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CARBON AND OXYGEN ISOTOPE STUDY OF CARBONATES FROM HIGHLY SHOCKED CLASTS OF THE POLYMICT BRECCIA OF THE HAUGHTON CRATER (CANADA). P. Agrinier, I. Martinez, M. Javoy, and U. Schärer, Université Paris 7 et IPG Paris, 2 place Jussieu, 75251 Paris cedex 05, France.

It is known that the release of volatiles on impact is an important controlling factor in cratering processes in carbonate terranes and in the mobility of chemical elements [1,2,3].

In order to assess the nature and the role of carbon- and oxygen-bearing volatiles during impact-induced metamorphism of sedimentary rocks, the $^{13}\text{C}/^{12}\text{C}$ and $^{18}\text{O}/^{16}\text{O}$ ratios and carbonate contents were determined for 30 shocked clasts from the Haughton Crater polymict breccia as well as for some unshocked carbonates from the sedimentary cover adjacent to the crater. Shock-induced CO_2 loss during decarbonation of calcite is known to be a function of peak pressure and ambient partial pressure of the volatile species [2,3]. In our clast samples, shocked from 20 to 60 GPa, we expect about 20% to 100% CO_2 loss and preferential depletion in ^{13}C and ^{18}O in the residual carbonate [4]. Rayleigh model (progressive loss of CO_2) and batch model (single-step loss of CO_2) curves for this depletion are shown in Figs. 1 and 2. The magnitudes of the ^{13}C and ^{18}O depletions increase with the increase of the CO_2 loss. In addition, these isotopic depletions should be correlated with an enrichment in CaO and MgO in the residual solid.

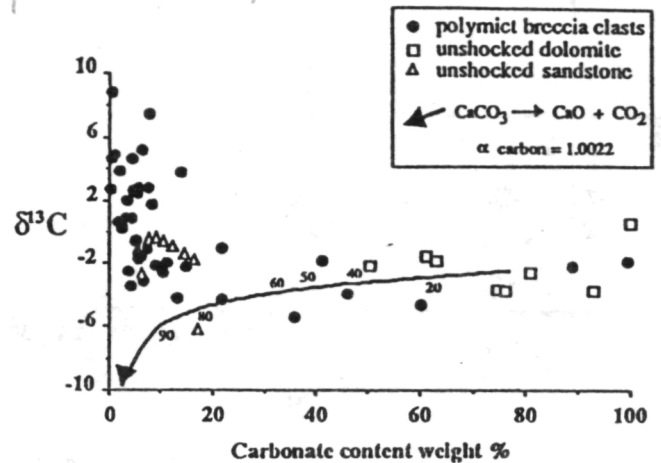


Fig. 1. $\delta^{13}\text{C}$ vs. carbonate content diagram. The numbers along the curve correspond to the degree of Raleigh degassing.

In the shocked clasts, carbonates represent between 0.5 to 10 wt% of the rock and display isotopic composition of carbon between -4 to $+9$ ‰. When compared to the unshocked samples, they are mostly enriched in ^{13}C ($\delta^{13}\text{C}$ up to 9 ‰) or unchanged

TABLE 1. Carbon and oxygen isotopic compositions of carbonates from clasts of the Haughton Crater polymict breccia and from the adjacent sedimentary cover. Rocks were attacked in phosphoric acid [5] in order to analyze carbonates only.

