Geochemical, Mineralogical, and Lithological Linkages in a Thick, Early Permian, Siliciclastic Succession, Midland Basin, West Texas, USA

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The latest Pennsylvanian and Early Permian (Wolfcamp, Dean, and Spraberry interval) of the Midland Basin, West Texas, represents a thick (often >1000 feet), mixed succession of shale, carbonate, and siltstone/sandstone lithologies that accumulated in a deep-water environment under variable hydrographic restriction. The succession is a prime target for petroleum companies working in the Permian Basin, of which the Midland Basin is an integral part. Because the succession is very thick and lithologically variable, it is critical to understand and predict the stratigraphic and lateral variability of the rocks. A highly-resolved (2-inch vertical) XRF-based chemostratigraphic study was undertaken on the Sun Oil D.E. Richards #1 drill core, recovered from Martin Co., Texas. While the core does not preserve a continuous record of the interval, it does contain long, uninterrupted sections of the upper Wolfcamp shale/siltstone through the lowermost Clearfork equivalent strata, just above the uppermost Spraberry operational unit. Major and trace element analyses were conducted on the slabbed core face using a Bruker Tracer IV-SD ED-XRF spectrometer. Elemental concentrations for 2567 sample intervals were calibrated from raw x-ray spectra using a set of reference materials developed from a broad range of mudrock lithologies (Rowe et al., 2012), and a subset of depth-matched sample powders (n = 229) was collected from the back of the core for mineralogical (XRD) and organic carbon analysis (LECO).

A data refinement approach that incorporates elemental results from XRF and mineralogical results from XRD powders is developed in order to highlight element-mineral linkages and to convert the 2-inch XRF data into a “model” 2-inch XRD data set. The XRF-modeled mineralogy can be utilized by geologists, petrophysicists, and geomechanical engineers in order to resolve sub-well log-scale lithological variability and its impacts on rock strength, and rock layering attributes—both of which are important characteristics to understand in order to generate an optimal frac-ing strategy during well development. Comparing the low-resolution XRD data with the 2-inch XRF data, it is observed that large-scale changes in elemental concentrations in %Al, Si/Al, %Ca, and %Mg can be interpreted as changes in mineralogical abundances of clays, quartz/clay, calcite, and dolomite, respectively. Furthermore, the Fe/Al and Mn/Al ratios can be used to understand the ferroan and manganoan characteristics of dolomitic intervals and the % S can be used to estimate the abundance of pyrite preserved in the mudrock intervals. A discussion of the chemostratigraphy in the context of mineralogical changes, rock strength changes, and the selection of more detailed analyses (e.g., SEM, NMR, rock mechanics) will be undertaken.