Sequence stratigraphy and its bearing on reservoir characteristics of shale successions – examples from the Appalachian Basin

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Variations of gas reservoir properties, many of which reflect the physical and chemical nature of the depositional environments of the reservoir rocks, can be linked to base level fluctuations. The resulting sequence stratigraphic framework, then, can be extrapolated into regions of minimal data control. Our sequence stratigraphic paradigm is based on the transgressive-regressive (T-R) sequence concept. A single T-R sequence comprises transgressive systems tract (TST) deposits overlain by a regressive systems tract (RST) succession, the contact being a maximum flooding surface (MFS), and is bounded on top and bottom by maximum regressive surfaces. Ongoing studies of the Devonian shale succession of the Appalachian basin reveal that such parameters as mineralogy and microfabric vary predictably within the T-R sequence stratigraphic framework. A general increase in silica, much of which is diagenetic, and reduction of clay upward through the TST reflects the rapid landward migration of the shoreline. Early precipitation of silica cement preserves porosity and inhibits the development of a planar clay grain microfabric. TST deposits are commonly pyritiferous and organic-rich; indeed, TOC and pyrite content are maximum close to the MFS. Increasing thermal maturity of these deposits is accompanied by increasing porosity (principally nanoporosity) as a consequence of the transformation of kerogen. Under some conditions, bacterial reworking of organic-rich sediment deposited during transgression, especially proximal to the base level maximum, results in suppression of vitrinite reflectance. Accumulation of RST deposits is marked by increasing terrigenous sediment flux (clay and detrital quartz) and concomitant dilution of the organic contribution. This favors the more widespread development of a strongly planar clay-grain microfabric disrupted only by discrete laminae of detrital quartz or isolated grains. The base level minimum is defined by minimal TOC and local carbonate horizons. The predictive capabilities inherent to sequence stratigraphy make it especially applicable to exploration programs of seemingly homogenous shale successions.