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VONSENITE AT THE JAYVILLE MAGNETITE DEPOSIT, ST. LAWRENCE COUNTY, NEW YORK*

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ABSTRACT

The opaque mineral vonsenite, a high-temperature borate of the ludwigite-vonsenite series having the composition $(Fe''_{1.92}Mn_{.01}Mg_{.04})$ $(Fe'''_{.96}Al_{.07}Ti_{.004})B_{.98}O_5$, occurs in skarn in the pyrometasomatic magnetite deposit at Jayville, New York. One magnetite zone contains 4.80% B_2O_3, perhaps equivalent to 36 weight per cent vonsenite. Major associates are biotite, dark clinoamphiboles, salite, and hypersthene. Quartz, fluorite, zircon, chlorite, ferroan talc, hematite, pyrite, chalcopyrite, goethite, and unidentified minerals are sparingly present. Fluorite and ferroan anthophyllite are locally abundant in neighboring skarns. Vonsenite is also present, though rare, at the Clifton mine, near Degrasse, New York.

In hand specimen, Jayville vonsenite is black, metallic to adamantine, granular, weakly magnetic, and indistinguishable from associated magnetite. In polished section, vonsenite forms polygonal aggregates and occasional stubby prisms having a diamond-shaped cross section; reflection-pleochroism very strong, gray or brown to blue, slightly intensified in oil; anisotropism very strong, black to fiery orange, slightly reduced in oil; $\overline{R}_{air}=13\%$ (green), 12.5% (orange), 12% (red); $\overline{R}_{oil}=3\%$ (orange); hardness F or >; HCl (+), aqua regia (+) but weak, other standard reagents (−). G. = 4.77. Cell dimensions: $a_0\sim9.47$, $b_0\sim12.31$, $c_0\sim3.07$ Å (from *x*-ray powder data).

The chemical composition of Jayville vonsenite, corrected for sparse impurities, is: FeO 54.04, MnO 0.28, MgO 0.56, Fe_2O_3 30.14, Al_2O_3 1.48, TiO_2 0.13, B_2O_3 13.37; sum 100.00 weight per cent. Spectrographic analysis shows 0.x% Sn. In composition, this vonsenite closely approaches the $Fe''\ Fe'''BO_5$ end-member of the ludwigite-vonsenite series.

INTRODUCTION

In the winter of 1947, Leonard found an unidentifiable metallic mineral in ore from two drill holes at the Jayville magnetite deposit, New York. The striking optical properties of the unknown set it apart from other metallics that had been investigated mineragraphically and described in the literature. It was thought for a while that the unknown might be ilvaite. In the spring of 1950, G. G. L. Henderson, then of Princeton University, investigated the unknown under the direction of Edward Sampson. Henderson made the usual etch tests and bored from the polished specimen enough fairly pure material for spectrographic analysis and *x*-ray study. His *x*-ray work showed that the unknown was not ilvaite, but attempts to identify the mineral were fruitless for want of matching *x*-ray data. During January 1951, samples isolated by Henderson were studied by J. M. Axelrod and Janet D. Fletcher of the U. S.

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Geological Survey. *X*-ray work by Axelrod and spectrographic analysis by Miss Fletcher identified the unknown as vonsenite (ferrous ferric borate). Later, W. T. Schaller purified a 3-gram sample of the vonsenite, determined its specific gravity, and arranged for further chemical and *x*-ray study.

Vonsenite at first appeared to be something of a mineral curiosity at Jayville. However, the routine assays for one core interval known to contain vonsenite showed a very high soluble Fe content (about 38%) for the nonmagnetic fraction.* The quantity of hematite visible in the cores was far too small to account for so much soluble nonmagnetic Fe. With some hesitation, we ascribed it to vonsenite. Lacking material for a detailed mineralogic study of this core interval, we obtained cuts of the ground samples originally used for iron assay. Upon analysis, the composite sample of crude ore showed B_2O_3 equivalent to about 36 wt. per cent vonsenite. The nonmagnetic fraction (tails) showed B_2O_3 equivalent to about 42 wt. per cent vonsenite. Some iron-rich boron-bearing mineral is thus a major constituent of part of the ore zone, and it seems reasonable to conclude that most if not all the boron is present in vonsenite.

Vonsenite has been found in one specimen of ore from the Clifton magnetite deposit, 13 miles northeast of Jayville, but it has not been identified in other ores from the district. Possibly, traces of other borates occur in a few of the many ore specimens examined, but confirmation of this suspicion is still lacking.

A preliminary note on the Jayville vonsenite was recently published (Leonard and Vlisidis, 1960). Vonsenite, first described and analyzed by Eakle (1920), is now known to be isostructural with ludwigite (W. T. Schaller, *in* Leonard and Vlisidis, 1960). The crystal structure of ludwigite was first determined by Takéuchi, Watanabé, and Ito (1950). A more refined determination was made by daSilva, Clark, and Christ (1955). Takéuchi (1956) determined the crystal structure of vonsenite. Federico (1957) determined the crystal structure of breislakite and showed that this disputed mineral is identical to vonsenite. Members of the ludwigite-vonsenite series are orthorhombic, with space group *Pbam*. The structural formula $4[Mg_2Fe'''BO_3O_2]$ reported by daSilva, Clark, and Christ (1955) may be generalized for the series to $(Mg, Fe'')_2\,(Fe''', Al)BO_5$. In this paper, the name ludwigite is given to members of the series in which Mg atoms > Fe″ atoms, and vonsenite to members in which Fe″ atoms > Mg atoms. Only a few published analyses of vonsenite were known

* *Soluble Fe* is iron soluble in HCl. *Magnetic Fe* is HCl-soluble Fe determined on a magnetic concentrate made in a Davis tube. For magnetite ores of the sort found in St. Lawrence County, magnetic Fe determined by the Davis tube method corresponds very closely to the iron content of magnetic concentrates milled from the same ore.

in 1960. These represent material from the River Dogdo, Chersky Range, Siberia (Vakar, Knipovich, and Shafranovskii, 1934); Riverside, California (Eakle, 1920); Monte Cimino, Italy (Federico, 1957); Kamaishi mine, Iwate prefecture, Japan (Watanabé and Ito, 1954); and Jayville, New York. The compound $4FeO \cdot Fe_2O_3 \cdot B_2O_3$, a synthetic Fe″-vonsenite, has been synthesized by Andrieux and Weiss (1944), Chevallier, Mathieu, and Girard (1948), Bertaut, Bochirol, and Blum (1950), and Federico (1958).

A subsequent paper will consider the distinction of vonsenite from ilvaite.

The Magnetite Deposit

The Jayville magnetite deposit, west-central ninth, Oswegatchie quadrangle, St. Lawrence County, New York, is 1.25 miles east of the hamlet of Kalurah. The mine workings are on the east and west flanks of a low north-trending hill, just west of the former Jayville railroad station. The deposit, opened and abandoned in the latter half of the 19th century, yielded a small tonnage of iron ore from scattered pits and underground workings. The ore shipped ranged in grade from 40 to 60% Fe. The deposit was explored in 1941 by the Jones and Laughlin Steel Corporation, whose eight drill holes tested parts of the deposit to a vertical depth of about 250 feet. Drilling showed that the main ore body was a short lens, 6 to 17 feet thick, averaging 43 to 46% soluble Fe. Phosphorus, sulfur, and titanium are low. Other magnetite-bearing zones of similar grade were encountered, but these are smaller and thinner. The possibility of finding commercially significant tonnages of medium- or low-grade iron ore seems slight.

The main ore body appears to be a shoot, plunging moderately northward in steeply-dipping metasedimentary rocks on the northwest limb of a compound, overturned, isoclinal syncline enclosed by granitic rocks. (Figs. 1 and 2). The metasediments are mainly skarn (metasomatized limestone or dolomite), though some biotite-quartz-plagioclase gneiss and amphibolite are also present. These rocks are referred to the Grenville series, which, together with the granitic rocks, is of Precambrian age. Pertinent aspects of regional geology are treated by Buddington (1939), Dale (1935), and Engel and Engel (1953, 1958). The magnetite deposits and regional geology of the district are described in forthcoming Geological Survey reports (Buddington and Leonard, in preparation; Leonard and Buddington, in preparation). The geologic description of the Jayville deposit found therein is based on an excellent, unpublished report by Tyler and Wilcox [1942], supplemented by the studies of Buddington and Leonard.

