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Impact volcanism and upper mantle melting; megamelting

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It is now widely accepted that large-scale mantle melting initiated by energetic bolide impacts must have been a common event during the early history of the Earth, and igneous petrology can be used to address the fate of these mega-melts. In other words, the same 1000 km scale impact craters seen on the Moon did not form on Earth, but instead are envisaged to have formed gigantic melt-filled basins, of the order of >25 to ~100 km thick, which almost certainly differentiated during slow cooling, and may have helped to initiate the crustal dichotomy between sialic and basaltic terrains (Theriault, Grieve et al LPSI 2001). Different physical models for large impacts processes differ in detail, but converge on this result that for impact events above some critical size (~few hundred kilometres effective crater diameter), the volume of impact melt exceeds the transient crater volume. In addition, the contribution to substantially increasing volumes of impact melting (> 10e6 km3; Jones et al EPSL 2002) derived from decompression of the underlying mantle remains an important but largely unexplored concept.

The Sudbury impact melt sheet serves as a newly recognised example of differentiation from super-liquidus melts of re-melted sialic crust, but what about similar events in purely basaltic or peridotitic terrains (ie oceanic)? Igneous petrology provides the philosophical criteria for predicting how such processes as immiscible liquid fractionation and subliquidus phase fractionation will occur during thermodynamic crystallisation over the pressure range of what are effectively discrete small magma oceans. However, there is a huge gap in our knowledge of the high temperature data required, which extends well above the liquidus for silicates (>> 1900 K) at relatively low

pressures (< 5 GPa). Hence, a new era of experimental igneous petrology is urgently required to understand these superheated events in the Earth's ancient mantle. To put this into context, we can imagine the instantaneous formation of a gigantic superheated melt disc whose vertical height surpasses the total depth of even the thickest crust. How did such a superhot lid influence the underlying mantle? Lastly, such non-plume ideas (impact volcanism) need not be confined to the time period of the early Earth, and have been proposed to operate during the Mesozoic (Ontong Java Plateau; Jones Elements 2005) and on other planets, including Venus (Hansen JGR 2006).