PRELIMINARY ANALYSIS OF RELATIVE ABUNDANCES OF HYDROTHERMAL ALTERATION PRODUCTS IN THE C1-N10, Y6-N19, AND YAX-1_863.51 IMPACT MELT SAMPLES, CHICXULUB STRUCTURE, MEXICO. L. Zurcher[1], E. Lounejeva-Baturina[2], and D. A. Kring[1], [1]Lunar and Planetary Laboratory, University of Arizona, 1629 E. University Blvd., Tucson, Arizona 85721, [2]Instituto de Geología, Universidad Nacional Autónoma de México, México, D.F., 04510.

Introduction: This preliminary study examines the relative hydrothermal mineral abundances present in the C1-N10, Y6-N19, and Yax-1_863.51 impact melt samples recovered from the Chicxulub-1, Yucatán-6 and Yaxcopoil-1 boreholes. The boreholes are located ~20, ~50, and ~60 km from the center of the Chicxulub impact structure, respectively. These holes sampled different parts of what may be a continuous impact-related hydrothermal system that developed over the entire extent of the ~180 km diameter crater. The purpose of this investigation, thus, is to begin reviewing possible alteration zonation patterns at the scale of the impact structure.

Previous publications [1, 2 among others] have compared the alteration in C-1 and Y-6 samples, but have not focused on determining the relative mineral modal abundances. Here, we present the results of a GIS image analysis of electron microprobe element maps, as a first attempt at assessing this complex problem. Relative abundances of mineral phases were estimated by addition and subtraction of element grids. In conjunction with petrographic and electron microprobe studies, image analyses give first approximations to relative modal proportions of primary and secondary products, confirm cross-cutting relationships and spatial associations, and provide new information on the replacement process.

Results: To allow for a meaningful evaluation of the significance of hydrothermal phases from one borehole to the other, samples were selected from the impact melt units within the borehole sequences, which exhibit comparable primary compositions. First, we examine the igneous mineralogies and impact melt compositional homogeneity. Second, we present our comparative analysis of the relative extent of alteration products. A generalized summary of our modal estimates from the image analyses is given in Table 1.

Primary Mineralogy. The presence of comparable primary phases in the C-1, Y-6, and Yax-1 impact melt samples, and, in particular, the equivalent compositions of igneous pyroxene and plagioclase, imply that the silicate melt at Chicxulub may have been uniform. Compositional homogeneity of impact melt has also been observed at other impact sites [3]. However, there appear to be differences in how the melts crystallized.

In C1-N10, pyroxene and plagioclase phenocrysts are, in general, much larger (up to 0.7 mm) than those in Y6-N19 and Yax_1-863.51 (~0.015 mm),

Table 1. Modal abundance estimates between studied impact melt samples (in volume %), based on elemental map analyses.

Estimated phase and (summarized procedure)	**C1-N10**	**Y6-N19**	**Yax-1_864**
phyllosil. (Fe+Mg-all other minerals)	2	4	21
calcite (Ca-all other elements)	2	0	0
quartz (Si-all other elements)	16	10	2
Fe ox. (Fe-all other minerals)	1	2	1
K-feldspar (K-Fe-Mg-plag)	19	10	3
plagioclase (Na-Fe-Mg-px)	38	36	39
pyroxene (Fe+Mg+Ca-fsp)	18	28	28
anhydrite (Ca+S-all other minerals)	0	1	0
holes (from BSE image)	4	9	6
Total:	100	100	100

suggesting slower cooling. Even though the proportion of plagioclase is subequal in all three samples (estimated at ~37 vol. %), the modal abundance of pyroxene in C1-N10 appears to be less at ~18 vol. % (vs. ~28 vol. % estimated in Y-6-N19 and Yax-1_863.51). Moreover, C1-N10 may contain, in part, igneous K-feldspar and quartz (a fraction of 19 vol. % and 16 vol. %, respectively), whereas the Y-6 and Yax-1 samples do not (or no longer contain quartz except as clasts and hydrothermal veins).

Secondary Mineralogy. When assessing alteration in the samples, it is important to realize that C1-N10 and Y6-N19 were collected at about the same depth (1393 m and 1378 m, respectively); whereas the impact melt unit sample at Yax-1 is located some 500 m above at a depth of 864 m. Thus, this section of impact melt could have sampled a different level of the hydrothermal system. It is also evident that some relative modal percents are the sum of primary and secondary mineralogies.

The mineral composite image of C1-N10 (Fig. 1A), combined with previous work [i.e., 1, 2] and petrographic and microprobe analyses, illustrates that the alteration in C1-N10 occurred sequentially from early albitization of primary plagioclase, to specular hematite (<1 vol. % after ilmenite; previously recognized by [1]), to K-feldspar-quartz (observe the spatial association and irregular distribution of these two minerals in Fig. 1A), to traces of pyrite, chalcopyrite, and bornite, to late epidote, chlorite (~2 vol. %; mainly after plagioclase and pyroxene, respectively), and subordinate calcite.

