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Hydraulic Sorting of Heavy-Mineral Grains by Swash on a Medium-Sand Beach

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Abstract

Hydraulic sorting of detrital mineral grains in the swash zone was investigated using data on sedimentology and flow dynamics obtained from Fishermans Beach, on the east coast of Australia. The beach is characteristically reflective, displaying a steep beach face composed of medium sand and virtually no surf zone. Samples were taken from two beds enriched in heavy minerals, and from the adjacent beds above and below. The mineralogy of the samples was determined, and measurements of grain size and settling velocity were obtained. The heavy-mineral grains had both a smaller intermediate diameter and a smaller settling velocity than the light-mineral grains; the difference between the two mineral types was typically in the range 0.25-0.50 □ and 2.0-2.5 cm s^{-1}, respectively. On the basis of these sedimentological measurements alone, any one of three mineral sorting mechanisms could provide a feasible explanation for the development of the heavy-mineral-enriched beds: suspension sorting, entrainment sorting, or shear sorting. A numerical model for swash, based on the nonlinear shallow-water wave theory, is used to provide a quantitative description of flow dynamics in the swash zone at the time the heavy-mineral-enriched beds were formed. For the probable wave height responsible for producing the enriched beds, modeled maximum flow velocity and bed shear stress at the mid-swash position reached 3.5 m s^{-1} and 79.51 dynes cm^{-2}, respectively. Given the shallow water depths and the lack of sorting in the horizontal direction of flow, suspension sorting does not seem to be of overriding importance at Fishermans Beach. The large bed shear stresses seem to also preclude entrainment sorting, because for most of the time all mineral types are predicted to be in motion. This contrasts with previous studies on finer-grained beaches, where entrainment sorting was favored, and suggests that beach type may play a role in determining the sorting mechanism operating at a particular location. Shear sorting was found to be feasible within the modeled flow constraints at Fishermans Beach, but it does not provide an entirely satisfactory explanation for the observed mineral sorting patterns. We contend that the inability to unequivocally identify the true sorting mechanism is more a reflection of our poor understanding of the operation of these sorting mechanisms, particularly within the swash zone, rather than an indication

that any of these mechanisms are physically inoperative in the swash zone.

GeoRef Subject

sand Australia Australasia clastic sediments New South Wales Australia sediments sedimentation

Index Terms/Descriptors

Australasia | Australia | beaches | clastic sediments | coastal sedimentation | detrital sedimentation | dynamics | flows | grain size | heavy minerals | hydraulics | New South Wales Australia | numerical models | processes | sand | sedimentation | sediments | sorting

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