CONTRIBUTIONS TO THE MINERALOGY OF NORWAY

No. 22. Vesuvianite from Kristiansand, other Occurrences in Norway, the General Formula of Vesuvianite.

By

TOM. F. W. BARTH

To Professor Ivar Oftedal with kindest regards and congratulations on the occasion of his 70th birthday.

I

(1) From Eg at Kristiansand vesuvianites in rather large crystals, 7—10 cm long, are represented in the collections of various museums in Europe and elsewhere.* The crystals occurred in skarn rocks forming reaction rims around small layers of limestone in the Precambrian granitized migmatite of the Kristiansand area. See BARTH (1928), FALKUM (1963). The limestone used to be quarried for local consumption, but by the end of the last century operations in the quarries ceased completely, and it was no more possible to find even traces of vesuvianite. But in 1960 T. Falkum found a piece of vesuvianite sitting in a lose block evidently coming from a small, old quarry now mostly buried by the construction of a road just west of Eg.

(2) In Kongsgårdskogen, a forest north of Vollevann, about 5 km east of Eg a few cart-loads of garnet rocks were blasted in 1918 for abrasive material of which there was a shortage during the war. At this place BARTH (1928) found a rather large mass of vesuvianite

* VON ZEPHAROVICH (1864, p. 120) writes that around 1820 "brachte der Kopenhagener Mineralienhändler Nepperschmidt die anfänglich von Epidot gehaltenen Krystalle nach Deutschland, wo sie alsbald durch ihre ungewöhnliche Grösse und ausgezeichnet schalige Textur die Aufmerksamkeit der Mineralogen auf sich lenkten".

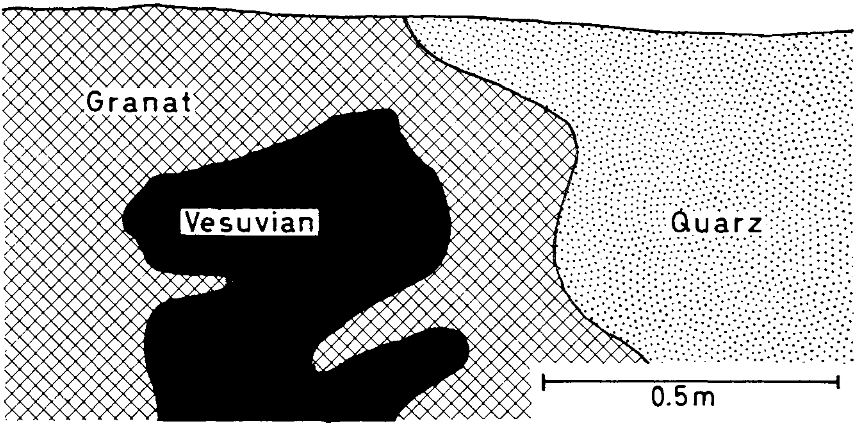

Fig. 1. Rock wall with vesuvianite and garnet in the small quarry as it looked before 1928. Kongsgårdskogen. From Barth 1928.

surrounded by the garnet rock; see Fig. 1. But today houses have been built in the forest, and gardens have been constructed; the occurrence has either been buried, or it can no longer be exactly located.

KEILHAU (1840) quotes a manuscript by Esmark from 1818 giving the first description of the occurrences in the vicinity of Kristiansand. Keilhau concludes by saying that there is very little vesuvianite left. Excerpt p. 339: "Dersom ikke nye Anbrud aabnes ved minering, saa er dette berømte Findested for Idokrasen, der herfra haves i alle Landes Mineral-Samlinger, nu at ansee næsten som udtømt." SCHEERER (1843) mentions vesuvianite "besonders bei den Höfen Eeg und Eie". Kongsgårdskogen extends from Vollevann to Eie, so it is possible that the place found by me in 1928 is part of the Eie occurrences which, since Scheerer's time, fell into oblivion.

Crystals of vesuvianite from Eg were first described by WEISS (1829); his results are incorporated in VON ZEPHAROVICH's paper (1864). Forms measured were: *c* (001), *m* (110), *f* (210), *a* (100), *p* (111), *t* (331), *o* (101), *i* (312), the crystals are long or short prismatic with prominent base (001) and prisms. The color is dark greenish brown to caledonian brown.

