The generation and evolution of the continental crust

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There is increasing evidence for marked changes in the crustal record at the end of the Archaean, and that these reflect changes in both the generation and the evolution of the continental crust. The post Archaean crust has marked peaks in crystallisation ages that coincide with the development of supercontinents. These peaks appear to be an artefact of preservational bias, in that magmas generated in some tectonic settings may be preferentially preserved in the geological record, rather an indication of periods of unusually large volumes of crustal magmatism. The creation and destruction of supercontinents require some form of plate tectonics, and yet the rates of crust generation and destruction along modern subduction zones are strikingly similar.

In the Archaean, and by implication the Hadean, the continental lithosphere was thinner, mountains were more difficult to support, and perhaps there was less erosion. There is also less evidence for the development of peaks of ages globally. Material must have moved up and down in the uppermost mantle, and yet the magmatic record is different from that commonly associated with subduction. The zircon record yields little evidence for the development of depleted mantle in the Hadean, and on that basis for large volumes of continental crust. Granitic crust was generated by the remelting of mafic crust, and there is some evidence for a shift from mafic to more evolved source rocks with time. The Hadean crust appears to have had a bimodal silica distribution, as also characterizes the early Archaean rock assemblages. These at present characterise intraplate rather than plate margin settings, and yet most of the crust was generated by the end of the Archaean, and the average crust has a composition similar to that of destructive plate margin magmatism.

Hf isotopes require no subduction in the Hadean?

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The Hf, Pb and O isotope data on results of an in situ isotopic study of 67 Jack Hills zircons (Kemp et al. 2010) are combined with Hf isotope data from zircons of the Narryer gneisses (3.65- 3.3 Ga) and from Neoarchaean granites that intrude the Jack Hills belt. The detrital zircons define a subchondritic ε_{Hf} – time array consistent with the protracted intra-crustal reworking of an enriched, dominantly mafic protolith that was extracted from primordial mantle at 4.4-4.5 Ga. There is no evidence for the existence of strongly depleted Hadean mantle, and on that basis for large volumes of continental crust. There is also no evidence for juvenile input into the parental magmas to the Jack Hills zircons.

This simple Hf isotope evolution is difficult to reconcile with modern plate tectonic processes, which generate magmas with both juvenile and reworked sources. Strongly unradiogenic Hf isotope compositions of zircons from several Archaean gneiss terranes, including the Narryer and Acasta gneisses, suggest that dominantly mafic Hadean source reservoirs were tapped by granitic magmas up to 1.8 billion years after the initial crust generation episode. This implies the presence of Hadean crust with a bimodal silica distribution, as also characterizes the early Archaean rock assemblages, but not modern arcs. It supports the notion of a long-lived and globally extensive Hadean protocrust that may have comprised the nuclei of many Archaean cratons. Such Hadean protocrust survived the postulated late heavy meteorite bombardment of the terrestrial planets at ca. 3.9 Ga and might not have endured if crust-mantle recycling processes like subduction were efficient in the Hadean.

[1] Kemp, A.I.S., Wilde, S.A., Hawkesworth, C.J., Coath, C.D., Nemchin, A., Pidgeon, R.T., Vervoort J.D. & DuFrane A. (2010) *Earth. Planet. Sci. Lett.* **296**, 45-56