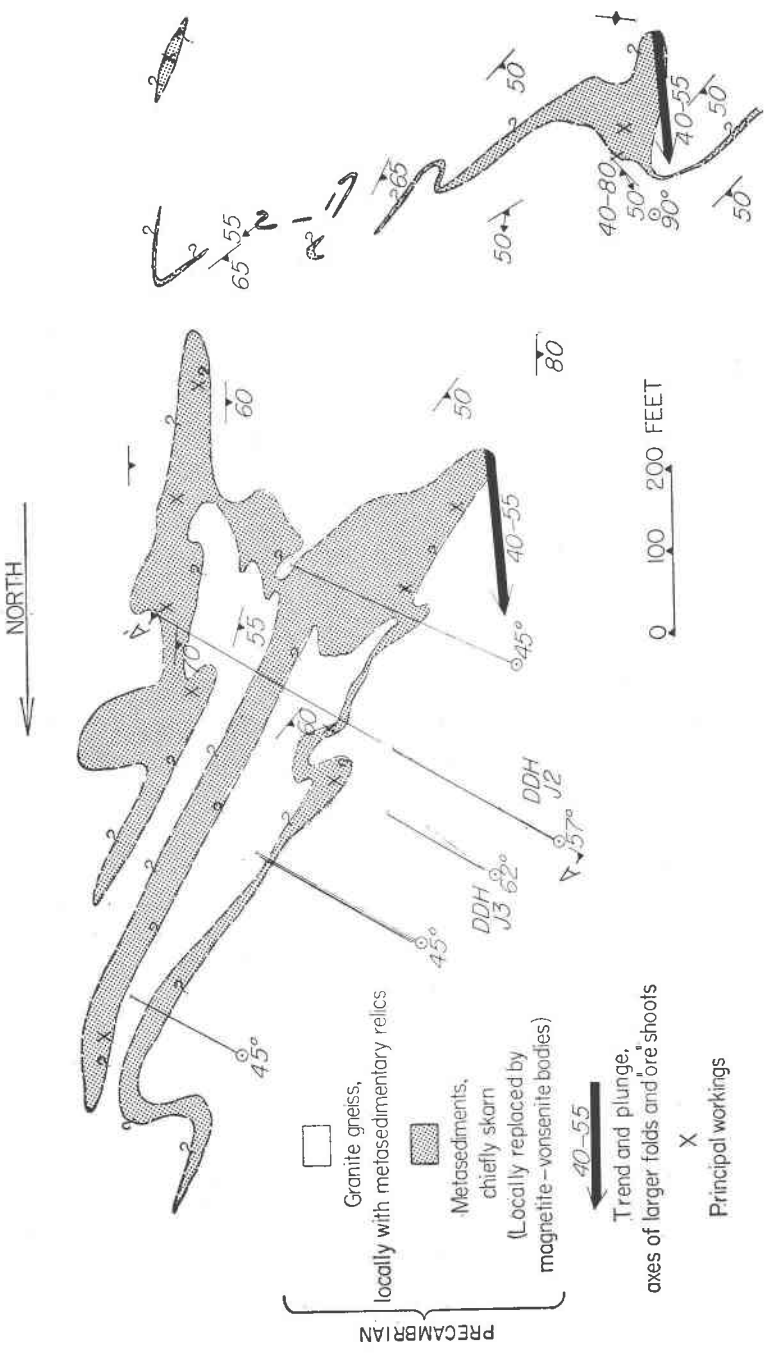

FIG. 1. Geologic sketch map of Jayville magnetite deposit, New York.

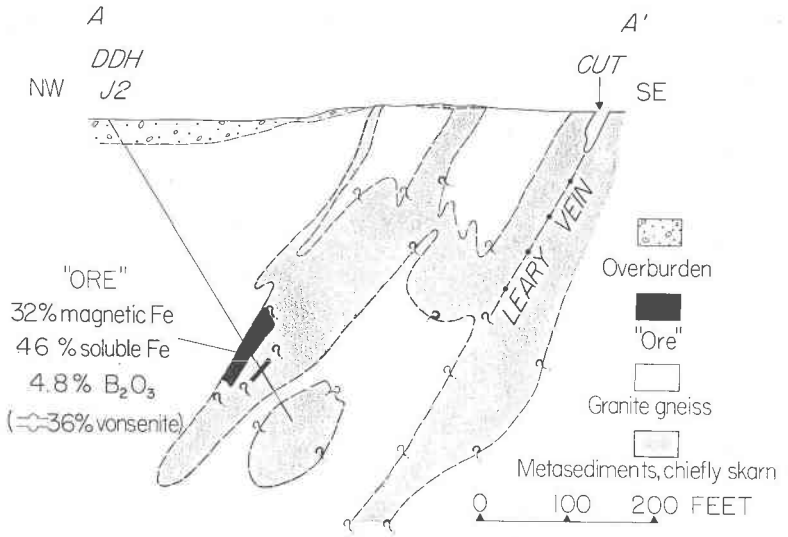

FIG. 2. Cross section of Jayville magnetite deposit.

Magnetite, the chief ore mineral at Jayville, is accompanied in places by vonsenite and by supergene hematite. The ore minerals selectively replace dark mica sköls*, pyroxene-amphibole skarn, and quartz-bearing amphibole skarn in dark skarn zones, predominantly pyroxenic, flanked by contaminated alaskite gneiss and soda granite. Parts of the skarn and ore are rich in fluorite. Anthophyllite skarn is prominent locally. The Jayville deposit is the unique example, among iron deposits of the district, of intense boron-fluorine metasomatism comparable to that described by Geijer (1939), Watanabe (1943, 1953), and Tilley (1951).

The quantitative importance of vonsenite in at least one part of the main ore zone is indicated by the data in Tables 1 and 2. From the known mineralogy of the cores, their high B_2O_3 content, and the high soluble Fe content of the nonmagnetic fraction, we infer that vonsenite is a major constituent of this part of the ore zone. This is the only part of the zone for which samples were magnetically separated and the soluble Fe content of the tails determined by the Jones and Laughlin Steel Corporation; for all other samples taken during exploration, only the soluble Fe content of the crude ore was determined. Thus there are in-

* A feature of some skarns is the presence of mica as contorted, streaky masses, thick selvages, partings, or thin films in skarn or magnetite ore. The selvages and partings are analogous to one type of sköl—or, mnemonically, shell—often noted by Fennoscandian geologists.

TABLE 1. GRADE (WT. PER CENT) OF MAIN ORE ZONE, JAYVILLE DEPOSIT, WHERE SAMPLED BY HOLE J2, INTERVAL 293.5–311 FEET[1]

	Crude ore	Magnetic concentrate[2]	Tails[3]
Soluble Fe	45.73	70.09	38.61
Magnetic Fe	32.05	—	—
P	0.013	—	—
S	0.110	—	—
Apparent thickness	17.5 ft.		
True thickness	14.5 ft.		

Analysts, chemists of Jones and Laughlin Steel Corporation.

[1] Data from Tyler and Wilcox [1942].
[2] Davis-tube concentrate.
[3] Nonmagnetic fraction from Davis tube.

sufficient chemical clues to the distribution of vonsenite throughout the magnetite shoots. However, vonsenite has been identified optically in other parts of the ore zones at Jayville, as well as in specimens from the dumps. It seems that the mineral is a major one for that deposit.

The chemical analyses of crude ore and tails (Table 2) cannot safely be recalculated in terms of ideal mineral composition, for it seemed probable

TABLE 2. PARTIAL CHEMICAL ANALYSES (WT. PER CENT) OF CORE FROM MAIN ORE ZONE, JAYVILLE DEPOSIT, HOLE J2, INTERVAL 293.5–311 FEET

	Crude ore	Magnetic concentrate	Tails
B_2O_3	4.80	0.32	5.66
Fe_2O_3	28.67	62.45	20.09
FeO	33.50	32.15	34.81
MnO	0.23	0.10	0.22
TiO_2	0.40	0.54	0.55
Insol. residue	18.93	1.93	20.93
Total	86.53	97.49	82.26
≈ Soluble Fe	~46	~69	~41
≈ Vonsenite*	~36	~ 2	~43

Analyst, Angelina C. Vlisidis.

