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The Brown Iron Ore District of Berkshire County, Massachusetts.

by N. E. Chute

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Abstract

Brown iron ore (limonite) deposits, that produced a few million tons of ore, were worked at intervals for a period of over 100 years in western Berkshire County, Massachusetts. Similar deposits occur in northwestern Connecticut and eastern New York. All of the mines are now abandoned; the last mine to operate in Massachusetts was closed in 1922.

The ore deposits occur commonly at the contact of the Stockbridge limestone and the overlying Berkshire schist. The Stockbridge limestone consists of interbedded limestone and dolomite of Cambro-Ordovician age partly recrystallized to marble. The Berkshire schist is a quartz-mica schist considered to be mainly of Ordovician age but said to include some older schist. Some geologists believe that the Berkshire schist was thrust westward over the Stockbridge limestone and is, therefore, separated from the limestone by a major overthrust fault. The limestone and schist have been compressed into folds that trend north to northeast. Most of the folds discernable in the limestone are overturned towards the west or northwest so that the prevailing dip of the beds is eastward. The schist now constitutes the major hills and ridges and the limestone the lower parts of the major valleys.

The largest iron deposits of Berkshire County are near West Stockbridge and Richmond. These deposits are at the contacts of small infolded or overthrust bodies of schist with the limestone of the floor of the main valley. The mode of occurrence and character of the ore bodies are now difficult to determine because glacial deposits cover most of the surface and conceal the ore deposits, and the mine pits are filled with water. Where the geologic relations of the ore deposits are known the schist forms the hanging wall and the limestone the footwall. The ore deposits are somewhat irregular tabular or lenticular bodies that lie on the schist-limestone contact and consequently strike north to northeast and dip eastward, generally about 45 degrees. The largest deposits are several thousand feet long, several tens of feet wide and have been mined to depths of 150 to 200 feet vertically below the surface.

The iron deposits are composed of limonite and goethite. Most of the ore near the surface is said to be soft and earthy, and to pass into hard, porous ore at depth. Analyses indicate that after the ore was washed it contained 40 to 56 percent iron, 1 to 2 percent phosphorus and a fraction of a percent to several percent of manganese, with silica, water and alumina as the other principal constituents. The iron made from this ore in charcoal furnaces was valued particularly for its shock resisting qualities, and it commanded a premium price until finally displaced by steel.

Several hypotheses have been presented to account for the origin of the ore. The writer believes that the scant evidence available indicates that siderite was deposited by replacement of the limestone, and to a certain extent of the schist, along the schist-limestone contacts. Subsequently, at a time when water tables were lower than at present, the siderite near the surface was changed to limonite by weathering. Siderite was found in some of the mines and it is presumed that the limonite grades into siderite within a few hundred feet of the surface.

Some of the mines are said to be worked out and there is no indication that others contain more than a small amount of high grade ore. Undiscovered ore bodies probably exist, but discovery is difficult, owing to the thick cover of glacial deposits.

Introduction

Brown iron ore composed of limonite ($Fe_2O_3 \cdot nH_2O$), was mined in more than 26 mines and prospects in Berkshire County, Massachusetts over a period of about 125 years. All of these mines are now abandoned. The Klondike mine in Richmond, the last mine to be worked, was shut down in 1922.

The writer, assisted by W. B. Allen, spent three months during the summer and fall of 1943 studying and mapping the iron deposits. A regional geologic map was made of the area between West Pittsfield and West Stockbridge (plate ~~2~~ 1), and plane table geologic and topographic maps were made of the surface at the larger mines (~~plates~~ figures 3, 4, 5 & 6). The work was done under the cooperative program for geologic investigations in Massachusetts between the Massachusetts Department of Public Works and the U. S. Department of the Interior, Geologic Survey. The study was coordinated with an exploratory project of the Bureau of Mines, Department of the Interior.

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Mr. J. D. Bardill, district engineer, and Mr. M. L. Thomas, project engineer of the Bureau of Mines, made available the results of the drilling at the Cheever Mine.

Location

Most of the iron mines of Berkshire County, Massachusetts, as shown on figure 1 ~~plates 1 and 2a~~, are in the towns of Richmond and West Stockbridge between the villages of West Pittsfield and West Stockbridge. Outside of this area a few mines and prospects are known in the towns of Sheffield, Alford, Lanesborough, Cheshire, Adams, and Lenox. The Tremper mine in Alford is the only iron mine in the valley area between West Stockbridge and northwestern Connecticut.

Topography

The region in which the iron deposits occur is characterized by a group of broad limestone-floored valleys between prominent northward and northeastward trending ridges of schist. This group of valleys is bordered on the west by the Taconic Mountains, and on the east by the Berkshire plateau. Between West Stockbridge and West Pittsfield, where most of the mines are located, the higher ridges rise 700 to 1000 feet above the bottom of the main valley. The valley has an altitude of about 1130 feet at West Pittsfield and about 900 feet at West Stockbridge. Yokum Seat, a peak just east of the Branch mine with an altitude of about 2135 feet, is the highest point in this area.

The floor of the main valley is irregular owing to the presence of small hills, terraces, and valleys which consist in part of glacial deposits, and in part of bedrock hills or terraces formed by stream dissection of the main valley floor. A rock terrace ranging in altitude from 1260 to 1275 feet can be traced from a point about a mile west of Richmond Pond southwestward for approximately 2 miles. (See pl. 1.) A similar rock terrace, which has an altitude of about 1230 feet, occurs on the other side of the main valley; on this the Bacon and Andrews mines are situated. Several of the small rock hills east of Richmond have summit altitudes between 1150 and 1200 feet. These terraces and roughly accordant hill tops are remnants of old valley floors formed by one or more cycles of stream erosion during pre-glacial time. Younger valleys were eroded in these old valleys before the last ice sheet spread over the region. Beginning about a million years ago the northern part of the United States was glaciated several times. The glacial ice modified the topography by eroding a few feet to a few tens of feet of the surface material and by redepositing much of it in the valleys. The last ice sheet is estimated to have disappeared from this region between 10,000 and 25,000 years ago. Since glaciation the streams have eroded their channels, but otherwise the glacial topography has been modified very little.

Geologic Formations

General statement

The brown iron ore deposits of Berkshire County are in the Stockbridge limestone, commonly at its contact with the overlying Berkshire schist. The ages of these formations are indicated in the accompanying table of geologic time.

General Geologic Time Division Era	 Period and epoch	Formations of Berkshire County, associated with the iron deposits	Estimated years from the beginning of the period to the presen on basis of radio-activity, Mass.
CENOZOIC	Quaternary		
	Recent	Swamp, lake, and stream deposits	25,000
	Pleistocene	Glacial deposits	1,000,000
	Tertiary	No deposits	
MESOZOIC	Cretaceous	No deposits	
	Jurassic	No deposits	
	Triassic	No deposits	
PALEOZOIC (Carboniferous)	Permian, Pennsylvanian, Mississippian.	No deposits	
	Devonian	No deposits	
	Silurian	No deposits	
	Ordovician	Berkshire schist* Upper part of the Stockbridge limestone	435,000,000
	Cambrian	Lower part of the Stockbridge limestone Cheshire quartzite Dalton formation	550,000,000
~~PRE-CAMBRIAN~~ PROTEROZOIC	Pre-Cambrian	No deposits*	Probably greater than all later geologic time

*See discussion on pp. 10-11.

Consolidated (bedrock) formations

Stockbridge limestone

The Stockbridge limestone in Massachusetts crops out in the valleys between the Taconic Mountains, along the western border of the State, and the Berkshire Hills and the Hoosic Range a few miles to the east. It is composed of interbedded limestone and dolomite, folded, and in part recrystallized into marble. No fossils have been found in the Stockbridge limestone within the area studied in detail (pl. 2), but fossils reported (5, p.57) as occurring at Canaan and Hoosick, New York and other more distant localities, indicate that the limestone is of Cambrian and Ordovician ages.

The Stockbridge limestone is overlain by the Berkshire schist, except where the schist has been removed by erosion, and is underlain, at least in part, by the Cheshire quartzite and the Dalton formation, both of Cambrian age. The findings of Prindle and Knopf (20)* in the nortnern part of Berkshire County and in southern Vermont, however, indicate that some beds mapped as Berkshire schist may have been thrust over the Stockbridge limestone from the east. If this is true for the Berkshire schist of this area, these formations are not in normal stratigraphic relation.

*Numbers in parenthesis refer to articles and pages cited in the bibliography pp. 59-60.

Dale divided the Stockbridge limestone into a lower "dolomitic limestone" 500 to 800 feet thick and an upper calcitic limestone 200 to 400 feet thick, and showed the distribution of these on his maps (5; p. 3 and pls. 1 to 5). The area mapped by the writer (pl. 2) is almost entirely within the area of Dale's upper "calcitic limestone", which he says contains some scattered beds and lenses of dolomite limestone. Numerous tests with acid made in the field by the writer showed that, in this area, there is considerable dolomite limestone interbedded with calcite limestone, and also that most of the calcite limestone contains admixed dolomite in various amounts. In this area the calcite and dolomite limestones are so intermixed as to make Dale's classification of doubtful value. F. H. Moore, reporting on the marbles and limestones of Connecticut (18, p. 19) reached the same conclusion. He says, "The writer believes, after two field seasons' work, that there occurs no such a regular distribution of these phases, as the map prepared by Dale would indicate. On the other hand there seems to be more or less of a 'spotty' distribution of the dolomite within the marble belt as a whole. Due to the scarcity of available outcrops it is at the present time impossible to delineate these phases with even a fair amount of accuracy."

In the area between West Stockbridge and West Pittsfield, white medium-grained calcite marble forms irregular lenses in the Stockbridge limestone. This marble, because of its more complete and coarser recrystallization and its white color, contrasts noticeably with the rest of the formation. The relations suggest that the development of the medium-grained marble was accomplished by solutions localized by fractures in the rock.

Heated solutions have affected the limestone in places, as is indicated by tourmaline crystals found by the writer in the limestone about a half mile northeast of the Werden mine. The best evidence, however, is in northwestern Connecticut near Canaan and Falls Village where in places the Stockbridge limestone contains, in addition to a large number of tremolite crystals several inches long, feldspar crystals and other silicates that require heated solutions for their formation.

The mica minerals muscovite and phlogopite are the most common of the metamorphic minerals in the Stockbridge limestone, both in Massachusetts and Connecticut. In places the mica is sufficiently abundant to form thin layers or lenses of schist in the limestone. Small quartz veins occupying tension cracks in the limestone are also common.

The differences in the amount of metamorphism shown by the Stockbridge limestone within short distances can be accounted for only partly by the fact that dolomite limestone recrystallizes less readily than calcite limestone. The stresses that caused the limestone to fold undoubtedly accomplished some of the metamorphism, but the writer believes that the more coarsely recrystallized phases of the limestone owe their origin in part at least to solutions that facilitated the recrystallization.

