Geology of Clinton County Magnetite District New York

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By A. Williams Postel

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Petrology and structural features of the rocks associated with the magnetite ore bodies

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GEOLOGY OF THE CLINTON COUNTY MAGNETITE DISTRICT, NEW YORK

A. WILLIAMS POSTEL

ABSTRACT

This report describes the pre-Cambrian, nontitaniferous magnetite district of Clinton County, N. Y. Descriptions of the petrology and structure of individual magnetite deposits and the rocks of the region as a whole are given. The work involved the geologic mapping of the Dannemora, Lyon Mountain, and Churubusco quadrangles, and that part of the Ausable quadrangle that lies north of the Ausable River. Structural interpretations are based on this mapping, on inspection of all the working and abandoned mines in the area, on detailed logging of many thousands of feet of diamond-drill core, and on a study of many new and old detailed dip-needle surveys. Petrological interpretations are based on many hundreds of thin sections from specimens collected during the geological mapping and the logging of diamond-drill-hole core. Interpretation of the magnetite relationships are based on the study of thin sections and polished sections.

Previous work in the area and ideas on the origin of the ore and associated rocks are reviewed. Earlier workers have assigned various origins to the magnetite. Some have been in favor of a sedimentary origin, others an igneous origin. Geologists preferring the igneous origin have explained the magnetite as (1) a direct crystal segregation from a magma, (2) the result of reaction with and replacement of older rocks by solutions of magmatic origin, (3) the result of the enrichment in iron of pegmatitic fluids on contact with gabbroic rocks, or (4) the result of pneumatolytic metasomatic replacement.

Pre-Cambrian rocks in the area, in order of decreasing age, are the Grenville series (metamorphosed sedimentary rocks), the gabbro-anorthosite complex, Hawkeye granite gneiss, quartz syenite gneiss and the Lyon Mountain granite gneiss complex which includes four distinct units. These are covered in part by sediments of the lower Paleozoic, and unconsolidated sediments of Quaternary and Recent age. Rocks younger than the pre-Cambrian are discussed only briefly; they include the Paleozoic Potsdam sandstone and the Beekmantown dolomite, and Pleistocene to Recent unconsolidated glacial debris and fluvial sands and gravels.

The metasediments of the Grenville series are considered to have been originally calcareous, argillaceous, and arenaceous sediments altered to their present condition by dynamic and contact metamorphism. The gabbro-anorthosites are considered to have been derived by differentiation from a magma. The quartz syenite and the Hawkeye granite gneisses are believed to be different phases produced by the solidification of a magma younger than the gabbro-anorthosite magma. The Lyon Mountain granite gneiss complex is believed to have originated in part by the emplacement of a granite magma, younger than the quartz syenite-Hawkeye, magma, and in part by granitization of magmatic origin.

The structure of the area is thought to be the result of regional plastic deformation. Synclines and anticlines of both major and minor dimensions are encountered throughout the region. The folding is in many cases isoclinal and sometimes is overturned. Faults of different magnitudes also exist. All these structures may be deciphered by observation of the foliation and mineral lineation that is typical of all the pre-Cambrian rocks of Clinton County.

The ore bodies are confined to the pre-Cambrian Lyon Mountain granite-gneiss complex, the youngest of the pre-Cambrian granite gneisses. The magnetite replaces a series of rocks within this formation, but the most important replacements occur in microperthite granite gneiss, plagioclase granite gneiss, microantiperthite granite gneiss or in pyroxene-contaminated phases of the foregoing rocks.

Some of the ore bodies have a plunging cigarlike shoot structure. These shoot structures are connected parallel to the strike of the enclosing rocks by zones of noneconomic magnetite. The ore occurs on the limbs and in the keels of synclines. Many of the magnetite localities examined show the magnetite either replacing rocks with cataclastic textures or associated with rocks, on the hanging or footwall side, having cataclastic textures.

The greater part of the magnetite is thought to be of pneumatolytic origin. It is suggested that iron-halogen emanations, derived from magmatic sources, penetrated the Lyon Mountain granite gneiss along sheer zones, and, on hydrolysis, deposited the iron as magnetite.

A brief account of the airborne magnetometer survey of this region is included. Traverses at quarter-mile intervals were flown over the magnetite districts. No new anomalies of importance were discovered.

INTRODUCTION

PURPOSE AND SCOPE OF THE REPORT

The study of the Clinton County magnetite district was begun during World War II as one of many such investigations in the United States whose purpose was to aid in the development of deposits of strategic minerals.

The report is concerned only with the nontitaniferous magnetite. Titaniferous magnetite, except at the Duncan Mountain prospect, is not found in the area.

Work was started late in the field season of 1944 and was resumed during the field seasons of 1945 and 1947. In the course of the investigations, two heretofore geologically unmapped quadrangles, Dannemora and Churubusco, were completed, the Lyon Mountain quadrangle was remapped, and part of the Ausable quadrangle was remapped to provide additional structural and petrological information. The area was mapped on the standard (1/62,500) topographic base; in addition, a few small areas were mapped on enlargements (2 to 3 times) of the 1/62,500 base. The geologic mapping, investigation of diamond-drill cores, and general petrographic study were supplemented by examination of approximately 675 thin sections and 30 polished specimens of ores. Approximately four winters were devoted to laboratory investigation of petrographic material and to compilation of the report and maps.

The purpose of this report is to assemble all previously existing information on the region and to add the new information that has resulted from this further field and laboratory investigation. New investigation, both in the field and in the laboratory, was guided by recent trends in geologic philosophy and technique.

LOCATION AND CULTURAL FEATURES

Clinton County is the extreme northeastern county in New York State. Its neighboring counties to the west and south are Franklin and Essex, respectively. The eastern boundary is Lake Champlain. The international boundary between the United States and Canada forms the northern limit. Plattsburg is the county seat. The area covered in the present investigation is shown in figure 1.

The region is dominantly agricultural. Dairy products, fruit, and potatoes represent the bulk of the farm output. Pulpwood is cut and marketed from the wooded sections. Manufacturing industries are confined to Plattsburg and vicinity. Electric power is generated at several points along the Saranac River.

An excellent road network permits access to the greater part of the area. The main roads, including secondary roads, are kept open throughout the winter. Timber trails lead to most of the rugged, forested sections though local knowledge is necessary for their use.

The main line of the Delaware and Hudson Railroad crosses the eastern part of Clinton County from north to south; a spur line is operated from Plattsburg to Lyon Mountain; another spur connects Plattsburg with Ausable Forks. The Rutland Railroad gives rail service to the northern part of the county.

TOPOGRAPHY AND DRAINAGE

Maximum relief in Clinton County is approximately 3,710 feet. The highest altitude is on Lyon Mountain, 3,830 feet; the lowest altitude is at the shore line of Lake Champlain, somewhat under 120 feet.

The area may be divided into two topographic units: a flat, gently rolling unit of low relief and a rugged mountain unit of high relief. The flat unit extends across the entire northern third of the county and projects southward along the shore line of Lake Champlain and westward from the lake for 10 to 15 miles. This is part of the St. Lawrence Valley physiographic province. The remaining southwestern part of the county is in the northeastern sector of the mountainous Adirondack province.

Known zones of magnetite deposits are restricted to the mountain zone. The major mountain blocks trend north, though some blocks have pronounced easterly trends. Local differential relief ranges from about 800 feet to 2,200 feet. The most important valleys are alined east and west.

Drainage in Clinton County empties into Lake Champlain and is controlled by four master streams whose dominant line of flow is eastward. These streams are from north to south, the Big Chazy, Saranac, Salmon, and Ausable Rivers. Innumerable small streams feed these main trunks. Small lakes and ponds abound in the region. Two large lakes, Chazy and Upper Chateaugay, should be given specific mention; they lie on the boundary between the Lyon Mountain and Churubusco quadrangles.

PREVIOUS WORK IN THE AREA

Ebenezer Emmons (1842) has presented one of the earliest accounts of the iron-mining industry in Clinton County. His work is of interest to those concerned with the historical aspects of New York State iron; it is also a valuable guide to those interested in reexamining old workings. Additional historical reviews have been written by Witherbee (1916) and Linney (1943). Geologic studies of the northeast Adirondack iron ores include the work of Newland (1908). Nason (1922) described the Adirondack ores and gave an estimation of ore reserves by districts. Two quadrangles adjacent to the Dannemora quadrangle, the Ausable quadrangle (Kemp and Alling, 1925) to the south and the Lyon Mountain quadrangle (Miller, 1926) to the west, have been mapped. Reports on these two quadrangles include descriptions of the important mines in the region. Alling (1939) in another paper presented his opinion on the origin of the Adirondack magnetite deposits.

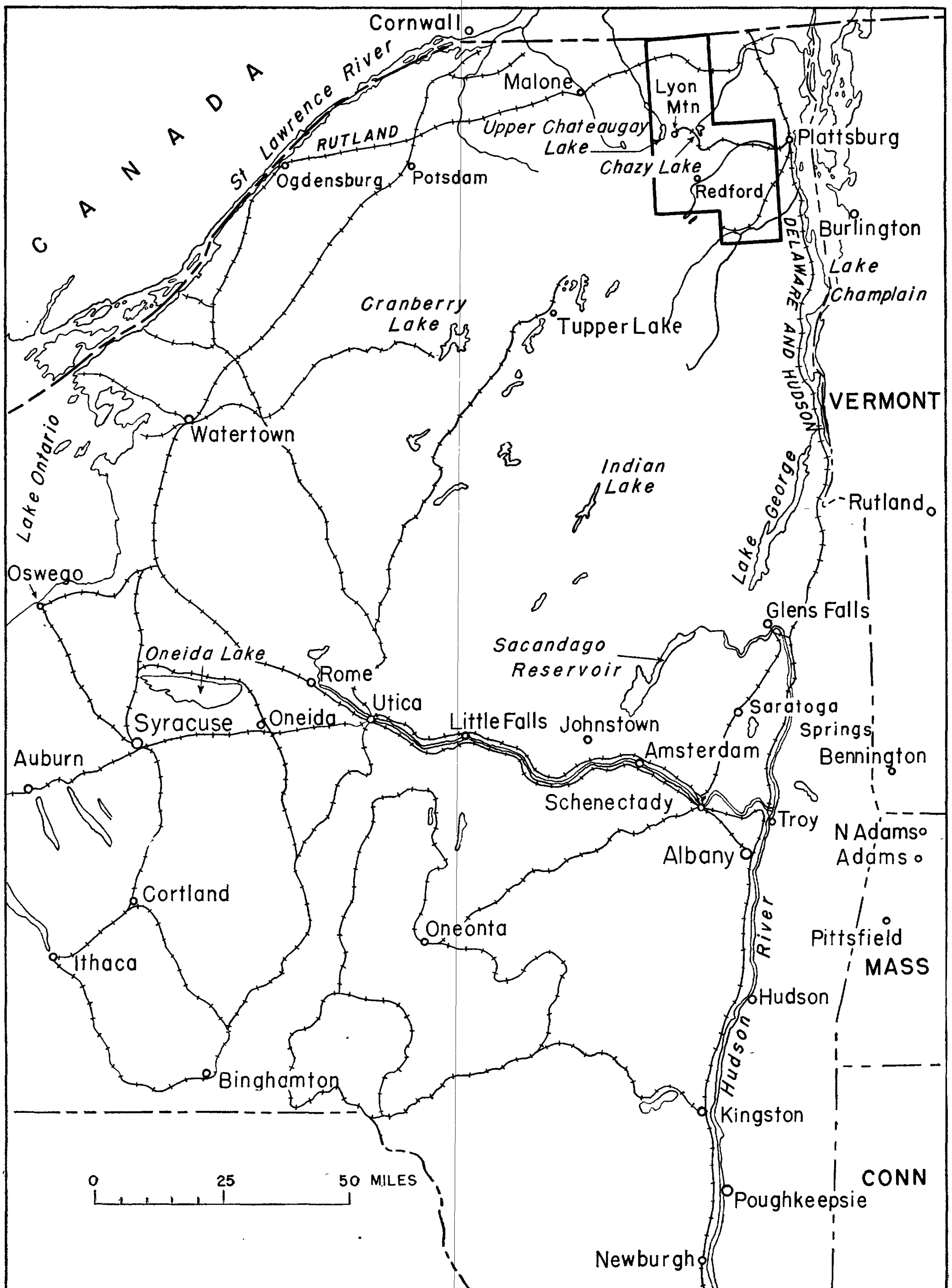

FIGURE 1.—Index map of part of New York showing location of Clinton County magnetite district.

He also gave (1942) a generalized description of various important mines in the Adirondacks.

An account of the deposits at the Chateaugay mine at Lyon Mountain was recently given by Gallagher (1937). A more recent overall description of the iron-mining industry in New York State may be found in the Adirondack Iron Mining issue of Mining and Metallurgy for November 1943. Oliver (1945) wrote a paper describing the beneficiation of Adirondack magnetite.

A popular account of the mineral industry of New York by Otte (1943) also refers to the magnetite ores of the state.

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DESCRIPTIVE GEOLOGY

METAMORPHIC AND IGNEOUS ROCKS

DEFINITION OF TEXTURAL TERMS

Nearly all the rocks described here possess a visible gneissic texture. The textural terms used in the tables of model composition refer only to textures as seen in thin section under the microscope.

The term "xenomorphic-granular" is used in the sense defined by Johannsen (1939, p. 39) it refers to a texture wherein the minerals composing the rock have crystallized nearly simultaneously so that they interfered with each other's growth and prevented the formation of crystallographic boundaries on any of the individual minerals. The term "granular" has the same significance as xenomorphic-granular, but it implies in addition that the minerals in the rock are generally equidimensional. "Schistose" and "gneissic" are fairly standard and need not be redefined. "Cataclastic" and "mylonitic" refer to the textures produced in rocks through deformation by crushing. If mechanical granulation has been extreme, to the point of producing very fine textures, the term "mylonitic" is employed; medium-grained textures are called cataclastic. This description is based on the generally accepted definition of "fine-grained," "medium-grained," and "coarse-grained" as applied to mineral aggregates in rocks. Fine-grained rocks have mineral units less than 1 millimeter diameter; coarse-grained rocks are composed of minerals having diameters larger than 5 millimeters. Mylonites are in the fine-grained category; cataclastic rocks may be medium- or coarse-grained. The description "recrystallized cataclastic" is used in subsequent tables to designate cataclastic textures where the grain boundaries have ceased to be sharp and somewhat angular and have become instead sutured or interlocking, owing to recrystallization. It must be admitted that this term when applied to advanced recrystallization is subjective in its application and depends on experience in observation of intermediate stages.

Textural designations other than the foregoing are, it is hoped self-explanatory; otherwise, reference may be made to Johannsen (1939).

GRENVILLE SERIES

Well-defined belts of the Grenville series (metamorphosed sedimentary rocks) are not predominant in the area mapped. The best exposure is in the west-central part of the Churubusco quadrangle, where the Grenville series, in a synclinal fold, crops out over an area of about 6 square miles. Smaller areas of the Grenville are in the Lyon Mountain, Dannemora, and Ausable quadrangles. At the outcrop the foliation of these rocks stands out as a strong ribbing.

The Grenville series shows a variety of compositions and includes amphibolites, biotitic and pyroxenic amphibolites, pyroxene skarn (skarn is an old

Swedish mining term for the silicate gangue of pre-Cambrian iron deposits), plagioclase pyroxene gneiss, plagioclase-garnet-pyroxene gneiss, biotite gneiss, quartz-feldspar gneiss, quartzite, granitized and migmatized (a gneiss into which igneous material has been injected parallel to the foliation) pyroxene gneiss. These various rock types in the metasediments are due in part to differences in original sedimentary composition and in part to the metamorphic histories of the rocks These rock types are shown by one symbol on the geologic map, as the small scale prohibits finer separation.

Many of the skarn rocks (table 1) are associated with magnetite deposits. The pyroxene skarn, consisting mainly of hedenbergitic diopside, $Z \wedge c$ 48° – 60°, is a dark-green coarse-grained rock whose color and coarse texture generally veil the foliation. The plagioclase-pyroxene gneiss (table 2) is generally a well-foliated, medium- to coarse-grained rock composed of alternate layers of grayish plagioclase and green pyroxene. Most of the biotite-plagioclase gneiss (table 3) is purplish gray and has a fine-grained to medium-coarse-grained texture. The granitized and migmatized gneisses (table 4) are medium- to coarse-grained and are pink or green, depending on the relative quantities of potash feldspar and pyroxene. The migmatite type of rock has strongly developed foliation.

In general the plagioclase of the rocks is oligoclase or andesine, though in the granitized gneisses—those having considerable potash feldspar—the plagioclase may fall in the albite-oligoclase range.

The pyroxene skarn has been interpreted by Buddington (1939) as calcareous, or impure cal-

TABLE 1.—*Modal composition of 2 samples of skarn*

[D, dominant; X, present; Gn, gneissic; Gr, granular]

	825B	832C
Scapolite	[1]35.1	
Quartz	7.0	9.4
Clinopyroxene	49.1	86.4
Accessories	6.5	4.2
Magnetite		D
Apatite		X
Sphene	D	
Texture	Gn	Gr

[1] nO 1.571, equivalent to 47 percent meionite (Winchell, 1933 p. 294).

825B. 1,000 feet northeast from Harrigan Corners, Churubusco quadrangle.

825C. On road 3,500 feet north of letter "v" in "Clintonville," map of Ausable quadrangle.

TABLE 3.—*Modal composition of 3 samples of biotite-plagioclase gneiss*

[Gr, granular; G. xenomorphic-granular; D, dominant; X, present]

	336	337	704A
Microcline	tr.		
Microperthite		1.0	
Microantiperthite		Tr.	
Plagioclase	An_{26} 56.5	An_{25} 60.2	An_{25} 35.4
Quartz	34.2	24.0	33.1
Biotite	7.6	10.2	16.3
Hornblende			1.1
Magnetite			12.9
Accessories	1.7	4.6	1.1
Magnetite	X		D
Zircon	X		X
Apatite			D
Sphene			
Chlorite			
Garnet	D	D	
Epidote			
Texture	Gr	Gr	G

336. 2,000 feet north of letter *k* in "True Brook", map of Lyon Mountain quadrangle.

337. 2,500 feet N. 10° W. of letter *k* in "True Brook", map of Lyon Mountain quadrangle.

704A. On the numeral "1" of altitude "1504, Sugar Hill", map of Dannemora quadrangle.

TABLE 2.—*Modal composition of 11 samples of plagioclase-pyroxene gneiss*

[D, dominant; X, present; G, xenomorphic-granular; Gn, gneissic; Gr, granular]

	282A	334D	[1]402	[1]457A	480A	[1]690B	825A	877	970	1018A	R14
Plagioclase[2]	An_{22} 59.1	An_{17}[3] 61.5	An_{28} 46.5	An_{22} 56.8	An_{32} 42.1	An_{22} 49.9	An_{21}[4] 58.1	An_{14} 60.9	An_{22}[3] 63.2	An_{35}[3] 61.4	An_{32} 48.3
Quartz	Tr.					Tr.	27.1		10.4		
Clinopyroxene	20.8	37.0	12.1	16.0	26.8	11.6	12.1	37.8	10.0	24.0	35.2
Hornblende	10.6		36.0	20.9	4.4	20.8					
Biotite				Tr.	9.7					5.1	
Garnet					12.3				7.2	7.8	
Tourmaline											13.6
Magnetite						14.6					
Accessories	9.5	1.4	5.3	6.2	4.6	3.0	2.7	1.2	9.1	1.7	2.8
Magnetite	X	D	D	D	D	X		X	D	D	D
Zircon	X	X	X		X	X	X	X	X	X	
Apatite	X	X	X	X	X	D	X		X	X	
Sphene	D	X					D	D	X		
Texture	Gr	G	Gn	Gn	Gr	G	Gr	G	Gr	Gr	Gr

[1] Pyroxenic amphibolite.

[2] Plagioclase compositions here and in all following tables, determined by interference-figure method.

[3] Some microantiperthite.

[4] Orthoclase, 1.2 percent.

[5] Chloritized.

282A. On main highway 0.5 mile west of Clayburg bridge, map of Lyon Mountain quadrangle.

334D. Outcrop in bed of True Brook, 1,000 feet south of letter "o" in "Moffitsville," map of Lyon Mountain quadrangle.

402. 4,000 feet N. 65° E. from letter "a" in "Russia," Johnson Mountain, map of Lyon Mountain quadrangle.

457A. 2,000 feet south of letter "e" in "Ore Pond," map of Lyon Mountain quadrangle.

480A. 500 feet N. 65° W. of letter "H" in "High Falls," map of Lyon Mountain quadrangle.

690B. Southwest escarpment of Terry Mountain, 1,500 feet N. 70° E. from letter "T" in "Terry Mountain," map of Dannemora quadrangle.

825A. 1,000 feet northeast from Harrigan Corners, map of Churubusco quadrangle.

877. 4,500 feet S. 30° W. from the "Bell School," map of Churubusco quadrangle.

970. 2,500 feet S. 25° E. from letter "e" in "True Brook," map of Lyon Mountain quadrangle.

1018A. 1,500 feet north from letter "y" in "Haystack Knob," map of Lyon Mountain quadrangle.

R14. 4,000 feet S. 80° E. from the letter "v" in "Little Ausable River," map of Dannemora quadrangle.

TABLE 4.—*Modal composition of 9 samples of granitized pyroxene gneiss*

[X, present; D, dominant; Gn, gneissic; G, xenomorphic-granular; Gr, granular]

	355	366	427	614	622	629	771	1018	R129
Microcline	[1]2.5	....	14.1	27.8	....	19.0	[2]22.3	....	....
Microperthite	....	28.9	....		24.4			30.1	....
Plagioclase	An_{38} 67.2	An_{17} 31.3	An_{22} 60.7	An_{10} 14.7	....	An_{10} 32.6	An_{15} 30.6	An_{28} 43.4	An_{22} 48.3
Quartz	6.7	Tr.	21.1	....	....	5.2	22.4	17.6	....
Clinopyroxene	6.7	27.6	[3]2.7	28.6	29.2	39.4	21.6	2.0	17.3
Hornblende	5.0	Tr.	....	....	....	....	....	5.2	....
Biotite	Tr.	....	....	....	....	....	....	....	....
Garnet	10.8	....	....	27.4	43.6	....	....	.9	....
Magnetite	....	7.1	....	....	....	....	....	....	....
Sphene	....	....	....	....	....	....	....	....	6.4
Accessories	1.0	5.4	1.3	1.4	2.7	3.7	3.2	.7	7.5
Magnetite	D	D	D	D	D	D	....	D	D
Zircon	X	....	X	X	....	X	....	X	....
Apatite	X	D	X	....	....	X	X	X	X
Sphene	....	....	X	....	....	X	D	....	D
Chlorite	X	X	X	....	....	....	....	....	....
Texture	Gn	G	Gn	G	Gr	Gr	Gn	G	Gr

[1] Orthoclase.
[2] Little microantoperthite.
[3] Chloritized.

355. 4,000 feet south of letter "H" in "Clark Hill," map of Lyon Mountain quadrangle.
366. 500 feet south of letter "R" in "Russia Mountain," map of Dannemora quadrangle.
427. 6,000 feet west of letter "k" in "True Brook," map of Lyon Mountain quadrangle.
614. 3,500 feet N. 40° E. from letter "L" in "Little Ausable River," map of Dannemora quadrangle.
622. 3,500 feet N. 45° E. from letter "L" in "Little Ausable River," map of Dannemora quadrangle.
629. 4,500 feet N. 10° E. from letter "L" in "Little Ausable River," map of Dannemora quadrangle.
771. 2,500 feet S. 70° E. from letter "l" in "Black Brook," map of Dannemora quadrangle.
1018. 1,500 feet north from letter "y" in "Haystack Knob," map of Lyon Mountain quadrangle.
R129. Top of hill 2385, southwest of the letter "r" in Ellenburg Mountain, map of Churubusco quadrangle.

careous, sedimentary material that was altered to its present form through metasomatic replacement by iron and silica-bearing solutions of igneous origin. Skarn rocks presumably of this origin may be seen in Clinton County, particularly at Lyon Mountain. They occur as well-defined septa or lenticular masses in the younger Lyon Mountain granite gneiss.

The pyroxene skarn rocks of the area afford no possible evidence of sedimentary origin in themselves. Neither are such rocks found in Clinton County clearly interbedded with other types of metasediments of the Grenville series. On the contrary pure pyroxene rocks occur always in granite gneiss as tabular or lenticular layers parallel to the regional structure. These occurrences indicate only that the pyroxene rocks are older than the granite and therefore could be metasediments.

Gallagher (1937, p. 25) was of the opinion that the hedenbergitic diopside was of magmatic origin but was a mineral not in equilibrium with the magma that produced the Lyon Mountain granite gneiss. This idea is considered doubtful as the tabular habit of the skarn layers is more typical of inclusions of a preexisting country rock into which the magma was intruded.

Miller (1926, pp. 16 and 83) ascribes the pyroxene rocks to an alteration of hornblende-hypersthene metagabbros. Examination of thin sections led him to describe pyroxene as having replaced hornblende; examination of thin sections collected for this report however, indicate that where the two minerals coexist, the hornblende replaces the pyroxene. Miller also claims that the pyroxene "diallage" crystallized "approximately simultaneously" with magnetite. Subsequent discussion here will show clearly that magnetite is definitely later than pyroxene and replaces it. Also, if Miller's hypothesis were correct it would be probable to expect the existence of nearly pure hornblende bodies in nonmineralized areas—the counterparts of nearly pure pyroxene bodies, as seen at the Lynch prospect, that do exist in mineralized areas. Hornblende masses of such purity have not been observed.

Green clinopyroxenes with optical properties similar to those in the skarns also occur as fracture and vug fillings in granite (fig. 2). These could represent recrystallized remnants of skarn material that contaminated the granite; but a few large pyroxene grains of this kind enclose smoothly rounded blebs of microperthite, a mineral considered generally younger than the skarn rocks of this area. Recrystallization of the granite after crystallization of the microperthite may have enlarged the pyroxene crystals, thus enclosing the microperthite (poikiloblastic texture); or the microperthite may have replaced the recrystallized pyroxene. The evidence from thin sections is not clear, but if the pyroxene was later in origin than the microperthite then the rocks of

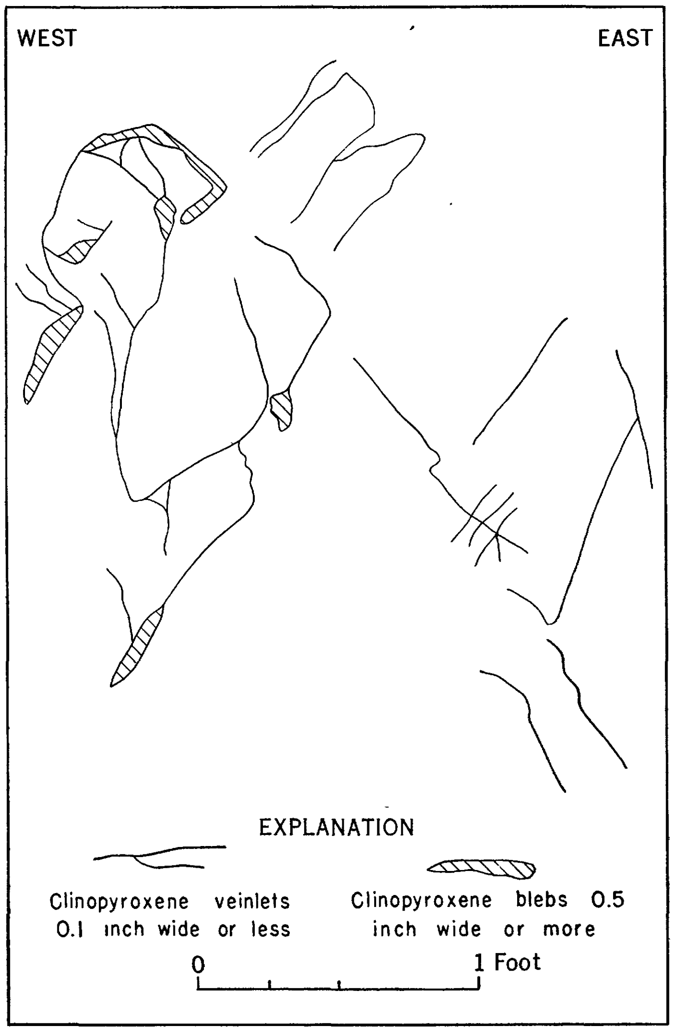


FIGURE 2.—Clinopyroxene veins in Lyon Mountain granite gneiss, Mitchell Mountain, Dannemora quadrangle.

Clinton County must include two generations of green pyroxene.

The septa of pyroxene skarn may be metasediments, whereas the pyroxenes filling veins and fractures in the granite may be of magmatic or hydrothermal origin. The latter possibility will be discussed further in a later section. (See p. 45.)

ANORTHOSITE AND GABBROIC ANORTHOSITE

The principal anorthosite mass in the area mapped is in an overturned anticlinal fold in the southeast corner of the Dannemora quadrangle, continuing southward into the Ausable quadrangle.

The anorthosite is a coarse-grained, pale-gray rock in which individual plagioclase crystals attain dimensions of as much as 3 by 4 inches. Mafic minerals include pyroxene, hornblende, and red garnet; the distribution and amount of these minerals are variable. Here and there thin gabbro layers are enclosed within the anorthosite. The typical anorthosite is very poor in ferromagnesian minerals. Locally, however, the ferromagnesian minerals increase to the point where strictly the rock should be classified as a gabbroic anorthosite, or even gabbro. Table 5 illustrates such variations.

TABLE 5.—*Modal composition of 5 samples of anorthosite and gabbroic anorthosite*

[D, dominant; X, present; Gr, granular; G, xenomorphic-granular]

	749[1]	776[2]	776A[1]	776B[1]	1167
Plagioclase	An_{32} 49.9	An_{32} 76.5	An_{42} 79.6	An_{42} 93.1	An_{37} 73.8
Quartz	....	Tr.	....	....	....
Clinopyroxene	29.3	....	12.4	1.0	[3]1.5
Hornblende	2.7	22.7	....	4.8	21.8
Biotite	4.6	.7	....	....	.8
Garnet	7.3	....	4.2	.6	....
Accessories	6.1	....	3.7	.5	2.0
Magnetite	D	D[4]	D[4]	D[4]	X
Apatite	X	X	....	X	X
Chlorite	X	X	X	....	....
Texture	Gr	G	G	G	G

[1] Little orthoclase present.
[2] Trace orthoclase.
[3] Chloritized.

749. 2,000 feet north of the letter "n" in "Cold Spring," map of Dannemora quadrangle.

776, 776A, and 776B. 1,500 feet south of the letter "r" in "Cold Spring," map of Dannemora quadrangle.

1167. 6,000 feet S. 45° W. from letter "o" in "Tolman Mountain," map of Lyon Mountain quadrangle.

METAGABBRO AND AMPHIBOLITE

Gabbroic bodies, now metamorphosed to amphibolites, are widely scattered throughout Clinton County. Generally, however, it is impossible to distinguish between the amphibolites of igneous origin and the amphibolites of the Grenville series. An igneous origin may be definitely assigned to certain very thick layers of amphibolites with relict ophitic textures in the centers of the masses. Two such amphibolite masses may be seen in the Lyon Mountain quadrangle: one just north of the main highway to the west of Clayburg, the other about a mile south of Russia Station. The amphibolites of the Grenville series were originally impure calcareous beds. They are analogous to the plagioclase pyroxene gneisses, with hornblende substituting for clinopyroxene.

Megascopically, the amphibolites are dark-colored medium-grained usually well-foliated rocks. Microscope examination shows the dominant minerals to be hornblende ($Z \wedge c = 23°$. Pleochroism: X, brownish yellow; Y, olive green; Z bluish green) and calcic plagioclase. Some types carry garnet as well as monoclinic and orthorhombic pyroxene. Biotite facies (in which biotite has replaced hornblende) and hypersthene facies (in which the hypersthene is pink to colorless in thin section) also are common.

Table 6 includes rocks of both igneous and sedimentary origin; but, as previously mentioned, the two types are difficult to distinguish. The composition of the hypersthene amphibolites is shown in table 7. Garnet is a common constituent of this group, but the grains are too large to be included in the area of an ordinary thin section. Hornblende is later than hypersthene and has replaced it. The establishment of a separate table for the hypersthene amphibolites has no genetic significance; the separation is only one of convenience for mineralogical description.

OLDER GRANITIC ROCKS

HAWKEYE GRANITE GNEISS

The Hawkeye granite gneiss usually has a pronounced phacoidal texture. This rock was named Hawkeye granite by Miller (1926, p. 24) when he mapped it in the Lyon Mountain quadrangle. Miller described the Hawkeye granite as a facies of his Lyon Mountain granite, but it is now considered to be an older, separate unit. The only exposure mapped

TABLE 6.—*Modal composition of 12 samples of metagabbro and amphibolite*[1]

[D, dominant; X, present; Gn, gneissic, G, xenomorphic-granular; Gr, granular; Op, ophitic]

	[2]260B	278	307	363	[2]371	375	468	[2]509B	604	714	[2]846	1129
Microcline	41.6	Tr.			13.8					7.5		
Microperthite								22.4			39.6	
Plagioclase	An$_{30}$ 12.5	An$_{26}$ 39.8	An$_{28}$ 45.8	An$_{30}$ 42.9	An$_{22}$ 34.4	An$_{30}$ 41.5	An$_{15}$ 54.6	An$_{16}$ 12.4	An$_{30}$ 34.6	An$_{32}$ 46.0	An$_{20}$ 39.6	An$_{32}$ 61.5
Quartz		Tr.						6.8	Tr.	6.9	1.2	
Clinopyroxene												16.4
Hornblende	32.1	51.4	47.0	44.1	43.5	31.6	31.0	42.6	45.9	34.3	16.9	
Biotite	3.2		1.8	7.3	X	18.1	2.4		9.2		Tr.	8.3
Magnetite							3.1	6.5				
Apatite								9.2				
Accessories	10.5	8.7	5.3	5.7	8.2	8.7	8.9		10.2	5.2	2.7	13.7
Magnetite	D	D	D	D	D	D	X	X	D	D	D	X
Zircon	X	X	X			X	X		X	X	X	
Apatite	X	X	X	X	X	X	X	X	X	X	X	X
Sphene	X						D					
Chlorite		X			X					X	X	D
Texture	Gn	Gn	Gn	Gn	G	Gn	Gr	Gn	Gn	G	G	Op

[1] Undifferentiated as to original material. [2] Granitized.

260B. 300 feet, S. 80° W. from the letter "S" in "State Penitentiary," map of Dannemora quadrangle.
278. At B.M. 1124 on Main highway 1.5 miles northeast of Redford.
307. 4,500 feet S. 60° E. from letter "k" in "Bullis Creek," map of Mooers quadrangle.
363. 500 feet south of the letter "i" in "Russia Mountain," map of Dannemora quadrangle.
371. Northwest bank of Saranac River 3,000 feet south of the letter "g" in "High Falls," map of Lyon Mountain quadrangle.
375. East bank of the Saranac River, 1,500 feet, S. 65° W. from the letter "M" in "Russia Mountain," map of Lyon Mountain quadrangle.
468. 300 feet N. 30° E. from the letter "w" in "Riverview," map of Lyon Mountain quadrangle.
509B. Johnson Mountain, 3,000 feet, S. 45° E. from the letter "k" in "Mountain Brook," map of Lyon Mountain quadrangle.
604. 2,500 feet S. 80° E. from the letter "L" in "Little Ausable River," map of Dannemora quadrangle.
714. 2,000 feet, N. 35° E. from the letter "r" in "Sugar Hill," map of Dannemora quadrangle.
846. On road 5,000 feet S. 40° W. from Ledger Corners, map of Churubusco quadrangle.
1129. 3,200 feet N. 23° E. from the letter "G" in "Goodrich Mill," map of Lyon Mountain quadrangle.

