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Element mobilization and redistribution under extreme tropical weathering of basalts from the Hainan Island, South China

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Abstract

Chemical weathering of rocks has substantial influence on the global geochemical cycle. In this paper, the geochemical profile of a well-developed basalt weathering profile (>15m thick, including soil, saprolite, semi-weathered rock and fresh basalt) on the Island of Hainan (South China) was presented. The soil and saprolite samples from this profile are characterized by high Al_2O_3 and Fe_2O_3 concentrations (up to 32.3% and 28.5%, respectively). The mineral assemblage is dominated by kaolinite, Fe-oxides/-hydroxides and gibbsite (or boehmite), indicating extensive desilicate and ferrallitic weathering. The acidic and organic-rich environment in the soil horizon may have promoted elemental remobilization and leaching.

The strongest SiO_2 depletion and Al_2O_3 enrichment at about 2.4m deep indicate that the main kaolinite hydrolysis and gibbsite formation occurred near the soil-saprolite interface. The mild Sr reconcentration at about 3.9m and 7.1m deep may be attributed to secondary carbonate precipitation. Mn-oxides/-hydroxides precipitated at 6.1m deep, accompanied by the strongest enrichment of Ba and Co. Uranium is mildly enriched in the middle part (about 7.1m and 9.1m deep) of the weathering profile, and the enrichment may have been caused by the decomposition of uranyl carbonates or the accumulation of zircon. Immobile element (i.e., Zr, Hf, Nb, Ta, Th and Ti) distributions at different depths are mainly controlled by secondary Fe-oxides/-hydroxides, and follow the stability sequence of Nb ≈ Ta ≈ Th ＞Zr ≈ Hf ＞Ti. The limited thickness (~15cm) of the semi-weathered basalt horizon at the rock-regolith interface (15.28m deep) suggests that plagioclase and pyroxene are readily altered to kaolinite, smectite and Fe-oxides under tropical climate. The marked enrichment of transitional metals (such as Cu, Zn, Ni, and Sc) along the rock-regolith interface may have associated mainly with increasing pH values, as well as the dissolution of primary apatite and formation of secondary phosphates. Our findings highlight the importance of secondary phosphates in the redistribution of transition metals, and in the possible Mg, Cu, and Ni isotopic fractionation under extreme weathering of basalt in tropic climate.

***Keywords*:** Chemical weathering; Basalt; Secondary minerals; Hainan Island (South China)