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Geology of the Charlemont-Heath Area, (with special reference to pyrite and copper deposits)

by

Alonzo W. Quinn 1899-

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Cooperative Geologic Project
of the
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Geological Survey

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Illustrations

Introduction

Within the vaguely-defined "mineral belt" extending from Rowe to West Cummington, Massachusetts (Figure 1) occur deposits of pyrite, copper, zinc,

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Figure 1. Key map showing locations of A. Plainfield-Hawley and B. Charlemont-Heath areas, Massachusetts.

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iron, and manganese. The southern half of the area, wherein lie the manganese and iron deposits, is described in another report.1/ The northern half, which

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1/ Geology of the Plainfield-Hawley area; manuscript completed

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is the subject of the present report, extends from Hawley to Rowe, and includes the abandoned Davis pyrite mine, which was probably the most successful mine ever operated in Massachusetts, the Mary Louise Mine, and the Hawks Mine. Charlemont, the only railway point, is the largest ~~mine~~ town of this area. In this, as in the ~~report on the manganese deposits~~ Plainfield-Hawley area, a detailed study was made of the surrounding area as well as of the mine areas. Both studies were made under a cooperative program of the Massachusetts Department of Public Works and the United States Department of the Interior, Geological Survey.

Base maps used in this work are advance sheets of parts of the Plainfield, Rowe, and Heath quadrangles supplied by the Topographic Branch of the Geological Survey.

During the field studies, which were made in the summer of 1943, the writer was ably assisted by Mr. Gilbert Corwin.

Acknowledgments

The writer is pleased to acknowledge indebtedness to ~~the following people who furthered the work in one way or another.~~ Mr. Guy M. Gray who spent considerable time guiding us through the Mary Louise Mine, and to Professor M. P. Billings of Harvard

University spent several days in the field and contributed much toward the understanding of the complicated structures of the surrounding country rocks.

Previous studies

Emerson's report on the "Geology of Old Hampshire County, Massachusetts" (1898) is the most complete account of the geology of this area. These and other references are listed on page 28. Rutledge (1906), Wood (1911), Crosby (1932), and several volumes of the "Mineral Resources of the United States" (by Geological Survey before 1925) contain brief information about the mines. Dana (1885), Crosby and Brown (1888), Flint (1908), and Perry (1934) describe some of the minerals found in the area.

Topography and surficial deposits

Much of western Massachusetts is a maturely dissected wooded upland of considerable scenic beauty. The highest hills in the Charlemont-~~Rowe~~ Heath area are slightly less than 2,000 feet in altitude and the lowest valleys are about 500 feet above sea level. The local relief along the Deerfield River is somewhat over 1,000 feet.

Most of the valleys are sharp or have only narrow flood plains. Deerfield River flows almost at right angles to the average trend of the bedrock formations, and just upstream from the area of Plate 1 it is characterized by strikingly

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Plate 1. Bedrock geologic map of the Charlemont-Heath area, Mass.

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entrenched meanders. Some of the tributaries and the intervening ridges trend with the bedrock formations. The course of Mill Brook, which enters Deerfield River from the north at Charlemont, is approximately along the fault contact between the Hawley schist and the Goshen schist.

The hills are rounded and the uplands have such gentle slopes that much of the upland area is suitable for farming. There appears to be a marked abcordance of summits, which has been interpreted by some geologists as evidence of a peneplane level, called the New England peneplane.

Although the main topographic features are due to stream erosion, glaciation during the last Ice Age modified them to the extent of further rounding off the hills, forming steep, plucked slopes on the lee sides, and depositing both stratified and unstratified drift. In the northern part of the area glacial striations in bedrock trend almost north-south, but are as much as 40 degrees east of south in Plainfield. Erosion by the ice removed any residual soils which may have formed before glaciation as well as any gossan material on the mineral deposits.

The material eroded by the ice was later deposited as an irregular mantle of till that effectively hides large areas of the bedrock, and extensive deposits of sand and gravel in the valleys. Several of the larger valleys, especially that of Deerfield River, contain extensive deposits of such sand and gravel. Much of the bedrock, both in the upland and in the valleys, is thus obscured by deposits of glacial origin, rendering it difficult to trace formation boundaries and to discover mineral deposits.

Bedrock formations

General statement

The bedrock formations exposed in the area include the Savoy schist, the Hawley schist, and the Goshen schist, as named and described by B.K. Emerson (1898; 1917) _/; his interpretation of the age relationships is shown in the following stratigraphic columns:

_/ Dates and page citations in parentheses refer to works listed in the bibliography at the end of the report.

System	Formation	Map Symbol
Silurian	Goshen schist	Sg ; Sga
Unconformity		
Ordovician	Hawley schist	Oh
(formerly called lower Silurian)	Savoy schist	Os (Osm; Osc; Osq)

These formations are composed principally of beds of sedimentary origin. For the most part the original sediments were sands and clays; these became consolidated into sandstones and shales, which were later metamorphosed into the quartzitic and micaceous schist beds that are now exposed.

Some of the beds, ~~however,~~ were doubtless calcareous and accordingly were metamorphosed into hornblendic layers; however, some, perhaps the greater part of these hornblendic beds, or amphibolites, were of volcanic origin. A few light-colored feldspathic siliceous beds also appear to have been of volcanic origin, as discussed below.

Emerson (1917) considered the Savoy schist and the Hawley schist to be of Ordovician age, although no fossils have been found to support this conclusion. He placed the Goshen schist in the Silurian system, because of its unconformable relationship to the Hawley schist and because it, together with the Conway schist and the Leyden argillite, lies beneath the fossiliferous Bernardston formation of Devonian age, which is exposed in the vicinity of Bernardston, about 10 miles east of this area. The present work was not extensive enough to discover any new evidence regarding the ages of these rocks, except to reveal that structural evidence seems generally to agree with the conclusion that the Savoy schist is the oldest and the Goshen the youngest of the formations. Emerson's evidence for an unconformity between the Hawley schist and the Goshen schist is not confirmed in the area here studied; the relations between the two formations may better be explained by a fault between them, or by a greater original thickness of the Hawley formation to the north. There is, however, no definite reason for disagreement with Emerson's assignment of the Goshen schist to the Silurian system.

Savoy schist

The Savoy schist includes three main rock types: impure quartzite, quartz-muscovite schist, and amphibolite; a minor amount of chlorite schist is also included. These different types, together with various intermediate phases, occur as interbedded and generally discontinuous lenses. Certain beds, particularly of amphibolite, may be traced hundreds of feet in areas where exposures are abundant, but in the more common situation where outcrops are sparse and scattered, it is not possible to correlate beds or even zones with assurance.

In the area mapped the lower part of the Savoy formation is the more quartzitic, and to the north of the Deerfield River it was found feasible to map this lower quartzite as a separate facies. The mica schist stratigraphically above it is exposed in a strip 500 to 2,000 feet wide. For almost a mile and a half north of the Deerfield River, a belt of vaguely defined chlorite schist lies within the (mica) schist facies of the Savoy schist.

