Geochemical and geomechanical study of basinal facies in the Wolfberry Play, Midland Basin, Texas

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Wolfberry production in the Midland and Val Verde Basins of Texas (including Leonard, Wolfcamp, and underlying Upper Pennsylvanian formations) totals 232 MMBBL of oil and 592 BCF of gas from 1998 through 2011 (53 MMBBL of oil in 2011, alone). Analysis of more than 1,000 feet of core from three wells near center of the Midland Basin in northern Reagan County shows that these basinal rocks can be divided into four facies: (1) siliceous mudrock, (2) calcareous mudrock, (3) muddy carbonate-clast conglomerate, and (4) skeletal wackestone/packstone. These facies are interpreted as hemipelagic deposits and sediment density-flow deposits reworked, locally, by bottom currents. Facies thickness ranges from inches (predominantly) to feet. Three scales of cyclicity have been observed: (1) cycles of alternating sediment density-flow and hemipelagic deposits seen in core (few ft thick), (2) sets (10s of ft thick) of repeating cycles defined by gamma ray log and facies in core, and (3) megacycles of dominantly calcareous or siliceous cycle sets (100s of ft thick).

Most siliceous mudrocks display values of C_{org}/N_{tot} <15, suggesting that the associated organic matter has a large marine component. Siliceous mudrocks contain relatively high total organic carbon (TOC) (up to 6.3 percent), rare burrows, and common phosphatic nodules and pyrite framboids. Collectively, these features indicate that anoxia prevailed during deposition of these fine-grained sediments. Coarser-grained conglomerates and wackestone/packstones have low TOC, few phosphatic nodules, and rare pyrite framboids. TOC varies widely by facies over small vertical distances (high in mudrocks, low in conglomerates and wackestone/packstones), covaries directly with geochemical proxies for marine productivity (Ni, Cu, Zn) and siliciclastic sediment (Al, Si, Ti), and covaries inversely with carbonate (Ca, total inorganic carbon).

Conglomerate deposition stopped near the Wolfcamp/Leonard boundary. Reasons for this may include increase in distance to source of carbonate debris or decrease in shelf-margin collapse, relative to earlier Wolfcamp time. Molybdenum and $d^{15}N$ content increased in late Wolfcamp/early Leonard time, perhaps as a result of changes in basin water stratification or circulation.

Measurements of unconfined compressive strength show that most Wolfberry wackestone/packstones are more brittle than Wolfberry mudrocks. Even so, mineralized fractures are present in all facies. Close vertical proximity of abundant organic carbon in mudrock and thin, brittle beds makes basinal Wolfcamp and Leonard strata targets for fracture stimulation and horizontal well completion. S_2/TOC data from the study wells identify zones of potential hydrocarbon production, which correlate with horizons that have produced 179-460 barrels of oil equivalent/day (30-day initial production) in nearby fields.