INESITE*

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CONTENTS

ABSTRACT

Inesite, a hydrous manganese, calcium silicate from Quinault, Washington, a new locality for that mineral, has been analyzed and the optical properties determined. For purposes of comparison, the optical properties of inesite from eight other localities have been redetermined and the chemical analyses compiled. These all show close agreement in optical properties, and chemical composition with the inesite from Quinault. The maximum variation of indices of refraction is 0.005, and agrees with the uniformity in chemical composition. The average indices of refraction of inesite are: $\alpha=1.616$, $\beta=1.640$, $\gamma=1.651$.

The analyses do not agree with the commonly accepted simple formulas. Calcium is present in fixed quantity and does not vary reciprocally with manganese, as it does in rhodonite. No simple formula could be determined for inesite. The most probable formula seems to be the complex one $15SiO_2 \cdot 3CaO \cdot 11MnO \cdot 10H_2O$.

INESITE FROM QUINAULT, WASHINGTON

Introduction

A small specimen of radiating, flesh-colored inesite, a hydrous silicate of manganese and calcium, was obtained by Mr. J. T. Pardee, geologist of the United States Geological Survey, from Mr. Ed Brooks of Piedmont (Crescent Lake), Oregon. Mr. Brooks stated that the sample came from Quinault, on the southwestern slope of the Olympic Mountains in the northern part of the state of Washington. The specimen, although only $3\frac{1}{2}$ centimeters in diameter, contains an unusually pure seam of inesite about 2 centimeters wide and constitutes about two-thirds of the specimen. It is shown, slightly enlarged, in Fig. 1.

The study of the specimens, the determination of the optical properties, and the compilation of published data on inesite were made by one author (J. J. G.); and the comparison of analyses, and the derivation of the chemical formula is the contribution of the other author (W. T. S.). The

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chemical analysis of the inesite from Quinault was made by J. G. Fairchild, and the spectrographic examination by George Steiger, both of the United States Geological Survey, to whom the authors are greatly indebted. The writers are also indebted to Professors Adolph Pabst, and N. F. Taliaferro, of the University of California, for the sample of inesite from Napa County, California, now deposited in the United States National Museum, and to Dr. W. F. Foshag, of the United States National Museum, through whose cooperation additional samples from various localities were secured.

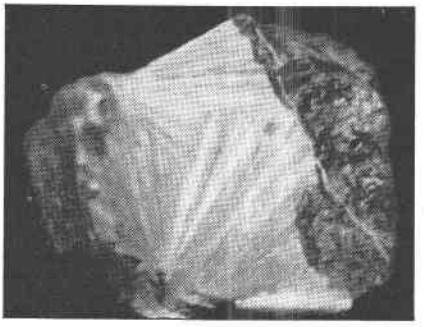

FIG. 1. Inesite from Quinault, Washington, showing the typical radial habit and the fiber-form of the crystals. The dark mineral is neotocite, and the thread-like veinlet is calcite. Slightly enlarged (4/3×).

Physical and optical properties

The inesite from Quinault occurs in flesh colored, radiating, slender laths, about a millimeter thick and 15 millimeters long, forming imperfect fan-shaped clusters. The vitreous to silky inesite is surrounded by dark liver-brown amorphous neotocite ($n=1.467$). Two cleavages, one visibly more perfect than the other, are present. On close inspection the laths show a lamellar habit giving the surface a striated appearance. Associated with the inesite is a thin crust of calcite between the ends of the laths and the surrounding neotocite.

The material used for optical determinations and chemical analysis was carefully hand picked from the purest portion of the specimen. The elongated lath-like plates commonly lie on the most perfect cleavage, $b\{010\}$, and are bounded on the edges by another nearly perfect cleavage, $a\{100\}$. The crushed fragments are colorless in transmitted light, and show no perceptible pleochroism.

