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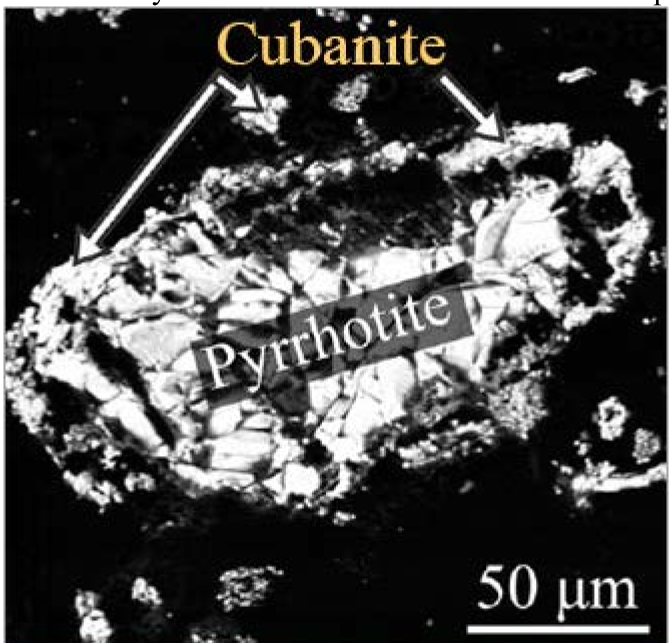
# *Circumstances of Cubanite in a Comet and Asteroid*

The copper and iron sulfide mineral cubanite ($CuFe_2S_3$) occurs in samples of comet 81P/Wild 2 returned by NASA's Stardust mission and in samples of ***CI primitive meteorites***.




(From Berger *et al.*, 2015, *M&PS*, v. 50(1), p. 1-14, doi: 10.1111/maps.12399.)

Experimentally produced sulfide minerals. Backscattered electron image shows cubanite ($CuFe_2S_3$) growth along edges of a grain of pyrrhotite ($[Fe,Ni]_{1-x}S$), described by Berger and coauthors as similar in occurrence as found in CI-chondrite Orgueil [***Data link*** from the Meteoritical Bulletin].

Because it changes irreversibly to another dimorph (crystal structure) at 210°C, the presence of cubanite can be used to place limits on the maximum temperature the solid was subjected to. This is true for the extraterrestrial cubanite and the parent bodies in which it formed. Making cubanite in the laboratory allows researchers to determine the aqueous conditions that existed during the mineral's crystallization.

Eve Berger (formerly at University of Arizona, now at NASA Johnson Space Center), Lindsay Keller (NASA JSC), and Dante Lauretta (University of Arizona) formed cubanite in the laboratory with carefully controlled conditions of pH, temperature, and ***oxygen fugacity***. They set the experimental conditions to mimic hydrothermal conditions expected on the CI-chondrite parent body, which were based on results of previous thermodynamic and mineralogical modeling and isotopic measurements of meteorite samples. These previously proposed ranges were: pH of 7–10, temperatures of 50–150°C, and oxidation conditions suitable for iron metal coexisting with magnetite, or even lower. Berger and colleagues placed reactants and oxygen buffer components in solutions (with a starting pH of ~9) into sealed, pressure vessels that were heated to a given temperature. Two experiments were heated to 150±3°C for 134 days and nine experiments were heated to 200±3°C for durations between 21–30 days. Experimental runs started with an oxygen fugacity corresponding to the iron-magnetite buffer. Finally, the vessels were removed from the furnace and quenched in ice-water baths, after which the mineral crystals were collected and prepared for analysis. Cubanite formed in all but one of these experimental runs. Using a combination of analytical techniques including electron microprobe analysis, X-ray diffraction, focused ion beam preparation, and transmission electron microscopy, the team confirmed the chemical composition and crystal structure of their synthesized cubanite.

In an earlier paper (2011) Berger and coauthors discussed ways cubanite could have formed by aqueous alteration of FeS on comet 81P/Wild 2 if conditions within pockets of liquid on the comet were analogous to those predicted for the CI-chondrite parent body. The laboratory experiments that produced cubanite have helped to constrain details of the possible low-temperature aqueous alteration on the comet and asteroid—helping us better understand the materials and processes that made and shaped our Solar System.

See Reference:
· Berger, E. L., Keller, L. P., and Lauretta, D. S. (2015) An Experimental Study of the Formation of Cubanite ($CuFe_2S_3$) in Primitive Meteorites, *Meteoritics & Planetary Science,* v. 50(1), p. 1-14, doi: 10.1111/maps.12399.
[ **abstract** ]
< See Also:
· Berger E. L., Zega T. J., Keller L. P., and Lauretta D. S. (2011) Evidence for Aqueous Activity on Comet 81P/Wild 2 from Sulfide Mineral Assemblages in Stardust samples and CI Chondrites, *Geochimica et Cosmochimica Acta,* v. 75(12), p. 3501-3513, doi:10.1016/j.gca.2011.03.026. [ **abstract** ]

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