Geochemistry and mineralogy of ca. 1.85 Ga corestone-saprolite interfaces

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The ca. 1.85 Ga Flin Flon paleosol formed under subaerial weathering conditions oxic enough and/or with sufficient time to quantitatively convert Fe(II) to Fe(III), but redox-sensitive element (U, Mo, Cr) signatures in contemporaneous marine deposits imply a decline in atmospheric oxygen, possibly to near-Archean levels, following the Lomagundi-Jatuli event and moving into the mid-Proterozoic. There are still insufficient proxy data from continental deposits, such as paleosols, to best constrain the source-to-sink weathering behaviour of numerous elements that can track surficial redox conditions in the Proterozoic.

Here, we present a comprehensive mineralogical and geochemical characterization of ca. 1.85 Ga corestone-saprolite interfaces in a deep, saprolite-dominated weathering profile developed on dolerite sills. A combination of scanning electron microscopy and mineral liberation analysis (SEM-MLA), electron probe micro-analyzer (EPMA), and high-precision ultra-trace element geochemistry was employed to understand element cycling at a centimeter to decimeter scale.

Petrographic observations reveal preferential preservation of chalcopyrite and pyrite grains within albite-dominated cores. Progressive alteration outwards is recorded by a complete loss of sulphide and increased abundance of chlorite and illite towards the rims. Apatite grains are concentrated along core-rim boundaries, Fe-Ti oxides (titanite, ilmenite, rutile) are more abundant in the saprolite, and concentric rindlets of Fe-oxides embay the cores.

At the scale of the evaluated corestone-saprolite interface, several trends have been observed: (1) evidence for localized mobilization of Fe from the cores to the rims prior to Fe oxidation, which appears to have had an imporant influence on the behaviour of other metals; (2) no pronounced Ce anomalies are measured despite being noted elsewhere in the same paleosol; (3) subtle mobility in U and Mo, coupled with their consistent depletion in the corestone relative to the protolith; and, (4) high mobility and variability in Cr evident in the most highly-weathered areas (CIA-K: 65-75, Cr/Ta = 5.03 to 22.23). We argue that these trends are coherent with the inference of lower surficial oxygen at ca. 1.85 Ga that favoured Fe and S oxidation, but did not significantly oxidize Mn or extensively mobilize some redox-sensitive trace elements (e.g., U) into groundwaters.