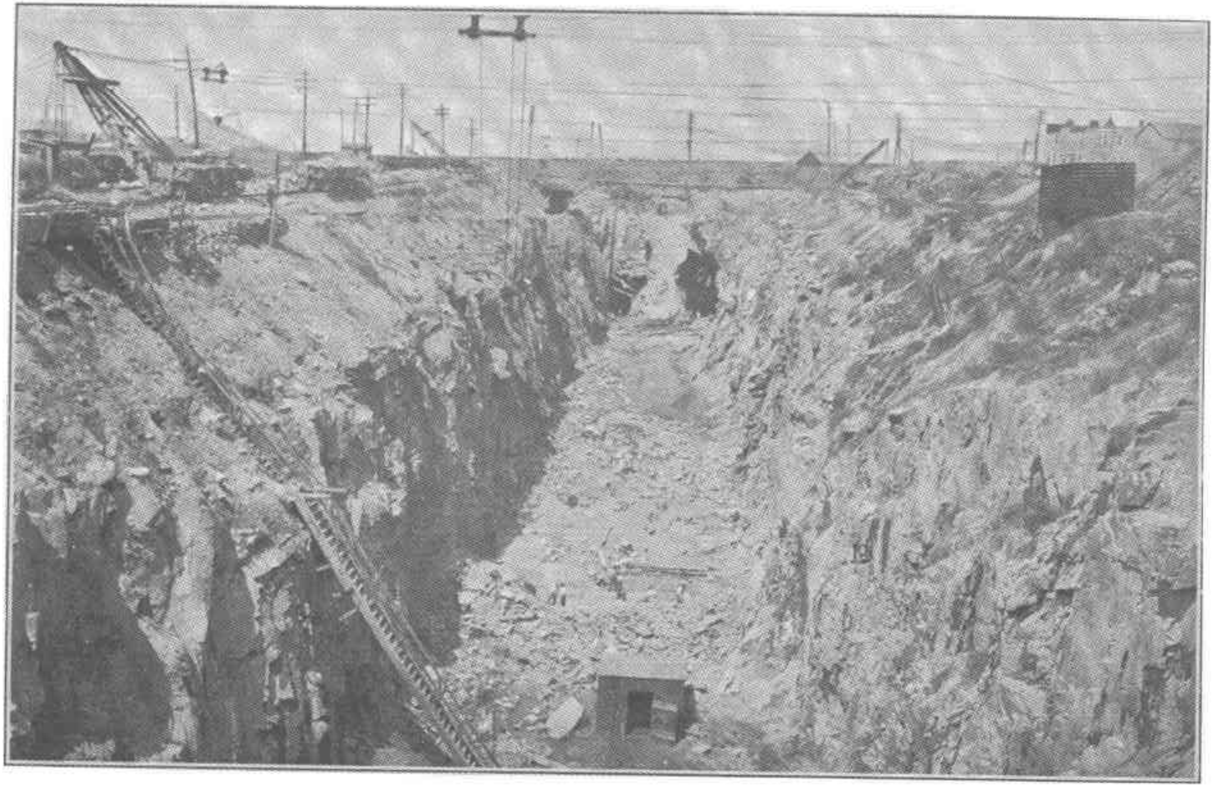
PLATE 10.



THE BERGEN ARCHWAYS
(A view of Cut No. 4 during construction)

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THE MINERALS OF THE BERGEN ARCHWAYS[1]

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Bergen Hill is about 19 kilometers (12 miles) long and 1.6 kilometers (1 mile) wide, comprizing a range of bluffs of Triassic diabase. It commences at Bergen Point and runs behind Jersey City and Hoboken to a point in Weehawken about opposite Thirty-fifth Street in New York City. Here it comes close to the Hudson River and continues north for some 29 kilometers (18 miles) to Piermont, being known as the Palisades.

The Bergen Hill region has long been noted as a locality for zeolites and associated minerals. When the announcement was made that the Erie Railroad Company had begun the construction of an open cut thru the hill, local collectors interested in mineralogy looked forward to the collecting of fine specimens. This interest was fully justified from the history of past borings thru Bergen hill. In the construction of the Pennsylvania cut at Mount Pleasant, the Erie and the two Lackawanna tunnels at Jersey City, the West Shore tunnel at Weehawken, and the Susquehanna tunnel at Edgewater, mineral specimens of unusual beauty were taken out. These have been so highly prized that they have found permanent resting places in museums and private collections thruout the world. The locations of these various operations are shown on the map, Fig. 1, on the succeeding page.

