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MINERALS ASSOCIATED WITH THE CRYSTAL-
LINE LIMESTONE AT CRESTMORE,
RIVERSIDE COUNTY,
CALIFORNIA

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CONTENTS

	PAGE
Description of the rocks	328
Igneous intrusives and metamorphism	328
Hills and quarries	329
Intrusive rocks	329
The limestone	330
Metamorphism of the limestone	331
Description of the minerals	332
Minerals disseminated in the white limestone of Chino Hill	332
Brucite	332
Hydromagnesite	333
Chondrodite	333
Graphite	333
Phlogopite	334
Serpentine	334
Minerals in the contact zones of Sky Blue Hill	334
Blue calcite	334
Wollastonite	334
Vesuvianite	338
Garnet	339
Diopside	340
Xanthophyllite, var. waluwewite	341
Monticellite	342
Wilkeite	343
Crestmoreite, a new mineral	344
Riversideite, a new mineral	347
Clinochlore	348
Apatite	348
Aragonite	348

	PAGE
Minerals associated with the intrusives	349
Feldspars	349
Augite	349
Hornblende and biotite	349
Titanite	349
Zircon	349
Epidote	349
Quartz	350
Tourmaline	350
Axinite	350
Datolite	350
Scapolite	350
Apophyllite	350
Okenite	351
Prehnite	351
Laumontite	352
Opal	352
Sulphide minerals	352
Oxydation products	353

DESCRIPTION OF THE ROCKS

IGNEOUS INTRUSIVES AND METAMORPHISM

At Crestmore, about eight miles westerly from Riverside, there is an isolated mass of granodiorite with a capping of crystalline limestone which is of exceptional interest because of the many minerals developed in the limestone by contact and hydrothermal metamorphism.

The Riverside Portland Cement Company's plant, situated at the base of the hill, uses both rocks in the manufacture of cement. The extensive quarrying is rapidly destroying the hills, and the different minerals and associations almost daily brought to view are immediately carted to the rock-crushers, so that a vast amount of material of scientific value and many fine specimens are lost.

The writer visited the quarries a few years ago and collected much of the material described here, but no detailed study of the deposits was made and no opportunity has presented itself for a second visit. Specimens have been collected by others and sent to the University, which have been of great help in making the list complete, and special thanks are due Mr. L. J. Childs of Rialto. He has kept in touch with the quarrying and collected minerals that otherwise would have been lost, and these with notes of their occurrence have been given to the writer. About fifty minerals are described in this paper, but these represent only a portion of what probably could be found by daily

visits. The cement contains the calcined remains of many beautiful, rare, and perhaps new, mineral species.

Hills and Quarries.—The Crestmore limestone forms two hills closely connected by a saddle-ridge. Both hills rest upon a common base of granodiorite somewhat elliptical in contour, with its longer axis trending northeast-southwest. The north is called Sky Blue Hill because of its blue calcite; while the south hill, having pure white marble, has been designated Chino Hill. Sky Blue Hill has a large quarry on its northern side called North Star quarry, a larger one on its eastern side named the Commercial Rock quarry, and between them a third one, the Lone Star quarry, has recently been opened. Chino Hill has one large quarry on its southwest side, and the accompanying view (pl. 21) shows this quarry and the plant of the cement company. The floor of the quarry marks approximately the juncture of the igneous base with the limestone capping.

The limestone forming the capping is a small remnant of a more extensive body of limestone which formerly covered this region. There is a larger mass similar to Crestmore about three miles west, and Slover Mountain near Colton may be another remnant left as a capping upon an intrusive mass.

Intrusive Rocks.—There are three types of igneous intrusives occurring in the hills and all three have been active agents in the metamorphism of the limestone. Granodiorite, quartz-monzonite porphyry and pegmatite are present and intimately associated with the contact phenomena.

The granodiorite is a hornblende-biotite rock with a fairly coarse granitic structure consisting essentially of orthoclase, plagioclase, hornblende, biotite, and quartz. The orthoclase, which appears to constitute the main portion of the rock, is mostly white, and the rock is consequently gray as the prevailing color, but patches of brick-red orthoclase occur, giving the rock a red color. Labradorite and oligoclase are the triclinic feldspars present, but very little albite twinning is seen. The rock is not fresh and all of the feldspars are muddy and opaque. The dark silicates are mostly black hornblende, which is dark green in thin section, and a few plates of biotite. Quartz is much subordinate to the feldspars in amount.

This granodiorite is used by the company as a substitute for clay in the cement. Daily analyses of it are made and three of them will serve to show the relative proportions of the bases.

SiO ₂	60.60%	60.78%	60.30%
Al ₂ O ₃	16.61	16.04	16.03
Fe ₂ O ₃	5.03	4.82	4.19
CaO	7.93	8.22	7.19
MgO	2.08	1.99	2.26
Loss	4.79	4.75	4.42
	<hr/>	<hr/>	<hr/>
	97.08	96.60	94.39

The alkalis are not determined in these analyses. Probably some potash and soda have been leached out in the alteration of the feldspars. The granodiorite has its best exposure on Chino Hill and is plainly seen underlying the white limestone. The rock is mined by tunnels into it from the side of the hill below the limestone.

The quartz-monzonite porphyry forms dikes and laccolithic-shaped masses in the limestone of Sky Blue Hill. The rock is very fine-grained, almost felsitic in character, with an ash-gray color. Under the microscope it is essentially a fine granular mixture of quartz, orthoclase and plagioclase with occasional large plates of feldspar and augite. Some pale green and slightly pleochroic hornblende is present, but most of the dark magnesian mineral is augite. It occurs in granular aggregates of a pale bluish-green color and shows no pleochroism. Titanite grains are common in the rock.

This rock forms a wide intrusion into the limestone of Sky Blue Hill, since tunnels run into the hill from the floor of the Commercial Rock quarry penetrate it for several hundred feet. It has been the most active agent in the formation of the metamorphic minerals of this hill.

The pegmatite occurs as intrusive dikes but it is difficult to trace out their boundaries. They appear to be associated more with the metamorphic masses of vesuvianite-garnet rock. The pegmatite consists mainly of white orthoclase and green epidote. Orthoclase occurs in large cleavage masses and is usually pure white in color. The epidote penetrates the feldspathic mass in long slender crystals, most of which are altered to a bronze-brown color. Quartz occurs as smoky granular masses but is not prominent. Zircon, tourmaline, axinite, pyroxene, and a few other minerals are occasionally found as accessories and some minerals have later been developed in the pegmatites by hydrothermal metamorphism.

The Limestone.—Daily analyses are made of the limestone and that from the Chino quarry has the following average compositions:

SiO ₂	4.50%	4.68%	4.26%	5.24%
R ₂ O ₃	1.20	1.24	1.66	1.40
CaO	50.78	50.85	50.00	50.33
MgO	2.50	2.25	2.54	2.60
Loss	40.60	40.36	41.54	40.40
	<hr/>	<hr/>	<hr/>	<hr/>
	99.58	99.38	100.00	99.97

Analyses show that about two and one-half per cent of magnesia is the average amount of that oxide in the white limestone or marble, and it is therefore not very dolomitic. Associated with, and merging into this rock are masses of similar white crystalline limestone containing much magnesia, as the mineral brucite, disseminated through it in pisolitic-shaped inclusions. The brucite rock apparently overlies the other limestone, and is seen very prominently on the south end of Chino Hill and near the surface in the Commercial Rock quarry on Sky Blue Hill. It may be a remnant of a separate and distinct bed of magnesian limestone, but the amount of the brucite varies considerably and it has evidently been formed from some other magnesium mineral, whose origin was due to contact metamorphism, and the source of the magnesia might have been in the solutions accompanying such metamorphism.

