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Sequence Stratigraphy Of A Wave-Dominated Fan Delta In The Fountain Formation (Morrowan-Atokan) Near Colorado Springs, Colorado, USA

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The lower part of the Fountain Formation near Colorado Springs, Colorado, consists of 12-15 high-frequency sequences developed on a small (~25 km^2) wave-dominated fan delta. Wave-dominated marine parasequences are interpreted from coarsening upward cycles with abundant marine trace fossils. An ideal succession consists of four facies (starting at the base): (i) sandy gray shale with *Lingula* brachiopods and abundant burrows such as *Arenicolites, Palaeophycus, Chondrites*, *Thalassinoides,* and others is interpreted as transitional to offshore marine; (ii) very fine- to fine-grained sandstone with hummocky cross stratified (HCS) bedding and abundant marine burrows, such as *Macaronichnus, Rhizocorallium, Eione* and others is interpreted as lower shoreface; (iii) pebbly trough-cross bedded, coarse- to very coarse-grained sandstone is interpreted as upper shoreface where it occurs directly above the HCS beds; and (iv) pebbly coarse-grained sandstone with low-angle parallel bedding is interpreted as foreshore deposits.

The marine parasequences are separated by transgressive lag deposits from a continental facies assemblage composed of coarse- to very-coarse-grained pebbly sandstone and purple mottled mudrock. The sandstone contains abundant large clasts up to 20 cm, trough cross beds, abundant cut and fill structures and is interpreted as alluvial channel and splay deposits. The mudrocks have red, yellow, green, and purple mottles, lack internal stratification, contain common blocky to columnar peds, small to large rhizoliths and trunk steinkerns, very small- to medium-diameter simple burrows, organized sets of slickensides, and coarse-grained filled desiccation cracks. These units are interpreted as paleosols.

A sharp erosional surface separates continental facies assemblages from the marine facies assemblage. Locally, alluvial facies rest on lower shoreface facies, showing an abrupt basinward shift in facies. These erosional surfaces are interpreted as sequence boundaries that formed during a relative lowering of sea level. The alluvial facies assemblage is interpreted to fill incised valleys developed on the fan delta, and the marine facies are interpreted to occur in the transgressive to highstand systems tracts.

In some cases, a pedogenically modified zone separates continental facies assemblages from the marine facies assemblage. Locally, weakly- to well-developed, but subtle paleosols rest on

lower shoreface and offshore marine facies, also showing an abrupt basinward shift in facies. We have also documented several previously unrecognized paleopedogenic zones and associated biogenic structures that represent discontinuity surfaces with sequence stratigraphic significance. Current innovations in continental ichnology and paleopedology have provided recognition criteria to identify discontinuity surfaces that reflect soil formation and related biotic activity in subaerially exposed sediments deposited in marine settings. For example, sandwiched between two successions of marine lower to upper shoreface facies assemblages is a paleosol about 50 cm thick. It is characterized by a dark reddish purple color with red and green mottles around vertical, horizontal, and backfilled burrows, rhizoliths, and desiccation crack fills. Most of the paleosol contains no original stratification and the sediment texture appears to be homogenized; only near the base of the pedogenically modified zone are sedimentary structures present and, for the most part, resemble those from the units below. This zone can be traced along the exposure over 100 m. In another instance, the distal sandy shale (mudstone) units were previously interpreted as marine offshore facies deposited in low energy settings. Reinvestigation revealed pedogenic and ichnologic features consistent with subaerial exposure, pedogenic modification, and bioturbation by continental organisms. This part of the unit is also characterized by a dark reddish color with subtle red and purple mottles, particularly associate with rhizoliths. The uppermost meter of this unit is reinterpreted as a paleosol bioturbated by tree roots of *Stigmaria*, nondescript rhizoliths, and soil organisms.

Recognition of pedogenic features and subaerial bioturbation is critical to developing a robust stratal framework for the Fountain Formation. Sequence boundaries are interpreted from the abrupt transition from open marine to terrestrial facies at sharp, laterally continuous, erosional surfaces. These surfaces formed in response to relative falls of sea level which allowed fluvial facies to incise offshore marine sandstone and mudstones. The sequence boundaries delineate genetically related stratal units that punctuate the stratal succession of the fan delta.