The construction of the new cut was commenced in October, 1906, and with a force of 1,100 men working in day and night shifts, the work was completed in June, 1910, requiring three and two-thirds years to build. The cost of this new entrance to New York City amounted to $8,000,000. The task of cutting thru the hill was stupendous. The cut is 1,300 meters long, and 80 per cent. of this was thru solid rock. It has an average

[1] The Bergen Archways is the name given to the Erie Railroad open cut thru Bergen Hill, Jersey City, N. J.

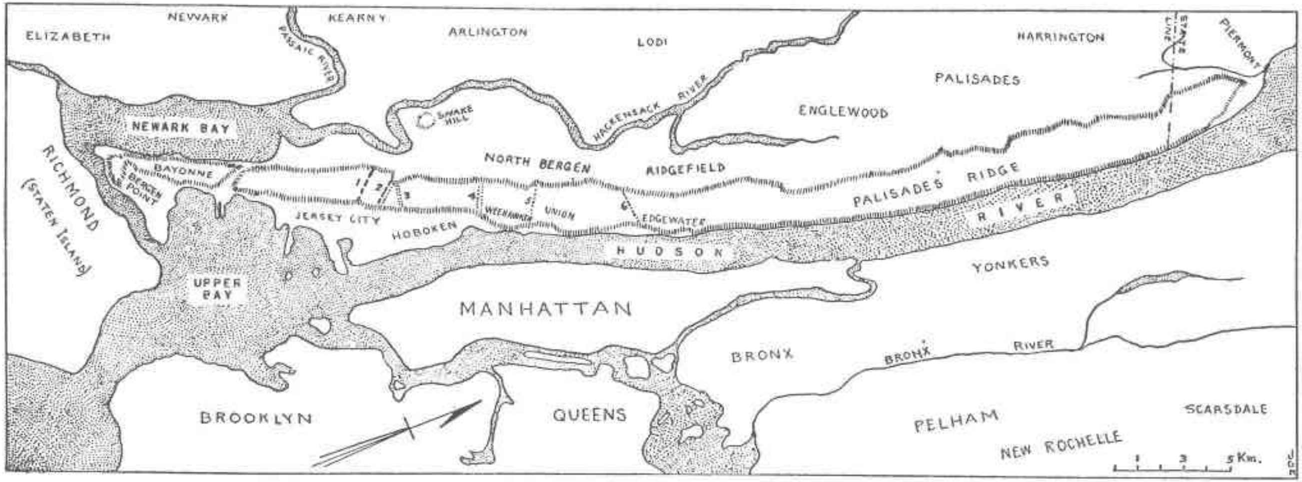


FIG. 1. Map of the Bergen Hill—Palisades Region.
Showing location of railroad cuts and borings thru the ridge.

1. Pennsylvania Railroad cut. 2. The Bergen Archways and Erie Railroad tunnel. 3. Delaware, Lackawanna & Western Railroad tunnels. 4. Pennsylvania Railroad tunnels connecting with tubes under the Hudson River. 5. West Shore Railroad tunnel. 6. New York, Susquehanna & Western Railroad tunnel.

depth of 25 meters and is 17 meters wide at the bottom. It is for the most part open, but intersecting streets made it necessary to tunnel nearly 400 meters in all. One hundred and twenty-five thousand cubic meters of earth and 500,000 cubic meters of rock were taken out.

The progress of the work was closely watched by local collectors and at first did not hold out much prospect for specimens. Later, when the work was well under way, minerals began to come out. The writer's first visit to the cut was about the time the dirt covering had been removed and of course no specimens were found. Sometime later, thru a letter of introduction to the resident engineer, Mr. F. B. Moorshead, free access to the cut was obtained.

In constructing the cut the work was divided into four sections. In the first three sections, commencing from the easterly end, practically no minerals were found. In cut No. 4, between Bevans Street and the Hudson Boulevard, a view of which is shown in the frontispiece, was located the mineral zone, and every mineral here noted came from that section. The specimens were found in almost vertical veins and as the workings became deeper these veins looked like bands of ribbon running down the sides of the cut, ranging in width from less than a centimeter to open ellipsoidal cavities almost wide enough to insert one's head and shoulders. At first the rock was taken to a dump a short distance away, but as the work progressed most of the material was put thru a crusher and made into road metal. The rock was removed with such speed that there was little chance to examine the material before it was loaded into cars and taken away. To obtain specimens it was therefore necessary to go into the workings and prospect among the rocks soon after a blast. The writer was able to devote three or four hours a week for about a year to collecting at the cut, and obtained a bountiful supply of minerals. On some of the trips a load of specimens weighing 25 kilograms (55 pounds) would be obtained in a half hour's work. As the rock was being put thru the crusher night and day it is no exaggeration to say that tons of good mineral specimens were lost.

