DEFORMATION AND SHOCK METAMORPHISM IN THE CENTRAL UPLIFT OF THE EAST CLEARWATER LAKE IMPACT STRUCTURE. A. S. P. Rae¹, R. A. F. Grieve², G. R. Osinski²,³, G. S. Collins¹ and J. V. Morgan¹, ¹Department of Earth Science and Engineering, Imperial College London, SW7 2BP, UK, a.rae14@imperial.ac.uk. ²Department of Earth Sciences, University of Western Ontario, London, ON, N6A 5B7, Canada. ³Department of Physics and Astronomy, University of Western Ontario, London, ON, N6A 5B7, Canada.

Introduction: The formation of central peaks in craters requires structural uplift to occur. However, the kinematics and dynamics of this process remains unclear. In particular, the timing and distribution of deformation during cratering is largely unknown. Here, combined structural, petrographical, and numerical modelling techniques are used to constrain the process of central uplift formation.

Located in northern Quebec, Canada (56°4’N, 74°6’W), East Clearwater Lake is generally considered to be a 22-km diameter central-peak impact structure. Originally thought to be coincident with the West Clearwater Lake impact event (286 ± 2.2 Ma), recent dating has indicated that the East Clearwater Lake impact structure is significantly older (460-470 Ma) [1]. There are no sub-aerially exposed outcrops within the East Clearwater Lake structure. However, 2 drill cores were recovered during the mid-1960s by the Dominion Observatory, alongside 5 drill cores from West Clearwater Lake. The locations of the 7 drill cores are indicated in Figure 1. One of the two East Clearwater Lake cores (1-64), located close to the centre of the East Clearwater Lake structure penetrated ~ 120 m of water, ~ 12 m of glacial drift, ~ 25 m of post impact sediments, and ~ 880 m of deformed para-autochthonous basement rocks. The second core at East Clearwater Lake (2-63) was located away from the centre of the structure and penetrated several hundred metres of post-impact sediments and allochthonous impactites. The hole deviated significantly from vertical with depth and did not reach para-autochthonous impactites. The composition of the impact melt rocks in this core indicate that the impactor was chondritic [2,3]. A comprehensive review of the West and East Clearwater Lake structures can be found in [4].

The aim of this study is to understand the kinematics of central uplift formation during complex crater collapse. Here, core logging and shock barometry results are presented. Furthermore, comparisons are drawn between East Clearwater Lake and West Clearwater Lake with respect to shock barometry and the results of numerical simulations [5].

Methods: The drill core, 1-64, was logged and petrographically analysed. Alongside the lithology, particular attention focused on the styles and extent of structural deformation. The distribution of deformation in the core was statistically analysed. Petrographical analysis was carried out on thin sections of the core, alongside the core logging.

After initial logging and petrographic description, shock barometric estimates of the para-autochthonous rocks were made by obtaining measurements of planar deformation features (PDFs) in quartz. These measurements were acquired through the use of a Zeiss 4-

Figure 1: The Clearwater Lake impact structures: left) Satellite image of Clearwater Lake taken by Landsat (Image Source: Landsat Operational Land Imager/ USGS), right) Outline map of Clearwater Lake, contours are in intervals of 50 m above lake level. Red dots indicate the locations of drill cores in both the West and East Clearwater Lake impact structures (Data source: CDED, Geo-Base Canada). Modified from [5].
axis universal stage and optical microscope. PDFs were indexed using ANIE v1.1 [6], individual quartz grains were assigned shock pressures based on [7, and references therein], and overall shock pressure estimates were obtained using the method of [8].

Numerical modelling of the East Clearwater Lake impact event was accomplished using the iSALE shock physics code [9, and references therein].

**Results and Discussion:** Our observations from core 1-64 suggest that cataclastic shear is the primary mechanism of deformation during central uplift formation. These deformation zones are localized, but abundant, occurring with a ~1-10 m spacing, frequently displacing texturally and/or compositionally distinct target lithologies against each other, and which, individually, can range from sub-mm to 10 cm in size where the average width decreases as depth increases. Furthermore, the extensive comminution that has occurred to produce each cataclasite indicates that they were continually, or even repeatedly active, during crater modification. Melt veins are infrequent and breccias (>30% of clasts larger than 2 mm [10]) are rare.

Our shock barometry results (Figure 2) indicate that the para-autochthonous rocks currently found in the central uplift of the East Clearwater Lake structure experienced shock pressures up to 15 GPa. Compared to results from the central drill core, 1-63, at West Clearwater Lake [5], this is a slightly lower maximum shock pressure. There is a similar attenuation rate with depth between the two cores.

The amount of variability in the shock estimates in core 1-64 decreases with increasing depth. This correlates with a decrease in the frequency of observed deformation towards the bottom of the core. Additionally, the shock reversals at ~550 m and ~850 m depth, coincide with increased occurrences of striated fracture surfaces. These observations may indicate that the “scatter” in the shock estimates reflects a real variation due to the increasing size of individual fault bounded blocks with depth.

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![Figure 2: Results from shock barometry estimates made of samples from the East Clearwater Impact Structure. Data from East Clearwater Lake is indicated by the blue points, data from core 1-63 in the West Clearwater Lake impact structure is shown in red for comparison (See [5]). Left, estimated peak shock pressures using the method of [8] by sample depth. Right, number of indexed PDFs per grain (N*/n) by sample depth.](image)