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Storm-flood-dominated delta: A new type of delta in stormy Oceans

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Summary

Storms are increasingly identified as a key depositional process. Their deposits show unique sedimentary characteristics, distinct from deposits of fair-weather wave processes, but are not currently separated in classic ternary deltaic classification schemes. The term 'storm-flood-dominated delta' is proposed for a new type of delta that more fully represents deltas dominated by storm-flood processes. This study describes several outcrop cliffs of the Gallup Formation, deposited during the Late Turonian to Early Coniacian in north-west New Mexico, that exemplify storm-generated facies and provide examples that can be used to generate a facies model for storm-flood-dominated deltas. Key identification criteria include extensive sharp-based planar to hummocky cross-stratified sandstone beds, commonly presenting as large sized gutter casts. They are interbedded with mudstones that show low bioturbation intensity and normally and inversely graded beds, suggesting direct deposition from river plumes. Major types of gutter casts are classified based on geometry and dimension. The gutter casts are interpreted as storm channels of storm-flood-dominated deltas and formed by erosion and infill of submerged channels resulting from offshore-oriented downwelling currents that may include localized rip currents. These amalgamated channels are likely linked to multiple feeding rivers and distributary channels that ensured high sediment supply rates and highly efficient offshore-directed sediment transport through hyperpycnal flows. A four-component pyramidal classification scheme of deltaic deposition is employed to emphasize storms as a distinct process in contrast to the traditional classification that lumps storm and fair-weather processes in a single 'wave' end-member. The four-component depositional model can be readily applied to interpret storm dominated environments and provide new insights into depositional processes of the marine realm. Recognition of storm processes in deciphering depositional evolution will also help to better understand control mechanisms of sequence stratigraphy, such as relative sea-level changes, and to analyze sedimentary processes governing sediment transport in 'source to sink' systems.

Theory / Method / Workflow

Results, Observations, Conclusions

The Gallup Formation crops out along the western and southern margins of the San Juan Basin, New Mexico, providing a 160 km long extensive well-exposed outcrop belt for stratigraphic and sedimentological studies. Facies architectural analysis is applied to document storm deposits, focused on several well-exposed cliff sections with significant gutter casts in the main study area. Seventy-one sedimentological sections, including grain size, sedimentary structures and texture, ichnology, fossil content and palaeo-current directions, were measured from the entire outcrop

belt to establish the regional high-resolution sequence stratigraphic framework by Lin et al. (2019). The studied stratigraphic intervals are within Parasequence Set 8 of Lower Gallup Sequence 4 and Parasequence Set 16 of Upper Gallup Sequence 7, separated by the upper bentonite layer (Lin et al., 2019). Three sections presented in this study represent the most storm-dominated deposition and the spatial facies variation. Photographic panoramas also allow for analysis of lateral and vertical distribution of storm deposits, as well as measuring the dimensions of gutter casts.

Novel/Additive Information

Storm-floods represent a critical and effective mechanism of sediment transport in the shallow marine realm but the link to rivers may be under-appreciated. A new type of delta is proposed herein, termed 'storm-flood-dominated delta', which is defined to be deposited predominantly by storm-flood processes. This newly defined type of delta highlights storms as a key element in deltaic systems that should be added to the current ternary deltaic classification. This paper documents depositional facies of storm-flood-dominated deltas, investigates the critical diagnostic facies of gutter casts and their formative mechanisms, and presents a possible depositional model of storm-flood-dominated deltas.

References

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