Among the zeolites and related minerals found were: stilbite, laumontite, gmelinite, analcite, natrolite, apophyllite, pectolite and datolite, and of common occurrence with these were quartz, calcite, pyrite, chalcopyrite, sphalerite and diabantite. While the minerals from the extrusive basalts of West Paterson, Great Notch, and Upper Montclair, are found in cavernous openings, amygdules, vugs, etc.,. the Bergen Archways minerals were confined to veins. Prehnite, heulandite and thomsonite, found so abundantly at the former localities, were not noted, tho Dana lists these minerals from Bergen Hill. A brief description of minerals found by the writer follows; they are taken up in the order of the genetic table of minerals of zeolite deposits, prepared by Mr. Gordon.[1]

Diabantite: A chlorite mineral provisionally assigned to diabantite was found in seams and crevices of the trap, in foliated and concentric forms, of a greenish black color. During the construction of the cut there were a number of accidents to the laborers caused by the material sliding after a blast. No doubt it was the presence of this chlorite as the binding material that caused the rock to slip; for it is very greasy in nature, and in fact was not inaptly called by the workmen "soapstone."

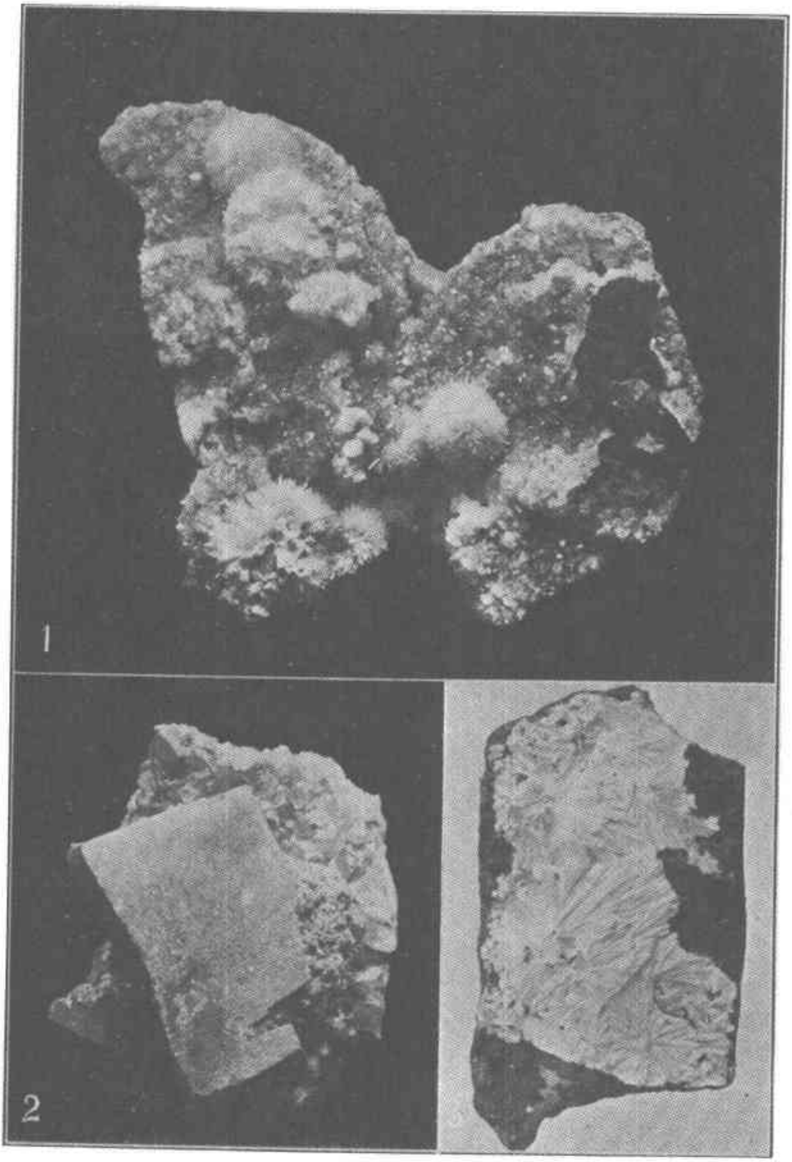
Pyrite: This mineral was of frequent occurrence and, in fact, upon almost every specimen collected at least traces of it could be found. This is interesting when it is considered that there is no record of pyrite having been found in the trap rock at the Paterson or Hopewell, N. J., quarries.[2] Those noted were of the common cubic form, ranging in size from microscopic to 4 mm. in diameter. Calcite crystals showing a second growth of crystal faces were found that contained numerous minute pyrite crystals on the original faces, but none on those of the second growth.

