Did methanogenic bacteria and sulfate-reducing bacteria coexist in 2.7 Ga oceans?

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It has been uncertain as to wheather methanogenic bacteria coexsited with sulfate reducers in 2.7 Ga oceans. Through the micro-analyses of sulfur isotopes of pyrite in 2.7 Ga shales, it is concluded that sulfate reducers were not active in oceans, but in sediments.

Abnormally light carbon isotope compositions (-35 to -50 per mil) of organic matter have been found in 2.7 Ga shales from many places in the world. It is interpreted that such light carbon isotope compositions were caused by involvement of methanogenic and methanotrophic bacteria in the carbon cycle in 2.7 Ga oceans. Methanogens and sulfate reducers are not coexisting in modern marine sediments because sulfate reducers outcompete methanogens in sulfate-rich environments. The activities of methanogens in 2.7 Ga oceans raise a question if 2.7 Ga oceans were sulfate-poor and methanogens were outcompeteing sulfate reducers.

Black shales from the 2.7 Ga Jeerinah Formation, Australia and the 2.7 Ga Dolero Group, Canada were examined for sulfur isotope compositions of pyrite, carbon isotope compositions of organic matter and concentrations of S(py) and C(org). Carbon isotope compositions of organic matter of the examined samples are ranging from -35.1 to -38.4 per mil for the Jeerinah shales and -44.4 per mil to -42.2 per mil for the Dolero shales. Concentrations of S(py) of both shales (0.2 to 1.1 wt %S for the Jeerinah samples; 0.1 to 7.7 wt %S for the Deloro samples) are much higher than these of modern fresh water sediments (<0.2 wt %S). Furthermore good correlations between S(py) and C(org) are found in some samples. Such characteristics indicate that 2.7 Ga oceans were sulfate rich and sulfate-reducing bacteria were responsible for pyrite formation.

Microscale heterogeneity of sulfur isotope compositions of pyrite can distinguish pyrite formed in water column (syngenetic pyrite) from pyrite formed in sediments (diagenetic pyrite); syngenetic pyrite must be abundant if sulfate reducers were coexisting with methanogens in the water column. Large sulfur isotope variations were detected in thin section scales (up to 10 per mil variation in the Jeerinah samples; up to 7 per mil variations in the Deloro samples), suggesting that pyrite in the examined samples were diagenetic in origin. It is, therefore, concluded that sulfate-reducing bacteria were not coexisting with methanogens in the water column as mixed cultures. It is still uncertain as to whether only methanogens were active in the water column or both bacteria were restricted in sediments, more like to modern sediments.