Metamorphism of the Limestone.—The two hills are utterly dissimilar in the effects of metamorphism. The limestone of Chino Hill was converted into a white marble with very little development of included metamorphic minerals. It does not appear to have suffered successive metamorphism and recrystallization as would be induced by later injections of igneous rock, and the original intrusion of the granodiorite accounts for its simple metamorphism. At the south end of the quarry the rock grades into a brucite-graphite limestone; and the brucite and graphite are so thickly disseminated as to warrant the assumption that the original rock was a highly carbonaceous, magnesia-bearing limestone which, by metamorphism, became converted into a mixture of calcite, periclase, and graphite, the periclase subsequently altering to brucite.

The Sky Blue Hill portion of the limestone capping was subjected to later and more intensified metamorphism by intrusions of the quartz-monzonite and pegmatite, and by the hydrothermal action of the silicated-carbonated solutions accompanying or following these intrusions. Practically all of the minerals developed are products of hydrothermal metamorphism. These solutions also carried phosphates

and small amounts of metallic sulphides. The beautiful blue calcite occurring only in the north hill is a recrystallization by these solutions, and some of the minerals, like the brucite, apophyllite, okenite, crestmoreite, prehnite, laumontite, etc., have been formed by the action of such solutions on pre-existing minerals.

Zones or bands of contact metamorphic silicates separate the white crystalline marble from the dikes of monzonite and pegmatite, and some of the material is a compact massive and inseparable mixture. Vesuvianite, garnet, and wollastonite are the abundant silicates of Sky Blue Hill. Plate 22 shows three views of the Commercial Rock quarry on this hill.

DESCRIPTION OF THE MINERALS

MINERALS DISSEMINATED IN THE WHITE LIMESTONE OF CHINO HILL

Brucite.—The magnesia hydrate is not disseminated through the limestone as plates or scales but occurs wholly in rounded, pisolitic bodies. The pisolites are generally quite prominent because of their gray, yellow or pink color in contrast to the white calcite. Magnified sections show them to be composed of a congeries of thin, overlapping, curved plates and threads, more or less concentrically arranged, and with a cross-fibered structure. This internal structure indicates great strain and pressure in their formation, and little can be made of them optically. The general interference colors are low, but their compressed, interwoven fibrous structure prevents extinction. An analyses of the pisolites gave:

MgO	67.48%
Fe ₂ O ₃	0.55
H ₂ O	31.73
	99.76
G	= 2.39

Some of the brucite is deeply colored by ferric oxide, which imparts a yellow and red spotted appearance to the white limestone. Near the surface of the hill in the Commercial Rock quarry, where the brucite has been weathered out, the limestone is cellular, with the cavities lined with the yellow or red oxide.

Periclase is assumed to be the original mineral which has changed to brucite by simple hydration. No periclase has been observed and no other mineral occurs in the limestone from which brucite could be derived. The very regular form of the pisolites suggests an

original isometric crystal with an octahedral shape such as periclase would have had. The internal structure of the brucite clearly indicates that they have formed under great pressure, such as would be produced by expansion within a confined space. In a change from the anhydrous periclase to the hydrous brucite an increase in volume of nearly two and one-half times that of the periclase is necessary under normal conditions, and this great swelling has caused sufficient pressure not only to produce the twisted and fibrous internal structure of the pisolites, but also to curve slightly the twinning planes of the calcite bordering the cavities.

The names *predazzite* and *pencatite* were given to a similar brucite limestone from Predazzo in the classic Monzoni district of Tyrol. Specimens of the predazzite show the same compressed and strained brucites in the white limestone, and they have generally been held to be brucite derived from periclase, and some unaltered periclase has been found. Lanacèk¹ holds from a petrographic study of the predazzite that the pisolites are hydromagnesite rather than brucite. Some of the brucite of the Crestmore limestone is altered to hydromagnesite as a later change but the pisolites are in the main brucite, as shown by the analysis.

Hydromagnesite.—Some of the brucite pisolites have altered by weathering into earthy white material which qualitative tests prove to be the hydrocarbonate of magnesia. It is evidently secondary from brucite and not from any periclase direct.

Chondrodite.—This is the only mineral in the list of which there is no well-authenticated proof of its existence in the quarries. Chondrodite and its characteristic associate, spinel, might be expected among the products of metamorphism in the Commercial Rock quarry, but apparently fluorine was absent, as tests of the spotted limestone which suggest chondrodite failed to show its presence. Specimens of chondrodite have been collected from the Colton limestone. Brucite may form from chondrodite but it much more probable that periclase was the original mineral of the Crestmore rock.

Graphite.—The only place in the quarries where graphite is prominent in the limestone is on the south end of Chino Hill, in close association with the brucite. It is so thickly disseminated through the limestone as small flakes and scales that the rock is of a dark gray color in consequence. The pisolites of brucite are often surrounded by a border of black graphite, probably so oriented by the solutions

¹ Min. u. petr. Mitth., vol. 12, pp. 429, 447, 1892.

causing the change from periclase to brucite. Graphite was not prominent in the quarries on Sky Blue Hill.

Phlogopite.—A few flakes of brown phlogopite mica have been observed in the white limestone of Chino Hill.

Serpentine.—Very little serpentine has been found on either hill. A few small patches and streaks occur here and there in the white marble of the Chino quarry.

MINERALS IN THE CONTACT ZONES OF SKY BLUE HILL

Blue Calcite.—The blue calcite occurs only in the Commercial Rock quarry. Some of it is intensely blue, especially when freshly exposed, but it fades somewhat to more of a sky-blue color. It does not occur as one large mass of blue calcite, but rather as seams, bands, and patches intimately mixed with the various metamorphic minerals. When the quarry was first opened the blue calcite was very common and was used for road rock and in sugar refining, but very little is now seen. It is one of the contact metamorphic minerals; and in the recrystallization of the carbonate larger rhombohedrons have resulted, some of the cleavage rhombohedrons measuring four to five centimeters in diameter. The cause of the blue color has not been determined, but is believed to be due to minute inclusions of carbonaceous matter. Slight heat completely decolorizes it. This blue calcite forms the matrix for wilkeite, crestmorite, xanthophyllite, and monticellite, and contains, besides, minute crystals of vesuvianite and diopside. Pale green and pale pink specimens of calcite are occasionally seen, but the prevailing colors are blue and white.

Wollastonite.—The calcium silicate has been most abundantly formed in the limestone, especially on Sky Blue Hill. It forms great masses in the North Star quarry and tons of it can be obtained. Four structural types or habits may be ascribed to the Crestmore wollastonite.

The first has the common reticulated columnar and fibrous structure which is so characteristic of wollastonite. Crystals of this type are long, narrow and much striated, and generally show no end-faces. Masses of this kind of wollastonite have occasionally been encountered in the limestone of the Chino quarry.

The second type is represented by large well-formed crystals having the forms and habit of the usual wollastonite crystals. Glassy white crystals, several centimeters long and more than a centimeter broad,

occur in direct association with garnet and vesuvianite. They are elongated parallel to the *b*-axis and have one end terminated by fairly good faces. The forms observed on these crystals are:

<i>a</i> (100)	<i>m</i> (110)	<i>v</i> (101)	<i>s</i> ($\bar{2}$ 01)
<i>c</i> (001)	<i>x</i> (120)	<i>a</i> ($\bar{1}$ 02)	<i>p</i> (111) new
<i>g</i> (011)	<i>z</i> (320)	<i>t</i> ($\bar{1}$ 01)	

The orthopinacoid and base are broad while the domes are very narrow; this gives the crystals an appearance of elongated square prisms. One crystal had a rough face of the front unit pyramid, which is a new form for wollastonite. Figure 1, plate 23, shows this type. The angles obtained with the two-circle goniometer and those calculated are as follows:

Forms	Measured		Calculated	
	ϕ	ρ	ϕ	ρ
<i>c</i> 001	90°00'	5°34'	90°00'	5°30'
<i>a</i> 100	90 00	90 00	90 00	90 00
<i>m</i> 110	43 40	90 00	43 39	90 00
<i>x</i> 120	25 31	90 00	25 30	90 00
<i>z</i> 320	55 10	90 00	55 03	90 00
<i>v</i> 101	90 00	45 21	90 00	45 35
<i>a</i> $\bar{1}$ 02	90 00	$\bar{1}$ 9 36	90 00	$\bar{2}$ 0 03
<i>t</i> $\bar{1}$ 01	90 00	$\bar{3}$ 9 13	90 00	$\bar{3}$ 9 35
<i>s</i> $\bar{2}$ 01	90 00	$\bar{6}$ 0 03	90 00	$\bar{6}$ 0 14
<i>g</i> 011	4 42	46 36	5 39	44 12
<i>p</i> 111	47 10	53 36	46 29	54 34

