Occurrence, petrography and chemical compositions of black shale in the Isua supracrustal belt: A potential to decode surface environmental conditions on the early Earth

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The Earth is the only planet, which has been covered with H_2O-ocean throughout the geologic time, in the Solar System. Therefore, it is very important to understand the origin and evolution of the Earth's oceans. Generally speaking, there are two ways to decipher the Earth's early evolution. The first is numerical calculation, and the second is the analysis of geological samples. The numerical calculations provide general solutions that may have occurred on Earth, but may not provide specific events that have occurred only on Earth. Therefore, this study adopts the latter method. In particular, to estimate the surface environment of the early Earth, it is essential to examine sedimentary rocks formed on the early Earth, and it is important to find sedimentary rocks such as black shale, that are suitable for the estimation, from the Eoarchean geological terrains. There will be.

One of the significant events on the early Earth was the Late Heavy Bombardment (LHB). It is considered that the event occurred 4.2 to 3.8 Ga based on age-distribution of the moon's craters, and that the event caused significant impacts of a large number of meteorites on the earth. However, no evidence is, so far, found from terrestrial materials so that it is still controversial whether the event really took place. It is generally known that meteorite impacts leave anomalous signatures of a platinum element group in abyssal sedimentary rocks. However, the concentration of Ir in the banded iron formations (BIFs) in the Isua supracrustal belt has been analyzed, but no significant anomaly has been found. Generally speaking, it is regarded that the BIFs was slowly deposited, analogous to modern deep-sea pelagic sediments such as chert. On the other hand, it is widely known that the banded iron formation is derived from intermittent hydrothermal activity. It is more important to study sedimentary rocks with a low sedimentation rate, such as black shale.

Relatively, less metamorphosed supracrustal rocks, under the amphibolite facies or less conditions, are present in the Isua area in southern West Greenland. In 2016, we conducted a geological survey of the Isua Supracrustal Belt, and discovered new black shale outcrops. Black shale, rich in organic matter, has been reported in the western part of the Isua Superficial Rock Zone (Rosing, 1999), but no black shale has been reported in the northeastern part In addition, the previous report did not show detailed description of the geological occurrence such as accompanied lithology and detailed lithostratigraphy. This presentation reports the geological occurrence, mineralogical description, major and minor chemical compositions of the black shale, and discusses its significance.

The Isua Supracrustal Belt (ISB) is located approximately 150 km northeast of Nuuk, and has an arcuate shape. The ISB is composed of ultramafic rocks, basalts with pillow structures, BIFs, chert, carbonate, and clastic sedimentary rocks such as conglomerate, sandstone and pelitic rocks. It is intruded by the Eoarchean (3.7 to 3.8 Ga) granitic gneiss (Itsaq gneiss). Although they have undergone metamorphism under the greenschist to amphibolite facies conditions, we mention the rocks as rock names of the estimated precursors hereafter. The northeastern part consists of piles of about 10 fault-bounded

subunits, which have similar lithostratigraphy of basaltic layer, chert and clastic sedimentary rocks in an ascending order to each other. The lithostratigraphy is similar to modern ocean plate stratigraphy. The existence of the imbricate structure and oceanic plate stratigraphy suggests that the belt was an accretionary complex.

Black shale occurs mainly in two regions of the northeastern part of the ISB; the northern black shale has been previously described as mafic sedimentary rocks (Komiya et al., 1999) or chert (Nutman & Friend, 2009). The black shale stratigraphically underlies the BIFs. It is considered that the BIFs in the ISB belong to the Algoma-type because it is regarded that all of them occur on basaltic lava so far. However, this work presents another occurrence of the BIFs, which were deposited on black shale. In addition, the discovery may allow us to detect the LHB signatures from the Eoarchean sedimentary rocks because black shale, generally speaking, is deposited quietly slowly in open ocean.

In this study, microscopic observation and chemical analysis were performed in addition to the geological observation. The northern black shale contains quartz, calcite and chlorite, whereas the southern black shale consists of quartz, amphibolite and biotite. We will also discuss the results of chemical analysis.

Keywords: Black shale, The early Earth, Late Heavy Bombardment

