Compaction and Quartz Cementation Modeling for Reservoir Quality Prediction in Sub-Salt Reservoirs of the Deepwater Gulf of Mexico

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We use the methods of Lander and Walderhaug (1999) to make pre-drill predictions of reservoir quality on deepwater Gulf of Mexico subsalt prospects by modeling the compaction and quartz cementation of sandstone throughout its burial. The procedure combines 1D basin models with petrographic point count data.

Compaction can be modeled through the effective stress history and the intergranular volume, a measure of grain packing. Porosity is reduced exponentially between the endpoints of depositional porosity and the lower limit of intergranular volume, found to be about 26% in the quartz-rich mid to lower Miocene intervals. Quartz cementation is modeled with the Arrhenius equation and the extent is largely dependent on the reservoirs thermal exposure. The process is assumed to be 'rate limited' meaning abundant quartz is available for precipitation but the reaction rate is limited by the parameters specified in the equation. The sand composition and textural grain size determine the available surface area for nucleation of quartz cement.

Good reservoir quality has been found in deep sub-salt reservoirs due to the salts ability to dissipate heat. The geothermal gradient in salt is found to be roughly one-third of the gradient in sand/shale. Since reservoir quality is largely temperature dependent at these depths, the cooler thermal conditions preserve porosity by slowing down the rate of quartz precipitation.

The workflow for reservoir quality prediction is to calibrate the burial history and quartz kinetics parameters by comparing predicted porosity with actual on wells with petrographic and petrophysical data. We modeled the reservoir in a deep lower Miocene well and then forward modeled the porosity at a prospect location. Results help to quantify resource estimates as well as assess reservoir quality risk.