TABLE 7.—*Modal composition of 9 samples of hypersthene amphibolite*

[D, dominant; X, present; G, xenomorphic-granular; Gr, granular]

	346	347	349	384	[1]431C	443	705	805	R137
Plagioclase	An$_{46}$ 45.2	An$_{45}$ 33.8	An$_{47}$ 37.3	An$_{34}$ 47.4	An$_{32}$ 77.7	An$_{41}$ 42.7	An$_{28}$ [2]55.7	An$_{49}$ 46.1	An$_{29}$ 54.3
Quartz					5.7		6.6		
Hypersthene	5.0	22.7	13.2	18.7	14.8	5.8	1.4	17.3	9.3
Clinopyroxene	29.6								.9
Hornblende	16.7	27.4	47.9	20.3	Tr.	46.3	31.2	28.0	24.8
Biotite		4.8	Tr.	5.9	Tr.	4.4		7.3	
Magnetite		4.7							
Apatite		6.5							
Accessories	3.4		1.5	7.7	1.8	.7	5.0	1.2	10.6
Magnetite	D	X	D	D	D	D	D	D	D
Zircon				X	X		X	X	X
Apatite		X		X	X	X	X	X	X
Sphene									
Texture	G	G	G	Gr	Gr	G	G	Gr	G

[1] Trace orthoclase.
[2] Includes 3.1 percent orthoclase.

346. On road 500 feet north of letter "C" in "Clark Hill," map of Lyon Mountain quadrangle.
347. 500 feet S. 80° E. from the letter "s" in "Corners Brook," map of Lyon Mountain quadrangle.
349. 4,500 feet S. 50° E. from the letter "C" in "Clark Hill," map of Lyon Mountain quadrangle.
384. 9,000 feet N. 55° E. from the letter "r" in "Ore Pond," map of Lyon Mountain quadrangle.
431C. 3,500 feet S. 75° W. from the letter "B" in "True Brook," map of Lyon Mountain quadrangle.
443. Just north of main highway 0.3 mile southwest from the King School, map of Churubusco quadrangle
705. 1,500 feet S. 35° E. from the letter "r" in "Sugar Hill," map of Dannemora quadrangle.
805. On main highway 0.5 mile from the King School, map of Churubusco quadrangle.
R137. Hilltop 2,500 feet west of Gregory School, map of Churubusco quadrangle.

outside the Lyon Mountain quadrangle is on Ellenburg Mountain in the Churubusco quadrangle.

The fresh rock is pink and usually has a coarse texture. One outcrop in the southwest corner of the Lyon Mountain quadrangle is green. The quartz and potash feldspar in the rock have an elongated tabular habit that determines the foliation and the phacoidal texture. The Hawkeye granite gneiss is very low in mafic minerals but it includes a little monoclinic pyroxene, hornblende, or biotite. The ferromagnesian minerals are mostly chloritized and the feldspars are sericitized. Some of the rock has a little microantiperthite. Table 8 gives the compositional range of the group.

QUARTZ SYENITE GNEISS

The largest body of quartz syenite gneiss in Clinton County is in the Lyon Mountain quadrangle. It extends northward-northwestward from Union Falls to a point a little east of Goldsmith, covering an area approximately 2 miles wide by 5 miles long. Two other smaller bodies were mapped in the Ausable quadrangle north of the Ausable River. The more important of the two bodies crops out along the river road for a distance of about 2 miles, starting at a point half a mile east of Ausable Forks.

TABLE 8.—*Modal composition[1] of 5 specimens of Hawkeye (phacoidal) granite gneiss*

[D, dominant; X, present]

	335	430	430A	433	439
Microcline and microperthite	53.3	....	....	....	....
Microperthite	....	57.5	57.5	43.0	61.0
Plagioclase	An_{18} 19.2	[2]12.7	[2]15.4	An_{19} 19.0	An_{20} 11.0
Quartz	24.6	22.7	26.2	29.3	25.2
Clinopyroxene	[3]1.8	....	....	....	....
Hornblende	....	....	....	1.2	[3]1.2
Biotite	....	.9	.1	....	Tr.
Garnet	....	4.9	Tr.	....	....
Accessories	1.0	1.2	.8	7.5	1.6
Magnetite	D	D	D	X	D
Zircon	....	X	X	X	....
Apatite	X	....	....	X	....
Sphene	X	X	....	....	X
Chlorite	....	X	X	D	....
Calcite	....	....	....	....	X

[1] The coarse texture of these rocks makes determination of modal compositions from ordinary thin sections very inaccurate. The compositions given therefore should be considered only as indicative.

[2] Sericitized.

[3] Chloritized.

335. 2,500 feet N. 30° E. from the letter "k" in "True Brook," map of Lyon Mountain quadrangle.

430, 430A. Hilltop 6,500 feet west of the letter "B" in "True Brook," map of Lyon Mountain quadrangle.

433. 2,500 feet S. 10° E. from the letter "B" in "True Brook," map of Lyon Mountain quadrangle.

439. 10,000 feet north of Main highway, 1 mile west of Ledger Corners, Churubusco quadrangle.

The fresh quartz syenite gneiss is a medium-grained rock that ranges from dark green to greenish gray. Weathering changes the color to a medium brown. Many weathered outcrops of the rock have a

TABLE 9.—*Modal composition of 12 samples of quartz syenite gneiss*

[X, present; G, xenomorphic-granular]

	From the Ausable quadrangle							From the Lyon Mountain quadrangle				
	841	841A	842	842A	842B	[1]950	[2]950A	1039	1070	1099	1115	D76
Microperthite	....	....	[3]57.4	[3]67.3	59.3	....	....	52.2	43.6	42.6	46.8	40.9
Microperthite and Microantiperthite	67.1	52.7	....	....	....	....	74.6	....	....	....	....	....
Plagioclase	Tr.	....	1.2	3.7	2.1	An_{37} 46.2	....	An_{13} 9.4	An_{17} 16.9	An_{17} 9.5	An_{17} 17.6	An_{17} 17.4
Quartz	25.4	30.2	30.7	5.8	28.0	....	19.0	24.2	20.8	28.2	21.2	22.7
Olivine	....	Tr.[4]	6.5	....	Tr.[4]	....	[4]1.4	....	....	....	....	....
Orthopyroxene	....	....	....	....	....	9.4	....	....	....	[4]6.0	....	....
Clinopyroxene	3.5	....	Tr.	....	.6	....	....	Tr.	....	....	....	Tr.
Hornblende	....	17.1	....	21.6	7.9	37.9	....	11.9	16.2	11.0	13.6	13.7
Biotite	....	....	....	Tr.	....	.8	....	....	....	Tr.	....	....
Fluorite	....	....	1.1	....	2.1	....	....	....	....	....	....	....
Accessories	4.1	....	3.1	1.5	....	5.7	5.0	2.3	2.4	2.6	.7	5.2
Magnetite	X	X	X	X	X	X	X	X	X	X	X	X
Apatite	X	....	X	X	X	X	....	....	X	X	X	....
Zircon	X	X	....	....	X	....	X	....	X	X	X	....
Epidote	X	X	X	X	....	....	X	....	X	X	....	....
Calcite	X	....	....	....	....	....	....	....	....	....	....	....
Fluorite	....	....	....	....	....	....	X	....	....	....	....	....
Chlorite	....	....	....	....	....	....	X	....	....	....	....	....
Texture	G	G	G	G	G	G	G	G	G	G	G	G

[1] Amphibolite zone in quartz syenite.

[2] Contaminated phase (adjacent to 950).

[3] Trace microantiperthite.

[4] Altered.

841. On river road 1.9 miles west of Ausable Forks, Ausable quadrangle.

841A. Same as 841.

842. Quarry on river road 1.5 miles west of Ausable Forks, Ausable quadrangle.

842A. Same as 842.

842B. Same as 842.

950. On river road 1.7 miles west of Ausable Forks, Ausable quadrangle.

950A. Same as 950.

1039. On Main highway 0.7 mile east of French Road, Lyon Mountain quadrangle.

1070. Hilltop, N. 60° E., 1.8 miles from Duncan Mountain (alt. 2,728), Lyon Mountain quadrangle.

1099. Hilltop, S. 60° E., 0.35 mile from end of French Road, Lyon Mountain quadrangle.

1115. Summit of peak (alt. 2,612) between Duncan Mountain and Alder Brook Mountains, Lyon Mountain quadrangle.

D76. Hilltop, N. 25° E., 1.3 miles from Duncan Mountain (alt. 2,728), Lyon Mountain quadrangle.

chalk-white outer surface. In hand specimens hornblende when present is easily discernible.

Under the microscope the quartz syenite gneisses are seen to have a xenomorphic-granular texture. In most of them the quartz content is too high for strict classification as quartz syenite; they are actually granites. The common ferromagnesian mineral is hornblende ($Z \wedge c = 20° - 24°$; $2V = 60° - 70°$. Optically negative. Pleochroism: X, yellow brown; Y, brown; Z, brownish green).

Table 9 gives the modal compositions of this group. Inspection of the table shows that the quartz syenite gneisses can be divided into two types: the type of the Ausable quadrangle and the type of the Lyon Mountain quadrangle.

The type of the Ausable quadrangle is anomalous in that some of the rocks contain olivine as well as considerable quantities of modal quartz. The olivine is both fresh and altered to serpentine and iddingsite (?). Some of the rocks also have a little fluorite, which occurs as discrete grains, but it also has embayed magnetite and olivine. Buddington (1939, p. 126) has described this rock. Some of the quartz appears to be late, as it cuts across minerals. Some of the accessory magnetite also appears to have replaced the original minerals. The nonperthitic plagioclase content of these rocks is usually very low. Some of the specimens examined contain microantiperthite.

Large quantities of fluorite are associated with the iron ore of the Palmer Hill mines, which lie 1.5 miles north of the quartz syenite gneiss. It is possible that some of the excess quartz, late magnetite, and fluorite were introduced into the quartz syenite gneiss by the mineralizing processes that operated at Palmer Hill.

The quartz syenite gneiss of the Lyon Mountain quadrangle is characterized by fair quantities of nonperthitic plagioclase and by the absence of microantiperthite. Olivine is absent, orthopyroxene is rare, and clinopyroxene occurs sparingly in a few specimens.

The two types of gneiss also differ in the kind of microperthite that represents the dominant potash feldspar. In Alling's terminology (1938) the Ausable type has plume microperthite and the Lyon Mountain type has rod perthite.

YOUNGER GRANITIC ROCKS (LYON MOUNTAIN GRANITE GNEISS)

The dominant rock in the pre-Cambrian complex of Clinton County is a pink, medium-grained, foliated granite gneiss with microcline, microperthite, plagioclase, and microantiperthite varieties. Locally the color may be white, yellowish, or greenish. This rock was called the Lyon Mountain granite by Miller (1926, p. 27) and the "ore formation" granite by Kemp and Alling (1925, p. 51). Miller's designation modified by the addition of the term "gneiss" is used in this report.

Examination under the microscope shows that mineralogically the Lyon Mountain granite gneiss is complex. It may be divided into four main units on the basis of the dominant feldspar: microcline granite gneiss, microperthite granite gneiss, plagioclase granite gneiss, and microantiperthite granite gneiss. These units cannot be distinguished by eye for practical field mapping. The four main units are each further divided into two subunits on their content of ferromagnesian silicates or lack of them. In the first subunit the common ferromagnesian minerals are clinopyroxene, hornblende, and biotite; these minerals may occur in any of the main groups, singly or in various combinations. The second subunit contains no ferromagnesian silicates and has been called magnetite granite gneiss from its dominant accessory mineral magnetite; the microcline and microperthite types are similar to rocks called alaskite by Buddington (1939, p. 137). The magnetite granite gneisses contain from 1 to 9 percent magnetite, which forms small discrete and commonly euhedral grains enclosed in the later minerals.

It is probable that the granite gneisses with high percentages of ferromagnesian minerals are formed, in part at least, by varying degrees of assimilation or incorporation of metasediments. Locally the gneisses contain so much pyroxene (30 percent or more) that the term "contaminated granite gneiss" or "granitized skarn" is more descriptive than pyroxene granite gneiss. The term "skarn migmatite" is also appropriate if the pyroxene forms well-defined layers in the gneiss. Many exposures of gneiss show a marked increase in pyroxene content in zones near contacts with skarn layers. Amphibolite layers within the gneiss are common throughout the area.

In many places the quartz content of the gneisses is so low that in strict classification the rocks should be called quartz syenite gneisses, or even syenite gneisses.

Two small exposures of sillimanite granite gneiss were mapped. Both are in the Lyon Mountain quadrangle. The first is on the top of Second Mountain—first mountain southeast of Parsons Knob—near the 81 mine. The rock at this locality is pink and fine-grained and weathers to rusty brown. The other locality is in a zone of mixed rocks on the northeast end of Duncan Mountain. The rock here is medium-grained and has a pinkish color. At both localities the sillimanite is in fine, white needlelike crystals.

Examination under the microscope shows that the sillimanite is associated with biotite. Table 10 shows the modal composition of the rock.

TABLE 10.—*Modal composition of a sample (D82)*[1] *of sillimanite granite gneiss*

[X, present]

Microperthite	28.6	Garnet	0.8
Plagioclase	An_{11} 13.8	Sillimanite	X
Quartz	45.5	Magnetite	X
Biotite	10.8	Zircon	X

[1] The granite crops out on the northeast end of Duncan Mountain, 2,400 feet due north of the letter "k" in "Casey Brook", map of Lyon Mountain quadrangle.

MICROPERTHITE GRANITE GNEISS

Microperthite is a potash feldspar, microcline, that has inclusions, often regularly arranged, of sodic plagioclase. The inclusions occur as rods, blebs, plumes, or patches. The microperthite granite gneiss has much the same characteristics as the microcline granite gneiss. Its main difference is in the proportions of microcline and microperthite, microcline being absent or occurring in lesser amounts than microperthite. It is important to note that when

TABLE 11.—*Modal composition of 12 samples of microperthite granite gneiss with ferromagnesian silicates*

[D, dominant; X, present; G, xenomorphic-granular; Gr, granular; C, cataclastic]

	265	319	372	405	497	636	658	662	678	804	[1]1	[2]2
Microcline and Microperthite	55.6	66.0			47.7	71.7	59.8	50.5			49.2	
Microperthite			67.5	53.5					65.8	59.4		57.4
Plagioclase	An_{10} 9.7		Tr.	An_9 10.4	An_{15} 13.4		An_7 10.9	An_7[3] 19.7	An_{10} 7.9	[4]5.1	An_9 16.9	An_9 7.8
Quartz	26.1	30.1	10.6	20.0	25.2	17.9	19.3	19.9	19.1	31.2	24.1	20.3
Clinopyroxene	[5]3.2		[5]12.8				1.6	1.4			2.6	4.1
Horneblende				2.8		5.2		1.3	3.9		2.2	4.6
Biotite	Tr.	1.3		9.3	11.2					[5]3.8	1.1	1.4
Accessories	5.4	2.5	9.0	3.9	2.4	5.2	8.3	7.1	3.3	.4	3.8	4.3
Magnetite	D	D	D	D	D[6]	D	D[6]	D[6]	D[6]		D	D
Zircon	X	X	X	X	X	X		X	X	X	X	X
Apatite	X	X	X			X	X	X	X	X	X	X
Sphene	X	X	X			X	X	X	X		X	X
Chlorite											X	
Calcite	X											
Epidote						X		X	X			
Texture	G	G	Gr	Gr	Gr	G	G	G	G	G		

[1] Average of 11 analyses.
[2] Average of 7 analyses.
[3] Little microantiperthite.
[4] Myrmekite.
[5] Chlotitized.
[6] Euhedral.

265. On main highway, 1,800 feet N. 50° W. from the letter "D" in "Dannemora Mountain," map of Dannemora quadrangle.
319. Dannemora Mountain, 2,500 feet S. 30° E. from the letter "D" in "Dannemora Mountain," map of Dannemora quadrangle.
372. Northwest bank of the Saranac River, 3,000 feet south of the letter "a" in "High Falls," map of Lyon Mountain quadrangle.
405. South end of Johnson Mountain, 3,500 feet N. 15 E. from the figure "9" in "B.M. 1489," map of Lyon Mountain quadrangle.
497. On dirt road, 4,000 feet S. 85 W. from the letter "S" in "Salmond River," map of Dannemora quadrangle.
636. Mount Etna, 2,000 feet S. 60 W. from the letter "M" in "Mount Etna," map of Dannemora quadrangle.
658. 2,000 feet S. 40° W. from the letter "b" in "Little Ausable River," map of Dannemora quadrangle.
662. Top of mountain, 4,000 feet S. 60° W. from the letter "b" in "Little Ausable River," map of Dannemora quadrangle.
678. Top of mountain, 6,000 feet S. 10° W. from the letter "k" in "Hogback," map of Dannemora quadrangle.
804. Ellenburg Mountain, 5,000 feet N. 30° W. from the letter "G" in "Great Chazy River," map of Churubusco quadrangle.

TABLE 12.—*Modal composition of 11 samples of magnetite microperthite granite gneiss*

[G, xenomorphic-granular; Gr, granular; X, present]

	293	299	334	340A	341	346A	507	605	637	690	R58
Microcline plus microperthite	60.9	65.4	41.7	53.0	43.3	65.5			56.6	57.3	62.4
Microperthite							64.2	48.9			
Plagioclase	An_8 10.5	An_5 9.0	An_{10} 27.0	An_{10} 35.0	An_{15} 20.3	[1]22.7	An_9 8.9	An_{10} 11.6	An_8 16.4	An_{10} 9.7	An_9 7.5
Quartz	24.8	20.9	29.5	10.0	34.3	10.6	21.8	35.9	24.6	29.8	21.9
Biotite	Tr.			Tr.	Tr.						Tr.
Magnetite	3.2	2.3	.3	[2].4	.9	.8	[2]3.5	3.1	1.7	[2]2.9	[2]7.5
Accessories	.6	2.3	1.4	1.5	1.2	.4	1.6	.4	.6	.2	.6
Zircon	X	X	X	X		X	X	X		X	X
Apatite		X		X	X		X		X	X	X
Sphene	X						X	X	X	X	
Chlorite		X		X	X	X	X			X	
Calcite			X		X						
Epidote										X	
Texture	G	G	G	Gr	Gr	G	G	G	G	G	G

[1] Sericitized.
[2] Euhedral.

293. Dannemora Mountain, 1,000 feet S. 60° E. from the letter "t" in "Dannemora Mountain", map of Dannemora quadrangle.
299. Dannemora Mountain, 2,500 feet S. 50° W. from the letter "t" in "Dannemora Mountain", map of Dannemora quadrangle.
334. In bed of True Brook, 1,000 feet south of the letter "o" in "Moffitsville", map of Lyon Mountain quadrangle.
340A. On True Brook road 800 feet N. 40° W. from the letter "B" in "True Brook", map of Lyon Mountain quadrangle.
341. On True Brook road 1,300 feet N. 50° W. from the letter "B" in "True Brook", map of Lyon Mountain quadrangle.
346A. On dirt road 500 feet N. 20° W. from the letter "C" in "Clark Hill", map of Lyon Mountain quadrangle.
507. Johnson Mountain, 1,500 feet N. 45° W. from the figure "4" in elevation "2482", map of Lyon Mountain quadrangle.
605. 3,500 S. 80° E. from the letter "L" in "Little Ausable River," map of Dannemora quadrangle.
637. Mount Etna, 1,200 feet S. 45° W. from the letter "M" in "Mount Etna," map of Dannemora quadrangle.
690. Southwest escarpment of Terry Mountain, 1,500 feet N. 70° E. from the letter "T" in "Terry Mountain," map of Dannemora quadrangle.
R58. East peak of Slush Pond Mountain, Dannemora quadrangle.

microperthite and microcline occur together the plagioclase content of the rock is higher than when microcline is absent. The plagioclase ranges in composition from albite to oligoclase. Some of the magnetite is euhedral. The magnetite in the magnetite subunit ranges from 0.3 percent to 7.5 percent. The common pyroxene is a green hedenbergitic diopside ($Z \wedge c = 60°$). A few specimens contained blue arfvedsonite ($X \wedge c = 11° - 14°$) instead of the common green hornblende. A few grains of pyroxene enclose microperthite, but many grains enclose rounded quartz blebs.

Minerals in the microcline granite gneiss and the microperthite granite gneiss have the same paragenetic sequence, which may be summed up as follows (the arrows indicate decreasing age):

$$\left.\begin{array}{l}\text{Apatite}\\ \text{Zircon}\\ \text{Magnetite}\\ \text{Sphene}\end{array}\right\} \longrightarrow \text{pyroxene} \longrightarrow \text{hornblende} \longrightarrow$$

biotite⟶ plagioclase⟶

potash feldspar⟶ quartz.

The following group of minerals is a late introduction in the above sequence and is probably related to the magnetite mineralization (see p. 43).

Plagioclase⟶ quartz⟶ magnetite⟶

sphene⟶ biotite.

MICROCLINE GRANITE GNEISS

The microcline granite gneiss is a pink, medium-grained rock. The ferromagnesian variety usually has a distinct foliation. The magnetite-bearing variety in some places has a very indistinct foliation. Common ferromagnesian minerals are green pyroxene (hedenbergitic diopside), hornblende, and biotite. The pyroxene is often chloritized. Plagioclase is found in both varieties of the microcline granite gneiss and is albitic in composition. The magnetite content in the magnetite subunit of the granite gneiss ranges from 1.2 percent to 8.3 percent. A content greater than 3 percent of accessory magnetite may be due to addition of later secondary magnetite. Euhedral magnetite is common. Some of the early magnetite is rimmed by a late biotite.

In some of the rocks examined late sphene rims the grains of magnetite. Also a little of the sericitized myrmekite is rimmed by later fresh plagioclase. Much of the microcline contains rounded inclusions of early quartz.

PLAGIOCLASE GRANITE GNEISS

Well-defined but thin belts of plagioclase granite gneiss occur in the Dannemora, Lyon Mountain, Churubusco, and Ausable quadrangles. Some specimens of the rock are white to light gray, but the common color is pink. The texture is medium to coarse. The plagioclase granite gneisses have the same range in ferromagnesian and magnetite con-

TABLE 13.—*Modal composition of 10 samples of microline granite gneiss with ferromagnesian silicates*

[D, dominant; X, present; G, xenomorphic-granular]

	264C	270C	277	278B	319	457	597	625	818	R40
Microcline	75.0	70.4	63.6	[1]40.7	66.0	[1]66.9	43.9	[1]47.9	72.3	55.6
Plagioclase	....	....	Tr.	[2]1.5	....	Tr.	An_8 10.2	An_9 21.4	Tr.	An_6 14.8
Quartz	5.9	21.6	26.0	37.8	30.1	23.0	36.8	26.1	23.4	22.2
Clinopyroxene	14.4	[3]2.9	....	6.6	....	[3]5.1	[3]6.2	....	....	....
Hornblende	....	....	3.2	....	....	1.0	....	....	....	....
Biotite	Tr.	3.2	3.0	[4]5.4	1.3	....	....	1.0	.8	1.7
Accessories	4.6	1.8	4.1	7.9	2.5	3.9	2.8	3.5	3.5	[5]5.6
Magnetite	X	D	D	X	D	[5]D	[5]D	[5]D	D	D
Zircon	X	X	X	X	X	X	X	X	X	....
Apatite	X	X	X	X	X	X	....	X	....	X
Sphene	X	X	X	D	X	....	....	X	....	....
Chlorite	X	....	....	....	....	X	X	....	....	X
Epidote	....	....	....	....	....	....	X	....	....	....
Calcite	....	....	....	....	....	....	X	....	....	....
Texture	G	G	G	G	G	G	G	G	G	G

[1] Little microperthite.
[2] Myrmekite.
[3] Chloritized.
[4] Colorless mica.
[5] Euhedral.

264C. On main highway 1,000 feet N. 75° W. from the letter "D" in "Dannemora Mountain," map of Dannemora quadrangle.
270C. On west bank of Saranac River 2,000 feet south of the letter "s" in "High Falls," map of Lyon Mountain quadrangle.
277. Off main highway 4,000 feet southwest of the letter "H" in "High Falls," map of Lyon Mountain quadrangle.
278B. On main highway 5,500 feet southwest of the letter "H" in High Falls," map of Lyon Mountain quadrangle.
319. 2,500 feet S. 35° E. from the letter "D" in "Dannemora Mountain," map of Dannemora quadrangle.
457. 2,000 feet south of the letter "r" in "Ore Pond," map of Lyon Mountain quadrangle.
597. East side railroad tracks, 7,000 feet S. 35° W. from the letter "H" in "Harkness," map of Dannemora quadrangle.
625. Hilltop 8,500 feet S. 70° W. from the letter "M" in "Mount Etna," map of Dannemora quadrangle.
818. 2,500 feet N. 60° W. from the letter "S" in "Spruce Hill," map of Churubusco quadrangle.
R40. 500 feet S. 60° E. from the letter "n" in "Mitchell Mountain," map of Dannemora quadrangle.

TABLE 14.—*Modal composition of 9 samples of magnetite-microcline granite gneiss*

[X, present; G, xenomorphic-granular; Gr, granular; C, cataclastic]

	260	260A	263	267	282	686	767	R23	R125
Microcline	[1]63.4	[1]72.5	[1]69.8	[1]78.5	[2]65.8	69.4	[2]51.0	68.8	73.2
Plagioclase	An_8 1.4	An_8 1.8	... 1.0	...	An_7 8.7	([3]) ...	An_8 19.9	... 2.6	...
Quartz	25.9	21.0	24.0	17.3	20.6	25.7	25.4	25.4	24.6
Magnetite	[4]8.3	3.5	[5]1.3	[5]3.6	1.2	1.8	2.7	[5]2.2	[5]1.8
Accessories	.9	1.2	3.8	.5	3.7	3.0	.9	.9	.4
Zircon	X	X	X	X	X	X	...	X	X
Apatite	X	X	...	X	...	X	X	...	X
Sphene	X	...	...	...	X	...	...	...	...
Chlorite	X	X	X	X	...	X	...	...	X
Calcite	...	X	...	...	...	...	...	...	...
Epidote	...	...	...	...	...	...	X	...	...
Texture	G	G	C	G	G	G	G	Gr	G

[1] Trace of microperthite.
[2] Little microperthite.
[3] Little serecitized plagioclase.
[4] Such relatively high amounts of accessory magnetite may be due to a latter introduction of small quantities of secondary magnetite.
[5] Euhedral.

260, 260A. On main highway 3,500 feet S. 80° W. from the letter "S" in "State Penitentiary," map of Dannemora quadrangle.
263. On main highway 1,000 feet S. 60° W. from the letter "D" in "Dannemora Mountain," map of Dannemora quadrangle.
267. 2,500 feet N. 85° E. from the triangulation station on Dannemora Mountain, map of Dannemora quadrangle.
282. On main highway 0.5 mile west of the Clayburg bridge, Lyon Mountain quadrangle.
686. Terry Mountain, 3,000 feet N. 25° W. from the letter "P" in "Patton Road," map of Dannemora quadrangle.
767. Terry Mountain, 4,000 feet N. 60° W. from the letter "P" in "Patton Road," map of Dannemora quadrangle.
R23. Top of hill 3,500 feet N. 30° W. from the letter "i" in "Mitchell Mountain," map of Dannemora quadrangle.
R125. 5,500 feet S. 85° W from the letter "g" in "Ellenberg Mountain," map of Churubusco quadrangle.

tent as the potash feldspar granite gneisses. The principal difference is that in the plagioclase granite gneiss sodic plagioclase substitutes for potash feldspar. The plagioclase is albite or albitic oligoclase, and all of it is well twinned.

The ferromagnesian plagioclase subunit includes plagioclase syenite gneiss and plagioclase quartz syenite gneiss. The usual pyroxene is hedenbergite ($Z \wedge c = 48°$) which includes rounded blebs of plagioclase. Common green hornblende, arfvedsonite, and kataphorite ($Z \wedge c = 30°$) are of sparse occurrence. Rare scattered grains of microcline are found in a few of the rocks. The plagioclase gneiss in some places contains a little garnet.

The magnetite plagioclase granite gneiss has a magnetite content ranging from 2.7 percent to 5.6 percent. In both subunits the magnetite may be euhedral.

Megascopic identification of the plagioclase granite gneiss in the field is not easy. In places, the albite-twin striations may be seen on the plagioclase cleavage surfaces; such striations, however, are not

TABLE 15.—*Modal composition of 10 samples of plagioclase granite gneiss with ferromagnesian silicates*

[D, dominant; X, present; G, xenomorphic-granular; Gr, granular; Grl, semigranular; Gn, gneissic]

	268	269	305	334C	420	716	718	R16	R34	[1]3
Plagioclase	An_9 71.6	An_7 52.5	An_7 68.0	An_8 78.0	An_8 76.6	An_{12} 68.5	An_7 63.6	An_9 82.4	An_6 67.3	An_9 64.4
Microcline	5.3	Tr.	...	...	...	Tr.	...	...	...	2.4
Quartz	14.3	27.3	24.3	Tr.	12.1	24.2	25.3	8.9	20.9	17.6
Clinopyroxene	[2]6.9	...	...	13.5	[3]4.8	2.7	7.7	...	5.1	8.2
Hornblende	...	15.3	...	...	...	3.1	...	5.2	...	2.7
Biotite	...	1.6	5.4	7.3	4.3	...	Tr.	...	...	.4
Accessories	1.8	3.2	2.2	1.2	2.2	1.4	3.3	3.4	6.7	4.6
Magnetite	D	D	D	...	D	X	D[4]	D	D[4]	D
Zircon	X	X	X	X	X	X	X	X	X	X
Apatite	X	X	X	...	X	X	X	X	X	X
Sphene	...	...	...	D	...	D	X	...	X	X
Chlorite	X	...	...	X	...	...	...	...	...	...
Calcite	X	X	...	...	X	...	...	...	...	...
Epidote	...	...	...	...	...	...	...	...	...	...
Texture	G	G	G	G	Gn	G	Grl	G	G	...

[1] Average of 21 analyses.
[2] Replaced by chlorite and calcite.
[3] Chloritized.
[4] Euhedral.

268. 3,000 feet N. 85° E. from the letter "t" in "Dannemora Mountain," map of Dannemora quadrangle.
269. 3,500 feet N. 80° E. from the letter "t" in "Dannemora Mountain," map of Dannemora quadrangle.
305. 3,600 feet S. 50° E. from the letter "k" in "Bullis Creek," map of Mooers quadrangle.
334C. In bed of True Brook, 1,000 feet south of the letter "o" in "Moffitsville," map of Lyon Mountain quadrangle.
420. Southeast end of Johnson Mountain, 2,000 feet N. 5° E. from the numeral "9" in "B.M. 1489," map of Lyon Mountain quadrangle
716. 2,200 feet N. 55° W. from the letter "T" in "Terry Mountain," map of Dannemora quadrangle.
718. 2,500 feet S. 75° W. from the letter "T" in "Terry Mountain," map of Dannemora quadrangle.
R16. Hilltop 4,500 feet S. 40° E. from the letter "v" in "Little Ausable River," map of Dannemora quadrangle.
R34. Hilltop 2,000 feet north of the letter "h" in "Mitchell Mountain," map of Dannemora quadrangle.

TABLE 16.—*Modal composition of 5 samples of magnetite-plagioclase granite gneiss*

[X, present; G, xenomorphic-granular; C, cataclastic; Grl, semigranular]

	271	688A	694	R63	R74
Plagioclase	An_{11} 53.3	An_{12} 66.3	An_{14} 64.1	An_{10} 65.2	An_{7} 69.7
Microcline	8.6	....	....	....	....
Quartz	33.9	27.7	31.4	30.4	22.7
Biotite	....	....	....	....	Tr.
Magnetite	3.0	3.4	[1]2.7	[1]3.4	[1]5.6
Accessories	1.1	2.5	1.7	.9	2.0
Zircon	X	X	X	X	X
Apatite	X	X	....	X	X
Sphene	....	....	X	....	....
Chlorite	....	X	....	X	X
Texture	G	C	Grl	G	G

[1]Euhedral.

271. 400 feet south & 50 feet west in terms of base-line coordinates of Ellis ore bed, map of Dannemora quadrangle.

688A. Southwest end of Terry Mountain, 1,200 feet S. 65° W. from the letter "T" in "Terry Mountain", map of Dannemora quadrangle.

694. Top of Hogback Mountain, altitude 2189.

R63. 2,600 feet N. 80° E. from the letter "M" in "Military Pond", map of Dannemora quadrangle.

R74. Top of Mountain, 9,200 feet S. 15° W. from the letter "H" in "Harkness", map of Dannemora quadrangle.

common. Final identification can best be made with the microscope.

MICROANTIPERTHITE GRANITE GNEISS

Microantiperthite is a sodic plagioclase that has inclusions of potash feldspar—microcline or microperthite. The host-inclusion relationship is the reverse of that in microperthite. The microantiperthite granite gneiss has a widespread distribution in Clinton County. This unit may be divided into the same two subunits as the preceding granite gneisses.

The unit is characterized by microantiperthite as the dominant feldspar, a feldspar that is thought to owe its origin to the action of sodic emanations or solutions.

The microantiperthite unit includes syenitic and quartz syenitic varieties. The ferromagnesian unit contains green pyroxene, hornblende, and biotite. Some of the pyroxenes have rounded inclusions of quartz and microperthite. Hornblende ($Z \wedge c = 27°$ –32°. Pleochroism: X, yellow; Y, yellowish green; Z, dark green) may occur in euhedral form. Some of the biotite appears to be very late and cuts across the microantiperthite. Comb texture is common at the contacts of microantiperthite, quartz, and primary plagioclase.

The magnetite content of the magnetite microantiperthite granite gneiss ranges from 0.6 percent to 5.2 percent.

Observation of many thin sections reveals differ-

FIGURE 3.—Photomicrograph showing mortar texture in microcline granite gneiss. Probable starting point in the formation of microantiperthite granite gneiss. Crossed nicols.

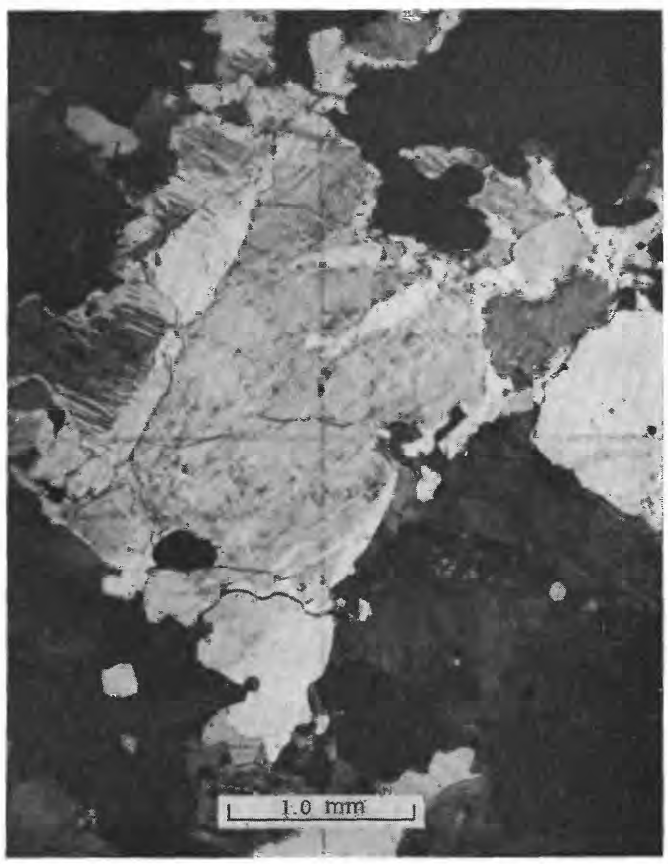


FIGURE 4.—Photomicrograph showing possible initial phase of replacement of potash feldspar by oligoclase in the formation of microantiperthite granite gneiss. Crossed nicols.

