

TABLE I. GEIKIELITE: MICROPROBE ANALYSIS

	wt%	cations per 3 oxygens	
MgO	25.0	Mg	0.783
MnO	8.1	Mn	0.144
FeO	3.9	Fe	0.068
CaO	0.3	Ca	0.007
SiO <sub>2</sub>	0.2	Si	0.004
TiO <sub>2</sub>	63.0	Ti	0.995
	100.5		

Energy dispersive analysis at 15kV

TABLE II. GEIKIELITE: REFLECTANCE DATA

$\lambda_{nm}$	Air		Oil	
	R <sub>o</sub>	R <sub>e</sub>	R <sub>o</sub>	R <sub>e</sub>
400	17.7	13.9	5.51	3.25
420	17.25	13.5	5.19	3.09
440	16.8	13.1	4.97	2.91
460	16.4	12.75	4.76	2.74
480	16.1	12.45	4.58	2.60
500	15.8	12.2	4.40	2.49
520	15.5	12.0	4.29	2.42
540	15.4	11.85	4.23	2.37
560	15.3	11.8	4.20	2.36
580	15.2	11.75	4.20	2.37
600	15.2	11.7	4.24	2.40
620	15.2	11.8	4.31	2.48
640	15.3	11.8	4.44	2.59
660	15.3	11.8	4.56	2.71
680	15.35	11.8	4.72	2.84
700	15.4	11.8	4.78	2.92

Colour values relative to illuminant C

x	0.304	0.303	0.302	0.301
y	0.307	0.306	0.300	0.296
Y%	15.4	11.9	4.3	2.4
$\lambda_d$	469	468	449	457
P <sub>e</sub> %	3.6	3.9	5.6	6.7

Colour values relative to illuminant A

x	0.442	0.442	0.443	0.444
y	0.404	0.403	0.399	0.396
Y%	15.3	11.8	4.3	2.4
$\lambda_d$	482	481	457	457
P <sub>e</sub> %	1.5	1.6	2.2	3.5

c = complementary wavelength in oil. This may result from the contribution of a blue/red (purple) component from internal reflections. This effect is more marked in the less reflective e' direction.

All % values measured relative to SiC standard, Zeiss no. 472, using conditions and equipment described in detail by Criddle et al. (1983).

between 420 and 640 nm for a range of ilmenite-geikielite solid solutions, indicate a decrease in reflectance values with an increase in Mg content. Reflectance values reported here are close to those given by Cervelle for a geikielite with 25.7 wt. % MgO.

Although ilmenites with substantial geikielite components (microilmenites) occur in kimberlites (Wyatt, 1979), phases with > 70% MgTiO<sub>3</sub> end-member component have been reported only from metamorphosed magnesian limestones (Murdoch and Fahey, 1949; Wise, 1959) or associated with chromite in serpentinites (Efremov, 1954). The occurrence of geikielite reported here is in accord with the metamorphosed Mg-limestone paragenesis, but this geikielite has a composition much richer in the pyrophanite component (MnTiO<sub>3</sub>) than geikielites previously described.

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KEYWORDS: geikielite, reflectance data, perovskite, serpentine-marble, Baltistan, Pakistan.

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## An occurrence of the hydrous lead-copper-iron silicate creaseyite in South Africa

CREASEYITE, a hydrous lead-copper-iron silicate Cu<sub>2</sub>Pb<sub>2</sub>(Fe,Al)<sub>2</sub>Si<sub>5</sub>O<sub>17</sub>·6H<sub>2</sub>O was first described by Williams and Bideaux (1975) from Arizona and Sonora, Mexico, followed by a later report from the Rio Negro province in Argentina by Hayase and Dristas (1978). During a recent investigation of the iron formations and gossans of Bushmanland in Proterozoic metamorphites from the Namaqua mobile belt, creaseyite and other rare secondary minerals were identified. Creaseyite from the iron-formation of the Aggeneys Mountains is, as far as known, the fourth reported occurrence in the world and is the first to be described on the African continent.

