

**DISCOVERY OF METEORITIC LAKARGIITE (CaZrO_3),
A NEW ULTRA-REFRACTORY MINERAL FROM THE
ACFER 094 CARBONACEOUS CHONDRITE**

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Introduction: During a nano-mineralogy investigation of the Acfer 094 carbonaceous chondrite, lakargiite (CaZrO_3) was identified as sub-micrometer inclusions in an isolated hibonite grain in section USNM 7233-1. The hibonite grain was described in [1]. Lakargiite is a recently found perovskite-group mineral from high-temperature skarns in ignimbrites of the Upper-Chegem volcanic structure, the North Caucasus, Russia [2]. Reported here is the first extraterrestrial occurrence of lakargiite, as a new ultra-refractory mineral in a primitive meteorite, among the first solids formed in the solar system. Field-emission SEM with EDS and electron back-scatter diffraction (EBSD) was used to characterize its composition and structure and associated phases.

Occurrence, Chemistry, and Crystallography: Lakargiite [$\text{Ca}_{0.95}(\text{Zr}_{0.87}\text{Ti}_{0.16})\text{O}_3$] occurs along with tazheranite [$(\text{Zr}_{0.52}\text{Ti}_{0.18}\text{Ca}_{0.16}\text{Y}_{0.06}\text{Fe}_{0.05}\text{Sc}_{0.03})\text{O}_{1.75}$], Zr-bearing perovskite [$\text{Ca}_{0.94}(\text{Ti}_{0.98}\text{Zr}_{0.06})\text{O}_3$] and Os-W-alloy [$\text{Os}_{0.81}\text{W}_{0.13}\text{Fe}_{0.06}$] as fine-inclusions scattered in the central area of the hibonite [$\text{Ca}(\text{Al}_{11.70}\text{Ti}_{0.14}\text{Fe}_{0.10}\text{Mg}_{0.06})\text{O}_{19}$] grain (Fig. 1). Lakargiite appears as irregular or subhedral lath-shaped grains, 300 nm – 900 nm in size, sometimes in contact with Os-W or perovskite. Associated tazheranite is a Ca-stabilized cubic zirconia (CSZ), likely being the first reported meteoritic CSZ. EBSD analysis revealed that the lakargiite has a perovskite *Pbnm* structure, identical to that of synthetic CaZrO_3 [3], showing $a = 5.591 \text{ \AA}$, $b = 5.762 \text{ \AA}$, $c = 8.017 \text{ \AA}$, $V = 258.3 \text{ \AA}^3$, $Z=4$.

Origin and Significance: Lakargiite is a new Zr-dominant ultra-refractory mineral, joining the Zr-rich refractory minerals allendeite ($\text{Sc}_4\text{Zr}_3\text{O}_{12}$) [4], tazheranite (Sc- or Y- stabilized cubic zirconia) [4,5] and panguite [6]. Texturally, lakargiite, tazheranite, Zr-bearing perovskite and Os-W formed before host hibonite. Lakargiite is likely an early condensate. Further work is under way to determine its place in the nebula.

References: [1] Simon S.B. and Grossman L. 2011. *MAPS* (in press). [2] Galuskin E.V. et al. 2008. *Am. Min.* 93:1903-1910. [3] Koopmanns H.J.A. et al. 1983. *Acta Cryst. Sec. C* 39:1323-1325. [4] Ma C. et al. 2009. *40th LPSC*, Abstr. #1402. [5] Ma C. and Rossman G.R. 2008. *GCA* 72:12S, A577. [6] Ma C. et al. 2011. *42nd LPSC*, Abstr. #1276.



Fig 1. BSE image showing lakargiite in Acfer 094.