INTRODUCTION

Large (multi-mm to cm) igneous-textured inclusions poor in metal and sulfide occur in ~4% of ordinary chondrites and hold important clues for early heating processes in the solar system. Most have major-element compositions and oxygen isotopic compositions broadly similar to chondrules, and fall into two main chemical types, relatively unfractonated (Unfr) and vapor fractionated (Vfr). These appear to have formed by melting of chondritic material with (Vfr) or without (Unfr) chemical exchange with nebular gas [2,3]. Other inclusions have distinctly different compositions and could have been produced dominantly by igneous differentiation [4]. We used the Cameca 7f-Geo ion microprobe at Caltech using an energy filtering technique [5] to determine the concentrations of 37 elements in 2 Unfr and 7 Vfr inclusions in various type 3-6 ordinary chondrites (Table 1), obtaining the largest trace element data set yet obtained for such materials. The compositions of all principal phases were measured, and modal reconstruction was used to determine bulk compositions.

- Among Unfr inclusions analyzed with SIMS, both 7871-I1 and 8645-I1 are texturally integrated with their hosts implying in situ metamorphism. Both have large chondrule-like Fe/Mg-silicate compositions, but oxygen isotopic compositions more consistent with the H-group and L-group, respectively, suggesting derivation from different source regions [3].

- Among Vfr inclusions analyzed with SIMS, all have variable Fe/Mg-silicate compositions (in Tdk-I2 only pyroxene is variable, olivine is uniform), suggesting they were not significantly metamorphosed in situ. As typical for Vfr inclusions in type 3 hosts, MET-I1 and MET-I3 have O-isotope compositions that lie well outside of ordinary chondrite fields with $\Delta^{17}O$ values falling between H chondrites and the TF line, suggesting exchange with nebular gas of distinctive composition [3].

Table 1: List of inclusions studied by SIMS

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Unfr</th>
<th>Vfr</th>
</tr>
</thead>
<tbody>
<tr>
<td>7871-I1</td>
<td>Unfr</td>
<td></td>
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<tr>
<td>8645-I1</td>
<td>Vfr</td>
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CONCLUSIONS

1) The two Unfr inclusions 7871-I1 and 8645-I1 could have formed by melting of chondritic materials and metamorphic equilibration.

2) The Vfr inclusions Par-I2 and Tdk-I2 probably formed by evaporative melting during brief events that chemically disturbed the ultramafic residua but which did not result in highly refractory objects overall.

3) Three other Vfr inclusions including Par-I1, MET-I3, and Khr-I1 likely formed as fractional melt condensates.

4) The data support the idea that Vfr inclusions formed in a space environment.