The third structural type is granular and very unusual for wollastonite. Large masses of snow-white, fine-granular wollastonite occur in the white limestone of the North Star quarry of Sky Blue Hill. The material is loosely coherent and friable; specimens can readily be crushed between the fingers into fine grit and glassy grains. An analysis of this unusual variety gave the composition:

SiO ₂	51.77%
Fe ₂ O ₃	2.12
CaO	44.85
Ign.	1.02
	99.76

The general tendency of wollastonite is to crystallize in long columnar forms; when found occurring as a fine granular mass it must mean a peculiar condition of crystallization. Wollastonite usually occurs imbedded in limestone as inclusions, but massive boulders of this granular variety are quarried containing no associated

calcite. This friable granular variety has every appearance of having been thrown down as crystalline precipitated granules from a cooled saturated solution of the lime silicate. The precipitate was crystalline as every grain is transparent glassy, but the imperfectly formed crystals were not cemented into a compact mass which would have been ordinarily the case in a dense crystallization such as this implies. Presumably this mass, which seems to be a large segregation in the limestone, was formed by rapid crystallization and sudden precipitation from a solution whose temperature was rapidly lowered. This variety is only found on the northern end of the hill and at some distance from the intrusive dikes.

The fourth type consists of distinct crystals which have formed by later silica solutions acting upon the limestone in the vicinity of the pegmatite dikes and on the outer border of the contact zones. Acicular and slender crystals with terminations on one end occur associated with apophyllite and okenite. The crystals are clear and colorless, with bright lustrous faces. By pressure they separate into silky fibers. They possess perfect orthopinacoidal cleavage and have the usual elongation parallel to the *b*-axis. Twenty-three forms were observed, of which twelve were new, as follows:

<i>c</i> (001)	<i>v</i> (101)	<i>g</i> (011)	<i>u</i> ($\bar{1}44$) new
<i>a</i> (100)	τ (104) new	ρ (744) new	ϕ (122)
<i>l</i> (740) new	θ ($\bar{1}04$) new	<i>o</i> (344) new	μ ($\bar{1}22$)
<i>h</i> (540)	<i>k</i> ($\bar{1}03$)	<i>n</i> (144) new	ω (142) new
<i>q</i> (340)	<i>a</i> ($\bar{1}02$)	η (744) new	ϵ ($\bar{1}42$) new
<i>m</i> (140) new	<i>t</i> ($\bar{1}01$)	<i>i</i> ($\bar{3}44$) new	

The crystals are slender and consequently the dome faces are narrow and apt to be striated. The base, orthopinacoid and three domes *v a t* are common to all the crystals. One crystal gave readings for narrow but distinct forms corresponding to two new domes (104) and ($\bar{1}04$). The end terminations of the crystals are remarkable. The unit prism (110) and clinoprism (120), which are common forms on wollastonite, are absent, and a new prism (140) predominates; the prisms (540) and (340), known forms but very rare, are common on these crystals. The pyramidal forms are likewise remarkable in showing a similar odd series of symbols and no forms common to the usual crystals of wollastonite. Practically all of the pyramids are new forms. The forms (144) and ($\bar{1}44$) are common on all, with (344) and ($\bar{3}44$) usually present. Two of the crystals have small faces of the forms (744) and ($\bar{7}44$). The forms (544) and ($\bar{5}44$), which

would complete the two odd series, may also be present, as some approximate readings indicated them, but their occurrence could not be established with absolute certainty. Two very small and poor faces corresponding to the forms (122) and $\bar{1}22$ and a line face of (011) occur. The two new forms (142) and $\bar{1}42$ were line faces and gave only approximate measurements.

Another unique fact about these crystals is that for every positive pyramid there is a negative one with like symbols; but the symbols for the rear faces do not correspond to the front ones. It is characteristic that the crystals have three or four prism faces on their ends each representing a different form. Figures 2 and 3, plate 23, show the combinations on some of the crystals. Figure 3 shows the end of the crystals with the rear faces drawn in the left half in reversed position. Figures 4 and 5 are orthographic projections on the clinopinacoid which bring out better the combination of faces.

Only one end of the crystals is terminated, sometimes the right and again the left end. The disposition of the faces indicates a lower grade of symmetry as there is no apparent axis of symmetry, and the crystals could belong to the hemimorphic class of the monoclinic system, or to the triclinic system. The mineral is strongly tribo-luminescent and this physical property is an evidence of a more complex molecular structure. The dome faces on these crystals are identical with those of all wollastonite crystals, but the terminated ends are totally dissimilar.

Forms	Measured		Calculated		No. of measurements
	ϕ	ρ	ϕ	ρ	
c 001	90°00'	5°30'	90°00'	5°30'	25
a 100	90 00	90 00	90 00	90 00	30
l 740	59 03	90 00	59 04	90 00	7
h 540	49 57	90 00	50 01	90 00	8
q 340	35 35	90 00	35 35	90 00	10
m 140	13 25	90 00	13 25	90 00	13
v 101	90 00	45 33	90 00	45 33	22
τ 104	90 00	18 35	90 00	18 07	1
θ $\bar{1}04$	90 00	7 41	90 00	7 40	1
k $\bar{1}03$	90 00	11 36	90 00	11 56	1
a $\bar{1}02$	90 00	20 00	90 00	20 00	19
t $\bar{1}01$	90 00	39 33	90 00	39 35	24
g 011	5 12	45 44	5 41	44 12	1
p 744	60 29	62 19	60 31	63 03	3
o 344	38 59	51 16	39 10	51 19	6
n 144	18 33	45 33	18 40	45 37	11
b 744	$\bar{5}8$ 20	61 41	$\bar{5}7$ 30	60 58	2
i $\bar{3}44$	$\bar{3}1$ 42	48 37	$\bar{3}1$ 38	48 39	7

Forms	Measured		Calculated		No. of measurements
	ϕ	ρ	ϕ	ρ	
<i>u</i> 144	8 09	44 16	7 55	44 19	11
ϕ 122	30 38	47 24	28 57	48 09	1
μ 122	19 02	45 14	20 41	45 58	1
ω 142	15 35	62 51	16 05	63 35	1
ϵ 142	11 04	62 57	10 41	63 05	1

An analysis of the clear crystals gave:

SiO ₂	50.42%
CaO	48.29
MgO	0.60
Fe ₂ O ₃	0.51
Ign.	0.07
	99.89

The optical data were kindly determined by E. S. Larson of the U. S. Geological Survey:

$$\alpha = 1.614; \beta = 1.629; \gamma = 1.631; 2E = 58^\circ \pm 5^\circ; 2V = 35^\circ \pm 4^\circ;$$

Y || fibers; Z \perp fibers. Parallel extinction; dispersion perceptible $\rho > v$.

The indices are close to those for pure artificial wollastonite:

$$\alpha = 1.616; \beta = 1.629; \gamma = 1.6321; 2V = 39^\circ.$$

Vesuvianite.—Massive vesuvianite is very common in the metamorphic zones between the monzonite dikes and limestone. It is intimately associated with garnet and diopside. Most of this massive variety has a light yellowish color and shows broad crystal faces. Simple crystals of this yellow color are also common, some of them being very perfect. The blue calcite contains crystals of a darker brown color with brilliant faces and somewhat fused appearance.

Two general habits of the crystals are prominent. The simpler type consists of the doubly terminated pyramid without any modifying faces on the edges, as illustrated in figure 6, plate 24. Occasionally the edges of these are truncated by the second-order pyramid as narrow faces, and a small base may also be present. The sizes of these crystals range from less than one-fourth centimeter to more than six centimeters in width. All of them are of the light yellow color and they are associated with the white crystalline limestone.

