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A sub-Cambrian weathering profile at the top of the Arabian-Nubian Shield in southern Israel

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The properties and scale of Precambrian-Cambrian chemical weathering, if can be assessed, may prove remarkably important because they are thought to reflect the interaction between the lithosphere and the atmosphere at that time. The occurrence of weathering profiles at the sub-Cambrian peneplain exposed in southern Israel and in other localities across North Africa and Arabia suggests that chemical weathering affected widespread segments of the north Gondwana margin during Late-Neoproterozoic – Cambrian times. Despite of their paleoenvironmental significance, their exact properties were hardly investigated.

In the present study, we investigated the petrography, mineralogy and geochemistry of weathered Neoproterozoic basement rocks of the northern Arabian-Nubian Shield exposed in southern Israel below a mid-Cambrian siliciclastic succession. We analyzed drill core samples in order to establish the pedogenic nature of the upper part of the Timna Massif where the granitic rocks exhibit significant weathering. The results were compared to an equivalent outcrop at the Roded Massif, a few km to the south. Several features are in favor of weathering at ambient temperatures. The altered profile consists of two main subunits: the top is a reddish claystone of <1 m thick, whereas the bottom is a few meters clayey granite which preserves the original crystalline texture. The two horizons are interpreted as a plasmic zone over a saprolite. The plasmic zone is enriched with Fe and Al and depleted with Si, Ca, Mg and K relative to the saprolite. The Ba/Sr ratio indicates moderate leaching. The chemical index of alteration (CIA) displays a general trend of increase towards the top of the weathering profile, as is typical for present-day weathering profiles. Nonetheless, the maximum CIA indexes are 75 - 85, lagging significantly behind maximum values observed in strongly leached present-day soils in the tropics.

Petrographic examinations reveal iron oxide stains that testify for iron mobility under local fluctuating redox conditions, well documented in modern and Proterozoic soils. The ultimate evidence for the plasmic zone being a near surface feature (rather than a late post depositional alteration) is clay illuviation and the variety of sepic plasmic microfabrics induced by shrinkage and expansion of clays during wetting and drying cycles. Both features are typically pedogenic and have survived deep burial digenesis and a hydrothermal Devonian event revealed in previous works from zircon fission tracks. Illitic illite-smectite phases (sericite) and kaolinite coexist in the saprolite whereas the proportion of kaolinite increases toward the top of the weathering profile. It is therefore suggested that diagenetic illitization affected an original smectite, or smectitic illite-smectites, and not kaolinite. This distinguishes the sub-Cambrian weathering profile from other Proterozoic soils. All observations are in accord with the current weathering profile being a remnant of a thick lateritic profile whose top was truncated by fluvial incision just prior to deposition of the overlying Cambrian siliciclastic sequence.