Platinum Group Element Geochemistry in Granitoids as a Fertility Indicator for Gold and Copper Mineralization

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The link between copper, copper-gold, and felsic rocks is well known. What is not known is why some felsic suites are ore-bearing whereas other, apparently similar suites, are barren. What is the fundamental difference between barren and fertile granitic systems? The hypothesis we are testing is that if a magma becomes saturated with an immiscible sulfide melt and precipitates a significant amount of sulfide prior to becoming volatile saturated, the chalcophile elements (Cu, Au, Pt, Pd, etc.) are locked in the sulfide phase in an underlying magma chamber, where they are less available to dissolve in a hydrothermal fluid and form a Cu or Cu-Au deposit. Alternatively, if the magma becomes volatile saturated before significant sulfide precipitation occurs, the chalcophile elements remain in the melt and are available to be collected by the potentially ore forming volatile phase.

Platinum group element (PGE) geochemistry is the best method of determining the point of sulfide saturation in an evolving magma system for two reasons. First, the PGE are over a thousand times more sensitive to sulfide saturation than Cu or Au. Second, Cu and Au are mobile in an ore environment, which makes it impossible to determine the primary concentration of these elements in altered rocks. We have tested out hypothesis by applying it to two oceanic basalt-rhyolite suites, three barren felsic suites, four porphyry systems, and one volcanic massive sulfide deposit. The results show that PGE geochemistry can be used to determine the timing of sulfide saturation in an evolving magma suite and to estimate the rate of sulfide precipitation. Both have an important bearing of magma fertility. The barren suites are characterized by early sulfide saturation, which rapidly strips Cu and Au from the evolving magma. By the time it becomes volatile saturated, the Cu and Au contents of the magma are negligible. As a consequence the hydrothermal system is barren, with the ilmenite and magnetite series of Japan being examples. At El Abra, in Northern Chile, sulfide saturation occurs shortly before volatile saturation. Au is stripped for the magma but Cu, with its lower partition coefficient, is barely affected. The El Abra porphyry is a Cu-only deposit. Finally, if volatile saturation occurs before sulfide saturation, or if the amount of sulfide to form is very small so that it barely affects Pd, with its extreme partition coefficient into immiscible sulfide melts, Cu-Au deposits result. Grasberg is an example of the former and Cadia of the latter. The study found that PGE geochemistry can be used to distinguish ore-bearing from barren felsic suites, and in the case of ore-bearing suites, it is possible to predict the tenor of the ore.