YAXCOPOIL-1 IMPACT MELT BEARING BRECCIAS: THE CONTROVERSY OVER MULTIPLE COMPOSITION MELTS AND THE ROLE OF HYDROTHERMAL ALTERATION. H. E. Newsom, M. J. Nelson and M. N. Spilde. University of New Mexico, Institute of Meteoritics, Dept. of Earth and Planetary Sciences, Albuquerque, NM 87131 U.S.A. Email:newsom@unm.edu.

Introduction: The Chicxulub impact crater, Mexico, was formed in a layered target of carbonates and silicates [1, 2]. The Yaxcopoil-1 drill core, in the annular trough of the crater consists of layered impactites with upper "reworked suevite", and lower "impact melt breccia" [3]. Impactites are Mg-, Al-, and K-rich in certain units. Elemental signatures in the impactites cannot be explained by any one unaltered parent lithology. Models that explain the Mg and K signatures can be divided into categories: (1) Formation of Chicxulub impactites from a single silicate melt later altered by aqueous or hydrothermal fluids, or (2) derivation of impactites from at least two Mg-, and/or K-rich primary melt compositions, or (3) some combination of aqueous and hydrothermal alteration and multiple impact melts [4, 5].

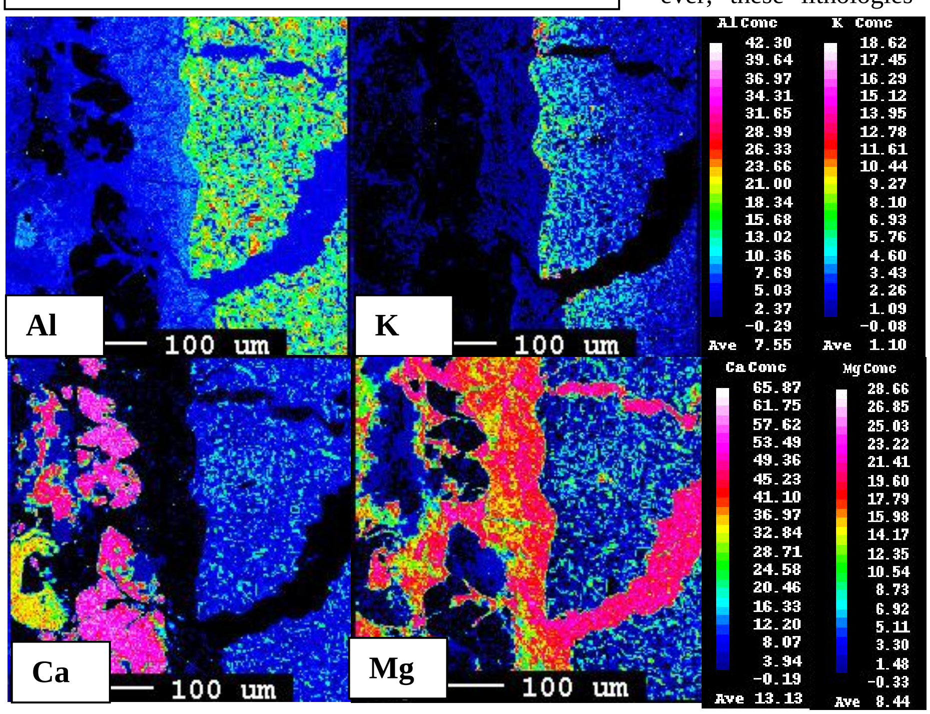
Results: Microprobe, SEM, and X-ray diffraction analyses were conducted to determine textural and chemical relationships of melt clasts and matrix, the origin of major element signatures, and to determine if the impactites contain hydrothermal minerals. Quantitative element maps coupled with backscattered electron images were particularly useful for determining the relationships between the chemistry and textures. The results are as follows:

- The matrix is physically distinct from the melt clasts and locally exhibits flow texture around clasts, and alteration to smectite clay.
- The Mg-enrichment is found only in the matrix.
- Calcite is ubiquitous only in matrix material.
- The K-enrichment is present only in the rims of the Si-, Al- rich melt clasts.
- XRD analyses did not detect the presence of chlorite or other hydrothermal minerals.

The lower units at a depth below about 847 m, and presumably deposited first, contain an melt breccia. K-enrichment is seen on puzzle-like angular, silicate melt clast rims in element maps, while the matrix material consists of a separate Mg-rich (20% or greater), lithology with no K-enrichment.

The upper suevite layers above 846 m, and presumably deposited slightly later in time, also contain two lithologies: a Mg- rich matrix lithology containing calcite, and a Si-, Al-, sometimes K- rich lithology. However, these lithologies are represented in both the groundmass and schlieren melts, with evidence for melt immiscibility.

Fig. 1. Quantitative element map with oxides in weight percent of impact melt in Unit 4, sample 641. The data shows an Al-bearing melt clast with puzzle-like fit (upper left) and K-enrichment on edges (upper right). Clasts are crosscut by Mg-rich matrix. Matrix also contains calcite (Highest Ca in lower left).



Discussion***: Hydrothermal fluids and/or seawater alteration?*** Alteration by hydrothermal fluids has been suggested by several authors [3, 6 – 9]. If the Mg in the matrix material is the result of fine clast material altered by an influx of hydrothermal fluid, then it should have also affected the glass or finely crystalline material of the larger melt clasts. The melt clasts, however, maintain sharp boundaries, with quenched textures at the edges, and no Mg-enrichment. The lack of chlorite or zeolites in the matrix also argues against an extensive hydrothermal regime for the formation of the melt breccia matrix. Ion probe data for Li, Be, B, and Ba by Newsom et al. [10] do not indicate fractionation of these elements, arguing against an extensive hydrothermal system at Yax-1.

