

LETTER

**Calcium Tschermak's pyroxene, CaAlAlSiO<sub>6</sub>, from the Allende and Murray meteorites:  
EBSD and micro-Raman characterizations**

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ABSTRACT

Calcium Tschermak's pyroxene (CaTs), CaAlAlSiO<sub>6</sub>, is well known as an important component in pyroxene. It is a member of the Ca clinopyroxene group in which Al dominates in the M1 site. Pyroxenes with more than 80 mol% CaTs were observed previously in Ca-,Al-rich refractory inclusions (CAI) from five carbonaceous chondrites. This study re-investigated the near end-member CaTs in the Allende and Murray chondrites. Electron backscatter diffraction (EBSD) is used to establish that its crystal structure is monoclinic, *C2/c*; *a* = 9.609 Å, *b* = 8.652 Å, *c* = 5.274 Å, β = 106.06°, *V* = 421.35 Å<sup>3</sup>, and *Z* = 4. Its EBSD pattern is an excellent match to that of synthetic CaAlAlSiO<sub>6</sub> with the *C2/c* structure. MicroRaman is also carried out to confirm the crystal structure. The Allende CaTs, with 46.00 wt% Al<sub>2</sub>O<sub>3</sub> and 97 mol% Al in the M1 site, has the formula Ca<sub>1.02</sub>(Al<sub>0.97</sub>Fe<sub>0.01</sub>Mg<sub>0.01</sub>)Σ<sub>0.99</sub>(Si<sub>1.00</sub>Al<sub>1.00</sub>)Σ<sub>2.00</sub>O<sub>6</sub>. It occurs as micrometer-sized crystals along with melilite, hibonite, perovskite, spinel, corundum, Ti<sup>3+</sup>-rich pyroxene, and grossular in a fluffy Type A CAI. It is probably a secondary phase resulting from the alteration of gehlenitic melilite. The CaTs in Murray, with a formula Ca<sub>0.98</sub>(Al<sub>0.81</sub>Mg<sub>0.16</sub>Ti<sub>0.04</sub><sup>4+</sup>)Σ<sub>1.01</sub>(Si<sub>1.11</sub>Al<sub>0.89</sub>)Σ<sub>2.00</sub>O<sub>6</sub>, occurs with hibonite and Al-rich diopside in a glass-free refractory spherule. This sample formed by solidification of a once-molten droplet early in the history of the solar system.

**Keywords:** Calcium Tschermak's pyroxene, CaTs, CaAlAlSiO<sub>6</sub>, Al-rich pyroxene, refractory inclusion, Allende meteorite, Murray meteorite, carbonaceous chondrite