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The fluid evolution and growth processes of the modern seafloor hydrothermal sulfide chimney: Constrains from in situ sulfur isotope and micro-scale trace elements of pyrite

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The petrographic and geochemical features of the modern hydrothermal sulfides can reveal the growth processes of chimney and the evolution of hydrothermal fluids. To clarify the geochemical variations and ore-forming fluids evolutions during the chimney growth, we performed laser ablation ICP-MS and Nano-SIMS (Nanometer-second ion mass spectrometry) to characterize the variations of trace elements and S isotopes of pyrite across a pyrite-dominated chimney collected from the hydrothermal field on East Pacific Rise. Three types of pyrite were distinguished from exterior to interior of the chimney, which varies from anhedral through euhedral to massive textures. Trace elements of pyrite evolves from high-temperature (Cu, Se, Sn, Bi, Co and Ni) to low-temperature characteristics (Zn, Pb, Cd, Tl, Ag, Mn, Ba, Mg and V) with the decreasing degrees of crystal morphologies from core to rim in response to the changes in temperature and fluid chemistry caused by seawater-fluid mixing. The massive pyrite in core features lower Se/Tl ratios but higher Co/Ni ratios relative to euhedral pyrite, possibly attributed by the decreasing T or $fS2$ of fluids with the waning hydrothermal circulation. The δ34SV-CDT values of pyrite range from -0.51 to 6.43‰ (avg. 3.56‰ n=39). The decreasing S isotopic values in the mineral sequence of chimney result from the decreasing seawater derived-S, whereas the incorporation of approximately 8%–24% of bacteria derived-S lead to partial anhedral pyrite with negative δ34SV-CDT values (down to -0.51‰.The systematic variations in the S isotopic compositions and morphology of the pyrite across the chimney wall reflect multiple stages of mineralization and fluid evolution. Based on in situ sulfur isotope and micro-scale trace elements compositions of pyrite, we propose a chimney growth model that focuses on different degrees of fluid-seawater mixing and variations of the permeability across the chimney.