Asteroid impact-induced magmatism and tectonics on the early Earth

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We have discovered numerous meteorite-fragments (MFs) and impact spherules, together with tsunami-disturbed sediments, in the lowest ~40m section of the Apex Basalt that overlies the 3.46 Ga Marble Bar Chert/Jasper beds in the ABDP #1 drill core from Pilbara, WA (see Graham et al., this session). The close similarities in trace element geochemistry between the Apex Basalt and the 120-90 Ma Ontong Java Oceanic Plateau Basalt, and their restricted spatial distributions, suggest that the Apex Basalt (~3 km-thick) represents the magmas generated by the impact-induced rapid-decompression-melting of the deep-mantle peridotite; the magmas quickly filled the crater (probably ~150 km diameter) created on a deep (>2 km) ocean floor by a large (~10-20 km diameter) asteroid impact, engulfing the MFs, impact spherules and tsunami deposits.

Comparing the geological and petrological data of the Pilbara and Kaapvaal Cratons, we suggest that: (1) Prior to ~2.7 Ga, magmatism and tectonics on the Earth were mostly dictated by frequent impacts (mostly in the oceans) of large asteroids. Punctuations of the thick oceanic (and continental) crusts, as well as the large-scale, rapid melt-generation in the upper mantle by large asteroid-impacts, provided effective mechanisms to release the interior heat of the early hot Earth. (2) Rapidly declining meteorite impact events after ~2.7 Ga was the probable cause for the initiation of the plate- and plume tectonics, because the Earth had to find alternative ways to release its interior heat. (3) All major igneous-rock formations in the Archean greenstone belts, including komatiite, basalt and granitoiods, developed from the magmas generated by impact-induced melting of mantle peridotite, and by the interactions between these magmas and the heterogenous oceanic crust. (4) Until ~2,7 Ga, no significant difference in composition and thickness existed between the continental and oceanic crusts; they were both heterogeneous and thicker than ~10 km. True continental crust did not exist. (5) The plate tectonics, which possibly began ~2.7 Ga, caused preferential melting of the felsic-intermediate rocks (compared to the mafic-ultramafic rocks) of the heterogenous Archean oceanic crust during its subduction, which led to the formation of the buyant continental crust and the homogeneous basaltic oceanic crust.