Bureau of Mines
Report of Investigations 5392



# INVESTIGATION OF MANGANESE AREAS, HAMMOND PLANTATION AND HODGDON TOWNSHIPS SOUTHERN DISTRICT, AROOSTOOK COUNTY, MAINE

By N. A. Eilertsen

United States Department of the Interior — April 1958

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UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

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by

N. A. Eilertsen[1/]

CONTENTS



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Report of Investigations 5392

CONTENTS (Con.)



ILLUSTRATIONS



TABLES

TABLES (Con.)

## SUMMARY

This report describes field investigations conducted in 1953 of two occurrences of manganese and a separate magnetic anomaly in the Southern manganese district of Aroostook County, vicinity of Houlton, Maine - the Pierce deposits, in Hammond Plantation Township; the Burnham anomaly, also in Hammond Plantation; and the Nickerson-Farm prospect in Hodgdon Township. The manganese occurs in a thinly laminated sedimentary rock containing manganiferous carbonate interlayered with fine-grained metamorphosed sediment, rich in chlorite or hematite. The surrounding rocks are mostly dark gray-green slates.

Samples composited for metallurgical testing from the Pierce deposits and the Nickerson-Farm prospect assayed 9.0 to 12.3 percent of manganese. More than 90 percent of the manganese could be extracted with sulfuric acid, but in most instances 30 to 40 percent of the iron was also extracted. Leaching tests indicated that, after being reduced in a hydrogen stmosphere at 600° C., about 85 percent of the manganese could be selectively extracted by a solution of ammonia-ammonium carbonate with iron extraction of only 14 percent.

The Pierce deposits were explored by 6 short diamond-drill holes, which indicated that the manganiferous beds varied from 6.5 to 50.7 feet in thickness. The manganese content varied from 9.6 to 12.9 percent. The extent of the deposits is indicated by 3 parallel magnetic anomalies, which range in length from 4,600 to 8,400 feet.

The Burnham anomaly, partly explored by the Bureau in 1951, was investigated further. No manganiferous material was intersected by the one diamond-drill hole drilled to test the unexplored north contact of the igneous rock which may be either a flow or a sill. It was concluded that this rock is entirely responsible for the anomaly.

The Nickerson-Farm prospect was explored by 2 short diamond-drill holes and 1 trench after 2 magnetic anomalies had been outlined by a ground-magnetometer survey. The anomalies, which are nearly at right angles to each other, are 1,000 and 1,800 feet in length. One of the two diamond-drill holes in the east-west deposit indicated a thickness of 64 feet and an average 9.3 percent of manganese. Channel samples cut in 30 linear feet of trench, exposing weakly magnetic shale near the center of the north-south deposit, also yielded an average assay of 9.3 percent of manganese.

## INTRODUCTION

This project is part of a program begun by the Bureau of Mines in 1949 to investigate low-grade manganese deposits in the three districts of eastern Aroostook County, Maine. Manganese minerals in the Aroostook deposits are microscopic in particle size and refractory to concentration by ore-dressing methods. However, some upgrading can be accomplished by removing the magnetic iron.

Southern-district deposits have been surficially examined by various interests during the past 20 years and have been described in published reports of the Federal and State Geological Surveys. Bureau of Mines metallurgical studies of material from deposits of the Southern district covered by this report indicate that manganese is largely present as a carbonate and that much of the iron content is magnetite. Manganese can be recovered from carbonate-type ores, after heat treatment, by leaching with certain ammoniacal solutions. Ores of the Southern district would thus appear to be more amenable to this type of beneficiation than those of the Central and Northern districts. Detailed magnetic surveys are required to determine if the limited surface exposures indicate large deposits and whether subsurface exploration is necessary to sample the material.

## ACKNOWLEDGMENTS

Acknowledgment is made to A. P. Burnham, a State game warden, for assistance rendered the Bureau of Mines when the manganiferous float at "B" stream, Hammond Plantation, was discovered during the summer of 1952.

Louis Pavlides and L. A. Brubaker of the Federal Geological Survey logged the diamond-drill cores and furnished the diamond-drill-hole logs (table 15) in this report.

## LOCATION AND ACCESSIBILITY

The Pierce deposits in Hammond Plantation Township are on the northwestern boundary of the Southern manganese district in Aroostook County, Maine, about 8 miles northwest of Houlton, the county seat.

The Burnham anomaly is also in Hammond Plantation Township on "B" road, three-quarters of a mile south of the Pierce deposits.

Hammond Plantation is accessible by traveling 1 mile north of Houlton on U. S. Route 1 (see fig. 1), then northwest on improved "B" road, 5 miles to "B" school. The Pierce deposits are then accessible by traveling 2-1/2 miles westerly from "B" school on "B" road, thence, on a graveled woods road leading north, 1-1/4 miles to a bridge across "B" stream.

The Nickerson-Farm deposit is in Hodgdon Township on the southern boundary of the Southern manganese district. It is accessible from Houlton by traveling south over U. S. Route 1 for 8 miles to the Nickerson home. The anomalies are south of the dwelling.

The Bangor-Aroostook Railroad serves the area and carries freight and passenger traffic through Houlton. The Canadian Pacific Railway has a freight terminus at Houlton over a track that crosses the international boundary east of Houlton.

The New England Telephone & Telegraph Co., part of the Bell System, serves the area, and electric power is distributed by the Maine Public Service Co.

Northeast Airlines, Inc., provides daily scheduled service through Houlton.

The nearest ocean-shipping point is Searsport, by rail 30 miles south of Bangor and 166 miles from Houlton.

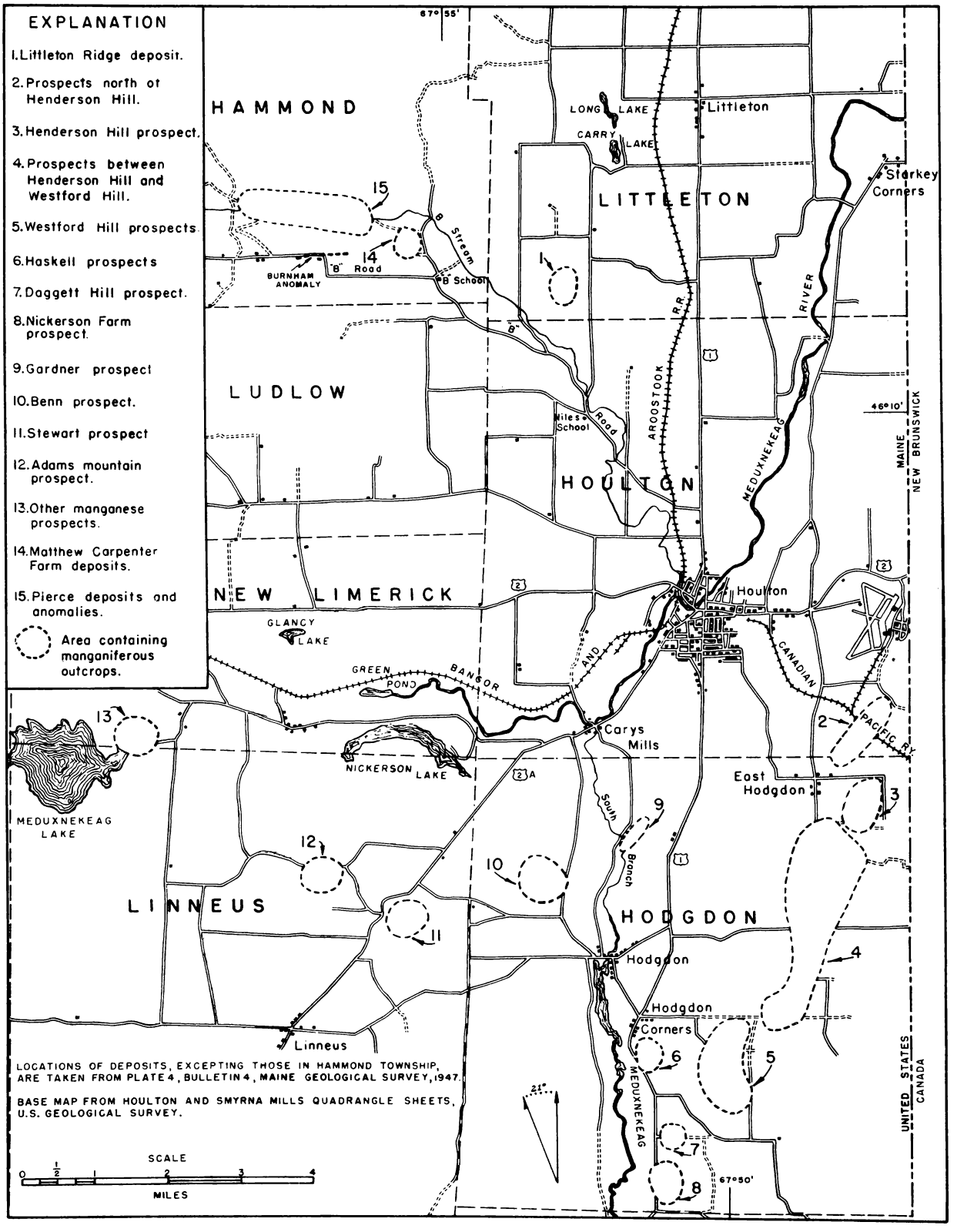


Figure 1. - Location map, manganiferous deposits, Southern District, Aroostook County, Maine.

## PHYSICAL FEATURES AND CLIMATE

Hammond Plantation is a rugged wooded area of second-growth pine and spruce forest, inaccessible by road, except in the partly cultivated strip inside its southern border. "B" stream meanders easterly across the southern part of township "B," and a series of tributary brooks drains low areas between several ridges, which rise in a northwesterly direction. In 7-3/4 miles across the township the stream drops 282 feet from "B" lake (altitude, 722 feet in southwestern Hammond Plantation to the eastern boundary of the township (altitude, 440 feet).

The Nickerson-Farm prospect in Hodgdon Township is on the southwestern slope of Daggett Hill, fronting the Meduxnekeag River at an elevation of 470 feet.

The climate of Aroostook County is pleasant and mild in summer but severe in winter. The average annual temperature is about 40°,[2/] and annual precipitation about 30 inches.

## HISTORY AND OWNERSHIP

The three parallel Pierce deposits (Nos. 1, 2, and 3) in Hammond Plantation were discovered during the Bureau of Mines investigation of the area in 1953, following reconnaissance by the Bureau in 1952. They are in the southern portion of lots 28 and 29 - woodlands owned by the Great Northern Paper Co., Madigan & Pierce, agents, Houlton, Maine.

The Burnham anomaly is on the farm of Henry and Arthur Carpenter in Hammond Plantation. This anomaly was partly explored by the Bureau of Mines in 1951, when a search was being made for the source of the Burnham float.[3/] The float consists of manganiferous magnetite-rich boulders, containing up to 13 percent Mn.

The Nickerson-Farm prospect contains the southernmost outcrops of manganiferous sedimentary rock in the Southern district. The deposits are on the 163-acre farm of Chester H. Nickerson. Paul F. Eckstorm examined and sampled the outcrops on the Nickerson Farm and other manganese deposits in Aroostook County during 1941 for the State of Maine, and his work is referred to in the published reports of Trefethen[4/] and Miller.[5/]

## DESCRIPTION OF DEPOSITS

### Pierce Deposits

The Pierce deposits are three beds of manganiferous sedimentary rock. The material composing the deposits is lithologically complex, as the manganiferous rock ranges from a chloritic carbonate stratum to impure siliceous hematite beds. The deposits are enclosed and separated by a series of interbedded shales, slates, and graywacke.

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2/ U. S. Weather Bureau, Climatological Data, New England. Annual Summary, 1950; vol. 62, No. 13, pp. 394 and 397.

3/ Eilertsen, N. A., Investigation of the Littleton Ridge Manganese Deposit and Vicinity, Southern District, Aroostook County, Maine: Bureau of Mines Rept. of Investigation 5104, 1955, pp. 32-39.

4/ Trefethen, Joseph M., Report of the State Geologist; State of Maine, 1942-43, p. 30.

5/ Miller, Ralph L., Manganese Deposits of Aroostook County, Maine: Maine Geol. Survey Bull. 4, 1947, pp. 38, 73, and 74.

Deposits 1, 2, and 3, numbered consecutively from south to north, are about 300 and 1,000 feet apart, respectively. They are concealed by overburden, except where Pierce deposit No. 1 is exposed in three Bureau of Mines trenches near a bridge that crosses "B" stream. The deposits are indicated by 3 narrow anomalies, which strike about N. 83° W.; the longest, outlining Pierce deposit No. 1, measures 8,400 linear feet. Spot drilling on the deposits by the Bureau of Mines indicated a dip of 57° to 60° SW. and a thickness of 6.5 to 50.7 feet.

### Burnham Anomaly

The Burnham anomaly is 4,500 feet long. Trending east-west, it is 1,800 feet north of the Burnham-float area on the Henry and Arthur Carpenter Farm in southeastern Hammond Plantation. The anomaly is caused by a dark-green vesicular igneous rock, which may be either a flow or sill of andesite. It contains disseminated magnetite, which is responsible for the magnetic attraction. A flat slab of manganiferous rock float, composed of fine red and gray laminations, was found in 1951 in a trench that exposed the south side of the andesite. This lent encouragement to exploring the north side of the anomaly.

The south side of the flow or sill is in contact with gray-green slate, and the north side was found by diamond drilling to be in contact with gray-green, fine-grained quartzite, with green and gray slate interbeds.

### Nickerson-Farm Prospect

Several manganiferous rock outcrops are found on the Nickerson Farm in Hodgdon Township on U. S. Highway No. 1 (see fig. 2). The surface indicates beds of manganese-stained, magnetite-rich shale or slate - material similar in composition and texture to the chlorite rock of the Pierce deposits in Hammond Plantation. An exposure in a rock cut on the east side of U. S. Highway No. 1, fronting the Nickerson-Farm buildings, contains manganiferous rock similar to that found on the south side of a knoll, 500 feet east of the road, and in several small outcrops 1,000 feet southeast of the knoll.

Two deposits are outlined by magnetic surveys, and the patterns produced indicate that the area has been intensely folded and faulted. Because of irregularities in strike and dip, exploration would be difficult without the aid of magnetic surveys.

## CHARACTER OF ORE

### Pierce Deposits

The manganiferous rock of the Pierce deposits is characterized by fine-grained, thin laminations, blocky fracture, high specific gravity, and nonuniformity of hematite and magnetite content. It has a wide range of color, from hematitic red through gray, gray-green and black. Light-color siliceous laminae and thin, nearly white bands in unweathered rock contain impure manganese carbonate. The rock is cut by fine microfaults and gash veinlets containing minor feldspar, quartz, and calcite.

Magnetite, which probably results partly from local recyrstallization of hematite, is not uniformly distributed. Heavy concentrations of magnetite occur as thin laminae in dark bands, as much as 1 foot in thickness. A scattering of fine pyrite and pyrrhotite is noted in some drill cores. Chemical tests indicate that most of the manganese is combined with iron as impure carbonate. Several specimens taken from these deposits were found to average 3.55 specific gravity, equivalent to about 10 cu. ft. per long ton of ore in place.

