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PGE Chemistry and Magma Fertility of El Teniente Porphyry Copper Deposit, Central Chile

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The El Teniente Porphyry Copper Deposit, located in Central Chile, is one of the biggest concentrations of copper in the world with ~100 Mt of metal. Although there are many factors that might have contributed to the high metal content of this deposit (e.g., tectonic setting, length of magmatic activity, wall-rock composition), this study evaluates the role the timing of sulphide saturation, relative to volatile exsolution, plays in El Teniente's magma fertility.

Previous studies have determined the onset of sulphide saturation using platinum group elements (PGEs) because they behave similarly to chalcophile elements (e.g., Cu and Au) during magmatic differentiation. However, the PGEs better preserve the original geochemistry of intrusions in magmatic-hydrothermal systems because they are less mobile in hydrothermal fluids. These studies also suggest that PGE geochemistry can be used to distinguish between mineralized and barren systems.

The magmatism at El Teniente includes a large premineralization intrusive complex containing older mafic facies and a younger and smaller core of hydrous intrusions, as well as five younger and smaller pulses of felsic intrusions linked to mineralization. Cu-mineralized magmatic-hydrothermal breccia pipes and postmineralization mafic lamprophyre dikes are also present in the district. The wide range of magmatic compositions make El Teniente an ideal case to study the magmatic evolution of a porphyry deposit.

We have studied rock samples from the different intrusions from El Teniente District, located within ~12 km of the El Teniente mine, which range in composition from gabbro (5.3 wt % MgO) to dacite porphyries (0.6 wt % MgO). Whole-rock major and trace elements concentrations have been determined by XRF and LA-ICP-MS, respectively. The PGE concentrations are at ultratrace level and they have been determined using the nickel-sulphide fire assay, isotope dilution method.

Preliminary results show that the concentrations of PGEs decrease with the decrease of MgO, which suggests that sulphide saturation in the El Teniente magmatic system occurred prior to the MgO content of the magma falling below 5.3 wt % (MgO content of the most primitive sample analysed). This early sulphide saturation seems not to be affecting the ability of the magmatic system to form an ore deposit, which may be because the amount of sulphide that separated from the melt was too small to have a significant effect on the copper content of the magma. However, the early sulphide saturation decreased significantly the Au content of the magma, due to its higher partition coefficient in sulphide melts, leading to the formation of a Cu-dominated porphyry deposit, rather than a Cu-Au deposit.

The PGE data also confirms that the Pd/MgO against Pd/Pt and Pd/MgO versus Y diagrams proposed by Park et al. (2019) and Hao et al. (2019), respectively, can be used to discriminate between barren and fertile suites in this region. We will also report new geochronological and geochemical data from zircons from regional intrusions in the El Teniente District, which will be compared with the results from ore-related intrusions associated with this and other porphyry Cu and Cu-Au deposits.