Stratigraphic architecture and characterization of a Neoproterozoic continental slope system, Windermere Supergroup, east-central British Columbia, Canada

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Introduction and Research Question

The deep sea is host to the largest depositional elements on earth, termed turbidite systems, that are built up of sediment transported down the continental slope principally by turbidity currents and mass wasting processes. However, the inaccessibility (i.e., extreme water depths), unpredictable timing, and destructive nature of these processes in modern systems has resulted in a poorly developed understanding of their internal stratigraphy and how these systems change in time and space. To bridge this gap, ancient turbidite deposits provide valuable insight into the formative processes and stratal architectures that shape these systems. At the Castle Creek study area in the Cariboo Mountains of western Canada, deep-marine rocks of the Neoproterozoic Windermere Supergroup (WSG) are exceptionally well-exposed and comprise an upward-shoaling succession of basin floor terminal fans of the Kaza Group and leveed slope channels of the Isaac Formation (Figure 1). Strata described here are part of the Isaac Formation and show a systematic and repetitive stacking of its composite architectural elements. Detailed analysis of lithology, geochemistry, and stratigraphic architecture aims to identify relationships between architectural elements and the factor(s) that may be forcing these systematic changes in stratigraphy.

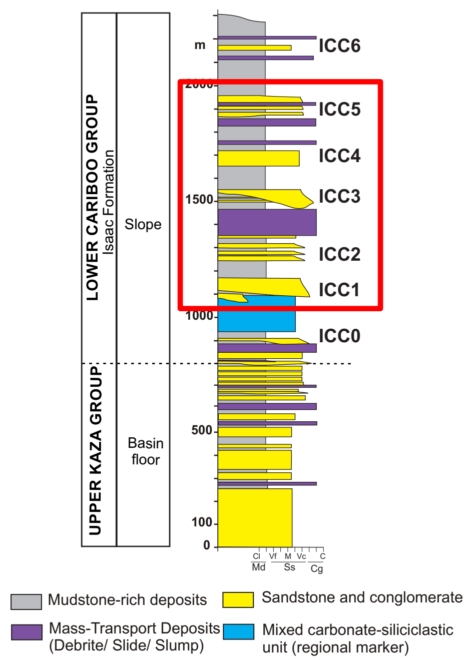

Figure 1. Stratigraphic column at the Castle Creek study site; area described here is outlined in red.

Observations

Exposed in the Hill Section outcrop are continental slope deposits of the Isaac Formation, which exhibit a stacking pattern comprising three main architectural elements: mass transport deposits (MTDs), channels, and levee deposits. The occurrence of MTDs provides insight into the state of gravitational stability on the slope at the time of deposition, which everywhere are overlain by channel elements that stratigraphically upward show a change from aggradationally filled to laterally accreting channel fills. Levee deposits crop out adjacent to or overlie channel fills and are exceptionally well-exposed, allowing for detailed description of both lateral and vertical trends in lithology. The consistent upward change from MTD to aggradational to laterally accreting channel fills, and adjacent levee deposits, reflects systematic and recurring changes in slope stability, sediment supply, and sea level, which collectively are integral to understanding the temporal evolution of the system.

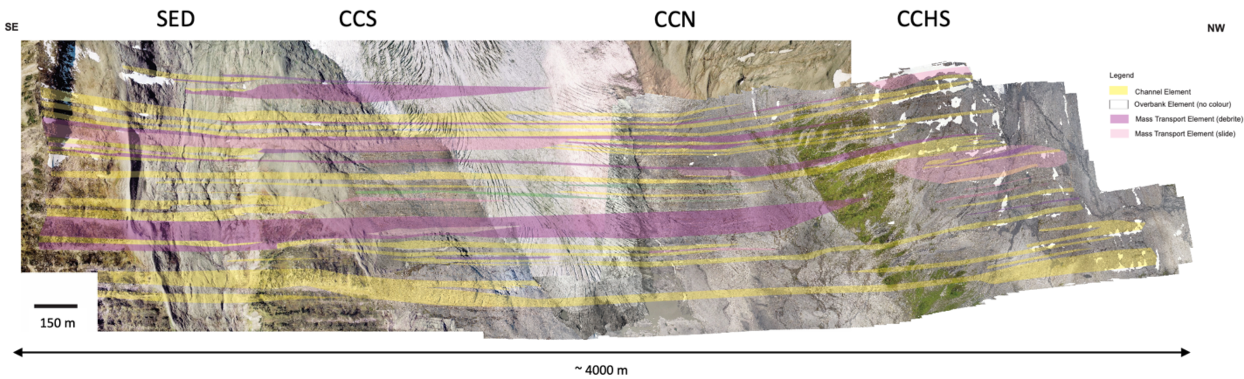

Figure 2. Stratigraphic correlation of continental slope strata in the greater Castle Creek study area showing the spatial distribution of the component architectural elements. Specific study areas include: Hill Section (CCHS), Castle Creek North (CCN), Castle Creek South (CCS), and Southeast Drainage (SED), and the component architectural elements are: MTDs (pink and purple), channel complexes (yellow), and overbank strata (no colour).

