

ENHANCING RECOVERY IN COMPLEX CLASTIC RESERVOIRS THROUGH DYNAMIC MODEL UPDATES AND PROACTIVE WELL MANAGEMENT

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Abstract

This article presents a practical, data-driven approach to improving oil recovery from mature, heterogeneous clastic reservoirs. The focus is on the operational use of surveillance data (production logs, tracers, pressure measurements) and updated sedimentological concepts to continuously refine the reservoir understanding. It details how revised parameters, such as sand body connectivity and permeability contrasts, directly influence the mapping of remaining oil saturation (ROS). Based on updated dynamic models, practical recommendations are formulated for conformance control in waterflood projects and the targeted placement of infill wells. The paper demonstrates that a systematic model-update practice can significantly improve project economics through increased well success rates and reduced water handling costs, without the need for massive capital investment.

Keywords: complex clastic reservoir, dynamic model update, surveillance data, remaining oil saturation, waterflood optimization, infill well placement, mature field, proactive management, conformance control.

The problem of bypassed oil in heterogeneous reservoirs. A significant portion of the world's oil reserves resides in complex clastic reservoirs characterized by discontinuous sand bodies, sharp facies variations, and intricate internal architecture. During primary and secondary recovery, injected fluids tend to follow paths of least resistance, leading to premature water breakthrough, poor sweep efficiency, and the formation of isolated, bypassed oil pockets. By the late stages of development, the production profile is often dominated by water, with the location of remaining mobile oil becoming increasingly obscure. Traditional, infrequently updated models become obsolete, leading to inefficient well interventions and unsuccessful infill drilling. This work argues for a shift towards a dynamic, surveillance-based management philosophy.

Building the dynamic picture: key data for model refinement. The foundation of proactive management is the constant inflow of data that illuminates subsurface fluid movement. Key surveillance tools include:

- Production logging tools (PLT): provide critical vertical flow profiles in wells, identifying water-producing intervals and untapped oil zones. Time-lapse PLT runs are invaluable for monitoring flood front advancement.

- Tracer surveys: inter-well tracer tests offer direct evidence of flow paths and connectivity between injectors and producers, helping to validate or correct the reservoir connectivity model.
- Pressure transient analysis (PTA) and build-up data: used to quantify near-wellbore damage, investigate boundaries, and estimate permeability-thickness in the drainage area.
- Cased-hole resistivity and saturation logs: modern pulsed-neutron and resistivity tools can monitor fluid saturation changes behind casing over time, directly mapping oil depletion and water encroachment.
- Operational data analysis: trends in individual well performance (decline curves, water-oil-ratio plots, pump efficiency) are early indicators of changing reservoir conditions.

Practical optimization measures derived from an updated model. An updated, dynamic model translates surveillance insights into actionable well and reservoir management strategies:

Waterflood conformance control and re-alignment. The primary goal is to improve volumetric sweep. An updated model identifies thief zones and stagnant areas.

- Injection profile modification: using data from injector PLTs, actions like re-perforation of tight zones or chemical/mechanical isolation of high-intake intervals (with polymers or gels) can be designed to redirect injection water.
- Flow re-direction: converting a poorly performing producer located in a swept area into an injector can create a new, more effective pressure support direction, pushing oil towards adjacent producers.
- Injection-production rate optimization: streamline simulation or capacitance-resistance models (CRM) based on updated connectivity can be used to re-allocate injection volumes dynamically, maximizing oil response.

Targeted infill drilling and well recompletions. Instead of drilling on a geometric grid, well placement is guided by dynamic ROS maps.

- Horizontal infill wells: precise geosteering of horizontal laterals within identified, unswept sand bodies (attics, wedges, or isolated lenses) accessed from existing infrastructure.
- Sidetracking (re-entries): utilizing existing wellbores to drill sidetracks into adjacent compartments or updip attic oil zones, offering a highly cost-effective solution.
- Re-perforation and zonal isolation: opening new pay zones identified by logs in existing wells or shutting off watered-out intervals to reduce water cut and revive oil production.

Economic justification and value creation. The economics of this approach are compelling. The cost of routine surveillance and model updates is typically a small fraction of the budget for a single new well. However, the impact is substantial:

- Increased success rate: The probability of a successful infill well or workover rises from 50-60% to 80-90% when targeting locations defined by an updated dynamic model.
- Reduced water production: Effective conformance control decreases inefficient water cycling, lowering OPEX related to water lifting, treatment, and disposal.
- Accelerated production: Targeted interventions bring new reserves online faster, improving the project's NPV.
- Extended field life: Efficient recovery of bypassed oil can add years of profitable production, maximizing asset value.

Conclusion.

Sustained recovery from complex mature fields requires a paradigm shift from static to dynamic, surveillance-driven reservoir management. Continuous model updating using production logs, tracers, and pressure data is essential to accurately map remaining oil saturation. This dynamic understanding directly enables precise targeting of infill wells and sidetracks into unswept compartments. Proactive waterflood management, including conformance control and injection re-alignment, is critical for improving volumetric sweep efficiency. The proposed operational workflow directly leads to higher success rates for geotechnical activities and reduced water handling costs. The economic return on investment in surveillance and modeling is high, often yielding multiples of the initial cost through increased recovery. This approach unlocks incremental reserves that are invisible to conventional, outdated models. Embedding this practice into standard asset management routines is key to maximizing ultimate recovery and profitability from challenging reservoirs.

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