Chalcopyrite: Several specimens of chalcopyrite crystals were found embedded in the diabantite coating the trap rock. Small tetragonal crystals were noted on a crystal of calcite. Some vein material was found containing a center of calcite with two outer edges consisting of feldspar. By etching out the calcite there were exposed at the point of contact beautiful crystals of chalcopyrite and pyrite. Other specimens, after etching out the calcite would show the chalcopyrite embedded in clusters of small milky quartz crystals attached to the vein wall. Vein material was also found filled solidly with pectolite, and lying between the pectolite and the vein wall would be crys-

[1] A review of the genesis of the zeolite deposits of First Watchung Mountain, N. J. S. G. Gordon. *Am. Min.*, 1 (5), 80, 1916.

[2] Absence of pyrite from certain zeolite localities. J. Volney Lewis. *Am. Min.*, 1(6), 92, 1916.

PLATE 11.



MINERALS OF THE BERGEN ARCHWAYS

1. NATROLITE ($\frac{1}{2}$)

2. CALCITE ($\frac{1}{3}$) 3. PECTOLITE ($\frac{1}{2}$)

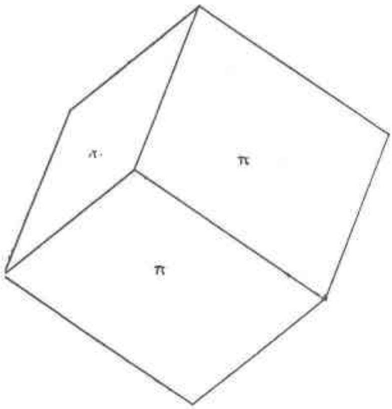
tals of chalcopyrite. A description of some crystals obtained from one of the calcite filled veins is presented by Dr. Edgar T. Wherry, at the end of this paper.

Sphalerite: This was occasionally found in black massive crystalline aggregates with few crystal faces, associated with calcite, datolite and stilbite. The largest specimen measured about 7 cm. in diameter.

Quartz: While quartz is plentiful in the crevices of most New Jersey traps, very little was noted at this locality, and then only lining the narrow veins filled with calcite. By etching out the calcite, clusters of small milky quartz crystals would be exposed.

Calcite: Calcite crystals occurred in abundance, in sizes up to 12 cm. in diameter. Many resembled those taken from the old Erie tunnel, over fifty years ago. They were mostly of an amber yellow color, but owing to a slight roughening on the crystal faces, were seldom transparent (Plate 11, Fig. 2). However, a few transparent specimens were found, and in color resembled the beautiful golden brown calcites from Joplin. Occasionally a large crystal would be found broken, and this would furnish fine specimens of clear calcite of the Iceland spar variety. Crystals were found of simple rhombohedral habit embedded in a matrix of pale green datolite, and scattered over the whole are small flake-like crystals of stilbite. Clusters of calcite crystals associated with datolite and stilbite, their order of sequence invariably being a base of datolite, then calcite and then stilbite, which sometimes would be followed by another layer of small calcite and pyrite crystals. One specimen 12 cm. in diameter is a fine example of twinned rhombohedrons. "Paper-spar" crystals implanted on rhombohedrons, and stilbite crystals implanted on and at right angles to the rhombic faces of the paper-spar crystals, but not on the edges of the crystals, were also noted.