Stockbridge limestone showing very little metamorphism may be seen in the railroad cut about 1 3/4 miles northwest of West Stockbridge, and an example of the medium to coarse-grained marble may be seen in the quarry about 2½ miles south of West Stockbridge on the east side of Route 41.

Much of the Stockbridge limestone between West Stockbridge and West Pittsfield contains scattered grains of quartz sand. The abundance of the quartz grains varies in different beds; commonly they are concentrated in thin layers along the bedding. The quartz grains are not as soluble as the calcite and dolomite and consequently they stand in relief on weathered surfaces. Some dolomite grains also stand in relief and resemble quartz grains in appearance, but they are much softer than the quartz and can be distinguished by testing the hardness.

Berkshire schist

The Berkshire schist forms the higher hills and ridges in and near the Housatonic valley of western Massachusetts and eastern New York, it extends northward into Vermont and southward into Connecticut. Dale states (5, p.3) that the schist has a maximum thickness of half a mile. The Berkshire schist as formerly mapped was thought to be entirely of Ordovician age, but from the work of E. B. Knopf and L. M. Prindle (20) it includes some schists of Cambrian and perhaps pre-Cambrian age. In the lexicon of geologic names of the U. S., Wilmarth (27) says, "For many years the Berkshire schist was classified as Ordovician, but additional work proved that in some areas the rocks mapped under that name included Cambrian and pre-Cambrian rocks". No means was found of determining the age of the Berkshire schist mapped for this report (pl. 2). The fact that the schist overlies the Stockbridge limestone, which is of Cambrian and Ordovician age, does not help date the schist because of the possibility that the two formations are separated by a major overthrust fault. The confusion as to the age relationships of beds mapped as Berkshire schist cannot be dispelled until much more detailed mapping has been done in adjacent areas, and the suggested Ordovician age of the Berkshire schist is therefore tentative. Indeed, further work may demonstrate the existence of two schist formations, one of Ordovician age, and one of Cambrian or pre-Cambrian age, that have been mapped as Berkshire schist.

In the area studied by the writer the formation is predominantly a quartz-mica schist or a quartz-sericite schist. A thin layering, which represents the bedding of the original rock can be seen in many of the outcrops. In general the foliation of the schist is parallel to the bedding and both structures have been deformed together into complicated folds. Short quartz veins parallel to the foliation are abundant in the formation.

The degree of metamorphism shown by the formation diminishes westward, coarse garnet-staurolite schist predominating on the east side of the Housatonic valley and only phyllite and slate being found in eastern New York.

Several small bodies of schist have been found within the limestone between West Stockbridge and West Pittsfield. One of these bodies lies west of the Werden mine. Others have been mapped by Dale (5, pl. 2) at the Hudson and Leet mines in West Stockbridge and the Cone and Klondike mines in Richmond. They are probably downfolded or downfaulted portions of the Berkshire schist, but the exposures are not good enough to exclude the possibility that some may be interbedded with the limestone. These beds are of special significance because the iron ore bodies tend to occur along their contacts.

Structure

The Stockbridge limestone and Berkshire schist are complexly folded and faulted. The deforming forces acted in east-west directions and squeezed the limestone and schist into folds that trend northward to northeastward.

The difficulty of interpreting the structure is increased by the possibility that folding and faulting may have occurred several times, first at the end of the Ordovician period, again at the end of the Devonian period, and once more near the close of the Paleozoic era.

As shown on plate 2a, the beds of the Stockbridge limestone strike north to northeast and with few exceptions dip eastward, the dips ranging from 10 to 80 degrees. The folds have been overturned toward the west causing both limbs of the folds to dip eastward. Many small folds can be seen in the limestone outcrops, but the structure is so complicated that the large folds can rarely be delineated.

The axes of the minor folds tend to be parallel to the axes of the major folds. The pitch of the axis of a minor fold, therefore, indicates the pitch of the axis of the associated major fold. Between West Pittsfield and Richmond the axes of most of the minor folds in the Stockbridge limestone are within a few degrees of horizontal; south of Richmond they pitch southwestward more steeply.

The Berkshire schist is also strongly folded into both large and small folds. On the limbs of the folds the main foliation of the schist parallels the original bedding of the rock and the foliation has itself been folded. Later shear planes and foliation have been superimposed on the original foliation. The axes of the minor folds in the schist, so far as is known, pitch similarly to those in the adjacent limestone.

The schist and limestone have undoubtedly been faulted in many places; however, the lack of distinctive marker beds, which would reveal such displacements, and the scarcity of outcrops, make it very difficult to locate the faults.

According to Prindle and Knopf (20) the Berkshire schist in northern Massachusetts and southern Vermont has been thrust westerly over the Stockbridge limestone. Many of the iron deposits are known to be at the contact of the limestone and the schist. If such a fault exists where the iron deposits occur, it was probably an important factor in their localization.

Unconsolidated formations

Glacial deposits

Introduction. New England was glaciated one or more times during the Pleistocene epoch ~~"Glacial Period"~~, which began about a million years ago and terminated approximately 10,000 to 20,000 years ago. Abundant deposits formed by the last ice sheet now cover the region. Deposits left by older ice sheets have been either destroyed, covered, or obscured by the younger deposits.

The last ice sheet must have been several thousand feet thick in western Massachusetts for it covered the highest hills in the region and moved southeastward across them. The glacial striae made by stones held in the bottom of the ice and dragged over the bedrock are still preserved on some of the outcrops of Berkshire schist. Striae are rarely seen on the Stockbridge limestone because it weathers so rapidly that they have been destroyed. Striae trending S. 35°- 40°E. were found on the Berkshire schist north and southeast of the Werden mine. (See pl. 1). Benton reported (2, p. 24) the directions of striae from thirteen different localities in this region to range from S. 35°E. to S. 70°E., and to average S. 45°E.

The glacial deposits include till, sand, and gravel. Till is a heterogeneous mixture of rock and mineral fragments of all sizes ranging from clay to the largest boulders; such material was deposited directly by the ice, and hence is not stratified. The sand and gravel deposits were formed in streams or lakes of glacial melt water, and consequently are sorted and stratified, to various degrees.

Till. Most of the area mapped between West Stockbridge and West Pittsfield (pl. 8a), is covered by till. In the lower parts of the valleys and in the drumlin-like hill the fill in places may exceed 100 feet in thickness, but the average thickness is much less.

Four rows of roughly oval-shaped drumlin-like hills composed chiefly of till trend southeastward across the main valley between West Stockbridge and West Pittsfield. One row crosses the valley along the south side of Richmond Pond, another crosses it a mile farther southwest and a third crosses it northwest of the Truman Andrews mine, two miles southwest of Richmond Pond. A single large hill of till lies between the last two rows, on the west side of the railroad. A fourth, less well developed row crosses the valley between the Carr and the Dixon mines. These rows are elongate approximately parallel to the direction of ice movement as indicated by the glacial striae, and the individual hills have smoothly curving surfaces characteristic of drumlins. Most of them, however, are more irregular in outline than typical drumlins, a condition possibly due to a change in the direction of ice movement during their formation.

Richmond boulder trains. The Richmond boulder trains are roughly linear surface concentrations of boulders of a distinctive greenish, more or less schistose, basic igneous rock. The longest boulder train is said to extend for a maximum of about 20 miles southeastward from a peak called "The Knob", on the crest of the Taconic mountains. On this peak which is in New York state about five miles directly west of West Pittsfield, consists of a small body of igneous rock similar in character to the boulder.

The history of scientific thought concerning the origin of these boulder trains is of unusual interest because the trains were discovered and described before continental glaciation was generally accepted. Dr. S. Reid (23) of Richmond discovered the boulder trains and described them for the first time in 1842. Hitchcock discussed them briefly in 1845, but neither Reid nor Hitchcock could explain how they originated. In 1848 H. D. Rogers and W. B. Rogers (24) wrote a paper on the boulder trains in which they expressed the opinion that the trains were formed by a sudden discharge of the Artic Ocean southward across the land, caused by tremendous earthquakes near the North Pole. Great blocks of ice were supposed to have struck the mountain top from which the rock was derived and to have torn off blocks of the rock, which were then strewn over the ground along the path of powerful eddy currents. Sir Charles Lyell (17) explained the boulder trains somewhat differently. He assumed the region to have been submerged by the sea and attributed the boulder trains to icebergs which dropped the boulders along their course of movement through low places in the mountain ridges. In 1872 Agassiz (1) brought the problem out of the realm of fantasy and correctly interpreted the boulder trains as due to simple glacial action. This was fully substantiated by Benton (2) in 1878 who publisned a detailed report and map of the trains.

Benton found three boulder trains in a belt two miles wide just north of the village of Richmond. The best developed of the three trains extends across the valley from northwest to southeast on the row of till hills northwest of the Truman Andrews mine. The writer observed these boulder trains in the area mapped and was impressed by the abundance of the boulders forming parts of the main train.

Sand and gravel deposits. The sand and gravel deposits between West Pittsfield and West Stockbridge were found only in a small area northwest of Richmond Pond and in the area north and west of West Stockbridge. (See pl. 1).

The deposits northwest of Richmond Pond consist of a small outwash plain bordered on the west by a narrow kame terrace. The deposits in the vicinity of West Stockbridge are much more extensive. There, during the final stages of the disappearance of the ice, when irregular ice blocks still remained in the valley, meltwater streams that may have come from the valley to the northwest, in New York, deposited sand and gravel in the spaces between the valley walls and the ice blocks, and within holes in the ice blocks. When the ice finally melted away the sand and gravel were left as hills and terraces.

The large nearly flat-topped deposit of sand and gravel about three-quarters of a mile northwest of West Stockbridge is a delta deposited in a hole in the ice. The deltal structure is clearly shown in a large sand and gravel pit at the northwest end of the deposit.

Three short eskers were found south and west of the Klondike mine in Richmond. These are sand and gravel ridges formed by glacial stream deposits that, at the time of origin, were confined between ice walls. When the ice melted they remained as narrow sinuous ridges a few tens of feet high.

Post-glacial deposits

Deposits variously composed of gravel, sand, silt, clay, and peat have been formed since glaciation along streams and in marshes and ponds. These deposits are so small and so difficult to distinguish from the glacial deposits that they were not mapped separately for this report.

Iron Deposits

Introduction

Brown iron-ore (limonite) deposits are found in the limestones of Cambrian and Ordovician age in Vermont, western Massachusetts, northwestern Connecticut and eastern New York. Mining of these deposits began between 1731 and 1735, when the Ore Hill mine at Lakeville in northwestern Connecticut was opened, and continued intermittently for about 190 years to 1923 when the last of the mines was closed.

