Shock-induced deformations in feldspar grains from Siljan impactites (Sweden)

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Various shock-induced deformations are known from both alkali feldspars and plagioclase, including, with increasing shock pressure, fracturing, plastic deformation, planar fractures (PFs), or more frequently planar deformation features (PDFs), and at high pressure regimes diaplectic glass. However, these features have been much less studied and characterized than corresponding features in quartz. Therefore, they have not traditionally been used as indicators of meteorite impact. Increasing the knowledge of shock-induced microscopic deformation features in feldspars is especially of interest in the case of study of extraterrestrial material, as quartz is generally lacking in these rocks. In addition, with the current state of knowledge on impact metamorphism of feldspar, impact structures formed in targets devoid of quartz are hard to confirm.

We present here preliminary results from a petrographic study of feldspar grains in shocked granitic rocks from the Siljan impact structure (Sweden). Quartz crystals in these samples were previously studied in detail, and used for assigning shock pressures to localities across the structure by Holm et al. (2011). Our observations show that planar microstructures, including fracturing, plastic deformation, PFs and PDFs occur in alkali feldspar grains from localities estimated to have been subjected to a pressure range of 10-20 GPa. Feldspar in samples subjected to pressures below this range display no obvious shock-induced planar microstructures. Most of the plagioclase feldspar grains are strongly altered to sericite and clay minerals throughout all the investigated samples, hampering study of them. However, in grains that are somewhat less altered, no obvious planar microstructures were seen, suggesting that somewhat higher pressure is possibly required for their formation in plagioclase feldspars. Further investigations will be necessary to confirm this observation.

References
Holm, S. et al., 2011: Meteoritics and Planetary Science 46, 1888–1909.

Direct mineral melting in the Maniitsoq structure, West Greenland

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The impact melt zone of the 3.01 Ga, deeply exhumed Maniitsoq structure, displays abundant direct mineral melting, localised intense crushing and subsequent fluid-induced anatectic melting. Upper-crustal mineral melts are normally preserved as mineral glasses or microcrystalline aggregates, but their deep-crustal counterparts exposed at Maniitsoq solidified to larger, monocrystalline grains at ambient granulite-facies P-T conditions. K-feldspar, plagioclase, biotite and pyrrhotite each display different melt and crush textures, governed by their differential liquidus and solidus temperatures as well as the timing of their solidification relative to the ambient intensity of the impact-induced crustal reverberation. Impact melt patches in tonalitic orthogneiss contain new, black, euhedral plagioclase megacrysts. They show intense fracturing, interpreted as impact-induced crustal reverberation immediately after their crystallisation. With less intense shock melting plagioclase is split into a strongly fractured, unmelted calcium-rich interior surrounded by an albitic melt component without fractures. Shock-melted biotite forms large, highly irregular grains with long, slender protrusions into cracks of adjacent, variably crushed plagioclase, or constitutes a monocrystalline matrix between angular plagioclase fragments. Chemical zonation is observed, with magnesian interiors and dark brown, ferroan margins. Kink banding and folded fractures are common. K-feldspar porphyroblasts in augen gneiss become strongly distorted, but roughly retain their outer shape. In other samples K-feldspar commonly forms partial collars on other, unmelted minerals as well as highly irregular, interstitial melt patches with lobate, Ba-rich margins. Accessory pyrrhotite in orthogneiss may fill fractures in crushed K-feldspar and appears to be the last shock-melted mineral to recrystallise.

Continental boninitic norite intrusions as meteorite impact modified mantle indicators

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The newly discovered 3.00 Ga old Maniitsoq impact structure in southern West Greenland overlaps geographically with contemporaneous, Ni-mineralised norites and with two ~800 Ma younger, conjugate clusters of boninitic norite (BN) dykes. A straightforward explanation for this geographic linkage between the Maniitsoq impact and later-stage BN magmatism is that the impact must have been large enough to physically mix continental crust down into the underlying sub-continental lithospheric mantle, thereby creating an impact-modified mantle spot, that when perturbed later by thermal events produced the BN intrusions.

BN intrusions, similar to the West Greenland ones, have been emplaced worldwide between 2.9–2.0 Ga. The intrusions are of considerable economic interest as the BN-magmas are thought to have been parental to some of the most significant magmatic Ni, Cu, PGE and Cr deposits on Earth. The BN intrusions have hitherto been interpreted as either komatiitic, high-degree partial mantle melts that were subjected to contamination by large volumes of Archaean crust, or as more moderate-degree partial melts from a highly depleted, fossilized mantle wedge that had been enriched by slab-derived adakitic melts. Our interpretation of the southern West Greenland BN intrusions offers a new and alternative petrogenetic model for BN-intrusions, i.e., being the result of a meteorite impact modified mantle.

In the present study we review the special field relationships and petrographical/geochemical characteristics of the southern West Greenland BN dykes, which lead us to suggest a meteorite impact modified mantle origin. We also explore other BN-provinces across the World and discuss if they might have similar, yet undiscovered links to impacting.

Ni-mineralised norites and post-kinematic diorites from the Maniitsoq area, southern West Greenland: Evidence for impact-related source modification

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