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Fingerprints of S-Cl-rich Fluids in Kamchatka Lavas: Evidence from Mineral Microinclusions and Ore Metal Geochemistry

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We present new data on metal and mineral microinclusions and distribution of chalcophile and siderophile ore elements in fresh Kamchatka lavas ranging from ankaramite and andesite (Avachinsky volcano) to basalt (Mutnovsky and Gorely volcanoes) and adakite (Bakening volcano). Independently of host lava composition and degree of differentiation, olivine, pyroxene, amphibole, plagioclase phenocrysts and groundmass glass in Kamchatka samples contain abundant microinclusions of silver chloride (with minor Cu) and acanthite (with minor Cu and Zn) along with native Bi, Pb, W (with minor Fe and Mn), Cu-Ag-Au, Zn-Cu and Sn-Cu alloys in association with Cl-apatite and barite. In addition, Avachinsky ankaramite contains native Au, Pt, Ni (bunsenite) and Sn, Sb-Pb-alloy, Sb-Pb-chloride, Bi-chloride, arsenopyrite, composite Zn-Pb-Sb-Cu sulfide; Avachinsky andesite – Cl-F-apatite, Pb-Sb-bearing Fe-oxide, Mo-bearing Ni-magnetite, oxidized Sn, cassiterite; Mutnovsky basalt – chalcocite and, possibly, native antimony and zinc; Bakening adakite – chalcopyrite, Cu-bearing pyrrhotite, cassiterite and Cl-apatite.

All Kamchatka lavas display enrichments in Cu, W, Ag and, in case of the Bakening and Gorely volcanoes, Bi in respect to other chalcophile and siderophile metals (Co, Ni, Zn, As, Mo, Cd, Pb) normalized to the upper continental crust. Avachinsky ankaramite also shows extreme enrichment in Au (4266 ppb) in respect to platinum-group elements (Ir+Ru-Rh+Pt+Pd = 9.55 ppb), which is consistent with presence of abundant Au-rich microinclusions in olivine and pyroxene phenocrysts as well as mafic groundmass glass in all studied lavas from the Kamchatka volcanic arc.

Abundance of diverse chlorides and sulfides associated with barite and Cl-apatite microinclusions in Kamchatka lavas suggests involvement of fluids containing significant amounts of sulfur and chlorine. These S-Cl-bearing aqueous fluids influence the mobility of such ore metals as Cu, Ag, W, Bi and, to a lesser extent, Zn, Sb, Sn and Pb and facilitate their transport from mantle wedge and subducted oceanic slab to magmatic conduits in the arc crust beneath the active front volcanoes of Kamchatka. Further transformation and modification of ore metals and alloys in shallow oxidized sub-volcanic environments can potentially contribute to the formation of porphyry, skarn and epithermal mineralization in subduction-related geodynamic settings.