Mineralogy of Ni-Fe-Cu sulfides and associated noble metal nanoparticles from the mantle beneath Tallante (southeast Spain)

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INTRODUCTION

Base-metal sulfides (BMS) and platinum-group minerals (PGM) are common accessory phases in mantle peridotites. The stability of these minerals largely controls the mobility of the highly siderophile elements, i.e. platinum-group elements (PGE) plus gold (Au), and semi-metals (Se, As, Te, Bi, Pb) in the subcontinental lithospheric mantle (SCLM). Based on their microstructural relations, mineralogy, major and trace elements compositions, different populations of BMS and PGM may be ascribed to different petrogenetic processes, such as partial melting or mantle metasomatism (Lorand and Luguet, 2016). In this contribution, we couple detailed microstructural observations with in situ chemical characterization of BMS and PGM from a set of peridotite xenoliths from the Tallante volcanic field (Eastern Betics, southeast Spain), in order to infer the melt-rock reaction processes that control the mobility and storage of metals in the SCLM.

GEOLOGICAL SETTING

The Tallante volcanic field represents the youngest (2.92 Ma) magmatic activity of the Neogene Volcanic Province (NVP) of southeast Spain, which extends for ~ 150 km from Cabo de Gata to Murcia along the Mediterranean coast. Calc-alkaline volcanic activity in this area began approximatively 15 Ma ago in response to westward roll-back migration of an east dipping subduction zone, which triggered stretching of the Alborán continental lithosphere in a back-arc supra-subduction setting. Transition towards ultrapotassic volcanism, i.e. shoshonites and lamproites, in the Late Miocene was due to melting of the SCLM in response to the progressive upwelling of the asthenosphere beneath the southeast Iberian margin (Duggen et al., 2005).

DESCRIPTION OF XENOLITHS

Sulfide-bearing xenoliths from Tallante are fertile spinel (± plagioclase) lherzolites, which consist of medium- to fine-grained olivine, orthopyroxene, clinopyroxene, and spinel. Plagioclase crystals are locally observed as interstitial patches or rims around spinel. Rock fabric is characterized by a granoblastic to equigranular texture. Olivine forms a fine-grained matrix of poorly strained polygonal grains that almost erase few porphyroclastic relicts characterized by kink bands, subgrain boundaries, and common shape-preferred orientation. Orthopyroxene and clinopyroxene form unstrained, anhedral crystals that are interstitially scattered among the olivine grains. Both pyroxenes are commonly in contact with fine-grained, amoeboid spinels forming clusters randomly scattered through the peridotite matrix. Both orthopyroxene and spinel commonly display highly curvilinear grain boundaries, or poikilitic texture, against olivine, suggesting they formed by melt-rock reaction involving olivine dissolution and orthopyroxene (+ spinel + clinopyroxene) precipitation.

SULFIDE MINERALOGY

The Tallante peridotites host abundant droplet-like inclusions of Ni-Fe-Cu sulfides within metasomatic clinopyroxene and orthopyroxene. These mainly consist of monomineralic pentlandite or composite aggregates of pentlandite coexisting with chalcopyrite and/or bornite (Fig. 1a). Minor millerite and covellite are observed in places as alteration rims over pentlandite and chalcopyrite, respectively (Fig. 1b, c). Some pentlandites host nano-to-micron sized platinum-group minerals, which form euhedral inclusions either located at the margin of pentlandite or dispersed within it. Qualitative EDS microanalyses show that some of these PGM are rich in Pt, Pd and Sn. A careful FIB-TEM analysis indicates they are euhedral crystals of tatyanite (ideally $Pt_9Cu_3Sn_4$) with no crystallographic continuity relative to the host pentlandite. In addition, pentlandite may also host nano-to-micron sized grains of native gold (± platinum), again with no microstructure controlling their location in their host sulfide.

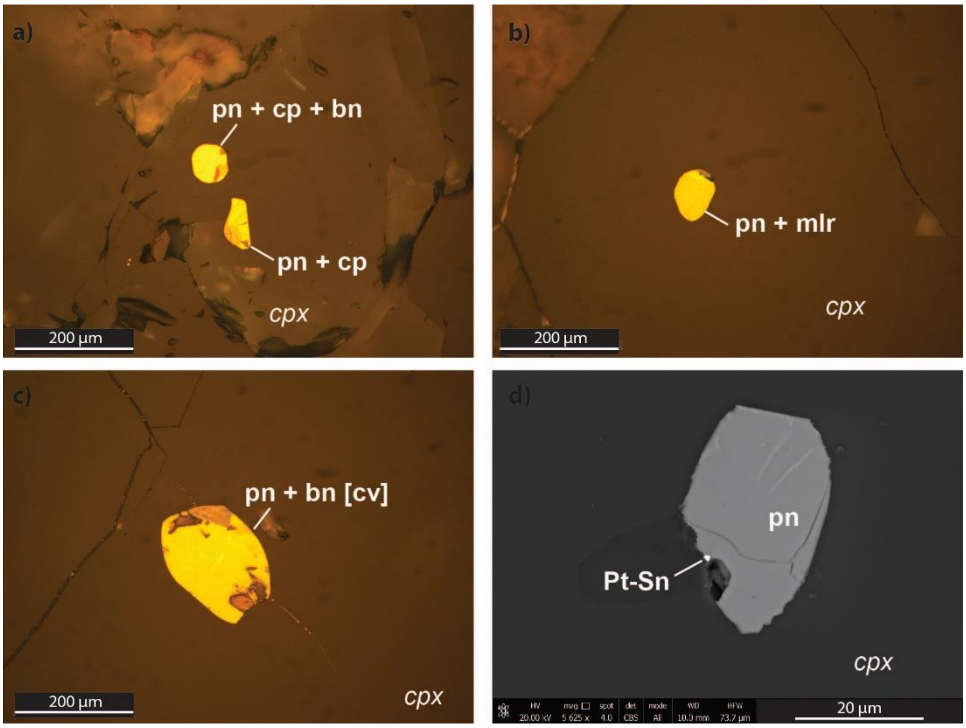

Fig 1*. Reflect-light photomicrographs (a, b, c) and backscattered images (d) of sulfide grains in peridotite xenoliths from Tallante.*

CONCLUSIONS

Sulfide grains in Tallante peridotites display both mineralogical and textural features that are typically reported in mantle sulfides crystallized in a lithospheric mantle undergoing mantle refertilization at decreasing melt volumes. Sulfide grains, which are hosted in metasomatic pyroxenes, may represent the low-temperature re-equilibration product of immiscible droplets of sulfide melts trapped within growing pyroxenes during mantle metasomatism. On the other hand, PGM and gold particles included in Tallante sulfides display euhedral crystal morphologies and no microstructural control by fractures or crack, suggesting they crystallized earlier than BMS, either from sulfide or silicate melts, during the percolation event that finally refertilized the subcontinental lithospheric mantle.

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