The most important of the Massachusetts iron mines are located in central Berkshire County between West Pittsfield and West Stockbridge. ~~(See pls. 1 & 2a.)~~ The Kemper mine in Alford is the only mine between West Stockbridge and the Connecticut State line. North of West Pittsfield there are mines at Lanesboro, Cheshire, and North Adams, and to the southeast there are mines in Lenox.

Few statistics are available on the output of brown iron ore in Massachusetts. Lewis (16, p. 217) stated that before the panic of 1873 "The Berkshire County, Massachusetts, mines produced 65,000 tons yearly, of which 20,000 tons were used for anthracite iron, and 45,000 tons smelted into charcoal pig." During this time the yearly output of brown iron ore in New York Connecticut, and Massachusetts together amounted to 530,000 tons, but it fell to 180,000 tons in 1876. Four years later it had risen again, as the U. S. Tenth Census credited the three states with 245,328 tons of ore in 1880.

Newland (19, p. 137) says that the total output of these three states, estimated from all available data, amounts to not less than eight or nine million tons.

There is general agreement that iron mining in these States came to an end because of economic conditions and not because of exhaustion of ore in all of the mines, though doubtless some of the mines were depleted. The "Salisbury iron", as the iron made from the brown iron-ore deposits of the region was known, was a superior iron owing to its unusual tensile strength caused in part at least by the presence of manganese in the ore. It was greatly prized for articles required to resist shock, such as railroad car wheels and gun barrels.

With the development of steel, the Salisbury iron ore lost its advantage of superiority needed to compete with other sources of higher-grade iron ore. This change is clearly expressed by H. C. Keith (14, p. 15) as follows:

> The increased production, and the superior qualities of steel, the ease with which its composition could be controlled to a nicety never dreamed of before, together with its cheapness, as developed between 1890 and 1910 annulled the advantage that the Salisbury District and the State of Connecticut had because of their superior ore. Steel first destroyed their prestige in the iron industry and finally ousted them completely from the business.

Pynchon (21, p. 236) in 1899 pointed out that steel was replacing Salisbury iron. He wrote:

> Of late years steel has become so cheap that it is used for many purposes for which iron was formerly employed; and it is a curious fact that the brown hematite of Connecticut, while producing the best of cast and wrought iron, is not a good steel ore. Nevertheless the demand for this iron for certain special uses, notably for the manufacture of car wheels, will always keep the industry alive.

S. G. Colt of Pittsfield, formerly the president of the Richmond Iron Company, told the writer that his company sold all of its output of iron to the Pennsylvania Railroad Company for the manufacture of car wheels, but that about 1920 the railroad company began to use larger freight cars and the Salisbury iron was no longer considered strong enough for the car wheels and steel was used instead. The loss of the car wheel market could not be overcome and the Richmond Company's furnace and mine were closed soon afterward.

Character of the Iron Ore

The iron ore is composed of brown hydrous iron oxide minerals that are referred to collectively as limonite ($Fe_2O_3 . nH_2O$). Goethite ($Fe_2O_3 . H_2O$) is one of these minerals and apparently constitutes much of the ore. The coarsely crystallized goethite has the typical radiating needle or blade-like structure.

According to their state of consolidation the ores were referred to by the miners as "rock ores" or "loose ores" (wash ore). The rock ores are composed of compact fine-grained limonite with variable amounts of the fibrous goethite. Rock ore usually contains cavities of irregular shape ranging from a fraction of an inch to several inches in length. Newland (19, p. 138) states that, "the loose ores include limonitic granular 'limonite' in earthy materials which represent the decay and wash of the country limestones and schists, in places intermixed with glacial debris." He also states that "it was the common experience in mining, if we credit contemporary accounts, for the loose or wash ore to give way in depth to solid ledges of limonite or carbonate, which necessitated a change from pick and shovel methods to drilling and blasting on the part of the operator."

The following analyses of iron ore from some of the iron mines in Massachusetts are reproduced with modifications from the report by W. H. Hobbs (12, pp. 174-175):

Table of Analyses of Some Massachusetts Brown Iron Ores, modified after W. H. Hobbs (12, pp. 174 & 175).

Name of Mine and Type of Ore	Fe	Mn	SiO_2	S	P_2O_5	CaO	MgO	Al_2O_3	H_2O	Analyst.	Date
Cone - - - - - - - - - - - -	43.08	2.01	19.88	0.19	.311	.715	Tr.	3.18	10.75	J. S. Adam	1879
Cone picked sample - - - -	62.20		5.40		.007	.560	"organic matter"		6.95	Chapman	
Cone low grade - - - - - -	36.05		34.50			1.500	.500		9.00	C.T.Jackson	
Cone Average run - - - - -	55.30		4.30			.700			12.00	C.T.Jackson	
Bacon, Brown - - - - - - - -	47.04		14.10	Tr.	1.660	.670	.310		9.64	Chapman	
Bacon, Blue - - - - - - - -	30.90		17.90	Tr.	1.270	.700	.500			Chapman	
Goodrich, Brown - - - - -	55.24		8.20	Tr.	.250	.100	Tr.			Chapman	
Hudson #1 - - - - - - - - - -	42.74		23.70	Tr.	.520	.640		.220	13.20	Chapman	
Hudson #2 - - - - - - - - - -	48.50		22.60	.007	.560	.040	.030		6.98	Chapman	
Leet - - - - - - - - - - - -	42.17	2.25	20.75	.016	.312	.390		4.250	10.07	J.S.Adams	1879
Cheever #2 - - - - - - - - -	42.70		21.60	.130	.580	.380			12.23	J.S.Adams	
Cheever - - - - - - - - -	45.94	2.30	15.18	.011	.552	Tr.	Tr.	3.983	11.62	J. S.Adams	1879
Branch #1 - - - - - - - - -	43.84		21.92	.020	.170				10.66	J.S.Adams	1879
Shaker - - - - - - - - - -	47.56	.36	12.49	.012	.920			6.152	11.99	J.S.Adams	1879
Colby - - - - - - - - - - -	53.59	1.95	24.71		.810				9.77	J.S.Adams	1879
Colby, Poor grade - - - -	33.42	7.38	20.86	.113	.889			9.985	10.18	J.S.Adams	1879
Pomeroy - - - - - - - - - -	49.37	1.09	10.52							J.S.Adams	1879

In places the iron ore contains a small amount of zinc, not reported in the analyses, which accumulated as a coating in the furnace stacks. According to Newland (19, p. 137) the zinc is present in the ore as the zinc sulfide mineral, spalerite. He also stated that a sample of the coating from the Ancram, N. Y., furnace "showed on analysis 96.10 percent ZnO, the rest carbon and iron oxide." S. G. Colt told the writer that a zinc oxide coating accumulated in the stack of the Richmond furnace at Richmond, Mass., and was removed periodically and sold to the New Jersey Zinc Company.

Masses of siderite ($FeCO_3$) are said to have been found in masses in the ores of the Cheever and Leet mines. As explained in the discussion of the origin of the ore, the ore bodies are presumed to have been composed originally of siderite or some similar iron carbonate, and to have been changed to limonite by weathering.

Character of the Ore Bodies

As nearly as can be determined the deposits in general are irregular, roughly tabular bodies that usually occur at the limestone-schist contact, the schist constituting the hanging wall. Newland stated (19, p. 146) that the ore bodies measured from 10 to 50 feet in thickness, averaging 20 to 25 feet. According to former miners interviewed by the writer the thickness of the ore may have locally exceeded 50 feet.

The depth to which the ore extends down the dip is unknown. The larger mines have been worked for 150 to 200 feet vertically below the surface, reputedly without reaching the bottom of the ore.

The writer's conception of the usual occurrence of the iron ore bodies is illustrated by the two diagrammatic cross-sections given in ~~plate 9~~ figure 8. In both of the sections the ore body is shown in its most common position, at the contact of the schist and limestone; in figure 8A the ore body is shown dipping away from the valley into the hill. whereas in figure 8B it dips toward the valley. This difference is significant because in a deposit situated like that illustrated by figure 8B the limonite could theoretically extend farther down the dip. The reason for this is that in pre-glacial time, before deposition of the till, the siderite of the deposite situated as illustrated in figure 8B was nearer the surface for a greater distance down the dip, enabling more of it to be oxidized to limonite. Thus an ore body that dips in the same direction as the pre-glacial hill slope would contain more limonite ore, other conditions being equal, than an ore body that dips into the hill.

Most of the deposits seem to occur as illustrated in figure 8B. The Branch mine is the only good example known of a deposit that dips into the hill. In both figures of ~~plate 9~~ figure 8, limonite is shown ending irregularly against siderite in depth. Siderite has been mined at the Burden Mines near Hudson, N.Y., but owing to the fact that this mineral contains less iron than pure limonite, it is doubtful whether it could have been worked successfully in the Massachusetts deposits.

Limonite does not form readily at depths where the rock is continuously saturated with ground water; therefore, the limonite ore bodies that contain in excess of 35 percent iron are not likely to extend more than a few hundred feet vertically below the old pre-glacial surface.

The deepest known occurrence of limonite in these deposits is at the Cheever mine where, as reported by the Bureau of Mines (see under Cheever mine), a limonite deposit, located at the schist-limestone contact, was penetrated by drill hole #6 from 400 to 457 feet below the surface. The same deposit was found in hole #4 at a depth of 317 to 380 feet (see section D-D', ~~plate 19~~ figure 9); the analyses tends to show that below 200 to 250 feet, the iron content of the deposit diminishes considerably, a condition likely to exist in most of the deep deposits. The depth to which ore extends varies in different deposits, and also in different parts of the same deposit. S. G. Colt told the writer that the ore in the mine that he operated on the Weslowski farm, about one-half mile northwest of Cheshire, pinched out at a depth of about 45 feet. Other mines, such as the Cone mine in Richmond, are reported to be in ore at depths of 200 feet or more.

The various ore bodies differ greatly in horizontal length. The ore body of the Potter, Hudson, Leet and Goodrich mines has been worked along its strike for about 3800 feet; that of the Klondike, Cone, and Carr mines has been worked for about 2500 feet; and that of the Bacon and Andrews mines has been worked at intervals for about 1700 feet. The other ore bodies have shorter proved lengths.

Persons acquainted with the mines during operations agree that the ore bodies are generally bordered by "blue marl" on the hanging wall and "yellow ocher" on the footwall. The "blue marl" is probably in part bluish-gray till and in part disintegrated schist. The "yellow ocher" isapparently clay that is stained with residual limonite from the weathering of the limestone. Judging by the accounts of former mine workers, the "yellow ocher" forms an irregular layer on the footwall, between the ore and the limestone, and ranges from a few inches to a few feet in thickness.

