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ABSTRACT

The Katahdin pyrrhotite deposit is in a heavily timbered, mountainous region in southern Piscataquis County, Maine. Slate, sandstone, phyllite and schist, presumably of Silurian age, have been intruded by a gabbroic stock which encloses the pyrrhotite deposit, and by a larger granite stock a mile to the west of the pyrrhotite deposit.

The limonitic gossan, which once completely covered the pyrrhotite deposit, was worked extensively for iron during the last century and the ore was smelted at a charcoal furnace at Katahdin Iron Works village. Primary sulfide ore uncovered by these early mining operations is now exposed in many places. It is composed of pyrrhotite, calcic plagioclase, and orthorhombic and monoclinic pyroxenes. Approximately two-thirds of the ore by weight is pyrrhotite. At the surface the ore averages 44 per cent iron and 27 per cent sulfur. Small percentages of cobalt, nickel, chromium and copper are also present, but the only apparent economic value of the ore lies in its iron and sulfur content.

The ore body is 2050 feet long and averages 400 feet wide. It was diamond drilled by the General Chemical Company in the early 1930's, but the drilling records are not available so that the subsurface dimensions of the deposit are not known to the writer. Geologic evidence at the surface and the analogy to other similar deposits elsewhere indicates that the deposit is not superficial, and that it probably extends at least several hundred feet under ground. Assuming that the surface dimensions and the surface grade of ore are persistent downward, 4,100,000 long tons of metallic iron and 2,500,000 long tons of sulfur would be present for every 100 feet of depth of the deposit.

In the surrounding region the bedrock geology, where exposed, does not favor the existence of other pyrrhotite deposits. Three iron-rich springs, which seep from the floodplain of Pleasant River north west of Silver Lake, are the only indications of possible mineralization noted by the writer. Magnetic anomalies are present near the known pyrrhotite deposit, but no comparable anomalies were found in the vicinity of the iron-bearing springs. The iron in the spring waters is probably derived from commercially unimportant deposits of bog iron ore in the unconsolidated valley fill of Pleasant River. No geological or geophysical information is available to indicate whether sulfide deposits may exist beneath the extensive drift-covered areas.
INTRODUCTION

LOCATION OF THE DEPOSIT

The Katahdin pyrrhotite deposit is in the west central part of Township 6, Range 9, 10 miles northwest of Brownville Junction and 1 mile west of the village of Katahdin Iron Works in southern Piscataquis County, not far from the geographical center of Maine (plate 2). It lies on a spur of Ore Mountain 800 feet above sea level and 200 feet above Silver Lake, which is the local base level for the surrounding drainage.

Katahdin Iron Works village may be reached by a newly graded gravel road from Brownville Junction. A tote road, impassable to automobiles, leads west from the village to the mine. Katahdin Iron Works is 30 miles south of Mt. Katahdin, and is separated from it by a range of mountains, of which Saddlerock Mountain is the most prominent.

TOPOGRAPHY

The pyrrhotite deposit is on the south edge of a mountainous wilderness, which extends more than 100 miles northward to the Canadian border. Ore Mountain, on the slopes of which the deposit lies, rises 600 feet above the rolling, wooded lowland to the south, but mountains to the west and north are considerably higher (plate 1).

Fig. 1
Sketch showing surface coated with limonite wash several hundred feet downhill from the pyrrhotite deposit.

Plate 2
Map of Maine showing the location of the Katahdin Iron Works region.
of the mine (plate 1) were made. The 1944 field investigation was devoted to a magnetic survey of the area with a Hotchkiss superdip. Traverses were made from the ore body to Silver Lake and also along upper Pleasant River. The field and office work in 1943 were sponsored jointly by the Federal Geological Survey and the Maine Development Commission. The 1944 field and office studies were under the auspices of the Federal Geological Survey.

