

BOOK REVIEWS

Clay minerals in onshore and offshore strata of the British Isles: Origins and clay mineral stratigraphy. C. V. Jeans and R. J. Merriman (editors). [Hardback issue of *Clay Minerals* – *Journal of Fine Particle Science*, March 2006 issue.] Mineralogical Society of Great Britain and Ireland, 2006, 550 pp. [ISSN 0009-8558] Price £70 (£49 to members of CMS and other societies participating in *Elements*).

This long-awaited compilation owes its origin to a 1971 monograph by R. M. S. Perrin of the University of Cambridge on the clay mineralogy of British sediments, in which available data were tabulated and discussed within a geological context. Even as this was published, Bob Perrin and his young colleague at Cambridge, Chris Jeans, were making plans for a much expanded successor monograph, and in the late 1970s the UK Clay Minerals Group took this on as a publication initiative. Each successive chairman of the CMG, myself included, was determined to see it published during his term of office, but this aspiration did not take into account the difficulties of holding contributors (actual and potential) to submission deadlines! Its appearance now is due in very large part to the industry and persistence of the senior editor who has led from the front in contributing three weighty chapters, and it is a fitting sequel to the series of ‘Cambridge Conferences’ on the relevance to hydrocarbon exploration and production (also published as special issues of *Clay Minerals*) that he organized in the 1980s and 90s.

The book follows the stratigraphic succession in reverse order, and in the first chapter, J. M. Huggett and R. W. O’B. Knox deal with both onshore Tertiary clays and their much more extensive, but stratigraphically less complete, offshore equivalents. Smectite is a dominant component of these clay mineral assemblages, occurring both as an alteration product of water-deposited volcanic ash resulting from pyroclastic activity associated with the opening of the North Atlantic, and also as a detrital component from weathering of smectite-rich soils on adjacent land areas. The authors draw attention to the fact that although Paleocene and Eocene sandstones are important hydrocarbon reservoirs in the North Sea and Faroe-Shetland basins, there are few published details on the authigenic clays.

Jeans next describes the clay mineralogy of onshore Cretaceous strata, drawing heavily on data occurring in unpublished PhD theses and similar less accessible literature, as well as presenting 1400 previously unpublished clay mineral analyses from his own research over the last thirty years aimed at ‘filling in the gaps’. This chapter is abundantly illustrated by

nested XRD traces of clay mineral assemblages, and supported by extensive tables of clay mineral relative abundances. In this chapter, stratigraphical and regional variations in clay mineralogy are effectively used to provide an insight into the changing palaeogeography, climate, detrital source areas, soil types, volcanism and depositional conditions in this very important period of geological time.

Cretaceous and Jurassic clays of the northern and central North Sea hydrocarbon reservoirs are covered in the next chapter by M. Wilkinson, R. S. Haszeldine and A. E. Fallick. The status of key clay minerals is reviewed. Changes in kaolinite morphology are tracked with increasing depth of burial, and the role of meteoric water flushing is discussed. Factors controlling the formation of fibrous illite are reviewed – an interesting topic as illite growth has been proposed at diagenetic temperatures ranging from 15 to 140°C. Although there is an extensive dataset of K-Ar ages of authigenic illites from the North Sea, the authors of this chapter appear sceptical as to the value of these data.

The next chapter on the clay mineralogy of onshore Jurassic strata by Jeans follows the same approach as that for the Cretaceous chapter, and is backed up by a further 1800 new XRD analyses by the author. Emphasis is placed on the cyclical nature of the clay mineral assemblage on scales ranging from the results of regional tectonic changes to intrabasinal variations at the meter level. One of the big problems in UK Jurassic clay mineralogy is the distinction between volcanogenic and non-volcanogenic authigenic assemblages – the palaeogeographic setting of eastern and central England during the Middle Jurassic was well within the reach of airborne ash resulting from major volcanism in the Central North Sea. Jeans notes that evidential linkage between concentrations of clay minerals such as smectite and volcanic ash is weak (in only one instance is the evidence irrefutable), and lists this as a definite topic for further study.

