

and unlike the relatively total iron-rich, paragenetically very late-stage petalites, such as those from Transbaikalia that fill cavities and fissures and replace spodumene. The spodumene from Meldon is very coarse, with crystals several centimetres long, showing some good crystal faces; it is pale lilac in colour, sometimes semi-transparent. The only mineral associated with spodumene is fine granular pollucite. Compositionally this spodumene falls into the second category of Heinrich's (1978) classification: zonal spodumene from intermediate zones and cores, low in total iron, may contain significant manganese, some is pink or lilac (Table I). It closely resembles chemically spodumenes from Pala, Portland, Harding, Seymour, and Keystone.

Stewart (1978) grouped Meldon with occurrences of petalite in near surface contact aureoles of granite that suggest the components of petalite are readily transported in gases, and Chaudhry and Mahmood (1979) concluded the petalite is of metasomatic origin the metasomatic processes responsible for its formation having been operative only at certain points in the aplite intrusion. This conclusion is in agreement with the very low obliquities of feldspars from pegmatite and pegmatitic veins at Meldon (Chaudhry, 1971), with Cerny's (1970) observation of natural and experimental metasomatic replacement of feldspar by petalite, and with the textures of the Meldon petalite. Only two other occurrences are known of coarse accumulations of petalite in unzoned aplite: Hirvikallio and one vein at Lehtisaari (Vesasalo, 1959); these petalites are similar compositionally and somewhat similar texturally and paragenetically to those at Meldon. The composition of spodumene and its association with pollucite suggest its late-stage crystallization: a similar association of large

crystals of spodumene is described by Mandarinov and Harris (1965) and an association of pink-lilac spodumene formed from residual hydrothermal solutions with pollucite is noted by Rossovskii (1977).

*Acknowledgements.* I am most grateful to Mr J. P. Fuller, Department of Mineralogy, British Museum (Natural History) for access to and guidance through the A. W. G. Kingsbury Collection and donation of material; to the Department of Geological Sciences, University of Durham for use of facilities during a sabbatical leave spent there, and to Dr A. Peckett of that Department for the analyses.

## REFERENCES

- Cerny, P. (1970) *Freiberger Forsch.* **C270**, 47–67.  
 Chaudhry, M. N. (1971) *Mineral Mag.* **38**, 179–85.  
 — and Mahmood, A. (1979) *Ibid.* **43**, 307–9.  
 Edmonds, E. A., Wright, J. E., Beer, K. E., Hawkes, J. R., Williams, M., Freshney, E. C. and Fenning, P. J. (1968) *Geology of the country around Okehampton*. Mem. Geol. Survey Gt. Britain.  
 Heinrich, E. W. (1978) *J. Mineralogia*, **7**, 59–65.  
 Kingsbury, A. W. G. (1966) Some minerals of special interest in South-West England. In *Present views of some aspects of the geology of Cornwall and Devon* (K. F. G. Hosking and G. J. Shrimpton, eds.). Royal Geological Society of Cornwall, 247–66.  
 McLintock, W. F. P. (1923) *Mineral Mag.* **20**, 140–50.  
 Mandarinov, J. A. and Harris, D. C. (1965) *Can. Mineral.* **8**, 377–81.  
 Rossovskii, L. N. (1977) *Dokl. Akad. Nauk SSSR*, **236**, 157–60.  
 Stewart, D. B. (1978) *Am. Mineral.* **63**, 970–80.  
 Vesasalo, A. (1959) *Bull. Comm. Geol. Finlande*, **184**, 59–74.

[Manuscript received 11 February 1985]

© Copyright the Mineralogical Society

KEYWORDS: petalite, spodumene, pegmatite, aplite, Meldon, Devon.

*Department of Geology and Mineralogy, University of Queensland,  
 St Lucia, Queensland, Australia 4067*

D. J. DRYSDALE

MINERALOGICAL MAGAZINE, DECEMBER 1985, VOL. 49, PP. 759–61

## X-ray powder data for susannite and its distinction from leadhillite

SUSANNITE, the dimorph of leadhillite, was named as a distinct species by Haidinger (1845) although the entry in Palache *et al.* (1951) is devoid of

supportive data. The latter authors do, however, suggest that susannite may represent a primary occurrence of the uniaxial polymorph of leadhillite

obtained by heating that species'. Mrose and Christian (1969) reported leadhillite to be the low-temperature polymorph of susannite, this being established from leadhillite precession photographs taken at room temperature and 200 °C. They concluded that susannite from Leadhills was trigonal with  $a = 9.05$  and  $c = 11.54$  Å, and that its X-ray powder pattern was indistinguishable from that of leadhillite. From precession photographs these authors also ascertained that leadhillite from Tintic, Utah, was monoclinic with the following parameters  $a = 9.08$ ,  $b = 20.76$ ,  $c = 11.56$  Å and  $\beta = 90.46^\circ$ .

