that the presence of the needles is one of the early phases of the replacement of bornite by chalcopyrite.

(5) Fig. 4 illustrates one of the common relationships between the two minerals. Here finger-like masses of chalcopyrite show an elongation and somewhat rectilinear outlines parallel to the orientation of the two sets of needles. This case exemplifies one of the later stages in the replacement of the bornite, which is interpreted as the development of the finger-like masses by the enlargement and coalescence of the chalcopyrite needles with the retention in general of an orientation parallel to the cleavage planes of the bornite.

The mineragraphic evidence, therefore, seems to substantiate the field evidence that chalcopyrite is replacing bornite; and it also draws attention to one other case of the lack of homogeneity of the mineral bornite.

MINERAL LOCALITIES IN THE VICINITY OF MIDDLETOWN, CONNECTICUT

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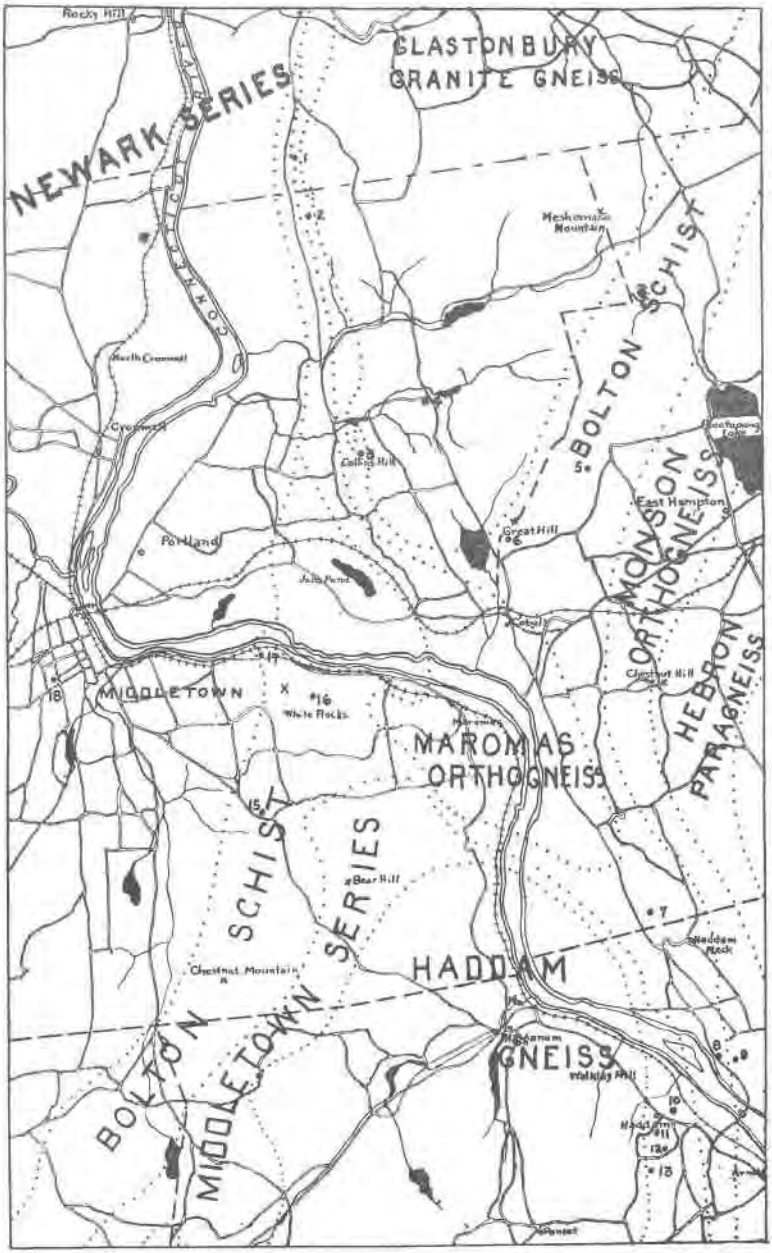
A few of the pegmatite quarries in the vicinity of Middletown, from which minerals have been taken in the past, are still being worked. Many others have been abandoned, and their locations may be lost, if a permanent record is not somewhere preserved. It was with this thought in mind that the following paper was written.

