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DISCUSSION

Discussion of: Bird, E.C.F., 1996. Lateral Grading of Beach Sediments: A Commentary. *Journal of Coastal Research*, 12(3), 774–785.

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In the introduction the author says, with reference to the experience gained from Chesil Beach in the U.K. and Hawke Bay Beach in New Zealand, as follows: "several factors have contributed to lateral grading, and there is no single, simple explanation for the phenomena". This is repeated in the conclusion of his paper.

Examples on the complexity of the problem compare the Chesil and Hawke Bay Beach, both gravel beaches. Generally grading is influenced by attrition, sorting developed by longshore drift, wave exposures, shoreline configuration, offshore bottom characteristics (steepness, materials) and the nature and rate of supply of beach materials. The author examines these factors in relation to results from the two cases.

No doubt factors like grain size and gradations, wave exposures by magnitude and direction, material characteristics, longshore and crossshore configurations are determining factors, but large variances in grain sizes of beach materials (sand to gravel and cobble stones) may cause deviating results, so that *e.g.* one grain size may move predominantly "northward" while another moves "southward" as a result of deviating wave action and tidal elevations.

If grain sizes are limited to "fine" and "medium" sands (0.15 to 0.4 mm), things are more simple. Wave energies by magnitudes and directions, off-shore slopes, being important for backpassing of material which washed out during storms, become important parameters. As an example of that the writer is now referring to a (normal) case of that nature.

Figure 1 shows results of analyses of grain sizes on the Danish North Sea Coast, a total length of 300 km sandy shores. Twenty independent winter beach samples picked in the surf zone were mixed and analyzed at each particular location. The results are shown in Figure 1 (Bruun, 1954). The North Sea Coast is exposed to heavy to medium wave action from the western quadrant. Tidal range varies from 0.2 m (northen section) to about 2 m (southern section). The results were summarized as follows in Bruun (1954), references added in the text:

(a) The particle size is largest on the coasts, including the headlands, that are subject to the severest action and on the eroding coasts, i.e. where the beach profile is usually steepest. The largest particle size is found between Lodbjaerg and Hanstholm, the maximum size being 0.31 mm on the open coast and 0.32 mm on the windward side of the jetty at Hanstholm.

(b) The particle size is smallest on the coasts subject to the weakest action, including the bays, and in places where progradation occurs, in this case areas where the beach is flattest. The smallest particle size, or 0.17 mm, occurs at the inmost part of Jammer Bay. Incidentally, the same minimum particle size was found in some investigations made on the California coast in the U.S.; see Bascom (1951, p. 874).

(c) The particle size decreases from the assumed nodal point at Lodbjaerg-Stenbjaerg and southwards. Likewise the particle size decreases towards the north (Grenen), but not so regularly, on account of the bays. There is, however, less reason to assume that the above mentioned decrease is due to the material being "worn" rather than to the grading caused by the transport method; see U.S.A.C.E., B.E.B. (1951, pp. 67–71).

(d) The uniformity coefficient (d 60%/d 10%) fluctuated between 1.2 and 1.9, the figure being generally greatest for the largest mean diameter.

A detailed petrographic analysis of the shape of the particles may give information about the distance travelled; see U.S.A.C.E., B.E.B. (1952, p. 14).

Largely, these 45-year-old Danish results confirm some of the findings by the author. That is:

(1) Grain sizes are largest where beach exposure is heavier. This is due to meteorological, wave mechanics, coastal geomorphological (longshore and crossshore) features.

(2) Grain sizes generally decrease in the direction of the littoral drift, but may increase, if exposures and bottom

