Marine Geology 311-314 (2012) 67–70

Contents lists available at SciVerse ScienceDirect

Marine Geology

journal homepage: www.elsevier.com/locate/margeo

Discussion

Reply to the comment on "Shoreface sand supply and mid- to late Holocene aeolian dune formation on the storm dominated macrotidal coast of the southern North Sea" by E.J. Anthony, M. Mrani-Alaoui and A. Héquette [Marine Geology 276 (2010) 100–104]

Edward J. Anthony [a,*], Méha Mrani-Alaoui [b], Arnaud Héquette [c]

[a] Aix Marseille Univ, Institut Universitaire de France, CEREGE, UMR CNRS 6635, Europôle Méditerranéen de l'Arbois, B.P. 80, 13545 Aix en Provence, France
[b] Institut Supérieur du Génie Appliqué-IGA, 38 Avenue des FAR, 30000 Fès, Morocco
[c] Université du Littoral Côte d'Opale, Laboratoire d'Océanologie et de Géosciences, LOG, UMR CNRS 8187, 32 Avenue Foch, 62930 Wimereux, France

ARTICLE INFO

Available online 28 January 2012

Keywords:
Holocene
tide- and storm-dominated coast
tidal flat
aeolian dune
shoreface
sediment supply
southern North Sea

ABSTRACT

Baeteman and Mauz (2012) raise three main points of disagreement with Anthony et al. (2010) regarding the probable age and mode of formation of an inland dune on the North Sea coastal plain of France: (1) the proposed chronology of dune formation, (2) the interpretation of the stratigraphic data from the dune, and (3) the proposed model of dune formation. The chronology proposed as an alternative by Baeteman and Mauz (2012) is not based on radiometric ages directly derived from this inland dune. Baeteman and Mauz (2012) propose a sea-level-driven mechanism of coastal evolution that fails to demonstrate how this dune was formed, and they do not provide any evidence in support of what they refer to as a 'surge drift line' involved in the formation of this dune, nor of the mechanisms of dune formation. We highlight numerous flaws in the comments and interpretations of Baeteman and Mauz (2012) that demonstrate failure to take into account recent findings on the main sediment-transport mechanisms and morpho-sedimentary outcomes characterising the shallow, sediment-rich, mixed storm- and tide-dominated macrotidal shoreface of the southern North Sea, compounded by an inadequate understanding of morphodynamic processes and sediment-supply conditions involved in coastal progradation.

1. Background

The shore deposits bordering the tide- and storm wave-dominated southern North Sea include a unique 7 km-long, 0.3–0.6 km-wide, and up to 7 m-high aeolian sand unit, the Ghyvelde dune, occurring astride the French–Belgian border in an apparently 'anomalous' inland location. In a letter published by Anthony et al. (2010), the dune has been interpreted as part of an ancestral North Sea sand flat and mudflat environment that probably formed around 3500 yr BP under a pulse of abundant sand supply resulting from the attachment, to a mid Holocene North Sea tidal-flat shore, of a shoreface tidal bank under repeated storms. Baeteman and Mauz (2012) disagree with (1) the proposed age of the inland dune, (2) the interpretation of the stratigraphic data from the dune, and (3) the proposed model of dune formation. We will reply successively to these three points.

2. (1) The age of the inland dune

Baeteman and Mauz (2012) seem to be putting undue emphasis on a so-called dune chronology that still has to be established, completely missing the main thrust of the letter which, as synthesised by its title and its keywords, concerned the mechanisms of sand supply for coastal, and especially aeolian dune, accretion from a shallow storm- and tide-dominated shoreface. We will come back to this in point (3). The ^{14}C dates reported by Baeteman (2001, 2004) are part of unpublished 'grey literature' (field excursion guides) that does not provide evidence regarding the absolute age of the Ghyvelde dune. The so-called eight 'time slices' and radiocarbon ages evoked by Baeteman and Mauz (2012), in reference to these reports, do not concern the Ghyvelde dune *per se*. We note that Baeteman and Mauz (2012) evoke a chronology that 'indicates' (quoting the authors) dune formation from ca. 5000 cal BP onwards. These authors further concede in their comments that the "chronology proposed by Baeteman (2001, 2004) is based on the stratigraphical context of the inner dune, established from a detailed palaeogeographical reconstruction of the area surrounding the dune". We understand, therefore, that data from the area surrounding the dune (in reality, Baeteman (2001) culled data from former marshlands inland of the

