HIGH-FREQUENCY ALTERNATION OF WAVE- AND RIVER-DOMINATED DELTA FRONTS, CAMPANIAN CHIMNEY ROCK TONGUE, WYOMING/UTAH

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Abstract:
This report focuses on the regressive deltaic succession of the Upper Cretaceous, Campanian Chimney Rock Tongue that exhibits high-frequency alternation of wave- and river-dominated delta fronts. The deltaic succession is exposed in a dip-oriented, ca 15 km long outcrop belt in the Flaming Gorge area, Utah/Wyoming. The delta succession, ca 95 m thick, consists of eastward-prograding clinothem sets. The river vs wave-dominated delta fronts are recognized by specific facies associations. River-dominated delta fronts tend to consist of upward-coarsening packages of turbidites, slumped beds and mouth-bar deposits. The wave-dominated delta fronts consist of offshore transition to shoreface deposits. The river-dominated clinothems tend to have a higher degree of sandstone and mudstone alternations, whereas wave-dominated clinothems are sandy in their upper parts. In addition to the sedimentary facies and lithological differences, the wave and river-dominated clinothems are geometrically different, as river-dominated clinothems are steeper and shorter than wave-dominated clinothems: 200-400 m long and dip at 2-4°, and more than 800 1200m long and dip at 0.1-0.3° respectively. Tops of both types of clinothems are locally cut by distributary channels. The distributary channels are filled with fluvial and tide-influenced fluvial deposits.

The wave- and river-dominated clinothems alternate within individual clinothem sets (parasequences). The clinothem sets display the following alternation styles: (1) river-dominated delta toes are sharply overlain by a wave-dominated delta front; (2) a river-dominated delta front is seaward sharply replaced by a wave-dominated delta front; (3) a wave-dominated delta front is seaward replaced by a river-dominated delta front; and (4) wave-dominated delta toes are overlain by a river-dominated delta front. These sub-parasequence scale alternations indicate that autogenic rather than allogenic processes, like relative sea-level changes, hinterland tectonics or major climate changes control the alternations of wave – and river-dominated delta fronts. Moreover the alternation styles indicate that older river-dominated delta front packages are partially reworked by wave processes, and river-dominated delta fronts may be replaced seaward by wave-dominated delta fronts or vice versa. These lateral and vertical relationships suggest that the river-dominated delta fronts may be associated with active distributary channel mouth bars. As a distributary channel gets abandoned, the river-dominated delta fronts are partially or completely reworked by waves. This interpretation is supported by high feldspar content in the wave-dominated deposits, indicating a local sediment source rather than far-range long-shore transport.

Recognizing river- and wave-dominated delta fronts, and their alternation frequency and style has significant implications for correlation strategies, as well as for understanding reservoir heterogeneity.

West-to-east trending vertically over-exaggerated view of photomosaic interpretation that illustrates the alternation of river-dominated (brown) and wave-dominated (yellow) delta front packages. Distributary channels are shown in green. The red line marks an unconformity at the top of the deltaic succession. This photomosaic shows Clinothem sets 3, 4, 5 and 6 (see Fig below) in the “Main outcrop”.

West-to-east trending correlation panel of the regressive deltaic portion of the Chimney Rock sandstone. Note the sub-parasequence scale alternation of wave- and river-dominated delta fronts.

This project:

Tectonic/stratigraphic setting:
The Western Interior basin is a foreland basin that formed as a response to Late Cretaceous thrust sheet loading in the Sevier thrust belt, dynamic loading, and a high Cretaceous eustatic sea-level. Sediments were sourced from the Sevier Orogenic Belt at the western margin of the basin. Shorelines periodically advanced and retreated into the basin. The Lower Campanian Chimney Rock Tongue belongs to the Rock Springs Formation, it overlies Blair Sandstone, and is overlain by Black Butte Shale, and Brooks, McCourt and Ericson Sandstones

Data used:
This study focuses on the regressive deltaic succession of the Chimney Rock Tongue. The database includes 28 detailed measured sections, GPS datapoints, numerous photosamais, and detailed outcrop photos, along delta-direct view outcrop belt, ca 15 km long. This report includes a detail study of the upper, estuarine part of the Chimney Rock Tongue. A report by Jay Skinner documents the details of mouth bars in the most landward portion of the exposures.

Hypotheses/ Key questions:
(1) the frequency of alternation of river vs wave-dominated delta fronts;
(2) the implications of wave- to river-dominated delta front alternations for understanding the delta-front dynamics and controlling factors, and
(3) the pragmatic implications for correlation strategies and reservoir properties.

Key lessons:
1. The Early Campanian Chimney Rock delta succession displays alternation of river- and wave-dominated delta fronts within individual clinothem sets (sub-parasequence scale).
2. The river- and wave-dominated delta fronts are lithologically and geometrically distinct. Wave-dominated delta fronts consist of offshore to shoreface deposits, and tend to be shorter (<200-1200 m) and gentler (0.1-0.3°), as their seaward dip is essentially a shoreface profile controlled by wave processes. In contrast, river dominated delta fronts consist of sediment gravity flow, mass transport and mouth-bar deposits, and tend to be shorter (200-400 m) and steeper (2-4°), as they are controlled by delta-front strength and thus essentially the gravitational processes.
3. The frequency of the river- and wave-dominated delta front alternations indicates autogenic controls, like distributary channel avulsions. River-dominated delta fronts are associated with active distributary channels. As distributary channels are abandoned, fluvial sediment supply decreases dramatically, and the previously deposited river-dominated sediments are reworked above the storm- and especially the fair-weather wave base. The latter is supported by the high content of feldspars in the wave-dominated deposits, indicating that these sediments were locally derived, rather than transported by far-range long-shore movement. A wave-dominated delta front will then be replaced by a river-dominated delta front if a distributary channel avulses back to a previous (or close to) position, or if a river-dominated lobe expands laterally.
4. Recognizing river- and wave-dominated delta fronts has implications for correlation strategies and understanding of reservoir properties. Recognizing the river- and wave-dominated delta fronts alternate within clinothem sets, across lateral distances of a few kilometers, and vertical thicknesses of a few to a few tens of meters, alerts for caution for correlations across large distances. Although, the clinothem set boundaries do correlate across the whole deltaic succession for more than 15 km, the clinothem sets are internally heterogenic on a scale of a 100s of meters to a few kilometers.