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LETTER

Decagonite, $Al_{71}Ni_{24}Fe_5$, a quasicrystal with decagonal symmetry from the Khatyrka CV3 carbonaceous chondrite

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ABSTRACT

Decagonite is the second natural quasicrystal, after icosahedrite ($Al_{63}Cu_{24}Fe_{13}$), and the first to exhibit the crystallographically forbidden decagonal symmetry. It was found as rare fragments up to ~60 μm across in one of the grains (labeled number 126) of the Khatyrka meteorite, a CV3 carbonaceous chondrite. The meteoritic grain contains evidence of a heterogeneous distribution of pressures and temperatures that occurred during impact shock, in which some portions of the meteorite reached at least 5 GPa and 1200 °C. Decagonite is associated with Al-bearing trevorite, diopside, forsterite, ahrensite, clinoenstatite, nepheline, coesite, pentlandite, Cu-bearing troilite, icosahedrite, khatyrkite, taenite, Al-bearing taenite, and steinhardtite. Given the exceedingly small size of decagonite, it was not possible to determine most of the physical properties for the mineral. A mean of seven electron microprobe analyses (obtained from three different fragments) gave the formula $Al_{70.2(3)}Ni_{24.5(4)}Fe_{5.3(2)}$, on the basis of 100 atoms. A combined TEM and single-crystal X-ray diffraction study revealed the unmistakable signature of a decagonal quasicrystal: a pattern of sharp peaks arranged in straight lines with 10-fold symmetry together with periodic patterns taken perpendicular to the 10-fold direction. For quasicrystals, by definition, the structure is not reducible to a single three-dimensional unit cell, so neither cell parameters nor *Z* can be given. The likely space group is $P10_5/mmc$, as is the case for synthetic $Al_{71}Ni_{24}Fe_5$. The five strongest powder-diffraction lines [*d* in Å (I/I_0)] are: 2.024 (100), 3.765 (50), 2.051 (45), 3.405 (40), 1.9799 (40). The new mineral has been approved by the IMA-NMNC Commission (IMA2015-017) and named decagonite for the 10-fold symmetry of its structure. The finding of a second natural quasicrystal informs the longstanding debate about the stability and robustness of quasicrystals among condensed matter physicists and demonstrates that mineralogy can continue to surprise us and have a strong impact on other disciplines.

Keywords: Quasicrystal, aluminum, meteorite, chemical composition, TEM, X-ray diffraction, new mineral, decagonite