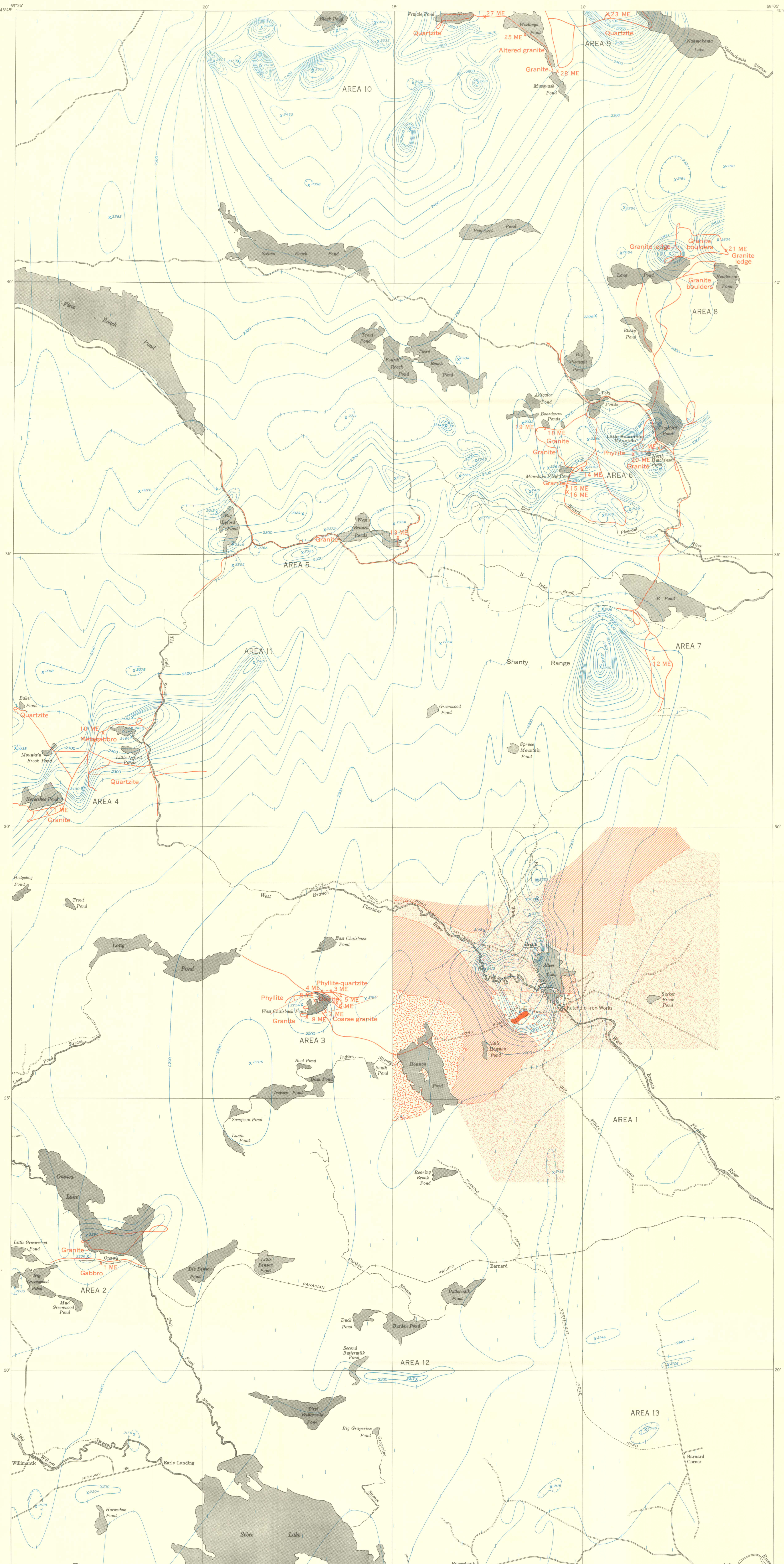
PREPARED IN COOPERATION WITH
THE STATE OF MAINE
DEVELOPMENT COMMISSION



Lower half of base compiled from published quadrangle maps, upper half from aerial photographs