Sections lying on the best cleavage, $b\{010\}$, show a nearly centered interference figure, negative, $2V=74°$. The dispersion of the optic axes is strong, $r>v$. Assuming the c axis to be parallel to the elongation,

$Z \wedge c = 29°30'$, $Y \wedge c = 60°30'$. Cleavage plates parallel to $a\{100\}$ show no interference figure, and extinguish 13° to 15° against the elongation. Polysynthetic twinning is occasionally seen on some of the pieces with low birefringence. The indices of refraction measured by the immersion method are: $\alpha = 1.616$, $\beta = 1.641$, $\gamma = 1.652; \pm 0.001$.

Chemical composition

The chemical analysis of selected material is shown in the following table:

TABLE 1. ANALYSIS AND MOLECULAR RATIOS OF INESITE FROM QUINAULT, WASHINGTON

[J. G. Fairchild, Analyst]

	Analysis	Molecular ratios		
SiO_2	45.67	0.7599	or 3.00	or 2.00
MnO	35.10	0.4951		
FeO	0.92	0.0128	0.6955 or 2.75	or 1.83
MgO	0.86	0.0213		
CaO	9.33	0.1663		
H_2O-	2.13	0.4778	or 1.89	or 1.26
H_2O+	6.53			
Al_2O_3, PbO	None			
	100.54			

These ratios do not yield any simple formula, and differ considerably from both of the commonly accepted formulas of inesite, namely $3SiO_2 \cdot 3RO \cdot 2H_2O$, and $2SiO_2 \cdot 2RO \cdot H_2O$. A study of published analyses was, therefore, undertaken and the results of a comparative study are given in a later section.

A spectrographic analysis of the inesite from Quinault, Washington, made by George Steiger, showed potassium and tin to be present in small quantities. The following elements are absent: Ba, Sr, Cs, Rb, Li, B, Ag, As, Bi, Pb, Sb, Zn, Be, Cd, Ge, and Tl. The mineral was placed directly in the arc, using graphite electrodes, and this method would detect quantities of from two or three hundredths of one per cent.

OPTICAL PROPERTIES OF INESITE

For the purpose of comparing the optical properties of inesite from Quinault, Washington, with those of inesite from other localities, five additional specimens from Rumania, Germany, two localities in Sweden, and Napa County, California, were also studied.

Nagybanya, Transylvania, Rumania (U.S.N.M. Cat. No. 103077). This specimen showed typical radiating laths of a very pale flesh color and a silky luster. The outward pointing laths terminate in a banded zone of chalcedonic, glassy white, and amethystine quartz. The central points from which the laths of inesite radiate have become altered to a light brown carbonate, apparently calcite, and only the long ends of the laths embedded in the quartz have retained their original character. (No. 8, Table 2.)

Nanzenbach, Nassau, Germany (U.S.N.M. Cat. No. 4003). Small fan-shaped clusters of radiating rose-colored laths of inesite are intergrown with snow-white calcite and embedded in a mass of dark liver-brown amorphous neotocite ($n=1.467$). The specimen closely resembles the one from Quinault, Washington, both in structure and in mineral association. (No. 9, Table 2.)

Pajsberg, Sweden (U.S.N.M. Cat. 51468). The specimen is composed largely of dark brown, compact, amorphous neotocite, with small aggregates of flesh-colored radiating laths of inesite. A little calcite is associated with the inesite along the boundary of the neotocite. (No. 10, Table 2.)

Långban, Sweden (U.S.N.M. Cat. No. 95306). This specimen exhibits the typical radial habit of inesite more strikingly than do most of the specimens studied. The flesh-colored inesite forms radiating clusters about $2\frac{1}{2}$ centimeters in diameter, embedded in white barite. Other associated minerals are amber-colored andradite ($n=1.895$); a brown-red mica-like mineral (manganophyllite?) resembling fine-grained muscovite ($2V=0°$ to $5°$, $\alpha=1.550$, $\beta=1.579$, $\gamma=1.580$, pleochroism strong, pale pinkish brown to brownish red); a little calcite; and a few grains of a black opaque, unidentified mineral. (No. 11, Table 2.)