Good exposures of the quartzite facies may be seen around the Mary Louise Mine and on the hilltops to the southwest. At most of these places the quartzite is greatly contorted. Thin section studies reveal that the main constituents are quartz, untwinned oligoclase, and the micas, muscovite, and biotite. Garnet is generally not abundant in the quartzitic phases. Hornblende is common and all gradations may be found between quartzite and amphibolite, and between quartzite and muscovite schist. Accessory minerals include magnetite, ilmenite, pyrite, chlorite, apatite, and a variety of epidote having optical properties resembling those of zoisite. Near the Mary Louise Mine radial blades of chlorite may be seen, apparently an alteration of radial amphibole crystals.

Mica schist beds are generally light tan to silvery gray. Commonly the foliation planes show small crenulations. The main constituents are muscovite, quartz, garnet, and biotite. The garnets range in size from a pinhead to 3 centimeters in diameter; they cut across the foliation of the schist and are usually at small folds in the schist. Some of the garnets, in fact, appear to have been rolled during the metamorphism of the rock, giving a striking spiral pattern in thin section. Many of the biotite crystals are discordant to the foliation. Scattered grains of feldspar and bright-green chlorite are visible on many of the foliation surfaces. Accessory minerals are magnetite, ilmenite, chlorite, zircon, apatite, tourmaline, and pyrite.

Hornblendic beds appear in the formation at many places, but are not mappable as a unit or units. They range in composition from hornblendic quartzite to amphibolite, and in thickness from a few inches to several hundred feet. Conglomeratic texture is preserved in some of the lighter beds.

The amphibolite varies from light to dark gray, depending on the proportion of amphibole present. Amphibole occurs usually as medium-sized needles, but in the more quartzitic phases it is commonly in striking large plumose crystals, the "fasciculite" rock of Emerson. In thin section, the amphibole is generally seen to have the following pleochroism X - light yellow, Y - green, Z - bluish green, Z Y X. The indices of refraction, though variable, are usually near ~~Greek~~ alpha = 1.662, ~~Greek~~ beta = ~~1.665~~ 1.675, ~~Greek~~ gamma = 1.683. These properties indicate that it is hornblende or perhaps pargasite. Other main constituents of the amphibolite are quartz, calcite, oligoclase, and iron-poor epidote near zoisite in optical properties. Garnet is common to abundant. Accessory minerals include pyrite, ilmenite, and magnetite.

The origin of these amphibole rocks is somewhat problematical. The compositions of the darker bands are very similar to those of certain igneous rocks, except that these schists generally contain from 5 to 10 percent calcite. The thin and discontinuous character of the bedding, the gradations to quartzite and muscovite schist, and the conglomeratic texture indicate a sedimentary rather than an igneous origin; however, the sediments may have contained variable amounts of volcanic pebbles and other detritus derived from the rapid erosion of volcanic rocks. Explosive volcanic eruptions also may have added some material directly to the sediments.

The chloritic bed within the Savoy schist is largely quartzite containing considerable chlorite and biotite, and in places scattered grains of ankerite.

Hawley schist

The Hawley schist occupies a great belt 1½ miles to 2 miles wide across the area. It consists of amphibolite in considerable variety, calcareous rocks, chlorite schist, feldspathic schist, and quartzite. Here the formation differs in several respects from places to the south. Its much greater width of outcrop is probably due to faulting. The lower calcareous zone has fewer of the carbonate beds than to the south. Another difference is the presence here of a great many rather massive amphibolite beds, many of which resemble intrusive diorite or gabbro. Also light feldspathic rocks, which resemble metamorphosed volcanic beds of rhyolitic and andesitic composition, are more common in the northern area.

The main mineral constituents are green to very dark green amphibole, very similar to that of the Savoy schist, feldspars, iron-poor epidote, ankerite, quartz, and chlorite. Each of these may be the principal constituent, and the formation as a whole therefore comprises beds of amphibolite, quartzite, and schists containing large amounts of ankerite (evident from its brown color on weathered surfaces), epidote, chlorite, and feldspar. Garnet, biotite, muscovite, and magnetite are common. Accessory minerals include rutile and pyrite.

The amphibolites are commonly either fine-grained green, or coarse-grained almost black beds; they usually contain considerable quartz, and in some of them the ankerite constitutes up to 10 percent of the rock. These amphibolite beds are the most abundant of the formation; some are schistose, as in the Savoy formation, and some are massive. The massive amphibolites are well exposed in the gorge just above Charlemont village, and along the brook for more than a mile below the Davis Mine. Many of these rocks show thin discontinuous bedding, conglomeratic texture, and other indications of a sedimentary origin. Some of the amphibolites ~~Certain others~~, however, cut the bedding at an acute angle and are, therefore, intrusive; these are somewhat metamorphosed, but some of them retain traces of a porphyritic texture. The amphibolites grade into quartzite and conglomerate, in which, especially, the "fasciculite" rock is common. (Emerson 1898, p. 165) In certain impressive beds are garnets one-inch or more in diameter, that occur at the centers of large radial groups of amphibole crystals. Separate mapping of an amphibolite facies of this formation, however, is not practicable at present.

Associated with the dark intrusive rocks, but less abundant, are some very light-colored rocks of approximately rhyolitic composition. Certain of them are probably intrusive, although others, which show a conglomeratic texture, probably were deposited as arkosic sediments. A belt of this type of rock, 240 feet wide, crosses the brook 1.1 miles below the Davis Mine at about 1,090 feet above sea level. It is a very light gray schistose rock, and in thin section is seen to consist of phenocrysts of oligoclase in a matrix of oligoclase, quartz, biotite, and epidote; accessory minerals include magnetite, garnet, apatite, and muscovite. The texture is quite irregular. The composition and texture suggest that it was of volcanic origin probably an andesitic tuff. Emerson (1898, pp. 168, 169) described this rock as "white gneiss" and mapped it as extending for several miles on either side of the brook; however, careful search of the hills on either side convinced the writer that it does not extend far in any direction, but is discontinuous like most of the other beds in the Hawley schist. It is perhaps significant that Emerson did not describe or map the "white gneiss" in his later report (1917). Extensive exposures of a similar rock may be seen 1 3/4 miles northwest of Charlemont, between altitudes of 650 and 800 feet along the brook flowing south toward the Deerfield River.

Other beds within the Hawley formation include chlorite schist, ankerite-chlorite schist, and ankerite-epidote-amphibole schist. Several exposures of these rocks may be seen in the road cut at the foot of Mount Peak, and about a mile west of the village of Charlemont.

The Hawley formation appears to have been formed by both sedimentary and igneous processes. Some beds originally consisted of quartz of various proportions, sand, clay and calcareous sediment; many must have consisted of dark or of light volcanic debris; and others may have been volcanic flows. There were also many sill-like intrusions. The whole series was later metamorphosed to the present condition.

Goshen schist

Only the lower part of the Goshen schist appears in the area studied. Here the schist consists mainly of alternating beds of fine graphitic schist and schistose quartzite. These rocks are exposed in several road cuts within a mile to the east of Charlemont village; several flagstone quarries in them were opened in the hill one-half to three-fourths of a mile east of the village.

Graphite is especially abundant near the base of the formation, as it is to the south in Plainfield. At one place, 1.4 miles north and slightly east of the Davis Mine, it was once mined in a small way, but apparently for only a short time. This lower graphitic zone is probably to be correlated with a similarly appearing zone in Plainfield.

Thin-section study reveals that the main constituents of the Goshen schist are muscovite and quartz. The rock shows a well-developed schistosity. Large biotite flakes lie discordant to the schistosity. Numerous small garnets contain inclusions oriented in a spiral pattern which suggests that the garnet crystals were rolled during the metamorphism. Accessory constituents are magnetite, graphite, pyrite, and tourmaline.

