**ALLENDE 10 B 41: MEGACHONDRULE, OR IMPACT MELT CLAST?**

E. S. Bullock¹, N. G. Lunning² and T. J. McCoy¹. ¹Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC, USA. Email: BullockE@si.edu. ²Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996.

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**Introduction**

Recent examination of the Allende CV3 carbonaceous chondrite revealed a large, rounded object, ~1.6cm in diameter (figure 1), designated “Allende 10 B 41”. Initial examination of this object shows similarities to objects found in other chondrites known as “mega-chondrules” [e.g. 1-3]; however there are several differences compared to typical chondrules. Here we explore the possibility that this object instead represents an impact melt clast within a CV3 chondrite.

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**Method**

FEI NOVA NanoSEM 600 SEM: bulk compositional data & BSE images.
Jeol 8900 Superprobe: Quantitative chemical data for major elements.

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**Results**

**Olivine**: coarse-grained, normal zoning from Fo₆₃-₈₈, same range in the core and towards the edge (figure 2, 5, 6).

**Pyroxene**: Coarse-grained, augite.

**Chromite**: Small (~50 μm)

Opaque material: Fe metal/magnetite fills fractures within olivine (figure 6).

**Bulk composition**: see Table 1, consistent with bulk Allende [4]. Ratios of Ca/Al and Mg/Si consistent with bulk Allende [4], but not with typical chondrules.

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**Discussion**

Initially thought to be a “megachondrule” based on rounded shape and porphyritic texture, BUT some key differences:

- Lack of fine-grained rim
- Bulk composition closer to bulk Allende than to typical chondrules (Table 1; data from [4]).
- Mg/Si ratio consistent with melt formed from bulk Allende
- Localized melting has been shown to produce very similar textures to those shown here [5].

**Was it molten?**

Yes, based on porphyritic texture and smooth zoning profiles within olivine grains.

Coarse grain size suggests either slow cooling or a lack of nucleation sites.

Presence of normally zoned olivine crystals in direct contact with matrix suggests this was once a larger object that underwent comminution before incorporation into the parent body (figure 5).

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**Table 1. Bulk composition of 10B41 versus average bulk composition of Allende and typical Allende chondrules (wt% oxide) [4], ratios for Ca:Al & Mg:Si.**

<table>
<thead>
<tr>
<th></th>
<th>Allende 10 B 41</th>
<th>Bulk Allende</th>
<th>Chond. “A”</th>
<th>Chond. “C”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na₂O</td>
<td>1.12</td>
<td>0.45</td>
<td>0.11</td>
<td>10.6</td>
</tr>
<tr>
<td>MgO</td>
<td>28.46</td>
<td>24.62</td>
<td>10.82</td>
<td>15.17</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>4.34</td>
<td>3.27</td>
<td>31.61</td>
<td>17.78</td>
</tr>
<tr>
<td>SiO₂</td>
<td>40.24</td>
<td>34.23</td>
<td>29.79</td>
<td>40.19</td>
</tr>
<tr>
<td>CaO</td>
<td>3.16</td>
<td>2.61</td>
<td>26.76</td>
<td>5.28</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.09</td>
<td>0.15</td>
<td>0.99</td>
<td>0.12</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>0.39</td>
<td>0.52</td>
<td>0.06</td>
<td>0.19</td>
</tr>
<tr>
<td>MnO</td>
<td>0.16</td>
<td>0.18</td>
<td>0.02</td>
<td>0.1</td>
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<tr>
<td>FeO</td>
<td>22.66</td>
<td>27.15</td>
<td>0.37</td>
<td>8.77</td>
</tr>
<tr>
<td>Ca/Al</td>
<td>0.98</td>
<td>1.1</td>
<td>1.14</td>
<td>0.4</td>
</tr>
<tr>
<td>Mg/Si</td>
<td>0.92</td>
<td>0.93</td>
<td>0.47</td>
<td>0.49</td>
</tr>
</tbody>
</table>

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**Figure 6. Olivine with metal/magnetite stringers. Field of view = 1mm.**

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So: how did this clast form? Possibly by shock. Although Allende has a shock grade S1, well below that required for minimum melting, it does contain some olivine grains that exhibit planar fractures, a shock feature [6, 8].

If this clast is an impact melt, it potentially could have formed prior to accretion, and undergone fragmentation and rounding before incorporation into the Allende parent body.

**What next?**

Future analysis of the oxygen and Al-Mg isotopic systematics will help to determine whether this is a megachondrule or an impact clast.

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