# Deformation and Shock Metamorphism in the Central Uplift of the East Clearwater Lake Impact Structure


A. S. P. Rae[1*], R. A. F. Grieve[2], G. R. Osinski[2,3], G. S. Collins[1], and J. V. Morgan[1]

[1]Impacts and Astromaterials Research Centre, Department of Earth Science and Engineering, Imperial College, London, SW7 2BP, UK
[2]Department of Earth Sciences, University of Western Ontario, London, ON, N6A 5B7, Canada
[3]Department of Physics and Astronomy, University of Western Ontario, London, ON, N6A 5B7, Canada

*Corresponding address: a.rae14@imperial.ac.uk


Imperial College London

IARC Impacts & Astromaterials Research Centre

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## 1. Introduction

- The kinematics of complex crater formation are uncertain, particularly in crystalline rocks.

- Comparing geological observations of deformed shocked target rocks with numerical simulations of complex crater collapse can resolve this uncertainty.

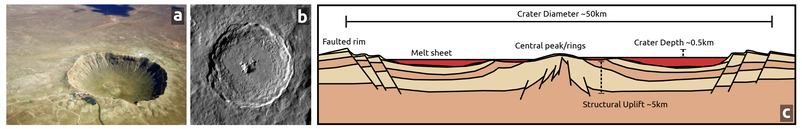


***Figure 1:*** *a) Barringer, a simple crater, b) Tycho, a complex central peak crater, c) a schematic cross-section of a complex crater, based on [1].*

- Here, we investigate deformation and shock metamorphism at the East Clearwater Lake impact structure.

## 2. Case Study: East Clearwater Lake

East Clearwater Lake (**Figure 2**) is a 460-470 Ma old [2], 22 km diameter complex crater [3]. The West Clearwater Lake impact structure is younger (286.2 +/- 2.2 Ma), and larger than the East Clearwater structure [4]. Drill core data indicates that East Clearwater posseses a central uplift.

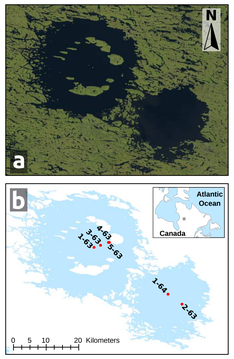


***Figure 2:*** *a) Satellite image of Clearwater Lake. b) Outline map of Clearwater Lake Red dots indicate the locations of drill cores. Modified from [4]*

## 3. Methods and Materials

Firstly, core 1-64 was logged, focussing on structural deformation. Secondly, estimates of peak shock pressure were made by petrographic analysis. Shock pressure estimates were made following the method of [5].

Numerical simulations were carried out using the iSALE shock physics code [6].

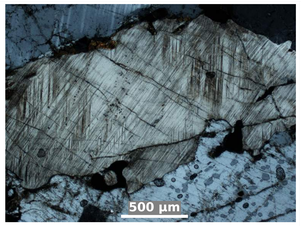


***Figure 3:*** *Two PDF sets in quartz under cross-polarised light.*

| Shock Feature | Pressure Interval |
|---|---|
| No PDFs, within shatter cone radius | 2-5 GPa |
| (0001) | 5-10 GPa |
| $(10\bar{1}3)$ | 10-20 GPa |
| $(10\bar{1}2)$ | 20-35 GPa |
| Diaplectic Quartz | >35 GPa |

