Coupled Fe–S isotope composition of sulfide chimneys dominated by temperature heterogeneity in seafloor hydrothermal systems

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Seafloor hydrothermal chimneys and massive sulfides are significant metal resources and are critical to marine chemistry balance, but the mechanism of their formation remains largely unexplored. Here, we report lateral Fe and S isotopes from sulfides across a chimney wall in detail from the Deyin-1 hydrothermal field (DHF) on the South Mid-Atlantic Ridge. Pyrite was characterized by increases in both $\delta^{34}S$ and $\delta^{56}Fe$ from the exterior to the interior within the chimney wall, which is likely related to enhanced S and Fe isotope fractionation between pyrite and fluids derived from the temperature gradient. Furthermore, $\delta^{56}Fe$ displayed a well-defined positive correlation with $\delta^{34}S$ in pyrite from the DHF as well as in pyrite from other areas. A model of hydrothermal pyrite formation suggests that different temperatures and similar pyrite–H_2S exchange degrees could result in the observed linear relationships between $\delta^{34}S$ and $\delta^{56}Fe$. The regular and coupled Fe–S isotope variations within the chimney wall efficiently constrain the process of hydrothermal sulfide formation.