

A new model of snowball Earth; the core controlled the surface environment of the Earth

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[Previous model]

The snowball Earth at 0.75-0.60 Ga and presumably at 2.3 Ga has been regarded as caused by decrease of greenhouse effect by atmospheric CO₂. Probably not, we will show a new model. We present two new data sets to constraint the model.

(1) Growth curve of continental crust by Pb-isotope age of river mouth zircon

Growth rate of continental crust is highly variable depending on the geologic age; the value at 2.6-2.8Ga and 2.0-2.2Ga is maximum about 10 times more than the minimum value at 2.4-2.5Ga or 0.9-0.8Ga. The snowball time at 0.75-0.60 Ga and at 2.3 Ga never coincide with the minimum periods mentioned above, when both plate tectonic and plume activities were minimum, hence CO₂-input from the mantle into atmosphere were minimum. Instead, the snowball times correspond to the periods to produce the large amounts of continental crust, e.g., the period at 0.75-0.60 Ga was a maximum during the last 1.0Ga. Another possible period of snowball at 2.3Ga does not correspond to the minimum time at 2.4-2.5Ga, but three times higher than that at minimum period. These evidences suggest that the plate tectonic movement and mantle convection during the snowball time was active enough to transport the large amounts of mantle CO₂ to the surface. Nevertheless, the surface T was minimum to yield snowball glaciation.

(2) Secular change of magnetic intensity

Relative intensity of geomagnetic field (dipole moment) through geologic time is compared with the periods of glaciation, particularly snowball times, using the compilation by Kono and Tanaka (1995) and Yoshihara et al.(2003). The result indicates the large variation from 25% to 150%, compared with the modern value ($8 \times 10^{22} \text{Am}^2$), and cyclic change, roughly speaking, every 500-1000m.y. The maximum periods are 2.5-2.4Ga, 1.1-1.4Ga and 3.5Ga, whereas minimum period was 2.8Ga, 2.3 Ga, 2.0-1.8Ga, 0.75-0.40Ga. Global glaciation seems to have occurred at periods when geomagnetic fields was lowered than 50% of today's level.

[A new model]

To explain the two new data sets, the snowball Earth model must include the mechanism to relate the increasing albedo by decreasing geomagnetic intensity. Presumably, formation of cloud can be potentially promoted by input of cosmic ray and solar plasma due to weak geomagnetic barrier, as originally pointed out by Ney (1959). If this is correct, the surface T of the Earth was controlled by the core dynamics, rather than the greenhouse effect of atmosphere.