The second type consists mainly of the unit bipyramid (111) and second-order prism (100) in about equal development, as shown in figure 7. This type is often modified by very small planes on the edges and on the points of the lateral axes, making a more general combination, as illustrated in figure 8. These crystals have a dark brown

brilliant surface, with lighter brown interiors, and they occur imbedded in the blue calcite in association with the wilkeite.

The small faces grouped about the ends of the axes are often rounded and give readings which yield improbable symbols, but the ones identified are:

<i>c</i> (001)	<i>p</i> (111)	<i>y</i> (441)
<i>a</i> (010)	<i>b</i> (221)	<i>s</i> (131)
<i>m</i> (110)	<i>t</i> (331)	<i>i</i> (132)
<i>o</i> (011)	<i>z</i> (121)	<i>n</i> (154) new
		<i>b</i> (285)?

The new form (154) occurs on several of the crystals; the narrow face of (132) rounded into a narrow face which gives a good reflection and corresponds to the symbol (285), but it is not repeated on any other crystal and must be classed as doubtful.

The measured and calculated angles are as follows:

Forms	Measured		Calculated	
	ϕ	ρ	ϕ	ρ
<i>c</i> 001	0°00'	0°00'	0°00'	0°00'
<i>a</i> 010	90 00	0 00	90 00	0 00
<i>m</i> 110	44 50	89 50	45 00	90 00
<i>o</i> 011	0 00	28 20	0 00	28 15
<i>p</i> 111	44 55	37 11	45 00	37 14
<i>b</i> 221	44 56	56 43	45 00	56 40
<i>t</i> 331	45 00	66 19	45 00	66 19
<i>z</i> 121	26 19	49 56	26 34	50 14
<i>s</i> 131	18 30	59 30	18 26	59 32
<i>i</i> 132	18 31	40 23	18 26	40 22
<i>n</i> 154	11 00	34 30	11 18	34 25
<i>b</i> 285	14 30	41 55	14 03	41 34

An analysis of the green vesuvianite by J. B. Wright gave:

SiO ₂	36.88%
Al ₂ O ₃	17.61
Fe ₂ O ₃	3.11
FeO	0.46
MnO	1.50
CuO	1.06
CaO	33.27
MgO	4.73
Na ₂ O	0.34
H ₂ O	0.61

99.57

G = 3.36

Garnet.—The cinnamon-colored grossularite is abundant in association with the vesuvianite. Most of it is compact massive and shows

only an occasional broad face of the dodecahedron. Good crystals also occur and some of the rhombic dodecahedrons measure ten centimeters in diameter. All of those collected are simple dodecahedrons without other forms. Some of the crystals are mere shells of garnet enclosing a center of white calcite.

The massive grossularite was analyzed by J. B. Wright with the following result:

SiO ₂	35.53%
Al ₂ O ₃	21.11
Fe ₂ O ₃	3.95
FeO	0.60
CuO	0.70
CaO	36.06
MgO	0.78
Na ₂ O	0.20
H ₂ O	1.23
	100.15
G	= 3.39

Granular yellow garnet and dark brown massive varieties also occur, apparently in connection with the pegmatite dikes. No analyses of them have been made to determine the particular species.

Diopside.—Associated with garnet in the zone of metamorphic lime silicates, a deep green massive pyroxene occurs, which is probably a diopside of a darker color than the crystals scattered through the calcite. All of the crystals are of a pale yellowish green color and occur as single crystals imbedded in the blue calcite. Most of them are small, only a few millimeters long, but some have been found four centimeters in length. They are all of one general type: short prisms tapering off by a succession of unit pyramids to pointed ends, with or without small basal planes. Figures 9 and 10, plate 24, show this general habit and some of the combinations. The observed forms are:

<i>e</i> (001)	<i>e</i> (011)	λ ($\bar{3}$ 31)	<i>d</i> (131)
<i>a</i> (100)	<i>z</i> (021)	<i>o</i> ($\bar{2}$ 21)	μ (121)
<i>b</i> (010)	<i>v</i> (221)	<i>s</i> ($\bar{1}$ 11)	<i>t</i> ($\bar{2}$ 11)
<i>m</i> (110)	<i>u</i> (111)	<i>t</i> ($\bar{1}$ 12)	ϵ ($\bar{1}$ 21)
			n ($\bar{2}$ 31) new

The new form truncates the edge (110) ($\bar{1}$ 21) and occurs on several crystals. The edges have many rounded faces and some of the symbols corresponding to them are given unlettered in the following table of measurements and calculations. They are doubtful forms.

Forms	Measured		Calculated	
	ϕ	ρ	ϕ	ρ
<i>c</i> 001	90°00'	15°50'	90°00'	15°50'
<i>b</i> 010	0 00	90 00	0 00	90 00
<i>a</i> 100	90 00	90 00	90 00	90 00
<i>m</i> 110	43 34	90 00	43 33	90 00
<i>e</i> 011	25 40	32 58	25 43	33 11
<i>z</i> 021	13 29	50 30	13 32	50 29
<i>u</i> 111	55 04	45 55	55 04	45 50
<i>v</i> 221	49 45	61 40	49 59	61 23
<i>t</i> 112	1 11	16 51	0 44	16 25
<i>s</i> 111	25 12	33 05	25 07	33 04
<i>o</i> 221	35 32	55 23	35 22	55 19
λ 331	38 17	66 12	38 19	66 04
<i>d</i> 131	25 27	62 42	25 31	62 58
μ 121	35 37	55 29	35 36	55 24
π 231	25 27	62 41	25 19	62 55
<i>i</i> 211	55 04	45 41	55 04	45 50
ϵ 121	13 53	50 27	13 12	50 27
352	20 18	57 07	20 24	57 36
753	45 20	55 09	46 11	54 50
836	57 49	29 14	57 32	28 47
14.3.10	60 57	27 41	70 32	27 57
10.12.7	27 01	48 18	27 04	48 37

Xanthophyllite, var. *waluwite*.—The rare brittle-mica xanthophyllite with its associate monticellite from Crestmore has recently been described by the writer,² so only the main facts concerning the minerals will be incorporated here. Xanthophyllite was first described and named by Gustave Rose³ as a wax-yellow mineral in scales and plates, occurring as a constituent of a talc-schist in the Shiskimskaya Mountains in the Urals. Years later the green variety was found and named *waluwite* by Kokscharof.⁴ The waluwite or valuevite occurs as a constituent of chlorite schist in the Nicolai-Maximilian mine, near Slatoust in the Urals. These two occurrences are apparently the only ones reported and in both cases the mineral was a schist constituent. The Crestmore waluwite is a product of the contact metamorphism and occurs disseminated through the blue calcite. Masses of the blue calcite speckled with the green waluwite were once very plentiful at the quarry, but none is now seen.

The waluwite occurs in hexagonal-shaped basal plates of a deep grass-green color and vitreous to slight pearly luster. The plates are

² Jour. Wash. Acad. Sci., vol. 6, p. 332, 1916.

³ Pogg. Ann. d. Phys. und Chem., vol. 50, p. 654, 1840. Also in his *Reise nach dem Ural*, vol. 2, pp. 120, 514, 527, 1842.

⁴ Zeitschr. für Kryst. vol. 2, p. 51, 1877. Also in his *Mineral d. Russ.*, vol. 7, p. 346.

seldom grouped together and they average one-half centimeter broad and four millimeters thick. A few large ones have been found measuring several centimeters in width and thickness. While the basal planes are very brilliant the edges are dull, furrowed and impossible to measure. The thicker crystals show polysynthetic twinning like the micas and extinguish in striated sectors. Thin cleavage plates give a biaxial figure with an apparent optic angle of about twenty degrees. Measurements of the optic angle in sodium light showed a variation from twelve degrees to eighteen degrees. The plane of the optic angle is (100) and the mineral is negative. The refractive indices β and γ in the basal section are practically the same, determined as 1.660.

Several analyses of the waluwite from the Urals have been published and two of them are inserted here for comparison with the Crestmore mineral.