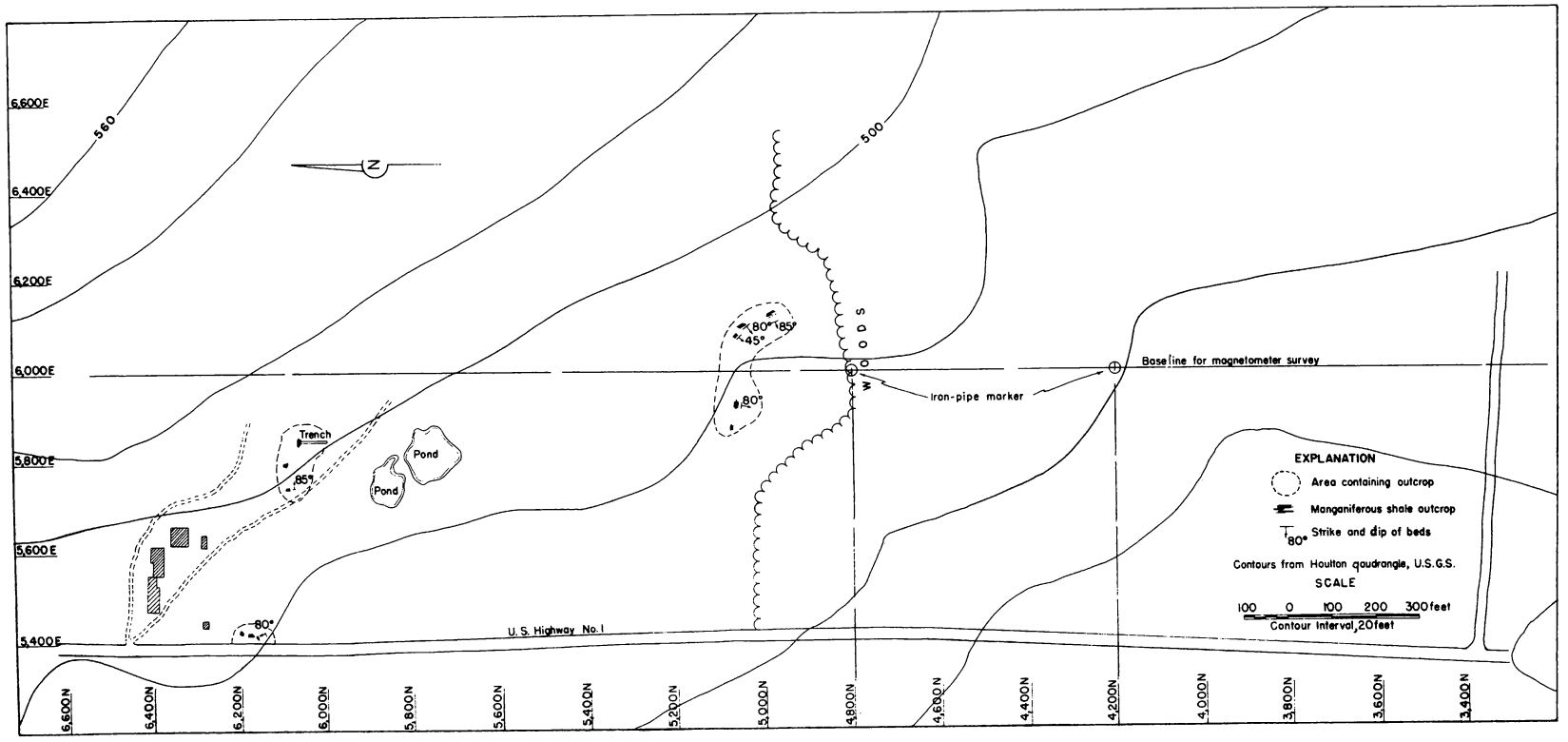


Figure 2. - Plan showing outcrops of manganiferous rock on Nickerson-Farm prospect, Hodgdon Township.

Nickerson-Farm Prospect

The manganese-bearing rock of the Nickerson-Farm-prospect deposits is fine grained and thinly laminated. The parts of the deposits that have been intensely folded contain both magnetite and hematite. The weathered surface is stained by black manganese oxide. Primary manganese minerals are obscure. Chemical tests indicate that manganese occurs as an impure carbonate associated with iron and silica. The colors of the rock range from gray-green through shades of red to black. Pyrite occurs in minor quantities as scattered metacrysts and as fine-grained, thin laminae and veinlets.

Dark-gray shale, which may be weathered siliceous chlorite-carbonate rock, is exposed in a trench in the southern part of the south Nickerson anomaly. This part of the deposit does not appear to be greatly disturbed by folding. The material is not attracted by a hand magnet. Assays of manganese and iron in the nonmagnetic shale are identical with assays of the highly metamorphosed material of the north anomaly, which is rich in magnetite.

Fine-grained, impure manganese carbonate occurs as thin, light-gray laminations and also as layers, 1/4 to 1/2 inch in thickness, scattered or bunched in the hanging-wall and foot-wall shales of the east-west trending deposit outlined by the north Nickerson anomaly. The laminations and layers, which are highly siliceous, turn buff to black after exposure to weathering.

The specific gravity of material from the Nickerson-Farm prospect was found to range downward from 3.60 to 3.00, depending upon the manganese and iron content in the specimens weighed. Tonnage factors would thus range from 10 to 11 cu. ft. per long ton of ore in place.

## WORK BY THE BUREAU OF MINES

Following reconnaissance in the "B" stream area in Hammond Plantation during the summer of 1952, the Bureau of Mines conducted further investigations in the Southern district of eastern Aroostook County during the spring of 1953. The work completed during the 2-1/2-month period from April 15 through June 26, 1953, was confined to discovery and exploration of the Pierce deposits in Hammond Plantation, further investigation of the Burnham anomaly (also in Hammond Plantation), and exploration of the Nickerson-Farm prospect in Hodgdon Township. Magnetometer surveys were employed to outline the deposits, and spot sampling was accomplished by core drilling and trenching.

The site of the Nickerson-Farm prospect in Hodgdon Township, far removed from Hammond Plantation, was chosen for investigation because it is the southernmost of the manganese areas in the southern district, is readily accessible, and reports of the Federal and State Geological Surveys record material that assayed about 9 percent Mn.

The Bureau of Mines contracted with the Federal Geological Survey to furnish a magnetometer-survey party. The magnetic contours, which appear on maps of this report, were traced from work maps prepared in the field for the Bureau of Mines by Bromery[6/] and Shuler.[7/]

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6/ Bromery, R. W., geophysicist, Geophysical Branch, Federal Geological Survey.
7/ Shuler, R. M., scientific aide, Geophysical Branch, Federal Geological Survey.

Details of field work completed and results of sampling and laboratory tests are described in the following chapters.

## Pierce Deposits

The manganiferous deposits in the vicinity of "B" stream, Hammond Plantation Township, were completely covered by overburden, and it was apparent that ground magnetometer surveys were needed to locate, outline, and trace the deposits before other exploration could be undertaken.

A winter road, 1-1/4 miles in length, used for hauling timber and pulpwood from "B" stream to "B" road, was repaired and conditioned for an access road.

While the 2 diamond drills were in operation - 1 each at the Burnham anomaly in Hammond Plantation and the Nickerson-Farm prospect in Hodgdon Township - transit surveys of base lines for mapping the Pierce anomalies were started May 1. The base lines originate from a point on the north side of "B" stream, arbitrarily designated as map coordinates 5,000 N. and 5,000 E. A total of 43,600 feet of transit-surveyed base lines and traverse lines were brushed in the vicinity of "B" stream, and stakes were set at 200-foot intervals. The magnetometer-survey party brushed and extended traverse lines north-south for an additional 20,000 linear feet. Readings were taken on more than 1,350 stations at measured intervals ranging from 25 to 50 feet over 50,000 feet of traverse lines. As a result of this work, three east-west-trending anomalies (see figs. 3, 4, 5, 6), were mapped. The first and southernmost anomaly, outlining Pierce deposit No. 1 was traced for a distance of 8,400 feet; the second, Pierce deposit No. 2, 300 feet north of Pierce deposit No. 1, was traced 4,600 feet; and the third anomaly, Pierce deposit No. 3, 1,000 feet north of Pierce No. 2, was traced intermittently for a length of 5,200 feet.

Diamond drilling of the Pierce deposits was only of a preliminary nature to investigate the character of the ore and obtain samples for metallurgical tests. Six short, inclined holes were drilled, totaling 945 feet. A total of 210.3 feet of core was split and divided into 39 samples for assaying. Determinations for manganese and iron are shown in table 1. Details of sampling the deposits are described separately.

### Pierce Deposit No. 1, Diamond Drilling and Trenching

The deposit was tested by 2 short, inclined, diamond-drill holes and 3 surface trenches. Drill holes 1 and 3 are plotted in plan (see fig. 3). The average true thickness of the intersections of ore in the 2 holes (see fig. 7) is 12.5 feet; the ore contains 10.2 percent Mn and 19.6 percent Fe. The average dip of the deposit, as indicated by drilling, is 60° SW. The dip of the bed is indicated by the fine lines on the vertical sections (see fig. 7).

Three trenches, opened to bedrock across Pierce deposit No. 1, total 195 linear feet. The average true thickness of the ore exposed by trenching is 13.8 feet; it averages 12.2 percent Mn and 25.5 percent Fe. A total of 9 channel samples was cut, and the corresponding assays are shown in table 2.

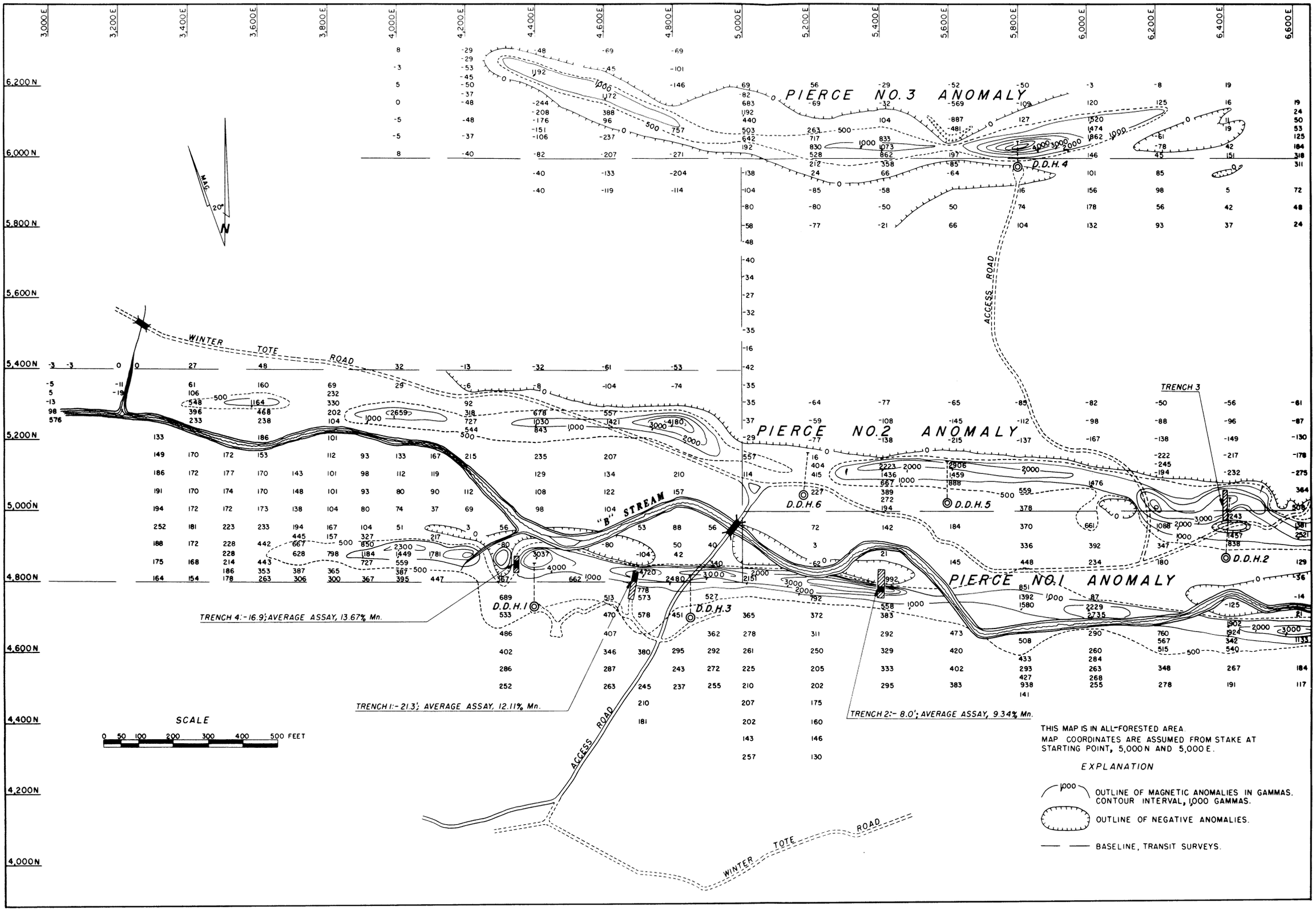



Figure 3. - Sheet 1 of 4, plan of Pierce anomalies, Hammond Plantation.

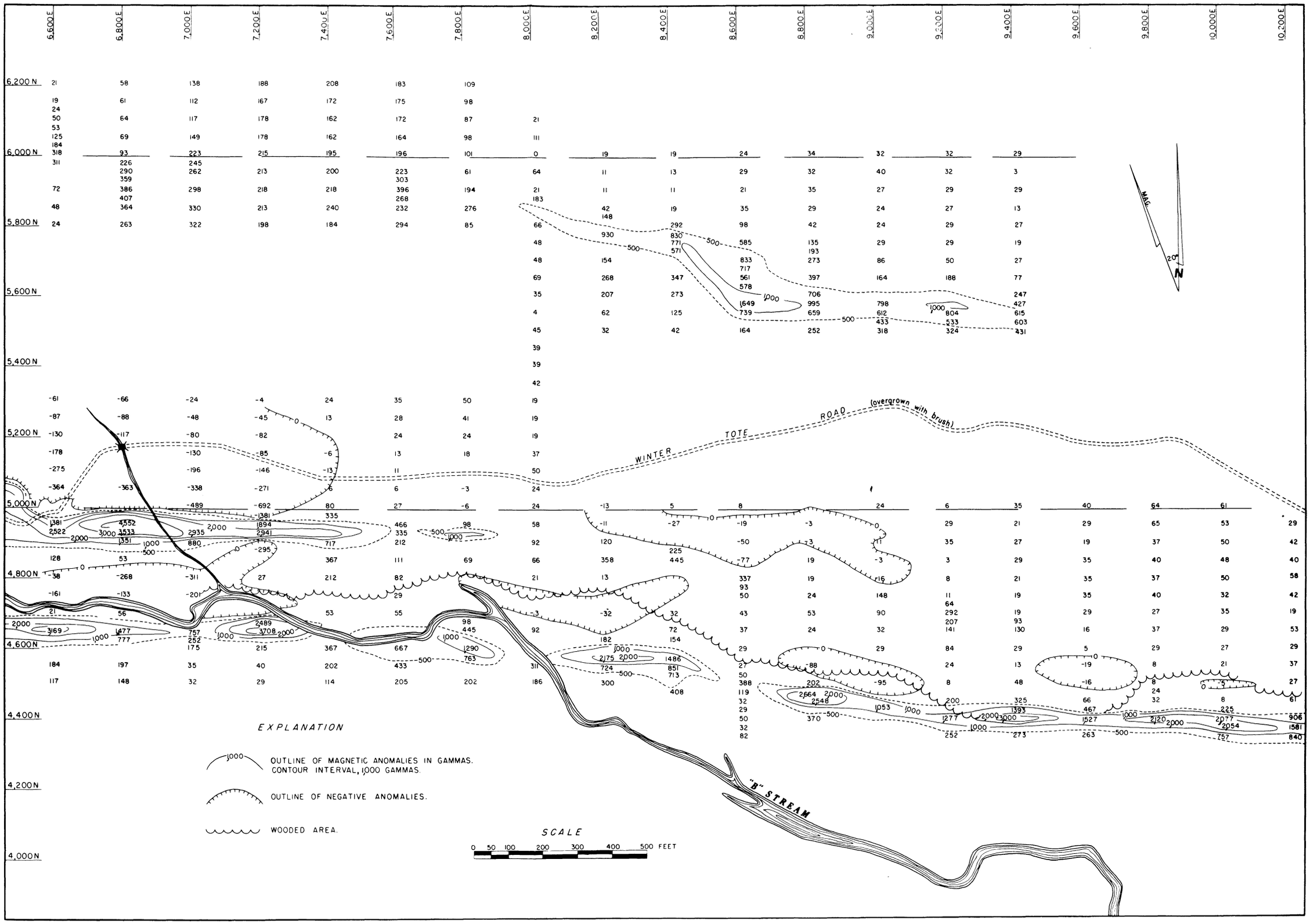



Figure 4. - Sheet 2 of 4, plan of Pierce anomalies, Hammond Plantation.

