Oxidants in the Atmosphere of a Snowball Earth

Mao-Chang Liang
Division of Geological and Planetary sciences
California Institute of Technology
1200 E. California Blvd., Pasadena, CA 91125
USA
mcl@gps.caltech.edu

Hyman Hartman
Department of Biology
Massachusetts Institute of Technology
31 Ames Street, Cambridge, MA 02139
USA

Joseph L. Kirschvink
Division of Geological and Planetary sciences
California Institute of Technology
1200 E. California Blvd., Pasadena, CA 91125
USA

Yuk L. Yung
Division of Geological and Planetary sciences
California Institute of Technology
1200 E. California Blvd., Pasadena, CA 91125
USA

One puzzle in the early Earth is the development of oxidized environments. An example is the deposition of manganese oxides 2.4 billion years ago (Kirschvink et al. PNAS, 2000), right after the retreat of a catastrophic snowball event. However, little is known about the mechanisms for the formation of those oxidants, which triggered the deposition of these manganese oxides. Here, we propose that the formation of hydrogen peroxide in the atmosphere which is then transported to the interface of snow/ice and buried in the snow/ice would be the major oxidant which can oxidize manganese when the Earth emerged from the snowball. We performed a one-dimensional calculation for the conditions of a snowball Earth, where most of the water was frozen out and the atmosphere was oxygen poor. We found that for 1 mm/yr in the ice/water hydrological cycle on the snowball Earth the deposition rate of the hydrogen peroxide at the surface is on the order $\sim 10^{9\text{-}10}$ cm^{-2} s^{-1}. This proposed mechanism is similar to that found in the current Martian atmosphere, where oxidants can be produced in cold and dry environments (Hunten, J. Mol. Evol., 1979).