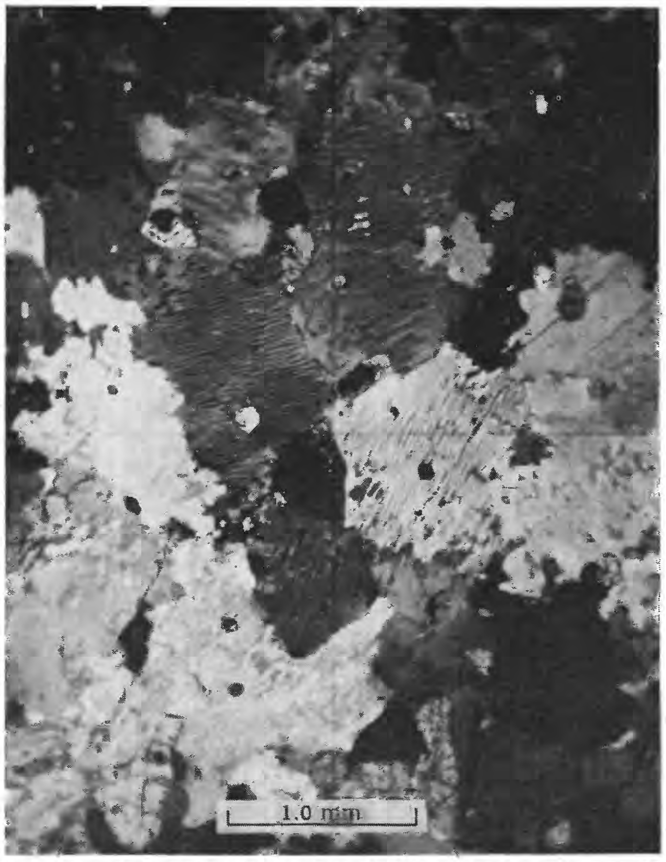


FIGURE 5.—Photomicrograph of microantiperthite granite gneiss, possible end phase of replacement of potash feldspar by oligoclase. Crossed nicols.

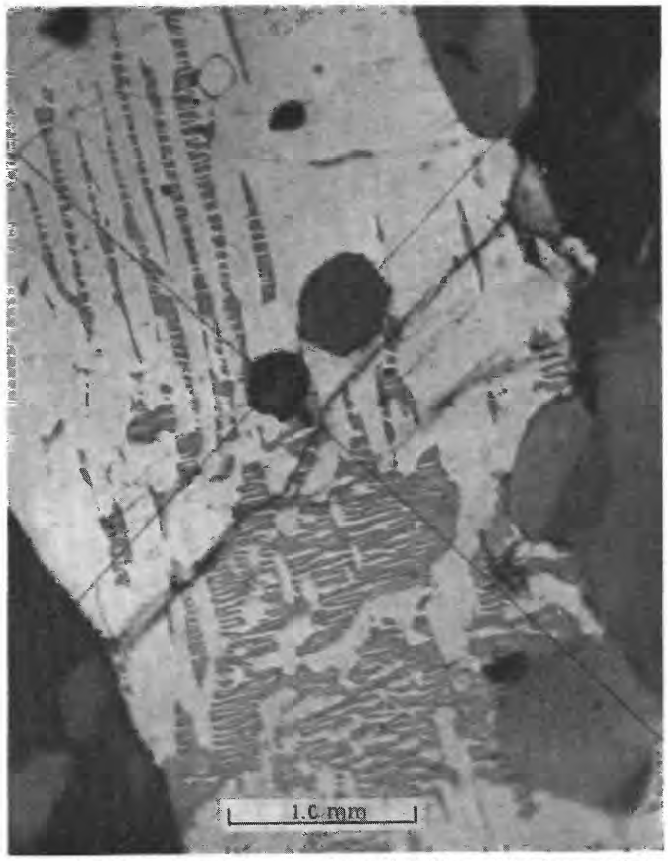


FIGURE 6.—Photomicrograph of microantiperthite. Oligoclase replaces potash feldspar (microperthite). Crossed nicols.

ent kinds of microantiperthite (fig. 3, 4, 5, 6). One kind, which cannot be classified strictly as an antiperthite, is microcline or microperthite surrounded by a rim of secondary albite; numerous tongues of albite penetrate into the potash feldspar from the rim. Another, somewhat similar kind, has well-developed albite tongues that penetrate far into the potash feldspar from the outside rim; Alling (1938)

TABLE 17.—*Modal composition of 10 samples of microantiperthite granite gneiss with ferromagnesian silicates*

[D, dominant; X, present; Cl, recrystallized cataclastic nests and channels between xenomorphic-granular grains; G, xenomorphic-granular; Gr, granular]

	264	264B	316	545	724	827	862	[1]4	R57	[1]5
Microantiperthite	79.3	68.7	....	46.7	....	....	77.2	....	51.8	50.3
Microantiperthite and microperthite	....	....	48.9	....	43.3	63.9	....	57.5	....	....
Plagioclase	....	....	An_{5} 12.8	An_{12} 13.9	An_{8} 15.9	An_{10} 13.0	An_{10} 4.3	An_{8} 8.1	An_{12} 24.4	An_{8} 16.5
Quartz	....	22.1	36.6	32.0	36.6	3.3	....	20.7	8.6	11.8
Clinopyroxene	18.7	5.0	....	....	....	15.1	9.6	6.7	....	9.4
Hornblende	....	....	....	[2]2.4	3.8	....	3.9	2.8	10.2	1.2
Biotite	....	Tr.	1.1	Tr.	Tr.	....	Tr.	.3	2.1	5.8
Accessories	2.0	4.2	.6	4.9	.3	4.6	4.9	3.8	2.9	5.1
Magnetite	X	D	D	D[3]	D[3]	D[3]	D[3]	D	D	D
Zircon	....	X	X	X	X	....	....	X	X	X
Apatite	....	....	....	....	BX	....	....	X	....	X
Sphene	D	X	X	....	....	....	....	X	....	....
Chlorite	....	....	....	....	....	X	....	....	X	....
Calcite	X	....	....	....	....	X	....	....	....	....
Tourmaline	....	....	X	....	....	....	....	....	....	....
Epidote	....	....	....	....	X	....	....	....	....	....
Texture	Cl	G	Cl	G	G	G	G	....	G	....

[1] Average of 10 analyses. [2] Arfvedsonite. [3] Euhedral.

264 and 264B. On main highway 1,000 feet N. 75° W. from the letter "D" in "Dannemora Mountain," map of Dannemora quadrangle.
316. 4,000 feet S. 25° E. from the letter "D" in "Dannemora Mountain," map of Dannemora quadrangle.
545. 1,700 feet west from the letter "s" in "Little Ausable River," map of Dannemora quadrangle.
724. Hilltop 4,200 feet S. 35° W. from the letter "C" in "Cold Spring," map of Dannemora quadrangle.
827. 4,100 feet N. 85° E. from Hogan School, map of Churubusco quadrangle.
862. 6,600 feet S. 52° W. from the letter "z" in "Hazeltine Hill," map of Churubusco quadrangle.
57. West peak of Slush Pond Mountain, Dannemora quadrangle.

has called rocks with this kind of texture plume perthite. Typical microantiperthite has patchy or rodlike areas of potash feldspar entirely surrounded by sodic plagioclase. The microantiperthite embays and cuts across primary plagioclase and primary quartz. Twinning in the microantiperthite is rare. The cleavages of the "host" and "guest" parts of the mineral are for the most part parallel and continuous. The composition of the secondary plagioclase is albitic oligoclase.

TABLE 18.—*Modal composition of seven samples of magnetite microantiperthite granite gneiss*

[X, present; C, cataclastic replaced by microantiperthite; Cl, recrystallized cataclastic nests between xenomorphic-granular grains; G, xenomorphic-granular]

	321	362	387	617	R135	R141	D36
Microantiperthite	......	An_{13} 78.2	An_{12} 35.3	......	62.2	58.9	39.2
Microantiperthite and microperthite	47.0	......	......	51.6	......	......	......
Plagioclase	An_5 21.4	......	......	An_8 15.4	An_{12} 5.5	......	An_{12} 21.8
Quartz	23.5	15.7	13.9	28.2	29.7	39.2	31.2
Biotite	......	......	......	......	Tr.	......	......
Magnetite	.6	5.2	3.8	[1]4.5	[1]1.1	1.6	X
Accessories	7.5	.8	.4	.2	1.4	.3	7.8
Zircon	X	X	X	X	......	X	X
Apatite	X	......	X	X	......	......	......
Sphene	X	......	X	......	......	X	X
Chlorite	......	......	......	......	X	......	......
Calcite	......	......	[2]46.5	......	X	......	......
Texture	Cl	Cl	G	C	G	G	G

[1] Euhedral.

[2] Replacing plagioclase.

321. 2,100 feet N. 5° E. from the letter "S" in "State Penitentiary", map of Dannemora quadrangle.

362. 400 feet S. 25° E. from the letter "a" in "Russia Mountain", map of Dannemora quadrangle.

387. 4,300 feet S. 15° W. from the letter "n" in "Russia Mountain", map of Lyon Mountain quadrangle.

617. Hilltop, 3,000 feet N. 10° E. from the letter "L" in "Little Ausable River", map of Dannemora quadrangle.

R135. South side of top of Cobble Hill, Churubusco quadrangle.

R141. 4,200 feet N. 50° E. from the letter "c" in "Spruce Hill," map of Churubusco quadrangle.

D36. Scarp face 7,500 feet due west from letter "N" in "Norton Peak", map of Lyon Mountain quadrangle.

The foregoing mineral relationships probably represent a progressive replacement by sodic plagioclase of the microcline or microperthite granite gneiss culminating in the formation of the typical microantiperthite granite. The first stage in the process is probably the crushing of a potash feldspar granite; sodic emanations or solutions then traveled through the crushed material to react with and replace the original potash feldspar. Nearly complete replacement resulted in the formation of microantiperthite and the obliteration finally of the original cataclastic texture. This interpretation is based, in part, on the assumption that the replacement of the original mineral (potash feldspar) proceeded from the outside of grains inward.

GRANITIC MIXED ROCKS

The mixed rocks may be divided into two general groups: a group in which the invading granite magma has reacted with calcic and ferromagnesian materials, metagabbro or amphibolite, and a group in which the granite magma reacted with silicic materials, presumably from the Grenville series. In general the rocks of both groups are migmatitic in character, as the granite magma injects preexisting structures bed by bed. The Grenville rocks include both silicic and ferromagnesian materials, so both groups of mixed rocks may exist in the same migmatite area.

An excellent example of the calcic and ferromagnesian type of mixed rock may be seen in the river gorge of Union Falls in the Lyon Mountain quadrangle. Here the rock is composed of alternating bands of hornblendic material and pink granite material. A further step in this kind of migmatization, where the hornblende is converted to biotite, may be observed in the migmatite exposed in the road cut on the south side of Dannemora Mountain in the northwest corner of the Dannemora quadrangle. Pyroxene skarn migmatites, as exposed in the trail 2,000 feet northwest of the Lynch prospect, Dannemora quadrangle, might also be included in this rock type.

The silicic type of mixed rock may be studied in a series of outcrops along the Ausable River road, about 2.5 miles east of Ausable Forks, in the Ausable quadrangle, or along the Ore Bed road (near Ore Pond) south of Redford in the Lyon Mountain quadrangle. The rocks at these localities are banded prominently in green and pink, colors that result from the proportion of soda and potash feldspars, respectively.

The previously mentioned ferromagnesian mixed rock at Union Falls gives way near the northeastern end of Duncan Mountain and Alder Brook Mountains to a siliceous hybrid rock consisting of a pinkish biotite-garnet-sillimanite granite gneiss. This rock probably represents interaction between the magma that produced the Lyon Mountain granite gneiss and a biotite-plagioclase gneiss of the Grenville series.

To generalize, the silicic mixed rocks are characterized by dual coloring, green and pink; the coloring is usually banded but is locally blotchy. Mineralogically, this group has a high biotite content; other prevalent minerals are hornblende, pyroxene, garnet, and epidote. Pink pegmatite is also commonly associated with these rocks.

Nearly all the areas where the Grenville series is shown on the accompanying geologic map include local mixed-rock types that cannot be differentiated on so small a scale. Miller (1926) described other localities in the Lyon Mountain quadrangle, not mentioned here, where mixed rocks may be observed.

Many of his mapped bodies cannot be shown on the map without undue scale exaggeration.

PEGMATITES AND QUARTZ VEINS

Pegmatites have a widespread distribution throughout the area mapped and are encountered in all the mines. Two types exist: a pink type and a white type. The coarseness of texture in both types is variable, and the minerals range in size from units not much coarser than the minerals of the enclosing rocks to units measuring several inches. The pink pegmatites carry potash feldspar, microperthite; the white pegmatites have soda feldspar, albitic oligoclase. Both types have quartz and may or may not contain masses of coarse green pyroxene and magnetite.

No detailed petrographic study was made of the pegmatites; Gallagher (1937) and Alling (1939) have described their mineralogy.

Quartz veins are common in the area, though not so common as the pegmatites. Some of the quartz veins are associated with pegmatite, as described by Miller (1926, p. 29); others occur unrelated to pegmatite. Magnetite may be associated with the quartz.

Miller (1919a) proposed the term "silexite" for dikes, segregation masses, or inclusions of nearly pure quartz of igneous or aqueo-igneous origin. In his work on the Lyon Mountain quadrangle (1926, pp. 44-45) he presented his interpretation of the origin of the isolated silexite and pegmatites contained in the Lyon Mountain granite gneiss. He was of the opinion that the "streaks, lenses, and eyes" of pegmatite and quartz were segregation products formed while the host magma was still fluid and that magmatic flow during segregation tore the pegmatite and quartz masses into the lenslike blebs as now seen. This explanation is not considered valid, as the present investigation reveals that these pegmatite and quartz masses exist not only in the Lyon Mountain granite gneiss but also in the quartz syenite gneiss and the Grenville series. The last-named rocks were not involved in any of the processes associated with the crystalization of a primary magma. Also if Miller's hypothesis is correct it involves magmatic differentiation by silicate immiscibility —for which there is little evidence—in two different magmas: the magma that produced the Lyon Mountain granite gneiss and the magma that produced the quartz syenite gneiss.

The interpretation resulting from the present investigation is that the drawn-out and segregated pegmatite and quartz masses were produced from pre-existing pegmatite and quartz veins injected into the country rocks prior to regional plastic deformation. It is thought now that they represent boudins drawn out and alined in the country rock. This is supported by the fact that at Duncan Mountain the pegmatite strings are drawn out in the foliation of the Lyon Mountain granite gneiss parallel to the mineral lineation of the surrounding rock. There is of course also the possibility that the segregated pegmatite and quartz masses were formed by anatexis during regional plastic deformation.

The evidence for regional plastic deformation is discussed under the heading "Structure" in this paper. A complete discussion of the silexite pegmatite will be presented in a separate paper.

ORIGIN AND AGE SEQUENCE OF THE GRANITIC ROCKS

In order to discuss the origin and age relations of the previously described granitic rocks, it is necessary to evaluate the relative quantities of the types that are present in the area mapped. A basis is thus provided for understanding the relative importance of the modes of origin of the rocks involved. This can be done in terms of the areas occupied by each type. Such an approach is satisfactory for the granite gneisses of the older complex (quartz syenite gneiss and Hawkeye granite gneiss), but it would not be satisfactory for the granite gneisses of the younger complex (Lyon Mountain granite gneiss) because the younger complex includes four subdivisions that are very difficult to identify in the field. Such an areal analysis, with the younger complex undivided, gives the following results:

Approximate area occupied by granitic rocks

	Square miles	Percent
Quartz syenite gneiss	12	5
Hawkeye granite gneiss	58	25
Lyon Mountain granite gneiss	164	70

This tabulation indicates the importance of subdividing the Lyon Mountain granite gneiss, as this formation occupies more than half of the area.

TABLE 19.—*Percentage grouping of granite-gneiss types from drill core within the Lyon Mountain granite gneiss*

	Microperthite granite gneiss	Microcline granite gneiss	Plagioclase granite gneiss	Microantiperthite granite gneiss	Total
Clinopyroxene..	30.8	2.4	14.6	6.7	54.5
Hornblende....	5.5	.2	.2	1.9	7.8
Biotite........	1.4	....	3.4	3.3	8.1
Magnetite.....	[2]17.2	[2]2.9	3.5	5.9	29.5
Total......	54.9	5.5	21.8	17.8	100.0

[1] Total core footage microscopically identified was 4,984.1 feet; total core footage used in computation was 9,831.3 feet.
[2] Alaskitic.

Two lines of approach were used in attempting to arrive at an estimate of the relative amounts of the various granitic types in the Lyon Mountain granite gneiss. Neither method is strictly quantitative, but both may be considered as indicative. First, the thin sections of rock specimens used for control in the general field mapping were classified and tabulated. These specimens may be considered random samples, as their exact compositions were not known at the time they were collected. The results of the classification of 165 thin sections may be seen in the following table:

	Percent
Microperthite granite gneiss	36
Microcline granite gneiss	11
Plagioclase granite gneiss	24
Microanthiperthite granite gneiss	29
	100

The second approach was to classify and tabulate diamond-drill core logs. Intervals identified by thin-section analysis were evaluated in terms of total footage logged, and these were recalculated to 100 percent, table 19. Each group was also subdivided in terms of the dominant ferromagnesian mineral present.

ORIGIN OF THE OLDER GRANITE-GNEISS COMPLEX

The older granite gneiss complex includes the quartz syenite gneiss and the Hawkeye granite gneiss. The former may be correlated with the Tupper-Saranac complex of Buddington (1948, p. 24); the latter may be correlated with his Diana and Stark complexes. The correlation of the Hawkeye granite gneiss with the Diana complex and of the quartz syenite gneiss with the Tupper-Saranac complex is also based on the detailed descriptions given by Buddington (1939, p. 73 et seq. and p. 111 et seq.)

The area occupied by the quartz syenite gneiss in Clinton County is so small that positive evidence on the origin of the rock is difficult to assemble. A few septa of amphibolite and biotite-plagioclase gneiss were observed, and they were interpreted to indicate the intrusive nature of the rock. Buddington (1948, p. 28) has described dikes of quartz syenite gneiss cutting across anorthosite and gravity stratification in the quartz syenite gneiss of the northwest Adirondacks. The correlation of the quartz syenite gneiss of Clinton County with the Tupper-Saranac complex makes a magmatic origin for the gneiss seem reasonable.

The Hawkeye granite gneiss has a great abundance of inclusions of metasediments of the Grenville series. These inclusions are composed of feldspathic gneisses, biotite-quartz-albite schists, mixed rocks, amphibolites, and biotite amphibolites. The inclusions range from small bodies to septa many hundreds of feet wide. Inclusions of this type are interpreted here as indicating intrusion of the Hawkeye into the original Grenville series. It is also believed that the mixed rocks and biotite amphibolites are the result of contact action between the magma and the Grenville.

ORIGIN OF THE YOUNGER GRANITE-GNEISS COMPLEX

In discussing the origin of the Lyon Mountain granite gneiss four subdivisions must be considered: the microperthite, microcline, plagioclase, and micro-antiperthite subdivisions. The plagioclase unit shows little tendency toward gradational trends into the other units. There are, however, gradational types among the other three units. The mineralogic differences of these subdivisions may be obtained from studying tables 11 to 18.

It is the opinion presented here that granitization processes must be considered in discussing the origins of the subdivisions of the Lyon Mountain granite gneiss. The following discussion is presented to support this conclusion. The results must be considered tentative in view of the present uncertainties in interpreting evidence pro and con.

The strongest evidence for assigning a magmatic origin to the microperthite granite gneiss is that dikes of this rock cut both the quartz syenite gneiss and the Hawkeye granite gneiss. These dikes are both concordant and discordant to the foliation of the surrounding rocks. The contacts are knife sharp. These phenomena are interpreted, from the viewpoint of the magmatist, as pointing to magmatic injection. The microperthite granite also has within it numerous inclusions and tabular layers of metasediments of the Grenville series. The smaller inclusions do not show rotation, but this is believed to be due to later deformation which drew out any rotated inclusions parallel to the secondary foliation of the region. Lack of rotation of the inclusions could be interpreted as resulting from directed flow of the magma; but this interpretation is not adopted here for reasons that will be stated later. This phase of the granite also has marked contact effects in areas where it is adjacent to older rocks. The pyroxene content of the granite is unusually high where the granite is in contact with septa of skarn, forming a hybrid rock. The abundance of migmatites and mixed rocks is assumed to indicate assimilation and reaction effects between an intruding magma and older, preexisting rocks. Many of there criteria are susceptible of different interpretations. The dikes could be interpreted by granitizationists as diffusion channels or narrow replacement zones. The inclusions could be considered as relicts, that is incompletely granitized materials, or, in the case of some of the amphibolitic layers, as basic front concentrations. It is felt, however, that, in view of past work in the Adirondacks, such interpretations should not be applied too hastily at the present time, as rigid criteria for differentiating and interpreting the various phenomena have not yet been worked out.

The microcline granite gneiss unit may have a complex origin. Alling (1938, pp. 157, 159, 163) has indicated that some microperthites may be derived from microcline by exsolution, or "unmixing," on decreasing temperature. It may be possible therefore that the microcline granite gneiss was produced from the magma that crystallized to produce the microperthite granite gneiss, but at a slightly different temperature of consolidation. Buddington (1948, pp. 36-99) has expressed the opinion that, in other areas in the Adirondacks, microcline granite gneiss is derived in part by the direct consolidation of sheets of magma, in part from the granitization of metasediments, particular reference to the sillimanite granites, and in part from the metamorphic recrystallization of the microperthite granites. The uniformity of mineral composition of the magnetite or alaskitic phase of the microcline granite gneiss may perhaps be evidence that it crystallized from a homogeneous magma. However, the occurrence of mixed microcline-microperthite granite gneiss in strongly deformed areas in Clinton County is considered as evidence that a great deal of the microcline results from the recrystallization of microperthite into microcline and plagioclase.

The origin of the plagioclase granite gneiss also raises problems. It may have been derived as a byproduct of the granitization of plagioclase gneisses and amphibolites of the Grenville series, or it may have resulted from an anatectic magma—a magma generated by the local remelting of preexisting rocks—generated by soda-rich solutions (Buddington, 1948, p. 40). There is some field evidence in Clinton County to support both ideas. Serial thin sections taken across two large outcrops exposing granitized skarn and amphibolite also show that both plagioclase granite gneiss and microperthite granite gneiss are closely associated with the altered rocks. Similar associations were noted in diamond-drill core. At the Battie mine, plagioclase and microantiperthite granite gneisses are closely associated with amphibolite and biotite schist. However, at other localities, as at Palmer Hill and the Mace mine, plagioclase granite gneiss and microantiperthite granite gneiss occur in alternate bands with microcline or microperthite granite gneiss, and without associated metasediments. A short diamond-drill hole at Arnold Hill is entirely in plagioclase granite gneiss. This makes it evident that granitization of metasediments is not the only factor in the production of plagioclase granite gneiss. The occurrence of plagioclase granite gneiss without metasediments lends some support to Buddington's theory of anatectic magma. Core sections from the Bowen-Signor mine indicate that normal microperthite granite gneiss is in contact with amphibolite layers and has no immediate association with plagioclase granite gneiss. This evidence is further support for the belief that the plagioclase granite gneiss has, at least, a dual origin.

Wahl (1946) has recently advanced another mechanism that might explain the origin of some plagioclase granite gneiss. Recent work has demonstrated in the laboratory that liquids and gases may be differentiated by thermodiffusion-convection. As a possible field example of this process Wahl cites the Almunge stock in central Sweden, where enrichment in soda feldspar occurs at the contact between the stock and the country rock. This type of differentiation probably operates only on a small scale, but it could, perhaps, explain some bodies of plagioclase granite gneiss.

In conclusion, the plagioclase granite gneiss can probably be regarded as having formed in several ways. It may result (1) from local anatexis, (2) from soda-rich solution produced during granitization by a potash-rich magma, and (3) perhaps locally by thermodiffusion-convection at contact zones of the potash-rich magma that produced the microperthite type of granite.

The microantiperthite granite gneiss is considered to be entirely of replacement origin. Evidence for this belief has been previously presented. It is thought to result from the nearly complete replacement of the potash feldspar by sodic plagioclase in the microperthite or microcline granite gneiss. Successive stages of this replacement may be seen in thin sections. Gallagher (1937, p. 23), while not describing plagioclase or microantiperthite granite gneiss as such, has mentioned a late-stage introduction of sodic plagioclase into the zone of the ore body at Lyon Mountain. He believed that the microperthite of the Lyon Mountain granite gneiss formed by exsolution and that it was replaced by a later untwinned albite. This description is consistent with what is here interpreted as an early replacement stage in the formation of the typical microantiperthite granite gneiss.

Certain points involving the time of albitization have a bearing on the origin of the introduced soda. The microantiperthite granite gneiss has replaced an earlier potash feldspar rock, and some of the magnetite ore bodies have replaced microantiperthite rock. The introduced sodic materials therefore were probably more closely related in time of origin to the magnetite than to the plagioclase granite gneiss. Though the evidence is not conclusive, this belief is further supported by the difference in mineralogical character of the plagioclase and microantiperthite gneisses. The plagioclase gneiss is devoid of potash and perthitic feldspar. It is proposed that the enrichment in soda was related to the introduction of magnetite. In other words, in some areas ore formation probably was preceded by albitization of some of the granite rocks. A subsequent section on the origin of the magnetite advances the opinion that the magnetite was emplaced by pneumatolytic processes. It is assumed then that perhaps the soda also was introduced pneumatolytically. Microantiperthite rocks are associated with several of the magnetite bodies (see p. 46). It is not possible to say whether the soda came directly from a deeper zone of magmatic activity or whether the soda was leached from deeper zones of the country rock during the passage of the mineralizing agents. Microantiperthite rock that occurs unassociated with magnetite may perhaps be explained on the assumption that the magnetite mineralizing agents did not penetrate into that area.

In summation, a generalized statement can be made concerning the origins of the four units included in the Lyon Mountain granite gneiss of Clinton County. On the basis of the foregoing discussion, 60 percent of the granitic rocks of the younger complex can be assigned to a magmatic origin; and 40 percent can be said to have originated through processes of granitization and albitization. These figures are arrived at by averaging the results of tabulating thin-section data from field specimens and diamond-drill core, previously presented. All the microperthite granite gneiss is interpreted to be of magmatic origin, and all the microantiperthite granite gneiss is considered to have been derived by granitization. The microcline and plagioclase granite gneiss units, where two or more origins are probable, are arbitrarily divided in half; the parts were then assigned respectively to the two main genetic groups. The figures represent only probabilities, but they may indicate that in Clinton County the process of granitization had a more dominant role than it had in the northwest Adirondack region described by Buddington (1948, p. 43), where granitized rocks are considered to account for only 15 percent of the total volume of younger granite gneisses.

The foregoing discussion is necessary as in recent years the subject of the origin of granites and granitic rocks has again become controversial. Two general schools of thought exist. One school maintains that granites are for the most part derived from the crystallization of a silicate melt (magma) that on intrusion makes room for itself in preexisting rocks. The other school believes that granitic rocks are for the most part derived by a process of granitization of preexisting rocks, a reconstituting or replacing of earlier nongranitic rocks. Grout's definition of granitization (1948, p. 46), is that it "includes a group of processes by which a solid rock—without enough liquidity at any time to make it mobile or rheomorphic — is made more like a granite than it was before, in minerals or in texture and structure, or in both." The processes involved include the introduction of alkalies and silica into country rock by gaseous or hydrous emanations of magmatic origin, or even by ionic migration through solid material from deeper zones in the earth's crust. For a presentation of ideas on ionic diffusion see Backlund (1946) and Reynolds (1946 and 1947).

Both sides of the argument have been represented in a series of papers presented before the Geological Society of America (1948). The main difficulties involved are the scale on which the processes operated, and the difficulty in establishing criteria to determine which process operated. Many of the questions raised are unanswerable at the present time and are chiefly of academic interest. With reference to the scale problem, Buddington (1948, p. 21) and Grout (1948, p. 53) have stated that, in terms of their experience, some 85 percent of the granites that they have investigated owe their origin to the crystallization of a granitic magma. The problem of criteria is confusing in that followers of both schools interpret the same field evidence differently. Writers have expressed the opinion that many of the effects usually explained as being typical of magmatic injection are actually explainable in other ways. Backlund (1946, p. 110) defines the conditions under which he believes granite-intrusive effects can be achieved at high stratigraphic levels in the "geosynclinal pile." Reynolds (1947, p. 221) cites evidence which, in her opinion, makes it possible to interpret some sharp contacts of granite against country rock as diffusion limits rather than as intrusive contacts. Relict fragments (skialiths) and replacement dikes have been described by Goodspeed (1948, p. 63 et seq.) in such a way as to emphasize the problem of adopting criteria by which true xenoliths and intrusive dikes may be distinguished from similar phenomena of replacement origin.

The general situation today is that most magmatists believe in the validity of small-scale granitization by emanations of magmatic origin, but they express considerable doubt concerning the validity of granitization by ionic migration (Bowen, 1948, p. 80 et seq., and Buddington, 1948, p. 21). On the other hand the extreme granitizationists deny the existence of any deep-seated granite magma; they consider the existence of such a magma to be purely hypothetical (Reynolds, 1947, p. 214).

It is to be hoped that extremes in this controversy will be resolved and that future work both in the laboratory and in the field will clarify the role of ionic migration in geologic processes. The evidence for the latter process is still insufficient to permit positive interpretations in the field. The present writer feels, however, that granitization by alkalic emanations of magmatic origin is commoner than generally supposed. The granitic terrane of the Adirondacks will provide excellent material for future research on many of the problems involved in granitization.

AGE SEQUENCE OF THE GRANITE GNEISSES

No contacts between the two units of the older granite-gneiss complex were observed in the field, but if an analogy may be made to Buddington's work (1948, p. 23) in the northwest Adirondacks, the Hawkeye granite gneiss is older than the quartz syenite gneiss.

The younger granite-gneiss complex is separated from the older granite-gneiss complex by a period of orogenic deformation (Buddington 1948, p. 23). Contacts between the subdivisions of the younger complex are obscured in the field by the difficulties involved in their megascopic identification. Examination of diamond-drill cores shows that many of the granitic rocks have haphazard relations to each other. Certain age relations have, however, been established. Dikes of the microperthite granite gneiss have been observed in the Hawkeye granite gneiss and in the quartz syenite gneiss; this demonstrates the younger age of the microperthite granite gneiss. The microcline granite gneiss is contemporaneous with or younger than the microperthite granite gneiss, as it may have developed from the same magma, or developed from reaction of the magma with country rock. The plagioclase granite gneiss is presumably also younger than the microperthite granite gneiss, as it probably resulted from reactions during the intrusion of the microperthite granite magma. The microantiperthite granite gneiss is younger than the microcline and microperthite granite gneiss, as it replaces them. Relations between the microcline granite gneiss and the plagioclase granite gneiss are unknown; this is also the situation with regard to the plagioclase granite gneiss and the microantiperthite granite gneiss, though probably the latter is the younger. The following sequence therefore is tentative and is based on both factual and theoretical considerations. The direction of arrows indicates successively younger rocks:

Hawkeye granite gneiss ⟶ quartz syenite gneiss ⟶

$$\text{deformation} \longrightarrow \begin{cases} \text{microcline granite gneiss} \longrightarrow \\ \text{microperthite granite gneiss} \longrightarrow \end{cases}$$

$$\left.\begin{matrix} \text{microcline granite gneiss} \\ \text{plagioclase granite gneiss} \end{matrix}\right\} \longrightarrow$$

microantiperthite granite gneiss.

DIKE ROCKS

DIKES OF LYON MOUNTAIN GRANITE GNEISS

Several dikes of Lyon Mountain granite gneiss crosscutting and parallel to the structure of the Hawkeye granite gneiss have been encountered in the Lyon Mountain quadrangle. A brief description of the dike phase is therefore given in this section, though strictly speaking the Lyon Mountain granite gneiss is not a dike rock.

These dikes range from less than a foot to several tens of feet in width. The material is pinkish when fresh; on weathering it becomes yellow. The texture is, in the thin dikes, on the fine side of medium-grained. The large dikes are best seen on Silver Lake Mountain. An excellent exposure of a small dike may be seen on a ledge of Hawkeye granite gneiss 1.7 miles N. W. from Clayburg.

A thin section from one of the thin dikes shows a composition and texture typical of the magnetite microperthite phase of the Lyon Mountain granite gneiss.

Miller (1926, p. 41) has described many aplite dikes in the Lyon Mountain quadrangle that occur in the Hawkeye granite gneiss. It was his opinion that the Lyon Mountain granite gneiss and the Hawkeye granite gneiss were derived from a single magma. That this interpretation is not correct has been demonstrated by Buddington (1939 and 1948). It is, therefore, also probable that the dikes Miller described as aplites are the same as the dikes now described as dikes of the Lyon Mountain granite gneiss.

DIABASE DIKES

Numerous diabase dikes exist in the pre-Cambrian rocks of Clinton County. The diabase is fine-grained and dark gray (fig. 7). Both porphyritic and nonporphyritic varieties exist.

In surface exposures the diabase dikes range in thickness from about an inch to 6 feet. Gallagher (1937, p. 53) reports underground thicknesses of 20 feet at Lyon Mountain. The dikes usually strike east or northeast and the dips are steep to vertical. Dikes with strikes west of north exist, but they are not common. Emplacement of the dikes is controlled by the joint systems and faults of the country rock; rarely dike emplacement is controlled by the foliation of the host rock. The thicker dikes show well-defined chilled borders.

Many thin dikes are offset by small faults. Fault breccia composed of diabase and granite has been observed in diamond-drill core from Palmer Hill.

Contact action on the wall rock by diabase is rare, but a granite gneiss cut by diabase in the road cut ascending the south side of Dannemora Mountain has a deeper red color than normal and is cut by innumerable small fractures that show discoloration.

FIGURE 7.—Diabase dike in back of west crosscut, 2113 level, Chateaugay mine, Lyon Mountain, N. Y.

TABLE 20.—*Modal composition of six samples of dike rock*

[I, intersertal (Johannsen, 1939, p. 47); T, trachytic; X, present; G, xenomorphic-granular]

	482–21	79–1	265Q	329	947A	1026
Orthoclase			58.5	68.4		
Microperthite					75.5	35.2
Plagioclase	72.7	An_{45} 68.0	An_{14} 11.5	An_{12} 9.1	An_{11} 9.0	[1]22.8
Quartz			Tr.	Tr.	13.0	38.6
Altered pyroxene (?)	13.4	8.6				
Biotite	1.6	6.1				
Magnetite	10.4	9.7	5.9	6.5	X	X
Chlorite	X	[2]7.5	21.5	15.9		
Calcite	2.0		2.7	X		
Apatite	X	X			X	X
Zircon					X	X
Hematite					X	
Accessories					2.6	3.3
Texture	I	I	Tr.	Tr.	G	G

[1] Highly altered.

[2] Includes calcite.

482-21. Diabase, from DDH 482, southeast limb of the 81 Mine syncline, Lyon Mountain quadrangle.

79-1. Diabase, from DDH 79, Palmer Hill Mine, Ausable quadrangle.

265Q. Syenite dike, on main highway 1,700 feet, N. 45° W. from "D" in "Dannemora Mountain", map of Dannemora quadrangle.

329. Syenite dike, 3,000 feet, N. 55° E., from letter "D" in "Dannemora Mountain", map of Dannemora quadrangle.

947A. Dike of the Lyon mountain complex, prominent ledge 1.7 miles, N. 45° W. from Clayburg, Lyon Mountain quadrangle.

1026. Dike of the Lyon Mountain complex, East side Lyon Mountain, 3,200 feet N. 60° W. from letter "S" in "South Inlet," map of Lyon Mountain quadrangle.

The few thin sections of diabase examined showed considerable alteration. Pyroxene is replaced in part by chlorite and calcite, and the plagioclases are dusty with inclusions. With the exception of the chlorite, the only fresh ferromagnesian mineral is biotite. The textures are intersertal (Johannsen 1939, p. 47). These diabases are similar to diabases described in the literature as occurring throughout the pre-Cambrian rocks of the Adirondack Mountains. They should not be confused with fresh diabases of Devonion age that exist in New England.

