EVIDENCE FOR THE SHOCK MELTING OF CARBONATES FROM METEOR CRATER, ARIZONA.

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Introduction: The response of carbonate rocks to hypervelocity impact remains a controversial subject within the impact community. Many questions remain to be answered, such as the relative importance and role of impact melting versus decomposition. Here, we present the results of an analytical SEM study of carbonate-bearing impact-melted materials from Meteor Crater, Arizona.

Samples and Geological Setting: Cm-size, vesiculated impactites were collected outside the crater about 150 m down from the top of the crater rim on the SE slope. Of the hundreds that were sectioned, five are composed of > 90% pyroxene accreta, internal pyroxene enclaves, and carbonates.

Petrography: The samples studied possess >95 vol% crystals, predominantly euhedral or skeletal clinopyroxene of variable composition ($En_{38-47}Fs_{7-23}Wo_{42-47}$), skeletal olivine ($Fo_{90-96}Fa_{4-10}$), carbonate, and barite ($BaSO_4$). These pyroxenes and olivines are more Ca- and Mg-rich, respectively, than in previously studied impactites from Meteor Crater [1]. Fe-rich pyroxenes typically occur in circular to irregularly shaped enclaves in a ‘host’ of more Ca-rich clinopyroxene. Carbonates are present in three distinct settings in these samples: (1) isolated spherules (up to ~200 µm in diameter) composed of either entirely $CaCO_3$, or zoned examples with rims of $CaCO_3$ and Mg-rich cores; (2) euhedral to anhedral crystals of $CaCO_3$ within a groundmass of clinopyroxene; (3) irregularly-shaped ‘pockets’ of carbonate within enclaves of Fe-rich pyroxene. There is always a sharp contact between the two phases, with euhedral crystals of calcite projecting into the pyroxene and vice versa. The pockets are typically zoned, from $CaCO_3$ to Mg-rich cores. SEM EDS analyses reveal that the carbonates in all these settings can contain up to ~0.8 wt% SiO_2 and ~0.4 wt% Al_2O_3.

Origin of the Carbonates: Two explanations are possible for the origin of these carbonates: (1) aqueous alteration, or (2) impact melting. Vesicles are present within crystallized regions of these samples. However, they are typically irregularly shaped and are either empty or infilled by debris. It would be rather fortuitous if only the perfectly spherical vesicles were infilled by carbonate. Furthermore, no evidence for aqueous alteration has been observed in these samples, except on their surfaces. The presence of euhedral crystals of calcite within a groundmass of pyroxene and the intergrowth of calcite with pyroxene at the edge of carbonate pockets is hard to reconcile with an origin through alteration, but is consistent with an impact melt origin for the carbonates. The presence of SiO_2 and Al_2O_3 in carbonates has been recognized at the Haughton and impact structure and is interpreted as rapid crystallization of carbonate minerals from a melt [2].

The melting of carbonates is also supported by the unusual composition of associated pyroxenes and olivines: Ca-rich pyroxene (diopside/wollastonite) and Mg-rich olivine (forsterite) in these samples are common in carbonatitic igneous rocks. We also note that these minerals are also common products of the breakdown of siliceous carbonates during metamorphism. This suggests an origin for these impactites through the shock melting of part of the dolomite and sandstone-bearing Kaibab Formation.

References: [1] Hörz F. et al. (2002) *Meteorit. Planet. Sci., 37,* 501-531. [2] Osinski G. R. and Spray J. G. (2001) Earth Planet. Sci. Lett., 194, 17-29.