BOOK REVIEWS

DESERT DUST: Origin, Characteristics and Effect on Man

T.L. Péwé (ed.)

The Geological Society of America Special Paper 186, 1981, 303p., \$30.00 U.S.

The possibility of climatic change as a result of atmospheric dust has stimulated a great deal of research in the last twenty years, and much has been written about desert dust from the Sahara. However, this book has special interest and originality because most of its articles concern desert dust that has come from North America and China.

These papers present synopses dealing with the origin of dust and its transport over relatively long distances, its composition and physical properties, and finally the role this dust plays in climate, sedimentology and human lives. L. Schütz, R. Jaenicke and H. Pietrek report that the total current world production of mineral dust in the troposphere is between 130 and 800×10^6 tonnes annually, of which between 10% and 20% is the result of human activity. The main source is apparently the Sahara, with an annual production of between 60 and 200×10^6 tonnes. Seventy per cent of the dust travelling westward from the Sahara is deposited in the tropical Atlantic, while 30% goes beyond the Caribbean Sea.

J.M. Prospero demonstrates with very well-reproduced satellite photographs that Sahara dust reaches the Amazon, the West Indies and the North American continent (Florida and occasionally further north). The Indian Ocean is affected by dust from the Arabian peninsula, Africa, East Asia and Australia. The Pacific receives dust from Asia, Australia, and the Central and South American deserts. The South Atlantic also collects dust from the Sahara and the deserts of South Africa. Clearly, no region of the globe escapes desert dust.

Two interesting articles written by Chinese scientists deal with a sandstorm over northern China between April 17 and 20, 1980, triggered by dynamic movements associated with the westerly jet stream. The suspended dust was caught up in the jet stream and carried eastward, where part was deposited in eastern China after travelling about 1500 km. Another portion was probably carried over the Pacific. The sediment deposited in eastern China compares very well in particle size and composition with typical loesses of China. The authors show that examination of the trace elements makes it possible to distinguish clearly between the dust caused by this sandstorm and dust of industrial origin, such as coal.

An original article by R. Greeley and others, accompanied by excellent satellite photos, gives examples of dust storms and

Soil particle motions during wind erosion: a particle collision followed by "splashing" of the soil.

eolian forms on the planet Mars. The conditions of the eolian process are examined and compared with those of the Earth and Venus.

In another contribution, M.L. Jackson describes O^{18}/O^{16} ratios of authigenic silica grains (such as chert and quartz) in eolian deposits. He shows that siliceous particles from the Northern Hemisphere have high average O^{18} values, while those from the Southern Hemisphere have statistically lower values. Jackson attributes this phenomenon to the fact that the northern hemisphere continents have spent much of geological time under warm climates, while most southern hemisphere continents have been under the influence of cold or temperate climates.

The effect of dust storms on man is discussed by several authors. In some years these storms lead to serious soil erosion and disturbance of farming activities – photographs illustrate this phenomenon strikingly – or even to serious highway accidents, in Arizona for example. In the south

Major paths of airborne soil dust from West Africa and North Africa (from Rapp, 1974)

western United States, fungi spores carried with the dust give rise to violent allergic reactions in some people, at times fatal. C.R. Leathers provides a diagram of the annual changes in atmospheric pollen content (pollen calendar) for Arizona.

S.B. Idso presents a very useful history of ideas on the possible climatic effects of atmospheric dust. Curiously earlier workers, dating at least as far back as Benjamin Franklin in the late 18th century, all thought that the presence of dust in the air resulted only in a cooling of the climate. It was not until 1969 that R.J. Charlson and M.J. Pilat demonstrated that dust could cause both cooling and, through absorption of solar radiation, warming of the earth's surface. Idso's now classic experiments in Arizona showed that the infra-red thermal radiation received at the surface during a dust storm increases and causes warming. Beyond a certain concentration of dust in the troposphere, however, the cooling effect predominates.

