

**PRESERVATION OF BIOLOGICAL SIGNATURE WITHIN IMPACT MELT BRECCIAS, HAUGHTON IMPACT STRUCTURE.** P. Lindgren<sup>1</sup>, J. Parnell<sup>1</sup>, S.A. Bowden<sup>1</sup>, C. Taylor<sup>1</sup>, G.R. Osinski<sup>2</sup>, P. Lee<sup>3</sup>, <sup>1</sup>Dept. of Geology, University of Aberdeen, Aberdeen AB24 3UE, U.K., (P.Lindgren@abdn.ac.uk), <sup>2</sup>Canadian Space Agency, Saint-Hubert, Quebec J3Y 8Y9, Canada, <sup>3</sup>SETI Institute, NASA Ames Research Center, Moffett Field, CA 94035-1000, U.S.A.

**Introduction:** The response of organic matter to impact events is of widespread interest for what it tells us about the likelihood of survival of life and/or fossilized biological signatures [1,2,3] following impacts. This is relevant to the history of life on Earth, and to our exploration of other solar system bodies, including Mars.

The Tertiary Haughton Impact Structure, Canadian High Arctic [4], is well suited to such studies because the target bedrock consists of Lower Palaeozoic carbonates that contain kerogen and pre-impact hydrocarbon residues. A further advantage of using the Haughton Impact Structure is that there has been no heating in the crater after the impact event and subsequent hydrothermal activity. This enables us to compare the impact-affected rocks with rocks from outside the crater.

**Objectives:** Previous research showed that although the crater centre registered greater heating than the rest of the crater, it still contains organic compounds that are a signature of fossil biological activity [3].

In the next phase of this research we have examined the Haughton carbonate impact melt breccia. This is a crater-fill deposit which is composed of lithic (non-melted) fragments of the target rocks, including clasts of the carbonate bedrock, embedded in a matrix of a carbonate/silicate melt. The melt experienced temperatures of at least 600 °C [5] and possibly much higher. Our objective is to determine if biomarkers survived within the carbonate clasts embedded in the hot melt, and if so, to compare heating at the edge and the centre of the clasts, were the centre may have been buffered from extreme heat.

**Sampling and analytical procedure:** The carbonate clasts in the melt breccia vary in size from less than a centimetre to a few meters across. For investigation of a possible increase in heating from the centre of a clast to the edge of a clast, samples of clasts each of ca 20 cm<sup>3</sup> were sampled. Smaller sizes of clasts were also selected to see if there is a minimum size in which organic molecules are preserved. The matrix attached to the edge of the clasts was removed and the samples were cleaned with solvent to eliminate possible contamination. Material 0-1 cm from the edge and material from the centre of the

clasts was sub-sampled, Soxhlet extracted and analysed with gas chromatography-mass spectrometry for detection of biological signatures. Particular attention was paid to mass fractions  $m/z=191$  (hopanes) and  $m/z=217$  (steranes). Biological marker maturity parameters were used to measure the relative amount of heating in the center compared to the edge of the clasts. The maturity parameters presented in this study are thought to reflect carbon-carbon cracking and include the pregnane/sterane ( $C_{22}/C_{29}$  regular steranes) and tricyclic terpane/hopane ( $C_{23}/C_{30}$  terpanes) maturity parameters [6]. These parameters have previously been used to evaluate the degree of heating in reservoirs where oil has been cracked to gas by exposure to relatively high temperatures (up to 215 °C) for millions of years.

**Results:** Despite the high temperatures (600 °C or more) of the melt breccias, biological signatures in each of the isolated carbonate clasts have survived (Fig.1), even at the edge of the clasts, which were in direct contact with the impact melt. This is probably a consequence of the relatively short period of time for which the clasts were exposed to these high temperatures. The matrix that the clasts are embedded in was melted, but cooled relatively quickly from very high temperatures to form glass. Kinetic modelling suggests that after the instantaneous shock heating in the crater following impact, a lower temperature heating at a maximum of 210 °C carried on for ~5000 years [3].

Most of the data obtained so far indicate that we can measure a thermal gradient in the clasts with higher maturity (more heating) at the edge of the clast and lower maturity in the centre of the clast. In three of the four carbonate clasts, this trend is shown by both maturity parameters. The other clast shows this trend using the pregnane/sterane parameter, but the tricyclic terpane/hopane parameter yields a reverse trend. A sample of smaller clasts each of 2 cm<sup>3</sup> gives higher maturity values similar to the values seen at the edge of the larger clasts. Samples from outside of the crater, not affected by the impact, have similar or lower values than the centre of the larger clasts.

