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Platinum-group element geochemistry used to determine Cu and Au fertility at the Northparkes porphyry Cu-Au deposits, Australia

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Porphyry deposits are the world's most significant source of Cu, Au and Mo. Most of these deposits are associated with subduction zone-related intermediate to felsic magmas. However, the reason why some felsic systems are ore bearing whereas other apparently similar systems are barren is unclear. Our initial hypothesis is that if an evolving magma becomes sulfide saturated early in its evolution, the chalcophile elements, which include Cu and Au, will become trapped in sulfides in the magma chamber and are unavailable to enter the ore fluid to form an ore deposit. Alternatively, if the magma becomes fluid-saturated before it reaches sulfide saturation, or shortly after it becomes sulfide saturated, the chalcophile elements will be available to enter the ore-forming fluid.

Platinum-group elements (PGE) has been used to identify the timing of sulfide saturation in evolving magmatic systems for two reasons: first, because their partition coefficients into immiscible sulfide melts are at least one to two orders of magnitude higher than Cu or Au, making them more sensitive indicators of sulfide saturation; second, because they are less mobile in an ore environment than Cu or Au.

The Northparkes porphyry Cu-Au deposits, which are located in the mid-west of New South Wales, Australia, were chosen for study. We analysed the PGE geochemistry of the barren and ore-associated suites in the Northparkes Cu-Au porphyry region, emphasizing the timing of sulfide saturation and its influence on the tenor of the associated hydrothermal mineralization.

The concentrations of PGE in the two barren suites, the Goonumbla and Wombin volcanic and associate intrusive rocks, decrease continuously during fractional crystallization. This is attributed to early sulfide saturation with the fraction of immiscible sulfide precipitation, which locked most of the Cu and Au in a sulfide phase in the cumulus pile of a deep parental magma chamber, so that when the magma reached volatile saturation, it did not have access to the Cu and Au. The contrasts with the relatively late sulfide saturation in the ore-associated suite, which occurred at 1.2 wt.% MgO and was followed shortly afterwards by volatile saturation. Therefore, differences in PGE geochemistry can be used to distinguish between the ore-bearing intrusions of the Northparkes porphyry system and the barren intrusions. In addition to the sulfide saturation process, our study also suggests that Rayleigh fractionation, which is able to concentrate incompatible Cu and Au prior to sulfide saturation, is as at least as important as the initial concentration of chalcophile elements in the parent magma in determining the fertility of felsic magma suites. Furthermore, the short crystallization interval between immiscible sulfide and volatile saturation in the Northparkes ore-associated suite allowed some Au and Cu to be stripped from the evolving magma. Gold, with its higher partition coefficient into immiscible sulfide melts, was more affected than Cu. As a consequence, the Northparkes are Cu-Au deposits.