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BOOK REVIEWS

RELATIONSHIP OF ORGANIC MATTER AND MINERAL DIAGENESIS. By Donald G. Gautier, Yousif K. Kharaka and Ronald C. Surdam. SEPM Short Course Notes 17, Tulsa, 1985, 279 pages. $17.00 (US).

This quarto-sized, soft-covered volume is the text presentation of a 1985 SEPM short-course lecture series. The general topic of this course is one that probably has not specifically been covered by any previous review, possibly because of the multidisciplinary nature of the topic. Inevitably, the degree of success of such a review depends upon how uniformly the authors have integrated their multidisciplinary material and how completely they have covered their stated subject. Measured from this viewpoint, this short course, or review, is a qualified success.

The volume is divided into three chapters. The first chapter outlines the influence of shallow burial (*i.e.*, less than about 1000 m) on organic material and sets the stage for the later chapters that deal with deeper burial. In chapter one the three early-diagenetic biochemical zones are described; these are, in order of occurrence with depth, the aerobic zone, characterized by the microbial aerobic oxidation of organic material, the sulfate-reduction zone, in which organic material is oxidized by means of the reduction of sulfate to sulfide, and, at greater depths, the zone of methanic diagenesis where methanogens (methane-producing bacteria) generate methane by fermentation of organic material and by reduction of CO_2 to methane. The precipitation of carbonate and sulfide in these zones and their characteristic isotopic compositions of carbon, oxygen and sulfur are well described and illustrated, particularly with regard to the growth of carbonate concretions in shale. Oddly, silica is not mentioned in the first part, in spite of the many studies that have documented its importance during early diagenesis.

The first chapter includes a good account of how parameters such as the ratio of total sulfur to total organic carbon in the sediment and the isotopic composition of sulfur in diagenetic sulfides can be used to draw inferences concerning the chemical environment immediately above and below the sediment-water interface, and its subsequent evolution during the first few tens of centimetres of burial. Methanogenesis and its influence on the isotopic composition of carbon in carbonate concretions are well described. However, no consideration is given to the influence of upward advective fluid-flow during compaction. At one point a mass-balance calculation is presented, which demonstrates that the amount of carbonate required for cementation within a given zone in a particular shale sequence is greater than that which could be generated by CO_2 derived from the methanogenesis of organic material within that zone. The authors suggest that additional CO_2 migrates downward from the "interface of the SO_4^{2-} reduction and CO_2 reduction zones" to satisfy this mass-balance requirement. It seems far more likely to this reviewer that migration of dissolved components in a compacting shale sequence will be upward, not downward, because of advective fluid-flow.

The second, and lengthiest, part or chapter of this volume is devoted to the chemistry of subsurface solutions in sedimentary basins and, as such, represents a digression from the title of the volume. Aside from this defect, this part is an excellent account of the origin of the isotopic and chemical composition of subsurface waters. The prevalence of organic acids such as acetic acid in basinal fluids at temperatures greater than 80°C is documented convincingly. The authors demonstrate clearly that the acidity of these deeper subsurface fluids tends to be controlled by acetic and other organic acids rather than by carbonic acid, and show how this will favor the occurrence of minerals such as kaolinite that are more stable in acid environments. Less satisfactory is the absence of any systematic discussion concerning the influence during burial of variations in physical parameters such as temperature and fluid pressure on solution compositions and mineral assemblages. This is puzzling because some examples of studies of basinal sequences in which zones of diagenetic minerals have been linked with the profound variations in temperature and pressure associated with overpressured sediments are cited, but they are not discussed. Instead, the emphasis is firmly on the description of methods by which groundwaters are sampled and the application of correction factors to the analysis of sampled groundwaters and to the description of a geochemical model of groundwater chemistry (SOLMNEQ II) that enables the calculation of the saturation states of the various mineral-species in contact with these groundwaters.