Of the many feldspar prospect-holes opened in Middlesex and adjacent portions of Hartford counties, Connecticut, fourteen may be selected as more or less famous for the minerals they have produced. The entire group lie within a radius of 14 kilometers (9 miles) of Wesleyan University (Locality 18, Fig. 1). The Connecticut pegmatite dikes are composed of predominating quartz and perthitic feldspar with some muscovite and biotite. Most of the gem minerals occur in pockets from a few centimeters to over one meter in diameter. Some of the larger pockets have shown quartz crystals 6 decimeters long, and 3 decimeters in diameter. Perthite crystals with well developed planes have equalled the quartz in their dimensions. These minerals project from the walls of the cavities, and are covered by platy crystals of cleavelandite which form a background for the rarer minerals.


Rocky Hill
GLASTONBURY GRANITE GNEISS
NEWARK SERIES
CONNECTICUT
Meshomasic Mountain
BOLTON SCHIST
North Cromwell
Cromwell
Portland
Great Hill
MONSON ORTHOGNEISS
East Hampton
MIDDLETOWN
White Rocks
MAROMAS ORTHOGNEISS
HEBRON PARAGNEISS
Bear Hill
Chestnut Mountain
HADDAM GNEISS
Haddam Neck
BOLTON SCHIST
MIDDLETOWN SERIES

Eight of the fourteen localities occur in the Bolton schist, and four others lie within the Middletown series of metamorphic sediments which are closely allied to the Bolton schist. Only two localities are found in orthogneiss, the Pelton quarry (Locality 4), east of Collins Hill and within the Glastonbury gneiss, and a locality from which precious beryl has been taken (Locality 9) near the Gillette quarry, south of Haddam Neck. These facts attain greater significance when the map accompanying this paper is studied. Pegmatite dikes occur within the gneisses, as well as within the schists, and the gneisses outcrop over far larger areas than the schists, yet the important mineral localities are confined almost exclusively to a narrow band of schist surrounding the Glastonbury gneiss and lying between the Monson, Maromas and Haddam gneisses. It would appear that the pneumatolytic fluids were squeezed out of the granites, and collected in the tightly folded sediments within the zone of contact metamorphism.

Taking up the mineral localities in order, the Husband quarry (Locality 1) is still being worked. A number of the older and larger pits are abandoned, but new excavations are being made. The feldspar is rated as of high quality by the trade, and yet it has proved relatively poor in rare minerals. Torbernite is the only rare mineral which may readily be found. Molybdenite and rose quartz are occasionally encountered.

Southward along the state road from Glastonbury there are a number of quarry openings. The only one which has produced rare minerals is the Hale or Andrews quarry (Locality 2), situated just south of a small stream at an elevation of 55 meters (180 feet) approximately. The quarry is no longer worked, but in its day it was one of the best in the region. Large, well formed monazite crystals (2 to 3 cm. in diameter) were found here, and are not known elsewhere in the district. Other minerals were molybdenite, sphalerite, rose quartz, zircon, columbite, massive green apatite, purple heterosite (secondary after triphylite), and uraninite. The uraninite analyzed by Hillebrand[1] in 1889 was from this quarry. It will be noted that the quarry is within the limits of the town of Portland, not in Glastonbury as stated in most references. A single blast about the year 1884 yielded 100 kilograms or more of columbite, the largest single yield from one pocket known in this vicinity. The entire mass was without crystalline planes.

[1] *Bull. U. S. Geol. Surv.* No. 78, 43, 1891.

