Carbon isotope and chemical compositions of the metasedimentary rocks from Saglek Block (>3.95 Ga), Labrador, Canada: Discovery of the oldest life and its habitat environment

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The Earth is the only planet where liquid water and organisms are present. However, our knowledge of early earth as well as origin of life is still poor because of little preservation of Eoarchean supracrustal rock. This study first presents geological, petrological and geochemical features of the 3.95 Ga supracrustal rocks including pelitic rocks, conglomerates, carbonate rocks, cherts, chert nodules and ultramafic rocks from 3.95 Ga Saglek Block. This presentation is composed of two topics. The first topic aims at revealing the origin of graphite in the metasedimentary rocks based on petrographic observation and carbon isotope analyses. The purpose for the second topic is elucidating the protolith of the carbonate rocks, and estimating the redox condition of the Eoarchean seawater on the basis of petrographic observation and major and trace element analyses.
We obtained carbon isotope compositions of graphite ($\delta^{13}C_{org}$) from -28.2 to -11.0‰ in pelitic rocks, from -27.6 to -20.8‰ in conglomerates, from -9.9 to -6.9‰ in carbonate rocks and from -10.3 to -9.9‰ in chert nodules, respectively. The maximum $\delta^{13}C_{org}$ values of the graphite in pelitic rocks of each locality increase with increasing metamorphic grade from amphibolite to granulite facies, indicating that the variation of the $\delta^{13}C_{org}$ values is due to later metamorphism so that a primary $\delta^{13}C_{org}$ value is lower than the minimum $\delta^{13}C_{org}$ value. The crystallization temperature of the graphite, estimated from Raman spectroscopic analyses, is consistent with metamorphic temperature of the host rocks except for chert nodules, suggesting that the graphite does not originate from later contamination. On the other hand, the carbon isotope compositions of carbonates range from -3.8 to -2.6‰. The large fractionation ($\delta^{13}C_{carb}$ - $\delta^{13}C_{org}$), up to 25‰, implies the presence of autotroph utilizing the reductive acetyl-CoA pathway or Calvin cycle at least 3.95 Ga, ca. 110 Ma earlier than previous records.
We analyzed major element compositions of the carbonate rocks, pelitic rocks, conglomerates, chert nodules and ultramafic rocks and their trace element compositions except for conglomerates and chert nodules are reported. The origins of the carbonate rocks in the Eoarchean metamorphic terrains are always controversial because of severe later carbonate metasomatism and presumption of acidic seawater condition (so-called a soda ocean model) due to quite high CO_2 atmosphere. The rare earth element + yttrium (REE + Y) patterns of some carbonate rocks are obtained in order to reveal the origins of the carbonate rocks, namely metasomatized mafic rock or chemical sedimentary rock. They are disrupted by input of crustal detritus or post-depositional disturbance. However, the carbonate rocks, which preserve seawater-like REE + Y patterns, still exist in all of our studied areas, indicating the chemical sedimentary origin of the carbonate rocks. All carbonate rocks in Saglek Block have no Ce anomalies, supporting the reduced condition of the Eoarchean ocean. The combination of carbon isotope values of the graphite and REE patterns of the carbonate rocks suggest the presence of the autotroph using the reductive acetyl-CoA pathway or Calvin cycle except for cyanobacteria at least 3.95 Ga.

Keywords: The oldest evidence for organism, Eoarchean, Saglek Block in Labrador, Carbonate rock

