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Amesite from Antarctica

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Abstract

Amesite crystals from the Dufek Massif, Pensacola Mountains, in Antarctica have been identified as the $2H_2$ and $6R$ polytypes. The crystals universally are twinned on (001), and the twinned aggregates exhibit apparent hexagonal diffraction symmetry. An untwinned sector of a $2H_2$ crystal, however, has an optic angle of 18° and triclinic diffraction symmetry $P1$.

Amesite is a relatively rare 7 Å-layer silicate that, to the authors' knowledge, has been well documented only from three localities, namely in the emery deposit at Chester, Massachusetts (Shannon, 1921), the Postmasburg Mn-ores at Gloucester, South Africa (de Villiers, 1945), and the Saranovskoye chromite deposit, North Urals, U.S.S.R. (Steinfink and Brunton, 1956). A few Ni-rich and Mn-rich occurrences, for which different species names have been proposed, also are known. Other reported occurrences appear more likely to be either some other serpentine-type mineral or a 14 Å chlorite.

Amesite from a previously unreported locality in Antarctica has been made available to us by Dr. J. C. Behrendt and Dr. T. S. Laudon. The specimen was collected by Behrendt in 1957 on the Filchner Ice Shelf Traverse at 52° 43.3′ W, 82° 35.5′ S in the Pensacola Mountains. It comes from the lower portion of the Dufek Massif, a stratiform mafic intrusive (Ford and Boyd, 1968). The amesite occurs on the surface of a hand specimen of apparent contact-metamorphic origin as small crystals along with idocrase and chlorite. The amesite crystals are in the form of hexagonal prisms, are pale green in color, and in some cases have a thin reddish surface coating.

Electron microprobe analyses of two crystal fragments gave the following results, expressed as oxide percentages.

	SiO_2	Al_2O_3	MgO	FeO	MnO	K_2O	Na_2O
Sample 1	22.39	33.73	23.69	7.49	0.344	0.0	0.0
Sample 2	23.11	32.64	24.18	8.30	0.355	0.0	0.0

An average of the two analyses yields the following structural formula on the basis of seven formula oxygens:

$$(Mg_{1.702}Al_{0.951}Fe_{0.315}Mn_{0.014})(Si_{1.085}Al_{0.915})\ O_5(OH)_4.$$

Thus the amesite contains significant Fe, assumed to be in the ferrous state. A slightly larger substitution of Al in the octahedral sheet than in the tetrahedral sheet is balanced by octahedral vacancies.

The crystals universally are twinned on (001) either as 6-fold biaxial sectors, as shown in Figure 1, or as more complex twins joined along sutured boundaries. An optic angle $2V$ of 18° was obtained on an untwinned sector, cut with a razor blade from a twinned aggregate, and refractive indices of $\alpha = 1.5967(5)$, $\beta = 1.5986(5)$, and $\gamma = 1.615(1)$ were determined for the Na_D line by use of high-dispersion oils and a spindle stage. Although amesite usually has been considered to be hexagonal (Steinfink and Brunton, 1956), these observations prove that the true symmetry must be lower.

X-ray precession photographs of about 30 crystals showed that the majority are of the structural type typical of most other amesites, designated $2H_2$ by Bailey (1969). The intensities given by the twinned aggregate crystals closely approximate hexagonal symmetry, but untwinned sectors have triclinic diffraction symmetry $P1$. A crystal structure refinement of the latter, to be reported separately, attributes the lower symmetry to ordering of tetrahedral and octahedral cations (Hall, 1974; Bailey, 1975).

Several amesite crystals were found to have a 6-layer periodicity. These crystals usually are smaller than those of the $2H_2$ polytype and have a slightly

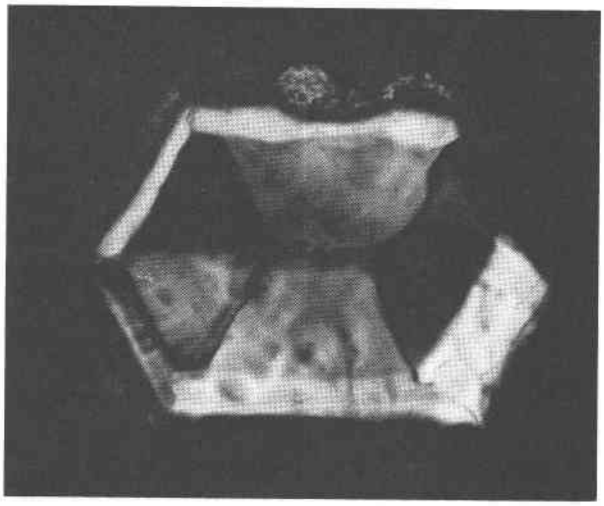

FIG. 1. Sector twinning on (001) in amesite-$2H_2$ under crossed nicols. Crystal is 1.0 mm in diameter. Triangular sector in lower left corner was excised for structural refinement.

