

GEOLOGICAL PROCESSES

a16 Emergence in physical systems < synergy >

Words—so innocent and powerless as they are, as standing in a dictionary [but] how potent for good and evil they become, in the hands of one who knows how to combine them! —Nathaniel Hawthorne.¹

Think ... of an experience from your childhood. Something you remember clearly ... But here is the bombshell: you weren't there. Not a single atom that is in your body today [save permanent tooth enamel] was there when that event took place. ... Matter flows from place to place and momentarily comes together to be you. Whatever you are, therefore, you are not the stuff of which you are made. —Steve Grand.²

... emergence, self organization and adaptation [are] processes characterized by complex causal interactions that are not reducible to linear sequences of causes and effects. —Federica Raia.³

Geological change is brought about by the operation of *processes*. Typical geological processes, to name just four, are weathering, erosion, lithification, and metamorphism. These processes are understood not to violate any known laws of physics and chemistry. They themselves, however, cannot be expressed as laws. Geological processes emerge from the combined action of simpler physical and chemical processes.

Reductionism asserts that a complex system is but the sum of its parts. Antireductionism asserts that the whole is more than the sum of its parts when properties are emergent that cannot be explained in terms of discernible parts. *Emergence* is a single word for “hierarchic level of complexity” of observed qualities and functions inexplicable in terms of known constituents. “More is different” finds P. W. Anderson.⁴ For example, water is a structure of hydrogen and oxygen. However, the properties of water cannot be derived from the properties of hydrogen and oxygen. John Horgan characterizes an “emergent” as “unpredictable, irreducible, and holistic.”⁵

Measurables such as temperature and concepts such as entropy can be used to account for the bulk behavior of systems of particles. However, the same lose all meaning at the level of individual particles and forces. Philip Anderson’s *More Is Different* article in *Science*, 1972, gives examples.⁶ Most evident is that nothing like consciousness (awareness), an imponderable (not measurable), experienced directly, and individually, and not through the senses, is there at the level of individual cells, and nothing like life is there at the level of atoms and molecules. In vain we look for sense in quantum phenomena (Steven Weinberg in *Dreams of a Final Theory* relates this anecdote: “... our conversation turned to a young theorist who had been quite promising as a graduate student and who had then dropped out of sight. I asked Phil what had interfered with the ex-student’s research. Phil shook his head sadly and said, “He tried to understand quantum mechanics.”)⁷



Vladimir Ivanovich Vernadsky (1863-1945),⁸ pioneer in geochemistry and founder of systematic studies of the biosphere.

Emergent processes in geology are those that produce distinctive results different from what one could easily anticipate from an understanding of the chemistry and physics which a simple model for these would involve. Weathering is a process that changes rock to soil. However, residual soil cannot come to be in the absence of plants. And plants are an unanticipated component in that they are alive.

V. I. Vernadsky upon reading G. T. Carruthers letter in *Nature*, 1889, (the ongoing magazine founded in 1869 by T. H. Huxley and J. D. Hooker as a voice for *X-club* members who would study science free of intrusion from church or religious precepts)⁸ of a locust swarm

of 24 quadrillion (40 billion by modern estimate) insects, realized that life by processing and transporting mass, accelerates the rate of planetary change in ways novel to mere inorganic weathering and denudation of rock of equal mass. Thirty years later, he recounts this inspiration in *La Géochimie*, 1924: “That swarm of locusts, expressed in terms of chemical elements and in metric tons, may be seen as analogical to a rock formation, or, more precisely; to a moving rock formation endowed with free energy.”⁹

“Order and regularity emerge from interactions of components that seem to prescribe nothing more than chaos and disorder” notes Phillip Ball.¹⁰ In geomorphology, self-organizing systems are apparent in sand dunes, dendritic drainage patterns, and river meanders. Information theory is that emergent objects and processes can be ranked by the distance between them and what would be easily expected of the constituent parts. To date little has come of this study although its proponents claim, according to Timothy Ferris, that it is “an emerging approach to understanding the world that could eventually transform the philosophical underpinnings of science, though to date it remains shrouded in fog.”¹¹ *Information* itself, often muddled in such discussions, is succinctly defined in *Unweaving the Rainbow* by Richard Dawkins, as ‘surprise value, measured as the inverse of expected probability’—which is an excellent way of explaining why, for instance, a ream of yellowed fish-wrapping paper increases in information value if it is found to contain, say, a lost Bach cantata.”¹²

In *A New Kind of Science*, 2002, Stephen Wolfram reveals:

The pivotal discovery that I made some eighteen years ago is ... that despite the simplicity of their rules, the behavior of [cellular automata] was often far from simple. ... At the outset there was no indication that simple programs could ever produce behavior so diverse and often complex.” Generalizing this insight “yields a resolution to ... the greatest mystery of the natural world: what secret it is that allows nature seemingly so effortlessly to produce so much that appears to us so complex.”¹³

What is emergent is limited by the realities of our natural world. It is these realities, which the exact sciences, by reductionist methods, strive to describe¹⁴ but in that direction have arrived at a mathemancy that makes of all nothing but waves in a nonexistent medium.¹⁵

Beyond what inanimate nature has produced is, say, a radio. Although easy to understand by reductionist analysis, it was an invention that without our intervention was not in the scheme of things. Unlike ourselves, which Darwin revealed are in the scheme of things as a result of a process called *evolution*; guided by natural selection, itself a process segued by contingencies. That is, in the world in which we are, we are possible. This is what cosmologists call the *anthropic principle* and may be the single thing they have nearly right. The cosmologists’ anthropic principle, so named by Brandon Carter in 1973 (in Krakow, Poland, during a special two-week series of lectures commemorating Copernicus’s 500th birthday),¹⁶ is lifted from Alfred Russel Wallace’s proposition¹⁷—which is distinguished by being called the “strong anthropic principle” and was lampooned by Mark Twain (*non-de-plume* of Samuel (Sam)Langhorne Clemens (1835–1910))—that the Universe was designed expressly to accommodate humankind.¹⁸ Adjust the fundamental constants and flex the laws beyond tiny tolerances and we wouldn’t be here to observe it. That is, the inverse of the fine-structure constant alpha must be very close to 137 or the universe would expand too fast or too slowly, or become too hot or too cold for us as a possibility.¹⁹ Nicholas Humphrey writes:

I have a strong hunch—no, actually, it’s a reasoned argument, which I spell out in the book [*Leaps of Faith*]²⁰—that, if the laws of nature were to be adjusted to allow for paranormal phenomena, that too would have a disastrous effect—it would be the end of life as we know it and very possibly enough to prevent life ever having started.

That we have come to be is unlikely, but no surprise to an alien, finding only our fossils—but a found radio is a thrill as no unselfaware physical system has it in its stream of natural nonpatentable results.²¹ Not that all natural results will ever show. For example, in the game of chess all games by its rules are possible, but not all will ever be played. A radio has a surprise value that is astonishing. Communication by other devices are possible but telepathic communication is a surprise that may never be because its existence would violate the natural world. And we would not be. □