* Based on B_2O_3 content of analyzed vonsenite, sample J2.21, Table 3, No. 1, and Table 7.

during the analytical work that the silicate minerals were considerably attacked by the acid treatments given the samples. No sharp distinction could thus be made between the acid reactivity of the vonsenite and magnetite, and that of the associated silicates. The low totals of the analyses are to be expected, owing to the high content of volatiles in the gangue minerals. (See petrography, below.)

The Vonsenite

Physical Properties in Hand Specimen

In hand specimen, vonsenite is indistinguishable from the fine-grained magnetite with which it commonly occurs. The vonsenite forms dark-gray to black, granular aggregates with metallic (locally adamantine) luster. On rough-sawn surfaces, vonsenite looks black and adamantine against magnetite, the latter appearing dark gray and metallic. Stubby prisms of vonsenite are sometimes distinguishable on sawn surfaces. Powdered vonsenite is weakly magnetic, but because of the intimate association of vonsenite and magnetite, this property is not of much use in distinguishing the two minerals where they constitute ore. If one examines polished specimens of ore with the naked eye, one sees that the vonsenite is definitely metallic. Relative to magnetite, the vonsenite appears bluish; and its reflectivity or "brightness" relative to magnetite is about the same as the reflectivity of magnetite relative to primary crystalline hematite.

Microscopic Occurrence

The quantity of vonsenite, as well as its mineral association, varies considerably in the specimens studied. The approximate modes of three specimens are given in Table 3, and the optical properties of their major skarn silicates are given in Table 4. Details of the crystal habit of vonsenite are given in a separate section.

A thin section of "high-grade ore" (Table 3, No. 1) from a biotite sköl shows magnetite and vonsenite (both gray and opaque, but the vonsenite darker) replacing a crystalloblastic aggregate of pale-green biotite and strongly pleochroic hypersthene. A few grains of blue pargasite are also present, as well as traces of zircon and one or more unidentified accessories. The paragenetic sequence inferred from the shapes of the constituent minerals is: hypersthene→pargasite and biotite→magnetite and vonsenite. Vonsenite has replaced biotite in preference to hypersthene, though it has also attacked the latter. The polished section of this rock shows aggregates of magnetite and vonsenite, generally as polygonal grains, replacing the nonopaques. Vonsenite also occurs as scattered sub-

TABLE 3. MINERAL COMPOSITION (VOL. PER CENT) OF SOME VONSENITE-BEARING ORES AND SKARN AT JAYVILLE[1]

	1	2	3
	J 2.21	J 3.11	J 3.10
Vonsenite	35	25.4	0.8
Magnetite	27	—	58.0
Hematite	<1	—	x
Pyrite	—	—	1.0
Chalcopyrite	—	tr.	—
Goethite	—	0.4	—
(Metallics)	(62)	(25.8)	(59.8)
Quartz	—	—	5
Biotite	25	—	<1
Clino-amphibole	1	22	35
Clinopyroxene	tr.	52	—
Orthopyroxene	12	—	—
Zircon	tr.	—	—
Fluorite	—	tr.	—
Unidentified accessories	tr.	x	x
Chlorite	x	x	x
Talc	—	x	—
Unidentified alteration product	x	x	—
(Gangue)	(38)	(74)	(40)
Total	100	100	100

[1] Because of holes in the thin sections, values for nonopaque minerals are crudely approximate. All specimens are generally medium-grained.

No. in table	*Specimen no.*	*Description*
1	J 2.21	"High-grade ore" from dark-green biotite sköl, hole J2, depth 299 ft.
2	J 3.11	"Low-grade ore" from medium-green pyroxene-amphibole skarn, hole J3, depth 267 ft.
3	J 3.10	"High-grade ore" from dark-green amphibole skarn, hole J3, depth 258 ft.

hedral and euhedral crystals in the gangue. (See crystal habit, below.) The magnetite and vonsenite appear to be contemporaneous. A few hair-thin veinlets of secondary hematite cut both gangue and vonsenite. Ragged, crudely bladed patches of hematite replace the vonsenite locally. Some vonsenite grains show thin partial rims of hematite. Commonly the hematite rim is confined to a single edge of a vonsenite grain, has a smooth outer edge and a ragged inner edge, and occurs between vonsenite and gangue.

TABLE 4. OPTICAL PROPERTIES OF SOME SKARN SILICATES ASSOCIATED WITH VONSENITE AT JAYVILLE

	1*a* J 2.21 Hypersthene	1*b* J 2.21 Pargasite	1*c* J 2.21 Biotite	2*a* J 3.11 Actinolite	2*b* J 3.11 Talc	3 J 3.10 Hornblende
α[1]	1.738	1.647	1.551	1.616	~1.560	1.652
β	1.750	1.655	1.588	1.628	1.600	1.666
γ	1.756	1.667	1.588_5	1.639	1.600	1.675
γ-α	0.018	0.020	0.037_5	0.023	~0.040	0.023
Optic sign	(−)	(+)	(−)	(+)[3]	(−)	(−)
$2V_{meas.}$	$69\frac{1}{2}° \pm 1°$[2]	$81\frac{1}{2}° \pm 2°$	11°	$87° \pm 1°$	5° or <	$78° \pm 3°$
Dispersion of optic axes	1st axis: $r<v$, strong 2nd axis: $r<v$, very strong	A: $r<v$, weak B: $r<v$, weak	$r<v$, weak	A: $r<v$, weak B: $r<v$, strong	—	A: $r>v$, moderate B: $r>v$, strong
$Z \wedge c$	~0°	$21\frac{1}{2}° \pm 1\frac{1}{2}°$	—	$21\frac{1}{2}° \pm 1°$	—	$22\frac{1}{2}° \pm 2°$
X	pink	very pale greenish yellow	colorless	very pale yellow	colorless	pale yellow
Y	yellowish pink	green	very pale greenish gray	pale yellowish green	colorless	dark gray-green
Z	green	blue	very pale greenish gray	pale greenish blue	colorless	dark blue or greenish blue
Absorption	Z>X>Y	Z≈Y>X	Z≈Y>X	Z≈Y>X	—	Z>Y>X
Orientation	X=one crystal axis	Y=*b*	—	Y=*b*	—	Y=*b*
Lamellae	{100}	{001}	—	—	—	{001}[4]

[1] Refractive indices, determined in Na light, are ±0.002 for 1*a*, ±0.001 for the rest.

[2] Other values of 74°, obtained indirectly.

[3] Sign obtained by U-stage. Negative sign obtained by differences in refractive indices is incorrect, owing to low accuracy (±0.001) of index determinations.

[4] Also rare pair twins with composition plane {100}.

The biotite (Table 4, No. 1*c*) is a variety common in the sköls at Jayville. Its optical properties, intermediate between those of analyzed phologopite and biotite from sköls of the district (Leonard and Buddington, in preparation) suggest that it is moderately ferroan.

The hypersthene (Table 4, No. 1*a*) is unusual. Hypersthene is a rare mineral in skarns in the district. Moreover, the Jayville hypersthene has peculiar properties; namely, anomalously high interference colors, abundance of prominent partings, and comparative rarity of {110} cleavage. Identification of the mineral as hypersthene has been confirmed by an *x*-ray powder diagram (Richard Marquiss, 1956, personal communication). Diagnostic optical properties suggest a composition near $Mg_{25}Fe_{75}$. (Cf. Fig. 2 of Hess, 1952.) In the terminology adopted by Poldervaart and Hess (1951, p. 474), the mineral is a *eulite*.

