Biogeoevolution: Interactions from the Planetary Scale Down to the Micro-scale of the Fungi, Bacteria and Mineral Worlds

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This presentation illustrates the close interaction and parallel evolution of the bio- and geo-spheres through a couple of selected examples. If the "Cool Early Earth" hypothesis is correct, it can be speculated that life already originated in the Hadean, perhaps shortly after the cooling of the magma ocean. If this is the case, the question of the role at ~ 3.8 Ga of the Late Heavy Bombardment recorded on the Moon and in meteorites as a mass extinction agent can be proposed. The invention of photosynthesis by cyanobacteria around 2.7 Ga led to another major biosphere change, mainly the decrease of the methanogenesis with as possible consequences, a decrease in greenhouse gases and the beginning of major cooling of the climate culminating in the first Snowball Earth episodes. The Neoproterozoic is marked by repetitive Snowball Earth events, probably triggered by systematic reductions of the amount of CO_2 in the atmosphere. The same periods sees the rise of more sophisticated multicellular organisms. The Ediacara soft body fauna appears at the end of this sequence of major coolings, and subsequently give way to the shelly organisms across the Precambrian-Cambrian boundary. In the Phanerozoic, mass extinctions and radiation of organisms witness the interplay between the geo and biosphere. So far no satisfactory or global explanation have been advanced for the extinctions taking place in the Late Devonian, or Frasnian-Famennian boundary and at the Triassic-Jurassic boundary. The Late Ordovician biotic crisis seems to be linked to a major cooling, perhaps a last attempt of the Earth to return to Snowball conditions. A major pulse of volcanism, the eruption of the Siberian traps, coupled with environmental conditions derived from the existence of a unique continental Pangea could explain the Permo-Triassic mass extinction. The Cretaceous-Tertiary mass extinction is most likely triggered by the impact of a large asteroid on the Yucatan peninsula releasing brutally dust, CO2 and SOx components in the atmosphere. Recently, it was also proposed that an anomalously high input of extraterrestrial material, as witnessed by the micrometeorites recovered from limestone sequences in Sweden and China triggered the major radiation of organisms taking place in the Mid-Ordovician. At another much smaller scale, fungal and bacterial interactions affect minerals in various ways. For example Ca-oxalates and glunshinskite are produced through fungal interaction with CaCO3 substrates and seawater as a process of bio-induced recycling of elements and neo-mineral formation. Such microorganisms could play a major role in bioweathering and sediment diagenesis and lead to the production of minerals as biomarkers. Moreover, coccoidal-like chains of putative microbial origin have been identified along with magnetite encrustations on hematite and can perhaps be used as biomarkers for early life on Earth and on other planets.

Key words: *biogeoevolution, mass extinction, radiation, biomarkers*