As far as the authors are aware, X-ray powder diffraction data for naturally occurring susannite do not appear to have been published. The aim of this note is to correct this deficiency and to demonstrate, additionally, that susannite may be distinguished from leadhillite by measurement of

one particular line. Highly accurate measurements are not required, although the characteristic line is rather low in intensity.

Within the Mineral Powder Diffraction File (1980) there are examples of virtually indistinguishable X-ray data for minerals with differing compositions, e.g. epidote and piemontite, mullite and sillimanite, etc. Conversely, there are minerals with almost identical chemistry, and powder data which may be distinguished on the basis of a single line, e.g. chalcocite and djurleite. Leadhillite and susannite unquestionably fit into the latter category.

Powder data are presented in Table I for susannite from the Susanna Mine, Leadhills (RSM No. 734a.5). Because of the scarcity of susannite, it is only possible to present relative intensities estimated visually. The susannite data are indexed, after least squares refinement, on a hexagonal cell

TABLE I. X-ray powder data for susannite from Leadhills, Scotland (indexed on a hexagonal cell,  $a = 9.072$ ,  $c = 11.539$  Å and space group R $\bar{3}$ )

$d_{\text{meas}}$ Å	$I$	$hkl$	$d_{\text{calc}}$ Å	$d_{\text{meas}}$ Å	$I$	$hkl$	$d_{\text{calc}}$ Å
11.52	mw	001	11.539	2.045	vw	{ 115	2.057
*6.52	w	101	6.494			{ 312	2.038
5.78	w	002	5.770	1.954	m	223	1.954
4.538	ms	110	4.536	1.939	m	{ 304	1.939
4.223	w	111	4.222			{ 401	1.936
3.722	vw	201	3.719	1.897	vw	313	1.896
3.571	vs	112	3.566	1.860	vw	402	1.859
3.249	w	202	3.247	1.826	vw	215	1.822
3.071	vw	210	2.970	1.780	w	{ 224	1.783
2.937	s	113	2.934			{ 321	1.781
2.890	mw	004	2.885	1.736	m	{ 314	1.739
2.622	s	300	2.619			{ 305	1.731
2.552	w	301	2.554	1.696	vw	411	1.696
2.440	w	114	2.434	1.644	w	{ 007	1.648
2.316	m	{ 204	2.325			{ 412	1.643
		{ 005	2.308			{ 404	1.624
2.271	w	220	2.268	1.621	vw	{ 225	1.618
2.225	w	221	2.225	1.567	vw	{ 500	1.571
2.177	vw	310	2.179			{ 413	1.566
2.113	ms	222	2.111	1.554	m	{ 501	1.557
2.066	m	214	2.069			{ 306	1.550

Co-K $\alpha$ , 1.7903 Å, Fe filter, camera diameter 114.6 mm.

\* The line may not be photographically recorded if the sample spindle is too thick (with electronic recording, for leadhillite, an  $I/I_0$  of  $< 1$  was obtained; however, this value may be erroneously low). Baptista (1983) reported four synthetic susannites produced an intensity range of 9–16 for the line at 6.5 Å. In this work photographic recording consistently showed the susannite (101) line to have marginally greater intensity than the (002) reflection at 5.78 Å, Baptista demonstrated the lines possessed virtually equal intensity.

with  $a = 9.072$  and  $c = 11.539$  Å and in space group  $R\bar{3}$ .

Despite the close similarities between leadhillite and susannite powder patterns, susannite may be differentiated from leadhillite by comparing the positions of the line near 6.6 Å. In susannite the line occurs at 6.52 Å and is indexed as (101) whereas in leadhillite it occurs at 6.70 Å and is indexed as (111) (Russell *et al.*, 1983). Greater distinction between the dimorphs might have been possible by comparing the second orders of these lines. However, while (202) is sharp at 3.249 Å for susannite (Table I), (222) for leadhillite occurs as part of a broad line at 3.37 Å which also includes (033) (Russell *et al.*, 1983).