In Y6-N19 (Fig. 1B), pyroxene coronas around quartz clasts can be recognized. The sequential cross-cutting relations here are given by mafic, anhydrite

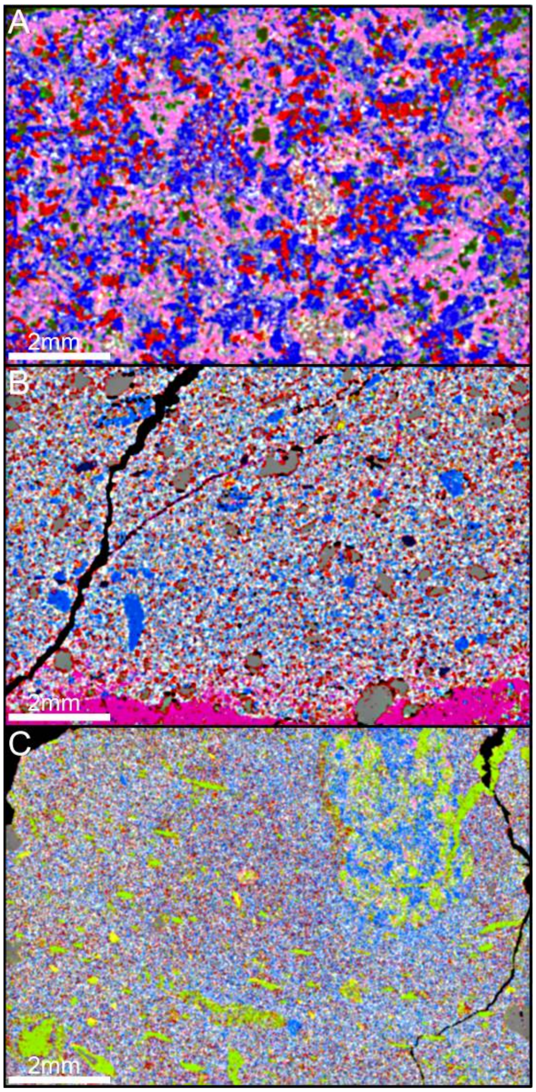

Figure 1. False color composites: A) C1-N10 image showing primary pyroxene and variably albitized plagioclase phenocrysts in a groundmass partially replaced by K-feldspar and quartz. B) Y6-N19 image showing primary clinopyroxene coronas about quartz clasts, anhydrite and mafic fragments, and a K-feldspar vein along the base of the image. C) Yax-1_863.51 image showing quartz and mafic clasts, primary clinopyroxene, albitized plagioclase, subordinate K-feldspar after plagioclase microcrysts, and clay after mafic clasts. Red = cpx, Blue = plag, Pink = kspar, Gray = qtz, Black = holes. White scale bar is 2mm.

(1 vol. %), and quartz clasts (10 vol. %; some with included anhydrite), early magnetite (fraction of total 2 vol. %), a prominent K-feldspar vein with anhydrite-quartz-chalcopyrite stringers (see BSE image in Fig. 2), and late subordinate phyllosilicates (~4 vol. %; chlorite [1] and clay).

Cross-cutting relations in sample Yax-1_863.51 (Fig. 1C) include quartz and mafic clasts, variable early albitization of primary plagioclase, incipient K-feldspar after plagioclase (up to 3 vol. %), and clay

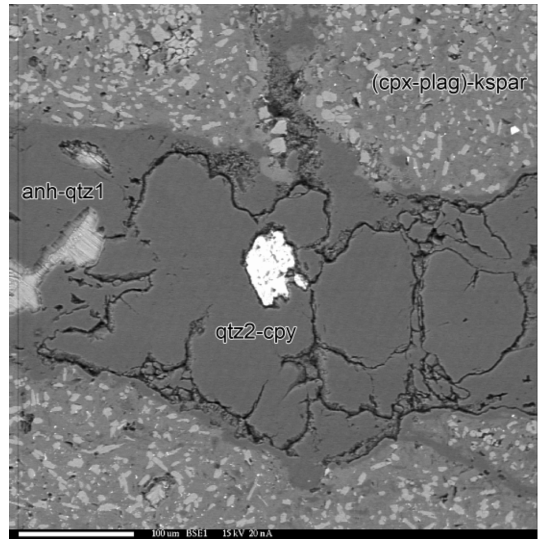

Figure 2. BSE image showing an anhydrite-quartz1 and quartz2-chalcopyrite vein cutting primary clinopyroxene and partially albitized plagioclase microcrysts in a groundmass replaced by K-feldspar.

after mafic clasts and as a vein [4]. This alteration style does not show anhydrite-quartz-sulfide veins like sample Y6-N19. However, it is important to note that these veins occur in the Yax-1 core below the impact melt unit at a depth interval of 900 to 1000 m.

Discussion: This initial assessment of alteration associations and literature research [i.e., 5] suggests that a possible zonation may exist at the hydrothermal system scale. Early specularite at C-1, followed by decreasing K-feldspar and quartz associations from C-1 to Y-6 to Yax-1 imply a crater center to crater rim radial cross-section from higher temperature at C-1, to intermediate temperature at Y-6, to lower temperature at Yax-1. Considering the phyllosilicates only, epidote-chlorite in C-1, chlorite-clay in Y-6, and abundant clay in Yax-1 also support a late down-temperature superposition that advanced from the rim to the center of the crater. Extension of the anhydrite-quartz-sulfide zone from Y-6 to Yax-1 further suggests that the intermediate temperature regime may have been present below the impact melt unit at Yax-1.

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