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Isotopic systematics of shallow hydrothermal vents systems on the Milos shelf, Aegean Sea, Greece

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Hydrothermal vents are generally classified as either “shallow” or “deep-sea,” depending on whether they occur above or below a depth of approximate 200 meters. Shallow-water vent fields are predominantly linked to volcanic arcs and typically exhibit lower temperatures compared to deep-sea systems, mainly due to phase separation. These shallow-water vent systems are also characterized by the emission of geothermally altered fluids enriched in metals and sulphide, which play a crucial role in local geochemical processes and contribute to mineral deposition. Several factors might influence the mobilisation, transport, and deposition of these metal sulphides, including the composition of the host rock, pressure and temperature, phase separation, and magmatic degassing. Milos is a volcanic island in the Aegean Sea that lies along the Hellenic Volcanic Arc and is host of a shallow-water hydrothermal vent systems that is driving the formation of metal sulphide and mineral precipitates. To determine the influence of rock type, temperature and phase separation on the (isotopic) geochemical composition of hydrothermal fluids, and thereby gain insights into the mechanisms that lead to the formation of the metal mineralisation, we analysed the hydrothermal fluids from Thiorychia (southeast off the coast of Milos) and Vani (northwest off the coast of Milos). The hydrothermal fluids were sampled during research cruise M192 and analysed for their lithium (Li), boron (B) and strontium (Sr) concentration and isotope composition.

The findings reveal notable differences in isotopic compositions among the two vent sites. Geochemical analysis of hydrothermal fluids indicates phase separation, with a brine phase emanating from Thiorychia and a vapor phase from Vani. Li, Sr, and B concentrations in the end-member fluids from Thiorychia are higher than those of seawater, whereas they are lower in Vani. In addition, $\delta^{7}Li$ values are heavier in the SE than in the NW. The $^{87}Sr/^{86}Sr$ ratios at both vent sites are more radiogenic than seawater, while $\delta^{11}B$ values are extremely low. In combination, these isotopic signatures indicate substantial fluid–sediment interaction and a contribution from magmatic fluids. Overall, the results confirm that Sr, Li, and B respond differently to water–rock interaction processes within the hydrothermal system.