STRONTIUM AND OXYGEN ISOTOPE STUDY OF M-1, M-3 AND M-4 DRILL CORE SAMPLES FROM THE MANSON IMPACT STRUCTURE, IOWA: COMPARISON WITH HAITIAN K-T IMPACT GLASSES. Joel D. Blum, C. Page Chamberlain and Michael P. Hingston, Dept. of Earth Sciences, Dartmouth College, Hanover, NH 03755; Christian Koeberl, Institute of Geochemistry, Univ. of Vienna, A-1010 Vienna, Austria.

Strontium and oxygen isotope analyses were performed on 8 samples from the M-1, M-3, and M-4 cores recently drilled at the Manson impact structure. The samples were three clastic sedimentary rocks (of probable Cretaceous age) which occurred as clasts within the sedimentary clast breccia, two samples of crystalline rock breccia matrix, and three samples of dolomite and limestone. The $^{87}Sr/^{86}Sr$ (corrected to 65 Ma) ratios were much higher than those in impact glasses from the Haitian Cretaceous-Tertiary (K-T) boundary. Isotope mixing calculations demonstrate that neither the silicate or carbonate rocks analysed from the Manson crater, or mixtures of these rocks, are appropriate source materials for the Haitian impact glasses. However, the $^{87}Sr/^{86}Sr_{(65Ma)}$ ratio and $\delta^{18}O$ value of the Ca-rich Haitian glasses are well reproduced by mixtures of Si-rich Haitian glass with platform carbonate of K-T age.

The Manson, Iowa impact structure has a diameter of 35 km, making it the largest well-preserved impact crater in the United States. Both the Manson [1] and Chicxulub, Mexico [2,3] structures have radiometric ages indistinguishable from the K-T boundary and the age of Haitian impact glasses [3,4]. Although the Manson structure is smaller than the Chicxulub structure (~180 km diameter), it may be considered at least one element in the events that led to the mass extinctions at the K-T boundary. Impact glasses from the K-T section in Haiti [4,5] have been crucial in establishing a connection with documented impact processes [5-7] and provide an opportunity to test the connection between specific impact structures and the impact glasses.

In this study 8 drill core samples from the M-1, M-3, and M-4 holes, recently drilled at the Manson impact structure, were analysed (Fig. 1). Drillhole M-1 is located at the flank of the central peak of the structure, while M-3 and M-4 are located in the terrace terrane of the structure. Details of drillhole locations, core stratigraphy and some major element analyses of these samples can be found in ref [8]. The crater is completely covered by Quaternary glacial deposits that are underlain by Cretaceous clastic sediments and flat-lying carbonate sediments of Phanerozoic age, as well as Proterozoic red clastic, metamorphic, volcanic and plutonic sequences (e.g. [9]). Core samples are referred to below by the drill hole name (i.e., M-1, M-3, M-4) followed by the depth in feet.

Three samples of Cretaceous shale (M1-186.0), silty sandstone (M1-194.1), and siltstone (M2-320.8) have $^{87}Sr/^{86}Sr_{(65Ma)}$ ratios of 0.71324–0.73161 and $\delta^{18}O$ values of 12.4–14.3‰; two samples of glassy matrix in crystalline rock breccia (M1-359.6 and M1-475.3) have $^{87}Sr/^{86}Sr_{(65Ma)}$ ratios of 0.72244–0.72498 and $\delta^{18}O$ values of 8.7–8.9‰; and three samples of dolomite (M4-1116.0 and M4-1200.0) and limestone (M3-274.1) have $^{87}Sr/^{86}Sr_{(65Ma)}$ ratios of 0.70803–0.71000 and $\delta^{18}O$ values of 23.4–26.6‰. Strontium analyses by Premo [10] of the Pierre Shale in Colorado (thought to be equivalent to the shale found at Manson) yielded $^{87}Sr/^{86}Sr_{(65Ma)}$ ratios of 0.71004–0.72520. Analyses of Si-rich impact glass from the K-T boundary in Haiti yield $^{87}Sr/^{86}Sr_{(65Ma)}$ ratios of 0.70820–0.70878 [5,11] and $\delta^{18}O$ values of 6.2–9.0‰ [5,12] whereas analyses of Ca-rich impact glass from the K-T boundary in Haiti yield a $^{87}Sr/^{86}Sr_{(65Ma)}$ ratio of 0.70796 [5] and $\delta^{18}O$ values of 13.1–14.5‰ [5,12]. A single analysis of Si-rich melt rock from the Chicxulub structure yielded $^{87}Sr/^{86}Sr_{(65Ma)}$ ratios of 0.70837 [13] and a similar Si-rich melt rock from Chicxulub analyzed by us yielded a $\delta^{18}O$ value of 8.2‰.

