MAJOR AND TRACE ELEMENT VARIATIONS IN IMPACT CRATER CLAYS FROM CHICXULUB, LONAR, AND MISTASTIN, IMPLICATIONS FOR THE MARTIAN SOIL. H. E. Newsom[1,2], M. J. Nelson[1,2], C. K. Shearer[1,2], F. J. M. Rietmeijer[2], R. Gakin[3], and K. Lee[3], Univ. of New Mexico, Institute of Meteoritics[1], Dept. of Earth & Planetary Sciences[2], Albuquerque, NM 87131 newsom@unm.edu, Southwestern Indian Polytechnic Institute[3], Albuquerque NM 87184

Introduction: The catastrophic Chicxulub event should have generated a large hydrothermal system with volatile element mobilization, producing interesting alteration materials and clays. The Yaxcopoil-1 (YAX) drill hole is located in the annular trough, about 70 km southwest of the crater center, in an area where the impactite layers are relatively thin (~ 100 m thick). We have analyzed samples from the YAX drill core and from other impact craters including Mistastin and Lonar to determine the nature of alteration and trace element mobilization.

Analytical approach: Samples were imaged and analyzed for major elements using the new JEOL 8200 and a JEOL SEM. Trace elements Li, B, Be, and Ba were measured with our Cameca ims 4f ion probe, using primary O^- ions accelerated through a nominal potential of 10 kV; a primary beam current of 10 nA and spot diameter of 8 to 10 µm. Secondary ions were filtered with an offset voltage of 105 V and an energy window of 50 V [e.g. 1]. Element concentrations were calculated using measured Trace-Element/$^{30}Si^+$ ratios, normalized to known SiO_2 content.

Clay compositions –Clays in the Lonar drill core samples were shown by Hagerty and Newsom [2] to consist of well defined Fe-saponite and celadonite, consistent with low temperature alteration of basalts. The three Chicxulub samples considered here (Figs. 1-5) have a range of chemical compositions that are intermediate between saponite and Fe-rich montmorillonite compositions, with the sample from the upper suevite (809.39 m) having more of a montmorillonite component. There is a considerable spread in FeO and MgO concentrations (Fig. 2). Mistastin clays are less MgO rich, but otherwise similar to the YAX samples.

Trace element abundances in clays from the drill cores at Lonar and Chicxulub are substantially fractionated, in contrast to the two impact melt breccia samples from Mistastin (Figs. 3-5). The Li, Be, and Ba contents of the Lonar clays range in abundance from near crustal to depleted, while boron abundances range from crustal to 10 times enriched. The clays in the YAX core samples have Li, B and Ba abundances ranging from crustal in lower units to enriched in the upper unit, while Be abundances stay close to crustal. Interestingly, barium is positively correlated with Li, Be, and B in Lonar and negatively correlated for the most part with Li, Be and B in the YAX samples.

Although there are two different types of clay or clay end members in the Lonar and YAX samples, there is no correlation between the trace element abundances and the types of clay end members based on the very limited numbers of analyses available.

Discussion– The average clay compositions in the YAX core suggest a different, more Si and Fe enriched bulk composition of the protolith for the altered material in the upper unit 2 compared to the material in units 4 and 5. The heterogeneous clay compositions and trace element abundances in the clays compared to the uniform abundances in the samples from the much larger Mistastin melt sheet also suggest that the impact deposits at Lonar and the Yaxcopoil core represent material that has undergone only limited (or incipient) hydrothermal alteration at low temperatures.

The variable compositions of clays on a small spatial scale are consistent with hydration of impact generated fine-grained material, either fine-grained glassy material or a mixture of metastable dehydroxylate condensates from the impact cloud [e.g. 3,4]. The YAX clays are remarkably co-linear with the join between two metastable eutectic dehydroxylate (MED) end members, MED-pyrophyllite and MED-serpentine (Fig. 2a). Vapor condensation of dust-sized particles can produce these metastable materials, which have successfully explained the composition of interplanetary dust particles (IDPs) [3]. Vertical transport of Li, B, and Ba, presumably by hydrothermal fluids is suggested by the trace element data, although variations in the protolith of the clay material is not ruled out. Further analysis and x-ray studies are being conducted to better understand these relationships and the nature of the clay protolith.

Implications for Mars – Based on our results, there is a possibility that the martian soil contains mixed layer clays of heterogeneous composition by hydration of an impact generated protolith. This possibility could also be consistent with chemical arguments for Fe-rich clays in the martian soil [e.g. Nelson and Newsom, 5, 6]. The formation of metastable eutectic dehydroxylates in impacts that subsequently are annealed to form clay minerals could provide a source of chemical energy leading to conditions favorable for the origin of life [3]. Evidence in the YAX samples for vertical transport of trace elements such as Li, Ba and B also suggests that the martian soil may be enriched in such mobile elements [e.g. 7].