SYENITE DIKES

Syenite dikes were recognized at only two localities in Clinton County: on the main highway at the top of Dannemora Mountain and on the north flank of Dannemora Mountain, both in the Dannemora quadrangle. Both dikes are in the Lyon Mountain granite gneiss. The road cut exposes an aphanitic dike about 4 feet thick with an approximate east strike and a vertical dip. The rock is a dark purplish red. The dike on the north flank of Dannemora Mountain is of coarser texture; feldspar laths are clearly discernible to the unaided eye. The color is pinkish to purplish gray.

Thin sections from these localities show the rock to have a definite trachytic texture. Potash and soda feldspar are present. The plagioclase occurs in laths that are subparallel to the orthoclase laths. Original ferromagnesian minerals have been replaced by chlorite.

MELASYENITE DIKES

Gallagher (1937, p. 54) has described melasyenite dikes that he observed in the Chateaugay mine at Lyon Mountain. According to his description the rock is dark greenish black and aphanitic. It is composed of anorthoclase, albite, pyroxene, amphibole, biotite, magnetite, apatite, calcite, and chlorite. No new specimens of this rock were collected.

Table 20 shows modal compositions for the dike rocks. Owing to alterations and the fine texture of the diabase the compositions should be considered only as indicative.

AGE RELATIONS OF THE DIKES

Relations of crosscutting among the foregoing dikes were not observed within the area mapped. But as the diabase dikes cut the Lyon Mountain granite gneiss, dikes of the Lyon Mountain granite gneiss are older. The presence of diabase pebbles in the conglomerate of the Potsdam standstone (upper Cambrian) established the pre-Potsdam age of the diabase (Cushing 1898b, p. 242). Gallagher (1937, p. 55) states that the diabase dikes are cut by the melasyenite, and from a consideration of the literature he says that the diabase dikes are pre-Potsdam, whereas the melasyenite dikes, which he correlates with the bostonite of Kemp and Marsters (1893), are post-Ordovican. But this correlation, Eakle (1893, p. 33) has pointed out, may be in error, as the bostonite of Kemp and Marsters has no ferromagnesian minerals. Cushing (1898b, pp. 242–247) described ferromagnesian-bearing syenite-porphyry dikes of pre-Potsdam age in Clinton and Franklin Counties. Fragments of these dikes were found in the Potsdam sandstone. Consequently Gallagher's melasyenite should possibly be correlated with Cushing's syenite porphyry, as it is evidently rich in ferromagnesian minerals. If the presence or absence of ferromagnesian minerals is a valid criterian for correlation, the two syenite dikes reported here can be assigned to the pre-Potsdam dikes of Cushing (1898b).

Consideration of the foregoing makes it evident that two interpretations of the age relations of the dikes are possible. The evidence is considered too indecisive to make a perference. The following are possible age sequences; the arrows indicate successively younger rocks to the right:

Lyon Mountain granite-gneiss dikes $\longrightarrow$ *pre-Potsdam* $\left\{\begin{array}{l}\text{diabase dikes}\\ \text{syenite dikes}\end{array}\right.$

or

Lyon Mountain granite-gneiss dikes $\longrightarrow$ *pre-Potsdam* diabase dikes $\longrightarrow$ syenite dikes

or

Lyon Mountain granite-gneiss dikes $\longrightarrow$ *pre-Potsdam* $\left\{\begin{array}{l}\text{diabase dikes}\\ \text{syenite dikes}\end{array}\right.$ $\longrightarrow$ *post-Ordovician* melasyenite dikes

SEDIMENTARY ROCKS

PALEOZOIC ROCKS

Potsdam sandstone.—The Potsdam sandstone of the Upper Cambrian age covers the northern two-thirds of Churubusco quadrangle and occupies the central portion of the Dannemora quadrangle. The basal part of the formation is conglomeratic, with pebbles an inch or more in diameter. Much of the conglomerate is arkosic. The conglomerate is white or red. The sandstone ranges from fine- to coarse-grained. The color is white, pink, red, green, and brown.

The bedding of the Potsdam sandstone is horizontal to subhorizontal. Cross bedding and ripple marks are common. The thickness of the sandstone is unknown, but consideration of the topographic range of outcrops in the Churubusco quadrangle would indicate a minimum thickness of 550 feet. A well log given by Cushing (1901, p. 69) for a hole drilled at Morrisonville, Dannemora quadrangle, showed a thickness of 775 feet. The drilling was stopped within the sandstone and did not penetrate the arkosic beds at the base of the formation.

Passage beds of Cushing.—The Potsdam sandstone is separated from the Beekmantown dolomite by 50 feet of passage beds. No outcrop of the passage beds was observed in the field, but Cushing (1901) reported their presence in the drill hole at Morrisonville. The passage beds, which are composed of alternate layers of sandstone and dolomite, according to Cushing, usually have been classed with the Potsdam.

Beekmantown dolomite.—Good exposure of the Beekmantown dolomite of Lower Ordovician age are rarely encountered and are usually seen only in the beds of the larger streams. Within the area mapped the dolomite is on the extreme eastern side of the Dannemora quadrangle. From here it extends eastward into the Plattsburg quadrangle. Good outcrops may be observed in the town of Peru and along the Saranac River near the border of the quadrangle. A drill hole at Morrisville showed 500 feet of dolomite (Cushing, 1901).

The rock is very fine grained, and in color is gray. Thin sections show a trace of quartz; otherwise the rock is composed of rhombic dolomite and interstitial calcite. The material is weakly effervescent with dilute hydrochloric acid.

As previously mentioned, Cushing (1901, p. 69) has published a log of an oil well (dry) drilled at Morrisonville late in the past century. This log is of sufficient interest to be added here:

Log of Morrisonville well, Plattsburg Township

	Feet
Pleistocene. Glacial deposits	20
Calciferous. [Beekmantown] Dolomite	500±2
Passage beds. Alternating layers of dolomite and sandstone	50
Potsdam. Mostly a hard, quartzose white sandstone except for a considerable thickness of red beds, penetrated between 800 and 900 feet. (The well was still in Potsdam sandstone, with no sign at this depth of the arkose beds which always come in as the base of the formation is approached.)	775±2

The Paleozoic rocks originally covered a much larger area. Cushing (1900) refers to an old limekiln on the road from Alderbrook post office to the north branch of the Saranac River that operated on calciferous boulders which he supposed represented the remains of an outlier of limestone. During the present mapping some large, rectangular, close-fitting blocks of Potsdam sandstone were observed on the extreme northwestern end of Johnson Mountain. It is possible that these two occurrences are part of the formerly more extensive cover.

GLACIAL DEPOSITS

Moraines.—Unsorted, heterogeneous moraine deposits are common in the region investigated. Very typical moraine boulder gravels may be seen on the main road leading south from Dannemora. The material includes grade sizes from sand to large boulders. All rock types from the pre-Cambrian to the Paleozoic may be observed.

The thickness of the glacial debris is quite variable; it may be only a few feet thick, or it may attain thicknesses of a hundred feet or more. This variability in thickness can cause considerable difficulty and delay in diamond drilling, and the irregularity of variation makes it difficult to predict before the drilling starts what conditions will be encountered.

Eskers.—A typical esker may be seen southwest of Dannemora, near the western border of the Dannemora quadrangle. This esker, which has a height of some 20 feet, may be traced for about 1½ miles. The only other esker seen lies in the Churubusco quadrangle, just south of Ellenburg Depot. It is about a mile long and attains a maximum height of about 80 feet. Both eskers are composed chiefly of sand.

Kames.—Miller (1926) has called attention to a belt of kames, associated with depressions, that extends in a northeasterly direction from a point near Goldsmith to Hammond School in the Lyon Mountain quadrangle. Similar kames may also be seen east and north of Clayburg. The kames are composed of sands and gravels.

FLUVIAL DEPOSITS

Two well-developed river terraces composed of bedded sands are particularly noteworthy. One of the terraces is in the Lyon Mountain quadrangle, at Moffitsville at the junction of the Saranac River and True Brook; the other is in the Dannemora quadrangle near Peasleeville on the Salmon River. The top of the terrace at Moffitsville lies slightly above the 1,000-foot contour. The top of the terrace near Peasleeville is about at the 900-foot contour.

Excavation in 1947 for a new power dam near Moffitsville exposed bedded pink and white river gravels that in places attain a thickness of more than 100 feet. These gravels probably represent the old channel of the Saranac River.

A prominent lake terrace may be observed around the upper end of Chazy Lake in the Churubusco quadrangle.

DIRECTION OF ICE MOVEMENT

In the Churubusco and Dannemora quadrangle the direction of movement of the glacial ice is readily inferred from glacial striae, chatter marks, and crescentic gouges on the flat bedding surfaces of the Potsdam sandstone. Movement in the Churubusco quadrangle was dominantly between S. 15° W. and S. 40° W.; locally it was north or S. 60° W. In the Dannemora quadrangle movement was S. 40° W., though south of Danemora Mountain motion was S. 15° E.

Miller (1926, p. 71) says that in the Lyon Mountain quadrangle glacial striae vary from S. 30° W. to S. 85° W. In the northwestern part of the quadrangle movement was S. 30° W. to S. 40° W. Along the Saranac Valley the ice moved toward the west-southwest.

Kemp and Alling (1925, p. 73) say that the glacial striae in the Ausable quadrangle mainly indicate a movement of the ice from S. 40° W. to S. 60° W. At Clintonville, however, the movement was southward.

STRUCTURE

The structure of the pre-Cambrian rocks of the area is extremely complex. Contacts concealed by glacial overburden, the Paleozoic rocks and vegetation make it difficult to give a complete generalization of the regional structure. All the rocks, except the late dikes, show foliation, and some have well-developed mineral lineation. With the exception of the dike rocks, the folia of adjacent dissimilar rocks are always parallel. Foliation is most clearly defined in those rocks that have dark minerals.

In general, the regional strike of the foliation in Clinton County lies between north and N. 30° E.

Locally strikes swing eastward where plunging folds intersect the ground surface. Two belts with dominant easterly strike may be noted: the first includes the Bowen-Signor ore belt which extends for about 6 miles parallel to the Saranac River south of Redford; the second occurs in the valley of the Ausable River and extends westward from Rogers for 6 miles. Dips in the Clinton County area range from gentle to steep, both to the east and to the west, and reflect the intricate folding of the region.

FOLDS

The attitude of regional foliation as shown by symbols on the geologic map indicates that all the pre-Cambrian rocks are involved in folded structures, both anticlinal and synclinal. Some of the folds are inferred from widely separated structural measurements. Other folds, of both small (fig. 8) and large sizes, may be observed directly and traced continuously in the field, as they are exposed by mining operations, diamond drilling, and magnetic surveying. Direct observations by these means add strength to the interpretation of folds that are inferred from scattered field data.

Three types of folds exist: isoclinal folds, overturned folds, and open folds. It is possible, however that the open folds are crests or troughs of truncated isoclinal folds. Figure 9, sketched from an outcrop in the Churubusco quadrangle, illustrates an overturned synclinal fold. The sketch shows how the dip of the folds changes direction through a vertical plane. That is, instead of changing through a horizontal plane as in normal folds, the dip reverses through a vertical plane. This phenomenon is common throughout the region.

In general the folds plunge to the north or northeast, but southward-plunging folds have been observed. Plunge as used here designates the inclination of the trough, crest, or axes of the folds measured from the horizontal in a vertical plane.

Grenville series.—The two largest areas of outcrop of the Grenville series are in synclines. One area of synclinal folding covers about 2 square miles south of Hammond School in the Lyon Mountain quadrangle. Minor folding indicates that the fold plunges 40° to the northeast and is overturned to the northwest. The other syncline, in the west-central part of the Churubusco quadrangle, covers

FIGURE 8.—Small-scale folding in Lyon Mountain granite gneiss, vertical section, Williams Street, Lyon Mountain, N. Y.

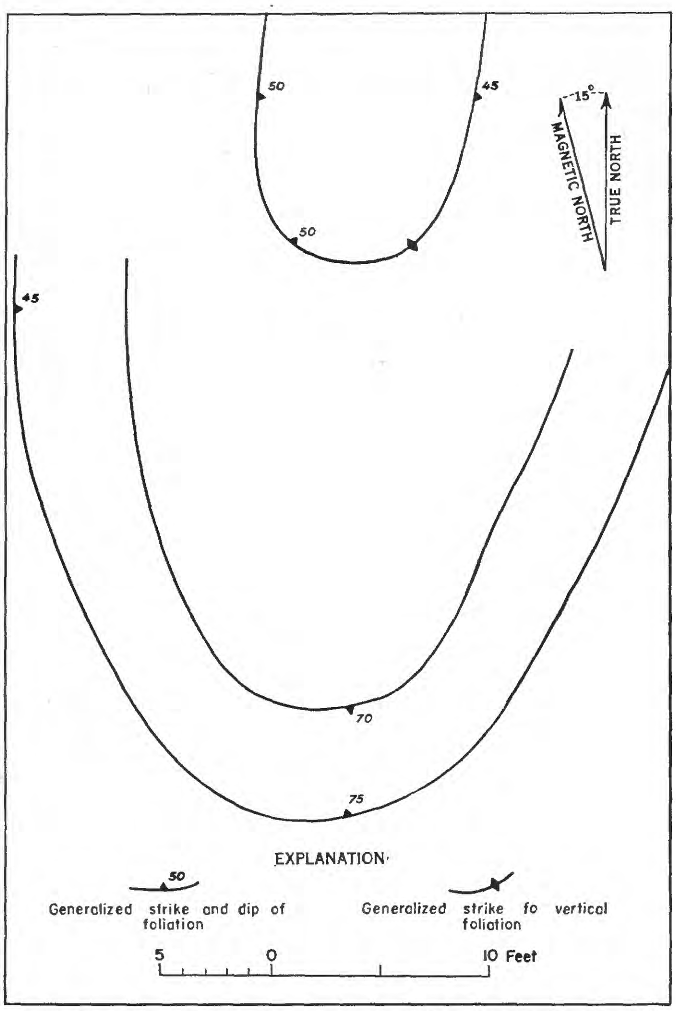


FIGURE 9.—Generalized sketch of complex folding near Hazeltine Hill, Churubusco quadrangle.

about 3 square miles. It plunges 35° to the north. Outcrops of the central part of the area indicate a simple open syncline, but in outcrops on the southern end of the east limb the dips are eastward and reversed. The syncline probably is complex and consists of a series of tight folds. The eastward dips, however, may be due to reversal through the vertical on synclinal limbs such as has been observed elsewhere in Clinton County.

Anorthosite and gabbroic anorthosite.—Anorthosite and gabbroic anorthosite covering approximately 4 square miles may be seen in the extreme southeast corner of the Dannemora quadrangle and in the southward adjoning part of the Ausable quadrangle. The major structure of the mass is not clearly revealed, but outcrops at the northern end indicate an anticline, overturned to the east and plunging 12° to the south.

Hawkeye granite gneiss.—The Hawkeye granite gneiss forms major anticlinal bodies in the Lyon Mountain quadrangle. Two such bodies may be described, one centering around Averill Peak-Lyon Mountain and the other centering around the Silver Lake Mountains.

The Averill Peak-Lyon Mountain body covers some 21 square miles. It is interpreted as an anticline that plunges 30° northeastward, with steep to moderately steep limbs. Both limbs of the anticline are flanked by the Lyon Mountain granite gneiss; the contacts, however, are obscured by drift and vegetation.

The Silver Lake Mountain body occupies approximately 12 square miles. This anticline has limbs of moderate dip and plunges about 25° to the north. The structure of the Lyon Mountain granite gneiss north and east of this mass is conformable.

Both of these anticlines have local synclinal structures within the main bodies of the anticlines.

Another body of Hawkeye granite gneiss in the Lyon Mountain quadrangle west of Moffitsville and north of Redford, covering about 10 miles, has incorporated within it the overturned syncline of the Grenville series that has already been described. The structure of the Hawkeye granite gneiss here is difficult to interpret, but it may be a syncline overturned to the north, similar to the syncline of the Grenville series.

Quartz syenite gneiss. —Quartz syenite gneiss crops out over an area of approximately 12 square miles in the Lyon Mountain and Ausable quadrangles; the major area includes Duncan and Alder Brook Mountains in the Lyon Mountain quadrangle. The structure here is a syncline overturned to the west with a plunge of about 30° to the north. The Lyon Mountain granite gneiss wraps around the outside of this syncline.

SYNCLINAL STRUCTURES IN THE LYON MOUNTAIN GRANITE GNEISS

The Lyon Mountain granite gneiss, which is the largest body of granitic rock in Clinton County, forms major and minor synclines and anticlines. The synclines are of particular economic importance, as they contain many of the magnetite mines. For this reason and because the Lyon Mountain granite gneiss is the major granitic rock of the area, the major synclines and anticlines are described separately.

81 syncline.—The 81 syncline is in the Lyon Mountain quadrangle north of the town of Standish. The true nature of this structure was not understood until recently when the Republic Steel Corp. explored the area in detail. Dip-needle maps show clearly that the old 81 mine is located on the northwest limb of a syncline. The magnetic high extends a short distance southwestward from the mine, curves sharply beneath a drift-covered area, and then turns back parallel to the line of the old mine. Both limbs of the syncline have a strike of N. 45° E. The ground distance, at right angles to the strike, between the two magnetite-bearing limbs is a little more than 2,000 feet. Examination of the old workings and the new diamond-drill cores indicates that the syncline plunges 30° northeastward. Stripping operations show that the syncline is not simple but is made up of tightly compressed folds.

Underground observations along the old mine drifts show that the dip of the ore zone is not constant. In the central part of the mine the ore zone and wall rock dip steeply to the southeast, whereas at the northeast end of the workings the dip is 60° northwestward. This reversal of dip along the strike is common throughout the region. It indicates that a single structure can be in part normal and in part overturned.

Surface outcrops and diamond drilling indicate that the southeast limb of the syncline is in normal uninverted position; the dips are uniformly to the northwest. The rocks forming this limb can be traced for some 8,800 feet, parallel to the strike, until they pass around a small anticlinal fold and connect with the most southwesterly workings of the Chateaugay mine.

Bodies of amphibolite associated with the granite are also involved in the 81 syncline.

Chateaugay synclines.—The Chateaugay mine is in the village of Lyon Mountain. Most of the ore shoots here occur in two synclines called the west syncline and the east syncline. The synclines are separated by an intervening anticline. The east limb of the west syncline shows small but prominent anticlinal rolls. The west syncline, if projected to the ground surface, has a width from limb to limb of about 1,800 feet. The major structures plunge about 40° in a direction somewhat east of north.

Gallagher (1937, p. 56) describes three orders of folds at Lyon Mountain. Major folds in dimensions of hundreds of feet, second-order folds in dimensions of tens of feet, and third-order folds in dimensions of feet or inches. Gallagher interpreted the structure at the mine as consisting of two first-order contiguous anticlines. He considered all synclinal structures in the mine to belong to folds of the second order. Zimmer (oral communication) does not adopt Gallagher's interpretation; he considers the structure to be as described here.

Palmer Hill syncline.—The Palmer Hill syncline may be observed on Palmer Hill in the Ausable quadrangle. This syncline contains the magnetite mines of the Palmer Hill group.

The structure may be traced by measuring dips and strikes at outcrops that encircle the hill. It is also clearly outlined by the positions of the old mine workings. The mine openings start on the southeast side of Palmer Hill and trend in a general southwesterly direction until they reach the southern end of the hill, where they turn sharply back northward. The turn marks the heel of the syncline. The structure plunges 25° to the northeast. The width of the syncline from limb to limb in the magnetite zone is at least 1,000 feet.

The northwest limb of the syncline is connected by a small anticline with another syncline on the next hill to the north of Palmer Hill.

Ellis syncline.—The Ellis syncline is on the southeastern flank of Dannemora Mountain in the Dannemora quadrangle. The southeast limb and heel of this syncline contain the three pits of the Ellis ore bed.

The magnetite of the Ellis ore bed follows the southeast limb of the syncline and continues around the heel of the structure. The U-curve of the heel of the syncline can be observed directly in the most northeasterly of the three mine pits. The map of the magnetic anomaly (Donnerstag, 1945) also shows the hook of the structure. This syncline is narrow and has a gentle plunge to the southwest.

Russia Station syncline.—The Russia Station syncline makes up the greater part of Johnson Mountain in the Lyon Mountain quadrangle. The structure encloses three parallel magnetite zones, of which the Phillips zone crops out in the railroad cut at Russia Station.

Direct observation of this syncline is not possible. Its existence and attitude are inferred from dip and strike measurements, from observation of small-scale folds, and from the fact that other magnetite zones occur in synclinal structures. The small-scale folds are isoclinal and are strongly overturned to the west. If inference from the data is made, the major structure is interpreted as isoclinal, overturned to the west, with a plunge to the north.

West of north, the syncline connects with the Averill Peak-Lyon Mountain anticline. East of north the syncline is separated from the Ellis syncline by an anticlinal fold; farther on it converges with the Ellis syncline.

ANTICLINAL STRUCTURES IN THE LYON MOUNTAIN GRANITE GNEISS

REGIONAL ANTICLINES

Large anticlines entirely within the younger granite gneiss are well developed in the Dannemora quadrangle. The large structures cannot be observed directly, but their existence is inferred from the regional dip and strike determined by measurements at many outcrops.

The Terry Mountain anticline forms the main mountain mass south of Peasleeville in the Dannemora quadrangle. This anticline plunges 30° to the northeast. A small synclinal structure is on the flanks of the main anticline.

The Hogback Mountain anticline centers over Hogback Mountain in the southwest corner of the Dannemora quadrangle. The plunge of the anticlinal axis is 15° to the north.

The Mount Etna anticline extends north and south from Mount Etna in the Dannemora quadrangle. The main part of the anticline plunges 15° to the northeast. Small synclinal folds are associated with it.

In the northwest corner of the Lyon Mountain quadrangle a prominent anticlinal structure exists in the area of Birch Hill. It differs from the previous structures in that it has both a pronounced trend and inferred plunge eastward. This anticline probably in connected with the 81 syncline. The dip of the limbs of the anticline in places, like the dip of the 81 syncline, tends to vary through the vertical.

CLOSED FOLDS

There is both direct and indirect evidence that dome- and basin-shaped folds exist in the younger Lyon Mountain granite gneiss. The closed folds have smaller dimensions than the large regional anticlines and synclines. They may, however, reach 2,000 feet parallel to their longest dimension. The closed structures probably represent wrinkles or bulges on the limbs of larger structures.

An excellent example of a dome-fold structure, in part replaced by magnetite, has been revealed by the mining operations in the Chateaugay mine at Lyon Mountain. In the mine the dome fold is called the 750 hump. It is an elliptical hump in the hanging-wall vein, about 1,000 feet long, which parallels the strike of the hanging-wall vein. The two ends of the fold plunge in opposite directions; one end plunges in a general northeasterly direction with the plunge of the containing syncline; the other plunges opposite to the regional plunge. Zimmer in an oral communication states that the hump is not a simple dome fold but a series of tight isoclinal folds. The hump, which is also reflected in the footwall vein, gradually smooths out and disappears.

Another dome structure may be traced by outcrops around the southernmost peak of the Mitchell Mountain mass in the southwest corner of the Dannemora quadrangle. The Hogback mine is on this peak.

The peak is circular, and the dips of the outcrops are all outward away from the central vertical axis of the mountain, indicating the domical nature of the structure. The dome fold, however, is probably not a simple one. A diamond-drill hole put down on the Hogback mine shows that the direction of the dip is reversed underground.

A basin structure is inferred from outcrops about a mile northeast from the Hogback mine dome, in the Dannemora quadrangle. Here around two smoothly oval hills most of the outcrops dip inward about the central vertical axis of the area. The southeastern side of the structure shows a local anticlinical bulge. The Mitchell test shaft is on the west side of the basin.

PLANAR STRUCTURES

It is doubtful if any of the pre-Cambrian rocks in Clinton County can be considered structureless. In varying degrees they all show foliation on careful examination. The foliation in many of the isolated outcrops is obscured by weathering and vegetation, but if the moss cover is stripped back and the weathered material is hammered off, the attitude of the foliation can be determined. Many outcrops, however, have clearly defined foliation (fig. 10).

Grenville series.—Most of the metasediments of the Grenville series are extremely well foliated. The biotitic rocks of the series show the foliation by a strong alinement and parallelism of the biotite

FIGURE 10.—Foliation in granitized amphibolite with crosscutting diabase dike, horizontal surface. Main highway (N. Y. 3) 1.1 miles west of Clayburg, N. Y.

plates. In the feldspathic pyroxene gneisses the foliation is emphasized by parallel layers of pyroxene. In the amphibolites the long axes of the hornblende crystals are always parallel to the foliation. The foliation of weathered outcrops of Grenville rocks is often brought out sharply as a heavy ribbing; these are instances where weathering reveals instead of obscures foliation. Foliation in the pyroxene skarns is often difficult to see, as the coarse texture and dark green color of the rock veils the structure. The skarn migmatites are perhaps indicative of the intruded granite following planes of weakness and foliation in the original skarn; the foliation of the skarn migmatites is always parallel to the foliation of the surrounding rocks.

The foliation of the Grenville series in the Clinton County area probably is parallel to the bedding of the original materials. This belief arises from the fact that the foliation was nowhere seen to transgress lithologic units. Different lithologic units are parallel to each other and to the foliation.

Gabbroic anorthosite.—The foliation of the anorthositic rocks is well defined in the gabbroic facies. Foliation planes in the gabbroic type are emphasized by layered segregation of the pyroxene, hornblende, and garnet components of the rock.

Hawkeye granite gneiss and quartz syenite gneiss.—The phacoidal Hawkeye granite gneiss has a very strong foliation. The foliation is marked by the parallel orientation of the blocky feldspars and by the elongated form of the quartz. These mineral constituents occur in much coarser textures than in any of the other granite rocks.

In the quartz syenite gneiss the foliation is determined by the parallel arrangement of the mafic constituents and by the parallel arrangement of tabular feldspars.

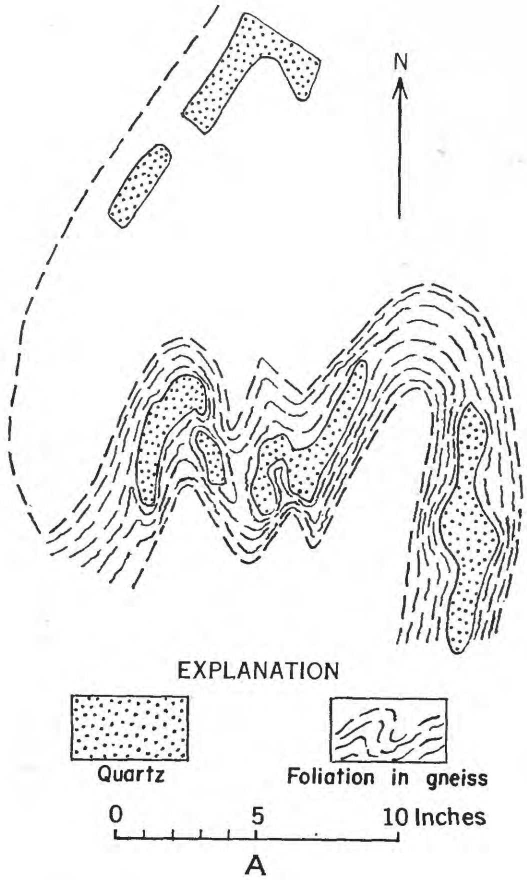
Lyon Mountain granite gneiss.—The subdivisions of the younger granite gneiss that are rich in ferromagnesian minerals have a clearly defined foliation owing to the planar arrangement of these constituents. Foliation in the alaskitic types is usually less distinct and in some rocks is very difficult to see. Close inspection, however, usually shows that foliation is outlined by a slight coarsening of texture in some of the layers, by planar arrangement of the accessory magnetite, by a slight flattening of the quartz grains, or sometimes by a layered arrangement of very small vugs. To obtain the orientation of the indistinct foliation, it is essential that the rocks be examined in all three dimensions. In some places weathering gives clear delineation to the foliation (fig. 11).

BOUDINAGE

Boudinage structures (Cloos, 1946) are not uncommon in Clinton County. They may be seen in both the Grenville series and in the Lyon Mountain granite gneiss.

Quartz boudins occur in a biotite-garnet gneiss of

FIGURE 11.—Foliation in Lyon Mountain granite gneiss, crosscutting pegmatite at upper right. Exposure on creek at Black Brook mine, N. Y.



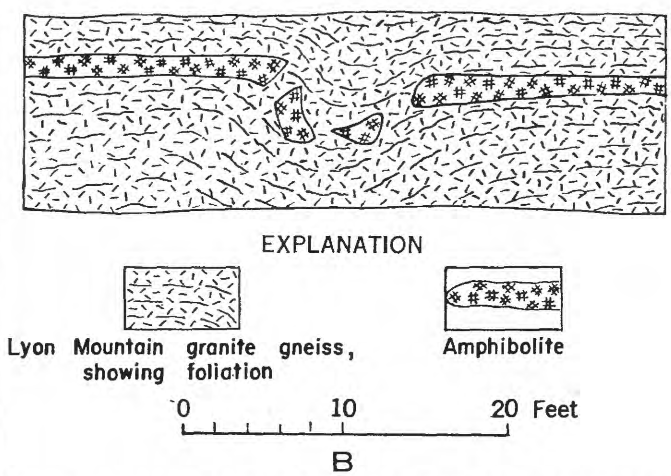


FIGURE 12.—*A*, Quartz boudins on horizontal surface in biotite-garnet gneiss of the Grenville series on low hill 0.6 mile N. 56° E. from "h" in "Goldsmith," Lyon Mountain quadrangle, N. Y. Sketch traced from photographs. *B*, Boudinage of amphibolite in roof of 2113 level, east footwall drift in Chateaugay mine, Lyon Mountain quadrangle, N. Y.

the Grenville series east of Goldsmith in the vicinity of Two Brooks, both north and south of the Saranac River. The boudins are to be seen as small elongated lenses and blebs of quartz. The foliation of the enclosing gneiss is parallel to the long axes of the quartz lenses. Where the quartz lenses bend, the foliation of the gneiss bends with them (fig. 12 *A*). These boudins are interpreted as quartz veins that were injected into the metasediments prior to deformation. During plastic regional deformation the competent quartz veins were broken apart and the metasediments, acting incompetently, flowed into the intervening spaces. Wegman (1932) has described a similar occurrence of amphibolite boudins in schist.

Figure 12*B* illustrates amphibolite boudins in the Lyon Mountain granite gneiss as seen underground in the Chateaugay mine. Here the amphibolite acted as the competent rock and the granite gneiss as the incompetent rock during plastic deformation. Pyroxene skarn boudins (fig. 36) can also be seen at the outcrop of the footwall vein at the Chateaugay mine.

FIGURE 13.—Pegmatites parallel to mineral lineation of Lyon Mountain granite gneiss, viewed from underside of foliation plane. South end of Duncan Mountain, N. Y.

LINEAR STRUCTURES

Linear structures associated with foliation are fairly common in the pre-Cambrian rocks in Clinton County. The linear elements usually trend northward or a little to the east of northward and have a moderate plunge in the same direction. The trend is generally close to the strike of the foliation plane in which the lineation occurs, but there are examples of lineation where the plunge is directly down the dip of the foliation plane. The road cut on the south side of Dannemora Mountain exposes a rare example of horizontal lineation in rocks with horizontal foliation.

The commonest type of lineation is one in which minerals with long axes aline parallel in the plane of foliation. The lineation is usually marked by the ferromagnesian minerals, hornblende or pyroxene, but elongated quartz grains can also be the linear element. A less common type of lineation is that created by the exposure of the axes of small folds. This type of lineation is seen as a linear plication in the crests or troughs of the small folds. Lineation can occur in foliation planes that have either low or steep dips.

The Grenville series shows both mineral lineation and plication lineation on minor folds.

Mineral lineation in the anorthositic rocks has been observed. Hornblende crystals and occasional garnets are strung out in parallel lines.

Mineral lineation in the Hawkeye granite gneiss becomes pronounced near the crests or troughs of plunging folds. Under these conditions the foliation becomes indistinct and difficult to observe. Buddington (1939) described similar phenomena which he noted in the Diana complex. The linear element is produced through a lengthening of the quartz grains in the rock.

The quartz syenite on the east flank of Duncan Mountain exhibits unusually strong mineral lineation. Parallel alinement of hornblende in the foliation planes of the rock is chiefly responsible for this structure.

Many of the units of the younger Lyon Mountain granite gneiss show well-developed mineral lineation. As in previously described cases, the lineation is seen as an alinement of dark minerals in the foliation plane of rock. In general the trend of the lineation is near the strike of the foliation plane bearing it. Two localities, however, show the linear element plunging straight down the dip of the foliation. One locality is on Johnson Mountain, north of Russia Station; the other is on the southern end of Duncan Mountain; here pegmatites (fig. 13) are also parallel to the mineral lineation. Both localities are in the Lyon Mountain quadrangle.

RELATIONSHIP OF LINEATION TO FOLDING

Three types of mineral lineation must be discussed: the lineation that has a trend close to the strike of steeply to moderately dipping foliation, the horizontal lineation that occurs in horizontal foliation, and the lineation that has a plunge parallel to the dip of the foliation plane.

Lineations that trend nearly parallel to the strike of the foliation are interpreted as being closely parallel to the fold axes of the region. This relationship has been demonstrated in the underground working at the Chateaugay mine, and by diamond-drilling exploration on the 81 syncline. In the Chateaugay mine the linear structures are parallel to the plunge of the ore shoots; the ore shoots, in turn, are almost parallel to the axes of the containing synclines. Diamond drilling on the 81 syncline indicates that the trend and plunge of its axis is very close to the trend and plunge of the mineral lineation on the wall rock in the old mine.

Horizontal lineation in horizontal rocks has a trend parallel to nearby plunging folds. The horizontal lineation exposed in the road cut on the south side of Dannemora Mountain trends nearly parallel to the axis of the gently plunging syncline that contains the Ellis ore body. This area showing horizontal lineation is probably a transitional zone connecting the gently southwestward plunging folds of the Ellis ore body with the northward-plunging, more intensely deformed Russia Station syncline.

Two types of linear structure that plunge parallel to the dip of the enclosing foliation plane have been observed. One type occurs on the flank of a fold; the other on the nose of a fold.

An interesting example of a down-dip lineation on the flank of a fold is shown in the outcrops of the rocks of the Russia Station syncline on Johnson Mountain. The syncline has been interpreted as a structure sharply overturned to the west. In intense deformation of this kind it is probable that the lineation is developed parallel to the direction of shear between the foliation planes.

The second type of down-dip mineral lineation is on the south and west side of Duncan Mountain in the Lyon Mountain quadrangle. The Duncan Mountain syncline, though overturned, has not been overturned to the extent of the Russia Station syncline. The plunging heel of the Duncan Mountain syncline, which is exposed to direct observation, shows a well-developed mineral lineation plunging nearly parallel to the dip of the enclosing foliation. This lineation is apparently parallel to the fold axis of the main structure. The eastern limb of the syncline has normal lineation trending close to the strike of the foliation; the trends of the two types of lineation are closely parallel.

Linear elements that trend closely parallel to the strike of the foliation plane, horizontal lineation that lies in a horizontal foliation plane, and lineation on the heel or nose of a fold that plunges parallel to the dip of the foliation are given similar interpretations. These lineations are parallel to the axes of the major regional folds. They are parallel to the axis of rotation, or *b* axis, of the tectonic fabric. Lineation of this type is at right angles to the direction of shear between the foliation planes.

The lineation found on the flank of a fold and plunging parallel to the dip of the foliation is interpreted as being at right angles to the major axis of folding and parallel to the direction of shear between the foliation planes. Such a lineation is parallel to the axis of transport, or *a* axis, of the tectonic fabric. It is characteristic of extreme deformation and is not to be confused with the foregoing types of lineation. It should be emphasized that in Clinton County this type of lineation has been observed only on Johnson Mountain. Its geometric orientation is based on the assumption that the major structure with which it is associated is a sharply overturned syncline. Some writers have also suggested that this type of lineation is the result of secondary movements at right angles to the lineation.