There were also taken out compound crystals consisting of two superposed habits corresponding to two generations of calcite deposition. The earlier generation is represented by crystals of a simple rhombohedral habit consisting of the negative rhombohedron (Fig. 2, *a*). In a number of instances these rhombohedral elements occur uncombined with the combination of the later generation and attain a size of 5 cm. on an edge. They have in these instances a markedly cubic aspect. The compound crystals which were noted consist of the rhombohedral element noted above, upon the polar angles of which are superposed in parallel position the scalenohedral combination shown in figure 2, *b*. The compound crystals average 10 mm. in vertical length.[1]



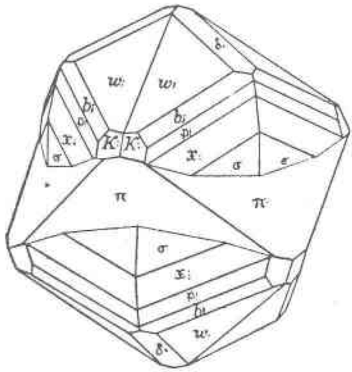


FIG. 2*a* Calcite FIG. 2*b*

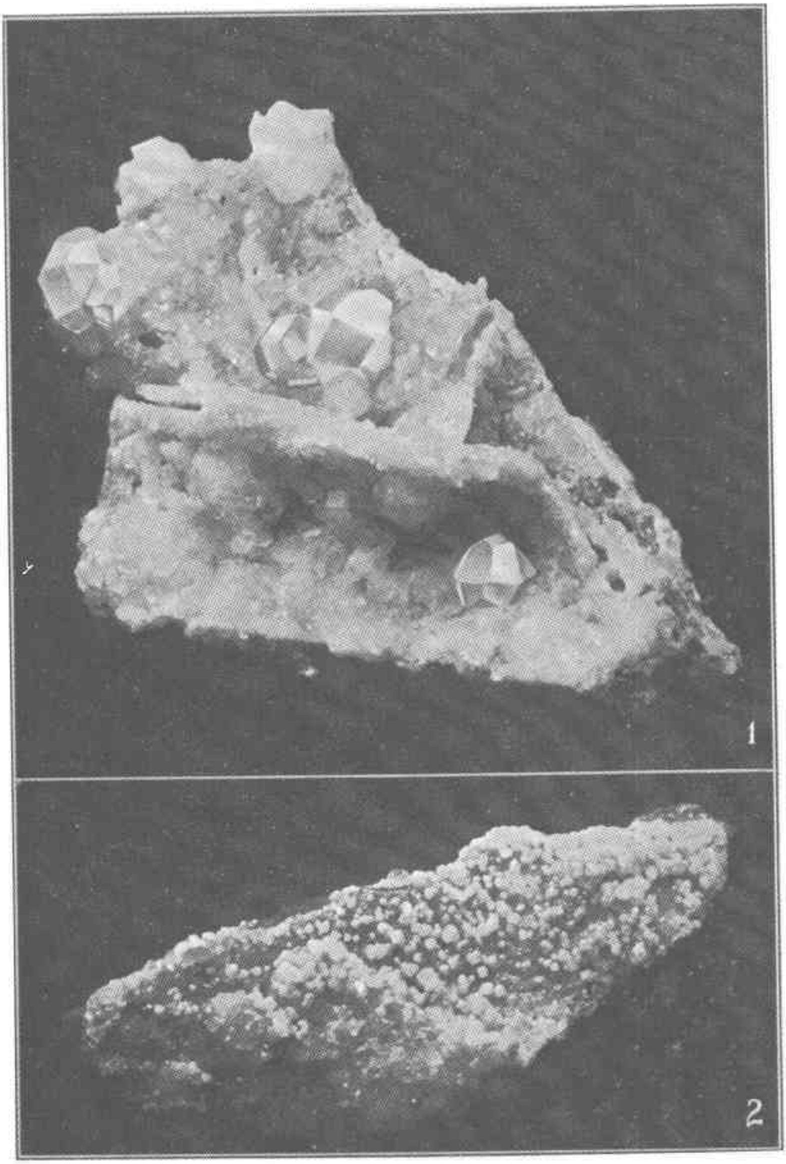
ANALCITE: One of the most striking minerals of the zeolite group is analcite. It is not as common as some of the other zeolites one meets with in the New Jersey trap rocks. Remarkably fine specimens were found, consisting of nearly transparent colorless crystals, of ideal symmetry, embedded in a matrix of beautiful pale green datolite crystals, some of the latter showing small crystals of datolite implanted on the larger ones, evidently a second generation (Plate 12, Fig. 1). Other specimens showed analcite of a milky color deposited on datolite and on calcite, with beautiful apophyllite crystals on the analcite (Plate 12, Fig. 2). Still others showed analcite crystals on apophyllite. This series of specimens makes an interesting illustration of the varying sequence of these minerals.