*Occurrence.* The minerals occur in the oxidation zone of the lead-zinc-copper ore body at Black Mountain, near Aggeneys. Creaseyite is found in close association with other secondary silicates (such as diopside and chrysocolla), sulphates, phospho-sulphates, and sulpho-carbonates (anglesite, linarite, beaverite, brochantite, plumbogjarosite, pyromorphite, corkite, leadhillite, and caledonite), as well as the chlorides atacamite, paratacamite, and diaboileite. Creaseyite seems to have been one of the last minerals to form and occurs in veinlets (fig. 1a) together with blue anglesite as a fine earthy, yellowish-green powdery substance on magnetite/hematite. Two varieties, one yellowish-green (analysis no. 1) and the other (no. 2) slightly darker green in colour, were observed. The material is, however, only obtainable in minute quantities.

*Optical and physical properties.* Williams and Bideaux (1975) as well as Hayase and Dristas (1978) reported creaseyite to occur as fibrous crystals and aggregates. When observed under low magnification during the present study no fibres were at first noticed and the creaseyite appeared to be a cryptocrystalline earthy, powdery substance. However, under a magnification of 500, fibrous crystals of creaseyite were recognized. The fibrous nature of the creaseyite was verified with the scanning electron microscope (fig. 1b).

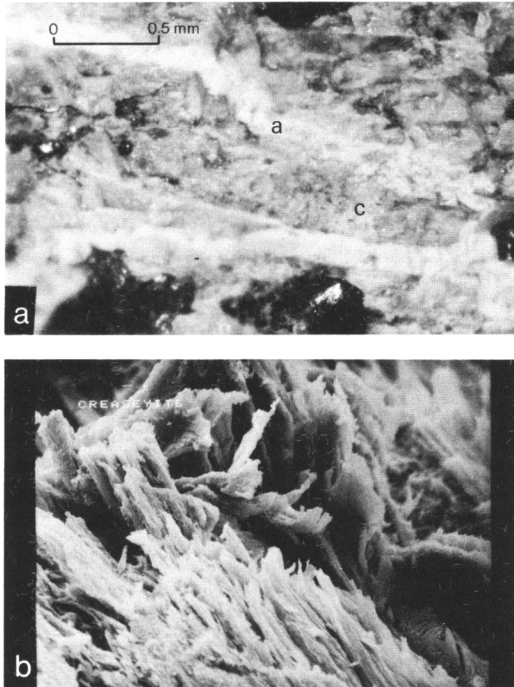


FIG. 1. (a) Photomicrograph of a vein of creaseyite (c) and anglesite (a) in a matrix of various iron oxides. (b) Electron photomicrograph of creaseyite illustrating its fibrous nature. Length of right-hand scale bar represents 1  $\mu\text{m}$ .

The colour (analysis no. 1) corresponds to a moderate yellowish-green (5 GY 7/4) of the rock colour chart of the Geological Society of America (1975). The Mohs hardness was determined as between 2 and 2½. Due to the small quantity and the softness of the material, difficulties were encountered in preparing thin sections. Creaseyite from Aggeneys is very weakly pleochroic and strongly birefringent. The indices of refraction are  $\alpha$  1.730,  $\beta$  1.740, and  $\gamma$  1.750.

*Chemistry.* Creaseyite from Aggeneys was analysed by a Cameca Camebax electron microprobe. Because the mineral contains water and tends to disintegrate during analysis, a low accelerating voltage was used and numerous analyses were performed. Water is calculated by difference. The results are presented in Table I. Sample no. 1 (yellowish-green variety) contains more Fe and less

TABLE I - Chemical analyses and empirical formulae of creaseyite specimens

	1	2	3	4
SiO <sub>2</sub>	27.35	26.56	25.50	26.86
Al <sub>2</sub> O <sub>3</sub>	0.19	0.34	2.10	6.92
Fe <sub>2</sub> O <sub>3</sub>	23.61	16.95	12.30	7.13
PbO	31.79	36.01	37.00	33.94
CuO	9.36	12.29	13.50	12.48
ZnO	0.02	0.03	1.20	0.97
H <sub>2</sub> O	*7.68	*7.82	8.80	8.75
TOTAL	100.00	100.00	100.40	97.05