Origin of the Ore

Several hypotheses of origin have been proposed for the iron ore deposits in Berkshire County. Because of the present lack of exposures of the ore it is very difficult to ascertain the relative merits of these hypotheses, however, the hypotheses are reviewed and judged as far as the inadequate evidence permits. The hypotheses may be classified as follows:

Group 1) The limonite ore was formed essentially in place by the weathering of pre-existing iron carbonate minerals.

a) The iron carbonate was deposited as a chemical sediment in beds within or at the top of the Stockbridge limestone.

b) The iron carbonate was deposited by replacement of the limestone.

Group 2) The iron was leached from the Berkshire schist and, after some transportation, was deposited as limonite in the Berkshire schist or as siderite in the Stockbridge limestone. The siderite was subsequently weathered to limonite.

James D. Dana (6, pp. 398-400) was one of the first to express the opinion that the iron ore was formed by the weathering of siderite and other iron carbonates. In 1884 he stated that the iron carbonate had been deposited as chemical sediment during the transition period between the deposition of the Stockbridge limestone and the Berkshire schist. At that time, however, it was thought that the schist rested on the limestone in normal stratigraphic sequence.

E. C. Eckel (7, pp. 341-342) in 1904 classified the iron deposits into four types. The limonite of three of the types was formed by the weathering of iron carbonate that had been deposited by replacement in the Stockbridge limestone. Eckel's classification is as follows:

Type 1 - The iron carbonate was formed in a thin bed of limestone within the Berkshire schist.

Type 2 - The iron carbonate was formed at the contact of the Stockbridge limestone and the Berkshire schist.

Type 3 - The iron carbonate was formed by the replacement of a bed of limestone entirely within the Stockbridge limestone.

Type 4 - The iron was deposited directly as limonite in a basin, cavity or cavern in flat lying limestone. (This hypothesis was intended to explain the origin of the ore body at the Davis mine in Connecticut).

It is doubtful if any of the limonite deposits in Massachusetts are of Type 3. In referring to the Hudson, Leet, and Goodrich mines in West Stockbridge Eckel (7, p. 337) wrote: "The ore body evidently lay on or in the limestone, as no schist or quartzite is exposed anywhere in its vicinity, and certainly none could have occurred in direct contact with the ore body....The exposures near the Leet mines are very satisfactory in spite of the present condition of the mines, and prove conclusively that no schist or quartzite beds were concerned in the localization of this ore body".

W. H. Hobbs (12, pp. 179-180) stated in 1907 that his belief the limonite was not formed by the alteration of iron minerals in situ but had been introduced from some outside source, probably from the leaching of pyrite in the Berkshire schist. He thought that the limonite was formed by the replacement of Berkshire schist and the iron carbonate by the replacement of limestone. According to him the ore deposits were localized by, 1) the proximity of an upland area that caused vigorous ground water circulation, 2) local fracturing, and 3) the depression of a block of much fissured schist within walls of dolomite.

In 1936 Newland (19, pp. 152-155) published a comprehensive study of these deposits. He concluded, as did J. D. Dana, that the limonite had formed through the weathering of iron carbonate beds which had been deposited as chemical sediment.

The writer found an exposure of schist impregnated with limonite forming the hanging wall of the ore body at the east end of the eastern most pit of the Leet mine. This exposure of ore is shown on ~~plate~~ figure 6. The presence of schist on the hanging wall of this ore body is verified by Dale (5, pl. II) who shows on his map a narrow body of schist on the east side of the ore body. Several of the ore bodies have outcrops of limestone or dolomite on the foot-wall side and no outcrops on the hanging wall side. This is true at the Cheever mine where drilling has shown that schist forms the hanging wall although there is no indication of it at the surface. Similarly, at the Bacon and Andrews mines there are no outcrops on the hanging-wall side of the ore body but the dumps contain small schist fragments indicating that the hanging wall probably consists of schist.

The writer's conclusions concerning the origin and occurrence of the iron deposits are as follows:

1. The limonite deposits are older than the glaciation, as is evident from the fact that numerous fragments of the limonite ore have been found in the glacial deposits. According to Smith (26, p. 39) the ore used in the forges at Pittsfield was obtained at first chiefly from boulders of the limonite ore found scattered over the fields and buried in the glacial drift. The amount of limonite formed since glaciation is probably negligible.

2. Siderite has been reported to occur in the lower parts of the Cheever and Leet mines. It has also been reported from mines in Connecticut and New York. The writer agrees with Dana, Eckel, and Newland that siderite or a similar iron carbonate is probably the source of the limonite of the ore deposits. Small amounts of pyrite have been found near the ore bodies, but there is no indication that pyrite was present in sufficient quantity to have been the main source of the limonite.

3. Although the evidence is not conclusive the writer favors Eckel's hypothesis that the siderite is younger than the Stockbridge limestone and was deposited by replacement. Parts of the ore bodies cut across the limestone beds to such an extent as to indicate that the original siderite bodies were formed after the limestone and are not sedimentary beds.

4. The siderite on exposure to weathering was changed to limonite above the water table and possibly below in places of vigorous water circulation. The fact that limonite is known locally to extend several hundred feet in depth, far below the present water table, indicates that the water table probably was much lower when most of the limonite was formed than it is now. This condition probably existed in late Tertiary time when the region must have stood several hundred feet higher relative to sea level than now.

5. The larger limonite deposits are known to be at the schist-limestone contact, with the schist forming the hanging wall. Most of the other deposits probably have a similar occurrence. A few of the small deposits may be in the schist where they were localized by fractures or thin beds of limestone.

6. Most of the iron ore bodies are at the contacts of long narrow bodies of schist isolated in the Stockbridge limestone. As these bodies are very poorly exposed, some of them not cropping out at all, they are difficult to locate. Most if not all of them probably are erosion remnants of Berkshire schist preserved where the schist was down-folded or down-faulted into the top of the Stockbridge limestone. If the schist is Berkshire schist then the limestone in contact with the schist should be the top part of the Stockbridge limestone unless the two formations are separated by a thrust fault as stated by Prindle and Knopf. Examination of Dale's maps (5, pls. I & II) will show that with minor exceptions all of the iron mines are in the upper part of the Stockbridge limestone. New ore bodies, therefore, are most likely to be found at the contacts of the schist, particularly the erosion remnants of schist within the upper part of the Stockbridge limestone as mapped by Dale (5).

The main part of the ore body in the Cone mine apparently trends northeastward between the Klondike mine and the Carr mine (see fig. 3). The northwest arm of the Cone pit, which is at right angles to this trend, indicates that a part of the ore body cuts across the beds of limestone. An even more striking example is afforded by the large open pit of the Leet ore body in West Stockbridge. The pit is nearly circular and, as is shown in figure 6, it cuts across the limestone beds exposed in the prominent hill on the northeast side of the pit. Here the crosscutting relationship may be due to faulting.

Descriptions of Mines and Prospects.

Comparatively little information could be obtained concerning the individual mines. No maps of the underground workings of any of them could be located, and the published descriptions are very meager. Some information was obtained from men formerly connected with the mining companies, but several of those who knew most about the mines have recently died.

The mines and prospects are discussed by towns from north to south. Locations of mines are shown in figure 1 and plate 2.

Cheshire

Bliss mine. (Mason and Bliss mine). The Bliss mine is on the farm of Mrs. Anna Weslowski, about a mile by road northwest of the village of Cheshire. According to Lewis (16, p. 228) the mine was first opened in 1782, and the ore worked in a forge. It was reopened in 1872. Putnam (22, p. 87) reported that 1367 tons of ore was mined in 1880. The mining was by open pit (see fig. 7).

About 1905 the mine was purchased from the Richmond Iron Works by S. G. Colt of Pittsfield. Mr. Colt told the writer that he sank a shaft southwest of the open pit. (See fig. 7.) The only good ore found was between 15 and 45 feet below the surface for a distance of 75 to 100 feet north of the shaft. This ore, high in phosphorus, was mined out and several drifts 300 to 400 feet long were run from the shaft in search of more ore, but without success. The mine was abandoned in 1907.

Jagger mine. This mine is located about one-half mile west of Cheshire village, at the east foot of a prominent ridge. It is 1500 to 1800 feet southwest of the Kitchen Brook crossing on the road leading west from the village. According to G. G. Reynolds of Cheshire (personal communication), this mine was worked about a hundred years ago by a Mr. Jagger from New York, but the ore was too "spotty" to be profitable.

The ore was mined from two open pits (fig. 7) which appear to be on the contact of the Stockbridge limestone and the Berkshire schist. There are no outcrops near the pits and only glacial drift is now exposed in the walls.

Bennett prospect. This prospect is on the E. L. Martin dairy farm about one and one-half miles east of the village of Cheshire. (See fig. 1.) The workings, which consist of one pit about 100 feet in diameter and 20 feet deep and several other shallow pits 15 to 40 feet in diameter, are 1500 to 2000 feet north of Mr. Martin's house. Owing to the lack of outcrops in the vicinity of the prospect pits, there is no certainty that any ore was found in place. The "ore bed" is indicated on the map of Cheshire in the atlas of Berkshire County, published in 1876 by F. W. Beers.

Lanesboro

Colby (Sherman) mine. The Colby mine was opened in 1856, and at least during the later years of its operation was owned by J. C. Colby. The ore was smelted at Lanesboro in a furnace also owned by Mr. Colby. The mine was closed in 1888 or 1889.

A map of the Colby open pit is shown on figure 7. According to Morris Hagerty of Pittsfield, the mine had three vertical shafts. The writer found one of these about 100 feet northeast of the north end of the pond in the open pit. The south and middle shafts, according to Mr. Hagerty, are about 100 feet deep and were worked out when abandoned; the north shaft is 75 to 80 feet deep and was completed only a couple of months before the mine closed. It is also reported that good ore was left in this shaft.

Pittsfield

Shaker mine. The Shaker mine workings are on both sides of U. S. Route 20, about 500 feet west of the railroad at West Pittsfield. In his history of Pittsfield, Smith (26, p. 39) stated that the Shaker mine "was excavated before the year 1810 to a depth of 60 feet." The mine has been closed since 1897 or 1898.

The mining was entirely underground. According to Morris Hagerty and John Corbett the depression occupied by the pond just south of Route 20 is due to caving of the underground workings and is not an open pit. Mr. Hagerty told the writer that the first mining was done north of Route 20 where there is a vertical shaft 75 feet deep, and that from there the mining progressed southward. Two shafts were sunk south of the highway. One, now filled and obliterated, is located between two houses about 500 feet west of the railroad bridge; the other is about 300 feet farther south, a short distance east of the pond. These shafts are said to extend to the bottom of the mine a depth of about 125 feet. The mine is said to have had four levels, with workings that extended about 300 feet south of the southernmost shaft. It was very wet and had to be timbered throughout. Considerable difficulty was encountered in sinking and maintaining shafts because of the presence of water-soaked ground that behaved like quicksand; this is said to have been one of the causes for the closing of the mine.

