Depositional environment of graphite-bearing metasedimentary rocks and banded iron formations in >3.7 Ga Isua Supracrustal Belt, West Greenland

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Biogenic graphite in > 3.7 Ga metasedimenrary rocks, Isua Supracrustal Belt (ISB), West Greenland, has been reported as the oldest remnants of life (Rosing, 1999; Ohtomo et al., 2014). However, ecosystem spreaded in the >3.7Ga ocean is still poorly understood. Depositional environments of metasedimentary rocks containing biogenic graphite and surrounding banded iron formations (BIFs) could give an insight into microbial activities in the >3.7Ga ocean. Graphite-rich schist reported by Ohtomo et al. (2014) contains rare earth element (REE) minerals such as monazite, zircon and xenotime. These REE minerals could have been deriven by one or some of the following processes: detrital transport, precipitation from a seafloor hydrothermal fluid, generation during diagenesis and precipitation from a metamorphic fluid. Occurrence, geochemical composition and chronological information of the REE minerals might constrain their origin and provide information of depositional and/or alteration process of the graphite-rich schist. Here, we performed a geological survey in the west side of the ISB and investigated the petrographic and geochemical characteristics of sedimentary rocks to reconstract the depositional environment. Chemical Th-U-total Pb Isochron Method (CHIME) was conducted on monazite to determine the age.
Samples collected in the whole west side of the ISB consist of alternate layers of magnetite-amphibote-chlorite-rich and quartz-rich layers. The samples were roughly divided into magnetite-rich type, which distributed at northeast to south, and silicate-rich type, mostly distributed at northwest, based on the dominant minerals. Bulk chemical compositions of the examined samples showed that magnetite-rich type are abundant in Fe, whereas silicate-type are rich in Mg. Magnetite-rich type primarly composed of Fe-rich amphibole, grunerite, whereas silicate-rich type contains more Mg or Ca-rich amphibole. Similarly, chemical compositions of chlorite in magnetite-rich type are Fe-rich, whereas that of silicate-rich type are Mg-rich. Amphibole and chlorite compositions in graphite-rich metasedimentary rocks are Mg-rich, which is similar to silicate-type BIF samples. The results suggest that Mg-rich characteristics of BIFs and graphite-rich metasedimentary rocks at north west, and Fe-rich characteristics of BIFs at north east to south are a primary signature. Ti and Al concentrations in BIFs and graphite-rich sedimentary rocks showed a positive correlation, indicating contribution of detrital components to them. Graphite-rich schist sample consisted of graphite-chlorite- and quartz-cummingtonite-dominated microlayers, containing high amounts of REE compared to samples showing low graphite content. The graphite-rich sample contained euhedral monazite, zircon and minor xenotime 2-10 μm in diameter, which were accumulated in graphite-chlorite microlayers and concordant with orientation of lamination, whereas most of the monazite in samples showing low graphite content were anhedral. CHIME age of the monazite in graphite-rich schist samples indicated 3630±91Ma, which ranges in the ages of prograde metamorphism and detrital zircon in previous report (Nutman et al., 2009). Considering monazite occurrence concordant with lamination of the graphite-rich schist, it is most likely that monazite was syngenetic with host rocks, probably derived from detritus and the age was modified during metamorphism, or crystalized during diagenesis to early metamorphism. Our results suggest that BIFs and graphite-rich schist at north west of west side of the ISB deposited where clastic components such as Mg, Al, Ti and REE were supplemented at a relatively high rate, evoking that photosynthetic

microorganisms might have been flourished in >3.7Ga shallow ocean.

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