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Evolution of sand banks

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The paper by Chaumillon et al. [7] presents an interesting case where a sufficiently long record of hydrographic surveys allows following the evolution of an estuary sand bank. In contrast with offshore sand banks that were not precisely positioned on former nautical charts, such coastal shoals, that represent a threat for navigation, were mapped using horizontal sextant with an accuracy of a few metres. Since 1822, the bank experienced changes in deposition and/or erosion rates, possibly in relation with anthropic effects. The data set also demonstrates that at least the upper part of such sand banks is still in equilibrium with the present-day hydrodynamic regime, with an average progradation rate of about 6 $m\,yr^{-1}$ for the southwestern flank of the bank. The mechanisms of sand accretion are not known for the 'Longe de Boyard', but in the southern North Sea, very precise repeated bathymetric surveys demonstrated that deposition on the 'lee' side of the Middelkerke Bank happened during major storms that eroded sediment from the top of the bank [12, 13]. Along the Dutch coast, van de Meene [24] was able to date shells from internal clinoforms of shore-connected ridges, and inferred a net migration rate of 0.5 to 1 $m\,yr^{-1}$ of the 'steep' side of the ridges. Using precise radio-electrical positioning, it has also been shown that tidal dunes off the Cherbourg Peninsula, 7–8 m in height, were migrating northward at a rate of 12 $m\,yr^{-1}$ [1, 3], whereas barkhan-like dunes in the Dover Strait, 8–10 m in height, migrate towards the northeast at 70 $m\,yr^{-1}$ [2].

As a matter of fact, the long lasting debate between oceanographers considering that all large bedforms are moribund, and those in favour of active processes, has no more reason to persist. There is no doubt that, in areas where current velocity near the sea-floor reaches value of about 0.6 $m\,s^{-1}$ during spring tides, and/or if combined wave and current shear stress is sufficient for transport of any size of sand, large bedforms experience migration that can be detected through successive bathymetric surveys.

This does not mean that longer time-scales, such as the 'deglacial' sea-level rise, are inappropriate for understanding the origin of sand banks: the seismic data of Chaumillon et al. [7] clearly show that the Longe de Boyard consists of two distinct units, the uppermost being characterized by relatively steep (5°?) clinoforms, whereas the lowermost displays high amplitude, sub-parallel reflections. The authors interpret these two seismic facies as high-energy and low-energy indicators, similar to the upper- and lower-shoreface facies described by Rabineau et al. [18] on the wave-dominated shelf of the Gulf of Lions. They propose that this internal structure could correspond to a two-step scenario of bank construction, in relation with a stepped sea-level rise during the Holocene. It is however difficult to conclude considering the lack of sampling of the bounding surface between the two units. In any event, such 'cored' sand ridges have been reported from contrasted environments including the southern North Sea [6, 8, 15, 22], the New Jersey and Maryland shelves [10, 17], and the southern Yellow Sea [25]. Snedden and Dalrymple [20] proposed that such 'cores' represent in fact the initial topographic irregularities that are necessary for sand bank initiation in the Huthnance [14] numerical model. In other situations, Berné et al. [5] considered that the inner parts of sand banks, which display very different lithologies and seismic facies compared to the classical clinoforms, represent remnants of former deposits that have been 'cannibalised'. Such a process may happen when substrate is erodible and sediment flux limited, and can be compared to the migration with a negative angle of climb of transverse bedforms [19].

Time-scales of processes responsible for formation and evolution of sand bodies are in relation with dimensions of these bed forms. Small ripples are the product of almost instantaneous hydrodynamic regime and may reverse their asymmetry during each single semi-diurnal tidal cycle, small dunes (megaripples) generally represent peak current velocities during spring tides, whereas the asymmetry of large dunes (sand waves) is mainly controlled by spring tidal currents or seasonal changes of net bedload

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transport [4, 16, 21]. Large (tidal) sand banks, such as the Longe de Boyard, result in fact of the combination of these different processes, together with longer-term changes due to 'deglacial' sea-level rise and decrease in sediment supply.

Surprisingly, more than 30 years after the pioneering work of Houbolt [11], very few comprehensive description of the internal lithology of modern sand banks are found in the literature, making the interpretation of bank genesis rather speculative. Attempts to drill with geotechnical vessels such formations were largely unsuccessful [9], best results being obtained with high frequency vibrocorers [23], whose penetration is unfortunately limited to about 5 m. Considering that some sand banks are more than 50 m thick, drilling and coring should be considered as the most important objective for fully understanding sand bank genesis.

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