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MONTICELLITE FROM SAN BERNARDINO COUNTY, CALIFORNIA, AND THE MONTICELLITE SERIES

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SUMMARY

Small grains of monticellite disseminated through a dolomite from the Dewey mine, Ivanpah Quadrangle, San Bernardino County, California, proved on analysis to be the purest of any described monticellite. The total percentage of other isomorphous bases, FeO and MnO, replacing the MgO, is less than 1.50. The indices of refraction, $\alpha=1.641$, $\beta=1.649$, $\gamma=1.655$ are likewise lower than those of any published measurements for the natural mineral.

The components of the isomorphous series $MgO \cdot CaO \cdot SiO_2$ (monticellite)-$FeO \cdot CaO \cdot SiO_2$-$MnO \cdot CaO \cdot SiO_2$ (glaucochroite) are discussed and their indices of refraction given as:

	α	β	γ	B	$2V$	Sign
$MgO \cdot CaO \cdot SiO_2$	1.641	1.646	1.652	.011	90°±	+?
$FeO \cdot CaO \cdot SiO_2$	1.696	1.734	1.743	.047	50°±	−
$MnO \cdot CaO \cdot SiO_2$	1.685	1.723	1.736	.051	61°	−

Their isomorphous mixtures in the monticellites from California (Dewey mine and Crestmore) and from Magnet Cove, Arkansas,

are calculated and comparisons made of the measured and calculated indices of refraction showing close agreement.

DESCRIPTION OF MINERAL

A sample of metamorphosed dolomite from the Dewey mine, Clark Mt. district, San Bernardino County, California, in the Ivanpah quadrangle, was collected by Dr. D. F. Hewett for study of its contained minerals.

According to Hewett, the Dewey mine lies about 1,000 feet southwest of the better known Copper World mine, which is about 6 miles east of Valley Wells on the Arrowhead highway. The Dewey mine includes two tunnels of which the longer, about 600 feet long, explores an area of Cambrian dolomite which is intruded by dikes and sills of gray fine-grained diorite. Near these sills the dolomite is locally altered to silicates and is thoroughly bleached. Monticellite forms round greenish, granular masses in white rather pure calcium carbonate. Black granular masses and small octahedra of spinel ($n=1.733$) and pink garnet ($n=1.736$ indicating grossularite) are common on the dump. In the lower tunnel, the 25 foot zone of carbonate rock overlying a sill of diorite shows considerable diopside, serpentine, deweylite, thaumasite and other ill-defined fine-grained silicates.

The specimen of dolomite studied contained disseminated small grains of monticellite and diopside and Hewett had recognized a narrow seam of thaumasite. A small quantity of the monticellite was separated from the rock by heavy solutions by Dr. C. S. Ross and its analysis is shown below in Table 1.

TABLE 1. ANALYSIS AND RATIOS OF MONTICELLITE FROM THE DEWEY MINE, SAN BERNARDINO COUNTY, CALIFORNIA

SiO_2	37.36	.62 or 1
MgO	24.90	
FeO	1.40	.64 or 1
MnO	0.04	
CaO	33.08	.59 or 1
H_2O-	0.04	
H_2O+	1.24	
Insoluble diopside	2.55	
	100.61	

The indices of refraction of the monticellite as measured, are somewhat lower than those usually given for this mineral and further study, with analysis, showed that this monticellite is the purest of any known occurrence, containing 96 per cent of $MgO \cdot CaO \cdot SiO_2$.

The ratios obtained from the small and not completely pure sample are close enough to a 1:1:1 ratio to show that the mineral is monticellite.

Optically, the mineral is biaxial, negative, $2V$ large (estimated 80°), with slight dispersion, $r>v$. The indices of refraction were measured independently by my colleagues, Dr. C. S. Ross and Miss J. J. Glass, with the following results[1] (Table 2).

TABLE 2. MEASURED INDICES OF REFRACTION OF MONTICELLITE FROM THE DEWEY MINE, CALIFORNIA

	α	β	γ	B
Ross	1.640	1.648	1.654	.014
Glass	1.641	1.649	1.655	.014
Schaller	1.642	1.649	1.655	.013
Average	1.641	1.649	1.655	.014

The purity of this monticellite means that the content of other isomorphous bases, as FeO and MnO, is a minimum and in harmony with this purity, the indices of refraction are lower than any determined on the natural mineral.

