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# 北鹿地域西観音堂黒鉱堆積物中に産する黄鉄鉱球晶：水曜海山との比較
# Pyrite spherulites found in the Nishi Kannondo Kuroko deposit in the Hokuroku district: Comparison with Suiyo Seamount.

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Pyrite spherulites are often observed in modern seafloor hydrothermal vents as well as ancient hydrothermal ore deposits. Sulfide spherulites are often considered as an important material in the origin of life by catalyzing metabolisms or acting like a cell. However, formation processes of the pyrite and their association to biotic processes are not well understood due to a lack of detailed investigations on mineralogical and geochemical characteristics of the pyrite. We found possible fossil of chimneys including much pyrite spherulites in the Nishi-Kannondo deposit which is one of Kuroko-type massive sulfide deposits Nishi Kannondo deposits generated by an ancient (~13Ma) hydrothermal system. It is located in the Hanaoka mining camp in the Hokuroku district, Akita Prefetcure, Japan. The same spherules were also found in sulfide-sulfate mounds at modern submarine hydrothermal field of the Suiyo Seamount in the Izu-Bonin Arc, Western Pacific. Objectives of this study are (1) to reveal detailed mineralogical and chemical characteristics of spherulitic pyrite, and (2) to examine the relationship of the formation of spherulitic pyrite and biological activities.

In the Nishi Kannondo deposit, we collected various ore samples. Pyrite-rich ores are commonly found in the western and northern part of the ore deposit. Black ores (consist essentially of sphalerite and galena) are found in the center of the ore deposit, and barite ores are from southern side of the deposit. These lithological variations correspond to the paleo-structures of chimney and mounds. Pyrite spherulites are found in barite-rich ores which may be located at the chimney out wall or mound inside: those were formed in low temperature and sulfate-rich environments, thus in distant from black smoker activities.

Based on microscopic observations, an individual pyrite spherulite, a few mm in diameter, is divided into core, and outer envelope parts. Core parts of 134 spherulites were grouped into 3 types according to morphology and constituent minerals. The most are i) multiple sulfide microcrystal type (69%, e.g., pyrite and tennantite), ii) pit or porous type (22%), and iii) sulfide single crystal type (9%, e.g., pyrite and tennantite) to the least. The pit or porous type is associated with pyrite, covellite, quartz and organic carbon (TOC ~ 0.1wt%) around the pit. Outer envelope parts are composed of radial pyrite crystals, and some have concentric layers with other minor minerals (e.g., chalcopyrite, tennantite and molybdenite). In chemical mapping of the pyrite layers, concentric zonings of As and Cu were observed. These characteristics of outer envelope parts of the pyrite spherulites indicate that the pyrites record periodical precipitation processes, which occur rapidly or slowly. We also propose that these differences of characteristics of core and outer envelope parts reflect changes in surrounding environments during the formation of pyrite spherulites, such as periodic discharge of "hot" hydrothermal fluids. Some pit or porous types contain organic matter. However, it is still uncertain if microbial activities initiated spherulite formations.

At the Suiyo seamount, black smokers are actively discharging, resulting the formation of large sulfide mounds on the seafloor. We collected various samples different in the formation phase, such as a freshly-formed chimney and aged sulfide mounds. Based on microscopic observations, spherulites are recognized in the matrix comprising barite, similar to that of Nishi Kannondo deposit. An individual spherulite, a few mm in diameter, consists essentially of pyrite and sphalerite. Those suggest to be performing similar process in case of the Nishi-Kannnodo deposit.

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