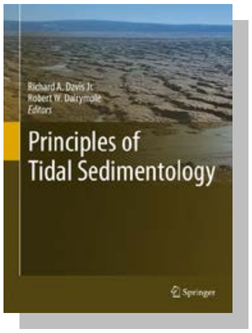

Principles of tidal sedimentology, by Richard A. Davis Jr. & Robert W. Dalrymple, 2011. Springer, New York, Heidelberg (www.springer.com/life+sciences?SGWID=0-10027-0-0-0). Hardcover, 621 pp. Price USD 279; EUR 199.95; CHF 287.00; GBP 180.00. ISBN 978-94-007-0122-9.

Coastal-systems veteran Richard Davis Jr. and tidal-sedimentology specialist Bob Dalrymple have edited a book with an ambitious title. This raises high expectations and, indeed, the book contains some excellent state-of-the-art reviews. It is, however, not the "comprehensive, contemporary view of tidal environments and deposits that cover the full spectrum of [...] both siliciclastic and carbonate deposits" that is promised by the publisher on the backside cover, as will be detailed below.

The book is divided in four parts: Chapters 1-4 provide overviews of the fundamentals of tides, sediment transport, criteria by which tidal deposits can be recognized and the ichnology of brackish deposits. Chapters 5-14 review sedimentary characteristics of a wide range of siliciclastic tidal environments, and in chapters 15-18 some classical cases in tidal sedimentology are revisited. Chapters 19-21 discuss shallow carbonate low- and high-energy environments on the basis of some modern and ancient examples.

A good introductory chapter at the start of the book which provides the reader with a framework of the various types of estuaries and tide-influenced offshore environments and its terminology is, unfortunately, lacking. Section 3.1 in Chapter 5 acts as a kind of introduction to several aspects of tide-dominated estuaries that are treated in the book. A similar attempt is made in the Introduction of Chapter 6. It would also have been useful to give an overview of all of the environments that are treated in the book, and of those that are not; this would have been useful particularly because only a small part of the plethora of present-day tidal systems and tide-influenced marine environments is actually investigated in some detail.

The sedimentary processes and products in estuaries are known mainly from studies of the Scheldt and the Bay of Fundy, whereas the sedimentology of estuaries in tropical and arctic areas is known in much less detail. Chapters 5 and 6 discuss the facies of macro- to mesotidal tide-dominated estuaries. A comparable chapter on wave-dominated, often microtidal estuaries is lacking, however, although their deposits are probably better represented in the sedimentary record. Note that, for instance, all estuaries along the Arctic Ocean are microtidal and at their entrance fringed by coastal barriers, which makes them wave-dominated in the widely accepted terminology of Dalrymple et al. (1992). It is surprising that nowhere in this book is attention given explicitly to the distinction between wave-dominated and tide-dominated estuaries (Dalrymple et al., 1992), nor to the striking difference between the sedimentology of estuaries with and without a low-energy central basin (Roy et al., 1980). This is particularly difficult to understand because the second editor, Bob Dalrymple, himself underpinned, explained and demonstrated the importance of this distinction in several of his publications, emphasizing this distinction as a framework for the sedimentological differentiation of estuaries and as a basis for the understanding of the sediment architecture of their deposits in sequence stratigraphy. The reader is referred to Boyd *et al*. (2006) for an outstanding review of this matter, which should have been given more attention in the book under review.

Book editors have an important task when a multi-author book is prepared. They should instruct the authors - and, if necessary, edit the text themselves - in such a way that much unduly overlap in themes and discussions are avoided. This editorial task has not been fulfilled: there is much overlap, which is possibly best illustrated by the repeated occurrence of one-and-the-same figure in different chapters in the book (see, for instance, on both page 43 and 256 the well-known flaser-linsen terminology of Reineck & Wunderlich,1968); another example is the figure showing amphidromes and tidal ranges in the North Sea (pages 8 and 337); that Houbolt (1968) is not referred to as the source of the latter figure, is also an editorial shortcoming, because both editors must have known this figure.