- No. 1. Waluwite from Crestmore.
 No. 2. Waluwite from Slatoust, Urals. Analyzed by Nikolajef.⁵
 No. 3. Waluwite from Slatoust, Urals. Analyzed by Clarke and Schneider.⁶

	1	2	3
SiO ₂	16.74%	16.39%	16.85%
TiO ₂	.....	.....	tr.
Al ₂ O ₃	42.70	43.40	42.33
Fe ₂ O ₃	2.85	1.57	2.35
FeO	0.41	0.10	0.20
CaO	13.09	13.04	13.30
MgO	20.03	20.38	20.77
Ign.	4.49	4.39	4.60
	100.31	99.77	100.40
	G = 3.081		

Monticellite.—The blue calcite contains monticellite in small masses and grains scattered through it in close association with the waluwite. One large specimen from the quarry consists of a wide band of massive monticellite separated from the blue calcite by a thin seam of waluwite plates, while the calcite has individual grains and plates, respectively, of the two minerals.

The color of the monticellite is flesh or pale brown and the luster is somewhat greasy. The irregular grains show cleavage faces, but no crystals occur. The mineral is practically infusible and is soluble in acids, forming a gelatinous mass when boiled almost to dryness.

⁵ Zeitschr. für Kryst., vol. 9, p. 579, 1885. Abstract.

⁶ Amer. Jour. Sci., vol. 43, p. 379, 1892.

		Gordon Surr, analyst
SiO ₂	36.02%	37.46%
FeO	2.82	2.94
CaO	34.36	35.14
MgO	24.74	25.32
Ign.	1.25	.....
	<hr/>	<hr/>
	99.19	100.86
G = 3.078		

The occurrence of the monticellite and waluwite in close association is interesting because both have crystallized from the same silicate mixture and the waluwite may be viewed as having the composition of monticellite plus the spinel and alumina hydrate molecules. In the discussion of the members of the clintonite group of silicates, Clarke and Schneider make the suggestion that waluwite may have the monticellite molecule in addition to its spinel and olivine molecules although no direct association of the two minerals was then known. Here we have the two crystallized together from a silicate mixture in which the monticellite molecule largely predominated and their crystallizations were practically simultaneous. The composition of the waluwite suggests a mineral mixture of monticellite + olivine + spinel + diaspore in an approximate ratio of 6:1:5:6.

These monticellite and waluwite masses have in all probability been formed by the metamorphism of the brucite-limestone, while the common vesuvianite and diopside, which also occur in the blue calcite, but not associated with the monticellite and waluwite, are evidently products of metamorphism of the ordinary limestone, which has little magnesia. The former two were quite local in their development and were soon exhausted, while the latter are the abundant minerals of the quarry.

Wilkeite.—This interesting lime mineral with the four acid radicals has already been described,⁷ so only the essential parts of that description will be given here. Boulders of blue calcite containing the granular pink wilkeite had just been blasted from the face of the quarry on the day the writer visited it, and fortunately specimens were collected of a mineral which would otherwise have gone unnoticed to the crusher.

The wilkeite occurs as small grains and minute hexagonal prisms disseminated through the masses of blue calcite. The mineral is clear

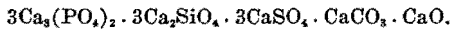
⁷ Amer. Jour. Sci., vol. 37, p. 262, 1914.

and glassy and usually pink but some grains are yellow. The mineral is essentially a calcium phosphate of the apatite group, with much of the phosphate replaced by the silicate, sulphate and carbonate molecules. A summary of the properties of the mineral are: Hexagonal system; $c = 0.730$ approx. Prominent forms $(10\bar{1}0)$ $(11\bar{2}0)$ $(10\bar{1}1)$ and (0001) . Imperfect basal cleavage. $H = 5$. $G = 5.234$. Color pale pink or yellow. Luster vitreous or greasy. Optically uniaxial, negative. $n = 1.640 \pm .005$; $n - n = .0004$.

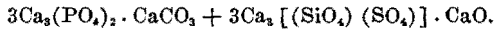
Chemical composition is:

SiO ₂	9.62%
CaO	54.44
MnO	0.77
P ₂ O ₅	20.85
SO ₃	12.28
CO ₂	2.10
H ₂ O	tr.
	<hr/>
	100.06

The formula derived from this analysis is:



In order to better show its relation to apatite this may be written:



During the past summer more of the wilkeite was observed in the quarry quite near the contact with the monzonite, in crystals several centimeters long, coated with its alteration product. This alteration substance coats the original grains and, in the absence of analyses, was thought to be okenite from its optical characters. There is a possibility that the delicate fibers optically tested are okenite; they cannot be separated from the intermixed wilkeite and their exact composition cannot therefore be determined. Much white secondary material has more recently been found which, as analyses show, does not have the ratio of lime to silica in the proper proportions for okenite. Since it is different from any known silicate, it is described below as a new mineral.

Crestmoreite, a New Mineral.—Since the appearance of the paper on wilkeite, blue calcite has been found in the Commercial Rock quarry containing much soft white material disseminated through it in small bunches, as if it were an alteration, in place, of former crystals and grains included in the carbonate. Some of the blue calcite also contains large individuals of this white material having sharply

defined crystal boundaries; apparently hexagonal in outline. No wilkeite occurs in it, but it is evidently an altered product, presumably from wilkeite. Analyses show that it is principally a hydrous calcium silicate with some of the silica replaced by the phosphate, sulphate and carbonate molecules. It is a new hydrous silicate of calcium having small amounts of the other oxides in place of the silica and the name *crestmoreite*, after the locality, is proposed for it.

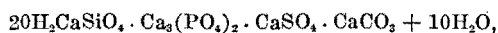
The mineral is compact snow-white with vitreous to dull lustre. $H=3$. $G=2.22$. It fuses quietly and easily to a slightly vesicular glass. It is very easily soluble in acid, leaving some flocculent silica, while most of the silica goes into solution. Some of the lime can be extracted by boiling water.

The earthy opaque material is not adapted to good optical determinations. It has parallel extinction, positive elongation, low birefringence and $\beta = 1.590 \pm .005$.

Analyses of different samples of the mineral were made, all of them showing phosphates and sulphate in the substance. Some of the CO_2 determined is due to calcite, which penetrates the mineral in thin seams

SiO ₂	36.12%	38.30%	34.42%
CaO	42.71	41.20	43.54
P ₂ O ₅	2.38	3.50	3.50
SO ₃	2.42	1.25	2.24
CO ₂	1.16	.....	.....
Ign.	14.98	15.17	16.24
	<hr/>	<hr/>	<hr/>
	99.77	99.42	99.94

These analyses correspond approximately to the formula :



and this requires the composition :

SiO ₂	35.23%
CaO	41.10
P ₂ O ₅	4.17
SO ₃	2.35
CO ₂	1.29
H ₂ O	15.86

If crestmoreite were a clear crystallized mineral like the wilkeite, there would be no doubt that the phosphate, sulphate, and carbonate belonged to it and should be reckoned in its formula; but its earthy structure and composition show that it is changing to a calcium silicate, and it is quite within reason to assume that the three acid radicals are small portions of those in the original wilkeite, which

have not been entirely leached out, in the hydration and silication of the latter mineral, and therefore have no part in the formula for crestmorite. An hydrous lime silicate is forming by the alteration of the wilkeite and the ratio of $\text{CaO} : \text{SiO}_2$ will be as 1 : 1 no matter how much water, or in what way, it enters into the composition.

Crestmoreite can be represented by the simple formula $\text{CaSiO}_3 \cdot \text{H}_2\text{O}$ which requires

SiO_2	44.78%
CaO	41.79
H_2O	13.43

This would make it a simple hydrous metasilicate like a hydrous wollastonite, but it seems more probable that crestmorite, from the water determinations and derivation from wilkeite, is a hydrous basic orthosilicate.

The following percentages of water were given off at the respective temperatures:

At 102°	1.25%
200	3.27
300	10.27
Red heat	15.11
Blast	16.76

In view of the fact that most of the water is expelled only at the higher temperatures it can be regarded as constitutional, and the above formula can be written H_2CaSiO_4 .

