GARSON MEMBER OF ONAPING FORMATION, SUDBURY: CONSTRAINTS ON PEAK RING ORIGIN?

R. A. F. Grieve[1], G. R. Osinski[1] and G. S. Collins[2], [1]Dept. Earth Sciences, Western Univ., 1151 Richmond St., London, ON, N6A 3K7, Canada, [2]Dept. Earth Sciences and Engineering, Imperial College, Prince Consort Rd., London, UK SW7 2BP.

Introduction: A recent review of the constraints on peak ring formation from remote sensed Lunar Reconnaissance Orbiter data, in comparison with numerical models, is somewhat equivocal as to supporting, or not, differing working hypotheses for the formation of peak rings [1]. As the only current source of such ground-truth data, observations at terrestrial impact structures provide important constraints on understanding impact processes. Peak rings, however, occur only in large impact structures of which there are limited examples preserved on Earth. Various lines of evidence suggest that the three largest known impact structures on Earth: Vredefort, Sudbury and Chicxulub, all had some form of peak ring [2]. Only the buried Chicxulub structure, however, has a preserved topographic peak ring, based on the extensive interpretation of reflection seismic data [3]. The analyses of Chicxulub geophysical data provide some constraints on current numerical models of peak ring formation, with the predictions of the models in general agreement with the interpreted architecture of Chicxulub [4]. The exact character of the peak ring at Chicxulub is currently being investigated through a joint IODP-ICDP drilling expedition [5].

The Sudbury impact structure and the Garson Member of the Onaping Formation: The 1.85 Ga Sudbury impact structure has an estimated original diameter in the 200-250 km range and, as such, the original structure most likely included a peak ring [2]. The outer portions of the Sudbury structure, however, are heavily eroded and no topographic expression of a ring structure remains. The interior of the Sudbury structure (the so-called Sudbury Basin), however, contains a complete section through the original impactite sequence from parautochonous crater floor lithologies, through coherent impact melt sheet (the Sudbury Igneous Complex (SIC)) to post-impact sedimentary infill lithologies. This preservation is due to folding and faulting by post-impact deformation.

The so-called Garson Member of the Onaping Formation provides proxy evidence of the nature of the now removed peak ring at the Sudbury impact structure. The Garson immediately overlies the main mass of the SIC in its SE lobe. It occurs over a strike length of 25 km and has a maximum thickness of ~ 500 m. Its original thickness may have differed, as it has been severely affected by the so-called South Range Shear Zone. The Garson was previously included in the "Basal Onaping", along with lithologies now interpreted as the roof rocks of the SIC and renamed the "Upper Contact Unit" [6]. Although occupying the same stratigraphic position and also representing the upper roof rocks of the SIC [7, 8] (and not, therefore, actually part of the Onaping Formation), the Garson differs in some important characteristics from the roof rocks of the SIC elsewhere. Most importantly, its lithic clasts are: much larger (up to > 50 m), much more abundant (up to 85 %) and essentially monomict (> 99 % being Mississagi quartzite). Clasts of Mississagi also occur in the underlying local Granophyre of the SIC. Included lithic clasts in roof rocks are most easily assumed to represent fallback material from some form of impact plume into the upper portions of impact melt sheets. While this is consistent with a polymict lithic clast population for roof rocks, in general, it is not so for an essentially monomict population, as in the Garson. Logic dictates, therefore, that the monomict clast population must have originated from a relatively "coherent" source of Mississagi, which was emergent from the coherent melt sheet, i.e., they are potentially a preserved sample of an original ring structure.

Interpretative Significance: The target rocks at Sudbury consisted of Archean granite-greenstone terrain overlain by 8-11 km of Huronian Supergroup meta-volcanics and -sediments, which includes the Mississagi. If the topographic source of the Mississagi clasts was part of an emergent peak ring, reconstructing the stratigraphic package for the Huronian in the area [9] puts the nominal original source depth for the Mississagi at ~ 7 km. This is somewhat shallower than the ~ 12 km estimated for the depth of origin of a ring structure at Sudbury from extrapolating the numerical simulation of peak ring formation at Chicxulub [4]. Some of the Mississagi clasts display heavily annealed shock features (PDFs), which provides an additional constraint for estimating original depth. Post-impact effects: inclusion and heating by the SIC, post-impact orogenesis and the locally very severe shearing by the South Range Shear Zone, however, all make the use of original recorded shock levels as a depth estimating tool more difficult.

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