Of the quarries active at the present time, the Strickland quarry at Collins Hill, Portland (Locality 3), is the most productive, and the best known.[2] Mr. F. E. Strickland, the owner, is an expert on the minerals of his quarry, and saves carefully any unusual crystals. The quarry was opened as early as 1840. There is a pitcher, bearing in gilt the name of Strickland, now preserved in Wesleyan Museum, which was made from feldspar taken from the quarry at that early date. For many years the quarry was inactive, but recently it has produced the best grade of feldspar known in the region. It is the only quarry in this part of Connecticut which has yielded asbestiform tourmaline, purple apatite, lithiophilite, and nailhead calcite. The greater part of the uraninite from Portland has come from a small area near the hanging wall of the quarry. Other minerals reported are sphalerite, pyrite, smoky, rose, and citrine quartz, pink (caesium) and aquamarine beryl, garnet, microcline, cleavelandite, spodumene, pink and green tourmaline, muscovite, biotite, lepidolite, cookeite, pinite, kaolinite, columbite, purple, and massive green apatite, and autunite. While not strictly a pegmatite mineral, iolite has been found within the Bolton schist a few centimeters from its contact with the pegmatite.

The Pelton quarry (Locality 4) has long been inactive. It probably produced a number of rare minerals in its day, but it is now known as the source of two minerals, unique for the region, bismutite and samarskite. Beryl and crystals of muscovite from the locality may be found in the Wesleyan museum. Another quarry long inactive is the Nathan Hall quarry (Locality 5). It is still noted for the abundance of the rose quartz to be obtained from its dumps. No other quarry compares with it in its yield of this mineral.

The Swanson quarry (Locality 7) lies far back from the road, along a cart-path leading east from the main road past the relatively new Swanson homestead. It is a road (not shown on the map) which follows the township line. Although the opening is not worked now, there is a great deal of lepidolite to be found, and some triplite. Within the district triplite has been found only at this quarry. The mineral is intimately intergrown with a dark blue, massive tourmaline. It was with the expectation that

[2] An article on this locality, by Earl V. Shannon, has already appeared in this magazine: *Am. Min.*, **5** (3), 51-54, 1920.

the lepidolite might be shipped to Germany as a source of lithium that the quarry was opened, just before the war. It is reported that shipments got no farther than the dock.[3]

The Gillette quarry (Locality 8) may be reached by automobile from Portland or Cobalt, but is probably more easily found by crossing the river from the Valley Division of the New York, New Haven, and Hartford railroad, leaving the train at Haddam, and taking a little used ferry directly to the quarry. The Haddam Neck locality, by which is usually meant the Gillette quarry, is one of the best known mineral localities in the United States. The quarry was abandoned a number of years ago because it had been worked to such a depth that it was impossible to keep out water. It was worked for a time by a New York jewelry company for its gem tourmalines. It is said that the last blast made by Mr. Gillette revealed a gem pocket from which tourmalines were taken which were sold to a New York museum for $700. Green, pink, "watermelon," and yellow varieties of tourmaline are known from the locality. Other minerals discovered are red fluorite, smoky quartz, microcline, albite, golden, pink (caesium) and aquamarine beryl, muscovite, biotite, lepidolite, cookeite, microlite, and white apatite. The muscovite is unique in that it occurs as sheaf-like aggregates of fibrous, columnar crystals, 4 cm. in diameter and 2 cm. in length. The crystals are attached by a small area at the side, and are so compact that an analysis was made before the determination was established. At present there is little to be found at the quarry.

On the hillside east of the Gillette quarry, and slightly south of a building stone quarry in the Monson gneiss from which blocks for the construction of Fort Hamilton in New York harbor were obtained, there was opened, 30 or 40 years ago, a pocket-like depression from which a number of valuable aquamarines were taken. The depression (Locality 9) was only a meter or two across, and is now overgrown with brush. The aquamarines were peculiar in that the greater part of the crystals were not of gem quality. Five millimeters or less from their tops they became clear and beautifully colored. A few of the crystals may be found in old collections.

On the west side of the river in the vicinity of the village of Haddam, there are a number of old mineral localities. Mr. E. W.

[3] Compare Shannon, *Am. Min.* **5** (4), 82-84, 1920.

