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ADNOC Offshore Conducts Rock Mechanics Tests to Predict Compaction Effects and Guide Depletion

Comprehensive rock mechanics testing by Schlumberger Reservoir Laboratory differentiates rocks with accelerated compaction based on porosity

Rock mechanics testing enables ADNOC Offshore to assess pore collapse propensity and prevent and mitigate compaction risks in mature stacked reservoirs.

ADNOC Offshore's concerns

After decades of production from multiple separate stacked reservoirs, ADNOC Offshore, Abu Dhabi National Oil Company's dedicated offshore arm, was now injecting water and gas for reservoir stimulation. The long-term field development plan indicated that one of the reservoirs will be depleted by 5,000 psi after 20 years. Such high levels of depletion can result in severe reservoir compaction and pore collapse, leading to a rapid loss in permeability, generation of fines as the byproducts of pore collapse and grain crushing, subsidence, wellbore instability, damage to well completion integrity, and loss of caprock containment. Rock mechanics data was needed to assess the possibility of pore collapse and to prevent and mitigate risks from adverse reservoir compaction.

What Schlumberger recommended

The Schlumberger Reservoir Laboratory in Abu Dhabi recommended a test sequence for evaluating rock failure parameters for representative samples. To better understand the different types of rock failure for field applications, a workflow was proposed to visualize the preproduction state of in situ stress conditions and the possible stress path K_o trajectories of the reservoir from triaxial $K_o = 0$ to hydrostatic $K_o = 1$ as a function of reservoir depletion. This display would be used to identify the level of depletion resulting from accelerated compaction (i.e., pore collapse) through laboratory testing.

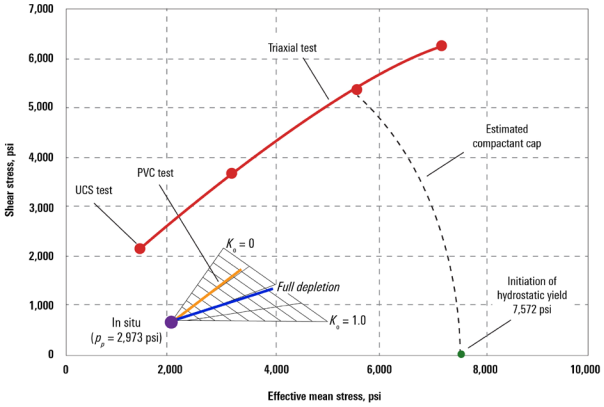
The tests to be conducted for assessment of reservoir compaction would be uniaxial-strain compression (far-field compaction), triaxial compression (near-wellbore compaction), hydrostatic (definition of the compactant cap), and constant stress-path (fixed K_o, far-field compaction). All of these tests using high-pressure triaxial load frames would be conducted locally in the recently commissioned Abu Dhabi reservoir laboratory.

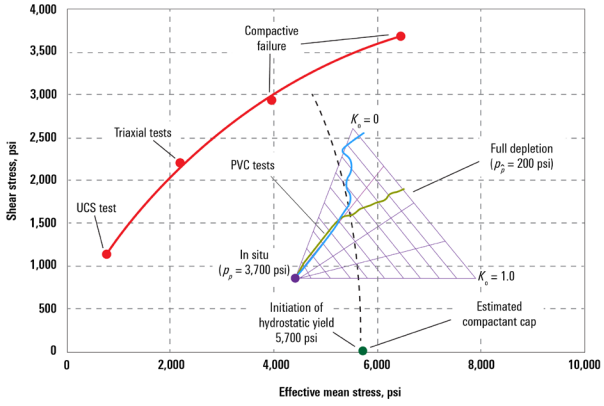
What ADNOC Offshore accomplished

Because the laboratory tests conducted on representative samples from the reservoir intervals were designed to capture all possible depletion scenarios during the potential life of the reservoir, ADNOC Offshore was able to use the comprehensive test data to predict potential rock failure through pore collapse. The results show that rock with >26% porosity has a propensity for accelerated compaction prior to attaining plan abandonment pressure. However, accelerated compaction does not occur for rock with porosity < 22%, even following extreme reservoir pressure depletion of 5,000 psi. With this insight, ADNOC Offshore's depletion plan for higher porosity intervals could be adjusted to minimize or eliminate pore collapse by pressure maintenance practices, mitigating potential loss of production.