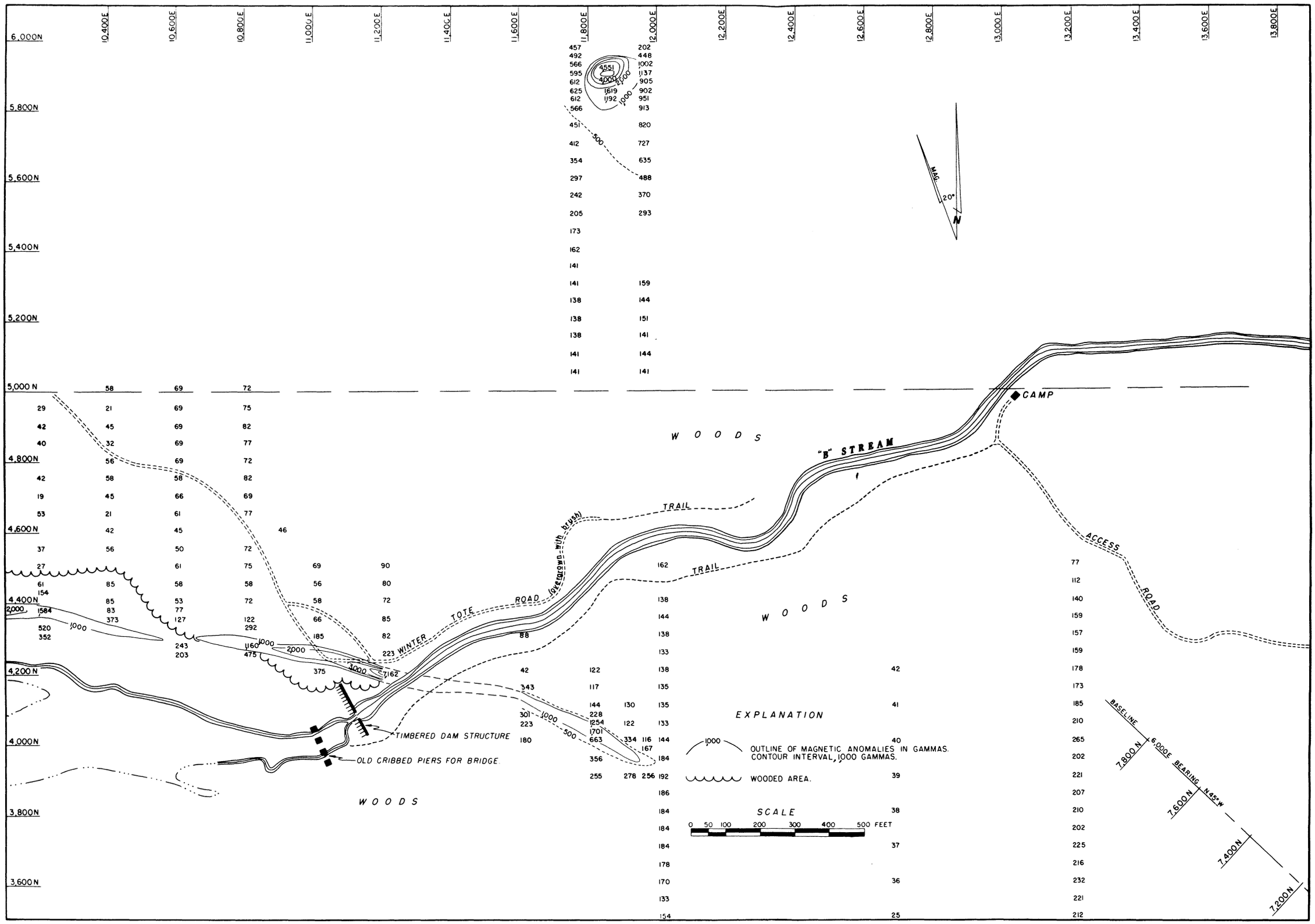



Figure 5. - Sheet 3 of 4, plan of Pierce anomalies, Hammond Plantation.

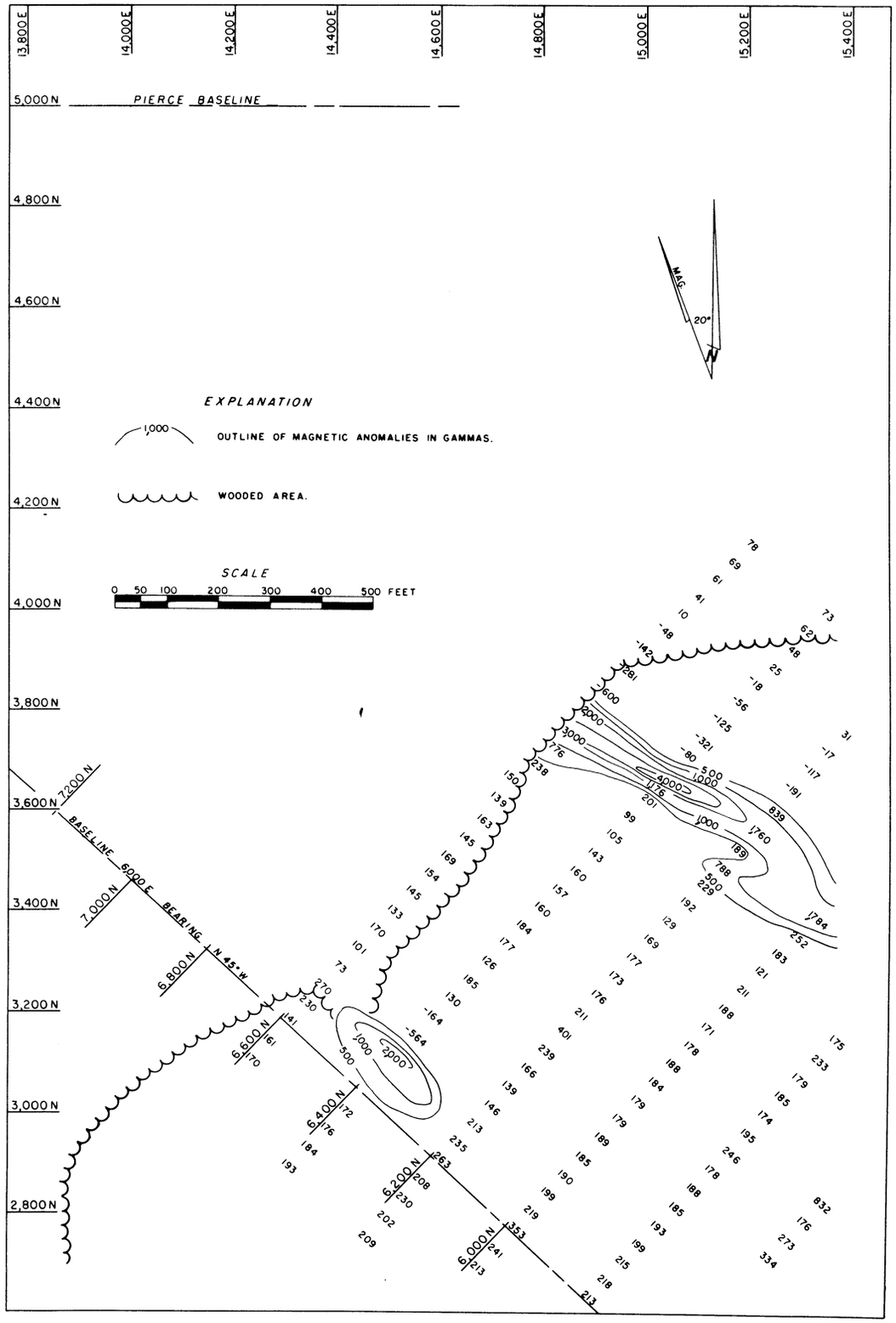



Figure 6. - Sheet 4 of 4, plan of Pierce anomalies, Hammond Plantation, showing relation to Matthew Carpenter-Farm anomalies.

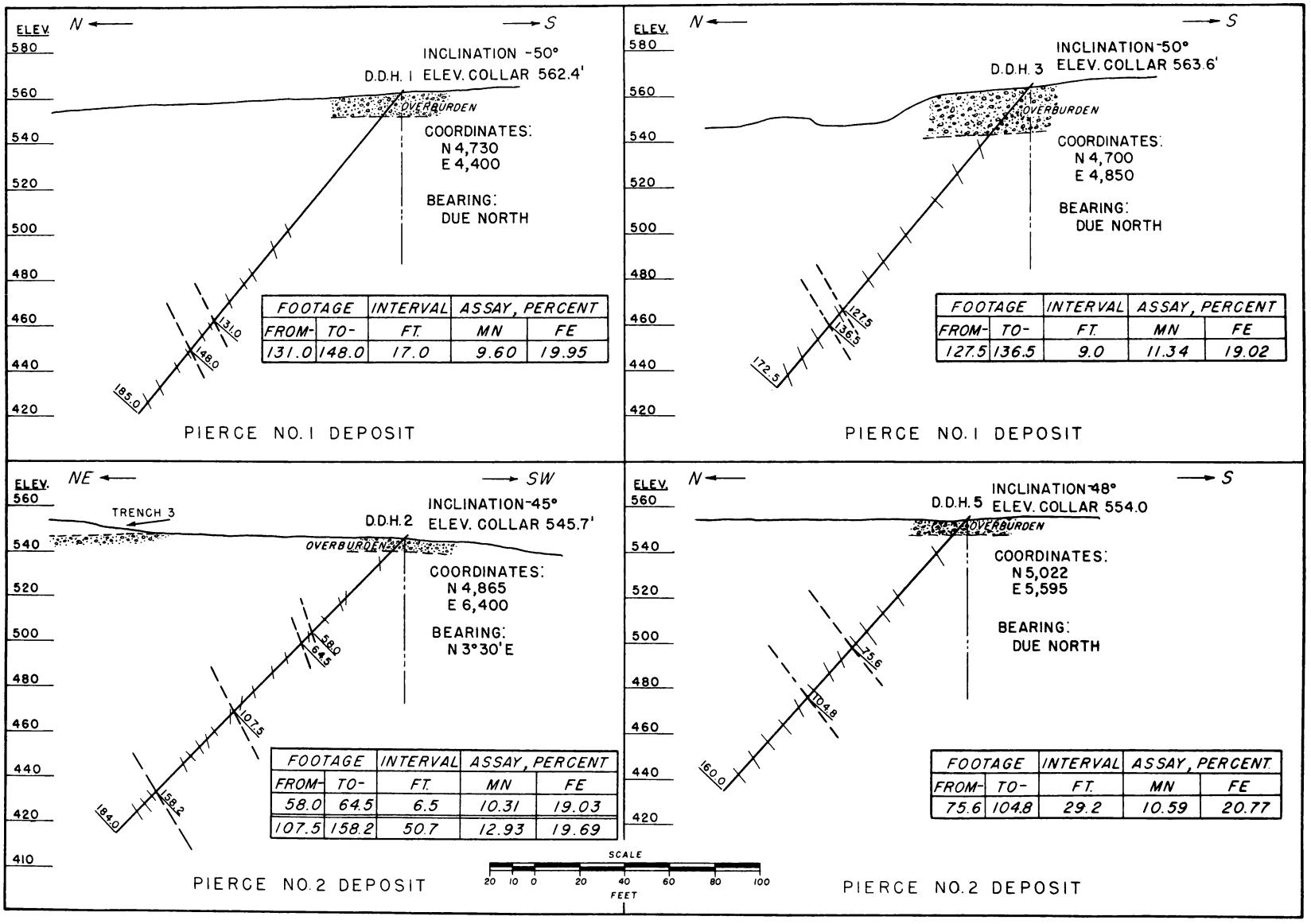



Figure 7. - Vertical sections through diamond-drill holes 1, 2, 3, and 5, Pierce deposits.

TABLE 1. - Analyses of diamond-drill cores, Pierce deposits

(Minus-65-mesh screen, Davis-tube magnetic separation)

Diamond-drill hole 1, Pierce deposit No. 1

| Footage | | Sample interval, | Core assay, percent | | | Magnetic fraction |
|---|---|---|---|---|---|---|
| From- | To- | feet | Mn | Fe | S | Weight, percent |
| 125.0 | 131.0 | 6.0 | 3.33 | 10.83 | 5.71 | - |
| 131.0 | 140.0 | 9.0 | 11.81 | 28.11 | .25 | 45.0 |
| 140.0 | 148.0 | 8.0 | 7.11 | 10.78 | .34 | 20.7 |
| Total ..... | | 17.0 | 9.60 | 19.95 | .29 | 33.6 |
| 148.0 | 153.0 | 5.0 | .57 | 3.88 | .79 | - |
| Total ..... | | 28.0 | - | - | - | Core recovery, 70.7 percent |

Diamond-drill hole 3, Pierce deposit No. 1

| | | | | | | |
|---|---|---|---|---|---|---|
| 127.5 | 128.5 | 1.0 | 9.68 | 31.98 | 0.58 | 50.9 |
| 128.5 | 133.5 | 5.0 | 15.38 | 22.38 | .39 | 33.4 |
| 133.5 | 136.5 | 3.0 | 5.17 | 9.11 | 1.26 | .1 |
| Total ..... | | 9.0 | 11.34 | 19.02 | .70 | 24.2 |
| 136.5 | 144.5 | 8.0 | .41 | 6.49 | .31 | - |
| 144.5 | 145.0 | .5 | .37 | 8.55 | 3.25 | - |
| 145.0 | 150.0 | 5.0 | .40 | 3.62 | .72 | - |
| 150.0 | 160.0 | 10.0 | .38 | 4.07 | .87 | - |
| Total ..... | | 32.5 | - | - | - | Core recovery, 86.5 percent |

Diamond-drill hole 2, Pierce deposit No. 2

| | | | | | | |
|---|---|---|---|---|---|---|
| 50.0 | 58.0 | 8.0 | 2.11 | 7.30 | 2.50 | - |
| 58.0 | 64.5 | 6.5 | 10.31 | 19.30 | 2.10 | - |
| 64.5 | 70.0 | 5.5 | 1.05 | 4.08 | .86 | - |
| Gray slate | | | | | | |
| 106.5 | 107.5 | 1.0 | 1.71 | 4.24 | .52 | - |
| 107.5 | 110.0 | 2.5 | 11.96 | 19.92 | .50 | 7.9 |
| 110.0 | 120.0 | 10.0 | 13.40 | 21.74 | .11 | 27.4 |
| 120.0 | 130.0 | 10.0 | 12.64 | 22.90 | .29 | 22.6 |
| 130.0 | 140.0 | 10.0 | 15.28 | 19.60 | .12 | 26.1 |
| 140.0 | 150.0 | 10.0 | 12.80 | 20.16 | 0.39 | 27.0 |
| 150.0 | 158.2 | 8.2 | 10.32 | 12.77 | .80 | .1 |
| Total ..... | | 50.7 | 12.93 | 19.69 | .33 | 20.7 |
| 158.2 | 163.0 | 4.8 | 2.23 | 7.88 | .47 | - |
| Total ..... | | 76.5 | - | - | - | Core recovery, 91 percent |

Diamond-drill hole 5, Pierce deposit No. 2

| | | | | | | |
|---|---|---|---|---|---|---|
| 75.6 | 78.0 | 2.4 | 10.17 | 33.55 | 0.19 | 46.3 |
| 78.0 | 86.0 | 8.0 | 11.64 | 24.15 | .49 | 17.9 |
| 86.0 | 89.8 | 3.8 | 13.94 | 18.71 | .31 | 27.5 |
| 89.8 | 96.0 | 6.2 | 11.32 | 20.52 | .56 | 14.1 |
| 96.0 | 100.0 | 4.0 | 9.47 | 16.89 | 1.12 | 4.9 |
| 100.0 | 104.8 | 4.8 | 6.40 | 13.91 | 2.77 | .3 |
| Total ..... | | 29.2 | 10.59 | 20.77 | .92 | 16.0 |
| Total ..... | | 29.2 | - | - | - | Core recovery, 100 percent |

TABLE 1. - Analyses of diamond-drill cores, Pierce deposits (Con.)

