A Comparison between Shale Gas Plays of the East European Platform and Lower Silurian Plays of the Middle East

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Abstract

Silurian period contains the most prolific source rocks of the Paleozoic era which accounts for 9% of the world's known hydrocarbon resources (15% of gas resources). Therefore, Silurian organic rich shale is likely to be an important target of shale gas exploration.

The East European Platform (EEP) Silurian sediments, with significant shale gas potential, extend from the Baltic states through Poland to Ukraine. The most prospective gas shales are documented in Poland (Baltic Basin and Lublin Basin). Very little exploration work has been done in Lithuania and Ukraine. The Lower Paleozoic play in Poland consists of 3 organic rich shale horizons: Ordovician (Caradoc), Llandovery (very rich in OM but relatively thin) and Wenlock (thick but leaner in OM). Wenlock shales are most important from the point of view of geographical coverage. Total gross thickness of organic rich shales is up to 800 ft with the highest TOC values of 11% (Llandovery), while the net thickness is usually between 100 and 150 ft with TOC averaging 2-4% wt. Documented effective drilling depth is between 6000 and 16000 ft. Thermal maturity of Type II Kerogen ranges from 0.6% Ro to overmature and generally increases from NE to SW. Depth to the top of dry gas window (1.4%Ro) is usually below 3500-4000 m (11500-13000ft) decreasing locally, in the most uplifted southwestern Lublin basin, to 2000 m (6500 ft).

In Poland the extensive shale gas exploration activities have been conducted since 2010 and 65 wells have been drilled with few successful horizontal fracked wells. Several international oil companies have participated in these efforts bringing most up-to-date technology and experience from the United States. Although drilling activities have recently slowed down significantly, the exploration licenses are still being evaluated and limited amount of data has been disclosed as yet. Nevertheless, using standard evaluation methods as well as implementing new reservoir evaluation techniques (e.g. TOC while drilling, pressure core) enabled the operators to achieve advanced technical understanding of greenfield unconventional resources. Some of the most important reservoir parameters have been evaluated (e.g. porosity, permeability, water saturation, controls on gas storage) that were not available based on the previous source rock analyses. However, the production test results revealed by some operators are considered to be disappointing with the initial flow rates on the order of 500-600 mcfd.

The Middle East Lower Silurian shale play is much larger than the EEP shale play and spreads over most of the Western Arabian Peninsula, Western Iraq, Eastern Jordan, Syria and Southeastern Turkey. The stratigraphic interval of the Middle East hot shales is Llandovery (Rhuddanian to Telychian). In the Southern Arabian Peninsula it is only the basal hot shale known as Qusaiba shale (or Sahmah in Oman) with the maximum thickness of 250 ft in the Rub' Al-Khali basin. In the northern Saudi Arabia, Iraq, Jordan and Syria there are two horizons (Lower and Upper hot shale) with the total net thickness of up to 200 ft in Iraq. The organic richness is up to 20% wt TOC, averaging about 3-

5% wt TOC in Saudi Arabia and 6 % wt in Iraq. The Lower Silurian hot shale contains type II oil prone kerogen with thermal maturity ranging from 0.6 to overmature, increasing with increasing burial depth towards NE. Top of dry gas window (1.4%Ro) is below 4000 m (13000ft).

The real size and resource of both plays is still to be defined. Technically recoverable resource (TRR) estimates for Poland EEP play conducted by EIA/ARI and USGS, using volumetric and probabilistic methods respectively, differs by two orders of magnitude (125 TCF and 1.3 TCF of gas respectively). The Middle East Silurian shale gas TRR estimated by EIA/ARI for 4 countries (Oman, UAE, Jordan, Turkey), covering less than 10% of the total hot shale area, amounts to 112 TCF of gas. However, shale gas resource estimates for frontier plays have to be used with caution. The EIA/ARI volumetric method is based on limited legacy data while the USGS estimates are based on US analogues which may not be truly appropriate and are not calibrated by any existing production.

Unconventional gas program has also been initiated in the Middle East but not much data is available. Therefore, typical reservoir parameters used for risk assessment (mineralogy, porosity, permeability, gas saturation), which can only be properly evaluated as a result of extensive shale gas core analysis program, can hardly be used in this comparison. If geochemical (source rock analysis) criteria are used, the Middle East Lower Silurian shales generally compares favorably with EEP shale play.

The objective of this paper is to compare the Silurian shale gas play of the East European Platform, which has recently been the area of an extensive shale gas exploration activities outside of USA, with the Lower Silurian hot shales of the Arabian tectonic plate - the world class source rock. Our analysis indicates that tectonic evolution and burial history are most important factors leading to significant differences in the exploration potential of the two shale gas plays. In the case of EEP play gas was generated before the Late Variscan deformation, uplift and erosion, which may have resulted in a substantial reduction of free gas saturation over the most uplifted and tectonically disturbed areas. Whereas the maximum burial and gas generation of the Middle East Lower Silurian play occurred recently. This is in favor of preservation of unconventional resources and confirmed by well-known accumulations sourced by the Qusaiba hot shales.