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Discussion

Comment on "Wave climate, sediment supply and the depth of the sand–mud transition: A global survey" by D.A. George and P.S. Hill [Marine Geology 254 (2008) 121–128]

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ABSTRACT

An extensive dataset of sediment grain size and wave conditions in the Ebro Delta (NW Mediterranean) is used to verify the local scale applicability of the work of George and Hill (George, D.A., Hill, P.S., 2008. Wave climate, sediment supply and the depth of the sand–mud transition: a global survey. Mar. Geol., 254, 121–128) on the definition of the sand–mud transition (SMT). The proposal of using either a mean grain size of 63 µm or a mud content of 25% to define the presence of the sand–mud transition was locally verified (96% well-classified of a total of 382 samples). However, determining the depth of the sand–mud transition (h_{SMT}) based only on the wave height shows several practical and conceptual inconsistencies that could be partially solved by including the wave period into the equation. On the Ebro Delta shelf, the use of the across-shelf distribution of skin friction accurately predicts the h_{SMT}.

1. Introduction

This note is a comment on the paper by George and Hill (2008), hereafter referred to as GH08, which proposes a method for predicting the depth of the sand–mud transition (h_{SMT}) of wave-dominated shelves. First, GH08 defined the sand–mud transition (SMT) as the boundary where mean grain size is 63 µm or the percentage of mud is 25%. Second, it compiled the depth of sand–mud transition from 17 sedimentary systems around the world to establish the linear relationship between h_{SMT} and the mean significant wave height (H_s).

The definition of a simple, general and statistically significant relationship between the sediment grain-size distribution across coastal shelves and some parameters characterizing environmental conditions has been tackled in different ways, based on the assumption of the existence of an equilibrium distribution (Niedoroda et al., 1985; Larson, 1991; Horn, 1992; Dunbar and Barrett, 2005). The method proposed by GH08 is, in fact, one specific application of the across-shelf equilibrium grain size distribution. Results of GH08 indicate that the h_{SMT} of wave-dominated shelves can be reasonably predicted ($r^2 = 0.84$) using H_s. However, the calculated relationship gives a range of variation of h_{SMT} of about 40 m with a 95% confidence interval (Fig. 5 of GH08). This means that a predicted h_{SMT} of 25 m water depth could range between 5 and 45 m water depth with a 95% confidence interval. Furthermore, the observed h_{SMT} of sedimentary systems used to establish the equation ranged between 5 and 55 m water depth. Therefore, the predictive and general character of the equation is doubtful, suggesting that additional parameters should be taken into account to improve the fit. Secondary parameters influencing the location of the h_{SMT} are hardly discussed by GH08, although they do mention the potential influence of sediment loads from rivers, shelf width and slope, currents and shoaling transformations of waves. They also finally recognize that storm wave parameters may be more appropriate than mean wave parameters for predicting h_{SMT}.

The objective of this note is to carry out a site-specific, highly detailed verification of the global equation proposed by GH08 to evaluate its small/local scale applicability and to introduce new insights into some of the secondary parameters that the paper mentions (mainly wave characterization). The extensive data set (sediment texture and waves) existing in the Ebro Delta area (NW Mediterranean), one of the study sites used in the GH08 paper, is used for this discussion. The specific points to be addressed are: 1) the equivalence between mean grain size and mud content as proposed by GH08 to define the sand–mud transition, 2) the accuracy of the GH08 h_{SMT} prediction method at a small scale, and 3) the implications of using H_s to predict h_{SMT}.

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2. Depth of the sand–mud transition in the Ebro Delta

The spatial distribution and temporal changes of grain size of surface sediment around the Ebro Delta was described by Díaz et al. (1996) and Guillén and Palanques (1997) using the sediment samples illustrated in Fig. 1. Those authors identified the sand–mud transition (mean grain size = 63 µm) in the delta at a water depth between 6 and 18 m, depending on the location along the delta coast. The shallowest locations of the SMT are located at the present river mouth and at both sides of the northern and southern spits, whereas the deepest ones are in shelf areas influenced by the presence of ancient delta lobes (Guillén and Palanques, 1997).

Fig. 2 shows the sediment mean grain size versus the corresponding mud content for all available samples on the Ebro Delta shelf (382 samples). As expected, the increase in mud content is accompanied by a progressive decrease in mean grain size, which can be fitted to a logarithmic function with a coefficient of determination, r^2, of 0.88. According to these data, the criteria proposed by GH08 to define the existence of an SMT from sediment textural parameters (based on both mean grain size and mud content) are simultaneously fulfilled by most of the samples. Only 15 samples (4%) indicate different conditions. From these results, we can conclude that GH08's decision to use the mean grain size or the mud percentage equally to define the SMT is very accurate for shelf sediments in a deltaic environment such as the Ebro Delta.

In order to apply GH08's proposal for defining h_{SMT} from sediment grain size data, Fig. 3 shows the across-shelf distribution of the two required parameters (mean grain size and mud content) of surface sediment samples in the Ebro Delta. The application of the GH08 criteria (d_{50}<63 µm, % mud>25%) to these curves results in a depth of 11.85 and 12.22 m, respectively. The two parameters provide equivalent depths for the Ebro Delta (~12 m), which are much shallower than the ones reported in the area by GH08 (30 m, Table 2 of GH08).

