Committee VI
Global Environmental Problems
161

Draft-for Conference
Distribution Only

Discussion Paper

by

Abraham Lerman
Professor of Geolical Sciences
Northwestern University
Evanston, Illinois, USA

on

J.E. Lovelock's
GAIA AS SEEN THROUGH THE ATMOSPHERE

and

Andrew J. Watson's
THE GAIA HYPOTHESIS: MECHANISMS AND TESTS

The Twelfth International Conference on the Unity of the Sciences
Chicago, Illinois November 24-27, 1983

Points for discussion of the papers "Gaia as seen through the atmosphere", by J. E. Lovelock, and "The Gaia hypothesis — mechanisms and tests", by A. J. Watson.

1. Are the organisms necessarily responsible for an atmosphere that is in a state of a chemical nonequilibrium?

— Points for consideration: equilibria between gases and mineral assemblages on the early Earth; frozen disequilibria on the Earth's surface; global temperature gradients between the interior and the surface; present-day evidence of the variations in the concentrations of the major and minor gases in the atmosphere.

2. Homeostasis in the Daisyland.

— Points for consideration: if the black and white daisies can control the CO_2 levels in the atmosphere and, hence, the mean surface temperature of the planet, one should ask a legitimate question, how did such a black-and-white community evolve, barring a hypothesis that they were imported and planted by The Little Prince?

3. Abiotic Earth.

— Points for consideration: if life were to be wiped out completely (Doomsday scenario), the chemical composition of the atmosphere and oceans will not necessarily return to the primeval. The results of the biogeochemical fractionation of the outer shells of the Earth (parts of the sedimentary cover, the hydrosphere, and the atmosphere) will evolve in the direction of the higher oxidation states of those reduced materials that are at present exposed to the inorganic oxidative processes. The length of time of such a doomsday-induced transition into the future may be of the order of 10^6 to 10^8 years.

4. Life in the Past and Life in the Future ?

— Points for consideration: biosynthesis that makes organic matter (CH_2O) and free oxygen is energetically by far not one of the more economical processes. Combinations of CO_2 with such electron donors as hydrogen gas, methane, hydrogen sulfide, or ammonia that produce organic matter, all require less energy per mole of CH_2O produced. The rate of production of free oxygen in the distant past might have been much lower that the average photosynthetic rate in our days, such that most of the oxygen produced did not accumulate free in the atmosphere, but it was consumed by inorganic sinks. The efficiency of making the organic matter, as reflected in the carbon/phoshor or carbon/limiting nutrient ratios, might have been a strongly promoting facto for "an increased pollution" of the early atmosphere with oxygen.

5. Life and Radioactivity (J. E. Lovelock's paper, p. 21)

— Questions, questions...: if organisms could have been responsible for concentrating uranium from waters until a mass needed for a fission reaction accumulated in a sedimentary basin (the isotope ^{235}U and its decay products), would not the destructive effects of radiation become the limiting factors before the mass accumulated could begin its reactor stage? Would not the disruption of the organic bonds by radiation (as opposed to the generally understood health hazards to higher organisms in a radiation environment) put a check on natural selection in a radioactive environment?

6. A test of the Gaia Hypothesis (A. J. Watson's paper, p. 9)

— In the words of the paper, "Gaia would regulate the oxygen level most of the time, with major changes occuring only at crisis points in the history of the earth". How can we identify such crisis points in the past? Extinctions are generally considered as turning points in the history of the metazoan biomass; but, can a crisis point in the future, treated as a mathematical catastrophe that imposes a new set of the boundary conditions on our model world, be related to the chemical composition of the atmosphere, insofar as the latter is presumably controlled by life? Understanding of the consequences of such a catastrophe in the past or in the future is dependent on our ability to decipher the homeostatic mechanisms in a world that is much more complex than the model Daisyland. Perhaps we have a better understanding at present of the inorganic arrows in this process, and it is our task to focus more on the more poorly understood daisies and the magnitude of their roles in shaping the surface environment of the Earth.

A. Lerman
Department of Geological Sciences
Northwestern University
Evanston, Illinois 60201