Constraining E- and N-type components in Baffin Island picrites

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The Baffin Island picrites are interpreted to represent primitive magmas (up to ~22 wt% MgO) that are minimally changed since leaving their mantle source. Lead and neodymium-samarium isotopes indicate that these lavas may be melts of a primordial mantle reservoir (~4.45-4.55 Ga). Silicate melt inclusions (MIs) trapped within olivine crystals during their crystallization are considered to be aliquots of their parental melts and thus their compositions provide a unique insight into the geochemical nature of the oldest known terrestrial mantle reservoir.

In this study, the ratio of potassium to titanium (K/Ti) is used as an analog for trace element enrichment as both these elements are incompatible in the olivine and plagioclase phenocrysts present in these lavas. We define depleted glass compositions (N-type) as those with $K/Ti < 0.2$ and enriched glass compositions (E-type) as those with $K/Ti > 0.2$, based on an apparent population minimum at ~ 0.2. The N-type MIs are characterized by low K/Ti, La/Lu, Zr/Y and chlorine contents ($Cl \leq 50$ ppm) while the E-type MIs appear to be mixtures of two distinct liquids, one a depleted end-member similar in composition to the N-type MIs and the other an enriched end-member characterized by high K/Ti, La/Lu, Zr/Y and chlorine contents ($50 \leq Cl \leq 200$ ppm). The chlorine concentration increases with trace element enrichment in E-type MIs which may indicate a relatively high Cl content in the E-type component. Whereas N-type MIs are hosted in olivines with a narrow range of forsterite contents, from Fo_{89} to Fo_{87}, the E-type MIs are found mostly in olivines with lower Fo contents (Fo_{87}-Fo_{83}), suggesting either the incorporation of the E-type component occurred later in the crystallization history of the N-type magmas or that the E-type component was less magnesian.

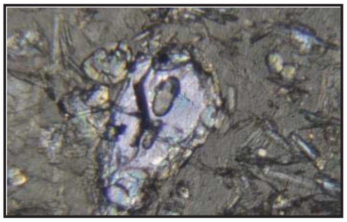

Figure 1: Melt inclusions in olivine crystal. Field of view is approximately 1 mm.

The large variation in K/Ti (0.05 to 0.6) in multiple melt inclusions within single olivine crystals suggests either that the growth of olivine phenocrysts during the magmatic differentiation of the N-type magma records the incorporation of the E-type component, or that the E- and N-type components were intermixed on a fine scale. The presence of two finely intermingled magmatic components in the mantle source of the Baffin picrites implies that Earth's primordial mantle was as heterogeneous as the asthenospheric source of modern-day mid-ocean ridge basalts.

Identity of oxidation products on surface of metallic antimony

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Introduction

Small arms bullets are predominantly made of lead (Pb) but antimony (Sb) is commonly used to harden bullets and can comprise up to 10% of the total mass. The fate of Pb in firing range soils has been investigated in a number of studies while the fundamental geochemical processes controlling the fate of Sb in soils and surface water are largely unknown. Anthropogenic deposition of Sb to soils on military and recreational shooting ranges represents an environmental risk due to Sb toxicity. Oxidation of bullet fragments containing metallic antimony under surface soil conditions ultimately leads to the release of Sb(V) to the soil solution and an accumulation of Sb(V) in soil. While Sb(III) is usually absent from soil solution or contaminated soil, its oxide (Sb_2O_3) precipitates readily during oxidation of Sb(0) under model conditions with deionized water and simulated groundwater. Mechanisms controlling speciation of precipitated Sb_2O_3 as well as relationship between solid and aqueous Sb speciation are not clearly understood.

Methods

The experimental study focused on understanding the effect of common cations (Na^+, Ca^{2+}) on the formation of precipitates on an Sb(0) surface during oxidation in simulated groundwater. Solutions were prepared at fixed ionic stregth ($I = 0.01$ mol L^{-1}) and a range of environmentally relevant pH values. We compared these results to the same processes in background solutions containing either deionized water or 30% hydrogen peroxide (H_2O_2). We determined the speciation and preferred orientation of the precipitates with grazing incidence x-ray diffraction and texture measurements, respectively. Results of the laboratory experiments were compared to Sb(0) weathered under field conditions in soils of varied texture and pH.

Results and Conclusion

The surface of Sb(0) oxidizes rapidly and within 24 hours we observed the formation of cubic and orthorhombic polymorphs of Sb_2O_3 (senarmontite and valentinite) of which valentinite exhibited strong preferential orientation with the *a* axis normal to the Sb(0) surfaces. An oxidation end member, hydrated Sb_2O_5, precipitated on Sb(0) surfaces only under the extremely oxidizing conditions of the H_2O_2 solution. The valentinite fraction in the precipitate increases with increasing solution pH but no measurable difference in speciation was found between Na^+ and Ca^{2+} background solutions. Drawing a connection between environmental conditions like soil pH and Sb(0) oxidation mechanisms helps to predict the fate of spent bullets and assists land managers in identifying appropriate soils to use in constructing new shooting ranges.