In a second interesting article, Idso reviews the problem of desert origins and desertification, discussing the ideas and theories of R.A. Bryson, J. Otterman and J.G. Charney in particular. Through his own experiments Idso has strongly refuted the theory of Otterman and Charney that views changes in the albedo through a disappearance of vegetation as the cause of desertification. Idso also draws attention to an idea of P. Squires that a reduction in rainfall can result from greater cloud stability, an effect caused by an increase in the number of condensation nuclei provided by atmospheric dust particles. The author of this review recently demon-

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strated, on the basis of data from the Quaternary of tropical Africa, how this idea could explain in detail the evolution of present and former climates (in *Quaternary Research*, vol. 18, p. 1-16, 1982).

At the end of his article Idso draws the astonishing conclusion that the climatic variations along the margins of the Rajasthan desert and in the Sahel are due to causes that are more local than worldwide and that, in the final analysis, those responsible for these variations are in fact its victims. The zonal extension of the drought of recent years to most of the tropical band is, however, a clear indication that this is not a local phenomenon but one primarily related to the general atmospheric circulation. Furthermore, when the density of human population was low or non-existent in prehistoric times, the climate of these regions varied greatly between arid and humid. Although the causes of these variations have not yet been entirely explained, precise studies show that the recent drought in the Sahel results primarily from persistent anomalies in Hadley circulation, related to a disequilibrium in the hemispheric and global heat balances. Palaeoclimatic data from the Holocene of Africa, the Antarctic and the Arctic tend to confirm this idea.

T.L. Péwé has edited a very eclectic book, considering the many aspects discussed and the facts and theories described. It should be recommended to those interested in the vast subject of dust of desert origin. Non-English-speaking readers will appreciate the ample summaries in four or five languages at the beginning of each article (German, French, Chinese, Russian).

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PHOSPHORITES ON THE SEA FLOOR – ORIGIN, COMPOSITION AND DISTRIBUTION

G.N. Baturin, (ed.).

Elsevier Scientific Publishing Company, Inc., 52, Vanderbilt Avenue, New York, N.Y. 10017, U.S.A. The Netherlands, 1982, 343 p., \$93.50 U.S.

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G.N. BATURIN

ELSEVIER

The study of contemporary mineral-forming processes on the sea floor has been exceedingly active in the past few years. Polymetallic sulfides and metalliferous sediments forming along active spreading axes are useful analogues for these types of deposits in the geologic record. Can study of phosphorite deposits of the current sea floor also result in valuable insights into the genesis of ancient phosphate deposits? G.N. Baturin's answer would surely be a resounding "yes",

and I believe that after reading his book most earth scientists would probably agree with him.

Originally published by the Nauka Press (Moscow) in 1978, a translation was prepared shortly thereafter by Dorothy B. Vitaliano, at the request of the U.S. Geological Survey. As the interest in sedimentary phosphorite was dramatically increasing at this time, Elsevier arranged for the publication rights and produced the volume in 1982. For the English

version, Baturin added two additional chapters, updated the references, added a foreword, and made some other minor changes. Although these additions have helped, the reference list is still somewhat out-of-date (most non-Russian references are pre-1978).

The timing of this book is also somewhat unfortunate because 1978 was also the inaugural year of the IGCP project on phosphorites – Project 156. This program has become an important focal point for all scientists active in the investigation of this important rock type. As a result, the number of publications in this field has virtually mushroomed. This chain of events could not have been foreseen, of course, and Baturin did recognize a very real need for a compilation of relevant marine studies. This was undertaken from a position of experience, for the author has been one of the most active investigators in the study of modern environments of phosphorite formation.

The first of eight chapters deals with a summary of the distribution of phosphorus in the oceans. Much information is given on the marine geochemical cycle of P in the sea, including its presence in organisms, sediments, particulate matter, interstitial waters, etc. Unfortunately, the data summary is presented with no attempt to evaluate its quality and little effort at synthesis. As a result, this chapter does not contribute to the principal subject matter of this book in a meaningful way.

The following chapter, however, contains a very nice summary of the distribution, characteristics and age of phosphorites on continental shelves. All of the major shelf deposits known are considered, with particular emphasis on the modern deposits located off Namibia, where Baturin has done much of his own work. The description of the modern deposits off Peru is also quite useful, in that it contains details of some Russian investigations not previously published in English. Particularly noteworthy in this regard is the section dealing with the age of the Peru shelf phosphorite – the occurrence of Recent diatoms contained within the phosphorite that is documented here provides further support for the Quaternary ages that have been derived by radiometric dating.