In addition to the above more general comments, the individual chapters of the book are reviewed in more detail in the following paragraphs.

Chapter 1 is authored by Erik Kvale. His contribution (Tidal constituents of modern and ancient tidal rhythms: criteria for recognition and analysis) is a splendid overview of the origin of the main tidal constituents and shows their preservation in tidal rhythms with many well-illustrated and convincing examples from the Carboniferous in the USA. The formation of such tidal rhythms requires a high sedimentation rate without erosional breaks. After having read this chapter, it remained unclear to me, however, where exactly this special, almost contradictory combination of conditions of low energy (preventing erosion) and a high deposition rate (suggesting nearby high energy) are found in the tidal domain. On page 2 it is stated that tidal rhythmites occur in deposits associated with tide-dominated deltas, tidal embayments and estuaries, unfortunately without giving any reference.

As far as I know, the rhythmites in modern examples are by far less continuous than the very thick successions from which Kvale took his examples. Also, most of them are reported from an intertidal setting with a low preservation potential. Ehlers & Chan (1999) claim that the best examples of tidal rhythmites in the modern record come from macrotidal systems. Whether or not this important statement also applies to the ancient examples shown by Kvale, remains unclear. Although it is suggested in the Introduction that tidal rhythmites can be used for estimating paleotidal ranges, such an analysis was not applied to the well-preserved continuous and thick Carboniferous rhythmites under discussion in this chapter. A possible explanation is – a bit late – given in Chapter 3, where Richard Davis concludes that "good methods do not exist to determine palaeotidal range other than the presence of a complete stratigraphic sequence from the base to the top of the intertidal zone".

Chapter 2 ('Principles of sediment transport applicable in tidal environments'), by Ping Wang, has a promising title, but this promise is not fulfilled by the contents. It starts with a treatment of some basic principles of sand transport by unidirectional flow and by waves and some processes that are important in the transport of mud. Many important aspects of sediment transport under estuarine conditions are completely neglected, however. For instance, nothing is said about the effect of non-uniformity and the non-steady and reversing character of currents, or about the resulting variation in hydraulic roughness on sand transport. Also the important link between bedload transport and bedforms is missing, and bedload formulas are presented that are not suited for tidal conditions as their application requires information on bedform roughness, which is never available under tidal conditions. The shortcomings in the treatment of cohesive sediment transport are also considerable: several mechanisms contribute to the so-called tidal pumping processes that are responsible for the high mud concentrations in suspension as well as for the deposition of mud drapes during slack water, a typical characteristic of inshore tidal environments. However, the treatment of these important processes remains restricted to the well-known scour-and-settling effect described first by Van Straaten & Kuenen (1957) and Postma (1967), without making reference to these benchmark works. Only little attention is paid to fluid mud layers, a typical feature of the estuarine turbidity maximum, without mentioning the important prerequisite condition of their origination at mud concentrations beyond the gelling point (Winterwerp, 2002).