Clasts Sample	Carbonate Content	$\delta^{13}\text{C}$ ‰PDB	$\delta^{18}\text{O}$ ‰SMOW	Reference Sample	Carbonate Content	$\delta^{13}\text{C}$ ‰PDB	$\delta^{18}\text{O}$ ‰SMOW
HAH 11	0.5	8.8	15.88	DI52a	36.1	-5.4	14.17
HAH 8	4	-3.5	15.15	DI52b	60.2	-4.7	14.09
HAH 25	21.8	-1.1	21.71	7275	21.7	-4.3	12.67
HAH 68	5.5	2.7	17.61	DI9	88.9	-2.2	20.55
HAH 69	6.4	5.2	17.78	71314	13.1	-4.3	9.70
HAH 5	0.5	4.6	19.45	DI21	99.6	-1.9	21.37
HAH 15	4.3	4.7	16.82	1984	41.2	-1.8	20.8
HAH 17	1.8	3.8	18.70	DIG2	92.9	-3.7	28.48
HAH 19	3.1	0.8	19.44	DIG1	76.2	-3.8	27.32
HAH 26	1	4.9	18.45	DIG3	74.6	-3.7	28.99
HAH 28	8.9	-2.1	19.01	DIG4	50.4	-2.1	24.10
HAH 74	4	0.9	19.75	DIG5	61.2	-1.5	24.74
HAH 73	3.3	1.9	18.53	DI95	10.7	-0.7	22.6
HAH 66	5.3	2.5	18.50	DI92	100	0.6	21.06
HAH 19	3.1	0.8	19.44	DI3	63.1	-1.8	24.29
HAH 39	5.1	-0.6	16.20	DI95	12.3	-1	24.83
HAH 34	14.8	-2.2	15.26	DI93	14.5	-1.4	23.06
HAH 21	8.1	1.7	16.23	DI96	7.6	-0.5	23.43
HAH 71	7.4	2.8	17.40	DI97	9.1	-0.4	22.7
HAH 29	7.8	7.5	17.24	DI19	17.1	-6.2	25.44
HAH 30	4.6	2.6	15.02	DI45	6.2	-2.7	24.24
HAH 67-1	13.8	3.8	15.50	DIG12	16.5	-1.8	24.61
HAH 67-2	1.7	0.6	19.66	814	80.9	-2.6	21.20
HAH um24	0.2	2.7	15.86	72614	46.1	-3.9	18.14

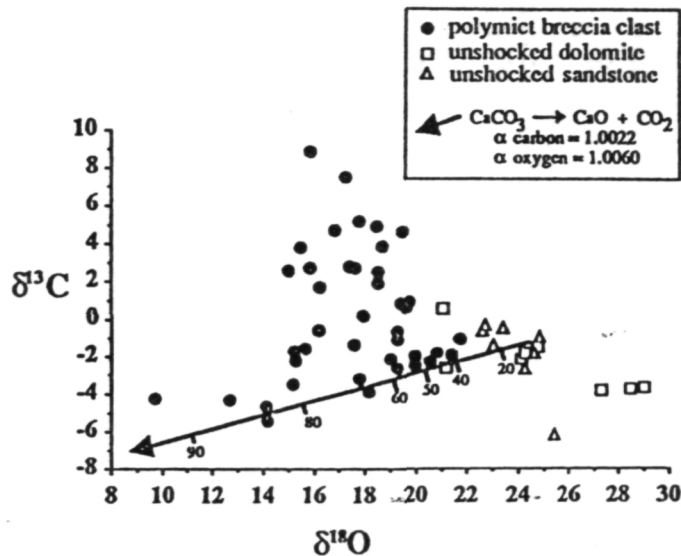


Fig. 2. $\delta^{13}\text{C}$ vs. $\delta^{18}\text{O}$ diagram. The numbers along the curve correspond to the degree of Raleigh degassing.

instead of being depleted as they should be if they were residues resulting from the ^{13}C -enriched CO_2 losses (Fig. 1). On the other hand, these carbonates are systematically depleted in ^{18}O . The magnitude of the ^{18}O depletion is variable (Fig. 2). Thus no systematic correlation between ^{18}O and ^{13}C was observed as expected from the Rayleigh model or the batch model for CO_2 loss (Fig. 2), nor was any clear relationship observed between the carbon and oxygen isotopic shifts and $\text{CaO} + \text{MgO}$ contents of the shock clasts. The spread of the carbon and oxygen isotopic composition is probably due to a variety of processes that may affect C and O during the shock. Several explanations can be suggested for the volatile release from sedimentary rocks: (1) degassing of CO_2 with a peculiar carbon isotope fractionation coefficient ($\alpha < 1$, CO_2 preferentially concentrates ^{13}C), (2) other reactions with production of CO or C, or (3) oxygen isotope exchange with coexisting silicates. Moreover, the absence of $\text{CaO} + \text{MgO}$ enrichments in the shocked clasts, which is a general feature, may indicate that substantial amounts of $\text{CaO} + \text{MgO}$ are mobilized during the shock processes since original sedimentary samples contain up to 66 wt%. The modalities of this inferred mobilization of $\text{CaO} + \text{MgO}$ are still unknown.