DOIs of original articles: 10.1016/j.margeo.2010.07.006, 10.1016/j.margeo.2011.07.004.
* Corresponding author.
E-mail address: anthony@cerege.fr (E.J. Anthony).

0025-3227/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.margeo.2012.01.001

dune, rather than surrounding the dune) were used as a proxy for the dune. Where then is the direct and irreproachable absolute dune chronology brandished by Baeteman and Mauz (2012)?

The claim that Anthony et al. (2010) dismissed the dune chronology proposed by Baeteman (2001, 2004) is unwarranted, notwithstanding the speculative character of this chronology. Anthony et al. (2010) used a limited set of four radiometric ages, and were conscious, throughout, of this limitation. Baeteman and Mauz (2012) discuss at length the material used in the four ages published by Anthony et al. (2010) and the validity of the dates, and yet ignore the caution and conditional terms employed by Anthony et al. (2010) regarding these ages (we have used italics for emphasis): "Although shell ages need to be considered with caution because of the strong possibilities of reworking by tidal channels as well as by waves, the two ages show a good age/elevation coherence that *suggests that they may*, together with the palaeosoil (Fig. 2) and one OSL age (3.04 ka ± 09 yr BP), *be reliable indicators* of the accumulation of at least a part of the Ghyvelde dune" (p. 103); "*If the dates in Table 1 are reliable indicators* of the age of the inland dune, then these processes have occurred over the last 3000 years" (p. 103). Concerning the dated *Cerastoderma edule* and *Scrobicularia plana* shells, we interpreted their environment as a sand flat consisting of very fine grey sand. Baeteman and Mauz (2012) claim that "the habitat of *Scrobicularia plana* is restricted to mud- and mixed tidal flat and that of *Cerastoderma edule* to mixed tidal flat". What is a 'mixed tidal flat'? We presume that this refers to a flat with a mixed sediment suite of mud and sand with transitions towards mudflats and sand flats. We maintain that these two common species are also characteristic of fine sand habitats such as the 'grey sand' found in the Ghyvelde dune cores and auger holes.

Baeteman and Mauz (2012) embark on a lengthy, but irrelevant, discussion of four aberrant OSL ages they have added to our Fig. 2. These ages were reported by Mrani-Alaoui (2006) in her PhD thesis but discarded by Anthony et al. (2010) following a reviewer's comments and letter manuscript length considerations. Baeteman and Mauz (2012) claim that these ages "can be explained by significant sediment reworking and recycling" associated with a so-called "tidal system that re-entered the coastal plain in the late Holocene",.... "associated with shoreface erosion and tidal channel formation". In the absence of an established absolute chronology, these remarks are extremely speculative and it is not clear how they are related to the formation of an aeolian dune located inland of the present shoreline dune.

3. (2) Data interpretation

Baeteman and Mauz (2012) claim that "a large amount of stratigraphical and palaeogeographical data" were "largely ignored by Anthony et al. (2010)". We maintain that we used to the best advantage the limited stratigraphic data available on the Ghyvelde dune and its environs, including data from Baeteman (2001) and from the various references on earlier stratigraphic work (see references in Anthony et al., 2010). Baeteman and Mauz (2012) go on to reinterpret our data simply on the basis of what they claim as 'interchanged' (quoting the authors) locations of cores labelled C2 and C3 in our letter. These cores were part of a larger set of eight cores published by Mrani-Alaoui and Anthony (2011) and the core renumbering was carried out for clarity following the suggestion of a reviewer. It is not clear from the reasoning by Baeteman and Mauz (2012) how an interchange in the numbering of cores C2 and C3 from the Ghyvelde dune should warrant a change in the interpretation of the facies depicted by these cores. The interpretation of the Ghyvelde dune deposits carried out by Baeteman (2001), and reiterated by Baeteman and Mauz (2012), lacks a coherent basis for explaining the diversity of facies, the corresponding beach, dune and tidal flat environments, and the sediment transport processes linking these environments. This is borne out in the unsupported hypothesis of inland dune formation proposed by these authors.