The material from Eg in the collections of the Mineralogical Museum of the University in Oslo corresponds to this description. The crystals are prismatic and, if not broken, always terminated by (001),

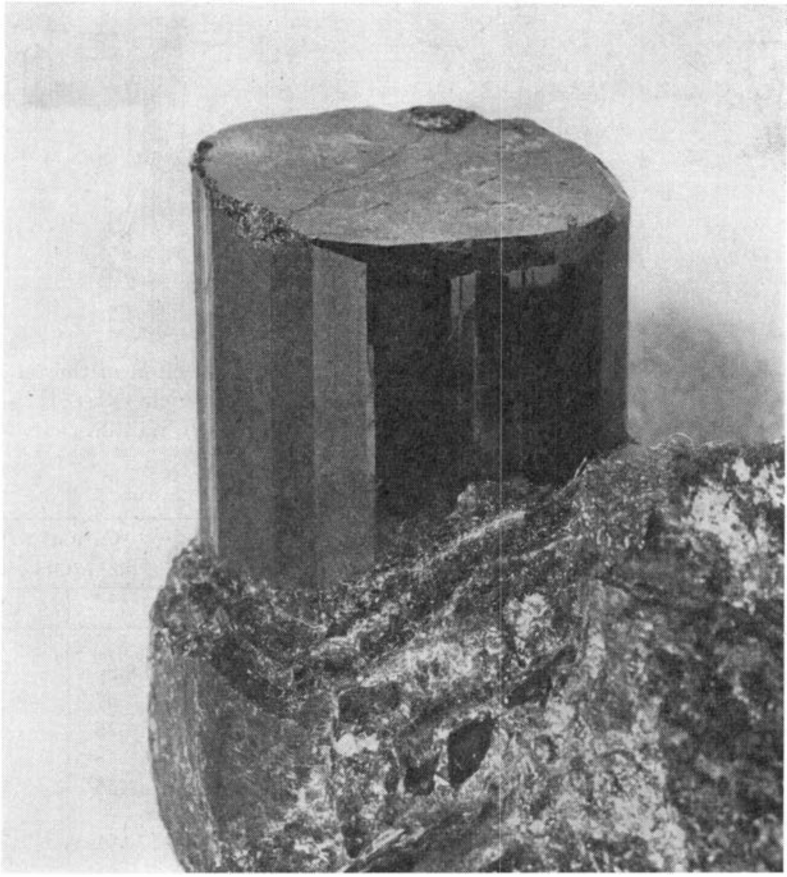

Fig. 2. Vesuvianite from Eg. The crystal is 3 cm high.

other terminating faces are very rare. See Figs. 2 and 3. Many crystals display a great number of prism faces (hk0), passing into vicinals making the crystals almost cylindrical in shape. The material from Kongsgårdskogen has only yielded broken crystals, but prisms up to 20 cm long were observed.

Crystals from Eg and Kongsgårdskogen give x-ray powder patterns that are identical in all observable details; the lattice spacings are similar to those of other Norwegian vesuvianites from crystalline limestone, but slightly larger than those of the cyprines from Telemark and of the vesuvianite from Seiland to be described later. But no exact

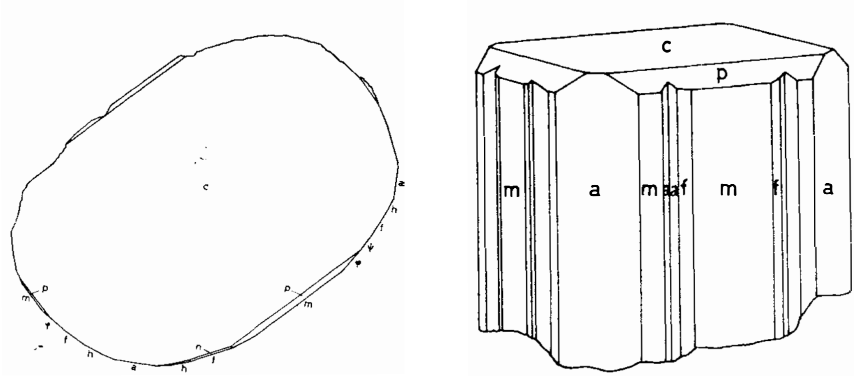

Fig. 3. Vesuvianite from Eg. Left: Crystal from the collection of the Mineralogiske Museum, Oslo. Right: Drawing of von Zepharovich (1864). c (001), p (111), a (100), φ (530), ψ (740), f (210), h (310), n (212).

Table 1. Vesuvianites from the Kristiansand area.

	Weight per cent			Cations to 38 O,(OH), F	
	1	2		1	2
SiO_2	36.68	36.10	Si	8.89	8.80
TiO_2	0.41	0.84	Ti	.07	0.14
Al_2O_3	16.70	16.42	Al	4.75	4.70
Fe_2O_3	2.62	2.52	Fe‴	.48	.45
FeO	2.76	3.27	Fe″	.55	66
MnO	trace	0.34	Mn	—	6
MgO	2.51	2.21	Mg	.91	80
CaO	34.97	34.78	Ca	9.05	9.07
Na_2O	1.18	0.51	Na } K	.64	23
K_2O	0.25	0.02			
H_2O+	1.15	1.30	Σ cations	25.34	24.91
F	1.32	2.45	(OH)	1.82	1.60*
	100.55	100.76	(F)	1.02	1.87
— O	.56	1.03	O	35.16	34.57
	99.99	99.73	Σ Anions	38.00	38.04

* 0.30 % H_2O is taken as hygroscopic and not included in the formula.