(Minus-65-mesh screen, David-tube magnetic separation)

Diamond-drill hole 6, Pierce deposit No. 2

| Footage From- | Footage To- | Sample interval, feet | Core assay, percent Mn | Fe | S | P | Magnetic fraction Weight, percent |
|---|---|---|---|---|---|---|---|
| 71.4 | 74.6 | 3.2 | 0.41 | 5.52 | 2.38 | - | - |
| 74.6 | 78.0 | 3.4 | 9.18 | 25.73 | 1.17 | - | 19.3 |
| 78.0 | 86.0 | 8.0 | 13.98 | 18.42 | .47 | - | 11.6 |
| Total .. | | 11.4 | 12.55 | 20.60 | .68 | - | 13.9 |
| 86.0 | 90.0 | 4.0 | 4.31 | 8.15 | .49 | - | |
| Total .. | | 18.6 | - | - | - | - | Core recovery, 91.3 percent |

Diamond-drill hole 4, Pierce deposit No. 3

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 30.0 | 34.0 | 4.0 | 3.73 | 11.23 | 0.53 | - | - |
| 34.0 | 35.5 | 1.5 | 6.48 | 16.43 | .36 | - | - |
| 35.5 | 43.0 | 7.5 | 1.52 | 9.59 | .11 | - | - |
| Total .. | | 13.0 | - | - | - | - | - |
| 43.0 | 44.6 | 1.6 | 11.60 | 17.49 | .23 | 0.547 | 11.8 |
| 44.6 | 53.2 | 8.6 | 12.20 | 21.56 | .57 | .732 | 36.8 |
| 53.2 | 54.6 | 1.4 | 9.23 | 30.38 | .14 | 1.194 | 51.7 |
| 54.6 | 55.5 | .9 | 20.32 | 10.62 | .34 | .279 | 20.4 |
| Total .. | | 12.5 | 12.38 | 21.24 | .46 | .727 | 34.1 |
| Total .. | | 25.5 | - | - | - | - | Core recovery, 94.5 percent |

TABLE 2. - Analyses of trench samples, Pierce deposit No. 1

(Minus-65-mesh screen, Davis-tube magnetic separation)

Trench 1
(Measured north to south)

| Footage From- | Footage To- | Sample interval, feet | Core assay, percent Mn | Fe | S | Magnetic fraction Weight, percent |
|---|---|---|---|---|---|---|
| 0 | 3.1 | 3.1 | 11.48 | 19.75 | 0.58 | 21.2 |
| 3.1 | 5.3 | 2.2 | 10.58 | 30.59 | .18 | 49.0 |
| 5.3 | 13.3 | 8.0 | 12.84 | 22.61 | .62 | 29.1 |
| 13.3 | 21.3 | 8.0 | 12.04 | 21.36 | .29 | 20.9 |
| Total ..... | | 21.3 | 12.11 | 22.55 | .44 | 26.9 |

Trench 2
(Measured north to south)

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 4.0 | 4.0 | 9.64 | 34.76 | 0.087 | 51.3 |
| 4.0 | 8.0 | 4.0 | 9.04 | 38.59 | .15 | 56.2 |
| Total ..... | | 8.0 | 9.34 | 36.68 | .12 | 53.8 |

Trench 4
(Measured north to south)

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 3.9 | 3.9 | 11.15 | 22.06 | 0.45 | 10.9 |
| 3.9 | 10.5 | 6.6 | 16.40 | 21.00 | .44 | 26.1 |
| 10.5 | 16.9 | 6.4 | 12.38 | 28.59 | .22 | 26.3 |
| Total ..... | | 16.9 | 13.67 | 24.12 | .36 | 22.7 |

Pierce Deposit No. 2, Diamond Drilling

Three inclined holes, totaling 499 linear feet, were drilled in Pierce deposit No. 2 at intervals of 400 and 800 feet along the strike (see fig. 3). They are also plotted in vertical section (see figs. 7 and 8). Diamond-drill hole 2 (DDH-2), drilled in a wider area in the anomaly, made two intersections of manganiferous material. The upper bed or lens, measuring 6 feet true thickness and liberally sprinkled with fine pyrrhotite, assayed 10.3 percent Mn, 19.3 percent Fe, and 2.1 percent S. The lower bed, 49 feet true thickness, assayed an average 12.9 percent Mn and 19.7 percent total Fe. DDH-5, drilled under a weaker magnetic area along the strike of the anomaly, intersected the deposit, cut 29.0 feet true thickness, and averaged 10.6 percent Mn and 20.8 percent Fe. DDH-6, in a gap of the anomaly, was drilled to determine if the deposit was continuous between local areas of high magnetic intensity. This drill hole intersected 11 feet true thickness of laminated, manganiferous, hematitic rock, containing relatively less magnetite than the quantity found in the other drill-core intersections. The core assayed 12.5 percent Mn and 20.6 percent Fe.

Excluding the upper intersection in hole 2, the 3 drill-hole intersections in the deposit averaged 29.7 feet true thickness and assayed an average of 12.1 percent Mn and 20.1 percent Fe. The average dip of the deposit, determined by drilling, is 57° SW.

Pierce Deposit No. 3, Diamond Drilling

It was necessary to open 1,350 feet of access road by a circuitous route through a swampy wooded area to reach Pierce deposit No. 3. Only one inclined hole (No. 4) was drilled in the anomaly; it intersected 12.5 feet true width of deposit and averaged 12.4 percent Mn and 21.2 percent Fe (see table 1). As intersected in the drill hole, the deposit dips 57° SW. An unusual, variegated section of core at 50.3 feet of hole depth, shown in photograph (fig. 9), is composed of thin laminations, in bands up to 1/4 inch in thickness, of siliceous hematite and slate, and includes bands or pods of impure manganese carbonate, as much as 3/16 inch in thickness. Four core samples, which assayed 10.6 to 30.4 percent Fe, were also analyzed for phosphorus and ranged from 0.279 percent in the sample containing the lowest assay of iron to 1.194 percent in the sample containing the highest assay of iron.

Diamond Drilling, Burnham Anomaly, Hammond Plantation Township

Burnham drill hole 1, shown in plan (fig. 10) was diamond-drilled, AX size (1-1/8-inch-diameter core), at 45° to test the unexposed rock in the vicinity of the north side of the anomaly. No manganiferous rock was found in the core. The drill hole passed through quartzite and slate interbeds and intersected chloritic igneous rock, variably magnetic at 294.5 feet. Drilling was stopped at 311.5 feet. Water under pressure was encountered between 200 and 207 feet. The vesicular andesite, thought to be an igneous flow or a sill, is indicated by drilling and trenching to be about 75 feet in width.

Nickerson-Farm Prospect, Hodgdon Township

Field work on the Nickerson-Farm prospect was started April 21 and completed May 26, 1953. A north-south base line was transit surveyed for a linear distance of 3,200 feet. Stakes were set at 200-foot intervals, and east-west traverse lines were turned and picketed from each stake. The magnetometer-survey party extended the traverse lines for an aggregate distance of 24,000 feet, and magnetometer

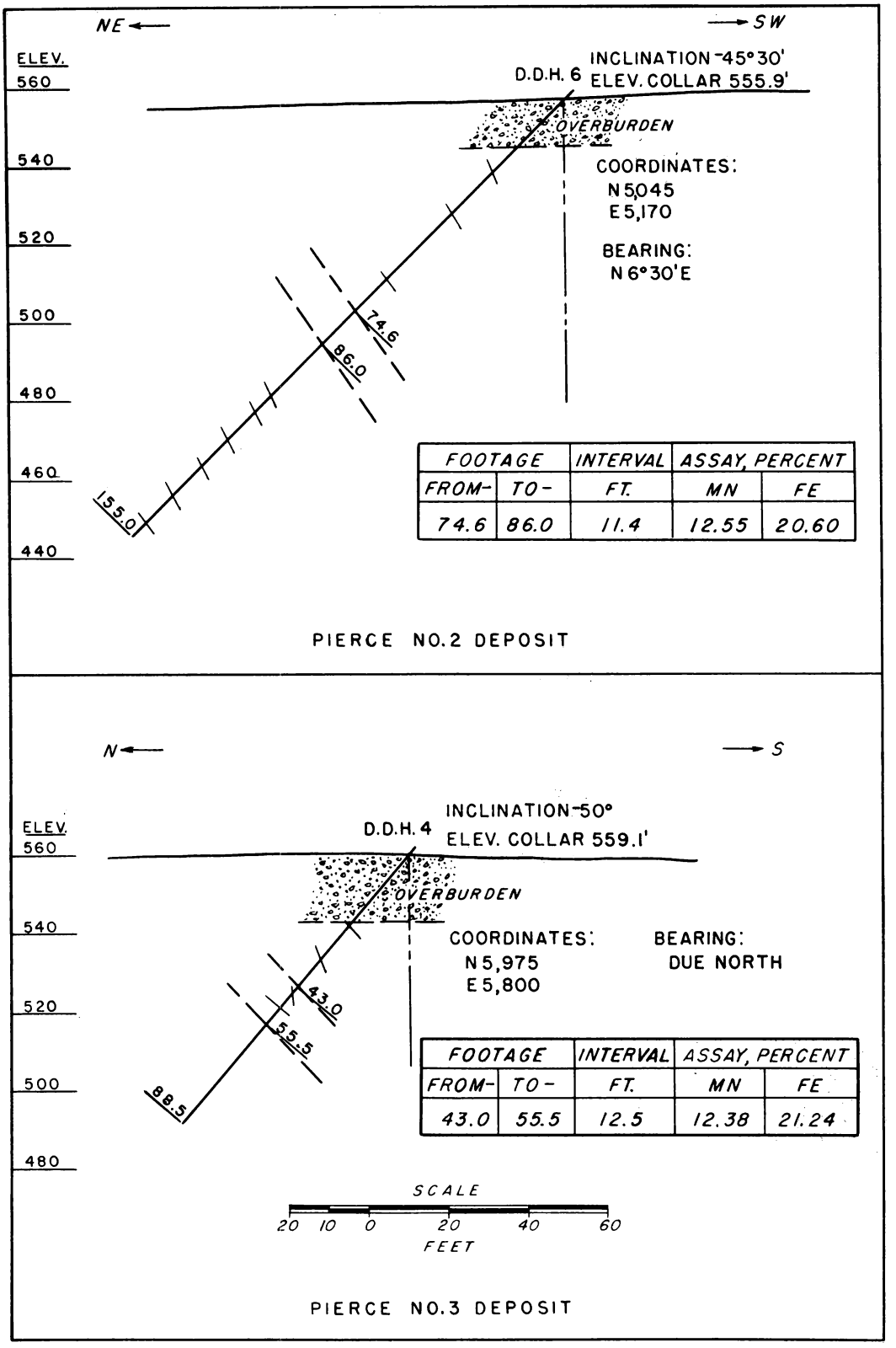
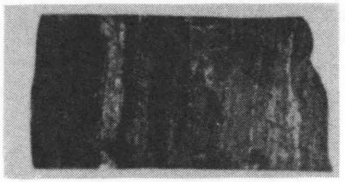
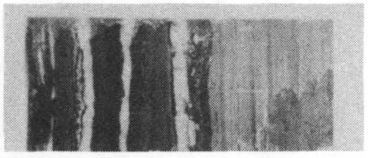


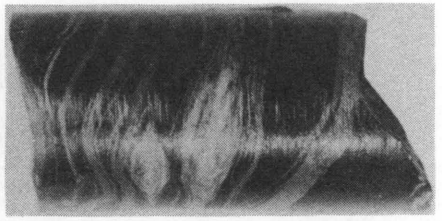

Figure 8. - Vertical sections through diamond-drill holes 4 and 6, Pierce deposits.



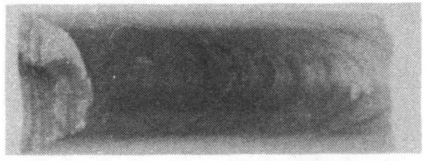
Split-core specimen of dark-gray siliceous manganiferous chlorite-carbonate rock containing laminae and bands of fine magnetite. From Pierce deposit No. 2, hole 2 at 131.5 ft.



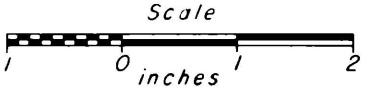
Polished surface of split core from Pierce deposit No. 3, hole 4 at 50.3 feet. Fine laminae and bands of hematite, magnetite and white siliceous manganiferous carbonate occur in magnetite-chlorite rock. Bands range in color: red, gray, black, and white.

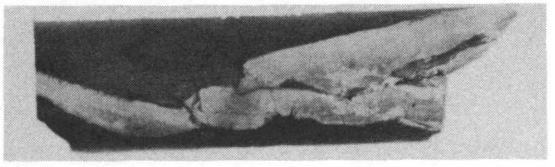


Polished-core specimen from Nickerson-Farm prospect, hole 2 at 37.5 feet. Bands and pods of white siliceous manganiferous carbonate follow folds in dark-gray slate. Bands darken after exposure to atmosphere.



Core specimen from Nickerson-Farm prospect, hole 2 at 94.6 feet. Magnetite-chlorite rock containing numerous thin laminae of fine magnetite and hematite. The rock is nearly black when polished.



Core specimen of dark-gray slate containing white to buff layer of siliceous manganiferous carbonate, assaying about 20 percent manganese, 5 percent iron, and 26 percent silica. From Nickerson-Farm prospect, hole 2 at 231.5 feet.