The hypersthene shows combinations of a number of very strong, regular, parallel, planar cracks that one would suppose to be cleavages. Some of these cracks are paralleled by minute, elongate opaque inclusions. Within 1°–3°, as determined by universal stage, these cracks are referable to the {100}, {010}, and {001} partings of hypersthene, and to the {110} cleavage. The {100} parting was observed most frequently. Equally well developed cracks could be referred to an assortment of pyramidal forms. A feature strongly resembling polysynthetic twinning of non-normal type is prominent in some grains. Its orientation corresponds to {100} of hypersthene. Ordinarily, one would interpret the features as exsolution lamellae of a ferroan clinopyroxene near hedenbergite in composition. Though some properties of the lamellae are consistent with that interpretation, others are not.

The lamellae are best seen on sections $\perp$ X of the host. In plane-polarized light, the lamellae are all but invisible, their color and refringence being virtually indistinguishable from those of the host. With nicols crossed and the host at extinction, the lamellae generally appear as fine to very fine, bright, straight, parallel bands that extend across the entire grain. A few lamellae pinch out toward the edges of the host. Lamellae are also visible on sections $\perp$ Z of the host. The lamellae are generally too thin to permit determination of their internal optical orientation. However, a few grains have lamellae in which the orientation of the principal optical planes can be established within about 5°. These lamellae seem to have $2V_z$ moderate or large, optic plane about 10° (?) from the optic plane of the host. These observations are inconsistent with the known relation between orthopyroxene (host) and clinopyroxene (exsolved lamellae), wherein the optic planes of the two pyroxenes are perpendicular. If the lamellae are due to exsolution, then the exsolved phase is not the expectable one—a clinopyroxene of the diopside-hedenbergite series.

If the lamellae are due to twinning, the "orthopyroxene" must be very slightly monoclinic or triclinic. H. H. Hess (1958, personal communication) examined the hypersthene and suggested that the lamellae might represent an unusual exsolved amphibole, though the data were inconclusive.

Pargasite (Table 4, No. 1*b*) is not known to be a common constituent of amphibole skarns in the district. Its recognition at Jayville is made more difficult because some of the skarns contain an optically negative hornblende of similar color, extinction angle, and α. (Cf. Table 4, No. 3.) Both varieties commonly show partial or complete lamellae (twinning, rather than exsolution?) $\parallel$ {001}. Pargasite similar to No. 1*b* has been found at the Clifton mine, where amphibole skarns are very sparse.

Vonsenite without magnetite occurs in a specimen of actinolite-salite skarn logged as low-grade iron ore (Table 3, No. 2). The fine- to medium-grained skarn has a strong foliation given by subparallel alignment of actinolite prisms and by layers alternately rich in actinolite, salite, or vonsenite, the last replacing both silicates. In polished section, most of the vonsenite occurs as nearly equant, roundish, elliptical, or polygonal grains, locally highly elongate. Some pairs of roundish grains are connected by narrow bridges. A few diamonds and laths of vonsenite are also present. (See crystal habit.) The very rare chalcopyrite replaces silicates and perhaps vonsenite as well. Filigree-like goethite, presumably supergene, partly replaces silicates near clusters of vonsenite. Rarely, goethite replaces vonsenite.

The pyroxene, a very pale green salite, has $\alpha = 1.686$, $Z \wedge c \sim 43°$. Presumably it is near $Ca_{50}Mg_{36}Fe_{14}$ in composition. (Cf. plate 6 of Hess, 1949.) Though some of the salite is fresh, much of it is partly or almost wholly altered to aggregates of very fine grained talc, locally accompanied by small patches of blue-green chlorite, limonite, and an unidentified isotropic, amber-colored mineral of low refractive index. Megascopically, the talc is visible as white specks, commonly somewhat stained by limonite. The optical identification of the talc (Table 4, No. 2*b*) was confirmed by an *x*-ray powder diffraction pattern (A. J. Gude, 1957, personal communication). The high refractive indices of the talc suggest a ferroan variety approaching minnesotaite in composition. This deduction regarding composition is borne out by the *x*-ray film, whose strong background Gude attributed to iron fluorescence.

The actinolite (Table 4, No. 2*a*) is uniformly fresh. Its grains—larger than those of pyroxene—are relatively stubby, not acicular. Though this amphibole is optically positive, its other characteristics are those common to actinolite.

Vonsenite is present as an accessory in "high-grade ore" whose host rock is quartz-bearing hornblende skarn (Table 3, No. 3). Pale-green biotite flakes and green chlorite patches are sparingly present in the skarn. The geometry of the fabric suggests that quartz, hornblende, and biotite grew simultaneously, the biotite perhaps forming late in the sequence. Magnetite and vonsenite replace hornblende, biotite, and quartz. Subhedral vonsenite grains, usually attached to magnetite, appear to be contemporaneous with or slightly younger than the magnetite. Pyrite replaces magnetite and gangue. Sparse secondary hematite is present as flecks and as crack fillings in gangue. Relations between chlorite and the opaque minerals are indeterminate.

The hornblende (Table 4, No. 3) is representative of one principal variety of clinoamphibole found in the Jayville skarns, the other being a ferrohastingsite of very similar color and extinction angle but having higher refractive indices and much smaller 2V.

Crystal Habit

Though the vonsenite is mostly granular (Figs. 3*a* and 5*b*), some euhedral and subhedral grains are present (Figs. 4*a* and 4*b*). In two dimensions, these are lath-, wedge-, and diamond-shaped, commonly with rounded corners. The crystals are relatively stubby, not showing the highly elongate or fibrous habit usually regarded as typical of members of the ludwigite-vonsenite series, including the synthetic Fe″ end-member. The observed forms of the Jayville vonsenite are {001}, {010}, {100}, {3.10.0}, {380}(?), {250}, {120}, {590}(?), and {320}, in the setting adopted by Eakle (1920, p. 142; $a:b \approx 0.76:1$) for Riverside vonsenite.* In cross section, most crystals are single prisms, locally modified by a front or side pinacoid. Domes have not been recognized. The forms were identified on suitably oriented crystals that were measured in their matrix in polished sections viewed microscopically. We were unable to isolate good crystals for measurement by goniometer.

The form {100} has not previously been reported for natural members of the ludwigite-vonsenite series, though Chevallier, Mathieu, and Girard (1948) observed it on synthetic vonsenite.

Rare grains show a few broad lamellae, resembling twins. Adjacent lamellae plainly differ in optical orientation; their crystallographic orientation could not be determined.

* The same setting was adopted by Chevallier, Mathieu, and Girard (1948) for synthetic $4FeO \cdot Fe_2O_3 \cdot B_2O_3$. This setting is consistent with all the *x*-ray data subsequently reported. Accordingly, it is adopted here, in preference to the setting used in Dana VII, 2 (1951, p. 322, 324; $a:b \approx 0.66:1$). Transformation, Dana VII to Eakle, 010/200/001.