Near the lower part of this formation is a layer of dark-gray porphyritic amphibolite similar to beds that are so common in the Hawley formation. It lies 200 to 500 feet east of the Hawley-Goshen contact and exposures indicate a thickness of 500 to 1,000 feet. (Emerson, 1898, p. 180.) Emerson interpreted a sedimentary origin for this bed, and quotes an analysis (op. cit., p. 46, anal. 74), but gave no reason for this interpretation; the writer considers it more probably igneous, because of the apparently porphyritic texture and the similarity to Hawley beds, some of which appear, for structural reasons, to be intrusive.

With the exception of the amphibolite beds, the Goshen schist is sedimentary and was formed by the accumulation of layers of black mud and sand.

Granitic intrusions

At a point 3900 feet directly east of the Davis Mine are a few irregular tabular bodies of light-gray, medium-grained granitic rock, that are apparently parallel with the bedding of the enclosing Hawley schist. These bodies are too small for mapping and are of importance only as indication of igneous activity. These intrusive bodies include shreds of schist and were therefore intruded later than the period of metamorphism.

Structural geology

Regional structure

By general principles of rock formation, it is known that this great thickness of sediments and volcanic debris accumulated as beds that were approximately horizontal. They were subsequently folded into their present attitudes and later metamorphosed into schists. Planes of bedding and schistosity here are generally parallel or nearly so.

The regional structure is comparatively simple. The beds dip commonly 65° to 85° east, and strike from approximately N 10° E near the south edge of the area to about N 40° E at the north edge. One of the few exceptions to this general simplicity is in the north wall of the Deerfield valley, where there are several small folds along the Savoy-Hawley contact. (See pl. 1.)

Contact of Savoy and Hawley schists

Emerson considered the contact of the Savoy and Hawley schists to be a fault, because he believed that amphibolite beds in the Hawley schist were discordant with this contact and because several mineral deposits to the south are near the contact. In this area there seems to be no discordance of the beds along the contact, instead, the contact is somewhat gradational. The map clearly shows that the mineral deposits have no obvious or close genetic connection with the contact. Furthermore, an exposure of this contact in Plainfield (brook exposure 1300 feet N 18° E of north pit of Betts manganese mines) shows no evidence for a fault.

Fault at contact of Hawley and Goshen schists

Evidence gathered in the present study indicates that the eastern contact of the Hawley schist rather than the western one is a fault. At Dell the brook falls over a bluff showing a fault zone between the Hawley schist and the Goshen schist. Within the fault zone, here about thirty feet thick, the beds are broken, contorted, and stained by weathering. The fault zone and the beds on both sides dip east about 75°; it is a bedding-plane fault. Drag folds in the fault zone indicate that this is probably a normal fault; that is, that the east block dropped relatively.

Similar relations are shown in the railroad cut 2750 feet east of Charlemont station. Mapping between these two exposures of the fault has not revealed any discordance or stratigraphic throw of the beds. There is considerable evidence that this fault extends to the south and accounts for the great narrowing of the outcrop of the Hawley schist in Plainfield.

Minor structures

In contrast to the simplicity of the larger structures is the complexity of the small folds. Isoclinal folds, to be seen in many places, range in size from mere "ripples" in the schistosity to folds several feet across. These small folds are not very systematic, for their axes were seen to lie at various angles from horizontal to vertical and several were seen to be considerably deformed by later folding. The small folds generally indicate that the east side rose relatively, thereby agreeing with the conclusion that the beds on the west are older, although there are many exceptions to this general condition. The folding of axes and several other small structures may be seen in cuts along the Charlemont-Rowe road 2 to 2½ miles west of Charlemont village. One of the striking and unusual minor structures here is shown by an amphibolite bed that has been so squeezed as to be pinched, or pulled, in two; this is known as "boudinage structure". (Quirke 1923; Wegman 1932)

Many beds of amphibolite show, in addition to schistosity, a linear arrangement of the amphibole needles. Most commonly it is approximately vertical, and at several places the lineation is also about perpendicular to the axes of the drag folds, but at many other places the relationship of the axes to the lineation cannot be determined so that no general rule is apparent.

Metamorphism

The complicated structures of the rocks here and throughout western Massachusetts indicate that they were subjected to great compression. The mineral composition indicates that fairly high temperatures also must have prevailed during the period of reconstruction. Further, the rocks must have been permeated by solutions, that were in part entrapped within the sediment when originally deposited and in part may have invaded these rocks from some outside deep-seated source. The combined effect of the pressure, high temperature and solutions was the recrystallizing of the rocks in layered or schistose form throughout the region—a process called regional metamorphism.

The original sedimentary rocks consisted of quartz sand beds, sandy beds containing clay and feldspar, clay beds, and impure limy beds with considerable iron. The volcanic debris, the lavas, and the intrusive rocks ranged from rocks consisting mainly of plagioclase and hornblende or pyroxene to those with potash feldspar, plagioclase, and quartz. These rocks were metamorphosed to form the various micaceous schists and some of the amphibolites. Their original chemical composition was modified to some degree by elements introduced by the invading solutions. Thus the sandy beds became quartzite or feldspathic schist, the clay beds became mica schist, and the impure limy beds became ankeritic schists. Garnet formed in the schists and quartzite, where the proper proportions of iron, alumina, and perhaps lime were present or were in part supplied by invading solutions. The volcanic and intrusive rocks became amphibolites, and feldspathic schists, according to their original composition.

Not only were new minerals formed, but the textures and structures were changed. The quartz grains of the sandstones and the phenocrysts of the intrusive amphibolites were crushed and granulated. The clay rocks, in particular, were made coarser; the flaky minerals like the micas and chlorite were developed parallel with each other, thus developing the schistosity. The needles of hornblende crystallize either with their long dimensions in the same plane, producing schistosity, or even parallel in the same plane, producing a lineation.

By comparison with metamorphic rocks elsewhere, these rocks appear to have reached the middle grade of metamorphism, as indicated by the grain size and the presence of such minerals ~~such~~ as hornblende, garnet, muscovite, and oligoclase.

The ~~iron and manganese~~ mineral deposits, however, show none of the effects of general crushing and recrystallization, so it is concluded that they were formed later than the metamorphism of the enclosing rocks.

Mineral deposits

General statement

Considerable development work or mining has been done at the Davis Mine, the Hawks Mine, and the Mary Louise Mine. Aside from these, there are only a few small mineral prospects or showings. The three deposits first named have certain characteristics in common, and the Davis and Hawks Mines especially are almost identical in mineral composition and structure. At these three mines also, the sulphide minerals, chiefly pyrite with some chalcopyrite, are greatly predominant; these minerals are minor in the manganese deposits in Plainfield. All these metallic minerals appear to replace quartzite or feldspathic schist beds, and to have been deposited by ascending hydrothermal solutions, at considerable depth. The source of the hydrothermal solutions is not known, but may be the same as that from which granitic intrusions 3900 feet east of the Davis Mine were derived.