Perhaps the best chapter in the book, Chapter 3, contains a description of the known occurrences of seamount phosphorites, their ages and possible origin. Since Baturin and his colleagues have done more work on these deposits than anyone else, this summary is particularly welcome. One may be somewhat disappointed, however, that he does not take a stronger position concerning the origin of these rocks.

More process-oriented treatments are provided in chapters on facies setting and on the stages of formation. Discussions of the principal characteristics of coastal upwelling zones (winds, currents, climate, etc.) are presented together with the sedimentary setting in this environment. Facies profiles of the Quaternary phosphorites off both Peru and Namibia provide a clear, although simplified picture of the sedimentary regime. The origin of marine phosphorite is discussed as a series of five "stages" of formation: (1) supply of P to the ocean; (2) consumption by biota; (3) supply to the sediments; (4) regeneration and precipitation within sediment pore waters; and finally, (5) concentration by reworking.

The summary of geochemical data on marine phosphorites also suffers somewhat from a lack of synthesis and evaluation of data. Still, there is some extremely interesting information here, much of it previously unavailable in English. The sections dealing with rare-earth element and uranium geochemistries are especially interesting, despite a rather generalized discussion of the evidence for the occurrence of uraninite in phosphorite.

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In Chapter 7, Baturin attempts to apply his model of formation to the ancient phosphate deposits of the geologic record. He believes that in general, his scheme of Recent formation "stages" is also applicable to pre-Quaternary phosphorite. To support his arguments, he cites examples from the large land deposits of Sechura (Peru), the Phosphoria Formation (western U.S.A.), the North African deposits and others. Baturin will surely receive criticism from some geologists who have studied the ancient deposits and feel that conditions may have been substantially different than at present. Many would not place as much emphasis on reworking as he does. The application of the modern phosphorite analogue to the geologic record is currently a lively debate, and Baturin has clearly added fuel to that fire. In the concluding chapter, Baturin summarizes the different theories proposed for the origin of marine deposits and reiterates his multi-stage hypothesis, which he refers to as the "biogenic-diagenetic phosphorite formation".

Baturin's book will be very useful to scientists involved in the study of these rocks. Soviet scientists have done an impressive amount of work on sea floor deposits, and an English compilation of their efforts (as well as those of Western scientists) is most welcome. The author presents excellent evidence that upwelling is the driving force behind the modern-day formation of phosphorite on the continental shelves of Namibia and Peru. In spite of a few shortcomings, the treatment is complete and well-organized. The actualistic viewpoint is presented quite well. From this perspective, Baturin hopes that one may avoid the "...flaming and fruitless scientific debates over conditions of formation ..." at the outcrop. Although this hope may not be fully realized, this volume is a nice attempt in that direction.

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GEOLOGICAL EVOLUTION OF THE EARTH DURING THE PRECAMBRIAN

L.J. Salop

Springer Verlag, Berlin, Heidelberg, New York, 1983, 459p.
\$65.80 (U.S.).

This is an interesting book that summarizes the views of a distinguished Russian authority on the Precambrian. It is a very useful up-to-date compilation of information on the Precambrian of the U.S.S.R., integrated and compared with that from elsewhere in the world. It gives an enlightening synopsis of current Russian thought on tectonic models applied to Precambrian belts. There is also a helpful compilation of key isotopic dates, including a surprisingly large number of published Pb-Pb dates on Katarchean rocks in the U.S.S.R.

The book presents a comprehensive treatment of the Precambrian organized by principal divisions or erathems. In the U.S.S.R. these are the Katarchean (>3500 Ma), the Palaeoprotozoic (3500-2600 Ma), the Mesoprotozoic (2600-1900 Ma), the Neoprotozoic (1900-1000 Ma), the Epiprotozoic

(1000-650 Ma), and the Eocambrian or Vendian (650-570 Ma). Each of these chapters reviews the physical and chemical environment on the earth's surface, lithostratigraphy, magmatism, sedimentation, life forms, tectonic regime and principal stages of geological evolution. There are also sections entitled "General Problems of Division of the Precambrian", "Evolution and Cyclicity of Geological Processes", "Periodicity of Orogenies", "Global Tectonics", and the "Actualism Principle in the Light of Precambrian Geology".