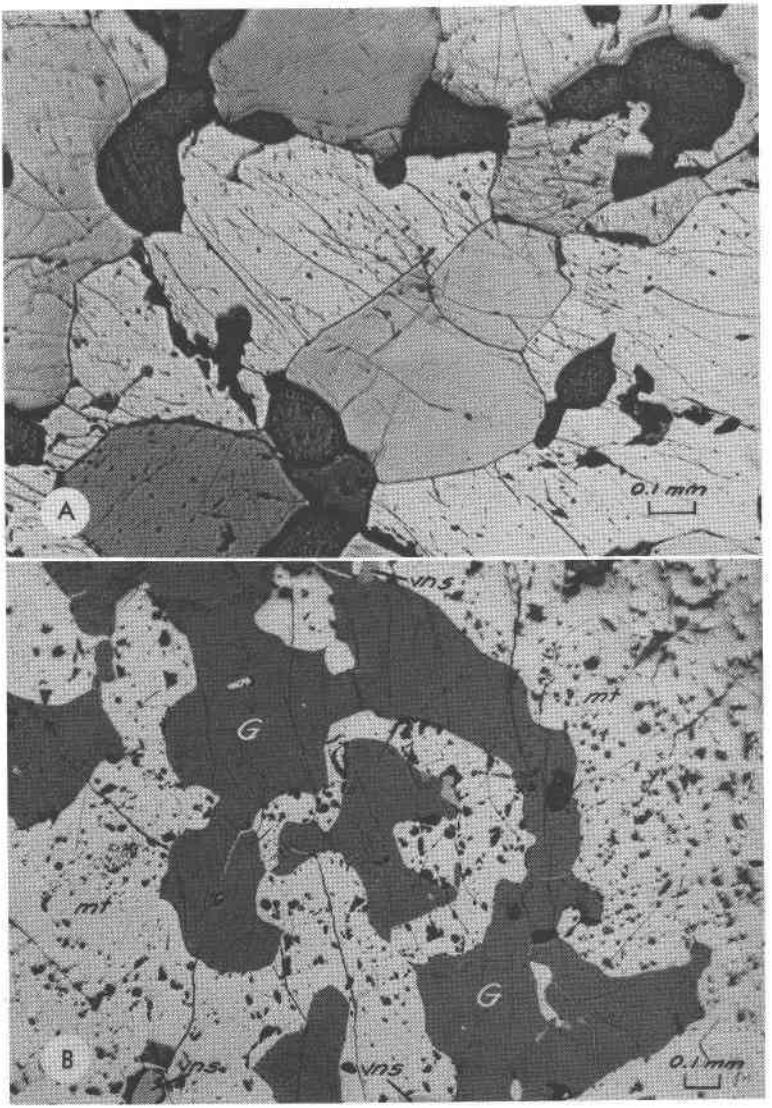

FIG. 3. Photomicrographs of polished sections of Jayville vonsenite.

(A) Granular habit of vonsenite. All but rough, nearly black material is vonsenite, in part slightly etched by HCl. Nicols partly crossed.

(B) Magnetite (mt) replacing gangue (G). Sparse vonsenite (vns) has intermediate reflectivity. Single nicol.

Optical Properties and Etch Tests

The vonsenite is opaque in thin section and in very finely crushed fragments. Crushed fragments are irregular, lacking distinctive shape. Their refringence is very high but indeterminate in oils, owing to complete absorption. In polished sections examined with the reflecting microscope, the vonsenite shows the following properties. *Color*—very strongly pleochroic from light gray or light brown to light blue-gray, slightly intensified by the oil-immersion objective ("in oil"). The brown color approaches that of magnetite; the blue-gray color looks very bluish against the brown of magnetite. Diamond-shaped vonsenite crystals—{001} sections bounded chiefly by {120}—look brown ∥ the long axis and blue-gray ∥ the short axis. Lath-shaped crystals are brown ∥ their length and gray or blue-gray across it. More fully stated, the reflection-pleochrosim is: a = gray (looks brown relative to b, but blue relative to c), b = blue or blue-gray, c = brown or pinkish brown. These relations were determined on specially cut sections of vonsenite from Riverside, California, as they could not be established on the Jayville material. Because the color of adjacent, variously oriented grains so markedly affects the apparent color ∥ a, the observer sees only bluish and brownish tones in an aggregate of vonsenite grains. *Reflectivity*—less than that of magnetite, but much greater than that of polished iron-rich pyribole and biotite. (See Figs. 3*b* and 5*a*.) Reflectivity measurements for vonsenite are reported in Table 5. These reflectivity measurements are part of a set whose relation to the data of other workers was previously established (Leonard, 1960). *Anistropism*—very strong, slightly diminished in oil. No internal reflection. Extinction ∥ long edges of laths but symmetrical in wedges and diamonds. Extinction details: with nicols set at 90°, four extinction positions per 360° rotation. The mineral is black at extinction; in the position of maximum illumination, it is fiery orange, somewhat resembling covellite as seen in the analogous position. With nicols nearly crossed, at 82°, two positions of extinction. The mineral is blue at extinction and pink or reddish brown at maximum illumination. The blue color seen between nearly crossed nicols corresponds to the blue-gray color seen in light from a single nicol; the pink or reddish brown corresponds to the light brown. Grains that show zero anisotropism under nicols set at 90°, are blue-gray in light from a single nicol. *Twinning*—broad twin lamellae are present in some grains.

Polarization figures—The polarization figures (Table 5) were obtained with a conventional ore microscope and strain-free high-power dry objective 6FL. The glass plate was inserted in place of the reflecting prism in the vertical illuminator, the ocular was removed, and the apparent

FIG. 4. Photomicrographs of polished sections of Jayville vonsenite.

(A) Vonsenite "diamond": {001} section showing {120} prism and {100} pinacoid. Bright grains at left is chalcopyrite (cp). Single nicol.

(B) Vonsenite "lath" (left): section $\parallel c$, truncated at beveled top by {001}. Part of a "diamond" shows at upper left. Other prism sections to right of center. Single nicol.

TABLE 5. REFLECTIVITY, ORIENTATION, POLARIZATION FIGURES, AND ROTATIONAL PROPERTIES OF JAYVILLE VONSENITE

Reflectivity (per cent) and orientation[1]

	Green	Orange	Red
Air			
Rg‖*c*	14.5	14.5	14.5
Rm‖*a*	12.5	12.5	12
Rp‖*b*	11.5	10.5	9.5
Rg−Rp	3	4	5
$\bar{R}$[2]	13	12.5	12
Oil			
$\bar{R}$	—	3	—

Instrument: Hallimond visual microphotometer.
Standard: In air, quartz {0001}. Accepted R_0=4.61% (green), 4.58 (orange), 4.54 (red), as reported by Hallimond (1953, p. 179).
In oil, galena from the Maggie M. mine, Central City district, Colorado (P. K. Sims' specimen S-543,53). R_{air}=39.9% (red), using quartz standard. For oil (n_{Na}=1.5145 at 24.0° C.), accepted standard value R_{oil}=27.13% (orange), determined by Cissarz (1932, p. 449).
Filters: green—Chance OGR 1; $\lambda_{max.}$=530 mμ, T_{max}=42%, HW=90 mμ.
orange—Ilford Spectrum Orange 607; $\lambda_{max.}$=590 mμ, $T_{max.}$=16%, HW=40 mμ.
red—Ilford Spectrum Red 608; $\lambda_{max.}$=730 mμ, $T_{max.}$=86%, HW>200 mμ.
blue (for rotational properties)—Schott PAL 660509; $\lambda_{max.}$=478 mμ, $T_{max.}$=54%, HW=20 mμ.
Filter characteristics determined in air by spectrophotometer by F. N. Ward. Data reported for visible spectrum only.

Polarization figures and rotational properties[3]

	Relative dispersion of reflection rotation (DR_r)	Apparent angle of rotation (A_r)			Relative dispersion of A_r (DA_r)	Amount of dispersion	Figure after rotation of analyzer	Figure at 45° position; × nicols
		Blue	White	Red				
{001} section, Spc. J3.11	v>r, weak	obs.[4] 1.9°	2.3°	3.1°	r>v, moderate	obs. 1.2°	Isogyres black; concave gray, convex reddish brown.	Isogyres black; v>r, strong; concave slightly greenish gray, convex brownish; center of field gray.
		corr.[5] 1.5°	2.1°	2.8°		corr. 1.3°		
		$e_{calc.}$[6] n.d.	1.9°	3.2°		n.d.		
Section‖*c*; grain showing maximum anisotropism, Spc. J3.11[7]	v>r, weak or moderate	obs. 2.8°	3.5°	4.6°	r>v, strong	obs. 1.8°	Isogyres black; concave bluish gray, convex brownish red, grading to central field of brownish gray.	Isogyres black; v>r, strong; concave grayish blue; convex brownish red, grading to central field of brownish gray.
		corr. 2.2°	3.0°	4.0°		corr. 1.8°		
		$e_{calc.}$ n.d.	4.0°	6.0°		n.d.		
Grain showing maximum anisotropism, Spc. J2.21[7]	v>r, weak or moderate	obs. 2.4°	3.1°	4.6°	r>v, strong	obs. 2.2°	Isogyres gray; concave blue to grayish blue, convex brownish red.	Isogyres black; v>r, strong; concave blue, convex brownish red. Center of field dark brownish gray.
		corr. 1.9°	2.7°	4.0°		corr. 2.1°		
		$e_{calc.}$ n.d.	n.d.	n.d.		n.d.		

