Shock metamorphic minerals in the Popigai impact structure, Siberia

James Whitehead[1], Richard A.F. Grieve[2], John G. Spray[1], and Victor L. Masaitis[3]
[1]*Planetary and Space Science Centre, Department of Geology, University of New Brunswick, Fredericton, NB E3B 5A3*
[2]*Geological Survey of Canada, 601 Booth Street, Ottawa, ON K1A OY3*
[3]*Karpinsky Geological Institute, 74 Sredny prospekt, St-Petersburg 199106, Russia*

The Popigai impact structure, located in northern Siberia (71°30'N, 111°01'E) is the fifth largest terrestrial impact structure so far discovered. Popigai also represents the least-eroded but best-exposed example of a ring impact basin on Earth. Other known examples are eroded, buried or tectonized.

Impact melt rocks derived by melting of the target gneisses remain in the impact structure, and are known locally as tagamites. Our 110 tagamite samples were collected from thirteen drill cores located in the south-west of the structure. The samples span a radial distance of 6.4 km, a rim-concentric distance of ~2 km and were collected from depths ranging from 0 to 780 m in the drill cores. The impact melts, which comprise a total estimated volume of 1,750 km^3, contain clasts entrained from the target rocks. These comprise up to 35.5 vol. % of the impact melt and vary in size from the micron scale up to 10.5 mm in diameter in the 23 thin section samples which we have accurately characterized.

The clasts within the tagamites display a range of shock metamorphic effects that demonstrate that the basement rocks have experienced shock pressures from <5 GPa to >100 GPa. Quartz clasts in the tagamites exhibit planar deformation features (PDF's) consistent with shock deformation. These are heterogeneously distributed, even within single grains. These PDF's commonly coincide with regions in which the quartz has assumed a brownish, 'toasted' nature, visible in both plane- and cross-polarized light. Other quartz clasts exhibit a so-called 'ballen texture' which may indicate that they were cristobalite, before reverting to quartz at lower temperatures. The quartz clasts are commonly partially assimilated by the surrounding superheated impact melt, but paradoxically retain high strain features inherited from the target.

Both plagioclase and pyroxene exhibit textures indicative of partial melting. Similarities between the composition of the melts hosted within the porous melting clasts and the surrounding groundmass melt indicate that the intra-clastic melts must have been forcefully injected from the groundmass, rather than forming by passive *in-situ* decomposition in the absence of flow. Secondary growths of Ca-rich plagioclase mantle the partially melted plagioclases, and seal the porous melt channels in the clasts. However, clasts which possess these rims are locally broken suggesting that turbulent mixing of the impact melt was still active, at least locally, during or after their growth.