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Geochemistry and mineralogy of a saprolite developed on Columbia River Basalt: Secondary clay formation, element leaching, and mass balance during weathering

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Abstract

This study presents chemical and mineralogical data on weathering trends in a saprolite that is preserved between flows of the Columbia River Basalt Group at Trinidad, Washington. Bulk chemistry, electron imaging, and X-ray mapping indicate early Fe and Mg depletion by dissolution of ferromagnesian minerals, followed by depletion of alkalis, Al, Ti, and P that corresponds to dissolution of feldspars, titanomagnetite, and apatite. Secondary coatings of nontronite clay in the deep saprolite display intricate, submicrometer-scale zoning in Fe and Mg content. Distinct aluminous zones in these clays become more prominent at shallower depths. The primary Fe-containing phase shifts from nontronite in deeper samples to hematite in shallow samples; samples at the boundary contain the assemblage kaolinite + nontronite, which may mark the transition from permeability-limited fluid flow to fully open-system behavior. This shift is observed in rocks that have lost 30–40% of the total rock mass to leaching, and coincides with the disappearance of feldspar, Fe-Ti oxides, and apatite. Rocks in the uppermost saprolite have been converted to an assemblage of Al-smectite + hematite (+kaolinite). These results suggest that the presence of nontronite in weathered samples may indicate weathering under conditions of limited permeability; however, it does not necessarily indicate weathering in a chemically closed system. These observations may be useful in interpreting the clay mineral assemblages observed on Mars and what information they contain about near-surface conditions in the planet's ancient past.

Keywords: Nontronite, basalt weathering, EXAFS, XANES