Figure 9. - Core specimens from Pierce deposits and Nickerson-Farm prospect.

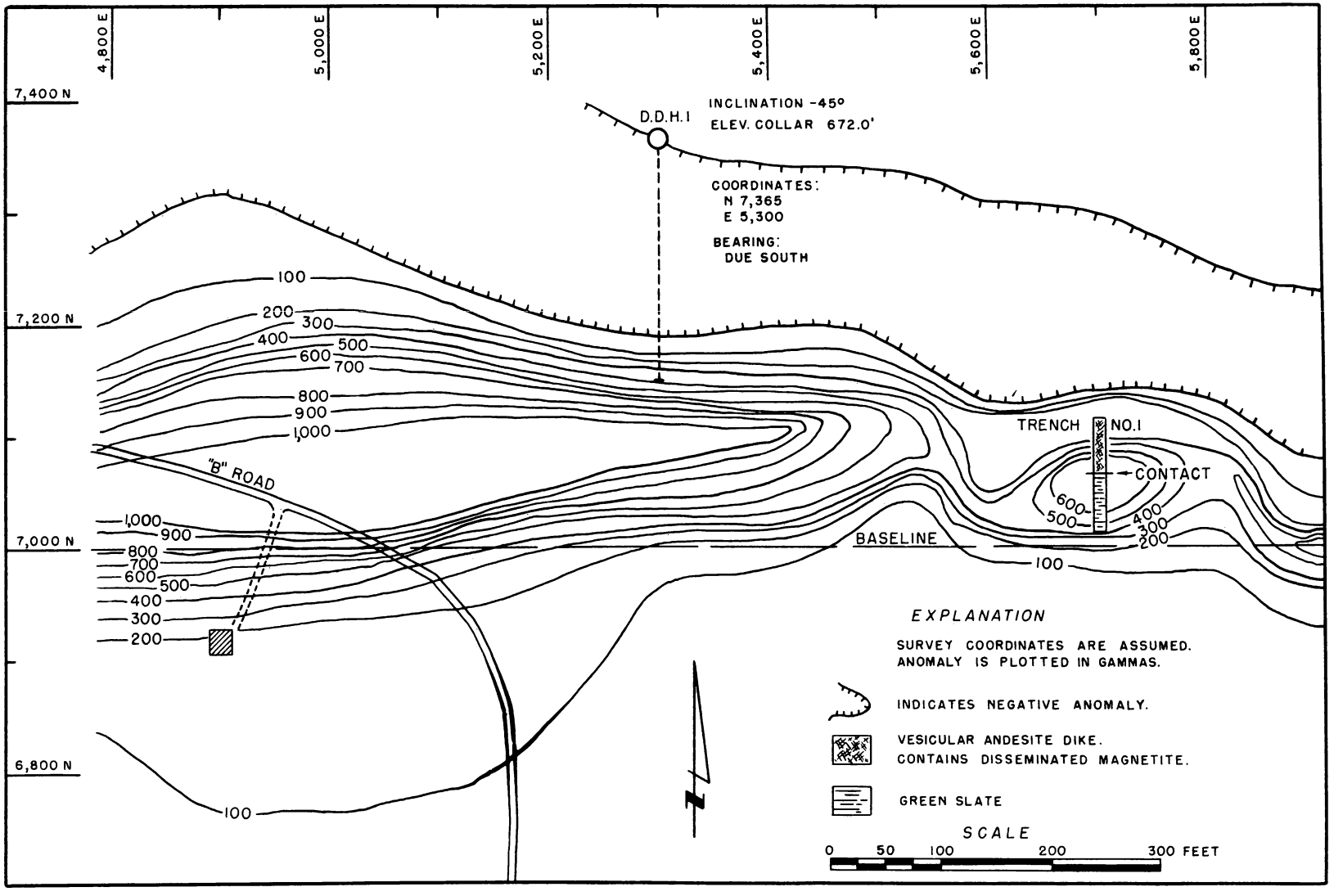



Figure 10. - Part of Burnham anomaly, showing location of trench 1 and diamond-drill hole 1.

readings were taken at 500 stations, measured at intervals ranging from 25 to 200 feet on the grid within the boundaries of the farm. Two anomalies were mapped (see fig. 11). The east-west anomaly is 1,000 feet in length, and the north-south deposit has been mapped by an anomaly for 1,800 feet. The necessity for a magnetometer survey to outline the trend of deposits under overburden is illustrated by comparing the map showing the relatively few manganiferous-rock outcrops (fig. 2) with the anomalies shown in figure 11.

### Diamond Drilling, Trenching, and Sampling the Nickerson-Farm Prospect

The east-west anomaly, the first to be mapped, was sampled by two diamond-drill holes. Nickerson drill hole 1, inclined 45° from the northeast side of the anomaly, was discontinued at 129 feet when it was found that the hole was being drilled from the footwall side of the deposit. The drill was then moved to the site of Nickerson hole 2 (see fig. 11), inclined 45° in the opposite direction (NE.). After passing through 10.8 feet of overburden, hole 2 entered gray-blue slate, which contains scattered thin laminae of impure (siliceous) manganese carbonate from 27 to 75 feet (See fig. 12). The main body of the deposit, intersected at 75 to 144.5 feet, averaged 9.27 percent Mn and 17.63 percent Fe. The footwall of the deposit is interbedded green and gray slate, with interbeds of manganiferous rock and scattered thin laminae of impure siliceous material containing manganiferous carbonate. Drilling was stopped at a depth of 233 feet in gray slate. The ore zone in hole 2, strongly contorted by folding, is 65 feet true width and dips about 65° SW.

A total of 261.2 feet of core in holes 1 and 2 was split and divided into 37 samples for assaying, as listed in table 3.

A small outcrop of gray-black shaly, laminated, manganiferous chloritic rock, discovered while transit surveying the north traverse line from base-line station 4,000 N., 1,900 feet south of drill hole 2, was later found to be near the center of the north-south anomaly. A trench was cut 30 feet in length, and 3 channel samples, each 10 feet in length, were chipped across the bedding. The average assay of these samples, as shown in table 6, is 9.27 percent Mn and 17.60 percent Fe. The local strike of foliation in the shale is northeast, and the dip 85° NW.

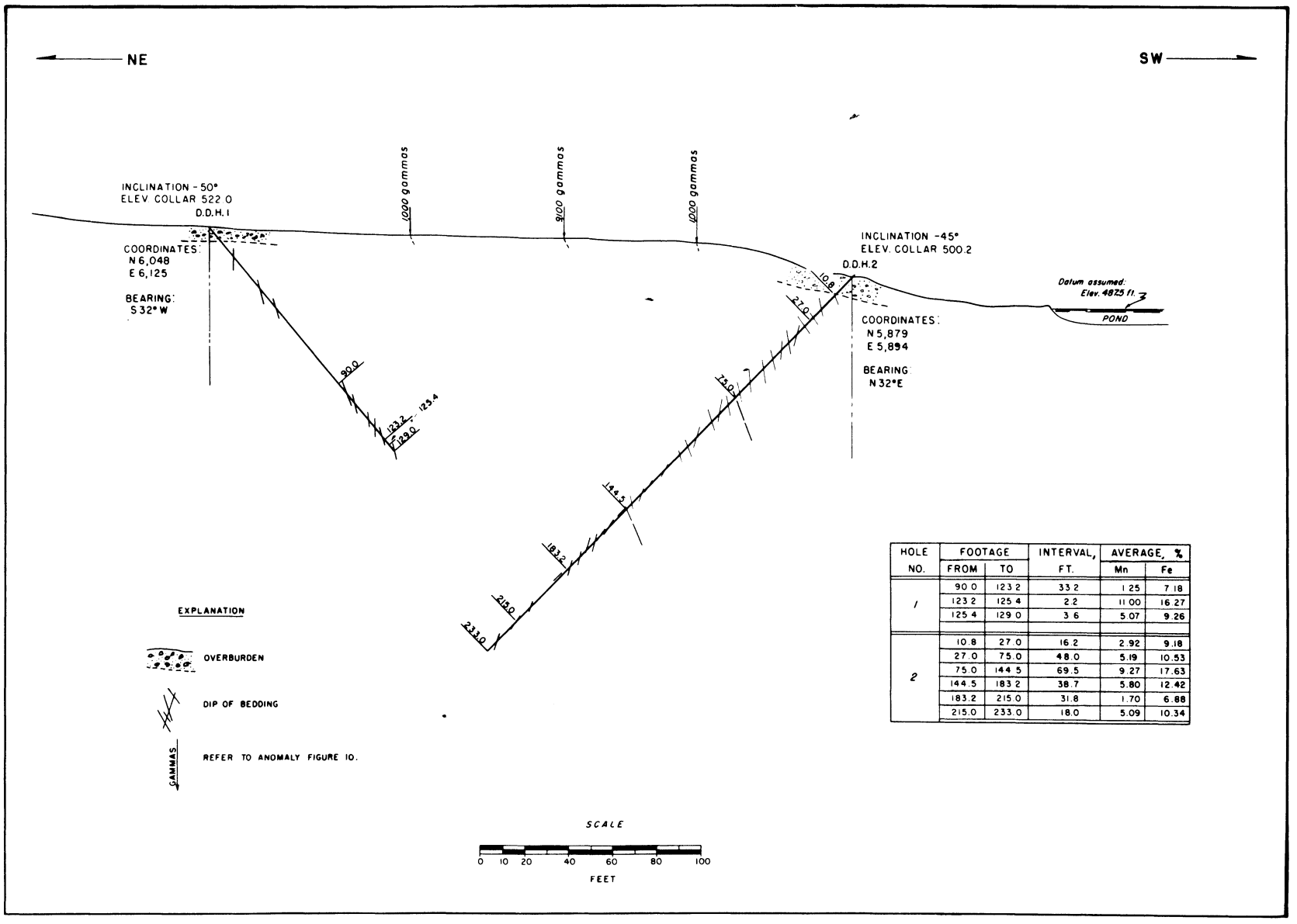
The coincidence of average assays obtained in the relatively high magnetite-bearing ore zone of drill hole 2 and the nonmagnetic material of the north-south deposit indicates that the two deposits are segments of the same manganiferous bed. Diamond drilling is necessary in both segments of the deposit to permit further sampling for metallurgical research.

## CHEMICAL AND METALLURGICAL INVESTIGATIONS

### Determination of Magnetic Fractions in Drill Core and Trench Samples

Core and trench samples, ground to pass 65 mesh were subjected to Davis-tube magnetic separation. The quantity percentage of magnetite recovered, as shown in tables 1 to 4, is only relative to the particle size of the grind. Fine grains of magnetite are not completely unlocked from other mineral constituents.


Figure 11. - Plan of Nickerson-Farm anomalies, including holes 1 and 2 and trench 1.




| HOLE NO. | FOOTAGE FROM | FOOTAGE TO | INTERVAL, FT. | AVERAGE, % Mn | AVERAGE, % Fe |
|---|---|---|---|---|---|
| 1 | 90.0 | 123.2 | 33.2 | 1.25 | 7.18 |
| | 123.2 | 125.4 | 2.2 | 11.00 | 16.27 |
| | 125.4 | 129.0 | 3.6 | 5.07 | 9.26 |
| 2 | 10.8 | 27.0 | 16.2 | 2.92 | 9.18 |
| | 27.0 | 75.0 | 48.0 | 5.19 | 10.53 |
| | 75.0 | 144.5 | 69.5 | 9.27 | 17.63 |
| | 144.5 | 183.2 | 38.7 | 5.80 | 12.42 |
| | 183.2 | 215.0 | 31.8 | 1.70 | 6.88 |
| | 215.0 | 233.0 | 18.0 | 5.09 | 10.34 |

Figure 12. - Vertical sections through diamond-drill holes 1 and 2, Nickerson-Farm prospects.

TABLE 3. - Analyses of diamond-drill cores, Nickerson-Farm prospect

(Minus-65-mesh screen Davis-tube magnetic separation)

Diamond-drill hole 1, east-west anomaly

| Footage From- | Footage To- | Sample interval, feet | Core assay, percent Mn | Core assay, percent Fe | Magnetic fraction Weight, percent |
|---|---|---|---|---|---|
| 90.0 | 100.0 | 10.0 | 1.34 | 7.10 | - |
| 100.0 | 110.0 | 10.0 | .90 | 7.02 | - |
| 110.0 | 120.0 | 10.0 | 1.02 | 7.66 | - |
| 120.0 | 123.2 | 3.2 | 2.75 | 6.39 | - |
| Total ..... | | 33.2 | 1.25 | 7.18 | - |
| 123.2 | 125.4 | 2.2 | 11.00 | 16.27 | - |
| 125.4 | 129.0 | 3.6 | 5.07 | 9.26 | - |
| Total ..... | | 39.0 | - | - | Core recovery, 93.1 percent |

Diamond-drill hole 2, east-west anomaly

| | | | | | |
|---|---|---|---|---|---|
| 10.8 | 13.0 | 2.2 | 6.17 | 9.58 | - |
| 13.0 | 20.5 | 7.5 | 1.96 | 9.10 | - |
| 20.5 | 25.0 | 4.5 | 1.97 | 8.38 | - |
| 25.0 | 27.0 | 2.0 | 5.07 | 10.86 | - |
| Total ..... | | 16.2 | 2.92 | 9.18 | - |
| 27.0 | 33.0 | 6.0 | 4.36 | 10.84 | - |
| 33.0 | 43.0 | 10.0 | 5.44 | 9.87 | - |
| 43.0 | 53.0 | 10.0 | 5.36 | 9.71 | - |
| 53.0 | 63.0 | 10.0 | 7.36 | 11.49 | - |
| 63.0 | 70.0 | 7.0 | 2.52 | 9.87 | - |
| 70.0 | 75.0 | 5.0 | 4.79 | 12.13 | - |
| Total ..... | | 48.0 | 5.19 | 10.53 | - |
| 75.0 | 80.0 | 5.0 | 7.06 | 21.98 | 10.42 |
| 80.0 | 90.0 | 10.0 | 10.60 | 16.48 | 15.03 |
| 90.0 | 100.0 | 10.0 | 10.39 | 17.87 | 23.72 |
| 100.0 | 110.0 | 10.0 | 6.25 | 16.00 | 14.63 |
| 110.0 | 120.0 | 10.0 | 9.26 | 16.85 | 23.67 |
| 120.0 | 130.0 | 10.0 | 9.14 | 18.22 | 7.67 |
| 130.0 | 140.0 | 10.0 | 10.43 | 17.09 | 22.17 |
| 140.0 | 144.5 | 4.5 | 10.68 | 20.11 | 33.17 |
| Total ..... | | 69.5 | 9.27 | 17.63 | 18.27 |
| 144.5 | 150.0 | 5.5 | 4.87 | 10.76 | 9.55 |
| 150.0 | 160.0 | 10.0 | 3.57 | 7.67 | .33 |
| 160.0 | 170.0 | 10.0 | 6.66 | 18.42 | - |
| 170.0 | 180.0 | 10.0 | 8.28 | 11.87 | - |
| 180.0 | 183.2 | 3.2 | 4.02 | 13.08 | - |
| Total ..... | | 38.7 | 5.80 | 12.42 | - |
| 183.2 | 190.0 | 6.8 | 2.83 | 7.02 | - |
| 190.0 | 200.0 | 10.0 | 1.77 | 7.18 | - |
| 200.0 | 210.0 | 10.0 | .94 | 6.39 | - |
| 210.0 | 213.5 | 3.5 | 1.22 | 7.26 | - |
| 213.5 | 215.0 | 1.5 | 2.40 | 6.71 | - |
| Total ..... | | 31.8 | 1.70 | 6.88 | - |
| 215.0 | 220.0 | 5.0 | 6.25 | 12.29 | - |
| 220.0 | 225.0 | 5.0 | 4.17 | 9.10 | - |
| 225.0 | 233.0 | 8.0 | 4.95 | 9.90 | - |
| Total ..... | | 18.0 | 5.09 | 10.34 | - |
| Grand total. | | 222.2 | - | - | Core recovery, 94.1 percent |

TABLE 4. - Analyses of trench samples, Nickerson north-south deposit

(Minus-65-mesh screen, Davis-tube magnetic separation)

Trench 1
(Measured west to east)

| Footage | | Sample interval, feet | Core assay, percent | | Magnetic fraction |
|---|---|---|---|---|---|
| From- | To- | | Mn | Fe | Weight, percent |
| 0 | 10.0 | 10.0 | 11.04 | 18.73 | 0.05 |
| 10.0 | 20.0 | 10.0 | 8.65 | 17.54 | None |
| 20.0 | 30.0 | 10.0 | 8.12 | 16.53 | None |
| Total ..... | | 30.0 | 9.27 | 17.60 | - |

Composite Samples From Drill Cores and Trenches

After being assayed, some of the excess material from core samples and trench samples, listed in tables 1 to 4, was combined by adopting a uniform weight in grams per linear foot of core or trench involved. This was done to check the average calculated assays in the above tables and to permit assaying for other elements in the deposits. Assays of all composite samples of diamond-drill intersections and manganiferous material in trenches are listed in tables 5 and 6, respectively. The average calculated assays from tables 1 to 4 are shown also for comparison.

