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	Research Area Information	Number of Research Area : 23B204 Project Period (FY) : 2023-2025 Keywords : Seafloor massive sulfide, Biomineralization, Sulfur isotope

Purpose and Background of the Research

● **Outline of the Research**

This study focuses on the formation mechanism of volcanogenic massive sulfide (VMS) and seafloor massive sulfide (SMS) deposits which are (or will be) an important metal resource, and this aims to create a new research concept called "BIOre" by combining several study areas: geology, biology, geochemistry, and chemical engineering. Previous studies explained VMS and SMS deposits have been mainly formed with inorganic chemical reactions; however, this study proposes the contributions of bio-geochemical reactions in this process. We especially focus on biomineralization and dissolution reactions related to sulfur bacteria activity and try to find their evidence in natural and synthetic sulfide samples by sulfur isotope, genetic analysis, cultivation test, and quantum chemical calculations. Furthermore, these scientific results will be utilized to develop a new mineral processing technology.

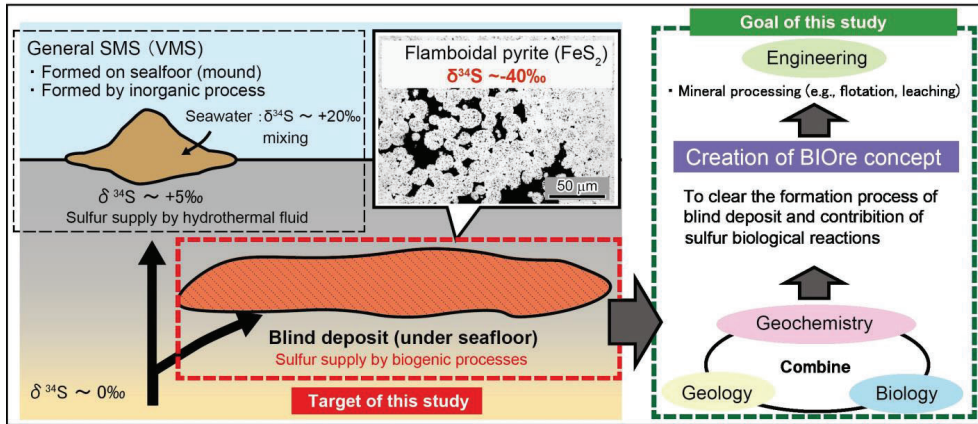


Figure 1. SMS formation process and our study concept in "BIOre"

● **Background and purpose**

① **SMS deposit formed by inorganic or biological process?**

Metal resources are essential to support our social activities; exploration, mineral processing, and smelting techniques of ores have been developed. Many researchers have examined the formation processes of VMS and SMS which is a former precursor. In seafloor hydrothermal environments, high temperature fluid over 300°C is venting; thus, many previous studies explained VMS and SMS have been mainly formed by inorganic chemical reactions. However, a recent study found evidence of biogenic sulfide mineral formation in the SMS sample, suggesting that biomineralization reaction could contribute to the SMS formation process.

② **Creation the new concept "BIOre" in resource development field**

This study aims to create a new study concept "BIOre" which covers all mining and materials processing, by combining several fundamental research areas (geology, geochemistry, biology, and chemical engineering. "BIOre" is a coined word of "biology" and "ore"; which expects not only to construct a new theory of biogenic deposit formation but also to develop a new mineral processing technique for sustainable supplement of mineral resources. Furthermore, we aim to create a new scientific community including young researchers and Ph.D. students to activate the resource development field.

Expected Research Achievements

● **Research topic of each study group**

A01: Geology group

【Head : NOZAKI Tatsuo (JAMSTEC)】

This group determines the order of mineralization by the petrological method using microscopic observation of natural massive sulfide samples. In addition, it quantifies contribution of biomineralization in the SMS and VMS deposit formation processes using stable sulfur isotope analysis of pyrite by nano-SIMS and comparison of theoretical calculation.

B01: Microbiology group

【Head : WAKAI Satoshi (JAMSTEC)】

This group clears microbiota to contribute SMS and VMS formation reaction by the microbial community analysis of natural samples and isolate sulfur bacteria from the samples to cultivate in laboratory. In addition, it tries to reproduce the biomineralization reaction under artificial hydrothermal condition and synthesize biogenic sulfide samples.

C01: Geochemistry group

【Head : FUCHIDA Shigeshi (TUMSAT)】

This group constructs a new kinetic model to quantify the biomineralization by comparison of a dataset of laboratory cultivate experiments, and it evaluates chemical composition and crystalline of natural and artificial biogenic sulfide minerals by specific analysis such as SEM-EDS, XAFS, and XPS.

D01: Chemical engineering group

【Head : OYAMA Keishi (Waseda Univ.)】

This group examines the utilization of sulfur bacteria collected from natural SMS samples to the seawater minerals and materials processing such as flotation of valuable sulfide minerals and leaching of valuable metals. For the experimental samples, it applies other group methods to clear the separation mechanism.

Supervision of all group 【 Head : FUCHIDA Shigeshi (TUMSAT)】

This group helps with outreach activities and construction of new networks in the resource development field. It also tries to introduce the "BIOre" concept to wider academic field members such as earth & planetary science, biology, chemical engineering and strengthen an industry-academia-public-private collaboration.

● **A ripple effect of this study**

This study's results and methods can contribute to reveal sulfur recycling on a global scale which is related to microbial activity as well as SMS and VMS deposits. It can help to investigate underground micro-biospheres and paleoclimatic reconstruction related to sulfur recycling because many core samples including sulfide minerals have been collected and preserved in research institutes.

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