Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.30586

Magmatic sulfide flotation in the Fatu Kapa magmatic field (NW Lau back-arc basin) and its implications for the formation of seafloor massive sulfide deposits

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Experimental studies have suggested the formation of magmatic sulfide bleb-vapor bubble compounds, but natural evidence in shallow magmatic systems remains scarce. The flotation of these sulfide-bubble compounds is economically significant, as it provides an efficient mechanism for transporting S, Cu, and Au from magmas to associated magmatic-hydrothermal systems, promoting metal enrichment in seafloor massive sulfide (SMS) deposits.

In this study[1], we present petrological and geochemical evidence supporting the occurrence of sulfide-bubble compounds in the Fatu Kapa magmatic system (NW Lau back-arc basin), which is associated with Cu- and Au-rich SMS deposits, despite magmas initially exhibiting MORB-like fO_2. Volcanic rocks from this system contain multiple sulfide blebs (10–65 μm in diameter), predominantly composed of pyrrhotite with minor Cu sulfides. Most are connected to larger bubbles (20 μm to several hundred μm in diameter), displaying textures indicative of partial sulfide dissolution and sulfur degassing into the vapor phase. These features suggest metal transfer from sulfides to vapor.

Geochemical indicators, including chalcophile element behavior, plagioclase-silicate melt hygrometry, and the water solubility of dacitic magmas, indicate that sulfide segregation and pre-eruptive bubble formation occur nearly simultaneously in andesitic-dacitic magmas. This supports the formation of sulfide liquid-vapor bubble compounds. Using a model of sulfide growth via sulfur diffusion and sulfide convection, we calculated isolated sulfide and sulfide-bubble radius evolution, as well as ascent/sinking velocities in H_2O-rich andesitic-dacitic magmas. The results suggest that isolated sulfides sink faster than the magma ascends, thereby inhibiting their upward transfer. Conversely, compound drops rise more quickly than the host magma, accumulating at the chamber's top and thereby preferentially transferring compounds upward during eruptions.

We propose that this process plays a critical role in enriching Cu and Au in SMS deposits by facilitating metal transfer from sulfides to bubbles during ascent and leaching of sulfides upon deposition in basement rocks. Our findings emphasize that late-stage sulfide saturation in Cu-Au-rich intra-oceanic subduction-derived felsic magmas promotes upward Cu-rich sulfide transfer via flotation.

Reference

[1] Jeanvoine, Park, Pelleter, Bézos, Chazot, Hwang & Fouquet (2024), Communications Earth & Environment 5(1), 462