

原生代前期全球凍結時の大気二酸化炭素分圧 Partial pressure of atmospheric CO₂ during the Paleoproterozoic global glaciation

渋谷 岳造^{1*}; 上野 雄一郎²; 小宮 剛³; 西澤 学¹; 北島 宏輝⁴; 山本 伸次³; 齋藤 拓也²; 高井 研¹; 吉田 尚弘²; 丸山 茂徳²; ラッセル マイケル⁵

SHIBUYA, Takazo^{1*}; UENO, Yuichiro²; KOMIYA, Tsuyoshi³; NISHIZAWA, Manabu¹; KITAJIMA, Kouki⁴; YAMAMOTO, Shinji³; SAITOU, Takuya²; TAKAI, Ken¹; YOSHIDA, Naohiro²; MARUYAMA, Shigenori²; RUSSELL, Michael⁵

¹ 海洋研究開発機構, ² 東京工業大学, ³ 東京大学, ⁴ ウィスコンシン大学, ⁵ ジェット推進研究所

¹JAMSTEC, ²Tokyo Institute of Technology, ³University of Tokyo, ⁴University of Wisconsin, ⁵Jet Propulsion Laboratory

The Paleoproterozoic Makganyene Glaciation is a particular enigmatic geologic event in that ice covered the oceans even at low latitude (Snowball Earth). This event might have drastically curtailed biological productivity but melting of the oceanic ice presumably induced a cyanobacterial bloom, leading to an acceleration of global oxygenation. It has been predicted that this event occurred as a result of the drawdown of greenhouse gases in the atmosphere. However, atmospheric CO₂ levels at that time are still under debate. Here, we constrained the CO₂ concentration in seawater based on fluid inclusions in subseafloor hydrothermal quartz deposits from the 2.2 billion years (Gyr) old Ongeluk volcanics, South Africa, in which the ancient water and carbon dioxide are preserved. The quantitative analysis of the concentration and stable carbon isotopes of CO₂ in the fluid inclusions revealed that the CO₂ concentration in the seawater was limited to be less than 7 mmol/kg. Because the Ongeluk seawater was locally open to the atmosphere, atmospheric CO₂ level was also estimated to be lower than 33 times the present atmospheric level (PAL) ($<1.3 \times 10^2$ bar) assuming equilibrium between the Ongeluk seawater and atmosphere. This CO₂ level was not enough to compensate the faint young sun and keep the ocean temperature sufficiently above freezing point by itself. Although the behavior of other greenhouse gases is still unknown, our results demonstrate that the deficient atmospheric CO₂ level was a significant contributing factor to the 2.2 Gyr global glaciation.