Upgrading Manganese by Magnetic Separation

Following Bureau of Mines instructions, a contract laboratory made two overall samples of Pierce deposits Nos. 1 and 2 by blending representative fractions from the composite-sample rejects listed in tables 5 and 6. The material had already been ground through 100-mesh for assaying.

Sample E-1072, Pierce deposit No. 1, was weighed at 3 grams per foot true width of ore zone intersected in the following diamond-drill holes and trenches:

| | Grams |
|---|---|
| Diamond-drill hole: | |
| No. 1 ..... | 45.0 |
| No. 3 ..... | 25.5 |
| Trench: | |
| No. 1 ..... | 58.5 |
| No. 2 ..... | 24.0 |
| No. 4 ..... | 49.5 |
| Total weight ..... | 202.5 |

Sample E-1073, Pierce deposit No. 2, was weighed at 4 grams per foot true width of ore zone intersected in the following diamond-drill holes:

| | Grams |
|---|---|
| Diamond-drill hole: | |
| No. 2 ..... | 192 |
| No. 5 ..... | 108 |
| No. 6 ..... | 44 |
| Total weight ..... | 344 |

TABLE 5. - Analyses of composite samples from diamond-drill cores

| Drill hole No. | Deposit | Footage From- | Footage To- | Interval, feet | (Assays, percent) Fus.[1] Mn | Total Fe | Total P | Fus.-Hf.[2] $SiO_2$ | Fus.[1] $Al_2O_3$ | S | CaO | MgO | Loss on ignition | Calculated assays from tables 1 and 3 Fus.[1] Mn | Total Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pierce No. 1 | 131.0 | 148.0 | 17.0 | 9.52 | 19.84 | 0.666 | 20.86 | 7.32 | 0.29 | 4.00 | 0.40 | 15.41 | 9.60 | 19.95 |
| 3 | Pierce No. 1 | 127.5 | 136.5 | 9.0 | 11.26 | 18.98 | .590 | 23.42 | 8.90 | .51 | 2.02 | .33 | 12.24 | 11.34 | 19.02 |
| 2 | Pierce No. 2 | 107.5 | 158.2 | 50.7 | 13.04 | 19.76 | .582 | 20.14 | 6.66 | .31 | 2.55 | .49 | 14.77 | 12.93 | 19.69 |
| 5 | Pierce No. 2 | 75.6 | 104.8 | 29.2 | 10.44 | 20.76 | .633 | 19.90 | 7.18 | .92 | 1.95 | .13 | 15.44 | 10.59 | 20.77 |
| 6 | Pierce No. 2 | 74.6 | 86.0 | 11.4 | 12.41 | 20.69 | .696 | 15.92 | 5.54 | .68 | 2.64 | .28 | 19.46 | 12.55 | 20.60 |
| 4 | Pierce No. 3 | 43.0 | 55.5 | 12.5 | 12.27 | 21.11 | .696 | 17.93 | 6.92 | .50 | 3.31 | .53 | 15.15 | 12.38 | 21.24 |
| 2 | Nickerson | 75.0 | 144.5 | 69.5 | 9.19 | 17.74 | .621 | 27.98 | 9.81 | .42 | 3.27 | .58 | 11.30 | 9.27 | 17.63 |

1/ Fusion method. 2/ Fusion and hydrofluoric method.

TABLE 6. - Analyses of composite samples from trenches

| Trench No. | Deposit | Footage From- | Footage To- | Interval, feet | (Assays, percent) Fus.[1] Mn | Total Fe | Total P | Fus.-Hf.[2] $SiO_2$ | Fus.[1] $Al_2O_3$ | S | CaO | MgO | Loss on ignition | Calculated assays from tables 2 and 4 Fus.[1] Mn | Total Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pierce No. 1 | 0 | 21.3 | 21.3 | 12.16 | 22.68 | 0.678 | 20.48 | 6.90 | 0.48 | 1.74 | 0.28 | 11.65 | 12.11 | 22.55 |
| 2 | Pierce No. 1 | 0 | 8.0 | 8.0 | 9.44 | 36.52 | 1.273 | 9.87 | 1.98 | .13 | 3.23 | .77 | 10.64 | 9.34 | 36.68 |
| 4 | Pierce No. 1 | 0 | 16.9 | 16.9 | 13.71 | 24.29 | .798 | 19.43 | 6.62 | .22 | 1.28 | .22 | 9.85 | 13.67 | 24.12 |
| 1 | Nickerson | 0 | 30.0 | 30.0 | 9.06 | 17.82 | .462 | 33.80 | 11.57 | .04 | 1.23 | .21 | 7.33 | 9.27 | 17.60 |

1/ Fusion method. 2/ Fusion and hydrofluoric method.

The two composite samples were subjected to selective magnetic separation in the Dings-Davis tube. Selectivity was accomplished by varying the magnetic intensity with a bank of lamps and a rheostat in the direct-current circuit. With this arrangement, the first magnetic concentrate was removed with a low magnetic flux, and a high-grade, clean separation was obtained. The tailing from the first separation was then passed through the tube and treated with the highest magnetic flux, which concentrated the weaker magnetic particles into a middling. The tailing from the second separation composed the nonmagnetic fraction.

By controlling the pull of the electromagnet, the weak magnetic material can be drawn off separately. After being assayed, the middling can be added to the concentrate if rich enough or, if too lean, can be rejected with the tailing.

The head samples and the corresponding three fractions resulting from magnetic separation were assayed; the results are shown in table 7. Before being assayed the nonmagnetic fraction containing most of the manganese was reduced by roasting to drive off all volatile matter.

TABLE 7. - Results of Dings-Davis tube tests for removing natural magnetite, percent

| Sample | Material | Mn | Fe | P | $SiO_2$ | $Al_2O_3$ |
|---|---|---|---|---|---|---|
| E-1072 | Composite head sample | 11.36 | 28.39 | 0.768 | 19.23 | 6.43 |
| A | Magnetic portion | 5.32 | 51.17 | .501 | 6.54 | 1.73 |
| B | Middling | 3.48 | 45.41 | .390 | 8.40 | 1.88 |
| C[1/] | Nonmagnetic portion | 15.64 | 17.88 | .972 | 26.06 | 9.45 |
| E-1073 | Composite head sample | 11.92 | 20.17 | .609 | 19.39 | 6.56 |
| A | Magnetic portion | 4.92 | 49.79 | .429 | 8.43 | 1.86 |
| B | Middling | 4.60 | 32.60 | .420 | 14.54 | 2.72 |
| C[1/] | Nonmagnetic portion | 15.92 | 19.46 | .788 | 26.30 | 8.62 |

| Sample | Material | S | CaO | MgO | Loss on ignition | Weight |
|---|---|---|---|---|---|---|
| E-1072 | Composite head sample | 0.346 | 2.38 | 0.31 | 12.35 | - |
| A | Magnetic portion | .085 | 1.61 | .67 | - | 19.7 |
| B | Middling | .130 | 1.77 | .80 | - | 5.2 |
| C[1/] | Nonmagnetic portion | .350 | 2.97 | .15 | 14.22 | 75.1 |
| E-1073 | Composite head sample | .555 | 2.47 | .34 | 15.89 | - |
| A | Magnetic portion | .210 | 1.37 | .96 | - | 11.9 |
| B | Middling | .280 | 2.21 | 1.08 | - | 3.8 |
| C[1/] | Nonmagnetic portion | .190 | 2.70 | .25 | 18.28 | 84.3 |

1/ Assayed after reduction roast.

Results of screen tests to determine the fineness of grinding three products from each of the samples listed in table 7 are shown in table 8.

Further tests were made in the laboratory of the Eastern Experiment Station of rejects (excess material after assaying, forwarded to the Bureau by contract laboratory) of samples E-1072-C and E-1073-C, listed in table 7. It was of interest to learn if manganese could be upgraded further by separating the synthetic magnetite produced by the reduction roast. As the rejects had been disturbed in making screen tests and some of the fine material had probably been lost in handling, each sample of manganese was check-assayed; the rejects were found to have been slightly upgraded in manganese to 16.0 and 16.2 percent, respectively. Subjected to Davis-tube magnetic separation, the two fractions produced from these samples (see table 9) showed no appreciable difference in concentration of manganese.

TABLE 8. - Screen tests on fractions resulting from Dings-Davis-tube magnetic separation of samples E-1072 and E-1073

| Mesh | Fractions | | | | | |
|---|---|---|---|---|---|---|
| | Magnetic, A | | Middling, B | | Nonmagnetic, C | |
| | Grams | Percent | Grams | Percent | Grams | Percent |
| | Sample E-1072 | | | | | |
| +100 | - | - | - | - | 2.50 | 5.5 |
| -100+150 | - | - | - | - | 3.10 | 6.8 |
| -150+200 | - | - | - | - | 2.05 | 4.5 |
| -200+270 | 1.75 | 13.9 | 0.15 | 9.3 | 3.75 | 8.3 |
| -270+325 | 2.10 | 16.7 | .50 | 21.1 | 6.60 | 14.5 |
| -325 | 8.75 | 69.4 | .96 | 59.6 | 27.40 | 60.4 |
| Total | - | 100.0 | - | 100.0 | - | 100.0 |
| | Sample E-1073 | | | | | |
| +100 | - | - | - | - | 4.30 | 8.3 |
| -100+150 | - | - | - | - | 4.40 | 8.5 |
| -150+200 | - | - | - | - | 3.80 | 7.3 |
| -200+270 | - | - | 0.10 | 3.6 | 5.15 | 9.9 |
| -270+325 | 0.45 | 8.6 | .09 | 32.1 | 4.70 | 9.1 |
| -325 | 4.75 | 91.4 | .18 | 64.3 | 29.45 | 56.9 |
| Total | - | 100.0 | - | 100.0 | - | 100.0 |

TABLE 9. - Removal of synthetic magnetite after roasting

| Description of sample | Mn | Fe | P | $SiO_2$ | Percent of total weight |
|---|---|---|---|---|---|
| | Percent | | | | |
| | Sample E-1072-C | | | | |
| Magnetic portion | 16.5 | 21.0 | 1.11 | 25.6 | 57 |
| Nonmagnetic portion | 15.9 | 13.9 | .85 | 35.1 | 43 |
| | Sample E-1073-C | | | | |
| Magnetic portion | 16.2 | 21.0 | .77 | 26.5 | 65 |
| Nonmagnetic portion | 16.7 | 15.9 | .76 | 32.9 | 35 |

Flotation Tests, Nickerson-Farm Prospect

The diamond-drill core of hole 2, Nickerson-Farm prospect, contains white to buff laminae and layers up to half an inch in thickness in the hanging- and foot-wall slates of the deposit. Particles of this material, when subjected to petrographic examination, indicated the presence of manganese carbonate - assumed to be rhodochrosite. A specimen, consisting of a layer half an inch in thickness, in the foot-wall slate was gouged from drill core at a depth of 231.5 feet. Its complex composition yielded assays as follows:

| | Percent |
|---|---|
| Mn | 20.30 |
| Fe | 5.27 |
| P | .12 |
| $SiO_2$ | 26.44 |
| $Al_2O_3$ | 5.13 |
| CaO | 2.88 |
| MgO | .21 |
| $Na_2O$ | 2.01 |
| $K_2O$ | .51 |

The material was not tested for other elements.

Flotation tests were tried on a composite section of slate core, averaging about 5 percent Mn from 27.0 feet in hole 2 (see table 10). The first test was made on a sample ground to pass 65-mesh, but loss of slime was high. To overcome this, subsequent samples were ground to minus-48-mesh. A total of 10 tests was tried, using various combinations of collectors and other flotation reagents. Assays of the rougher concentrates in the tests ranged from 13.3 to 17.6 percent Mn. Test 8 is typical of the results obtained. In this test the equivalent of 0.5 pound sulphuric acid per ton was used to adjust the pH of the pulp, and 0.6 pound oleic acid per ton as a collector.

TABLE 10. - Flotation test 8

| Product | Weight, percent | Analyses, percent | | | | Distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | Mn | Fe | P | $SiO_2$ | Mn | Fe | P |
| Rougher concentrates ..... | 12.8 | 13.8 | 14.8 | 0.42 | 21.5 | 31.6 | 18.0 | 27.8 |
| Rougher tailing ..... | 87.2 | 4.39 | 9.89 | .16 | - | 68.4 | 82.0 | 72.2 |
| Composite ..... | 100.0 | 5.6 | 10.5 | .19 | - | 100.0 | 100.0 | 100.0 |

Although it was found possible to concentrate some of the material composing the laminae and thin layers in the slate, no indication was given that a pure manganese mineral could be recovered by ore-dressing methods alone.

## Leaching Tests[8/]

Representative samples of ore were cut from the crushed and blended drill cores obtained from the Pierce deposits and the Nickerson Farm in southern Aroostook County. Samples were also cut from consolidated trench samples on the Nickerson Farm.

After the samples were ground to minus-65-mesh and thoroughly blended, they were analyzed for manganese and iron content. The manganese content ranged between 9 and 13 percent, and the iron content between 17 and 24 percent. These data are summarized in table 11.

TABLE 11. - Partial analysis of southern Aroostook County manganese-ore samples

| Designation | Ore body | Analyses, percent | |
|---|---|---|---|
| | | Mn | Fe |
| A-28 ..... | Pierce hole 1 ..... | 11.84 | 23.85 |
| A-29 ..... | Pierce hole 2 ..... | 12.33 | 20.80 |
| A-30 ..... | Composite of Nickerson hole 2 and trench 1 ..... | 9.06 | 17.73 |
| A-31 ..... | Composite of samples from Nickerson trench 1 ..... | 9.13 | 17.64 |

A number of sulfuric acid leaching tests were performed on the various samples to determine: (1) Whether differences existed in leachability, (2) the optimum time and temperature required for the best extraction of manganese, and (3) whether manganese could be extracted selectively. Results indicated that most of the manganese was extracted from all samples at 60° C., except A-31, which was a surface sample

8/ Section written by R. T. MacMillan, former chemist, Minerals Processing Branch, Bureau of Mines, Region VIII.

with manganese in a higher state of oxidation. This sample yielded manganese readily, however, when a small amount of reducing agent, such as ferrous iron or sulfur dioxide was added to the slurry. Although higher percentages of manganese than iron were extracted, sulfuric acid leaching was not particularly selective. Results of the tests are shown in table 12.

