GEOCHEMICAL CHARACTERISTICS OF IMPACTITES FROM THE YAXCOPOIL-1 ICDP DRILL CORE, CHICXULUB IMPACT STRUCTURE, MEXICO. M.G. Tuchscherer[1*], W.U. Reimold[1], C. Koeberl[2], and R.L. Gibson[1], [1]Impact Cratering Research Group, School of Geosciences, Univ. of the Witwatersrand, Private Bag 3, P.O. Wits 2050, Johannesburg, South Africa, [2]Dept. of Geological Sciences, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria ([*]tuchscm@science.pg.wits.ac.za).

Summary: Current geochemical results, major and trace elements, are presented from the Yaxcopoil-1 impactites. Major element compositions indicate that the impactites represent variable carbonate and siliceous target rock mixtures from the Yucatán subsurface. Heterogeneity is observed on a sub-sample scale. Volatiles and trace element analyses indicate that the upper and lower units have been the most affected by high water to rock interactions.

Introduction: The Yaxcopoil-1 borehole, located 60 km SSW of the center of the Chicxulub impact structure, intercepted 100 m of impactites at depths between 795 and 895 m. The impactites were initially subdivided into 6 subunits [1] based on petrographic observations. However, we recognize only 5 subunits [2], as we do not differentiate between units 1 and 2 of [1] due to more similar than contrasting petrographic characteristics in this upper package (795 to 822 m). Here, we describe variations in the geochemical character of these lithostratigraphic units. Our geochemical database includes analyses of 56 samples for major elements (by XRF) and of 109 samples for trace elements (by INAA).

Major Elements: Noticeable trends for our units 1 to 4 include a progressive increase of SiO_2, Al_2O_3, Na_2O, CaO, and K_2O and a decrease of FeO_{tot} abundances with depth. TiO_2, MgO, and MnO, which are found in variable concentrations, do not indicate trends with depth. With respect to SiO_2, Al_2O_3, TiO_2, MnO, Na_2O, and K_2O contents, our unit 1 (795 to 822 m) is very homogeneous. Unit 2 data scatter much more. As we only have three samples from unit 3, compositional variability of this segment cannot be fully ascertained, however, it is obvious that this unit contains relatively higher Na_2O and higher P_2O_5 (than all other units), and lower FeO_{tot} than units 1 and 2. Our two samples from unit 4 have similar compositions, with the greatest variability observed in the K_2O, Na_2O, and FeO_{tot} contents. Unit 5 is unique compared to all other units, with divergent trends from those of the upper sequence, i.e., lower concentrations of SiO_2, Al_2O_3, TiO_2, FeO_{tot}, Na_2O, K_2O, and higher MnO and CaO. The MgO content is relatively uniform throughout units 1 to 4, but much higher in unit 5.

Volatiles: Several trends are observed with respect to the CO_2, SO_3, and H_2O abundances. Unit 5 contains the highest CO_2 concentrations and, together with unit 1, has the highest H_2O contents (Fig. 1a). Although found in minute quantities, <0.15 wt %, the SO_3 abundances appear to decrease with depth, with relatively highest abundances found in unit 1. The varied SO_3 abundances can be correlated with modal proportions of anhydrite. Consequently, the L.O.I. is highest in units 1 and 5 and lowest in unit 4, the 24 m thick glass rich unit.

Trace Elements: Some notable trends observed with depth, from units 1 to 4, are: Cr, Zn, Rb and Cs contents decrease, whereas Sr, Ba, the REE, Th, and U increase in this direction. The Rb/Sr, Rb/Ba, Ba/Sr, K/U, Th/U ratios were observed to decrease with depth. These trends indicate that K-bearing phases rich in Rb are more abundant in the upper units of the impactites, or that Rb was preferentially sequestered by hydrothermal activity as the K content increases towards unit 4.

Linear trends are observed between Zr and Hf and Zr and Ti. The distribution of these immobile elements in the impactites has not been affected by secondary processes. A linear correlation is obtained for (Cs + Rb) vs. H_2O (Fig. 1a) and Cs vs. Rb (Fig. 1b), with highest values for unit 1. Thus, high fluid-rock interaction within the upper unit 1 can be inferred.

In general, impactites richer in silicate glass or minerals contain higher abundances of trace elements than the carbonate-rich samples. Thus, the carbonate rich unit 5 has the lowest concentrations of Sc, Cr, Co, Ni, Zn, Rb, Zr, Sb, Cs, the REE, Hf, and Ta. However, this unit displays some of the highest abundance of Ba - consistent with our petrographic observations on this unit, where authigenic euhedral barite crystals are found in vesicles and calcite veins. High U and Mn contents in unit 5 can not be explained yet, but it is thought that they could be derived from Cretaceous carbonate.

