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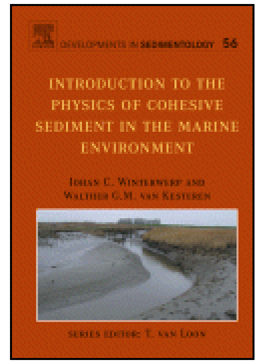
Introduction to the Physics of Cohesive Sediment in the Marine Environment, by J.C. Winterwerp & W.G.M. van Kesteren, 2004. Developments in Sedimentology 56. Elsevier, Customer Service Department, Linacre House, Jordan Hill, Oxford OX2 8DP, U.K. (Europe, Middle East, and Africa). Elsevier, Customer Service Department, 11830 Westline Industrial Drive, St. Louis, MO 63146, U.S.A. (U.S.A. and Canada). Hardbound, 559 pages. Price Euro 120.00; US$ 120.00; GBP 80.00. ISBN: 0-444-51533-4.



Is it possible to enjoy a scientific publication as much as the new Umberto Eco or the latest Harry Potter? I believe it is. Not that fiction should be confused with reality, but some scientific text books are as exciting as novels, without them marching onto the slippery path of popular science. Volume 56 in Elsevier's publication series "Developments in Sedimentology" (DIS-56) is such a book. The Dutch engineers Johan Winterwerp and Walther van Kesteren have succeeded in compiling a treasure of information on cohesive-sediment dynamics in a way that reaches far beyond their primary field of expertise, making this a modern classic for all scientists interested in the erosion, transport and deposition of fine-grained sediment. In the preface of DIS-56, they rightly state that there is no specialized book that summarizes recent work on cohesive-sediment dynamics. I am pleased to say that there is now.

DIS-56 starts with a list showing how cohesive sediment, or mud, affects mankind, both as a blessing and a curse. Mud provides fertile soils, healthy ecosystems, and resources for building and construction material, but it also attracts pollutants, contributes to siltation of navigation channels and harbors, and forms potentially damaging mudflows and turbidity currents. From a geological point of view, it should be added that cohesive sediment forms unwanted baffles to pore-fluid flow, but at the same time it provides valuable source rocks and seals to accumulations of, for example, hydrocarbons and groundwater. Moreover, the composition of fine-grained sediment and the mobility of chemical elements within it, are key to many diagenetic processes in the subsurface. The rheological appearance of cohesive sediment is highly variable, because it is closely related to sediment composition, sediment concentration, flow strength and consolidation history. The ensuing complexity is unmistakable, so it is praiseworthy that the authors use a systematic approach to tackle their discussion of physical processes. These processes include, in order of appearance, flocculation processes, transport and deposition of mud, turbulence modulation at high concentrations (as in near-bed fluid mud), consolidation processes, soil-mechanical behavior (including fractures and failures), and erosion of cohesive sediment.

After outlining the basic principles of boundary layer flow dynamics (Chapter 2), DIS-56 discusses the nature of cohesive sediment in Chapter 3. The granulometric, mineralogical and organic composition of muds and clays as well as their interparticle forces and porosity are treated in considerable detail. This information is then used to classify cohesive sediment in geotechnical terms. Soil-mechanical parameters such as plasticity index, liquidity index and undrained shear strength are explained and related to compositional parameters. The geotechnical discussion culminates in a functional sediment-phase diagram that classifies *in situ* cohesive sediment by means of clay-, silt- and sand-dominated fabric skeletons. The authors also propose a so-called "phenomenological" classification of cohesive sediment. This classification includes, with increasing sediment concentration and decreasing mobility, low- and high-concentration mud suspension, turbidity current, fluid mud (mobile and stationary), and bed (consolidating and consolidated).

Chapter 4 contains an in-depth review of flocculation and de-flocculation (or coagulation) processes. Subjects include the structure of mud flocs in the water column, the processes that govern their size, and the timing of their formation. Particularly interesting is that relatively weak turbulent motions in the water column may cause flocculation by making cohesive particles collide with each other, whereas stronger turbulent eddies may cause coagulation. Suspended sediment concentration and differential settling are important in flocculation behavior as well. Two simplified numerical models for flocculation of cohesive sediment are proposed and compared with field data from the Ems-Dollard estuary in The Netherlands. Settling of cohesive sediment, mostly in the form of flocs, is discussed in Chapter 5. A distinction is made between deposition in standing and flowing water. A comprehensive description of hindered settling of cohesive sediment in high-concentration suspensions is provided as well.