Chapter 3 ('Tidal signatures and their preservation potential in stratigraphic sequences'), written by the first editor, Richard Davis Jr., is devoted to a key subject. As the book is advertised on the back cover as "essential reading for geologists in extracting hydrocarbons from complex tidal successions", one would expect a detailed and well-illustrated in-depth analysis of structures and assemblages of structures that would allow the recognition of tidal deposits in outcrop and core, and – where possible – a discussion on diagnostic criteria of specific depositional sub-environments. Instead, most of the comparatively short text (only 20 pages) on this important subject refers to the recognition of tidal rhythmites, which were already discussed extensively in Chapter 1. In the remaining part, stromatolites and ripple marks are shown together with some biogenic structures such as animal tracks and burrow spoil that are not typically tidal. Very little attention is given to physical structures produced by tidal currents, and no attention at all to combined or alternating conditions of currents and waves. Non-rhythmic heterolithic beds are represented only by the classic diagram of Reineck & Wunderlich (1968), without any discussion on how to distinguish tidal flasers and linsen beds from similar-looking beds in fluvial or fluvial-tidal transitional settings. Inclined heterolithic bedding (IHS: Thomas et al., 1987), on which linsen and flaser bedding often is superimposed, should have been discussed here, but even the term IHS is not mentioned! Typical features of tidal cross-strata are not given the attention they deserve either. For instance, in the drawing and description of the reactivation plane in a cross-stratified set, the criteria by which a reactivation surface caused by the reversal of a tidal current can be distinguished from a purely fluvial reactivation plane, caused by a small dune that descends the front of a larger dune, such as described by among others Reesink & Bridge (2009), are neglected. The only reference in the section on tidal cross-bedding is to the work of Rinus Visser (1980) regarding his 'discovery' of the neap-spring tidal-bundle sequence. Indeed, one cannot deny that the work by Visser has attracted much attention by the sedimentology community, but after his publication many important details of the spring-neap cycle have been published that should not have been neglected in this book. In the Preface of the book, the work by Visser is awarded as a "milestone" in the study of tidal bundles, notwithstanding the fact that Richard Boersma (1969) more than a decade earlier already described in detail tidal-bundle structures in intertidal dunes. I think that this is really too much honor for Rinus Visser – at the time of publication a student – that published the observations from his teachers which he learned during a field training. The admiration of Richard Davis for Rinus Visser surpasses an unacceptable limit when he ascribes the diagram that presents the tidal-bundle sequence (Fig. 3.22) to Visser, although it was drawn and published by Yang & Nio (1985). By the way, most experts on tidal sedimentology know that a more elaborated diagram of the spring-neap cycle in tidal bundles, showing much more characteristic phenomena than only thickening and thinning of bundles, was published by Thom Roep (1991).

Chapter 4 ('Tidal ichnology of shallow-water clastic settings'), authored by Murray Gingras & James MacEachern, provides an excellent overview of ichnofacies characteristics of brackish-water environments. This is very useful, as knowledge of the brackish-water ichnofacies combined with physical sedimentary characteristics of estuarine environments strengthens the possibility to identify inshore tidal (estuarine) deposits in ancient rocks. The ichnofauna of both low- and high-energy tidal environments is considered, although in most cases it remains unclear from what subenvironments and what type of estuary the information originates. The photos of ichnofossils are illustrative, but unfortunately often printed in a too small size to see the details of the structure needed for recognition of the trace fossil.

In Chapter 5 ('Processes, morphodynamics, and facies of tide-dominated estuaries'), Bob Dalrymple and co-authors treat the general characteristics of the interaction of currents with the morphology of mutually evasive tidal channels and bedforms and the changes that accompany the increasing fluvial influence in the inner estuary. This chapter provides a good overview of the subject, giving reference to many studies of cases distributed worldwide. This worldwide covering makes the reader wonder, however, why only one area (the famous research spot of Bob Dalrymple: the Bay of Fundy) is the place where all the beautiful photos of bedforms and sedimentary structures come from. In this chapter, for the first time in this book a geological definition is given of an estuary. This is the definition already advocated by Dalrymple for several decades. A crucial part of it is the distinction made between *estuaries* that originate from a transgression during sea-level rise and tidally-influenced river mouths of prograding *deltas*. A disadvantage of this definition is that it is not always clear whether a specific tidal deposit is built of imported marine sediment in a transgressive setting, especially as many processes producing sedimentary structures in estuaries are similar to those in the wide river mouths of prograding deltas. In more common usage, the term 'estuary' principally refers to the water body (i.e. a river mouth), whereas the term 'delta' refers to the body of accumulated sediment protruding into a water body. The conceptual difference with the above definition is that the two are not mutually exclusive, which is implicitly admitted in other chapters of the book. For instance, on page 135 mention is made of "a well-mixed estuary at the delta river mouth". The claim that the seaward portion of (geologically defined) estuaries is flood-dominant, is misleading: the more dynamic ebb channels and ebb directions are often represented in preserved sedimentary structures, especially in deposits accumulated in deeper channels (Martinius & Van den Berg, 2011).