APPROXIMATE MEAN DECLINATION, 1954

TOTAL INTENSITY AEROMAGNETIC AND GEOLOGIC MAP

RELATIVE TO ARBITRARY DATUM

Scale 1:62500

Contour interval 20 gammas
Flown 500 feet above surface

Aeromagnetic survey by J. R. Balsley, 1951
Geologic reconnaissance by E. P. Kaiser, 1951
Geologic map of Area 1 by R. L. Miller, 1943-44

AEROMAGNETIC SURVEY AND GEOLOGIC RECONNAISSANCE OF PART OF PISCATAQUIS COUNTY MAINE

By J. R. Balsley and E. P. Kaiser

INTRODUCTION

In an effort to locate masses of gabbroic rock similar to that containing a deposit of massive pyrrhotite at the Katahdin Iron Works, Maine, the U. S. Geological Survey in cooperation with the State of Maine Development Commission conducted an aeromagnetic survey followed by geologic reconnaissance of part of Piscataquis County, Maine.

The deposit at the Katahdin Iron Works is a massive pyrrhotite body that is probably genetically associated with its enclosing mass of gabbroic rock. This gabbro is not spatially associated with granitic rock, as are most of the basic rocks of the region, but is a mile or more from the nearest granite mass and is surrounded by quartzite and phyllite.

Dip-needle and superdip surveys indicate that there is no distinct magnetic anomaly associated with the pyrrhotite deposit at the Katahdin Iron Works and it is not likely that other similar ore deposits would have a magnetic expression, so the major objective of the work was the discovery of bodies of gabbroic rock, which might contain sulfide concentrations. Thus, areas showing magnetic anomalies similar to those of the gabbro at the Katahdin Iron Works were visited and studied to determine the nature of the bedrock. Particular attention was paid to direct evidence of sulfide concentrations.

FIELD AND COMPILATION PROCEDURES

The aeromagnetic survey was made by J. R. Balsley, L. A. Anderson, and R. A. McCullough between June 28 and July 14, 1951. The measurements were made by a continuously recording AN/ASQ-3A airborne magnetometer installed in a DC-3 airplane. Aerial photographs were used for pilot guidance, and the flight path of the aircraft was recorded by a gyrostabilized continuous-strip camera. The distance from plane to ground was measured with a continuously recording radio altimeter. North-south traverses were flown approximately 500 feet above the ground at half-mile intervals. Four short intermediate traverses at quarter-mile intervals were flown in the vicinity of the Katahdin Iron Works. The approximate location, as determined by visual observation, of the anomalous areas and the approximate size and location of distinct anomalies were plotted on the aerial photographs used for pilot guidance. Copies of these photographs were forwarded to the geologic reconnaissance party and were used by them to guide the investigations discussed below. Copies of these photographs were placed on open file September 1, 1951.

Topographic quadrangle maps at a scale of 1/62500 were enlarged to 1/32680 and used for the compilation of the magnetic data for the southern half of the area. No adequate maps were available for the northern half, so a planimetric map was made from the aerial photographs by using the sketchmaster. Multiplex control of the center points of the photographs was used.

Aeromagnetic data are obtained and compiled along a continuous line, whereas ground magnetic surveys are made at separate points. Errors within the normal limits of any magnetic measurement may cause slight discrepancies between flight lines in an aeromagnetic map, which would be more obvious than similar discrepancies between points in a ground magnetic map, particularly in a region such as this where the magnetic gradient is low. For this reason as much care should be exercised in evaluating magnetic features that appear as elongations along a single aeromagnetic traverse as in interpreting an anomaly indicated by a single ground station.

