Highly saline Palaeoproterozoic seawater inferred from fluid inclusions in 2.4 Ga Ongeluk Formation: Evidence for hard snowball?

Takuya Saitou[1]; Takazo Shibuya[2]; Tsuyoshi Komiya[3]; Kouki Kitajima[4]; Shinji Yamamoto[5]; Manabu Nishizawa[6]; Yuichiro Ueno[7]; Shigenori Maruyama[8]

[1] Earth & Planetary Sciences, Tokyo Tech.; [2] Precambrian Ecosystem Laboratory, JAMSTEC; [3] Earth & Planet. Sci., Tokyo Inst. Tech.; [4] ORI. Univ. Tokyo; [5] Earth and Planetary Sci. Tokyo Institute of Technology; [6] EPS, Tokyo Tech.; [7] Global Edge Inst., Tokyo Tech.; [8] Earth and Planetary Sci., Tokyo Institute of Technology

Paleoseawater composition is one of the most important factors for decoding the environmental and biological evolution through the earth's history. We present microthermometry of fluid inclusions in hydrothermally precipitated quartz in 2.4Ga Ongeluk Formation, Transvaal Supergroup, Kaapvaal Craton, South Africa. The Ongeluk Fm. overlies Mackganyene tillite and is covered by drop-stone-bearing BIF of Hotazel Fm. Hence, the studied basaltic andesite lava probably erupted during Palaeoproterozoic Snowball Earth event (Evans et al., 1997; Kopp et al., 2005). The quartz crystals fill drainage cavities of the pillowed basaltic lava and were probably precipitated soon after eruption under seawater (Gutzmer et al., 2001; Cornell et al., 1996). The fluid inclusions may comprise a mixture of hydrothermal fluid and seawater, thus are prime target to obtain the information of seawater composition during the snowball period.

Primary fluid inclusions in the quartz are 1-60 um in size and two-phase (liquid-vapor) aqueous inclusions. We performed microthermometric experiments of the fluid inclusions and estimated their trapping temperature and composition. Final melting temperatures range from -31.4 degree C to -3.6 degree C, while homogenization temperatures range from 74.9 degree C to 160.0 degree C. These results indicate that a NaCl-$CaCl_2$-H2O system can be assumed (Bodnar, 2003). Thus, the salinity of fluid inclusion was calculated from its melting point (Naden, 1996). The estimated salinity shows bimodal composition. Based on the observed compositional variation, we recognize three end-members: (1) a low NaCl and high $CaCl_2$ end-member, (2) a high NaCl and low $CaCl_2$ end-member, and (3) a low NaCl and low $CaCl_2$ fluid end-member. The trend between (1) and (2) is consistent with albitization of igneous plagioclase (Ca/Na exchange reaction), which commonly occur in seafloor alteration processes. Based on this albitization trend, we conclude that the end-member (2) represents the composition close to that of 2.4 Ga seawater. The high NaCl composition of the end-member (2) gives minimum salinity of seawater, and thus suggests that the 2.4 Ga seawater was at least two times more saline than that of modern seawater. This may indicate that the Ongeluk ocean would have been

quantitatively frozen, in this case consistent with the 'hard'
snowball scenario.