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Editorial

Research on Submarine Hydrothermal Activity and Its Material Circulation, Magmatic Setting, and Seawater, Sedimentary, Biologic Effects

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Submarine hydrothermal activity has been a focused research topic since its discovery in the 1970s. It is widely believed that submarine hydrothermal activity offers significant prospects for the development of mineral and biological resources and that it considerably impacts the immediate seawater environment. The study of submarine hydrothermal activity is a multi-disciplinary topic that includes tectonics, petrology, mineralogy, sedimentology, chemistry, and oceanography. The development of hydrothermal circulation is controlled with tectonic and magmatic settings, including extensional tectonics where shallow magma reservoirs exist. The chemical compositions of hydrothermal fluids, which are affected by fluid–rock interactions beneath the seafloor and potentially by magma degassing are recorded in hydrothermal minerals, sediments, and seawater. Naturally, such a broad area of research cannot be accomplished without the development of exploratory and analytical techniques.

Recent improvements in science and technology greatly assist the development of research on these topics. This Special Issue aims to advance the understanding of the latest progress in research on submarine hydrothermal activity and its circulation of materials, its magmatic settings, and its seawater, sedimentary, and biological effects.

The chemical and isotopic compositions of sulfide minerals from seafloor hydrothermal sulfide deposits hold valuable information about the processes of seawater–fluid mixing and fluid–rock interactions in hydrothermal systems. In their report on the elemental and S-Pb isotopic compositions of sulfide minerals from the Noho hydrothermal field (NHF) in the Okinawa Trough, Zeng et al. [1] suggest that the sulfur content of hydrothermal fluid plays a controlling role in the precipitation of pyrite and marcasite in the hydrothermal sulfide deposits.

Zeng et al. [2] identified two types of anglesite in the seafloor hydrothermal deposit of the Okinawa Trough, namely low-Pb/high-S primary anglesite and high-Pb/low-S secondary anglesite. Analyses of the element concentrations and S-Pb isotope compositions of the anglesites revealed their formation processes and a model of secondary supergene enrichment of Bi and Ag in seafloor hydrothermal sulfide deposits was proposed.

Although extensive research has previously been conducted on the elemental and isotopic compositions of hydrothermal fluids in deep seafloor settings, knowledge of these compositions in shallow hydrothermal vent fluids is limited. Zeng et al. [3] reported the chemical and Sr–H–O isotopic compositions of the vent fluids and hydrothermal plumes in the Kueishantao shallow hydrothermal field and investigated the rock–fluid interactions, the evolution of hydrothermal fluids, and the hydrothermal Sr flux.

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Wang and Zeng [4] investigated the microtopography, mineralogy, and geochemistry of ferromanganese deposits in the Caiwei Guyot. The formation of ferromanganese crusts and nodules is a hydrogenic process influenced by global-paleo events; the crusts are formed in an environment with strong hydrodynamic conditions, whereas the nodules are generated in deeper water. At present, they are not affected by seafloor hydrothermal activity.

A long-term stable magma chamber in the shallow crust is necessary for seafloor hydrothermal systems to develop. Determining the stability and residence time of the magma from mixing to eruption helps assess magmatic systems. Zhang et al. [5] used Mg diffusion chronometry in minerals to estimate the residence times of andesitic and rhyolitic magma beneath the Iheya Ridge hydrothermal field in the Okinawa Trough. They showed that the andesitic magma formed by mixing basalt and rhyolite has a very short residence time before it erupts, suggesting an unstable seafloor magma reservoir unlikely to develop and preserve hydrothermal resources.

The magmatic system is an essential heat source that may directly supply volatiles and metals to the seafloor hydrothermal system. Therefore, it is important to study the volatile evolution process in shallow magma chambers. Chen et al. [6] measured the volatile concentrations of apatites trapped in phenocrysts at different stages of rhyolite evolution in the Yonaguni Knoll IV hydrothermal field, Okinawa Trough. They found that, although the magma is volatile unsaturated during its early evolution stages, the subsequent recharge via subduction-related mafic magmas may supply enough volatiles into the magma reservoir for volatiles to exsolve and contribute to the mineral control of the overlying hydrothermal system.

In addition, Du et al. [7] analyzed the F-Cl-S concentrations of the apatites in dacite from seafloor hydrothermal field in the East Manus Basin to determine the volatile compositions of magma before eruption. They observed high Cl/F and H_2O concentrations in the samples, which suggests the contributions of slab-derived fluids to the mantle source of the East Manus Basin. They estimated that subduction fluids contribute at least 14−21% of the total Cl concentrations in the magmas.

To ascertain the influence of subducted materials on the constitution of the mantle source beneath the back-arc basin, Zeng et al. [8] investigated the major element, trace element, and Li-O-Mg isotope compositions of lavas from the middle and southern Okinawa Trough. Their results suggest that, compared to the middle part, the mantle source of the southern region is influenced by a greater number of subducted components derived from the altered oceanic crust and/or sediments.

Subduction materials may also be transferred to the mantle beneath the mid-ocean ridge using mantle circulation. Ji and Zeng [9] presented data on major elements, trace elements, and Nd-Hf isotopes of the mid-ocean ridge basalt (MORB) on the mid-Atlantic ridge. Interestingly, these MORBs show distinct geochemical compositions compared to the normal MORB, e.g., the former is enriched in fluid mobile elements (e.g., U, Pb, and Rb) and has lower Nb/U and Pb/Ce. Combined with Hf-Nd isotope data, the authors suggest these anomalies were attributed to recycling subduction-modified mantle materials into the mantle source beneath the mid-Atlantic ridge.

A comprehensive understanding of the sedimentary environment surrounding seafloor hydrothermal fields is crucial for investigating the hydrothermal precipitation process. Zhu and Zeng [10] took advantage of zircon U-Pb geochronology to trace the provenance of sediments in the Southern Okinawa Trough. Their new results contrast with the previous popular viewpoint that the sediments in the southern Okinawa Trough are mainly sourced from the Taiwanese rivers; instead, they suggest the Yangtze River/East China Sea shelf may significantly contribute to the sediments in this area.

Furthermore, significant progress in the exploratory and analytical technologies for seafloor hydrothermal activity has also been recently achieved. Zeng et al. [11] developed a novel device to effectively extract metals (e.g., Au, Ag, Cu, and Zn) from the seafloor hydrothermal vent fluids. This method can minimize the damage to the marine ecological environment when mining the seafloor polymetallic sulfide resources and has great significance for developing and utilizing seafloor hydrothermal resources.

Gao et al. [12] developed a method that can simultaneously determine the fluorine and chlorine concentrations in marine and stream sediments using ion chromatography, which can suppress the volatilization loss in fluorine and chlorine and decrease the matrix effects. This method can help analyze large batches of geological and environmental samples, including seafloor hydrothermal products.

Du et al. [13] used near-bottom magnetic surveying to determine the magnetic anomaly of the seafloor, which can record information on hydrothermal circulation and mineralization. They collected the near-bottom magnetic data and determined the shallow magnetic structure in the Tianxiu Vent Field during the DY57th cruise in 2019. Their results established a connection between stronger magnetization and active hydrothermal vent clusters.

Above all, there is a relationship between the tectonic setting, magmatism, mineralization, fluid–rock interaction, and sedimentary processes in the seafloor hydrothermal system and the response, adaptation, record, and action of the organism, and it will be interesting to explore the synergetic metallogenic mechanism of magma, fluid, rock, sediment, seawater, and organisms in the seafloor hydrothermal field in the future [2].

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