ACKNOWLEDGMENTS

During the field work and the preparation of the report the writer was assisted by a number of people, whose contributions are gratefully acknowledged. Prof. Joseph Trefethen, State Geologist of Maine, supplied information and advice on the region. Mr. Carlisle and Mr. Clement of Prentiss and Carlisle Co. of Bangor made available for study some unpublished reports of Mr. Paul Eckstorm. Mrs. Sarah Green furnished information on the history of the mine. Mr. Charles Milton of the Federal Geological Survey made the petrographic determinations of the rocks and the chemical analyses of the ore samples, and Mr. K. J. Murata of the Federal Geological Survey made the spectrographic analyses of the ore samples. Mr. G. H. Espenshade and Mr. H. F. Hawkes of the Federal Survey read and criticized the manuscript. Mrs. Ansel Miller assisted in the field and in preparation of the illustrations.

GENERAL GEOLOGY

Metamorphosed sedimentary rocks are the most abundant rocks of the area. These were originally shales and silty sandstones, and are presumably of Silurian age.† They have been intruded by two bodies of igneous rock, the larger one granitic, the smaller gabbroic. The pyrrhotite ore body lies near the western edge of the body of gabbro and is entirely surrounded by it.

Regional metamorphism has altered the shales to slate, phyllite or schist, and has also slightly metamorphosed the sandstones, but has left the igneous rocks virtually unchanged. The foliation of the metamorphosed sedimentary rocks strikes from northeast to east, and is almost everywhere steeply dipping. Bedding is normally obliterated by the foliation, but in the few places where it was recognized, it was nearly parallel to the foliation. The regional metamorphism was in part contemporaneous with and in part subsequent to the igneous activity.

The whole region was strongly glaciated in Pleistocene time. The ice overrode even the highest peaks, eroding them deeply and depositing a thick mantle of glacial drift in the valleys and over the broad lowlands south of Silver Lake. Glacial striae on the crest of

Ore Mountain strike S 40° E, and the hills of glacial drift in the southern part of the area are streamlined in the same direction, showing a general trend of the glacial motion from northwest to southeast.

METAMORPHOSED SEDIMENTARY ROCKS

Slate, Phyllite, and Schist

Slate, phyllite, or schist underlie the southern slopes of Ore Mountain and Houston Mountain and most of Chairback and Saddlerock Mountains (plate 1). They probably also underlie most of the drift-covered lowlands around Silver Lake.

The slate is strongly cleaved, gray and non-calcareous. Bedding is normally completely obliterated. In many places the slate has been altered by regional metamorphism to phyllite, and locally it has become a fine-textured mica schist, containing considerable amounts of andalusite and cordierite. In a few places, notably on the southern slopes of Saddlerock Mountain, metacrysts of andalusite up to an inch in length are prominent in the schist. These parallel the plane of the schistosity, but have a random orientation in that plane. The change from slate through phyllite to schist is gradational over considerable areas, and sharp boundaries cannot be drawn between the three rock types. No fossils have been reported from these rocks and none were found by the writer.

In the Waterville region, 60 miles southwest of Katahdin Iron Works, Perkins and Smith* have described a thick sequence of shales that is similar to the slate sequence described here. They have named the formation the Waterville shale, and consider it to be of Silurian age, probably Clinton, because of the presence of Monograptus colbyensis. In the Lewiston region, 40 miles farther southwest, Fisher† has described a similar shale sequence, which he named the Sabattus shale and correlates with the Waterville shale. The belts of Sabattus and Waterville shales strike toward the Katahdin Iron Works region, and the similarity in lithology makes it probable that the shale, phyllite, and schist here described are at least in part equivalent to the Waterville and Sabattus shales. Definite correlations are not possible, however, until more detailed field work is done around Katahdin Iron Works and in the area between there and Waterville.

Sandstone

On Roundtop Mountain and the northern part of Houston Mountain, a series of gray, fine-grained, silty sandstones is present. The sandstones are everywhere slightly metamorphosed. Metacrysts of

mica and feldspar have developed locally, and minor amounts of rutile, zircon and chlorite are visible in thin section. Argillaceous beds in the sandstone have developed a schistose structure, and in places this rock may be nearly identical with the phyllite previously described.

