Understanding Reservoir Architecture and Diagenesis Away from Boreholes - Insights from Dynamic-to-Static Permeability Ratios in the Barik Tight-Gas Reservoir, Oman

German D. Merletti[1], Siyavash Motealleh[1], Peter Armitage[1], Khalil Al Rashdi[2], Martin Wells[1], Salim N. Al Hajri[2], Nigel Clark[1]

[1]bp
[2]bp Oman

Abstract

Prediction of reservoir deliverability and ultimate recovery in tight-gas reservoirs is partly dependent on matrix permeability, a multi-scale property that varies significantly with the scale of the medium under investigation. Wireline logs and core measurements provide pore- to meter-scale static measurements exclusively representative of the borehole vicinity, whereas well testing provides kilometer-scale dynamic permeability dependent on several assumptions including rock and fluid properties. This study demonstrates how different ratios between static and dynamic average permeability can be used to validate assumptions of reservoir quality and lateral connectivity away from boreholes.

The method starts with assessment of static permeability (at the borehole); we use comprehensive sedimentary and petrological data to quantify effects of depositional facies, mineral composition, and diagenesis on porosity- permeability functions. Permeability from Machine Learning (ML) using wireline logs is used for comparison and additional consistency check in areas where core is unavailable.

Dynamic permeability is primarily calculated using Pressure Transient Analysis (PTA) from pressure buildup tests in shut-in wells. Over twenty wells with tests achieving radial flow provide validation for gas effective permeability thickness. Since PTA does not densely cover the field, Rate Transient Analysis (RTA) from over a hundred wells are used to derive a pseudo-PTA permeability. Finally, we develop correlations between PTA- derived permeability and RTA-derived OGIP as an additional proxy for dynamic permeability in wells with more than 6 months of production.

The ratio between dynamic and static permeability provides valuable insights to reservoir architecture and heterogeneity away from borehole control. Ratios below unity reflect the preservation of interbedded thin mudstones which provided silica to occlude porosity and pore throats in adjacent sandstones during diagenesis. Mudstones and cemented sandstone shoulders provide additional tortuosity that greatly reduces connected gas volumes picked by transient analysis. Ratios above unity display fewer preserved mudstone layers and overall better sandstone quality; even though the sandstone thickness can be lower, dynamic permeability and connected volumes are consistently larger. Lower gross thickness is associated with burial history and the presence of less accommodation space in the proximity of basement highs, this setting prevented the preservation of interbedded mudstones (and associated damaging effects on reservoirs) and boosted reservoir lateral connectivity. The understanding of dynamic and static permeability ratios; and their linkage to the diagenetic overprint on depositional architecture contribute to identifying undeveloped resources (i.e., infill drilling) as well as better prediction of initial reservoir performance in new wells.