Earth's oldest (~3.4 Ga) lateritic paleosol in the Pilbara Craton, Western Australia

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Buick (1995) was the first to recognize the oldest (~3.46 Ga) erosional surface at a locality in the East Pilbara Craton, Western Australia and suggested a paleosol might be developed underneath it. Our work has revealed the presence of a 40 to 80 m thick clay (±pyrophyllite ± kaolinite ± muscovite ± silica)-rich alteration zone underneath the oldest unconformity at 10 locations dispersed over a ~120 km distance in the Pilbara Craton.

In the two areas studied in detail, the aluminous clay-rich zone is characterized by losses of most major elements (e.g. Si, Mg, Ca, Na, Al, Fe(II), Mn, etc.), gains of others (Fe(III), Si, K, and Na), loss of original rock fabric, and volume loss (up to 60%) with increasing proximity to the erosional surface. At five of the ten locations a 1-6m thick horizon of Fe-enrichment (hematite) occurs at depths of 0 to 12 m beneath and parallel to the oldest unconformity surface. Behaviors of many redox sensitive elements (Fe^{2+}, Fe^{3+}, Mn, V, U, Cr, Cu, Co, Ni, Ce, Eu), as well as many other elements, in the two studied sections strongly resemble those in the 2.2 Ga Hekpoort lateritic plaeosol in South Africa. Dating of samples from the two areas give a Sm-Nd isochron age of 3.47±0.2 Ga and Rb-Sr ages of 2.58±0.14 and 2.76±0.15 Ga. The age of 3.47 Ga corresponds to the timing of the mobilization/reprecipitaion of the major and most of the redox sensitive elements, along with the volume loss, and is contemporary with the age of the ancient land surface. The Rb-Sr age of ~2.6 Ga corresponds to the late introduction of K-rich groundwater from a proximal granitic dome.

Previous investigators have suggested that the alteration zone underneath the ~3.43 Ga unconformity in several of our studied areas was produced by hydrothermal fluids. However, the absence of Al-rich alteration above the unconformity and the various characteristics (geographical, geological, petrological, mineralogical, and geochemical) of the alteration zone underneath the unconformity strongly suggest that it represents the oldest (~3.46 Ga) lateritic paleosol. This implies the development of an oxygen-rich atmosphere and a flourishing terrestrial biomass at ~3.46 Ga ago.

Modeling mineral dust and dissolved iron deposition

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Mineral Dust and Dissolved Iron Deposition

GEOS-Chem, with a prognostic iron (Fe) dissolution scheme [1], was applied to estimate fluxes of Patagonian dust and dissolved Fe (DFe) to the South Atlantic Ocean (SAO). We show that the model is capable of capturing dust source regions, total fluxes, and seasonality of mineral dust and DFe.

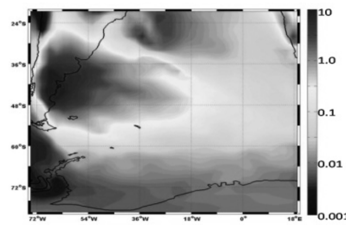

Figure 1: GEOS-Chem predicted annual DFe deposition rate ($\mu g/m^2/day$) to the SAO for Oct. 2006 to Sep. 2007.

The Fe dissolution scheme [2] was modified to account for DFe from clay minerals. Sensitivity studies demonstrated how initial Fe solubility and natural sources of SO_2 affect the total magnitude and spatial distribution of DFe over the SAO.

Study	Total	Dry	Wet
Baseline	0.86	0.64	0.22
Initial Fe solubility 0.1%	0.17	0.13	0.04
Clay dissolution	1.44	1.08	0.36
2x natural SO_2 emissions	0.92	0.69	0.23

Table 1: Sensitivity studies for GEOS-Chem simulated DFe deposition (Gg/month) to the SAO during Dec. 2006.

Results

Mineral composition of Patagonian dust, initial Fe solubility, clay dissolution, and variations in natural SO_2 sources can have considerable effects on the magnitude (Table 1) and spatial pattern of DFe fluxes to the SAO. Using C:Fe export efficiencies [3], we have quantified the overall impact of atmospheric DFe deposition on CO_2 sequestration in the SAO.

[1] Solmon *et al.* (2009) *J. Geophys. Res.*, **114**, D02305. [2] Meskhidze *et al.* (2005) *J. Geophys. Res.*, **110**, D03301. [3] de Barr *et al.* (2008) *Mar. Ecol. Prog. Ser.* **364**, 269-282.