The sandstone sequence grades into the slate through an interbedded zone, but whether the sandstones overlie or underlie the slates or are intercalated with them is not known. Perkins and Smith* have described a silty sandstone formation in the Waterville region, which they name the Vassalboro sandstone, and Fisher† has named a similar sandstone in the Lewiston region the Androscoggin sandstone. Because the Vassalboro sandstone is interbedded in places this rock may be variously described. With the are therefore only approximate. Along the west shore of Houston correlates it with the Vassalboro. Lithologic similarity and stratigraphic relations both suggest that the silty sandstones at Katahdin Iron Works are the equivalent of the Vassalboro sandstone, but more evidence is necessary before such a correlation can be considered established.

IGNEOUS ROCKS

Granite

The sedimentary rocks have been intruded by igneous bodies of two generations. The larger of these is a stock 11 miles long and 3 miles wide, which has been described by Philbrick**. He states that it consists of a granite core, surrounded by zones of granodiorite and quartz monzonite, with a basic border of quartz diorite, diorite, quartz norite, quartz gabbro and gabbro. The zoning is less regular toward the margins, and in places the basic border is said to be lacking. Flow structure, standing vertically and striking east-west, is visible in the eastern part of the intrusion, but was not noted elsewhere.

Only the eastern end of this intrusive mass appears on plate 1. Its margins have been transferred to the topographic base of that map from the small scale geologic map in Philbrick's report, and are therefore only approximate. Along the west shore of Houston Pond, granodiorite of this intrusive mass is abundantly exposed. Granodiorite has also been injected into the phyllites as dikes and sills nearly as far as the gap between Roundtop Mountain and Houston Mountain.

According to Philbrick an aureole of contact metamorphosed sedimentary rocks, averaging about 3500 feet in width, surrounds the stock. This consists of hornfels near the intrusive, grading into andalusite schist and then into the slate, which forms the country rock. These contact metamorphosed zones were not examined by the writer and are not shown on plate 1.

The granite of the stock is relatively non-resistant to erosion. In the part of the stock which appears on plate 1, the granite has been eroded to form a small basin occupied by Houston Pond. Farther west the granite lowland is occupied by other lakes and by swamps. The contact metamorphosed rocks surrounding the stock are more resistant than either the granite or the regionally metamorphosed sediments, which form the country rock. The aureole of contact metamorphism is thus marked by a chain of high mountains, which ring around the granite lowland. Chairback Mountain, Roundtop Mountain, Houston Mountain and Roaring Brook Mountain form the part of this rim which lies within the area of plate 1.

The foliation in the metasediments near the granite intrusion tends to parallel the margin of the intrusion, especially at its east end, but in some places the foliation is nearly at right angles to the margin.

Gabbro

A more basic intrusive rock crops out on the northeast slopes of Ore Mountain, and encloses the pyrrhotite ore body (plate 1). It is composed of gabbro, which has been intruded into the sandstones and slates in the form of a stock, which is roughly triangular in horizontal section. Most of the eastern part is concealed beneath glacial drift. Where exposed near the outlet of Silver Lake the outcrop of the stock is narrow and tapering eastward, and it probably extends only a few hundred yards east of the lake. The inferred borders of the gabbro beneath the glacial drift cover are indicated by dotted lines on plate 1. The borders may be less regular than shown, and gabbro may extend farther northward under the lowland west of Silver Lake.

The rock is a massive, medium to coarsely crystalline, gray, slightly altered gabbro. It consists dominantly of actinolite, hornblende and calcic plagioclase, and locally it contains abundant biotite. In a specimen taken near the ore body, hornblende appeared to be a replacement after augite, and the biotite was completely replaced by actinolite. Within a few hundred feet of the ore body, the gabbro contains disseminated pyrrhotite. Most of the pyrrhotite appears to be interstitial, but it was observed as a partial replacement of biotite in one thin section studied. Except for the presence of pyrrhotite near the ore body and the variation in biotite content, the gabbro is nearly uniform in different parts of the intrusion. No foliation or flow structure was noted in the gabbro.

At the bridge across Pleasant River in Katahdin Iron Works, basaltic dikes in the slate near the contact are offshoots from the stock. The thickest dike is 28 feet across, and has a medium-crystalline core, becoming more finely crystalline toward the margins.