TABLE 3. TABULATION OF MEASURED INDICES OF REFRACTION OF MONTICELLITE, WITH OTHER DATA

No.	FeO	MnO	α	β	γ	B	$2V$	Sign
1	0	0	1.639	1.646	1.653	.014	80°–90°	+(?)
2	1.44	0.04	1.641	1.649	1.655	.014	80°±	−
3	....	....	1.640	1.651	1.662	.022	Very large	−
4	3.98	0.52	1.646	1.654	1.661	.015	78°	−
5	4.79	1.63	1.651	1.662	1.668	.017	75°	−
6	5.11	1.17	1.650	1.662	1.667	.017	......	−
7	....	....	1.652	.....	1.669	.017	Fairly large	−
8	....	....	1.653	.....	1.668	.015	......	..
9	....	....	1.66±	.....	1.68±	.02	......	..

[1] There is a striking similarity, except for sign, between the optical properties of this monticellite and the γ modification of calcium orthosilicate. Thus:

	α	β	γ	B	Sign	$2V$
Monticellite	1.641	1.649	1.655	.014	−	80°
γ-Ca_2SiO_4	1.642	1.645	1.654	.012	+	60°

The preceding tabulation (Table 3) of known measurements of indices of refraction of monticellite shows the variations. The percentages of FeO and MnO are those obtained after deduction of unessentials and recalculation of the analyses to 100 per cent.

References

No. 1. Artificial $MgO \cdot CaO \cdot SiO_2$. Ferguson, J. B., and Merwin, H. E., The ternary system CaO-MgO-SiO_2: *Am. Jour. Sci.*, 4th ser., vol. **48,** p. 92, 1919.

2. Present paper.

3. Mineral "A" associated with merwinite from Crestmore, California. Larsen, E. S., and Foshag, W. F., Merwinite, a new calcium magnesium orthosilicate from Crestmore, California: *Am. Mineral.*, vol. **6,** p. 144, 1921. Referred to monticellite by Bowen, N. L., Two corrections to mineral data: *Am. Mineral.*, vol. **7,** p. 66, 1922, and by Tilley (Reference no. 9). The birefringence as given is too high. More accurate values, giving a birefringence of 0.015,[2] are given for this mineral under no. 4.

4. Crestmore, California. Moehlman, R. S., and Gonyer, F. A., Monticellite from Crestmore, California: *Am. Mineral.*, vol. **19,** pp. 474–476, 1934. Slight corrections of the indices of refraction are given in *Am. Mineral.*, vol. **20,** p. 138, 1935.

5. Magnet, Cove, Arkansas. Determinations by Penfield and Forbes. Penfield, S. L., and Forbes, E. H., Fayalite from Rockport, Mass., and on the optical properties of the chrysolite-fayalite group and of monticellite: *Am. Jour. Sci.*, 4th ser., vol. **1,** pp. 134–135, 1896.

6. Magnet Cove, Arkansas. Measured by Miss Glass.

7. Osborne, G. D., On the occurrence of custerite and monticellite in metamorphosed limestone from the Carlingford District, County South, Ireland: *Geol. Mag.*, vol. **69,** p. 62, 1932.

8. Bowen, N. L., Genetic features of alnoitic rocks at Isle Cadieux, Quebec: *Am. Jour. Sci.*, 5th ser., vol. **3,** pp. 3–4, 1922.

9. Tilley, C. E., A monticellite-nepheline-basalt from Tasmania: a correction to mineral data: *Geol. Mag.*, vol. **65,** p. 30, 1928. This monticellite was first erroneously described as a calcium silicate and named shannonite.