Napa County, California (U.S.N.M. Cat. No. 103078). Pearly, lavender-pink aggregates of thin, radiating blades are clustered together in narrow, sheaf-like bundles about 2 centimeters long and from 1 to 1.5 millimeters wide. They are embedded in a matrix of compact, very fine-grained, dark brown bementite, resembling brown chert, having a mean index of refraction of 1.650. Thread-like veinlets of calcite cut through the bementite. (No. 12, Table 2.)

The optical determinations made on these five specimens, with those determined on the Quinault material, are given in Table 2, together with the data taken from the literature,[1] which are included for comparison.

Up to the time of the present study only a few quantitative determinations of the optical properties of inesite have been made. The few early

[1] References are given at end of paper.

TABLE 2. COMPILATION OF ALL OF THE AVAILABLE OPTICAL DATA FOR INESITE FROM VARIOUS LOCALITIES

	I.			II.				III.						
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Locality	Nanzenbach	Dillenberg	Pajsberg	Pajsberg	Banska, Slovak.	Idzu, Jap.	Hokkaido	Nagybanya	Nanzenbach	Pajsberg	Långban	Napa Co., Calif.	Quinault, Wash.	Average exclusive of doubtful data
Data by	Schneider	Schneider	Flink	Larsen	Ulrich	Kato	Yoshimura	Glass	Glass	Glass	Glass	Glass	Glass	
System	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl	Tricl
Cleavage	*b*, *a*	*b*, *a*	.....	.....	.....	.....	.....	*b*, *a*	*b*, *a*	*b*, *a*	*b*, *a*	*b*, *a*	*b*, *a*	*b*, *a*
α	.....	.....	.....	*1.609	1.618	1.617	*1.624	1.614	1.619	1.615	1.616	1.616	1.616	1.616
β	.....	.....	.....	*1.636	.....	1.640	1.643	1.638	1.642	1.640	1.640	1.641	1.641	1.640
γ	.....	.....	.....	*1.644	.....	.....	1.651	1.649	1.654	1.651	1.652	1.653	1.652	1.651
$\gamma-\alpha$	.....	.....	.....	0.035	.....	.....	*0.027	0.035	0.035	0.036	0.036	0.037	0.036	0.035
Sign	—	—	.....	—	—	—	—	—	—	—	—	—	—	—
$2V$	.....	*63°[a]	.....	*56°[b]	.....	Large	.....	74°	74°	75°	74°	75°	74°	74°
Disp.	$r>v$	$r>v$	.....	$r>v$	.....	.....	.....	$r>v$	$r>v$	$r>v$	$r>v$	$r>v$	$r>v$	$r>v$
Ext. on b(010)	29°	60½°	30°	60°	.....	60°	.....	29°	30°	30°	29½°	33°	29½°	30°
$Z\wedge c$														
Ext. on a(100)	.....	12°	15°	10°	.....	.....	.....	12°	12°	13°	13°	15°	13°	13°

I. Data by early investigators: 1, 2, 3.

II. Data, some of which is doubtful or incomplete: 4, 5, 6, 7.

III. Data obtained from recent investigation by the writer: 8, 9, 10, 11, 12, 13.

* Doubtful data.

[a] Axial angle measured on cleavage fragments parallel to *b*: $2G_{a.y.}=63°28'$ Na (Adams polariscope with $n_y=1.7782$ Na for the glass).

[b] Value for $2V$ calculated from indices.

optical observations made on analyzed material are given in Table 2, Nos. 1, 2, and 3. Chemical analyses have been made on inesite from Nanzenbach, Germany, and from Pajsberg, Sweden, and optical determinations have been recorded on material from these two localities, but not on the analyzed material. Optical data and chemical analyses both made on the same material, are available from only two localities, namely, that from Idzu, Japan, and from Quinault, Washington.

The results of observations made by Schneider on the materials from Nanzenbach and Dillenberg, and by Flink on material from Pajsberg, show close agreement with the new data.

