

PLATINUM GROUP ELEMENT AND SULFIDE MELTS IN OCEANIC PICRITE LAVAS FROM KAMCHATSKY MYS PENINSULA (KAMCHATKA, RUSSIA)

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Silicate-sulfide liquid immiscibility in mantle-derived magmas has important control on the budget of siderophile and chalcophile metals, and is considered to be instrumental in the origin of orthomagmatic sulfide deposits. We present the report of the crystallized sulfide melts in the oceanic picrites of the (presumably) Cretaceous age Kamchatka Mys ophiolite complex in Eastern Kamchatka (Far East Russia). The Kamchatka Mys ophiolite complex is renowned for its present-day tectonic position at the junction of the Kuril-Kamchatka arc, Aleutian arc, and the inferred starting point of the Hawaiian-Emperor seamount chain (Portnyagin et al., 2008).

The olivine-phyric (picrite) rocks with magmatic sulfides have been recently discovered in the serpentinite mélangé that borders the ultramafic massif of Mt. Soldatskaya (Savelyev, 2014). Picrites have a cumulative nature and are enriched in olivine phenocrysts. Sulfides occur as rounded inclusions in olivine and as droplet-shaped or shapeless clouds (up to 0.3 mm) in the groundmass. Temperatures of parental magma crystallization, estimated with the help of Al-in-spinel thermometer, range from 1230 to 1270 °C at Fo_{87.5-89.7}, that is similar to primitive MORB.

Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) analyses of sulfides were carried out at CODES Analytical Laboratories, University of Tasmania (Savelyev et al., 2018).

The sulfide melt inclusions in olivine and the groundmass of studied rocks are composed of several sulfide phases that correspond to the monosulfide (Fe-Ni; Mss) and intermediate (Fe-Cu-Ni; Iss) solid solutions. Several <0.5 mm Pd-Sn, Pt-Ag, and Au-Ag phases are recorded within the matrix sulfides, commonly along phase boundaries and fractures. Major elements (S, Fe, Cu, Ni, Co), platinum group elements (PGE), and gold analyzed in the homogenized olivine-hosted sulfide melt inclusions, and phases identified in the matrix sulfides record the range of magmatic sulfide compositions. The most primitive sulfide liquids are notably enriched in Ni and Cu [(Ni+Cu)/Fe, at% > 0.5], continuously evolve with crystallization of (e.g., increasing Cu/Ni and Au/PGE) and demonstrate metal fractionation between Mss and Iss. Although the compositional systematics found in this study are consistent with those previously recorded, the compositions of individual sulfide phases are strongly affected by the noble metal (PGE, Au) “nuggets” that exsolve at subsolidus temperatures and form during serpentinization of the rocks. We conclude that the budget of noble metals in the studied picrites is controlled by sulfides, but the abundances of Pt and Au are influenced by mobility in post-magmatic alteration.

The iridium-group PGE correlate exceptionally well with each other in both Mss and Iss of the matrix sulfides and sulfide melt inclusions, but are 3–4 times more abundant in Mss (Fig. 1). In contrast, the platinum-group PGE and Au show different systematics to each other and IPGE. For example, the average abundances of Rh are similar in Mss, Iss, and sulfide melt inclusions (~0.2 ppm), covariate with IPGE only in Mss and melt inclusions, but remains relatively constant in Iss. Palladium and gold show weak and strong preference, respectively, for Iss, however, they are not correlated with each other and other PGE in either of studied phases.

Our study of the MORB-type picrite rocks from Kamchatka demonstrate that magmatic sulfides in volcanic rocks and associated silicate and oxide minerals and their silicate melt inclusions is a natural laboratory for understanding silicate-sulfide immiscibility and related partitioning of noble and chalcophile metals. Our data and observations imply that magmatic sulfide liquids undergoing cooling and solidification separate into Fe-Ni and Fe-Cu-Ni phases that have significant compositional ranges in terms of metal/metal, metal/sulfur, and PGE ratios. These two principal sulfide phases not only share the trace and noble metals dissolved in the parental sulfide liquid, but are also responsible for in situ fractionation of these elements. The established partitioning of IPGE and PPGE+Au into Mss and Iss, respectively, should be further studied using matrix sulfides from modern MORB. Our data can be also used for modeling sulfide saturation at crustal pressures and understanding behavior of the noble metals in primitive oceanic magmas.