\* Calculated by difference

- Aggeneys (mean of 10 analyses) (light green)  
(Pb<sub>1.53</sub>Cu<sub>1.26</sub>Fe<sup>2+</sup><sub>1.21</sub>Zn<sub>0.00</sub>)<sub>4</sub>(Al<sub>0.04</sub>Fe<sup>3+</sup><sub>1.96</sub>)<sub>2</sub>Si<sub>4.88</sub>O<sub>17</sub>4.57(H<sub>2</sub>O)
- Aggeneys (mean of 10 analyses) (darker green)  
(Pb<sub>1.81</sub>Cu<sub>1.73</sub>Fe<sup>2+</sup><sub>0.45</sub>Zn<sub>0.00</sub>)<sub>4</sub>(Al<sub>0.07</sub>Fe<sup>3+</sup><sub>1.93</sub>)<sub>2</sub>Si<sub>4.96</sub>O<sub>17</sub>4.93(H<sub>2</sub>O)
- Arizona and Sonora (Williams and Bideaux, 1975) (mean of all analyses)  
(Pb<sub>1.82</sub>Cu<sub>1.87</sub>Fe<sup>2+</sup><sub>0.15</sub>Zn<sub>0.16</sub>)<sub>4</sub>(Al<sub>0.45</sub>Fe<sup>3+</sup><sub>1.55</sub>)<sub>2</sub>Si<sub>4.67</sub>O<sub>17</sub>5.38(H<sub>2</sub>O)
- Argentina (Hayase and Dristas, 1978)  
(Pb<sub>1.67</sub>Cu<sub>1.72</sub>Fe<sup>2+</sup><sub>0.47</sub>Zn<sub>0.13</sub>)<sub>4</sub>(Al<sub>1.49</sub>Fe<sup>3+</sup><sub>0.51</sub>)<sub>2</sub>Si<sub>4.91</sub>O<sub>17</sub>5.34(H<sub>2</sub>O)

TABLE II. Unit cell parameters of creaseyite

	a <sub>0</sub>	b <sub>0</sub>	c <sub>0</sub>	Locality
1.	12.487	21.382	7.303	Aggeneys, South Africa (light green)
2.	12.499	21.394	7.295	Aggeneys, South Africa (darker green)
3.	12.483	21.395	7.283	Tiger, Arizona (Williams and Bideaux, 1975)
4.	12.497	21.375	7.283	Potter Cramer mine (Williams and Bideaux, 1975)
5.	12.472	21.446	7.272	Cruz del Sur, Argentina (Hayase and Dristas, 1978).

The power patterns for the two Aggeneys specimens are available on request from the authors.

Cu than the second darker green variety. Structural formulae were calculated according to the method of Hayase and Dristas (1978) where (Fe<sup>2+</sup> + Pb + Cu + Zn) = 4 and (Al + Fe<sup>3+</sup>) = 2 for the different samples. The results are presented in Table I. The creaseyite from Aggeneys differs from the previously described material in that virtually no Zn and Al is present and the Fe content is much higher.

*X-ray powder diffraction data.* Creaseyite was examined by X-ray diffraction, using a Philips PW 1051 diffractometer with nickel-filtered Cu-K $\alpha$  radiation. A single-crystal study was precluded by the fine-grained nature of the material and all the results were obtained by Debye-Scherrer films (114.6 mm diameter) using the small sample method (Hiemstra, 1956). Unit cell parameters were refined using the least squares programme of Appleman *et al.* (1972). The data are presented in Table II where the Aggeneys occurrences are compared with those of Arizona and Argentina. When the b<sub>0</sub> unit cell length is compared with the chemistry, a correlation is noted with

the  $\text{Fe}_2\text{O}_3$  content (fig. 2). The sample from Aggeneys has a shorter  $b_0$  unit cell length than the sample from Cruz del Sur and the iron content of the two samples are inversely proportional to the unit cell lengths.