[1] Crystallographic orientation is that of Eakle (1920), which agrees with subsequent *x*-ray data.
[2] $\bar{R}=(Rg+Rp)/2$.
[3] Methods and notation are those of Cameron and Green (1950).
[4] Observed angle.
[5] Angle corrected for rotation induced by reflecting glass plate. (See Cameron, Hutchinson, and Green, 1953, p. 587.)
[6] Angle calculated from the equation e (in radians) $=\frac{1}{2}(\rho-1)/(\rho+1)$, where $\rho=Rg/Rp$, and R is expressed as a decimal ratio, not per cent. (Cf. Hallimond, 1953, p. 120.) The value of e reported for white light represents $\frac{1}{2}(e_{orange}+e_{green})$.
[7] Data for most strongly ansiotropic grain found. Photometry shows that no single grain in the polished section shows true maximum bireflection; hence the discrepancy between $e_{calc.}$ and A_r.

angle of rotation was measured by rotating the analyzer. The methods and notation are those of Cameron and Green (1950).

The agreement between A_r (measured, uncorrected) and e (calculated) is rather good for the one grain, the {001} section, that had a crystallographic axis parallel to the microscope axis. The values for A_r measured on grains having apparent maximum anisotropism, also shown in Table 5, are the best obtainable on dozens of grains checked. However, reflectivity measurements show that no single grain in these specimens is so oriented as to exhibit true maximum bireflection. Rg and Rp can, of course, be measured and confirmed on separate grains, but the true maximum value of A_r can be measured only on an Rg–Rp section, which was not found here.

By the technique he devised, Capdecomme (1946, p. 35) found the maximum angle of rotation ω_M of ludwigite from Banat to be $<3°$ (blue), $\sim 3°$ (yellow), and $\sim 5°$ (red). His values of ω_M for ludwigite are slightly lower than the e's of Jayville vonsenite, a relation to be expected because of the lower Fe'' content of ludwigite.

Hardness—scratching hardness F or >, or about 6 on Mohs' scale; powder is black, opaque, and dull to moderately reflecting. The polishing hardness is less than that of hematite, and about equal to that of magnetite.

Magnetism—pure mineral powder is attracted to a magnetized sewing needle.

Etch tests, originally made by Henderson and confirmed by Leonard, give the following reactions: HCl—positive; aqua regia—weakly positive; HNO_3, KCN, $FeCl_3$, KOH, $HgCl_2$, H_2O_2—negative. With HCl, no reaction at 30 seconds. At about 40 seconds, drop turns yellow. Etching begins at about 1 minute. A good etch, emphasizing cracks and scratches, requires 2 minutes. With aqua regia, no reaction in 1 minute. At about 2 minutes, drop turns yellow and some grains are faintly etched. Other grains are not etched after 3 minutes. The other reagents are negative, regardless of time.

All qualitative mineragraphic properties of Jayville vonsenite are identical with those of vonsenite from the type locality at Riverside, California. The quantitative mineragraphic properties of the two vonsenites are slightly different, in accordance with the known differences in Fe'' content. The ore microscopy of Riverside vonsenite, never reported by Eakle (1920), will be presented subsequently in a summary paper on the distinction of vonsenite from ilvaite.

Brief accounts of the ore microscopy of other vonsenites have been given by several workers. Chevallier, Mathieu, and Girard (1948), in their monograph on synthetic $4FeO \cdot Fe_2O_3 \cdot B_2O_3$, used unpolished crystal

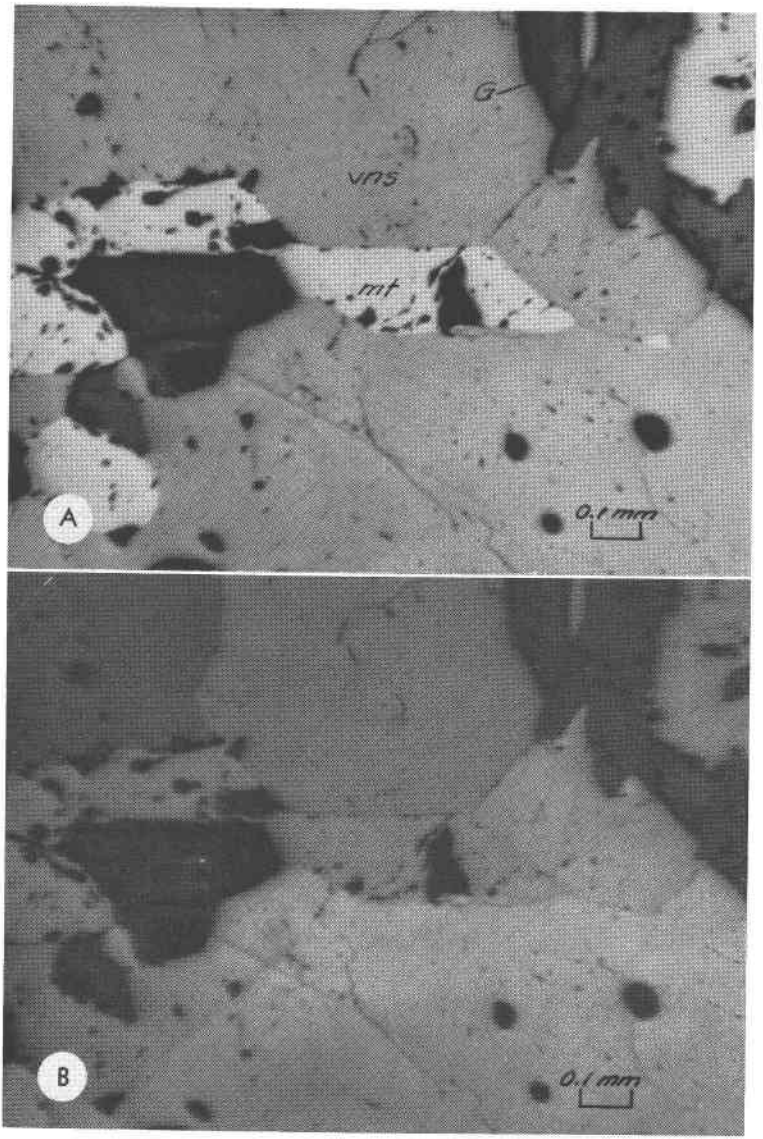

FIG. 5. Photomicrographs of polished sections of Jayville vonsenite.

(A) Vonsenite (vns), showing reflectivity intermediate between that of magnetite (mt) and gangue (G). Single nicol.

(B) As above, but nicols partly crossed.

faces for observing reflection-pleochroism and anisotropism, and for measuring reflectivity. Watanabe and Ito (1954) presented the first useful description of natural vonsenite, their "paigeite" from Kamaishi. The only mineragraphic property noted by Vakar, Knipovich, and Shafranovskii (1934) for vonsenite from the Chersky Range was its anisotropism. The ore microscopy of ludwigite is reported in detail by Ramdohr (1955, p. 811).

X-Ray Powder Data

An *x*-ray powder diffraction diagram of the Jayville vonsenite was prepared by Fred A. Hildebrand, using material purified for chemical analysis. Hildebrand's data are given in Table 6, no. 1, together with data on vonsenites from Monte Cimino, Italy (Federico, 1957), and Riverside, California (Thompson and Gower, 1954). Federico's data (1958) for synthetic $4FeO \cdot Fe_2O_3 \cdot B_2O_3$ are included. The table is fully annotated. Thompson and Gower (1954, p. 523) give *x*-ray powder data for some other anhydrous borates, including ludwigite from Philipsburg, Montana. Watanabe and Ito (1954, p. 87) give indexed data for ludwigite from Hol Kol, Korea, and Kilbride, Scotland. Shabynin (1955) gives *x*-ray powder data for ludwigites from Hungary, eastern transbaikal region, and California, the last presumably representing a vonsenite. The data for Shabynin's ludwigite from the eastern Transbaikal region are unfortunately attributed to ilvaite in one abstract (Zbl. Mineralogie, Jahrgang 1956, pt. I, p. 170–171, 1958). Powder data for ludwigite are also given by Serdyuchenko (1956—analyzed sample) and by Barsukov and Kuril'chikova (1957).

