Recognition of Bounding Surfaces: An Example from the Lower Cretaceous, Upper Mannville Group (Sparky, Waseca, and McLaren Formations), West-Central Saskatchewan

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The Lower Cretaceous Upper Mannville Group (Sparky, Waseca, and McLaren formations) of the Lloydminster area of west-central Saskatchewan comprises an interval up to 60 m thick, consisting of weakly consolidated sandstones, shales, heterolithic bedsets, and minor coals, which were deposited in shallow-marine to coastal plain/delta plain environments. Despite the abundance of core and well logs and its importance as a heavy oil producing area, a sequence stratigraphic framework for these Upper Mannville units has not been constructed. The majority of previous interpretations have relied largely on lithofacies analysis and well-logs characteristics. The deposits, however, exhibit marked vertical and spatial variability owing to several autogenic and allogenic processes, which has led to a complex stratigraphic architecture. The integration of ichnological data with physical sedimentological data leads to a better understanding of the depositional framework and can be used to discriminate the different coastal margin subenvironments. The data can also be employed effectively to aid in the recognition of subtle changes in base level, changes in the degree of marine influence, identification of various discontinuities, and to assist in their genetic interpretations. Stratigraphic surfaces associated with base-level rise include marine flooding surfaces (MFS), transgressive surfaces of erosion (TSE), maximum flooding surfaces (MxFS), and flooding surfaces (FS). Surfaces related to base-level fall correspond to both subaerial unconformity (SU) and regressive surface of marine erosion (RSME). In some locations, surfaces associated with base level rise are amalgamated with surfaces generated by relative base level fall (FS/SU). Each surface type possesses discernible sedimentologic and ichnologic characteristics.

Formation boundaries are characterized by a sharp contact between underlying proximal facies and overlying distal facies, and can be correlated across the study area. These are interpreted as marine flooding surfaces (MFS). Where evidence of erosion is apparent (e.g., truncation of underlying structures, presence of palimpsest ichnological suites, concentrations of rip-up clasts), such MFS are interpreted as TSE. Less extensive flooding surfaces (FS) bound shoreface successions (FA2), and are used to define parasequence boundaries. Within deltaic deposits (FA3), however, minor autogenic flooding surfaces are also present, which display limited lateral extents and do not correspond to the FS defining FA2

parasequences. Differentiation of mixed river-wave delta successions from shoreface deposits, therefore, is critical for guiding parasequence correlations. In the study interval, a single subaerial unconformity (SU) is identified. The discontinuity marks the base of incised valleys, but also correlates to interfluve areas that are typified by root-bearing pedogenically modified units. In most locations, the SU is erosionally modified by a transgressive surface of erosion. The subaerial unconformity passes seaward to RSME, overlain by lowstand delta and shoreface successions (FA3).

Upper Mannville strata can be separated into parts of two depositional sequences. The main deposits of the lower sequence comprise two highstand systems tracts (HST), corresponding to the Sparky Formation and the Lower Waseca Member. The base of the Lower Waseca marks the onset of a transgressive systems tract (TST). A maximum flooding surface (MFS) marks the end of transgression and the resumption of progradation for the remainder of the Lower Waseca. Following highstand progradation a relative base-level fall produced a subaerial unconformity, which marks the base of the upper sequence. Fluvial valley incision led to sediment bypass, and deposition of forced regressive and lowstand shoreface and delta complexes of the falling stage systems tract (FSST) and lowstand systems tract (LST) towards the northern part of the study area. TST accumulation is largely confined to estuarine infill of the incised valleys of the Upper Waseca Member. The Upper Waseca is separated from the McLaren Formation by a maximum flooding surface (MFS). The overlying McLaren Formation marks a return to regional shoreline progradation, and corresponds to a highstand systems tract (HST).