Haughton Impact Structure: Re-evaluation and reassessment of its history and current state. Virgil L. Sharpton, [1]University of Alaska Fairbanks, Fairbanks, AK 99775 and Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058 (buck.sharpton@alaska.edu).

Introduction: The Haughton impact structure is located at 75º 22´N; 89º 41´ W on the western portion of Devon Island in the Canadian Arctic. The target consists of ~2-km of well-stratified, nearly flat-lying marine sediments overlying crystalline basement (Fig. 1). The allogenic impact breccia forms a nearly continuous unit ranging from ~10 m to over 100 m in thickness within the 10-kmwide central basin and beyond. This breccia was derived primarily from the platform rocks; however, a 10-15 wt% silicate component proves that the excavation cavity penetrated into the subjacent crystalline basement.

In a series of recent papers, Osinski and coworkers boldly re-interpret the history and current state of the Haughton impact structure. Unfortunately several of their assertions are weakly founded and other explanations appear more plausible. Herein, I address several of these assertions and present alternative perspectives.

Crater-fill deposits are carbonatitic melt rock [1,2]. Previous to the work of [1,2] Haughton's crater-fill deposits were universally interpreted to be allochthonous polymict breccias composed of lithic and mineral clasts, representing the sedimentary target rock assemblage and shocked to various degrees, embedded in a fine-grained carbonate clastic matrix [e.g. 3]. Based on their interpretation of microscopic 'carbonate-silicate liquid-immiscible' textures observed within the fine-grained, carbonate-rich matrix, however, Osinski and Spray reinterpret the crater-fill deposits as carbonatitic melt rock. However, this fails to consider that high static pressures (>kbar) are required in order to melt (rather than decarbonate or calcinate) $CaMg(CO_3)_2$ [4]. While extremely high dynamic pressures are part of the impact process, it is the *release* from this initial compression that generates melting and vaporization [5]. While limited development of carbonate melts as small-scale enclaves is not disputed, it seems unlikely that this P-T regime would result in widespread carbonatitic melt rock formation, where the matrix is composed of carbonate melt. As an alternative, I suggest that most, if not all, the microtextural features interpreted to represent carbonate-silicate immiscibility [1,2] is instead due to vesiculation, alteration, and carbonate decomposition as the highly reactive crater fill deposits were formed, emplaced, cooled, and altered.

CO_2 released upon impact is considerably less than previously estimated [1]. A direct result of Osinski and co-workers conclusion above is that the vast majority of the carbonate was not calcinated and remains unaltered in the melt rock. This interpretation, however, is not consistent with their further work which states "the presence of immicible textures between carbonate and SiO_2 glass at Haughton would suggest initial textures (sic) of >1500-2000˚C" [3]. This is well above the calcination temperature of carbonates (~850˚C). Therefore, much of the CO_2 would have been removed from any crater fill experiencing these residual temperatures by the reaction:

$CaCO_3 \rightarrow CaO + CO_2(g)\uparrow$ (above 850˚; 1 bar)

As the crater cooled and the crater lake formed, a second reaction occurred:

$CaO + H_2O \rightarrow Ca(OH)_2$

Which, over time, the crater fill becomes a CO_2 sink:

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$,

resulting, after nearly 40 million years in complete reversion of the original carbonate component. These reactions will occur if post emplacement temperatures exceeded the calcination temperature as expected and accepted by [1]. They result in volume changes over time, which could explain the shallow dips in the lake beds of the Haughton Formation observed by [Hickey et al]. Of more immediate concern, however, these reactions demonstrate that the present volume of carbonate observed in crater fill deposits – whether in Haughton, Ries, or Chicxulub – cannot be used to estimate the atmospheric release of CO_2 resulting from these impact events.

Haughton crater-fill rocks originally exceeded 200 m depth and 12 km^3 in volume [2]. This interpretation is based on the observation that vestiges of the original deposit occur up to 140 m above the lowest lying occurrences. However, the highest deposits are located on the flanks of the structure and the lowest deposits are at the structure center [Fig 1], consistent with the deposits being draped over subjacent para-autochthonous crater floor and walls, as seen in all well-preserved impact craters. Consequently, current topographic variations in crater fill deposits in Haughton are not a reliable indicator of the original unit volume or the amount of subsequent erosion these deposits have experienced. The presence of post-impact lacustrine deposits, however, does provide some constraints on original crater-fill dimensions and these do not support thickness nor volumes as great as Osinski and Spray indicate.

Based on assessment of seismic data and outcrops, I estimate the original basin fill to have been less than 8 km^3.

