Characteristics and Origin of Fine-Grained Composite Particles (Aggregates) in the Cenomanian Dunvegan Prodelta “Mudstones” — Implications for Depositional Processes and Reservoir Quality

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Abstract

Based on their apparently fine-grained nature, mudstones have historically been interpreted as deposited via suspension fallout under mostly quiet conditions. An increasing number of petrographic studies of ancient mudstone successions, however, show that these “mudstones” actually consist of coarse-silt to sand-sized fine-grained composite particles of various origins. This study focuses on the allomember E of the Cenomanian Dunvegan Formation, a fluvial-dominated delta system in the Western Canada Sedimentary Basin. Polished thin sections and ion-milled samples were made from cores located within the proximal incised valley to distal prodelta environments. Detailed petrographic analysis (optical and scanning electron microscopy) was conducted to determine the characteristics, distribution, and origin of various types of composite particles in this ancient delta system. Fine-grained composite particles derived from a wide range of origins can be differentiated. Those that are relatively hard (compaction-resistant) include volcanic rock fragments (vitric or felsic in composition), chert fragments, shale lithics (argillaceous or siliceous in composition), metamorphic rock fragments, and chlorite/siderite clasts. “Soft” composite particles include rip-up clasts (can be argillaceous, siderite-rich, or siliceous) and possibly floccules. All types of composite particles are present in samples from the incised valley and prodelta deposits, suggesting that a significant proportion of fine-grained composite particles deposited in distal marine

environments are supplied by rivers draining the hinterland. Rip-up clasts with varying water content were likely derived from intra-basinal erosion of previously deposited shelf mudstones that have undergone various degrees of compaction. Regardless of the origin or type, composite particles decrease in size from the incised valley to prodelta environment (from fine-sand to coarse-silt size), reflecting the preferential deposition of coarser particles in proximal settings. For mudstones in general, a better understanding of their composition and true grain-size distribution is critical to the interpretation of their depositional conditions. The presence of multiple types of composite particles that show a wide range of composition, texture, and cementation characteristics essentially controls the observed heterogeneity in petrophysical properties and porosity-permeability characteristics of mudstone hydrocarbon reservoirs.