THE ROLE OF PYRITE AS CARRIER OF PLATINUM-GROUP ELEMENTS IN MAGMATIC SULFIDE DEPOSITS

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ABSTRACT. Recent studies have revealed that pyrite can host appreciable amounts of PGE in Ni-Cu-PGE magmatic sulfide deposits. It is the only of major sulfides hosting Pt and is, generally, the richest in Rh; it also contains Os, Ir and Ru in similar abundances to pyrrhotite and pentlandite and, in some cases, exhibits a distinct and marked PGE compositional zoning. These results highlights that pyrite must be taken into account to understand the distribution of PGE in this ore type.

In recent years, the development of microanalytical techniques such as laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) has led to better understand the distribution of platinum-group elements (PGE: Os, Ir, Ru, Rh, Pt and Pd) in Ni-Cu-(PGE) deposits by measuring the *in situ* concentrations of these elements in sulfides (i.e., pyrrhotite, pentlandite and chalcopyrite) (e.g., Dare et al 2011; Piña et al 2012; Vukmanovic et al 2014). These studies show that Os, Ir, Ru and Rh typically occur in solid solution in pyrrhotite and pentlandite, whereas Pt occurs as discrete platinum-group minerals (PGM, bismuthotellurides, tellurides, arsenides and sulfides) associated with base metal sulfides. Palladium occurs both in solid solution in pentlandite as well as discrete PGM. Despite pyrite being a relatively common phase in magmatic sulfide deposits, it has been neglected as carrier of PGE. Only few studies report PGE data in pyrite from Ni-Cu-PGE ore deposits: Oberthür et al (1997) in the Great Dyke of Zimbabwe, Dare et al (2011) in the McCreedy East deposit of Sudbury, Djon & Barnes (2012) in Lac des Iles and Piña et al (2012, 2013) in Aguablanca. These studies show that pyrite can host substantial amounts of PGE, especially Rh and, interestingly, Pt, a PGE typically absent in pyrrhotite, pentlandite and chalcopyrite.

A review of the inventory of available PGE data leads to the following conclusions:

1. Pyrite replacing pyrrhotite contains similar Os, Ir, Ru and Rh (IPGE) abundances to those of host pyrrhotite. It is thought that pyrite inherits the IPGE contents of the pyrrhotite. Similarly, pyrite replacing silicates is depleted in PGE because silicates do not host any PGE.

2. Pyrite is much richer in Pt and Rh than any of the other base metal sulfides (up to 244 ppm Pt in the Great Dyke and 113 ppm Rh in McCreedy East). Despite these high Pt contents, mass balance calculations indicate that pyrite only accounts 5 % or less of Pt due to a combination of the low modal abundance of pyrite (generally less than 5 vol. %) and the tendency of Pt to form PGM. In some cases, pyrite does account most of Rh present in the rock. There is a positive correlation between Pt and As. The ability of As to enter the pyrite and not the pyrrhotite structure may be the reason that Pt enters pyrite but not pyrrhotite.

3. Laser ablation ICP-MS maps reveal the presence of trace element zoning in pyrite from McCreedy East and Aguablanca consisting of Os-Ir-Ru-Rh-As-rich layers and PGE-depleted and Se-Co-rich layers parallel to the grain boundaries (Fig. 1a). A model of boundary layer effect during pyrite formation from pyrrhotite explains this zonation (Dare et al. 2011; Piña et al. 2013). Some pyrite from Aguablanca further shows Pt-rich bands that coincide with high Co values rather than with high IPGE values (Fig. 1b). Probably, in those cases where pyrrhotite hosts Pt-bearing phases, the fluids responsible of pyrrhotite replacement by pyrite dissolved these phases, making Pt available for incorporation into pyrite.

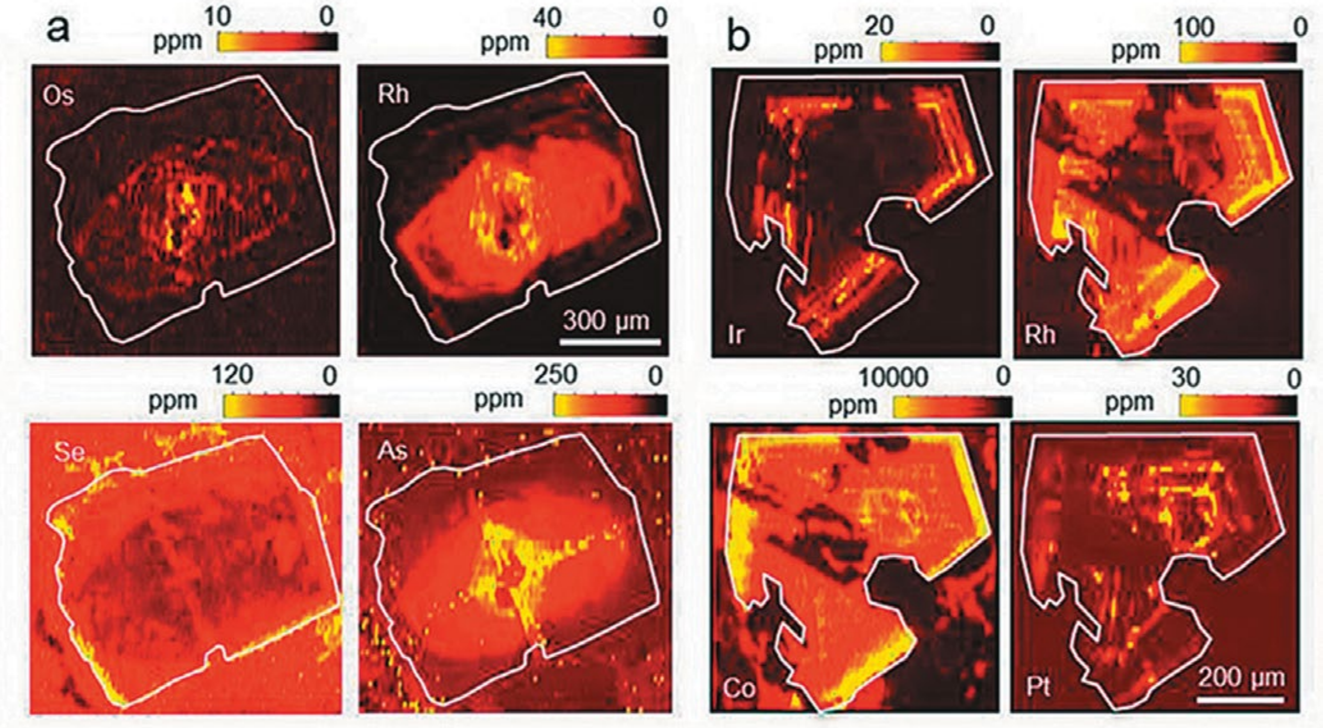

Fig. 1. Typical compositional Os, Rh, Se and As zoning (a) and unusual zoning with respect to Pt (b) in pyrites from the Aguablanca Ni-Cu sulfide deposit (Piña et al. 2013)

In summary, the identification of significant amounts of PGE in pyrite from a number of Ni-Cu-PGE sulfide deposits remarks the importance of pyrite to fully understand the magmatic and postmagmatic/hydrothermal evolution of PGE in magmatic sulfide systems.

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