Chapter 6 ('Stratigraphy of tide-dominated estuaries'), authored by Bernadette Tessier, deals with the generic characteristics of the sedimentary architecture of tide-dominated estuaries from a large number of modern and ancient cases. This interesting chapter ends with a number of keys that help with the discrimination of sedimentary successions in terms of sequence stratigraphy of these estuaries from their wave-dominated counterparts. Readers without much knowledge of this topic will, however, have great difficulty in understanding this part of the chapter as the sedimentology of typical wave-dominated estuaries is nowhere treated in the book.

Chapter 7 ('Tide-dominated deltas'), by Steven Goodbred & Yoshiki Saito, follows a more or less similar approach. It ends up in a series of schematic sedimentary logs of specific modern examples of tide-dominated deltas.

Chapter 8 ('Salt marsh sedimentation'), by Jesper Bartholdy, on depositional processes in salt marshes in the Danish part of the Wadden Sea, provides interesting information on the interaction of morphology with vegetation. An empirical model simulating the growth rate for several scenarios of sea-level rise suggests that a sea-level rise of up to 1 mm per year can be 'handled' by the vertical growth of salt marshes.

Chapter 9 ('Open-coast tidal flats'), by Daidu Fan, presents a window on literature in Chinese in an excellent and up-to-date review of a still relatively unexplored subject: muddy alongshore tidal flats of open coasts, such as found in the Yellow Sea and along the Guyana coasts of South America. An interesting subject for experts in the oil and gas industry, because these types of flats often owe their origin to uncommonly large mud supplies by huge rivers, and therefore to retrograding coasts with sedimentary products that have a high preservation potential. The review covers many aspects, including the prerequisite conditions of their occurrence, processes of erosion and sedimentation at various time scales, morphology and detailed information of sedimentary structures and their background in terms of hydraulics and the complex interaction with the bed, and the formation and erosion of a fluid mud layer. Present-day progradational sedimentary sequences, together with some ancient analogues, are represented by some illustrative examples.

Chapter 10 ('Siliciclastic back-barrier tidal flats') is less inspiring than Chapter 9, mainly because it deals with inshore siliciclastic tidal flats, a subject treated in detail in many textbooks, starting with the famous book by Reineck & Singh (1980). This chapter, written by Burg Flemming, does not add any generic knowledge. On the contrary, the presentation of sedimentary characteristics is rather poor and several aspects of this chapter are already dealt with earlier in the book. In Figure 10.19, the presence is claimed of several types of spring-neap cycles in a box core taken from a tidal dune, which I seriously doubt. For instance, a rhythmic alternation of fine and coarse cross-beds is interpreted as representing tidal bundles, although it does not show any of the characteristic criteria (Martinius & Van den Berg, 2011). Alternating fine grainfall and coarse grainflow deposits, as often found in normal cross-bedding, are a much more obvious explanation.

Chapter 11 ('Tidal channels on tidal flats and marshes'), by Zoe Hughes, focuses on the origination of tidal channels, their patterns and their differences with fluvial channels. It is a pity that, despite its importance for the understanding of the preservation of tidal channel deposits, hardly any attention is given to channel dynamics.

Chapter 12, by Duncan FitzGerald and co-authors ('Morphodynamics and facies architecture of tidal inlets and tidal deltas'), fortunately pays more attention to this important aspect. It is shown how morphological processes in inlets produce the facies architecture and large-scale bedding surfaces that define tidal-inlet and associated tidal-delta deposits. The second part of this well-illustrated chapter reviews several case studies and discusses the variability and complexity of tidal inlets. The preservation potential and several examples of tidal inlet deposits, as recognized in the rock record, are presented at the end of this chapter.