THE $MgO \cdot CaO \cdot SiO_2$ (MONTICELLITE)-$FeO \cdot CaO \cdot SiO_2$-$MnO \cdot CaO \cdot SiO_2$ (GLAUCOCHROITE) SERIES

General Statement

The three analogous magnesium, iron, and manganese calcium orthosilicates, the first and third occurring as minerals—monticellite and glaucochroite—probably form a series of isomorphous mixtures, similar to the monoclinic pyroxene diopside-hedenbergite-johannsenite series or to the olivines. However, the only two

[2] The corrected values (see under no. 4 for reference) of the indices of refraction give $\alpha = 1.6463$ and $\gamma = 1.6605$; hence the correct birefringence is 0.0142. The indices, as given in this paper, are given only to three decimals and if the fourth decimal is 5 (or greater), the third decimal is increased by 1.

members occurring as minerals are rare, glaucochroite being exceedingly so. Consequently, no mineral containing these three components in large proportions has yet been found. Such mixtures occur though, not rarely, in artificial furnace slags.

In the following pages, a discussion is presented, aiming to give as accurately as possible the indices of refraction of the three components and then to discuss their intermediate isomorphous mixtures where these occur as minerals. This discussion, however, is brief as the isomorphous mixtures of which the chemical composition and the indices of refraction are known, are limited to the two monticellites from California (Dewey mine and Crestmore) and that from Magnet Cove, Arkansas.

The indices of refraction of pure $MgO \cdot CaO \cdot SiO_2$ are first calculated from the known data for these three occurrences of monticellite. This involves the indices for the analogous iron and manganese components and the derivation of these values is given after the discussion of those of the magnesium component. The values of the iron component have been determined on artificial material. Two analyses of glaucochroite, one containing a little MgO, are used for the calculation of the indices of refraction of the pure manganese component.

$MgO \cdot CaO \cdot SiO_2$ (Monticellite)

The indices of refraction for pure (artificial) $MgO \cdot CaO \cdot SiO_2$ generally accepted are: $\alpha = 1.639$ $\beta = 1.646$, $\gamma = 1.653$, $B = .014$, representing the average of the values given by Ferguson and Merwin,[3] who give a range for α from 1.638 to 1.640 and for γ from 1.651 1.655.

The monticellites from the Dewey mine, from Crestmore,[4] and from Magnet Cove, are so dominantly $MgO \cdot CaO \cdot SiO_2$ (at least 84 weight percentage), that the indices of refraction for pure $MgO \cdot CaO \cdot SiO_2$ can be calculated from the measured values, allowing for the small quantities of the analogous iron and manganese components, whose indices are known.

The results obtained are as follows (Table 4).

[3] Ferguson, J. B., and Merwin, H. E., The ternary system $CaO\text{-}MgO\text{-}SiO_2$: *Am. Jour. Sci.*, 4th ser., vol. **48**, p. 92, 1919.

[4] Moehlman, R. S., and Gonyer, F. A., Monticellite from Crestmore, California: *Am. Mineral.*, vol. **19**, pp. 474–476, 1934. Slight corrections of the indices of refraction are given in *Am. Mineral.*, vol. **20**, p. 138, 1935.

Table 4. Calculated Indices of Refraction of Pure $MgO \cdot CaO \cdot SiO_2$, as Obtained from the Data on Natural Monticellites

Mineral	Composition			Indices of refraction	
	$MgO \cdot CaO \cdot SiO_2$	$FeO \cdot CaO \cdot SiO_2$	$MnO \cdot CaO \cdot SiO_2$	Measured	Calculated for $MgO \cdot CaO \cdot SiO_2$
Dewey mine, California	96	4	0	$\alpha=1.641$ $\beta=1.649$ $\gamma=1.655$ $B=.014$	$\alpha=1.639$ $\beta=1.645$ $\gamma=1.651$ $B=.012$
Crestmore, California	88	$10\frac{1}{2}$	$1\frac{1}{2}$	$\alpha=1.646$ $\beta=1.654$ $\gamma=1.661$ $B=.015$	$\alpha=1.640$ $\beta=1.643$ $\gamma=1.649$ $B=.009$
Arkansas (Penfield and Forbes)	84	12	4	$\alpha=1.651$ $\beta=1.662$ $\gamma=1.668$ $B=.017$	$\alpha=1.643$ $\beta=1.649$ $\gamma=1.654$ $B=.011$
Arkansas (Miss Glass)	84	13	3	$\alpha=1.650$ $\beta=1.662$ $\gamma=1.667$ $B=.017$	$\alpha=1.642$ $\beta=1.649$ $\gamma=1.652$ $B=.010$

The average of the available data, summarized in Table 5, gives the values: $\alpha=1.641$, $\beta=1.646$, $\gamma=1.652$; $B=0.011$, which values are used in the discussion of the natural monticellites on the following pages.

