The rise of continents on a cooling Earth

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We consider the consequences of the secular cooling of the solid Earth for the evolution of plate tectonics, topography, sea level and the composition of the oceans.

If Earth's mantle was 100-300ºC hotter in the Archean, the oceanic crust would have been thicker than at present, hindering the subduction of less negatively buoyant oceanic lithosphere. However, we show that the gravitational collapse of thick early continents, formed by the accumulation and differentiation of mantle plume products, could have resulted in transient episodes of plate tectonics [1].

Once tectonic plates became mobile, continental collisions would have contributed to shaping Earth's surface. However, because the Archean continental lithosphere was hotter, continents were unable to sustain high topography [2]. Similarly, thick continental flood basalts accumulated on top of continental crust did not result in large topography but remained at or below sea level [3].

A thicker oceanic crust in the Archean would have decreased the water carrying capacity of the ocean basins, and sea levels would have been 500-2,000 m higher than at present [4] [5]. Combined with lower continental elevations, higher sea levels would have resulted in large-scale flooding of existing continental platforms, and as little as 2-12% of the Earth's surface might have been above sea level in the Archean [4] [5].

As the solid Earth progressively cooled, plate-tectonics became self-sustaining and the continents emerged. This continental emergence is recorded in the Neoarchean shift of the $^{87}Sr/^{86}Sr$ of marine carbonates towards radiogenic values [5]. We suggest that surface geochemical proxies record Neoarchean continental emergence rather than a pulse in continental growth. The continental crust could have been extracted from the mantle early in Earth's history, but it was isolated from external envelopes until the late Archean.

[1] Rey, Coltice & Flament (2014) *Nature* **513**, 405-408. [2] Rey & Coltice (2008) *Geology* **36**, 635-638. [3] Flament, Rey, Coltice, Dromart & Olivier (2011) *Geology* **39**, 1159-1162. [4] Flament, Coltice & Rey (2008) *EPSL* **275,** 326-336. [5] Flament, Coltice & Rey (2013) *Prec. Res.* **229,** 177-188.