Davis Mine

History

The Davis pyrite mine probably had the longest period of successful operation of any mine in Massachusetts. The deposit had been known for fifty years before 1882, when Mr. Herbert J. Davis examined it and started mining. Mining continued, apparently with few interruptions, from June 1882 until 1910, and shipments of ore recovered from the dumps extended into 1911. Crosby (1932) states that shipments of pyrite continued into 1916. The village of Davis, now extinct, was built, and the mine is said to have employed as many as 200 men at one time.

Past production

Records of production are scanty. The output is reported to have been upwards of 30,000 tons in 1885 and 57,000 tons in 1886 (U. S. Geol. Survey, Mineral Resources of the United States, for 1885 and 1886.) For other years, the reported output is included with that of other states. Emerson (1898, p. 170) reported that the total production of this mine up to January 1, 1892, was 334,552 tons. The daily capacity was apparently 300 to 400 tons, but Rutledge (1906) stated that the average daily output was 100 tons. The volumes of "Mineral Resources of the United States" report also the following amounts of blister copper as having been produced principally by the Davis mine: 1,700 pounds in 1905, 9,774 pounds in 1906, and 7,863 pounds in 1908.

Analyses of ore

Analyses of the ore are also scarce. Two are given in "Mineral Resources of the United States" (1883-1884 p. 878; 1885 p. 503.) as follows:

Sulphur	48.0	49.27
Iron	44.0	45.30
Copper	1.6	1.47
Zinc, lead, etc.	1.5	—
Silica	3.7	—
Silica and insoluble residue	—	3.83
Arsenic	(?)	—
	98.8	99.87

Rutledge (1906, p. 774) gives the following analysis:

Sulphur	47
Iron	44
SiO_2	3
Cu	1.5
Zn	trace

Ore free of arsenic

Development.

Mining operations are said to have opened the ore body for 900 feet along the strike and 1400 feet down the dip. W. C. Phalen _/ is authority

_/ U. S. Geol. Survey Mineral Resources of the United States, 1911. p. 952.

for the statement that "During the early summer of 1910 the Davis mines were exhausted and the company started to rob the pillars with the result that the mine collapsed, presumably closing it for all time." (See fig. 2.)

Figure 2. Map of surface workings at Davis pyrite mine

The ore body was described by Emerson (1898, p. 170) as a lens or vein of pyrite, with a common thickness of 24 feet and a maximum reported thickness of 61 feet. The ore was mostly granular pyrite, but some chalcopyrite was found as veins and bunches which could be separated by hand. Rutledge (1906 p.175) indicated that the copper was more abundant in the deeper workings.

Contrary to repeated rumors about the re-opening of the old mines or the opening of new veins no mining has been done since the collapse of the mine workings. ~~The rumors have not come to pass.~~ In "Mineral Resources of the United States, 1912" it was stated that a new lens was to be opened in 1913. Local people have reported to the writer that an extensive program of prospecting by electrical methods was carried out in 1928 and that a new vein was located southwest of the old mines. The two prospects indicated on figure 2 are said to have uncovered this vein. The walls of these prospects have fallen in, but the small dumps that presumably came from those excavations contain pieces of typical Davis pyrite ore. Exposures are not sufficient to reveal whether or not this pyrite body is on the same vein as the Davis vein.

Present conditions

As is indicated by the above history, the Davis Mine went through a long period of successful operation. Although both Emerson (1898) and Rutledge (1906) described it, at no time during its operation was a detailed mineralogic or geologic description made. The mine is now full of water and the extensive dumps are greatly weathered, as might be expected of a pyrite deposit. The bed of the brook, as far down as Charlemont, is strikingly stained brown by the iron oxides resulting from the weathering of this ore. The pyrite vein may be seen at the south end of the north opening, but is not accessible for close examination; it appears to be four to five feet thick and parallel to the beds and schistosity of the enclosing rocks which are mainly quartzite or feldspathic schist.

Minerals as determined from the mine, the dumps, specimens in old mineral collections, and from earlier reports, include pyrite, chalcopyrite, bluish sphalerite, gahnite (as well-formed octahedrons), garnet, muscovite, ilmenite, rutile, apatite, epidote, calcite, and molybdenite.

Hawks Mine

The Hawks or Mt. Peak Mine lies on the south side of Deerfield River, about 1800 feet southwest of Charlemont station and just above a prominent stream terrace which is being excavated for sand and gravel.

Only a few published references to this mine were discovered. Rutledge (1906, p. 674) refers to it as a small prospect. Three volumes of the "Mineral Resources of the United States" make brief mention of this deposit; the report for 1908 (part 2, p. 665) reveals that a 135 foot shaft had been sunk, that for 1909 (part 2, p. 692) states that no work was being done there in January, 1911, and the report for 1917 (part 1, p. 41) indicates that development was going on with the hope of production in 1918.

The best report on this mine is a thesis written in 1914 by C. P. Ross, and now in the library of the Massachusetts Institute of Technology. His examination was made in 1913, when the mine workings were partly inaccessible. According to him there was a vertical shaft, 140 feet deep, an adit 37 feet below the collar of the shaft and 226.5 feet long, a stope 90 feet long and 50 feet high at the 100-foot level of the shaft, and a cross-cut 100 feet long at the 130-foot level. He reports the mineral composition of the ore as pyrite, chalcopyrite, sphalerite, galena, chlorite, green mica, biotite, muscovite, quartz, garnet, spinel, apatite, calcite, and ankerite. He states also that a hole in the hill yielded two carloads of ore which contained 13 percent copper, but does not identify the hole. He states further that the shaft was sunk through 20 feet of massive sphalerite with some pyrite and chalcopyrite, and that below this, and in the adit, sphalerite does not occur in appreciable quantity.

At the time of the writer's visit, a smoke stack remained and some of the underground workings could be seen (see fig. 3). The shaft was ~~particularly~~ practically full

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Figure 3. Map of old surface workings at Hawks mine.

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of debris, but it could be seen that the adit followed a pyrite vein very similar to that at the Davis mine, but only about one foot wide. The strike of the veins and the beds here is N 20° E, and the dip is 75° E. The footwall is chlorite schist containing many pyrite cubes; the hanging wall is quartz-muscovite schist. Just above the adit is a cut exposing 50 feet of alternating beds of chlorite schist and muscovite schist, with several pyritic zones. For 700 feet up the hill and along the same strike are scattered prospects in the same mineralized zone. The mineral body is in quartzitic beds, and the pyrite is disseminated through the rock rather than being concentrated as solid masses. For a few hundred feet farther southeast there are a few additional small pits which show very little mineralization of any kind.

The ore is practically identical with that at the Davis Mine. The main minerals of the Davis deposit—pyrite, chalcopyrite, gahnite, and garnet—are present here also, although the gahnite is less abundant and occurs as smaller crystals. A few pieces of brown sphalerite were found near the shaft. No galena was seen, but its presence was reported by Ross. Exposures of the ore zone at the Hawks Mine are better than at the Davis Mine, and they indicate that the ore was formed by the replacement of quartzite and feldspathic schist beds.

The smaller size and poorer quality of the ore apparently prevented development on a scale as great as at the Davis Mine. The only apparent advantage it had over the Davis Mine is that it is reported to have contained at least two rich pockets of ore, one of copper and one of zinc; not much is known about ~~these~~. ~~T~~the details of occurrence of these bodies, however, ~~is that~~ ~~so~~ and there is little information to guide exploration for additional ore bodies of these metals.