According to Dr. Salop the key elements of the Katarchean are, in order of increasing age: the Saamian orogeny (3750-3500 Ma), the Isua Complex (4000-3750 Ma), the Godthaabian orogeny (4000 Ma), preceded by the Slyudyankian, Sutamian, Fedorovian, Ungran and Iyengran Complexes. At the base of the Iyengran Complex are the oldest rocks in the world — quartzites which were precipitated from siliceous solutions extracted from a weathering crust of now-unexposed sialic rocks. It will be interesting to see if these five complexes in the U.S.S.R. prove to be as old as predicted above when more reliable age determinations are available. North American geologists will be surprised by the definition of the Grenville gneisses and Grenville Supergroup as Katarchean in age, for 1350-1000 Ma is most widely accepted for the main regional metamorphism and deformation.

The author's concept of the tectonic evolution of orogenic belts, present and past, is no less than intriguing. The plate tectonics concept is, of course, not accepted: "the subsidence of large portions of continental crust is an indisputable fact." According to Salop, the Pacific Ocean with contours close to the modern ones began to form in the Neoprotozoic. In the early Katarchean, eclogite lithosphere "plunged" into the mantle and some of this mantle reached the surface along fractures between the submerged blocks to form extensive basalt flows. Parts of crust with abundant granite "retained their floatability" and remained on the surface of the ocean bottom uncovered by basalt. These are seen today in the Rockall Plateau in the North Atlantic and in much granulite-gneiss material dredged from the East Indian Ridge and the East Pacific Rise. Thus the oceanic depressions form by subsidence of the lower crust into the upper mantle, and plate drift, therefore, is unnecessary. The appearance of modern fold structures, island arcs, marginal seas and intra-oceanic rises was due particularly to expansion of the earth during the Meso-Cenozoic. I leave the reader to judge on such concepts in 1983.

Dr. Salop clearly has great difficulty in understanding why 'geosynclinal piles' and modern orogenic belts form on old sialic basements, although there is no problem with that in the plate tectonic concept. Regarding ophiolites he states, "it is absolutely impossible to regard the discrete lens-like bodies of hyperbasite that represent intrusions or protrusions of abyssal matter in fracture zones as remains of a bed of the shut-in ocean." Also "the Baltic Shield which appeared as a large positive morpho-structure soon after the Karelian folding 1900 Ma ago ... exists up to now as an area of stable rising. ... These are certainly arguments against a significant horizontal drift of continents." Precambrian and Phanerozoic geological phenomena can only be explained if an "alternation in time in the processes of expansion and compression of the earth is accepted." Such quotations convey the essence of Dr. Salop's concepts.

It is a pity that the translation gives rise to such anomalies as "magmatism becomes of homodromic character" and "the geocratic epochs of the Phanerozoic", which mean absolutely nothing at all in English. However, the book has a very good, up-to-date list of references both of Russian and "western" origin plus an excellent subject index and an index of local stratigraphic units. I recommend the book to those interest-

Geological Evolution of the Earth During the Precambrian

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ed in gaining access to the Precambrian geology and literature of the U.S.S.R., and to those keen to understand the beliefs of Dr. Salop. The book sensibly separates data from ideas, so you can absorb the one without the other.

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DEPOSITIONAL AND DIAGENETIC SPECTRA OF EVAPORITES

C.R. Handford, R.G. Loucks and G.R. Davies (eds.)

SEPM Core Workshop No. 3, Society of Economic Palaeontologists and Mineralogists, Tulsa, Oklahoma, U.S.A., 1982, 395p., \$15.00 (U.S.).

The only regret the reader will have as he works through this handbook will be that of not having had the opportunity to participate in the workshop when it was held in Calgary in June 1982. The various contributions deal concisely with the diverse textures and sedimentary structures of evaporites. This is a book to read and study, with a very useful and practical reference collection of well-chosen photographs.

