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Vertical and temporal fluid evolution recorded by sulfide trace elements: Insights from the epithermal Profitis Ilias Au deposit, Milos Island, Greece

ANNA GROSCHE[1], KATJA DENKEL[1], REINER KLEMD[1], MANUEL KEITH[1], KARSTEN M. HAASE[1], PANAGIOTIS C. VOUDOURIS[2] AND DIMITRIOS ALFIERIS[3]

[1]GeoZentrum Nordbayern, Friedrich-Alexander-Universität (FAU) Erlangen-Nürnberg

[2]Faculty of Geology & Geoenvironment, National and Kapodistrian University of Athens

[3]Research and Consulting Geoscientist, DALFEX, Athens

Presenting Author: anna.grosche@fau.de

The fractionation of metal(loid)s in hydrothermal systems is crucial for the element distribution in ore deposits and is often controlled by multiple fluid processes. Drill core samples from the Profitis Ilias Pb-Zn-Ag-Au-Te-Cu vein mineralization on Milos Island, Greece [1], provide unique insights into the vertical and temporal evolution of a shallow-crustal hydrothermal system. New trace element (LA-ICP-MS) data of galena record decreasing Au, Te, and Se, but increasing Ag, Sb, and Tl concentrations with increasing elevation, which may be associated with progressive cooling and boiling during the main ore stage. This is in accordance with previous fluid inclusion data that showed boiling of the fluid at decreasing temperatures of 250 to 150°C during ascent from 500 m depth to the surface [2]. The pronounced element zonation suggests that Ag is less sensitive to fluid cooling and boiling than Au and Te, and gets enriched towards the upper and cooler parts of the boiling zone, as also observed in NW Milos [3]. Abundant hessite inclusions in porous pyrite cores in the deep stockwork display the co-precipitation of Te, Ag, and Au during strong boiling, followed by abundant base metal sulfide deposition. Supergene processes caused a secondary Au enrichment associated with Fe oxides and sulfates in the shallowest part of the Profitis Ilias deposit. Three different pyrite generations from the shallow stockwork document the fluid evolution from the ore stage to the supergene mineralization stage. Disseminated pyrite has higher Tl/Pb and Co/Ni ratios than vein-related pyrite from the ore-stage, indicating precipitation from the high-Cl boiled fluid that has infiltrated the altered host rocks. Late-stage anhedral pyrite has high Tl/Pb ratios and very low Co, Ni, Ge, In, and Sn contents, which reveals mixing of the boiled fluid with metal-poor meteoric waters near the paleowater table. Our results highlight the importance of sulfide trace element data in defining fluid processes such as cooling, boiling, and secondary fluid mixing in multistage hydrothermal systems.

[1] Alfieris et al. (2013), *Ore Geology Reviews* 53, 159-180.

[2] Kilias et al. (2001), *Mineralium Deposita* 36, 32-44.

[3] Schaarschmidt et al. (2021), *Chemical Geology* 583, 120457