Table 5. Indices of Refraction of $MgO \cdot CaO \cdot SiO_2$

	α	β	γ	B
Artificial	1.639	1.646	1.653	0.014
Calculated from measurements of monticellite from:				
Dewey mine	1.639	1.645	1.651	0.012
Crestmore	1.640	1.643	1.649	0.009
Arkansas (P. & F.)	1.643	1.649	1.654	0.011
Arkansas (G.)	1.642	1.649	1.652	0.010
Average	1.641	1.646	1.652	0.011

The average values given above are almost identical with the previously accepted values, determined on artificial material. They are believed to be slightly more accurate as the birefringence of pure $MgO \cdot CaO \cdot SiO_2$ (0.011) should be less than that found for the mineral from the Dewey mine (0.014) and from Crestmore (0.015). Both these minerals contain small quantities of the analagous iron component, $FeO \cdot CaO \cdot SiO_2$, whose birefringence (0.047) is strong and about four times that of $MgO \cdot CaO \cdot SiO_2$, so that the presence of a small quantity of $FeO \cdot CaO \cdot SiO_2$ in a monticellite rapidly increases the birefringence.

The calculated values of the indices of refraction for $MgO \cdot CaO \cdot SiO_2$ for the different occurrences (Table 4) show a greater variation than was expected; thus the maximum difference for α is 0.004, for β 0.006, and for γ 0.005. The birefringence however is consistently lower than 0.014, ranging from 0.009 to 0.012.

$FeO \cdot CaO \cdot SiO_2$

The indices of refraction for the artificial compound $FeO \cdot CaO \cdot SiO_2$ (not known as a mineral), are given by Bowen, Schairer, and Posnjak[5] as: $\alpha = 1.696$, $\beta = 1.734$, $\gamma = 1.743$, with $B = 0.047$. These values are close to the indices of glaucochroite, but slightly higher. They confirm the results found previously for the monoclinic pyroxenes hedenbergite and johannsenite, namely, that in analogous or isomorphous series, the indices of refraction of the iron component are slightly higher than those of the manganese component, but the birefringence is slightly less.

$MnO \cdot CaO \cdot SiO_2$ (Glaucochroite)

Only three analyses of glaucochroite have been published—the original one by Penfield and Warren,[6] a later one by Palache,[7] and a third analysis made by R. B. Gage and listed by Palache in his Franklin report.[8]

[5] Bowen, N. L., Schairer, J. F., and Posnjak, Eugene, The system, Ca_2SiO_4-Fe_2SiO_4: *Am. Jour. Sci.*, 5th ser., vol. **25**, pp. 287–288, 1933. Also, The system, CaO-FeO-SiO_2: *Am. Jour. Sci.*, 5th ser.,vol. **26**, p. 262, 1933. The value for β is calculated from α, γ, and $2V$.

[6] Penfield, S. L., and Warren, C. H., Some new minerals from the zinc mines at Franklin, New Jersey, and note concerning the chemical composition of ganomalite: *Am. Jour. Sci.*, 4th ser., vol. **8**, p. 339, 1899.

[7] Palache, Charles, Mineralogical notes on Franklin and Sterling Hill, New Jersey: *Am. Mineral.*, vol. **13**, pp. 307–308, 1928. Analysis by Dr. L. H. Bauer.

[8] Palache, Charles, The minerals of Franklin and Sterling Hill, Sussex County, New Jersey: *U. S. Geol. Survey*, Prof. Paper **180**, p. 79, 1935.