Mary Louise Mine

The Mary Louise Mine, also known as the "Kork", "Davenport", and "Gray" mine, is 3½ miles north of Charlemont village and 1.3 miles west of the Davis Mine. It is easily accessible by paved highway, good country road, and a quarter-mile steep lane. The present owner is Mr. Guy N. Gray of Greenfield, Massachusetts.

History of past operations.

Available data of past operations are scant. The mine is reported by Mr. Gray to have been opened in 1903 and to have been developed and worked intermittently up to 1912. A crushing plant and smelter were constructed and remains of the old smelter may still be seen. The "Mineral Resources of the United States" for 1907, p. 561, states: "Some copper matte was produced at the Davenport mine but not marketed." The deposit is described briefly in "Mineral Resources of the United States" for 1917 (part 1, p. 41). This is apparently the deposit described by Weed (1911, p. 34), although he gives its distance from the Davis Mine as 2 miles and states that it was opened in 1900. Weed's description is partly quoted from W. O. Crosby (H. J. Stevens, Copper Handbook, vol. 6, p. 746, 1906.)

Country rocks.

The mine is within the lower quartzite beds of the Savoy schist (see pl. 1). The quartzite here is light gray to greenish, and contains considerable biotite, chlorite, and muscovite. Some of the chlorite occurs as radial blades, and alteration of amphibole crystals. A few thin beds of biotite schist and dark amphibolite may be seen nearby.

Structure of the country rocks.

The general strike of the schistosity is about N 45° E, but in the immediate vicinity of the mine it is N 50° - 70° E and the dip 60° - 90° SE. The quartzite shows many small close folds and the schistosity is parallel to the axial planes of these folds in contrast to the usual situation in this area where the schistosity and the bedding are parallel. Linear elements on the folds strike about N 60° E and plunge 30° - 35° NE.

The mineralized zone follows the strike of the schistosity, but is apparently vertical, for the outcrop of the mineralized zone at prospect #3 and the shaft collar are directly above the drift and winze in the ore body 120 feet below (see fig. 4). It is apparent that this deposit is not in the same stratigraphic

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Figure 4. Map of surface and underground workings at Mary Louise Mine, Rowe.

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position as that at the Davis Mine, and there is no evidence that these are in the same general zone of mineralization.

General description of the mineral deposit.

The ore body lies in a poorly-defined fracture zone which ranges up to 15 feet or more in width where exposed (see fig. 4). Within this zone are thin veinlets of quartz and chalcopyrite which range up to 8 inches or more in thickness, but in which the proportion of chalcopyrite is greatly variable. The veinlets are not uniform in trend or thickness and they commonly wind irregularly through the mineralized zone. Individually they do not appear to be continuous for long distances, though their general continuity cannot be determined in the present accessible workings. Some disseminated chalcopyrite occurs in the walls of these veinlets, but much of the fracture zone appears to be barren.

The minerals of the deposit, besides those that constitute the country rock, are quartz, chalcopyrite, and pyrite. A small amount of fine-grained molybdenite was seen in loose pieces of ore, but this mineral was not seen in place.

Underground workings.

The old shaft is 125 feet deep, and apparently follows the mineralized zone (see fig. 4). About 120 feet below the collar it meets the adit, which was driven into the steep hillside of schist for 710 feet and through the ore body. From the adit a west drift 25 feet long, and an east drift 50 feet long were driven in the ore body. A few feet east of the adit is a winze that was sunk about 50 feet below the adit level and developed into an underhand stope.

The shaft and old stopes above the adit level were not accessible.

About 143 feet from the portal, the adit crosses a 6-inch quartz-pyrite vein that strikes N 70° E and dips 65° SE. About 20 feet farther north is a barren shear zone that strikes N 40° E, and dips 60° SE.

In the face of the winze two veins were seen, each containing up to 2 inches of chalcopyrite. On the east face of the winze-stope the following section was seen:

12" mica schist (south end of section)
6" to 12" quartz and chalcopyrite, not more than 25% chalcopyrite.
60" quartzite and schist.
2" to 7" vein of quartz and chalcopyrite (predominantly quartz)
12" biotite-schist with a few grains of pyrite and chalcopyrite.
30" quartzite
½" chalcopyrite
8" biotite schist (north end of section)

The face of the west drift showed the following section:

1/8" rusty quartzite (south end of section)
53" quartzite
2" to 6" quartz and chalcopyrite, the chalcopyrite totalling less than 1". This vein extends about 40 feet upward into the stope, as far as can be seen.
11" quartzite.
42" schistose quartzite, much folded, with a few 1/8" stringers of chalcopyrite.
24" quartzite (north end of section)

Surface workings

The several surface pits and trenches are indicated on figure 4.

At prospect no. 1, a vertical cut about 6 feet high on the side of the hill shows two half-inch weathered veins of quartz and chalcopyrite.

At prospect no. 2, a rectangular opening 15 feet long, 10 feet wide, and 3 feet deep exposes an 8-inch vein of rusty quartz and sulphides, pyrite crystals distributed sparsely in adjacent rock material, and a 1-inch vein of quartz and sulphides.

At prospect no. 3, a zone 6 feet wide is exposed, in which may be seen a 1-inch vein composed chiefly of chalcopyrite, a 6-inch zone of chalcopyrite and quartz stringers, and a 2-inch to 6-inch vein of quartz and chalcopyrite; the proportions of chalcopyrite and quartz are markedly variable, but quartz predominates. The rest of the exposed zone is apparently barren schist.

At prospect no. 4, the exposed part of the mineralized zone is 4 feet wide and shows four chalcopyrite veinlets, each about a quarter of an inch wide.

At prospect no. 5, a mineralized zone 2 to 4 feet wide is exposed in a pit 2 feet deep, and on an adjacent bluff to the east. It is composed mainly of rusty quartz with a few veinlets and scattered grains of partly weathered sulphide minerals.

~~irregular veinlets throughout the zone, it would be necessary to mine the larger part or all of the zone.~~ No particularly rich parts of the mineralized area are indicated by available data.

Summary statement.

The ore body lies in a general, but vague, fracture zone 10 to 15 feet wide (as now exposed), and consists of several narrow discontinuous veinlets of quartz, chalcopyrite, and pyrite. In places the sulphide minerals are disseminated in the rock and not concentrated in veins. Generally at any one place the mineralized zone contains three or four veinlets, each ranging from a quarter of an inch to 8 inches in width and each varying in composition from almost solid chalcopyrite where narrow to mainly quartz with only a few grains of chalcopyrite. At no place seen does the chalcopyrite form more than a very small fraction of the total width of the rock that would have to be mined.

Prospect excavations indicate that the mineralized zone extends over a distance of 500 feet along the schistosity. To the east of the bluff at prospect no. 5 no exposures are to be found along the strike of the zone for at least 500 feet. To the west of prospect no. 1 scattered outcrops show very few small rusty patches through a distance of 600 to 700 feet; no copper minerals were seen in these outcrops.

The small veinlets of ore tend to follow the schistosity, but they also cut irregularly across it, and, in places, follow small folds in the quartzite. Within the mine, the mineralized zone is almost vertical for 170 feet, so that it apparently does not follow the southeasterly dip of the schistosity.

Mineralogical evidence indicates a hydrothermal origin at considerable depth. The solutions rose along the fracture zone and partly replaced the rock adjacent to the fractures. The mineralogic character and structural data lead to the belief that the deposits may continue downward for a considerable distance, but marked increase of metal content with depth is not indicated or suggested by any available data. The vein is perhaps a little richer at the adit level than at the surface, but this difference would need to be confirmed by careful sampling.

