Paleosol evidence on Precambrian oxygen evolution

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The Precambrian paleosols have been efficiently utilized for evaluating the oxygen evolution during the Precambrian. Especially the mobilities of redox sensitive elements such as Fe, Mn and Ce have been utilized for semi-quantitative estimates of the oxygen concentrations of the Precambrian. Ideally changes accompanying chemical weathering should be carried out on isovolumetric basis. However, the Precambrian paleosols might have suffered an unknown amount of compaction due to burial and erosion, so that such a direct comparison is not possible unless the effects of burial are unraveled. Here, we propose that the ratio of immobile elements such as Al, Ti in equal columns of paleosol and parent rock should be equal to the compaction factor (CF, fraction of original thickness), unless there was no erosional loss. This supported by the fact that these immobile elements should be conserved through out all stages of paleosol development. Estimation of CF will allow the calculation of retention of important elements such Fe and Mn, which in turn can reveal the atmospheric oxygen levels. Calculation of CF and retention of Fe (as Fe2O3T, Fe2O3, FeO) and Mn (as MnO) are carried out for five definite paleosols ranging in age from Late Archean to Paleoproterozoic.

The results indicate that the CF values of all the Paleoproterozoic paleosols are well within the range of that is expected if modern vertisols are subjected to similar burial conditions. Hence it can be safely assumed that the retention values (shown with a suffix R) for Fe and Mn are not affected by erosional loss in these paleosols. The Fe2O3TR values are very low for Late Archean (2750 Ma; Fe2O3TR: 0.08-0.2) and earliest Paleoproterozoic (2450 Ma; Fe2O3TR: 0.4), while they become close to 1 in paleosols of 2250 Ma onwards. The Fe2O3R is close to 1 in all the Paleoproterozoic paleosols indicating that the Fe2O3 has behaved essentially like an immobile element during weathering at least from Paleoproterozoic onwards. The FeOR in all the Paleoproterozoic paleosols is less than 1 and in the paleosols less than 2250 Ma age, the loss in FeO is compensated by the gain in Fe2O3. The MnOR is less than1 in all the paleosols of more than 1850 Ma age and is close to 1 (0.87) only in Flin Flon paleosol. Incidentally, these 1850 Ma old paleosols are also characterized by Ce anomalies. It appears that the atmospheric oxygen has increased sufficiently high enough to oxidize entire Fe by ~2250 Ma and to oxidize all the Fe, Mn and Ce by ~1850 Ma, probably indicating a step-wise pattern during the Paleoproterozoic.