RADIAL DISTRIBUTION OF IMPACT DAMAGE AT MANICOUAGAN: SHOCK, COMMINUTION AND SHATTER CONES. L. M. Thompson[1], [1]Planetary and Space Science Centre, 2 Bailey Drive, University of New Brunswick, Fredericton, New Brunswick E3B 5A3 Canada. lthompso@unb.ca

Introduction: Shatter cones are the only diagnostic, macroscopic evidence of shock damage observed as a result of the meteorite impact process. However, their exact formation mechanism and the range of shock pressures at which they form remain poorly constrained. Recent field work and drilling at the ~80-90 km diameter Manicouagan impact crater, Canada provides new insights into the distribution of shatter cones and associated microscopic shock and other damage effects, both radially from the centre of, and vertically within the crater.

Distribution: A WNW-ESE exposed transect from ~10 km out to 23 km from the geometric centre of the structure reveals a radial decrease in the observed occurrence of shatter cones in the fractured floor of the crater immediately underlying the impact melt sheet and basal, melt-bearing breccias. Shatter cones and curvilinear fracture surfaces are ubiquitous in the exposures closest to the point of impact and are observed in both finer and coarser grained gneisses, manifest as smaller and larger scale cones respectively. There is a systematic decrease in the number and quality of shatter cones observed in exposures towards the edge of the crater. Shatter cones also occur within the centrally uplifted, anorthositic gneisses of the structure, in close proximity to shock veins with associated, relatively high pressure phases stishovite and maskelynite.

Microscopic Shock and Damage Effects: Concomitant with a decrease in the intensity and quality of shatter cone formation radially out from the centre of the structure is a decrease in the microscopic shock effects observed in the respective feldspar dominated gneisses. Almost all feldspar and associated minor quartz grains within shatter coned gneisses from a 7-12 km radius exhibit multiple sets of planar deformation features (PDFs) and possible diaplectic glass. The number of feldspar grains exhibiting evidence of shock and the number of sets of PDFs observed within these grains decrease towards the edge of the crater, such that the gneisses associated with the furthest shatter cone location, 27 km from the centre of the structure, exhibit feldpsars that show very little evidence of shock and deformation appears to be dominated by fracturing.

Feldspars within the shatter coned anorthositic gneisses of the central uplift reveal realtively little evidence of shock, with the damage being manifest primarily as fracturing. However, on the scale of a thin section, an increase in the formation of PDFs within the feldspars is observed towards the shatter cone fracture surface, a feature not observed from other locations.

Many of the thin sections examined also show evidence of comminution along shatter cone fractures, both within the rock and along the exposed shatter cone surface. These comminuted zones appear to cross-cut and post-date the PDF formation in the feldspars, many exhibiting imbrication or offset.

Conclusion: The shatter cones at Manicouagan are found in lithologies (fine and coarse grained) that record a wide range of bulk shock metamorphic effects, indicating that they formed over varying pressure ranges. The radial distribution of shatter cone occurrences and their associated microscopic shock effects suggest a zone of enhanced formation and peak shock at a radius of ~7-12 km from the centre of the structure. This coincides with the transition between shock zones III and IV of Dressler [1]. Shock deformation within the feldspars is manifest as fracturing, planar fractures and PDFs as well as possible diaplectic glass. Shock barometry of feldspars is not as well developed as for quartz, but based on work by [2}, the most shocked samples (7-12 km) are likely recording pressures in the 14 GPa or higher range, compared with the samples from a 27 km radius, which do not show much evidence for shock and are probably indicative of pressures of 1-2 GPa.

The shatter cones from the anorthositic gneisses of the central uplift, closest to the centre of the structure, do not preserve evidence of high shock pressures within the feldspars, despite their proximity to a location, less than a kilometer away, with shock veins and associated high pressure phases stishovite and maskelynite [3]. It should be noted though, that the feldspars within the anorthositic gneisses of the central uplift have a higher An content than those of the surrounding intermediate gneisses and that shock deformation may not be manifest the same in feldspars of different compositions. The shatter cones within the central uplift may have formed at higher shock pressures than those typically attributed to their formation, as indicated by the presence of stishovite and maskelynite; or the centrally uplifted lithologies were exposed to lower, bulk shock pressures, which resulted in the generation of the shatter cones and that the stishovite and maskelynite represent the manifestation of localized shock excursions.

Finally, many of the shatter cone surfaces have cataclasite associated with them, which postdates the formation of the PDFs and preserves textures indicative of movement and shear related to their formation. This supports previous work [4], which has suggested SC's form after the passage of the shock wave.

References: [1] Dressler B. O. *(1990) Tectonphysics, 171*, 229-245. [2] Ostertag R. (1983) *JGR, 88,* B364–376. [3] Biren M. B. and Spray J. G. (2011) *EPSL, 303, (3),* 310–322. [4] Baratoux D. and Melosh H. J. (2003) *EPSL, 216,* 43-54.

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