The spectrum ranges from continental evaporites, including the trona facies, through coastal evaporite complexes to basin facies, though the book deals mainly with deposition and penecontemporaneous diagenetic features. It commences with a comprehensive but tight review illustrated by examples on a near world-wide basis, and ends with some thoughts on evaporites as source rocks for hydrocarbons. The welcome contribution on salt dome cap-rocks reminds the reader that diagenesis is a continuing process and that profound changes can and do take place in the course of exhumation.

Almost half of the papers deal with or refer to coastal evaporites, with examples from the Permian to Recent. These evaporites do not occur in isolation, but as a facies in what are mostly regressive carbonate and/or clastic cycles. The subfacies of the associated sediments record a diversity of coastal environments from simple supratidal flats to widespread complexes of migrating shoals, bars, lagoons and tidal flats, few if any of which were dependent on evaporitic conditions for their origin. These facies were the results of the interplay between hydrographic regime, the supply of sediment and the trend of coastline, and they could have developed in any climatic setting where appropriate conditions prevailed. It was their occurrence along arid shorelines which sets the scene for emplacement of evaporites.

Thus many of the subfacies of the sediments associated with evaporites are already known from studies elsewhere. That knowledge is important. It provides the information necessary to identify the depositional environment of the evaporites, because some of their textures and sedimentary structures are far from being unequivocal with respect to environment. The Permian Upper Minnelusa Formation of Wyoming dealt with by C.W. Achauer, and the Lower Cretaceous Ferry Lake Anhydrite of East Texas discussed by R.G. Loucks and M.W. Longman, are cases in point. In the former, nodular anhydrite rocks occur at the top of regressive marine cycles and are evidently of sabkha facies. In the Ferry Lake Anhydrite on the other hand, the nodules lie in carbonate cycles which, on the basis of the faunas, ranged from normal marine to hypersaline. The positions of the anhydrite beds in those cycles strongly suggest that the evaporites were lagoonal and subaqueous in origin. Absence of environmental

indicators in the associated sediments can leave identification of depositional environment of the nodular anhydrite rocks unresolved, as is the case in the siliciclastics of the Permian Yates Formation of west Texas described by G.A. Crawford and J.B. Dunham.

The problem of the origins of nodular anhydrite is one which arises in many contributions. The introductory review by B.C. Schreiber, M.S. Roth and M.L. Helman is particularly useful in this respect because it focuses attention on relationships between gypsum and nodular anhydrite by reference to Messinian and other Neogene evaporites of Europe and the Mediterranean region. In many of the Neogene occurrences, much of the original primary gypsum is preserved unaltered, presumably because the rocks were never sufficiently deeply buried to have carried them out of the temperature stability field of that mineral. The Neogene outcrops also carry porphyroblastic and alabastine secondary gypsum formed as a result of late hydration of anhydrite as the rocks were exhumed. This secondary gypsum is mostly white and stands in marked contrast to the crystals of primary gypsum. These Neogene evaporites therefore provide vital information about depositional and early diagenetic processes which is not easily deduced from the study of more deeply buried evaporite formations which have lost all their primary gypsum.

The deposits of primary gypsum in the Neogene show great diversity. They include crystals which grew displacively in earlier formed sediments, beds of competitively arranged crystals which evidently grew subaqueously from the floors of brine bodies, current bedded gypsum sands and delicately laminar gypsum sands and silts. The beds of competitively grown crystals range in thickness from a few millimeters to tens of meters and, in some of the thick beds, individual crystals reach several meters in length.

However, whatever the origin of the primary gypsum, there are numerous exposures where it can be seen to have been partly altered to anhydrite. There are also places where what was a complete lateral transition from a bed of primary gypsum into nodular anhydrite can be seen in one exposure. The extent of the alteration of the primary gypsum varies from bed to bed in vertical successions, and this suggests that the change mostly took place penecontemporaneously with deposition on a 'lit-par-lit' basis. The significant fact which emerges is that the early diagenetic anhydrite is mostly nodular, irrespective of the structure of the bed of gypsum which it replaced.

Preservation of beds of primary gypsum in many Neogene evaporites raises the question, not addressed in this manual, of what would have happened if the formations had been more deeply buried and carried down to depths where rock temperature was above that of the stability of gypsum. If this caused a change to anhydrite, what sort of structures and crystal fabrics might be expected to develop, and in what ways would that later diagenetic anhydrite differ from its early diagenetic nodular counterpart?