*Perkins, E. H. and Smith, E. S. C., op. cit.
†Fisher, L. W., op. cit.
In one of the old mine pits a more acid dike, 4 inches thick, cuts across a massive ledge of pyrrhotite ore. The dike rock consists essentially of orthoclase, sodic plagioclase, quartz, and biotite, but also contains black, opaque, ore grains. This rock appears to be an end-stage product of the differentiation of the gabbro, and to be only slightly later than the formation of the ore body.

The relative ages of the gabbroic intrusion on Ore Mountain and the granitic intrusion near Houston Pond are not known. The two are nowhere in contact, nor have any dike rocks definitely associated with one been found cutting the other. Both intrusions cut the slate-phylite-schist sequence, of probable Silurian age, and are therefore presumably post-Silurian.

THE PYRRHOTITE DEPOSIT

SURFACE GEOLOGY

The pyrrhotite deposit lies near the western edge of the gabbro, and on the north slope of a spur extending northeast from Ore Mountain. The region around the ore body is entirely timbered, except along the drainage channels below the ore body where the acid waters coming from the mine have stunted or killed the trees. During the course of the mining operations in the last century, the trees were stripped from the area underlain by workable gossan, and the surface was pitted with broad, shallow cuts mostly less than 15 feet deep. Tailings were dumped on the downhill side of each cut, and many tailings piles grew to large size. In the fifty years since mining ceased, the scarred hill has been partly reclaimed by the forest, and the mine on the mountain side can hardly be seen from a distance.

At the surface the pyrrhotite ore body is 2050 feet long and averages 400 feet wide (plate 4). The long axis trends N. 75° E., which corresponds closely with the structural trend of the metasedimentary rocks surrounding the gabbroic intrusive. The marginal relations between the pyrrhotite ore body and the enclosing gabbro are similar on all sides of the deposit. The contact is gradational over a zone 20 to 30 feet wide. At the outer edge of this zone the rock contains less than 10 per cent pyrrhotite, whereas at the inner edge it contains more than 50 per cent pyrrhotite. No place was found where a continuous exposure across this border zone could be studied, but it was partly exposed at several places. Specimens representing nearly all stages of gradation were collected, though not from one locality.

The pyrrhotite ore body was originally everywhere mantled by a blanket of limonite or gossan, which was mined and smelted for iron before 1890. Most of the gossan has now been removed or buried beneath tailings piles, but in a few cuts the gossan capping still remains on the primary pyrrhotite. For a few feet above the
pyrrhotite the gossan is composed of soft, porous, light brown limonite formed by the oxidation in place of the sulfide and the removal of most of the sulfur and some of the iron in solution. The contact between primary sulfide ore and residual gossan is very irregular, knobs of the former extending upward and pockets of the latter downward.

Overlying the residual gossan are layers of bedded limonitic gossan which incline downhill at about the same angle as the surface of the hillside. This bedded gossan normally consists of relatively clean limonite in the lower part, but encloses glacial and talus boulders of all sizes near the surface. It was formed by deposition from percolating ground waters, which had dissolved some of the iron and sulfur of the primary sulfides. When these waters reached the surface, partial evaporation took place, and most of the iron was precipitated in the oxide form. The sulfur and some of the iron continued in solution to join the nearest stream. Convergence of numerous mineralized seeps from the ore body toward the main surface drainage channels has formed deposits of limonitic wash very much like the terrace deposits from hot springs. The most prominent of these extend hundreds of feet downhill below the ore body, and are shown on the mine map (plate 4). Figure 1 is a sketch showing a surface entirely coated with limonite wash. Over this surface are scattered boulders of all sizes, many of which are partly enclosed by the limonite.

The rapidity with which the deposits of limonite form at the surface is indicated by the presence of hewn timbers largely covered by limonite, by the deep brown color of the water in the streams draining the ore body, and indirectly by the strong smell of hydrogen sulfide which pervades the air on damp days. Several pieces of wood were found that had not only been almost buried by limonite wash but also completely replaced by limonite.

Specimens of transported limonitic gossan containing organic matter were submitted for analysis many years ago and were identified as a “brown hematite (limonite) resembling bog iron ore.” This statement was apparently responsible for the erroneous classification of the ore body as a deposit of bog iron ore, a statement which appears even in some recent textbooks on ore deposits.

