The Biggest Seven Events through Geologic History of the Earth

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<Method employed and purposes>

The main purpose of this study is to propose a working hypothesis for the evolution history of the Earth. This includes the dynamic changes of the whole Earth from central core through mantle, ocean-atmosphere and biosphere to magnetosphere.

We have employed the following methods: (1) Detailed field mapping of several selected regions in the world and systematic sampling for petrochemical investigations. (2) Predicted events deduced from results of physical approaches such as ultrahigh-pressure experiments and simulation of mantle rheology, particularly from the view suggested by hierarchy of the Earth's orogenesis. (3) Review and synthesis of previous studies on the evolution of the Earth.

<Results>

We proposed seven biggest events through the Earth's history. These are: (1) Birth of the Earth, (2) Initiation of plate tectonics, (3) Birth of strong magnetosphere, initiation of photo-synthesis, and surface environmental change, (4) Formation of first supercontinent, (5) Initiation of return flow of seawater into mantle, (6) Mass extinction at the Permo-Triassic boundary, and (7) Birth of human being and initiation of Science.

(1) Birth of the Earth (4.56 Ga, Fig. 1-1)

The Earth was born by the extensive collision-amalgamation of planetesimals and subsequent heavy extra-terrestrial bombardments at 4.55-4.56 Ga. These events are well documented on the surface geology of the Moon, which may have been formed by a giant impact at this stage. If this were the case, the Earth would have been melted even in the central portion.

(2) Initiation of plate tectonics (4.0 Ga, Fig. 4-4)

The Earth materials suggesting the ages from 4.56 Ga to 3.96 Ga is absent except for some detrital clastic zircon grains on the Earth. The oldest Acasta gneiss is derived from an andesitic protolith, indicating the presence of TTG formation at ca. 4.0 Ga. The occurrence of these lithologies suggests that the plate tectonics has started at this time. The surface geology in Isua of West Greenland documents the presence of rigid lithospheric plate at 3.9-3.8 Ga as surface temperature of the Earth was calculated at $< 100^{\circ}C$, and mantle temperature $150^{\circ}C$ higher than the present mantle. The original carbon isotope ratio corrected by late-stage regional metamorphism suggests the presence of early life at 3.8-3.9 Ga. The possible cause of the initiation of the plate tectonics is the birth of proto-ocean.

(3) Birth of strong magnetosphere and initiation of photosynthesis (2.7 Ga, Fig. 1-5)

The strong magnetosphere appeared at ca. 2.7 Ga, when stromatolite appeared along the coastal lines on most continents; suggesting photosynthesis by cyanobacteria has started. This period has also been well known as a time of extensive formation of BIF, probably related to initiation of photosynthesis to produce free oxygen.

Extensive magmatism and formation of Pacific-type orogenic belts are also characteristic aspects in this period, after the quiescent time of orogenesis at 3.0-2.9 Ga. The sudden reactivation of plate tectonics may be the result of mantle overturn, by which occurred localized refrigeration on the surface of outer core to bear the birth of strong magnetosphere. During the extensive change of surface environment, life evolved from procaryotes to eucaryotes.

(4) Formation of the first supercontinent (1.9 Ga, Fig. 1-6)

The present North American continent is the largest remnant of the first supercontinent. More than 80% of the continent may have been amalgamated together at 1.9 Ga. This event suggests the cooling Earth by this time to form a few cold super-downwellings to make a surface movement to swallow all continents into one place. Since then, the Wilson cycle has become a major tectonic style on the Earth's orogenesis.

(5) Initiation of return-flow of seawater into mantle (0.75 Ga, Fig. 2 and Fig. 1-7,-8)

The Latest Proterozoic is the timing of most dramatic evolution period of life resulting in the appearance of large multi-cellular organisms and diversification of life. Mantle has become active again after the almost-dead time of the Earth called the snowball Earth. The supercontinent Rodinia started to rift at 0.8-0.7 Ga dispersed and collided again to form the next supercontinent Gondwana at 0.54 Ga, indicating extremely fast ocean-floor spreading. All of these apparently geologic-related phenomena can be explained by the initiation of return flow of seawater into mantle at 750Ma. This was deduced by the global compilation of space and time distribution of subduction zone high- and ultrahigh-P metamorphic rocks in the world. Mantle rheology and melting temperatures of mantle rocks depend strongly on water content. The decrease in the sea level enlarged the size of landmass from 5% to 30% around 0.6 Ga, by which large amounts of sediments were accumulated to protect the oxidation of organic matters. This process extensively increased free oxygen content in the atmosphere, and enhanced the life evolution. The increased oxygen eventually moved upwards to form an ozone layer to cut off the ultraviolet rays. Thereafter life migrated from sea to land by 0.45 Ga.