Anderson (1948) in a recent paper has presented the opinion that the direction of shear and lineation are always parallel. It is considered here that lineation both parallel to and at right angles to the direction of shear exists in the Adirondacks. Buddington (1939, pp. 308–310) has discussed the relation of lineation to folding in other parts of the Adirondacks; the relations are very similar to those in Clinton County.

The commonest type of lineation encountered is the type that is parallel to the regional fold areas.

TYPE OF DEFORMATION

Previous views. — Several interpretations have been advanced to explain the origin of the structure of pre-Cambrian rocks in the Adirondacks. Many workers in the field have advanced the idea that the structure of the granitic rocks is due to the control of intruding magmas by the structures of the preexisting Grenville series. This may be true in part for other areas but it does not seem to be a valid explanation for the structure of Clinton County, as the volume of Grenville rocks exposed compared to the volume of granitic rock is negligible. Thus it is hard to visualize how such a small quantity of Grenville rocks could control the entry of such large volumes of granitic rock. It would be difficult to advance the idea that the volume of the Grenville series was reduced during intrusion by magmatic assimilation, as large-scale assimilation would have produced a greater quantity of hybrid types of igneous rocks than are extant in the area.

If the present structure of the area was controlled by the structure of the Grenville series, the theory of regional granitization would be more applicable, in fact the relative volumes of granitic rocks and metasediments might be taken to support this view. Replacement of the Grenville rocks by granitizing substances would preserve the original structure. Replacement of earlier structures has been demonstrated for other areas, but such an interpretation probably should not be applied to the Adirondacks until more evidence is available than is now at hand. Previous discussion has attempted to show that the greater part of the granite rocks of Clinton County are of magmatic origin.

Many writers have also expressed the opinion that the structure of the granites is the product of primary magmatic flow. Primary magmatic flow structures are relatively simple patterns (Balk, 1937). It is therefore difficult to conceive of magmas flowing in structural patterns as complex as those seen in Clinton County. If the structure was produced by primary flow, it would be expected that the foliation of igneous rocks of different ages would not be parallel as they are, but that successively younger rocks would have foliations parallel to their contact zones. This is based on the assumption that the successive intrusions during pre-Cambrian time were not conformable.

Miller (1916) wrote a lengthy paper to substantiate his view that the structure of the granite gneisses was caused by magmatic flowage under mild external compression. He restated this view in 1926 in his work on the Lyon Mountain quadrangle. More recently both Gallagher (1937, p. 58) and Alling (1939, p. 145) have advanced the opinion that the structure in the granite gneisses is due to primary magmatic flow and not to regional stress. The principal evidence advanced to support this interpretation is the existence of "miarolitic cavities,"—a better term would be drusy vugs (Pecora and Fisher, 1946, p. 384)—ranging in size from a few inches to several feet, in the younger granite gneiss of the Chateaugay mine at Lyon Mountain; it is maintained that such cavities could not have remained open during the operation of postconsolidation stresses. Mining operations since the publication of the foregoing papers have revealed that diabase dikes form one side of several "miarolitic cavities," thus indicating that the vugs are not truly miarolites but are younger than the diabase intrusion, otherwise the diabase would have flowed into and filled the cavities. Zimmer (1947b, p. 653) mentioned five cavities which have diabase for one wall. Gallagher (1937, p. 55) states very definitely and correctly, that the diabase dikes cut all other rocks and structural features and therefore are younger than the deformation of the granite rocks.

The common phenomenon that the foliation planes between folds in the younger granite gneiss change direction of dip through the vertical instead of the horizontal has been interpreted by Buddington (1939, p. 324) as the result of magmatic flow. Probably a better interpretation is that it is the result of differential yield while the rock mass was reacting plastically to the regional stresses.

Another argument makes it difficult to explain the Clinton County structure as a product of primary magmatic flow. The commonest type of lineation in the pre-Cambrian rocks of Clinton County is parallel to the fold axis, the *b* axis of the tectonic fabric This is the type of lineation common to deformed rocks. In primary magmatic flow the principal lineation is parallel to the *a* fabric axis, except possibly where it results from the type of flowage present in phacolithic structures. The single example of lineation parallel to the *a* axis that exist in Clinton County (on Johnson Mountain) can be explained as the result of extreme deformation. These criteria have been discussed by Turner (1948, pp. 181-182). The general lineation of the region, therefore, is more characteristic of secondary deformation than of primary magmatic flow.

Present interpretation.—Buddington (1937, p. 51) was of the opinion that the structure of the Santa Clara quadrangle resulted from plastic yield and flow of solid rocks during a period of regional stress. Plastic deformation is controlled by the mechanical factors of crystal gliding, rotation, and crushing. Physicochemical factors that operate in plastic deformation includes recrystallization, differential mineral solubilities under different conditions of temperature and pressure, ionic interdiffusion, and the action of permeating gases and fluids.

Evidence is presented which indicates that the structural pattern of Clinton County probably resulted from similar conditions.

Regional foliation.—Rocks of all ages in Clinton County from the Grenville series to the Lyon Mountain granite gneiss show parallel arrangement of their foliation planes. Contact areas between granitic rocks of different ages or between granitic rocks and metasediments are always parallel regardless of the complexity of the local structure. This structural parallelism is evident in several areas, as at Duncan Mountain where the structure involves granite gneisses of different ages, or in the area west of

Moffitsville where granite gneiss and the Grenville series are involved. The structural parallelism of metasediments and igneous rocks of different ages is taken to indicate that all the rocks were deformed plastically at the same time. This last stage of deformation probably reoriented and changed former structures formed by primary magmatic flow or earlier periods of deformation. It is highly probable, however, that earlier structures acted as guide planes, or control planes, during the last period of plastic deformation.

Regional lineation.—Contact areas of rocks of different ages also show parallel lineation. The lineation in the Lyon Mountain granite gneiss and in the Hawkeye granite gneiss is parallel in the Lyon Mountain area. This is again interpreted as indicating that all the regional lineation was formed during the same period of plastic deformation.

The Hawkeye granite gneiss shows weak foliation and strong lineation in regions near the crests of anticlinal structures. Buddington (1939, p. 310) has expressed the opinion that this phenomenon is consistent with a combination of flexure folding and plastic flow since shear between foliation planes is at a minimum in the crest of an anticline.

Mineralogical and textural evidence.—The quartz in the Hawkeye granite gneiss is characterized by its coarse, elongated, ribbonlike habit. On a smaller scale, some of the quartz grains in the alaskitic phase of the Lyon Mountain granite gneiss also show a tendency to elongation. Elongation of quartz grains in this fashion is not typical of the texture of granites that have resulted from direct magmatic crystallization. The habit is therefore interpreted as indicating recrystallization during regional deformation.

It is also interesting to note that in the Duncan Mountain area the pegmatites show a linear stretching parallel to the mineral lineation of the enclosing gneiss (fig. 13). The parallelism of these linear elements probably results from plastic deformation.

The subdivisions of the Lyon Mountain granite gneiss are involved in the regional deformation. Additional evidence of recrystallization is given by the microperthite granite gneiss. Buddington (1939, p. 331) has described the breakdown of microperthite on recrystallization to microcline and plagioclase. Though it is not impossible, perhaps, that this recrystallization could be induced by static pressure, such an explanation is thought to be improbable, as static pressure would not produce the present regional structure. Inspection of the modal composition tables of the microperthite granite gneiss shows that in general the microperthite granite gneiss with both microperthite and microcline contain more plagioclase than the microperthite granite gneiss that contain no microcline. The higher content of plagioclase in the group with both microperthite and microcline is interpreted to indicate that recrystallization occurred during a period of plastic deformation after consolidation of the microperthite magma. That the greater part of the microperthite granite gneiss has been subjected to recrystallization is indicated by the fact that the microperthite granite gneisses containing microcline are much commoner than those lacking microcline.

Microstructures. — Buddington (1939, pp. 301, 331) has described microstructures that he considers indicative of recrystallization during plastic deformation. The granoblastic textures described and figured by him are very similar to textures here designated by the nongenetic term xenomorphic-granular. The Clinton County granitic rocks also frequently exhibit granular, cataclastic, mortar, and mylonitic textures. Cataclastic textures are particularly common in ore zones that are associated with folded structures. All these textures are considered by Buddington to indicate recrystallization during regional plastic deformation. It is doubtful that any of the cataclastic structures described here for the Lyon Mountain granite gneiss are of protoclastic origin—granulation of early crystallized minerals caused by flowage of the still fluid portion of the magma—as nearly all the rocks of the area have them.

Conclusion. — The evidence presented makes it seem improbable that the greater part of the structure of Clinton County resulted from the control of intruding magmas by the structure of the Grenville series, from primary flow, or from large-scale regional granitization. The parallelism of planar structures, and parallelism of linear elements for all the rocks of the region, and the predominance of microstructures that are characteristic of crushing and recrystallization are interpreted as indicating a yielding plastically of the rocks of the area to regional stresses while in a solid state. It is quite possible, however, that structures due to earlier deformation or magmatic flow acted as control planes for the final plastic deformation.

TIME AND DIRECTION OF STRESS ACTION

Major overturning of folded structures occurs to the west and northwest. This would indicate that the stress operating on the area came from the east and southeast. The strongest overturning observed in the district is on the east and southeast side of the Hawkeye granite gneiss mass at Averill Peak and

Lyon Mountain. This is suggestive that the Hawkeye may have stood as a relatively rigid mass during deformation.

The folded structures of the region involve the youngest pre-Cambrian rocks in the area, which belong to the Lyon Mountain granite gneiss. It is therefore evident that the last period of orogenic stress occurred during or after the intrusion of the magma that produced the Lyon Mountain granite gneiss.

RELATION OF MAGNETITE DEPOSITS TO FOLDS AND LINEATION

Several of the ore bodies in Clinton County are in synclines. The structure of some of the ore bodies has been clearly revealed by mining operations. The Chateaugay, 81, Palmer Hill, and Ellis ore bodies are known to occur in synclines. The Russia Station ore bodies are inferred to be in a synclinal structure. Information on most of the other ore bodies in the district is to sketchy to permit definite statements concerning the structural relations.

In none of the ore-bearing synclines is the ore evenly distributed throughout the structure; it is usually confined to one limb of the fold, as in the Chateaugay mine. In the 81 mine the ore is confined to the northwest limb and the keel of the syncline. The southeast limb is magnetite-bearing for a considerable distance, but nowhere does the magnetite attain sufficient concentration to make ore. At Palmer Hill the line of the old workings indicates that ore follows the southeast limb and goes part way around the heel of the syncline before it dies out. The Ellis ore body is on the southeast limb of a small syncline. The most northerly of the old pits and the magnetic anomaly show that the ore follows around the heel of the syncline and then disappears. It is not possible to make a positive statement concerning the relation of the Russia Station ore bodies to the Russia Station syncline, as the southern end of the structure is covered with glacial drift.

Anticlinal ore-bearing structures of large size have not been proved in the district. Anticlinal and dome-shaped rolls found in the Chateaugay mine are of minor importance compared with the major ore zone. Magnetite at the Lynch prospect may lie on the flank of an anticline, as inferred from outcrops in the vicinity of the prospect. The Hogback mine may be located on the flank of a dome, but such an interpretation is complicated by a reversal in the direction of dip underground.

No reasonable hypothesis has been found to explain why several of the major magnetite deposits of the district are in synclines rather than in anticlines. The ore is not confined to a limb common to an anticline and a syncline; in one place ore can be followed into the keel of the syncline, and in other places it can be traced around the heels of plunging synclines.

It is also somewhat difficult to explain why ore concentration is confined to one limb of a syncline. A possible explanation may be that during deformation the limbs of the synclines sheared differentially; that is, shearing was more intense on one limb than on the other. The more intensely sheared limb would then be more permeable to the mineralizing agents. The evidence for this belief is not positive. The ore-bearing limb at the 81 mine is the limb that shows reversal of dip; this might be expected to be accompanied by a greater amount of shear. The Russia Station syncline was overturned to the point where some overthrusting developed; it is to be expected that shearing would be intense under such conditions. However, surface exposures at the Palmer Hill mines indicate that the barren limb of the syncline has the steeper dip, and it would be reasonable to suppose that the more steeply dipping limb would have been subjected to the greater shearing stress.

Some of the magnetite bodies, as has been demonstrated at the Chateaugay and 81 mines, have a pencillike form. These bodies lie parallel to the foliation of the enclosing rocks, which are synclinally folded, and they plunge parallel to the axes of the folds and to the mineral lineation of the surrounding rocks. The ore shoots are not separated or isolated from each other. They are connected along the foliation either by thin, noneconomic stringers of rich magnetite or by relatively thick zones of weakly disseminated, noneconomic magnetite.

The Palmer Hill and Arnold mines are described in the literature as having similar ore shoots. Two diamond-drill holes put down adjacent to the Bowen-Signor mine by the United States Bureau of Mines did not intersect ore. This may indicate that ore at this locality also occurs in pencillike shoots; that is, the holes may have passed between the ore shoots.

Shoots were probably localized by replacement along lines of weakness or they formed parallel to the *b* fabric axis during the original deformation of the host rock.

In summary, several important magnetite deposits in Clinton County occur in synclines. Some of the magnetite is in pencillike shoots within the foliation of the syncline; the shoots plunge with the syncline and parallel to the mineral lineation of the host rock. The existence of true tabular ore bodies has not been demonstrated in the region.

FIGURE 14.—Migmatite showing reverse-fault drag against pegmatite-filled overthrust-fault plane. Road cut on main highway (N. Y. 374) near top of southeast side of Dannemora Mountain, N. Y.

Some allowance should be made for the local structural pattern of ore shoots; otherwise erroneous interpretations might be made should a drill hole pass between shoots.

The trend and plunge of ore shoots may be approximated from the trend and plunge of the mineral lineation of the outcrops in the vicinity of the ore zone.

FAULTS

Faults of both small and large magnitude exist in Clinton County.

Small faults with displacements of a few inches are encountered throughout the region. These small faults include both normal and overthrust faults (fig. 14). The small overthrust faults may be seen on the southern end of Johnson Mountain in the Russia Station syncline and in the road cut on the south side of Dannemora Mountain.

The large faults, all of which appear to be normal, are best seen in the Dannemora and Lyon Mountain quadrangles. They are shown by prominent brecciation, as at .Russia Mountain, or by marked discordance of the strike of the gneisses on opposite sides of the fault, as south of Terry Mountain, or by a definite topographic feature, such as the pronounced change of slope that separates the Paleozoic sedimentary rocks from the granite southwest from Harkness. It is not possible to ascertain the amount of movement on any of these large faults.

Russia Mountain fault.—The Russia Mountain fault crosses Russia Mountain and overlaps the Dannemora and Lyon Mountain quadrangles. It is just south of Moffitsville on the Saranac River. The fault breccia may be observed in a quarry on the north side of the mountain. Much brecciated granite is exposed in this quarry. A tunnel driven through the nose of the mountain in 1947, in conjunction with the construction of a new dam at Moffitsville, gave excellent definition to the fault. The fault zone has an approximate west-northwest strike and a vertical dip; the south block moved up relatively. The brecciated zone is about 40 feet wide and is cut by several diabase dikes. The strike length of this fault cannot be ascertained, but it is possibly very great.

Terry Mountain fault.—The Terry Mountain fault is south of the Terry Mountain block and separates it from the Hogback-Mitchell Mountain-Etna Mountain block in the Dannemora quadrangle. The fault is not exposed. Its position is inferred from a line across which the regional foliation shows a marked discordance of strike. North of the line the regional foliation has a general easterly to northeasterly strike; south of the line the regional foliation has a general northerly strike. The line is also marked by sporadic boulders of brecciated granite. A probable spur fault branches from the main fault and extends up the west end of Terry Mountain; its position is marked by a prominent slickensided scarp. The north side of the spur fault moved up relatively. The strike length of the main fault may be a few miles.

Palmer Hill fault.—The position of the Palmer Hill fault is indicated by a line on the southeast side of Palmer Hill near the mines; across this line there is discordance of the regional strike. Southeast of the line the regional strike is northwest; northwest of the line the regional strike is northeast. Diamond-drill holes cut a brecciated zone and permit fairly accurate location of the fault. The breccia is composed of granite and diabase fragments. The fault has a general northeast strike and a dip of 60° NW. Evidently the fault plane passes beneath the ore zone. The length of the fault parallel to the strike is not determinable.

Harkness fault.—The existence of the Harkness fault is inferred from topographic considerations. A prominent ridge of the Lyon Mountain granite gneiss extends southwestward from Harkness in the Dannemora quadrangle. The ridge is bordered on the northwest by a flat wedge of Potsdam sandstone. The sandstone contact is 500 feet lower than the summit of the ridge. The rise in altitude from the sandstone flat to the granite summit is abrupt, so that the front of the granite ridge forms a pronounced topographic scarp. A fault with a strike length of at least 3 miles is inferred from this evidence; presumably the southeast side of the fault is the upthrown side.

On the accompanying map not all the contacts between the Paleozoic and crystalline rocks are shown as fault contacts; normal contacts are shown where evidence not as definite at the foregoing is lacking. It is possible that many of these contacts are fault contacts. Miller (1926) has suggested that the basins of Chazy and Upper Chateaugay Lakes are fault valleys.

Lyon Mountain faults.—Zimmer (1947a) has described two sets of faults observed underground at the Chateaugay mine. One set has an easterly strike; the other set has a northeasterly strike. Both fault systems have vertical dips; the fault planes may be filled with diabase. In the east-striking system the north side is the upthrown block; in the northeast-striking system the northwest block is upthrown. Movement is probably vertical. The movement on these fault systems is apparently not great. Gallagher (1937, p. 61) also described underground faults with northwesterly strikes. The northwest system offsets diabase dikes.

Chazy Lake fault.—There is a possibility that a fault of considerable extent may exist in the Lyon Mountain and Churubusco quadrangles. This fault, if substantiated, would truncate the western extremity of the body of Hawkeye granite gneiss in the Churubusco quadrangle, pass along the western shore of Chazy Lake, and extend southward just west of Moffitsville in the Lyon Mountain quadrangle. This fault would have a strike length of at least 12 miles.

Evidence for the existence of the Chazy Lake fault involves the interpretation of the Hawkeye granite gneiss of Ellenburg Mountain as an offset and downthrown segment of the Hawkeye of the Lyon Mountain block. Additional evidence for this possible fault might be taken from the foliation strike pattern northwest and west of Moffitsville. The southern end of this fault may cut or connect with the Russia Mountain fault; there is, however, no positive evidence for this.

The Chazy Lake fault is shown on the accompanying maps by a symbol denoting its doubtful nature. Additional evidence should be obtained before a fault of such magnitude is definitely accepted.

Redford fault.—A small outcrop of granite-diabase breccia is on the main highway at the west side of Redford. The exposure is now almost completely concealed, but Miller (1926, p. 67) reported the zone to be nearly 100 feet wide.

The strike of the granite-diabase breccia is approximately parallel to the valley of the Saranac River at Redford. There is, therefore, the possible implication that the valley of the Saranac River may be controlled at this point by a fault. Again, however, the evidence is so weak that this fault too is shown on the accompanying maps by a symbol implying doubt as to its existence and extent.

Age of the faults.—A general age relation between the faults and the diabase dikes may perhaps be stated. Some of the faults are younger than the diabase; as some of the fault systems offset the dikes. This relationship may be observed underground in the Chateaugay mine and elsewhere in the area. The existence of granite-diabase breccia at Palmer Hill also demonstrates younger fault movements.

There is, however, the possibility that the faults are both older and younger than the diabase, or contemporaneous with it. The diabase may have entered older fault zones, and later renewed movement may be responsible for the offsets and brecciation.

Definite evidence in the Chateaugay mine indicates that the eastward-trending and the northwestward-trending fault systems are younger than the ore deposition. The hanging-way and footwall veins are offset by both systems.

The following time sequence indicates a possible relationship between the fault systems and other events in the area; the arrows indicate decreasing age:

Late plastic deformation ⟶ ore deposition ⟶
faulting ⟶ diabase intrusion ⟶ faulting.

JOINTS

All the rocks of Clinton County show strong jointing. The dominant joint systems of the region trend northward and eastward. Minor systems have strikes in a general northwesterly or northeasterly direction.

GEOLOGIC HISTORY

The geologic history of Clinton County is very similar to that of other parts of the Adirondacks as described by other workers in the field, notably Buddington (1939) and Buddington and Leonard (1945). The oldest rocks in the area are the metasedimentary rocks of the Grenville series. Into the Grenville rocks were successively intruded anorthosite, gabbro, Hawkeye granite gneiss, quartz syenite gneiss, Lyon Mountain granite gneiss (microperthite and microcline granite gneiss, plagioclase granite gneiss), pegmatites, quartz veins, dikes of metadia-

Synopsis of Geologic History

Quaternary	River sands and gravels Gravel, sand, clay, till, etc.
	——Unconformity——
Post-Ordovician	Melasyenite dikes (?)
	——Intrusive contact——
Ordovician	Beekmantown dolomite Passage beds
Cambrian	Potsdam sandstone with basal conglomerate
	——Unconformity——
Late pre-Cambrian	Late pre-Cambrian diabase dikes and syenite dikes
	——Intrusive contact——
Middle and Early pre-Cambian	Lyon Mountain granite gneiss { Pegmatite and quartz veins; Ore deposition; Microantiperthite granite gneiss
	Period of orogenic plastic deformation and metamorphism
	Lyon Mountain granite gneiss { Pegmatite and quartz veins; Plagioclase granite gneiss; Microcline granite gneiss; Microperthite granite gneiss
	——Intrusive contact——
	(?) Period of orogenic plastic deformation and metamorphism
	Quartz syenite gneiss Hawkeye granite gneiss
	——Intrusive contact——
	Metagabbro and amphibolite
	——Intrusive contact——
	Anorthosite Gabbro anorthosite
	——Intrusive contact——
	Grenville series; metasediments { Amphibolites, biotitic and pyroxenic amphibolites, pyroxene skarn, feldspathic garnet-pyroxene gneiss, feldpathic pyroxene gneiss, biotite gneiss, quartz-feldspar gneiss, granitized and migmatized pyroxene gneiss.

base, syenite porphyry and possibly melasyenite dikes. These pre-Cambrian rocks are covered in parts of the area by relatively flat lying Cambrian conglomeratic sandstones and Ordovician dolomite and by Quaternary deposits. Quaternary deposits are shown on the map only where they are so thick as to preclude the mapping of the basement complex. Actually, a thin veneer of glacial debris is found throughout the area mapped.

The age succession of the igneous rocks is probably as given, though within the relatively small area of Clinton County contacts are rarely seen. The structural trends of the various adjacent pre-Cambrian rocks are parallel.

Most rocks of the area have well-defined foliation. The structural patterns as now seen were produced by plastic deformation under regional stress in pre-Cambrian time, preceding, during, and after the intrusion of the youngest granite magma. Any original primary magmatic flow structure probably was destroyed or modified by the final plastic deformation.

The geologic history of the area is summarized in the following table. The evidence for the period of deformation and metamorphism between the quartz syenite gneiss and the Lyon Mountain granite gneiss is not clear in Clinton County. The period is included in the following table as it can be demonstrated for the northwest Adirondacks (Buddington, 1939). The division of the pre-Cambrian into middle and early is also based on the work of Buddington.

CLASSIFICATION OF MAGNETITE DEPOSITS

The magnetite deposits are classified in terms of different kinds of host rocks; but in terms of magnetite content the deposits are essentially all of a single type.

Two forms of magnetite concentrations are to be seen in Clinton County. The concentrations of major importance are in the younger granitic rocks and their incorporated metasediments. Concentrations of minor importance are in pegmatites and quartz veins. The minor concentrations are the younger and are considered to have had different origins. The Hawkeye granite gneiss and the quartz syenite gneiss do not contain economically important concentrations of magnetite.

The magnetite of the mineralized zones is later than the primary magnetite of the magnetite granite gneisses and the associated rocks containing ferromagnesian silicates. It can usually be differentiated in thin sections from the primary magnetite by the fact that it is not generally in small irregular or euhedral grains but is instead in irregular coarse masses that have embayed and replaced earlier minerals, or it is in veinlets that have followed mineral boundaries or cut across preexisting minerals (fig. 15).

Some of the general large-scale structural features of the ore deposits have been referred to in a preceding section on structure. Specific details of the structures of individual deposits, where known, will be given in the section on magnetite mines and prospects (see p. 49).

Concentrations of magnetite occur in the following host rocks of the Lyon Mountain complex: pink microperthite-microcline granite gneiss, plagioclase granite gneiss, microantiperthite granite gneiss, skarn migmatite, granitized skarn (contaminated granite gneiss), skarn, quartz veins, pegmatite veins, and mixed types. The quantity of magnetite in these rocks may range from noneconomic concentrations to concentrations of commercial importance.

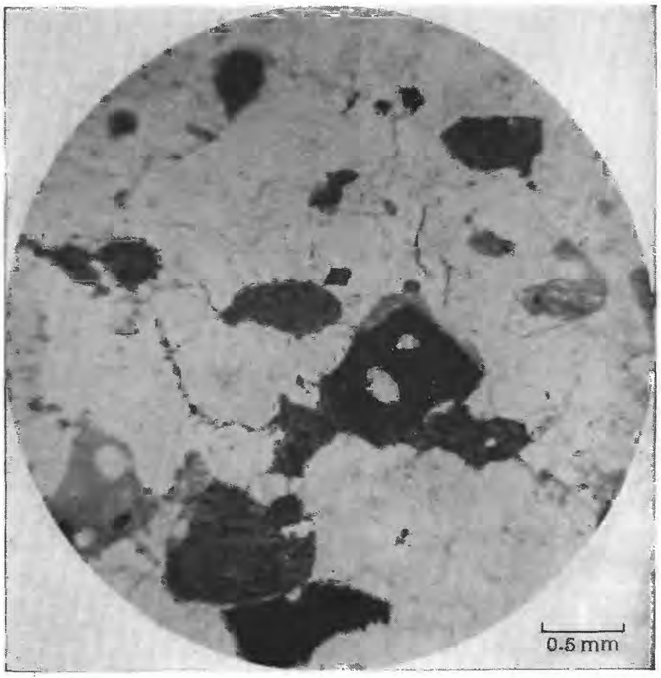


FIGURE 15.—Photomicrograph showing primary magnetite (black, euhedral) and secondary magnetite (black, containing unreplaced inclusions of microperthite), in Bowen-Signor mine. Crossed nicols.

DEPOSITS IN THE LYON MOUNTAIN GRANITE GNEISS

Microperthite granite gneiss (alaskitic type) mineralized by magnetite is typical of the Palmer Hill mines in the Ausable quadrangle. The magnetite occurs disseminated in a pink, medium-grained microperthite-microcline granite gneiss. Pyroxene and biotite, though sometimes present, are rare. Granite gneisses with fluorite and dark-red garnet are found in the old dumps and in old diamond-drill cores. The garnet has replaced pyroxene.

Large magnetite ore bodies that have replaced plagioclase granite gneiss are found in Clinton County. The best example is the 81 mine near Standish in the Lyon Mountain quadrangle. The plagioclase granite gneiss is a grayish coarse-grained oligoclase-quartz rock containing in places thin layers of coarse green pyroxene skarn and more rarely thin layers of microperthite granite gneiss. The magnetite has replaced the plagioclase granite gneiss, as well as some layers of the skarn.

Part of the magnetite ore in Clinton County is in a pyroxene-contaminated microantiperthite granite gneiss. In the hand specimen the ore is in a medium-grained grayish-green rock. The magnetite has replaced pyroxene, microantiperthite, and plagioclase. An example of this type of ore is found at the Battie mine.

DEPOSITS IN SKARN-TYPE ROCKS

The Ellis ore bed is a typical example of what is interpreted to be mineralized and granitized skarn. The magnetite is in a medium-grained microperthite-pyroxene rock, of pinkish or greenish color depending upon whether the feldspar or pyroxene predominates.

The Hogback mine contains a good example of ore in skarn migmatite. The host rock is a medium-grained white microantiperthite granite gneiss with layers of green pyroxene. The bulk of the magnetite is confined to the pyroxene layers, the intervening layers of microantiperthite being but sparsely replaced.

The only typical pyroxene skarn ore occurs in the Dannemora quadrangle at the Lynch prospect. Magnetite is seen at the outcrops, and its presence at depth is indicated by the magnetic anomaly. The outcrop consists of layers of coarse green magnetite-bearing pyroxene skarn within the granite gneiss country rock.

DEPOSITS IN QUARTZ VEINS

Vein quartz carrying appreciable quantities of magnetite is commonly seen on old dumps and waste piles. The material is a coarse aggregate of smoky quartz and magnetite and probably comes from gash veins.

Good examples of this material may be seen on the dump at the Mitchell test shaft in Dannemora quadrangle.

DEPOSITS IN PEGMATITE VEINS

Magnetite-bearing pegmatite veins, common in all the mineralized areas in the northeast Adirondacks, have a particularly prominent development on Third and Fourth Mountains, southeast of Parsons Knob in the Lyon Mountain quadrangle. There, flat-lying pink pegmatites, rich in magnetite, crop out over a considerable area. Field estimates place the magnetite content of the pegmatites at approximately 30 percent by volume. Assays made on channel samples by Republic Steel Corp. from material on Fourth Mountain confirm this estimate and indicate a high titanium content. It is the general opinion that the proportion of pegmatites to host rock is too low for the magnetite pegmatites to have any great value as a source of iron.

DEPOSITS IN MIXED-HOST ROCKS

Many of the ore deposits in Clinton County occur in host rocks of mixed type. Frequently two types of host rock are involved. The Russia Station ore body is an excellent example of this type of deposit. The magnetite occurs in a pink medium-grained pyroxene-low quartz-microperthite granite gneiss as well as in a gray medium-grained quartz-free plagioclase syenite; both host rocks are subdivisions of the Lyon Mountain granite gneiss.

Another example of ore in a mixed type of rock is at the Bowen-Signor mine near Redford in the Lyon Mountain quadrangle, where material obtained from the old mine dumps shows that the magnetite occurs both in a green coarse-grained quartz-rich pyroxene skarn and in a gray to pink medium-grained pyroxene-plagioclase granite gneiss.

The same host rocks are also seen westward along the strike of the gneisses between the Bowen-Signor mine and the old Clayburg and Tremblay mines.

MICROSHEARING

Microshearing or microgranulation of the host rocks of ore is usually not evident in a rough broken hand specimen but may be seen in many diamond-drill cores as thin sheared zones.

Under the microscope rocks from many of the mineralized areas show some degree of granulation. This granulation may give typical cataclastic textures, peripheral granulation, local nests of crushed materials, fractured mineral grains, or well-developed mylonitic channels. Crushed areas show strong recrystallization in some places. Magnetite ore, when associated with such textures in crushed or recrystallized rocks, is clearly later in origin than

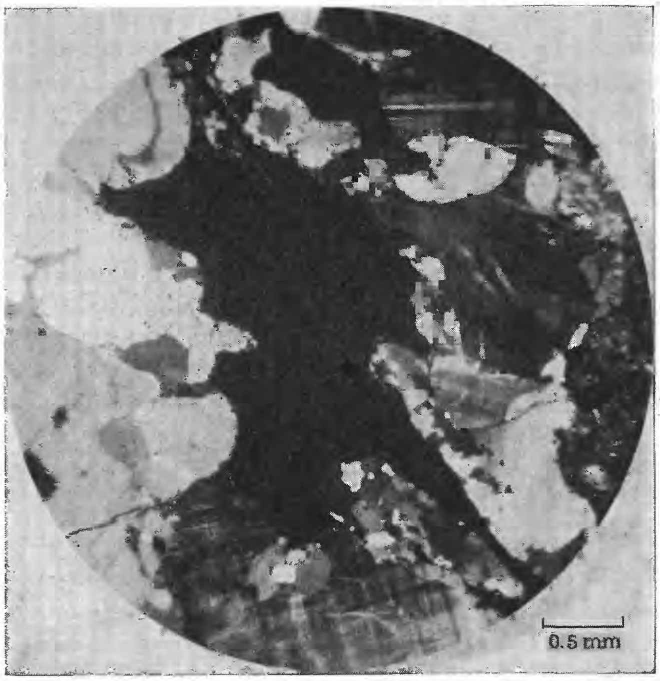


FIGURE 16.—Photomicrograph showing secondary magnetite (black center area) replacing and crosscutting cataclastic texture, Bowen-Signor mine. Crossed nicols.

FIGURE 17.—Photograph showing secondary magnetite (black) replacing shattered quartz, Tremblay mine. Crossed nicols.

the textural features (figs. 16 and 17); it cuts across grain boundaries and replaces the crushed fragments. The crushing effects are more apparent in ores with a granite host than with a granitized skarn host. However, the latter type of ore, such as at the Ellis mine, is associated at many places with cataclastic textures in the hanging-wall or footwall zones.

Examination of thin sections from mineralized zones in Clinton County revealed shearing in the minerals associated with the ore or in the hanging-wall and footwall rocks in 41 percent of a total of 250 sections. General field mapping was controlled by some 400 additional thin sections, of which only 10 percent revealed some type of cataclastic textures. Of the 27 mines investigated, 72 percent have some type of granulation associated with the mineral deposits, either in the gangue or in associated rocks. Table 21 shows this association. Such an association suggests that the mineralizing emanations may have entered the host rock selectively along shear zones.

MINERALOGY OF THE ORES

OPAQUE MINERALS

MAGNETITE

The principal ore mineral is magnetite (Fe_3O_4), a black magnetic oxide of iron. Hand specimens of ore show that the magnetite is distributed through a variety of gangue minerals as irregular fine- to coarse-grained aggregates.

TABLE 21.—*Cataclastic texture in mineralized zones*

Mine	In ore gangue	In hanging walls or footwalls
Arnold		X[1]
Averill	([2])	([2])
Bannerhouse	X	
Battie	X	X
Bowen-Signor	X	X
Chateaugay	X	X
Clayburg		X
Duncan	X	
81		X
Ellis	X	X
Hogback	([2])	([2])
Jackson		X
LaMar	([2])	([2])
LaVake	([2])	([2])
Lynch	([2])	([2])
Mace	X	X
Miner	([2])	([2])
Mitchell		X
Nelson Bush	X	X
Palmer Hill		X
Russia Station	X	
Rutgers	([2])	([2])
Tremblay (mine)	X	
Tremblay (pit)	X	
Winter	X	X

[1] X, shows for each mine the place where the cataclastic texture was noted.
[2] No cataclastic texture noted.

When examined in polished mounts under the ore microscope in plane-polarized light magnetite is a pale whitish gray. If, however, it is associated with martite it takes on a faint pale pinkish cast. Under crossed nicols it is isotropic. A drop of concentrated hydrochloric acid placed on the magnetite becomes yellow; the area adjacent to but beyond the drop tarnishes. Etching with hydrochloric acid sometimes reveals very thin spindles of ilmenite, some of which are arranged in a rhomboid grid pattern, that otherwise are not visible even with very high magnification. Edwards (1949) described such textural relations as resulting from exsolution intergrowths of hematite and magnetite. Some examples of late quartz rimming or cutting across the ore magnetite have been observed. Under the reflecting ore microscope the magnetite is seen to have definitely replaced the gangue; much of it has replaced crushed gangue minerals, cutting across or embaying them.

Inspection with a binocular microscope of polished mounts of magnetite in quartz-feldspar matrix reveals a variety of interesting textures. The transparent nature of the gangue permits three-dimensional observation of the mount. Under these conditions some of the magnetite is seen to have a honeycomb texture. Many large aggregates are connected by feeder veins and sheets. A few small rodlike bodies plunge into the gangue and are connected by thin sheets of magnetite, similar to the relationships of the large-scale ore shoots of the Chateaugay and 81 mines.

MARTITE

Martite is a black ferric oxide (Fe_2O_3) that is pseudomorphous after magnetite; it is produced by oxidation of magnetite. In hand specimens martite may be distinguished from magnetite by its blue-black color, its red streak, and its very low magnetic susceptibility.

As will be noted in succeeding sections, many of the magnetite mines have considerable quantities of martite associated with the magnetite; this is particularly true of the Arnold Hill group of mines. In the Arnold Hill area martite is so extensive that it even proxies for accessory magnetite in the granite gneiss that adjoins the ore deposits, i.e., martite granite gneiss takes the place of the regional magnetite granite gneiss (alaskite).

