

## **Up-slope migrating bedforms in a proglacial Gilbert-delta: Cyclic steps from river-derived underflows?**

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Here we report and describe short-wavelength, backstepping strata ascribed to as cyclic steps in a well-constrained depositional and bathymetric setting. These sedimentary structures are located on a Gilbert-like proglacial fluviodeltaic system with steep- foresets and top-lying, flat-based topsets. This deltaic system, Upper-Pleistocene in age, and emplaced near Sept-Îles (North Shore of the Gulf of St. Lawrence, Québec, Canada) experienced a rapid ice retreat following the Last Glacial Maximum and a subsequent glacio-isostatic rebound.

Packages of hummocky-shaped backstepping cross strata, cropping out in the lower part of the delta front, consist of sand, gravels and sand intraclasts forming top cut-out turbidite beds. These beds are bounded on their extremity by 10-20 m spaced, seaward-oriented, concave-up erosion surfaces. The whole structure is seaward-dipping with a mean slope of 11-12°. Sand and gravel beds onlap upslope on concave erosion surface while they are sharply truncated by them downslope. Above, deep asymmetrical scours carved into those backstepping strata, interpreted as chutes-and-pool, display a coarse and mainly massive infill mode. Above, immediately below the topset truncation, well-stratified upslope-climbing cross beds are interpreted as antidunes.

The present contribution deals with very shallow (<15 m) depositional palaeo-bathymetries of these short-wavelength backstepping cross strata inferred as being cyclic steps. We explore here the link between proglacial river effluent and cyclic steps development on the delta front as plunging underflow without mouth bar collapse as triggering process. We rather invoke a process known as tidal drawdown that has drastically increased both the suspended-sediment concentration and bedload of the river effluent that thus directly plunged down the delta slope. Finally, we propose that the very low aspect ratio (wavelength/height) of these cyclic steps, forming an end-member amongst cyclic steps documented in the literature, is directly linked with the steep depositional slope and grain-size of the involved material.