The indices of refraction given by Penfield and Warren are: $\alpha=1.686$, $\beta=1.722$, $\gamma=1.735$.[9] $2V=61°$. The only extraneous base given in the analysis is 1.74 per cent of PbO, the interpretation of which is difficult as the 38.00 per cent MnO reported already slightly exceeds the theoretical percentage of MnO (37.90) in glaucochroite. Nasonite is reported as an associated mineral and it would require only 2.6 per cent of nasonite to yield the 1.74 per cent of PbO reported. No MgO is reported in the analysis.

The indices of refraction given, therefore, probably represent those of pure glaucochroite.

The second reported analysis, by Bauer, as published by Palache, is given after 3.29 per cent willemite (based on the ZnO content) is deducted and the analysis recalculated to 100 per cent. In this form, the analysis still contains 0.32 per cent PbO and 0.98 per cent Al_2O_3. If these two bases are also deducted and the analysis recalculated to 100 per cent, the following composition is obtained (Table 6).

TABLE 6. RECALCULATED ANALYSIS OF GLAUCOCHROITE AFTER DEDUCTING IMPURITIES
[L. H. BAUER ANALYST]

SiO_2	32.34			
MnO	34.75			
FeO	0.11	Composition	$MnO\cdot CaO\cdot SiO_2$	91 per cent
MgO	2.34		$MgO\cdot CaO\cdot SiO_2$	9 per cent
CaO	30.46			100
	100.00			

The small percentage of MgO present is due to isomorphous $MgO\cdot CaO\cdot SiO_2$, and calculation shows that Bauer's recalculated analysis can be interpreted as representing an isomorphous mixture with 9 per cent of monticellite.

The indices of refraction of glaucochroite given by Larsen and Berman[10] on "Type material" probably were made on the material analyzed by Bauer, as the indices are very close to the less exact

[9] The two indices α and β determined by the prism method and γ calculated from α, β, and $2E$ (measured).

[10] Larsen, E. S., and Berman, Harry. The microscopic determination of the nonopaque minerals, 2d ed.: *U. S. Geol. Survey*, Bull. **848**, p. 191, 1934.

ones previously determined by Berman and published by Palache,[11] as the following comparison shows (Table 7):

TABLE 7. INDICES OF REFRACTION OF GLAUCOCHROITE ANALYZED BY L. H. BAUER

Larsen and Berman, 1934		Berman, 1928	
α	1.679	α	1.68
β	1.716	β	1.71
γ	1.729	γ	1.725
B	.050	B	.045

The indices of refraction for the pure compound $MnO \cdot CaO \cdot SiO_2$ calculate out as: $\alpha = 1.683$, $\beta = 1.723$, $\gamma = 1.736$, using the more exact determinations given by Larsen and Berman for a mineral composed of 91 per cent of $MnO \cdot CaO \cdot SiO_2$ and 9 per cent of $MgO \cdot CaO \cdot SiO_2$. These values are remarkably close to those given by Penfield and Warren and averaging them, the following values (Table 8) are obtained which are taken as representing the indices of refraction for pure glaucochroite.

TABLE 8. INDICES OF REFRACTION OF PURE GLAUCOCHROITE

	α	β	γ	B
Penfield and Warren	1.686	1.722	1.735	.049
Recalculated, based on Bauer's analysis	1.683	1.723	1.736	.053
Average	1.685	1.723	1.736	.051

The indices of refraction ($\alpha = 1.685$, $\beta = 1.7105$, $\gamma = 1.7205$, with $B = .0355$), given by Greer[12] for artificial glaucochroite do not agree closely with those just given. The value for α is identical but γ is low and the birefringence given by him is much too low.

ISOMORPHOUS MIXTURES OF THE THREE COMPONENTS

The calculated chemical composition and the optical properties of the three components, $MgO \cdot CaO \cdot SiO_2$, $FeO \cdot CaO \cdot SiO_2$, and $MnO \cdot CaO \cdot SiO_2$, are given in Table 9.

[11] Palache, Charles, Mineralogical notes on Franklin and Sterling Hill, New Jersey: *Am. Mineral.*, vol. **13**, p. 307, 1928.