A large part of Chapter 6 is devoted to a literature review of the effect of non-cohesive and cohesive sediment particles on flow dynamics at concentrations where drag reduction becomes apparent, turbulence is modulated or fluid mud is formed. In all these cases, the basic law of the wall for boundary-layer flows no longer applies. Field examples show how sediment/fluid interactions affect the sediment dynamics in the turbidity maximum of the Ems estuary and how these interactions cause rapid siltation in the Port of Rotterdam. Special attention is paid to the concept of supersaturated suspensions, which are prone to collapse to a high-density fluid mud separated by a low-density outer flow region. Interestingly, the saturation models imply that the sediment-carrying capacity decreases significantly when a flow collapses. The authors believe that the collapse is irreversible as long as the fluid mud remains soft, so that no turbulence can be generated at the water/mud interface. If true, this concept has major implications for flow dynamics and deposit signature in settings where fine-grained cohesive sediment occurs in large quantities, such as in estuaries and turbiditic deep-marine environments. Potential collapse mechanisms should be tested by investigating supersaturated flows under controlled laboratory conditions.

Consolidation of cohesive sediment deposits under the influence of its own overburden is treated in Chapter 7. The Gibson equation for consolidation of soft mud layers is described in detail, before being applied to the Scheldt River in Belgium. A new consolidation model based on fractal descriptions of bed structure is proposed as well. This model is validated with laboratory-derived consolidation data. Chapter 8 is arguably the most specialist, and therefore most complex chapter of DIS-56. Various aspects of the mechanical behavior of fine-grained sediment beds are discussed in descriptive and quantitative terms. Ductile, shear and tensile failure mechanisms are dealt with at length. Other key subjects are elastic and plastic stress/strain relations, cyclical stresses, creep, and strain-rate dependent (rheological) behavior.

Chapter 9 takes the logical step from mechanical behavior to erosion of cohesive bed material. Special attention is paid to variations in erosion rate as a function of consolidation history and flow properties (unidirectional flow, waves, turbidity currents). The authors distinguish between four modes of erosion: (1) entrainment, when the mud is soft enough to act as a viscous fluid; (2) floc erosion, involving disruption of individual flocs from the bed; (3) surface erosion, usually accompanied by liquifaction and swelling; and (4) mass erosion, involving local failure within the bed (e.g., cracking). All these modes are assessed comprehensively. Of practical use is a classification diagram that relates erosion mode to shear strength of bed material and shear stress within the boundary flow.

Chapters 10 and 11 deal with biological and gas-related processes in cohesive sediment. Although relatively short in length, these chapters contain valuable information, often missing from other text books of fine-grained sediment dynamics. DIS-56 ends with a bonus in the form of five appendices and a subject index. Two appendices summarize mathematical symbols and equations used in the main text. A further appendix provides a useful overview of measuring techniques, e.g., for the analysis of particle size, suspended-sediment concentration, rheology, soil mechanics, and settling velocity. After a summary of tensor analysis for use in mechanical behavior studies, the final appendix presents the numerical equations of Delft Hydraulics' 1DV Point Model, used in DIS-56 to simulate water movement and transport of matter.

The first edition of *Introduction to the Physics of Cohesive Sediment in the Marine Environment* sold out quickly. There is no better proof for the importance of the subject and the quality of the content. Elsevier have recognized this as well. A reprint is in the making and it should be available when this review is published. So is there nothing to be unhappy about? Very little, in fact. The book is perfectly sewn, with heavy white paper, high-quality black print and good quality figures. Even the front cover is rather attractive, if you like 'muddy' brown as primary color. Technical editing has been excellent as well. The authors use field examples mainly from the Dutch coastal zone. They could have selected a wider range of geographical locations, yet their choice may well be warranted, because no doubt a lot of the fundamental work on cohesive sediment dynamics has been carried out in the authors' back garden. The price is characteristically high for an Elsevier publication, but it is good value for money nonetheless.

On their website, Elsevier mention a target audience of researchers, professors, and academic libraries within the fields of geology, marine science and engineering. I would have no problem adding postgraduate students to that list. DIS-56 has given me a lot of new ideas, and it will undoubtedly stimulate others as well. There can be only one recommendation for the interested reader: buy the book before it runs out of print again.

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