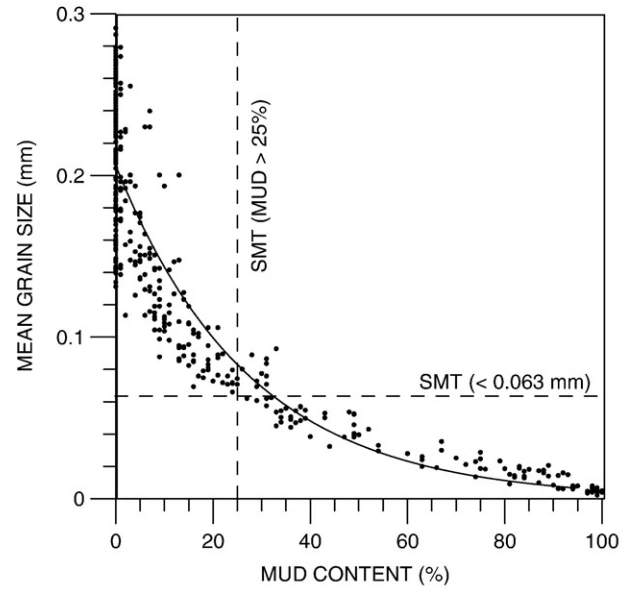

Fig. 2. Mean grain size versus mud content for sediment samples on the Ebro Delta shelf. Dashed lines show the sand–mud transition (SMT) boundary using both sedimentological criteria.

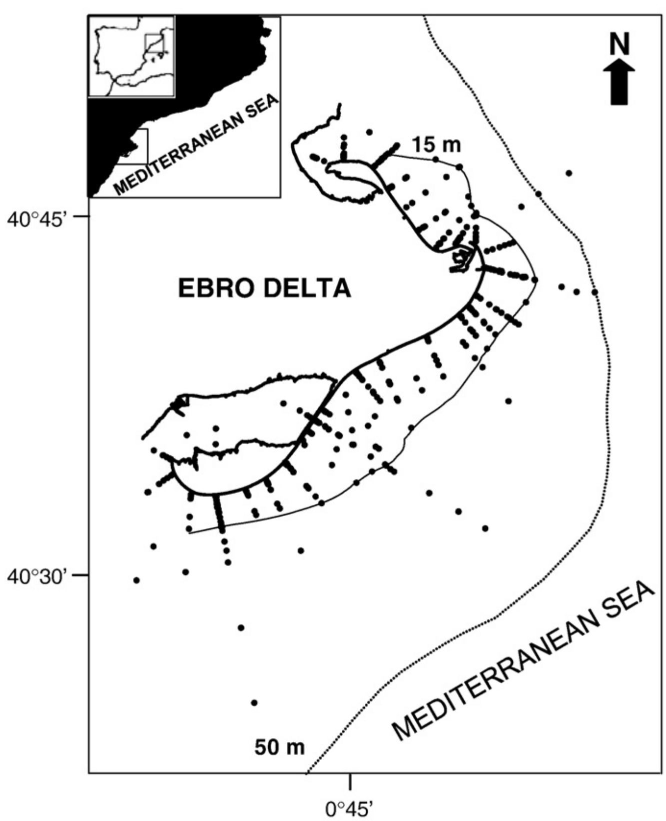

Fig. 1. Location of surface sediment samples on the Ebro Delta shelf (Spain, NW Mediterranean).

3. Depth of sand–mud transition and waves

Once the h_{SMT} definition from sediment data proposed by GH08 has been applied to the Ebro Delta, the remaining part to be validated is its prediction by using wave data. GH08 propose a predictive relationship for h_{SMT} $(=(18.5\pm10.8)\ H_s+(5.2\pm17{:}2))$ where the significant wave height, H_s, is the only variable characterizing the wave climate. The application of the GH08 relationship to Ebro Delta wave conditions results in an h_{SMT} value of 20 m, which is 50% shallower than the measured value reported by GH08 (30 m) and 67% deeper than that obtained from our intensive sediment grain size data set (12 m). It must be stressed that although both measured h_{SMT} values lie between intervals associated with GH08's predictive formula, these intervals should not be accepted. The reason is that, according to GH08, predicted h_{SMT} is 20 m but could vary between 0 (in fact it strictly predicts a negative value) and 45.8 m, which would imply that for such a huge range no predictive relationship should be needed.

We believe that this wide range in the prediction may lead to inconsistent results and could even question the validity of a global relationship for predicting h_{SMT} by using the mean H_s. First, the assumed correlation between wave height and period introduced by GH08 is not necessarily true in all the cases, but will depend on the scale of the analysis. As an example, Fig. 4 shows simultaneous Tp and H_s values for waves recorded off the Ebro Delta during the period 1990 to 2004, clearly showing the absence of such a Tp–H_s correlation. More importantly, even if H_s and Tp are well correlated, as GH08 states, the simple use of H_s for a global predictive formula implies that the Tp–H_s relationship will be the same regardless of the site where the transition is to be calculated. According to this, a given H_s value in the Mediterranean (e.g. the Po or Ebro Deltas) should have the same associated period as in the Pacific (e.g. Eel) and, in consequence, the application of GH08's relationship will predict the same h_{SMT} for a given H_s for both short- and long-period wave environments. However, for a given H_s the longer the wave period, the larger the