Super light rain in supercontinents

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Continously exposed weathering profiles on Earth rarely exceed ~80 Ma, limiting the use of the isotopic composition of pedogenic minerals in paleoenvironmental reconstrutions. However, buried weathering profiles and detrital supergene minerals generated from the erosion of previously existing weathering profiles may record useful environmental information, if timing of mineral precipitation and independent environmental data ($\delta^{18}O$, δD, etc.) can be extracted from the same phase. The combination of (U-Th)/He geochronology with SHRIMP-SI $\delta^{18}O$ analysis of supergene goethite provides a suitable tool for probing the environmental conditions prevaling at the surface of continents in the remote past.

Massive indurated detrital goethite blocks from colluvium deposits in the Quadrilátero Ferrífero, Brazil, and the Flinders Ranges, South Australia, yield average (U-Th)/He ages of 271 ± 32 and 158 ± 14 Ma, respectively. These ages reveal that these minerals precipitated from weathering processes active in the interior of Pangaea and Gondwana. SHRIMP-SI analysis of ancient detrital goethite from the Quadrilátero Ferrífero yield $\delta^{18}O$ signatures in the -24.2 ± 0.6 to -12.4 ± 0.3 ‰ range, while Flinders' goethites yield $\delta^{18}O$ signatures ranging from -15.1 ± 0.2 to -11.2 ± 0.2 ‰. These results represent some of the lightest isotopic compositions ever measured for any supergene goethite on Earth, with equivalent results (-13.2 and -15.5‰) only measured in goethites from Alaska. Independent studies suggest that supergene goethite may record the isotopic composition of local meteoric precipitation. If the isotopic compositions of the ancient detrital goethites from the Quadrilátero Ferrífero and the Flinders Ranges do indeed record the isotopic composition of precipitation, they reveal that rainfall in supercontinents must have been extremely fractionated and depleted in ^{18}O. Given the distance from the sampling sites to the ancient oceans at the time, the extreme isotopically light rainfall could result from Rayleigh distillation as ocean-derived moisture reached the interior of supercontinents. Another possible explanation for the light isotopic compositions is the cold climates that may have persisted at the time. Either way, further combined (U-Th)/He geochronology and SHRIMP-SI analysis of supergene goethite may help in the reconstruction of paleoclimatic conditions prevailing at the Earth's surface in the remote past.