The original thickness of the residual and bedded gossan is difficult to determine, because it has been mined out over almost the entire area of the pyrrhotite ore body. It seems to have been highly variable, however, ranging from a few inches in some places to 20 or perhaps 30 feet in the deepest pockets. Mining stopped in 1890 because almost all the good gossan ore was exhausted.

The primary sulfide ore beneath is now exposed at numerous places as rounded knobs and sizeable ledges. Plate 3b shows the wall of a cut in which massive pyrrhotite beneath the hammer and to the right is overlain at the left by darker colored, residual, limonitic gossan. Both pyrrhotite and residual gossan are overlain at the top by bedded limonitic gossan containing well rounded glacial and talus boulders.

Hand specimens of the fresh ore appear to the unaided eye to be made up almost entirely of bronze to yellow pyrrhotite \( \text{(Fe}_8\text{S}_8) \), but examination with the hand lens or microscope reveals numerous crystals of silicate minerals. Charles Milton, who made thin section and polished surface studies of a typical specimen of the ore, reports that the silicates are calcic plagioclase and orthorhombic and monoclinic pyroxene, with a small amount of strongly chloritized biotite. The pyrrhotite is in rounded grains about the size of the silicate crystals, and appears to have crystallized later than the silicates. The proportion of pyrrhotite to silicate minerals by weight is about 2 to 1. A few small crystals of chalcopyrite are present and seem to be more closely associated with the silicate minerals than with the pyrrhotite. The order of crystallization seems to have been: silicates, chalcopyrite, pyrrhotite. Along fractures and basal cleavages the pyrrhotite has been altered to marcasite, and thin films of limonite are visible along fractures in the silicate minerals.

Most of the pyrrhotite is tarnished, and in places at the surface it is coated by a yellow or white powder. The former is copiapite, the latter probably szomolnokite. Both are hydrated sulfates of iron.

The uniformity of the primary sulfide ore over a surface area of approximately 845,000 square feet is remarkable. Except for one small dike, every outcrop of primary rock seen by the writer within the limits of the ore body consisted of high-grade, massive pyrrhotite ore.

### CHEMICAL COMPOSITION OF THE ORES

The composition of the limonitic gossan ore is principally a matter of historic interest, for the amount of gossan remaining is negligible.

Seven analyses of the limonite have been found and are reproduced in Table 1. The first was by Dr. T. Drown of Lehigh University, and the second by J. B. Brittain, whose affiliation is unknown. Analysts of the other five samples are not known.

#### TABLE 1

| Analyses of limonitic gossan from the Katabdi pyrrhotite deposit. |
| --- | --- | --- | --- | --- | --- | --- |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| **PeO** | 77.87 | 76.95 | 47.75 | 57.54 | 49.80 | 39.50 | 53.50 |
| **SO** | 54.51 | 48.82 | 1.19 | 1.73 | 1.24 | 0.66 | 1.93 |
| **SiO** | 2.48 | 2.48 | 3.90 | 4.32 | 3.90 | 3.89 | 3.90 |
| **P** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **H** | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |
| **O** | 0.71 | 0.66 | 0.017 | 0.25 | 0.40 | 0.35 | 0.34 |

### COMPOSITION OF THE ORES

The composition of the limonitic gossan ore is principally a matter of historic interest, for the amount of gossan remaining is negligible.
The metallic iron in the analyses ranges from 39.50 per cent to 57.34 per cent, and averages 50.17 per cent. Both sulfur and silica are low, showing that these elements are largely removed in solution during the leaching of the primary, silicate-bearing sulfide ore. Silica may have been higher, however, in those samples with lower percentages of iron.

Four analyses of samples of primary sulfide ore collected at the surface are available, and are shown in Table 2. Samples 1 and 2 were collected in 1917 by E. S. Bastin of the Federal Geological Survey, and were analyzed by Ledoux and Company, and Ricketts and Company respectively. No. 3 and No. 4 were collected by the writer in 1941. No. 3 is a composite sample of chips from 34 outcrops of primary ore from the eastern half of the deposit, and No. 4 is of chips from 47 outcrops of primary ore from the western half of the deposit. Both were analyzed chemically for iron and sulfur by Charles Milton of the Federal Geological Survey, and were analyzed spectrophotographically for minor elements by K. J. Murata, also of the Federal Survey. The spectra of the two samples were so nearly identical that the analyses have been combined, and recorded as one. Most of the spectrophotographic percentages are given in terms of the first significant figure, i.e. an element listed as .0X per cent is present to the extent of at least .01 per cent but less than 0.1 per cent. For those elements which are listed as not found, the approximate percentage of each element is given, which could be present without the element being detected.

