Mudstone aggregates and their implications for shale sedimentology and stratigraphy

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Shale represents approximately two thirds of the sedimentary rock record and form important components of petroleum systems, providing sources, reservoirs, and/or seals. Despite their abundance and significance, shale is still perhaps the least understood sedimentary rock. Traditional over simplification of depositional environment interpretations have lead many geologists to assume that all shale units are deposited through suspension deposition in quiet water settings. Recent flume experiments show that mud can be transported by traction currents in relatively energetic settings as aggregate grains which behave as hydrodynamic equivalents to sand. Upon compaction and dewatering, both the ripples and the aggregate grains that comprise them are flattened and become difficult to recognize in the rock record.

The Late Cretaceous Carlile Formation of the Colorado Group in eastern Alberta is a shale dominated succession which contains relatively uncompacted, mud-dominated, current ripples. Thin sections of these ripples show abundant aggregate mud clasts. These aggregates are relatively uncompacted and were likely dewatered prior to transport and deposition. Firmness of the aggregates was sufficient to preserve porosity between many of the aggregates. These grains contribute to reservoir permeability and porosity. The aggregates have a similar appearance to the matrix and are often difficult to identify in thin section. Positive identification of the aggregates is made possible by interlamination with silt size quartz grains, which provide a visible outline for the aggregates to differentiate them from the matrix. Chemical analyses show that the aggregates have a different composition than the matrix, suggesting they were transported over large distances.

Internal grain alignments suggest a fecal origin as the most likely source for these aggregates. They are interpreted to be crustacean corpolites of the genus favreina. These rod-like pellets are widely documented in limestones, but are rarely identified in shale. It is possible that they are more common in shale, but have not been widely recognized due to the difficulty in identifying them in shale. Crustacean coprolites like these are linked to hardground/firmgrounds associated with stratigraphically significant erosional surfaces or condensed sections and are used in sequence stratigraphic interpretations. In the Carlile Formation of eastern Alberta, they accompany a condensed section associated with an interpreted maximum flooding surface (MFS). The presence of these coprolite aggregates supports previous sequence stratigraphic interpretations in the study area. Thus, not only do these aggregates provide important insights into the depositional processes of the shale, they also assist in delineating reservoir facies and production fairways in shale gas reservoirs.