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# Euxinic environment inferred from 3.2Ga black shale sequence in DXCL, Pilbara, Western Australia.

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The 3.2 Ga Dixon Island - Cleaverville formations in the coastal Pilbara terrane, Western Australia, are one of the best-preserved Mesoarchean sedimentary sequences in the oceanic arc setting. In addition, a non-weathered rock sample greatly helps us to understand the paleoenvironment with high-resolution. In Dixon Island-Cleaverville drilling project (DXCL), three fresh-drilled cores (DX, CL2 and CL1 in ascending order) were collected. These cores have 200 m long and totally 130 m stratigraphic thickness. This study describes detailed lithology, stratigraphy and stable sulfur isotope ratio of them to reconstruct the ocean floor environment.

These core samples are mainly composed of carbonaceous sedimentary rocks. The DX core, covers the upper part of the Dixon Island Formation, shows very fine laminae, which comprise fine-grained black shale, gray chert and laminated pyrite. In contrast to DX core, CL1 and CL2 cores, cover the lower part of the Cleaverville Formation, are silt-size black shale, banded pyrite and thin volcaniclastic sandstone with cross-lamination. Lithological variation from DX core to CL cores is characterized by thickening and coarsening upward of black shale layers.

The sulfur content of black shale increases from 0.9 wt.% (DX) to 1.8 wt.% (CL1) on average. Contrastive to the sulfur content, the content of Corg decreases from 1.21 wt.% (DX) to 0.6 wt.% (CL1) on average. The Corg/S ratios (by wt.%) range from 0.5 (CL1) to 1.7 (DX) on average. Despite a few stratigraphic levels that have $>$2.0 Corg/S (organic carbon to sulfur) ratios, most of the samples in these three cores have Corg/S ratios $<$ 1.0.

Sulfur isotope compositions were measured for pyrite laminae and tiny pyrite crystals in black shale by EA-IRMS. They range from ?10.1 to +26.8 permil and randomly vary with stratigraphic level. Highly $^{34}$S-enriched values are outstanding in the Archean S isotope record published to date.

Also, we carried out a preliminary in-situ analysis of tiny pyrite crystals using the high lateral resolution secondary ion mass spectrometer (NanoSIMS). Measurement is proceeded as the spot analysis, 1 micrometer in diameter, at intervals of 1˜2 micrometers along 33 analytical lines of 11 crystals. In a result of measurement, remarkable wide isotopic fractionation range, up to 45 permil, and heterogeneity were discovered within micro area, less than 10 micrometers, in each crystal. This result is similar to values that are shown after Proterozoic.

Based on lithological observations, depositional area of Dixon Island-Cleaverville formations changed from calm and deep condition to relatively shallower condition. In addition, we focus the formation of pyrite; tiny pyrite crystals were formed in syngenetically or during early diagenesis. Those pyrite crystals likely formed in euxinic environments like Black Sea, as suggested by the relationship between their Corg and S contents. Such the environment is further supported by an interpretation of the S isotope evidence; $^{34}$S-enriched pyrite is interpreted to have formed as a result of active and rapid sulfate reduction by bacteria in euxinic condition with intense Rayleigh fractionation. Micro-scale heterogeneity of tiny pyrite crystal probably reflects that the diversity of reduction rate which is caused by high activity of microbial habitations at the time.

Keywords: Archean, sedimentary environment, pyrite, sulfur isotope, in situ analysis by NanoSIMS, sulfate reducing bacteria