Early Earth's crustal diversity increased by differentiation of impact melt sheets

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Bolide impact is a ubiquitous geological process that produced craters and basins filled with superheated impact melt sheets on all the terrestrial planets. It remains controversial whether these sheets were able to undergo large-scale igneous differentiation, or not. Resolution of the dilemma is hampered by lack of consensus on the origin of the conspicuous norite-gabbro-granophyre stratigraphy of the Sudbury Igneous Complex (SIC) – the best preserved impact melt sheet on Earth. This stratigraphy has been attributed to both internal differentiation by fractional crystallization and compositional stratification prior to onset of crystallization. Here, we report on the discovery of angular bodies (up to 700 m in size) of melanorites that occur throughout almost the entire stratigraphy of the SIC and are, even locally, developed along its roof. These melanorites initially grew from the top of the melt sheet downwards but were later disrupted and collapsed as blocks onto the temporary floor. The Sudbury impact thus caused complete mixing of melted target rocks to form a homogeneous melt sheet that crystallized, on cooling, melanorites from both the top and the bottom. The compositional stratigraphy of the SIC is, therefore, produced by fractional crystallization, implying that more ancient, Hadean impact melt sheets on the Earth and other terrestrial planets also underwent large-scale igneous differentiation. The near-surface differentiation of these giant impact melt sheets may have contributed to the lithological diversity of the Earth's Hadean proto-continental crust, in addition to processes involving recycling of primitive basaltic crust by deep geodynamic processes.