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Digital Rock Analysis Provides Data Unobtainable in the Laboratory to Improve Tight Carbonate Model Certainty

CoreFlow services accurately characterize flow properties of low-permeability matrix at high-pressure reservoir conditions

The limitations posed by the low-permeability, high-pressure carbonate reservoir for laboratory analysis were overcome by integrating CoreFlow* digital rock and fluid analytics services to quickly provide critical permeability values for resolving model uncertainty.

Reduce reservoir uncertainty

In the absence of core data, the initial models for the reservoir penetrated by a wildcat well were calibrated to published values, resulting in a high degree of uncertainty that affected reserves estimates for the extensively diagenetically altered reservoir. Although production from the formation is primarily related to an extended fracture corridor, lack of measurement of the properties of the low-permeability carbonate matrix from the initial well contributed further uncertainty for development planning.

Conduct digital rock and fluid analysis

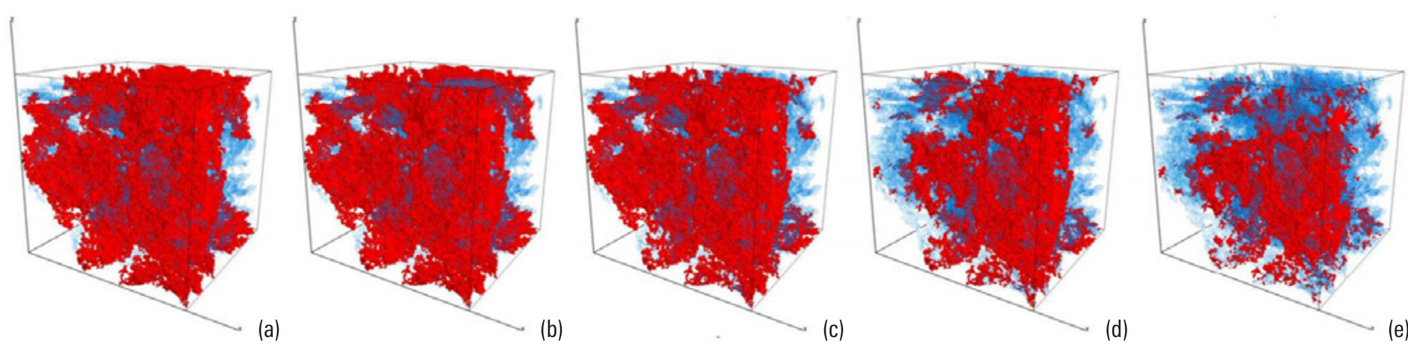
Coring was conducted in the second well of the field's appraisal program for cutting 145 1.5-in plug samples for both routine and special core analysis (RCAL and SCAL, respectively). Because the high reservoir pressure at 10,600 psi was not reproducible in the laboratory and a significant number of samples had Klinkenberg-corrected gas permeability values that were too low for laboratory SCAL analysis, CoreFlow digital rock and fluid analytics services were included in the SCAL program. The digital rock focus was on samples with gas permeability values less than 1 mD, which describes 44% of the reservoir. The digital fluids were derived from PVT data to account for reservoir conditions.

Obtain accurate data for refining simulation models

CoreFlow services complement and expand on conventional evaluation methods to accelerate reservoir characterization and provide sensitivity studies to reduce uncertainty. The workflow employs DHD* direct hydrodynamics pore flow simulation to integrate the digital rock and fluid models. Then pore-scale simulations using high performance computing further expedite feedback for the parameters used in the reservoir simulation, such as relative permeability and capillary pressure.

Digital rock models were built using X-ray microCT data at 2-um resolution and SEM datasets at 500- and 20-nm resolution. Digital fluid models of air and brine, dead oil and brine, and live oil and brine were constructed for multiphase flow modeling, including digital porous plate tests that were performed at reservoir conditions, beyond the laboratory's pressure limits for experimental studies.

This combined experimental and digital workflow was a fast, robust approach to obtaining critical data to refine the simulation modeling. Conducting steady-state flow tests with CoreFlow services made it possible to construct relative permeability curves that included estimates of moveable oil for samples representing the low-permeability layers. From this, the functional dependency between reservoir properties and the oil displacement coefficient was determined to distribute reliable property values throughout the reservoir that improved the forecast quality of the hydrodynamic model.



3D phase saturations at selected time intervals progressing from (a) to (e) during steady-state flooding of a sample. Water is blue and oil is red in the transparent digital rock.

CoreFlow services also enabled early assessment of the need for and effectiveness of primary methods to increase oil recovery. Multiphase filtration modeling on digital core showed a significant decrease in the water-phase permeability k_{rw} from 0.3 to 0.05, confirming the low efficiency of reservoir pressure maintenance by the field's water injection system. The reliability of the digital rock analysis was confirmed by inclusion of k_{rw} in the dynamic model, which resulted in a precise history match to production data for a more accurate forecast of the possible start of water breakthrough.

More technical details

Read SPE-198610-MS

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