

Mechanisms of fluid degassing in shallow magma chambers control the formation of porphyry deposits

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ABSTRACT

Magmatic fluid degassing within shallow magma chambers underneath the ore bodies is critical to the formation of porphyry Cu-Au deposits (PCDs). Yet, it remains unclear how the fluid degassing influences the development of PCDs. Here, geochemical data of apatite, amphibole, and plagioclase from ore-bearing and coeval barren porphyries have been analyzed in Sanjiang metallogenic belt, China. The ore-bearing porphyries normally exhibit high and wide X_F/X_{Cl} (31.76–548.12) and X_F/X_{OH} (0.779–7.370) ratios of apatites, which are evidently higher than those of the barren porphyries (X_F/X_{Cl} of 1.03–26.58; X_F/X_{OH} of 0.686–3.602). Combined with the continuous variation features of Cl/OH ratios and H₂O contents of melts calculated by amphiboles, as well as fluid migration models, we constrained the mechanisms of fluid degassing within shallow magma chambers underneath PCDs. There are three different ways of fluid degassing, while only fluid degassing via fluid channel stage can migrate and focus the metal-rich fluids effectively, conducive to the development of PCDs. The mechanisms of magmatic fluid degassing processes are further controlled by the storage depths of magma chambers and initial H₂O contents of the magmas revealed by the compositions of amphibole, plagioclase, and thermodynamic modeling. Magmas with shallower storage depths and higher initial H₂O contents are more likely to experience extensive and focused fluid degassing, leading to the generation of PCDs. This study demonstrates the potential utility of integrated mineral analyses and thermodynamic modeling for investigating the mechanisms of magmatic fluid degassing in porphyry systems, as well as for identifying prospective buried PCDs.

Keywords: Porphyry deposit, magma degassing, magma chamber, thermodynamic modeling, apatite, amphibole