

Formation of probable lateritic soils ~3.43 Ga in the Pilbara Craton, Western Australia

H. OHMOTO¹, Y. WATANABE¹, A. ALLWOOD²,
I.W. BURCH³, L.P. KNAUTH⁴, K.E. YAMAGUCHI⁵,
I. JOHNSON¹ AND E. ALTINOK¹

¹Astrobiology Research Center & Dept. of Geosciences, Penn State Univ., University Park, PA, 16802 USA

(ohmoto@geosc.psu.edu; yumiko@geosc.psu.edu;
ijohnson@geosc.psu.edu; ealtinok@geosc.psu.edu)

²NASA Jet Propulsion Laboratory, Pasadena, CA 91109, USA
(aallwood@jpl.nasa.gov)

³Dept. of Earth and Planetary Sciences, Macquarie Univ.,
North Ryde, NSW2109, Australia

⁴School of Earth and Space Exploration, Arizona State
University, Tempe, AZ 85287, USA (Knauth@asu.edu)

⁵IFREE, JAMSTEC, Yokosuka, Kanagawa 237-0061, Japan
(kosei@jamstec.go.jp)

An alteration zone (~20-80 m thick), characterized by the abundance of pyrophyllite (aluminum-rich clay) and the depletion of iron and most elements, is widely developed in pre-3.4 Ga submarine basalts that occur beneath the oldest-known (~3.4 Ga) erosional unconformity (i.e., oldest land surface) in the North Pole Dome region of the northern Pilbara Craton, Western Australia. Some previous researchers suggested this alteration zone as a product of hydrothermal activity ~3.4 Ga.

We have recently discovered more than 100 iron pods (each ~1 to ~6 m thick and ~1 to ~50 m long) within the iron-depleted pyrophyllite-rich zone at seven sites over a ~30 km expanse in the studied area. They typically occur as clusters at 0 - 30 m below and generally parallel to the ~3.4 Ga unconformity, rather than being parallel to the modern groundwater tables. These iron are mostly composed of well-crystalline hematite (~30 to ~90 wt% Fe₂O₃) and pyrophyllite.

The geometrical, geological, mineralogical, and geochemical characteristics of iron pods and alteration zone in the studied area (e.g., the rarity of quartz-sulfide veins; sizes and crystallinity of hematite; trends of Al/Ti, Mg/Ti, Fe/Ti, Ca/Ti, Na/Ti, and K/Ti ratios; trends of trace element ratios; REE behaviors) resemble those of "groundwater-type" laterites of the Phanerozoic and Proterozoic ages (e.g., the ~2.2 Ga Hekpoort and Hokkalampi paleolaterites). Groundwater-type laterites require the following conditions for formation: (i) distinct wet/dry seasons; (ii) the development of microbial mats/vegetation on/in soils during wet seasons, which produce abundant organic acids that leach both ferric and ferrous irons from the soils and create ferrous-rich groundwater; and (iii) an abundance of oxygen molecules supplied from the atmosphere to the soils and groundwater, mostly during dry seasons, to precipitate the aqueous ferrous iron as ferric (hydr)oxides. Therefore, if the North Pole Dome ironstones are indeed ~3.43 Ga laterites, they suggest the very early developments of the terrestrial biosphere and an oxygen-rich atmosphere.

Mass dependent isotopic fractionation of Ce and Nd in geochemical samples

TAKESHI OHNO AND TAKAFUMI HIRATA

Department of Earth and Planetary Sciences, Tokyo Institute
of Technology, Japan (ohno.t.ab@m.titech.ac.jp;
hrt1@geo.titech.ac.jp)

The study of naturally occurring mass dependent isotopic fractionation of rare earth elements (REEs) has a potentially significant influence in geochemical research fields. Isotopic fractionation of REEs with their chemical similarities and gradual changes of ionic radius may provide new insights about chemical weathering processes. One of the most attractiveness of REEs is anomalous behavior of Ce mainly due to the existence in not only the trivalent state but also the tetravalent state. Since the valence of Ce depends on the redox conditions, differences of isotopic fractionation between Ce and the other REEs could provide information about the redox conditions of depositional environment. Among the other REEs, Nd could play an important role in the stable isotope geochemistry of REEs as a reference compared to Ce. Moreover, radiogenic growth of ¹⁴³Nd can also provide chronological constraints on a sample formation process.

In this study, we have developed a new chemical and mass spectrometric procedure for the investigation of mass dependent isotopic fractionation of Ce and Nd in geochemical samples. In order to detect the small isotopic fractionation, mass discrimination effects on Ce and Nd isotopes were externally corrected by Sm and Eu, respectively. The resulting analytical precisions for $\delta^{142/140}\text{Ce}$ and $\delta^{146/144}\text{Nd}$ were better than 0.01% (2SD). Isobaric interferences were eliminated by an extraction chromatography using a Ln spec. resin. We examined isotopic fractionation of Ce and Nd during the separation procedure. The result of the test demonstrated that the cumulative isotopic value of the eluent showed no detectable isotopic fractionation through a few percent loss during the chromatographic separation.

Cerium and Nd isotopic compositions of GSJ geochemical reference samples (Basalt, JB-1a; Andesite, JA-2; Manganese Nodule, JMn-1; Chert, JCh-1; Dolomite, JDo-1) have been measured in order to examine the possible isotopic fractionation of Ce and Nd. The isotopic data of Ce and Nd for the samples revealed $\delta^{142/140}\text{Ce}$ and $\delta^{146/144}\text{Nd}$ data for JDo-1 were different from that of the igneous rock samples. Moreover, there was positive correlation between the resulting $\delta^{142/140}\text{Ce}$ and $\delta^{146/144}\text{Nd}$, implying that the isotopic variation of Ce and Nd observed in JDo-1 might be caused by non-redox reactions such as preferential precipitation or dissolution processes, rather than the redox reaction. In this presentation, Ce and Nd isotopic data on several geochemical materials and possible mechanism of isotopic fractionation will be discussed.