Richmond

Branch mine. The Branch mine is on the farm of L. H. Yerkes about three-quarters of a mile south of Richmond Pond. The mine was opened in 1856 by William Branch (Lewis, 16, p. 227). According to Mr. Seymour of Stevens Corners, Richmond, the mine was finally closed about 75 years ago. A moderate amount of ore was mined and was hauled to the main line of the railroad on horse-drawn railroad cars. The mine is said to have had underground workings. All that can be seen today are dumps and a pit about 100 feet long, 50 feet wide and a few feet deep. At the east end of the pit the writer found a hole that may have been a shaft. There are no outcrops in the vicinity of the mine.

Some reported old workings known as the Stewart mine, on the farm of F. J. Skates, about one-quarter of a mile north of the Branch mine, were not seen by the writer.

Lovelace mine. The Lovelace mine is one and one-quarter miles north of the Richmond railroad station on the property of Mrs. M. Jossier. (See fig. 2). Lewis (16, p. 228) states that the mine was opened in 1866 by W. A. Lovelace but was not worked very extensively.

In addition to the open pit, which is about 30 feet deep, the mine is said to have had two shafts. One is at the south end of the open pit the other was not located. According to reports three or four holes were drilled about fifty years ago near the open pit, but little or no ore was found.

Outcrops are lacking in the vicinity of the mine so that the geologic relations of the ore body are not apparent.

Andrews mine. The Andrews mine, located two miles northeast of the village of Richmond, was opened in 1871 and was closed a few years later. The mine is on the Andrews farm now owned by Mrs. Ira J. Palestine of New York City.

The open pit of the mine is filled with water. John Fairfield of Richmond measured the depth of the pond in the pit and found it to be 65 feet at a point about 150 feet from its south end. The mine may have had a shaft, but it is doubtful if much ore was obtained by underground mining. The ore was drawn by horse carts to the furnace at West Stockbridge.

As may be seen on ~~plate~~ figure 5, the closest outcrops, limestone, are 200 feet northwest of the mine. The beds strike northeast and dip southeast, and are probably parallel to the strike and dip of the ore body. The mine dump contains many small fragments of schist and it therefore seems probable that the orebody is at a limestone schist contact, the schist forming the southeast or hanging wall.

Bacon mine. The Bacon mine is 700 feet southwest of the Andrews mine. Putnam (22, p. 87) stated that the mine was first opened in 1846 and was reopened in 1880, after having been idle for a number of years. It was finally closed in 1881 or 1882. The mine is now owned by Mrs. Ira J. Palestine of New York City.

The mine workings consist of an open pit, 600 feet long, and three shafts. The two shafts on the southeast side of the pit appear to be shallow prospecting shafts. In 1880 or 1881, according to Putnam (22, p. 87), the shaft 50 feet beyond the north end of the pit was 50 feet deep and had drifts 50 feet south and 60 feet north.

Putnam (22, p. 87) reported the output of ore in 1880 to have been 280 tons. The total output of the Bacon mine he estimated to be 28,000 tons.

Only glacial till and dump material are exposed around the open pit. The closest outcrops are of Stockbridge limestone, 75 feet northwest of the pit. (See fig. 5). The limestone beds dip southeast, and are probably to the dip of the ore body.

The Bacon mine is on line of strike with the Andrews mine but it is not known whether both mines are on one ore deposit or two separate deposits. There is an interval of 600 feet between the mines that, as far as is known, has not been explored. The ore bodies of both mines apparently are at the same schist-limestone contact and are elongate parallel to the contact, thus accounting for their alinement and their parallelism to the regional structure.

Truman Andrews mine. The Truman Andrews mine is located about one and one-quarter miles northeast of the village of Richmond. The mine workings consist of an open pit 180 feet long and 50 to 100 wide, partly filled with water. Only glacial till is exposed around the edge of the pit. Two boulders of good ore were found at the southeast end of the pit, but no ore was seen in place. The mine is old and no information concerning its history could be obtained.

Werden mine. The Werden mine is located one and one-half miles east of Richmond. The workings consist of an open pit about 150 feet long and 100 feet wide, partly filled with water. No ore is exposed in the walls of the pit and there are no outcrops of bedrock within several hundred feet of it. The mine is very old and little is known about it. The general opinion is that only a small amount of ore was mined.

Cheever mine. The Cheever mine is on the farm owned by Mrs. Jacob North, about one mile east of the village of Richmond. According to reports the mine was opened at the time of the Civil War, when the region was being actively prospected for iron ore, and it was closed finally in 1886.

The mine workings consisted of an open pit and underground workings. The open pit (fig. 4) is 1050 feet long and is partly filled with water. It is said to be about 75 feet deep at its northeast end, where it is widest and deepest. Levis (16, p. 227) says that in 1876 the mine had four shafts, each about 150 feet deep, and seven levels with drifts from 150 to 500 feet long.

The vertical shaft on the southeast side of the road was the main shaft during the later years of operation. This shaft is 160 feet deep, according to Putnam (22, p. 87). The northernmost shaft, located in the swamp, is also vertical and is estimated to be 100 feet deep. Little is known about the shaft southeast of the center of the pit. The writer was told that it was sunk by a Mr. Pasco, on property held by the Stockbridge Iron Co. The inclined shaft on the northwest bank of the pit was completed shortly before the mine was closed in 1886 and was never used. The collar of the shaft can be seen at the edge of the pond that now fills the pit.

It is believed that the inclined shaft was sunk for the purpose of continuing the underground mining southeastward. This shaft is said to be inclined 45 degrees southwest and to connect with the main drifts at the bottom of the mine.

All of the mine workings are now know as the Cheever mine; however, in 1885 Putnam (22, p. 87) mentioned the "Banks" mine as adjoining the Cheever mine on the west. The "Banks" mine of Putnam apparently was the southwestern part of the open pit. According to Putnam the "Banks" mine was operated for eight months in 1880 by the Stockbridge Iron Company, and during that time supplied 5,040 tons of ore. Analyses of samples reported by Putnam as as having been taken from a stock pile of 2000 tons of mixed washed and rock ore were as follows:

	Fine ore	Rock Ore
Metallic iron	59.12%	50.48%
Phosphorus	0.248	0.183
Phosphorus in 100 parts of iron	0.634	0.363

Putnam stated (22, p. 87) that the Cheever mine, operated by the Richmond Iron Company, supplied 33,482 tons of ore from June 1, 1871 to June 1, 1877. In 1880 the output was 12,034 tons. An exceptional amount of rock ore was found in the mine. Samples from 300 tons of washed ore and 25 tons of rock ore are reported by Putnam to have contained.

	Washed ore	Rock ore
Metallic iron	45.82%	43.82%
Phosphorus	0.168	0.234
Phosphorus in 100 parts of iron	0.367	0.534

As can be seen from the shape of the open pit and the distribution of the shafts, the ore bed of the Cheever mine is about parallel to the bedding of the adjacent Stockbridge limestone. The ore bed is reported to have a dip of about 45° SE, which is also the approximate dip of the limestone beds. Buff-colored dolomite is exposed near the southern end of the southwest side of the pit, but no iron ore is exposed anywhere in the area.

The widest part of the ore body, was found, according to local reports, at the northeast end of the pit, where the horizontal width was about 60 feet; at the south end of the pit, the ore body had a horizontal width of about 15 feet, and at the bottom of the vertical shaft on the southeast side of the road it had a horizontal width of 8 to 10 feet. Nothing is known about the character of the ore body at the north end of the underground workings. According to J. McCartny the underground workings do not extend very far north of the northernmost shaft, in the swamp. (See fig 4.)

which is about 400 feet northeast of the drill hole and presumably ends in the upper deposit, is said to be about 160 feet deep and to connect with the mine workings under the open pit.

The sections on ~~plates 9~~ figures 8 and ~~10~~ 9 show the bedding of the limestone, the plane of the ore body and the foliation of the schist as parallel to one another. If the schist and limestone are in fault contact and not in normal sedimentary contact they may not be parallel. The outcrops of limestone on the footwall side of the Cheever mine open pit show that the portion of the ore body near the surface was at least approximately parallel to the bedding of the limestone, but the schist forming the hanging wall is completely concealed and nothing is known of the orientation of its foliation.

Significant data of the drill logs not shown on ~~plate 10~~ figure 9 are discussed below for each drill hole.

Editor's note: The Federal Bureau of Mines made many analyses of iron contents of drill cuttings but the data has not been released for publication. In that Bureau's War Minerals Report 367 (Cheever Mine; Richmond, Berkshire County, Mass.) a summary of reserves states analyses that range from 20.7 to 26.7 percent iron, and from 45.8 to 51.3 percent "insoluble" material; a lower bed is reported to contain 14.8 percent iron.

Diamond drill hole #1 - The till-sand contact in this hole is not precisely located; it may be a few feet higher than indicated in Section A - A', of ~~plate 10~~ figure 9.

Under the microscope the samples analysed showed varying amounts of limonite in fine-grained quartz sand of comparatively uniform grain size. Owing to mechanical difficulties that prevented deeper drilling, the bottom of the drill hole extends only 2 feet into limestone.

Diamond drill hole #2 - The fine-grained sand penetrated by this hole contains only a few percent of iron.

Diamond drill hole #3 - Two attempts were made to drill this hole to bedrock. At a depth of 28 feet in the first hole a boulder was penetrated through which the casing could not be driven, and the hole was abandoned. A second hole, located a few feet from the first, penetrated limonitic sand similar to that found in holes 1 and 2; besides quartz, this sand showed a small amount of muscovite.

Churn drill hole #4 - The till-schist contact in this hole was difficult to locate exactly; but was interpreted to be about 30 feet below the surface, where the last trace of limestone was found in the cuttings. From 30 feet to 195 feet the cuttings consisted of mica schist fragments typical of the Berkshire schist, vein-quartz fragments, and considerable fine clayey material which could have been derived from the schist.

Although the drilling was easier than expected for solid rock and the hole had to be cased to prevent caving, the absence of limestone and types of rock other than mica schist in the cuttings indicates that the material is probably soft schist rather than till. The log of the hole below 195 feet was made by the Bureau of Mines.

Churn drill hole #5 - The till-schist boundary was difficult to locate from the cuttings of this hole. Limestone and other types of rock were found in the cuttings to a depth of 35 feet, which was taken as the bottom of the till. Below that point and to a depth of 189 feet the cuttings consisted entirely of mica schist and quartz. Some of the cuttings were of partly weathered schist. From 189 feet to the bottom of the hole at 271 feet the cuttings contained considerable limonite. The other minerals in the cuttings were chiefly quartz and muscovite, with the quartz several times more abundant than the muscovite.

