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PELLYITE: NEW LOCALITIES AND NEW DATA

ADOLF PABST AND JOAN HARRIS
Department of Geology and Geophysics, University of California, Berkeley, California 94025, U.S.A.

ABSTRACT

Pellyite, first recognized as a new mineral in Ba-silicate rocks from a remote locality in the Yukon Territory, has been found in a similar association in two localities in California and one in Baja California (Mexico). Pellyite from all localities has a composition that varies but slightly and conforms to the formula assigned by Montgomery *et al.* (1972), $Ba_2Ca(Fe,Mg)_2Si_6O_{17}$. However, low-Al and high-Al variants have been recognized in which aluminum mostly substitutes for silicon. Cell dimensions of pellyite from the occurrence in which it is most copious, in Fresno County, are (in the standard orientation): *a* 14.234(6), *b* 15.667(7), *c* 7.156(4) Å; there is but slight variation in these dimensions. The optical properties of this specimen are: $\alpha \| c$ 1.631, $\beta \| b$ 1.635, $\gamma \| a$ 1.649, $2V$ (meas.) 56(1)°. The melting point of pellyite is 900 ± 15°C. Sanbornite and gillespite are the most abundant Ba-silicate minerals at all the localities, but the minerals with which pellyite is immediately associated at the Fresno County locality are quartz, celsian and taramellite.

Keywords: pellyite, chemical composition, cell dimensions, optical properties, California, Baja California (Mexico).

SOMMAIRE

La pellyite, identifiée d'abord comme nouvelle espèce minérale dans les roches à silicates de baryum d'un endroit isolé du territoire du Yukon, fait aussi partie d'une association semblable à deux endroits en Californie et un en Basse Californie (Mexique). Elle ne varie que légèrement en composition dans chaque localité, et répond à la formule chimique qu'avaient proposé Montgomery *et al.* (1972), $Ba_2Ca(Fe,Mg)_2Si_6O_{17}$. On reconnaît toutefois la présence de variantes riche et pauvre en aluminium, dans lesquelles ce cation remplace surtout le silicium. Les paramètres réticulaires de la pellyite du comté de Fresno, où elle est en plus grande abondance, sont (en orientation standard): *a* 14.234(6), *b* 15.667(7), *c* 7.156(4) Å. On ne trouve que de légères variations dans ces dimensions. Propriétés optiques: $\alpha \| c$ 1.631, $\beta \| b$ 1.635, $\gamma \| a$ 1.649, $2V$ mesuré 56(1)°. La pellyite fond à 900 ± 15°C. Sanbornite et gillespite sont les deux silicates de baryum les plus abondants à chaque localité, mais pellyite, quartz, celsian et taramellite forment un assemblage courant dans la localité du comté de Fresno.

(Traduit par la Rédaction)

Mots-clés: pellyite, composition chimique, dimensions réticulaires, propriétés optiques, Californie, Basse Californie (Mexique).

INTRODUCTION

Pellyite was recognized as a new mineral and described under another name (unpublished) from Ba-silicate rocks near the headwaters of the Ross and Pelly Rivers in Yukon Territory, not far from the boundary with the Northwest Territories, by J.H. Montgomery (1960). A formal description did not appear until twelve years later (Montgomery *et al.* 1972). An occurrrence of pellyite in Fresno County, California, recognized seven years earlier, was also mentioned. During an extended study of the occurrence of taramellite, another complex Ba-silicate, at eight localities in western North America (Alfors & Pabst 1984), pellyite was recognized in two more localities, and superior specimens were obtained from the Fresno County locality.

It is the purpose of this report to put on record information concerning the geological setting and associated minerals at each locality and the variation of properties and composition of pellyite.

LOCALITIES AND MATERIAL

The localities are: 1) Trumbull Peak, Mariposa County, California, 2) Big Creek, Fresno County, California and 3) the La Madrelena mine in northern Baja California. All three have been briefly described by Alfors & Pabst (1984). In all three localities, the occurrence is in rather limited lenses or bands of rock consisting largely of Ba silicates within metamorphic rocks, mostly quartzites, at or close to contacts with large bodies of granitic or granodioritic rocks. The Trumbull Peak and Big Creek occurrences are on the western fringe of the Sierra Nevada batholith. The La Madrelena mine is on the western edge of a large body of granodiorite that makes up most of the Sierra Juarez in an area mapped in reconnaissance by Gastil *et al.* (1975). This is part of the Mesozoic batholith of Southern and Lower California (Larsen 1948, p. 135, Fig. 3).

