Evidence of crust during the first 100 m.y. of Earth history: Lu-Hf, $\delta^{18}O$, and Ti thermometry results for Hadean zircons

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Large deviations in $\varepsilon_{Hf(T)}$ from bulk silicate Earth seen in >4 Ga detrital zircons from Jack Hills, Western Australia, have been interpreted as reflecting a major differentiation of the silicate Earth at 4.4 to 4.5 Ga. We have expanded the characterization of $^{176}Hf/^{177}Hf$ (*Hf*) initial ratios in Hadean zircons with most measurements employing concurrent Lu-Hf and $^{207}Pb/^{206}Pb$ analyses permitting assessment of the age of the volumetrically larger domain sampled by laser drilling against the spatially more restricted ion microprobe ages. Our new results confirm and extend the earlier observation of significant negative deviations in $\varepsilon_{Hf(T)}$ throughout the Hadean, although no positive $\varepsilon_{Hf(T)}$ values were documented in this study. Monte Carlo modelling of these data yields an essentially uniform spectrum of model ages between 4.56 and 4.20 Ga for extraction of the zircons' protoliths from a chondritic reservoir. To assess whether the 5 data plotting close to solar system initial (Hf_o) are statistically robust, we derived the error propagation equation for a parameter, ε_o, which measures the difference of a sample from Hf_o. Our analysis suggests that this limited data is indicative of source sequestration in a crustal-type Lu/Hf environment prior to 4.5 Ga. Oxygen isotope data and Ti thermometry from Hadean zircons show little obvious correlation with *Hf*, consistent with their derivation through fusion of a broad suite of crustal rock types under water-saturated conditions. Together with other isotopic and trace element data obtained from these ancient zircons, our results indicate essentially continuous derivation of crust from the mantle, beginning in the first 100 million years of Earth history. These results represent further evidence that by 4.35 Ga, portions of the crust had taken on continental characteristics.

Maximum granite catena differentiation

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Savanna soils provide a template for the most extensive ecosystems in sub-Saharan Africa. Many savannas have been shaped by millennia of catenary processes, including the redistribution downslope of water as well as the products of chemical weathering, but these processes have not been quantified. Along a 150-m catena in Kruger National Park, South Africa, textural differences created a seepline, where total mass losses indexed to the underlying granite peaked at 0.95 Mg m^{-2}. This ecotone was abrupt: clay content 35 cm below the surface increased from 11 to 77 kg m^{-3} over a distance of only 7 m, and 20 m further downslope, clay content peaked at 149 kg m^{-3}. Loss of SiO_2 accounted for 47 to 91% of total mass loss, depending on hillslope position. While Al, Fe, and P accounted for smaller fractions of mass loss ($\bar{x}$ =13, 2, and 2%, respectively), these elements showed mass losses upslope and gains downslope of the seepline. These changes in mass were indexed with hillslope enrichment factors (HEF), which were calculated as the difference between downslope and upslope total mass balances. These HEF for the South Africa catena were generally the same sign as, but an order of magnitude larger than, those reported for other granitic catenas in Australia and Germany. Soil differences along this catena are maximized by the long residence times, which we estimated at 200 ky and constrained using ^{10}Be analyses from sediment and saprolite samples. Catena differences are also maximized by the semiarid climate, granite parent material, and bioturbation. Bioturbation appears to be concentrated in the sandy upslope portions of catenas: epigeous termites, aardvarks, and treethrow haploidize upslope—but not downslope—pedons, maximizing both infiltration and upward pumping of weatherable minerals, thereby catalyzing weathering and the transfers downslope of weathering products. Illuviation of clay downslope initiates incision, which could help account for the offset between soil production and catchment-averaged erosion rates.