These thoughts lead the reader on to enquire about the original mineralogy of the evaporites of the Permian Castile Formation of Texas and New Mexico, which are well described in the contribution by W.E. Dean and R.Y. Anderson. The intervals of nodular anhydrite appear to be early diagenetic as Dean and Anderson imply. However, the crystal fabric of the nodules is different from that of the anhydrite of the laminites, and the reader wonders whether the laminites were deposited as anhydrite, or as gypsum which was later converted as a consequence of burial. One poses the question because in the Messinian of Cyprus there are expo-

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tures of primary gypsum laminites which at intervals carry nodular secondary gypsum after former nodular anhydrite.

Stability of gypsum is a theme which continues through into the contributions that deal with the halite facies of evaporites. Halite pseudomorphs were found by C.R. Handford and R.L. Bassett in the Permian of the Texas Panhandle, and pseudomorphs of primary gypsum preserved as halite, polyhalite, sylvite and anhydrite are described by T. Lowenstein from the Permian Salado Formation of New Mexico and Texas. Where the gypsum is replaced by anhydrite it is precisely pseudomorphed. Not only are the shapes of the original crystals strictly preserved, but the zones of included sediment are also held tightly in place, indicating clearly a totally different mode of replacement of gypsum to that which generated nodular anhydrite.

There are many other worthwhile contributions in this book, and there is a wealth of information, much of it new. Each contribution sets the reader thinking and raises questions which are relevant to a better understanding of evaporites. In so doing the book points the way forward, and that to me is good science.

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NIGERIA: Its Petroleum Geology, Resources and Potential, Volumes I and II

A. Whiteman

Graham and Trotman Ltd., Sterling House, 66 Wilton Road, London SW1V 1DE, 1982, 394p., £54.00 (surface mail) or £57.00 (airmail)

This is the second book in three years on the petroleum geology and resources of Nigeria, following an earlier publication prepared jointly by the U.S. Department of Energy and the U.S. Geological Survey. It represents a modification of a two-volume commercial petroleum consultancy report prepared 1971-72.

Whiteman's two-volume book with 306 figures is for the most part a literature review summing up the findings of numerous stratigraphers in the sixties and a few petroleum geologists in the seventies. It is unfortunately lacking in new material of interest to the Nigerian petroleum industry.

Volume 1 consists of an introductory chapter which describes the production history of Nigeria, ranking its reserves with the rest of the world. Chapter 2 reviews in detail the stratigraphy of each Nigerian basin, and is an update of Reymont's "Aspects of the Geology of Nigeria" (Ibadan University Press, 1965). However, Whiteman's assessment of the petroleum potentials would have been more useful had it taken into account material published in recent years.

Volume 2 kicks off with structural analyses of the various Nigerian sedimentary basins. Plate tectonic models for the origin of the Benue trough are discussed extensively in this chapter as is the evolution of the Niger Delta, including the origin of growth faults, rollover anticlines and shale diapirs.

A chapter on the pattern of oil and gas occurrences in the Niger Delta presents case histories of four fields and is followed by a compilation of production and reserve estimates. There is also a chronological review of selected exploration and production developments for the Nigerian petroleum industry spanning the period 1908-1979. The second volume closes with a presentation of 16 detailed concession situation maps and exploration data for 1963-1979.

This is a useful though prohibitively expensive book that will be of interest to many geologists in academia both from the standpoint of its detailed tectonic analysis and its regional stratigraphic discussions. However it is unlikely that it will achieve popularity with the petroleum industry because what it offers is already known.

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SOFT CLAY ENGINEERING (Developments in Geotechnical Engineering v. 20)

E.W. Brand and R.P. Brenner (eds.)

Elsevier/North-Holland Inc., 52, Vanderbilt Avenue, New York, N.Y. 10017, U.S.A., 1981, 779p., \$134.00 (U.S.)

The problem of soft clays has been affecting society for over a thousand years, since the first heavy structures were constructed in north Europe. When the city wall of Stockholm was constructed about 1250, the builders had many problems with the foundations because they were working in soft clay. Another aspect of the soft clay problem was involved when a large part of the town of St. Jean Vianney in Quebec was destroyed by a landslide in 1971. These two examples illustrate the main aspects of the problem – landslides and the difficulty of putting foundations into soft clays; these are largely what this book is about.

