COMPLEX CRATER FORMATION AND COLLAPSE: OBSERVATIONS AT THE HAUGHTON IMPACT STRUCTURE, ARCTIC CANADA. G. R. Osinski, J. G. Spray, Planetary and Space Science Centre, University of New Brunswick, 2 Bailey Drive, Fredericton, NB E3B 5A3, Canada. (osinski@lycos.com).

Introduction: It is generally believed that the processes involved in the formation of an initial transient crater and its subsequent excavation, are common for all craters, regardless of their size. A critical assumption is that the depth/diameter ratio of a transient crater remains constant for any given crater size [1,2]. The morphological diversity of impact structures is, therefore, attributed to the modification or collapse of an initial simple hemispherical transient crater [e.g., 2]. The mechanisms of impact crater collapse remain one of the least understood stages in the impact cratering process. Indeed, standard strength models used in conventional hydrocode modeling techniques are not successful in describing crater collapse [2]. Numerical models have also rarely been constrained by field data from terrestrial impact structures. This is, however, a catch-22 situation because very few detailed field investigations of the tectonics of complex impact structures have been made.

Here, we present new constraints on the formation of complex impact craters based on detailed field studies of the Haughton impact structure, Arctic Canada.

Geological setting: The 23 Ma, 24 km diameter Haughton impact structure has been the focus of detailed field investigations over the course of 4 field seasons (1999-2002) as part of the PhD thesis of GRO. Haughton is superbly exposed due to the prevailing polar desert environment. The target rocks consist of 1880 m of almost flat lying sedimentary rocks overlying Precambrian metamorphic basement. Key stratigraphic horizons provide evidence for the depth of excavation and amount of structural uplift and deformation.

Reconstruction of the transient crater: Questions remain as to the exact size of the transient crater at Haughton. Seismic reflection data suggest a diameter of ~12 km [3]. The presence of basement gneisses in the crater-fill melt rocks indicates a depth of excavation (H_{exc}) between 1880 m and ~2200 m. It is generally considered that the depth of the transient crater (H_{tc}) is ~2-3 times greater than H_{exc} [4]. This would yield a H_{tc} of ~4-6 km for Haughton. However, this is incompatible with our field studies and previous seismic investigations [3] that do not indicate significant deformation and displacement of the Precambrian basement (depth to upper surface: 1880 m).

Modification of the transient crater: Our work has revealed that the tectonic modification of the early-formed Haughton crater involved the complex interaction of a series of interconnected concentric and radial faults.

Radial faults. Radial faults record predominantly oblique strike-slip movements. There is generally little (<10 m) or no displacement of marker beds across radial faults. This is despite the fact that substantial volumes of fault breccia (>8 m) are typically present. Importantly, these radially orientated faults are cut and offset by later concentric faults.

Concentric faults. It is noticeable that the intensity and style of concentric faulting changes around the periphery of the crater. They are predominantly listric extensional faults with rotation of beds in the hanging-wall up to ~75°. The outermost concentric faults generally dip in towards the centre of the crater. We suggest that these faults were initiated during the inward collapse of the crater walls. The innermost faults, however, tend to dip away from the crater centre and may represent the outward collapse of the central uplift. The outermost concentric faults typically display two episodes of deformation: (1) early major dip-slip extensional movement; (2) later minor oblique strike-slip movement resulting in the offset of radial faults. A zone of (sub-) vertical faults and bedding occurs along the edge of the central uplift (~6 km radius). This suggests complex interactions between the outward collapsing central uplift material and the inward collapsing crater walls.

Comparison with models: It appears that the transient crater at Haughton was significantly shallower than current models for the cratering process predict. This may suggest a decrease in the depth/diameter ratio of transient craters with increasing crater size. This will have important implications for estimating the size of deeply eroded large impact craters (e.g., Vredefort).

Field studies at Haughton indicate that deformation during the modification stage of complex impact crater formation was brittle and localized along discrete fault planes. We find no evidence to support the hypothesis of 'acoustic fluidization' throughout the whole crater. The presence of little offset along radial faults, despite the large thicknesses of fault breccia, may suggest limited block oscillation along discrete fault surfaces as proposed by Ivanov et al. [5]. However, the scale seen in the field at Haughton is greater than in the models [5].

Acknowledgments: This work represents part of the PhD thesis of GRO and was funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) through research grants to JGS.

References: [1] Grieve R. A. F. et al. (1981) *LPS XII*, 37-57. [2] Melosh H. J. and Ivanov B. A. (1999) *Annu. Rev. Earth Planet. Sci.*, *27,* 385-415. [3] Scott D. and Hajnal Z. (1988) *Meteoritics & Planet. Sci., 23,* 239-247. [4] Melosh H. J. (1989) Impact Cratering: A geologic process. Oxford University Press, 245 pp. [5] Ivanov, B. A. et al. (1996) *LPS XXVII*, 589-590.