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CROSSROADS IN EARTH AND PLANETARY MATERIALS

Mineralogy of paloverde (*Parkinsonia microphylla*) tree ash from the Sonoran Desert: A combined field and laboratory study

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ABSTRACT

This study describes the wood chemistry and ash mineralogy of the desert tree *Parkinsonia microphylla* (Torr.) and follows the mineralogical effects of natural and laboratory aging and weathering. Ash was collected in the field (field ash) following a wildfire east of Phoenix, Arizona, May 8th, 2011, and its mineralogy compared with ash produced under laboratory conditions (laboratory ash): 25 minerals were identified by powder X-ray diffraction (XRD) in the fresh and weathered ash. To guide the interpretation of the XRD patterns, the major ash-forming elements (for elements of Na and heavier) in the wood were determined by particle-induced X-ray emission (PIXE) spectroscopy. Mg (816 to 3677 ppm), K (3965 to 17 581 ppm), and Ca (935 to 61 772 ppm) were the dominant metals, and P (to 1528 ppm), S (to 1024 ppm), and Cl (318 to 2648 ppm) were the dominant non-metals. In general, smaller branches and bark showed higher concentrations of ash-forming cations than mature wood. Powder XRD patterns from fresh field ash were dominated by various proportions of fairchildite [$K_2Ca(CO_3)_2$], calcite ($CaCO_3$), lime (CaO), bütschliite (dimorph of fairchildite), and periclase (MgO), with traces of other K-bearing salts. Following gentle rains (total 0.7 cm) at the end of May, a brittle ash crust formed that was dominated by calcite, with variable amounts of fairchildite, sylvite (KCl), kalicinite ($KHCO_3$), magnesian calcite [$(Ca,Mg)CO_3$], magnesite ($MgCO_3$), $K_2CO_3 \cdot 1.5H_2O$, and arcanite (K_2SO_4). Further exposure to rain (total of 7 cm) in July and August left an ash dominated by calcite, magnesian calcite, and periclase. Ash collected two years after forming was dominated by calcite, magnesian calcite, and minor nesquihonite ($MgCO_3 \cdot 3H_2O$). The mineralogy of ash produced in the laboratory from wood collected in the fire zone was dependent on the diameter and hence age of the wood. Ash from thin branches was dominated by calcite and fairchildite, consistent with the high Ca revealed by PIXE. Ash from large logs was dominated by fairchildite, with reflections from nine additional minerals including KOH, K_2CO_3, and periclase: this mineralogy is consistent with high K as determined by PIXE. KOH and K_2CO_3 disappeared within a few hours exposure to air and peaks for baylissite [$K_2Mg(CO_3)_2 \cdot 4H_2O$], $K_4H_2(CO_3)_3 \cdot 1.5H_2O$, and $K_2CO_3 \cdot 1.5H_2O$ appeared. Further washing with water left periclase and magnesian calcite. The mineralogical changes observed through natural and laboratory weathering show that fairchildite rapidly weathers to calcite and magnesian calcite, with solubilization and removal of K. Despite the initial mineralogical complexity, the weathered ash is consistent with that found in anthropogenic ash deposits, which is dominated by calcite. Periclase is unaffected by the relatively short-term laboratory weathering, however it was largely absent in field ash collected two years after the fire. Periclase is commonly reported from wood ash, and this study suggests an important role for biomass burning in Mg cycling.

Keywords: Fairchildite, ash, biomass burning, Mg cycling, PIXE, powder X-ray diffraction