The quantity of mixed martite-magnetite ores emphasizes the need for research on the efficient and economic reclamation of the martite component.

When examined in polished specimens under the reflecting ore microscope, martite shows a silvery gray color and a marked anisotropism. This is in definite contrast to the pale pinkish color of magnetite and its isotropism. Martite does not take as high a polish as magnetite, and it does not react with hydrochloric acid. As seen under the reflecting ore microscope martite occurs as isolated areas within magnetite, as rims on and embayments into magnetite, or as replacement zones along fracture cracks. The most definite evidence that martite is later than and has replaced magnetite is the common euhedral form of the crystals as octahedra pseudomorphs after magnetite. The anisotropism of the martite is adequate to distinguish it from magnetite.

ILMENITE

Ilmenite ($FeO \cdot TiO_2$) is present in the Clinton County ores, but it is not distinguishable in hand specimens.

Much of the "nontitaniferous" Adirondack iron ore contains some titanium; assays range from a trace to less than one percent of TiO_2. Some spotty high values have been reported, the highest being 2.55 percent TiO_2 in one sample from Palmer Hill.

Examination of polished ore samples under the reflecting ore microscope shows that the titanium is in the mineral ilmenite. Some TiO_2 may also be derived from accessory sphene. The ilmenite commonly occurs as very small spindles or rods, sometimes arranged in grid patterns, within the magnetite, though it may occur also as large discrete grains. Under the reflecting ore microscope it is readily identified by its optical properties, which are different from those of magnetite and martite. In plane-polarized light it has a gray color of a different tone from that of the magnetite. Under crossed nicols ilmenite has a strong anistropism in gray to brown. The mineral takes a smooth polish. If hydrochloric acid is applied to ilmenite the solution becomes faintly yellow.

No attempt was made to determine quantitatively the ilmenite present in the magnetite; in general it amounts to very little.

SULFIDES

Sulfides are not common in the Clinton County magnetite ores. Only one sample with pyrite was found among many polished ore mounts examined from the district; this was obtained from the Battie mine. Old assays show this mine to have one of the highest values for sulfur, 0.12 percent.

NONOPAQUE MINERALS

SPHENE

Sphene is an accessory mineral in many of the ores. Most of it forms small discrete grains; a little of it forms secondary rims around magnetite. The best example of the secondary rims of sphene was seen in a sample from the Hogback mine.

Any contamination of the iron concentrate by titanium from accessory sphene would result from the secondary sphene rims around magnetite, since ordinary grinding would probably not entirely remove such rims. Contamination by the discrete grains of sphene would not be expected, as magnetic separation after grinding should remove them. The bulk of the titanium shown by assays is derived from ilmenite enclosed in magnetite.

APATITE

Apatite is a common accessory mineral in the ores, characteristically in very small quantities but in fairly large grains. Most of this mineral is removed during magnetic separation of the ore. The phosphorus reported in ore assays, however, is probably due to apatite that adheres to the magnetite grains.

The LaVake mine is the only mine examined that shows appreciable quantities of apatite in the gangue. This apatite is exceedingly coarse grained.

QUARTZ

Most of the quartz associated with the magnetite occurs as large easily separable grains. Some of the magnetite has rims or crosscutting veinlets of quartz that might be difficult to separate by grinding. This later quartz would account in part for the high silica content shown in some assays.

The best examples of the silica rims on magnetite were seen in polished mounts or sections of ore from the LaVake mine and the Lynch prospect (fig. 18).

The quartz content of the gangues in the district has a wide range. Therefore, the silicosis hazard

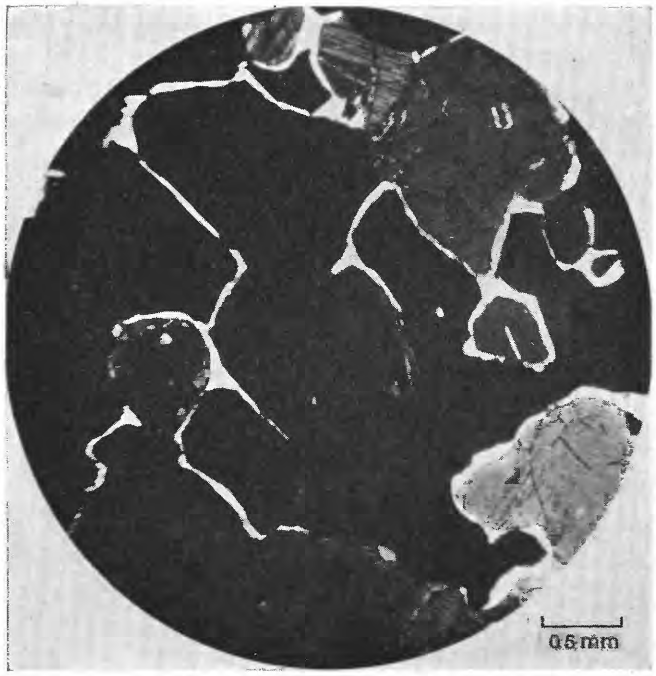


FIGURE 18.—Photomicrograph showing secondary quartz (white) separating magnetite (black) from pyroxene (gray), Lynch prospect. Crossed nicols.

involved in mining operations must be evaluated for each individual deposit.

CLINOPYROXENE

Green clinopyroxene is usually a common constituent of the ore gangue; it occurs also in the granite rocks, pegmatites, and skarns of the area and in part fills fractures and veins. The pyroxene is of somewhat uncertain origin and it probably has more than one origin. The widespread occurrence of this mineral justified some detailed optical and chemical investigation.

The clinopyroxenes that occur in the various types of granite gneiss and skarn show a wide range in color, in shades of green, both in hand specimens and under the microscope. Individual specimens under the microscope show a wide range in optical properties, and when crushed and separated in heavy liquids, they show an appreciable range in specific gravity. Separations according to the specific gravity of a single sample show several shades of green.

In hand specimens the clinopyroxenes in the granite gneisses range from medium green to blackish green; in skarn from dark green to blackish green. On surfaces with a semismooth finish, such as diamond-drill core, the clinopyroxenes of all the rock types are medium green.

Under the microscope in transmitted light most of the clinopyroxenes of the granite gneisses are pale green and show a weak pleochroism. The clinopyroxenes of the skarns are deep emerald green; the pleochroism is generally weak though occasionally strong.

On the basis of their color in thin section, the clinopyroxenes fall into two groups: the pale-green pyroxenes of the granite gneisses and the emerald-green pyroxenes of the skarns. The other optical properties within the color grouping show considerable variation. The variability of the optical properties is shown in table 22.

TABLE 22.—*Universal-stage determination*[1] *of optical constants from thin sections*

[772 and 815 are from granite gneisses. TrM-2 and BS-3 are modified skarn pyroxene]

Sample No.	Color[2]	[3]2V	Range 2V	Z∧c[4]	Range Z∧c	Percent[5] of Diop-side	Heden-bergite	Acmite
772.....	Pale green	[6]60°	52°–64°	[6]47°	46°–49°	30	68	2
815.....	Pale green	[7]66°	62°–67°	[6]48°	36°–52°	70	20	10
TrM-2..	Emerald green	76°	68°–82°	[6]51°	48°–60°	80?	....	20?
BS-3...	Emerald green	73°	69°–78°	[6]61°	58°–63°	19	56	25

[1] Determined by Dr. Dorothy Wyckoff, Department of Geology, Bryn Mawr College.
[2] Color arranged in order of increasing intensity from top to bottom.
[3] ±4°, correction for dispersion.
[4] ±2°, correction for dispersion.
[5] Winchell (1933, p. 233). Composition determined from the optic angle and extinction angle.
[6] Average of five determinations.
[7] Average of four determinations.

When the optical data are used in conjunction with Winchell's (1933) diopside-hedenbergite-acmite diagram no precise composition can be obtained. It is not possible to achieve a point intersection for values of the optic angle, intermediate index of refraction, and extinction angle. The chemical analyses of Adirondack pyroxenes indicate that pyroxene molecules other than those used in the diagram are possibly the cause of this lack of agreement. The general compositional areas indicated by the diagram are hedenbergitic diopside, with, in all cases, the acmite molecule being the smallest component.

One of the modified skarn-type pyroxenes (sample TrM-2; analyst, Lee C. Peck) was selected for chemical analysis. The results are as follows:

SiO_2	52.11	K_2O	0.06
Al_2O_3	1.86	K_2O+	.12
Fe_2O_3	4.59	H_2O-	.05
FeO	7.93	TiO_2	.06
MgO	11.32	MnO	.23
CaO	20.16		
Na_2O	1.61		100.10

TABLE 23.—*Universal-stage determinations of optical constants from crushed and separated material (sample TrM-2) submitted for chemical analysis*

[Determined by Dr. Dorothy Wyckoff, Department of Geology, Bryn Mawr College]

2V[1]	Range 2V[2]	$Z \wedge c$[1]	Range $Z \wedge c$[3]
64°	51°–82°	52°	46°–58°

[1] Average of nine determinations.
[2] ±4° correction for dispersion.
[3] ±2° correction for dispersion.

The indices of refraction of sample TrM-2 were determined by Dr. H. H. Hess (1949) of Princeton University with the following results:

$$\left.\begin{aligned}\alpha &= 1.6977\\ \beta &= 1.7055\\ \gamma &= 1.7240\end{aligned}\right\} \pm 0.001$$

$$\text{Birefringence} = 0.0263 \pm 0.0003$$

Recasting the chemical analysis in terms of standard pyroxene molecules gives the following results:

Diopside	58.30	Fe_2O_3	0.12
Hedenbergite	26.60	SiO_2	.24
Acmite	9.54	Al_2O_3	1.12
Enstatite	4.11		100.03

OTHER NONOPAQUE MINERALS

Gangue minerals, apart from those already described, vary from one deposit to another. At any locality the host rock is the determining factor. The common gangue minerals are quartz, plagioclase, microcline, and microperthite. The grain size of these minerals is such that ordinary grinding and magnetic separation should produce a clean magnetite concentrate.

ORIGIN OF MAGNETITE ORES

In the past many theories have been advanced to account for the origin of the Adirondack magnetite ores. Most of the older geologists believed that the ore was of sedimentary origin. In fact, as late as 1922 Nason (1922a) was still inclined to place emphasis on this theory.

In 1898 Kemp suggested that the magnetite was formed by solutions of igneous origin and that it was the result of contact action and replacement; in 1910 he changed his opinion and interpreted the ore as a basic segregation in the syenite—equivalent to the Lyon Mountain granite gneiss.

Newland in 1908 suggested that solutions of an igneous origin were responsible for the ores. It was his opinion that the iron was derived from an acid magma deficient in lime and magnesia, the excess iron being concentrated by hot vapors and waters.

In 1923 Colony maintained an igneous origin for the magnetite in southeastern New York. The process he invoked called for the differentiation of a basic magma to produce a mobile end-phase "aqueo-igneous" solution rich in magnetite, quartz, and gases. This end-phase in turn was split into pegmatite and magnetite fractions. The magnetite fraction then replaced the calcareous facies of the Pochuck gabbro gneiss and the Grenville series during a period of stress.

Kemp and Alling in 1925 in discussing the ores of the Ausable quadrangle decided that the magnetite was derived by the differentiation of a plagioclase granite magma which produced abnormal amounts of magnetite instead of the usual ferromagnesian minerals. The differentiation may have been stimulated by the chill-Soret principle through the presence of metasediments of the Grenville series and metagabbro. They also believed that some magnetite may have been concentrated by pegmatitic activity and the action of heated vapors.

Another paper by Alling in 1925 gives an excellent tabulation of the history of the ideas relating to the origin of Adirondack iron ores and restates his belief that the magnetite is the result of replacement by aqueo-igneous magnetite-rich solutions derived from a differentiating granitic magma.

Miller's interpretation (1919b) of the mineralization of the Lyon Mountain granite gneiss, advanced the idea that the vehicle for iron concentration was the end-stage pegmatitic fluids charged with gases from the Lyon Mountain granite gneiss. These solutions became enriched in iron on contact with the metagabbros and hornblende gneisses of the area. The enrichment in iron was partly achieved through solution of the magnetite of the foregoing rocks but principally through alteration of the hornblende and hypersthene of the basic rocks to a monoclinic pyroxene. The iron-bearing solutions, being under pressure, were then forced to higher levels, where they deposited the magnetite between the earlier minerals of the Lyon Mountain granite gneiss.

Newland (1920) objected to Miller's hypothesis, claiming that the mass of gabbro ingested by the granite, and necessary to produce the iron deposits, was too great. Miller (1921) replied to Newland's criticism, and in 1926 restated verbatim his arguments of 1919.

Gallagher in 1937 advanced the idea that the magnetite in the Lyon Mountain granite gneiss owed its origin to a pneumatolytic metasomatic replacement of the Lyon Mountain granite gneiss.

Alling in his resummation of the situation in 1939 was evidently satisfied that the chief process involved in the formation of the ore was pneumatolytic metasomatism, and adds that it was associated with a late-stage hydrothermal introduction and con-

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centration of magnetite, operating after the principal pneumatolytic stage.

No final interpretation of the origin of Adirondack magnetite ore can be given until evidence covering the entire area has been correlated. The following discussion involves only Clinton County; it undoubtedly will have to be modified in terms of future work in other areas.

It must be emphasized that every ore deposit in Clinton County has certain characteristics of its own. To arrive at a satisfactory explanation of the origin of these ores, one must consider all individual peculiarities. A recapitulation of these characteristics is in order.

The ore occurs in a variety of host rocks. In some mines the ore is found in a single type of host rock; in other mines two or more host rocks may carry the magnetite. In some mines the magnetite has largely replaced a single mineral in the host rock, whereas in other mines it has replaced all the minerals of the host rock; or in two mines with the same host rock, one mineral has been replaced in one mine and another mineral has been replaced in the other mine. Rarely, the gangue minerals of ores are serpentinized and chloritized; but most of them show no effects of hydration. Ore in some places is associated with fluorite, scapolite, and late apatite. Magnetite in some places clearly has replaced cataclastically deformed minerals. In some mines there is evidence of mechanical breaking in the footwalls or hanging walls; in others there is no association with such textures. Several of the mineralized zones are in synclines. It can also be demonstrated that some ore shoots are narrow and elongated, plunging parallel to the mineral lineation in the surrounding rocks.

The relationship between ore and different host rocks clearly demonstrates introduction of ore into the host rocks after their formation. The frequent association of ore with cataclastic zones, in which the magnetite is undeformed, may indicate the nature of the channelways along which the iron was introduced. The occasional association with fluorite, scapolite, and late apatite indicates that volatiles accompanied the emplacement of at least some of the magnetite, but no implication is intended that these minerals are formed only by pneumatolytic action. On the other hand, the hydrated gangue minerals and the magnetite found in late pegmatites and in quartz veins would indicate that at least some of the magnetite was introduced during a lower-temperature hydrothermal stage. The general picture then is that the bulk of the ore magnetite was introduced by pneumatolytic action, but some of the magnetite was introduced hydrothermally during the waning stage of the mineralization.

The source of the iron is thought to be a granitic magma, presumably part of the magma that produced the Lyon Mountain granite gneiss. Some discussion is necessary to account for the presence of an iron-rich magnetite-producing end stage, or near end stage, in a granitic magma and to account for the introduction of the magnetite into its present position. Zies (1929), in his observations on fumarole incrustations, found magnetite being deposited under conditions indicating that the iron came in with a halogen in a vapor phase. He suggested (1929, p. 9) that the following reaction proceeds to the right if the gases are cooling and have reached a temperature near 550° C:

$$Fe_2Cl_6 + FeCl_2 + 4H_2O \leftrightarrows Fe_3O_4 + 8HCl$$

He also pointed out that halides of titanium hydrolyze more readily than halides of iron and, therefore, cannot be transported over such great distances. This property may explain the low titanium content of the granitic ores, as compared with the titanium-rich iron ores produced by magmatic segregation of the anorthosite and gabbros. It is possible, though, that a difference in the initial titanium content of the magmas might be more significant. Zies (1929, p. 10) also pointed out that in the laboratory, at 250° C, the following reaction may occur:

$$3Fe_3O_4 \text{ (magnetite)} + 3Cl \longrightarrow 4Fe_2O_3 \text{ (martite)} + FeCl_3$$

This may be a possible explanation of the presence of martite ores in part of the Clinton County field. Fenner (1943) also cites the work of Zies (see also Jahns, 1944) and discusses principles that may apply to the formation of the Clinton County ores. Ferric chloride has been frequently detected in emanations from volcanic vents and fumaroles. This material also has a high vapor pressure (872.6 mm. Hg at 318.4° C). It is, therefore, possible that when the iron-enriched magma reached a depth where the hydrostatic pressure of the overlying rocks became less than the vapor pressure of the ferric chloride (or fluoride) contained within the magma this halogen compound would boil off and ascend into the covering rocks. Actually the hydrostatic pressure of the overlying rock plus the pressure arising from the continuity with the surrounding rocks would be the maximum factor. Pore space would be necessary to permit motion, therefore boiling pressure could be as low as the hydrostatic pressure of the pore solution plus the friction of gas in passage (Fenner, 1943). On cooling, the ferric chloride (or fluoride) would be hydrolyzed to precipitate magnetite in accordance with the first of the foregoing equations. In Clinton County this mechanism must be considered in terms of its relation to the microantiperthite granite gneiss, as the magnetite has replaced this secondary rock. Sundius (1935) points out that magmatic gases leach soda from the country rock and thus form alkaline solutions. It is possible that, in the Clinton County area, gases with higher vapor pressures preceded the ferric chloride, leaching soda from the plagioclase of the country rock, concentrating it, and redepositing it to form the microantiperthite granite gneiss that was later replaced by magnetite. An alternative possibility is that early gas in boiling through the magma picked up and entrained low-vapor-pressure sodium chloride, which was carried into the surrounding rocks to effect the formation of the microantiperthite that preceded the magnetite. Still another possibility would be that complex sodium vapors with higher vapor pressures than ferric chloride may have caused the early formation of microantiperthite. It is perhaps possible that some iron also was carried in this early phase. This iron in conjunction with the soda might then be responsible for the formation of the vein or fracture-filling clinopyroxene and the clinopyroxene that has rounded inclusions of microperthite.

If in the ore-forming magma there was an excess of iron over vapor (halogens), iron would be left to be carried out later in the hydrothermal and pegmatite stages.

The following steps summarize the sequence of events that may have been involved in the process of magnetite mineralization.

1. Injection of part of the magma that produced the Lyon Mountain granite gneiss into the older granite gneiss and Grenville series. Skarn rocks formed at this time by reaction between calcareous sediments and solutions from the magma. Injection was prior to or contemporary with regional compression.

2. Deformation by plastic flow. End-stage brittleness permitted "micro shearing."

3. A still mobile part of the iron-enriched magma rose into the foregoing materials, or it may have been squeezed up during the folding.

4. When hydrostatic pressure of the materials overlying the magma became less than that of high-vapor-pressure gases, upward penetration of the gases through the overlying shear zones was possible. These gases, carrying some iron, leached soda from the surrounding rocks, which, combining with iron and other materials, deposited pyroxene as fracture fillings. Excess soda formed microantiperthite granite by replacement.

5. If a long-range analogy to fumarole encrustations is permitted, ferric chloride (or fluoride) vapor then boiled off from the magma. Later hydrolysis in the overlying rocks deposited magnetite. Temperature and pressure balances probably determined what materials were replaced. Part of the gases released by the hydrolysis went to form scapolite, fluorite, and apatite. Replacement was also controlled by lines of weakness in directions of mineral lineation.

6. With decrease of temperature and exhaustion of chlorine (or fluorine) excess iron went over into the pegmatitic end stage and crystallized as magnetite in the younger pegmatite and quartz veins.

EXPLORATION AND DEVELOPMENT

The iron deposits of the northeast Adirondacks have been known since early in the past century. Judging from the number of prospect pits and shafts in the district early exploration was thorough. The earlier exploration was both systematic and haphazard. The Bowen-Signor ore belt was carefully traced and exploited before the middle of the nineteenth century by Peter Tremblay. Records in the Tremblay family indicate that Peter Tremblay also did exploration work on the Russia Station and Chateaugay ore belts (oral personal communication from Daniel Tremblay, Redford, N. Y.). In the Ausable district the old mining companies gave good coverage to their areas. Haphazard exploration is indicated by the existence of barren test pits that have no relation to ore zones.

Several of the old land surveys recorded the existence of magnetic anomalies. These anomalies no doubt guided astute prospectors to original discoveries. It is doubtful, however, that any systematic dip-needle surveying was done until very late in the past century or early in the present century.

By the turn of the century the mining companies operating in the area were engaged in diamond drilling to explore the continuations of known ore bodies.

It would appear that the mining and exploration activities of the past hundred years or more have disclosed the higher-grade iron deposits of this district. In the interests of determining the country's resources of iron ore there is, however, much work yet to be done in this region, particularly with regard to diamond drilling and detailed ground magnetic surveys.

ROCKS REPLACED TO FORM ORE BODIES

Future exploration in the Clinton County area should be guided by two factors: the magnetic anomalies and the rocks that are known to act as hosts to concentrations of magnetite. Given below is a list of the ore bodies in the area, arranged according to the type of rocks that were replaced to form the ore bodies. The list is based on data from the section on magnetite mines and prospects as given in this report.

Rocks predominantly rich in soda. Microantiperthite and plagioclase granite gneisses:
- Nelson Bush.
- Arnold.
- Battie.
- Russia Station.
- Miner.
- 81.

Rocks predominantly skarn, migmatitic and feldspathic skarn, and strongly pyroxene-contaminated microperthite granite gneiss (containing more than 10 percent pyroxene):
- LaVake.
- Mitchell.
- Averill.
- Ellis.
- LaMar.
- Bowen-Signor.
- Tremblay mine.
- Tremblay pits.
- Bannerhouse.
- Cook.
- Lynch.
- Chateaugay.

Rocks strongly pyroxene-contaminated microantiperthite and plagioclase granite gneisses or migmatites:
- Rutgers.
- Hogback.
- Clayburg.
- Earl.

Microperthite (alaskitic) granite gneiss, in part with fluorite:
- Palmer Hill.
- Jackson Hill.
- Winter.

Microcline granite gneiss:
- Mace.

Pegmatite:
- Black Brook.
- Third and Fourth Mountains.

Gabbro complex:
- Duncan.

Excluding the pegmatite and gabbro magnetites, the foregoing information may be assembled on a percentage basis:

	Number of bodies	*Percentage*
Ores in soda-rich rocks	6	23
Ores in pyroxene-rich microperthite granite gneiss and skarn	12	46
Ores in pyroxene-rich soda rocks	4	15
Ores in microperthite granite gneiss (alaskite)	3	12
Ores in microcline granite gneiss	1	4
	26	100

This compilation indicates the high frequency with which pyroxene-rich rocks are replaced by magnetite. If both sodic and potassic pyroxene-rich rocks are combined, 61 percent of the mines and prospects of the area occur in such rocks. If sodic and potassic ores are compared, excluding pyroxene content, 62 percent of the deposits are in rocks whose dominant feldspars are potassic; the converse of this statement, however, should be emphasized—namely, that 38 percent of the magnetite deposits are replacements of rocks whose dominant feldspars are sodic—as this is an appreciable portion of the total number of deposits. This may be further summarized by stating that 84 percent of the magnetite bodies are in modified granitic rocks, modified either by incorporation of metasediments (pyroxene rocks, 61 percent), or by anatexis or metasomatism (soda-rich rocks, 23 percent). Only one magnetite body is known in microcline granite gneiss. No magnetite bodies are known in hornblende granite gneiss in this area.

Of the two operating mines in the region, one, the Chateaugay, shows magnetite replacing a pyroxene-rich microperthite granite gneiss which gives place to a plagioclase granite gneiss at depth; the other, 81, shows magnetite replacing a plagioclase granite gneiss.

MAGNETIC ANOMALIES AND DIP-NEEDLE SURVEYS

The survey of the area included a considerable amount of detail and reconnaissance dip-needle work to determine the lengths of known ore belts and to investigate anomalies detected by the airborne magnetometer. Geophysical surveys in the region were conducted by the United States Bureau of Mines and the United States Geological Survey. During the course of this investigation all geophysical work was transferred from the Bureau of Mines to the Geological Survey.

The United States Bureau of Mines during its operations in the Clinton County area completed detailed dip-needle surveys on the Ellis-LaMar-Averill zone in the Dannemora quadrangle and on the

Bowen-Signor and Russia Station zones in the Lyon Mountain quadrangle.

The Ellis-LaMar-Averill anomaly has been described in previous reports (Donnerstag, 1945, and Bardill, 1947a).

The Russia Station anomaly consists of three distinct parallel anomaly zones (Bardill, 1947c). The central one, which passes through Russia Station, has been designated the Phillips anomaly; the one to the east is the Kimball anomaly; and the one to the west is the Dorothy anomaly. These anomalies have been traced for some 15,000 feet parallel to the strike; the width of the zone of anomalies at right angles to the strike is 3,000 feet. Old mine workings lie along all three of the anomalies.

The Dorothy anomaly was established as an individual unit separate from the Phillips and Kimball anomalies by the Geological Survey late in the field season of 1944. The highest dip-needle reading (up to +74°) are on the Dorothy and Phillips anomalies.

Detailed dip-needle surveys over the abandoned Bowen-Signor mine cover some 37,000 feet, including the extensions of the anomaly eastward and westward from the mine (Bardill, 1947b). Calculations based on old drilling records indicate a considerable tonnage of magnetite remaining underground.

All the magnetic anomalies in Clinton County show the same general pattern. The magnetic contours show closures that are discontinuous parallel to the strike, an effect that has been described as a "string of beads." This may indicate, at least in some cases, that the ore occurs in cigarlike shoots—that is, the contour closures may indicate the intersection of an ore shoot with the ground surface.

Much reconnaissance with the dip-needle was carried on in the area by both the Geological Survey and the Bureau of Mines.

In Clinton County the Bureau of Mines did reconnaissance work in the Standish, Palmer Hill, Arnold Hill, LaVake, Rutgers, and Hogback areas and on the Mitchell prospect. In Franklin County preliminary investigations were carried on at the Bannerhouse mine and at the Duncan Mountain and Studley Hill prospects.

The Geological Survey undertook some 17,800 feet of magnetic reconnaissance in the area. This work included the Lynch and the Rock prospects, the Black Brook mine, and part of the Dorothy anomaly.

AIRBORNE MAGNETOMETER SURVEY

The airborne magnetometer survey of the northeast Adirondack magnetite district was started in the summer of 1945 and was completed in the summer of 1946. This survey was made by James R. Balsley, of the Branch of Geophysics, United States Geological Survey, with the assistance of M. E. Hill, Herbert E. Hawks, and D. L. Rossman.

The airborne magnetometer was flown over the area at an altitude of approximately 1,000 feet above the ground. Usually the traverse lines were spaced a quarter of a mile apart, though some flights were made on a spacing of one-third of a mile.

The air-detected anomalies will be plotted on an aeromagnetic map now in preparation. The strike of magnetite zones that have great length is clearly shown when the anomalies are plotted and contoured on the map. The effect of multiple parallel mineralized zones, as at Russia Station, is detected as a mass effect by the airborne magnetometer and not as separate parallel zones. Individual, single, or isolated anomalies may be expected to have a strike length on the ground no greater than the distance between the survey flight lines, provided that the flight lines are at right angles, or nearly so, to the regional strike. On the contoured magnetic map anomalies of this kind show as isolated closures of the contours.

Consideration of these facts leads to helpful aids in field procedure when the anomalies are checked on the ground. If the anomaly is not picked up in the area over which it is plotted, the ground survey should be taken out some 500 feet along and at right angles to the flight line before work is abandoned. When an anomaly is located by dip-needle, ground traverses should be run at right angles to the strike to check the possibility of multiple parallel mineralized zones.

In Clinton County and adjacent districts preliminary plotting of the air survey gave a very rapid delineation of areas for ground investigation. The air survey also gave valuable information on the length and continuity of known mineralized belts.

All the important anomalies recorded were over the Lyon Mountain granite gneiss. Of interest were anomalies recorded over the Potsdam sandstone in the Churubusco quadrangle. These anomalies indicate the possible presence of concealed magnetite deposits in the Lyon Mountain granite gneiss beneath the sandstone cover; they could, however, be local sedimentary concentrations in the sandstone. No anomalies were recorded over the Hawkeye granite gneiss, the quartz syenite gneiss, or the anorthosite.

More than 117,000 feet of reconnaissance dip-needle surveys were conducted by the Geological Survey to investigate air-detected anomalies.

New discoveries of magnetite deposits, as compared with known deposits, were not great. To date, none of the new areas tested on the ground by dip-needle surveys have turned out to be truly significant. This is in contract to results obtained from similar aeromagnetic surveys in St. Lawrence County. (A. F. Buddington, written personal communication.)

DIAMOND DRILLING

During the investigation of Clinton County five diamond-drill holes were put down by the Bureau of Mines. Two of these holes were drilled on the Ellis ore bed in 1949. The length of the two holes totaled 99.5 feet. Of the remaining three holes, drilled in 1947, two were on the Bowen-Signor mine, and the third was on the westward extension of the Bowen-Signor anomaly, between the Tremblay and Clayburg mines. These three holes had a total length of 1,442.4 feet. All the holes were logged by the United States Geological Survey; the results are described in later sections.

In addition to the diamond-drill core made available from the above source, nearly 13,000 feet of core in the possession of the Republic Steel Corp. was logged in detail. This core was divided as follows: Standish (81 mine) area,[1] 2,824.5 feet; Palmer Hill-Jackson Hill area,[2] 6,074.6 feet; Arnold Hill,[2] 331.0 feet; Battie-Mace area,[2] 2,709.9 feet; and Hogback-La Vake area,[2] 679.0 feet.

The Republic Steel Corp. initiated a diamond-drilling program to explore the Russia Station anomalies late in 1948 after the Geological Survey personnel had left the area.

GUIDES TO FUTURE EXPLORATION

If additional ore bodies are to be discovered, the following associational factors may be of aid in the northeast Adirondack area.

1. Many magnetic anomalies are multiple; that is, two or three bands of anomaly may occur with parallel strikes. Individual anomalies should be prospected by reconnaissance traverses run at right angles to the strike.
2. Ore zones often show considerable persistence parallel to the strike; therefore exploration should not be terminated too quickly in the direction of the strike.
3. Synclinal structures are typical of several of the best mineralized zones.
4. In general, the ore bodies conform to the planar structures of the enclosing rocks. The strike and dip of the foliation determines the strike and dip of the ore body.
5. The trend and plunge of pencillike ore shoots may be determined from the trend and plunge of the mineral lineation in nearby outcrops. This factor should be considered in locating diamond-drill holes.
6. Several of the ore bodies of the northeast Adirondacks occur in pyroxene-contaminated microperthite and plagioclase granite gneiss, or granitized skarn and skarn magmatite.
7. Plagioclase granite gneiss and microantiperthite granite gneiss may serve as hosts to strong magnetite concentrations.
8. The regional alaskitic granite gneiss carrying accessory magnetite is apparently barren of economic magnetite concentrations, though such granite gneiss may occur in the footwall or hanging wall of mineralized rock.

It is interesting to note that several of these factors have already been described by Hotz (1945) as applying to the Sterling-Ringwood area of New Jersey and New York.

FUTURE DEVELOPMENT

Additional investigations will be necessary before a complete understanding of the magnetite ores of Clinton County is possible.

Many of the iron ore deposits of the area have not been subjected to quantitative examination to determine size, grade, and continuity of the ore. This is particularly true of that part of the Ausable quadrangle that lies north of the Ausable River and that part of the Dannemora quadrangle that lies south and west of the Paleozoic cover. The Republic Steel Corp. has several thousand feet of diamond-drill core from this area. Examination of this in its entirety should be of considerable value in guiding any future programs.

As many of the magnetite zones are singularly persistent along the strike, it is recommended that detailed dip-needle surveys followed later by drilling programs be planned by those concerned with the future mineral economics of the area. In the Ausable quadrangles, the Palmer Hill-Jackson Hill zone should be investigated. In the Dannemora quadrangle, the LaVake-Rutgers-Hogback and the Mitchell-Lynch zones should be examined. Between the two quadrangles, the Cook-Battie mineralization should be explored. Also, if the problem of economically recovering black hematite or martite is solved, the Arnold Hill (Ausable quadrangle) deposits might become valuable again.

In those parts of the area where detailed magnetic work has been done by the Bureau of Mines, an

[1] Some skeletonized core stored by Republic Steel Corp., at Chateaugay mine, Lyon Mountain, N. Y.

[2] Core stored by Republic Steel Corp. at Mineville, N. Y.

adequate drilling program still remains to be carried out.

Attention should also be drawn to areas in the Churubusco quadrangle where the airborne magnetometer detected several isolated anomalies over the Potsdam sandstone. These areas should be surveyed with instruments more sensitive than the dip needle. Valuable magnetite deposits may be concealed beneath the Potsdam sandstone cover. Similarly, the Finch-Nelson Bush magnetite zone in the Ausable quadrangle should be investigated to determine whether it extends northward under the Potsdam sandstone.

MAGNETITE MINES AND PROSPECTS

The only mines operating in the area covered by this report are the Chateaugay mine and the 81 mine of the Republic Steel Corp. in the village of Lyon Mountain and near Standish, respectively. The first is an underground operation working a low-grade magnetite deposit which forms two parallel zones designated as the "hanging-wall vein" and the "footwall vein." The 81 mine was reopened as an open-cut operation in 1949; future development will involve underground mining. These mines are briefly described in a succeeding section. Mr. Paul W. Zimmer, geologist for the Republic Steel Corp., plans to publish a detailed description of the mines.

The mineral rights of the greater part of the known mineralized zones in Clinton County are now controlled by the Republic Steel Corp., which took them over from the Witherbee, Sherman Co. and the Chateaugay Ore and Iron Co. These rights cover the mines of the Palmer Hill and Arnold Hill district in the Ausable quadrangle and the Bowen-Signor and Russia Station mines in the Lyon Mountain quadrangle.

The only known mineralized zones worthy of note that remain in the hands of small holders are the

TABLE 24.—*Summary of data on the magnetite mines and prospects*

Mine or prospect	Approximate production (tons)	Approx. iron (percent)	Approx. length (feet)	Maximum slope depth (feet)	Average thickness (feet)	Remarks
Ausable district						
Nelson Bush			600	900	3–25	Two slopes.
Arnold	600,000	62[1]	700	800	3–27	Three parallel veins.
Indian					2–11	Three (four?) parallel veins.
Finch						
Palmer Hill	1,000,000	33–58	2,500	2200	9–20	
LaVake		Low grade	400		12	
Rutgers		42?			12	
Hogback		Low grade			16 and 11	Two zones.
Jackson Hill		44?	500 600?	100	10–12	Three zones.
Black Brook			100? 300?		6–8	Two zones. Two groups of open-cuts.
Cook			200?			Multiple ore zone.
Battie		Low-medium grade	600–800		10–20	
Winter					10	Three zones.
Mace		48?	500		4	
Mitchel						
Lynch			100?		5	
Rock ore bed						
Dannemora district						
Averill		35	1000	100	10–30?	
Ellis		21	750		12	
LaMar			Several hundred		8–10	
					22	Three zones.
Russia Station		21				
Miner Farm		38?	300		8	
Saranac Valley belt						
Bowen-Signor	260,000	34	2,000	125	25	
Earl anomaly		35			10	
Clayburg		30	Several hundred		8	
Tremblay		28	150–200	80		
Lyon Mountain belt						
Chateaugay	15,000,000	26	4,500	2350	20	Two zones.
81		35–40	1,000	400	18	
Phillips				1400	20	Two zones.
Parkhurst	40,000	50	2,500?	145	48	

[1] Total iron.

Ellis-LaMar-Averill belt in the Dannemora quadrangle, parts of the Russia Station anomalies, and parts of the Bowen-Signor anomaly. The Bannerhouse mine in Franklin County is on private land.

