Carbon cycle system and the Neoproterozoic snowball Earth phenomena

Eiichi Tajika[1]

[1] Dept. Earth Planet. Sci., Univ. of Tokyo

http://www-sys.eps.s.u-tokyo.ac.jp/~tajika/

It is considered that global glaciations may have occurred repeatedly during the Neoproterozoic. Such an idea, called a snowball Earth hypothesis, is based on the evidence for low-latitude glaciations, negative excursions of carbon isotopic composition of seawater, existence of iron formation, and formation of cap carbonate. Although this issue has been studied intensively by geological survey and chemical analysis of geological samples, the cause for such a runaway cooling has still been unknown. I therefore investigate possible causes for the snowball Earth phenomena by using a one-dimensional energy balance climate model combined with a carbon geochemical cycle model.

According to theoretical analysis of the carbon cycle system and the climate system, I found the critical condition required for initiation of the snowball Earth phenomena: in order to initiate the snowball Earth phenomena, pCO2 should decrease to about 100ppm under the lower luminosity of the Sun during the Neoproterozoic, and a net CO2 input flux to the atmosphere-ocean system (= CO2 degassing rate due to volcanism + weathering rate of organic carbon - burial rate of organic carbon) should become very small value (less than about 1/100 of the present-day flux). Such a condition can be achieved owing to a decrease in the degassing rate, a decrease in the weathering rate, and/or an increase in the burial rate of organic carbon.

By using a carbon isotope mass balance model with carbon isotope record during the Neoproterozoic, variations of the burial rate of organic carbon and the net CO2 input flux can be estimated when we assume the degassing rate of CO2 and the weathering rate of organic carbon to be constant. According to the results, the burial rate of organic carbon increases greatly just before the glaciations, but, still, the net CO2 input flux does not achieve the critical value. I will discuss several factors for the net CO2 flux to achieve the critical condition during the Neoproterozoic.