

Plant establishment in sulfide ore-derived mine tailings stabilizes arsenic *in situ* despite promoting arsenopyrite oxidation

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A compost-assisted phytostabilization strategy at the Iron King Mine tailings in Arizona, USA aims to establish a self-sustaining vegetative cover as a low cost option to reduce human exposure to metal(loid) contaminants. Plant growth on contaminated land reduces dispersion of particulate matter caused by erosion, but less is known regarding the effect of phytostabilization on subsurface metal(loid) speciation and lability. Biogeochemical mechanisms controlling arsenic speciation and lability were examined in a three year 1.5 ha field trial in which dairy compost and irrigation water were added to aid plant growth. Bench-scale chemical analyses were combined with synchrotron-based X-ray spectroscopic methods applied as a function of time, depth and specific treatment. Arsenic and iron K-edge X-ray absorption near-edge structure (XANES) of untreated samples show oxidation of pyritic [FeS₂, FeAsS] minerals to ferric (oxy)hydroxide [e.g. ferrihydrite] and (oxy)hydroxide sulfates [e.g. jarosite-type minerals; XFe^(III)₃(OH)₆(SO₄)₂, where X = K⁺, H₃O⁺, Pb²⁺] in near-surface tailings, indicating an oxidation front penetrating the profile. Arsenic XANES indicate that both irrigation and compost are associated with enhancement of sulfide oxidative weathering (Figure). Importantly, an increase in As lability related to compost addition has not been observed. Sequential chemical extraction and Fe XAS results indicate that sulfide weathering may be associated with formation of an ammonium oxalate-resistant Fe mineral phase, affecting the mobility of Fe-sorbed As in the tailings.

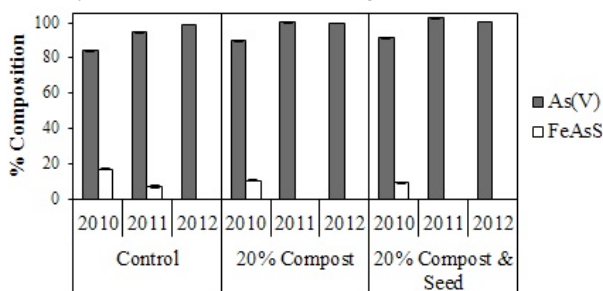


Figure 1. As K α XANES linear combination fits of amended and control field samples, fit with arsenopyrite and 2-line ferrihydrite. The binary fits, not normalized to unity, account for 99-102% of the spectral features.

Major melting on EL enstatite chondrite parent body

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Chondrites are amongst the most primitive objects of the solar system. Their constitutive chondrules represent either condensates, or interstellar dust that was once molten and quenched. Overall, chondrites are undifferentiated rocks that did not experience core separation associated with planetary formation. Some groups of chondrite are considered to represent building blocks at the origin of planets, including the Earth. Here we show that one group of enstatite chondrites (EL) bears evidence for large scale melting, yet showing little (if any) sign of differentiation. We have compared the two enstatite chondrite groups (EH and EL). Differences between EH and EL subtypes regarding both their bulk major element compositions as well as their mineralogy have long been recognized [1,2]. Here, we used in-situ, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses of minerals present in both enstatite chondrite subtypes (enstatite, and the two sulfides troilite (FeS) and oldhamite (CaS)). We show that each subgroup possesses a unique signature. EH chondrite trace element patterns are compatible with condensation signature, followed by equilibration during metamorphism from type 3 to type 5. They may thus be considered as primitive. On the contrary, EL chondrite patterns are suggestive of equilibrium during large scale melting on their parent body. They may therefore evidence melting processes that would yet essentially preserve the undifferentiated nature of their parent body, except in equilibrated types (EL5-6) wherein slight melt depletion is observed. Timescales for this melting should be long enough to allow for melt / crystal equilibration, but short enough to prevent metal / silicate separation. Alternatively, melting may have occurred in a low gravity field, either a small planetary body, or a molten disk following the collision of two large objects.

[1] Keil (1968), *J. Geophys. Res.* 73, 6945-6976. [2] Wasson & Keileynen (1988), *Phil. Trans. R. Soc. Lond. A* 325, 535-544.