THE RAMAN SIGNATURE OF SHOCKED CARBONATES FROM THE HAUGHTON IMPACT STRUCTURE, DEVON ISLAND, CANADA. P. Lindgren[1], C. Broman[1], N. G. Holm[1], J. Parnell[2], S.A. Bowden[2], G.R. Osinski[3], P. Lee[4], [1]Department of Geology and Geochemistry, Stockholm University, S-106 91 Stockholm, Sweden, [2]Department of Geology and Petroleum Geology, University of Aberdeen, Aberdeen AB24 3UE, U.K., [3]Departments of Earth Sciences and Physics and Astronomy, University of Western Ontario, 1151 Richmond Street, London, Ontario, N6A 5B7 Canada, [4]SETI Institute, NASA Ames Research Center, Moffett Field, CA 94035-1000, U.S.A. Email: (paula.lindgren@geo.su.se)

Introduction: Carbonates are the major component in the sedimentary target succession of the Haughton impact structure, Canada. The carbonates are mainly composed of calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$). It has been debated whether impacts in carbonate-rich targets have caused CO_2-degassing, triggering climate changes and extinction events [1,2]. The shock decomposition of carbonate minerals have been studied both in experiments [3] and natural targets [4]. More recently it has become apparent that melting is a common, and perhaps dominant response of carbonates to impact [5].

We have investigated the Raman signature of calcite and dolomite in shocked carbonate clasts within the Haughton impact melt rocks.

Target rocks and impactites: The Haughton impact structure [6] on Devon Island, Canadian High Arctic, formed about 39 million years ago [7]. Haughton is a complex impact structure, with an apparent diameter of 23km [8]. It is a relatively well-preserved structure, located in a region where no major metamorphism has occurred after the impact. This makes Haughton suitable for studies concerning impact-induced effects of target components.

The Haughton target succession consists of a 1880m thick Lower Paleozoic sedimentary sequence, overlying a Precambrian crystalline basement. Carbonate rocks comprise ~75-80% of the sedimentary succession [8]. The impact caused the formation of clast-rich impact melt rocks. These impact rocks fill the center of the crater, and consist of lithic (and melted) clasts derived from the various target rocks, primarily of carbonates (Fig. 1), set in a fine-grained groundmass composed of carbonate, sulfate and silicate impact melt phases [9]. The carbonate clasts in the melt rocks often exhibit shatter cones, which are an indicative feature of impact events and shock pressures >2GPa [10].

Samples and analytical procedure: Three samples of carbonate clasts from the impact melt rock, one sample of carbonate bedrock from outside the crater, and for comparison one sample of a typical euhedral dolomite from St. Gotthard, Swiss Alps, were investigated by Raman analyses. The Raman spectrometric analyses were conducted at the Dept. of Geology and Geochemistry, Stockholm University. Raman spectra were acquired by using a multichannel Dilor XY Laser Raman spectrometer. The laser source was an Innova 70 argon laser with a wavelength of 514.5nm (green line). Laser focusing on the sample was performed through a petrographic microscope fitted with a 100X objective. The laser power was set at 200mW at the entrance of the microscope. The spectra were accumulated in 20 increments with a measuring time of 3s each. Calibration was made with respect to wavenumber using a neon laser and a silicon standard.

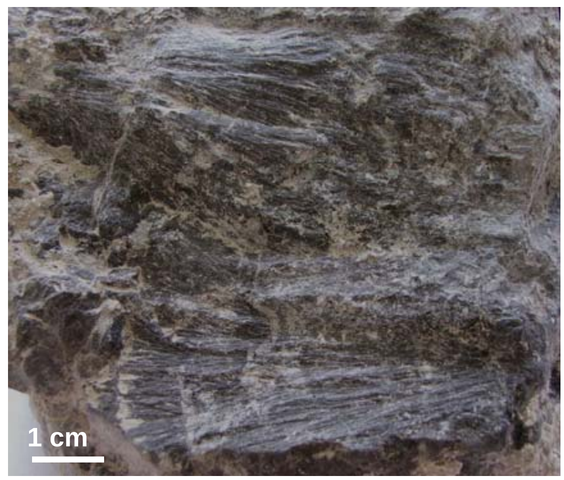

Fig. 1. A carbonate clast with shatter cones from the Haughton impact melt rock

Results and discussion: Raman analyses were performed on three different calcite crystals and three different dolomite crystals in the carbonate samples from Haughton. Whereas the Raman spectra of calcite showed no variation between the samples, the Raman spectra of dolomite clearly differed between the shocked carbonate clasts and the carbonate bedrock from outside the crater (Fig. 2). The structure of dolomite has a slightly lower symmetry than calcite. Dolomite could be described as one layer of $CaCO_3$ from calcite, and one layer of $MgCO_3$ from magnesite. The Mg in magnesite is coordinated with six O atoms, and these MgO_6 octahedra show a significant compression with increased pressures [11]. This make dolomite less rigid than the calcite structure and thus likely to be more affected by the shock pressures during impact.