Wilkeite is represented by the formula $3\text{Ca}_3(\text{PO}_4)_2 \cdot 3\text{Ca}_2\text{SiO}_4 \cdot 3\text{CaSO}_4 \cdot \text{CaCO}_3 \cdot \text{CaO}$, and it can readily be seen how the orthosilicate can increase at the expense of the more soluble phosphate and sulphate through the wilkeite alteration by carbonated and silicated waters. These waters were the heated ascending solutions which brought about some of the later crystallizations, and in the formation of the orthosilicate part of the calcium was replaced by basic hydrogen. The exact formula for crestmorite depends upon the water and therefore no formula can be advanced that is not open to criticism. As a basic silicate most of the water must be considered as constitutional.

The formula proposed for crestmorite is $4\text{H}_2\text{CaSiO}_4 + 2\text{H}_2\text{O}$. This requires:

SiO_2	43.32%	
CaO	40.43	
Constitutional H_2O	12.99	} 16.25
Crystallization H_2O	3.26	
		—————
		100.00

Riversideite, a New Mineral.—Some of the masses of vesuvianite contain narrow seams of a white fibrous mineral which has similar properties to crestmoreite but with only half as much water, and it does not occur as an alteration of wilkeite, at least not as a direct alteration *in situ*. The mineral occurs in compact fibrous veinlets in the crevices of the massive vesuvianite and has a silky luster resembling satin spar. $H=3$. $G=2.64$. Fuses at 2 to a white glass. Easily soluble in dilute acid leaving flocculent silica.

The mineral is a fibrous crystallization from the solutions carrying the altered wilkeite or crestmoreite and the analyses show that a lime silicate with a ratio $CaO:SiO_2$ equal to 1:1 is, like crestmoreite, the principal constituent with small amounts of the phosphate and sulphate present. In this case also the P_2O_5 and SO_3 are hardly to be considered as belonging to the mineral.

Analyses of the fibers gave:

			Mean
SiO ₂	41.29%	41.22%	41.26%
CaO	44.62	44.55	44.58
P ₂ O ₅	.....	3.84	3.84
SO ₃	1.84	.....	1.84
H ₂ O	8.05	8.17	8.11
			99.63

The water determination gave

At 102°	0.80%
150	1.00
250	1.37
Red heat	7.77
Blast	8.05

This water analysis would indicate that it is mainly constitutional, but it is a difficult matter to construct a basic formula for the mineral that is satisfactory. The simplest formula to express the composition of riversideite is $2CaSiO_3 \cdot H_2O$. It may be likened to okenite with its basic hydrogen replaced by calcium:

Okenite	$(H_2Ca)Si_2O_4 \cdot H_2O$
Riversideite	$Ca_2 Si_2O_4 \cdot H_2O$

The formula $2CaSiO_3 \cdot H_2O$ requires:

SiO ₂	48.00%
CaO	44.80
H ₂ O	7.20

The analyses of riversideite correspond pretty closely to the formula $15\text{H}_2\text{CaSiO}_4 \cdot 15\text{CaSiO}_3 \cdot \text{CaSO}_4 \cdot \text{Ca}_3(\text{PO}_4)_2 + 5\text{H}_2\text{O}$, which requires:

SiO ₂	42.00%
CaO	44.43
SO ₃	1.87
P ₂ O ₅	3.31
H ₂ O	8.39
	100.00

Disregarding the phosphate and sulphate it appears that the silicate formed is a combination of the basic orthosilicate and the metasilicate, and a formula to express the mineral may be written $6\text{H}_2\text{Ca}_2\text{Si}_2\text{O}_7 \cdot \text{H}_2\text{O}$. This requires:

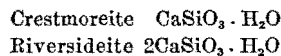
	SiO ₂	47.43%
	CaO	44.27
	Constitutional H ₂ O	7.11
	Crystallization H ₂ O	1.19
		8.30
		100.00

The optical properties of riversideite kindly determined for the writer by Mr. E. S. Larsen are:

$$\begin{array}{ll} \alpha = 1.595 \pm 0.003, & \text{Parallel extinction.} \\ \gamma = 1.603 \pm 0.003. & \text{Z parallel to fibers.} \end{array}$$

The name *riversideite*, after the county in which it occurs, is proposed for this new hydrous lime silicate.

The water content of a mineral is always subject to different interpretations; and it is not always possible to differentiate between hygroscopic, crystallization and constitutional water. Both of these new minerals might be interpreted as simple hydro-wollastonites.



Clinochlore.—Small pale green flakes of clinochlore were found in the vesuvianite-masses at the Commercial Rock quarry.

Apatite.—Specimens of greenish blue apatite in granular form associated with green diopside and white wollastonite in white calcite were obtained from the quarry, but it does not appear to be an abundant mineral and no crystals of it have been collected.

Aragonite.—Some of the lime carbonate has subsequently crystallized into the orthorhombic form. It occurs sparingly as fibrous and foliated thin layers interspersed with layers of quartz and calcite.

MINERALS ASSOCIATED WITH THE INTRUSIVES

Feldspars.—Orthoclase, microcline, oligoclase, and labradorite are present in the quarries as constituents of the igneous rocks. Orthoclase appears to predominate and it forms the larger part of the pegmatites. It occurs red and white. An analysis of the pure white from the pegmatites gave:

SiO ₂	64.54%
Al ₂ O ₃	20.86
Fe ₂ O ₃	tr.
CaO	1.86
MgO	tr.
Ign.	0.52
Na ₂ O	1.18
K ₂ O	11.85
	100.81
G	= 2.54

Pyroxene.—Besides the good crystals of diopside which are scattered through the calcite, there is a deep green pyroxene resembling omphacite, mixed with cinnamon-garnet, which has formed at the contact of the pegmatite and limestone.

Augite.—Occurs as a constituent of the quartz-monzonite porphyry.

Hornblende and Biotite.—Both of these minerals are constituents of the granodiorite, the hornblende greatly predominating. Neither seems to occur in the monzonite or pegmatite.

Titanite.—Granular titanite is rather abundant in the monzonite as a constituent. It occurs pale brown with a marked pleochroism to deeper brown. None of the grains has a crystal boundary.

Zircon.—Minute crystals and larger grains of zircon are scattered through some of the white pegmatite rock. The color of the mineral is clove-brown and some of the crystals show the forms (100), (110), (111), (331).

Epidote.—Deep green epidote occurs as one of the contact minerals of the Commercial Rock quarry. Slender and long crystals and grains are imbedded in some of calcite masses. The mineral is very prominent as a constituent of the pegmatites and is one of the original minerals of the rock. It is present in the pegmatite as long slender crystals having a prominent basal cleavage. The fresh crystals are deep leek-green, but most of them have altered to a bronze-brown and resemble astrophyllite. The elongation of the crystals is parallel to

the *b*-axis as usual, and they show striated domes with the cleavage base, but no end-faces.

Quartz.—Specimens of compact granular quartz rock found in the talus of the Commercial Rock quarry indicate that seams of quartzite were formed in the crystallized limestone by its metamorphism. It is quite possible that sandstone seams occurred in the original formation and that these have been the source of much of the silica necessary to form such an abundance of silicate minerals. Quartz is a minor constituent of the igneous rocks and occurs in the usual smoky-brown color. Small druses of the mineral are occasionally found, but large crystals are rare.

Tourmaline.—Boron is a characteristic element in the rocks of Southern California and practically all of the pegmatites of that region carry boro-silicates, especially tourmaline. Three of these boro-silicates have been observed in the pegmatites of Sky Blue Hill and a few specimens have been collected, but the writer is without any data concerning them.

The tourmaline is black columnar and occurs sporadic in the pegmatite.

Axinite.—Violet-colored axinite associated with cinnamon-garnet occurs in large fragments in the pegmatite. Bright crystal faces, often striated, occur but crystals are not complete enough to measure. Axinite appears to be common in this particular region, as it is abundant at the Riverside quarry and has been noted in other places in the vicinity. Rogers⁸ has described a large crystal from Riverside.

