Evidence for Impacted-Induced Shock Melting in Carbonaceous Chondrites

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RESULTS

Evidence of melting includes rounded sulfides and iron-nickel metal grains, reduction in pore space, recrystallization, and pockets of glass. The rounded iron sulfide and iron-nickel metal grains indicate high temperature atures that melted those minerals into droplets.

EVIDENCE FOR IMPACTS AS THE CAUSE FOR MELTING

Chondritic meteorites, or chondrites, are aggregates of pre-planetary dust that formed in the nebular disk surrounding the infant Sun. This dust included (1) silicate and metal grains, (2) melilite silicate droplets called chondrules, and (3) ceramic-like assemblages called calcium-aluminum-rich inclusions (CAIs) – that are the first solids to have formed in the solar system\textsuperscript{1}. These 3 components slowly accreted together in the nebula to form asteroids and planets, but the asteroids from which these particular meteorites came never grew large enough to melt and destroy all traces of the original dust, forming asteroids. Their dust has been preserved in cosmic debris for 4 ½ billion years. For this reason, studying chondritic meteorites gives critical clues to how our Solar System formed and how the planets accreted.

In a previous study\textsuperscript{2}, small pockets of melted matrix were found around the edges of a large CAI and were attributed to “hot accretion” – i.e., the CAI was very hot when it accreted onto the asteroid causing the matrix it contacted to melt. Alternatively, but not considered in that earlier work, the melting might have been caused by much-later impacts of large bodies onto the asteroid; in this case, the kinetic energy of the impacting body was instantaneously converted into heat that caused local (“impact or shock-induced”) melting of the asteroid. We tested the second hypothesis, by looking for evidence that can discriminate between hot-accretion and impact-induced melting. In particular, a distinctive feature of shock waves passing through a porous medium (such as chondrites) is that the effects are very heterogeneous. Large objects such as CAIs may concentrate the shockwave forcing during an impact creating highly-localized melting.

We studied the CAI-matrix contacts around 2 CAIs from the Leoville and Efremovka carbonaceous chondrites (a sub-variety defined by being carbon rich and noted for having abundant and large CAIs). Leoville and Efremovka exhibit significant compression (flattening) of all components. Figure 2 (left) in contrast to Allende and Vigarano which have more rounded CAI features. We searched for two types of evidence: that melting occurred, and that this melting is impact-induced shock melting.

METHODS

We used an FEI Nova NanoSEM 600 scanning electron microscope (SEM) to take backscatter electron (BSE) images of impact melt textures, generate element maps of selected areas, and conduct point-and-shoot analysis of crystals and glass. Higher precision chemical analyses of olivine and glass were collected using a JEOL 8530F Plus Hyperprobe.

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REFERENCES

\textsuperscript{1}\textsuperscript{1} K. Ito and N. Asami (2001) \textit{Journal of Geophysical Research} 106:10, 20,941-20,958.