The geologic reconnaissance of the major areas of anomalies was made by E. P. Kaiser between August 15 and October 6, 1951, with the assistance of G. J. Neuerburg during the first part of the work. Ten areas, each several miles in diameter, were visited; they are indicated by number on the accompanying map. Significant samples of outcrops were collected (see table 1). During the first part of the work, the available roads and trails were used to gain access to the areas. Later a pontoon airplane was used for transportation to the nearest lake.

In this region travel is difficult and outcrops scarce, so it was not possible in the time available to check all the magnetic anomalies in detail. Experience gained in the Katahdin Iron Works area and other areas during this investigation showed that a mass of rock different from the usual granitic or sedimentary rocks can be detected from the boulders of it in glacial or alluvial float even though the mass does not crop out extensively. The absence of basic igneous rock types in the float of an area can, therefore, be used as evidence that rocks of those types are probably absent. Because the Katahdin pyrrhotite deposit is considered to be generally related to its enclosing gabbro, the absence of similar basic rocks was presumed to indicate the probable absence of pyrrhotite bodies.

All data accumulated during geologic reconnaissance were plotted on aerial photographs and transferred by sketchmaster to the planimetric maps used as the base for the magnetic contours. The geology shown on the map in the vicinity of the Katahdin Iron Works is taken from Miller (1945).

GENERAL GEOLOGY

The geology of the region is shown on the geologic map of Maine (Keith, 1933). The Onawa pluton of granitic rocks, in the southern part of the region, was studied by Philbrick and is shown on a generalized map (Philbrick, 1936). The Katahdin Iron Works area was studied and mapped by Miller (1945).

The bedrock of the region consists almost entirely of large bodies of granitic rocks and of quartzitic or phyllitic metasedimentary rocks. No fossils have been found; the metasedimentary rocks are considered to be early Paleozoic, the granites late Paleozoic (Keith, 1933; Philbrick, 1936, p. 5, 7).

The ore deposit at the Katahdin Iron Works is an irregular body of massive pyrrhotite with very low content of metals other than iron (Miller, 1945). The deposit is enclosed in a body of gabbroic rock. No structural control of the deposit is known, perhaps on account of the poor exposure. This gabbro is surrounded by metasedimentary rocks, in contrast to the other basic rocks of the region, which form border zones or selvages around, or on the margin of, large granitic bodies. These border-zone rocks range in composition from monzonite to gabbro. Hurley and Thompson (1950) found ultrabasic rocks in an adjacent region, west of Moosehead Lake, but none were found during this investigation.

AEROMAGNETIC MAP

The most striking feature of the aeromagnetic map is the extraordinarily flat magnetic gradient in the southern half. This flat gradient is particularly surprising as the area is one of considerable topographic relief and includes not only metamorphosed sedimentary rocks but also two intrusive bodies of granite (see geologic map), which would normally have a considerably higher magnetic susceptibility than the slates and quartzites that occur here. The granite exposed in the northern half of the area mapped, the Mount Katahdin pluton, exhibits a characteristic magnetic pattern described by Hurley and Thompson (1950) as "bird's-eye maple" and considered by them as diagnostic of granites in the region immediately to the west. Apparently, therefore, the Onawa pluton and the smaller granitic intrusive body to the south are of different composition and probably of different origin or age than the Mount Katahdin pluton and other granitic intrusive bodies to the west. If it can be shown that the gabbro at the Katahdin Iron Works is genetically related to the Onawa pluton, the difference in the composition and, possibly, in the origin of this pluton from that of other granite intrusives in this region may serve as a criterion for delimiting areas in which to search for other masses of gabbros, which might contain deposits of pyrrhotite.

The anomalies shown on the magnetic map are roughly circular and are isolated as individual highs or as anomalous areas containing a few closely spaced highs. Most are similar to the anomalous area associated with the mass of gabbro containing the known ore deposit; and, because the geologic information was not available, all were considered possible indications of gabbroic rock; therefore as many were visited as time permitted. The results of this ground reconnaissance are discussed below and have been used to interpret the magnetic data in the areas not visited.