The indices of refraction determined by Larsen on inesite from Pajsberg (Table 2, No. 4) are apparently slightly low, and since the birefringence (0.035) is in accord with more recent data, it is probable that the index media were out of adjustment. The value for the α index found by Ulrich (Table 2, No. 5) is in agreement with the new data. This value, he asserts, was several times "confirmed" in an effort to match Larsen's lower (and apparently incorrect) value. Optical properties by Kato (Table 2, No. 6) on material from Idzu are in agreement with those newly determined. The value for α in Yoshimuri's determinations (Table 2, No. 7), is probably too high. The values for β and γ are in agreement with the data obtained in the present investigation.

The optical properties of inesite from the six localities studied (Table 2, Nos. 8, 9, 10, 11, 12, 13), are remarkably constant, the variations being but slightly greater than the errors of measurement. The uniformity of the optical data from nine different localities indicates a constant chemical composition for the mineral, a conclusion arrived at independently from a consideration of the available analyses. (See also Fig. 2.)

Chemical Composition of Inesite

The formula for inesite is commonly written $2(Mn,Ca)O \cdot 2SiO_2 \cdot H_2O$, although Schneider, the original describer, suggested $(Mn,Ca)(MnOH)_2Si_3O_8 + H_2O$ or $3(Mn,Ca)O \cdot 3SiO_2 \cdot 2H_2O$. This last formula was adopted by Ford,[2] writing it $H_2(Mn,Ca)_6Si_6O_{19} \cdot 3H_2O$, following Farrington. Berman[3] writes the formula $(Ca,Mn)_3Si_3O_8(OH)_2$ or $3(Ca,Mn)O \cdot 3SiO_2 \cdot H_2O$, ignoring half the water, and suggesting a close relation, chemically, to xonotlite, $Ca_3Si_3O_8(OH)_2$. These formulas have a 1:1 ratio of silica to bases.

Previous writers have generally grouped the CaO with the MnO, as (Mn,Ca)O indicating a reciprocal variability of the CaO with MnO.

[2] Ford, W. E., A Textbook of Mineralogy by E. S. Dana, 4th ed., p. 640, **1932.**

[3] Berman, Harry, Constitution and classification of the natural silicates: *Am. Mineral.*, vol. **22,** pp. 360, 391, 1937.

Where these are written separately a ratio of MnO:CaO of 4:1 is general adopted. Fairchild's analysis of the inesite from Quinault gives a ratio of SiO_2:(MnO+CaO+FeO+MgO):H_2O of 3.00:2.75:1.89, with a marked deficiency in the bases for a 1:1 ratio to silica. As shown on the following pages, all analyses of inesite show a similar deficiency and in none of them is the ratio of SiO_2:RO equal to 1:1.

The compilation of available analyses of inesite (Table 3) was made in order to see if a suitable and simple formula could be derived. Two analyses have been excluded[4] from this compilation as they were made on impure material.

TABLE 3. COMPILATION OF CHEMICAL ANALYSES OF INESITE FROM VARIOUS LOCALITIES

	1*	2*	3*	4	5	6**	7**
SiO_2	43.92	43.92	43.67	44.89	42.92	44.50	45.67
MnO	37.87	38.23	37.04	36.53	36.31	37.80	35.10
FeO	0.69	0.69	1.11	2.48	—	0.55[a]	0.92
MgO	0.33	0.28	0.15	trace	0.37	0.27	0.86
CaO	8.40	8.00	9.38	8.24	8.68	7.86	9.33
H_2O-	4.54	8.49	7.17	3.88	10.48	3.66	2.13
H_2O+	4.68			4.32		4.90	6.53
Al_2O_3	0.29	0.29	—	—	—	0.43	none
PbO	—	—	0.77	—	0.73	—	none
	100.72	99.90	99.29	100.34	99.49	99.97	100.54
G.	3.03	3.103	3.03	2.965			

* The single asterisks indicate analyses for which partial optical data are given. (See Table 2, Columns 1, 2, and 3.)

** The double asterisks indicate analyses for which more complete optical data are given (See Table 2, Columns 7 and 13.)

[a] Fe_2O_3.