A further, lengthy chapter by Jeans on Permo-Trias (excluding Rotliegende) clay mineralogy onshore and offshore follows. The origin of the clay minerals, which include sepiolite, palygorskite, smectite-chlorite and corrensite, is discussed in relation to current hypotheses on the development of the Mg-rich assemblages associated with the evaporitic red-bed facies of Europe and North Africa. However, the point is made that the full significance of these varied clay mineralogical assemblages cannot be understood until they can be placed in an improved chronostratigraphical framework. K. Ziegler provides a complementary chapter specifically on the diagenetic clay minerals of Rotliegende

sandstones of the North Sea and adjacent areas of the Netherlands and Germany, in which she deals comprehensively with factors controlling their mineralogy, morphology and regional distribution.

D. A. Spears describes the variety of different clay-bearing sediments in the onshore UK, which range from shales (marine and non-marine) and turbidites, through fireclays and seat-earths, to K-bentonites and tonsteins. H. F. Shaw deals with the relationship between clay mineralogy and porosity in Carboniferous on- and offshore reservoir sandstones, highlighting questions such as the preservation of smectite in sediments that have been buried to >2 km at temperatures >100°C.

Clay assemblages in the marine Devonian sediments of SW England and in continental red bed facies cropping out from South Wales to the extreme north of Scotland are described by S. Hillier, M. J. Wilson and R. J. Merriman. This review highlights the widespread occurrence of dioctahedral chlorite and dioctahedral chlorite-smectite (tosudite), especially in the Lower Old Red Sandstone, attributing their origin to prograde diagenetic alteration of kaolinite. Overall, the present clay mineral assemblage of the ORS is interpreted in terms of an original smectite-dominated precursor assemblage subsequently modified by diagenesis/low-grade metamorphism. Provenance and retrograde diagenesis appear to have had a role, but the authors are clearly divided as to the extent. This divergence only serves to illustrate the value of reviews of this type. Interpretations that appear perfectly reasonable based on evidence from suites of samples from a restricted geographical area or stratigraphic sequence are often called into question when a wider synthesis is undertaken. By documenting their differences of opinion in this way, the authors have provided a valuable service to a continuing debate.

Finally, Merriman summarizes the mineralogy of Lower Palaeozoic mudstones, shales and slates, referring extensively to the Kübler index of illite 'crystallinity'. He recognizes two regional clay mineral assemblages linked to geotectonic settings of the original depositional basins. Mudrocks that evolved in extensional settings developed both K-rich and Na-rich representatives of the 2:1 dioctahedral reaction series together with sporadic pyrophyllite, whereas the assemblages found in plate-convergent settings contain only K-rich phengitic micas and chlorite, negligible Na-micas and no pyrophyllite. He concludes that the tectono-thermal history of these basins rather than inherited compositional differences is the controlling factor determining final clay mineral assemblage.

This book is packed full of data on the clay mineralogy of British sediments, so why should it be of interest to clay mineralogists outside the UK? The short answer is that it addresses many generic questions of clay mineral evolution during varied geological events at a regional scale. It doesn't necessarily come up with the answers, but it assembles the evidence for

others to judge and compare. From the UK perspective, it has placed clay mineralogy firmly back as an important tool for interpreting geological processes, and I sincerely hope that it will inspire a new cohort of clay mineralogists to supplement the existing, but rapidly diminishing, band of geologically-oriented clay scientists currently active in the UK.

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Handbook of Clay Science. F. Bergaya, B.K.G. Theng and G. Lagaly (editors). *Developments in Clay Science*, Volume 1, Elsevier Science, Amsterdam, 1246 pp., 2006, ISBN-13: 978-0-08-044183-2; ISBN-10: 0-08-044183-1. Price: GBP £105, US \$165, EUR €150.

The 'Handbook' is a monumental undertaking edited by three prominent scientists. On a five-star basis it ranks 4.5 and deserves to be on the bookshelf of every clay (materials) scientist. Hopefully, a paperback edition will soon follow that will make the book more affordable for students.

