Anandite, a new barium iron silicate from Wilagedera, North Western Province, Ceylon

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[Read 9 March 1967]

Summary. Anandite is a new barium iron silicate found in the magnetite ore zone of the Wilagedera iron ore body, in the North Western Province of Ceylon. The mineral is named after the late Dr. Ananda Coomaraswamy, the first director of the Mineral Survey of Ceylon.
Anandite is monoclinic, with a 5·412, b 9·434, c 19·953 Å, β 94° 52′, space group $C2/c$. D 3·94, hardness 3–4. Optically positive, $b \parallel \beta$, $\gamma \wedge a$ 12°, β 1·85$_5$, $\gamma >$ 1·88. Pleochroism: β green, γ brown. Chemical composition corresponds to the simplified formula $(Ba,K)(Fe,Mg)_3(Si,Al,Fe)_4O_{10}(O,OH)_2$ with $Z = 2$. The data available indicate that the mineral has the trioctahedral structure of the brittle micas.

IN 1964 during detailed examination of drill cores of the Wilagedera iron ore prospect in the North Western Province of Ceylon by one of the authors (D.B.P.) monomineralic bands of a black lustrous almost opaque mineral were found within the iron-ore-bearing zones. The optical properties of this mineral could not be determined due to the high body absorption. A rapid chemical analysis carried out by J. P. R. Fonseka in the Geological Survey laboratories gave a BaO content of nearly 19 %. A study of the physical properties of the mineral indicated the possibility that it was a new species. X-ray and further chemical analysis were carried out in the Geological Survey laboratories (Colombo, Ceylon), at the Institute of Geology of the University of Helsinki (Finland), and at the Department of Geology of Leeds University (England). The results of this work confirm that this mineral is a new species of brittle micas with the simplified formula $(Ba,K)(Fe,Mg)_3(Si,Al,Fe)_4$ $O_{10}(O,OH)_2$.

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The new mineral is named *anandite* in honour of the late Dr. Ananda Coomaraswamy, the first director of the Mineral Survey of Ceylon, in recognition of his many contributions to the geology and mineralogy of Ceylon. The name has been approved by the International Mineralogical Association Commission on New Minerals and Mineral Names.

Occurrence. The Wilagedera iron ore prospect, which was the first banded magnetite deposit found in Ceylon, occurs within a succession of calc-schists and calc-gneisses of Precambrian age (Fernando, 1958

TABLE I. Powder pattern of anandite. Filtered iron radiation with internal silicon standard

hkl	Intensity	$d_{meas.}$	$d_{calc.}$	hkl	Intensity	$d_{meas.}$	$d_{calc.}$
*002	60	9·92	9·95	*026	50	2·716	2·712
*004	85	4·99₅	4·98	*13Ī	45	2·681	2·676
022	10	4·27	4·26	Ī17	15	2·521	2·513
*113	20	3·700	3·700	*008	80	2·490	2·485
*024	40	3·430	3·430	028	20	2·240	2·238
*006	100	3·320	3·315	0.0.10	35	1·991	1·988
Ī15	25	3·165	3·150	0.0.12	35	1·660	1·657
115	25	2·929	2·928				

* Line used for calculating the unit cell dimensions.

and 1960, 1961–62). The main ore mineral present is magnetite and is associated with chalcopyrite, pyrite, and pyrrhotine. The magnetite-bearing ore zone is capped by banded magnetite–baryte rock the origin of which is problematical. The ore zone and the interbanded succession of calc-schists and gneisses are of meta-sedimentary origin, the sediments having been subject to high temperature and pressure conditions appropriate to the granulite facies (Pattiaratchi, 1961).

Anandite occurs generally as distinct monomineralic bands $\frac{1}{4}$ in. to 2 in. or more in thickness closely associated with magnetite and sulphide minerals. Occasionally the mineral is disseminated as lenses, which are, however, distinct due to the black lustrous property of the mineral.

X-ray crystallography. The mineral was studied with both single crystal and powder X-ray methods. A series of Weissenberg and precession photographs revealed a monoclinic symmetry with the following types of reflections: hkl with $h+k = 2n$, $h0l$ with $l = 2n$ ($h = 2n$) and $0k0$ with $k = 2n$. Accordingly, the space group is $C2/c$ (or Cc). The unit-cell dimensions measured from single crystal photographs are: a 5·42 Å, b 9·45 Å, c 19·97 Å, β 95°.

The powder pattern of the mineral recorded with a Philips Norelco

diffractometer is reproduced in table I. The indexing of the powder lines was made using the IBM–1620 computer of the University of Helsinki. The intensities of the reflections were checked on the single crystal photographs. The unit cell dimensions calculated from the powder pattern are: a 5·412±0·005 Å, b 9·434±0·005 Å, c 19·953±0·01 Å, β 94° 52'±10'. These values agree reasonably well with the data obtained from single crystal photographs. The values calculated from the powder pattern are considered to be more accurate and are adopted in this paper.

