Arsenic, Te, Se and S contents in basaltic melt at arsenide, telluride, sulfide and selenide saturation: the role of metal ligands and implications for PGM formation from silicate melts

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The concentrations of PGE and semimetals (As, Sb) and chalcogenes (Se, Te, S) in natural magmas are much lower than their measured solubilities in silicate melts, yet they form discrete magmatic phases (alloys, arsenides, sulfides, tellurides and antimonides). Even though PGE solubilities are measured relative to pure metals, they are assumed to be dissolved as oxide species in the silicate melt (complexes). Here, we determine the concentrations of Pt, Pd, As, Te, Se and S in basaltic melt saturated with Fe, Pt or Pd arsenides, tellurides, selenides and sulfides and show that the concentrations of these elements are much lower than their solubilities in silicate melts saturated with pure metals. We equilibrated basaltic melt with immiscible Fe, Pt, and Pd arsenide, selenide, telluride and sulfide melts in a piston cylinder apparatus at 1250°C, 5 kbar and relative fO_2 of ~FMQ to FMQ+1. The concentrations of As, Te, Se and S in the basaltic melt vary considerably with the metal ligand reservoir; the highest concentrations are recorded when the ferrous iron cation is the principal metal ligand. When instead Pt or Pd arsenides, selenides or tellurides are used as As, Se, and Te reservoirs, the concentrations fall drastically. Platinum and Pd increase the activities of semi-metals and chalcogenes in the silicate melt more than Fe does. Implications are that these metals can form stable complexes (fundemental building blocks) with chalcogen and semi-metals before the melt attains saturation in Fe sulfides, arsenides and tellurides. Platinum-group mineral (PGM) formation from basaltic melt does not require saturation in FeS. The experimentally determined solubilities of PGE metals in silicate melts are not applicable in nature.