1. Nanzenbach, northeast of Dillenburg, Germany. Bärwald, analyst.
2. Dillenburg, Germany. Hampe, analyst.
3. Harstig mine, Pajsberg, near Persberg, Vermland, Sweden. Flink, analyst.
4. Villa Corona, Durango, Mexico. Farrington, analyst.
5. Jakobsberg, Nordmark, Långban, Sweden. Lundell, analyst.
6. Anjo mine, Idzu, Japan. Tanaka, analyst.
7. Quinault, Washington. Fairchild, analyst.

These seven analyses of inesite, made by seven different analysts over a period of 50 years, on material from six different localities from five

[4] Analysis of agnolite, a mineral later shown to be identical with inesite, Breussig, E., *Neues Jahrb. Min., Beil. Band*, vol. **13**, p. 265, 1900, and one of inesite, Goldschmidt, V. M., *Videnskaps. Skrifter*, No. **1**, p. 392, 1911.

countries show a remarkable uniformity in composition, the variations in the percentages being notably small. The SiO_2 content varies from 42.92% to 45.67%, with a difference of 2.75%; MnO from 35.10% to 38.23%, with a difference of 3.13%; CaO from 7.86% to 9.38%, with a difference of only 1.52%; and H_2O from 7.17% to 10.48%, with a difference of 3.31%. Even the minor constituents are consistently small, FeO reaching a maximum of 2.48 per cent and MgO a maximum of 0.86 per cent.

Recalculating the analyses to a common basis of 100.00 per cent by discarding Al_2O_3 and PbO, which never reach one per cent in any analysis, and combining the small quantities of FeO and MgO (only two determinations exceed one per cent) on an equivalent basis with MnO, the results obtained are shown in Table 4.

TABLE 4.—RECALCULATED ANALYSES OF INESITE

No.	1	2	3	4	5	6	7	
	Germany, Bärwald	Germany, Hampe	Sweden, Flink	Mexico, Farrington	Sweden, Lundell	Japan, Tanaka	Washington, Fairchild	Average
SiO_2	43.63	44.00	44.18	44.75	43.24	44.65	45.14	44.21
MnO	38.87	39.48	39.07	38.86	37.46	38.88	37.08	38.54
CaO	8.34	8.01	9.50	8.21	8.74	7.88	9.22	8.56
H_2O	9.16	8.51	7.25	8.18	10.56	8.59	8.56	8.69
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The percentages given in Table 4 are plotted in Fig. 2 in the order of increasing percentages of CaO and hence in the order of analyses Nos. 6, 2, 4, 1, 5, 7, 3, to show diagrammatically the constancy in composition of the several inesites. Not many of the less common minerals show seven analyses on samples from different localities with such a uniformity of chemical composition. The very slight variability in percentages of CaO (shaded in Fig. 2) may be due in part at least to contamination by calcite as every specimen of inesite examined contained calcite, and even hand picked and purified samples show a slight effervescence in acid although none of the analyses report any CO_2.

It is obvious that MnO and CaO do not vary reciprocally in inesite. The percentages of CaO are fully as constant as are those of SiO_2 and of MnO.

Compare, for example, the extent of the variation in the percentages of CaO in inesite, from 7.88 to 9.50 (in the recalculated analyses), with the variations in several sets of analyses of rhodonite, in which CaO and

