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Mineralogical Variations in Mudstone Dominated Clinoforms, Central Alberta, Canada

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Abstract

The mudstone dominated succession of the upper Colorado Group in central Alberta contains laterally extensive accumulations of biogenic gas. The distribution and location of reservoir facies is controlled by complex clinoform architectures, which are difficult to map because of their small scale relative to regional well-log correlations. Identifying mineralogical and geochemical variations on a variety of scales enhances understanding of sediment distribution through the basin, and when coupled with sedimentological data provides insights into the location of perspective reservoir targets.

The presence of the clinoforms can be attributed to interactions of subaqueous currents, accommodation space, and sediment behavior. These clinoforms are relatively broad, and span over 50 km with only approximately 50 m in relief over that distance. The scale of these mudstone clinoforms makes them difficult to correlate in cross sections using traditional techniques. A new method of correlating in these units was developed to aid in delineating the complex internal architecture of these units. This technique uses closely spaced induction logs in conjunction with XRF and XRD data to delineate complex clinoform architectures.

Clinoform systems tracts are often separated by erosive surfaces, which correspond to sharp variations in mineralogy, with varying amounts of quartz, calcite, and clay minerals. These variations demonstrate that significantly distinct sedimentary processes or sources produced the various systems tracts. Quartz concentrations increase vertically through the majority of the systems tracts, corresponding to upwards coarsening cycles observed in core.

Smaller scale variations within individual facies show that quartz trends are inversely proportional to the clay minerals, as increased quartz deposition displaced clay vertically through each systems tract. These trends of increasing quartz are also accompanied by increases of Zr concentrations and decreases in TOC, indicating increased terrestrial influence and dilution of organic matter. In addition, vertical increases in the degree of bioturbation, larger traction current ripples, and decreases in redox-sensitive elements Mo, and V indicate increased circulation and oxygenation.

Individual mudstone grains can be observed and analyzed using an SEM electron microprobe for specific identification of specific mineral grains. Backscatter images show sand sized mudstone aggregates interlaminated with quartz silt and sand, indicating approximate hydrodynamic equivalence, and allowing for the deposition of clinoforms through the movement of sediment in traction currents. SEM microprobe analyses show that these mudstone aggregates have a different mineralogical composition than the surrounding matrix, with higher amounts of Mg relative to the surrounding clay. This indicates transport of the mudstone aggregates over sufficiently large distances to have a different source than the surrounding clay matrix.

The Upper Colorado Group of Eastern Alberta contains complex internal architectures which control the distribution of reservoir facies. Compositional variations in the mudstones provide valuable data when compared with sedimentological and stratigraphic data. Connecting the large scale mineralogical and stratigraphic variations to the smaller scale mineralogical, geochemical, and sedimentological observations creates a robust framework for predicting and delineating reservoir facies within the complex clinoform architecture of the Upper Colorado Group in Eastern Alberta.