Mixing, hetero- or homogeneous?: Recent observations [4] on several Y6 borehole samples indicated that the impactites in this core have a heterogeneous composition. Our petrographic and geochemical analyses indicate that Yax-1 samples are of heterogeneous composition. The variable compositions are primarily the product of mixing of different proportions of supracrustal carbonates of the Yucatán platform with siliceous crystalline basement rocks [3]. In order to understand the compositional variability of the silicate fraction, major element analyses were recalculated on a calcite and volatile free basis. The results reveal that for Na_2O, K_2O, and FeO_{tot} the trends are similar as before but that all other major oxides have now uniform concentrations with depth. Unit 5 is different from the other units, with an elevated MgO content indicating a significant dolomitic component.

Heterogeneity can also be observed at a microscopic scale as melt particles of various compositions are typically found in proximity to one another in units 1 through 3. Heterogeneity is also observed in the glasses of units 1 to 4, as these have undergone considerable yet variable hydrothermal alteration, e.g., conversion to phyllosilicate phases (illite, smectite, and sepiolite mixtures) as observed by XRD and EMPA.

Glass Compositions: As noted by, e.g., [1, 2], glasses in the Yax-1 impactites are variegated, an indication of their origin from different precursors and variable compositions. Major element analyses of four brown glass and two green glass samples, both with relatively low L.O.I., indicate the latter is more mafic than the former. The brown glass is characterized by comparatively higher CaO content. The averaged Na_2O and K_2O contents of the two glass types are within standard deviation of each other. These results are, however, not in agreement with our EMP analyses, as we identified green and brown glasses of both feldspathic and biotitic compositions. Green glasses have been analyzed with high alkali and low MgO concentrations. Brown glasses, in contrast, have been analyzed with high FeO_{tot} contents. We attribute the highly heterogeneous character of the glasses at the microscopic scale to i) poor mixing of the primary melt phases, ii) conversion of the glasses to phyllosilicate phases, and iii) remobilization of alkalis during hydrothermal activity.

Discussion: Several processes can be called upon to explain the geochemical variability reported within the Yax-1 impactites. An increased rock/water interaction in the upper part of the sequence can be discerned by the highly anomalous Cs and Rb abundances (Fig. 1a, b). The tight clustering and low compositional variability of major elements observed in unit 1 indicates these upper rocks have been thoroughly mixed. This is in good agreement with the inferred aquatic reworking of this upper package (795 to 822 m), as proposed by several researchers [1, 2, 5, 6, 7]. Unit 4 that is 24 m thick and is flow textured, brecciated, and has a low volatile content has similarities to a melt unit in the Y6 borehole [7]. This is thought to represent an impact melt derived from the crystalline basement. Bulk analyses of green and brown glasses have a unique composition. However, the glass compositions at a microprobe scale do not coincide with bulk analyses indicating heterogeneity at the ten micrometer scale. Unit 5 is compositionally unique, suggesting it underwent primary and/or secondary processes independent of the overlying units; it contains a larger carbonate component and experienced a pronounced late hydrothermal Ba and Sr overprint (barite) [8, 9].

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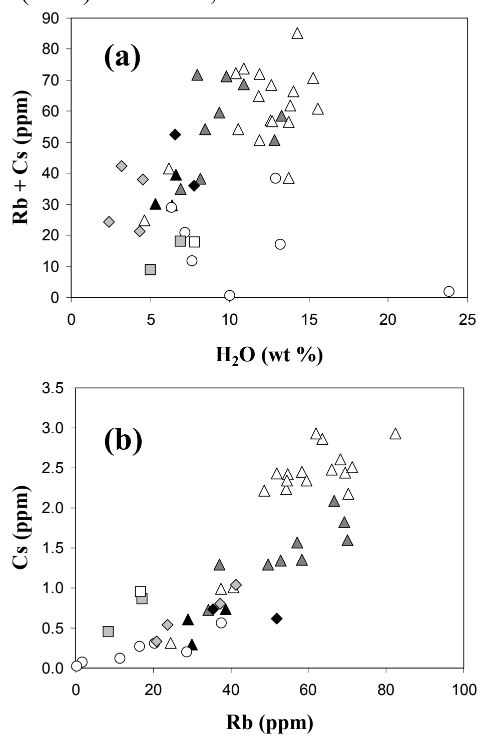

Fig. 1 (a) Concentrations of (Rb + Cs) vs H_2O for each impactite subunit. (b) Concentrations of Cs vs. Rb. Note the linear trends. Symbols: open triangle = unit 1, grey triangle = unit 2, black triangle = unit 3, black diamond = unit 4, white triangle = unit 5, grey diamond = brown glass, open square = Tertiary Lmst., grey square = Cretaceous Lmst