Deep subcrater shock effects in large terrestrial impact structures

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Mid- to deep-crustal effects of asteroid impacting on Earth can effectively only be studied in its two largest impact structures: the poorly exposed, 2.02 Ga Vredefort structure in South Africa eroded to ~10 km below the impacted surface, and the well-exposed, 3 Ga Maniitsoq structure in SW Greenland, exhumed by as much as 20–25 km.

Bulk shock melting at surface and, with decreasing shock wave intensity, formation of quenched single-mineral melts, diaplectic mineral glass, shock lamellae, etc., are well-known shock-related, near-surface phenomena. But what happens under large structures where the shock wave is not attenuated already in the upper crust?

Re-formation of shock-melted K-feldspar as an interstitial crystalline network rather than a glass was first reported from pelitic granulites close to the centre of the Vredefort structure, whereas adjacent shock-melted biotite recrystallised as mixtures of several new, anhydrous phases. A new study at Maniitsoq (Keulen et al. 2015) shows that shock-melting of K-feldspar was very widespread (d ~ 80 km). K-feldspar melts invaded into impact-induced fractures in adjacent plagioclase where a new ternary alkali feldspar melt was formed, resulting in rocks with three alkali feldspars and complex melt- and exsolution textures. Shock-melted biotite at Maniitsoq was re-formed as biotite without volatile loss.

At Vredefort, low-grade hydrothermal alteration without concomitant melting is known from both country rocks and pseudotachylytes, whereas no phenomena ascribed to seismic shaking have so far been reported. At Maniitsoq, the shock mineral melting was accompanied by impact-induced seismic shaking, transforming its inner part into a 35 by 50 km large, mechanically homogenised domain. Subsequent impact-induced mantle melting resulted in a 75 km long, curvilinear belt of norite intrusions, and deep-crustal hydrothermal alteration led to pervasive recrystallisation and formation of granitic melts.

References:

Keulen, N., Garde, A.A. and Jørgart, T. 2015: Shock melting of K-feldspar and interlacing with cataclastically deformed plagioclase in granitic rocks at Toqqusap Nunaa, southern West Greenland: implications for the genesis of the Maniitsoq structure. Tectonophysics, 17 pp.
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