SURSASSITE FROM NEW BRUNSWICK[1]

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ABSTRACT

Sursassite, previously known only from Oberhalbstein, Graubünden, Switzerland, occurs in veinlets cutting Middle Silurian Fe-Mn ores about five miles west of Woodstock, New Brunswick. The composition based on a new analysis is $Mn_9 Al_4 (Si,Al)_{12}O_{39} \cdot 6H_2O$. Associated minerals are barite, calcite, and quartz, and the veins appear to have been formed near the end of a period of low-grade metamorphism, by solutions operating under the intensity environment of the greenschist facies.

INTRODUCTION

During the summer of 1958, while investigating manganese deposits in eastern Maine and adjacent New Brunswick, the writer found a copper-coloured fibrous mineral which he did not recognize. Subsequently it was identified as sursassite, a mineral that previously had been found at only one locality. The cost of the chemical analysis and thin sections was defrayed by Michigan Memorial Phoenix Project No. 150. The writer also is indebted to E. B. Gross for laboratory assistance and to Dr. E. H. Nickel for directing his attention to several references.

History

In 1916 Müller published two papers (1916*a*, *b*) describing the mineralogy of a manganese deposit at Oberhalbstein, Graubünden, Switzerland. In the first article Müller identifies psilomelane, polianite, zoisite, piedmontite, rhodochrosite, rhodonite and a copper-coloured mineral resembling a mica about which he says (1916*a*, p. 224): "Auzerdem fand sich ein kupferfarbenes, an Glimmer errinnerndes Mineral das ebenfalls in enger Verbindung mit dem Manganerz auftritt und auf Grund einer Analyse als ein wasserhaltiges Mn-Silikat zu bezeichen ist." The analysis was presented in Müller's second paper (1916*b*), but the mineral was not given a name. Arbenz & Tarnuzzer (1923) refer to sursassite as "rotbraunen faserigstrahligen Epidot" (p. 260).

Jakob discussed the mineralogy of the deposits in several papers, in the first two of which (1923, 1926*a*) he described three new minerals—parsettensite [$Mn_5Si_6O_{13}(OH)_8$], errite [$Mn_7Si_8O_{18}(OH)_{10} \cdot 4H_2O$?], and

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tinzenite. In the next two (1926*b*, 1933) he described the mineral that was first mentioned and analysed by Müller. Jakob reanalysed it, naming it sursassite.

Tinzenite was subsequently shown to be manganoan axinite by Milton *et al.* (1953) who studied manganese ore from deposits in Aroostook County, Maine, which are similar to those in New Brunswick and but a short distance away. These authors did not specify the locality for their manganoan axinite ("tinzenite"), nor did they describe the geology or mineralogy of the occurrence, stating only (p. 1149) that ". . . a special study was made of the rare manganese silicate ganophyllite, which had been found there."

A monograph on the geology and mineralogy of the Graubünden manganese deposits appeared in 1948 (Geiger, 1948). A summary description was included in a survey of the Fe-Mn deposits of the Swiss Alps (Niggli, 1950).

In company with the late Prof. Paul Niggli the writer examined the Graubünden manganese deposits in 1950, at which time he collected specimens of sursassite, parsettensite, and "tinzenite." Remembering the appearance of the Swiss sursassite he compared the *x*-ray powder patterns of the two and established the identity of the New Brunswick material.

Location

The deposit in which the sursassite occurs is in west-central New Brunswick, about five miles west-northwest of Woodstock and about eight miles east of Houlton, Maine. It forms part of the Plymouth ore body, which lies mainly on the south side of the Meduxnekeag River. The sursassite veins were found in large blocks of manganese ore scattered near a small ore loading chute, a few hundred feet west of old workings.

The Woodstock deposits were discovered by Dr. C. T. Jackson in 1836, and in 1848 a 7-ton per day blast furnace was constructed for the initial exploitation for iron (Sidwell, 1957). The deposits were mined intermittently until 1884, during which period 70,000 tons of iron ore were smelted (Stockwell, 1957). In 1957 the deposits were drilled by Stratmat Ltd. to outline the ore bodies.

GEOLOGY

The Fe-Mn ores occur as elongate lenticular masses in strata of Middle Silurian age. The beds consist of sedimentary rocks which have been deformed into northeast-trending, steeply dipping and steeply plunging folds and which have been subjected to very low grade regional metamorphism (Caley, 1936). The shales have been transformed into slates; the sandstones and graywackes have been but little altered. Sidwell (1957) has split the host rocks into three groups:

1. Gray-green slates, sandstone and graywacke directly overlying pre-Silurian strata.
2. Gray-green, green, gray, and red slates.
3. Contorted dark gray calcareous slates.