Chemical Composition

A chemical analysis of 1.9 grams of nearly pure vonsenite, separated by W. T. Schaller, is given in Table 7. (The sample is field no. J 2.21, hole J 2, depth 299 feet; laboratory sample no. 144483; laboratory report IWC-473.) For a mode of the host, see Table 3, no. 1.

The insoluble residue reported in Table 7 is hypersthene with less than one per cent of biotite and a trace of an unidentified accessory mineral. G. of eulite of composition $Mg_{27}Fe_{73}$ is 3.77. (Cf. Hess, 1952, Fig. 2.) This value was used to obtain the corrected G. for the vonsenite.

The recalculated analysis yields the oxide ratios 4.01:1.07:1.00, close to the ideal $4FeO \cdot Fe_2O_3 \cdot B_2O_3$. The composition may be expressed as $4[(Fe''_{1.92}Mn_{.01}Mg_{.04})(Fe'''_{.96}Al_{.07}Ti_{.004})B_{.98}O_5]$, based on the structural formula of daSilva, Clark, and Christ (1955). In chemical composition, the Jayville vonsenite closely approaches the Fe_2'' $Fe'''BO_5$ end-member of the ludwigite-vonsenite series.

TABLE 6.—*X*-RAY POWDER DIFFRACTION DATA FOR VONSENITES

(1) Vonsenite, Jayville, N. Y. $Fe''_{1.92}Mn_{.01}Mg_{.04}/O_5$ $a_0=9.47\pm.02$, $b_0=12.31\pm.01$, $c_0=3.07\pm.01$ Å (B.F.L.) FeKα; $\lambda=1.93728$ Å Mn filter F. A. Hildebrand				(2) Synthetic vonsenite Fe''_2/O_5 $a_0=9.44$, $b_0=12.26$, $c_0=3.065$ Å FeKα Bertaut (1950) Federico (1958)		(3) Vonsenite, Riverside, Cal. $Fe''_{1.38}Mg_{.64}$ to $Fe''_{1.17}Mg_{.85}/O_5$ $a_0=9.33$, $b_0=12.31$, $c_0=3.04$ Å (B.F.L.) FeKα, Mn oxide filter ($\lambda=1.937$ Å) Thompson and Gower (1954)		(4) Breislakite, Monte Cimino, Italy. $Fe''_{\sim1.87}Mn_{.05}$ $Mg_{.21}/O_5$ $a_0=9.50$, $b_0=12.40$, $c_0=3.10$ Å FeKα Federico (1957)	
hkl	d_{calc}	d_{obs}	I_{obs}	d_{obs}	I_{obs}	d_{obs}	I_{obs}	d_{calc}	I_{obs}
110	7.51	7.52	3			7.42	4	7.55	4
020	6.16	6.16	2			6.16	2	6.20	8
—	—	5.66 (β-120)	3	5.63 (β)	vw	5.63 (β)	1		
120	5.16	5.16	50	5.19	m	5.12	7	5.20	100
200	4.735	4.73	13	4.72	w	4.70	1	4.75	72
210	4.42	—							
—	—	4.13	0.3						
130	3.77	3.77	4	3.75	w	3.74	1	3.80	9
220	3.75	—							
—	—	3.38	0.3						
—	—	3.221*	0.3						
—	—	3.135	0.5						
230	3.101	—							
040	3.078	—		3.06	w	3.04	4	3.10	8
310	3.059	3.061 br	3					3.08	8
140	2.927	2.938	2			2.92	1	2.95	8
—	—	2.846 (β-240)	18			2.83 (β)	5		
320	2.809	2.805	4	2.83	ms	2.75	3	2.82	9
021	2.746	2.753	9	2.76	w				
—	—	2.622 (β)	0.5						
240	2.580	2.580	100	2.56	vs	2.56	10	2.64	100
330	2.502	2.494	0.5					2.52	6
150	2.383	2.372 br	25	2.36	ms	2.36	5	2.40	6
400	2.368					2.33	½	2.38	72

(*Continued on next page*)

* Hypersthene?

1. Analyzed sample—field no. J 2.21, Schaller series no. V-15. Film no. W-8495, made by F. A. H. with a Debye-Scherrer powder camera (114.59 mm. diameter); Straumanis technique; cut-off at $2\theta\sim5°$. α_1 and α_2 were not sufficiently resolved to measure separately. Measurements were made with a Hilger-Watts film-measuring rule with a vernier precision of 0.05 mm. A shrinkage correction was determined and appropriately applied to the measurements. Intensities were measured with calibrated film strips. The powdered mineral (~2 mg.) was mixed with a binder of granular ethyl cellulose dissolved in toluene and was rolled into a thin rod for mounting in the camera. Pattern indexed by B.F.L. Spacings calculated only for lines observed in films of the various vonsenites. Hypersthene is the only known contaminant of this analyzed vonsenite. Hypersthene lines tentatively assigned by B.F.L. after comparison with Marquiss' film of hypersthene J 2.21. Other major hypersthene lines coincide with observed vonsenite lines.

2. Synthesized, Fe_2O_3/FeO confirmed, and *x*-rayed by Federico (1958). Indexed by B.F.L. on the basis of Bertaut's (1950) unit cell for synthetic $4FeO\cdot Fe_2O_3\cdot B_2O_3$.

3. Their "paigeite" (vonsenite); not chemically analyzed. Indexed by B.F.L. The line $d=1.068$ indexes as 821 and 3·10·1 only. The lattice constants of another vonsenite from Riverside are, according to Takéuchi (1956), $a_0=9.37_0$ [correction for typographic error in the original], $b_0=12.35_7$, $c_0=3.05_8$ Å.

4. Her microchemically analyzed breislakite, which she showed to be "paigeite" (vonsenite). Original Fe'' content uncertain, owing to partial oxidation of breislakite to hematite (cf. Federico, 1958). Indexed by Federico (1957). d_{calc} by B.F.L., using mean values derived from her sin θ's (λ not stated) and unit-cell dimensions. I reduced by B.F.L. from her $I_{max.}=47400$.

TABLE 6. (*continued*)

(1) Vonsenite, Jayville, N. Y. $Fe''_{1.92}Mn_{.01}Mg_{.04}/O_5$ $a_0=9.47\pm.02$, $b_0=12.31\pm.01$ $c_0=3.07\pm.01$ Å (B.F.L.) FeKα; $\lambda=1.93728$ Å Mn filter F. A. Hildebrand				(2) Synthetic vonsenite Fe''_2/O_5 $a_0=9.44$, $b_0=12.26$, $c_0=3.065$ Å FeKα Bertaut (1950) Federico (1958)		(3) Vonsenite, Riverside, Cal. $Fe''_{1.33}Mg_{.64}$ to $Fe''_{1.17}Mg_{.85}/O_5$ $a_0=9.33$, $b_0=12.31$, $c_0=3.04$ Å (B.F.L.) FeKα, Mn oxide filter ($\lambda=1.937$ Å) Thompson and Gower (1954)		(4) Breislakite, Monte Cimino, Italy. $Fe''_{\sim 1.8?}Mn_{.05}$ $Mg_{.21}/O_5$ $a_0=9.50$, $b_0=12.40$, $c_0=3.10$ Å FeKα Federico (1957)	
hkl	d_{calc}	d_{obs}	I_{obs}	d_{obs}	I_{obs}	d_{obs}	I_{obs}	d_{calc}	I_{obs}
410	2.325	2.331	0.5	2.28	vw	2.27	½	2.33	3
—	—	2.279 β*	2						
250	2.184	—		2.16	m	2.17	6	2.20	72
311	2.167	2.171 br	25			2.14	4		
—	—	2.137*	0.3						
321	2.072	2.074	18	2.06	m	2.05	7		
060	2.052	—						2.07	<1
430	2.051	—						2.06	<1
160	2.005	2.001	4	2.00	w	1.998	2	2.02	17
241	1.975	—				1.961	½		
350	1.941	1.937	18	1.93	m	1.926	7	1.954	9
331	1.940								
260	1.882	—				1.878	1	1.898	8
440	1.876	1.875	3	1.87	w	1.857	½	1.886	17
510	1.872	—						1.880	<1
520	1.810	1.810	2	1.79	w				
341	1.790	1.793	4			1.776	4	1.817	9
251	1.780	—							
—	—	1.764 β?	1						
170	1.729	1.728	doublet 2	1.72	vw			1.744	8
530	1.720	1.719						1.728	1
360	1.720	—						1.732	4
450	1.707	1.699 (or β)	1						
431	1.705								
161	1.679	1.678	1	1.65	w	1.670	1		
270	1.648	1.660 br (or β)	0.7						
540	1.613							1.621	1
261	1.605	1.602	13	1.60	m	1.586	5		
511	1.598								
600	1.578	1.579	0.5					1.584	8
521	1.559	1.558	3						
080	1.539	1.538	18	1.55	w	1.538	1	1.551	72
370	1.536			1.53	m	1.528	6	1.546	6
180	1.519							1.531	4
171	1.507	1.507	13			1.505	5		
550	1.501			1.50	m	1.487	4	1.510	8
531	1.500	1.499	13						
630	1.473	1.472	1						
280	1.464	1.456	0.7			1.466	½	1.475	<1
271	1.452								
541	1.428	1.426	0.7						
640	1.404	1.403	9	1.40	mw	1.388	5	1.411	72
611	1.395	—				1.366	½		
560	1.392	—						1.400	<1
380	1.383	1.375	2	1.37	w			1.393	1
371	1.373								