(6) Largest mass extinction at P/T Boundary (0.24-0.25Ga, Fig. 1-9)

The world-largest mass extinction occurred at the Permo-Triassic boundary, when supercontinent Pangea has rifted to form many extensive explosive volcanic activities. This process must have blocked sunlight and decreased photosynthesis activity on the Earth. The super-anoxic events have been recorded from not only continental platform deposits, but also from deep sea and seamount-top reef limestones of the Permo-Triassic ages. This may have resulted from the decrease in the oxygen level at this time.

(7) Birth of human being and initiation of Science (Fig. 2-10)

The rifting of the African continent has drastically changed the east African climate by the African plume about 4.5 Ma. Our ancestors of human being appeared at this time. Through the periodical inventions such as tool, agriculture, and industry, we have finally developed the modern culture and initiated the modern science.

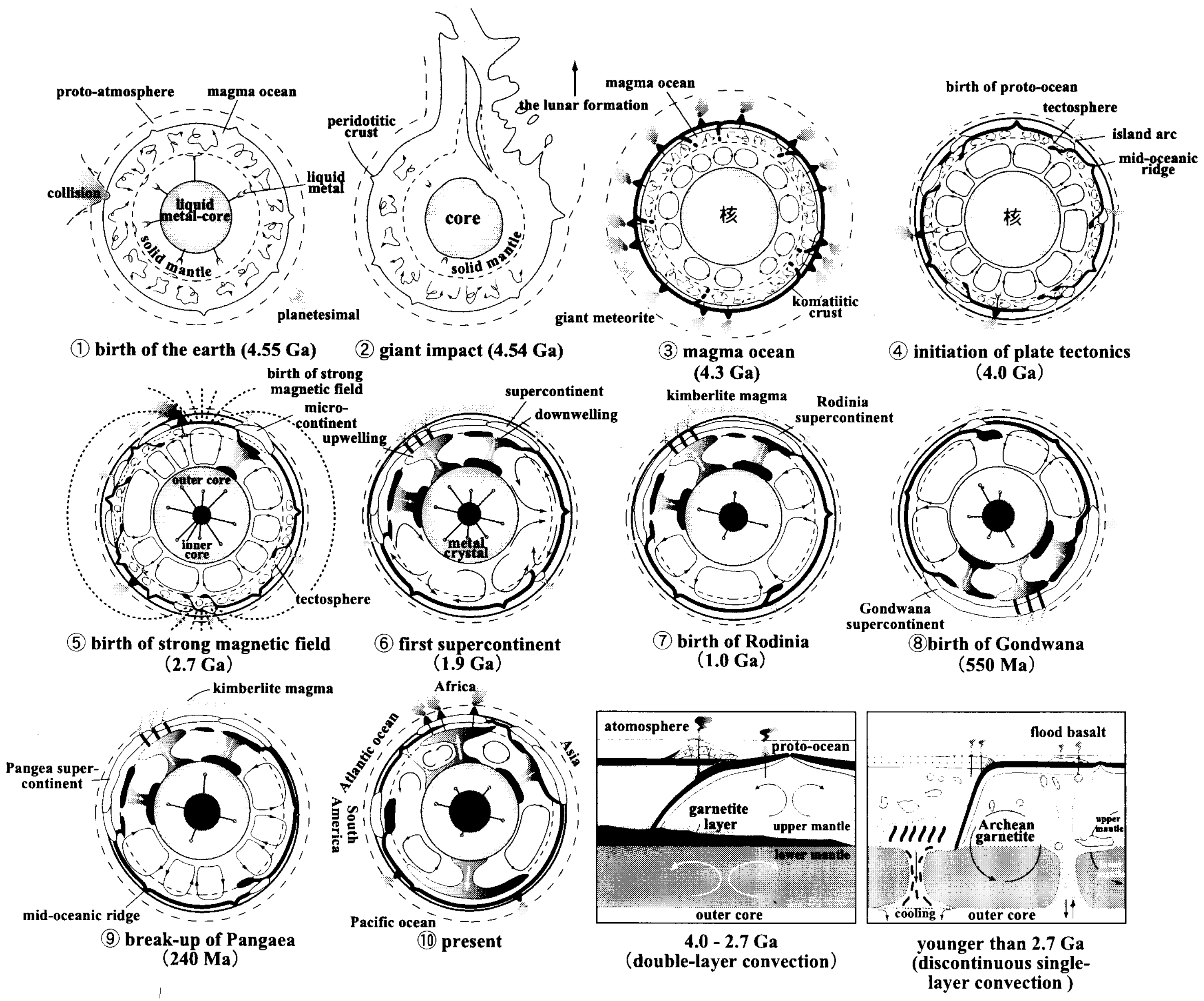

Fig.1 Evolution of the Earth

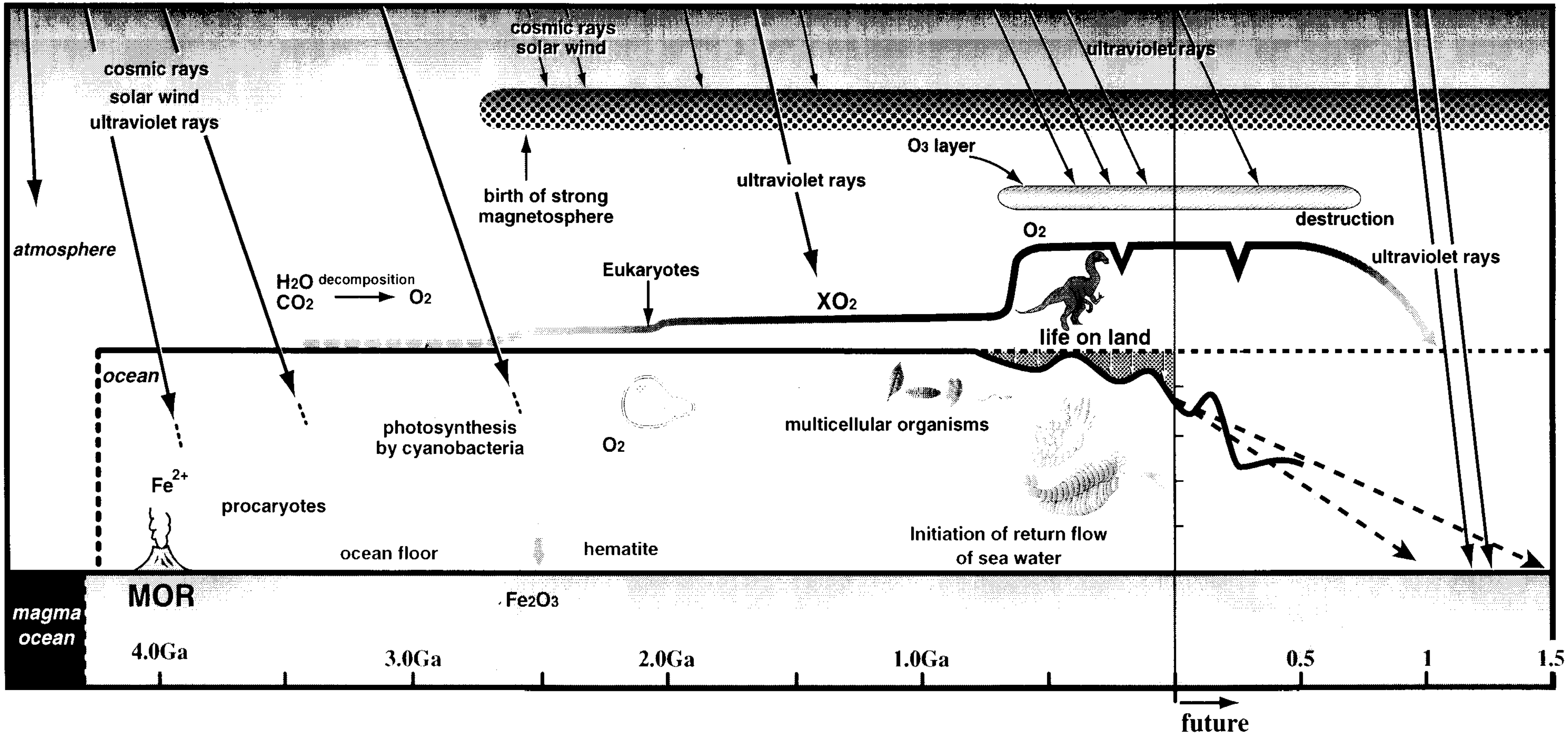

Fig.2 Evolution of life and surface environment of the Earth