Chemostratigraphic units were identified based on trends in the abundance of elemental proxies, namely strontium (Sr) for carbonate and zirconium (Zr) for siliciclastic sediment, which then were used to subdivide the stratigraphic column into systems tracts. The Transgressive Systems Tract (TST) is typically characterized by increasing Sr and decreasing Zr, interpreted to represent growth and expansion of the shelf carbonate factory and reduced siliciclastic input from the hinterland. During the ensuing Highstand, Falling Stage and into the Lowstand Systems Tracts (HST, FSST and LST, respectively), Sr decreases whereas Zr increases, which most likely reflects the progressive shut-down of the carbonate factory and increased siliciclastic sediment input from the hinterland. These elemental trends combined with changes in architectural elements and their stacking pattern are interpreted to be related to changes in relative sea level. MTDs with common stromatolite and oolite fragments, in addition to carbonate cemented sandstone and mudstone clasts, are associated with highstand and falling relative sea level and indicate a period of gravitational instability on the upper slope and outer shelf. During the following LST, aggradational channel complexes dominate as sediment provided directly from the hinterland formed density-stratified turbidity currents and channels that filled from the bottom up. However, as relative sea level begins to rise during the TST, and transported sediment becomes dominated by coarse palimpsest and relict sediment sourced from the shelf, causing turbidity currents to become less stratified and sediment to be deposited on the inner bend margin of laterally migrating channels.

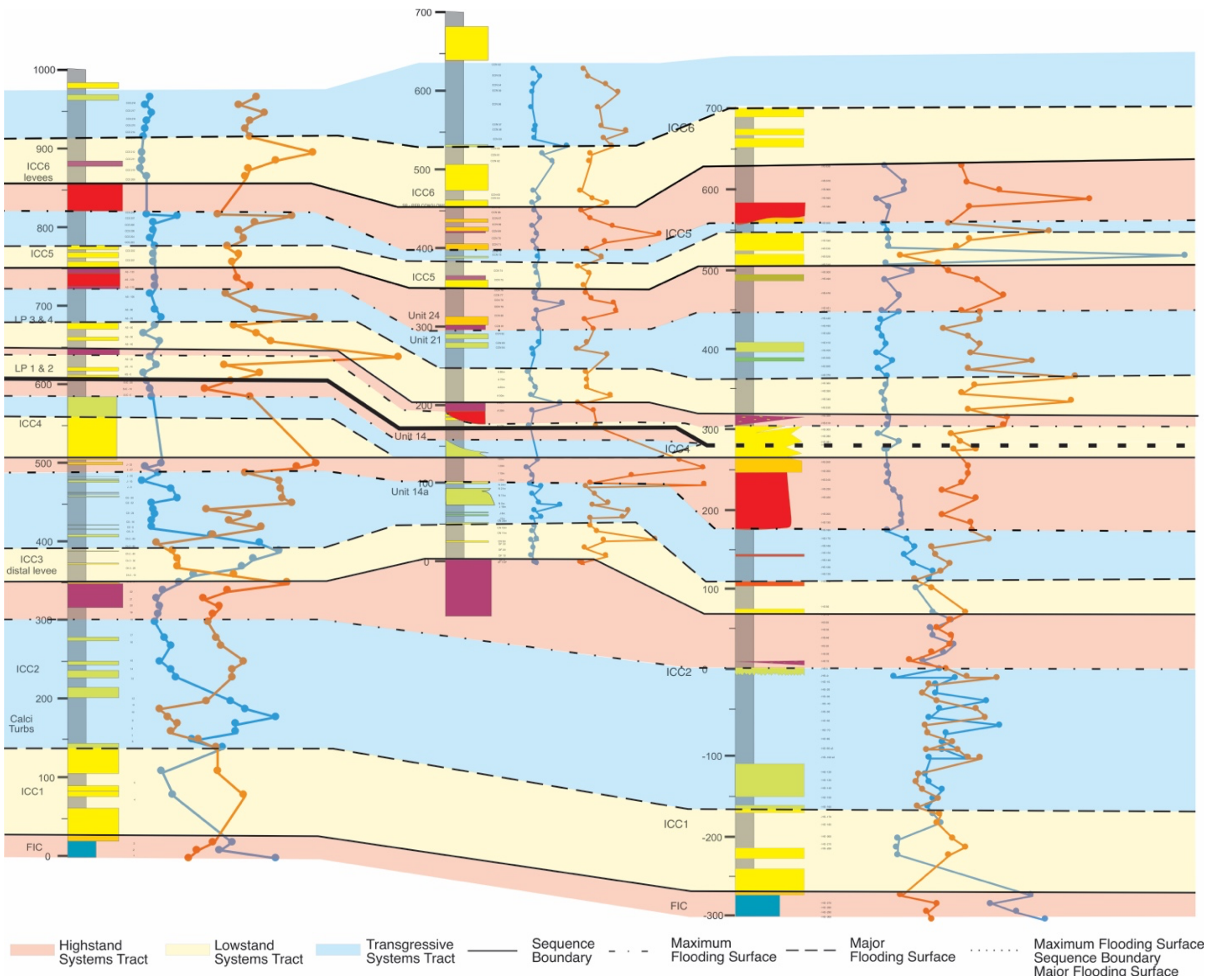

Figure 3. Chemostratigraphic correlation of CCHS, CCN, and CCS based on the relative abundance of Sr (blue) and Zr (orange); Sr and Zr contents are in ppm.

Conclusions

The systematic and recurring occurrence of MTDs overlain by aggradationally filled overlain by laterally accreting slope channels, in addition to consistent trends in elemental composition, illustrates periodic forcing on the system that most likely is related to long-term changes in relative sea level and sediment supply to the deep sea. Understanding these systematic patterns is important for assessing regional and potentially global changes in climate and eustasy, and how those changes are manifest in the deep-marine sedimentary record.

Acknowledgements

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