

LETTER

**Calcium Tschermak's pyroxene, CaAlAlSiO₆, from the Allende and Murray meteorites:
EBSD and micro-Raman characterizations**

CHI MA,^{1,*} STEVEN B. SIMON,² GEORGE R. ROSSMAN,¹ AND LAWRENCE GROSSMAN^{2,3}

¹Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125, U.S.A.

²Department of the Geophysical Sciences, University of Chicago, Chicago, Illinois 60637, U.S.A.

³Enrico Fermi Institute, University of Chicago, Chicago, Illinois 60637, U.S.A.

ABSTRACT

Calcium Tschermak's pyroxene (CaTs), CaAlAlSiO₆, 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 Å³, and *Z* = 4. Its EBSD pattern is an excellent match to that of synthetic CaAlAlSiO₆ with the *C2/c* structure. MicroRaman is also carried out to confirm the crystal structure. The Allende CaTs, with 46.00 wt% Al₂O₃ and 97 mol% Al in the M1 site, has the formula Ca_{1.02}(Al_{0.97}Fe_{0.01}Mg_{0.01})Σ_{0.99}(Si_{1.00}Al_{1.00})Σ_{2.00}O₆. It occurs as micrometer-sized crystals along with melilite, hibonite, perovskite, spinel, corundum, Ti³⁺-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_{0.98}(Al_{0.81}Mg_{0.16}Ti_{0.04}⁴⁺)Σ_{1.01}(Si_{1.11}Al_{0.89})Σ_{2.00}O₆, 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, CaAlAlSiO₆, Al-rich pyroxene, refractory inclusion, Allende meteorite, Murray meteorite, carbonaceous chondrite