RESULTS OF RECONNAISSANCE

Several indications of basic igneous rock were found (anomalous areas 2, 3, 4, and 6; see map). The rock in these areas is thought to be marginal to large granitic bodies. The other anomalous areas are underlain chiefly by granitic rocks, and the magnetic variations are presumably related to variations in rock composition, especially to variations in magnetite content. General conclusions and recommendations are given at the end of this report.

Area 1, Katahdin Iron Works.—The outcrops of both gabbro and pyrrhotite are very sparse and contacts must be inferred, except locally where either outcrop or open-cut exposures are plentiful. Definite magnetic anomalies, averaging 1° or 2° on a dip needle, are found along only part of the inferred pyrrhotite-gabbro contact. Elsewhere along the contact the magnetic variations are weak or absent.

A relatively very strong anomaly, about plus 15° on a dip needle, was noted at a small rock knob about 1600 feet due south of the southwestern end of the pyrrhotite deposit as outlined by Miller. The knob consists of deeply weathered and iron-stained igneous rock and quartzite; the high degree of weathering prevented determination of geologic relations. A few old shallow pits were noted here, but no evidence of more recent work.

The aeromagnetic data indicate that the gabbro is much more extensive than mapped by Miller (1945) and probably underlies most of the lowland formed by the valleys of Big White Brook and the West Branch of the Pleasant River. Because ground dip-needle traverses indicate no pronounced anomaly associated with the mass of pyrrhotite, the relationship of its position to that of the aeromagnetic high (2454) is considered to be indicative of some compositional or structural difference within the gabbro that may be related to the emplacement of the ore. For this reason aeromagnetic highs 2412 and 2506 should be investigated by surface geophysical methods. Depth estimates on anomaly 2506 indicate that the material producing the anomaly is close to the surface.

Area 2, Onawa Lake.—Gabbro is exposed in cuts along the Canadian Pacific Railway south of Onawa Lake. Outcrops are lacking to the north and are rare to the south, but the gabbroic rock probably is a border zone on the south margin of the large granitic Onawa pluton.

Area 3, West Chairback Pond.—Area 3 is on the northern boundary of the Onawa pluton. Instead of the coarse-grained quartz-rich granite exposed a mile to the south, the igneous rocks near the contact are generally fine-grained and quartz-poor. A body of dioritic rock crops out over a roughly circular area about half a mile in diameter on the east side of the pond. This body forms a salient of the Onawa pluton in the quartzitic and phyllitic sediments.

Area 4, Horseshoe-Little Lyford Ponds.—Almost no outcrops were found except on the periphery of area 4. Near the West Branch of the Pleasant River, east and southeast of Little Lyford Ponds, fine-grained gray quartzite crops out; similar rocks form the bare cliffs of the mountain southwest of the ponds. Boulders of granitic rock, probably of local origin, are common on the ridge south of Horseshoe Pond. In an area several miles in diameter west and northwest of Little Lyford Ponds no outcrop was seen but dark red soil is common. The most abundant float is biotite-rich, quartz-poor, dark igneous rock, generally so weathered and iron-stained that no further identification was possible. Some of the biotite has a poikilitic (skeletal) texture. This rock, like that in area 6, is interpreted as a metamorphosed basic igneous rock, possibly of volcanic origin.

Area 5, Big Lyford-West Branch Ponds.—The south contact of a large granitic body—the Mount Katahdin pluton—trends northeastward, south of the West Branch Ponds. Only a few outcrops were found in this area, but the float boulders represent many types of contact alteration material of the sediments, including migmatites. No basic igneous rocks were seen in the float, however, and it was inferred that none are present in the bedrock. The aeromagnetic anomalies are undoubtedly produced by variations of the magnetite content of the metamorphosed sedimentary rocks.