Petrographic data on the magnetite and associated rocks comprising the individual magnetite-bearing areas are presented in this section. Graphic logs of diamond-drill holes that cut magnetite zones are given when available. This physical information on the composition and arrangement of the rocks is provided in the hope that this should be useful in connection with future mining and metallurgical problems. Many of these data have been used to support the preceding discussions of the origin of the magnetite and the Lyon Mountain granite gneiss.

For convenience the mines and prospects of the area are grouped in four geographic units: the Ausable district, the Dannemora district, the Saranac Valley belt, and the Lyon Mountain belt.

Table 24 summarizes data for these areas. The table, though based on information given by Newland (1908), is modified in some instances by more recent information.

AUSABLE DISTRICT

The Ausable district comprises the ore bodies and magnetite zones that occur in the Ausable quadrangle north of the Ausable River and in the southern part of the Dannemora quadrangle. According to Newland (1908) this area had produced about 2,000,000 tons of ore. The district is the oldest ore producer in the northeast Adirondacks. Ore was first discovered on Arnold Hill in 1806, and mining commenced shortly after.

The largest mines in the area are the Arnold Hill and Palmer Hill groups. Other mines are the LaVake, Rutgers (Redgars), Hogback, Jackson Hill, Winter, Mace, Cook, Battie, and Black Brook. Besides these mines, numerous test pits and shafts and small old workings, such as the Mitchell and the Chalifou mine, are found in the area.

The Republic Steel Corp. controls the mineral rights in the district by acquisition of the holdings of the Witherbee Sherman Co.

Arnold Hill group of mines.—The Arnold Hill group of mines is in the Ausable quadrangle one mile west of the railroad at Ferrona. The group includes, from north-northeast to south-southwest, the Nelson Bush, Arnold, Indian, and Finch workings. The last two were small workings that were abandoned when the larger Arnold and Nelson Bush ore bodies were discovered. Kemp and Alling (1925, p. 98) state that the Arnold mine was the largest producer of the group. All the workings are now inaccessible, so information concerning them is dependent on the literature, on meager diamond-drill material in the possession of the Republic Steel Corp. and on material obtainable from the mine dumps.

Smock (1889, p. 40) estimated the production of the Arnold mine, from its opening in 1830, to be 400,000 tons. Newland (1908, p. 100) states that mines on Arnold Hill produced 600,000 tons; of this, 150,000 tons was produced before 1864.

Nelson Bush mine.—The Nelson Bush mine was the last of the group to be worked. Kemp and Alling (1925, p. 95) state that it was reopened in 1903 and operated for 3 years. The ore lenses are reported to have variable thicknesses ranging from 3 feet to 25 feet. The ore bodies narrow with depth and are displaced by small cross faults.

Material obtained from the mine dump (table 25) shows that the ore is associated with a plagioclase granite gneiss, with schlieren of hornblende, that ranges in color from white through pink to dark red. The dump waste shows evidence of brecciation and shearing, with a late-stage introduction of jasper and calcite vein material. Newland (1908, p. 96) also mentions the occurrence of purple fluorite with the calcite. The dumps contain a considerable tonnage of martite ore. The martite ore was presumably separated from the magnetite ore before the latter was sent to the mill. Putnam (1886, p. 120) cites the following assays for material from the Nelson Bush mine:

	1308	1309
Metallic iron	61.62	54.60
Phosphorus	.102	.344
Titanic acid	Tr.	....

1308. From 300 tons of separated ore.
1309. From 1500 tons of furnace ore.

TABLE 25.—*Modal composition of five samples of martite ore and associated plagioclase granite gneiss from the dumps of the Nelson Bush mine*

[D, dominant; X, present; G, xenomorphic-granular; C, cataclastic]

	Ag-1	Ag-1A	Ag-2	Ag-3	Ag-3B
Plagioclase	An_6 52.8	An_9 64.2	An_7 39.9	An_7 58.0	An_7 46.9
Quartz	21.5	6.1	33.7	25.4	23.6
Clinopyroxene	....	....	[1]3.4	....	Tr.
Hornblende	Tr.	....	7.3	3.5	21.2
Biotite	....	Tr.	....	....	....
Martite	6.5	19.4	15.6	8.9	....
Chlorite	12.5	....	....	....	....
Accessories	6.6	10.3	....	4.2	8.2
Apatite	X	X	X	....	X
Zircon	X	X	X	X	X
Martite	....	....	....	....	D
Calcite	D	....	X	X	....
Chlorite	X	D	D	....	X
Sphene	....	....	....	X	X
Texture	C	C	C	G	G

[1] Chloritized.

Outcrops in the vicinity of the Nelson Bush mine strike N. 15° – 35° E., and dip 55° – 80° NW. Putnam (1886, p. 119) describes the ore zone as having a strike of N. 23° E. and a dip at the surface of 71° NW.

Arnold mine.—The Arnold mine is about 0.2 mile south-southwest from the Nelson Bush mine.

Three ore bodies were developed by the workings: from east to west, the "gray," "black," and "blue" veins.

Table 26 gives the modal composition of three samples obtained from the mine dump.

The United States Bureau of Mines has recently made partial assays of character samples obtained from the mine dumps. The Bureau of Mines defines a character sample as one that is representative of the ore body as a whole. To select a sample to fit this definition is difficult, so some of the "character samples" quoted may be nonrepresentative. The assays were as follows:

Sample No.	Total Fe	SiO_2
994-30	64.20	7.33
994-31	61.98	6.16
994-32	63.30	8.30
994-33	62.40	6.72

Samples 994-30, 994-31, and 994-32 are black hematite or martite ores with a gangue of quartz, plagioclase, chlorite, and hornblende. Sample 994-33 is a magnetite ore with 98.2 percent of the iron recoverable from the magnetic fraction.

TABLE 26.—*Modal composition of three samples of martite ore in plagioclase granite gneiss from the dumps of the Arnold Mine*

[G, Xenomorphic-granular; Gl, xenomorphic-granular with mylonite; C, cataclastic; X, present]

	977	977A	977B
Microperthite and microantiperthite			14.9
Plagioclase	An_6 42.3	An_8 29.8	[1]32.1
Scapolite		3.9	
Quartz	24.4	15.3	9.6
Clinopyroxene			Tr.
Biotite		Tr.	Tr.
Martite	29.0	42.1	38.6
Accessories	4.2	8.8	4.7
Zircon	X	X	X
Apatite	X	X	X
Chlorite	X	X	X
Epidote			X
Calcite	X		X
Texture	Gl	G	C

[1] Mostly completely altered plagioclase.

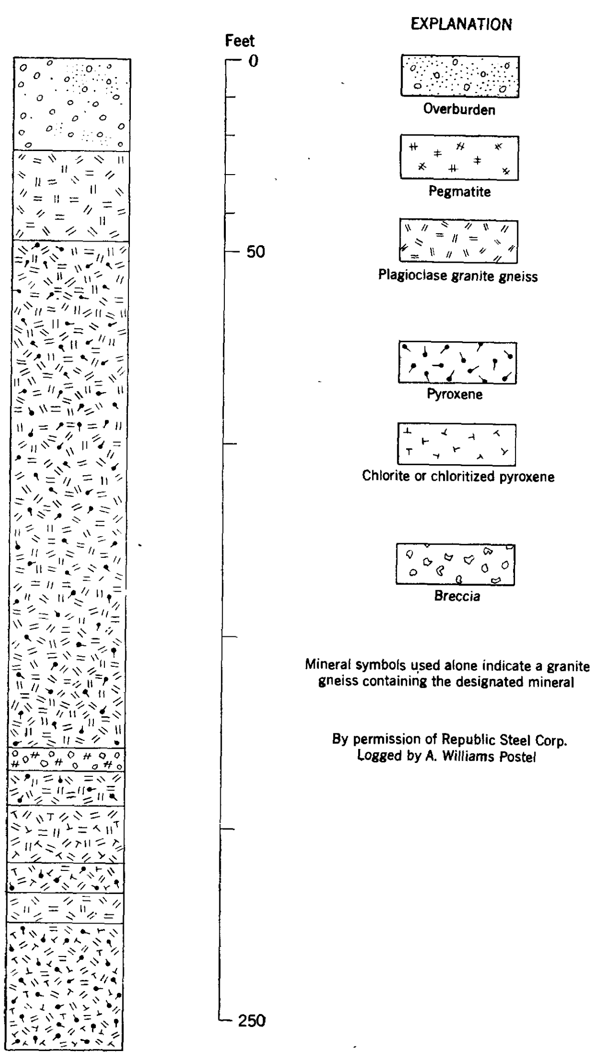

FIGURE 19.—Graphic log of diamond-drill hole 36, Arnold mine.

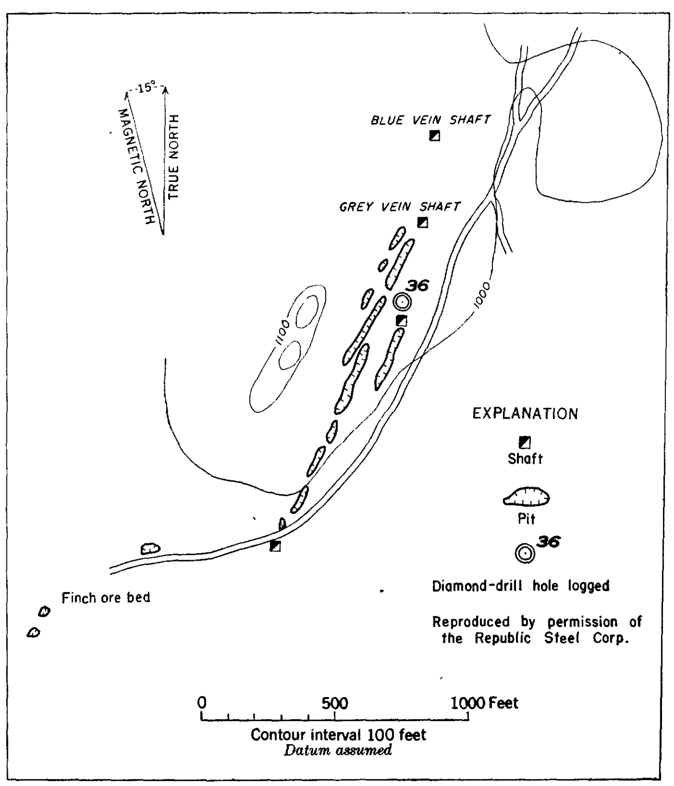

FIGURE 20.—Location map of diamond-drill holes at Arnold mine.

Putnam (1886, p. 119) gives the following assays of samples from the gray, black, and blue veins:

	1305	1306	1307
Metallic iron	59.92	61.28	62.84
Phosphorus	.097	.113	.012

1305. Gray vein. 1306. Black vein. 1307. Blue vein.

Three short diamond-drill holes (core now in the possession of Republic Steel Corp.) drilled by the operators of the Arnold mine intersected only lean ore (table 27). The prevailing rock in the deepest hole logged (DDH 36) is a plagioclase granite gneiss (figs. 19 and 20). The rock has been subjected to chloritization and brecciation. Martite is the common accessory mineral in the associated nonmineralized plagioclase granite gneiss.

TABLE 27.—*Modal composition of samples of plagioclase granite gneiss from the Arnold mine, diamond-drill hole 36*[1]

[G, xenomorphic-granular; C, cataclastic; X, present]

	36–1	36–2	36–3
Plagioclase	An_{10} 73.1	An_9 71.8	An_7 81.9
Quartz	19.1	17.9	7.4
Pyroxene	....	3.7	....
Hornblende	....	tr.	....
Martite	6.5	2.8	5.8
Accessories	1.2	3.7	4.8
Apatite	X	....	X
Sphene	X	X	....
Zircon	X	....	....
Chlorite	X	....	X
Calcite	....	X	X
Depth (feet)	35.8	70.1	196
Texture	G	G	C

[1] This and following petrographic tables, based on diamond-drill cores from the Ausable and Lyon Mountain districts, are given by permission of the Republic Steel Corp. The core from the Ausable district is stored at Mineville, N. Y.

Putnam, (1886, p. 119) described the ore bodies as having a "shoot" structure and says that they pitch 40° NNE. The ore bodies are described as pinching, swelling, and narrowing at depth. Newland (1908, p. 97) gives the thickness dimensions of the three bodies:

Gray vein	3–25 feet
Black vein	3–27 feet
Blue vein	3–27 feet

The three "veins" are separated from each other by about 40 feet of granite rock. The gray vein is composed of magnetite and light-colored gangue; the black vein also carries magnetite; the blue vein is martite ore mixed with a gangue of vein quartz and ferruginous calcite. Smock (1889, p. 39) states that at this mine the strike is north-northeast and the dip at the surface 60°–70° NW. To this may be added Putnam's (1886, p. 119) statement that the angle of dip decreased to 55° at a depth of 325 feet. This would perhaps indicate that the deposits are occupying the easterly limb of a syncline. However, the log of the hole previously mentioned indicates a general dip throughout of about 42° over a depth of 320 feet.

The opinion has been expressed that the Nelson Bush mine is on a continuation, or extension parallel to the strike, of the gray vein; Newland (1908, p. 97) has denied this. Evidence available neither affirms nor denies the possibility.

Indian mine.—The Indian mine is about 0.2 mile south-southwest of the Arnold mine.

This mine is perhaps on the south extension of the Arnold mine ore bodies. Emmons (1842, p. 293) states that trials made with the ore from this locality were unsatisfactory.

Finch mine.—The Finch mine is 0.3 mile south-southwest from the Indian mine.

The mine is now caved, but evidently the ore contained considerable martite.

Palmer Hill group of mines.—The major workings in the Palmer Hill group of mines are on the east and south slopes of Palmer Hill. From the south end of Palmer Hill a line of abandoned mines and pits extends for 0.5 mile in a north-northeast direction.

Mining started on Palmer Hill in 1825 and continued until 1890 (Newland, 1908).

The ore is disseminated magnetite in a pink medium-grained microperthite-microcline granite gneiss (table 28). Granite gneiss from the dumps has a little pyroxene replaced by garnet. The host rocks of the magnetite ore are unusually free of the ferromagnesian silicates that are found in other mines. Examination of diamond-drill cores shows that much of the granite gneiss contains a small percent of purple fluorite—it is reported that large masses of fluorite were found during mining. In some of the holes plagioclase granite gneiss and microantiperthite granite gneiss are present in the footwall and the hanging wall of the mineral zone.

TABLE 28.—*Modal composition of 2 samples of magnetite-bearing microperthite granite gneiss from dumps of old workings on east side of Palmer Hill*

[X, present; G, xenomorphic-granular]

	Pal-3	Pal-4
Microperthite and microcline	53.7	28.4
Plagioclase	An_7 8.2	.... 2.6
Quartz	26.1	48.5
Biotite	Tr.	Tr.
Magnetite	11.9	20.4
Zircon (accessory)	X	X
Magnetite[1] (percent by weight)	21.0	33.9
Iron[1] (percent by weight)	15.1	24.6
Texture	G	G

[1] Computed from mode.

Thin sections from diamond-drill cores reveal thin brecciated or mylonitized zones on the hanging-wall

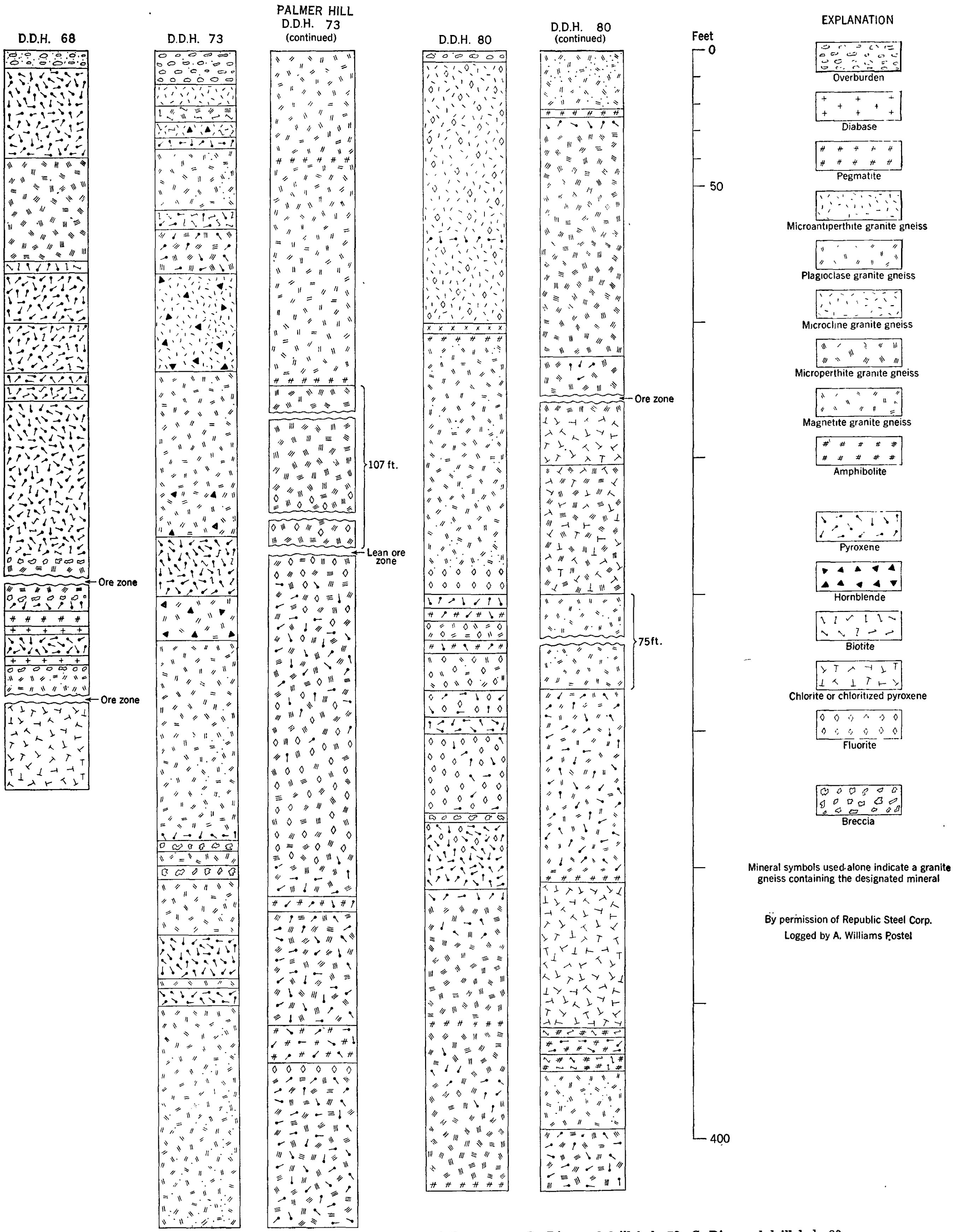

FIGURE 21.—Graphic logs, Palmer Hill. *A*, Diamond-drill hole 68. *B*, Diamond-drill hole 73. *C*, Diamond-drill hole 80.

side of the ore (table 29). In one hole the breccia lies both on the immediate hanging wall and footwall sides of the mineral zone. Figures 19, 20, and 21 are graphic logs of diamond-drill holes put down on the Palmer Hill mines.

Assays from drill cores show that the tenor of metallic iron is variable. Values range from subore to more than 40 percent metallic iron. Subore is rock bearing magnetite with a content of metallic iron too low to permit economic exploitation at the present time. Assays by the United States Bureau of Mines of character samples from the dumps gave the following results:

Sample No.	Total Fe	S	TiO_2[1]	SiO_2
994-38 (southwest area)	47.80	0.01	2.55	26.98
994-42 (northeast area)	58.20	.01	1.27	15.93

[1] The high TiO_2 content probably is derived from ilmenite.

Putnam (1886) gives the following assays of four samples:

	1301	1302	1303	1304
Metallic Iron	44.94	66.03	33.52	63.45
Phosphorus	.023	.007	....	.002

1301. 6,000 tons of crude ore from the Rogers pit.
1302. 7,500 tons of separated ore from the Rogers pit.
1303. 500 tons of crude ore from the Peru Steel & Iron Co. pit.
1304. 1,000 tons of separated ore from the Peru Steel & Iron Co. pit.

TABLE 29.—*Modal composition of 28 rock samples from diamond-drill holes 68, 73, 80 and 81 on Palmer Hill*

[G, xenomorphic-granular; Gr, granular; C, cataclastic; B, breccia]

	68-1	68-2	68-3	73-1	73-2	73-3	73-4	73-5	73-6	73-7	73-8	73-10	73-11	73-12
Microcline	55.5	36.0							23.2	5.6	3.6	1.5	34.1	
Microperthite			32.7				50.1							44.8
Microperthite and microantiperthite				56.4	48.2									
Microantiperthite						34.4		44.6			67.6		11.0	
Plagioclase	5.5	20.4	4.9	An_{10} 5.3	9.8	An_{11} 30.6	An_{10} 10.1	3.5	An_7 38.8	An_8 60.8	An_{10} 24.1	An_8 52.9	An_{10} 18.7	An_{10} 21.6
Quartz	30.5		23.4	32.2	37.9	30.1	38.2	14.9	36.8	28.4	1.9	37.4	30.6	28.2
Pyroxene														
Hornblende						3.3		36.1		Tr.	Tr.			
Biotite			Tr.		Tr.	Tr.		Tr.		Tr.	Tr.	Tr.		
Chlorite														
Fluorite													Tr.	2.4
Magnetite		10.0	31.4											
Calcite		28.8												
Accessories	8.5	3.7	7.5	6.1	4.2	1.5	1.5	.8	1.1	5.1	2.7	8.1	5.6	2.9
Magnetite	X			X	X[1]	X	X[1]	X	X	X[1]	X[1]	X[1]	X[1]	X[1]
Apatite	X			X	X	X				X				
Sphene	X	X		X	X	X	X	X		X	X	X	X	
Zircon	X		X								X		X	X
Chlorite	X	X	X	X	X		X	X	X	X	X	X	X	X
Calcite			X	X								X		
Epidote	X													
Muscovite									X					
Depth (feet)	63.8	246	247	21	22.3	31.8	81.9	104.2	162.2	179.4	230	497.5	670.6	690.2
Texture	C	B	C	Gr	Gr	Gr	Gr	Gr	Gr	G	Gr	Gr	Gr	Gr

	73-13	73-14	73-15	73-16	73-17	73-18	80-1	80-2	80-3	80-4	80-5	80-6	80-7	80-8
Microcline	42.9	43.7		51.4		51.2	46.6		59.7	54.9				
Microperthite			46.8		42.5			69.2			40.4			61.6
Microperthite and microantiperthite														
Microantiperthite														
Plagioclase	An_9 24.4	An_7 31.3	An_8 15.6	An_8 11.5	An_9 17.9	An_{10} 15.4	An_9 10.1	2.1	An_{10} 4.5	An_{10} 11.7	An_{11} 20.5	An_9 68.1	An_{17} 51.7	An_{18} 15.4
Quartz	30.0	22.8	35.0	34.3	33.6	27.0	32.6	.5		27.1	30.7	28.9		10.4
Pyroxene				1.2		2.5		29.2	34.9			Tr.		5.8
Hornblende													32.4	
Biotite													1.5	
Chlorite											5.8			
Fluorite		Tr.	.2	Tr.			6.3							
Magnetite														
Calcite														
Accessories	2.6	2.2	2.4	1.5	5.9	3.9	4.4	1.4	.8	6.3	2.5	3.0	14.4	6.7
Magnetite	X	X[1]	X	X[1]	X[1]	X[1]	X[1]		X	X	X	X[1]	X	X
Apatite												X	X	X
Sphene	X	X		X	X	X	X	X	X	X	X	X	X	X
Zircon		X					X		X		X			
Chlorite		X	X		X	X				X		X		
Calcite					X	X		X			X	X		
Epidote			X											
Muscovite														
Depth (feet)	713	718.7	777	863	923	999	38	113.5	347	596	697	805.5	937.2	997
Texture	Gr	Gr	Gr	Gr	G	G	G	G	Gr	G[2]	G	Gr	G	G

[1] Euhedral.

[2] Xenomorphic-granular with mylonite channels.

68-1. Magnetite-microperthite granite gneiss.
68-2. Magnetite-microcline syenite gneiss.
68-3. Ore in microperthite granite gneiss.
73-1. Magnetite-microantiperthite granite gneiss.
73-2. Magnetite-microantiperthite granite gneiss.
73-3. Hornblende-microantiperthite granite gneiss.
73-4. Magnetite-microperthite granite gneiss.
73-5. Hornblende-microantiperthite granite gneiss.
73-6. Magnetite-microcline granite gneiss.
73-7. Magnetite-plagioclase granite gneiss.
73-8. Magnetite-microantiperthite syenite gneiss.
73-10. Magnetite-plagioclase granite gneiss.
73-11. Magnetite-microperthite granite gneiss.
73-12. Fluorite-microperthite granite gneiss.
73-13. Magnetite-microperthite granite gneiss.
73-14. Magnetite-microperthite granite gneiss.
73-15. Fluorite-microperthite granite gneiss.
73-16. Pyroxene-microperthite granite gneiss.
73-17. Magnetite-microperthite granite gneiss.
73-18. Pyroxene-microperthite granite gneiss.
80-1. Fluorite-microcline granite gneiss.
80-2. Pyroxene-contaminated microperthite syenite gneiss.
80-3. Pyroxene-contaminated microperthite granite gneiss.
80-4. Magnetite-microperthite granite gneiss.
80-5. Chlorite-microperthite granite gneiss.
80-6. Magnetite-plagioclasegranite gneiss.
80-7. Biotite amphibolite.
80-8. Pyroxene-microperthite granite gneiss.

The general strike on the east side of Palmer Hill is N. 30° E.; the dip varies but averages 30° NW. On the west side of Palmer Hill the strike is N. 30° E. and the dip is 80° SE. This indicates that the ore lies in a syncline. The heel of this structure can be followed on the ground surface by the mine workings, which swing sharply westward and then northward on the south side of Palmer Hill.

Smock (1889, p. 38) describes the ore bodies as shoots. Examination of the workings would indicate that the shoots plunge 25° N. If lean ore zones seen in diamond-drill cores from about 2,500 feet northwest of the old mine may be correlated with the main ore zones, the ore-bearing syncline is bounded on the northwest by a weakly mineralized anticline. The main workings are bounded on the southeast by a fault which probably has a strike to the northeast and a 60° dip to the northwest (fig. 22). This fault is later than intrusion of the diabase, or movement was renewed after intrusion, as diabase-granite breccia was seen in some of the drill core examined.

The ore shoots that were mined were 9 to 10 feet thick; locally they were thicker. Drill holes on the extreme northeast extension of the old pits perhaps indicate that the ore zones decrease to a thickness of about 3 feet.

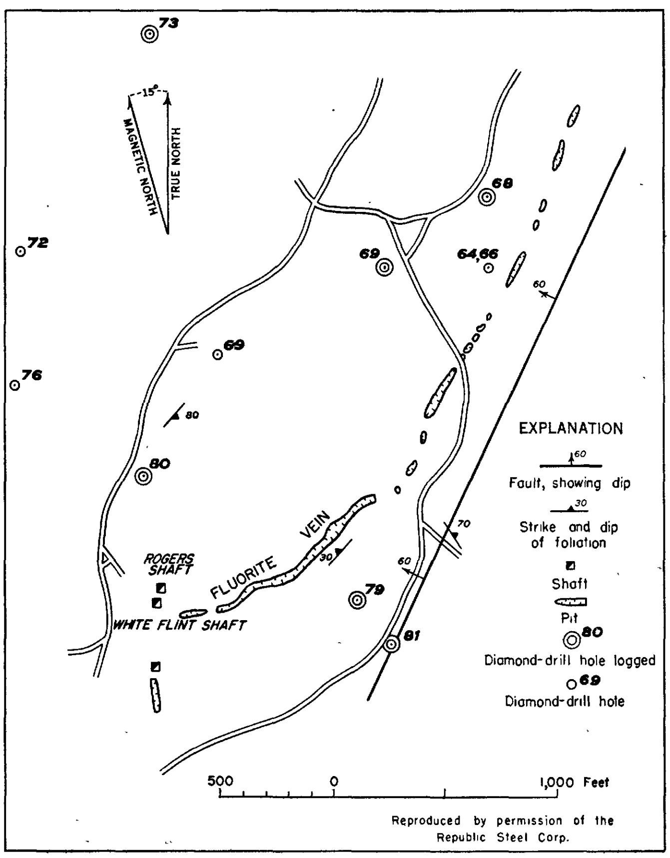

FIGURE 22.—Location map of diamond-drill holes at Palmer Hill.

Newland (1908, p. 102) estimates that the Palmer Hill group of mines produced more than 1,000,000 tone of ore.

LaVake-Rutgers-Hogback mines.—The LaVake-Rutgers-Hogback zones cover about a mile of magnetite-bearing rock, just north of the southern border of the Dannemora quadrangle, which trends roughly parallel to and about 0.1 mile west of the 73°40′ meridian.

Old dip-needle maps in the possession of the Republic Steel Corp. indicate an irregular distribution of magnetite throughout the area with local concentrations represented by the now abandoned LaVake, Rutgers, and Hogback mines. These three mines do not, however, indicate a continuous concentration of magnetite; they lie en echelon from south to north in the order given.

The diamond-drilling program carried out many years ago also illustrates the irregular nature of the ore but does not clearly show the size or structure of the ore bodies.

The strong mineral lineation clearly seen at the Rutgers mine suggests that the magnetite concentrations may occur in elongated shoots. That the ore is related to complex folding is illustrated by the Hogback mine.

No information is available concerning the tonnage produced from these mines. Compared with the production of the Palmer and Arnold Hill group of mines, it was probably small.

The LaVake mine is sometimes referred to in the literature as the Dills and LaVake mine. The mine is in the Dannemora quadrangle just north of the southern boundary of the quadrangle and adjacent to the west side of the 73°40′ meridian, or 0.03 mile due south of the number "1" in "Bench Mark 1308."

Inspection of the old mine, now flooded, shows that the ore is in a pyroxene-rich microperthite syenite gneiss of the Lyon Mountain granite gneiss, or a pyroxene skarn migmatite. Extremely coarse crystals of apatite are abundant. Its abundance is illustrated by the following petrographic analyses of gangue rock and ore, table 30.

TABLE 30.—*Modal composition of ore and gangue rock from the LaVake mine*

[G, Xenomorphic-granular]

	[1]52-1	647
Microperthite	20	
Plagioclase	An_{10} 7	
Clinopyroxene	6	68.0
Hornblende	3	
Biotite	1	
Magnetite	40	5.2
Apatite	20	26.8
Sphene	3	
Depth (feet)	119	
Texture	G	

[1] Composition estimated; texture too coarse for accurate Rosiwal analysis.

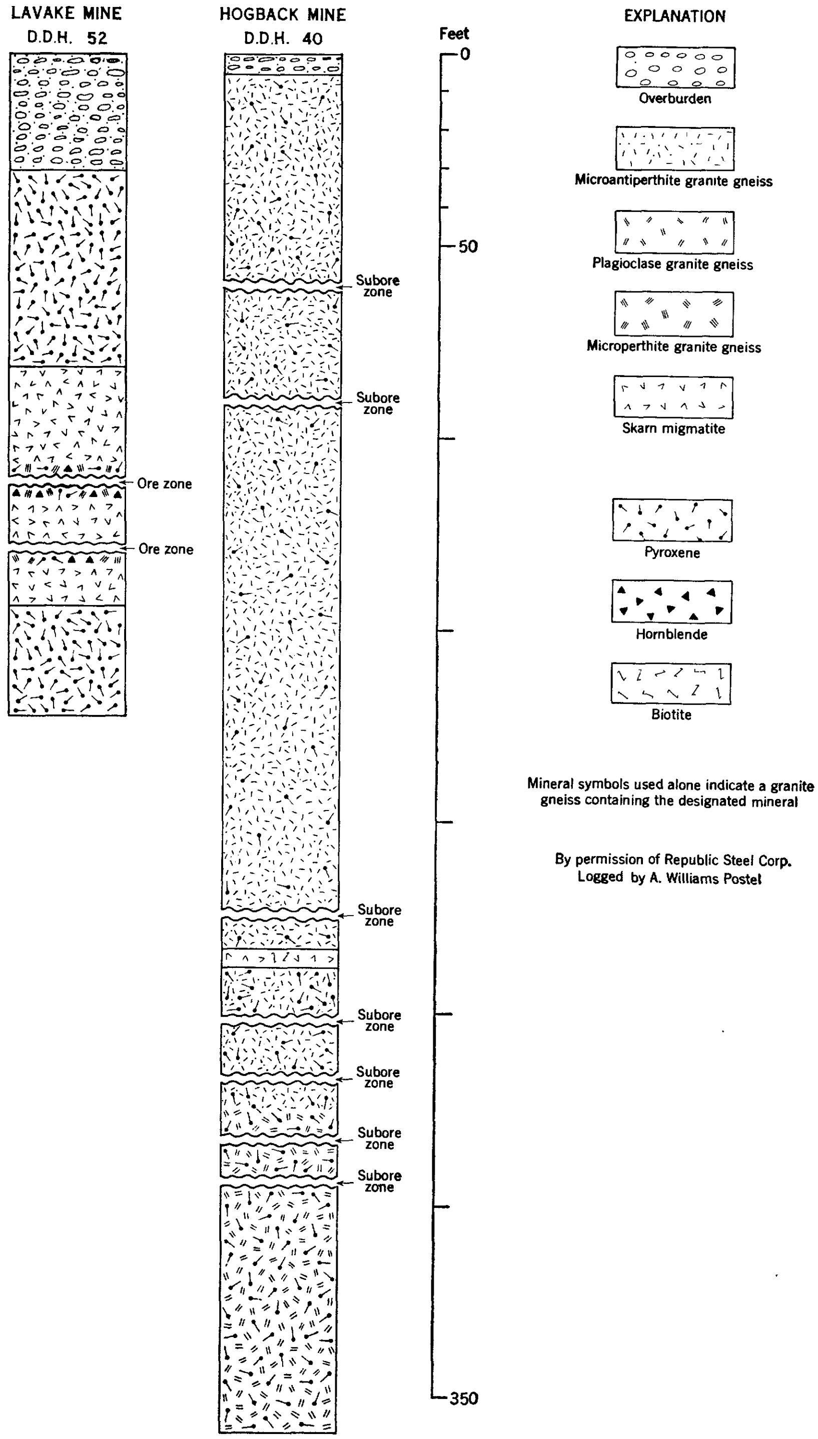

FIGURE 23.—Graphic logs. *A*, Diamond-drill hole 52, LaVake mine. *B*, Diamond-drill hole 40, Hogback mine.

Assays obtained from diamond-drill core north of the main pit reveal a low-grade ore. Figure 23A shows a typical diamond-drill core.

The rocks at the LaVake mine have a strike of N. 20° W. and a dip of 65° E. Examination of a diamond-drill hole north of the mine indicates that the angle of the dip decreases to about 40° at depth. The data shows also that the ore is split into two zones. The main ore zone, as seen at the open-cut, has a true thickness of about 12 feet. Drilling has shown 400 feet of ore parallel to the strike.

The Rutgers mine is known also as the Redgars mine. It is 0.4 miles to the north of the LaVake mine.