The Fe-Mn deposits occur within five units near the base of Group 2: silicified slates, manganiferous hematite rock, red to purple ferruginous slates, green chloritic slates and brown cherty slates (Sidwell, 1957).

The green slates consist mainly of very fine-grained quartz and chlorite, locally cut, transverse to the bedding by veinlets of lighter-coloured, coarser-grained chlorite. The ferruginous slates contain fine-grained quartz, sericite and hematite with minor carbonate; veinlets of quartz, cut across the bedding.

The geology of the United States counterpart deposits has been investigated by White (1943), Miller (1947), and Eilertsen (1952, 1958).

MINERALOGY

Paragenesis. No complete study of the Fe-Mn ores or the associated rocks has been attempted. Only the veins have been studied in detail. The data in Table 1 represent a compilation of information from the

TABLE 1. MINERALOGY OF THE NEW BRUNSWICK AND MAINE MANGANESE DEPOSITS

Maine		New Brunswick	
Rock and ore minerals	Veins	Rock and ore minerals	Veins
quartz	quartz	quartz	quartz
sericite	pyrite	sericite	quartz-rhodochrosite ±chalcopyrite
biotite (rare)	chlorite	chlorite	galena, sphalerite
chlorite	chlorite-pyrite	Mn-chlorite	chalcopyrite
spessartite	quartz-calcite	albite	calcite
calcite	quartz-albite-chlorite	pyroxene	quartz-calcite-barite-surssasite-albite
manganoan calcite	quartz-albite-calcite	calcite	quartz-sursassite
calcian rhodochrosite	quartz-albite-ganophyllite	dolomite	
manganoan dolomite	quartz-chlorite-carbonate	rhodochrosite	
braunite	albite	manganoan siderite	
bementite	albite-rhodonite-rhodochrosite	braunite	
manganoan axinite	pyrophanite	hausmanite	
collophane	stilpnomelane	rhodonite	
barite (rare)	manganian pennine	manganoan axinite	
pyrite	manganian talc	hematite	
pyrrhotite	neotocite	magnetite	
hematite		limonite	
magnetite		apatite	
limonite		pyrite	

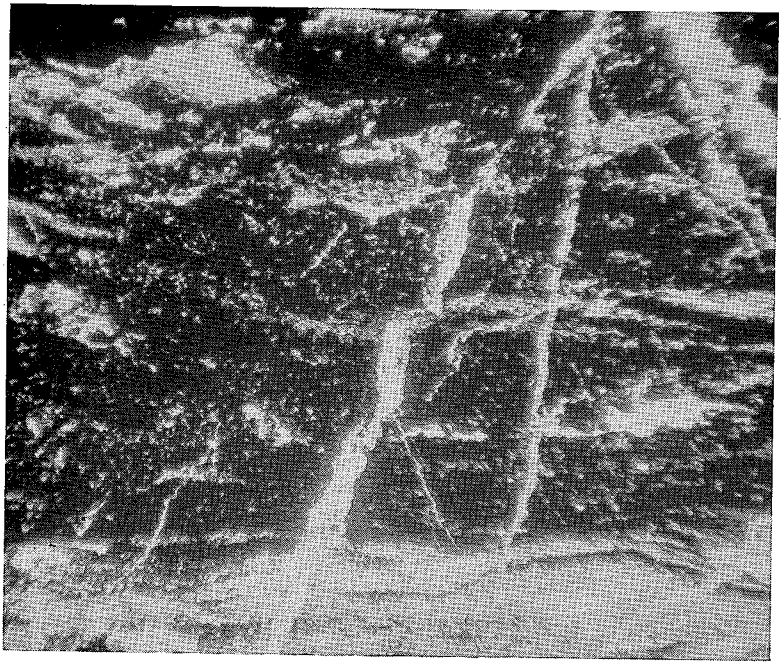

FIG. 1. Banded braunite-hausmannite-hematite ore, cut by quartz veinlets, Plymouth, N.B. Polars not crossed. 45×.

literature and those obtained from thin sections of the ores, associated slates, and the veins.

The sursassite veins cut black Fe-Mn ore, some of which shows crude banding (Fig. 1), and some of which is brecciated. The Mn-rich ore shows the x-ray powder spacings of both braunite and hausmannite. The veins range in thickness from a little less than $\frac{1}{4}$ inch to about two inches. Some veins contain mainly sursassite, in most cases arranged in cross-fibre orientation (Fig. 2). In others calcite, quartz, and lesser amounts of barite are present; in sursassite-poor veins the fibres may be randomly oriented or occur as rosettes and semi-rosettes. Traces of albite occur in a few veins. Small vugs, lined with minute quartz crystals, appear locally in the veins. A few small rhombohedra of black, manganiferous calcite are perched on quartz crystals.