X-ray diffraction data for four synthetically produced susannites were published by Baptista (1983). The (101) lines all fall into the 6.5 Å scheme of the present authors, the range being 6.51–6.56 Å and intensity 9–16. Dr Baptista kindly supplied the authors with portions of his synthetic preparations designated  $F_1$ ,  $F_2$ ,  $Q_1$ , and  $Q_2$ . Our measurements (6.51–6.58 Å) confirm the (101) susannite spacing, and infra-red spectra corroborate the identifications, especially for  $F_2$  (the others contain small quantities of impurities, but are almost certainly susannites).

Dr Baptista worked on single crystals of natural susannite for his Weissenberg studies and also produced 'susannite' powder data from two natural samples numbered 2216-M and 1407-M. We would like to point out that, while the former has recently been shown to contain leadhillite (Baptista, pers. comm.), it may well be all leadhillite, as shown by a line at 6.78 Å and intensity 5. The latter sample is highly impure, for the powder pattern shows several additional high-intensity lines.

To check the validity of the distinction based on the  $d$  (101) and  $d$  (111) spacings eight different, susannite specimens from the Leadhills–Wanlockhead area were examined. They yielded a  $d$  (101) range of 6.50–6.56 Å (average 6.52 Å). Fourteen leadhillites from the same district gave  $d$  values over the range 6.67–6.80 Å (average 6.74 Å). In spite of very slight  $d$  spacing shifts noted for various leadhillites by Russell *et al.* (1983) and ascribed to small, mutual replacement of  $SO_4$ ,  $CO_3$ , and OH, the detected difference between the dimorphs is

well outside leadhillite shifts. Indeed, since no intermediate values between 6.5 and 6.7 Å were recorded in this study, the designated lines can be of diagnostic value. Co-existing susannite and leadhillite on a small hand specimen also manifested the 0.2 Å difference. Tsumeb and Arizonan leadhillite  $d$  (111) values were also close to 6.7 Å, confirming that this value is not specific to Leadhills–Wanlockhead material.

Two samples from the Royal Museum of Scotland Collection, ostensibly susannite on the basis of morphology and colour, produced lines at 6.75 Å and are thus leadhillite according to this work. The identification has been confirmed by infra-red spectroscopy, which is also capable of distinguishing susannite, leadhillite and macphersonite (Russell *et al.*, 1984). Additionally, Milodowski and Morgan (1984) heated leadhillite, with a line at 6.76 Å, in a continuous-heating camera at 100 °C and converted it to susannite. The leadhillite line at 6.76 Å was replaced by one at 6.49 Å.

*Acknowledgements.* The authors are indebted to Dr M. J. Wilson and Mrs Lynne Forsyth of the Macaulay Institute for providing the susannite X-ray data and to Mr A. Walker and Mr J. G. Francis for running the least squares refinement and indexing programmes respectively.

#### REFERENCES

- Baptista, A. (1983) *Ann. Acad. Brazil Cienc.* **55**, 263–70 (in Portuguese).  
 Haidinger, W. (1845) *Handbuch der bestimmenden Mineralogie*, 505, Vienna.  
 Milodowski, A. E., and Morgan, D. J. (1984) *Clay Minerals*, **19**, 825.  
 Mrose, M. E., and Christian, R. P. (1969) *Can. Mineral.* **10**, 141 (Abstract only).  
 Palache, C., Berman, H., and Frondel, C. (1951) *Dana's system of mineralogy*. 7th edn., **2**, 299. John Wiley & Sons, New York.  
 Russell, J. D., Milodowski, A. E., Fraser, A. R., and Clark, D. R. (1983) *Mineral. Mag.* **47**, 371.  
 ———, Fraser, A. R., and Livingstone, A. (1984) *Ibid.* **48**, 295.

[Manuscript received 2 April 1984]

© Copyright the Mineralogical Society

KEYWORDS: susannite, leadhillite, X-ray powder diffraction data, Leadhills, Scotland.

Department of Geology, Royal Museum of Scotland, Chambers Street, Edinburgh  
 Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen

A. LIVINGSTONE  
 J. D. RUSSELL