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Hadean heat and hidden crust

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The absence of a geological record for much of the Hadean leaves us with a dearth of knowledge on Earth's oldest crust. Existing geodynamic models for the Hadean exhibit a wide and at times conflicting range of behaviours. Few, however, consider the full range of heat transport mechanisms operable, or heat sources available, and thus are incomplete pictures of this period. Here we develop models incorporating not just convection and diffusion heat transport, but also advection due to melt transport, and statistical melt transport-emplacement algorithm. We also incorporate chondritic and non-chondritic radiogenic heating, as well as heat implanted in the Earth via impacts, using stochastic models of impact flux. We show that under these conditions, i) heating due to impacts can dwarf other heat sources during the Hadean, leading to significantly elevated geotherms, and ii) volcanic heat transport tends to remove heat from the mantle and emplace it within the crust, further increasing crustal temperatures. Our models show that Hadean crust would have been partially molten below a few kilometers, with melt fractions below 5 km exceeding the limit for rigid crustal behaviour. This weak Hadean crust would have been effectively recycled back into the mantle. The waning impact flux after 3.9 Ga meant the effect of impacting became negligible after this time, allowing crust developed during this period to finally stabilise, and thicken.