1. Eg: $\left[(Ca, Na)_{9.7}\ (Mg, Al, etc)_{6.6}\right]_{16.3}\ Si_{8.9}\left[O_{35.2}(OH)_{1.8}\ F_{1.0}\right]_{38.0}$

2. Kgs: $\left[(Ca, Na)_{9.4}\ (Mg, Al, etc)_{6.6}\right]_{16.0}\ Si_{9.0}\left[O_{34.6}(OH)_{1.6}\ F_{1.8}\right]_{33.0}$

1. Vesuvianite from Eg, Vogel (1887).
2. Vesuvianite from Kongsgårdskogen, analyst B. Bruun.

Fig. 4. Vesuvianite (V) in contact with garnet (G), epidote (E), and quartz (Q). Kongsgårdskogen. Diameter = 7 mm.

measurements were made. The analysed material from Kongsgårdskogen is optically homogeneous uniaxial (or slightly anomalously biaxial) negative, $\omega = 1.711$, $\varepsilon = 1.708$. A vesuvianite crystal from Eg gave $\omega = 1.722$, $\varepsilon = 1.720$.

Analyses of vesuvianite from Eg were first published by RAMMELSBERG (1855). But the first complete analysis comes from VOGEL (1887). The Eg crystals have not been reanalysed, but a new analysis was made for this paper of vesuvianite from Kongsgårdskogen. See Table 1.

The analyses are similar to other analyses of vesuvianite, and correspond fairly well to the formula

$$X_{10-u}\, Y_{6+u}\, Z_9\, (O, OH, F)_{38}, \text{ where } u \lesseqgtr 1.$$

For discussion of this formula, see p. 468.

The mineral associations. Under the microscope some of the larger crystals of vesuvianite show numerous, irregular intergrowths of epidote, garnet, quartz, and corroded grains of calcite. In places the inclusions are so numerous that the mineral assemblage almost be-

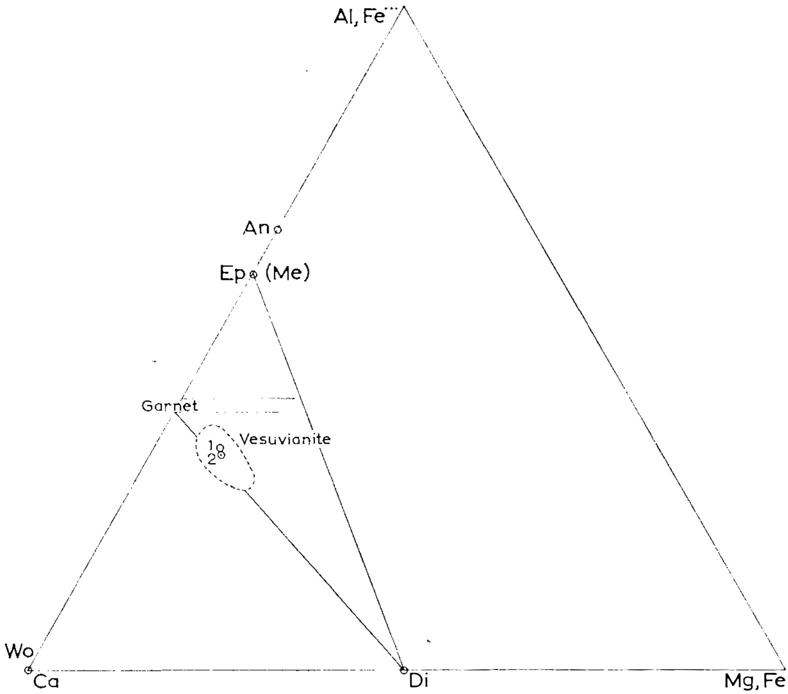

Fig. 5. A'CF diagram illustrating the chemical relations of vesuvianite. 1 and 2 are analyses of vesuvianite coexisting with epidote and garnet from Kristiansand (Table 1). Both vesuvianite and epidote contain ferric iron and hydroxyl: they are effectively separated chemically by the field of garnet (grossularite-andradite series), the association is, therefore, probably unstable.

comes a pseudomorph after vesuvianite. SILLEM (1852) described a pseudomorph of garnet and scapolite after vesuvianite from Eg.

