The unconventional boom that has transformed North America’s hydrocarbon landscape is expanding its horizons into international markets as operators consider launching ambitious campaigns in plays with potentially rich source rock. A detailed understanding of the economic viability of the reservoir, however, is critically important in providing companies with the data and confidence they need to make quick, informed decisions to drill exploratory pilot wells in new unconventional frontiers.

Early unconventional exploration wells tend to be considerably more expensive than equivalent production wells in North America, where extensive data, conventional well production and established efficiencies enable timely decision-making with considerably less economic risk.

A new exploration workflow, tailored for the burgeoning international unconventional market, is giving operating companies in several regions the necessary decision-making packages to move forward with appraisal drilling programs. The multidisciplinary workflow integrates existing reservoir information including core, log and seismic data in a 3-D depth model to calibrate a petroleum systems evaluation to map the fairway or sweet spot and estimate recoverable resources.

Several rapid resource assessment workflow case studies have been performed globally, including the Middle East, North Africa and Western Europe. The primary objective has been to evaluate the potential of unconventional source rocks by integrating all available reservoir data in a seven-phase process over a period of just three months. The methodology provides valuable information in determining the economic viability of an initial exploration program.

The initial concept for each resource assessment study focuses on key reservoir quality (RQ) elements. Combined with completion quality (CQ) maps, a multidisciplinary team determines if there are viable locations for testing reservoir potential in a given basin. Once a location with a high chance of success has been identified, the team provides detailed data, planning and recommendations for a pilot program to appraise the formation.

**Baseline of understanding**

An important aspect of the early exploration resource assessment workflow is to establish a baseline of key production drivers defined by lessons learned in North America that can be applied to emerging unconventional developments considering that every shale is unique. Production drivers

---

**Richard Salter, Schlumberger**

A detailed workflow allows operators to de-risk international shale plays.

**A generalized workflow allows for exploration of unconventional source rocks.**

(Source: Schlumberger)
include charge or hydrocarbon-generation factors as well as migration and maturation risks and volume related to the organic material in the source rock; RQ features such as porosity, hydrocarbon saturation, thickness, lithology, total organic carbon/kerogen type and maturity of the petroleum system; structural components, including natural fractures and complexity; CQ factors, including fracture geometry, fracture conductivity, geomechanics and lateral CQ variability; and fluid-related deliverability components, including pressure, viscosity and fluid phase envelope.

For each study performed with the workflow so far, limited logging data across the source rock interval and some previous geochemical analysis of the source rock has been used. We place initial emphasis on log analysis. Petrophysical shale evaluation on selected log suites from existing wells that have penetrated the source rock interval provide an understanding of the formation. Typically, three to five key wells are selected for shale gas analysis. However, all available existing well data in the area of interest are incorporated into the model and for constraining data inputs into other phases of the study.

The goals are to assess the potential of the source rock and make recommendations for core and log measurements needed in future boreholes targeting further assessment of the source rock. Shale evaluation data also integrate into the other phases of the study.

The next phase of the workflow, seismic reservoir characterization, integrates available 2-D and 3-D seismic data to construct a 3-D depth model over the entire area of interest. As large basin areas of 2,000 sq km to 5,000 sq km (772.2 sq miles to 1,931 sq miles) are commonly assessed, the seismic plays a critical role in building and representing the structural framework that feeds into the petroleum systems modeling workflow. By converting inverted seismic attributes such as acoustic impedance and Poisson’s ratio into lithology and porosity measurements, spatial maps of reservoir characteristics can be created to better understand the depositional environment and locate spatial variations, which are key indicators of reservoir quality.

**Determining play viability**

The centerpiece of the workflow is petroleum systems modeling to quantify and understand the subsurface and provide insight into the viability of shale plays. Accumulated hydrocarbons generated and retained within the source rock interval are modeled by reconstructing the burial history of the rock to understand when the rock reached the depth of burial and temperature where the organic material began converting to hydrocarbons. Organic material matures and converts in different phases of hydrocarbon—bitumen, oil and gas—at different temperatures and is dependent on the time exposed to sufficient heat flow for the maturation process.

Results from the petrophysical evaluation, seismic reservoir characterization and petroleum systems modeling are integrated to generate play fairway maps, which determine viability and identify the target areas where an operator would have the best chance of drilling a successful pilot exploration well.

Based on the RQ and CQ production drivers, the maps determine how much of the organic material has converted to hydrocarbons based on being buried at the right temperatures. If the conversion ratio is too low, the play typically won’t generate enough mobile hydrocarbons to be producible; if the transformation ratio exceeds a certain threshold, there is a reasonable chance enough mobile hydrocarbons will accumulate in the pore spaces to be producible.

Other variables often used in the play chance mapping include porosity, vitrinite reflectance and hydrocarbon saturation. It also is important to understand the potential variability of CQ. The expectation is that any uncon-
ventional source rock would require multistage hydraulic fracturing to produce desirable economic rates. Based on tectonics or stress predictions, a CQ mapping layer can provide early indications of where the operator might best place locations with a high chance of being able to initiate fractures in the source rock.

The final step is to perform an economic viability assessment by dividing the study areas into assessment units characterized by similar RQ. A probabilistic assessment of the range of resource volumes in place is then calculated using a specialized toolkit to perform simulations as part of the unconventional resource assessment. By assigning screening economic assumptions on well density together with drilling and completion costs, EURs, and initial production in each assessment unit, it is possible to further account for variable CQ.

Information from the play fairway mapping combined with these petroleum engineering estimates can provide probabilistic estimates of economically recoverable resource volumes in each assessment unit, establish whether there is opportunity for economically viable production and select the most favorable areas for further evaluation and/or exploration drilling.

Using this information delivered in a rapid time frame and encompassing a broad range of parameters, including economics, the unconventional exploration workflow enables operators to make informed decisions, fast-tracking pilot programs into high chance-of-success locations in new formations and avoiding drilling expensive exploration pilots in areas with no or low potential.

This is only the first step in providing a systematic and efficient decision-making package for the unconventional life cycle. Once a successful pilot program has been undertaken, the model can be rapidly updated during a further de-risking/acreage characterization phase. This becomes the catalyst for an initial ramp-up phase by providing a ranked well inventory. With continued success in the ramp-up phase, the way is then clear for the development of more detailed sector or field development plans.