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Is dissolved salt necessary for the formation of continental shelves?

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Nearly all continents and large islands such as Papua New Guinea are surrounded by continental margins, each composed of a shelf, slope and rise. Here we consider siliciclastic margins constructed by fluvial input of terrigenous sediment, rather than carbonate platforms. Continental shelves tend be wider along passive margins and narrower along active margins, and in some cases bulge seaward in the vicinity of deltas. Shelves are nevertheless bench-like morphologies which continue from delta to delta without break. At stratigraphic time scale, this gigantic morphology has been interpreted as coastal plain that was exposed at low stand, but subsequently drowned during transgression. But even though near-stillstand has prevailed for the last 6000 years, there are many locations where shelves or protoshelves are being actively constructed by subaqueous morphodynamic processes, as manifested by offshore-migrating clinoforms. In the case of large freshwater lakes such as Lake Malawi or Lake Baikal, however,deltas appear as isolated protrusions with no connecting bench-like clinoforms. Here it is hypothesized that the difference between the two cases is mediated by dissolved salt. In so far as freshwater lakes present no density barrier associated with dissolved salt, rivers carrying suspended load show a strong hyperpycnal tendency, according to which they deposit their gravel and sand at deltas, and then plunge to form turbidity currents that carry mud directly into deep water. In the case of the ocean, however, the suspended sediment concentration required for river water to be heavier than standard seawater is 43,000 mg/l, a value that is only rarely exceeded in nature. As a result, nearly all river flows into the ocean are hypopycnal, forming surface plumes rather than plunging. As mud rains out in relatively shallow nearshore water, it can deposit a platform of terrigenous sediment to a height that is modestly in excess of wave base. This mud can then be mobilized by combined wave-current flows, delivered seaward and then deposited to form an offshore-migrating clinoform. This same sediment can be redistributed by alongshelf processes, so forming benches connecting deltas. It is thus hypothesized that continental shelves possess an aspect that is unique to seawater.

Keywords: continental shelves, deltas, turbidity currents, seawater, fresh water, siliciclastic margins