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Comparative Sequence Stratigraphy and Organic Geochemistry of Unconventional Gas Shales: Commonality or Coincidence?

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Comparison of some Paleozoic and Mesozoic unconventional gas shales has revealed a generally common sequence stratigraphy, consisting of, from the base upward: transgressive surface of erosion (TSE) upon which sits a transgressive systems tract (TST) enriched in organic matter, then a somewhat 'cleaner gamma-ray' highstand or regressive systems tract (HST/RST). When resolveable, this stratigraphy occurs at 2nd, 3rd, and 4th order relative sea level cyclicity, forming couplets of relatively organic-rich (TST and condensed section-CS) and organic-poor (HST/RST) strata at these time scales. The higher frequency cycles are superimposed upon lower frequency cycles, giving rise to a complex stratigraphy of several couplets of differing thickness and distribution. A higher order sequence stratigraphy can be developed for Mesozoic shales than for Paleozoic shales owing to greater biostratigraphic age resolution of the former. Most shales contain a common suite of minerals, in addition to organic matter (TOC), but the proportions of the minerals vary both between and within stratigraphic sequences.

There also are several commonalities in geochemistry of gas shales. Prolific gas shales are usually >200ft. (65m) thick, contain >3% TOC, HI values >350mgHC/g, Type II kerogen and organic maturity values >1.1%Ro. Organic-rich shales typically contain minerals such as pyrite and phosphates (apatite) and show biomarker ratios (pristane/phytane, steranes distribution, C_{13}-C_{20} regular isoprenoids and C18 aryl isoprenoids) indicative of anoxic conditions during source rock deposition. In high maturity areas, there is a reversal in ethane isotope abundance owing to secondary cracking of hydrocarbons; such a reversal is normally associated with best gas production.

Relative hydrocarbon potential (S1 + S2/TOC) is a geochemical parameter which reflects oxygenation conditions in the depositional environment. It can be related to relative sea level fluctuations within a sequence stratigraphic framework. Thus, knowing the sequence stratigraphy of shale provides a powerful tool not only for regional-to-local stratigraphic correlations, but for high-grading stratigraphic intervals most favorable for preservation of organic matter (ductile), gas storage, and hydraulic fracturing (organic-poor, relatively brittle).