Area 6, Yoke-Crawford-Mountain View Ponds.—Most of area 6 is underlain by granitic rock, but phyllite forms the summit of Little Boardman Mountain and quartzite occurs in several places.

In the area north of North Hutchinson Pond and in the area east of Mountain View Pond are red soils and exposures of deeply weathered and iron-stained rock of igneous aspect, with large poikilitic biotites. These rocks are thought to be metamorphosed basic igneous rocks, possibly of volcanic origin, but there are not sufficient outcrops to show field relations.

The highest magnetic anomaly appears to be related to the metamorphosed basic rocks, and the numerous smaller anomalies are apparently produced by the variations of the magnetic properties of the border phases of the granite.

Area 7, Shanty Range.—The anomaly in area 7, the highest observed in the survey, is centered just north of the crest of the Shanty Range. Because of the high relief and time required for traversing in this region, there was not sufficient time to permit an examination of the location of highest magnetic intensity. Traverses were made along the foot of the north and east slopes of the range, but no basic rocks were found in the float. A few outcrops of quartzite rock were found on the ridge that forms the east end of the Shanty Range, south of the center of B Pond. It is inferred that there are no basic rocks in the area, but it should be noted that no traverses were made closer than 1 mile from the center of the anomaly.

Area 8, Long-Henderson Ponds.—Abundant float and rare outcrops indicate that area 8 is underlain by granitic rock, generally coarse-grained and quartz-rich. No float of basic igneous rock was seen.

Area 9, Nahmakanta Lake.—Coarse granite is exposed on the west shore of Nahmakanta Lake, at the north end of Musquash Pond. It is also exposed on Pollywog Pond and Wadleigh Pond one-half mile north of the area mapped. South of Nesuntabunt Mountain, on the west side of Nahmakanta Lake, the granite is in contact with fine-grained gray quartzite, but this contact could not be traced east or west because of lack of exposures. Between Wadleigh Pond and Female Pond are a few outcrops of fine-grained dark hornblende-rich rock suggestive of a greenstone, or metamorphosed basic volcanic rock. No other evidence of basic rock was seen.

Area 10, Black Pond.—The magnetic anomalies in area 10, which was not visited, are more discrete and of higher intensity than those associated with the contact phases of the granite (areas 4, 5, 6, and 9); and their discontinuous nature makes it unlikely that they are produced by local variations within a metamorphosed sedimentary rock. Apparently the anomalies are produced by local variations in the magnetite content of a mass of greenstone. This is indicated by the nature of the anomalies, by the exposures in area 9 of what appears to be greenstone or metamorphosed basic volcanic rock, and by Keith's (1933) map.

Area 11, anomaly 2415.—The proximity and similarity of anomaly 2415 to the anomalies in areas 4 and 5 and its elongation parallel to the granite contact strongly suggest that this feature, like those in areas 4 and 5, is produced by variations of the magnetic property of the border phases of the granite or possibly of the metamorphosed sediments.

Area 12, Second Buttermilk Pond, and area 13, Barnard Corner.—This belt of elongate anomalies is in the broad magnetically flat southern half of the area, which is mostly underlain by slate and quartzite of Cambrian, Ordovician, and Silurian age. The anomaly near Second Buttermilk Pond may be produced by a small basic dike, but the group of anomalies in and between areas 12 and 13 appear to have been produced by one or more zones within the metamorphic sequence.

SUMMARY OF RESULTS

The aeromagnetic data indicate that the Onawa and Mount Katahdin plutons have different origins. Both the geologic and the magnetic evidence show that the border phases of the two are markedly different: the Onawa pluton shows along its border two discrete anomalous areas—2 and 3—produced by basic igneous rocks, whereas the Mount Katahdin pluton exhibits a continuous anomalous zone along its south border (areas 4, 5, 6, and 11) apparently related to variations within the granite and to metamorphosed basic rock, possibly of volcanic origin. The north border of the Mount Katahdin pluton does not exhibit a continuous anomalous zone, but the relationships in area 9 are identical with those along the south border.

