Direct evidence for significant oxygen in the Late Archean atmosphere from paleosols of the Fortescue Group, western Australia

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The 2.76 Ga old Mount Roe Basalt paleosols (MR#1 and MR#2), recognized within the Fortescue Group, Western Australia, represent some of the oldest certified examples of Archean paleoweathering profiles. The loss of Fe in these reference paleosols has been considered as strong evidence for low oxygen in the Late Archean atmosphere. However, the robustness of such interpretations suffers both from the scarcity of paleosol exposures and the superposition of post-weathering alteration over primary soil profiles. Here we report new exposures of the MR#1 paleosol as well as a number of new basalt-derived paleosol occurrences distributed in the Mount Roe Basalt and the 2.73 Ga old Kylena Formations of the Fortescue Group. We show that all these paleosols were strongly affected by post-weathering reductive alteration that resulted in significant depletion of iron. Particular care is therefore required when bulk chemical profiles of iron in such paleosols are used as atmospheric paleobarometers. In contrast, the detailed characterization of mineral assemblages is critical to discriminate between pedogenic and post-weathering processes. We discovered early lithologic units, locally preserved within the hydrothermally-altered paleosols, with distinct chemical and mineralogic compositions: (i) 13C-depleted carbonaceous-rich, diaspore - pyrophyllite boudins likely inherited from the bauxitisation of the parent basalt and (ii) Fe-sericite associated with authigenic sphene and containing early relics of sulfate-bearing iron-rich smectite or berthierine. We argue that smectite relics constitute a part of the primary pedogenic mineral assemblage formed in the presence of significant atmospheric oxygen, while berthierine and sphene formed during diagenesis through the circulation of reductive fluids.