# Evolution of solid earth and surface environment of early Earth

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Understanding the thermal and compositional evolution of the mantle is the essential to decoding the whole history of the Earth. Recently, three important observations for evolution of early differentiation and surface environment in Hadean were reported; positive anomalies of ipsiron142Nd of ca. 3.8 Ga Isua sediments and volcanics (e.g. Caro et al., 2003), ipsiron182W anomalies of terrestrials rocks (e.g. Kleine et al., 2002), and positive anomaly of delta18O of 4.1-4.4 Ga detrital zircons in Jack Hills (Valley et al., 2002).

Ancient crustal rocks provide the only direct evidence for surface tectonics and mantle differentiation. We reinvestigated geology and geochronoloby of the oldest Acasta Gneiss Complex. We recognized six distinct lithofacies, and at least eight tectonothermal events based on detailed 1:5000 scale geological mapping and petrographic investigation of about 1000 specimen. It mainly comprises early Archean Gray, White and Layered Gneisses and middle Archean Foliated Granite. Gray Gneiss originated from quartz-diorite, and occurs as enclaves within White and Layered Gneiss, which is originally pale-gray tonalitic and white granitic rocks. The gneissic structure of White Gneiss is concordant with the shape of the included Gray Gneiss blocks, but completely discordant to those within the Gray Gneiss. The cross-cutting relationship indicates that the Gray Gneiss and the included hornblendite pods are older than the well-dated White Gneiss (ca. 4.03 Ga).

Recently, Komiya (PEPI, 2004) estimated the secular variation of the composition and temperature of upper mantle based on composition of greenstones from 3.8 to 1.9 Ga. The results indicate that the upper mantle was highly enriched in FeO, and contain 10 wt % in FeO (c.f. 85-87 in Mg#), but that the FeO content was constant until early Proterozoic, and then decreased. The potential mantle temperature was also higher than that of modern MORB, and was about 1480 C. The fact indicates that the mantle even in the Early Archean was hotter by at most ca. 150 to 200 C than the modern mantle, and cooled episodically or variably, concomitant as FeO decreased. Ultra-high-pressure experiment implies some of Fe2+ ions transformed into Fe+Fe3+ during slab penetration into lower mantle because aluminous Mg-perovskite contains Al3+Fe3+ instead of Mg2+Si4+. The formation of the metallic iron may decrease the FeO content of the upper mantle. At production rate of oceanic crust in the Archean, it takes ca. 3.1 billion years for the whole mantle to decrease from 10 to 8 wt % in FeO. In this case, the metallic iron accumulated on the core would reach ca. 57 km thick.

Distribution, composition, and mineralogy of the carbonate rocks and minerals give constraints on physical and chemical properties of paleoseawater because carbonate minerals in microbial or abiotic environment were deposited equilibrated with ambient water. In 3.5 Ga North Pole area (NP), carbonate rocks was formed as carbonatization of greenstones due to hydrothermal alteration at mid-oceanic ridge. Since late Archean, thick carbonate layers were deposited repeatedly at 2.72 Ga Tumbiana Fm. (TU), 2.56 Ga Wittenoom Dolomite (WD), ca. 2.3 Ga Kazput Fm. (KZ) and 2.2 Ga Duck Creek Dolomite (DC). We found stromatolitic structures in WD and KZ as well as TU and DC. We made in-situ analyses of major, trace and rare earth elements of carbonate minerals with well-preserved texture using EPMA and LA-ICP-MS. Primary carbonates are enriched in Sr and P. They have chondrite-normalized LREE-enriched pattern. Carbonate minerals in TU and modern On-tong Java Plateau display slightly and moderately Ce anomalies, respectively, and the latter is consistent to oxic seawater in the Phanerozoic. But, those in NP, WD, KZ, DC, and ca. 600 Ma Baratal Limestone, Gorny Altai have neither Ce nor Eu anomalies. Carbonates in WD, KZ and DC have Gd anomalies. Mn-carbonate exists there. The lines of evidence imply redox state of paleoseawater.