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There is only minor variation in the iron and sulfur percentages of the four analyses. The analyses of samples 3 and 4, which were collected from many different outcrops, are probably more representative of the average composition of the deposit than are analyses 1 and 2. Analyses 3 and 4 also show little variation between the eastern and western halves of the deposit, and thus corroborate the evidence from field outcrops of a general uniformity in surface composition of the ore body.

The analyses indicate that the ore is composed almost entirely of iron, sulfur and insoluble constituents, the latter being largely silica and alumina. Other metallic elements are present in very small percentages, with nickel and cobalt at about 0.1 to 0.2 per cent the highest. The pyrrhotite seems definitely not to be commercially nickeliferous. As determined by spectrographic analysis, platinum is less than .003 per cent, or less than 0.85 ounce per ton. The 3 to 7 per cent unaccounted for in analyses 1 and 2 is probably made up largely of magnesium, calcium, sodium and potassium, which are combined with silica and alumina in the silicate minerals disseminated through the ore.

**MAGNETIC CHARACTER OF THE DEPOSIT**

The pyrrhotite deposit is weakly magnetic. A Brunton compass is not disturbed even directly over the ore body, but pulverized samples of the ore contain occasional particles that are attracted by a small horseshoe magnet.

The writer ran traverses with a Hotchkiss superdip across several parts of the deposit to determine its magnetic character, and to establish control for magnetic prospecting in the surrounding region. The magnetic stations at and near the pyrrhotite deposit are shown by circles on plate 4, and the traverses are labelled AA' to EE'. Magnetic profiles of these traverses have been plotted on plate 5, in which the distances between stations in feet are plotted horizontally, and the instrument reading in degrees, after correction for temperature and daily variation, are plotted vertically. Because the super-dip used was a new instrument, which required adjustments between traverses several times during the course of the work, the instrument readings have not been reduced to gammas of magnetic force. The absolute values of the instrument readings in different traverses may thus be slightly different, but each profile is uniform and accurate within itself, and the profiles have the same relative size and shape they would have if based on the absolute values of magnetic force. A sensitivity setting (2) of 2° was used throughout.

Profiles AA' and BB' are across the narrow dimension of the ore body. The positions of the contacts between the pyrrhotite ore body and the enclosing gabbro are shown by short vertical lines crossing the profiles, with the attached horizontal bars pointing inward toward the ore body. Both profiles are irregular, with AA'...
showing a low for nearly 1000 feet north of the ore body and a prominent high 100 feet north of the contact. Stations over the ore body have average values, with a minor low near the south contact. BB' has a small high in relatively the same position with regard to the contact as the prominent high of AA', but otherwise shows no pronounced deviations.

Profiles CC' and DD' cross the contacts from ore body to country rock at opposite ends of the deposit. Each shows a very prominent anomaly just beyond the surface limits of the ore body, at one end a positive anomaly, and at the other a negative. EE' is a traverse along the trail which runs north of the ore body. The station which causes the lowest reading of EE' is the same as the last station of the DD' profile. Almost the whole EE' profile shows anomalous readings, in general low ones.

These five profiles show that the pyrrhotite ore body is sufficiently magnetic to be readily detected by the superdip. Furthermore the strongest anomalies are found at the two ends and near the north edge of the deposit. No correspondingly strong anomalies were noted near the south side.

DOWNWARD EXTENSION OF THE ORE BODY

Little information is available as to the behavior of the ore body at depth. The following opinions must therefore be considered tentative, based as they are on meager geologic and geophysical evidence.

