

# Preservation of marine dunes

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## Abstract

As seen from the numerous works that were done in the past few years about dunes (this term follows the guidelines defined by Ashley (1990) and includes what is still commonly called sandwaves), these sedimentary bodies are quite common both on river beds and continental shelves, either clastic or carbonaceous. The measured migration rates of these bedforms seem to be inversely proportional to their size (see e.g. Fenster et al., 1990) and depend on their shape (2 or 3D, e.g. Berné et al., 1998) but there is no doubt that they move! Nevertheless, very high values of migration rates have to be taken with care, especially when they concern observations made with low accuracy positioning systems, compared to the modern sub-metric systems. The dune migration leads to the complete bedform rebuilding within a couple of years. In these conditions, can one imagine that dune preservation has any meaning ? To start answering this question, two points are discussed in this talk : 1) How is it possible to preserve a dune in the geological record ? and 2) What kind of bedding will be preserved ?

## 1. Dune preservation

Ripple and dune bedding is among the most common sedimentary figures encountered along outcrops or sub-surface records, especially when the sediments consist of siliciclastic shelf deposits. Nevertheless, the preservation of the dune itself including its shape is far from common. A nice example has been described by Brew (1996) off the North Sea Northumberland coast. High-resolution seismic profiles reveal the presence of a series of 2.0 to 5.5 m-high dunes buried beneath muddy Holocene sediments. It is the only place where such dunes have been observed in the North Sea Basin despite the widespread present-day occurrence of these features. The author interprets the preservation of these dunes as due to a change of basin morphology, from restricted embayment to open shelf, within rapid sea-level rise conditions. Other examples have been observed along the French Charente Coast by Berné (2000) or Weber et al. (2003). In this case, a series of about 5 m-high dunes are lying on the bedrock and are capped by highstand muds. Dunes are interpreted as transgressive sand dunes developed on an incised-valley floor that transformed in an estuary as the sea-level rose. The sediment transition between dune sands and highstand muds seems to be less abrupt than in the North Sea former example and consists in a layered alternation of sand and mud indicating a slow change from high-velocity to a quite, estuarine environment. A third example has been observed in the Black Sea where sand dunes revealed by multibeam echosounding are present at water depths of about 80-90 m (Lericolais, 2003). At this depth, the present-day current conditions cannot build and move sand dunes and mud is slowly burying these features. The preservation of the dunes in this case has been interpreted as due to a very rapid sea-level rise in the Black sea with sea water cascading from the Mediterranean Sea when the sea-level reached the level of the strait with the Mediterranean sea. Some authors such as Shimkus et al. (1997) connect this sudden rise with Noah's flood !

## 2. Preserved bedding

### 2.1 Preservation potential

The low probability of dune preservation may be due to the present-day high sea-level conditions and to the fact that most studies have been done in low sediment supply and slow subsidence rate areas. It seems easier to preserve shelf sand bodies in sea-level rise conditions. One of the nicest examples, even if bigger than dunes, consist in the so called 'tidal' sand banks (Liu et al., 2000) that were deposited as late transgressive deposits above estuarine sediments deposited under forced regression conditions (*sensu* Plint and Nummedal, 2000) in East China Sea (Berné et al., 2002). This occurred many times during the Pleistocene made possible by the high sediment supply from the Chinese continent and by the relatively high subsidence rate.

In these conditions, it is not sure that our present-day view of dunes represents what can be preserved. Moreover, the examples previously cited (Brew, 1996, Berné, 2000 or Weber et al., 2003) do not preserve the complete dune shape. Brew (1996) indicates that the shape of the dune in vertical view can be altered by crest flattening prior to burial, this flattening being due to wave action.

## 2.2 Types of bedding

When the dune is preserved one may address the question of what kind of bedding can be preserved. Part of the answer seems to be technologically controlled, firstly due to the bad knowledge of the full dune geometry, secondly due to the lack of ground truth over well documented modern sand dunes. As it is classical for ripples, dunes do not produce the same bedding when their crest is linear or sinuous in other terms when they are of 2D or 3D shape (Ashley, 1990). Brew (1996) has not enough seismic profiles to determine whether the dunes are 2D- or 3D-dunes. He believes that their crests are linear but the evidences are fragile.

The same problem arises on numerous studies, even recent, on modern dunes using single-beam echosounding leading to some difficulties in reconstructing precisely the dune envelope. With the increasing use of multi-beam echosounding that gives high-quality images, the development of 3D seismics for shallow waters is a challenge that only a few institutions can take up.

