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The atypical fan-delta of the Burdekin River (Australia), implications for hydrogeology

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Fan deltas are often conceptualised as features formed along high relief environments marginal to lakes and seas. While this is true for many such systems, we present evidence for a comparatively low relief coastal fan delta formed by the Burdekin River of northern Queensland. Previous studies have concentrated on the Holocene coastal fringe of the system, defining it first as a wave or mixed wave-tide delta and more recently as tide dominated. However, when viewed as a whole, the delta is clearly river-flood dominated, as documented by Fielding *et al.* (in press) and forms a fan delta. It is the delta as a whole that is the focus of this abstract.

The Burdekin River descends 150 m from the Hervey Range, part of Australia's Great Escarpment, approximately 130 km upstream of the delta mouth. For approximately 70 km it flows through an incised valley before debouching onto the coastal plain at an elevation of $\sim$50 m. A major constriction in the present channel occurs where the river passes through two hills at a location known as *The Rocks* (elevation $\sim$20 m). From this point to the mouth of the river is a further 30 km, characterised by a sub-aerial gradient of 1:1500, or 0.038 of a degree. This gradient is very low compared to other documented fan deltas and most alluvial fans.

Despite the low gradient and long transport distance from the scarp, the sediments of the Burdekin Delta are dominated by coarse sediments. Analysis of the logs from 73 bore holes show that the succession consists of 37% gravels and 32% sand. The predominance of coarse-grained, especially gravely, sediments indicates that high energy river-flood processes dominated sedimentation. The presence of 7% gravely muds indicates that some mass flow deposition also occurred, associated either with channel

or levee bank collapse or localised high density flows. Fine-grained sediments make up 29%, with organic-rich (marginal marine) sediments 1%. The gravels are composed of subrounded to rounded clasts of volcanics, intrusives, and metasediments. The sand grains are composed of angular to subangular quartz and feldspar. Some quartz grains preserve crystal terminations, which indicate limited weathering and rapid erosion of the source area and comparatively short transport distances.

The combination of textural and compositional immaturity with low gradients and long transport distances is consistent with sediment transport occurring during episodic high volume, bed-load dominant flows of short duration. The Burdekin River floods peak at over 35,900 cumecs during floods triggered by very intense, short-lived cyclonic rainfall events. This is comparable to the peak flows of rivers such as the Rhine or Mississippi. However, unlike those rivers, the major discharge events are of very short duration, rarely longer than a few days, compared to tens of days for the Rhine and over a hundred days for the Mississippi. For much of the year the flow in the Burdekin is close to zero.

The distributary system of the Burdekin Delta consists of an upper delta plain with a single entrenched low sinuosity braided channel. Several fossil distributary lodes are preserved on the upper plain. The lower delta plain consists of a series of active and inactive distributaries associated with the current or sub-recent complex of channel estuaries, tidal flats, and accretionary beach ridges. This morphology closely resembles that of classic fan systems where the upper fan lobes are entrenched when deposition shifts further down the flow system. Progradation is occurring onto a shallow water shelf. Despite its low gradient, the Burdekin Delta has many of the characteristics of alluvial fan deltas found in higher relief areas.

The fan-delta geometry of the Burdekin has major implications for modelling of groundwater flow in the irrigation region, whether for resource estimation, artificial recharge calculation, or managing salt water intrusion. Previous interpretations, emphasising the presence or absence of interstitial mud, have represented the succession as mud-dominant, with isolated channel sands. A fan-delta geometry implies the reverse, with isolated lenses or drapes of mud locally separating stacked bodies of gravely sand. The greatest variability in hydraulic properties is likely to be down-fan, with variations of approximately 14 orders of magnitude predicted. This contrasts with conventional deltas where variability is greater across the distributary system.

Reference

Fielding, C. R., Trueman, J. D., and Alexander, J. In press. Sedimentology of the modern and Holocene Burdekin Delta of north Queensland, Australia – controlled by river output, not waves and tides. *In* Bhattacharya, J. and Giosan, L. (eds.). Deltas.

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