Other prospects

Approximately 1.35 miles N 43° E of the Davis Mine are two shallow prospects, now filled with debris. The surrounding exposures, which are numerous, show only a few cubes of weathered pyrite. This is at about the same stratigraphic position as the Davis deposit, but surface indications do not indicate a large deposit. It has been reported that these pits were opened on the basis of an electrical survey made in 1938.

Approximately 0.70 miles N 60° E of the portal of the Mary Louise adit is a small copper prospect, on the farm of Mr. Louis Davenport. A small shaft follows a vein of pyrite and chalcopyrite, 2 to 6 inches wide, for about 20 feet. This is reported to have been worked during the last activity of the Davis Mine. The mineralization, which is similar to that at the Mary Louise Mine, appears to be too slight and low-grade to be of value. This deposit is apparently several hundred feet stratigraphically above the Mary Louise deposit. A personal note from Mr. G. F. Loughlin of the Federal Geological Survey states: "We also saw Capt. Davenport's prospect (fall of 1902) which then consisted of a tunnel about 30 feet long which followed an 8 to 10 inch vein of white quartz with a promising showing of chalcopyrite."

On the Charlemont-Rowe road, a little more than 2½ miles from Charlemont, and on the north side of Deerfield River (nearly opposite Mohawk Park) a small adit follows a quartz vein 15 to 20 feet into the hill. The only indication of mineralization, other than the quartz, are a few brown stains from the weathering of sulphide minerals. Some local reports are to the effect that copper was sought here and others that the mine was explored for gold. It is quite apparent that no important amount of copper is present; no gold was seen by the writer and no assay records are available.

Emerson (1899, pp. 170-175) gave brief descriptions of several other prospects and showings. Some of these were seen by the writer, but none of them shows evidence of commercial concentration. Several could not be found, owing to inadequate descriptions of their locations or because the small exposures have been completely obscured by forest growth.

Suggestions regarding future prospecting

Published information indicates that the Davis pyrite deposit was almost exhausted before the mine collapsed, although local reports deny this. It is unfortunate that careful descriptions of the mine were not made from time to time during its operation so that more definite knowledge about its condition might be stated.

Whatever the reasons for closing the Davis Mine, present conditions appear to be unfavorable to the working of such a deposit. The sulfur deposits of the Gulf Coast supply most of the needs of industry, although 659,498 long tons of domestic pyrite was recovered in 1941 as a byproduct from the milling of sulphide ores of various metals and from coal mines. The average market value of pyrite in 1941, $3.09 per long ton, is too low for the primary mining of pyrite.

The only hope for profitable working of these ores seems to lie in the possibility that they contain other valuable elements. Both zinc and copper have been reported from the Davis ore, but of these only the copper has been marketed. A total of 19,307 pounds of copper is reported to have been produced principally by the Davis Mine in 1905, 1906, and 1908, and old analyses indicate a copper content of about 1.5 per cent (U. S. Geol. Survey Mineral Resources 1883-1884, p. 878; 1885, p. 503; Rutledge, 1906, p. 774). It is very doubtful that these figures give a reliable indication of the average copper content of the ore, however. The absence of copper in the mine waters, noticed by Rutledge (1906, p. 725) and by the writer, suggests that copper may be very scarce in this ore body. Even if the copper content is 1.5 percent, the total value of the copper and the pyrite would be only about \$6 to \$7 per ton (with copper priced at 12¢ per pound). Another unfavorable fact is that the recovery of the copper involves added expense, either to transport the ore to smelters or to build a smelter near the mine and to transport fuel.

The immediate future of these deposits does not seem promising, for the data do not indicate other known deposits and, moreover, economic conditions would not now favor the working of deposits of similar type, if they were known. Future prospecting is suggested only on the possibility that there are undiscovered deposits which may come to have commercial value because of changed economic conditions or because of a greater content of copper or other metals. The finding of such deposits would be a matter of considerable difficulty and expense, for glaciation must have destroyed any gossan which might have developed and the glacial drift is thick in many places. The present geological study has indicated that there are few clues for further surface prospecting, inasmuch as (1) the known deposits are at various different stratigraphic positions, (2) although they are generally in quartzitic rock, not all such rocks are mineralized, and (3) ~~it is~~ they are not yet known ~~that they are not~~ to be associated with any definite structural feature. Geophysical methods might be successful in discovering hidden deposits. Any deposits discovered by geophysical means would have to be thoroughly explored by core drilling to discover the size and composition. Even with these means it may not be practical to prospect the whole area, but to seek first for extensions of known deposits.

The prospects at the Davis Mine (see fig. 2) should be examined first. The ledge is reported to have been reached at a depth of 20 to 25 feet. Drilling or trenching seems feasible. The very poor prospects 1.35 miles northeast of the Davis mine probably indicate an extension of the ore, but the prospects show only very poor mineralization.

At the Hawks Mine trenching and prospect pits have revealed considerable low-grade mineralisation to the south. It is doubtful whether further surface excavation would reveal much more. The most hopeful possibility is that richer bodies lie at depth. Drilling seems to be the best method to test this suggestion, although the finding of richer bodies by any method seems rather unlikely. A further possibility is suggested by the fact that apparently the greatest mineralisation is at the north end where the terrace deposits cover it. The deposit may extend underneath the sands and gravels, although the former mining operations should have tested that possibility.

At the Mary Louise Mine there is no evidence that copper was anywhere concentrated enough to be workable and there is no evidence of marked increase with depth.

The other prospects and outcrops seem to be too small and too low-grade to be of value. There is no evidence that they improve with depth.

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Geology of the Charlemont-Heath area (with special reference to pyrite and copper deposits)
A.W. Quinn

Figure 1 - Key map showing locations of A. Plainfield-Hawley and B. Charlemont-Heath areas, Massachusetts

same as Fig 1 of Geology of the Plainfield-Hawley area (with special reference to deposits of manganese and iron minerals) by A.W. Quinn

