The Red Fork delta of Oklahoma revisited for resource plays

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In 1985, Masera Corporation geoscientists started a project to map the Middle Pennsylvanian Red Fork sandstone-shale complex across Oklahoma. Up to that time, the Red Fork was like the example of multiple scientists wearing blindfolds and trying to describe an elephant. Many workers had described different parts of the delta, but a comprehensive map was not available—primarily due to the sheer size of the sedimentary complex.

The Red Fork sandstone is one of several transgressive-regressive sequences (cyclothems) developed within the Desmoinesian Cherokee Group. This includes the underlying Bartlesville sandstone which is produced in the giant Glenpool Field south of Tulsa, OK. In Osage County north of Tulsa, OK both the Red Fork and the Bartlesville sandstones produce in the large Burbank Field which is one of the few fields in Oklahoma undergoing CO2 injection.

Sea level changes, together with varying significant subsidence, were dominant factors controlling the general stratigraphic (correlative) characteristics of the Red Fork interval. Progradation of the Red Fork delta was episodic, with sand deposition from the north during periods of eustacy and from the south during periods of tectonic activity in the Amarillo-Wichita Uplift. The provenance for most of the Red Fork clastics was most likely from a drainage system that probably extended as far as the Canadian Shield or even Greenland and appears to be subparallel to the Midcontinent Rift (Figure1).

The Red Fork deltaic complex consists primarily of alluvial-valley and plain (fluvial) bodies in the northernmost part of northeastern Oklahoma, alluvial-deltaic bodies in most of the remaining parts of the shelf area, and marine bar deposits in the mid-shelf areas, and off-shelf submarine-fan and slope basinal-floor complexes within the deeper part of the Anadarko basin. These deeper sediments are interfingered with alluvial fans and fan-deltas from the south. Multiple erosional incised valleys formed during lowstands were followed by valley-fill deposition in the more stable areas during sea level rises.

Determination of Red Fork genesis, geometry, and reservoir trends required integration of rock and log data. Core descriptions were derived from various master's theses combined with core donated from companies working the Red Fork. Logs were calibrated to cores in order to estimate depositional environments accurately and to make a reasonable assessment of diagenetic overprints. To understand the geometry of this large deposit, 33,000 logs were correlated across Oklahoma. A map of Red Fork sand trends reveals an alluvial-deltaic complex covering most of Oklahoma. Multiple depositional systems tracts were identified as low-stand, transgressive and high-stand.

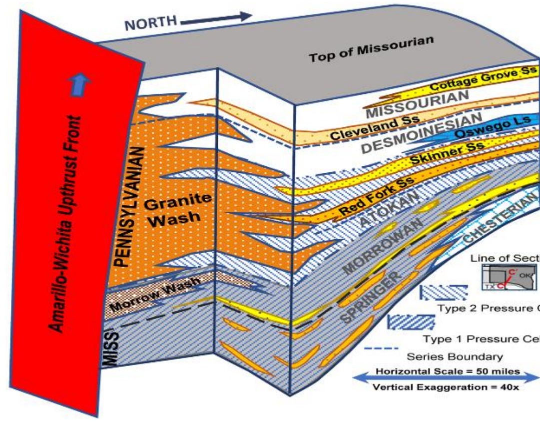

Figure 1. Anadarko Basin stratigraphic block diagram.

New sequence stratigraphic methods were used to correlate the Red Fork deltaic system. The Red Fork appears to represent one Vail-type third-order sequence. It can be divided into at least three (probably five) fourth-order sequences which for the purpose of this study are called upper, middle and lower. Each sequence represents a transgressive-regressive episode often separated by thin regional limestones or shale markers. Correlation of these sequences is relatively easy from the lower shelf to the basin, and more difficult on the upper shelf. In addition, each sand interval was divided into fifth-order sequences or parasequences. Each of these were given a depositional indicator based on core and log response which proved to be the key to mapping.

Red Fork reservoirs are charged with oil and gas from both Devonian and Carboniferous source rocks. The Red Fork and surrounding Cherokee Group sands and shales form a system of complex hydrocarbon saturated reservoirs. Much of the oil and gas has been trapped in stratigraphic traps, and a significant amount of oil is in channel sandstones with trends at high angles to the structural grain.

In some areas, secondary clay, in particular chloritic clay, has resulted in microporosity, high water saturation, and correspondingly low resistivities in logs. Dissolution of feldspar grains, and metamorphic rock fragments has resulted in significant secondary porosity. Red Fork reservoirs average just 3 percent primary porosity but have up to 20 percent secondary porosity. In addition, compartmentalization of the reservoirs has restricted recovery rates from oil and gas accumulations developed with vertical wells. It makes the Red Fork reservoir a viable target using horizontal drilling and modern hydraulic fracturing methods even in older depleted or nearly depleted fields. As a result, there is opportunity for multiple unconventional resource plays within the large Red Fork deltaic complex.