Though the Trumbull Peak occurrence is the type locality for sanbornite and as such has been mentioned by Rogers (1932), Melhase (1935) and Douglass (1958), it has received but little attention. Our knowledge of this locality is based entirely on visits by one of us (A.P.) in 1950 and 1953 and on copious material collected at that time. The occurrence consists of three separate lenses of Ba-silicate rock, each about a metre thick and a few metres in extent, with sharp contacts to the enclosing quartzite at an elevation of about 1340 m (~4,400 feet) on the north flank of Trumbull Peak. This is within the El Portal (1:24,000) quadrangle, approximately 9 kilometres west of Yosemite National Park.

The Fresno County occurrence is limited to a single body of Ba-silicate rock in the SE¼of the SW¼ of section 22, T. 11 S, R. 25 E, Mount Diablo base line and meridian. This locality lies within the Big Creek area of scattered Ba-silicate deposits, extending over much of sections 22 and 27, from which seven new barium silicates were described by Alfors *et al.* (1965).

The occurrence at the La Madrelena mine in northern Baja California has been briefly described in unpublished reports by Hinthorne (1974) and Werner (1980). According to Werner, who made a geological map of the surrounding area on a scale of 1:2,080, the occurrence of Ba silicates, mostly sanbornite, is limited to a small block about 2 × 3 metres in area that had been excavated to a depth of 3 metres. Within this block the Ba silicates are in contact with quartzite, tremolite schist and tonalite. We had available for study specimens supplied by the late Professor E.C. Allison of San Diego State University, specimens collected by Miss Josephine Scripps and supplied by Mr. C.W. Chesterman, and specimens obtained from two mineral dealers. All of these specimens are closely similar, suggesting that they are fully representative of Ba silicates at this locality.

ASSOCIATED MINERALS

Montgomery *et al.* (1972) listed the minerals associated with pellyite at the Ross River locality in the Yukon Territory as "barite, hedenbergite, quartz, andradite, taramellite, gillespite, sanbornite, chalcopyrite and witherite." Except for andradite and chalcopyrite, the same minerals have been found with pellyite at the other localities. A full listing of the minerals at the other localities has been given by Alfors & Pabst (1984, Table 7). Besides the minerals just mentioned, both pyrite and pyrrhotite, as well as the new barium chlorapatite *alforsite,* occur with pellyite at each of the localities here described. Montgomery (1960) described an unknown mineral which, on the basis of his description, can now be positively identified as muirite, described and named by Alfors *et al.* (1965) and also found in the Big Creek area.

Though we did not have any type pellyite for comparison, we have been able to examine a specimen from the Yukon locality provided by the late Professor R.M. Thompson of the University of British Columbia in 1960 and labeled "Gillespite, Upper Ross River, Yukon Territory". From this specimen it was possible to isolate, besides gillespite, celsian and taramellite, *two* types of pyroxene, diopside (colorless, β 1.680) and salite (flesh-colored, β 1.704). Diopside–salite is found with the Ba silicates at each of the pellyite localities, and usually only one type of pyroxene is found.

Sanbornite and gillespite are the most conspicuous Ba-silicates at each of the pellyite localities, though not necessarily the most abundant in immediate association with pellyite. Celsian also occurs with pellyite in every case and is most abundant at the Big Creek locality. Barite, reported with pellyite from the Yukon, though present in some other California deposits of Ba silicates, has not been recognized at the pellyite localities. Witherite is always present in the rocks containing pellyite, but usually in minor amount and possibly secondary in part.

In material from the Trumbull Peak area, pellyite was recognized only in concentrates from crushed specimens representing two of the three lenses of Ba-silicate rocks at this locality. Grains of pellyite are anhedral, up to 1 mm across and commonly have celsian attached. Thin sections show that quartz, sanbornite, gillespite, taramellite and, in one case, witherite are the principal constituents of the rock. Pellyite is a very minor constituent; it was not recognized with certainty in thin section.

In the material from the La Madrelena mine, pellyite was recognized megascopically in several specimens. It occurs in small, faintly yellowish patches surrounded by sanbornite and quartz. The pellyite is anhedral and very fine grained.

So far as known, pellyite in the Big Creek area is limited to the SE¼, SW¼, T. 11 S, R. 25 E, Mount Diablo baseline and meridian, Fresno County, California (Patterson Mtn. quadrangle, 1:62,500). Here, pellyite is relatively abundant and the principal constituent of some specimens. By means of the optical orientation, which had been established on crystals set up for X-ray examination, it was possible to determine that pellyite crystals at this locality, embedded in quartz, are tabular {010} (Fig. 1). They commonly are about 1 mm thick, with a maximum dimension on the order of 1 cm. No forms other than {010} have been recognized.

