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Supratidal beach deposits in Giralia Bay (Exmouth Gulf, Western Australia) – a record for past tropical cyclones?

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Past coastal flooding events related to tropical cyclones (TCs) and tsunamis may be inferred from geomorphic and sedimentary archives, i.e. in the form of particular landforms (beach ridges, washover fans), deposits (washover sediments in lagoons) or erosional features. In Giralia Bay, southern Exmouth Gulf (Western Australia), sandy ridge sequences in supratidal elevations form the landward margin of extensive mudflats. The formation of these ridges, as in other mudflats of NW Australia, is assumed to be mainly driven by TCs, although their relation to depositional processes and inundation levels during spring tide conditions, exceptional precipitation and discharge events, and storm surges needs to be clarified. Based on a simple process monitoring setup using a time-lapse camera and pressure gauges, geomorphological mapping by means of unmanned aerial vehicle survey and structure-from-motion techniques, as well as sedimentological and geochronological investigations, this study aims at (i) establishing the chronostratigraphy and reconstructing the formation of the supratidal beach deposits; (ii) identifying the most important driving processes involved in their formation; and (iii) understanding their significance for recording past TC activity.

Sediment trenches cross the youngest, most seaward part of the ridge sequence. At the base of the sedimentary succession, sandy units are interbedded with mud layers, reflecting depositional conditions similar to the present distal mudflat. In the upper part of the ridges, mud intercalations recede, and sand layers of varying grain size distribution and mineralogical content dominate. Younger sediment layers clearly attach to older ones documenting the stepwise accretion of the ridges onto the mudflat. Muddy intercalations in the upper part of the succession are interpreted to represent deposition in locally restricted swales. Monitoring covered the time period between August 2013 and 2015 and capture an exceptional precipitation event in April/May 2014 as well as a considerable storm surge during TC Olwyn in March 2015. While this data suggests that tidal processes have only limited effects on ridge activity, sediment transport, erosion and deposition seems to be driven by both storm surges induced by TCs and high magnitude precipitation events causing surface discharge. The accretionary sand units are thus assumed to represent phases of morphodynamic activity during (in most cases) cyclone-induced flooding since the mid-Holocene. Thereby, OSL dating results show that ridge activity is recorded in a roughly decadal resolution and over historical as well as prehistorical/Holocene timescales. Beach ridge evolution over a millennial time scale is also indicated by the landward rise of the sequence possibly corresponding to the mid-Holocene sea-level highstand of WA of at least 1-2 m above present mean sea level.