Platinum-group element geochemistry to track magmatic evolution of the Yerington porphyry copper district (Nevada, USA)

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The Yerington batholith is located in western Nevada (USA) within a volcanic-arc area. This pluton is approximately 15 km in diameter, extends to 7-8 km in vertical dimension and consists of 3 granitic units: the McLeod Hill quartz monzodiorite (1,000 km$^3$), the Bear quartz monzonite (256 km$^3$) and the Luhr Hill granite (70 km$^3$), together with three mineralized porphyry centres: Yerington, Bear, MacArthur and Ann-Mason porphyry copper deposits. It is overlain by coeval the Artesia Lake and Fulstone Spring volcanic rocks. The batholith was emplaced into Triassic and Jurassic volcanic and sedimentary rocks at ca. 168 Ma. This event was related to the subduction of the Pacific plate, west of California. It was a part of a belt of Andean-type arc magmatism that developed on the continental margin in both North and South Americas. The complex was then cut by three sets of normal faults, which caused the batholith to drop ca. 2.5 km deep along the faults that tilted the area, so that it is now exposed in cross-section. This event now allows sampling of volcanic and plutonic rocks from each unit, which were originally emplaced at depths of 1 to 8 km.

It is widely accepted that porphyry deposits are genetically related to subduction zones but what is not understood is why some porphyry systems are ore-bearing while others, apparently similar systems, are barren. The key question remains unanswered: what controls magma fertility? Understanding the processes involved in the creation of metal deposits is a crucial aspect for the exploration industry. A bottom line in determining the fertility of a porphyry suite is likely to be the relative timing of sulfide and volatile saturation. If sulfide saturation occurs early, the chalcophile elements may be locked in an underlying magma chamber at depth and unavailable to enter the hydrothermal fluid when magma eventually becomes volatile saturated.

Plots of whole-rock concentrations of SiO$_2$, total FeO, CaO and V against MgO show that all samples, from all three units, cumulate and volcanic rocks, follow the same trend line, and are therefore likely to be related by fractional crystallization. Attempts to determine the timing of sulfide saturation using Cu were unsuccessful. A plot of whole-rock Cu against MgO showed that the Cu concentrations are scattered, with no clear correlation, which is attributed to overprinting by hydrothermal mineralization. For this reason, the behaviours of Cu during magma processes cannot be deducted. As a consequence, we have turned to the platinum group elements (PGE) to determine the timing of sulfide saturation. The PGE have the advantage of having much higher partition coefficient into immiscible sulfide melts than Cu, and lower solubilities into hydrothermal
fluids, so that they are less affected by secondary processes. We will address the problem of identifying sulfide saturation by reporting the concentration of PGE, Re and Au, measured by fire-assay isotope dilution method, for 20 samples from the Yerington batholith. Detection limits are ca. 15 ppt of Pd and less than 1 ppt for the other PGE.