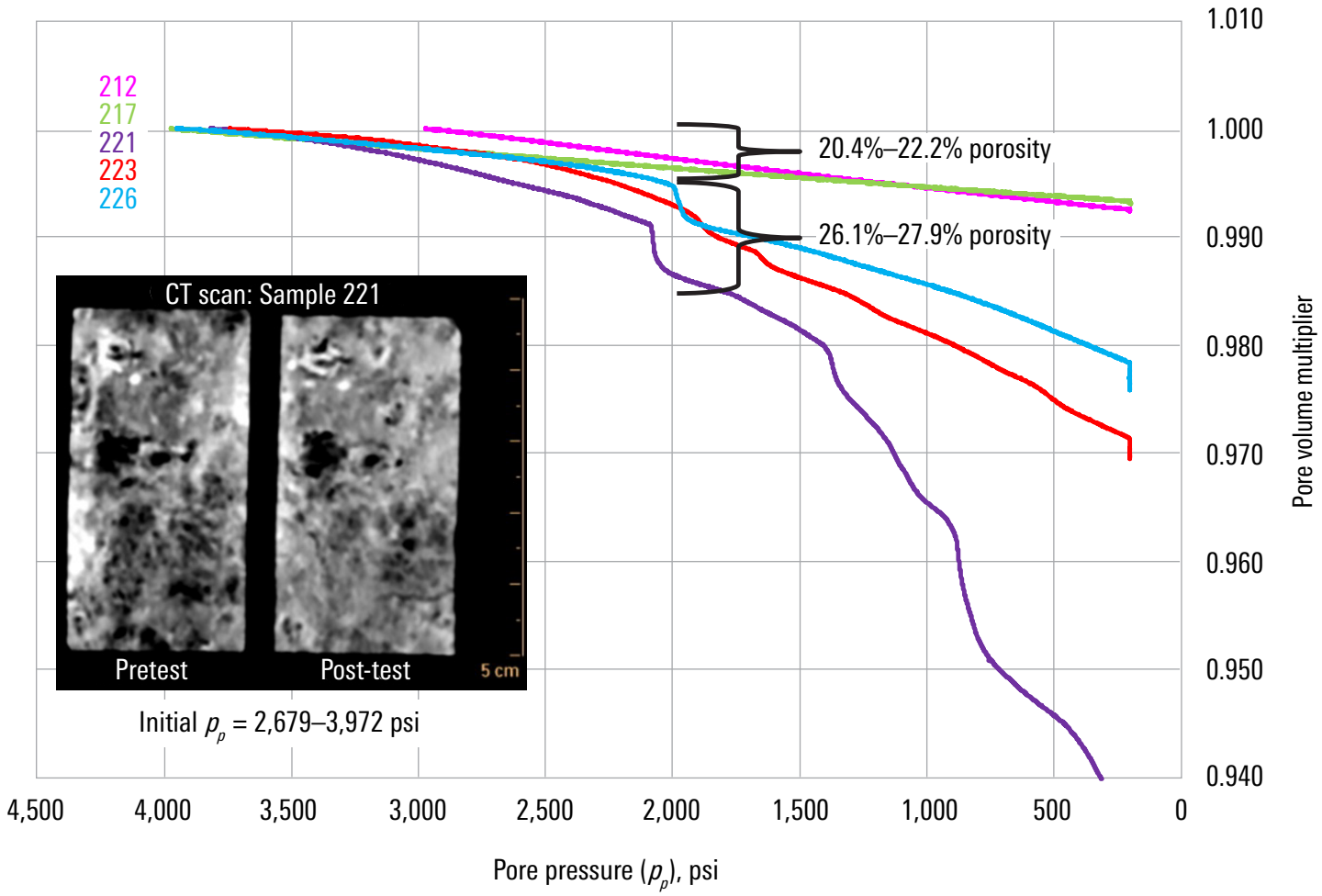
More technical details

Read SPE-193072-MS





The q-p failure envelope for the reservoir rocks differentiates lower porosity (22%, left) and higher porosity (>26%, right) rocks. The peak/yield compressive strengths for vertical unconfined stress (UCS) and multistage triaxial compression tests (red dots) estimate the dilatant failure surface, with multistage triaxial tests exhibiting hardening or compactant behavior at higher confining pressures. Yield during hydrostatic compression was 7,572 psi (lower porosity) and 5,700 psi (higher porosity) and was used to estimate one boundary of the compactant failure surface, shown in relation to the pore volume compaction (PVC) depletion test (orange curve). For reference, the stress trajectories for K_0 values of 1.0, 0.75, 0.50, 0.25, and 0 are indicated originating from the in situ stress state prior to depletion. The estimated reservoir depletion is plotted across the K_0 stress paths at 300-psi intervals from the initial reservoir pressure to a maximum depleted condition of approximately 0 psi. From the data presented, rocks with porosity < 22% do not approach either the dilatant or estimated compactant failure surfaces. Conversely, the higher porosity (>26%) intervals exhibited accelerated compaction after intersecting the compactant failure surface.



The change in normalized pore volume during simulated reservoir depletion from preproduction to projected abandonment pressure for samples with <22% porosity was similar to the behavior of sample 212 (pink curve), with less than 1% change in pore volume at the maximum depleted condition. In contrast, samples with >26% porosity, such as sample 221 in the inset, exhibited accelerated compaction, often midway through the projected maximum depletion condition.

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