Chapter 13 ('Shallow-marine tidal deposits'), by Jean-Yves Reynaud & Bob Dalrymple, is a brave attempt to explain hydraulically the wide variation in the bedform configurations that are found in shallow-marine tidal environments. This aspect is still poorly understood, and information on the nature of the deposits of this multitude of environments is scanty. Seen from this perspective, the author' attempt is successful. They start with a review of tidal processes in shallow seas, among other things explaining how the minimum size of an oscillating tide depends on the Rossby radius, and how the oceanic tide deforms in shallow seas. This is followed by a useful treatise regarding the origin and dynamics of the various types of bedforms and their terminology. It is unfortunate and sometimes even confusing that this terminology is not followed everywhere else in this book. The chapter continues with some examples of internal structures of compound offshore tidal dunes, and with the sedimentary architecture of some modern tidal ridges. The chapter is concluded with a discussion on the transgressive stratigraphy that characterizes most sandy tidal deposits on modern shelves.

Chapter 14 ('Deep-water tidal sedimentation'), by Mason Dykstra, provides evidence that tidal rhythmites are not restricted to shallow near-shore and inshore environments, but can also represent deep-water environments. His arguments are supported by several examples from the Cretaceous.

Chapters 15 ('Precambrian tidal facies') and 16 ('Hypertidal facies from the Pennsylvanian period: eastern and western interior coal basins, USA'), by Kenneth Eriksson & Edward Simpson and by Allen Archer & Stephan Greb, respectively, are reviews of several classical ancient examples of tidal rhythmites. Chapter 1 has dealt with such rhythmites in detail, and these nice case studies do not add any generic knowledge to what has already been presented there.

Chapters 17 ('Tidal deposits of the Campanian western interior seaway, Wyoming, Utah and Colorado, USA') and 18 ('Contrasting styles of siliciclastic tidal deposits in a developing thrust-sheet-top basins – The Lower Eocene of the central Pyrenees, Spain'), written by Ronald Steel and co-authors and Allard Martinius, respectively, present some well-illustrated and well-documented examples of high-energy tide-influenced environments. The influence of tides is demonstrated by many characteristics, such as tidal bundles, oppositely directed cross-beds and double mud drapes. Characteristics of various subenvironments are discussed; these range from ebb-tidal deltas and tide-influenced seaways to transitional fluvial-tidal and bay-head delta on the landward part of the spectrum.

Chapters 19 ('Holocene carbonate tidal flats') by Eugene Rankey & Andrew Berkeley, 20 ('Tidal sands of the Bahamian archipelago') by Eugene Rankey & Stacy Lynn Reeder, and 21 ('Ancient carbonate tidalites'), by Yaghoob Lasemi and co-authors, deal with a number of recent and ancient examples of carbonate tidal facies. These chapters partly fill the gap created by the absence of overviews of the environments and signatures of carbonate tidal deposits that one would expect somewhere in the first part of the book. Chapters 19 and 20 focus mainly on characteristics of tidal flats of the Bahamian Archipelago: Chapter 19 deals with low-energy tidal flats, whereas in Chapter 20 more energetic tidal sandy environments are treated. Unfortunately, the description is strongly biased to geomorphic features. Sedimentary features are presented in detail only at the microscopic scale. Large-scale sedimentary structures are illustrated in some schematic drawings without any supporting evidence from core, outcrop or seismic data. In Chapter 21, this shortcoming is slightly compensated, especially with respect to characteristic sedimentary structures of tidal flats and supratidal areas.

My overall conclusion is that this book is not worth a purchase for those who are interested in the core of tidal sedimentology: siliciclastic estuaries. They are better off by obtaining the book 'Facies models revisited' and reading the chapter written by Boyd, Dalrymple & Zaitlin (Boyd *et al.*, 2006). On the other hand, the book under review contains outstanding chapters on tidal rhythmites, ichnofacies, facies architecture of tidal inlets, the sedimentology of muddy alongshore tidal flats of open coasts, processes, a state-of-the-art review of bedforms and sedimentary products of some examples of shallow-marine tide-dominated environments. The book may therefore be useful for those who are interested in one or more of these aspects and who are not bothered to pay almost 300 dollars.

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