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Deciphering the role of sulfides and volatiles in the transfer of copper towards the surface: insights from the volatile and sulfur saturated magmas of Fatu Kapa (NW Lau back-arc basin, SW Pacific)

AURÉLIEN JEANVOINE[1], JUNG-WOO PARK[1], EWAN PELLETER[2], GILLES CHAZOT[3], FOUQUET YVES[4], ANTOINE BÉZOS[5] AND JIWON HWANG[1]

[1]Seoul National University
[2]UMR6538 CNRS-IFREMER-UBO-UBS, Laboratoire Geo-Ocean
[3]Université de Bretagne Occidentale
[4]IFREMER
[5]Université de Nantes

Presenting Author: aurelien.jeanvoine@gmail.com

In the long-standing debate focused on understanding which mechanisms lead to Cu enrichment of some (but only few) sulfide hydrothermal ore deposits, particular attention has been paid to low-density aqueous fluids exsolved from source magmas. More recently, studies stressed out the potential role played by dense sulfides exsolved from magmas during their evolution, especially when they are attached to bubbles of aqueous fluids and consequently transferred towards the surface. However, both the rarity of such bubble-sulfide association in natural settings and the incomplete magmatic trends where this association is observed prevent us from understanding whether sulfides play an important role in the transport of Cu or whether volatile exsolution alone is required to explain these Cu-rich ore deposits. We present a unique example of preserved sulfide-bubble associations in the well-defined transitional and slab-decoupled suite of Fatu Kapa (basalts to trachy-dacites) associated with Cu-rich seafloor massive sulfide deposits. We analysed the Cu, Pb and Zn contents of glasses and whole-rocks by LA-ICPMS and ICP-MS, respectively, and analysed the Pd contents of glasses and whole-rocks by nickel-sulfide fire assay. We integrated these elements in a model of fractional crystallization coupled with assimilation where these magmas are firstly sulfur saturated (basalts) and secondly become volatile saturated (basaltic andesites). According to the results of this model, the Cu concentration of these magmas drops by a factor of ~2 during the first stage of sulfur saturation, involving that an important part of the initial Cu budget is trapped in the lithosphere due to Cu fractionation in dense sulfide blebs. Once magmas get both sulfur and volatile saturated, the Cu concentrations drop again by a factor of ~2 until the most felsic silicate liquids are reached. During this stage, most of the Cu budget fractionated in both the fluid and the sulfide phases is transferred towards shallower depths due to sulfide flotation. We emphasize that such Cu fluxing is more efficient in arc settings than it is at Fatu Kapa because sulfide saturation and volatile exsolution occur almost simultaneously, therefore decreasing the amount of Cu lost in isolated and dense sulfide blebs.