However, for some samples, late secondary processes may have partly altered the primary characteristics (nature) of the residues resulting from the volatile release because carbonate crystals are observed along cavity walls (bubbles, cracks). It suggests that some C-rich fluids (CO_2 ?) were pervasive during the formation and the cooling of the polymict breccia. In these samples, the observed ^{13}C enrichments can therefore be partly explained by the trapping of some heavy CO_2 released during the shock process itself.

References: [1] Kieffer S. W. and Simonds C. H. (1980) *Rev. Geophys. Space Phys.*, 18, 143–181. [2] Lange M. A. and Ahrens T. J. (1986) *EPSL*, 77, 409–418. [3] Tyburczy J. A. and Ahrens T. J. (1986) *JGR*, 91, 4730–4744. [4] Bottinga (1968) *J. Phys. Chem.*, 72, 800–808. [5] McCrea J. M. (1950) *J. Chem. Phys.*, 18, 849–857.

RESEARCH CORE DRILLING IN THE MANSON IMPACT STRUCTURE, IOWA. R. R. Anderson¹, J. B. Hartung¹, D. J. Roddy², and E. M. Shoemaker², ¹Iowa Department of Natural Resources Geological Survey Bureau, 109 Trowbridge Hall, Iowa City IA 52242-1319, USA, ²U.S. Geological Survey, Branch of Astrogeologic Studies, 2255 North Gemini Dr., Flagstaff AZ 86001, USA.

The Manson impact structure (MIS), located in north-central Iowa, has a diameter of 35 km and is the largest confirmed impact structure in the United States. The MIS has yielded a $^{40}\text{Ar}/^{39}\text{Ar}$ age of 65.7 Ma [1] on microcline from its central peak, an age that is "indistinguishable" from the age of the Cretaceous-Tertiary boundary.

In the summer of 1991 the Iowa Geological Survey Bureau and U.S. Geological Survey initiated a research core drilling project on the MIS. The first core (M-1) was located on the edge of the Central Peak (Fig. 1). Beneath 55 m of glacial drift, the core penetrated a 6-m layered sequence of shale and siltstone and 42 m of Cretaceous shale-dominated sedimentary clast breccia (Fig. 2). Below this breccia, the core encountered two crystalline rock clast breccia units. The upper unit is 53 m thick, with a glassy matrix displaying various degrees of devitrification. The upper half of this unit is dominated by the glassy matrix, with shock-deformed mineral grains (especially quartz) the most common clast. Clast content increases toward the base of the unit. The glassy-matrix unit grades downward into the basal unit in the core, a crystalline rock breccia with a sandy matrix, the matrix dominated by igneous and metamorphic rock fragments or disaggregated grains from those rocks. The unit is about 45 m thick, and grains display abundant shock deformation features. Preliminary interpretations suggest that the crystalline rock breccias are the transient crater floor, lifted up with the central peak. The sedimentary clast breccia probably represents a postimpact debris flow from the crater rim, and the uppermost layered unit probably represents a large block associated with the flow.

The second core (M-2) was drilled near the center of the crater moat in an area where an early crater model suggested the presence of postimpact lake sediments. The core encountered 39 m of sedimentary clast breccia, very similar to that in the M-1 core. Beneath the breccia, 120 m of poorly consolidated, mildly deformed and sheared siltstone, shale, and sandstone was encountered. The

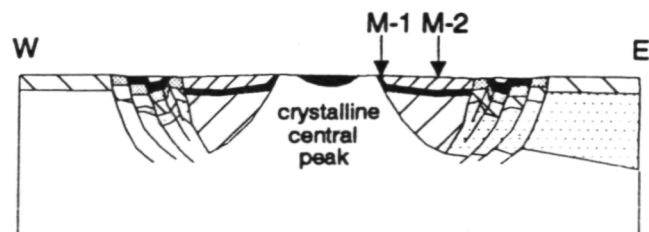


Fig. 1. East-west cross section of the Manson Impact Structure showing the location of the Manson M-1 and M-2 cores.