It is thought that anomalies in area 10 indicate a greenstone mass and those in areas 12 and 13, zones within the metamorphosed sedimentary rocks that contain a slightly higher quantity of magnetite.

CONCLUSIONS

No direct evidence of the existence of previously unknown massive sulfide deposits was found during this work. The thickness and extent of overburden are so great, however, that a deposit may be present in the bedrock, below the overburden, but near enough to the surface to be detected by geophysical techniques or by drilling. A few pieces of float with disseminated pyrite were seen, but these are not uncommon in regions of metamorphosed rock. The red color of the soil in areas 4 and 6 is produced chiefly by weathering of biotite and possibly of other iron-rich silicates.

No gabbro directly analogous to the Katahdin Iron Works deposit was found. The gabbro and diorite in areas 2 and 3, respectively, are selvages on the margin of the granitic Onawa pluton. The rocks of basic aspect in areas 4 and 6 are probably regionally metamorphosed igneous rocks. They may have been originally basic intrusive rocks, and if so the possibility exists that sulfide bodies are associated with them. On the other hand, they may be of volcanic origin, and therefore less likely to contain sulfide deposits.

No evidence of the occurrence of sulfide bodies in sediments was found. Most of the magnetic anomalies are in or on the margin of bodies of igneous rocks.

The Katahdin Iron Works deposit was found by direct surface observation. Erosion had brought it within the reach of weathering processes on a hillside, where active erosion and oxidation (presumably preglacial) produced lump iron oxide, which remained in the soil. A sulfide deposit that emerges at the bedrock surface, but that is covered by a thick mantle of glacial till or lake and stream sediments would not be found by direct observation. It might, however, be found either by magnetic tests or by electrical tests, if it were near enough to the surface for differences in magnetic or electrical characteristics to be observed on the surface.

Many sulfide bodies are very weakly magnetic and have magnetic susceptibilities within the range of those of ordinary igneous rocks. It may be difficult, therefore, to decide whether a magnetic anomaly indicates a different kind of rock (for example, a sulfide deposit within a gabbro mass, or gabbro within granite) or whether it indicates variations within rocks of the same general type (for example, granite containing various quantities of magnetite). Apparently many of the anomalies in this region are produced by minor variations in rock composition.

RECOMMENDATIONS

(1) Area 7, in particular, and area 10 should be studied closely to determine what material is producing the magnetic anomaly.

(2) Magnetic anomalies 2412 and 2506 in area 1 should be investigated by self-potential, inductive, or resistivity methods to determine whether a sulfide deposit is related to the structural or compositional difference within the gabbro producing these anomalies.

(3) By analogy with known sulfide deposits of the Katahdin Iron Works type, anomalies in areas of basic igneous rocks should be given priority in further work. Those in areas of granitic rock are unlikely to be related to massive sulfide deposits.