In a previous study [12] we suggested that the variation in $\delta^{18}O$ and major element composition of the Ca-rich (yellow) Haitian glasses could be readily explained by a mixture of 58% of the most Si-rich (black) glass with 42% platform carbonate to produce the most Ca-rich impact glasses. Although we were able to show that the impact glasses were mixtures of siliceous rocks with carbonates we were unable to differentiate between the Manson and Chicxulub structures as both have appropriate combinations of the two target lithologies [12,17]. With the additional data presented here we suggest that the Manson structure is not likely to be the source of either the Si-rich or Ca-rich Haitian K-T glasses.

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On Fig. 1 we have plotted $^{87}Sr/^{86}Sr_{(65Ma)}$ – $\delta^{18}O$ mixing hyperbolas for several relevant endmember compositions. Curve A was calculated using average values for Si-rich clastic rocks and carbonates from Manson as endmembers. Curve B was calculated using average values of glassy matrix and carbonate from Manson as endmembers. Curve C was calculated by starting with average values for the Si-rich Haitian impact glasses as one endmember, considering the Ca-rich glass as a 58% mixture of the first endmember and 42% mixture of an unknown Ca-rich endmember (following ref [12]), and then calculating the values for the hypothetical Ca-rich endmember. The figure inset shows curve C at an expanded scale along with the estimated value for marine carbonates at 65 Ma [14, 15] which is close to our calculated carbonate endmember.

Several conclusions can be drawn from the data and mixing calculations. First, neither the Si-rich or Ca-rich rocks analyzed from the Manson drillholes are plausible source rocks for the Haitian K-T glasses. Second, the glassy matrix from the crystalline rock breccia in hole M-1 is isotopically distinct from the analyzed clastic rocks supporting the hypothesis that the glassy matrix formed from the Proterozoic crystalline basement. And third, although more data are needed to be conclusive, the isotopic composition of Haitian K-T glasses are consistent with a mixture of melt rock from the Chicxulub crater with marine carbonate of K-T age–strengthening the link [2,3,13,16,17] between the Chicxulub impact structure and the Haitian K-T impact glasses.

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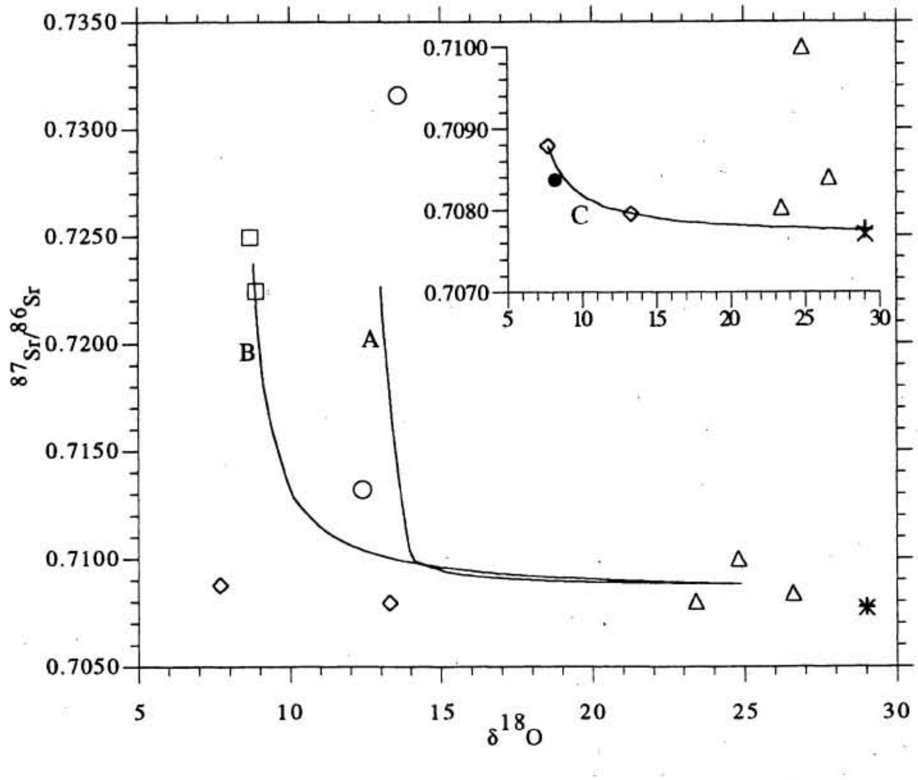

Fig. 1: Plot of $^{87}Sr/^{86}Sr_{(65Ma)}$ versus $\delta^{18}O$ for clastic sedimentary rocks (circles), glassy matrix (squares) and carbonates (triangles) from Manson core samples. Also included are Haitian impact glasses (diamonds), a calculated hypothetical platform carbonate endmember (plus sign), an estimated K-T age carbonate (X) and a value for meltrock from Chicxulub (solid circle). Curves A, B and C are mixing hyperbolas between average compositions of several rock types. Inset shows impact glasses and carbonates at expanded scale. See text for references, sample descriptions and discussion of figure.