Log of drill hole #5:

Depth in Feet		Rock Type, etc.
From	To	
0	35	Till, contains limestone fragments.
35	65	Quartz, mica schist, slightly weathered; some schist is graphitic.
65	70	Quartz, mica schist weathered and much stained by limonite; some schist is graphitic.
70	125	Quartz, mica schist weathering diminishes downward; schist not weathered at 125 feet.
125	145	Quartz, mica schist, not weathered.
145	163	Quartz, mica schist, partly weathered.
163	189	Quartz, mica schist, contains 3 to 10 percent limonite.
189	271	Limonite deposit, chief impurities are fine granular quartz and fine mica.

(Logged below 242 feet by the Bureau of Mines.)

<u>Rotary drill hole #6</u> - The log of this hole, as reported by the Bureau of Mines, is as follows:

Depth in Feet		Rock Type, etc.
From	To	
0	170	Overburden
170	173	Broken core. Rotten, soft, grey schist.
180	190	Grey, chloritic schist, soft, some pyrite.
190	195	Grey, chloritic schist, soft, contorted folia.
206	216	Grey, soft chloritic contorted schist with some quartz bands. Core broken.
216	226	Do.
226	236	Do. Better core, pieces up to 6 inches long.
236	241	Do. Plus garnet metacrysts. 2-7 mm - red.
241	249	Do.
249	254	Do. More quartz laminae.
254	261	Do.
261	264	Broken fragmental core. Grey, weathered, chloritic schist, with considerable quartz in bands up to 2" thick, and with disseminated pyrite.
264	340	Do.
340	349	Schist. No core.
349	400	Schist. Sludge turned red (Iron showing at 400').
400	457	Limonite
457	462	Limestone

Rotary drill hole #7 - This hole was drilled under difficult conditions and, according to J. D. Bardill of the Bureau of Mines, the samples obtained were not fully satisfactory. The log of the hole as reported by the Bureau of Mines is as follows:

Depth in Feet From	To	Rock Type, etc.
0	90	5" tricone rock bit. All glacial till.
90	245	Dark, fine-grained, contorted, decomposed schist. Heavy water flow estimated to be 150 gallons per minute came in at 190 feet. Much sand with the schist.
245	249	Mixed schist and limonite. Hole caved cutting off tricone bit and 40 feet of rod. 150 g.p.m. of water flowing from collar.

Dixon mine. The Dixon mine is on the R. J. McColgam farm, two-thirds of a miles southeast of the village of Richmond.

According to reports, the mine was originally opened by a Mr. Dixon and about 50 or 60 years ago mining was resumed for a short time by Charles Bostwick. The workings consist of an open pit, now partly filled with water, shown in plan on plate 8. The pond in the pit is said to be no more than 20 to 25 feet deep, so apparently not much ore was mined. There are no outcrops in the vicinity of the mine. The boulders in the glacial till exposed in the walls of the pit are chiefly of limestone.

Cook mine. The Cook mine is one and three-quarters miles southeast of the village of Richmond on the property of C. Rumplik. It is an open pit about 100 feet wide and 150 feet long, and is partly filled with water. The mine is unusual in that it is in an area of Berkshire schist where there is no indication of the presence of limestone. The geology of the deposit could not be determined as only glacial till is exposed in the walls of the pit. Schist crops out a short distance southwest of the pit.

The mine reportedly had a small output. The ore is said to have occurred as irregular bunches and not as a "true vein" or bed. The writer was told that two or three attempts have been made to work the mine, the last being about 60 years ago by Captain Maynard, and Englishman, who may have been associated with the company that worked the Branch mine.

Carr mine. The Carr mine shaft is 500 feet north of the Cone mine open pit, on the farm owned by Mr. Gilmore. (See ~~pl.~~ fig. 3.) The mine is very old and no information could be obtained as to when it was worked or how much ore was found. According to John Bissett the mine was operated by Rathbone, Sard and Co., stove manufacturers.

The workings consisted of a shaft, said to be about 100 feet deep and short drifts.

Cone mine. The Cone mine, worked by the Richmond Iron Co., is one of the oldest and largest of the iron mines in Berkshire County. Kreutzberg states (15, pp. 65-67) that the open pit of the mine was worked from about 1827 to 1904. The Cone mine had five shafts, the vertical shaft near the road south of the pit (~~pl.~~ fig. 3) was the first shaft sunk, in 1873 (16, p. 226); in 1876 it was 70 feet deep, two shafts are under water at the southwest corner of the pit and another shaft, inclined 45 degrees southeastward, is under water at the northeast end of the pit. This inclined shaft, according to reports, is about 175 feet long, measured on the incline, and was in use during the later years of operation. The fifth shaft, southeast of the northeast end of the pit, is vertical and, according to John Bissett who ran the hoist there, is about 200 feet deep. It was the last shaft to be used.

The underground workings of the Cone mine are said to extend northeastward beyond the road that leads past the Carr mine and southwestward almost to the workings of the Klondike mine.

W. H. Hobbs (12, p. 167) stated that the Cone mine was the only mine operating in the Richmond district during 1907. According to W. A. Campbell of Richmond, the Cone mine was abandoned in 1908 as a result of being accidentally flooded. An engineer at the mine at the time it closed told the writer the the mine was accidentally flooded by water that came from a reservoir in the open pit. Owing to the difficulty of pumping the water and the poor condition of the workings, the mine was abandoned and work started on the Klondike mine to the south.

The output of the Cone mine in 1880 is given by Putnam (22, p. 87) as 7,827 tons; he reported that a sample from a pile of 1000 tons of washed ore gave the following analysis:

Metallic iron	41.80%
Phosphorus	0.102
Phosphorus in 100 parts of iron	0.244

The ore body at the Cone Mine is at the schist-limestone contact, and the available evidence indicates that the main part of it parallels the contact in strike and dip. Dolomite and dolomitic limestone are exposed in two places on the northwest side of the open pit on the footwall, but the writer found only a small doubtful exposure of the schist in a gully at the northeast end of the pit. That schist forms the hanging wall is shown by Hobbs (12,p. 168) in his cross-section of the mine; also, Dale (5, pl. 2) mapped a narrow body of schist at the Cone and Klondike mines. S. G. Colt told the writer that the schist hanging wall was followed when drifting on the ore body in both the Cone and Klondike mines.

The northwest arm of the open pit is transverse to the strike of the limestone beds and at right angles to the main part of the open pit. Exposures are inadequate to reveal the cause of this position, but it may be due to the presence of a branch of the main ore body, possibly following a fracture zone.

Klondike mine. The Klondike mine is adjacent to the Cone mine on the southwest and is probably on the same ore body.

According to local reports development work was begun on the Klondike mine two or three years before the Cone mine was abandoned in 1908. After the Cone mine was closed the Klondike mine was reopened and worked steadily from 1909 to 1923 when it also was abandoned.

Except for a very small open pit, all of the mining was done underground. The mine has one shaft inclined about 45 degrees southeastward, parallel to the ore body. The shaft is said to be 150 feet long measured on the incline. The workings extend northeastward to a point near the Cone mine workings, and southwestward for a distance variously estimated to be from 200 to 1500 feet.

The Klondike mine was wet and pumps had to be kept going 20 hours a day pumping an average of 500 gallons of water per minute (28). Like all of the underground mines the Klondike mine had to be timbered. The mine had all modern equipment, including electric pumps and hoists, and much of this equipment was left in the mine when it was abandoned.

The geologic details of the Klondike mine are obscure as there are no published accounts of it and no outcrops near the mine. S. G. Colt informed the writer that the southeast or hanging wall side of the ore body is schist. Apparently the ore body is at the limestone-schist contact and is the southwest continuation of the ore body at the Cone mine. Mr. Colt also stated that the ore body was 2 to 3 feet wide near the surface and widened downward to a width of 200 to 300 feet at the bottom of the workings. The maximum downward extent of the ore is not known, as good ore is reported to have been found in the lowest workings. The ore had to be blasted and crushed and subsequently washed to free it of clay. As mined, the ore contained about 40 percent ochre and mud, but after washing it averaged 40 to 50 percent in iron.

West Stockbridge

Goodrich mine. This mine is located about 800 feet north of the Moffat mine on the east side of the road. (See fig. 6.) It consists of a small open pit, and a shaft said to be located in the bottom of the pit. There are no outcrops near the pit and no information could be obtained concerning it. A map called a "Plan of the Towns of Stockbridge and West Stockbridge" published in 1855 by E. M. Woodford shows this mine under the name of "Gay and Woodruff's ore bed".

Moffat mine. The Moffat mine shaft is on the east side of the road formerly known as Baker St., east of the Leet mine. (See fig. 6.) The shaft is now filled and nearly obliterated. The descriptions by Lewis (16, p. 227) and Putnam (22, p. 86) of what they call the Goodrich mine apparently are of the Moffat mine. The Goodrich mine as located for the writer and referred to in this report is the small open pit mine 700 feet north of the Moffat shaft.

Putnam (22, p. 86) says that the Moffat mine was opened in 1875 and re-opened in 1879. In 1880 it was being worked by Lawrence Moffat and in that year it supplied 2,197 tons of ore. At that time the shaft of the mine was 125 feet deep and the workings were about 200 feet long at a depth of about 108 feet. According to Putnam samples from 100 tons of washed ore and from 30 tons of rock ore gave the following analyses:

	Washed Ore	Rock Ore
Metallic iron	40.71%	46.87%
Phosphorus	0.142	0.124
Phosphorus in 100 parts iron	0.348	0.264

It is reported that a Mr. Morehouse bought the mine from Lawrence Moffat, and that a lawsuit closed the mine sometime between 1882 and 1885. The Hudson Mining Company reported shipping 186 tons of ore from the Moffat mine in 1882.

Leet (Richmond) mine. The Leet mine, about one and one-half miles west of West Stockbridge, is on the north side of the highway leading to the village of State Line on the farm owned by J. J. Keresey. It is adjacent to the Hudson mine property on the northeast and on the same ore body.

The Leet mine workings consist of the main open pit, a smaller pit adjoining the main pit on the east, known as the Bradley pit, and underground workings. The Pittsfield Public Library has several pictures of the main open pit taken when the mine was in operation. The pit, now filled with water, is estimated to be between 80 and 100 feet deep. According to reports there are a vertical and an inclined shaft in the bottom of the main pit. The inclined shaft is the newer and is inclined about 45 degrees toward the south or southwest. Child (4, p. 385) reported that the mine had been worked to a depth of 160 feet by 1885.