CHEMICAL COMPOSITION

Table 1 shows the chemical composition reported for pellyite from the type locality by Montgomery *et al.* (1972), in connection with the initial published description, and that determined by electron microprobe, as reported by Meagher (1976), in connection with the crystal-structure determination, together with results of electron-microprobe analyses of pellyite from the three Californian localities. These analyses were obtained using the ARL–SEMQ electron microprobe in the Department of Geology and

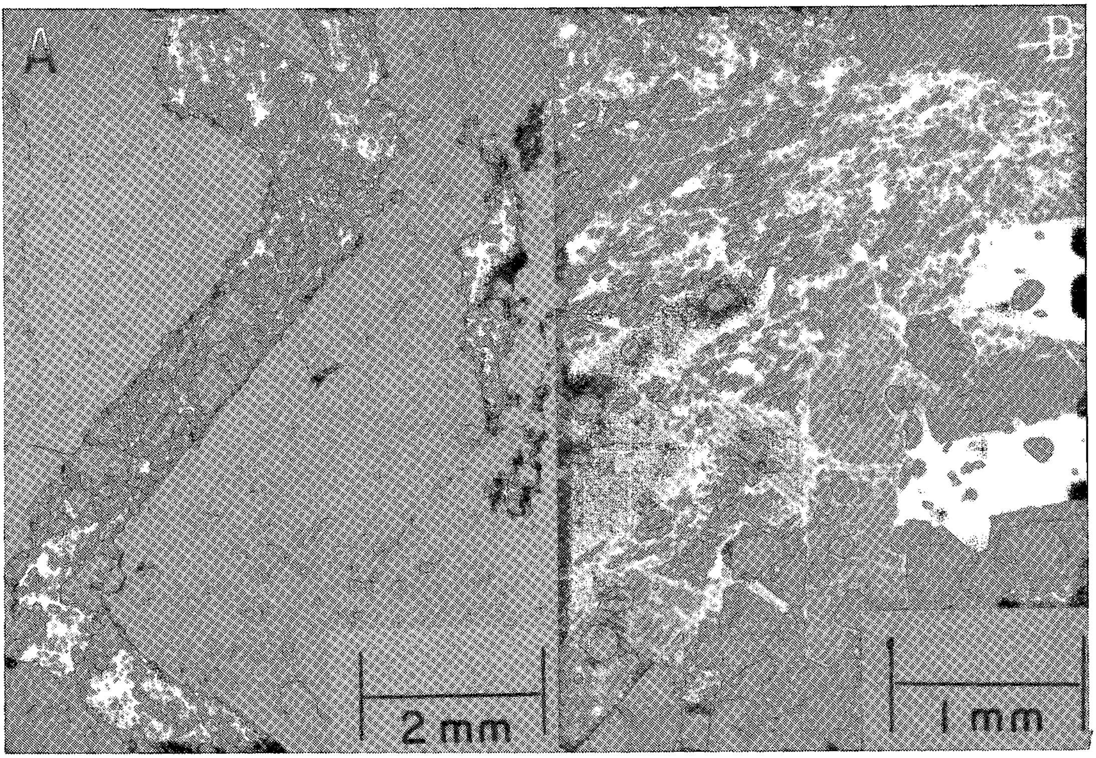

FIG. 1. Pellyite from Big Creek, Fresno County, California. A. Isolated crystals of pellyite embedded in quartz; celsian occurs in scattered, colorless grains in quartz; ragged cluster of pellyite and taramellite at right. B. Pellyite with sharply bounded, pleochroic crystals of taramellite enclosing rounded grains of celsian.

Geophysics at the University of California, Berkeley. An accelerating voltage of 15 kV, a sample current of 0.03 μA and a 10-second integration time were used in all analyses. The X-ray measurements were corrected following the procedure of Bence & Albee (1968).

