Quantitative prediction of sandstone reservoir quality via simulation of compaction and quartz cementation

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Laporan (Report)

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Abstrak (Abstract)

Techniques presently available for quantitative reservoir quality prediction typically are limited in applicability to specific depth intervals, geographic areas, and lithostratigraphic units; require input data that is difficult or impossible to obtain; or demand specialized high-end computer hardware. We have developed a forward numerical model (referred to as Exemplar) to provide a method better suited for sandstone porosity prediction in both mature and frontier basin settings. Exemplar takes commonly available geologic data as input and produces predictions that can be directly compared to petrographic thin sections.

The diagenetic history is modeled from the time of deposition to the present. Input data required for a simulation includes burial depth, fluid pressure, and temperature histories together with the porosity, composition, and grain size of the modeled sandstone upon deposition. Burial history data can be obtained from basin models while sandstone texture and compositional data can be derived from thin section point count analyses and Recent depositional analogs.

Compaction is modeled by an exponential decrease in intergranular volume as a function of vertical effective stress. This approach is consistent with compaction arising from grain rearrangement, ductile grain deformation, and brittle failure of grains and accounts for the effects of fluid overpressures and stable grain packing arrangements. Quartz cementation is modeled as a precipitation rate controlled process according to the method of Walderhaug (1994, 1996). Quartz surface area available for precipitation of quartz cement is a function of the proportion and size of detrital quartz grains, the coated fraction of quartz grains, and the available pore space.

The computational execution speeds of the model are fast (e.g., seconds) on desktop computers, making model integration with parameter optimization and Monte Carlo simulation techniques practical. Parameter optimization routines are used to obtain distributions of 'best fit' parameter values when petrographic and basin modeling data from well control or outcrops are available for calibration. These 'best fit' distributions provide the basis for rigorous evaluation of inherent model uncertainties in pre-drill reservoir quality predictions when they are incorporated into Monte Carlo simulations. Monte Carlo-based predictions also can include uncertainties associated with the input parameters describing burial history and initial sandstone composition and texture making it possible to apply the model to frontier basin settings.

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