***Table 1:*** *Shock classification scheme. Based on [7].*

## 4. Core Logging and Shock Barometry Results

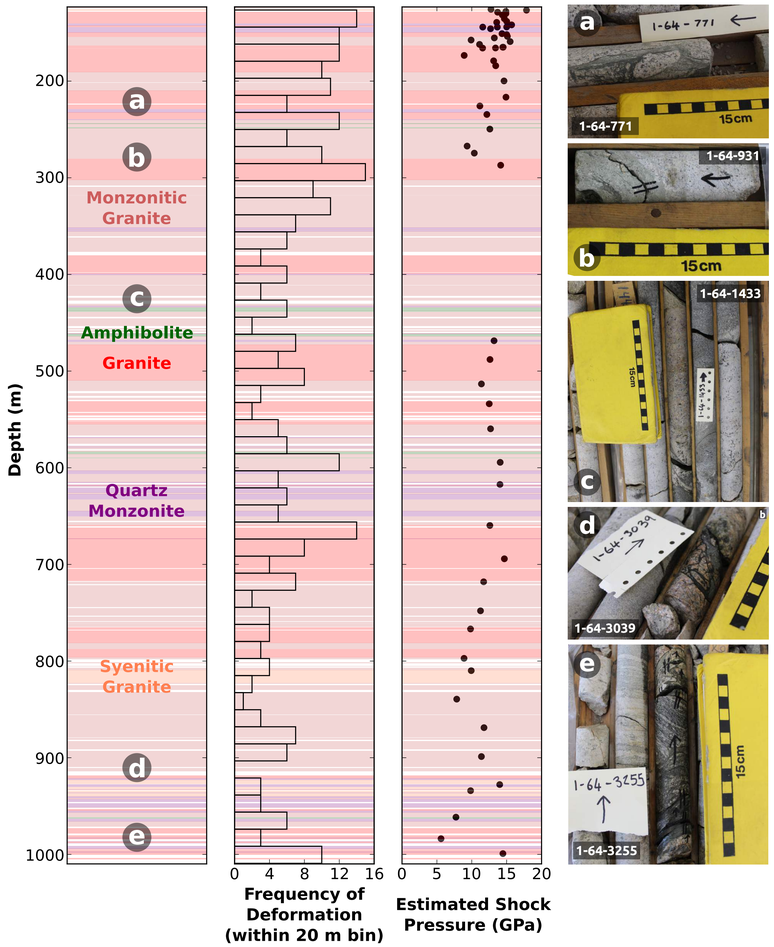


***Figure 4:*** *Core 1-64 log, with the occurence of deformation (cataclasites, melt veins/ pseudotachylites, and breccias), and shock pressure estimates. Drill core photographs are shown on the right.*

| Samples | No. of measured sets (N) | No. of indexed PDFs (N*) | Unindexed (%) | No. of quartz grains (n) |
|---|---|---|---|---|
| 58 | 2839 | 2570 | 10.5 | 1671 |

No. of PDF sets, % relative to n

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 7.5 | 39.5 | 41.5 | 10.1 | 0.3 |

Indexed plane abundance (absolute frequency %)

| (0001) | $(10\bar{1}3)$ | $(10\bar{1}2)$ | $(10\bar{1}1)$ | $(10\bar{1}0)$ | $(11\bar{2}2)$ | $(11\bar{2}1)$ | $(21\bar{3}1)$ | $(51\bar{6}1)$ | $(11\bar{2}0)$ | $(22\bar{4}1)$ | $(31\bar{4}1)$ | $(40\bar{4}1)$ | $(51\bar{6}0)$ | $(10\bar{1}4)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42.8 | 28.1 (+ 6.4) | 4.7 | 0.5 | 0.3 | 0.7 | 0.7 | 0.7 | 0.5 | 0.2 | 0.3 | 0.3 | 0.1 | 0.0 | 13.8 |

***Table 2:*** *Summary of all universal-stage results. PDF sets in overlap between $(10\bar{1}3)$ and $(10\bar{1}4)$ were assigned the $(10\bar{1}3)$ orientation. A 5° envelope was used to assign PDFs.*

## 5. Discussion and Conclusions

- There is a high variability of shock pressures in the upper 200 m, this is concurrent with a high frequency of deformation. These observations indicate that the size of coherent rock blocks in complex crater formation gets progressively larger away from the point of impact.

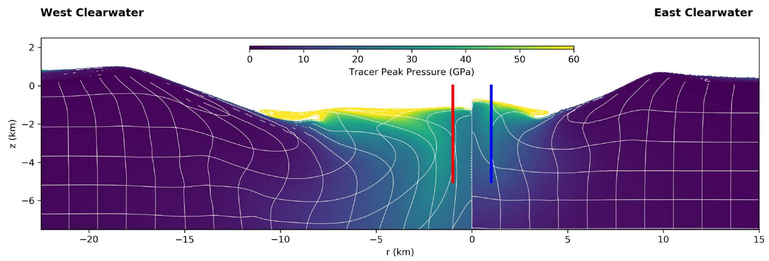


***Figure 5:*** *Comparison of the final shock distributions in numerical simulations of the East and West Clearwater impact events. All parameters (based on [4]), except for the impactor diameter, are constant between the two simulations.*

- Compared to West Clearwater, the magnitude of estimated shock pressures is similar, and observed shock pressures attenuate at a similar, or slightly greater rate, at East Clearwater.

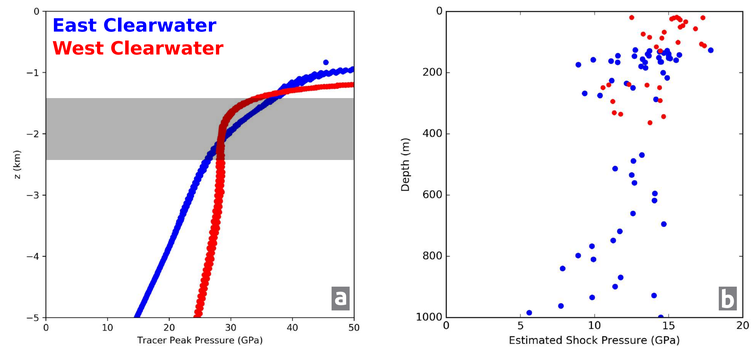


***Figure 6:*** *a) Shock attenuation in simulated drill cores with locations indicated on **Figure 5**, corresponding to drill cores 1-64 (East Clearwater) and 1-63 (West Clearwater). b) Measured shock attenuation in drill cores 1-64 (This study), and 1-63 [4].*

- There is a large discrepancy between predicted shock pressures in numerical simulations and observed shock pressures.

## 6. References


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## 7. Acknowledgments


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