The mine workings extend toward the south to the boundary with the Hudson Mining Company's property. The underground workings are said to extend northeastward under the Bradley pit to the road between the Leet mine and the Goodrich mine. The hole shown by a depression contour on ~~plate~~ figure 6, on the west side of this road, is said to be due to caving of the old workings.

The mode of discovery of the iron mines is a constant source of wonderment to one studying them at the present time, owing to the lack of exposures of iron ore and the extensive cover of glacial deposits. The story of the discovery of the Leet mine as given in the History of Berkshire County (3, p. 645) is therefore of interest: "In 1826 Isaac Nicholson, of Richmond, an Englishman somewhat familiar with the localities in which iron was found in his native country, seeing the burrow of a woodchuck on Mr. Leet's premises near the Benton road and north of Lane's corner, observed 'wash ore' and ocher in the earth thus thrown out to the surface, and from the location with regard to the limestone ledge close by believed a deposit existed there, and in connection with Eli Richmond obtained a lease of the lot from Mr. Leet, and making an excavation, discovered the vein there; further exploration have developed the existence of the great masses now known to lie near by, and from this beginning, though small at first, mining has been carried on to this time".

In 1829 D. D. Field (9, pp. 275-276) wrote that for 30 years iron ore had been occasionally picked up on several farms in the northwestern part of the town of West Stockbridge. In 1826 when the Leet mine was discovered, and in the two years following, more than 800 tons of iron ore were taken from the Leet mine.

Child (4, p. 384) stated that the Stockbridge Iron Company acquired the Leet mine in 1832 and continued working it until 1858, when they leased it to the Richmond Iron Company. The History of Berkshire County (21, p. 645), however, states that the Stockbridge Iron Company did not own the property until 1847. The Richmond Iron Company continued to operate the mine until it was closed, sometime between 1892 and 1895.

John Cone informed the writer that the Leet mine was abandoned and allowed to fill with water a year or so before the Hudson mine. Mining stopped at the Hudson mine in 1892, but the mine was kept pumped out for a year or more before it was finally abandoned. Mr. Cone, who helped remove the equipment from the Hudson mine when it was abandoned, said that the Leet and Hudson mine workings came so close together that the Hudson mine officials were afraid water from the abandoned Leet mine would leak into the Hudson mine. Extra pumps were kept ready but no great increase in the flow of water was noted. Some of the former mine workers maintain that there was an underground connection between the two mines at one time.

The Leet ore body, unlike most of the other deposits, appears to cut across the beds, in part at least, instead of paralleling them. The main open pit is nearly circular and cuts across the beds exposed in the prominent hill on the northeast side of the pit. (See fig. 6.) The ore body may have been offset by a fault, or follow a cross-fracture zone but, in the absence of any underground maps and published information on the geology of the mine, the true cause of the crosscutting relations remains uncertain.

Siderite was reportedly found in small quantities in the main part of the Leet mine and in considerable quantities in the Bradley pit. The writer found an exposure of low grade iron ore mixed with schist on the east side of the Bradley pit. This is the only exposure of iron ore in place seen by the writer in Massachusetts. A better exposure may be seen at the Amenia mine at Amenia, N.Y.

Few records of output are available. Putnam (22, p. 86) stated that from January 1, 1870 to June 1, 1877, 81,715 tons of ore were mined. He also reported that in 1880 the company shipped 9,210 tons of ore. The Richmond Iron Company shipped ore from the Leet mine over the Hudson Company's branch railroad, the Hudson Company charging the Richmond Company five cents per ton of ore hauled. The Hudson Mining Company's records, now in the Pittsfield Library, show that the Richmond Company shipped 51,380 tons of ore over this branch railroad between 1881 and 1888.

An analysis of 50 tons of washed ore from the Leet mine, as given by Putnam (22, p. 86), was as follows:

Metallic iron	46.65%
Phosphorus	0.174
Phosphorus in 100 parts of iron	0.373

Most of the people acquainted with the Leet mine are of the opinion that it was worked out when abandoned.

Hudson (Chauncey Leet) mine. The Potter, Hudson, Leet, Moffat, and Goodrich mines are adjacent and apparently on the same ore body. The Hudson mine is on the Condon estate on the south side of the highway to the village of State Line, about a mile and a half west of West Stockbridge.

According to the History of Berkshire County (3, p. 645), "The Stockbridge Iron Company acquired the ownership of the Leet property in 1847, and two years later sold the part on the south side of the highway, known as the 'Chauncey Leet Bed', to the Hudson Iron Company, and it has been continuously worked since." Other sources give the opening date as 1851 and 1852. The mine was closed in 1892.

The workings consist of an open pit about a thousand feet long, now filled with water, and underground workings. Three vertical shafts are located in the bottom of the pit. In 1880, according to Putnam (22, p. 86), the mine had two working shafts, and the lowest level was about 100 feet below the bottom of the old pit, or 140 feet below the original surface. The length of the workings at that time was between 700 and 800 feet. The mine was wet and most of it had to be strongly timbered.

The Hudson mine was one of the largest, if not the largest, producers of iron ore in Massachusetts. Child (4, p. 384) states that 125 men were employed in the Hudson mine in 1885 and that the output was about 50 tons of ore per day. Putnam (22, p. 86) estimated the total output of the Hudson mine up to about 1880 to have been 504,000 tons of ore. From 1880 to 1892 an additional 157,000 tons of ore was mined which makes the total output of the mine approximately 661,000 tons of ore. All of the Hudson mine ore was shipped for smelting to the company's furnace in Burden, N. Y. The record of the weight of ore shipped from the mine to the furnace from 1876 to 1892 is preserved in the Pittsfield Public Library. This record shows that the shipments during that period were as follows:

Brown Iron Ore Shipped from the Hudson Iron Mine to Burden, New York. 1876 to 1892.

Year	Production in short tons and pounds
1876	17,358 tons & 200 pounds
1877	16,668 tons & 1100 pounds
1878	18,940 tons & 1300 pounds
1879	16,035 tons & 900 pounds
1880	17,216 tons & 700 pounds
1881	16,548 tons & 000 pounds
1882	14,864 tons & 1400 pounds
1883	14,220 tons & 000 pounds
1884	16,626 tons & 900 pounds
1885	14,118 tons & 1300 pounds
1886	13,090 tons & 1000 pounds
1887	14,521 tons & 1700 pounds
1888	15,441 tons & 500 pounds
1889	13,770 tons & 400 pounds

1890	2,169 tons & 1600 pounds
1891	13,703 tons & 200 pounds
1892	8,199 tons & 400 pounds
Total	243,493 tons

A sample of ore taken from five car loads, as reported by Putnam (22, p. 86), contained:

Metallic iron	47.52%
Phosphorus	0.187
Phosphorus in 100 parts of iron	0.394

Men who worked in the Hudson mine are of the opinion that the mine is not worked out.

The mine workings are said to extend north to the property line of the Leet mine (see fig. 6), and south to the Potter mine property, marked by the fence northeast of the Potter mine shaft. It is reported that good ore was left in the southern part of the mine.

Little is known concerning the geology of the Hudson mine and the other mines in this group. There are no published descriptions of the Hudson mine ore body and no mine maps. Examinations of the present surface shows only that, in general, the Hudson mine ore body is parallel to the dolomite and calcite limestone beds on the northwest side of the open pit, when these beds strike northeast and dip about 45 degrees southeast. It is the writer's belief that the ore body is at a schist limestone contact with the schist on the southeast or hanging wall side of the ore body. Holland (13, p. 365) wrote that by 1855 the vein had been traced for 1300 feet and that it ranged in width from 40 to 100 feet. In 1885, according to Child (4, p. 384) the vein was from 25 to 75 feet wide and extended from 9 to 250 feet in depth.

The vein is also reported to have had a horizontal width of over 100 feet in places.

Mr. John J. Farlan told the writer that when he worked in the mine most of the ore was hard enough to require blasting. According to John Cone, who also worked in the mine, one drift 40 feet wide and 500 feet long was in such hard ore that it did not require timbering.

<u>Potter (Pomeroy) mine.</u> The Potter mine is a mile and a half west of the village of West Stockbridge, just southeast of the Hudson mine. (See ~~pl.~~ fig. 6.) It is now owned by A. W. Baldwin of West Stockbridge.

Child (4, p. 385) stated in 1885 that the Potter mine "was first opened by William M. Kniffen, but is now owned by stockholders in Boston, New Bedford and West Stockbridge. The vein is 50 feet wide. The company employed 25 men and mined about 25 tons of ore per day, but has done no mining since September 1883." The mine was subsequently reopened by the Richmond Iron Company and was finally closed, according to A. W. Baldwin, in 1893, at about the time the Hudson and Leet mines were closed.

The mining was entirely underground. The main shaft is the westernmost of the three shafts shown on ~~plate~~ figure 6. The other two it is reported, were earlier vertical prospect shafts about 100 feet deep, sunk by the Stockbridge Iron Company, but no ore was found in them. The main shaft is said to be inclined eastward and to be in the footwall of the ore body, close to the ore. The vertical depth of the shaft is estimated to be about 150 feet. According to local reports the shaft is inclined about 45 degrees eastward, the mine has three levels, the top level is 100 feet below the surface, measured on the incline, and the best ore was on the bottom level. The mine workings are reported also to extend from 100 to 200 feet south of the shaft.

In 1919 and 1920 the Potter mine property and the adjacent Hudson mine property were drilled for iron ore by the Sprague and Henwood Drilling Company of Scranton, Pa., for an unknown company. Five diamon drill holes were put down, according to local reports. The approximate positions of the drill holes are shown on ~~plate~~ figure 6. The results of the drilling were not divulged but it is believed that little ore was found. The hole about 700 feet southeast of the main Potter shaft is reported to be 290 feet deep and in a few feet of white limestone at the bottom.

Maple Hill prospect. The open pit and shaft (~~pl. 8~~ fig. 2) of the Maple Hill prospect are located about a mile southwest of West Stockbridge on the property of J. J. Keresey. (See ~~pls. 2, and 8.~~ plate 2 and figure 2) The prospecting is estimated to have been done 60 to 70 years ago.

It is said that a shaft 40 to 60 feet deep was sunk in the bottom of the open pit; and that some ore was found but not enough to justify further development. The writer found fragments of good ore on the dump.

Lenox

Belden mine. The Belden mine, consisting of two small open pits now partly filled with water, is about one and one-quarter miles west of the village of Lenox near the foot of Bald mountain, on the estate of Mrs. John D. Kennedy. According to reports the mine was owned and operated by Major A. G. Belden 65 to 75 years ago.

