The morphological and sulfur isotopic characteristics of pyrites in the sediments in Xisha Trough, South China Sea

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Pyrite is one of the common authigenic minerals in marine sediments, which is generally considered as the product of the coupled anaerobic reactions of methane oxidation and sulfate reduction. Previous studies have found that the crystallization and isotopic composition of pyrite are closely related to the geochemical environment where pyrite formed.

Authigenic pyrite, distributed in the form of vein in sediments, were collected at ~500 m below seafloor on the northwest slope of Xisha Trough, South China Sea. In order to study its formation mechanism, high resolution X-ray Computed Tomography (CT), Tescan Integrated Mineral Analysis (TIMA) , Scanning Electron Microscopy (SEM) and Focused Ion Beam SEM (FIB-SEM) were employed to observe the morphology and distribution of pyrite in the sediment, and its sulfur isotopic composition was analyzed with the method of chromium reducible sulfur (CRS) extraction.

The majority of pyrites are fine-grained truncated octahedral, implying that anaerobic methane oxidation and sulfate reduction were not that strong when pyrites formed. The change in crystal morphology during its growth may indicate that pyrite formed in a gradual sulphur-rich environment. The size of pyrite crystal in bulk sediments ranges in 25-65 (av. ~40) μm, while those crystals are generally larger (av. ~50 μm) in veins. The growth steps are well developed and easily observed on the crystal surfaces of pyrites, suggesting a low growth rate.

The $\Delta\delta^{34}S$ values of pyrites are in two ranges: 20.8 to 33.2‰, and 44.8 to 48.9‰ V-CDT, suggesting two stages of crystal growth. With a continuous low methane flux, the first-stage pyrite might have formed in an environment with good access to seawater, probably in sediments with fractures connecting to or close to seafloor; the second-stage pyrite, mainly developed in sediment fractures and appeared as veins, should have formed in an environment with limited availability of sulfate, probably due to connection weakening caused by the continuous sediment accumulation or sediment perturbation.