The newly reported results have been selected from numerous determinations of the composition of pellyite from each locality. All compositions agree fairly well with the requirements of the formula $Ba_2Ca(Fe,Mg)_2Si_6O_{17}$ ($Z = 4$), as seen from the calculations of the number of cations relative to 68 oxy-

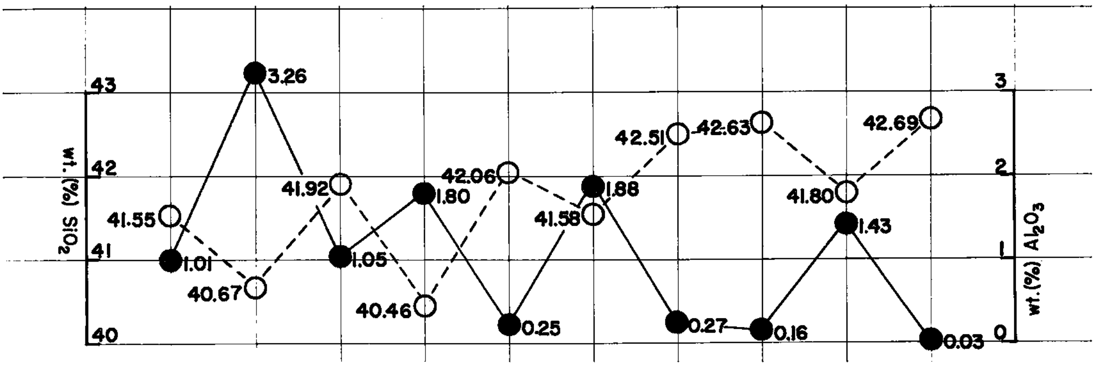

FIG. 2. Variation of SiO_2 and Al_2O_3 content at ten points along a trace across one grain of pellyite (in lieu of linescan, which was not feasible on microprobe used).

TABLE 1. CHEMICAL COMPOSITION OF PELLYITE

	Ross River Yukon Territory		Trumbull Peak Mariposa County	La Madrelena mine Baja California	Big Creek Fresno County		
	1	2	3	4	5	6	7
BaO	34.16	36.00	36.04(26)	37.25(40)	34.10(1.35)	35.63(51)	
CaO	6.25	6.62	6.32(12)	6.04(11)	6.06(24)	6.39(10)	
FeO	12.46	12.18	12.29(13)	10.04(26)	12.23(54)	12.47(15)	
MnO	0.57	1.54	1.36(07)	2.91(12)	1.44(18)	1.39(06)	
MgO	1.46	0.98	0.91(04)	1.55(21)	0.76(17)	0.95(06)	
ZnO	1.05	1.20	0.24(09)	0.61(09)	0.20(08)	0.16(06)	
Al_2O_3	3.53	0.28	0.01(02)	0.45(65)	3.59(1.70)	0.23(25)	
SiO_2	40.50	40.86	41.47(43)	42.44(52)	41.03(95)	41.88(33)	
	99.98	99.66	98.64	101.29	99.41	99.10	
	Number of cations relative to 68 oxygens, corresponding to content of one unit cell						"ideal"
Ba	7.51	8.18	8.22	8.24	7.55	8.01	8
Ca	3.76	4.11	3.94	3.66	3.64	3.70	4
Fe	5.85)	5.91	5.98	4.74	5.79	5.99	
Mn	0.27)	0.76	0.67	1.39	0.68	0.68	
Mg	1.22)	0.85	0.79	1.30	0.63	0.82	
Zn	0.43)	0.51	0.10	0.25	0.08	0.26	
Al	0.23)		0.01	0.28	1.00	0.16	
Σ	8.00	8.03	7.55	7.96	8.18	7.91	8
Al	2.10	0.19		0.02	1.37		
Si	22.73	23.70	24.14	23.98	23.05	24.04	
(Si, Al)	24.83	23.79		24.00	24.42		24

1. "Gravimetric analysis" reported by Montgomery *et al.* (1972), only slightly modified from results presented by Montgomery (1960). 2. Results of electron-microprobe analysis (Meagher 1976). 3-6 Results of electron-microprobe analyses by J.H.; 6 is average of two sets of data that agree closely. Standard deviations in brackets; high values in columns 4 and 5 reflect variation in Al content and, to a lesser extent, that of some other cations within a single crystal. 7 Expected content of cell based on structural formula of Meagher (1976).

TABLE 2. PHYSICAL PROPERTIES OF PELLYITE

		Ross River Yukon Territory	Trumbull Peak Mariposa County	La Madrelena mine Baja California	SE¼ SW¼ Sec. 22, Big Creek Fresno County, California	
Cell Dimensions	*a*	* 14.209(6)Å	# 14.201(7)	# 14.224(6)	#14.234(6)	## 14.214 - 14.238
	b	15.677(4)	15.674(5)	15.677(7)	15.667(7)	15.611 - 15.690
	c	7.151(2)	7.146(3)	7.146(3)	7.156(4)	7.142 - 7.156
Space group:		*Amma*				
Optical Properties	α	1.643(3)	α//*c* 1.630(1)	1.630	1.631	1.627 - 1.633
	β	1.645	β//*b* 1.632	1.633	1.635	1.629 - 1.636
	γ	1.649	γ//*a* 1.646	1.645	1.649	1.641 - 1.649
	2V	47°(estimated)	53(2)°(meas.)	61(1)°	56(1)°	53° - 57°