Datolite.—Glassy white datolite with slightly greenish tinge occurs in connection with the pegmatites. The specimens sent to the writer are compact massive.

Scapolite.—Specimens of scapolite were recently collected by Childs. The mineral is in close association with green pyroxene, quartz, feldspar, wollastonite, and grossularite garnet. The color of the scapolite is grayish white, but it contains violet-blue streaks. The variety is probably wernerite.

Apophyllite.—The masses of wollastonite which have formed on the contact between the pegmatites and limestone contain cavities lined with small crystals of apophyllite. The crystals are colorless to white and are usually closely interlocked. Two habits are prominent; one is the common cubo-octahedral type with small faces of the pyramid and the base and second-order prism about equal in size. The other

⁸ School of Mines Quar., vol. 33, p. 373, 1912.

one is the pyramid type with a very small or no base. Only the three forms (001), (100), and (111) occur on the crystals. Some of the crystals have been corroded by solutions and altered into white fibrous okenite.

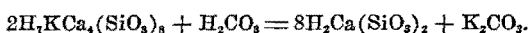
Okenite.—Radiating botryoidal coatings of okenite occur on the apophyllite evidently as an alteration product. The coatings consist of tufts of fibers and long slender needles. The acicular crystals are too slender for accurate measurements but they appear to be long prisms terminated on their ends by dull domes. Some approximate measurements and an analysis of the mineral were made by William Foshag.

	Measured
(110):(1 $\bar{1}$ 0)	33°40'
(010):(0 $\bar{1}$ 1)	52 00
(011):(0 $\bar{1}$ $\bar{1}$)	75 00

The analysis gave:

		Calculated for okenite H ₂ Ca(SiO ₃) ₂ ·H ₂ O
SiO ₂	56.17%	56.60%
CaO	26.10	26.42
H ₂ O	16.83	16.98
	<hr/>	<hr/>
	99.10	100.00

The crystals have parallel extinction and are probably orthorhombic. $H = 4-4.5$. $G = 2.206$. Index of refraction = 1.55. Low birefringence, 0.008–0.009. Solution in HCl yielding flaky silica. Fuses easily and gives water in a closed tube. It has formed from apophyllite through the action of carbonated waters, perhaps according to the equation:



Prehnite.—Two distinct varieties occur filling cavities in the white feldspar of the pegmatite. The first is the common green, drusy prehnite. This is intimately associated with laumontite, which may be secondary from it. The second variety is unusual for prehnite. It is light brown to colorless and lacks the drusy surface. In some of the cavities crystals line the walls, but they are so interlocked that single crystals are not separable. One crystal about five millimeters broad and one millimeter thick showed the forms c (001), m (110), a (100), and o (061). The base is large and bright but the edge-faces are dull. Most of this brown variety is compact granular with bright basal cleavage planes prominent. It is associated with massive datolite and gray quartz.

An analysis of this brown variety gave:

SiO ₂	44.10%
Al ₂ O ₃	24.20
CaO	25.20
H ₂ O	5.86
	<hr/>
	99.36

Laumontite.—The green prehnite has laumontite coating it in small divergent columnar and fibrous masses. It has the appearance of a secondary alteration of the prehnite and in all probability it is such, although there is no direct evidence to prove it. The mineral is snow-white with vitreous luster. Some of the stouter needles have the characteristic oblique cleavage ends. It fuses readily to a vesicular glass and is easily and completely soluble in HCl, yielding a thick gelatinous mass.

An analysis gave:

SiO ₂	53.49%
Al ₂ O ₃	22.01
CaO	10.80
MgO	tr.
H ₂ O	13.39
	<hr/>
	99.69

Opal.—White hyalite coats the walls of some of the cavities in the feldspathic pegmatite, and it coats the apophyllite and okenite to some extent. Under the electric spark it shows strong yellow luminescence, which is an indication that it contains uranium. The amount of material on hand is too small to determine the uranium chemically.

Besides this hyalite opal there is considerable wood opal in some portions of Sky Blue Hill. It is dark brown and black, becoming gray by heating. It shows the wood structure and some of it has small calcite rhombohedrons deposited on it.

SULPHIDE MINERALS

Arsenopyrite, pyrite, galena, sphalerite, greenockite, bornite, chalcopyrite, and tetrahedrite occur in the Commercial Rock quarry, mostly in association with the pegmatite intrusives.

Arsenopyrite has been found in a few small crystals about two millimeters long.

Pyrite is more disseminated than the other sulphides. It occurs in grains, cubes and pyritohedrons, and much of it is altered into brown limonite pseudomorphs.

Galena occurs in rather large cubes and also massive granular. The specimens collected are associated with garnet dodecahedrons, quartz, sphalerite, pyrite, and chalcopyrite.

Sphalerite is quite black but has the characteristic resinous luster and good cleavage. It occurs in the vesuvianite-garnet masses and some of it contains small coatings of bright yellow greenockite.

The copper minerals, bornite, chalcopyrite, tetrahedrite, and perhaps chalcocite, have been found in grains and small granular masses in the metamorphic zones of silicates.

OXYDATION PRODUCTS

Azurite and malachite occur as thin coatings and as stains in the vesuvianite-garnet mass of rock. Cerussite and anglesite have both been identified as earthy gray coatings on the galena.

The two oxides of iron, limonite and hematite, are common in small earthy masses and as stains. The weathered brucite limestone of the Commercial Rock quarry has much yellow earthy limonite and deep red hematite filling the cellular cavities left by the leached-out brucite. The crystals and grains of pyrite imbedded in the calcite and even in the pyroxene and other silicates have been largely altered into limonite pseudomorphs, probably readily changed by the action of the carbonated waters.

White clay from the orthoclase and chlorite from the epidote, augite, hornblende, and other silicates are natural alteration products.

PLATE 21

View looking northeast, showing the two hills and the cement plant of the Riverside Portland Cement Company at Crestmore, Riverside County, California. The quarry floor marks the juncture of the limestone and granodiorite.



PLATE 22

Three views showing different portions of the commercial rock quarry on the eastern side of Sky Blue Hill. The quarry face and boulders are mostly mixtures of blue and white calcite, brown vesuvianite and garnet and green diopside.

