**CARBONATE-RICH MATERIAL ASSOCIATED WITH METEOR CRATER IMPACT MELT PARTICLES.**
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**Introduction:** Because of the relatively small size of Meteor Crater, only a small amount of impact melt was generated [1]. The impact melt was produced mainly by the melting of sandy dolomite and complete degassing $CO_2$, creating a vesiculated ultramafic melt-mineral assemblage [2]. Carbonate coatings, however, were recently found around some of the silicate melt particles [1,3]. It is not yet clear if these carbonate phases are carbonate melts that were quenched before complete degassing of $CO_2$ or if the carbonate phases are secondary caliche coatings that precipitated on the silicate melt particles while buried in the ejecta blanket. To further evaluate the origin of the observed carbonate rinds, the chemical compositions and textures of three particles with carbonate coatings were investigated.

**Methods:** Thin sections of the samples were examined by petrographic microscopy to identify carbonate and evaluate any textures. Chemical analyses were obtained with a Cameca SX-100 and additional BSE images were made on a JEOL 50 SEM, both at NASA JSC.

**Sample descriptions:** (1) Sample Hxx13 (Figure 1) with a size of 6.4 x 5.1 mm is characterized by a highly vesicular, frothy melt with skeletal and anhedral olivine and pyroxene like that described by Hörz et al. [2]. This melt entrains relict anhedral quartz grains from the target. A 2.4 mm wide rim of the melt particle is coated by carbonate, including a small amount of dolomite (probably relicts of the target). The carbonate-silicate melt contact is sharp. The porous and inhomogeneous carbonate is composed of calcite and aluminium- and silicate-rich clay, plus some quartz and pyroxene minerals. In addition, carbonate is embedded within the silicate melt in the form of calcite globules and zoned globules with clay-rich cores and calcite rims.

(2) Sample Hxx15 (Figure 2) is an irregular, ~8 x 6 mm vesicular silicate melt particle composed of a fine-grained assemblage of olivine and pyroxene. The melt entrains anhedral, relict quartz crystals with cracks that probably represent a low level of shock deformation. This particle is not coated with carbonate, but has vesicles that are lined with mixtures of calcite and clay, or discrete zones of calcite-rich and clay-rich material. The carbonate-silicate melt contact at the edge of the vesicles is sharp. The carbonate areas incorporate anhedral quartz, pyroxene, and iron oxide particles.

(3) The sub rounded Sample Hxx11 (Figure 3) has an average diameter of 6 mm, is not vesicular, and is composed of quartz grains, showing several deformation structures, embedded in a brown-reddish matrix of almost pure iron oxide with traces of $SiO_2$ up to 10 wt %. Microprobe analyses reveal totals of less than 80 wt% confirming the interpretation of hematite, maghemite, or a mix of both. The existence of iron oxide and the lack of vesicles indicate that the particle is not an impact-generated melt, but is instead a component of the target sediment. It was selected for examination, because it has a patchy coating of fine-grained, white-grey carbonate, ranging from a width of 2.4 mm to 640 µm. The porous texture and the composition of calcite and clay is similar to that in Hxx13; the carbonate also encloses pyroxene and quartz, plus some feldspar, olivine, and small aggregates of iron oxide. Calcite also fills fractures that cross-cut quartz grains and the matrix close to the particle surface.

**Discussion and Interpretation:** In comparison to previously analyzed carbonate-bearing melt particles [1,3], the examined carbonate zones have different features and textures: (a) No melt fragments were found within the carbonate rinds. (b) Neither distinct transition zones between carbonate layers and underlying melts nor significant dolomite were encountered, except for a small amount in sample Hxx13. (c) Hxx15 lacks a carbonate layer on the surface. (d) Vesicles in our particles are sometimes filled with carbonate and clay.

In general, all carbonate zones display similar features and chemical compositions. The phases often look very porous, altered, and have holes, which may have contained mineral grains dissolved out by weathering (Figure 3).

The origin of the aluminium- and silicate-rich clay observed in every sample is not clear. However, it might be connected to caliche-forming processes.

The above-mentioned similarities indicate that the carbonate zones of all three studied particles might have the same origin.

The pyroxene grains in the carbonate phase of Hxx13 have the same composition as the pyroxene in the silicate melt, which suggests they are derived from a melt component.

Pyroxene exists in the carbonate rind of Hxx11, although Hxx11 is not a silicate melt particle. The observed pyroxene in the carbonate phase must therefore be derived from some other source like an adjacent melt particle in the ejecta blanket. This suggests the rind is a secondary product.