Chapter 3, entitled "Mechanisms of organic/inorganic interactions in sandstone/shale sequences" is more in keeping in its subject material with the title of the volume and as such is perhaps the most informative of the three chapters. Various lines of evidence are adduced to document the structure and composition of kerogen and its changes with depth. These changes indicate that carboxylic acids and

phenols are produced from kerogen during burial and control the pH of subsurface environments over the temperature range 80 to 120°C. It is argued that in kerogen these oxygen-bearing organic compounds surround a core of hydrocarbons, and this sheath of oxygenated compounds must be shed before hydrocarbons can be generated from kerogen. The intriguing suggestion is made that the production of carboxylic acids and phenols from kerogens is intimately linked to oxidation–reduction reactions that occur during clay diagenesis and the consequent loss of iron from clay minerals. These kerogen-derived organic acids are themselves linked to the generation of secondary porosity through the dissolution of carbonate and aluminosilicate minerals, and to the enhanced mobility of aluminum ions by the formation of soluble complexes. The fact that, contrary to dogma, an increase in pCO_2 may lead to carbonate precipitation rather than dissolution at depths where the pH is buffered by organic acids is well brought out. All of the various aspects of this chapter are synthesized into a convincing conceptual model involving maturation of organic material, mineral diagenesis and porosity changes.

The volume suffers slightly from the lack of a consistent format for equations, and inappropriate symbols are sometimes used, such as the use of parentheses in place of equal signs. In one place, two figure captions have been transposed. Apart from these minor editorial problems, the volume has two main shortcomings. The first, already alluded to, concerns the lack of emphasis on mineral diagenesis. Nowhere has mineral diagenesis been given the emphasis that has been accorded to the chemistry of subsurface solutions. Consequently the title of the volume is a bit of a misnomer. Secondly, some recent relevant studies on clay mineralogy and diagenesis (in Canada) and on early burial diagenesis (in Europe) have been ignored. Nevertheless, this volume represents an excellent summary of the results of modern research into the interaction of organic matter and the host sediments during burial and, at a price of $17 (US), it is a bargain.

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FLUID INCLUSIONS. By Edwin Roedder. Reviews in Mineralogy 12, Mineralogical Society of America, 2000 Florida Avenue, N.W. Washington D.C. 20009. 1984. $14.00 (US).

This book must be the best buy in the specialized textbook field. The 19 chapters include discussion of the origin and preservation of fluid inclusions, techniques for finding and studying them, and applications to interpreting sedimentary, metamorphic and igneous petrogenesis, ore deposition, and extraterrestrial environments.

The newcomer to research in fluid inclusions should not pick up the book in the expectation of easily learning how to study fluid inclusions and how to "avoid many of the pitfalls and blind alleys that beset anyone starting in a new field of research" (preface, p.*v.*). After the commitment is made to study fluid inclusions, and some data have been obtained, then Roedder's book will be found useful, and increasingly so as the research progresses. Particularly impressive are the high-quality reproductions of photographs of fluid inclusions, especially those that clearly illustrate progressions of phase changes with temperature. These are invaluable aids for interpreting phase behavior observed in inclusions during cooling and heating. The book is organized so one can quickly and easily find an answer to most questions through combined use of the subject and locality indices and table of contents at the beginning of each chapter. An innovation is that references in the extensive bibliography include the page numbers where the references are used in the text. Would that other writers follow this example! The geological community owes a large debt of gratitude to Roedder for this innovation.

It is extremely difficult to read large sections of the book page-by-page. The lack of coherence is due mainly to many paragraphs that have no obvious relevance to preceding or subsequent paragraphs, or have little relevance to the subject of fluid inclusions. Had these been deleted, the present 425,000 words could have been reduced to a more manageable length; for comparison, the next largest MSA volume has only 220,000 words.

"Fluid Inclusions" is not, as is printed on the front jacket, "an introduction . . .". It is an encyclopedia on the subject and related topics in the style of an annotated bibliography organized under chapter headings. Not to be overlooked or minimized, however, is the fact that Roedder has spent the last 30 years meticulously and relentlessly pursuing answers to hundreds of fascinating petrological problems. His thoughts on each can be found in the book. All petrologists, whether or not interested in a serious study of fluid inclusions, will therefore find "Fluid Inclusions" a useful reference to have on their bookshelves.

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