No striking differences exist in the contact relations between the ore and the enclosing gabbro on opposite sides of the deposit, and no place was found where the inclination of the gradational contacts could be noted. There is, however, at several places a faint layering in the otherwise massive ledges of pyrrhotite ore. This layering always appears to dip northward at moderate angles. Where best developed it has a strike of N 85° E, and dips from 31° to 34° to the north. The layering probably parallels the ore body as a whole and the deposit is therefore believed to be a tabular mass which dips northward beneath the surface at an angle of approximately 33°.

The uniformity in width of the deposit for hundreds of feet along the surface suggests that thickness changes with depth would not be great. The ore body is believed to extend at least a few hundred feet beneath the surface. This opinion is based on the supposed tabular shape of the deposit. Furthermore the composition of the ore at the surface is uniform except near the contacts with the gabbro. At no place does the ore show any increase in the proportion of gabbroic minerals, such as would be expected if the lower limit of the ore body were close beneath the surface.

ORE RESERVES

The specific gravity of the ore in three hand samples ranges from 3.69 to 4.24 and averages 3.97. The specific gravity may also be calculated indirectly from the composition of the ore. Mineralogical and chemical studies show that about two-thirds of the ore by weight is composed of pyrrhotite, and the remainder of silicate minerals that make up gabbro. The specific gravity of pure pyrrhotite is 4.5 to 4.6, and the specific gravity of gabbro normally is about 3.0. Combining these specific gravities in the ratio of 2 to 1, the calculated specific gravity for the ore would be 4.03, which agrees closely with the average of Bastin's measurements. A value of 4.0 is used for the specific gravity in the calculation of ore reserves below.

Because no information is available as to the size and shape of the ore body at depth, no estimates of actual or probable ore reserves are possible, but an approximation can be made to give some idea of the potentialities of the deposit. This estimate is based on these assumptions: (a) that the ore body is essentially tabular, and that it maintains the same horizontal cross section beneath the surface, and (b) that the composition of the ore beneath the surface is the same as that determined for the primary ore at the surface. On these assumptions 9,400,000 long tons of pyrrhotite ore would be present for every 100 feet of depth beneath the surface. Of this 4,100,000 tons would be metallic iron and 2,500,000 tons sulfur.

ORIGIN OF THE DEPOSIT

Copper-bearing pyrrhotite deposits in the Southern Appalachian region and in Vermont have been described by Ross, who ascribes a hydrothermal origin to them. These deposits seem to differ from the Katahdin pyrrhotite deposit, however, in that they contain introduced gangue minerals, notably feldspar, quartz and carbonate. Furthermore the deposits lie in rocks which have well developed directions or zones of structural weakness, such as are afforded by shear zones, by schistose or gneissic structure, or by sedimentary bedding.

The Katahdin deposit, on the other hand, lies in the midst of a body of massive gabbro which has no apparent structure. The pyrrhotite mineralization is confined to the immediate vicinity of the known deposit, and lies entirely within the gabbro. No introduced gangue minerals, whatever, seem to be present. Except for the presence of amphibole, which replaces other silicates in some of the gabbro, the only minerals in the ore which are not found in the normal, unmineralized gabbro are the pyrrhotite itself and minor

*Bastin, E. B., op. cit.

amounts of chalcopyrite. The pyrrhotite is interstitial to the silicate minerals in the gabbro near the contact, and engulfs them in the ore. No other contact phenomena distinguish the gabbro adjacent to the ore body from that some distance away, and no veins or veinlets ramify from the ore body into the country rock.

These features point to a magmatic origin for the deposit, and suggest that it is a differentiate from a sulfide-rich gabbroic magma, the sulfides being the last minerals to crystallize. The differentiation may have occurred in place, or the sulfides may have been segregated elsewhere in the magma and introduced at a late stage in the crystallization of the gabbro.

**POSSIBILITIES FOR OTHER PYRRHOTITE DEPOSITS IN THE VICINITY**

One of the main purposes of the investigation was to examine the geology of enough of the region around the pyrrhotite deposit to determine the chances of finding other similar deposits in the vicinity. More time was spent in traversing the surrounding mountains than in studies near the known deposit. The results of this traversing have been combined into the reconnaissance geologic map (plate 1).

The country rock in the region northwest, north and northeast of Ore Mountain is almost entirely sandstone, slate, phyllite and schist. No igneous bodies were seen except for several small dikes.