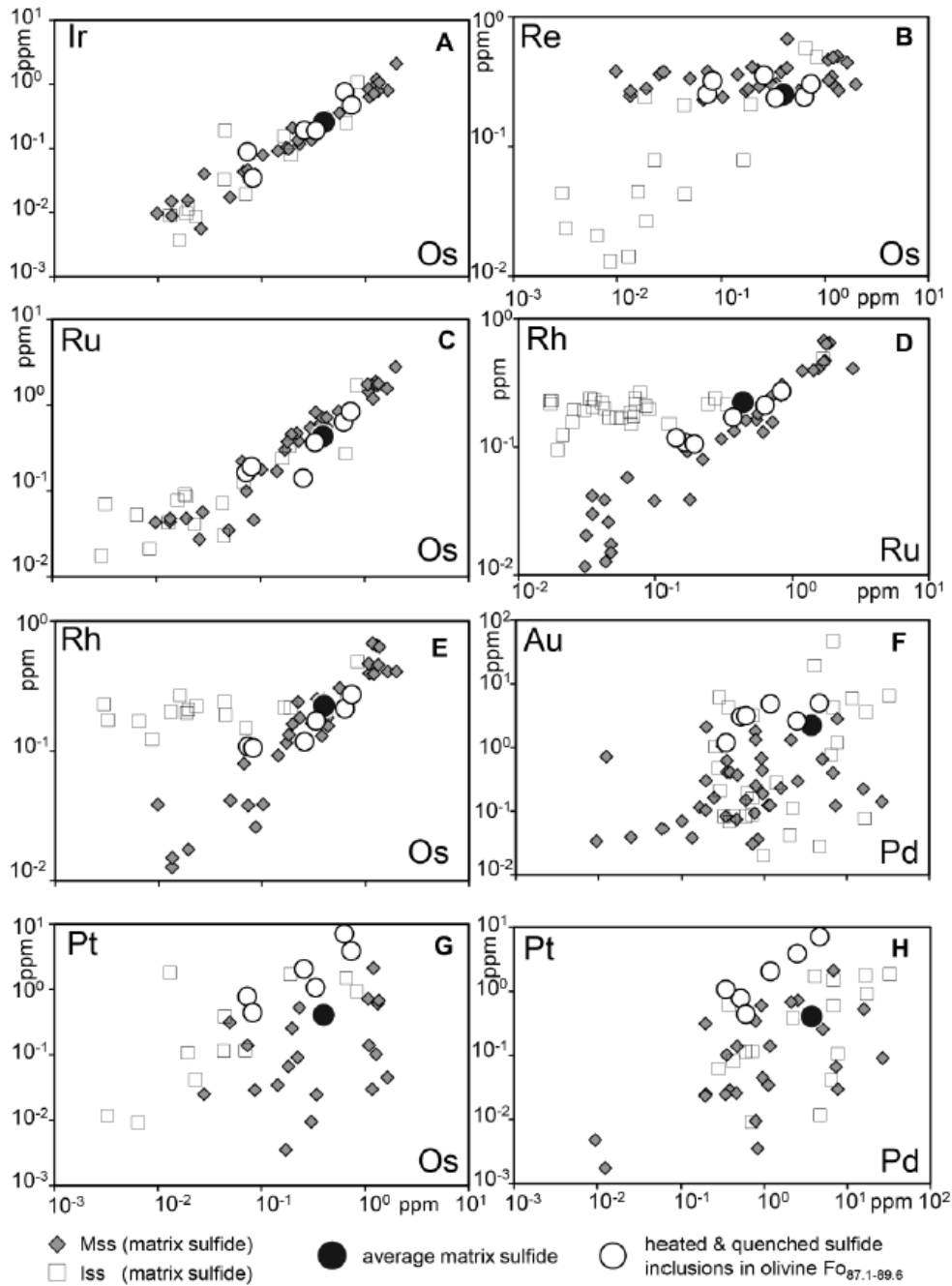


Fig. 1. Relationships between the noble metal (PGE, Au) contents in the matrix sulfides and sulfide melt inclusions (Fig. 10 from Savelyev et al. (2018)).

References

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