The association of vesuvianite with both epidote and garnet is rare. VON ECKERMANN (1923) in his discussion of skarn parageneses concluded that vesuvianite and epidote are thermally separated by garnet. Again vesuvianite and epidote are also chemically separated by garnet, as can be seen from Fig. 5. This indicates that vesuvianite is an early mineral that was succeeded by epidote. It should be added, however, that the microscopic textures give no clear evidence that vesuvianite has become unstable in the skarns at Kristiansand, see Fig. 4.

For further discussion of the paragenesis vesuvianite — epidote, see paper by Chatterjee (1962).

In the Precambrian of Southern Norway vesuvianites of the same mode of formation as at Kristiansand have been observed at various other places.

(3) Around Arendal there are a number of old mines and quarries in lenses and bands of crystalline limestone in the migmatite. In some of these quarries vesuvianite was found (LEONHARD 1841) together with diopside, garnet (but no epidote). It is said to grow in shells often with altered and corroded rims around a fresh core. That vesuvianite must be a very rare mineral at Arendal emerges from the fact that BUGGE (1943) who made a careful study of the area found crystals of vesuvianite only at an old mine in skarn rocks at Nøddebro, about 8 kilometers northwest of Arendal. This vesuvianite occurs with calcite, diopside, garnet; the color is redish brown; the indices of refraction are about 1.705; it is biaxial positive. VOGEL (1887) analysed large brown crystals labelled Arendal, showing the base (001) and prisms — the habit is similar to the crystals at Kristiansand. WIDMAN (1890) analysed "kolophonit" from Arendal and wrote (in translation): "that the investigated colophonite is truly vesuvianite and not garnet is apparent from the analysis and from the fact that a thin section by optical examination proved to be birefringent". Widman's analysis shows no fluorine, but 1.96 % B_2O_3. It is not included in Table 3. No subsequent study of the Arendal vesuvianite has been made.

(4) At Graslen in Froland and

(5) at Vegårdshei near Risør vesuvianites belonging to the same (Arendal—Bamble) metamorphic complex have been found, and are in the collections of Mineralogisk Museum, Oslo.

II

Vesuvianite also occurs in regional metamorphic rocks of younger age. In the crystalline schists of the Caledonian fold mountains it has been observed at:

(6) Røstøy between Hitra and Heim (RAMBERG 1943) in a quartzitic band of a metasedimentary complex of gneiss, calc-silicate schists, and marble. Diopside and epidote (but no garnet) are typically present. Vesuvianite has grown with the c axis perpendicular to the foliation of the quartzite; cleavages in the prism zone are common. It is colorless to pale green, uniaxial positive, $\omega = 1.702$, $\varepsilon = 1.707$.

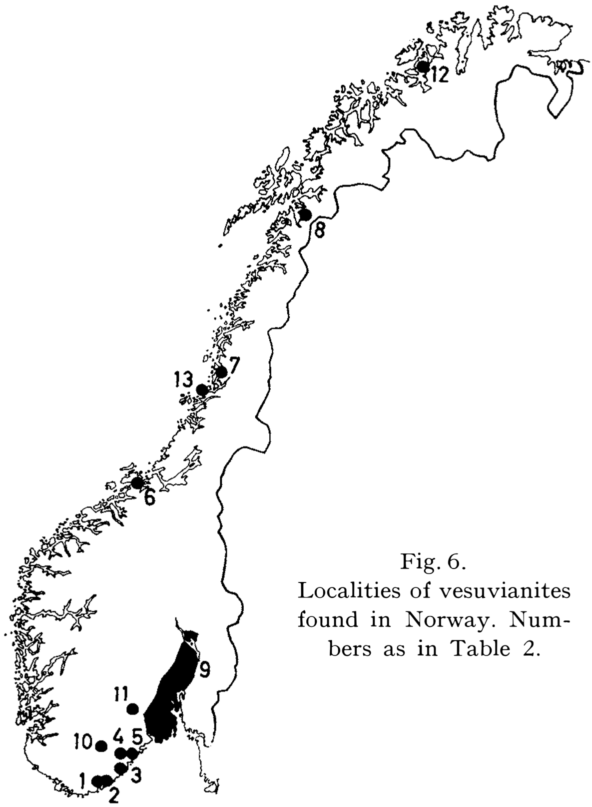

Fig. 6.
Localities of vesuvianites found in Norway. Numbers as in Table 2.

(7) Børjeøra in Velfjord (Min. Mus. No. 14101) on the contact of limestone and gneiss-granite in skarn rocks consisting mainly of diopside, epidote, and calcite with some sphene (but no garnet). The vesuvianite shows distinct cleavages after (110), it is optically homogeneous, but in places slightly biaxial, negative. The color is raisin to cocoa brown.

