New evidence for microbial sulfur metabolizm in 2.7 Ga marine environments

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Sulphur is an essential element for all organisms to promote metabolic reactions. Proteins and sulphur-containing coenzymes are major hosts of sulphur in modern micro-organisms. On the other hand, it is still uncertain if sulphur metabolism was essential for early life, and if geological samples could have recorded sulphur metabolism. Here we report results of TEM/STEM observations on carbonaceous matter from 2.7 Ga sedimentary rocks in Ontario, Canada. Sandstones and black shales were collected from Schreiber and Munro areas, respectively. These rocks contain organic matter, which were originated by microbial activities in 2.7 Ga shallow to deep marine environments. Kerogen was extracted from rock powders by acid-treated demineralization. Raman spectroscopic analyses indicate that a part of kerogen was graphitized and they recorded peak metamorphic temperatures. STEM observation identified nano-scale inclusions of elemental sulphur in kerogen from both regions. TEM images of the inclusions indicate that a part of Schreiber kerogen has regular arrangements of carbon and sulphur atoms. Nano-scale inclusions of Fe-S or Fe-S-Mo, which were covered by graphene layers, were also identified in Scriber kerogen. These sulphur inclusions were produced from sedimentary organosulfur compounds by metamorphism. No records of submarine hydrothermal activities in Schreiber area suggest that such organosulfur compounds were highly likely generated from microbial sulphur metabolism in 2.7 Ga sub-tidal to deep marine environments.