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Mild oxidative weathering and clay mineral diversification on land ~3 billion years ago

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The Archean Eon—a period dominated by anoxic conditions in the atmosphere-hydrosphere system—has been extensively described to be characterized by very limited clay mineral production on land during development of soil profiles. These conditions likely restricted pedogenic clay mineral diversification and mobilization of redox sensitive and/or bio-essential elements from continental rocks to aquatic habitats.

Here we examine clay mineralogy and trace element geochemistry of a well-preserved Mesoarchean palaeosol from the Pongola Supergroup, South Africa, to constrain the extent of chemical weathering processes and the magnitude of clay mineral production on the emergent continental landmass of the Kaapvaal Craton ~3 Ga ago. The samples were obtained from deep drill core, and the data show that the upper part of the palaeosol profile is exclusively represented by illite population with less than 5% of smectite mixed-layers. The lower part of the paleosol profile is characterized by Fe-rich chlorite with less than 5% of berthierine mixed-layers, together with illite with less than 5% of smectite layers. The entire paleosol profile shows evidence for mobilized redox-sensitive trace metals such as V, Cr, Mo, and U. Detailed XRD characterization indicates that smectite and berthierine were major clay components during soil formation in the Mesoarchean continental environments which is indicative for intense chemical weathering processes associated with a relatively high rate of clay mineral production and diversification on land. This implies significant amounts of CO_2 draw down due to silicate weathering of Archean landmasses that was potentially associated with aerobic and/or microaerophilic metabolisms.