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COMMENT AND REPLY ON

THE NORTH SEA AND NORTHEASTERN BERING SEA: A COMPARATIVE STUDY OF THE OCCURRENCE AND GEOMETRY OF SAND BODIES OF TWO SHALLOW EPICONTINENTAL SHELVES

COMMENT

A. H. STRIDE[1]

Hypothetical stratigraphic sections for the deposits of two tidal-current swept seas have been offered for discussion by NIO & NELSON (1982). It is apparent that their models need to be substantially improved and increased in number by taking more account of the deposits of modern seas, as well as the processes responsible for making these deposits.

First, the models must show that the early deposits were diachronous for the whole period of the relevant marine transgression, and that these were followed by deposition of the truly modern deposits laid down with respect to present sea level. For example, in the case of the Southern Bight of the North Sea, peats document the Holocene rise of sea level from a depth of almost 50 m, up to present sea level (EISMA ET AL., 1981). Tidal flat and associated shoreline deposits record a more widespread but similar portion of the marine transgression. Sand banks and supposed sand banks of deeper water taken all together around the British Isles seem to represent the whole depth range of the Holocene marine transgression. Thus, it has been argued that successive groups of these older sand banks were formed and maintained wherever conditions were suitable, but then became moribund at any site where tidal currents weakened significantly during the continuing transgression (JELGERSMA,1979; KENYON ET AL., 1981). Naturally, one doesn't expect to find the older deposit to have been laid out at all depths in each region. It is known, moreover, that as sea level rose during the transgression there could be much erosion of the earlier Holocene deposits at some sites, as, for example, of the tidal flat deposits of the Southern Bight of the North Sea (EISMA ET AL., 1981). Even the underlying peats may be missing in regions of intense scour.

Secondly, for the deeper water deposits overlying the basal peats and tidal flats, doubt must be cast on the proposal by NIO & NELSON (1982) that there is a lower sandy unit consisting of, 'sand bank complexes', overlain by a more extensive upper sandy unit consisting 'of a lateral and vertical succession of different sand wave generations'. Thus, it is know in modern tidal seas that where sand waves occur on the sand banks their presence is in keeping with the strength of the tidal currents sweeping over them. Indeed, the sand waves imply that a substantial amount of sand transport is taking place, while their profiles and the current data indicate opposing directions of sand transport on the two sides, so leading to maintenance of the crestline of the sand bank. The presence of these sand waves also implies that cross-bedding should be made during the growth of a sand bank. Such cross-bedding has, indeed, been recognised in cores (HOUBOLT, 1968; STRIDE ET AL., 1982). It follows that sand waves would also have been present during the making of the supposed 'sand bank complexes' of NIO & NELSON (1982) and cross-bedding would be present there, also. Thus, it is argued now that the lower and upper sandy units of NIO & NELSON (1982) are in reality deposits of the same age and should be shown as occurring side by side, as they do in modern seas. These deposits can be better designated as the sand bank facies (KENYON ET AL., 1981) and the sand sheet facies (JOHNSON ET AL., 1981). These two sand facies have similarities. For example, both show cross-bedding, because of the presence of sand waves. However, they also have notable differences. Thus, the sand bank facies represents sand trapped in a region of tidal currents that are more than strong enough to move it. In contrast in the case of sand sheet facies, the grain size of the sand at any site is largely in equilibrium with the associated tidal current strength. The controlling influence as to which of these two conditions applies at any point depends on the direction of net sand transport, which is largely determined by the tidal currents and thus by the basin shape and dimensions. In modern seas these two sand facies are alternatives so that in a stratigraphic section they need never lie one on top of the other, unless the net sand transport directions changed in time. MIDDLETON (1973) mentioned the existence of alternative facies in general

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terms, in his discussion of Walther's Law of correlation of facies.