GMELINITE: One of the most interesting minerals collected was gmelinite, which is not common at Bergen Hill. There were found several specimens of twinned gmelinite of a pinkish color, corresponding in forms to fig. 1, p. 593, in Dana's System, associated with datolite, apophyllite, and diabantite.

PECTOLITE: This mineral is often met with in New Jersey trap rocks, but after many visits to the cut it seemed as tho it

[1] Some Parallel Groupings of Calcite Crystals from the New Jersey Trap Region. H. P. WHITLOCK. *Fifth Rept. Dir. N. Y. State Museum*, **1908**, 219.

PLATE 12.



MINERALS OF THE BERGEN ARCHWAYS
1. ANALCITE ($\frac{2}{3}$) 2. ANALCITE ($\frac{1}{3}$)

was never coming out; as the workings became deeper, however, pectolite came to view. It was found in a number of interesting forms. Columnar or fibrous masses, with fibers often 10 to 12 cm. long, were very glassy and strongly triboluminescent. Some groups of stout crystals had fine terminations, which is quite rare for this mineral. Sometimes specimens of the trap rock would be found with a faint white streak no wider than a pencil line. On breaking the rock along this line, a very thin layer of pectolite of silky luster would show the familiar radiations of this mineral (Plate 11, Fig. 3). Another type was grouped cornucopia-shaped aggregates of fine capillary crystals with more or less space between each. No doubt this arrangement was caused by some alteration in the original mineral (Plate 13, Fig. 4). One slab 12.5 x 20 cm. is coated with datolite crystals, the datolite being partly covered by rhombohedral crystals of calcite and fine prisms of apophyllite, with silky tufts of pectolite implanted on both the calcite and apophyllite crystals.

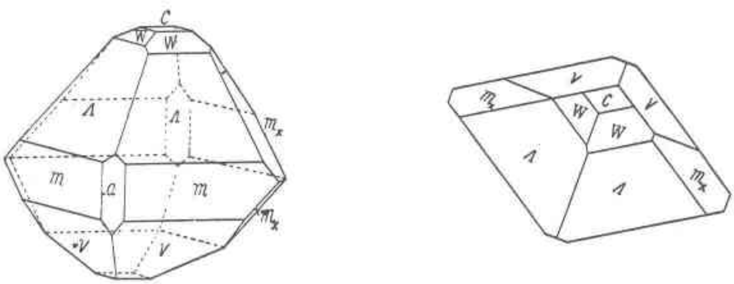


Fig. 3. Datolite

Datolite: A mineral of many forms is datolite, and the Erie cut was extremely prolific in it. To this locality must be given credit for producing single crystals of datolite completely and symmetrically developed, showing on the surface no evidence of previous attachment to other minerals (Plate 13, Fig. 2). They are colorless, perfectly transparent and their faces have a brilliant luster. Their size ranges from microscopic to 8 mm. in diameter. But of chief interest is the almost ideally symmetrical development which they possess, a thing of considerable rarity among datolite crystals.[1] (Fig. 3). The first lot of these crystals was found loose in the material on the ground just below a vein in

[1] Crystals of Datolite from Bergen Hill, N. J. W. E. Ford and J. E. Pogue. *Am. J. Sci.*, [4], **27**, 187, 1909.

the trap rock. Later one specimen of rock was found the surface of which was coated with a filamentary mineral resembling asbestus. The matted filaments, when mounted in balsam, were found to entangle a multitude of microscopic crystals of several minerals easily distinguishable from each other in polarized light.[1] Embedded in this were single crystals of datolite, apophyllite and laumontite. Some of the larger crystals of datolite under the microscope show inclusions of a fine, hair-like, asbestiform mineral. It is probable that the datolites, on crystallizing out of the vein-filling solution, attached themselves to these threads or filaments. As the datolite crystals increased in size and weight, and the solutions which tended to support them withdrew, the asbestus fibers could no longer stand the strain and they fell to the bottom of the cavities. Fine colorless transparent crystals of datolite were also found lying in the angular spaces between interpenetrating rhombohedrons of calcite. Others were noted as inclusions in a large crystal of amber yellow calcite.