(8) ? Veten, Tysfjord. Specimens of skarn rocks from a limestone horizon were collected by J. Rekstad in 1916 and labelled vesuvianite. However, x-ray and optical study of the rocks failed to identify vesuvianite. The skarns consist of calcite, quartz, garnet, diopside, and epidote. The epidote exhibits variable optical properties, there are grains with a very small optical axis, almost uniaxial, negative. They may have been taken for vesuvianite.

Table 2. Vesuvianite Occurrences in Norway. (See Fig. 6).

Geologic Relations	No.	Location	Encasing Rocks
I Precambrian regional metamorphism	1 2 3 4 5	Eg, Kristiansand Kongsgårdskogen Arendal Froland, Aust Agder Risør, Aust Agder	Crystalline limestones and skarns
II Caledonian regional metamorphism	6 7 8?	Røstøy, S. Trøndelag Børjeøra, Nordland Tysfjord, Nordland	Crystalline limestones and skarns
III Permian contact metamorphism	9	Many localities in the Oslo area	Hornfelses and skarns
IV Precambrian hydrothermal veins	10 11	Straumsheia, Setesdal Sauland, Telemark	Quartz veins and impregnations
V Caledonian pegmatites and igneous rocks	12 13	Seiland, Finnmark Hortavær, Nordland	Pegmatite Gabbro

III

Vesuvianites at magmatic contacts constitute the best known occurrences in Norway.

(9) In the hornfelses of the Oslo area (V. M. Goldschmidt 1911) vesuvianite is found in various places, e.g. Hørtekollen (with helvite, etc.), Konnerudkollen, Oslo (Slaktern, Slemdal, Vettakollen, Rodeløkka). Goldschmidt has investigated "eine ungemein grosse Anzahl von Hornfelsen der Klasse 10 ... deren Tonerden ... in Vesuvian gebunden sind." The intruding magmas were mostly of nordmarkitic-ekeritic composition, often rich in volatiles and capable of transforming large volumes of limestone into reaction skarn. Nothing new can be added to Goldschmidt's descriptions. An analysis of vesuvianite from Hamrefjell, Eker, is listed in Table 3.

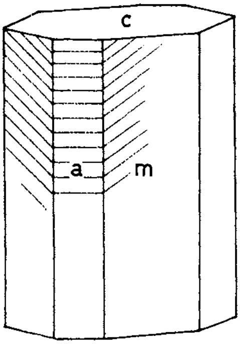

Fig. 7. Cyprine from Sauland, 9 mm high, 2 mm broad with diagonal lines on (110) and horizontal lines on (100). After von Zepharovich.

IV

Vesuvianites of hydrothermal-pegmatitic relations are found in two places in Norway. In both places it is the blue variety cyprine.

(10) Straumsheia (formerly known as Strømsheien) in Setesdal (NEUMANN 1956). Deposits of chalcosite with small amounts of bornite have been known for about 300 years. Intermittent mining was conducted until 1850. From this general area cyprine was sampled and brought to the Mineralogical Museum in Oslo. But the exact locality is lost, and in the last one hundred years no new material has been found. The museum samples show cyprine, quartz, hornblende, and much purple fluorite as veins in a gneissic rock. The cyprine is greenish blue, uniaxial negative, $\omega = 1.700 \pm 0.002$.

(11) Sauland in Telemark (NEUMANN and SVINNDAL 1955). In the immediate environment of the farm Øvstebø, six localities of cyprine have been mapped and described by Neumann and Svinndal. In five places cyprine occurs in quartz veins and lenses in amphibolite or quartz porphyry; in one place it is found in cavities in amphibolite close to the contact with quartz porphyry.

Cyprine is commonly associated with thulite, epidote grossularite, quartz, calcite, fluorite. It is well crystallized but easily broken, good crystals are difficult to obtain. The specific gravity (analysed material) is 3.421. The color is deep sky blue with variations in greenish blue to bluish green. It is uniaxial negative, $\omega = 1.705$, $\varepsilon = 1.697$ (for sodium light). The name cyprine was given to the Sauland vesuvianite by BERZELIUS (1820) in allusion to its blue color. He found the presence of copper by blowpipe analysis, and ascribed the blue color to the presence of that element.

The paragenesis represents a non-equilibrium: In addition to quartz the following five chemical constituents give rise to eight mineral constituents.

Chemical constituents	*Mineral constituents*
CaO MgO Al_2O_3 H_2O F	Thulite, epidote, grossularite, cyprine, diopside, tremolite, fluorite

The curious coexistence of zoisite and clinozoisite (thulite and epidote) was noted by Brøgger (1879). The paragenetic problem is somewhat similar to that of vesuvianite-epidote-garnet at Kristiansand, discussed on p. 462.

Chemical analyses of two cyprines are listed in Table 3.

V

Vesuvianites of igneous relations are also found in Norway.

