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Implications for reworking and growth of continental crust from zircon U-Pb and Lu-Hf isotope systematics of river sands

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Sialic continental crust renders Earth unique among all known planets. Therefore, knowledge of the growth history of continental crust is essential to understanding the evolution of Earth. A major issue in the study of continental growth is how to estimate the difference of its "actual" growth rate from the growth rate based on the present age distribution of continental crust. The difference can be caused by three main processes: (1) the erosion of crustal materials and subsequent deposition and diagenesis (intra-crustal recycling), (2) formation of granitoids from remelting of older crustal materials (crustal reworking), and (3) subduction of crustal materials into the mantle (crust-mantle recycling).

In order to understand crustal reworking rate and juvenile continental growth rate (i.e., growth rate corrected for the effect of intra-crustal recycling and crustal reworking), we carried out in situ U-Pb and Lu-Hf isotope analyses of detrital zircons from the Mississippi River in order to understand crustal reworking and continental-growth rates. Because of robustness of zircon to intra-crustal recycling, its U-Pb age represents magmatic age of its source rock, rather than subsequent sedimentation or metamorphic events. On the other hand, initial Hf isotopic composition of zircon provides information whether its source rock is juvenile or reworked (crustal reworking). The U-Pb analyses for 416 zircons reveal three major peaks of crust formation at 2.8–2.6 Ga, 1.8–0.9 Ga, and after 0.2 Ga. Initial Hf isotope ratios were obtained for 402 of the dated zircons, and only 8% of the zircons have $\varepsilon_{Hf(T)DM}$ values less negative than

–2.5. These data correspond to a crustal residence time of $<$120 m.y. This finding indicates that crustal reworking was a very important process in continental crust formation. The $\varepsilon_{Hf(T)DM}$ population demonstrates that reworking was predominant at 2.5–2.0 Ga and after 0.9 Ga, whereas juvenile crust formation dominated between 2.0 and 1.6 Ga. We calculated the mantle-extraction model ages to estimate continental-growth rate. Approximately half of the grains have model ages between 2.0 and 1.3 Ga, indicating rapid crustal growth during this time. The continental-growth rate suggests that 15% and 78% crust in the source region of the zircons was formed by 2.5 and 1.3 Ga, respectively.