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Dmitryivanovite: A new high-pressure calcium aluminum oxide from the Northwest Africa 470 CH3 chondrite characterized using electron backscatter diffraction analysis

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Abstract

Dmitryivanovite ($CaAl_2O_4$) is a newly described, calcium aluminum oxide from the Northwest Africa 470 (NWA470) CH3 chondrite (Ivanova et al. 2002). NWA470 contains abundant small Ca,Al-rich inclusions (CAIs), and dmitryivanovite, whose composition is close to stoichiometric $CaAl_2O_4$ [$Ca_{1.000}(Al_{1.993}Si_{0.003}Ti_{0.002})_{1.998}O_4$], was found in one of these CAIs. It occurs as ~10 μm subhedral grains intergrown with grossite ($CaAl_4O_7$), perovskite, and melilite. Electron backscatter diffraction (EBSD) analysis revealed that dmitryivanovite is a high-pressure polymorph of $CaAl_2O_4$ ($a = 7.95$, $b = 8.62$, $c = 10.25$ Å, $\beta = 93.1°$, space group $P2_1/c$, and $Z = 12$). Dmitryivanovite is the third phase to be described from nature in the binary system of $CaO–Al_2O_3$, the other two being hibonite ($CaAl_{12}O_{19}$) and grossite ($CaAl_4O_7$)—all are found in CAIs. The presence of $CaAl_2O_4$ in NWA470 suggests a local elevated dust/gas ratio in the solar nebula. The phase diagram of $CaAl_2O_4$ shows that ~2 GPa is required to stabilize the high-pressure $CaAl_2O_4$ polymorph at 1327 °C, above which $CaAl_2O_4$ condenses from the solar nebula. Because it is unlikely that the solar nebula ever had such a high total gas pressure, it appears more probable that condensation of the low-pressure polymorph occurred in the solar nebula with an enhanced dust-to-gas ratio and that subsequently the high-pressure polymorph was produced by shock metamorphism, most likely after the $CaAl_2O_4$-bearing CAI was incorporated into the NWA470 parent asteroid.

Keywords: Dmitryivanovite, CAI, electron backscatter diffraction, new minerals, CH chondrite