Reference of historic interest was made to the Belden mine by Rev. Samuel Shepard (25, p. 337) in 1829. In his account of the history of the town of Lenox he wrote as follows:

> In the west part of the town, iron ore is found in great abundance. From discoveries already made, it is probable a bed of this ore extends nearly through the town from west to east, and is inexhaustible. About 1780, a furnace was erected in the southeast part of the town, on the Housatonic river, by Mr. Job Gilbert, from the county of Bristol, in which, business has been carried on to this time, and frequently with much profit to its successive owners. Ore, for the supply of this furnace, has been dug in the west part of the town, and an abundance of coal is furnished from the forests in the west part of Washington. The ore is of an excellent quality, and is used for all the variety of castings common to such furnaces.

One of the pits is bordered on the east by limestone, the other has only glacial deposits exposed nearby.

Lenox mines. Edward Hitchcock (11, p. 197) wrote in 1841 that, "in Lenox as many as four or five beds have formerly been opened, and much ore has been carried away. One excavation was made in the village, and several others a mile or two west of the village; so that we have every reason to suppose the soil to abound with the ore."

According to reports there were two iron mines in the village of Lenox, one, an underground mine, was located in the center of the village, where the Clifford Coal Company building and the Wheeler Market building are situated at present; the other, an open pit mine, was filled and is now the Lenox playground. One or both of these mines, were worked by the Lenox Iron Company.

Alford

Tremper mine. This mine is located a mile and a half northwest of the village of Alford, approximately one-half mile east of the New York line. No information is available concerning its history or production. The ore was treated in a furnace a short distance south of the mine. As is shown on the surface map of the open pit (fig. 7) Berkshire schist is exposed on the west side of the pit. It is probably the footwall of the ore body, as the foliation dips eastward toward the pit.

Sheffield

Spurr prospect. The Spurr prospect is located two and one-half miles north of the Massachusetts-Connecticut boundary and about one-quarter of a mile east of Route 41.

The workings consist of a shallow pit 75 to 100 feet long which appears to have been merely a prospect cut. There are no rock outcrops in the vicinity.

Appraisal of the Iron Ore Resources

No additional iron ore deposits were found in the area between West Stockbridge and West Pittsfield mapped by the writer. Considering the wide distribution of the known deposits, however, it is probable that others remain undiscovered, concealed beneath a cover of glacial deposits. Such hidden deposits may have to wait chance discovery or the development of more effective geophysical or geological means of locating them.

The writer agrees with E. C. Eckel (8, pp. 259-260) who, in appraising these iron deposits in general in 1914, wrote as follows: "So far as future industrial importance is concerned, the northern brown ores do not offer much prospect of further development. The heavy covering of glacial drift makes both prospecting and mining much more expensive than in dealing with ores of similar type in the south."

In view of the fact that the underground workings of the mines had to be timbered because of yielding residual clays on the footwall and weathered schists and glacial deposits on the hanging wall, reopening of the underground workings of a mine would entail the expense of retimbering the shafts and drifts. There is no definite information as to the amount of iron ore left in the mines when abandoned, but there is no reason to believe that as much as 50,000 tons of high grade iron ore remains in any of them.

Commercial ore does not extend very deep. On the basis of theoretical conditions the limonite ore should grade into lower-grade primary iron carbonate deposits within a few hundred feet of the surface; probably for the most part the limonite ore will not be found more than about 300 feet below the glacial drift. In places, however, the glacial drift cover may be 100 feet or more thick. The information at hand indicates that none of the larger iron mines in Berkshire County was worked deeper than 150 to 200 feet vertically below the surface.

At the present time the most practical prospecting procedure is to drill for extensions of the known ore deposits along their strike. Only the larger properties are worth considering for such prospecting. The most favorable properties for such prospecting appear to be the Potter, Hudson, Leet and Goodrich mines in West Stockbridge; the Klondike, Cone, Carr mines in Richmond; the Cheever mine in Richmond; the Bacon and Andrews mines in Richmond; the Shaker mine in West Pittsfield, and the Colby mine in Lanesboro.

Very little is known concerning the possibility of extension of commercial ore beyond the limits of the mine workings at any of the old mines. The best indication seems to be afforded by the Cone mine, which was reputedly worked northeastward underground to the boundary of the Carr mine property and even beyond. The old boundary was about at the present road. If this is true, the Cone mine development was restricted by property lines rather than lack of ore. Bedrock outcrops are lacking north of the Cone mine and there is little to guide prospecting except the trend of the ore body at the Cone mine as indicated by the shape of the open pit. The absence of outcrops suggests that in places the glacial deposits may be 50 feet or more thick, so that underground mining would be necessary.

The possibility of an extension of the ore body toward the west and southwest is not known. The Klondike mine workings are variously estimated by former mine workers to extend from 200 to 1500 feet southwest of the mine shaft, but nothing is known concerning the character of the deposit exposed by these workings. There are no outcrops southwest of the Klondike mine to guide prospecting, and the surface is swampy and unfavorable for drilling.

It is also difficult to ascertain the possibility of extensions of the ore bed at the Potter, Hudson, Leet, and Goodrich mines. Nothing could be learned concerning the character of the ore body at the Goodrich mine. The surface northeast of the mine is covered by a sand plain and there are no outcrops to guide prospecting. At the southwestern end of the area the workings of the Potter mine are said to extend 100 to 200 feet southwest of the main Potter shaft. There is no information as to the character of the deposit exposed by these workings. Holes were drilled in 1919 in search of an extension of the ore body (see under Potter mine and ~~plate~~ figure 6) but apparently insufficient ore was found to justify reopening of the mine. There are no outcrops to guide prospecting southwest of the Potter mine shaft which indicates that the glacial till in that area is so thick as to increase the difficulty of prospecting and mining.

The extent of the ore body at the Bacon and Andrews mines, also is not known. The surface northeast of the Andrews mine and southwest of the Bacon mine, where extentions of the ore body might be found are covered with till and outcrops are lacking. No information is available as to the character of the ore found at the outer ends of the pits. So far as known, the area between the Andrews mine and the Bacon mine has not been mined except within about 100 to 120 feet of the northeast end of the Bacon mine pit. There remains about 600 feet of undeveloped ground between the mines.

The area at the Shaker mine (West Pittsfield) is less favorable for prospecting than some of the others. The south end of the mine workings underlies a swamp where drilling would be difficult. The location of the north end of the mine workings is not known.

There is also very little to guide prospecting at the Colby mine in Lanesborough except the trend of the ore body as indicated by the long dimension of the pit. The extent of the underground workings is not known. Mining was progressing northward when the mine was closed down and, according to Mr. Hagerty, some ore was left in the northernmost workings. Nothing can be determined at the surface concerning the possible extent of the ore.

In conclusion it is the writer's belief that unless an adequate method of geophysical prospecting is devised, the chances of discovering larger iron deposits are poor. There are few outcrops to control surface prospecting in the critical areas. The known deposits are not large enough or rich enough to justify a prospecting program that would have to be based to a large extent on chance, and would involve much drilling to trace and determine the limits of the ore bodies.

The comparatively high phosphorus content of much of the ore formerly mined, the generally siliceous character of the ore, and the relatively low average content of iron are unfavorable features.

REFERENCES CITED

1. Agassiz, L., Observations on boulders in Berkshire County: Boston Soc. Nat. History Proc., vol. 14, pp. 385-386, 1872.

2. Benton, E. R., The Richmond boulder trains: Harvard Coll. Mus. Comp. Zoology Bull., vol. 5, #3, pp. 17-42, 1878.

3. Beers, J. B. & Co. History of Berkshire County, Mass., 1885.

4. Child, H., Gazeteer of Berkshire County, Mass. 1725-1885. 527 pp. 1885.

5. Dale, T. Nelson, The lime belt of Massachusetts and parts of eastern New York and western Connecticut: U. S. Geol. Survey Bull. 744, pp. 67, 1923.

6. Dana, J. D., Notes on the making of limonite ore beds: Am. Jour. Sci., vol. 28, pp. 398-400, 1884.

7. Eckel, E. C., Limonite deposits of eastern New York and western New England: U. S. Geol. Survey Bull. 260, pp. 335-342, 1904.

8. Eckel, E. C., Iron ores: McGraw Hill Book Co., New York, 1914.

9. Field, D. D., A history of the county of Berkshire, Massachusetts, 1829.

10. Hitchcock, E., Description of a singular case of the dispersion of blocks of stone connected with drift, in Berkshire County, Massachusetts: Am. Jour. Sci., vol. 49, pp. 258-265, 1845.

11. Hitchcock, E., Final report on the geology of Massachusetts, 1841.

12. Hobbs, W. H., The iron ores of the Salisbury district of Connecticut, New York and Massachusetts: Econ. Geology, vol. 2, pp. 153-181, 1907.

13. Holland, J. G., History of Western Massachusetts, vol. I, 1855.

14. Keith, H. C., The early iron industry of Connecticut, pt. I: Connecticut Soc. of Civil Eng., 51st Ann. Rept., 1935.

15. Kreutzberg, E. C., Historic furnace in Berkshires: The Iron Trade Rev., pp. 65-67, 1914.

16. Lewis, J. F., The hematite ore mines and blast furnaces east of the Hudson River: Am. Inst. Min. Met. Eng. Trans., vol. 5, pp. 216-235, 1876.

17. Lyell, Sir Charles, Antiquity of Man, Second American Ed., p. 355, 1871.

18. Moore, F. H., Marbles and limestones of Connecticut: Connecticut Geol. & Nat. Hist. Survey Bull. 56, pp. 56, 1935.

19. Newland, D. H., Mineralogy and origin of the Taconic limonites: Econ. Geology, vol. 31, pp. 133-155, 1936.

20. Prindle, L. M. & Knopf, E. B., Geology of the Taconic quadrangle: Am. Jour. Sci., 5th ser., vol. 24, pp. 257-302, 1932.

21. Pynchon, W. H. C., Iron mining in Connecticut: Connecticut Mag., vol. 5, pp. 20-26, 232-238, 277-285, 1899.

22. Putnam, B. T., Notes on samples of iron ore collected in Connecticut, Massachusetts, and New York: U. S. Tenth Census Reports, vol. 15, pp. 83-144, 1885.

23. Reid, S., Berkshire Farmer, Lenox, Mass., 1842.

24. Rogers, H. D. & W. B., On the boulders trains of Berkshire County, Mass.: Boston Soc. Nat. History, Proc., vol. 2, pp. 79-80, 1848.

25. Shepard, Rev. S., History of the town of Lenox: pp. 336-343, Pittsfield, 1829.

26. Smith, J. E. A., The history of Pittsfield from the year 1800 to the year 1876, p. 725, 1876.

27. Wilmarth, M. G., Lexicon of geologic names of the United States; U. S. Geol. Survey Bull. 896, 1938.

28. (Anonymous) Richmond Iron Works, Richmond, Mass.: Pittsfield Eagle, Jan. 23, 1926.