Making Continental Crust on Water-bearing Terrestrial Planets

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Abstract
Debate regarding early Earth differentiation focuses on the fate, nature, origin, volume, and processes responsible for protocrust(s) and felsic crust formation. One specific aspect of this debate is how Hadean zircons and their felsic parental magmas fit with an expected ultramafic environment. Based on our new experiments, thermodynamic modeling, and elemental partitioning, we infer that felsic liquids could have been generated by shallow (< 20 km) interaction between primordial hydrated peridotite (serpentinite) and basaltic magmas. Felsic melts ($SiO_2 \geq$ 55 wt%) can be generated at a maximum melt fraction of 0.4 when starting serpentinite:basalt mass ratio is high (i.e., higher than 1.5:1). Here we show that felsic melts obtained in our experimental runs can account for the Hf isotope evolutionary array displayed by Hadean detrital zircons worldwide. We propose that open system interactions between serpentinite and basaltic melts at the end of the magma ocean stage after magma degassing and water ocean precipitation allowed the formation of extensive early Hadean felsic crust (4.4 - 4.5 Gy ago). Our calculations indicate that this felsic crust accounts for up to 50% of present-day continental crust mass. The abundant production of primordial felsic crust throughout the Hadean could be due to the impact-induced melting owing to frequent impacts. A similar process could have also occurred on Mars, and other rocky planets, provided that water was abundant at shallow and surficial levels, which would account for the existence of a thick felsic crust. The serpentinised protocrust had a dual role in the primitive planetary environment: to provide the first and most abundant felsic crust and to facilitate the emergence of life in the shallow hydrothermal environments of water-bearing terrestrial planets.

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