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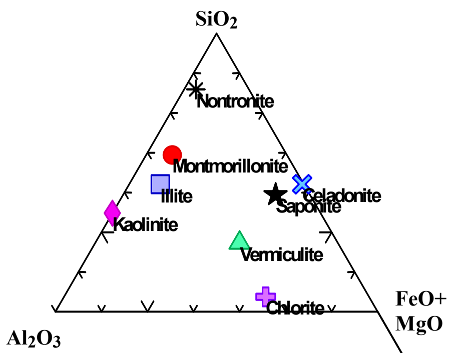
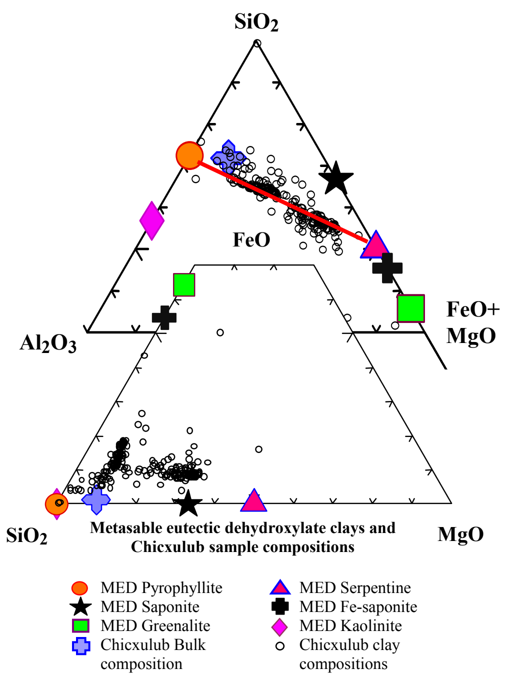
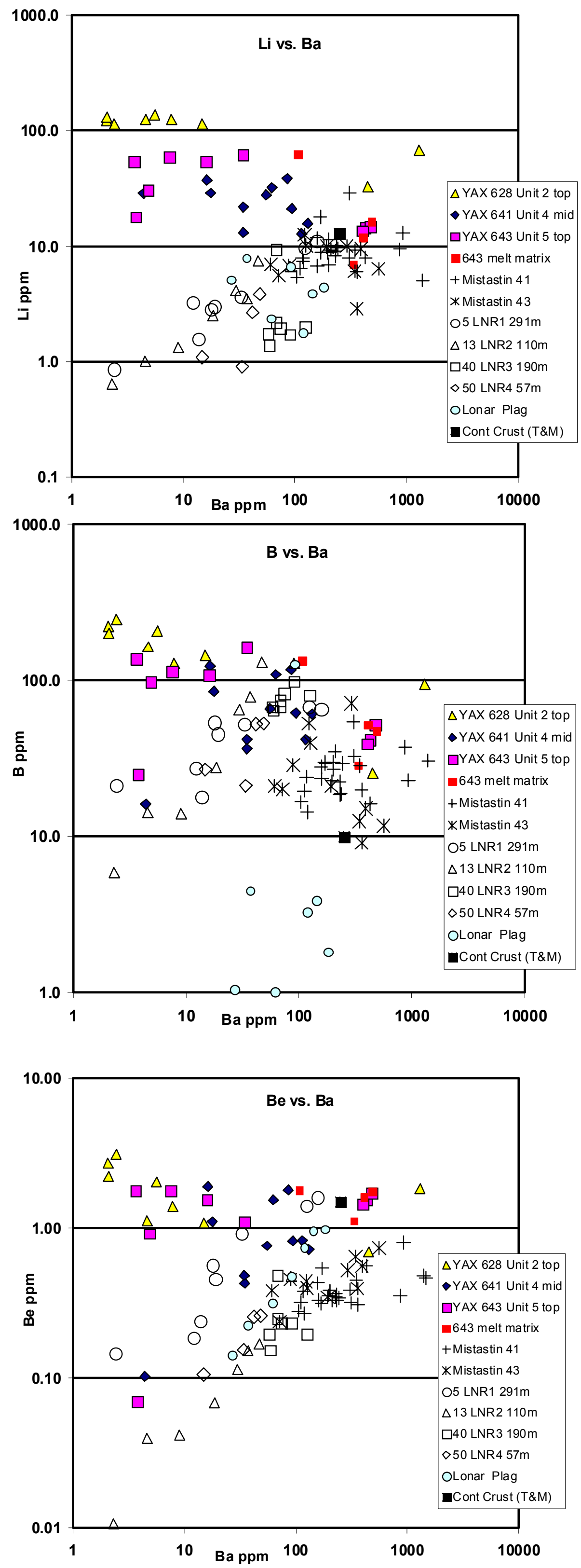


Fig. 1. Reference compositions of clay minerals for comparison with Fig. 2.



Figs 2a, 2b. Comparison of Chicxulub alteration material with metastable eutectic dehydroxylate clays [3] produces a linear trend outlined in red seen clearly in Fig.4a, and consistent with Fe-/Mg-enrichment trends, seen in Fig. 4b.



Figs. 3-5. Li, Be, B, and Ba trace element abundances. Continental crust abundances from [7].