(12) Seiland near Hammerfest (Barth 1927). Nepheline syenite-pegmatites of various kinds are known from the Seiland province. Vesuvianite was found in a canadite pegmatite in contact with scapolite and albite. The specific gravity is 3.435. The color is deep brown; in thin sections it shows a faint pleochroism ω = pinkish white, ε = light gray yellow. It is uniaxial negative $\omega = 1.722$, $\varepsilon = 1.718$ (in day light).

A chemical analysis is entered in Table 3.

(13) Hortavær, Nordland (Vogt 1915).

Hortite is an intrusive calcite-bearing mela-gabbro of hypidiomorphic-granular texture carrying a small amount of clear, anhedral vesuvianite in the interstices between the other mineral grains. The vesuvianite shows inclusions of pyroxene and apatite; the color is henna brown, it is optically uniaxial negative with $\omega - \varepsilon = 0.006$, and $\omega \leq 1.740$.

Two varieties of vesuvianite are found in Norway. Nos. 3 (from Nøddebro at Arendal) and 6 (from Røstøy) are said to be optically positive, thus corresponding to the variety called wiluite. Among the optically negative, varieties the copper-bearing cyprine has been found at two localities (No. 10, Straumsheia, Setesdal, and No. 11, Sauland, Telemark).

Chemical analyses of Norwegian vesuvianites are listed in Table 3.

Vesuvianites are chemically similar to certain garnets, as discussed on p. 462. McConnell (1939) demonstrated this by a diagram redrawn in Fig. 8. Additional data were supplied by Inoue and Miyashiro (1951). The Norwegian vesuvianite analyses are plotted onto this diagram. It is worthy of note that the igneous vesuvianite from Seiland plots close to other igneous vesuvianites, whereas all metamorphic vesuvianites plot inside a field of slightly higher contents of bivalent ions.

For vesuvianite the following general formula is here proposed:

$$X_{10-u}\, Y_{6+u}\, Z_9\, (O, OH, F)_{38}, \text{ where u} \lesssim 1.$$

Warren and Modell (1931) determined the crystal structure of vesuvianite. The dimensions of the tetragonal unit cell are $a_0 = 15{,}5$. $c_0 = 11.8$ Å; it contains four formula units corresponding to 152 oxygens (including F).

On each of the two fourfold axes of the unit cell there are two Ca ions together occupying a fourfold set of positions. Machatschki (1932) pointed out that the volume relation is such that not only Ca but also Mg, etc. might enter into this set of positions. Consequently, in the ideal formula of Warren and Modell (representing 1/4 of the unit cell) there is one Ca which may be partly replaced by Mg, etc. In order to illustrate this Machatschki doubled the formula. But it is simpler to say that Mg and Ca may replace each other diadochically over this set of positions. Again; the chemical analyses indicate that the positions assigned by Warren and Modell to Mg and Al individually, actually are interchangeable. Thus the relations between Warren and Modell's formula, and Machatschki's formula can be expressed as follows:

Warren and Modell:	Ca_9 (Ca)	Mg_2Al_4	Si_9	O_{34} $(OH, F)_4$
Machatschki:	Ca_9 (Ca, Mg)	$(Mg, Al)_6$	Si_9	$(O, OH, F)_{38}$

By using the customary symbols Machatschki's formula is conveniently presented in the following form:

$$X_{10-u}\, Y_{6+u}\, Z_9\, (O, OH, F)_{38}, \text{ with u} \lesssim 1,$$

Table 3. Chemical Analyses of Norwegian Vesuvianites.

	Kristiansand		Arendal	Oslo	Telemark		Seiland
	1	2	3	9	11a	11b	12
SiO_2	36.68	36.10	36.81	36.99	37.90	36.9	35.0
TiO_2	0.41	0.84	0.28	0.89	0.26	0.4	3.1
Al_2O_3	16.70	16.42	16.25	15.43	19.47	18.9	16.7
Fe_2O_3	2.62	2.52	3.92	3.46	0.40	1.1	4.4
FeO	2.76	3.27	2.21	1.51	0.21		—
MnO	trace	0.34	0.14	Spuren	0.91	0.6	—
MgO	2.51	2.21	2.72	3.04	2.17	2.2	1.85
CaO	34.97	34.78	35.49	35.81	36.06	35.8	34.44
Na_2O	1.18	0.51	0.52	0.81	0.14	0.2	—
K_2O	0.25	0.02	0.16	0.18	0.11	0.01	—
H_2O^+	1.15	1.00	0.98	0.87	0.67	1.41	—
F	1.32	2.45	1.36	1.35	1.72	1.5	—
Sum	100.55	100.76	100.84	100.34	100.75*	100.15**	95.49
— O	.56	1.03			0.72	0.6	
Sum	99.99	99.73			100.03	99.5	