The Raman spectra of different crystals within the same sample did not show any significant variation. The first two samples of melt rock carbonate clasts

(HS1 and HS2) give fainter dolomite Raman spectra and considerably broader full width at half maximum peaks (FWHM) at wavenumbers 300cm^{-1}, than the third carbonate clast (HS3) and the carbonate bedrock from outside the crater (HB1), i.e. 15cm^{-1} and 17cm^{-1} compared to 10cm^{-1} and 8cm^{-1} respectively (Table 1). This variation is probably a result of the shock pressures that the melt rock carbonate clasts have suffered during impact. However, the dolomite Raman spectra of the third carbonate clast (HS3) do not show any major deviation compared to the dolomite in the bedrock. This is probably due to a variation in shock pressures between different clasts in the melt rock. The third carbonate clast (HS3) does not exhibit shatter cones, as do HS1 and HS2.

Also worth noticing is that the Raman spectra of melt rock carbonate clast give broad peaks of carbonaceous material at around 1360cm^{-1} and 1600cm^{-1}, especially in sample HS3 (Fig. 2).

Furthermore, there is a difference between the peak-intensities at 300cm^{-1} and 1099cm^{-1} of the various samples (Table 1). This variation is due to the orientation of the analyzed crystal, and this is confirmed by analyses of a euhedral dolomite crystal, SG1 (St. Gotthard). These analyses were made on two different cleavage planes (SG1 and SG1b) of the same crystal, giving an intensity ratio (I_{300}/I_{1099}) of 0.38 and 0.87 respectively (Table 1).

Conclusion: This preliminary study implies that the impact shock effects of carbonate clasts from the Haughton impact melt rock can be observed with Raman analyses in dolomite, while the calcite structure remains intact.

Table 1. Raman analyses of dolomite in samples from Haughton and a sample of dolomite from St. Gotthard: Full width at half maximum (FWHM) of peak at wavenumber 300cm^{-1}, and the ratio of the intensities (I) of the peaks at wavenumber 300cm^{-1} and 1099cm^{-1}.

sample		FWHM(cm^{-1}) at 300cm^{-1}	I_{300}/I_{1099}
HS1	Carbonate clast, with shatter cones, in Haughton impact melt rock	15	0.64
HS2	Carbonate clast, with shatter cones, in Haughton impact melt rock	17	1.00
HS3	Carbonate clast in Haughton impact melt rock (no shatter cones)	10	1.81
HB1	Haughton carbonate bedrock from outside the crater	8	0.36
SG1	Dolomite from St. Gotthard, Swiss Alps	10	0.38
SG1b	Dolomite from St. Gotthard, Swiss Alps	10	0.87

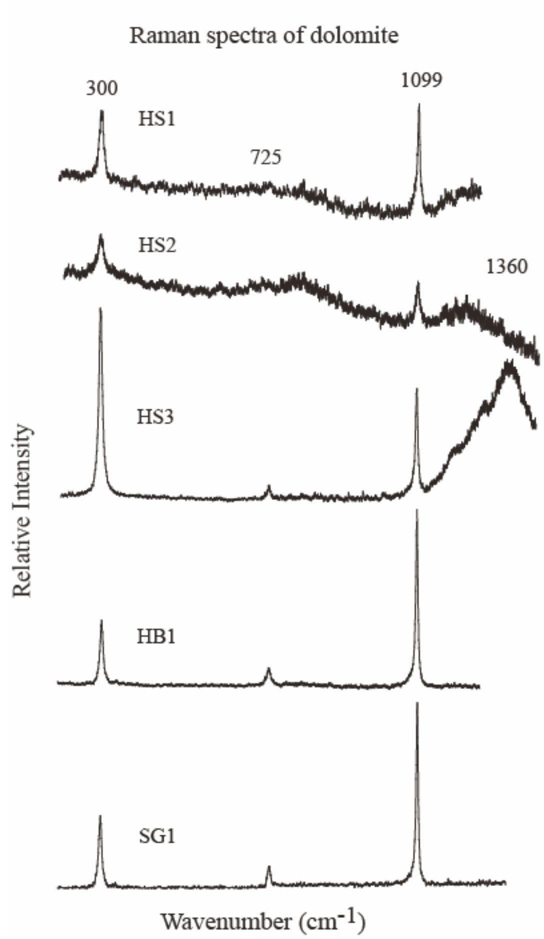

Fig. 2. Raman spectra of dolomite from 1) Haughton carbonate clasts within impact melt rock: HS1, HS2 and HS3, 2) Haughton carbonate bedrock from outside the crater HB1, and 3) Dolomite from St. Gotthard, SG1.

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