

Gold and Sulfur cycling in the unique Karambusel vent field, Conical Seamount, PNG: A hybrid between magmatic-hydrothermal venting and cold seepage revealed by sulfide microanalysis

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Research cruise SO299 (R/V Sonne) to Papua New Guinea discovered the active Karambusel vent field on the western flank of Conical Seamount. Karambusel is hosted by young K-rich lavas and combines characteristics of a high-temperature magmatic-hydrothermal system and cold hydrocarbon seepage forming a unique Au-rich submarine epithermal system. Here, we use a detailed petrographic approach coupled to microanalytical sulfide trace element (EPMA, LA-ICP-MS) and S isotope (SIMS) data of pyrite combined with bulk methods (ICP-OES, INAA, EA-IRMS, XRD) to reveal the evolution, metal sources, and S cycling processes during Au enrichment.

The main mineralization consists of polymetallic sulfides hosted within amorphous silica veins crosscutting variably altered ankaramite breccias. Gold occurs as 20- μ m sized electrum grains and within Au-rich orpiment resulting in bulk Au contents of up to 28 μ g/g. Mass balance calculation indicates that electrum accounts for the majority of Au (93 %) while orpiment serves as a secondary host (6 %). Coupled trace element and S isotope data of texturally distinct pyrite generations suggest that magmatic fluids are the primary source for Au while fluid boiling is likely triggering efficient Au precipitation. This main magmatic-hydrothermal event is overprinted by an As-Sb-Tl-Hg-rich stage related to the currently active venting of moderate temperature (up to 51°C), low salinity fluids and concomitant seepage of natural gas (~80% methane). Highly variable $\delta^{34}\text{S}$ (-21 to 4‰) and $\Delta^{33}\text{S}$ (-0.04 to 0.06) signatures in sulfides and native S suggest complex magmatic, biogenic, and methane-related S isotope fractionation processes during the evolution

from the Au-rich magmatic-hydrothermal system to the current venting and hydrocarbon seepage. The role of hydrocarbons on the precious metal mineralization remains ambiguous but is likely subordinate to the magmatic-hydrothermal processes. A comparison of our results with the previously reported Au-rich mineralization from the summit of Conical Seamount (up to 230 μ g/g Au) and with the world-class Ladolam Au deposit (50 Moz Au) on nearby Lihir Island allows us to develop a comprehensive mineralization model for this, first-of-its-kind, hybrid system combining magmatic-hydrothermal and cold hydrocarbon seep related mineralization.