Evidence of terrestrial life and an O2-rich atmosphere in the oldest (~3.4 Ga) paleosol in the East Pilbara Craton, Western Australia I. Johnson[1] (imj101@psu.edu), Y. Watanabe[1], B. Stewart[2] and H. Ohmoto[1] [1]Penn State Astrobiology Research Center and Department of Geosciences, [2]Department of Geology and Planetary Sciences, University of Pittsburgh.

Buick [1] discovered the Earth's oldest emergent land surface (unconformity) in the Pilbara Craton Western Australia and was the first to postulate that a ~50m thick clay-rich alteration zone beneath it may represent the Earth's oldest (~3.4 Ga) paleosol. Our subsequent investigations have revealed the presence of a series 20-100 m thick, ~0.5 to 1km long, tabular alteration zones at 9 localities directly beneath the unconformity on the flanks of two ~3.5 Ga granitic domes. These localities are spread over a >100 km linear (present day) distance indicating the alteration event occurred over a broad area. These alteration zones, characterized by an abundance of Al-rich clays (pyrophyllite and kaolinite), are developed in the steeply tilted Warrawoona Group (<3.525-3.43 Ga) submarine volcanics occurring parallel to the identically tilted unconformity surface. This type of alteration may be formed by either hydrothermal fluids (bottom to top) or by meteoric water (i.e. soil formation; top-down). The mineralogical, petrographical, and chemical evidence in these alteration zones is consistent with a top-down style of alteration, suggesting that soil formation may have occurred commonly across the >40,000 km^2 emergent land surface at ~3.4 Ga.

In modern soils, the lability, reprecipitation and/or sorption of many elements during pedogenesis is dependent on mineralogy, redox conditions, pH, rainfall levels, and the effects of organic activity. As a result, measurable differences in the behavior of specific elements can be used to discern the presence of microbial activity and the redox state of reacting fluids involved in water-rock interaction. At Trendall and Steer Ridge, two well characterized localities ~3 km apart, we have found signs of not only free atmospheric oxygen, but also microbial activity at the time of pedogenesis (~3.4 Ga). Such evidence includes: the apparent mobilization of refractory elements such as Fe(III), Al, Ti, P, Ni, and Th which are labile with the aid of microbial activity and its byproducts under typical surface conditions; the loss of Cr, V, Ni, and Cu which are fixed under reducing conditions, but labile under oxic conditions; horizons of hematite ($Fe^{3+}{}_2O_3$; 15 to 81 wt%) that contain enrichments of Mn, P, Ni, Cu, Co, Cr and LREEs, suggesting Fe and other elements were mobilized by either organic acids or oxidation and later fixed by either free O_2 or sorption onto goethite ($Fe^{3+}(OH)_3$). Formation of such goethite/hematite-rich bodies in modern soils (laterite or similar spodic horizons) requires the presence of organic acids and an O_2-rich atmosphere.

The geological and geochemical evidence found in the paleosol suggest that life flourished under an oxygenated atmosphere on the ~3.4 Ga terrestrial surface. This life likely took the form of microbial mats and subsurface soil bacteria.

References: [1] Buick, R. et al. (1995) Nature, 375, 574-577.