The sursassite-bearing veins cut simple quartz veins and in turn are cut by thin calcite veinlets and by veinlets of secondary manganese oxide minerals (Fig. 3). Within the sursassite veins the sequence is:

1. Barite (mainly at the walls—Fig. 4).
2. Calcite, sursassite, minor barite.
3. Quartz (mainly in vein centres), minor barite.
4. Manganiferous calcite.

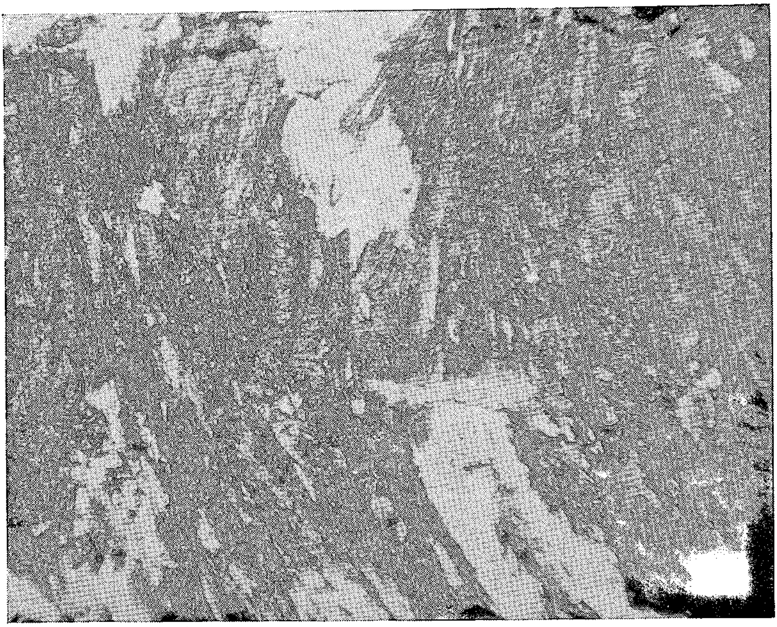

FIG. 2. Cross-fibre sursassite with minor quartz in veinlet. Plymouth, N.B. Polars not crossed. 45×.

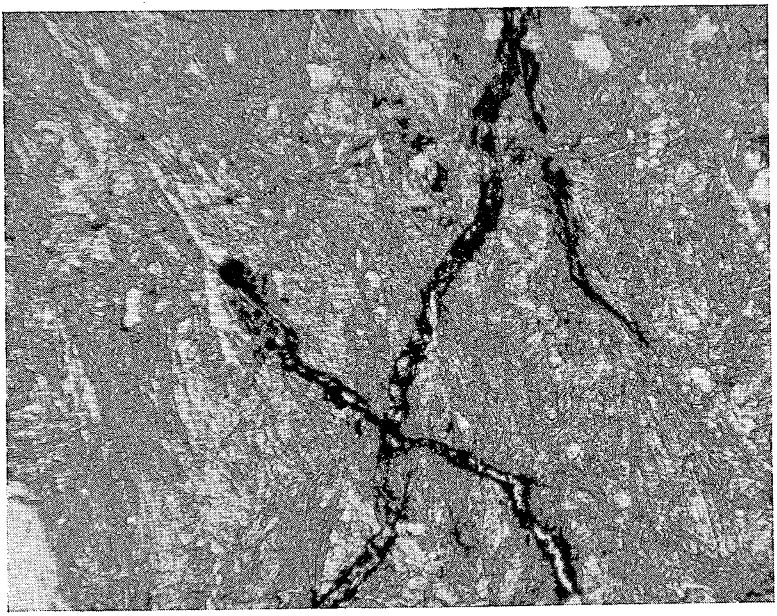

FIG. 3. Sursassite cut by veinlets of secondary manganese oxide minerals. Plymouth, N.B. Polars not crossed. 45×.

