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Characteristics of Sandy Hyperpycnite Deposits on the Southern Margin of Eocene Lake Uinta, Castle Peak Member of the Green River Formation of Northeastern Utah

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Abstract

Gravity flows play an important role in distributing clastic sediments into lacustrine basins at the front of fluvial-deltaic systems due to the tendency of high-density sediment-laden plumes to plunge along the bottoms of lower-density lake waters. Fluvially derived underflows can be relatively long lived and distribute substantial volumes of sand far into the profundal zone of a lacustrine system that is typically composed of carbonates and clay- and silt-sized clastics. This paper examines the properties of sandy hyperpycnites in the Castle Peak member of the Green River Formation using outcrop, core, and wellbore data. These deposits are of particular interest due to the active tight oil play that exploits them using horizontal wellbores. The Castle Peak member represents a third-order sequence consisting of thick highstand limestones followed by falling-stage siliciclastic deposits that primarily take the form of sandy hyperpycnal bodies. During early Castle Peak time, the Duchesne fault zone (DFZ) effectively partitioned the Uinta Basin into 2 distinct zones. To the south of the DFZ, siliciclastic input was sequestered updip on a large, low-angle alluvial plain, whereas the region north of the DFZ hinge point was part of Lake Uinta, where basin-center carbonates accumulated. By late Castle Peak time the southerly siliciclastic wedge eventually accumulated with sufficient dip to allow sediment-laden fluvial systems to plunge into the lake center when combined with climatic changes. Paleoclimate data tied to outcrop studies suggest arid conditions prevailed during late Castle Peak time punctuated by occasional large monsoonal floods. Arid conditions allowed for the accumulation of large volumes of loose sediments, particularly fine sand of possible eolian origin. These were then mobilized in dense floodwaters, creating suitable conditions for hyperpycnal flows when these floodwaters encountered the lake waters. Core and outcrop study of these late Castle Peak flows documents recurring sedimentary structures such as full and beheaded bouma sequences that represent fluvial-linked waxing and waning flow regimes. Soft-sediment deformation is common, particularly in the basal portions of the deposit, and typically includes ball and pillow, flame structures, and convolute bedding. Hyperpycnal sandstone lobes of up to a mile in width and several miles in length have been mapped using subsurface well data. Individual lobes branch off larger feeder channels, forming larger fans and fan complexes. These extensive, well sorted sandstone complexes are unlikely to originate in surge-like gravity flows such as shelf-collapse turbidites and instead likely represent fluvially linked sediment-laden underflows with a strong link to climatic variability.