Both hydrochloric and nitric acids were slightly more effective than sulfuric in extracting manganese from the samples. A reducing agent was required with sample A-31. One test with 1 part 20-percent HCl solution for each part of ore by weight produced a clarified liquor with a concentration of manganese high enough to deposit hydrated ($MnCl_2$) manganese chloride crystals on cooling. The results are shown in tables 13 and 14.

TABLE 12. - Results of dilute $H_2SO_4$ leaching tests[1/] on samples of ore[2/] from Pierce and Nickerson-Farm-prospect deposits

| Ore | | Time, | Temperature, | Recovery in leach solution | | | |
|---|---|---|---|---|---|---|---|
| | | | | Mn | | Fe | |
| Designation | Grams | hours | °C. | Grams | Percent | Grams | Percent |
| A-30 ..... | 9.25 | 0.5 | 25 | 0.376 | 44.80 | 0.123 | 7.47 |
| A-30 ..... | 9.26 | 1.0 | | .465 | 55.48 | .162 | 9.86 |
| A-30 ..... | 9.25 | 3.0 | | .572 | 68.22 | .240 | 14.64 |
| A-30 ..... | 9.26 | 7.0 | | .663 | 79.01 | .333 | 20.29 |
| A-31 ..... | 10.87 | .5 | | .027 | 2.74 | .038 | 1.98 |
| A-31 ..... | 10.87 | 1.0 | | .032 | 3.25 | .047 | 2.46 |
| A-31 ..... | 10.88 | 3.3 | | .040 | 4.01 | .073 | 3.78 |
| A-31 ..... | 10.88 | 7.0 | | .054 | 5.40 | .113 | 5.91 |
| A-31[3/] ..... | 10.88 | 3.0 | | .901 | 90.68 | - | - |
| A-31[3/] ..... | 10.88 | 7.0 | | .927 | 93.33 | - | - |
| A-28 ..... | 8.39 | .5 | 60 | .751 | 75.58 | .422 | 21.11 |
| A-28 ..... | 8.38 | 1.0 | | .830 | 83.60 | .506 | 25.31 |
| A-28 ..... | 8.38 | 3.0 | | .905 | 91.17 | .596 | 29.83 |
| A-28 ..... | 8.39 | 7.0 | | .915 | 92.13 | .639 | 31.96 |
| A-29 ..... | 8.05 | 1.0 | | .871 | 87.73 | .650 | 38.80 |
| A-29 ..... | 8.05 | 3.0 | | .894 | 90.07 | .717 | 42.83 |
| A-29 ..... | 8.05 | 7.0 | | .903 | 90.94 | .721 | 43.05 |
| A-30 ..... | 10.95 | .5 | | .733 | 73.90 | .350 | 18.01 |
| A-30 ..... | 10.96 | 1.0 | | .790 | 79.57 | .417 | 21.49 |
| A-30 ..... | 10.95 | 3.1 | | .860 | 86.65 | .518 | 26.69 |
| A-30 ..... | 10.95 | 7.1 | | .903 | 91.03 | .573 | 29.49 |
| A-31[3/] ..... | 10.87 | 7.0 | | .946 | 95.32 | - | - |
| A-31[4/] ..... | 10.88 | 3.0 | | .665 | 66.94 | - | - |
| A-31[4/] ..... | 10.88 | 7.0 | | .687 | 69.21 | - | - |
| A-31[5/] ..... | 10.88 | 3.0 | | .491 | 49.48 | - | - |
| A-31[5/] ..... | 10.88 | 7.0 | | .491 | 49.48 | - | - |

1/ Leaching solution consisted of 60 ml. of 1.506 N $H_2SO_4$; mole ratio acid/Mn = 2.5.

2/ Ore ground to minus-65-mesh.

3/ Approximately 10 grams $FeSO_4.7H_2O$ added to slurry - amount theoretically required to reduce $Mn^{IV}$ to $Mn^{II}$.

4/ Same as footnote 3, except amount of $FeSO_4.7H_2O$ reduced by half.

5/ 24 ml. $H_2SO_3$ (6 percent) added to slurry. Amount of $H_2SO_4$ available reduced so that mole ratio of total S/Mn = 2.5.

TABLE 13. - Results of dilute $HNO_3$ leaching tests on samples of ore from Pierce deposit DDH-2 and Nickerson-Farm prospect trench 1

| Ore[1] designation | Grams | Time, hours | Temperature, °C. | Recovery in leach solution | | | |
|---|---|---|---|---|---|---|---|
| | | | | Mn | | Fe | |
| | | | | Grams | Percent | Grams | Percent |
| A-29[2] ..... | 8.054 | 0.5 | 60 | 0.8725 | 87.86 | 0.5907 | 35.27 |
| A-29[2] ..... | 8.054 | 1.0 | | .9108 | 91.71 | .6603 | 39.42 |
| A-29[2] ..... | 8.054 | 2.0 | | .9273 | 93.37 | .6913 | 41.27 |
| A-29[2] ..... | 8.054 | 3.0 | | .9389 | 94.54 | .7214 | 43.07 |
| A-31[2] ..... | 10.867 | .5 | | .0613 | 6.18 | .1026 | 5.35 |
| A-31[2] ..... | 10.867 | 1.0 | | .0745 | 7.51 | .1370 | 7.15 |
| A-31[2] ..... | 10.867 | 2.0 | | .0867 | 8.74 | .1648 | 8.60 |
| A-31[2] ..... | 10.867 | 3.0 | | .0927 | 9.34 | .1880 | 9.81 |
| A-31[3] ..... | 10.867 | 3.0 | | .9755 | 98.32 | 1.705 | 88.94 |
| A-31[4] ..... | 10.867 | 3.0 | | .9519 | 95.94 | 1.380 | 71.99 |

1/ Ore ground to minus-65-mesh.
2/ 1.5 N $HNO_3$ used in Mn/acid mole ratio = 5.
3/ Sample reduced in $H_2$, 3 hours at 675° C.; 1.5 N $H_2SO_4$ used in mole ratio Mn/acid = 2.5.
4/ Sample reduced in $H_2$, 3 hours at 675° C.; 1.5 N $HNO_3$ used in mole ratio Mn/acid = 5.

TABLE 14. - Results of dilute HCl leaching tests on samples of ore from Pierce deposit DDH-1 and Nickerson-Farm prospect trench 1

| Ore[1] designation | Grams | Time, hours | Temperature, °C. | Recovery in leach solution | | | |
|---|---|---|---|---|---|---|---|
| | | | | Mn | | Fe | |
| | | | | Grams | Percent | Grams | Percent |
| A-31[2] ..... | 10.87 | 0.5 | 27 ± 2 | 0.0388 | 3.91 | 0.0504 | 2.63 |
| A-31[2] ..... | 10.87 | 1.0 | | .0464 | 4.67 | .0695 | 3.63 |
| A-31[2] ..... | 10.87 | 2.0 | | .0579 | 5.83 | .0983 | 5.13 |
| A-31[2] ..... | 10.87 | 3.0 | | .0731 | 7.37 | .1164 | 6.07 |
| A-31[3] ..... | 10.87 | 3.1 | 60 | .9398 | 94.69 | .2521 | 13.14 |
| A-31[3] ..... | 10.87 | 3.2 | | .9175 | 92.44 | .2529 | 13.19 |
| A-28[4] ..... | 8.39 | .53 | | .8629 | 86.92 | .5047 | 25.24 |
| A-28[4] ..... | 8.39 | 1.05 | | .9127 | 91.93 | .5540 | 27.70 |
| A-28[4] ..... | 8.39 | 2.0 | | .9318 | 93.86 | .5932 | 29.66 |
| A-28[4] ..... | 8.39 | 3.0 | | .9356 | 94.24 | .5999 | 30.00 |

1/ Ore ground to minus-65-mesh.
2/ Acid used, 60 ml. of 1.5 N HCl; mole ratio HCl/Mn = 5.
3/ Acid used, 60 ml. of 1.5 N HCl, with 7.18 grams $FeCl_2.4H_2O$ (27.6 percent Fe) added. Mole ratio HCl/Mn = 5.
4/ Acid used, 1.5 N $HNO_3$; mole ratio Mn = 5.

The ease with which manganese was extracted from these ores encouraged the belief that it might be present largely as an oxide instead of in the more complex silicate forms, which are found in other parts of Aroostook County. If this were so, the manganese could be extracted by ammonia-ammonium carbonate solution, provided the manganese was first reduced to its divalent form.

A test was made using ammonia-ammonium carbonate solution on ore reduced at 600° C. in a hydrogen atmosphere. Approximately 85 percent of the manganese and 14 percent of the iron were extracted.

Ammonia-ammonium carbonate extraction has an advantage over other solvents in that the manganese is readily precipitated from solution as an easily filtered manganese carbonate product. This is accomplished by driving off some of the ammonia under the influence of heat; the ammonia, of course, is collected and returned to the process. Extracting manganiferous slag clinker by ammonia-ammonium carbonate solution has been successfully tested on pilot-plant scale.9/

A 10-percent solution of ($NH_4Cl$) ammonium chloride was also found to be an excellent solvent for the manganese in these samples after the manganese was reduced to the divalent state. For the leaching reaction to proceed, the ammonia produced by the reaction must be removed by a jet of steam. After cooling and condensing, the resulting ammonia solution is available for selective precipitation of the manganese and iron hydroxides from the clarified extract liquor. Thus, reagent costs in such a process would be whatever is necessary to replenish losses. High-purity iron and manganese products would result by controlling the pH during the precipitation step. Eighty- to eighty-six-percent recoveries of manganese were obtained.

TABLE 15. - Diamond-drill-hole logs1/

Pierce DDH-1

| Interval, feet | Description |
|---|---|
| 0-13 ..... | Overburden. |
| 13-96 ..... | Dark-green, chloritic slate with laminae of very dark green chloritic slate. Quartz veins at 24.7, 28-28.5, and 30.5 feet. |
| 96-128 ..... | Dark gray-green slate, with calcareous laminae. |
| 128-131 ..... | Dark-gray, laminated slate. Massive sulfide zone, 1-1/2 inches in thickness, at 130 feet. |
| 131-148 ..... | Finely laminated and banded rock containing lightly colored red, hematitic laminae, as well as pods or beads, possibly of carbonate composition. At 133 and 134.5 feet: Quartz-feldspar veinlets containing a yellow-green mineral that suggests one of ganophyllite or bementite series. Pyrite also present. |
| 148-185 ..... | Dark-gray-green slate, with some calcaerous laminae. Pyrite abundant throughout this interval. Bottom of hole at 185 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 22.5 feet | 47° | 105 feet | 62° |
| 39 feet | 69° | 110 feet | 74° |
| 45 feet | 69° | 115 feet | 74° |
| 50 feet | 59° | 120 feet | 67° |
| 55 feet | 54° | 131 feet | 76° |
| 60 feet | 66° | 135 feet | 80° |
| 65 feet | 65° | 140 feet | 72° |
| 70 feet | 63° | 150 feet | 73° |
| 76 feet | 60° | 160 feet | 65° |
| 80 feet | 62° | 170 feet | 65° |
| 85 feet | 53° | 180 feet | 62° |
| 90 feet | 57° | 185 feet | 65° |
| 100 feet | 71° | | |

1/ See footnote at end of table.

9/ Heindl, R. August, Ruppert, J. A., Skow, M. L., and Conley, J. E., Manganese From Steel-Plant Slags by Lime-Clinkering and Carbonate-Leaching Process. Part I. Laboratory Development: Bureau of Mines Rept. of Investigations 5124, 1955, 98 pp.

TABLE 15. - Diamond-drill-hole logs[1/] (Con.)

Pierce DDH-2

| Interval, feet | Description |
|---|---|
| 0-8 ..... | Overburden. |
| 8-58 ..... | Gray-blue slate, with light-gray calcareous slate. |
| 58-64.5 ..... | Green, laminated and banded, manganiferous chlorite-carbonate rock.<br>Pyrrhotite abundant; appears to be disseminated along bedding as well as replacing beds. Rocks containing this sulfide are extremely magnetic at 63.5-64.5 feet.<br>The chlorite-carbonate rock is cut by quart-feldspar-chlorite veinlets at 59, 62.5 and 63 feet.<br>Red hematite pods and blebs (1/4 inch) at 58 feet. |
| 64.5-107.5 ..... | Gray slate with calcareous laminae; in places contains zones resembling stretched limestone pebbles at 68-70, 89-92, and 97-99 feet.<br>Highly calcareous (possibly microfossiliferous) zone between 71-73.5 feet. |
| 107.5-158.2 ..... | Dark-green to black to red, laminated and banded, manganiferous chlorite-carbonate rock, as previously described. Finely crystalline magnetite below 118 feet imparts strong magnetic property to this rock.<br>Small blebs and pods (1/8 to 1/4 inch) of light-color material occur elongate in plane of bedding.<br>Hematitic laminae, imparting a reddish color to rock, are present in many places at 137-140.5 feet.<br>Sulfide abundant, occurring both as distinct, distorted cubes (metacrysts) and along thin laminae at 137-140.5 and 157 feet.<br>Laminated green-slate interbed at 155-156 feet.<br>Quartz-feldspar veins at 109, 135.5, and 137-140.5 feet. |
| 158.2-184 ..... | Finely laminated and banded, dark-green and light-green slate. Very fine grained pyrite abundant, especially in dark-green slate.<br>Chlorite-carbonate rock interbed between 167.5-168 feet.<br>Bottom of hole at 184 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 10 feet | 52° | 120 feet | 82° |
| 15 feet | 60° | 125 feet | 65° |
| 36 feet | 45° | 130 feet | 77° |
| 40 feet | 62° | 135 feet | 90° |
| 55 feet | 43° | 140 feet | 75° |
| 60 feet | 51° | 145 feet | 90° |
| 65 feet | 65° | 150 feet | 85° |
| 74 feet | 62° | 155 feet | 85° |
| 83 feet | 50° | 160 feet | 90° |
| 95 feet | 58° | 165 feet | 85° |
| 103 feet | 37° | 170 feet | 80° |
| 110 feet | 48° | 183 feet | 80° |
| 115 feet | 60° | | |

1/ See footnote at end of table.

TABLE 15 - Diamond-drill-hole logs[1/] (Con.)