Hazen of Haddam kindly conducted Professor W. N. Rice and the writer to several of the openings last summer. One of the chance finds of the region was made in a roadside quarry, later used as a cellar (Locality 10). A number of chrysoberyls and garnets were unearthed, but there is no record that other minerals were found. The house built over the site was later removed. No further attempts were made to obtain more minerals.

On the hill across the road from this locality there is an abandoned quarry on land owned by Mr. Hazen (Locality 11) from which small plates of autunite may be obtained. Following the pegmatite ridge southward the Haddam epidote locality is reached. (Locality 12). A number of old collections have well crystallized specimens of clear epidote from this opening. There is a blast hole at the foot of a steep slope facing toward the east where the pegmatite dike dips beneath the meadow. With pick and shovel the moss and rubble were removed, and a limestone was disclosed in contact with the pegmatite. At the contact the limestone is transformed to epidote and garnet. Pockets of the more finely crystallized epidote are included in the more massive material. There have been no transparent crystals found at the locality for a number of years.

The road which lies to the south of the epidote locality leads toward the west and crosses a small brook. A hundred meters or so beyond the brook one climbs to the crest of a pegmatite ridge. Going southward along the crest for two hundred meters, one comes to the Tims Hill Locality (Locality 13). Associated with the contact of the Haddam gneiss with the Middletown series there is a peculiar type of pegmatite consisting of oligoclase, biotite, short, doubly terminated black tourmalines (5 to 10 mm. in length), and crystallized iolite showing alteration to fahlunite. Gahnite and allanite are also reported from the locality. Professor Rice and the writer attempted to relocate the blast hole from which the iolite came, but without success. Professor Rice had visited the locality many years ago, and had detailed notes on its situation. It was very apparent that we were in the immediate vicinity, but no trace of the peculiar pegmatite could be obtained.

There are a large number of quarry openings along the state highway between Middletown and Haddam. None of them, however, is known to have produced rare minerals, except the Toll Gate quarry (Locality 15). The opening has been long since

abandoned, and is fast being overgrown. It is situated slightly north of the highway. The road cuts across the southern end of the dike in making an abrupt turn to the southeast. In addition to the usual tourmalines and beryls, the quarry is known for the large size of a number of columbite crystals which were taken from it many years ago.

The ridge of pegmatite dikes through which the Connecticut river has cut in passing from the Newark sandstones to the crystalline rocks of the Eastern Highland is a prominent feature in the landscape as one looks eastward from Middletown. The ridge is known locally as White Rocks. Somewhat east of the ridge most conspicuous from Middletown, and south of the river, there is a feldspar quarry (Locality 16) which has been intermittently worked for a number of years. The locality is not especially rich in rare minerals, but occasionally odd varieties of the pegmatite types may be found. Opaque pink and green tourmalines may now be obtained. Lepidolite, uraninite, zircon, columbite, large, opaque beryls, microlite, and garnet are other minerals reported from the locality in the past.

Character of the Pegmatitic Intrusions

It may not be out of place to make a brief statement concerning the method of intrusion of the pegmatite dikes into the Bolton schist. The exposures at the Strickland quarry are interesting in making clear the character of the intrusions. The bodies are not, usually, cross-cutting as would be inferred by the use of the term "dike." The magma, while still in a fluid or viscous condition, seems to have been folded into the pliant schist, as putty is folded into the rolls of the paper in which it is contained. Thus, while the magma was intruded during the Appalachian mountain-building of New England, it crystallized after that event, and has not been rendered schistose by any subsequent movements. The shattering of the walls of some of the gem-pockets in the pegmatite tells of violent disturbances by earthquake movements, and the recementation of the fragments by pneumatolytic minerals, such as tourmaline and apatite, indicates that openings have allowed gases to escape from deep-seated sources. But there have been no crushing movements to metamorphose the pegmatites as a whole.

