The Hekpoort paleosol has long been interpreted to be a regional paleoweathering profile developed on ca. 2.2 Ga basaltic andesite lavas at the top of the Hekpoort Formation of the Pretoria Group, Transvaal Supergroup, South Africa. In five separate profiles, from outcrops along road cuts near Waterval Onder and in the Daspoort Tunnel and in three drill cores from the Bank Break Area (BB3, BB8, and BB14), the top of the paleosol is a sericite-rich zone. We sampled the underlying or parent basaltic andesite into which the chlorite zone grades downward into a chlorite-rich zone. In core BB8 and in the road cut at the Daspoort Tunnel we sampled the underlying or parent basaltic andesite into which the chlorite zone grades. We did not obtain samples of the parent material at Waterval Onder and in cores BB3 and BB14, but chemical analyses indicate that the chlorite and sericite zones in these profiles derive from underlying lavas similar to the ones we sampled in core BB8 and at the Daspoort Tunnel. The presence of rip-up clasts of the paleosol in the overlying ironstones of the Strubenkop Formation in the cores from Bank Break rule out the notion that most of the alteration was a result of interactions with hydrothermal fluids. Desiccation cracks at the top of the paleosol that were filled with sand during the deposition of the overlying sediments at Waterval Onder point to a subaerial weathering origin.

Al, Ti, Zr, Cr, and V were apparently immobile during weathering and all subsequent alteration. We have calculated retention factors for these elements in each profile, assuming that Al was perfectly immobile. In core BB8, which is the most complete profile we have, our calculations indicate that between 95 and 100% of the Ti, Zr, Cr, and V were retained in the soil profile. Thus, there was no significant loss of any of these elements from the soil as a whole. The coefficients of variation of Ti/Al, Zr/Al, Cr/Al, and V/Al are all very low with each soil profile, indicating that the elements were not significantly redistributed within the soil. Al, Ti, Zr, and Cr are typically immobile during weathering. V is somewhat mobile during aerobic weathering and its retention indicates that atmospheric oxygen levels were low when the Hekpoort paleosol formed.

The vertical distribution of Fe, Mg, Mn, Ni, and Co indicates that these elements were largely removed from the top of the soil during weathering. The values of the ratios Fe/Al, Mg/Al, Mn/Al, Ni/Al, and Co/Al in some samples at or near the top of the soil fall below 10% of the value of these ratios in the parent material. However, the retention factors for Fe (0.3 to 1.0), Mg (0.1 to 0.5), Mn (0.3 to 0.9), Co (0.2 to 1.0) and Ni (0.8 to 1.3) indicate that a significant fraction of the complement of these elements was lost from the top subsequently reprecipitated in the lower portions of the soil.

Previous work indicated that the distribution of Fe and Mg in chlorites in the Hekpoort paleosol were consistent with the formation of pedogenic Fe²⁺-rich smectite rather than pedogenic FeCO₃ in the lower portions of this soil. Divalent cations such as Mn²⁺, Ni²⁺, and Co²⁺ would readily substitute into such a smectite.

The distribution of Fe²⁺ should be best preserved in core samples, which have not been subjected to modern, oxygen-rich weathering. The molar ratio Ni²⁺/Fe²⁺ is typically highest near the top of the Bank Break core profiles. This ratio decreases with increasing depth until its value is similar to that found in the parent material. Co²⁺/Fe²⁺ is generally fairly constant. Mn²⁺/Fe²⁺ generally increases toward the bottom of the profiles as does the ratio Mg²⁺/Fe²⁺. The variations in these molar ratios are inconsistent with the wholesale introduction of these elements by a hydrothermal solution since the composition of such a fluid was probably uniform over the length scale of each of these profiles. Experimental data on the distribution of divalent cations between solution and a dioctahedral smectite indicate that the present distribution of divalent cations is best interpreted as resulting from their release during weathering and subsequent reprecipitation as constituents of pedogenic smectite.

The precipitation of pedogenic smectite rather than siderite indicates that atmospheric pCO₂ was less than 2 x 10⁻³ atm when the Hekpoort paleosol formed. At this CO₂ level the loss of Fe from the top of the profile during weathering indicates that weathering occurred with atmospheric pO₂ < 8 x 10⁻².