When Good Logs Lie: Pitfalls of Using Log Correlations in Reservoir Mapping

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Mapping and identification of reservoir facies is a critical first step to the understanding of reservoir development and trend analysis. The use of 3D seismic has benefitted these tasks greatly, enabling us to visualize the stratigraphic sequences within an exploration area to more refined levels than ever before. However, oftentimes our initial evaluation of a new exploration trend area or initial offset development involves picking formation tops and sequence boundaries using well log correlations, and, later on, trying to force these correlations to synthetic seismic ties. This type of approach at times could lead to misties, failure to accurately predict precise formation tops and reservoir trends, and missed opportunities in recognizing more subtle stratigraphic traps. A multivariate approach to subsurface analysis should therefore include detailed sample evaluation that calibrates log responses to actual rock **s**equences. Several examples of possible pitfalls of failing to incorporate sample data are presented here from the Permian Basin. These include applications to the Clear Fork of the Midland Basin, the Cisco-Canyon of southeastern New Mexico, post-Mississippian unconformity beds, and the Siluro-Devonian and Ellenburger basin-wide. Each of these formations present unique challenges to reservoir prediction because of their complex depositional and post-depositional histories.

The middle Permian Clear Fork in the Midland Basin produces hydrocarbons from both shelf-marginal oolite banks and detrital debris developed along shelf margins and slopes, from a number of time-distinct, clinoform sequences. The recognition of time-equivalent shelf-to-basin sequences is critical to an understanding of the relationships of shows and production for each sequence, and guides our selection of offset wells once production is established. Mapping of these sequences on the basis of well correlations alone will often be misleading, as well-to-well log correlations will easily cross time units and lead to an improper interpretation of the juxtaposition of depositional environments. Log responses, especially gamma ray signatures, are often similar from sequence to sequence because of the repetitive nature of deposition. A similar problem exists with the algal mound sequences that comprise major reservoir units in the Upper Pennsylvanian Cisco-Canyon, but these formations are also punctuated by karsted horizons, which add another element of uncertainty to reservoir recognition. Karsted horizons often show higher gamma ray responses, and are reported on mudlogs as shales, but are, in actuality, shale-supported karst and cave-fill facies with locally high interstitial porosity. Some of these karst-related facies can contribute substantial hydrocarbon reserves, but are generally overlooked as potential reservoir facies because they appear pessimistically shaly on well logs.

Large-scale faults in portions of the Permian Basin bound pre-Woodford reservoirs on their upthrown sides, and set up Mississippian and younger reservoirs on their downthrown sides. On the larger structures, particularly along the western and northern sides of the Central Basin Platform, these faults were re-activated several times throughout the lower Paleozoic, resulting in the differential removal of parts of the post-Woodford section. For example, there are many well-known structures where Atoka sands lay unconformably upon lower Mississippian (Osagian) carbonates, absent the entire section in between. In order to effectively explore for the downthrown reservoir trends, it is essential to know the precise stratigraphic sequence and the degree to which Mississippian and younger beds were removed. But it is often difficult to tell the difference among the carbonate formations simply by

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correlating well logs. For example, the occurrence of Chester detrital or oolite reservoirs requires that part of the Chester section is preserved and identifiable close to faults, but it is often mistaken for the early Atoka or Morrow limestone and, consequently, erroneously included in the Chester for mapping and seismic correlation purposes. Samples can be effectively used to distinguish among the many carbonate units that express themselves similarly on logs.

The Siluro-Devonian through Ellenburger sequence in the Permian Basin is especially prone to misinterpretation because of the prevalence of karst events that episodically affected the entire section. But it is most especially critical basin-wide where the sub-Woodford section had undergone tilting and erosional truncation. Major trends of the Fusselman pinchout play, for example, were developed by drilling a few feet beyond the base of the Woodford Shale, and testing at that point to determine production potential, assuming the carbonate to be Fusselman. There are numerous instances where fields have been erroneously designated as producing from the Fusselman, when later sample or core analyses identified the pay as the underlying Montoya or even the Ellenburger Formations, because of locally intense uplift, exposure, and removal of part of the section. Further confusing the picture are localized “stray shales” that are, in part, karst-related Montoya features, and partly associated local thickening of the Sylvan shale, and which occur at varying depths below the Woodford in closely-spaced wells. That the Montoya and Ellenburger might be productive in this way opens up other possible reservoir trends in areas where they may not have been envisioned before.

The Ellenburger, having been subjected to early post-depositional tectonics and karsting, often behaves structurally independent from overlying formations above the pre-Simpson unconformity. Simply mapping a structure on the Ellenburger is not enough to define a play; it is important to determine the structural attitude of the Ellenburger below the unconformity, and which member of the Ellenburger is present there, to more accurately map a prospect and determine offset locations. The same can be said about the Fusselman and the overlying Wristen and Thirtyone Formations throughout the basin, and karsting further confuses the picture here as well. This type of determination is only possible with good sample or core control, and good ties to 3D seismic data.