The pyroxene of sample Hxx15 differs a bit, but is still consistent with the type of variation seen in vesicular melt particles by Hörz et al. [2].

The olivine grain within the carbonate of Hxx11 (Fo75Fa25) has a significantly higher proportion of forsterite than the olivine population of the other investigated particles (Hxx11, Hxx13), as well as higher than that in particles examined by Hörz et al. [2], which ranges from Fo41 to Fo59. Derivation of the grain from impact melt is nonetheless tentatively supposed.

The observed pyroxene and olivine grains could have formed either by collision during the impact (although this requires the removal of residual silicate melt) or embedded during a caliche-forming process.

Previous work [3] examined bona fide caliche samples from the region that were characterized by a layered texture, consisting of calcite, quartz, and sometimes phyllosilicates. None of these textures appear in Hxx11, 13, or 15. The clay within the carbonate, however, might still be the result of caliche formation.

**Conclusions:** We investigated the texture, structure, and chemical composition of carbonate phases associated with Meteor Crater impact melt particles. Even in combination with previous studies the origin of the carbonate phases remains unclear. Some examples of carbonate have features related to both, caliche and carbonate melt, origins. To solve the enigma of formation of the carbonate phases, an extended systematic study of the remaining samples of carbonate-rich phases associated with Meteor Crater impact melt particles is needed.

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**References:** [1] Kring D. A. (2007) Guidebook to the Geology of Barringer Meteorite Crater, Arizona (a.k.a. Meteor Crater), *LPI Contribution No. 1355;* [2] Hörz F. et al. (2002) *Meteoritics and Planetary Science*, 37, p. 501-531; [3] Cernok A. and Kring D. A. (2009), *LPS XXXX*, Abstract #1825

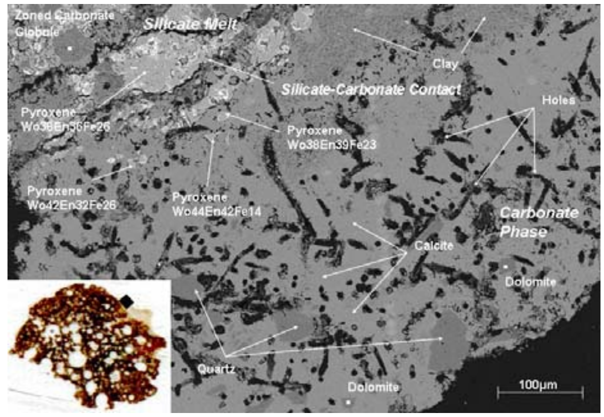


**Fig. 1 Porous carbonate layer of sample Hxx-13 including quartz, pyroxene and dolomite.**

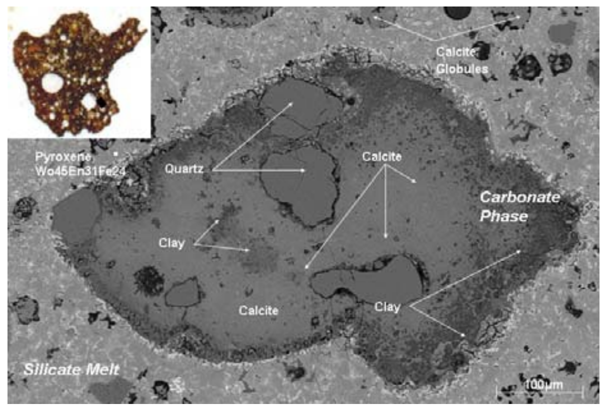


**Fig. 2 Sample Hxx15, Irregular formed, zoned carbonate clay-phase.**

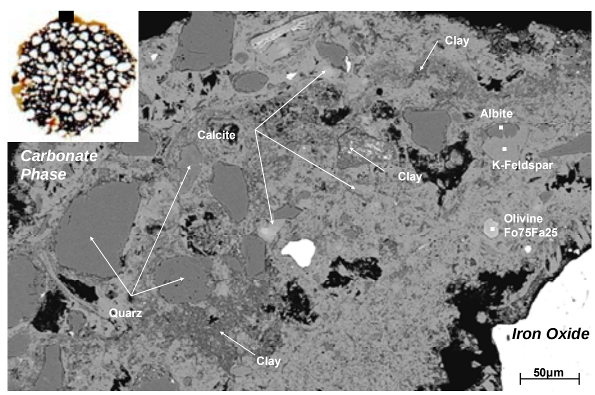


**Fig. 3 Sample Hxx-11, Carbonate-clay-layer with embedded quartz and pyroxenes on an iron oxide particle.**