Cations to 38 (O, OH, F)

	1x	2x	3		9		11a		11b		12
Si	9.00	9.00	8.92	9.00	8.97	9.00	9.05	9.05	8.81	9.00	8.7
Be			—		—		—		.17		—
Al			4.64		4.41		5.46		5.31		4.9
Fe			.71		.63		.07		.20		0.8
Cu			—		—		.13		.14		—
Ti	6.65	6.65	.04	6.73	.16	6.57	.04	6.51	.07	6.47	0.6
Fe			.45		.31		.04		—		—
Mg			.97		1.09		.77		.77		0.7
Mn			.03		—		.19		—		—
Ca	9.69	9.36	9.21	9.52	9.30	9.74	9.22	9.50	9.14	9.23	9.2
Na, K			.28		.44		.09		.09		—
O			35.35		35.54		35.65		34.63		
OH	38.00	38.00	1.57	38.00	1.42	38.00	1.06	38.00	2.24	38.00	
F			1.05		1.04		1.29		1.13		

* Includes CuO = 0.73 %.
** Includes CuO = 0.8, BeO = 0.3. H_2O^- = 0.03%.
x For further details, see Table 1.

1. Eg. Vogel, 1887.
2. Kongsgårdskogen. This paper.
3. Arendal. Vogel, 1887.
9. Hamrefjell, Eker, Oslo Area. Vogel, 1887.

11a. Sauland. Lindstrøm, 1888.
11b. Sauland. Neumann and Svinndal, 1955.
12. Seiland. Barth, 1927.

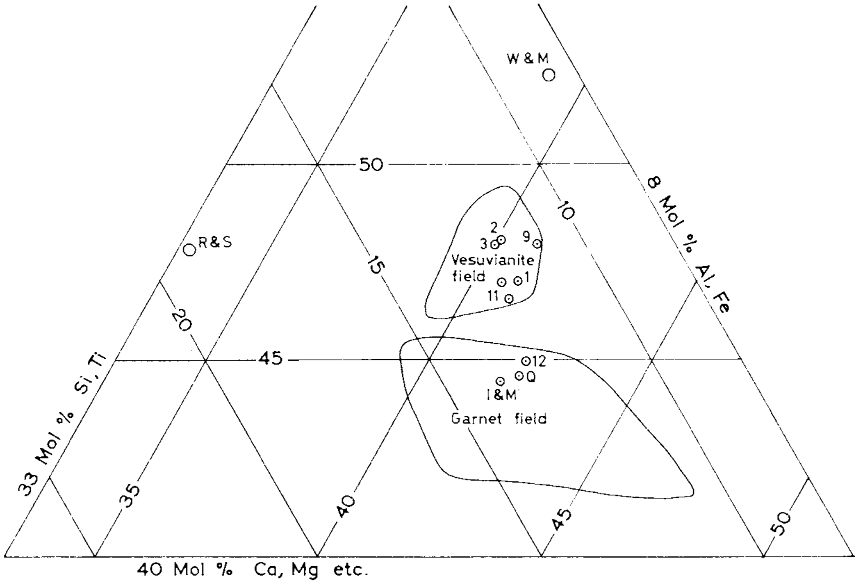

Fig. 8. McConnell diagram representing the chemical constituents of vesuvianite and lime garnets. Plots of Norwegian vesuvianites are marked by numbers as in Table 3. W & M = Formula of Warren and Modell, R & S = Synthetic vesuvianite of Rapp and Smith. All known analyses of igneous vesuvianites plot within the garnet field: 12 Seiland, Norway; Q Almunge, Sweden (Quensel 1915); I & M Furushinzan, Korea (Inoue and Miyashira 1951). All other vesuvianites lie outside the garnet field.

where X = Ca, Mn, Na, K; Y = Mg, Fe, Ti, Al, (Cu); Z is mostly Si with small amounts of Al.

The Machatschki formula fits the analytical results better than any other formula thus far proposed. An interesting synthesis by Rapp and Smith (1958) of vesuvianite of the formula $Ca_{10}Al_6(Al_2Si_7)\,O_{34}(OH)_4$ shows that Al may occupy all the Mg sites of the ideal formula of Warren and Modell; it also shows that Si to a large degree can be replaced by Al. It is obvious that vesuvianite is able to accomodate ions of various sizes and in various mutual proportions. But in natural vesuvianite the exchange possibilities seem to be more restricted, for vesuvianites from very different natural environments exhibit surprisingly small chemical variations.

N. G. U. = Norges Geol. Undersøkelse.
N. G. T. = Norsk Geol. Tidsskrift.

REFERENCES

BARTH, T. F. W. (1927). Die Pegmatitgänge der kaledonischen Intrusivgesteine im Seiland-Gebiete. Vid. Akad. Skr. Oslo, I, No. 8.