4. (3) Mechanisms of dune formation and coastal accretion

Baeteman and Mauz (2012) pursue a hypothesis, initially proposed by Baeteman (2001), and which we firmly contest, that this dune formed on a "surge-drift line" at the landward edge of a wide sand flat, and that it does not represent a former shoreline position. Where is their evidence for this hypothesis? What exactly is a 'surge drift line'? How does this so-called 'surge drift line' relate to sustained aeolian sand sourcing? How did it generate processes resulting in the formation of a 7 km-long, 0.3–0.6 km-wide, and up to 7 m-high aeolian dune?

The main point conveyed by Anthony et al. (2010) concerned the mode of formation of the Ghyvelde dune, identified from a combination of morphostratigraphic data from the dune and our current understanding of shoreface and coastal processes in the southern North Sea. We reiterate the fact that in the southern North Sea, the mixed tide- and storm-dominated hydrodynamic regime and the abundance of tidal sand banks on the shallow shoreface lead to a mode of shoreline accretion involving the episodic wholesale onshore welding of tidal banks driven from a shallow, sand-rich shoreface, over a timescale of years, by repeated storm wave activity. Storm-wave redistribution of sand brings the surface of the welded sand bank surface over time to intertidal/supratidal levels. Regarding this point, Baeteman and Mauz (2012) quote Anthony et al. (2010): "this surface then formed an extensive temporary intertidal beach-fronted sand flat that acted as both a basement and a sand source for the subsequent accretion of aeolian dunes". Baeteman and Mauz (2012) further pursue that "following the reasoning of the authors, the basement of the dune would be an intertidal beach" and that "it is not clear how the *Scrobicularia plana* and the *Cerastoderma edule* could be in living position there". Baeteman and Mauz (2012) fail to include in this quote that the processes reported by Anthony et al. (2010) involved 'a timescale of decades to centuries' (p. 101), and apparently confuse a 'wide sand flat' (liable to accommodate mud over the evoked timescale) fronted by a 'beach' with an active wave-exposed 'beach'.

The mode of dune formation proposed by Anthony et al. (2010) is supported by over a decade of research by two of the authors and several generations of their PhD students on the geomorphology, sediment dynamics and regional- to local-scale sediment budgets of the coast and coastal deposits of the southern North Sea and eastern English Channel (see main references in Anthony (2002), Anthony et al. (2006, 2010), and Héquette and Aernouts (2010)). Baeteman and Mauz (2012) ignore these efforts and offer an explanation for the inland Ghyvelde dune that is purportedly supported by what they claim as "our current understanding of Holocene coastal evolution of the Southern North Sea", the flawed nature of which will be demonstrated below.

Baeteman and Mauz (2012) claim that Anthony et al. (2010) have put strong emphasis on the occurrence of mud in the southern North Sea to buttress their proposed mode of coastal accretion, and declare that the reason for this emphasis is not clear. They pursue by claiming that "it seems that the authors want to use the presence of mud to explain the formation of the inner dune by analogy of a phenomenon that was observed in the area of Calais. However, that phenomenon of accretion of the beach and progradation of the sand flat by cross-shore wave reworking of sand from a welded shallow subtidal-intertidal sand bank with significant mud supply, is described as one of the rare actively accreting sectors of the coast in the southern North Sea (Aubry et al., 2009). Aubry et al. (2009) suggested amongst other possibilities that the presence of mud, which is a very recent phenomenon, might be explained by the proximity of the port of Calais".

Several elements are being missed here by Baeteman and Mauz (2012). Firstly, the presence of mud is completely irrelevant to the mechanism of formation of the Ghyvelde dune. Anthony et al.