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LETTER

Icosahedrite, $Al_{63}Cu_{24}Fe_{13}$, the first natural quasicrystal

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ABSTRACT

Icosahedrite, ideally $Al_{63}Cu_{24}Fe_{13}$, is a new mineral from the Khatyrka River, southeastern Chukhotka, Russia. It occurs as dark gray-black anhedral to subhedral grains up to 100 μm across, closely associated with spinel, diopside, forsterite, nepheline, sodalite, corundum, stishovite, khatyrkite, cupalite, and an unnamed phase of composition AlCuFe. Icosahedrite is opaque with a metallic luster, possesses a gray streak, and is brittle with an uneven fracture. The density could not be determined. 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. In plane-polarized incident light, icosahedrite exhibits neither bireflectance nor pleochroism. Between crossed polars, it is isotropic. Reflectance percentages ($R_{min} = R_{max}$) for the four standard COM wavelengths are 62.3 (471.1 nm), 60.6 (548.3 nm), 58.1 (586.6 nm), and 56.0 (652.3 nm), respectively.

The X-ray powder pattern was indexed on the basis of six integer indices, as conventionally used with quasicrystals, where the lattice parameter (in six-dimensional notation) is measured to be a_{6D} = 12.64 Å, with probable space group $Fm\bar{3}\,\bar{5}$. The four strongest X-ray powder-diffraction lines [d in Å (I/I_0) (n_1,n_2,n_3,n_4,n_5,n_6)] are: 2.006 (100) ($4\bar{2}0\ 042$), 2.108 (90) ($42\bar{2}\ \bar{2}22$), 1.238 (30) ($60\bar{4}\ 064$), and 3.41 (25) ($31\bar{1}\ \bar{1}11$). Average results of 34 electron-microprobe analyses gave, on the basis of total atoms = 100, the formula $Al_{63.11}Cu_{24.02}Fe_{12.78}Si_{0.03}Co_{0.01}Ca_{0.01}Zn_{0.01}Cr_{0.02}Cl_{0.01}$. The simplified formula is $Al_{63}Cu_{24}Fe_{13}$, which requires the mass fractions Al 43.02, Cu 38.60, Fe 18.38, total 100.00 wt%.

The new mineral is named for the icosahedral symmetry of its internal atomic structure, as observed in its diffraction pattern. Both the new mineral and mineral name have been approved by the Commission on New Minerals, Nomenclature and Classification, IMA (2010-042).

Keywords: Icosahedrite, new mineral, natural quasicrystal, electron-microprobe data, reflectance data, X-ray diffraction data, Khatyrka, Kamchatka, Russia