— (1928). Kak- und Skarngesteine im Urgebirge bei Kristiansand. Neues Jahrb. f. Min., BBd *57*, Abt. A, 1069.

BERZELIUS, J. (1820). Om blåsrörets användande i kemin och mineralogin. (Stockholm).

BRØGGER, W. C. (1879). Untersuchungen norwegischer Mineralien II. Zeit. Krist., *3*, 471.

BUGGE, J. A. W. (1940). Geological and petrographical investigations in the Arendal district. N. G. T. *20*.

CHATTERJEE, N. D.[1] (1962). Vesuvianite-epidote paragenesis as a product of greenschist facies of regional metamorphism in the Western Alps. Beitr. Min. Petr., *8*, 432.

ECKERMANN, H. VON (1923). The rocks and contact minerals of Tenberg. Geol. Før. Førh. *45*, 501.

FALKUM, T. (1963). Thesis, University of Oslo.

GOLDSCHMIDT, V. M. (1911). Die Kontaktmetamorphose im Kristiania-gebiet. Vid. Akad. Skr. Oslo I, No. 1.

INOUE, T. and MIYASHIRO, A. (1951). Occurrence of vesuvianite in nepheline syenitic rocks of the Fukushinzan district Korea; with general consideration of the relation between the composition and occurrence of vesuvianite. Jour. Geol. Soc. Japan, *57*, No. 665.

KEILHAU, B. M. (1840). Reise i Lister- og Mandals- Amt. Nyt Mag. Naturv. *2*, 331.

LEONARD, G. (1841). Briefwechsel. Neues Jahrb. f. Min., Jahrg. 1841, 75.

LINDSTRÖM, G. (1888). Tvenne idokrasanalyser. Geol. För. Förh., *10*, 286.

MACHATSCHKI, F. (1930). Die Summenformel des Vesuvians und seine Beziehung zum Granat. Centralbl. f. Min. Abt. A, No. 7, 284.

— (1932). Zur Formel des Vesuvians. Zeitschr. Krist. *81*, 148.

MCCONNELL, D. (1939). Note on the chemical similarity of idocrase and certain garnets. Amer. Min. *24*, 62.

NEUMANN, H. (1956). Kobberforekomstene på Straumsheia. N. G. U., *191*, 18.

NEUMANN, H., and SVINNDAL, S. (1955). The cyprine-thulite deposit at Øvstebø near Kleppan in Sauland, Telemark. N. G. T., *34*, 139.

QUENSEL, P. (1915). Vesuvian und Hastingsit aus dem Nephelinsyenit von Almunge. Cbl. Min., 201.

RAMBERG, H. (1943). En undersøkelse av Vestrandens regionalmetamorphe bergarter (with English summary). N. G. T., *23*, 34.

[1] See also the newly published paper by Braitsch, O., und N. Deb Chatterjee (1963), Metamorphe Mineralreaktionen in vesuvianführenden Paragenesen. Beitr. Min. Petr., *9*, 353.

RAMMELSBERG, C. F. (1855). Ueber die chemische Zusammensetzung des Vesuvians. Pogg. Ann. *94,* 92.

RAPP, G., and SMITH, J. V. (1958). Synthesis of Idocrase. Amer. Geol. Soc. Bull., *69,* 1741 (Abstract).

SCHEERER, TH. (1843). Geognostisch-mineralogische Skizzen, gesammelt auf einer Reise an der Süd-Küste Norwegens. Neues Jahrb. Min. (Jahrg. 1843). Nyt Mag. Naturv. *4,* 158.

SILLEM, Professor (1852). Bericht über eine Sammlung von Pseudomorphosen. Neues Jahrb. f. Min. (Jahrg. 1852).

VOGEL, H. (1887). Über die chemische Zusammensetzung des Vesuvian. Inaug. Diss. Univ. Göttingen (Abstract). Zeit. Krist. *17,* 1890, 216.

VOGT, T. (1915). Petrographisch-chemische Studien an einigen Assimilations-Gesteinen der norwegischen Gebirgskette. Vid. Akad. Skr. Oslo I, No. 8.

WARREN, B. E. and MODELL, D. I. (1931). The structure of vesuvianite. Zeit. Krist. *78,* 422.

WEISS, (1829). Über den Vesuvian von Eeg bei Christianssand. Verh. naturf. Freunde, Berl. *1,* 4. Stück, 261. (Excerption by Zepharovich.)

WIDMAN, O. (1890). Mineralanalytiska meddelanden från Uppsala kemiska laboratorium. Geol. För. Förh. *12,* 20.

ZEPHAROVICH, V. R. VON (1864). Kristallographische Studien über den Idokras. Sitzb. Wiener Akad. *49,* 116.

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