Origin of Archean quartzose sandstones

*Hikaru Sawada[1], Akira Ishikawa[1], Yukio Isozaki[1]

1. Department of General Systems Studies, the University of Tokyo

Granitic continental crust is produced in plate subduction zone. Continental growth through the history of the Earth is a significant matter to understand evolving planetary interior, especially secular change of plate tectonics. Most of the previous geochemical studies have treated continental crust as a single reservoir separated from the mantle and oceanic crust, and not focused on a form of each continent. In particular, the form of continents in the early half of the Earth’ s history have not determined yet.

The chemical composition of (meta-)sandstone is useful to identify sorting of detrital grains and difference in form of continents. Sandstones composed of not well-sorted grains have a composition similar to rocks in its provenance, whereas those composed of well-sorted grains have more quartzose composition. Quartzose sandstones have been found widely from even in the Archean greenstone belts after 3.5 Ga. These Archean quartzose sandstones could be interpreted as below; i.e. 1) large exposure of granitic continental crust in the Archean, or 2) extensive occurrence of silicified mafic/ultramafic rocks and/or hydrothermal chert.

The present study measured bulk trace and rare earth element concentration of Archean and early Proterozoic (3.5-2 Ga) sandstone sampled from S. Africa, N. America, and W. Australia. All measured samples show Zr content as high as granitoid, which indicates that contribution of silicified rocks and chert had been minor through 3.5-2.0 Ga. Data normalized by primitive mantle values shows positive Zr anomaly (=Zr/(Nd*Sm)^0.5) in approximately 70 % of the analyzed samples. The Zr anomaly indicates zircon-enriched sandstone by sedimentary sorting. The Zr anomaly in the middle Archean (3.5-3.0 Ga) and the early Proterozoic (2.5-2.0 Ga) is 10 times larger than those in the late Archean (3.0-2.5 Ga). The size of each continent was smaller in the late Archean (3.0-2.5 Ga) than middle Archean (3.5-3.0 Ga), and re-increased after 2.5 Ga. In other words, there were continents between 3.5 and 3.0 Ga as large as those between 2.5- 2.0 Ga Paleoproterozoic.

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