Title

Origin of graphite in the 3.8Ga Isua Supracrustal Belt in Greenland and constraints on the formational environments

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Summary of the thesis:

This thesis is composed of three chapters. Here I listed backgrounds of this study, outlines and major findings from each chapter. Occurrence of graphite has been recognized from the > 3.74 Ga Isua Supracrustal Belt (ISB) in western Greenland. ^{13}C-depleted graphite globules in turbiditic and pelagic sedimentary rocks are claimed as traces of ancient marine planktons. On the contrary, secondary origin of graphite formed by crustal processes is also widespread in ISB. Presence of contrast origin of graphite in the ISB postulates careful assessment of graphite genesis for tracing early life. Here we discovered new graphite-rich schist (up to 8.8 wt%), intercalated in banded iron formations. They comprised chlorite, cummingtonite, quartz and graphite, representing fine-laminated structure in microscopic scale. Chemical compositions of examined schist have mixed characteristics between chemical and clastic sediments. $\delta^{13}C$ values of graphite yield as low as -23.8 ‰. Those values are heterogeneous in microscopic scale, suggesting that carbon isotope exchange occurred between examined graphite and carbonic fluid in a crust. HRTEM images of the examined graphite show onion-like structures in nano-scale. These structures are analogous with pyrorized and

pressurized biogenic molecules in previous report. Those observations clarify characteristics of graphites generated in different process and provide new evidence for ancient traces of life in metamorphosed early Archaean rocks.

Extensive carbonation of 3.8 Ga volcanic and sedimentary rocks has been reported from the Isua Supracrustal Belt (ISB). However, their geological extension, nature of associated fluids and detailed chemical reactions are poorly understood in particular for the Garbenschiefer unit of the ISB. I performed geological investigation and characterized geological and mineralogical features of carbonate veins and carbonated rocks in the northwestern part of ISB. Field observation indicates that massive carbonate vein was developing inside folding axis parallel to BIF's strike, probably due to the tectonic control precipitation. Around the massive carbonate vein, carbonation becomes significant with variety of appearances and thickness and sometimes crosscuts bedding of BIF. The massive carbonate veins were found to be chemically zoned in Mg and Fe contents associated with carbon isotope zonation, probably reflecting the different degree of metasomatism or progressive chemical change of reacting fluids.

Banded iron formations are widespread in the Isua Spracrustal Belt, West Greenland. Detailed geological surveys of BIFs in the western side of Isua were performed to constrain their depositional environments. In the northwesten section, geochemical evidence suggests that clastic components were incorporated in BIFs, which preserved the primary micro banding of magnetite/quartz. Such BIFs were most likely deposited in the relatively shallow ocean environments at ca. 3.8 billion-years ago.

On the other hand, BIFs in other areas do not show geochemical evidence for detrital components, probably suggesting deep marine depositional environments.