Geophysical Research Abstracts
Vol. 16, EGU2014-10383, 2014
EGU General Assembly 2014

Continental emergence in the Late Archean reconciles early and late continental growth models

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The analysis of ancient sediments (Rare Earth Element composition of black shales, isotopic strontium composition of marine carbonates, isotopic oxygen composition of zircons) suggests that continental growth culminated around the Archean-Proterozoic transition. In stark contrast, the geochemical analysis of ancient basalts suggests that depletion of the mantle occurred in the Hadean and Eoarchean. This paradox may be solved if continents were extracted from the mantle early in Earth's history, but remained mostly below sea level throughout the Archean.

We present a model to estimate the area of emerged land and associated isotopic strontium composition of the mantle and oceans as a function of the coupled evolution of mantle temperature, continental growth and distribution of surface elevations (hypsometry). For constant continental hypsometry and four distinct continental growth models, we show that sea level was between 500 and 2000 m higher in the Archean than at present, resulting in $< 12\%$ of emerged land, compared to $\sim 28\%$ at present. If in addition the hot Archean lithosphere could not sustain high relief, as little as 2-3% of Earth's surface would have been emerged in the Archean. Using a geochemical box model for the strontium isotopic composition of the mantle and oceans, we show that a reduced area of emerged continental crust can explain why the geochemical fingerprint of continents extracted early in Earth's history was not recorded at the surface of the Earth until the late Archean.