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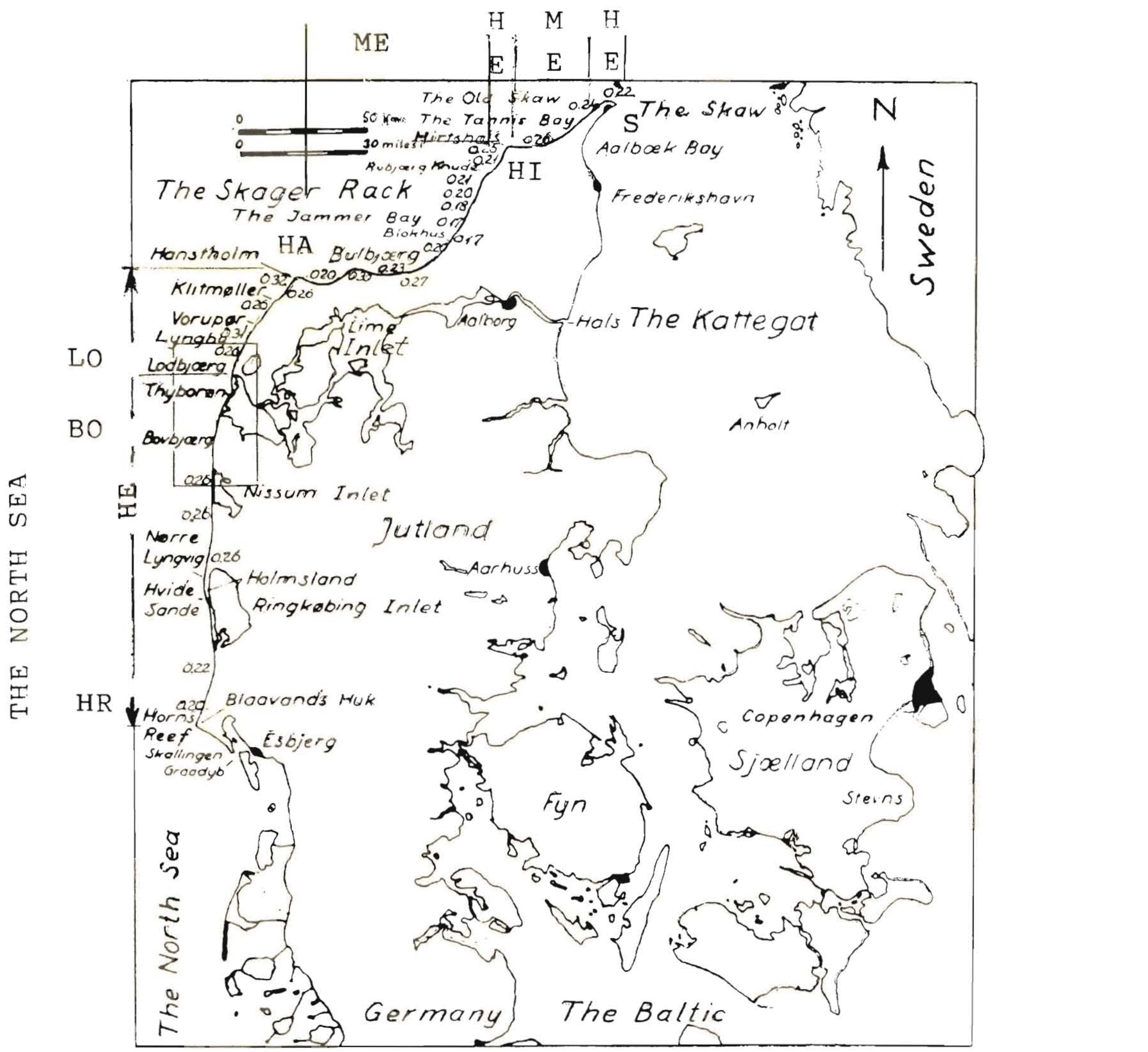

Figure 1. Particle size of sand along the West Coast of Denmark (BRUUN, 1954). HR = Horns Reef, BO = Bovbjaerg, LO = Lodbjaerg, HA = Hanstholm, HI = Hirtshals, and S = Skagen (The Skaw). Exposures: HE = heavy exposure and ME = median exposure. Drift on HE-sections ~ 1×10^6 m^3/year; drift on ME-sections ~ 0.5×10^6 m^3/year.

steepness increase, assuming that coarser material (gravel-size) is available.

(3) The steepest beaches had the coarsest grains.

Adding results from Figure 1:

(4) Headlands, like HA = HANTSHOLM, HI = HIRTSHALS, attract the larger sizes due to concentration of wave energies.

(5) A *zero area* (nodal area for littoral drift, like LO = Lodbjaerg) in Figure 1 which erode, have larger grain sizes. Grain size decreases in either direction away from the nodal area, if exposures as in the case of Figure 1 by westerly storms, decrease. On the about 15 km long shore from LO past the headland BO (Bovbjaerg) which is a moraine cliff, to HR (Horns Reef = a sand reef) erosion which is predominant on the northernmost 100 km of said shore, gradually is replaced by stability and even slight accretion.

(6) In addition to the above mentioned, it was observed that heavy minerals (magnetite) most showed in the upper uprush zone of the eroding shores, particularly following storms. This reveals the importance of fall velocities of the grains.

Referring to the author's result that the larger grains (gravel) migrated faster in the uprush zone than the smaller grains, it was observed on the Danish North Sea Coast, where the content of gravel in the sands is only a few per cent, that the separation of grain sizes occurred under swell action and during or following storms in the updrift corner of groins producing a steep accumulation or gravel ridge which was very unstable. It was also noted that gravel traveled faster than sand in the uprush zone where it tended to stay, as its fall velocity was of the order of 2 cm/sec against 1–2 mm/sec (0.1–0.2 cm) for sand. Tracer experiments with different colors will be able to elucidate the problem further.

The writer in paragraph (d) of the conclusion (1954) says that the uniformity ratio (= d 60%/d 10%) varied from 1.2 to 1.9, increasing with increasing grain size. This is a normal feature for a long shoreline as on the Danish North Sea Coast.

The author provided us with an interesting review of basic principles on sediment behavior on beaches with a strong variation in grain sizes.

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