
**Differentiation processes within the
Manicouagan impact melt sheet, Quebec**

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The impact crater site at Manicouagan, Quebec (51° 23' N, 68° 42' W) is the second largest of Canada's 30 confirmed impact structures. The Manicouagan impact structure (215.56 ± 0.05 Ma), is a complex impact structure (D = 90 km), formed within predominantly crystalline metamorphic and igneous rocks of the Grenville Province of the Canadian Shield. Previous studies (based on observable melt) describe a geochemically homogeneous melt sheet, with a post-erosion thickness of the melt sheet estimated at 230 m (with a further 50 m lost to erosion), and a preserved melt volume of around 1000 km³. As with all other terrestrial impact melts (excluding Sudbury, Ontario), differentiation was not recognized at Manicouagan.

This study examines >3100 m of melt sheet from 9 drill holes located across the impact melt sheet and confirms a (local) depth of c.1400 m (including clast-laden melt), and a macroscopic clast-free impact melt of ca.1000 m. On the basis of whole-rock geochemistry (major, trace, and REE element analysis) and degree of internal differentiation, the clast-free impact melt sheet at Manicouagan is divided into two distinct units - undifferentiated (U-IMS) and differentiated (D-IMS). The U-IMS is composed of a homogeneous quartz monzodiorite, showing little variation in terms of major, trace, or REE element chemistry with respect to depth.

The D-IMS shows considerably more variation, and can be subdivided into three clast-free to clast-poor melt units (total 1045 m), underlain by a clast-laden melt unit (450 m). The D-IMS progresses from a monzodiorite (Lower Zone) through quartz monzodiorite (Middle Zone and Upper Zone) to rare quartz monzonite. The compositional difference within the D-IMS is also reflected in trace and REE abundances.

Isotope analysis (Rb, Sr, and Pb) has shown the melt sheet to have a homogeneous isotopic signature, suggesting that foot-wall assimilation or contamination does not play a significant role in the differentiation of the D-IMS. It is speculated that the large volume of melted material in the D-IMS facilitated fractional crystallization processes, not seen in other shallower parts of the melt sheet.