The extent of the gabbro intrusion, in which the pyrrhotite deposit lies, is poorly known east and north of Ore Mountain. It could be more extensive in these directions than shown, but a heavy mantle of glacial drift and alluvium covers almost the entire region, and surface geologic studies cannot establish the limits of the gabbro accurately. It does crop out at the south end of Silver Lake, where it is hemmed in by outcrops of phyllite in a manner to suggest that the gabbro extends only a few hundred yards farther east. The absence of disseminated pyrrhotite in all outcrops of the gabbro seen by the writer, except near the known deposit, makes the existence of another deposit on Ore Mountain or near the south end of Silver Lake seem unlikely.

A superdip traverse was run from the vicinity of the pyrrhotite deposit to Katahdin Iron Works and thence northwest along the shore of Silver Lake. The stations of this traverse are shown on plate 1 between F and F′. Three stations near Katahdin Iron Works, which lie south of the traverse are shown on the profile at the positions they would occupy if projected into the line of traverse at right angles to it. Only the first stations of the profile of this traverse (plate 5), that is those near the known deposit, show abnormal readings. Thereafter the curve flattens markedly and contrasts with the profiles AA′ to EE′ previously described. Clearly the FF′ traverse did not pass near any concealed pyrrhotite or other magnetic ore body.

The granite mass, which extends 11 miles west of Big Houston Pond, was examined only along the eastern shore of the pond. No mineralization was seen here, and Philbrick*, who has studied and mapped the entire body, reports no mineralization. Another mass of granite on Ebeemee Mountain, which is 2 miles east of the edge of the area shown on plate 1, was examined by Eckstorm†, who reported no mineralization.

The only evidence pointing to the possible existence of another ore body in the region studied by the writer was the presence of three iron-rich seeps in the valley of the West Branch of Pleasant River in the northwest corner of the mapped area (plate 1). The water in all three seeps is marked brown and resembles the "iron-colored" waters prominent in the streams which drain the pyrrhotite deposit. Along Pleasant River, however, the iron seeps rise from the flat floodplain of the stream. The easternmost of the seeps lies 50 yards upstream from where the road crosses the western of two closely spaced tributaries of Pleasant River. The western seeps lie in the woods 200 and 400 feet south of a point on the road, which is itself 100 feet southeast of where the road drops into a dry stream bed. No bedrock crops out on the floor of the valley, but the rock on the lower slopes of Chairback Mountain to the south and of the mountain to the northeast is phyllite.

A superdip traverse was run along the road from a point half a mile east of the seeps to beyond the seeps (plate 1, GG′). The profile of this traverse is shown on plate 5. It is nearly a straight line, with not the slightest deflection as the iron seeps are approached. The whole valley, as well as the hills on either side, is probably underlain by phyllite, which is magnetically inert. The iron-rich waters are believed to owe their iron content to deposits of bog iron ore in the alluvial filling of Pleasant Valley. Deposits of this type would have no present commercial significance.

To summarize, geologic studies at the surface and magnetic traverses failed to reveal any signs of other pyrrhotite deposits in the vicinity of Katahdin Iron Works. The bedrock geology to the northwest, north and northeast does not favor the presence of deposits of this type. Nothing is known of the nature of the bedrock beneath the extensive, drift-covered areas to the south.

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*Philbrick, S. S., op. cit.
†Eckstorm, Paul, unpublished report.
Magnetic profiles in the region of the Katahdin pyrrhotite deposit
IN COOPERATION WITH
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MAINE DEVELOPMENT COMMISSION
MAINE GEOLOGICAL SURVEY
J. M. TREFETHEN, STATE GEOLOGIST

BULLETIN 2 PLATE 1

RECONNAISSANCE GEOLOGIC MAP OF THE VICINITY OF THE KATAHDIN
PYRRHOTITE DEPOSIT, PISCATAQUIS COUNTY, MAINE

GEOLGY BY RALPH L. MILLER

Topography from map of U.S. Geological Survey
Sebec quadrangle, 1939-40

Geology by Ralph L. Miller

The thin line shows the extent of a boundary that is in question. The heavier line shows the part, that is in doubt.