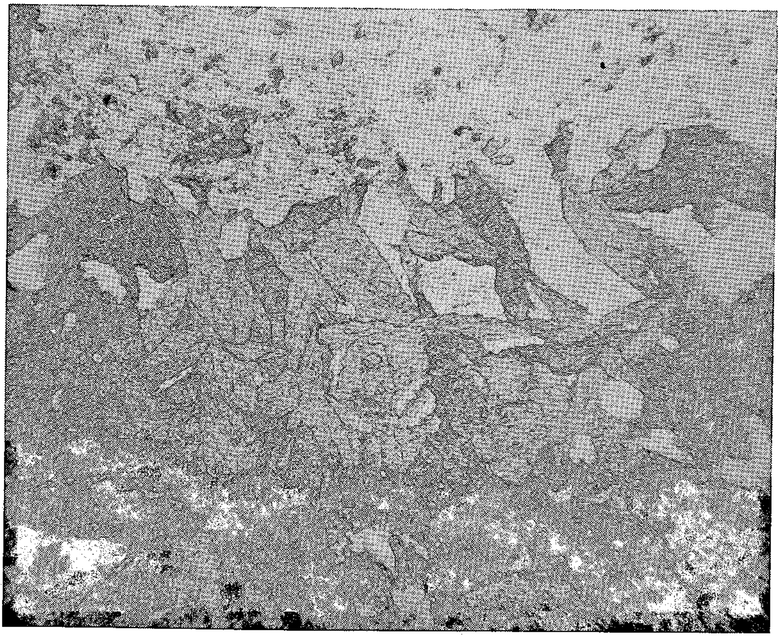

FIG. 4 Margin of sursassite vein, with selvage of barite (medium gray) against wall of manganese ore. Quartz (clear) toward vein centre. Plymouth, N.B. Polars not crossed. 45×.

There has been minor post-vein fracturing and small-scale faulting with slickensiding and brecciation.

Properties. The optical and physical properties of sursassite are presented in Table 2. The sursassite occurs as fibres, 0.1 to 1 inch long and as much as 0.05 inches across. The mineral is beautifully and strongly pleochroic. In megascopic appearance it strongly resembles piedmontite, with which it has been confused. It differs from piedmontite optically in having lower refractive indices, lower birefringence, less intense and less vivid pleochroism, in its negative optical character, and in its large extinction angle.

X-ray powder spacings are listed in Table 3.

Composition. Chemical analyses of sursassite are listed in Table 4. No. 1 by Müller (1916*b*) is presumably of sursassite, but there are serious discrepancies as compared to the others. The two analyses published by Jakob, his own and one by de Quervain, agree remarkably well.

TABLE 2. OPTICAL AND PHYSICAL PROPERTIES OF SURSASSITE

1 Barth and Berman, 1930	2 Winchell and Winchell, 1951 (additional data)	3 This paper
$\alpha = 1.736$		$\alpha = 1.735$
$\beta = 1.755$		$\beta = 1.753$
$\gamma = 1.766$		$\gamma = 1.767$
$\alpha = \gamma =$ almost colourless	$\alpha = \gamma =$ almost colourless	$\alpha = \gamma =$ (in thin section) colourless to very pale buff
$\beta =$ dark brown	$\beta =$ dark reddish brown	$\beta =$ deep golden brown
Monoclinic	Optic plane = (010)	Monoclinic
Elongation $\parallel b$	$a \wedge c = 55°$	
Biaxial (−)		
$2V =$ moderate		$2V =$ *ca.* 65°,
$r > v$ distinct		$r > v$ strong
	(001) cleavage	(001) cleavage. Cleavage fragments yield an eccentric optic axis figure and may show abnormal blue interference tints
$D = 3.252$ (Jakob, 1926*b*)		$D = 3.256$

TABLE 3. *X*-RAY POWDER DATA ON SURSASSITE
Filtered Cu Radiation

1 Oberhalbstein, Switzerland		2 Plymouth, New Brunswick	
*d*Å	*I*	*d*Å	*I*
4.6	*m*	4.60	*mw*
4.3	*w*		
4.1	*w*		
3.74	*s*	3.74	*mw*
2.9	*ms*	2.90	*m*
2.84	*vs*	2.84	*ms*
2.67	*ms*	2.67	*mw*
2.59	*m*	2.59	*mw*
2.46	*vw*		
2.38	*w*	2.39	*w*
2.28	*w*		
2.16	*s*	2.16	*m*
2.13	*vvw*		
2.06	*vvw*		
2.03	*vvw*		
1.97	*vw* (*b*)		
1.63	*vvw*		
1.57	*w*	1.57	*w*
1.542	*vvw*		
		1.48	*vw*
1.458	*w* (*b*)		
		1.34	*vvw*