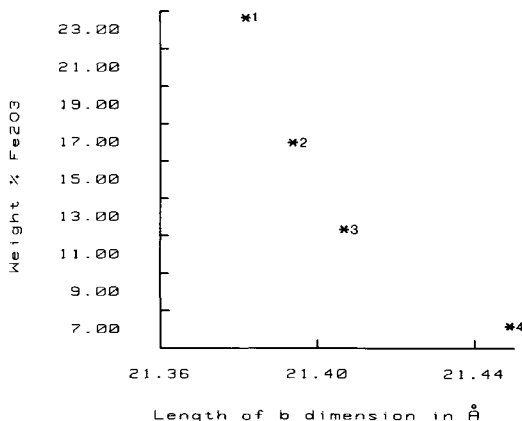


FIG. 2. Relationship between  $\text{Fe}_2\text{O}_3$  and the  $b_0$  unit cell length of creaseyite. The unit cell parameters of samples described by previous authors were recalculated according to the method of Appleman *et al.* (1972).

**Infra-red spectroscopy.** An infra-red absorption spectrum of creaseyite from Aggeneys was obtained with a Hitachi model 270-50 spectrometer with a wavenumber of  $250\text{--}4000\text{ cm}^{-1}$ , using KBr as reference material (fig. 3). Absorption peaks from  $900\text{ cm}^{-1}$  to  $1200\text{ cm}^{-1}$  are attributed to stretching of Si-O-M and H-O-M ( $M = \text{Pb, Cu and Fe}$ ). The peak at  $550\text{ cm}^{-1}$  may represent Si-O stretching whilst the peak at  $3200\text{ cm}^{-1}$  is regarded as a hydroxyl stretching band.

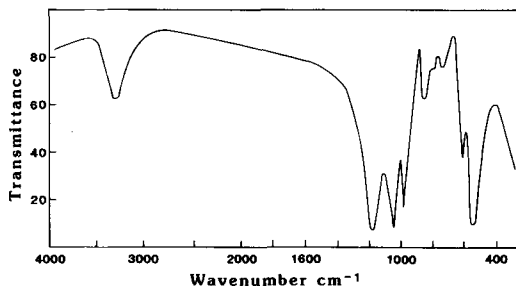


FIG. 3. Infra-red absorption spectrum of creaseyite.

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## A note on strontian chabazite from Kaiserstuhl, Baden, West Germany

A SMALL specimen labelled 'ittnerite' (number 680) in the Marquis of Breadalbane's collection consists of amphibole, aegirine, melanite, perovskite, sphene, phlogopite, magnetite, hauyne, calcite, and minor strontian chabazite. X-ray fluorescence and electron probe analysis revealed that the chabazite contained high levels of strontium. The analyses shown in Table I were obtained by crystal spectrometry using a Cambridge Instruments

TABLE I

Analyses of strontian chabazite from Kaiserstuhl, Baden

	1	2	3	4	5	6
$\text{SiO}_2$	42.35	43.25	42.64	41.20	39.33	42.09
$\text{Al}_2\text{O}_3$	25.86	21.50	21.55	19.40	19.69	19.47
CaO	6.96	6.51	6.48	5.86	5.89	6.52
SrO	6.39	7.16	6.94	8.08	7.98	7.26
$\text{Na}_2\text{O}$	1.69	0.05	0.05	0.13	0.18	0.07
$\text{K}_2\text{O}$	0.47	2.66	2.22	8.65	5.35	4.14
MgO	1.06	0.11	0.20	0.08	0.08	0.11
BaO	-	0.01	0.05	0.05	0.03	0.16
	84.78	81.25	80.11	83.45	78.53	79.82

1-3 and 5. single spot per grain.

4. potassium-rich area, approximately 30-40 microns across, in grain from which analysis 3 was obtained (see text).

6. second spot in same grain from which analysis 5 was obtained.