TABLE II. Chemical composition and atomic ratios on a basis of $O+OH = 48$ for anandite. 1, analysis by Fonseka and de Silva; 1a, corrected for admixed FeS_2; 1b, atomic ratios. 2, analysis by O. von Knorring; 2a, corrected for admixed FeS_2; 2b, atomic ratios

	1	1a	2	2a		1b			2b	
SiO_2	25·22	26·49	25·20	26·62	Si	10·56			10·68	
Al_2O_3	5·86	6·15	4·85	5·12	Al	2·88			2·40	
TiO_2	0·32	0·34	0·28	0·30	Ti	0·12	} 16·00		0·08	} 16·00
Fe_2O_3	6·47	6·80	6·98	7·37	Fe^{3+}	2·04			2·24	
FeO	33·42	32·14	33·10	31·46	Fe^{2+} {	0·40 / 10·28		{	0·60 / 9·96	
MnO	0·70	0·74	0·66	0·70	Mn	0·24	} 12·52		0·24	} 12·36
MgO	3·18	3·34	3·39	3·58	Mg	2·00			2·16	
BaO	19·60	20·59	20·35	21·50	Ba	3·20			3·36	
CaO	0·15	0·16	0·16	0·17	Ca	0·08			0·08	
Na_2O	0·15	0·16	0·10	0·11	Na	0·12	} 3·92		0·08	} 4·04
K_2O	0·95	1·00	0·93	0·98	K	0·52			0·52	
H_2O+	2·01	2·11	1·98	2·09	O {	40·00 / 2·40		{	40·00 / 2·40	
H_2O-	0·12	—	0·12	—						
S	2·52	—	2·96	—	OH ..	5·60	} 8·0		5·60	} 8·00
	100·67		101·06							
−O	1·26		1·48							
Total	99·41	100·02	99·58	100·00	D calc.	3·91			3·94	

A complete crystal structure analysis of the mineral has been undertaken by Dr. A. Vorma, of the Geological Survey of Finland. As pointed out by him, the X-ray data show a striking resemblance to the mica minerals representing the polytype $2M_1$.

Physical and optical properties. In hand specimen, the mineral is black in colour. No crystals with measurable faces have been found. The only prominent face is the perfect lustrous cleavage plane parallel to {001}. Occasionally flakes are observed that have hexagonal outlines and probably indicate poorly developed prism faces. Hardness 3–4.

The mineral is transparent only in very thin splinters making the determination of optical properties difficult. Further, due to the perfect basal cleavage, sections thin enough for optical examination could be ground only parallel to the cleavage plane. On the cleavage flake the

following refractive indices were measured in sodium light using high-index immersion liquids: γ' 1.88 ± 0.01 and α' $1.85_5 \pm 0.01$. The interference figure obtained on the flake indicates that the obtuse bisectrix is nearly perpendicular to {001} and that the optic normal is parallel to α'. Universal stage work showed that the true γ direction makes an angle of $12° \pm 4°$ with the crystallographic a-axis.

The optical properties may be summarized as follows: b parallel to β; $\gamma \wedge a$ $12° \pm 4°$; optically positive; β $1.85_5 \pm 0.01$; $\gamma > 1.88$; pleochroic with β green and γ brown; strong dispersion. The optic axial angle could not be measured.

The specific gravity of the batch chemically analysed by von Knorring was determined by suspending apparently pure fragments in water. The value 4.00 was obtained. Correcting for the pyrite contamination this value yields 3.94 as the specific gravity of pure anandite.

Chemical composition. Two independent chemical analyses were made, the one by Mr. Fonseka and Mr. de Silva, of the Geological Survey of Ceylon, and the other by Dr. von Knorring, of Leeds University. The results of these analyses are shown in table II. Between some of the cleavage flakes thin films of an opaque material were observed. A small amount of this opaque material was isolated by Dr. Vorma, of the Geological Survey of Finland, and was identified as pyrite by a powder pattern. It is extremely probable that all the sulphur shown by the chemical analyses is contained in the admixed pyrite. Table II gives also the results of the analyses corrected for admixed pyrite and for H_2O-. The results of the two analyses agree reasonably well with each other although the analyses were carried out independently and on different samples. The atomic ratios (based on $O + OH = 48$) calculable from both analyses are included in Table II.

References

FERNANDO (L. J. D.), 1958 and 1960. Administration Reports of the Government Mineralogist, pp. R. 28 and R. 32, respectively.
—— Administration Report of the Director, Geological Survey, for 1961–62, pp. R. 26 and R. 27.
PATTIARATCHI (D. B.), 1961. Some aspects of the genesis of iron ores in Ceylon (Abstract), Proc. 17th Ann. Sess. Ceylon Assn. Adv. Sci.

[*Manuscript received 10 August 1966*]