The difficulty to compare ancient and modern examples is also due to the difficulty to get cores that could give the ground truth in these sedimentary bodies. Except for some works made by Visser (1980) in the Schelde estuary on subtidal dunes or those from intertidal dunes (e.g. Dalrymple 1990), the lithologic informations are quite rare and do not allow a complete interpretation of the internal dune bedding. One of the major consequences is the difficulty to interpret the seismic reflectors as a given lithology (Le Bot and Trentesaux, 2004). Comparison with internal structure models like those proposed by Allen (1980) is therefore difficult.

## Conclusion

Our knowledge about the internal structure of marine dunes has to be highly improved as our view of the dune formation, growth and movement greatly changed thanks to the development of hydrodynamic models (e.g. Hulscher, 1996; Knaapen and Hulscher, 2000 or Idier, 2002), the increased possibilities of *in situ* measurements and the important improvement of multi-beam echosounding. In order to follow these improvements, the sedimentologist has to help in developing 3D seismic instruments and in designing high-quality coring devices adapted to shallow waters.

## References

- Allen, J. R. L., Sand waves: a model of origin and internal structure, *Sedimentary Geology*, 26, 281-328, 1980.
- Ashley, G. M., Classification of large-scale subaqueous bedforms: a new look at an old problem, *Journal of Sedimentary Petrology*, 60, 160-172, 1990.
- Berné, S., Architecture, dynamics and preservation of marine sand waves (large dunes), paper presented at Marine Sandwave Dynamics, International Workshop, Université de Lille 1, 2000.
- Berné, S., G. Lericolais, T. Marsset, J.-F. Bourillet, and M. De Batist, Erosional offshore sand ridges and lowstand shorefaces: examples from tide- and wave-dominated environments of France, *Journal of Sedimentary Research*, 68, 540-555, 1998.
- Berné, S., P. Vagner, F. Guichard, G. Lericolais, Z. Liu, A. Trentesaux, P. Yin, and H.-I. Yi, Pleistocene forced regressions and tidal sand ridges in the East China Sea, *Marine Geology*, 188, 293-315, 2002.
- Brew, D., S., Late Weichselian to early Holocene subaqueous dune formation and burial off the North Sea Northumberland coast, *Marine Geology*, 134, 203-211, 1996.
- Dalrymple, R. W., R. J. Knight, B. A. Zaitlin, and G. V. Middleton, Dynamics and facies model of a macrotidal sand-bar complex, Cobequid Bay-Salmon River Estuary (Bay of Fundy), *Sedimentology*, 37, 577-612, 1990.
- Fenster, M. S., D. M. Fitzgerald, W. F. Bohlen, R. S. Lewis, and C. T. Baldwin, Stability of giant sand waves in eastern Long Island Sound, U.S.A., *Marine Geology*, 91, 207-225, 1990.

- Hulscher, S. J. M. H., Tidal induced large-scale regular bed form patterns in a three dimensional shallow water model, *Journal of Geophysical Research*, 101, 20727-20744, 1996.
- Idier, D., Dynamique des bancs et dunes de sable du plateau continental : Observations in-situ et modélisation numérique, Thèse de Doctorat, Institut National Polytechnique de Toulouse, Toulouse, 2002.
- Knaapen, M. A. F., and S. J. M. H. Hulscher, Regeneration of sand waves after dredging, *Coastal Engineering*, 46, 277-289, 2002.
- Le Bot, S., and A. Trentesaux, Architecture of very large submarine dunes influenced by tide- and wind-generated processes (Dover Strait, northern France), *this volume*, 2004.
- Lericolais, G., Was the last rapid sea change in the Black Sea linked to a catastrophic event recorded by mankind ?, paper presented at Seattle Annual Meeting, Seattle, November 2-5, 2003, 2003.
- Liu, Z. X., S. Berné, Y. Saito, G. Lericolais, and T. Marsset, Quaternary seismic stratigraphy and palaeoenvironments on the continental shelf of the East China Sea, *Journal of Asian Earth Sciences*, 18, 441-452, 2000.
- Plint, A. G., and D. Nummedal, The falling stage systems tract: Recognition and importance in sequence stratigraphy. in *Sedimentary Responses to Forced Regressions*, edited by Hunt, D. and R. L. Gawthorpes, pp. 1-17, Geological Society, London, 2000.
- Shimkus, K. M., V. Moskalenko, G. A. Jones, P. S. Dimitrov, G. Gorür, M. Sakiñç, and H. Yüce, An abrupt drowning of the Black Sea shelf, *Marine Geology*, 138, 119-126, 1997.
- Visser, M. J., Neap - spring cycles reflected in holocene subtidal large-scale bedform deposits: a preliminary note, *Geology*, 8, 543-546, 1980.
- Weber, N., Chaumillon E., and M. Tesson, Variation of Quaternary stratigraphic pattern along an incised valley fill, revealed by high resolution seismic profiling : The Paleo-Charente River (French Atlantic coast), paper presented at AAPG Annual Convention, Salt Lack City, 2003.

