Polycrystalline and Intracrystalline Growth of Akimotoite in a Clinoenstatite in the L-6 Tenham Chondrite

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Introduction

- Akimotoite is a major constituent of the transition zone of the mantle
- Akimotoite has been reported by Sharp et al. and Tomioka et al. in shocked meteorite

Tomioka et al., Science, 1997
Introduction

- Stability of the subducting lithosphere is mainly calculated based on olivine polymorphs

- Hogrefe et al. (*Nature*, 1994) reported that enstatite-ilmenite transformation is slower than olivine-wadsleyite-ringwoodite

- Kinetics and mechanism of enstatite-ilmenite transformation is of great interest to discuss subduction dynamics
Reflected light observation

- Clinoenstatite grain entrained in a shock melt vein (SMV)
- Grain close to a vein wall
MicroRaman spectroscopy

- Referring to reflected light picture, light gray part is akimotoite with extending lamellae into dark gray which is clinoenstatite.
SEM investigation

- Polycrystalline part involving a solid state transformation starting at grain boundary
- Intracrystalline growth starting at akimotoite-clinoenstatite boundary and extending as thin lamellae to the interior
Polycrystalline akimotoite has a higher concentration in Ca, Al and Na than clinoenstatite.

Akimotoite lamellae have the same composition as clinoenstatite.

### Chemical Composition

<table>
<thead>
<tr>
<th>Oxide (wt%)</th>
<th>Akimotoite (polycrystalline)</th>
<th>Clinoenstatite and intracrystalline akimotoite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na2O</td>
<td>1.73</td>
<td>0.18</td>
</tr>
<tr>
<td>K2O</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td>FeO</td>
<td>13.4</td>
<td>14.38</td>
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<tr>
<td>SiO2</td>
<td>54.2</td>
<td>55.27</td>
</tr>
<tr>
<td>MgO</td>
<td>22.95</td>
<td>28.91</td>
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<tr>
<td>CaO</td>
<td>1.74</td>
<td>0.71</td>
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<tr>
<td>MnO</td>
<td>0.4</td>
<td>0.45</td>
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<tr>
<td>Al2O3</td>
<td>4.18</td>
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<tr>
<td>Cr2O3</td>
<td>0.23</td>
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<tr>
<td>P2O5</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>TiO2</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>TOTAL</td>
<td>99.09</td>
<td>100.39</td>
</tr>
</tbody>
</table>
• **Solid-state** transformation of clinoenstatite into akimotoite

• Similar mechanism as in olivine-ringwoodite transformation: both **polycrystalline and intracrystalline** mechanism

Beck et al., *Nature*, 2005  
Badjukov et al., *LPSc36*, 2005

• Higher concentration of Ca, Na and Al in akimotoite compared to clinoenstatite support a **diffusion** from the SMV into akimotoite
Model 1: Temperature gradient

- Simultaneous growth of polycrystalline and intracrystalline transformation triggered by a temperature gradient

- High temperature → polycrystalline transformation
- Low temperature → intracrystalline transformation
Model 2: Two stage model

- First stage: polycrystalline transformation starting at grain boundary and Ca, Na, Al diffusion

- Second stage: intracrystalline transformation starting from the akimotoite-clinoenstatite grain boundary
Clinoenstatite-akimotoite growth kinetics

- Akimotoite lamellae ~ 0.75µ thick – Polycrystalline ~ 25µ
- Polycrystalline transformation faster than intracrystalline transformation
- Rw lamellae in Tenham are 1-1.5µ (Beck et al., 2005, *Nature*)
- Enstatite-akimotoite intracrystalline transformation slower than olivine-ringwoodite
Conclusions

- Large clinoenstatite grain partially transformed
- Solid-state transformation and Ca, Al and Na diffusion
  - High Polycrystalline
  - Low Intracrystalline
- Intracrystalline transformation is slower compared to olivine ringwoodite
Conclusions

- Higher metastability of the subducting lithosphere
- TEM investigation
- Processing data of synchrotron XRD: structure of natural akimotoite