

Unravelling the origin of magmatic-hydrothermal hyper-enrichment of Sb on the seafloor: insights from the unique Kolumbo SMS diffuser vents

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Antimony is an important CRM for the EU, therefore, its sustainable supply greatly depends on understanding the Sb-ore precipitation mechanisms[1]. Fluid temperature decrease is the main mechanism for stibnite precipitation in epithermal deposits on land[2], meanwhile, Sb ore-mineralization in submarine hydrothermal systems is still unresolved[3]. Here, we investigated the hyper-enrichment of Sb in modern boiling SMS diffusers, Aegean Kolumbo submarine arc-volcano. Antimony mineralization includes stibnite and Sb-sulfosalts (semseyite and meneghinite), where the average and maximum concentrations of Sb (8,330 mg/kg and 2.2 wt.%, respectively) are the highest reported from modern SMS. LA-ICP-MS analyses showed a unique enrichment of Sb in all sulfide phases present, i.e., ≤ 9.8 wt.% in galena, meanwhile depth profiles in stibnite displayed spikes implying the presence of polymetallic(Zn-Ag-Tl-Au) nanoparticles. Depth profiles for Sb in pyrite exhibit both smooth and spiky parts indicating nanoparticulate and lattice bound Sb[5]. Synchrotron μ XRF mapping showed oscillatory zoned pyrite with respect to Sb, whereas spatial distribution of Sb/Pb(≤ 0.5) vs. Tl/Pb(≤ 0.02) ratios indicated boiling-induced precipitation[6], and alternated boiling-dominated, and fluid-seawater mixing-dominated zones. Geochemical and micro-textural evidence showed that Sb-rich SMS mineralization has been formed by fluids undergoing multiple recurrent intense-boiling and/or flashing, or gentle and/or non-boiling events. Boiling in Kolumbo is supported by: (1) the high contents of Sb, and, As, Hg, and Tl, as these metal(loid)s are easily mobilized in the vapor phase[4]; and (2) the evolving and dynamic magmatic-hydrothermal system of Kolumbo which can control fluxes of magmatic volatiles and metal(loid)s[4],[7]. Furthermore, evolving Kolumbo magmatic-hydrothermal system could include periods of magmatic quiescence that results in a seawater-dominated hydrothermal fluid[4],[7]. Therefore, Sb hyper-enrichment highly depends on magmatic degassing and variable degrees of fluid-seawater mixing and fluid boiling precipitation.

References

[1] European Commission (2023) [2] Kodera *et al.* (2024) *Mineralium Deposita*, 1-17 [3] Dekov *et al.* (2024) *American*