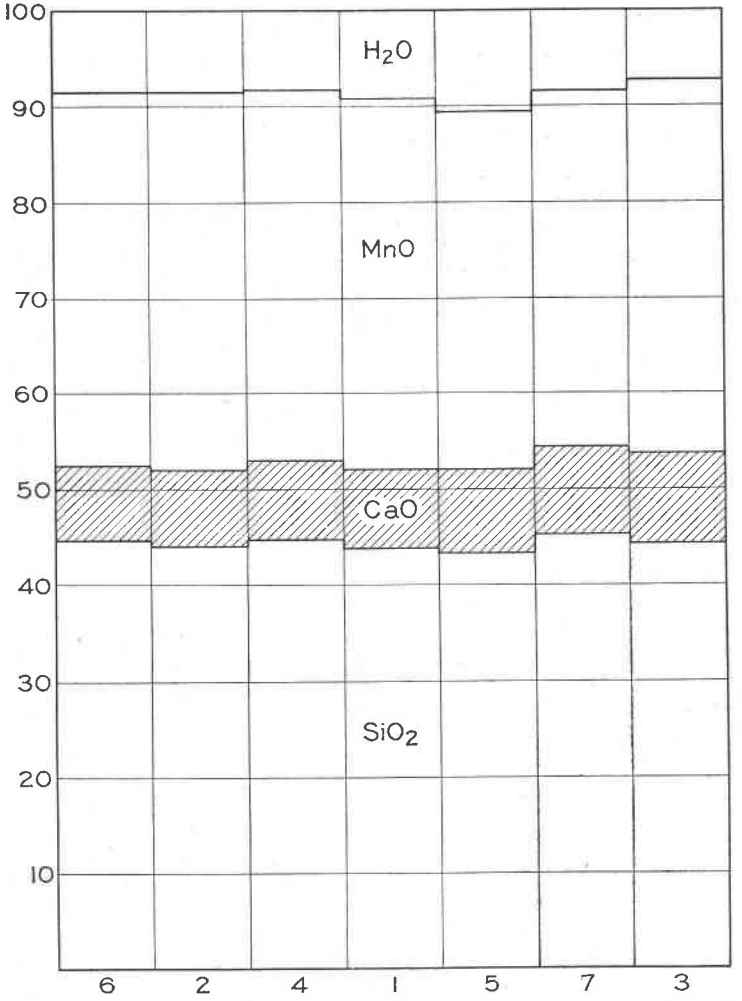

FIG. 2. Diagrammatic representation of the analyses of seven inesites, to show constancy of composition.

MnO vary reciprocally. Thus, in a compilation of 14 analyses of rhodonite with which optical determinations can be correlated,[5] the percent-

[5] Compilation made by W. T. Schaller.

ages of CaO range from 1.31 to 10.12; in seven analyses from Australia,[6] from 3.50 to 11.08; in seven analyses from New Jersey, listed by Palache[7] from 4.50 to 10.50; and in six analyses from Japan,[8] from 1.48 to 6.96.

The molecular ratios of the different constituents obtained from the recalculated analyses of Table 4 are given in Table 5 on the basis of $SiO_2 = 100$.

TABLE 5. MOLECULAR RATIOS OF ANALYSES OF INESITE, WITH $SiO_2 = 100$

	1	2	3	4	5	6	7	Av.
SiO_2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
MnO	75.5	76.1	75.0	73.5	73.4	73.8	69.4	73.9
CaO	20.5	19.5	23.0	19.7	21.7	18.9	21.9	20.8
H_2O	70.0	64.6	54.8	61.0	81.5	64.2	63.3	65.7
MnO+CaO	96.0	95.6	98.0	93.2	95.1	92.7	91.3	94.7
MnO+CaO+H_2O	166.0	160.2	152.8	154.2	176.6	156.9	154.6	160.4
$\frac{SiO_2}{MnO+CaO}$	1.042	1.047	1.021	1.074	1.052	1.079	1.095	1.056
$\frac{SiO_2}{MnO+CaO+H_2O}$	.602	.624	.655	.649	.566	.637	.647	.623
$\frac{MnO}{CaO}$	3.68	3.90	3.26	3.73	3.38	3.90	3.17	3.55

The molecular ratios shown in Table 5 bring out clearly a number of relationships between the constituents of inesite.

First, there is no simple ratio between SiO_2, MnO, CaO, and H_2O.

Second, the ratio of SiO_2 to MnO+CaO is never 1:1. The proportion of MnO+CaO is consistently less than 100, ranging from 91.3 to 98.0. Hence the ratio of SiO_2 to MnO+CaO is consistently slightly greater than 1.

Third, the ratio of SiO_2 to MnO+CaO+H_2O averages 0.623, or very close to 0.625, which gives a ratio of SiO_2 to MnO+CaO+H_2O of 5:8. Hence, the generalized formula of inesite may be written $5SiO_2 \cdot 8(MnO, CaO, H_2O)$.

