Predicting Sandstone Properties Using Coupled Deterministic / Stochastic Models

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In regions with high thermal exposures well and seismic data often are an inadequate basis for constraining rock properties in all areas of interest given that wells do not provide sufficient sample coverage and seismic data can be difficult to interpret unambiguously. Sandstone diagenetic models provide a unique means to augment more conventional approaches for rock property prediction in such cases when linked to sedimentologic, petroleum system/basin, and rock physics models.

The primary input for diagenetic models includes compositional and textural characteristics of sandstones at the time of deposition, the effective stress and temperature histories for the sandstones, and model parameter values. We also couple these deterministic models with stochastic methods that describe the variability in (and co-variations among) compositional and textural characteristics at deposition for a given sandstone type to predict distributions in rock properties through geologic time. The resulting predictions of sandstone composition and texture, in turn, provide input for rock property models.

A priori diagenetic models are available or in development for a number of important processes including compaction, quartz cementation, illite formation (from both smectite and kaolinite precursors), grain coating chlorite, feldspar secondary porosity, and plagioclase albitization, among others. We use an *a posteriori* approach that relies on analog sandstones to consider the effects of diagenetic processes for which accurate deterministic models have not yet developed. These combined diagenetic models predict the composition and texture of sandstone through geologic time. Our systems (Touchstone and TMap) use their diagenesis simulation results to predict absolute permeability and total porosity (as partitioned into intergranular, secondary, and microporosity). We also have developed a preliminary module for these systems that incorporates published rock physics models that predict shear and bulk moduli and seismic velocities.

To date the primary application of our systems has been for reservoir quality risk assessment associated with prospect prediction and play analysis. More recently, however, there has been increasing application of these systems for field development studies. One area where they have proven to be particularly useful is for predicting reservoir characteristics off the flanks of structures in an effort to better constrain water drive during production.

Looking forward we hope to improve the links between diagenesis/rock property models, well logs, and seismic attributes to improve rock property prediction accuracy and workflow efficiency. An additional future application of diagenesis/rock property models is to improve the accuracy of fault and fracture models by (1) providing an improved basis for constraining the geomechanical properties of the reservoir at the time of structural deformation and (2) by considering the post-deformation impact of diagenesis on fault and fracture sealing.