SEDIMENTOLOGY – SOME UNRESOLVED PROBLEMS AND NEW DIRECTIONS

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In this article eight sedimentologists briefly outline some of the major current issues in their special fields, ranging from deep to shallow water to terrestrial environments, and from modern to ancient deposits and processes. The first summary previews an international workshop on fine-grained sediments scheduled for Halifax, Nova Scotia, Canada, in August, 1982. The other seven contributions relate to special sessions organized by the International Association of Sedimentologists (IAS) at its 11th Congress being held in Hamilton, Ontario, Canada, also in August.

Toward an Anatomy of Fine-Grained Sediments

by

Dorrik A.V. Stow

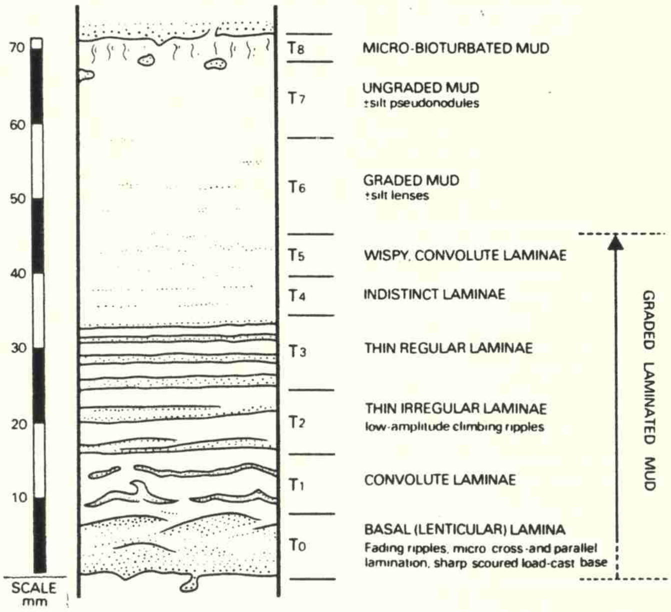
"Possibly many may think that the deposition and consolidation of fine-grained mud must be a very simple matter, and the results of little interest. However, when carefully studied . . . it is soon found to be so complex a question, and the results dependent on so many variable conditions, that one might feel inclined to abandon the inquiry, were it not that so much of the history of our rocks appears to be written in this language." (Henry C. Sorby, 1908)

Fine-grained sediments such as muds, silts, and oozes make up as much as 70 per cent of ocean basins fill as well as the modern cover of coastal areas and continental shelves. Although thick sequences of shales and chalks are abundant in the geological record, their apparent monotony has meant they have been relatively neglected by land geologists. The importance of this class of rocks is only now being rediscovered.

The understanding of fine-grained sediments has a valuable practical application; they are the source rocks for hydrocarbon generation, the substrate for sub-sea constructions, and the mobile coastal and fluvial sediments for environmental management. For these reasons, new work in sedimentology has been focussed at the fine end of the spectrum (e.g. Potter, Maynard and Pryor, 1980). Three frontier areas of research and discovery are outlined below:

Black shales are widespread organic-rich mudstones concentrated at certain stratigraphic intervals. Those of the Jurassic and Cretaceous periods are the source of most of the world's oil and gas. It is believed that they formed in restricted basins or where an expanded oxygen minimum impinged on the sea floor during an Oceanic Anoxic Event (Schlanger and Jenkyns, 1976; Thiede and Van Andel, 1977). Recent work has shown that their distribution and nature result from a more complex interplay of controls, including water mass circulation and stratification, water temperature, salinity and oxygen content, biological productivity, sedimentation rate and process and sea level changes. Careful integration of sedimentological, organic and inorganic geochemical studies should provide new insights into the regional and temporal variability of these controls and their effects on the sediments.

Silt and mud turbidites are abundant in the marine environment but they do not readily conform to the laws and models for classical sandy turbidites formulated in the 1950s and '60s. A recently-proposed facies model for the standard structural sequence in fine clastic turbidites (Stow and Shanmugam, 1980) shows that the complete sequence has nine subdivisions: T_0 - a basal silt lamina with sharp scoured base, internal lamination and fading-ripple top, T_1 - a graded silt-laminated unit with convolute laminae, T_2 - low-amplitude ripple laminae, T_3 - regular thin laminae, T_4 - indistinct laminae and T_5 - wispy laminae; and a graded T_6 - to ungraded mud T_7 - unit, bioturbated toward the top T_8. Similar work is in progress on fine carbonates.



Idealized sequence of structures in fine-grained turbidite. Equivalent to topmost CDE Bouma sequence. Stipple = silt, blank = mud. From: D.A.V. Stow and G. Shanmugam, 1980.

Muddy contourites form huge, elongate sediment drifts in the open oceans that mark the passage of deep thermohaline currents (Stow and Lovell, 1979). Undiscovered until the early 1960s, recognition of these sediments in past sequences provides a valuable new tool for the reconstruction of palaeocirculation and palaeoenvironments.

Fine-grained turbidites with "fading-ripple", an isolated example of Type C ripple-drift cross-lamination, Halifax Formation, Nova Scotia. Scale in cm.

In these and in other areas of fine-grained sedimentology, future advances will doubtless come from a two-pronged attack - on the one hand, the very detailed resolution of mud properties at the finest scale, and on the other, the mechanistic approach to larger-scale processes and controls of sedimentation.

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After doctoral studies at Dalhousie University, Halifax, Nova Scotia, **Dr. Dorrik A.V. Stow** joined the British National Oil Corporation in 1977. In 1980 he went to the Grant Institute of Geology, University of Edinburgh, West Mains Road, Edinburgh EH9 3JW, U.K., where he works in the field of fine-grained sedimentation and petroleum sedimentology. He is as much at home on the swell of the ocean as rock-tapping on land, and is a keen member of AGID with interests in energy resources and the law of the sea.

Effects of Organisms on Sedimentary Models

by

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Geologists have been aware for more than a century that animals affect the sediments in which they live, and that they can produce markings that are preserved in the rock record. The study of these markings has developed into ichnology, a subdiscipline of paleontology.

In the past few years ichnological research has moved away from describing and naming trace fossils, and has concentrated increasingly on the use of traces to provide essential data on environments of deposition. At the same time, a small number of scientists with experimental/biological interests in animal-sediment relations have been producing data on the effect of organisms on the chemical and physical dynamics of sediments.

Earlier phases of both lines of research, the descriptive and the experimental, tended to emphasize marine macrobenthos. Although this work has continued, there has been an encouraging trend toward working in freshwater environments, and in considering the effects of micro-organisms. Enough data are now available to show that organisms can control effective grain diameters, pickup and settling velocities, water and carbon content, mineralogy, physical and acoustic properties, and nutrient and trace element contents. In addition, the traces left in the rock record can provide information such as sedimentation rates, carbon content, physical properties, and environmental stability.

Although all this is well-known to "Bug People", who are aware of the effects of organisms on sediments, they sometimes feel they are engaged in a dialogue of the deaf with their sedimentologist colleagues. There has not been enough spreading "the word", nor receiving it - a problem in any new discipline. How many environmental reconstructions are based on grain-size analyses of peroxided sediment samples? Removal of the organic matter in any sediment, for example, by peroxiding, may destroy the original grain size distribution.