Fourth, the ratio of SiO_2 to CaO is rather consistently close to 5:1. The formula may then be written $5SiO_2 \cdot 1CaO \cdot 7(MnO,H_2O)$.

[6] Stillwell, F. L., The rocks in the immediate neighborhood of the Broken Hill Lode—their bearing on its origin: *Mem. Geol. Survey New South Wales, Geology*, No. **8**, Appendix II, p. 385, 1922.

[7] Palache, Charles, The minerals from Franklin and Sterling Hill, Sussex County, N. J.: *U. S. Geol. Survey, Prof. Paper* **180**, p. 67, 1935.

[8] Harada, Zyunpei, Chemische Analysenresultate von japanischen mineralien: *Jour. Faculty Science, Hokkaido Imperial University, Ser. IV*, vol. **3**, nos. 3–4, p. 279, 1936.

Fifth, the ratio of MnO:CaO is not 4:1, as generally stated, but averages about $3\frac{1}{2}$:1 with considerable variation, from 3.17 to 3.90:1.

Sixth, the ratio of MnO:H_2O is only approximately 1:1, with the MnO in slight excess.

From these relationships, particularly the third and fourth, the molecular ratios of the various constituents may then be restated by changing SiO_2 to 5.00 with the following results (Table 6). In this table, CaO is placed before MnO, immediately following SiO_2, to emphasize the 5:1 ratio between SiO_2 and CaO.

TABLE 6. MOLECULAR RATIOS OF ANALYSES OF INESITE, WITH $SiO_2=5.00$

	1	2	3	4	5	6	7	Av.
SiO_2	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
CaO	1.02	.97	1.15	.98	1.08	.94	1.09	1.04
MnO	3.78	3.80	3.75	3.67	3.67	3.69	3.47	3.70
H_2O	3.50	3.23	2.74	3.05	4.08	3.21	3.17	3.28
MnO+H_2O	7.28	7.03	6.49	6.72	7.75	6.90	6.64	6.98

A consideration of the ratios given in Table 6 shows a rather close agreement with a 5:1 ratio of SiO_2 to CaO and a 5:7 ratio of SiO_2:(MnO+H_2O). The slight variation from unity (both plus and minus) in the ratios of CaO are not balanced by corresponding variations in MnO. There is no reciprocal relation between CaO and MnO and the slight variations from unity for CaO are to be explained by errors in analysis and traces of calcite rather than by a real variation in the CaO content.

The ratio of SiO_2 to MnO never reaches 5:4 but varies slightly from 5:3.47 to 3.80, averaging closely to $5:3\frac{2}{3}$. The formula of inesite can then be written $5SiO_2 \cdot CaO \cdot 3\frac{2}{3}\ MnO \cdot 3\frac{1}{3}H_2O$ or $15SiO_2 \cdot 3CaO \cdot 11MnO \cdot 10\ H_2O$. A comparison between the average recalculated analysis (from Table 4) and the theoretical composition calculated from the above formula shows a close agreement, as shown in Table 7.

TABLE 7. COMPARISON OF AVERAGE RECALCULATED ANALYSIS WITH THE THEORETICAL COMPOSITION CALCULATED FROM THE FORMULA $15SiO_2 \cdot 3CaO \cdot 11MnO \cdot 10H_2O$

	Average Analysis	$15SiO_2 \cdot 3CaO \cdot 11MnO \cdot 10H_2O$	Difference
SiO_2	44.21	44.42	−0.21
MnO	38.54	38.42	+0.12
CaO	8.56	8.29	+0.27
H_2O	8.69	8.87	−0.18
	100.00	100.00	

The differences between the calculated percentages and the seven recalculated analyses (Table 4) are as follows (Table 8).