* Data from Montgomery *et al.* (1972); optical properties obviously copied from Montgomery (1960). Optical orientation not reported. # Data pertain to samples used for electron-microprobe analysis. ## Range of values for 10 crystals from 6 samples from the same locality.

gen atoms. However, the La Madreleña mine pellyite has markedly less iron than any of the others and correspondingly more substituents in the octahedral site.

Two compositions are given for pellyite from the Big Creek area as, in this case, a difference between high-Al and low-Al pellyite can be recognized. A similar difference occurs between the two compositions reported for the Yukon pellyite; it seems not unlikely that at the Ross River locality there are also high-Al and low-Al variants of pellyite. The greater values of the estimated standard deviations in column 5 than those in column 6 are attributable to the variable aluminum content within the high-Al pellyite. This variation is not related to sector zoning or core-to-rim zoning, but appears to be random variation, as shown by the plot of the results of a series of determinations across a single grain (Fig. 2). Incidentally, this also shows that Al substitutes for Si in the high-Al pellyite, though the calculations recorded in Table 1 suggest that some Al is in the octahedral site together with other substituents for Fe.

CELL DIMENSIONS AND OPTICAL PROPERTIES

The cell dimensions found for the Californian specimens of pellyite differ but slightly from those reported for the type material. In Table 2, they are given in the standard orientation recommended in *Crystal Data,* in which the space-group symbol becomes *Amma.* The total range of variation in *b* is only about ½%, and this variation is found among the Big Creek specimens. All cell dimensions of the type pellyite lie within the small range found for the Californian specimens. The density of pellyite from the Big Creek locality was found by Berman balance to be 3.55(9) g/cm^3, differing only negligibly from the density, measured and calculated, reported by Montgomery *et al.* (1972) for the type pellyite.

For the optical properties, agreement is not quite so good. Montgomery *et al.* (1972) failed to report the optical orientation. We have found the same orientation in all crystals in which it was determined (Table 2) and assume that this applies also to the Yukon pellyite. Our values for γ are close to the value given for the type pellyite. However, we find a substantially greater birefringence and lower values of α and β. Our $2V$ determinations, made conoscopically in immersion on mounted crystals oriented by X-ray diffraction, are consistent with the reported indices of refraction.

Upon heating in air, pellyite undergoes a complex series of changes, including expansion of *b* by about 2% (measured at room temperature) and changes in color as well as optical orientation, finally melting at 900 ± 15°C to a brown glass with $n = 1.68$ (see Table 3).

TABLE 3. SUMMARY OF CHANGES IN PELLYITE UPON HEATING IN AIR

Temperature	Unit-cell dimensions			Unit-cell volume	Indices of refraction and orientation				Color (pleochroism)		
					α//c	β//b	γ//a	2V	X	Y	Z
25°C	14.234Å	15.677	7.156	1587Å³	1.631	1.635	1.649	56°	- -	colorless	- -
114				no change							
285				no change							
385	14.18	15.68	7.11		1.651	1.653	1.665		yellow	paler	paler
450	14.02	15.93	7.04		α//b 1.683	β//a 1.69	γ//c 1.722		pale yellow	darker	darker
480 *	14.02	15.97	7.01		1.685	1.692	1.739		"	"	"
505				no further change observed							
605	14.05	15.95	7.01	1671Å³	1.686	1.698	1.740		"	"	"
680				darkened only, no other change							
765 *	14.25	15.98	(7.12) (7.37)#		1.666 ((1.671	1.674 1.674	1.675 1.678))	80° ##			
795					very weak birefringence, n = 1.666				pale brown, nonpleochroic		
850	almost "X-ray amorphous"				"	"	"	"	"		"
900				melting point 900±15°	n of brown glass is 1.68						

Data from crystals serially heated, except for those marked *, which are from crystals heated directly.
Spots on (001) locus correspond to two slightly differing spacings. ## Data in double brackets are from another crystal in the same lot.

The small variation in properties of pellyite from the Big Creek area is doubtless connected with the variation in composition for crystals from that locality, but no correlation has been established. Possibly the greater range in properties and composition found in the Big Creek pellyite is attributable to the greater abundance, and thus the greater availability, of material from that locality.

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