According to the publisher's information, the book "assembles the vast literature on the diverse aspects that make up the discipline of clay science. The topics covered range from the fundamental structures and properties of clays and clay minerals, through environmental, health and industrial applications, to analysis and characterization by modern instrumental techniques. There are also chapters on clays and microorganisms, layered double hydroxides, zeolites, cement hydrates, and the genesis of clay minerals, as well as the history and teaching of clay science." It contains "contributions from 66 authors from 18 different countries,...provides up-to-date concepts, properties, and reactivity of clays and clay minerals,...covers classical and new environmental, industrial, and health applications of clays, as well as the instrumental techniques for clay mineral analysis,...combines geology, mineralogy, crystallography with physics, geotechnology, and soil mechanics together with inorganic, organic, physical, and colloid chemistry for a truly multidisciplinary approach."

The encyclopedic nature of the text is evident in the titles of the 16 major chapters and subchapters: 1. General Introduction, Clays, Clay Minerals, and Clay Science; 2. Structures and Mineralogy of Clay Minerals; 3. Surface and Interface Chemistry of Clay Minerals; 4. Synthetic Clay Minerals and Purification of Natural Clays; 5. Colloid Clay Science; 6. Mechanical Properties of Clays and Clay Minerals; 7. Modified Clays and Clay Minerals with subchapters on Activation, Thermal Modification, Organic Interactions, the Origin of Life, and Pillaring; 8. Properties and Behavior of Iron in Clay Minerals;

9. Clays, Microorganisms and Biomineralization; 10. Clays in Industry containing expanded discussions of Conventional Applications, Catalysis, and Organoclay-Polymer Nanocomposites; 11. Clays, Environment and Health with discussions of Pollution Control, Pesticides, Clay Liners and Waste Disposal, Nuclear Waste Management, Human Health, and Clays as Drugs. A long chapter (12) on a critical assessment of some analytical techniques focuses on Mössbauer Spectroscopy, X-ray diffractometry, X-ray Absorption Spectroscopy, X-ray Photoelectron Spectroscopy, Small Angle Scattering Techniques, Fourier Transform Infrared Spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Electron Microscopy, Surface Area and Porosity, Cation and Anion Exchange, and Thermal Analysis. The methods chapter is followed by: 13. Some Other Materials Related to Clays, including subsections on Layered Double Hydroxides, Parallels and Distinctions between Clay Minerals, and also Cement Hydrates; 14. Genesis of Clay Minerals; 15. History of Clay Science: A Young Discipline; and, 16. Teaching Clay Science: A Great Perspective. A long list of references, some with 2005 publication dates, follows most chapters and the book contains an all-important Subject Index. One is hard-pressed to find a topic in clay science that is omitted.

In most chapters, the authors present a brief review of pertinent references and reviews followed by their own summaries of recent discoveries and examples of the general relationship of physical, chemical and mineralogical properties of clays and clay minerals to the topic being presented. The longest chapter on the colloidal nature of clays is one that best exemplifies the goals of the text. It illustrates how the colloidal chemist views clay properties that underpin many of the applications described in other chapters such as waste management or the fabrication of organo-clay nanocomposites. The publicity statement that “the Handbook is an excellent point of entry for students and scientists

seeking information on clays and clay minerals” is confirmed by the content.

The Handbook lost half of a star in this reviewer’s rating because of inconsistencies that are no doubt a consequence of trying to compile contributions from 66 authors. An important chapter such as that devoted to nuclear waste isolation is very myopic. One could get the impression that Sweden was the only country where investigations related to clay minerals and nuclear waste isolation had been performed. Other chapters were noticeably short considering the amount of information available. The discussion of transmission electron microscopy, an image-intensive characterization technique, without a single micrograph does not do justice to the fantastic work that has been done by the author and others in TEM and other electron microbeam techniques. X-ray diffraction patterns were noticeably absent from the chapter on qualitative and quantitative XRD methods. From one point of view, the last two chapters on history and education appear to be unrelated to the major goals of the book. Recounting the chronology of international conferences while ignoring the history and contributions of the various national clay groups and failing to note the contributions of such notable clay scientists as Georges Millot and George Brindley and others make the historical narrative incomplete. One could also take exception to the correctness of the opinions expressed in the summary of educational activities.

So, the book is not perfect! It is, however, an important contribution to the advancement of clay science at the beginning of the 21st century. It will serve as a benchmark in this field of scientific endeavor equivalent to the mid-20th century *Applied Clay Mineralogy* text of Ralph Grim.

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