Mineral Localities Not Pegmatitic in Origin

There are two or three mineral localities in the vicinity of Middletown which are not associated with pegmatite dikes. The best known of these is the Old Silver Mine, situated approximately three kilometers east of the center of the city (Locality 17). During the Revolutionary War the mine was worked for lead, which was fashioned into bullets. Slash veins occur in the crush zone along the great fault between the Bolton schist and the Triassic conglomerates. The minerals found are galenite, sphalerite, pyrite, marcasite, chalcopyrite, quartz, calcite, and fluorite. The pyrite is frequently found in cubes, elongated parallel to one axis. Dana describes it as "capillary" pyrite, but the diameter of the rods is generally too large for such an appellation.

South of Great Hill, north of Cobalt (Locality 6), at an elevation of approximately 450 feet, disseminated masses of chloanthite, and niccolite are found in the Bolton schist. Arsenopyrite and löllingite are found in quartz veins associated closely with the cobalt minerals. The locality has been worked over so frequently that there are few specimens to be obtained at present.[4]

In the bed of the brook north of the village of Higganum (Locality 14) well formed magnetite crystals occur in red pegmatite in the Haddam gneiss. The occurrence is only interesting in that such perfect crystals of magnetite are rare in the district.

Résumé

The following is a list of thirty-eight minerals which have been reported from the pegmatite dikes in the vicinity of Middletown, Connecticut.

Molybdenite,	Microcline,	Tourmaline,	Monazite,
Sphalerite,	Albite,	Muscovite,	Apatite,
Pyrite,	Oligoclase,	Biotite,	Triplite,
Fluorite,	Spodumene,	Pinite,	Lithiophilite,
Quartz,	Beryl,	Lepidolite,	Triphylite,
Magnetite,	Iolite,	Cookeite,	Torbernite,
Gahnite,	Garnet,	Kaolinite,	Autunite,
Chrysoberyl,	Zircon,	Microlite,	Uraninite.
Calcite,	Epidote,	Columbite,	
Bismutite,	Allanite,	Samarskite,	

[4] Shannon, *Am. Min.* **6** (5), 88-90, 1921.

Seven other minerals are found, either at the Great Hill locality, Cobalt, or at the Old Silver Mine. The list includes the following minerals, making a total of forty-five more or less rare minerals from the region, of which twenty-two have been found at the Strickland quarry.

Chloanthite,	Galenite,	Arsenopyrite,	Chalcopyrite.
Niccolite,	Marcasite,	Löllingite,	

A STUDY OF THE CONSTITUTION OF THAUMASITE

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The empirical formula of thaumasite has been shown by several analyses to be $CaCO_3.CaSO_4.CaSiO_3.15H_2O$. Penfield and Pratt[1] considered the mineral a silicate, but Wherry[2] has shown it to be more probably a sulfate, crystallographically related to connellite and hanksite. He points out that at the West Paterson locality the thaumasite has been formed by the action upon anhydrite of solutions capable of depositing calcite and zeolites. Penfield and Pratt made a study of the rate of dehydration of the mineral, and concluded that it contained thirteen molecules of water and four hydroxyl groups. A later study of the dehydration curve by Merwin[3] indicated fourteen molecules of water and two hydroxyl groups. Wherry's interpretation fits in best with the latter.

This paper is an attempt to decide between these interpretations of the water content, by means of the theory of molecular refractivity, which affirms that the molecular refractivity of a compound is equal to the sum of that of its components.[4] While this theory was developed with especial reference to organic liquids, it also holds well for inorganic solids;[5] and altho the crystallinity and consequent anisotropism may affect its applicability slightly, the deviation is not enough to vitiate the results arrived at in a study such as the present one.

[1] Penfield, S. L., and Pratt, J. H.: *Am. J. Sci.*, (4), 1, 229, 1896.

[2] Wherry, E. T.: *Proc. U. S. Nat. Mus.*, **54**, 373, 1918.

[3] Merwin, H. E.: *J. Wash. Acad. Sci.*, 4, 494, 1914.

[4] The refractivities are preferably calculated by the Lorentz-Lorenz formula: $R=\frac{n^2-1}{n^2+2}\cdot\frac{M}{d}$, where n is the mean index of refraction, M the molecular weight, d the specific gravity, and R the molecular refractivity.

[5] Pope, W. J.: *J. Chem. Soc.*, **69**, 1530, 1896.