Essential Petroleum System Workflows in Unconventional Reservoir Evaluation, with Examples from the Permian Basin of Texas and New Mexico

Andrew Pepper
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Abstract

Much petroleum systems effort to date in unconventional resource assessment has been performed with legacy geochemical concepts and workflows: many are now 40 years old. Impactful geoscience products need to be useful to the petrophysicist and engineer that will ultimately convert the data into a static or dynamic description of the reservoir. To derive these products, the following new workflows are needed: 1) Thermal Stress: Onshore environments with significant unconventional production, are in uplifted and eroded basins where nature has brought productive fluid zones shallower, within drillable depth. It's essential to reconstruct a picture of the thermal stress achieved at maximum burial. In terms of model calibration, vitrinite reflectance in marine rocks is a poor substitute for molecular thermal stress indicators (TSIs) based on the indigenous organic matter. Rather than 1-D models, map- or volume-based burial history models help impose consistency across a play and allow for lateral extrapolation of reliable but sparse TSI information 2) Source rock description: historically, due to low computing power, rules of thumb were devised to 'screen', 'average' or choose 'typical' source rock data among large datasets. However, with the objective of predicting fluid properties e.g. GOR, excluding rocks low in organic carbon can remove part of the source bed that expels/sources significant gas. Workflows to predict GOR require an accurate and unfiltered layer-by-layer description of the source bed's Organofacies, organic carbon and hydrogen index. The product required to feed a kinetic model is a

log of ultimate expellable oil (UEO) and gas (UEG). 3) Storage sweet spots: treating source beds as reservoirs; not source rocks. In the last year or so the weaknesses of GRI-type saturation measurements, originally designed for gas shales, have become apparent in liquid rich reservoirs. Water saturations have been under-reported significantly. Geochemical methods e.g. t!PsSAT, based on pyrolysis volatiles, provide a complementary technique to estimate saturation, confirming that our estimates of petroleum saturation in these reservoirs need to be revised downward. 4) Predicting fluid composition sweet spots is not just a ‘supply’ problem. An accurate prediction of the fluid composition expelled from organic matter is a necessary but insufficient step to predict reservoir fluid GOR, viscosity, liquid gravity etc. The GOR depends on the part of the expelled fluid that is captured, which is a function of the storage capacity of the pore system. Reservoirs with high storage behave closer to the cumulative end-member that can hold the entire fluid volume expelled from the OM, leading to a lower GOR. Reservoirs with poor storage behave closer to the instantaneous end-member, leading to a higher GOR. 5) Deliverability: liquid rate sweet spots occur at the optimum modeled pressure, viscosity and FVF.