Pierce DDH-3

| Interval, feet | Description |
|---|---|
| 0-28 ..... | Overburden. |
| 28-71 ..... | Dark-green, laminated slate containing sulfide at various places, for example, 32 feet.<br>Fault breccia or microboudinage at 32 feet.<br>Abundant limonite staining in badly broken core at 65-65.5, 67.5-68.5, and 69-70 feet; possible shear zones. |
| 71-109 ..... | Slaty, gray-blue siltstone, with a few thin, calcareous laminae. |
| 109-122.5 ..... | Finely laminated to massive gray-blue slate. Gray-white laminae are calcareous. Small fault at 116 feet. |
| 122.5-126.5 ..... | Gray, fine-grained quartzite. |
| 126.5-127.5 ..... | Dark-green, laminated slate. |
| 127.5-136.5 ..... | Manganiferous banded magnetite-chlorite rock and banded hematite rock. This interval is cut by abundant microfaults and gash veinlets. Limonitic layer at 128.5-129 feet probably represents altered carbonate-type ore. |
| 136.5-137 ..... | Light-green slate. |
| 137-144.5 ..... | Dark-green slate. |
| 144.5-145 ..... | Laminated green chloritic slate, with reddish-purple layers containing magnetite and hematite.<br>Large bleb of sulfide, 1 inch across, at 145 feet, surrounded by small leach cavities. |
| 145-172.5 ..... | Dark-green slate, with thin, gray, calcareous laminae.<br>Bottom of hole at 172.5 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 35 feet | 60° | 105 feet | 65° |
| 43 feet | 70° | 110 feet | 80° |
| 50 feet | 68° | 115 feet | 77° |
| 65 feet | 87° | 126 feet | 76° |
| 71 feet | 88° | 130 feet | 74° |
| 75 feet | 82° | 145 feet | 65° |
| 81 feet | 77° | 150 feet | 68° |
| 85 feet | 76° | 155 feet | 63° |
| 90 feet | 78° | 160 feet | 58° |
| 95 feet | 76° | 165 feet | 62° |
| 100 feet | 75° | 170 feet | 60° |

Pierce DDH-4

| Interval, feet | Description |
|---|---|
| 0-21 ..... | Overburden. |
| 21-34 ..... | Dark-green slate, with light-gray, calcareous laminae. |
| 34-35 ..... | Interbed of manganiferous laminated banded hematite (magnetic). |
| 35-43 ..... | Dark-gray, feldspathic, fine-grained rock; resembles a graywacke. Pyrite coating along joints is common. |
| 43-43.5 ..... | Manganiferous laminated rock, containing light-gray and red hematitic laminae. Rock is nonmagnetic. |
| 43.5-44.6 ..... | Brecciation in rock similar to core interval between 43 and 43.5 feet. |

1/ See footnote at end of table.

TABLE 15. - Diamond-drill-hole logs[1/] (Con.)

Pierce DDH-4 (Con.)

| Interval, feet | Description |
|---|---|
| 44.6-55.5 ..... | Manganiferous banded and laminated hematite rock varying from slightly magnetic to nonmagnetic in character, and banded magnetite-chlorite rock of a highly magnetic character; latter rock type is dominant between 53.5-54.5 feet. |
| 55.5-88.6 ..... | Dark-gray, massive graywacke similar to that between 35-43 feet. Bottom of hole at 88.6 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 23 feet | 80° | 45 feet | 45° |
| 30 feet | 75° | 50 feet | 90° |
| 34 feet | 60° | 55 feet | 85° |

Pierce DDH-5

| Interval, feet | Description |
|---|---|
| 0-9 ..... | Overburden. |
| 9-75.2 ..... | Gray-green silty slate, slightly calcareous. Between 36-66 feet the slate is well laminated; light-color laminae is calcareous. Thin lenses of pyrite at 67, 68, and 70 feet. |
| 75.2-90.2 ..... | Manganiferous, finely banded and laminated, variably magnetic rock consisting of hematitic laminae, shale laminae, light-color (presumably carbonate-bearing) laminae, and some green, chloritic laminae.<br>Rock is cut by abundant gash veinlets of feldspar and quartz containing a fibrous yellowish-green mineral, which may be of bementite-ganophyllite type. Pyrite is associated with or near these veinlets, as well as in laminae; also is finely disseminated without any apparent connection with veinlets.<br>At 86 feet some banded hematite rock display an intricate system of small normal faults, suggesting a preconsolidation feature generally developed in muds. |
| 90.2-104.7 ..... | Manganiferous, banded and laminated, dark-green, chloritic rock, resembling manganiferous siliceous, carbonate-type rocks contained in Littleton Ridge deposit. Lighter color laminae are presumably mostly impure carbonate (no effervescence with cold HCl), and some contain very finely divided hematite. This chloritic rock is more highly contorted and contains areas suggestive of microboudinage. Gash veining, also present in this sequence, is similar to that described in above unit. Sulfide also is present. Both are associated with quartz-feldspar veining and as thin veinlets of sulfide within manganiferous rocks. Quartz-feldspar veining at 102-102.5 , 103.5, and 104.7 feet. |
| 104.7-120 ..... | Laminated gray and green slate. Pyrite at 119.7 feet. |
| 120-160 ..... | Dark-gray to black slate, with some calcareous laminae, as well as a few green-slate interbeds. Pyrite occurs as massive laminae or is finely disseminated throughout rock or concentrated in small blebs. Calcite veins are also present throughout this lithology.<br>Bottom of hole at 160 feet. |

1/ See footnote at end of table.

TABLE 15. - Diamond-drill-hole logs[1/] (Con.)

Pierce DDH-5 (Con.)

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 15 feet | 69° | 100 feet | 90° |
| 20 feet | 75° | 105 feet | 75° |
| 37 feet | 70° | 110 feet | 70° |
| 45 feet | 75° | 115 feet | 75° |
| 50 feet | 81° | 120 feet | 82° |
| 55 feet | 83° | 125 feet | 85° |
| 60 feet | 82° | 130 feet | 83° |
| 65 feet | 80° | 135 feet | 82° |
| 73 feet | 85° | 140 feet | 77° |
| 76 feet | 71° | 145 feet | 79° |
| 82 feet | 65° | 150 feet | 82° |
| 86 feet | 75° | 155 feet | 68° |
| 90 feet | 70° | 160 feet | 74° |
| 95 feet | 73° | | |

Pierce DDH-6

| Interval, feet | Description |
|---|---|
| 0-16 ..... | Overburden. |
| 16-74.8 ..... | Gray silty slate, with a few light-gray laminae. |
| 74.8-78.0 ..... | Manganiferous banded chlorite-carbonate rock, consisting of siliceous carbonate laminae separated by black-shale partings. |
| 78-78.5 ..... | Dark-green slate. |
| 78.5-86 ..... | Manganiferous laminated and banded hematite rock; in places contains magnetite. Quartz-feldspar veins in a few places. |
| 86-104 ..... | Manganiferous laminated and banded gray-green, chlorite-carbonate layers and black slate. |
| 104-115 ..... | Dark-green chloritic slate, cut by a few gas veinlets of quartz-calcite. Pyrite abundant throughout this rock, both as irregular blebs and disseminated along bedding. |
| 115-155 ..... | Dark-green slate, with light-color, calcareous interbeds. Calcite veinlets at various places throughout this interval. Bottom of hole at 155 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 25 feet | 70° | 115 feet | 64° |
| 30 feet | 83° | 120 feet | 72° |
| 35 feet | 78° | 125 feet | 75° |
| 40 feet | 75° | 130 feet | 72° |
| 53 feet | 79° | 135 feet | 74° |
| 63 feet | 80° | 140 feet | 72° |
| 75 feet | 68° | 145 feet | 68° |
| 85 feet | 77° | 150 feet | 80° |
| 105 feet | 71° | 155 feet | 76° |
| 110 feet | 71° | | |

1/ See footnote at end of table.

TABLE 15. - Diamond-drill-hole logs[1/] (Con.)

Nickerson DDH-1

| Interval, feet | Description |
|---|---|
| 0-9.6 ..... | Overburden. |
| 9.6-129 ..... | Gray-green slate, with a few thin quartzite and calcareous laminae. Sparse manganese stains along fractures and cleavage between 9.6-15.5, 18-18.5, 20-21, and at 23.5, 26.5, 31.5, 34, 36.5, and 37.5 feet.<br>At 96 feet, thin, dark-green to black laminae; may be carbonaceous.<br>Pyrite (generally distorted cubes) at 60, 61, 75.5, 79.5, 85.5, 100, 101-104, 105, 108.5, and 120.5 feet.<br>Pyrite, associated with thin white laminae at 35, 40.5, 71.5, 77.7, 80, and 87-89.5 feet.<br>Finely laminated and banded manganiferous hematitic quartzite at 123.2-125.4 feet. Chlorite-carbonate rock and green slate between 125.4-129.0 feet.<br>Bottom of hole at 129 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 16 feet | 38° | 96 feet | 20° |
| 35 feet | 27° | 100 feet | 24° |
| 46 feet | 32° | 105 feet | 39° |
| 60 feet | 12° | 110 feet | 34° |
| 65 feet | 16° | 115 feet | 40° |
| 70 feet | 13° | 120 feet | 16° |
| 75 feet | 35° | 125 feet | 9° |
| 80 feet | 34° | 129 feet | 27° |
| 85 feet | 40° | | |

Nickerson DDH-2

| Interval, feet | Description |
|---|---|
| 0-10.8 ..... | Overburden. |
| 10.8-37.0 ..... | Gray-blue slate, with thin quartzite laminae. Bedding microcontorted in many places. Pyrite present along 1/4-inch laminae at 25 feet. |
| 37-75 ..... | Gray-blue slate, with thin quartzite laminae and manganiferous zones composed of chlorite-carbonate layers and reddish, hematitic laminae, with associated pyrite. Pyrite zones occur at 35, 36.5-37.5, 42.5-43, 44-44.5, 45.5-46, 52.5, 54-57, 60-61.5, 71.5-72, and 72.5-73.5 feet.<br>Possible shear zone at 50 feet, characterized by green, chloritic veinlets, with abundant sulfide.<br>Between 52-60 feet, abundant contortion and microfaults, quartz, and chlorite veins. |
| 75-144.5 ..... | Magnetic, finely laminated and banded, manganiferous, hematitic, magnetitie-chlorite rock; possibly contains carbonate. Pyrite present throughout this interval, in places forming 1/4- to 1/2-inch metacrysts. Bedding laminations pass through metacrysts and retain orientation of wall-rock layering at 175 feet. Sulfide also present as thin laminae as well as veinlets.<br>Quartz-chlorite-carbonate veinlets at 93-93.5, 96, 97, 121.5, 123-124, 125, 127, 129, 131.8, and 132.5 feet. |

1/ See footnote at end of table.

TABLE 15. - Diamond-drill-hole logs[1/] (Con.)

Nickerson DDH-2 (Con.)

| Interval, feet | Description |
|---|---|
| 75-144.5 (Con.) | Zone of white to pinkish pods 1 inch thick at 96.5 feet. Pods also at 90.5, 96, and 135.8 feet.<br>Green slate interbed at 107.5-110.5 feet.<br>Quartz veining at 99.5 and 102.5 feet.<br>Brecciation between 100.5-101 feet. |
| 144.5-183.2 ..... | Gray slate, with a few quartzite laminae interbedded with finely laminated and banded manganiferous rocks as described between 75-144.5 feet. Manganiferous zones at 147-147.9, 149.5-150, 154.7-156, 160-162, 163-173, 174.5-175, 176.5-177, 178.5-179.5, and 182.2-183.2 feet.<br>Quartz-feldspar-chlorite veinlets at 146, and 154.5-154.7 feet. |
| 183.2-233 ..... | Gray slate, with a few quartzitic- and sulfide-bearing laminae, which in a few places are highly contorted.<br>Chlorite-carbonate-rock interbeds at 215-219, 222.5-223.5, and 228.5-229.5 feet.<br>Contorted, pale carbonate (rhodochrosite) layer, 1/4 to 1/2 inch thick, at 231 to 232 feet emerges at 2 places along core; near bottom of hole a disrupted layer (1/4 inch thick) of similar material.<br>Bottom of hole at 233 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 11 feet | 60° | 110 feet | 76° |
| 15 feet | 45° | 120 feet | 16° |
| 20 feet | 58° | 130 feet | 20° |
| 25 feet | 82° | 135 feet | 15° |
| 30 feet | 80° | 140 feet | 55° |
| 35 feet | 32° | 145 feet | Parallel |
| 40 feet | 56° | 150 feet | 10° |
| 45 feet | 40° | 155 feet | 10° |
| 50 feet | 58° | 160 feet | 35° |
| 57 feet | 54° | 165 feet | 50° |
| 65 feet | 51° | 170 feet | 28° |
| 73 feet | 60° | 175 feet | 33° |
| 80 feet | 55° | 180 feet | 25° |
| 85 feet | 35° | 187 feet | Parallel |
| 90 feet | 63° | 206 feet | 25° |
| 95 feet | 15° | 216 feet | 10° |
| 100 feet | 26° | 228 feet | 26° |
| 105 feet | 67° | | |

1/ See footnote at end of table.

TABLE 15. - Diamond-drill-hole logs[1/] (Con.)

Burnham DDH-1

| Interval, feet | Description |
|---|---|
| 0-17 ..... | Overburden. |
| 17-47 ..... | Gray, fine-grained, massive quartzite. |
| | At 27.4 feet: Lenslike, small (1 inch) pods containing coarse-grained quartz, feldspar, and other material. These may be local conglomeratic layers. At 28.5 feet: Quartz vein. At 42.5-47 feet: Brown, limonite-stained, sheared, fine-grained quartzite. |
| | NOTE: The term "quartzite" is used only as a field name. The rocks are probably low-rank graywacke. |
| 47-58 ..... | Dominantly, gray-green slate, with a few quartzite interbeds. |
| 58-261 ..... | Gray and brown, fine-grained quartzite. |
| | Gray-blue slate interbeds at 111-114, 167.5-169, 184-186, 229-229.5, 231-231.5, 237-237.5, and 259-259.5 feet. |
| | Quartz veinlets at 127.6-128, 130, 131-132.5, 182, 194-195, 197-199, 215-217, 221.5, 223-226, 227-228.5, 231.5, 236-237, 250-250.5, and 253.5-254 feet. |
| | Coarse-grained quartzite between 167-196 feet. Graywacke, with black-slate fragments between 193-195, and 201-205 feet. |
| | Hit water between 200 and 207 feet. |
| | Breccia zone between 207-210 and 213-215 feet. |
| 261-261.6 ..... | Dark-green vesicular igneous rock (metaandesite?). Upper contact not apparent owing to broken nature of core. Lower contact suggests conformable contact with sedimentary rocks. Igneous rock highly chloritized and characterized by calcite-filled vesicles. Not clear if this is a sill or an interbedded extrusive; baking effects not noted on either side. |
| 261.6-294.6 ..... | Gray-green, fine-grained quartzite, with green and gray slate interbeds. |
| 294.6-311.5 ..... | Dark-green, chloritized, igneous rock similar to that between 261-261.6 feet. Contact relationships with the preceding sedimentary rocks not clear owing to broken nature of core. No baking effect discernible. Calcite-filled vesicles noted between 304.5-306 feet. This rock is variably magnetic. |
| | Bottom of hole at 311.5 feet. |

| Bedding at- | Makes angle with core axis- | Bedding at- | Makes angle with core axis- |
|---|---|---|---|
| 49 feet | 45° | 120 feet | 42° |
| 55 feet | 40° | 126 feet | 40° |
| 65 feet | 42° | 146 feet | 40° |
| 70 feet | 38° | 180 feet | 50° |
| 80 feet | 34° | 185 feet | 65° |
| 84 feet | 30° | 222 feet | 40° |
| 91 feet | 28° | 231 feet | 50° |
| 100 feet | 45° | 237 feet | 48° |
| 110 feet | 31° | 277 feet | 50° |
| 114 feet | 40° | | |

1/ Table furnished by Louis Pavlides and L. A. Brubaker, Federal Geological Survey.

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