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BOOK REVIEW

Clays in the Origin of Life, edited by A. G. Cairns-Smith and H. Hartman, Cambridge University Press, Cambridge, United Kingdom, 1986, 193 pp., hardbound. US$34.50.

That clays might have been instrumental in the origin of life is hardly a novel concept (cf. Genesis 2:7). Scientific elaboration of this concept, however, is current and is developing in two distinct, but interrelated, channels. In the Bernal conception (Bernal, 1952), clays served in the development of cellular life. In the more sweeping Cairns-Smith conception (Cairns-Smith, 1982), defective inorganic crystals having the functional attributes of living systems, most particularly clay minerals, served as prototypic life forms. Both hypotheses are rational in terms of clay structures and are investigable by observation of natural systems and by laboratory simulations. There is much legitimate, if complex and interdisciplinary, science to be pursued regarding the role of clays in the origin of life, two possible directions for which, replication and catalysis, are sketched in the book, *Clay Minerals and the Origin of Life,* edited by A. G. Cairns-Smith and H. Hartman.

This book is a synthesis of a workshop held in Glasgow in 1983. The workshop was the first formal intersection of clay mineralogists and proponents of the "clay-life" hypothesis. It was held to assess the present status of supporting evidence for, and to suggest investigative strategies for testing, the hypothesis that the first genes might have been clays. A number of issues are addressed in the book that are prerequisite to assessing the role of clays in either the Bernal or the Cairns-Smith framework. Among these are:

1. What are clays (treated by W. D. Keller, S. W. Bailey, F. R. Giese, H. van Olphen, and R. C. Reynolds)? Textbook clay classifications are surpassed, in that structural "information" carried by clays is examined in analogy with that carried by DNA, the replicable, mutable, informational molecule which serves as a design manual for cells.
2. How are clays formed (reviewed by D. D. Eberl, H. Harder, and B. Siffert)? This subject is reviewed via laboratory and natural routes.
3. Where have (might have) clays been found (discussed by G. S. Odin, R. C. Reynolds, H. Harder, G. Arrhenius, A. Banin, S. Chang, and T. Bunch)? The existence and nature of primordial and extra-terrestrial clays are assessed in the context of basic requirements for clay genesis and presumed conditions of early solar system environments.
4. How do clays control organic reactions, i.e., reactions of prebiological interest (covered by T. J. Pinnavaia, M. M. Mortland, and J. G. Lawless)? Clay surface chemistry is key to clay inclusion in molecular systems that could undergo synergistic reactions able to support self-organization and sustain proto-life.
5. What do we mean by life and living inorganic systems (sketched by H. Kamminga, A. L. Mackay, P. S. Braterman, and D. P. Bloch, with interleaved comments and discussions by H. Hartman and A. G. Cairns-Smith)? To test the "clay-life" hypothesis of Cairns-Smith, the definitions of "life" and "living" must be reassessed in conceptual, rather than compositional terms. Concepts of inorganic "life" and replication are useful to biology, even if the hypothesis is not verified. The book undertook this reassessment by projecting the origin of life forward from inorganic origins and, alternatively, backwards into protocells and inorganic precursors.

All of the papers included in this book are appropriate, and they contain much interesting information about clays and plausible conditions out of which life could have developed. They were written by highly qualified experts in the various fields and assembled in logical groups and sequences. The book falls far short of its promise, however, in spite of the fascination of the topic, the stellar array of contributors, and a number of excellent articles. Scholarly and editorial deficiencies, both of the conception and of execution, are numerous, and some of them are severe.

Recurrent problems of execution include: lack of, unreferenced, or fuzzy, definitions of key terms (such as local charge balance) not necessarily generally familiar to the anticipated diverse readership; loose translations of "loaded" terms from other disciplines (e.g., 'bio', and 'information'), which needed to be precisely rephrased or renamed, given their extended application; inadequate summary or referencing of basic concepts (e.g., evolution); sketchy referencing of prior investigative strategies and experimental results, poorly labeled figures, dogmatic assertions of opinion instead of scientific conclusions; lack of analysis of the limits of investigative capabilities, and too much speculation, i.e., smeared distinctions between matters of science and philosophy. In short, the subject does not seem to have been taken sufficiently seriously.

Few of the clay chemist contributors apparently felt comfortable in making concrete connections between their technical material and its possible application to the origin of life, and conversely, biologists and exobiologists to the utility of clays in forming first life. Those who tried, communicated in the language of their own backgrounds, rather than by establishing a basis of commonly perceived terminology and concepts. The assessment criteria for establishing a system as evolving focussed too much on arcane biological particulars, too little on definition and hierarchization of the general properties of evolving organisms. The overall organization was good, but significantly more integration and clarity of expression could have been achieved in the editorial overview. I did, however, enjoy Hartman and Cairns-Smith's debate in the last chapter of the book on the scale on which information would be useful for replication.

Problems of precision, general accessibility of basic material and integration of concepts are hard to overcome in a work like this one. Audience definition, thus forging of a common knowledge and its legitimate interpretation, is fiendishly taxing. True, authors needed to be encouraged to be open-minded and creative (i.e., *temporarily* to lay aside critique) in order to stimulate new thinking. Even so, the workshop environment and the proceedings are two very different scholarly devices. It is possible, however, to walk the fine lines of effective communication between the unwashed and the annointed, the scholar and the adventurer, in spite of the difficulties. In my opinion the two articles by R. C. Reynolds and that of A. Banin achieved these balances, and many others were close runners-up.

The major conceptual flaw in the book lies in the equation that was made between self-replicating systems and life forms. The view of Troland that ". . . gene replication and gene expression are the absolute preconditions for life" is a commonly, but by no means universally, held notion. It has led the fields of biology and chemical evolution into a dogma which may most simply be summarized as the "Cult of the Self-Replicating Molecule".

To define life, most particularly 'inorganic life', many operations occurring at the molecular level must be considered, e.g., segregation of materials and charge; catalysis; and harvesting, storage, and transduction of energy and information, all of which act synchronously to support numerous functional attributes of living systems, e.g., adaptation, replication, growth, repair. The workshop focussed on replication and included well-selected, but narrowly scoped, reference to pre-biotic catalysis. Entropy and energetics, the most fundamental considerations in discriminating between life and non-life, were not seriously considered. The book would have been better titled Clay Minerals and the Origins of Replication, rather than Life, in the face of numerous relevant, extant, research areas which were not represented. It should be viewed as a preview, rather than as a synopsis of thinking about the mineral origins of life.

LELIA M. COYNE

REFERENCES

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Cairns-Smith, A. G. (1982) *The Genetic Takeover and the Mineral Origins of Life:* Cambridge University Press, New York, 80 pp.