

gen bonded environments and networks) that emerge from molecular dynamics studies, and leave this reader, at least, hungry for further examples.

I conclude by expressing the hope that this volume will attract a wide readership, and increase the awareness and use of vibrational methods among clay scientists.

PAUL S. BRATERMAN
Department of Chemistry
University of North Texas
POB 305070
Denton, TX 76203-5070
USA

Mud and Mudstones: Introduction and Overview by Paul Potter, Barry Maynard and Pedro Depetris. Springer, 2005, xi + 297 pp. [ISBN 3-540-22157-3]. Price \$89.95.

In the preface to this interesting book the authors note that their aims are to provide answers to eight sequential questions:

- How are mud and silt produced?
- How are they transported and deposited?
- What is the role of oxygen at the site of deposition?
- What is known about mud in modern environments?
- What are the controlling processes and changes that occur with burial?
- How do we determine the provenance of mud and mudstone?
- How do we study ancient mudstone-rich basins?
- What are the practical aspects of muds and mudstones?

To my mind these questions are important and this book will be useful to sedimentologists if it meets these aims. In this review my aims are to consider whether or not the authors do provide answers to these questions and the extent to which other areas of this broad discipline are covered.

In order to meet their aims, the authors discuss in Chapter 1 (Overview) the thorny problem of the nomenclature used by researchers to describe fine-grained sediments and sedimentary rocks. In this discussion they initially take a narrow view that mud is sedimentary material (<4 μm) and silt is material between 4 and 63 μm . They then go on to take a rather more realistic position, namely that mud and mudstones are most commonly defined as being all-inclusive terms for fine-grained sediments and sedimentary rocks, respectively, with silt being defined as sediment in the grain-size fraction <63 μm to >4 μm and clay being defined as sedimentary material <4 μm (rather than the more usual usage of the silt/clay boundary being at 2 μm). With this point out of the way they describe the

commercial uses of these materials, and point out that in spite of being very common, they are generally poorly known relative to other sediment types.

In Chapter 2 (Production of Mud and Silt) the authors get down to the 'nitty-gritty' of meeting their stated aims with a discussion of the processes that produce fine-grained sedimentary materials. Sensibly, in my opinion, the authors break this subject down into a number of areas based upon the fundamental processes that produce mud in sedimentary systems. In this section they discuss (amongst others) the effects of chemical weathering and clay mineral production, inputs from volcanic activity, fine-grained sediment derived from glacial abrasion (loess) and the contributions that siliceous phytoplankton make to the silt fraction. To my mind, this represents a fairly comprehensive summary of the key processes that deliver detrital sediment to a basin; however, it only touches upon the contributions made by biological productivity (both organic and inorganic) to the sediment. I think this omission is important because productivity-derived components can make-up a significant proportion of fine-grained sedimentary material. The absence of any obvious recognition that this material exists and the controls on the production of these materials (e.g. nutrient availability, bathymetry *etc.*) is to my mind an oversight.

The process theme of this book continues in Chapter 3 (Transport and Deposition) where the authors reflect upon the mechanisms responsible for fine-grained sediment dispersal. Here they contrast the processes operating sub-aerially with those operating sub-aqueously. In addition, they consider the effects of mass movement (e.g. liquefaction, creep, failure and stability of underwater slopes), provide a review of settling, suspension and entrainment mechanisms (including Stoke's Law, the effect of pelletization and flocculation on the formation of liquid mud) and summarize the processes that underpin fine-grained sediment dispersal (including the effects of suspension-transport in rivers and the role of waves, hyperpycnal flows/turbidity currents, effects of contour currents and wind). Once the main dispersal processes have been discussed the authors summarize the sedimentary structures produced by these processes and how burrowing, compaction and soft sediment deformation can disrupt them. While I really appreciate the reviews provided in the first part of this chapter, I was a little disappointed that they did not include: (1) specific descriptions and illustrations of the typical sedimentary structures present; (2) a section dealing with the effects of small-scale infaunal sediment colonization; and (3) comments about the fact that it is very important to distinguish genetic bedding from lamina and bedsets in order to fully appreciate the roles of the various sediment dispersal mechanisms.

With the physical processes out of the way, the authors (Chapter 4) get on to a problem that has exercised the minds of many geologists working in fine-

grained sedimentary successions; namely the role that varying oxygen concentrations play in controlling mud and mudstone variability. They note and discuss the overriding need for aerobic organisms to have access to oxygen, that redox fronts develop in sediments as oxygen diffuses into the sediment, and that pyrite commonly precipitates where conditions are 'sulfidic.' With these observations in mind they then consider the effects of basin geometry on water column circulation patterns and how paleoenvironmental oxygen levels can be analyzed using techniques such as biomarker investigations, studies of fauna and flora diversity, the degree to which available Fe has been pyritized, distribution of framboid sizes, relative concentrations of redox sensitive and trace element and variations in sediment color. Once again, while I thought this chapter provided a fairly comprehensive review, I was disappointed that it did not include a discussion of how petrographic techniques can be used to study paleo-oxygenation levels.

