Understanding the depth of regolith in the context of O_2 and CO_2 in the atmosphere and soil

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Bob Berner investigated weathering and its control on climate throughout his career. A first-order puzzle in earth science that is related to weathering is the question, what controls the depth of regolith? In general, we do not know how to predict the depth of regolith, and nor do we know what are the most important variables controlling this depth. One such variable is the presence or absence of fractures in weathering rocks. During weathering, sometimes stresses build up and cause fracturing (weathering-induced fracturing, WIF). One case example of this is spheroidal weathering in granites, where oxidation of biotite can cause expansion that drives fracturing. We have hypothesized that the ratio of FeO to base cation oxides is important in determining whether the reaction front for oxidation reaches deeper into a rock than the reaction front for acid-promoted dissolution. This ratio, originally described by Dick Holland as R^o, indicates the electron-consuming capacity divided by the proton-consuming capacity. In rocks where the consumption of electrons normalized by consumption of protons over the full regolith depth is smaller than R^o (oxidation proceeds to shallower depths than dissolution proceeds) we have hypothesized that no WIF occurs. For example, in a diabase weathering in the Virginia Piedmont, we observed no WIF at depth, but we did see deep dissolution of pyroxene, without oxidation. In contrast, in rocks where the consumption of electrons normalized by consumption of protons over the full regolith depth is larger than R^o (oxidation proceeds deeper than dissolution proceeds) we have hypothesized that WIF occurs. Consistent with this, in the Virginia Piedmont we have observed WIF in granite but not in diabase. The presence of WIF in the granite is presumed to be the explanation for why regolith is deeper and the reaction front for plagioclase is wider than similar features of the diabase. These observations should help us not only understand the weathering thermostat of the earth, but also the relationships between weathering and atmospheric oxygen.