If both the Mg and K- enrichments were the result of downwelling seawater [6], then Mg and K would be expected to spatially correlate, and alteration of both matrix and clast glasses would be expected. In addition, studies of both high and low temperature alteration by seawater have found strong preferential enrichment of K, not necessarily Mg [11, 12]. *Therefore, seawater might explain the K enrichment in the melt clasts, but does not appear to be the process responsible for the matrix chemistry. Hydrothermal processes seem to have been of limited importance.*

Origin of Mg-rich matrix as a dolomitic melt? What additional observations constrain the origin of the Mg-rich matrix material? XRD analysis of carefully drilled powders showed that the matrix contains saponite, a Mg-rich clay. Formation of the Mg-rich clay by the fluid alteration of a more Al-rich material, like the melt clasts, is problematic, because Al is not fluid mobile. The least problematic way to explain the Mg-rich matrix is to have Mg-rich starting material in addition to the Si-rich material. Considering the composition of **c**andidate materials including granite, dolomite, basalt, and sedimentary rocks, dolomite is the only natural material of the three that approaches the high Mg concentration of the Yax-1 melt breccia matrix. The complexity of the target source materials for the melt particles has also been noted by Tuchscherer et al. [13]. Zürcher et al. [14] analyzed O , C, and H isotopes, and found a signature they concluded is consistent with the addition of a limestone component, but could very well represent a dolomite component as well.

Dual melts have also been identified at the Ries crater by Graup [15] and Osinski [16], and at the Haughton structure, Canada [17, 18], where evidence suggests that the two components of the matrix resulted from dolomite and silicate melts. In addition, experimental data for shock melting of pure dolomite, and equilibrium melting studies [e.g. 19] suggest that the Mg-Si-rich matrix material could have been produced from a high temperature, impure dolomite melt, while calcite could crystallize out as the other phase in the matrix. *An injected melt derived from dolomite in the target rock is therefore the best explanation for the chemistry and texture of the Mg-rich matrix material.*

Conclusions: These results support the following sequence of events to form the Yax-1 breccias:

(1) Impure dolomite and silicate basement lithologies were melted and ejected during crater formation.

(2) In the lower portion of the ejecta, at a depth associated with lateral surge ejecta dynamics, the silicate melt was quenched, brecciated, and enriched in potassium by seawater, or another K-rich fluid during transport or shortly after deposition. This deposit was slightly later permeated by Mg-rich dolomitic melt, possibly from melt bodies in the ejecta deposit that were not as well mixed as seen in the upper ejecta material. In addition, since other authors [8, 9, 20] have identified carbonate melts, including dolomite clasts in the drill core, this may mean there is actually a larger amount of dolomite melt than previously identified, given the dolomite-rich Cretaceous target.

(3) The dolomite and silicate melt textures in the suevitic upper units appear to be consistent with mixing in the ballistic ejecta down to the millimeter scale during transport. The suevite breccia above 824 m in the sequence consists of schlieren dolomitic and silicate melts containing immiscible melt textures.

References: [1] Alvarez L.W. et al. (1980) *Science*, *208*, 1095-1098. [2] Hildebrand A. R. et al. (1991) *Geology*, *19*, 867-871. [3] Dressler B.O. et al. (2003). *EOS Transactions, 84,* 125-130 [4] Dressler, B.O. et al. (2004) *MAPS 39,6*, 857-879. [5] Tuchscherer et al. (2004) *MAPS 39*, 955-978. [6] Ames, D.E. et al. (2004) *MAPS 39*, 1145-1168. [7] Zürcher L., and Kring D. A. (2004) *MAPS 39*, 1199-1222. [8] Hecht L., et al. (2004) *MAPS 39*, 1169-1186. [9] Dressler B.O. et al. (2004) *MAPS 39,* 857-878. [10] Newsom et al. (2006) *MAPS 41*, 1929-1945. [11] Staudigal H. and Hart S. (1982) *GCA*, *47*. 337-350. [12] Stroncik N.A. and Schmincke H.-U. (2000) *Eos*, *Transactions*, AGU, *81*, Suppl., pp. 1263. [13] Tuchscherer et al. (2004) *MAPS 41*, 1361-1379. [14] Zürcher L., et al. (2005) *Geological Society of America Spec. Paper 384*, 223-238. [15] Graup, G. (1999) *MAPS 34*, 425-438. [16] Osinski, G.R., et al. (2004) *MAPS 39*, 1655-1683. [17] Osinski, G.R., et al. (2001) *EPSL 194*, 17-29. [18] Osinski, G.R., et al. (2005) *MAPS 40*, 1789-1812. [19] Otto, J.W., and Wyllie, J.P. (1993) *Min. and Pet. 48*, 343-365. [20] Jones, A.P. et al. (2000) *Impacts and the Early Earth* (eds. I. Gilmour and C. Koeberl). pp. 343-361.

Acknowledgements: Yaxcopoil-1 core samples obtained from Chicxulub Scientific Drilling Project team. Research funding provided by NASA Planetary Geology and Geophysics program NNG 05GJ42G (H. Newsom) and NASA Mars Fundamental Research Program. NNG04GE87G (H. Newsom).