At least two markedly different stratigraphic models for the sand bank facies are required. In each the sequence may begin with the low sea level land and tidal flat sediments, as mentioned already. For example, when offshore sand banks, that have grown on top of these deposits, eventually become subject to tidal currents that are too weak to generate sand waves on them, the sand banks will be reduced in height and have lower slope angles because destructive forces are then dominant. Ultimately, some at least of these offshore moribund sand banks are likely to be covered in mud. In contrast, when estuarine sand banks reach up to a stable sea level their upward growth ceases but they can continue to grow in width or length. In time they are expected to converge by lateral growth into a broad body of sand and to be overlain by tidal flat deposits and ultimately by land deposits.

At least one stratigraphic model is required for the sand sheet facies. These deposits may overlie the basal deposits of peat and tidal flats of lower sea levels, if these have not been scoured away in part or whole (EISMA ET AL., 1981). For the case where the sand sheet facies is then subject to progressively weakening tidal currents there will be a lateral migration of structure and grain size zones equivalent to upwards fining in grain size of the sands at any site. Ultimately, sand could give way upwards to deposition of mud. Further information and ideas about this and some of the other sand facies have been given elsewhere (STRIDE ET AL., 1982).

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I wish to express my appreciation to Messrs. R. H. Belderson and N. H. Kenyon for time spent in discussion of an early draft of this comment.

REPLY

S. D. NIO[1]

The comments given by STRIDE illustrate the difference in approach when constructing modern process-response models and geological facies models. Although such is not clear from the title of our paper, the main purpose of the paper was to give a better insight in ancient analogues. For this purpose only a general and rather simplistic model was given. The elaboration of more detailed and accurate models as proposed by STRIDE was not our initial purpose but we certainly admit that such has to be done. We therefore believe that STRIDE's comments considerably improved the rather simplistic model presented by NIO & NELSON (1982). We would like to add a few aspects which are important for the validity of the model.

First, the geologic models are only valid for periods of marine transgressions. It seems that the formation of offshore tidal sand wave complexes was related to a rise of sea level (NIO, 1976). More important in geology is their preservation potential which is relatively high during such periods of active sea level rise.

The extent of these tidal sand waves in sedimentary basins is related to the basin morphology and the rate of basin subsidence. Development of tidal sand wave complexes can be extensive within a broad shelf basin during a widespread major transgression (e.g. the Lower Greensand), if sufficiently strong tidal currents are present.

Local development and a restricted distribution within a basin on the other hand indicate strong local tectonic subsidence and a more regional marine transgression (e.g. the Roda Sandstone). Regressive mega-sequences which represent a highly prograding system usually have thin or no inner or middle shelf deposits. Thick deposits within the shoreline-attached zone on the other hand tend to erase or modify the inner/middle shelf deposits during their progradation. Therefore, no or very little evidence of offshore tidal sand waves can be found in regressive mega-sequences.

Secondly, two stratigraphic models for the sand wave facies with a different sequential buildup can be distinguished. They represent the preserved sequence of either the aggradational or degradational stage of the sand waves (NIO, 1976; NIO & SIEGENTHALER, 1978; JOHNSON ET AL., 1981; STRIDE ET AL., 1982). These aggradational sand waves show a gently upward sloping masterbedding representing the stoss-side of the sand wave and a steeper leeside slope. The preserved internal structures of these aggradational sand waves consist of a sequence of upward oriented wedge-shaped mega-cosets along the stoss-

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side masterbedding. Degradational sand waves on the other hand display down slope oriented mega-cosets along the leeside slope (NIO & YANG, 1983). The degradational stage of sand waves generally has a higher preservation potential and will thus be observed more frequently in the geological record.

The distinction between the sand wave and sand bank facies in the field is rather difficult. STRIDE's suggestion to consider the sand bank facies as a vertical as well as a horizontal arrangement of different sand wave generations gives good criteria for the recognition of sand wave complexes in the field. More field evidence, however, will be needed to confirm this.

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