At this point in this book I was slightly surprised that the authors did not discuss the effects of early burial (included later, see Chapter 6) because microbial activity within the sediment porewaters and hence the effects of early diagenesis are intimately related to the availability of oxidants and reductants. Instead, here (Chapter 5), they choose to provide case histories of recent Muddy Depositional Systems. Appropriately, however, they do introduce the concept of accommodation availability. Unfortunately, they do not mention that it is also necessary in this context to consider definitions of 'base-level'. The absence of a discussion of 'base-level' is significant because 'base-level' in mud-dominated systems (whether productivity- or sedimentary detritus-dominated) is rather different to that in sand-dominated systems. This point aside, the authors provide very useful reviews of the controls on Recent mud deposition in a variety of environments (*e.g.* overbank deposits, lakes, loess covered landscapes, estuaries and fjords, deltas, mud-dominated coastlines, mud-dominated shelves, distal portions of submarine fans, epeiric seas and deep ocean basins) and the processes that lead to mud deposition in these settings being favored (*e.g.* floods, suspension settling, aeolian processes, flocculation, hyperpycnal flows, contourites, *etc.*) relative to other sediment types. As part of these discussions they raise significant issues about controls on primary productivity (nutrient availability and upwelling), and the relative roles of early diagenesis on facies variability in mudstones.

Once the recent case histories have been reported the authors return their attention to fundamental processes with a discussion of the effects of Burial (Chapter 6). Pragmatically, they divide their discussion into considerations of (1) physical, and (2) chemical processes. As part of their discussion they review dewatering and compaction and consider the influence that these have

on compaction curves in a variety of basins. Following from their review of physical processes they provide a summary of microbially mediated diagenesis and discuss the environments where processes such as sulfate reduction and methanogenesis occur. At this point they also include a brief discussion of the role of stable isotopes in studies examining the origin of concretions. Overall, I found this section to be a little disappointing as it did not consider the crucial effects of rates of sedimentation, role of Fe reduction, sulfide oxidation, reductant availability and the uses that other stable isotopes (in addition to oxygen and carbon) might have in understanding these systems. The absence of discussion of these controlling factors meant that the authors were not able to demonstrate convincingly (to me, at least) how diagenesis can be related to changes in relative sea levels. Once the early bacterially mediated diagenetic processes had been considered, the authors discussed deeper burial effects such as opal CT transformation to silica, mixed-layer illite-smectite transformation to illite, feldspar dissolution, and transformations within organic matter, prior to dealing with the reactions that occur during early metamorphism.

The authors considered the factors that influence the Provenance of Mudstones (Chapter 7) on the basis that information derived from these investigations can be used to inform geologists about 'varying relief, composition, climate and location of the source area' and from this understanding about why 'two mudstones with similar diagenetic paths have different final compositions'. As part of this review, the authors' comment on how the provenance of individual grains within these rocks might be investigated (*e.g.* stratigraphic methods, petrographic methods (*i.e.* SHRIMP, organic petrography, *etc.*), mineralogical (XRD) and chemical methods (both bulk and trace element analyses and isotopic methods). This section, however, did not include comments about the controls on varying primary productivity and how input of biological components varies to control mudstone variability in sedimentary basins.

With this broad review behind them the authors discuss the long-term spatial and temporal controls on basin-fill (Chapter 8, Muddy Basins). Here they specifically discuss the tectonic setting of different types of basins (rift, foreland, *etc.*) and the factors that determine whether their fill will be dominated by mud as opposed to sand. They also comment upon the relationship between accommodation availability and sediment supply and the controls on large-scale geometries of basin-fill. Here they also review the basic principles that underpin sequence stratigraphy and how these might be used to predict mudstone variability. This discussion concerns itself mainly with the recognition of large-scale sediment packages and does not address the practicalities of recognizing individual systems tracts and stratal surfaces. Finally, the chapter ends with a

discussion of the controls exerted by Croll-Milankovitch orbital cycles on mudstone variability and how these units vary through geological time.

In the last chapter, (Chapter 9, Practicalities) the authors review how the presence of mudstones impinges upon human economic activity. Here they include discussions of mudstones as barriers to fluid flow in the sub-surface, mudstones as hosts for metal ores and sources of industrial minerals, the roles that mudstones play in petroleum systems, and how mudstones impact upon civil engineering projects (from slope stability to waste disposal), acid mine drainage, *etc.*

Finally, the authors, in their appendices, review how mudstones might be described and the relevance of recognizing cycles defined by fining- and coarsening-upward trends as well as the significance of low relief discontinuities. In this section they stress the importance of careful field observations (utilizing both direct observation and remote techniques such as γ -ray spectrometry), and the imperative of using an appropriate nomenclature to describe rocks in the field, core and in thin-section. Surprisingly, given the prominence allowed to thin-section observations made in the first edition of this book and the elegant and informative atlas produced by O'Brien and Slatt (1990), there is very little emphasis placed here on thin-section analysis and in particular on the role of backscattered electron imagery.

I began this article with a question, namely do I think the authors have met their stated aims and objectives? To my mind the answer is a qualified yes. Certainly it provides a broad review, and eloquently summarizes

many aspects of mudstone sedimentology that have not been covered before. However, it also either misses or understates some crucial areas that are driving much current research activity. In particular, it does not really address how interpreting mudstones within a sequence stratigraphic framework can be used to inform our understanding of the links between sediment supply, accommodation availability, primary productivity and early diagenesis and says little about changing stacking patterns of mudstones within individual successions. Moreover, it does not really address the fundamental processes that control productivity and early diagenetic processes. That aside, *Mud and Mudstones: Introduction and Overview* does provide a useful summary of many of the processes operating to control mudstone variability. This book certainly provides a fine foundation from which to start advanced mudstone studies. That said, however, I do not think it provides a comprehensive overview of this subject area and it certainly should not be the only book that you buy if you want a comprehensive coverage of this discipline.

REFERENCE

- O'Brien, N.R. and Slatt, R.M. (1990) *Argillaceous Rock Atlas*. Springer, Berlin, 213 pp.

JOE MACQUAKER

School of Earth, Environmental and Atmospheric
Sciences,
University of Manchester,
Manchester M13 9PL
UK