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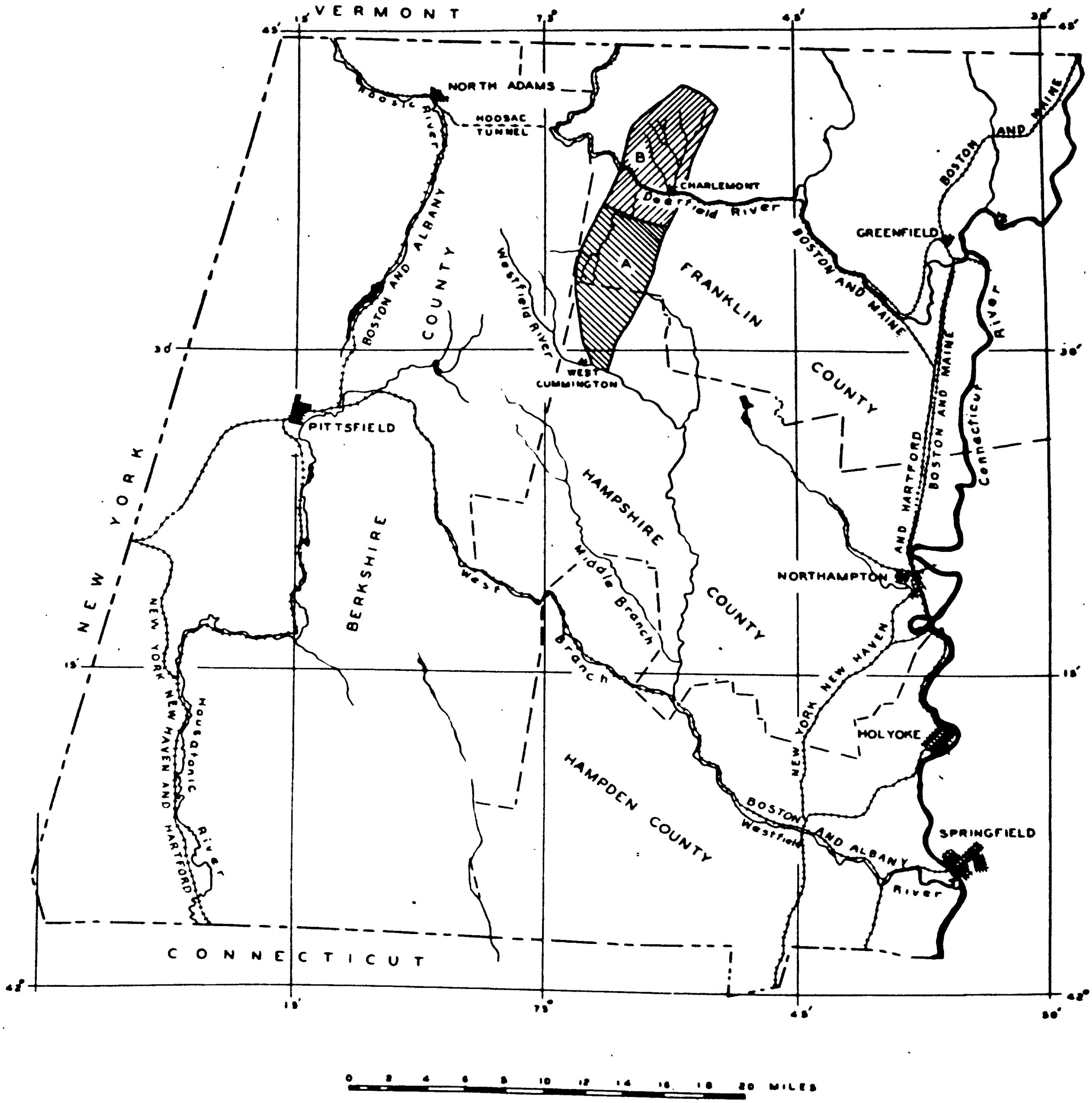

FIGURE 1 KEY MAP SHOWING LOCATIONS OF
A PLAINFIELD—HAWLEY, AND
B CHARLEMONT—HEATH AREAS
MASSACHUSETTS.

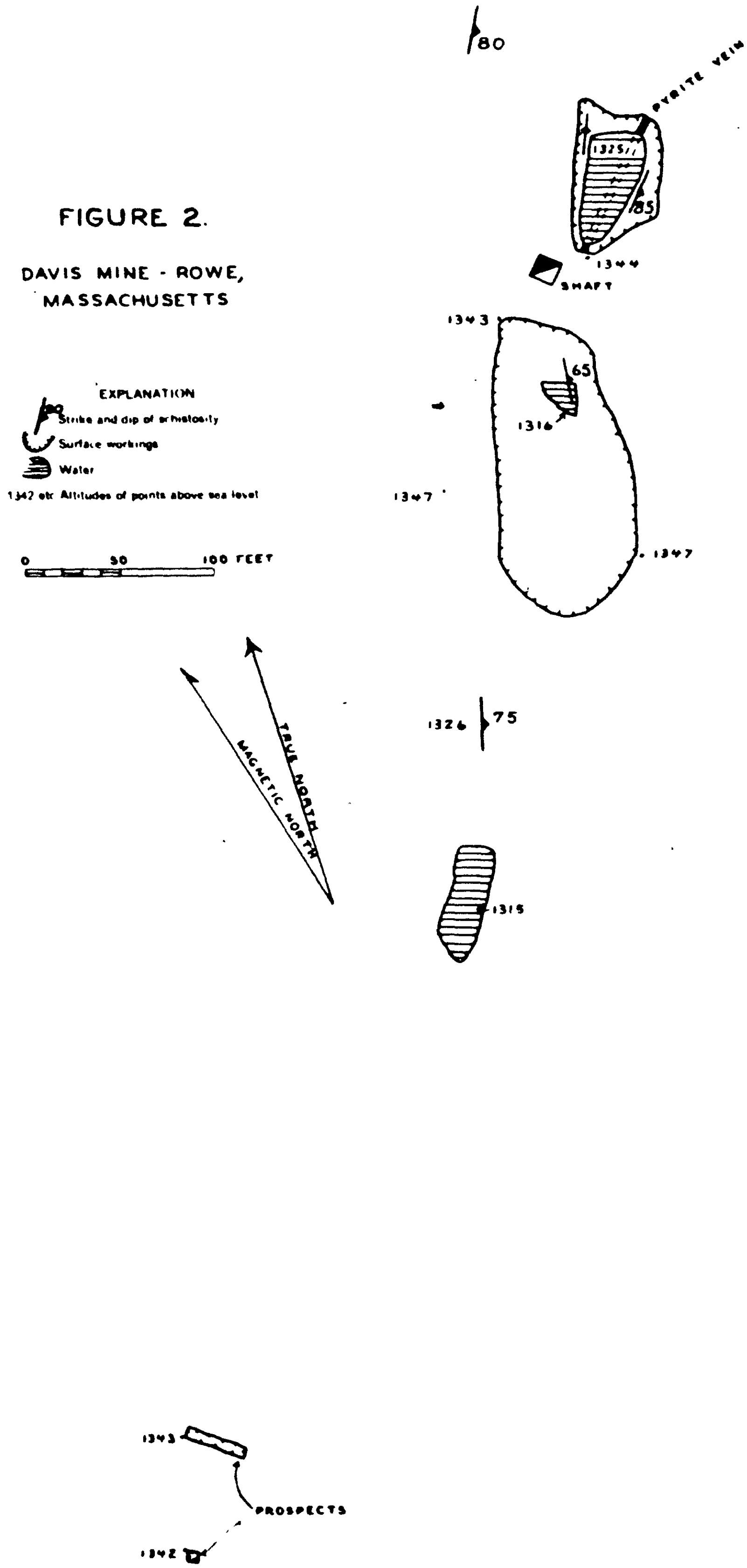

FIGURE 2.

