Evolution of Complex Earth Systems

Lynn S. Fichter and Eric J. Pyle, 2010, Department of Geology and Environmental Science, James Madison University, Harrisonburg, Virginia, 22807

Thinking has its strategies and tactics too, much as other forms of action have. Which avenues of thinking are apt to be useful and to help yield the truth depends not on how we might prefer to think about a subject, but rather on the inherent nature of the subject itself. To interlink thoughts about the Earth and get somewhere, one of the main things to know is what kind of problem the Earth is.

Earth systems are not simple systems (e.g. classical mechanics), or systems of disorganized complexity (classical thermodynamic). They are what Warren Weaver called problems of organized complexity, and Sylvia Prigogine called dissipative structures, and we call complex systems, in which a half-dozen and even several dozen quantities are all varying simultaneously and in subtly interconnected ways. The variables are many, but they are not helter-skelter; they are interrelated into an organic whole.

To approach Earth systems from a complex systems viewpoint we are interested in how the evolutionary processes in one sphere influence the evolutionary processes in another sphere. For example:

- The fracturing evolution of atmospheric gases over geologic time has been largely mediated by biological processes, but not all fractionations are biological (e.g. fractionation of atmospheric oxygen isotopes, and many but not all mineral fractionations).
- Over short geologic time scales (e.g. thousands of years), elaborating evolutionary change has little influence on how fractionation occurs, but at longer geologic time scales the evolution of biological fractionation mechanisms has changed the way that chemical fractionation occurs.
- The fracturing evolution of the atmosphere has at times changed opportunities for elaborating evolution and subsequently the long-term evolution of life on Earth.
- Meanwhile, the origin of life, and development and structure of ecosystems are not elaborating mechanisms, but self-organizing systems, and they influence how Earth environments have evolved through time.

By looking at evolution through the universality principles of chaos/complex systems we will see new dimensions and new possibilities that might not have occurred to us before. A whole new vision of leading based on complex evolutionary systems lies before us. At the same time there is a vast area of problems and understanding yet to be worked out.