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TABLE 1. ROCK DESCRIPTIONS

No.	Area No.	Area	Description
1ME	2	Onawa Lake	Medium-grained dark-gray diorite or gabbro, An_{60}.
2ME	3	West Chairback Pond	Fine-grained medium-gray biotite-hornblende diorite, An_{40}.
3ME	3	do.	Fine-grained light-gray biotite, diorite, or monzonite.
4ME	3	do.	Do.
5ME	3	do.	Do.
6ME	3	do.	Do.
8ME	3	do.	Do.
9ME	3	do.	Fine-grained granite or monzonite.
10ME	4	Little Lyford Ponds	Biotite-rich fine-grained rock, deeply weathered. Poikilitic biotite. Metadiorite or gabbro?
11ME	4	do.	Do.
12ME	7	Shanty Range	Various metasedimentary rocks.
13ME	5	Big Lyford-West Branch Ponds	Aplitic granite.
14ME	6	Yoke-Crawford Ponds	Granular or trachytic rock with poikilitic biotite and plagioclase about An_{50}. Metadiorite or gabbro?
15ME	6	do.	Medium-grained light-gray biotite granite.
16ME	6	do.	Fine-grained aplitic granite or felspathized sedimentary rock.
17ME	6	do.	Medium-grained granular rock with poikilitic biotites. Metadiorite or gabbro?
18ME	6	do.	Medium-grained biotite granite.
19ME	6	do.	Fine-grained iron-stained quartzite, locally pyritic.
20ME	6	do.	Fine-grained diorite or granite.
21ME	8	Long-Henderson Ponds	Coarse-grained biotite granite.
*22ME	9	Nahmakanta Lake	Medium-grained granite.
23ME	9	do.	Coarse-grained granite.
*24ME	9	do.	Do.
25ME	9	do.	Altered and silicified granite.
*26ME	9	do.	Coarse-grained granite.
27ME	9	do.	Fine-grained metagabbro?
28ME	9	do.	Coarse-grained granite ledge; float of pyritiferous rock, source unknown.

* Does not appear on map.

EXPLANATION

Magnetic contours with flight traverse; dashed contours indicate incomplete or doubtful data; hachured contour encloses area of lower magnetic intensity; 'x' and number denote location and value of measured maximum or minimum intensity within closed contour.

Foot traverse

Canoe traverse

x 3ME
Specimen location and number

Inferred geologic contact

SEDIMENTARY ROCKS

Quaternary glacial drift and alluvium

Silurian(?) slate, phyllite, schist, and sandstone

IGNEOUS ROCKS

Post-Silurian pyrrhotite deposit

Post-Silurian gabbro

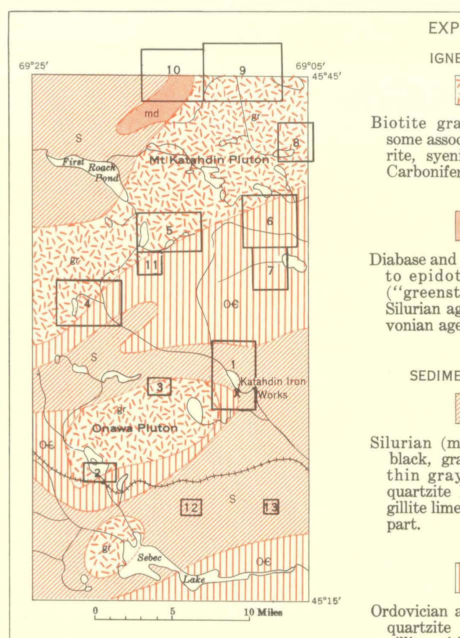
Post-Silurian granite

Geologic contact

Geologic contact of uncertain location

Inferred margin of gabbro intrusive beneath glacial drift

From Miller, Ralph L., Geology of the Katahdin pyrrhotite deposit and vicinity, Piscataquis County, Maine: Maine development Commission Bull. 2, Pl. 1, 1945



Enlarged from Keith, A., Preliminary Geologic Map of Maine, Maine Geological Survey, 1933

EXPLANATION

IGNEOUS ROCKS

Biotite granite . . . including some associated bodies of diorite, syenite etc. Mainly of Carboniferous age . . .

Diabase and amygdaloid altered to epidote-chlorite schist ("greenstone"). Mainly of Silurian age, but some of Devonian age.

SEDIMENTARY ROCKS

Silurian (middle and upper) black, gray and red slates, thin gray sandstones and quartzite layers, massive argillite limestone beds in upper part.

Ordovician and Cambrian gray quartzite and grit, gray argillite, with interbedded black and gray slates.

Area of anomaly discussed in text.

GENERALIZED GEOLOGIC MAP

AEROMAGNETIC SURVEY AND GEOLOGIC RECONNAISSANCE OF PART OF PISCATAQUIS COUNTY, MAINE

1954

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.
M R-3944
For sale by U.S. Geological Survey, price 75 cents