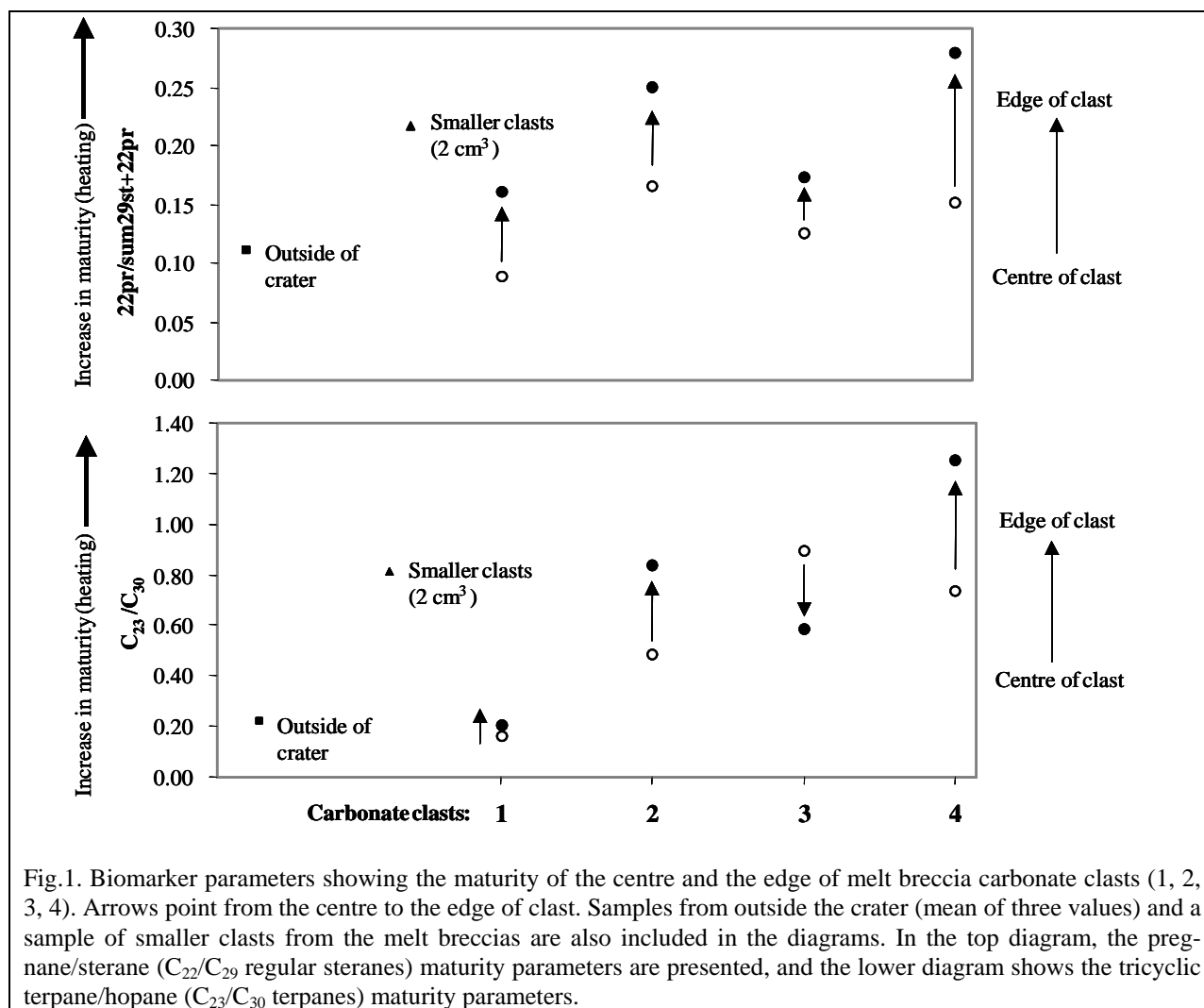


Fig.1. Biomarker parameters showing the maturity of the centre and the edge of melt breccia carbonate clasts (1, 2, 3, 4). Arrows point from the centre to the edge of clast. Samples from outside the crater (mean of three values) and a sample of smaller clasts from the melt breccias are also included in the diagrams. In the top diagram, the pregnane/sterane ( $C_{22}/C_{29}$  regular steranes) maturity parameters are presented, and the lower diagram shows the tricyclic terpane/hopane ( $C_{23}/C_{30}$  terpanes) maturity parameters.

**Conclusion:** This study shows that fossil biological signatures can be preserved in isolated clasts embedded in an impact melt. The survival of biosignatures even in the sample of smaller clasts (2 cm<sup>3</sup>), suggests that sampling and analyses of comparable material should be carried out during planetary exploration.

The results also indicate that there is a thermal gradient from the centre of a clast to the edge of a clast, which means that we are more likely to find biological signatures preserved in the centre. Impact cratering is an abundant process in our solar system. Therefore impact-processed rocks make up a significant proportion of the rocks exposed on Mars and other planets with little or no recent crustal reworking (plate tectonics or something similar). This material could potentially be analysed on Mars and other

planets for detection of organic molecules and biological signatures.

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