[12] Greer, W. L. C., Mix-crystals of Ca_2SiO_4 and Mn_2SiO_4: *Am. Mineral.*, vol. **17**, p. 138, 1932.

TABLE 9. CALCULATED CHEMICAL COMPOSITION AND OPTICAL PROPERTIES OF COMPONENTS

	$MgO \cdot CaO \cdot SiO_2$	$FeO \cdot CaO \cdot SiO_2$	$MnO \cdot CaO \cdot SiO_2$
SiO_2	38.40	31.97	32.12
MgO	25.76	.....	.....
MnO	.....	.....	37.90
FeO	.....	38.19	.....
CaO	35.84	29.84	29.98
	100.00	100.00	100.00
α	1.641	1.696	1.685
β	1.646	1.734	1.723
γ	1.652	1.743	1.736
B	.011	.047	.051
$2V$	Nearly 90°	50°±2°	61°
Sign	+?[a]	−	−

[a] Natural monticellites are optically negative with $2V$ large.

The comparison of the measured and calculated indices of refraction for the monticellite from the Dewey mine, California, is shown in Table 10. In this and the following comparisons, the analyses have been recalculated to 100 per cent after deduction of unessential constituents. The composition is expressed by weight percentages of the components.

In the monticellite from Crestmore, California, described in de-

TABLE 10. COMPARISON OF MEASURED AND CALCULATED INDICES OF REFRACTION OF MONTICELLITE FROM THE DEWEY MINE, SAN BERNARDINO COUNTY, CALIFORNIA

SiO_2	38.60
MgO	25.73
FeO	1.44
MnO	0.04
CaO	34.19
	100.00

Composition $\begin{cases} MgO \cdot CaO \cdot SiO_2 \ldots & 96 \\ FeO \cdot CaO \cdot SiO_2 \ldots & 4 \end{cases}$ 100

Indices of refraction

Measured		Calculated	
α	1.641	α	1.643
β	1.649	β	1.650
γ	1.655	γ	1.656
B	.014	B	.013

tail by Moehlman and Gonyer,[13] the quantities of FeO and MnO, isomorphously replacing the MgO, are greater than those in the monticellite from the Dewey mine, but less than those in the mineral from Magnet Cove, Arkansas.

The calculated analysis, with component composition, and measured and calculated indices of refraction, are given in Table 11.

TABLE 11. COMPARISON OF MEASURED AND CALCULATED INDICES OF REFRACTION OF MONTICELLITE FROM CRESTMORE, CALIFORNIA

SiO_2	37.48	Composition	$MgO \cdot CaO \cdot SiO_2$		88
MgO	22.80		$FeO \cdot CaO \cdot SiO_2$		$10\frac{1}{2}$
FeO	3.98		$MnO \cdot CaO \cdot SiO_2$		$1\frac{1}{2}$
MnO	0.52				100
CaO	35.22				
	100.00				
		Indices of refraction			
		Measured		Calculated	
		α	1.646	α	1.647
		β	1.654	β	1.656
		γ	1.661	γ	1.663
		B	.015	B	.016

Three analyses of monticellite from Magnet Cove, Arkansas, are available, one by Genth,[14] one by Penfield and Forbes,[15] who also give $2V=75°$ (measured) and $2V=74°$ (calculated from the indices), and one by Himmelbauer as given by Tschermak.[16]

All three analyses are very similar (FeO=5.25, 4.75, 5.08; MnO=1.17, 1.62, 0.66) so that, after deduction of unessentials and recalculation to 100 per cent, the average analysis must represent closely the composition of this monticellite from Magnet Cove. This average composition is used for a comparison of the

[13] Moehlman, R. S., and Gonyer, F. A., Monticellite from Crestmore, California: *Am. Mineral.*, vol. **19**, pp. 474–476, 1934. Slight corrections of the indices of refraction, vol. **20**, p. 138, 1935.

[14] Genth, F. A., Contributions to mineralogy, No. 50 (with crystallographic notes by S. L. Penfield and L. V. Pirsson): *Am. Jour. Sci.*, 3d ser., vol. **41**, pp. 398–400, 1891.