TABLE 8. DIFFERENCES BETWEEN THE SEVEN ANALYSES OF INESITE AND THE CALCULATED VALUES FOR THE FORMULA $15SiO_2 \cdot 3CaO \cdot 11MnO \cdot 10H_2O$

	1	2	3	4	5	6	7
SiO_2	−0.79	−0.42	−0.24	+0.33	−1.18	+0.23	+0.72
CaO	+0.05	−0.28	+1.21	−0.08	+0.45	−0.41	+0.93
MnO	+0.45	+1.06	+0.65	+0.44	−0.96	+0.46	−1.34
H_2O	+0.29	−0.36	−1.62	−0.69	+1.69	−0.28	−0.31

There is no consistent large discrepancy for any one constituent or for any one analysis. There are 14 negative differences and 14 positive differences. The discrepancies therefore are compensating and for the average analysis very small (Table 7).

It has not been possible to find a simple formula for inesite which agrees closely with the ratios derived from the seven analyses. If, however, in the average ratios (last column, Table 6), 0.28 H_2O be added to the 3.70 MnO, bringing it up to 3.98 or practically 4, the ratio of the remaining H_2O is 3.00, and the simple formula $5SiO_2 \cdot CaO \cdot 4MnO \cdot 3H_2O$ results. This formula requires 40.85 per cent of MnO, a value not reached in any analysis of inesite.

If a slight variability in the proportions of MnO and H_2O be assumed, and the general formula written as $5SiO_2 \cdot 1CaO \cdot 3MnO \cdot 3H_2O \cdot 1(Mn,H_2)O$, the following two simple formulas may be considered as representing the two extremes, between which all analyses of inesite would lie:

$$5SiO_2 \cdot 1CaO \cdot 3MnO \cdot 4H_2O$$
$$5SiO_2 \cdot 1CaO \cdot 4MnO \cdot 3H_2O$$

The percentage composition of these two formulas, compared with the average analysis, is shown in Table 9.

However, the general formula $5SiO_2 \cdot 1CaO \cdot 3MnO \cdot 3H_2O \cdot 1(Mn,H_2)O$ lacks complete definiteness and it seems unreasonable to express a formula with two variables (MnO and H_2O) when these same constituents are also given in the formula as constants. Hence the exact but more complex formula $15SiO_2 \cdot 3CaO \cdot 11MnO \cdot 10H_2O$ is to be preferred.

How the water functions in inesite is not known. The meager data as to H_2O- and H_2O+ are too variable and contradictory to be interpretable.[9] The H_2O- in the seven analyses varies from 2.13 to 4.54 per

[9] In at least one analysis (no. 3), the water was determined by loss on ignition. This method yields a wrong and too low a value, as shown by Farrington.

TABLE 9. COMPARISON OF AVERAGE RECALCULATED ANALYSIS WITH THE THEORETICAL VALUES FOR THE TWO FORMULAS $5SiO_2 \cdot 1CaO \cdot 4MnO \cdot 3H_2O$ AND $5SiO_2 \cdot 1CaO \cdot 3MnO \cdot 4H_2O$

	$5SiO_2 \cdot 1CaO \cdot 4MnO \cdot 3H_2O$	Average	$5SiO_2 \cdot 1CaO \cdot 3MnO \cdot 4H_2O$
SiO_2	43.29	44.21	46.86
CaO	8.08	8.56	8.75
MnO	40.85	38.54	33.17
H_2O	7.78	8.69	11.22
	100.00	100.00	100.00

cent. Farrington considers 5.99 per cent H_2O as water of crystallization as it was taken up again by the mineral on exposure to ordinary air. It seems doubtful though if any of the water given in the analyses of such a well crystallized mineral as inesite should be considered as unessential. Even if future work should yield a different ratio for H_2O from that here given, the complex formula $15SiO_2 \cdot 3CaO \cdot 11MnO \cdot 10H_2O$ cannot be reduced to a much simpler one as the ratio of CaO+MnO never equals that of SiO_2 but in all analyses is slightly lower.

Note. Since this paper was written, an abstract of a paper describing inesite from New Zealand has appeared.[10] The analysis gives 8.04 per cent CaO and 8.77 per cent H_2O, confirming the suggested constancy of the CaO content of inesite and agreeing closely with the calculated values of the complex formula.

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