DAVIS MINE - ROWE, MASSACHUSETTS

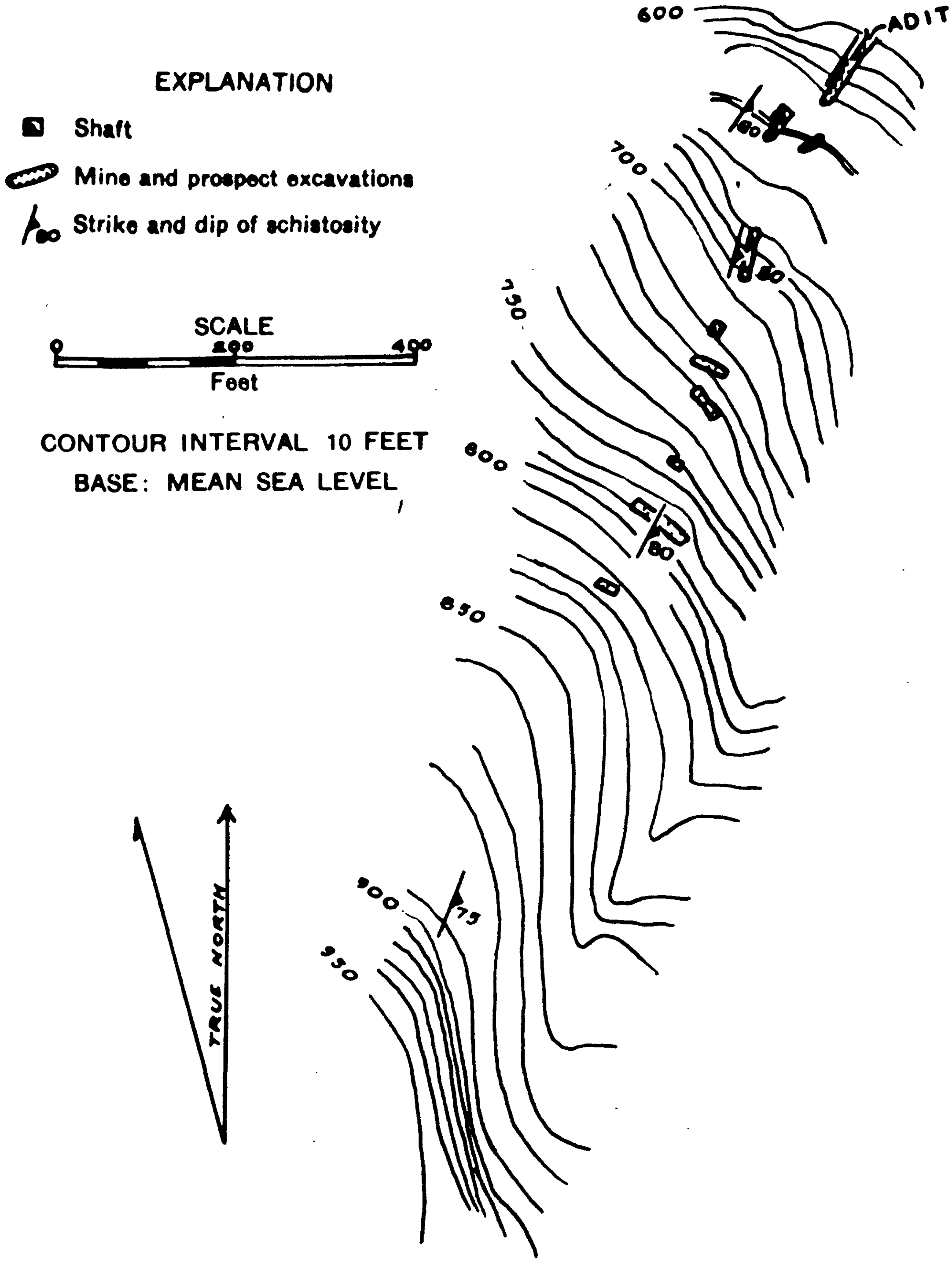

FIGURE 3. MAP OF OLD SURFACE WORKINGS AT HAWKS MINE.

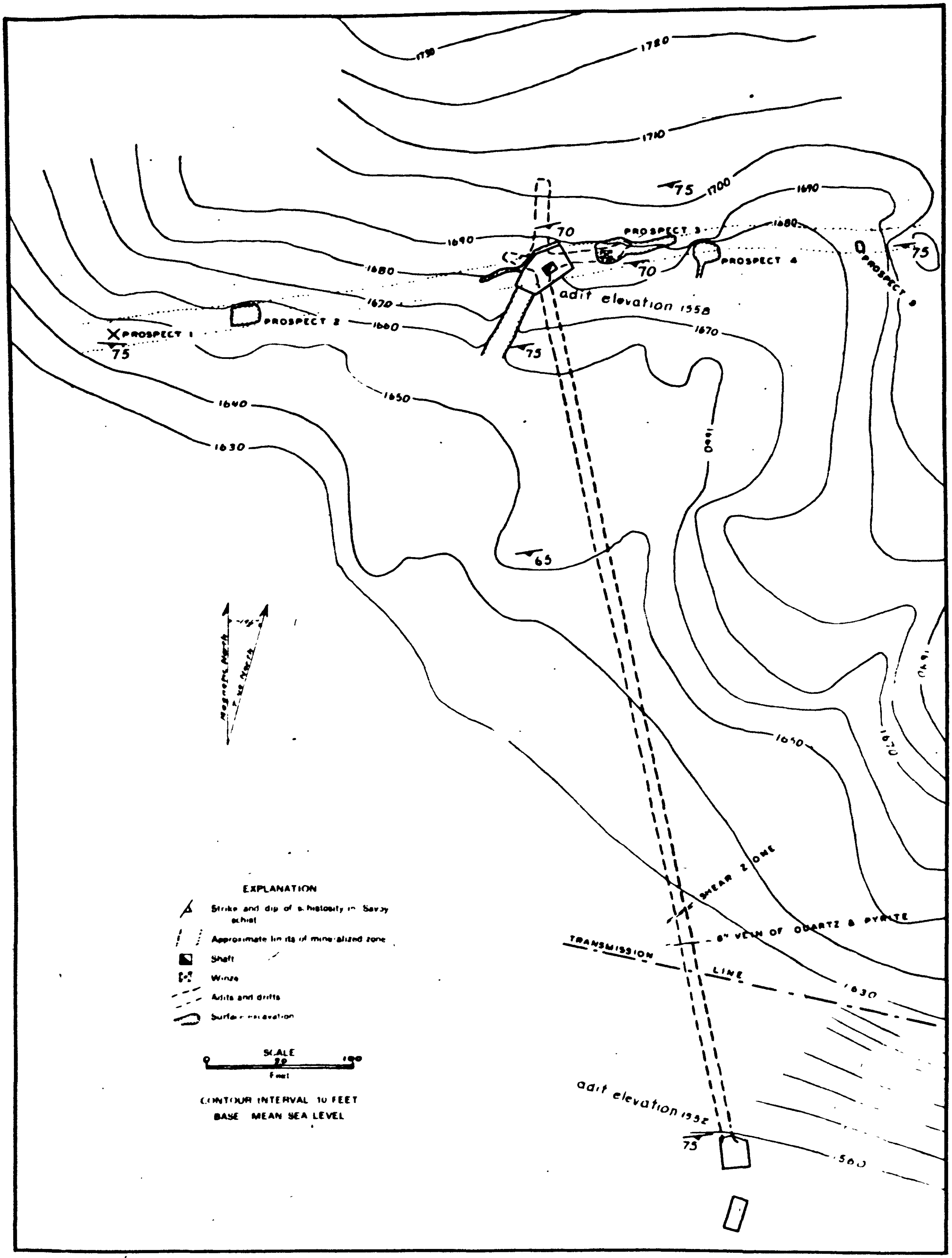

FIGURE 4 MAP OF SURFACE AND UNDERGROUND WORKINGS AT
MARY LOUISE MINE ROWE