Occurrence and compositions of the oldest sedimentary rocks in the Nulliak supracrustal rocks, Labrador (>3.92 Ga): Implications for a chemical composition of the Eoarchean seawater

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The earth is a unique planet where liquid water and life exist through geologic time. Therefore, estimate of a surface environment on the early earth is very important to understand the origin of life on the earth and gives an insight into the possibility of life on the earth-type planets. However, we have little knowledge of the environment of the early earth, because the first 500 m.y. history of the earth was almost completely lost. The surface environment of the early earth has been ever investigated from geochemistry and geobiology of the Isua supracrustal belt, southern West Greenland because the supracrustal rocks had the oldest age of 3.8 to 3.7 Ga up to now. Recently, older (>3.92 Ga) supracrustal rocks, called Nulliak supracrustal rocks, were found in the Saglek Block, northern Labrador. The supracrustal rocks contain banded iron formation (BIF), carbonate rocks, and clastic rocks of pelitic rocks and conglomerates as well as mafic and ultramafic rocks. Although the Isua supracrustal belt suffered from the extensive carbonation so that the carbonate rocks are skeptically considered as chemical sediments, the Nulliak supracrustal rocks avoided the later carbonation. In this study, we analyzed major and trace element compositions of carbonate rocks to estimate the trace element compositions of the Eoarchean seawater.

The Saglek block is located in the northeastern part of the Labrador Peninsula, northeast Canada, and is underlain by the Archean orthogneisses and supracrustal rocks. They underwent granulite to amphibolite facies metamorphism but escaped extensive carbonation and silicification. The supracrustal rocks contain ultramafic and mafic rocks, BIF, chert, carbonate rocks, pelitic rocks and conglomerates, and were intruded by the Mesoarchean mafic dikes (Saglek Dyke) and Eoarchean orthogneisses. Especially, in the St. John’s Harbour South area, the supracrustal rocks were intruded by the 3.92 Ga orthogneiss, indicating the supracrustal rocks have over 3.92 Ga age so that they are the oldest supracrustal rock in the world.

The carbonate rocks occur in the St. John’s Harbour South (SJHS), St. John’s Harbour East (SJHE), Big Island and Pangertok Inlet areas. We classified the carbonate rocks into three groups based on the field occurrence. The first group is characterized by the occurrence within mafic/ultramafic rock units and is composed of the carbonate rocks in the SJHS. The second group occurs between the BIFs and mafic volcanic rocks, and the type locality is the Pangertok Inlet. The third group comprises the carbonate rocks interlayered with or underlying the pelitic rocks in the SJHE and Big Island.

We analyzed major and trace element (Rb, Sr, Y, Zr, Nb, Cs, Ba, rare earth element (REE), Hf, Ta, Pb, Th, and U) contents of the carbonate rocks. Some carbonate rocks have high Zr, Ti and Al_2O_3 contents, possibly due to involvement of detrital and volcanic materials. We selected the carbonate rocks with low Zr, Ti and Al_2O_3 contents in order to remove the influence of contamination of the detrital and volcanic materials because they are not incorporated into the carbonate minerals. Their PAAS-normalized REE+Y patterns display flat to slightly LREE-depleted patterns with positive La, Eu and Y anomalies and without Ce anomaly. The positive Y anomalies indicate that the carbonate rocks were chemical sediments precipitated from seawater, and the lack of the Ce anomaly indicates that the Eoarchean seawater was anoxic as many previous works suggested. The presence of the Eu anomalies suggests that the carbonate rocks were deposited in marine environments strongly influenced by hydrothermal fluid.

The Eu anomalies are apparently correlated with lithostratigraphy and accompanied rocks; those in SJHS have larger positive Eu anomalies than those in the SJHE and Big Island, possibly due to the degree of the influence of hydrothermal influxes related to the distance from the volcanic sources. On the other hand, even the carbonate rocks accompanied with pelitic rocks have the distinct Eu anomalies, indicating that the seawater surrounding a continent had the Eu anomaly so that the seawater was dominated by hydrothermal influxes. In addition, there is a positive correlation between the Y and Eu anomalies.

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