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Upper-flow-regime bedforms at the toe of a prograding gravel beachface: sedimentary evidence for supercritical backwash flow and chute-and-pool conditions

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Upper-flow-regime bedforms and associated sedimentary structures are fairly common in various ancient and modern settings, yet field examples of beach and nearshore strata internally dominated by sedimentary structures arising from such flow conditions are poorly documented. This outcrop-based study contributes to fill this information gap and presents the first detailed analysis of depositional signature of possible upper-flow regime bedforms formed within a mid-Pleistocene prograding gravel beach in eastern central Italy.

A detailed sedimentological investigation of a depositional-dip exposure revealed a wide spectrum of beachface and shoreface deposits produced by wave- and storm-related processes along a gravelly-dominated strandplain. These sediments display a distinctive shallowing-upward trend including, from bottom to top, the following facies associations: i) the distal upper-shoreface, composed of alternating plane-parallel laminated and wave ripple cross-laminated sandstone beds; ii) the proximal upper-shoreface, composed of interfingering conglomerate-sandstone units emplaced into broad concave-upward erosional troughs; and iii) the beachface, composed of wave-worked clinostratified conglomerates.

Based on comparison to strata produced by flume experiments, the range of scour and fills observed in the proximal upper-shoreface facies association share common characteristics with those emplaced under chute-and-pool conditions by flow transformation from supercritical to subcritical. The depositional signature in the proximal upper-shoreface is dominated by an amalgamation of sediment wedges bounded by 30–50 cm-deep and 2–5 m-long concave-up erosional troughs. Sediments deposited in these troughs include: i) a pebble-grade conglomerate lag some decimetres to one-clast thick along the landward margin of the basal scour; ii) a later infill by an asymmetrical bedform showing a continuous stack of onshore-dipping sandy laminae that onlap onto the landward side of the troughs and fan out in a streamwise direction to greatly thinned and finer grained, flat and low-angle laminae; and iii) an interval of wave ripples superimposed locally on the larger-scale bedform.

These peculiar asymmetrical bedforms are interpreted to have been formed at the abrupt break in slope between the gravelly beachface and the sandy upper-shoreface (i.e. near the surf–swash transition zone) by storm-intensified, backwash flows. These flows rapidly accelerated and became thinner, supercritical and erosive moving down the steeply dipping beachface (chute), experienced abrupt deceleration and flow thickening passing through an upstream migrating hydraulic jump in the trough at the toe of the beachface (pool), and then waned to thicker and subcritical conditions just downstream of the hydraulic jump, initiating deposition of upstream-dipping (backset) sand laminae on the downflow side of the trough and of upper-stage flat sand laminae further downstream. Due to erosion by supercritical flows, fairweather wave ripples are regarded as having low preservation potential and only remnants of them are preserved in the sedimentary record of the proximal upper-shoreface, where amalgamated packages of storm-related backsets volumetrically predominate.

The rhythmic depositional theme in the distal upper-shoreface facies association suggests that these sediments were preserved on an event-by-event basis, with plane-parallel sandstones representing the seaward limit of the storm-related bedforms described in the proximal upper-shoreface and the wave ripples representing the ensuing reworking of the seabed by fairweather wave processes.