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Particle Size Evidence of Intertidal Elevation: A Basis for Quantitative Sea-level Reconstruction

Andrew Plater (1), Hayley Mills (2), Weiguo Zhang (3), and Chenyin Dong (3)

(1) University of Liverpool, Geography, Liverpool, United Kingdom (gg07@liverpool.ac.uk), (2) British Oceanographic Data Centre, Brownlow Street, Liverpool, United Kingdom, (3) State Key Laboratory for Estuarine and Coastal Research, East China Normal University, Shanghai, China

The relationship between particle size distributions and bed elevation within the tidal frame is controlled largely by hydroperiod and proximity to tidal ingress. Here, the upper part of the intertidal zone is characterised by poorly sorted, near symmetrical, platy- to mesokurtic, fine-grained particle size distributions due to particle settling from suspension as the tidal flow velocity decreases to high tide slack water. Indeed, an elevational or spatial gradient in particle size distribution can be observed whereby shorter hydroperiods (higher elevations) are accompanied by slower and more variable flow velocities. However, this gradient may become complicated by creek networks, whereby particle size can be observed to decrease away from creek margins, or extant vegetation that increases bed friction. Unvegetated, planar tidal flats in the Yangtze estuary offer an ideal test bed to explore evidence for a quantitative relationship between particle size distributions and bed elevation within the tidal frame. Such a relationship would then serve as an effective proxy for tidal level preserved within sediment cores, and thus a means for reconstructing past sea level. This principle is based largely on ecological transfer function-based reconstructions of Holocene sea level from foraminifera and diatoms. Surface sediment samples were collected along three transects extending eastwards from Chongming Island in South Branch channel of the Yangtze estuary. Sample positions relative to the high water mark were determined using RTK surveying, and particle size analysis was undertaken using laser granulometry. Unconstrained cluster analysis, based on unweighted Euclidean distance, was undertaken on the particle size classes at 0.25 phi intervals (up to 50 size bins) as well as Udden-Wentworth size classes (6-7 size bins). All three transects demonstrate a good clustering of particle size classes with distance and elevation, i.e. sites that are higher within the tidal frame and closer to the high water mark are characterised by higher percentages of clay and silt grades. Distance and elevation show a strong negative correlation for all transects (r2: -0.88 to -0.97), whilst cluster order is positively correlated with distance (r2: 0.41 to 0.80) and negatively correlated with elevation (r2: -0.68 to -0.75). A weighted average (WA) transfer function analysis of the relationship with elevation was then undertaken to examine how the predictability of elevation changes according to the number of data points and the number of size classes. For the largest dataset (middle transect), the WA elevation transfer function offers good predictability but limited precision (r2jack c.0.76, RMSEPjack c.0.60 m), both of which increase as the number of size classes is reduced. The smallest dataset (north transect) offers reduced predictability and precision (r2jack c.0.45, RMSEPjack c.0.60-0.90 m). Although the precision of these transfer functions is disappointing, due to the relatively widespread occurrence of size classes with elevation and distance, the r2jack values compare very well with ecological transfer functions used for reconstructing past tidal level. It is proposed that, in the absence or poor preservation of microfossils, particle size distributions offer a means for reconstructing trends in past sea level from dated sediment cores.