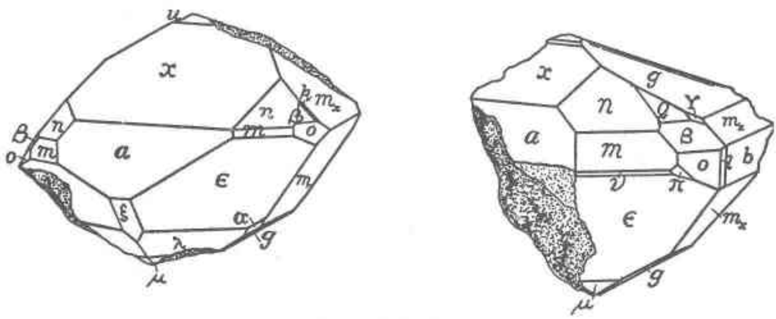
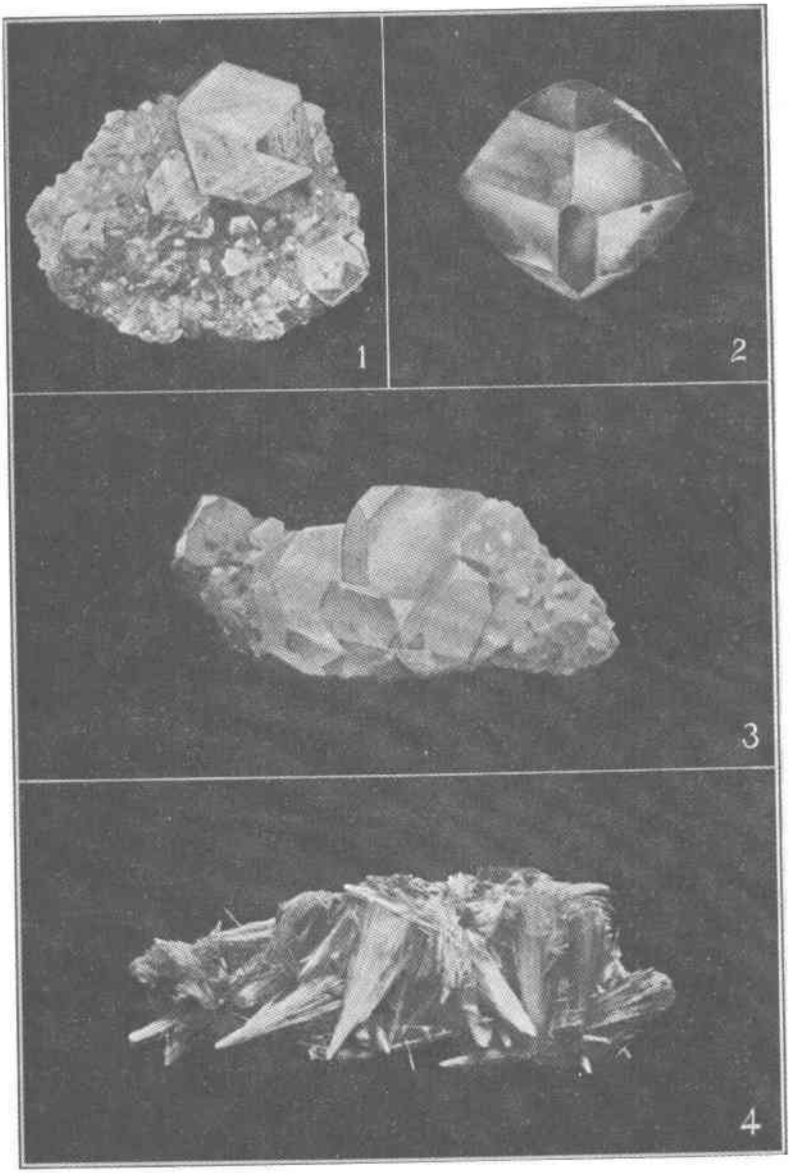


FIG. 4. Datolite

Mr. H. P. Whitlock, in studying a number of specimens sent to him, found that all four types described by E. S. Dana from the original Bergen Hill locality were represented by the Erie cut crystals, and in addition two forms apparently new to the species were encountered (Fig. 4). Of the new forms, k (132) was noted on ten crystals of the suite measured as an exceedingly narrow series of planes. In several instances only one plane of the form was noted on a single crystal. The pyramid Y (255)

[1] On the Origin and Sequences of the Minerals of the Newark Igneous Rocks of New Jersey. W. G. LEVISON. *Bull. N. Y. Mineralogical Club*, No. 2, p. 19, Dec. 1909.

PLATE 13.