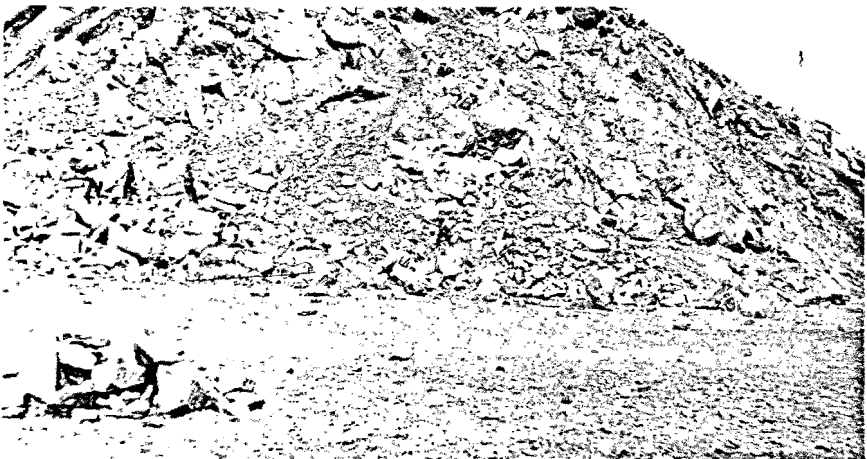
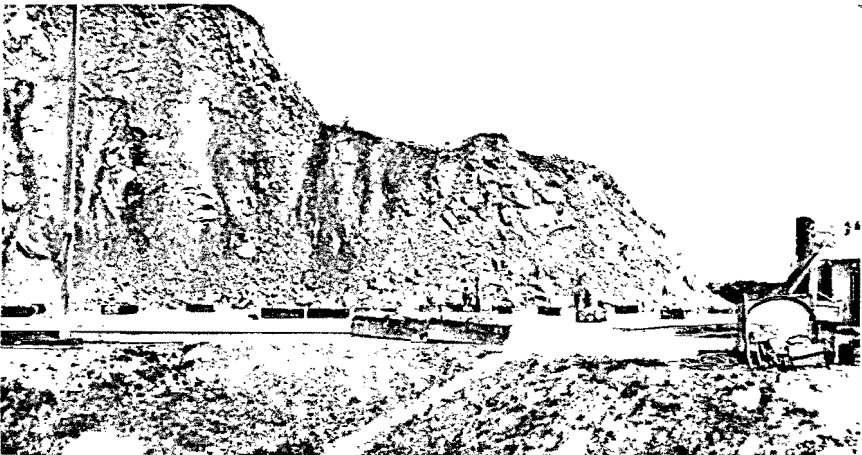
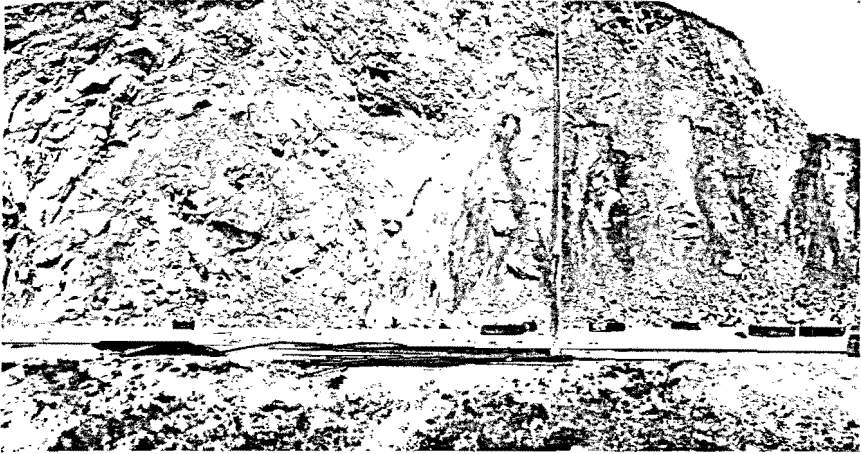


PLATE 23

Projections of wollastonite crystals, showing the different types and combinations of forms. Figure 1 is the type most common for wollastonite. Figures 2 and 3 are types common at Crestmore. The left half of figure 3 is the rear of the right half drawn to show a center of symmetry only, if the crystal were doubly terminated. Figures 4 and 5 are orthographic projections of the ends, showing better the front and rear faces and the absence of an axis of symmetry.

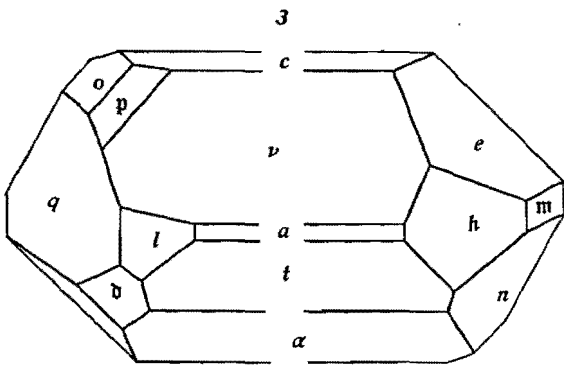
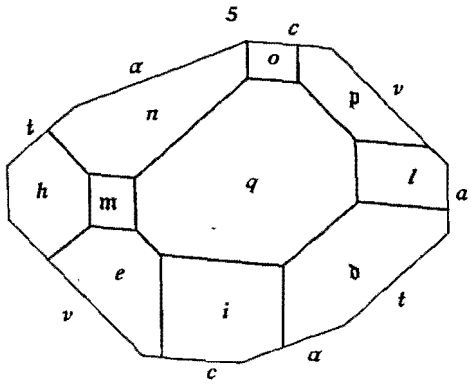
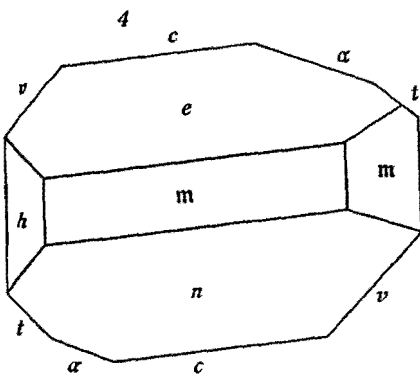
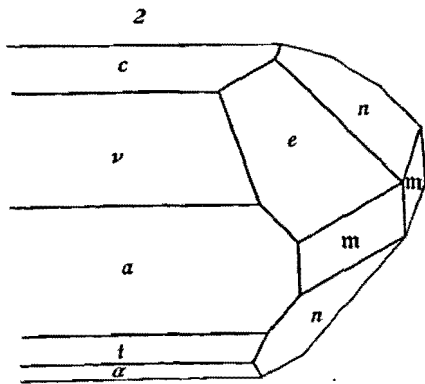
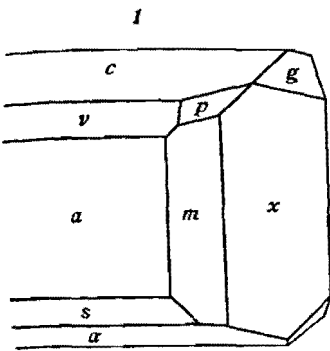
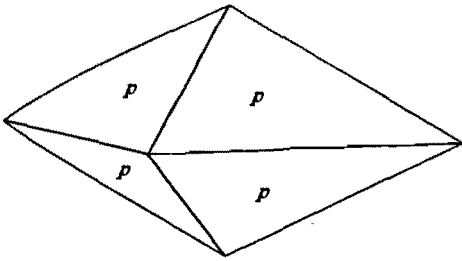


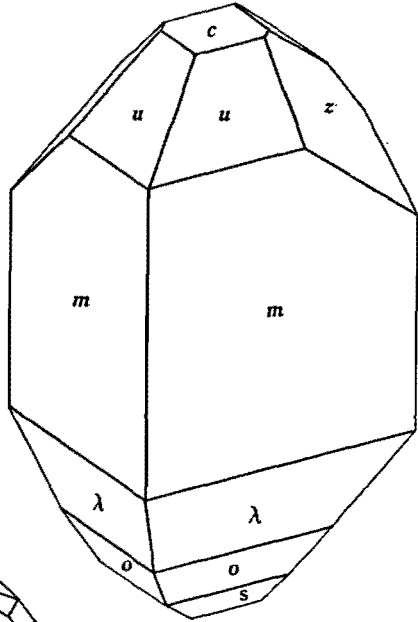
PLATE 24

Figures 6-8 are projections of vesuvianite crystals showing the general type, but different combinations of forms. Figures 9 and 10 are diopside, showing the characteristic type and combinations.

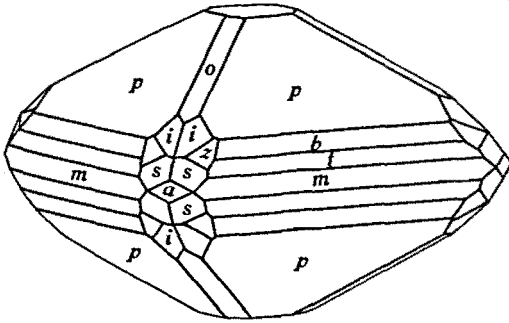
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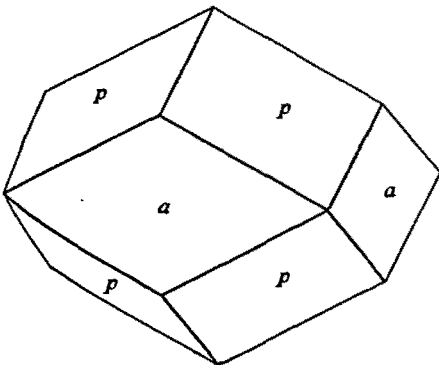
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8



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