ISTerre
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Antarctica. Cliché Jeff Vervoort

Growth and evolution of Earth's earliest crust

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One of the most fundamental and long-standing problems in Earth Sciences is the question of continental growth. Despite decades of work on this problem there is still no consensus on when the continents formed, what were the mechanisms of their formation, and how they have evolved through time. Resolution between the competing models requires insight into the earliest Earth, but the window into this critical time period is far from clear.

One reason for this uncertainty is the lack of old rocks in the geologic record. Crust older than 3.5 Ga constitutes less than 2% globally and the crust that remains is often a complicated mixture of components with different ages and isotopic compositions. Without a precise integration of age and isotopic composition, analysis of these complicated rocks can yield meaningless age and isotopic mixtures, which can further cloud our view of the early Earth.

Our approach to understanding the chemical evolution of the Earth is to integrate age and Hf isotope compositions in zircons from the Earth's oldest rocks. We do this using the laser ablation "split stream" technique whereby the aerosol from the zircon laser ablation is split to two mass spectrometers: one to determine U-Pb ages and the other to determine its corresponding Hf isotopic compositions. It this way we can unambiguously determine age and Hf isotopic composition on the same zircon volume.

Using this approach we find that the isotopic record for rocks older than 3.5 Ga is characterized by much less variation than has been recently suggested; instead of great heterogeneity, the record is characterized by relative isotopic homogeneity. Two features stand out from these data. First, there are very few samples with e_{Hf} values significantly above zero prior to 3.5 Ga, indicating the lack of a widespread depleted mantle before 3.5 Ga. Second, while there are negative e_{Hf} values for some ancient zircons consistent with recycling of early-formed crust, the lack of a complimentary depleted mantle reservoir from 4.4 to 3.5 Ga indicates that the volume of this early enriched (continental like) crust was modest. Our view, therefore, is that widespread continental crust formation did not begin in earnest until ca. 3.5 Ga. This is consistent with both the preserved crystalline rock record and the ages of detrital zircons in the sedimentary record.

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Salle Dolomieu d'ISTerre

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