MINERALS OF THE BERGEN ARCHWAYS

1. APOPHYLLITE ($\frac{7}{10}$)
2. DATOLITE ($\times 3$)
3. APOPHYLLITE ($\frac{1}{2}$)
4. PECTOLITE ($\frac{2}{3}$)

was observed on only one of the crystals measured. The single plane of this form noted is small but well defined and gave a fair reflection of the goniometer signal.[1]

APOPHYLLITE: Apophyllite crystals were found abundantly in various forms, mostly associated with datolite and analcite; the most common form being the cuboid, with striated diametral prism *a*, pearly base *c*, and well developed pyramid (Plate 13, Fig. 1). Some of the crystals are brilliant, glassy, and almost transparent, and, being embedded in a matrix of pale green datolite crystals, make very attractive specimens. Others are of a milky color and resemble those found in the West Paterson quarries. Another form of apophyllite not so common is the thin tabular habit, similar to that from Lake Superior, as figured in Dana; these are associated with fine crystals of white analcite (Plate 13, Fig. 3). Implanted on large crystals of apophyllite are clusters of apophyllite prisms about 1 x 4 mm., terminated by *p* and *c*, all transparent, and evidently secondary. One group of crystals on altered trap is a fine example of apophyllite altering to pectolite. The basal planes on most of the apophyllites collected are coated with a sprinkling of minute crystals of pyrite suggesting pepper dust.

Among the lot is one crystal showing a new pyramid for this mineral (Fig. 5). The crystal is quite clear and colorless, measures about 4 cm. in vertical length and is partly embedded in a matrix thickly encrusted with small apophyllite crystals. The pyramid is present as a series of eight narrow but well developed planes, truncating the edges between the *a* and *p* faces, The angles measured for this form correspond to the indices (711) and the letter *h* has been assigned to it.[2]

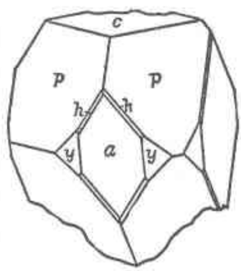


FIG. 5. Apophyllite

The entire lot of specimens collected is a typical collection in itself, showing as they do all the usual forms of apophyllite, with several not so common; and crystals altering to pectolite are but rarely found anywhere.

[1] Additional Note on Datolite from the Erie Cut, Bergen Hill, N. J. H. P. WHITLOCK. *School Mines Quart.*, **31** (3), 225–30, 1910.

[2] Apophyllite from the Erie Cut, Bergen Hill, N. J. H. P. WHITLOCK. *School Mines Quart.*, **31** (3), 231, 1910.

NATROLITE: Another member of the zeolite family popular with collectors is natrolite. Fine specimens of radiating groups, associated with datolite, apophyllite and pyrite, were found. Tufts of natrolite made up of groups of stout crystals with the "picket-fence" terminations were taken out and are probably as good as those from any locality (Plate 11, Fig. 1).

LAUMONTITE: Found only in microscopic crystals of the common form, showing the prism *m* and oblique termination *e*, entangled with microscopic crystals of datolite and apophyllite; the whole mass held together by an asbestiform mineral.

STILBITE: Sheaf-like aggregates of stilbite crystals were rare; those noted were mostly flattened six-sided crystals coating datolite and calcite. A specimen was found showing individual crystals of stilbite, tabular in habit with the forms shown in Dana's System, Fig. 3, and a millimeter or two in diameter. The outer portions of these crystals are colorless and transparent, but each contains an opaque white nucleus or "phantom" crystal, with the same shape as the crystal as a whole, and occupying about half its volume.

CHALCOPYRITE CRYSTALS FROM THE BERGEN ARCHWAYS

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The crystals of chalcopyrite mentioned by Mr. Manchester in the preceding paper[1] as brought to view by dissolving out calcite vein material proved to be well suited to crystallographic measurement, which was undertaken by the writer, using a Goldschmidt 2-circle goniometer. Two types were found to be represented.

In Type 1, the average development of which is shown in figure 1, the unit sphenoid, *p* (111) is dominant. The negative unit sphenoid, *p*, $(1\bar{1}1)$, is always present as small to medium sized faces, and the base, *c*, (001), as a well-marked narrow face. In addition the prisms *a* (100) and *m* (110) are distinctly developed, tho mostly only in the midst of striations, and the second-order pyramid *e* (011) occurs similarly, in marginal striations. The figure shows, in somewhat idealized manner, the positions of these forms and of the striations observed on a single crystal.

[1] The Minerals of the Bergen Archways, *Am. Min.*, **4** (9), 110, 1919.