[15] Penfield, S. L., and Forbes, E. H., Fayalite from Rockport, Mass., and on the optical properties of the chrysolite-fayalite group and of monticellite: *Am. Jour. Sci.*, 4th ser., vol. **1**, pp. 134–135, 1896.

[16] Tschermak, G., Metasilikate und Trisilikate: *Sitzungsber. math.-naturw. Kl., Akademie d. Wissenschaften*, Wien, vol. **115**, Abt. 1, p. 221, 1906.

indices of refraction measured by Miss J. J. Glass on a specimen of monticellite from Magnet Cove collected by Dr. C. S. Ross.

The comparisons of measured and calculated indices are shown below in Table 12.

TABLE 12. COMPARISON OF MEASURED AND CALCULATED INDICES OF REFRACTION OF MONTICELLITE FROM MAGNET COVE, ARKANSAS

	Penfield and Forbes		Average of three analyses	
SiO_2	37.13		36.33	
MgO	21.81		22.50	
FeO	4.79		5.11	
MnO	1.63		1.17	
CaO	34.64		34.89	
	100.00		100.00	
Composition $MgO \cdot CaO \cdot SiO_2$	84		84	
Composition $FeO \cdot CaO \cdot SiO_2$	12		13	
Composition $MnO \cdot CaO \cdot SiO_2$	4		3	
	100		100	
	Measured[a]	Calculated	Measured[b]	Calculated
α	1.651	1.650	1.650	1.649
β	1.662	1.660	1.662	1.660
γ	1.668	1.667	1.667	1.666
B	.017	.017	.017	.017

[a] Measured by Penfield and Forbes on material analyzed.
[b] Measure by Miss Glass on unanalyzed material collected by Dr. C. S. Ross.

The measured and calculated indices of refraction of these monticellites agree within 0.002 for all the comparisons. The close agreement between the birefringence as obtained from the measured and calculated indices confirms the suggestion earlier made that 0.014 is too high for pure $MgO \cdot CaO \cdot SiO_2$ and that 0.011 is more nearly correct.

ARTIFICIAL MONTICELLITE FROM FURNACE SLAGS

An attempt was made to interpret the data listed by Beliankin and Ivanov[17] for various artificial monticellites from furnace slags.

[17] Beliankin, D., and Ivanov, B., The system of monticellite: *Am. Jour. Sci.*, 5th ser., vol. **22**, pp. 72–80, 1931.

The results were very unsatisfactory, a condition the authors themselves acknowledge, as they call attention to the small number (2 out of 7 if the monticellite from Arkansas and glaucochroite from New Jersey be omitted) in which the ratio of $MgO+FeO+MnO$ to CaO is approximately 1:1. Furnace slags are apt to be very impure in composition and the analyses listed suggest the possibility that in this series, CaO-free compounds, such as $FeO \cdot FeO \cdot SiO_2$, may enter as components into these monticellite-like slags. The presence of such compounds in natural minerals of this series is not indicated by their analyses, though their number is far too small to draw a general conclusion.

For the slag from the Ural Mountains, described by Beliankin and Ivanov,[18] the percentage of CaO (28.41 as given in the analysis or 30.56 in the recalculated analysis) is too low for an isomorphous mixture of the three components $MgO \cdot CaO \cdot SiO_2$, $MnO \cdot CaO \cdot SiO_2$, $FeO \cdot CaO \cdot SiO_2$, whose content of CaO ranges from 29.84 per cent to 35.84 per cent

Their material consists of 51 per cent of $MgO \cdot CaO \cdot SiO_2$, 21 per cent of $FeO \cdot CaO \cdot SiO_2$, and 28 per cent of $MnO \cdot CaO \cdot SiO_2$, if calculated out on the assumption that only components of the $RO \cdot CaO \cdot SiO_2$ type are present. On this basis, α is calculated as 1.665, agreeing well with their measured value (1.666), but γ calculates out as 1.695 whereas they give the much lower value $\gamma = 1.682$. The birefringence should be nearly twice as great as the value 0.016 obtained from their measured indices of refraction.

[18] *Op. cit.*, pp. 77–80.