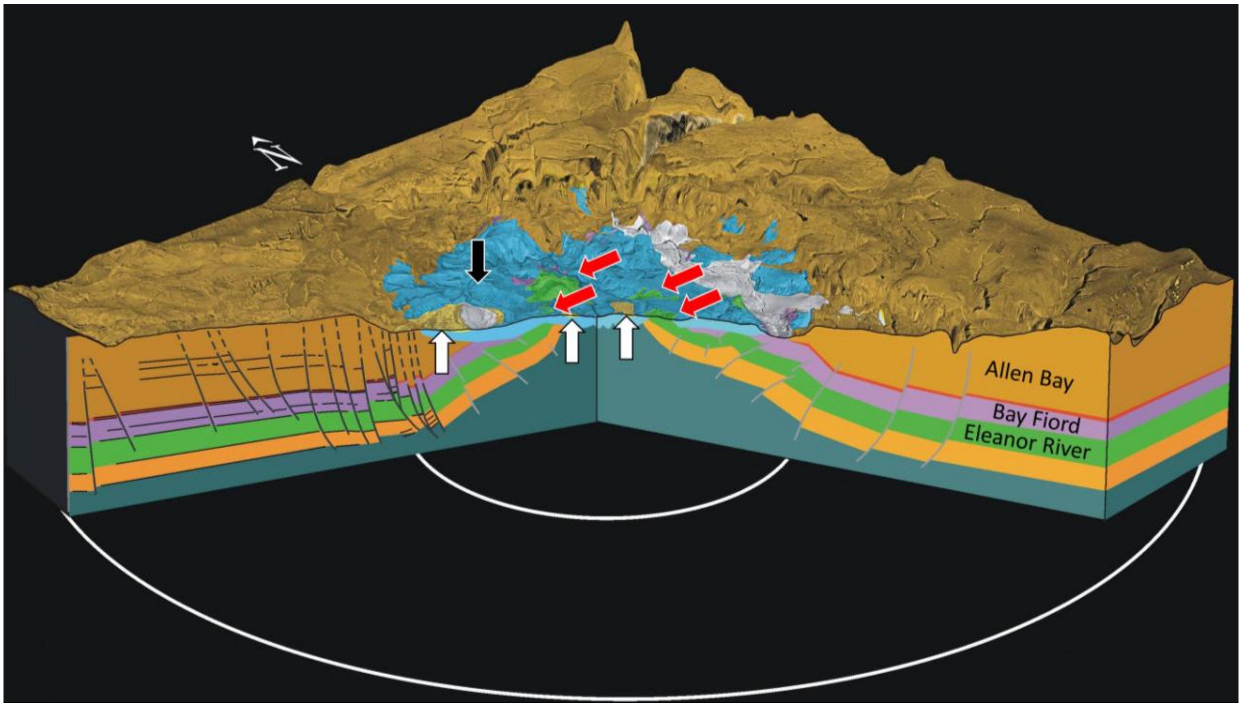

Fig. 1: Perspective view of Haughton impact structure topography and lithological relationships. White arrows signify major remnants of post-crater lake deposits; red arrows point to outcrops of Elenor River carbonates which form the central peak ring, and the black arrow points to the allogenic crater fill deposits which are shown in blue. Seismic line from [6], lithologies from [7], with updates.

"There is no central peak or peak ring at Haughton [3]". This interpretation arises from Osinski and Spray's estimate of the original crater fill volume [3]. They dismiss the importance of the subsequent deposits (i.e., the Haughton Fm.) laid down as a lake filled the crater. However, Hickey et al [5] present abundant evidence that limits the amount of reworking and erosion of the underlying crater fill deposits: "The gradational contact between the [Haughton] formation and the underlying ejecta blanket shows no sign that any protracted period of weathering or erosion intervened between formation of the crater and the onset of Haughton deposition". Thus, these lake beds originally covered the unmodified crater topography. My co-workers and I have documented residual deposits of these lake deposits near the center of the structure and along the flanks as shown in Fig. 1. Located at a mean radius of ~2.2 km is a discontinuous ring of parautochthonous inliers of Eleanor River and Bay Fiord Fm, uplifted from their normal stratigraphic positions by >1 km. Exposures exhibit shatter cones, as well as steep dips, fractures, and faults but retain their original stratigraphic relationships. Post-impact lake deposits partially cover the ring and adjacent breccias to the west. Three observations indicate that the ring of Eleanor River outcrops represents a true, albeit poorly-formed, peak ring:

1. The ring is covered in places by lake deposits, indicating it was exposed immediately after formation;
2. The base of the lake deposits is lower than the ring in virtually all locations, also indicating that the ring was a topographic feature;
3. Deep excavation (into the crystalline basement) must have occurred inside the, so the existing exposures do not represent a poorly exposed central peak.

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