Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)
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BPT022-06 Room:104 Time:May 24 14:30-14:45

LITHOLOGICAL CHARACTERISTICS AND SULFUR ISOTOPE RATIO OF PYRITE IN 3.2GA BLACK SHALE, PILBARA, WESTERN AUSTRALIA.

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The 3.2Ga low-grade Dixon Island and the Cleaverville formations lie at coastal Pilbara greenstone belt of Western Australia. In 2007 summer, we conducted scientific drilling (DXCL-DP) in the Cleaverville Beach to understand relatively deep marine environments in Mesoarchean. In DXCL-DP, we obtained three fresh drill cores (DX, CL2 and CL1 in ascending order). In these cores, obvious stratification by black shale, gray chert and pyrite is found. Pyrite shows a laminated structure and matches well with bedding plane of cores. Detailed research for laminated pyrite is important to understand the mechanism of its formation and reconstruct the sedimentary environment at the time. Therefore we carried out visual observation by microscope and SEM and sulfur isotope analysis using EA-irMS to reveal the characteristics and general variations of sulfur isotope ratio for laminated pyrite.

Laminated pyrite in these cores is divided into two types by shape; massive layer and graded layer. Massive layer is less than 1.5 cm in thickness and shows the pinch-and-swell structure that is tensioned parallel to bedding plane. Also this type is vertically segmented into several blocks by small quartz veins, include euhedral pyrite crystals, attendant later load deformation. Graded layer is 0.5 to 4 cm in thickness and shows gradual increase in the amount of tiny pyrite crystals.

Tiny pyrite crystals in these cores are divided into three shape types, 1) spherical, 2) hollow, and 3) filled types. The spherical type is 10 to 30 micrometer in diameter and shows spherical rim, less than 5 micrometer in breadth, with inner siliceous core. The hollow type is 10 to 50 micrometer in diameter and shows a small spherical hollow in the center of a crystal. Filled type looks like hollow type in that an inner hollow is filled by pyrite. Laminated pyrite is composed of an aggregate of three types of tiny pyrite crystals. We also found that these crystals gradually overgrew from spherical type to filled type in a single layer.

The isotopic composition of sulfur in laminated pyrite and tiny pyrite crystals in black shale are -10.1 to +23.5 per mil in DX, +1.7 to +24.9 per mil in CL1 and +4.4 to +26.8 per mil in CL2. Many samples show positive values, and very heavy isotopic ratios, over +20 per mil, are found in several samples.

In the formation of tiny crystals, spherical type is first crystallized as a spherical pyrite rim and changed into hollow type by an overgrowth of outer pyrite crystal. Finally it is settled as filled type. Euhedral pyrite crystals formed in later stage do not possess these characteristics. These suggest that the laminated pyrite formed before load deformation. The spherical crystal formed during sedimentation or in very early stage of diagenesis. Also, a part of laminated pyrite in these cores reflects concentration of tiny pyrite during the early stage of sedimentation.

Very wide range of sulfur isotope ratio of laminated pyrite indicates the very active microbial sulfate reduction. Positive isotope ratio might be created by intense sulfate reduction under sulfate-limiting condition. Very heavy isotopic ratios, like that of the modern ocean, suggest the existence of fractionated seawater sulfate in the Mesoarchean ocean.

Keywords: Archean, black shale, pyrite, sulfur isotope ratio, sulfate reduction, sedimentary environment