TABLE 1. Structure amplitudes for amesite-$6R$

hkl	F_{calc}	F_{obs}	*hkl*	F_{calc}	F_{obs}
0.1.8	89	97	0.3.6	141	125
14	71	79	12	111	145
20	51	56	18	92	96
26	36	43	24	58	69
32	27	37			
			1.1.0	8	9
$\overline{10}$	84	86	3	11	18
$\overline{16}$	64	65	6	34	34
$\overline{22}$	45	46	9	22	20
$\overline{28}$	32	40	12	17	18
$\overline{34}$	26	33	15	27	32
			18	18	18
0.2.4	42	46	21	25	24
10	60	56	24	29	24
16	74	60	27	20	15
22	79	65			
28	75	69			
$\overline{2}$	37	33			
$\overline{8}$	54	46			
$\overline{14}$	70	60			
$\overline{20}$	78	56			
$\overline{26}$	77	56			
$\overline{32}$	69	60			

F_{calc} values from Bailey (1969). F_{obs} values measured visually from precession photographs but not corrected for absorption or Lorentz-polarization factors. Overall residual R = 14.6%. Hexagonal indices used with i index omitted.

barrel-shaped morphology rather than planar prismatic faces. The most distinctive feature, however, is the radial extinction pattern under crossed nicols (Fig. 2). This is interpreted here as due to microtwinning. Precession X-ray photographs show rhombohedral systematic absences. The intensities (Table 1) fit well those of the $6R$ polytype of space group *R3c* derived by Bailey (1969). The extinction pattern suggests the true symmetry is lower. The $6R$ stacking sequence consists of successive $b/3$ interlayer shifts in the same direction (+ or −), whereas in the more common $2H_2$ structure, $+b/3$ and $-b/3$ shifts alternate regularly in successive layers. In both structures the I and II sets of octahedral positions are occupied in regular alternation (equivalent to rotating every other layer by ± 60° or 180°). Within experimental error $a_{6R} = a_{2H} = 5.322$ Å and $c_{6R} = 3c_{2H} = 42.156$ Å. This is the first reported natural occurrence of the $6R$ polytype for a trioctahedral 1:1 layer silicate, although nacrite is a dioctahedral example. Steadman and Nuttall (1962) have described a different 6-layer amesite from Saranovskoye, U.S.S.R. The latter structure can be described as resulting from the operation of a 3-fold screw axis on the ideal $2H_1$ structure (in which the interlayer shifts are of zero magnitude). This creates a layer stacking sequence in which interlayer shifts of $b/3$ along *Y* alternate regularly with zero interlayer shifts, and in which octahedral cation sets I and II alternate regularly. The authors observed twinning and a slight triclinicity of the interaxial angles of their crystal and believe that the true symmetry is *P*1 rather than the ideal *R*3. The diffraction pattern differs from that of the $6R$ structure by the presence of numerous 01*l* and 02*l* reflections with $l = 2n + 1$ (as indexed on hexagonal axes). In addition to the regular stacking sequences discussed

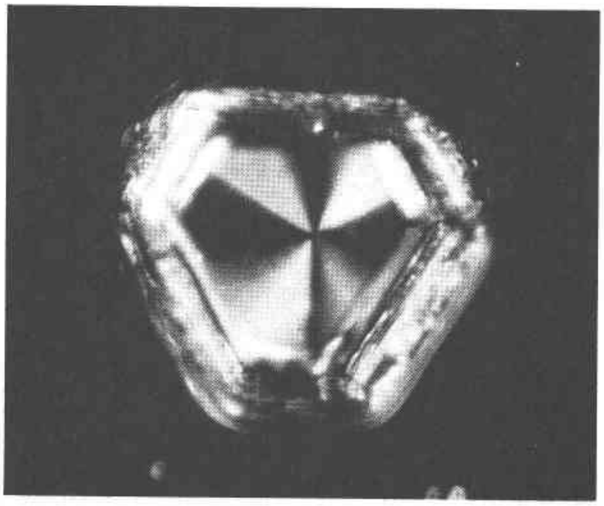

FIG. 2. Radial extinction pattern on (001) for amesite-$6R$ under crossed nicols. In contrast to the crystal in Fig. 1, this pattern does not change upon rotation of the microscope stage. Crystal is 0.4 mm in diameter.

here, Brindley *et al.* (1951) and Oughton (1957) have described an amesite with considerable ±*b*/3 stacking disorder and have discussed the relationships between regular and irregular sequences.

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