TABLE 4. ANALYSES OF SURSASSITE

	1	2	3	4	4*a*	4*b*	4*c*	4*d*
SiO_2	47.15	34.91	34.70	39.39	39.53	.6584	.72	12
TiO_2	—	0.10	0.14	0.05	0.05			
Al_2O_3	5.09	22.50	22.90	18.72	18.78	.1842	.12	2
Fe_2O_3	0.36		1.67	3.47	3.48	.5283	.54	9
FeO		1.36						
MnO	36.89	28.67	29.42	26.64	26.73			
MgO	2.99	2.80	2.79	2.68	2.69			
CaO	tr.	3.17	2.26	2.00	2.02			
Na_2O	0.07	0.43	0.12	0.18				
K_2O	1.21	0.15	0.23					
H_2O+	6.24	5.79	5.81	6.69	6.72	.3729	.36	6
H_2O-		0.00	0.00	0.01				
CuO	tr.							
TOTAL	100.00	99.88	100.04	99.83	100.00			

1. Müller (1916*b*).
2. Jakob (1926*b*, 1933).
3. de Quervain (Jakob, 1933).
4. This paper. Analyst: H. B. Wiik.

4*a*. Anal. 4 recalculated to 100% with alkalies and H_2O- omitted.
4*b*. Molecular quotients.
4*c*. Molecular quotients with .06 Al_2O_3 assigned to SiO_2.
4*d*. Molecular ratios.

Various formulae calculated from analyses 2 and 3 are presented in Table 5. The analyses do not lend themselves readily to determination of simple oxide ratios. The analysis by Wiik (No. 4) can be developed somewhat more readily into a relatively simple formula, particularly if it is assumed that some Al is occupying tetrahedral positions. It is also assumed that all Mn is present as Mn^{2+} and Fe as Fe^{2+}. It is possible that small amounts of Mn^{3+} are present. "Whether there is some Mn_2O_3 is hard to say. I should guess there is some because by dissolving the mineral in HF and H_2SO_4 all FeO is oxidized to Fe_2O_3" (Wiik, written comm.). The isomorphism may be: $Mn^{2+}Si^{4+}$–$Mn^{3+}Al^{3+}$.

TABLE 5. SUGGESTED FORMULAE FOR SURSASSITE

1.	$(Mn,Ca,Mg,Fe^{2+})_{20}Al_{16}Si_{21}O_{65}\cdot 12H_2O$	(Jakob, 1933)
2.	$MgMn_4Al_4Si_5O_{20}(OH)_2\cdot 2H_2O$	(Winchell & Winchell, 1951)
3.	$(Mn,Ca,Na,K)_2(Al,Mg,Fe,Mn)_3(Si,Al)_3(O,OH)_{13.5}$	(Geiger, 1948)
4.	$Mn_3Al_2(SiO_4)_3\cdot 2H_2O$	(Strunz, 1949)
5.	$Mn_5Al_4Si_5O_{21}\cdot 3H_2O$	(Hey, 1955)

The oxide ratios (Table 4, 4d) yield the formula:

$$Mn_9Al_4(Si,Al)_{12}O_{39}\cdot 6H_2O.$$

All of the H_2O appears to be of the same nature, inasmuch as the DTA curve, kindly prepared for me by D. G. Nussmann, shows but a single endothermic peak, at 785° C.

ORIGIN

The New Brunswick occurrence is similar in many respects to that in Switzerland. In both places the sursassite (1) occurs in veins cutting meta-sedimentary Mn ores, (2) is associated with other manganese silicates and carbonates and, (3) has identical vein mineral associates: quartz, calcite, barite, and albite. The chief points of difference are (1) the presence of radiolarites and ophiolites among the wall rocks of the Swiss occurrences; (2) the much greater abundance of Fe minerals, especially hematite, in the ores of the North American deposits; (3) the widespread occurrence of pyrite and pyrrhotite in the wall rocks of the North American deposits and, (4) the presence of Cu, Pb, and Zn sulfides in the Canadian veins.

The ore bodies and the enclosing rocks have resulted from the metamorphism of Mn-Fe sediments and shales under low-grade conditions. Intensity environments of the greenschist facies, sericite-chlorite subfacies, are indicated by the predominant association: sericite-chlorite-albite-quartz-carbonate-fine grained hematite. Locally, possibly slightly higher temperatures prevailed as indicated by scattered spessartite, stilpnomelane, magnetite, rhodonite, and rare biotite. During the folding of the sediments fracturing opened avenues for the circulation of solutions that appear to have obtained the bulk of their dissolved material from the wall rocks. The presence of minerals containing Ba, Cu, Pb, and Zn in the veins, as well as B in the wall rocks, although suggestive of the addition of elements from outside the system, is not proof, *per se*, of the additive nature of the solutions. These elements are present in very minor amounts and may also have been derived locally; Ba is especially abundant in some sedimentary Mn ores.

It is possible that sursassite, because of its close resemblance to piedmontite, has been overlooked in the past and that it may be somewhat more common than it is now known to be.

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