Platinum Group Elements Geochemistry Used to Distinguish Ore-Bearing from Barren Magmatic Systems at the Northparkes Porphyry Cu-Au Deposit, New South Wales

Hongda Hao,[1*] Ian H. Campbell,[1] Jung-Woo Park,[2] and David R. Cooke[3]

[1]Research School of Earth Sciences, Australian National University, Canberra, ACT 2601, Australia
[2]School of Earth and Environmental Sciences, Seoul National University, Seoul 151-747, South Korea
[3]ARC Centre of Excellence in Ore Deposits, University of Tasmania, Private Bag 79, Hobart, Tasmania 7001, Australia

*E-mail, hongda.hao@anu.edu.au

Porphyry deposits typically develop in arc-related intermediate to felsic magmas, but the reason why some intrusions are ore bearing whereas other apparently similar intrusions are barren is unclear. Our basic hypothesis is that if sulfide saturation occurs before volatile saturation in a fractionating magma, most of the Cu and Au are locked in a sulfide phase within a deep magma chamber and are unavailable to enter a hydrothermal fluid and form an ore deposit. Alternatively, if the magma becomes volatile saturated before it becomes sulfide saturated, most of the Cu and Au are available to dissolve in an ore-forming hydrothermal fluid.

Platinum group element (PGE) geochemistry has been used to identify sulfide saturation in the evolving Northparkes magmatic system for two reasons: first, because their partition coefficients into immiscible sulfide melts are two to three orders of magnitude higher than Cu or Au, making them more sensitive indicators of sulfide saturation, and second, because they are less mobile in an ore environment than Cu or Au.

The Northparkes porphyry Cu-Au deposits are located in the mid-west of New South Wales, Australia. Multiple intrusive phases have been identified in each of the quartz monzonite porphyry complexes, many of which are directly related to mineralization, while the regional intermediate to felsic Wombin Volcanics are barren. We analyzed PGE concentrations in 19 samples, including the regional volcanics, and most of the intrusions. The MgO content of the analyzed samples varies between 0.23 and 11.28 wt %. A plot of Pd against MgO shows two distinct trends. For the regional Wombin Volcanics and associated intrusions, Pd first increases with decreasing MgO but then falls rapidly once the MgO drops below ~4.2 wt %, indicating the magma became sulfide saturation at ~4.2 wt % MgO. For the ore-associated porphyry complexes, the Pd first increases slightly with decreasing MgO, but at ~1.25 wt % MgO, it decreases abruptly, suggesting the onset of sulfide saturation at ~1.25 wt % MgO.

Whole-rock MgO values for the intrusions associated with volatile saturation and ore formation range from 0.52 to 2.53 wt %, with most having MgO values greater than 1.25 wt %. This suggests that the volatile saturation probably occurred before 1.25 wt % MgO in most of the ore-bearing intrusions. That is volatile saturation occurred before or shortly after sulfide saturation in the ore-bearing intrusions. In contrast sulfide saturation of the regional Wombin Volcanics and intrusions occurred early, at around 4.2 wt % MgO, so most of the Cu and Au were locked in a sulfide phase prior to volatile saturation, preventing any significant mineralization from occurring. Therefore, differences in PGE geochemistry can be used to distinguish between the ore-bearing intrusions of the Northparkes porphyry system and the barren intrusions associated with the Wombin Volcanics.