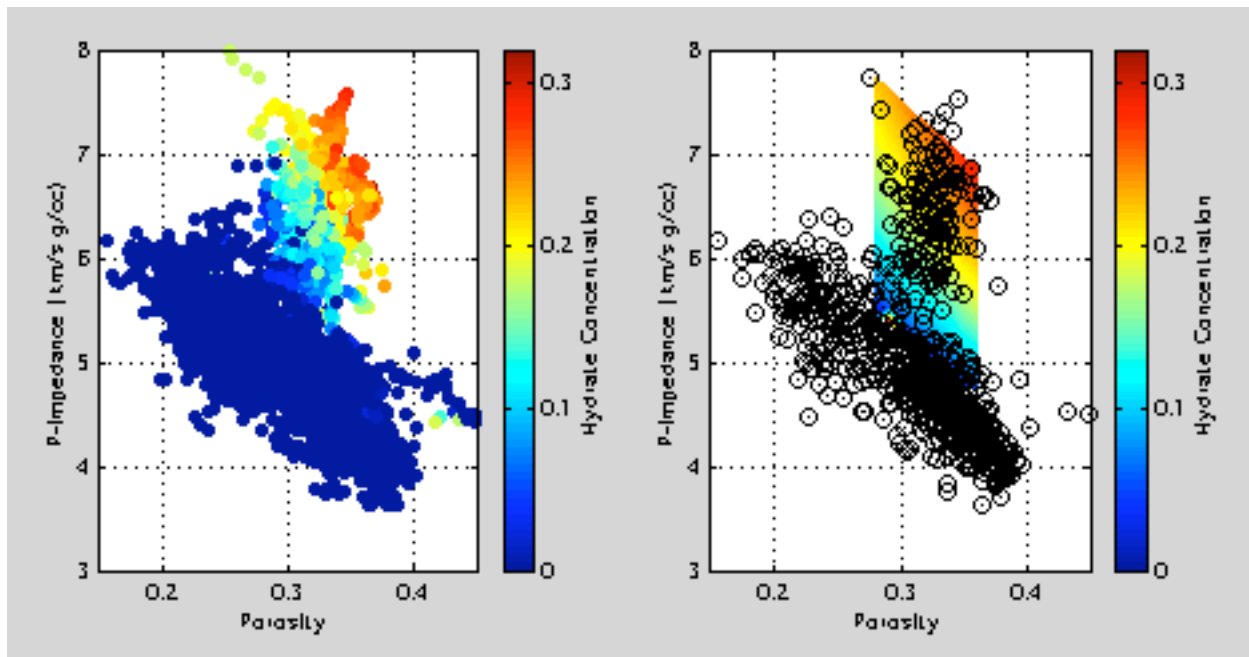


Figure 1. Left, impedance versus porosity in well Mallik 2L-38 in Arctic Canada, color-coded by hydrate concentration. The impedance is large due to the presence of methane hydrate in the pore space. Right, the same data (every fifth point) shown as empty black circles on the background of the modeled impedance strip. The modeled impedance is color-coded by hydrate concentration. The model accurately mimics the data.