TABLE 6. (*continued*)

	(1) Vonsenite, Jayville, N. Y. $Fe''_{1.92}Mn_{.01}Mg_{.04}/O_6$ $a_0=9.47\pm.02$, $b_0=12.31\pm.01$ $c_0=3.07\pm.01$ Å (B.F.L.) FeKα; $\lambda=1.93728$ Å Mn filter F. A. Hildebrand			(2) Synthetic vonsenite Fe''_2/O_5 $a_0=9.44$, $b_0=12.26$, $c_0=3.065$ Å FeKα Bertaut (1950) Federico (1958)		(3) Vonsenite, Riverside, Cal. $Fe''_{1.33}Mg_{.64}$ to $Fe''_{1.17}Mg_{.85}/O_5$ $a_0=9.33$, $b_0=12.31$, $c_0=3.04$ Å (B.F.L.) FeKα, Mn oxide filter ($\lambda=1.937$ Å) Thompson and Gower (1954)		(4) Breislakite, Monte Cimino, Italy. $Fe''_{\sim 1.87}Mn_{.06}$ $Mg_{.21}/O_5$ $a_0=9.50$, $b_0=12.40$, $c_0=3.10$ Å FeKα Federico (1957)	
hkl	d_{calc}	d_{obs}	I_{obs}	d_{obs}	I_{obs}	d_{obs}	I_{obs}	d_{calc}	I_{obs}
190	1.354	1.349	0.5			1.352	½	1.369	4
551	1.349					1.339	½		
650	1.329	—				1.315	6	1.335	3
720	1.321	1.321	9	1.31	mw	1.300	½	1.326	8
290	1.314	—							
480	1.290	—				1.283	3	1.299	17
570	1.289	1.289	4	1.29	w			1.296	3
730	1.285	—						1.290	3
390	1.255	1.258 br	1			1.251	2	1.264	8
660	1.251	—						1.258	1
740	1.238							1.244	<1
711	1.232								
0·10·0	1.231	1.231	0.7			1.217	2	1.241	3
1·10·0	1.221	1.221	0.7						
721	1.214	—				1.200	1		
—	—	1.203	0.5						
580	1.194								
2·10·0	1.191	1.189	2			1.183	2	1.201	<1
490	1.184								
800	1.184	1.182	3	1.18	ms	1.166	3	1.188	72
670	1.175	1.171	0.5						
661	1.158	1.158	0.3						
3·10·0	1.147	1.147 br	0.7	1.14	w	1.144	½	1.156	3
1·11·0	1.111	—						1.120	<1
—	—					1.131 (β?)	½		
590	1.109					1.105	½	1.116	3
680	1.102							1.108	<1
671	1.097								
4·10·0	1.092	1.094	0.3	1.09	vw	1.087	4	1.100	17
2·11·0	1.089	1.089 br	2						
821	1.087								
082	1.087	1.087 br	2			1.068	1		
3·10·1	1.074	1.073 br	0.5						
3·11·0	1.055	1.054	1			1.052	½	1.063	8
1·11·1	1.045								
591	1.043	1.045 br	2			1.044	2		
920	1.037	1.036	4	1.04	w			1.041	3
690	1.034	—				1.028	6	1.040	1
5.10·0	1.032	—						1.039	4
4·11·0	1.012	1.012	2						
—	—	1.009	1						
2·12·0	1.003	1.002	2			1.003	3		
—	—	1.000	1			.997	3		
—	—	.997	1			.992	1		
940	.996	.995	0.7			.983	4		
870	.982	.988 br	2						

TABLE 7. CHEMICAL ANALYSIS OF VONSENITE FROM JAYVILLE, NEW YORK

	Wt. per cent	Wt. per cent (recalc.)
FeO	53.06	54.04
MnO	0.27[a]	0.28
MgO	0.55[b]	0.56
Fe_2O_3	29.59	30.14
Al_2O_3	1.45	1.48
TiO_2	0.13	0.13
SnO_2	Present[c]	Present
B_2O_3	13.13	13.37
CaO	None	100.00
Acid insoluble	1.80	
	99.98	

Angelina C. Vlisidis, analyst, 1955

G. of analyzed sample = 4.75
G. corrected for acid insoluble = 4.77 } W. T. Schaller

[a] Amount of MnO recovered from the Mg precipitate. Total amount not determined.

[b] Corrected for the contained MnO (0.27 per cent).

[c] Not determined gravimetrically. Spectrographic determination (see below) indicates a small quantity, about 0.x per cent.

Spectrographic analysis, made in 1951 by Janet D. Fletcher, shows (report IWS-156):

	Per cent
Fe, B	>5
Mg, Si, Al	1–5
Sn, Pb, Zn, Mn, Ti	0.x
Cu, Cr, Zr, Ba, Ca	0.0x
Ag, Co, Ni	0.00x

Looked for but not found: As, Bi, Be, Au, Pt, Mo, W, Ge, Sb, Cd, Tl, Ga, V, Y, La, Th, Cb, Ta, U, Sr, Na, P.

The sample analyzed by Miss Fletcher was drilled from the surface of a polished section. The presence of Sn is of interest, for that element is a major constituent of the chemically related minerals hulsite and paigeite. Ludwigite from the Zheleznyi Kryazh deposit, Kalgan district, Chita region, U.S.S.R., contains 0.03–0.3% Sn, according to semiquantitative spectrographic analysis (Efimov, 1955, p. 1308).

VONSENITE AT CLIFTON

Vonsenite was identified in a single specimen from the Clifton magnetite deposit, hole 51, depth about 143 feet. The sparse vonsenite is asso-

ciated with martitized magnetite, cobaltoan loellingite, colloform graphite, pyrrhotite, sphalerite, chalcopyrite, and chalcocite(?) in mica-pyroxene-calcite marble from a weakly mineralized zone of diopside skarn. Mineralogical details are given in the forthcoming report by Leonard and Buddington. Optical identification of the vonsenite was confirmed by *x*-ray by A. J. Gude (1957, personal communication). Gude notes that the pattern from the very small sample confirms the presence of a mineral of the ludwigite-vonsenite series, though it does not permit an estimate of the relative position of the Clifton mineral in that series.

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W. T. Schaller would, except for his modesty, be appropriately listed as co-author of this paper. His generous contributions of advice, encouragement, data, and specimens are gratefully acknowledged.

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Note added in proof: Robert Carpenter, University of Wisconsin, reports the following values of A_r for Vonsenite in specimen J 3.11:

λ(mμ)	A_r(obs.)	A_i(corr.)
470	2.17°	1.70°
589	4.19°	3.41°
650	5.83°	4.82°

Carpenter obtained these by a more refined technique than ours. We are indebted to him for the data and to Professor Cameron for his interest in the problem.