This book is based on lectures given at a 1977 international symposium on soft clay held in Bangkok. The chapters provide good coverage of the important problems, and the book is neatly edited by E.W. Brand of the Geotechnical Control Office in Hong Kong, and R.P. Brenner then of the Asian Institute of Technology in Bangkok.

Although there is a chapter on engineering geology, the focus of the work is on engineering. There are chapters on exploration, sampling and in-situ testing, shear stress-strain properties, modern techniques for the analysis of engineering problems, foundations, consolidation and settlement, design and performance of excavations and tunnels, methods of improving the engineering properties, field instrumentation and seismic problems. A modest index is included. Most of the observations in this review, however, will relate to the geological implications.

How soft is 'soft clay' and what makes soft clay 'soft'? Soft clay is defined by Nils Flodin and Bengt Broms as a clay with a shear strength of less than 25 kPa. Flodin and Broms contribute a long (129p.) chapter on the historical development of civil engineering in soft clay. This is essentially a

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study of work done in Scandinavia up to 1948, with a brief mention of some Canadian problems. The rest of the book is an attempt to survey our current knowledge of the soft clay problem.

According to Flodin and Broms the main regions where soft clay is found are the Nordic countries (but not Denmark), Canada and northern parts of the U.S.A. (e.g. around Chicago and Boston) where deposits of postglacial clays are often more than 100 m thick. Other deposits occur in Mexico City, with its volcanic clay, and the major river deltas of the world, such as the Nile, Mississippi, Rhine, Elbe, Neva, Euphrates, Tigris, Ganges and the Yangtze Rivers – and the famous Bangkok clay. The emphasis, though, is very much on glacial materials and the Bangkok clay. A single focus on glacial clays might perhaps have been more desirable than the attempt to present a general view of everything which could be considered a 'soft' clay. The criterion of a shear strength of 25 kPa means that there are many geologically diverse materials which can be gathered together into a rather uncomfortable proximity.

The engineering geology chapter is a good review of the sensitive (and sometimes quick) clays of Scandinavia and Canada. The authors state that little information exists on the engineering geology of soft clays in tropical and subtropical regions. Just how similar are the tropical and the northern soft clays? Are we really justified in lumping them all together, even for engineering purposes? Is the coincidence of shear strength enough to unify our treatment, even when the geology and mineralogy are so diverse? There are great dangers in blindly applying rules and not thinking about the geology.

The sensitive volcanic clays of the North Island of New Zealand (not mentioned in the book) have recently participated in some damaging and expensive failures largely, it

appears, because of a lack of geological and mineralogical appreciation of the nature of the material. The Bangkok clay (45% kaolinite, 15-20% illite and 35-40% montmorillonite) does not have much mineralogical similarity to the Leda/Champlain clays of eastern Canada with their high proportions of primary minerals and negligible smectite; the engineering behaviours of these diverse clays can be expected to be quite different. This is why it is potentially dangerous to group them together under the cover-all term of 'soft' clay. Furthermore, northern hemisphere construction 'recipes' do not work on soils which are 80+% spheroidal halloysite.

The question of sensitivity is very significant in the northern clays and it is discussed at some length. It is good to see the term 'quick clay' being confidently used. It has drifted out of popularity in North America but such a graphic term should not be abandoned. The simple Swedish distinction whereby soils with sensitivities greater than 50 are called quick clays should be adopted. There is no place now for the unnecessarily detailed ranges of the early classifications: 4 to 8 ('very sensitive') succeeded by 8 to 16 ('slightly quick') never did make any sense.

Essentially this is an interesting and useful book, but one basic assumption has to be questioned. Is the approach to soft clays valid? Can we really say that there is a set of clays that have shear strengths less than 25 kPa and then group them together for engineering purposes? This looks like an approach which has led to disaster in the past. The Ruahiri canal collapse in New Zealand in 1981 was a classic example of a failure to appreciate the nature of the terrain materials. The term 'soft clay' should certainly be approached with caution.

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