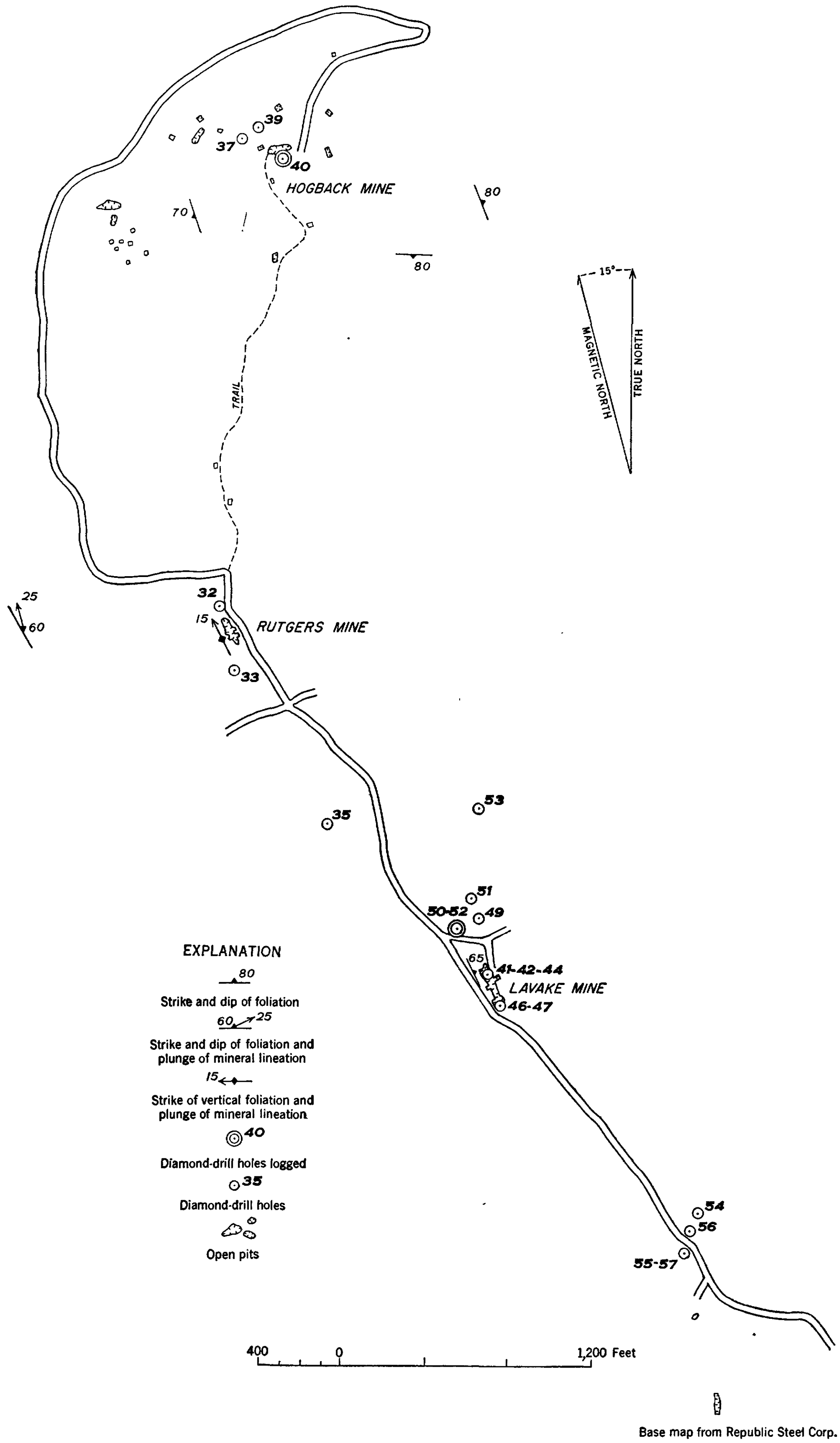

FIGURE 24.—Location map of diamond-drill holes at the LaVake, Rutgers, and Hogback mines.

The Rutgers ore occurs in a pink syenite gneiss and a plagioclase syenite gneiss of the Lyon Mountain granite gneiss containing numerous schlieren of pyroxene skarn. A typical specimen (No. 648) of the host rock has the following composition (X, present; G, xenorphic-granular):

Microperthite and microantiperthite	56.0	Clinopyroxene	34.1
Plagioclase	4.3	Accessories	3.9
		Magnetite	X
		Zircorn	X
Quartz	1.7	Apatite	X
Texture			G

An assay of a character sample by the United States Bureau of Mines gave the following results:

Sample No.	Total Fe	P	S	TiO_2	Insoluble
994-29	42.4	2.40	0.03	0.50	12.3

High phosphorus probably is due to apatite gangue adhering to magnetite. The magnetic fraction contains 92.6 percent of total iron.

The position of the walls of the mine indicates that the strike of the ore zone is N. 10° E. The dip is vertical. The wall rock shows a very strong mineral lineation that plunges 15° to the north. The thickness of the ore zone is obscured by water and vegetation, but it is probably not more than 12 feet.

The Hogback group of open-cuts is on the top of the hill some 0.25 mile north of the Rutgers mine. The main pit is about 100 feet long by 20 feet wide.

Examination of a diamond-drill core from the largest of the open pits shows that the main ore body is associated with white and pink pyroxene-microantiperthite granite and syenite gneisses of the Lyon Mountain granite gneiss. The rock is, in part, a skarn migmatite. The pyroxene layers are widely spaced and, as the magnetite replaces the pyroxene, the ore likewise is widely separated. The main ore body is divided into two zones: the upper zone has a true thickness of 16 feet and is separated from the lower zone by 13 feet of unmineralized pink pyroxene granite gneiss; the lower zone has a true thickness of 11 feet. The hanging wall of the upper zone and the footwall of the lower zone are white pyroxene granite gneiss. The magnetite-bearing rock of the two zones, as seen in the drill core, is low-grade ore to subore. Below the two major mineralized zones are five thin subore zones (fig. 23B). These minor zones all occur in a pink pyroxene plagioclase syenite gneiss. Table 31 gives the composition of rocks cut by diamond-drilling. The location of diamond-drill holes put down on the LaVake-Rutgers-Hogback mines is shown in figure 24.

TABLE 31.—*Modal composition of 6 samples of microantiperthite and plagioclase granite gneiss from the Hogback mine (diamond-drill hole 40)*

[G, Xenomorphite-granular; Gr, granular; X, present]

	40–1	40–2	40–4	40–5	40–6	40–7
Microantiperthite	57.5	44.2	37.2	34.8	......	......
Plagioclase	An_{10} 14.2	An_{11} 7.1	An_{10} 3.7	An_7 12.2	An_{13} 44.1	An_7 [1]67.5
Quartz	18.2	1.9	Tr.	......	4.5	4.3
Pyroxene	5.6	9.1	25.8	31.1	31.2	25.5
Biotite	......	Tr.	Tr.	......	Tr.	......
Magnetite	......	37.1	27.1	14.0	18.7	......
Accessories	4.4	.5	6.1	7.8	1.4	2.6
Magnetite	X	......	......	......	......	......
Apatite	X	......	X	X	X	X
Sphene	X	X	X	......	......	X
Zircon	X	......	......	X	X	X
Calcite	X	......	......	......	......	X
Chlorite	......	X	......	......	......	......
Depth (feet)	26.2	67	121.3	34.0	36.5	37.8
Texture	G	G	G	G	Gr	Gr

[1] 2.5 percent microcline.

The structure of the area is complicated. Surface outcrops near the mine have an east strike and a steep dip to the south. Surface outcrops on the east and west sides of the hill show strikes slightly to the west of north with steep easterly dips on the east side and steep westerly dips on the west side. The outcrops show abrupt reversal of the direction of dip. Drill cores indicate that the ore zones dip to the north. Surface mapping indicates that the hill is a structural dome.

Jackson Hill mines.—The Jackson Hill mines consist of a series of open pits lying both north and south of the road that runs northeast from Palmer Hill. Smock (1889) says these mines were closed about 1873.

The ore occurs in three parallel zones—one zone lies north of the road, the other two south of it.

In the middle zone the ore is a mixture of magnetite and martite in a quartz matrix, and in a pink microcline and microperthite granite gneiss (fig. 25*A*). Gangue material from the dumps of the southern pits shows much black to brown garnet replacing pyroxene disseminated in the granite gneiss. The immediate hanging wall and footwall is of aphanitic diabase.

A diamond-drill hole put down about 1,000 feet northeast from the most southerly of the old workings (fig. 25*B*) intersected a thin subore zone in quartz and microperthite granite gneiss. The hanging-wall of this zone is hornblende granite gneiss and the footwall is plagioclase granite gneiss. An additional diamond-drill hole in the middle zone is shown in figure 25*C*. Figure 26 gives the location of diamond-drill holes in this area.

The ore is somewhat similar to that at Palmer Hill. The composition of ores and associated gangue

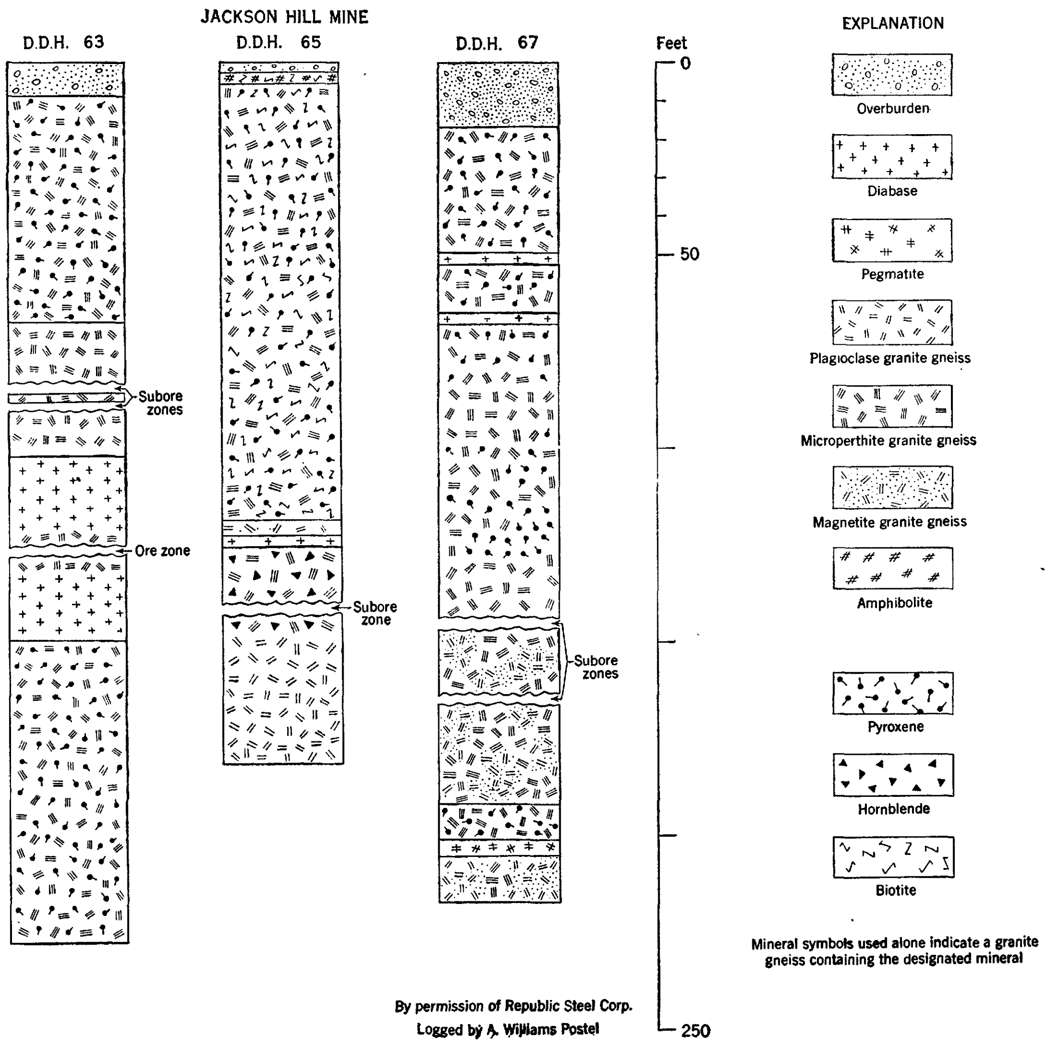

FIGURE 25.—Graphic logs, Jackson mine. *A*, Diamond-drill hole 63. *B*, Diamond-drill hole 65. *C*, Diamond-drill hole 67.

rocks is shown in tables 33 and 34. A character sample from the dumps assayed by the United States Bureau of Mines gave the following results. Of the total iron, 95.3 percent is in the magnetic fraction.

Sample No.	Total Fe	S	TiO_2	SiO_2
994-41	44.60	0.01	0.85	31.46

The ore zones have a strike of N. 10° – 20° E. Their dips vary; in the most northerly workings they are vertical; in the others they range from 50° to 80° W. Locally the direction of dip may reverse to the east.

Black Brook mines.—Two shafts are in the village of Black Brook in the Ausable quadrangle. One shaft, formerly the more important of the two, is right beside the main road, just west of the church. It is now completely filled in, and no observations are possible. The other shaft lies some 400 feet north of the main road near the cliffs on the east side of the brook. This shaft is now filled with water, but some vein material can still be seen.

TABLE 33.—*Modal composition of 4 samples of ore and microperthite granite gneiss from the Jackson Hill mine, southern pits*

[G, xenomorphic granular; D, dominant; X, present]

	1183[1]	1183A[1]	1183B[1]	1183C[2]
Microperthite	Tr.	51.6	27.8	46.2
Plagioclase	....	An_8	An_{10}	An_7
	....	8.3	3.9	19.1
Quartz	67.6	30.4	42.6	29.7
Pyroxene	....	....	....	3.4
Magnetite	31.8	5.5	24.9	....
Accessories	.6	4.1	.8	1.6
Magnetite	....	....	....	X
Apatite	....	X	....	....
Zircon	D	....	X	X
Sphene	....	D	....	D
Chlorite	....	X	D	....
Calcite	....	X	....	....
Magnetite (percent by weight)[3]	48.0	....	39.8	....
Metallic iron (percent by weight)[3]	34.7	....	28.8	....
Texture	G	G	G	G

[1] Collected from dumps.
[2] East wall of pit.
[3] As calculated from the mode.

TABLE 34.—*Modal composition of 11 samples of ore and associated rocks from Jackson Hill mines, drill holes 63, 65 and 67*

[X, present; G, xenomorphic-granular; Gr, granular]

	63–1	63–3	63–4	63–5	63–6	63–7	65–1	65–2	65–3	65–4	67–2
Microcline	5.2	39.2	36.9								44.4
Microperthite				6.7		30.6	51.6				
Microperthite and microantiperthite	37.4								51.7		
Microantiperthite											
Plagioclase	An_{15} 22.6	An_{10} 21.7	An_{15} 7.9	6.1		An_{11} 17.4	An_{10} 29.1		An_{7} 26.6	An_{11} 59.6	An_{18} 13.7
Quartz	30.9	33.9	38.0	36.6	58.6	19.6	10.0	90.1	12.3	35.4	35.6
Hornblende							5.7		7.1		
Biotite				Tr.		Tr.	Tr.	Tr.	Tr.		
Magnetite			15.9	48.4	41.4	30.5		9.9			
Martite											
Accessories	3.8	5 1	1.3	2.2		1.8	3.5		2.3	4.9	6.2
Magnetite	X	X					X		X	X	
Sphene	X						X	X	X	X	X
Apatite	X								X	X	X
Zircon	X	X	X						X		X
Calcite		X	X								
Garnet	X										X
Chlorite				X	X	X		X			
Depth (feet)	36.8	117.8	119	141	152	164.2	180.9	184	182	217	136
Texture	G[1]	G[1]	G[1]	G	G	G	G	G	G	Gr	G

[1] Local shear zones.

63–1. Plagioclase granite gneiss.
63–3. Plagioclase granite gneiss.
63–4. Subore in microcline granite gneiss.
63–5. Ore in microperthite granite gneiss.
63–6. Quartzose ore.
63–7. Ore in microperthite granite gneiss.
65–1. Hornblende microperthite granite gneiss.
65–2. Magnetite bearing quartz vein.
65–3. Hornblende microantiperthite granite gneiss.
65–4. Magnetite plagioclase granite gneiss.
67–2. Magnetite microperthite granite gneiss.

As seen in the shaft north of the main road and in the meager dump material, the magnetite occurs in a pegmatite composed of quartz and both pink and white feldspar. Nearby outcrops are composed of biotite granite gneiss with innumerable blebs and contorted stringers of pegmatite, similar to those described on Duncan Mountain. Thin layers of amphibolite are also present. The foliation of the granite that encloses the pegmatite has a strike of N. 80° E. and a dip of 35° N.

Composition of a sample (No. 1020) of microperthite granite gneiss associated with the ore vein

Microperthite and microcline	68.1	Accessories	9.5
Plagioclase	[1]4.9	Magnetite	X[2]
Quartz	22.1	Zircorn	X
Biotite	4.3	Apatite	X
		Epidote	G
Texture			G

[1] Altered.
[2] Euhedral.

A reconnaissance dip-needle survey over the shaft by the road gave a zone of moderate attraction that extends west from the shaft for 600 feet. A similar survey over the water-filled shaft showed a zone of moderate attraction extending over a distance of 100 feet in the immediate vicinity of the shaft. This anomaly does not cross the brook to the west.

Cook-Battie mines.—The Cook-Battie (also known as Beattie) zone starts on a hilltop 0.5 mile northwest of Lily Pond in the Ausable quadrangle and

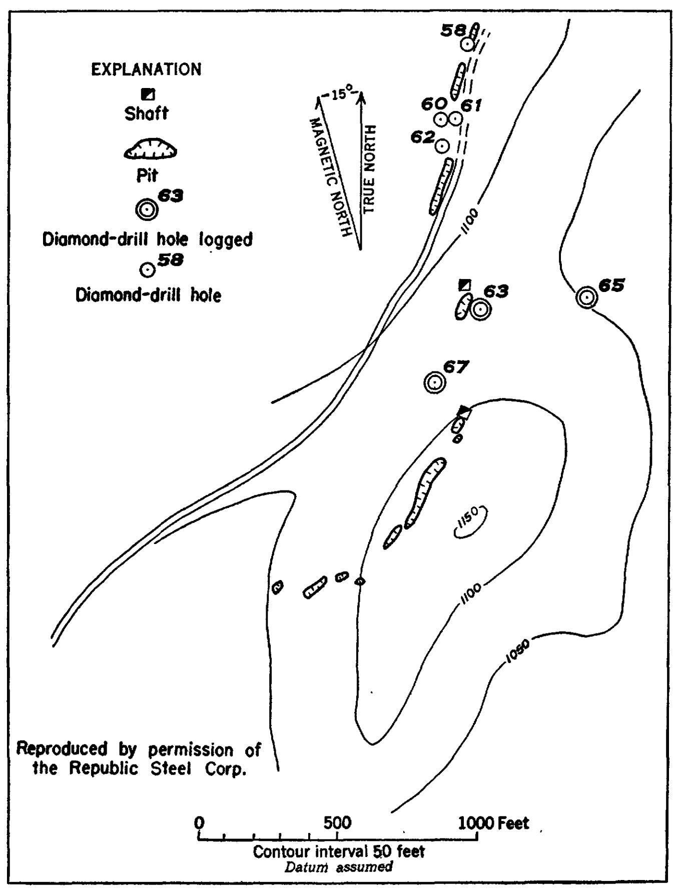

FIGURE 26.—Location map of diamond-drill holes at Jackson mine.

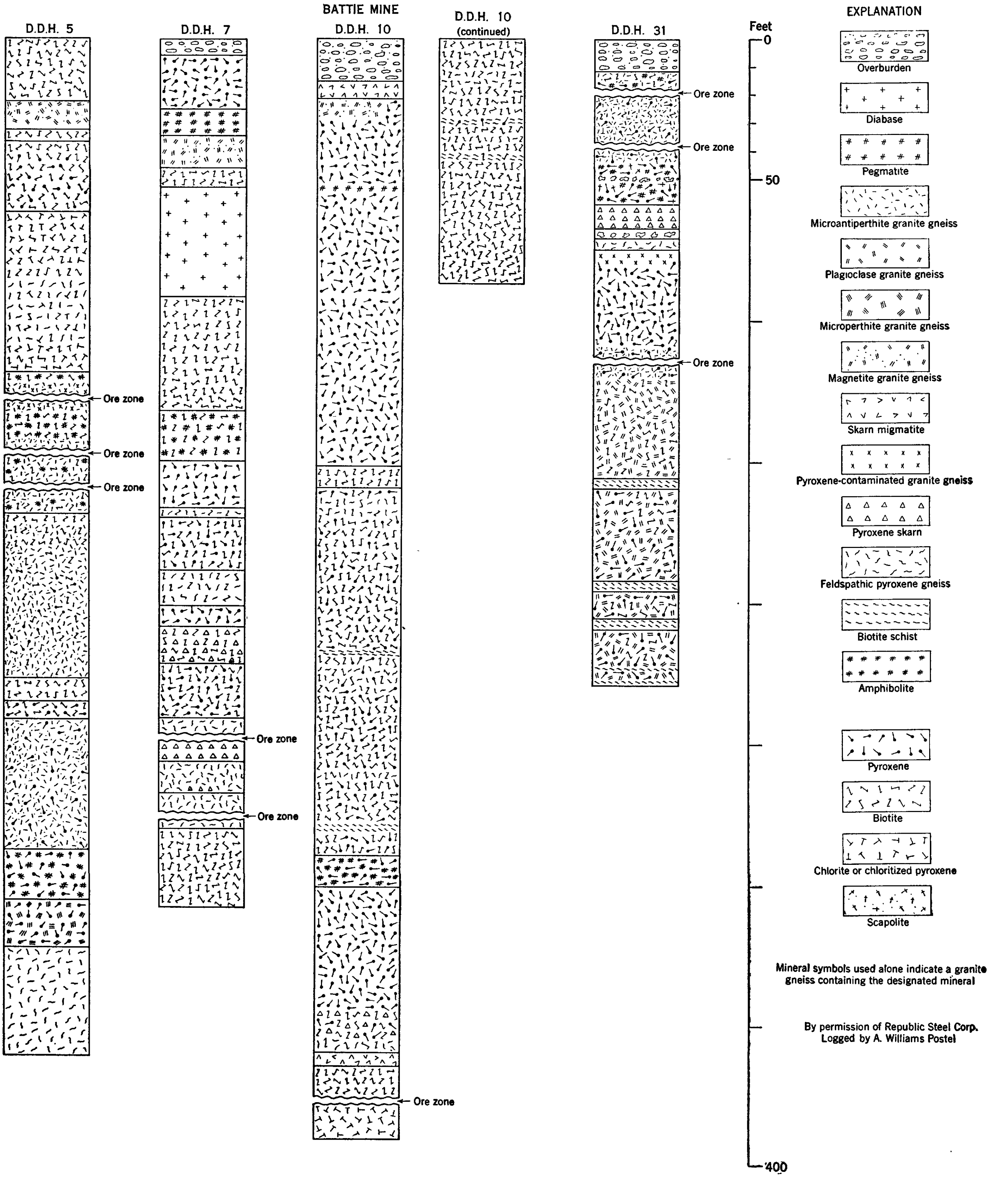

FIGURE 27.—Graphic logs, Battie mine. *A*, Diamond-drill hole 31. *B*, Diamond-drill hole 5. *C*, Diamond-drill hole 7. *D*, Diamond-drill hole 10.

runs northward for approximately 1.5 miles, approximately parallel to the 75° 35' meridian, into the Dannemora quadrangle. The Cook workings are in the Ausable quadrangle and the Battie workings are in the Dannemora quadrangle.

Old dip-needle work is inconclusive in showing continuity of mineralization between the two mining centers, and no new dip-needle work was undertaken. Emmons (1842, p. 320) however, claimed that the Cook ore body may be traced into the Battie ore body by surface ore for 1.5 miles. Both Newland (1908, p. 104) and Kemp and Alling (1925, p. 100) also say that the Battie mines are on a continuation of the Cook mines; this continuation, however, has not been proved. A rather intensive diamond-drilling program was carried on in the early part of the century on the Battie area.

No information is available on production from these mines. The Cook mines, according to Kemp and Alling (1925, p. 99), were opened prior to 1838 and were last worked in 1856.

The Cook mines are represented by two groups of workings in the Ausable quadrangle. The most northerly workings lie 0.6 mile due east from the railroad spur at Ferrona. The mine here is an open pit 300 feet long by 8 feet wide by 20 feet deep; this pit is paralleled closely on the west by another pit 50 feet long by 8 feet wide by 20 feet deep. The southern group of workings lies 0.8 miles S. 50° E. from the railroad spur at Ferrona. The main open-cut is 200 feet long by 50 feet wide and has a depth of about 40 feet; the pit branches to the north. This open-cut is paralleled to the east by another cut 200 feet long by 30 feet in width and depth. According to Emmons (1842, p. 301) the north group consisted of four veins, 2, 3, 6, and 13 feet in width.

In the western cut of the north group magnetite ore is about 6 feet in width, associated with a pink biotite granite gneiss; this gneiss in turn is associated with a pyroxene granite gneiss containing occasional bands of amphibolite. In the south group of pits the magnetite lies in a pink pyroxene granite gneiss with amphibolite schlieren.

A thin section of subore loaned by H. L. Alling had the following volume-percent composition (as estimated by Postel):

Microperthite	25	Clinopyroxene	40
Plagioclase	5	Magnetite	20
Quartz	10		100

The north group of pits has a strike of N. 12° E. with a dip ranging from vertical to 75° W.; mineral lineation plunges 35° to the north. The south group of pits has a strike of N. 20° E. and a dip of 50° to 70° W. The branching of the main pit to the north is suggestive of folding. In nearby outcrops to the west and southwest mineral lineations plunge from 15° to 30° to the north.

The Battie mines are in the Dannemora quadrangle 1.6 miles S. 23° W. from the road intersection at Harkness, at an elevation of about 650 feet, about a mile north of the north group of pits in the Cook mines. The mines were last operated about 1858. The main pit, now flooded, is about 300 feet long by 25 feet wide. The vein was further exposed for 500 feet to the south by trenching; the trench is now slumped and covers the ore zone. Emmons (1842, p. 303) states that the vein when exposed had a width of 13 to 14 feet.

The rocks associated with the Battie ore show greater variety than those in any other mineralized area in Clinton County (table 35). A diamond-drill hole (fig. 27A) 1,200 feet south of the main open-cut exposed three ore zones separated by 14 feet and 65 feet of unmineralized rock. The upper ore zone contains magnetite that has replaced a micro-

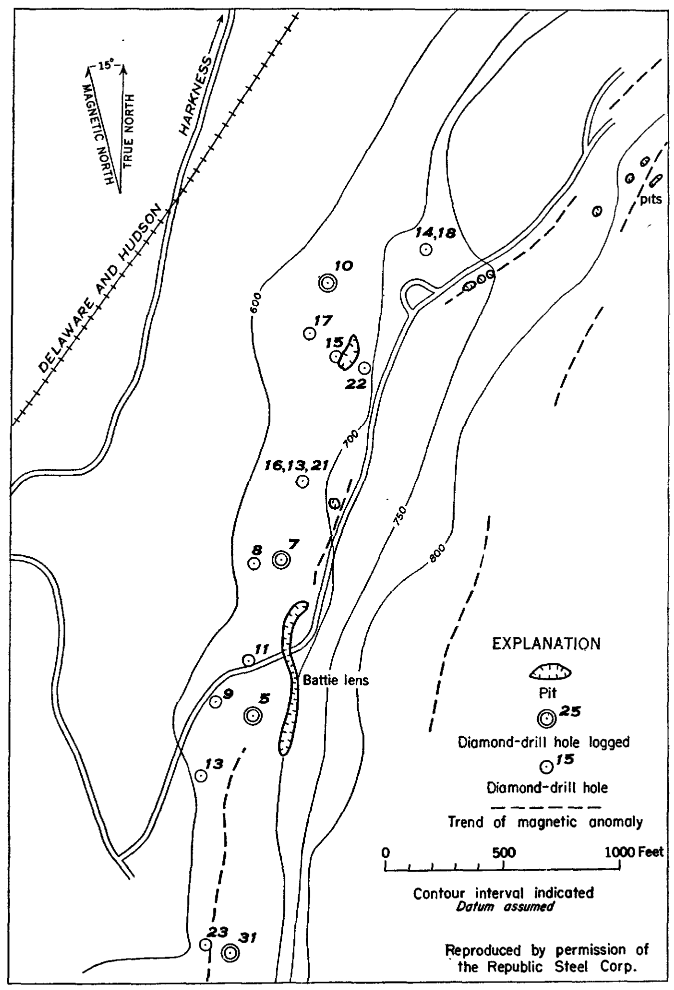

FIGURE 28.—Location map of diamond-drill holes at the Battie mine.

TABLE 35.—*Modal composition of 19 samples of rocks from Battie mine, diamond-drill holes 5, 7, 10 and 31*

[X, present; C, cataclastic; Cl, recrystallized cataclastic; Gr, granular; G, xenomorphic-granular]

	5–1	5–2	5–3	5–4	5–5	5–6	5–7	7–1	7–4	10–1	10–2	10–3	31–1	31–2	31–3	31–4	31–5	31–6	31–7
Microcline							2.4							Tr.			Tr.	3.3	
Microcline and microantiperthite				10.7															
Microperthite															[1]53.2				
Microcline and microperthite						50.2													
Microantiperthite		4.1	30.9										41.1	25.3			24.6		
Plagioclase		An_{10} 8.2	An_{10} 14.2	An_{7} 35.4	An_{25} 54.6	An_{10} 21.4	An_{22} 49.7	An_{18} 33.9	An_{17} 29.6	An_{23} 44.7	An_{30} 33.6		An_{8} 2.4	An_{8} 22.6	An_{8} 15.1		An_{7} 40.9	An_{7} 55.0	An_{25} 27.1
Scapolite				6.3												21.2			
Quartz	13.6	8.2	45.9	30.6		8.6			3.7			1.8	38.3	21.3	21.0		22.2	31.8	5.5
Pyroxene	[1]55.7	41.0		9.3	6.2	16.3	39.8				4.8		5			25.2		[3]3.5	
Hornblende					24.9			61.4	19.2	50.7	57.3			.5	Tr.	50.3			59.2
Biotite	23.4	Tr.	6.8	Tr.	3.1				32.2	2.8		31.3	Tr.	1.9	9.0		9.2	2.9	4.3
Chlorite												[4]25.5		19.2					
Magnetite		38.4			9.1				6.1			32.3	16.2						
Accessories	7.2		2.1	7.5	2.0	3.4	8.1	4.7	9.1	1.7	4.3	9.0		9.1	1.6	3.3	3.0	3.5	3.8
Magnetite	X		X	X		X	X	X		X	X			X	X	X	X	X	X
Chlorite				X	X			X	X[6]								X		
Apatite	X		X	X	X	X	X		X	X			X		X				X
Zircon			X	X	X									X	X		X	X	
Calcite	X				X				X			X	X						
Sphene						X	X												
Depth (feet)	176	199	262	390	478	523	603.5	53	207	325.7	442	577	18	22.4	36.5	49.5	147.5	196.5	249.8
Texture	C	Cl	Cl	Cl	Gr	G	Gr	Gr	G	G	G	G	G	G	G	G	G	Gr	G

[1] Some microantiperthite.
[2] Serpentized.
[3] Chloritized.
[4] With serpentine.

5–1. Quartzose biotite-pyroxene gneiss.
5–2. Ore in plagioclase-pyroxene gneiss.
5–3. Biotite-microantiperthite granite gneiss.
5–4. Pyroxene-scapolite-plagioclase granite gneiss.
5–5. Pyroxene-biotite amphibolite.
5–6. Pyroxene-contaminated microperthite granite gneiss.
5–7. Plagioclase-pyroxene gneiss.
7–1. Amphibolite.
7–4. Biotite amphibolite.
10–1. Biotite amphibolite.
10–2. Pyroxene amphibolite.
10–3. Ore in chlorite-biotite gneiss.
31–1. Subore in microantiperthite granite gneiss.
31–2. Chloritized microantiperthite granite gneiss.
31–3. Biotite-microperthite granite gneiss.
31–4. Scapolite-pyroxene amphibolite.
31–5. Biotite-plagioclase granite gneiss.
31–6. Pyroxene-biotite-plagioclase granite gneiss.
31–7. Biotite amphibolite.

antiperthite granite gneiss. The hanging wall is a biotite amphibolite and the footwall is a grey biotite plagioclase granite gneiss. The middle ore zone is similar to the upper ore zone; its hanging wall is a pink biotite granite gneiss and the footwall is a dark, brecciated scapolite-pyroxene amphibolite. The lower ore zone is similar to the foregoing zones but has a little more pyroxene in the gangue. The hanging wall is a pink pyroxene granite gneiss and the footwall is a pinkish biotite-plagioclase granite gneiss.

A diamond-drill hole (fig. 27*B*) that intersected the ore of the main open-cut exposed three mineralized zones. In all three zones magnetite replaces pyroxene-microantiperthite granite gneiss and plagioclase granite gneiss. The hanging wall and footwall of the ore zones are amphibolite and biotite amphibolite. The magnetite, as seen in thin sections, replaces material that has cataclastic texture. The ore zones are underlain by a biotite-microantiperthite granite gneiss.

A drill hole (fig. 27C) 300 feet north of the open-cut reveals two thin magnetite zones separated by about 20 feet of barren rock. The magnetite replaces coarse feldspathic skarn and pink pyroxene granite gneiss; the hanging wall and footwall of the two zones are feldspathic skarn and biotite-bearing feldspathic skarn. The whole zone is topped by a pink to greenish pyroxene-biotite granite gneiss and bottomed by a white to greenish biotite-pyroxene granite gneiss.

In a drill hole (fig. 27D) 1,500 feet north of the open-cut only one ore zone is penetrated. The magnetite is in a matrix of biotite and chloritized and serpentinized pyroxene. The hanging wall is a pink biotite granite gneiss and the footwall is a whitish to greenish chloritized granite gneiss. The location of this and other diamond-drill holes is given in figure 28. A character sample assay made by the United States Bureau of Mines gave the following result. The magnetic fraction contains 94.1 percent of the total iron.

Sample No.	Total Fe	S	TiO_2	SiO_2
994–40	54.10	0.12	0.57	18.14

Volume-percent composition of sample (R 72) from outcrop of hanging wall of Battie mine open-cut

[X, present; D, dominant]

Microcline and microperthite	51.2	Accessories	3.0
Oligoclase	8.2	Magnetite	D[1]
Quartz	35.7	Zircon	X
Biotite	1.9	Chlorite	X

[1] Euhedral.

An old magnetic map shows an anomaly that is parallel to and about 700 feet east of the old workings. This anomaly was not explored by drilling.

Surface outcrops in the vicinity of the mine have a strike of about N. 30° – 40° E., and dips are predominantly vertical, though steep dips to the northwest and southeast may be seen. The hanging wall of the main open-cut has a strike of N. 45° E. with a dip of 75° SE.; a strong mineral lineation plunges 30° in a northerly direction. Examination of the foliation of drill core adjacent to the open-cut shows that the dip reverses to the west underground.

Winter mine.—The Winter mine is in the Ausable quadrangle and lies 0.3 mile S. 30° E. from Lily Pond. Newland (1908, p. 105) says that three or more small mineralized zones occur here. The zone that was worked had a width of about 10 feet. The ore zone is cut by numerous diabase dikes. Thin sections of material from the wall rock loaned by H. L. Alling have the estimated volume percent composition shown in table 36.

TABLE 36.—*Composition by volume of 3 samples of wall rock from Winter mine*

[X, present; C, cataclastic texture; G, xenomorphic-granular]

	1094A	1094B	1094C
Microcline	50	63	....
Microperthite	....	....	40
Plagioclase	5	2	....
Quartz	42	32	45
Magnetite	3	3	15
Zircon	X	....	....
Apatite	X	....	....
Sphene	....	X	....
Chlorite	....	....	X
Texture	C	G	C

Newland (1908, p. 105) says the strike of the zone is somewhat west of north with a nearly vertical dip that changes to nearly horizontal toward the north. Nearby outcrops strike N. 50° W. and are vertical in dip.

Mace mine.—The Mace mine is in the Ausable quadrangle and lies 0.3 mile N. 40° E. from Lily Pond. The mine is an open pit 500 feet long by about 3 to 10 feet wide.

A diamond-drill hole (fig. 29) put down on this mine shows that the hanging-wall of the ore zone is a pale-greenish magnetite-microcline-microantiperthite granite gneiss. The ore zone appears merely to represent an increase in the magnetite content of the hanging-wall granite gneiss. The footwall is a white to pinkish magnetite-microcline-microperthite granite gneiss. The rocks of the ore zone, the hanging-wall, and the footwall show well-developed cataclastic textures.

The hole examined cut an ore zone with a true

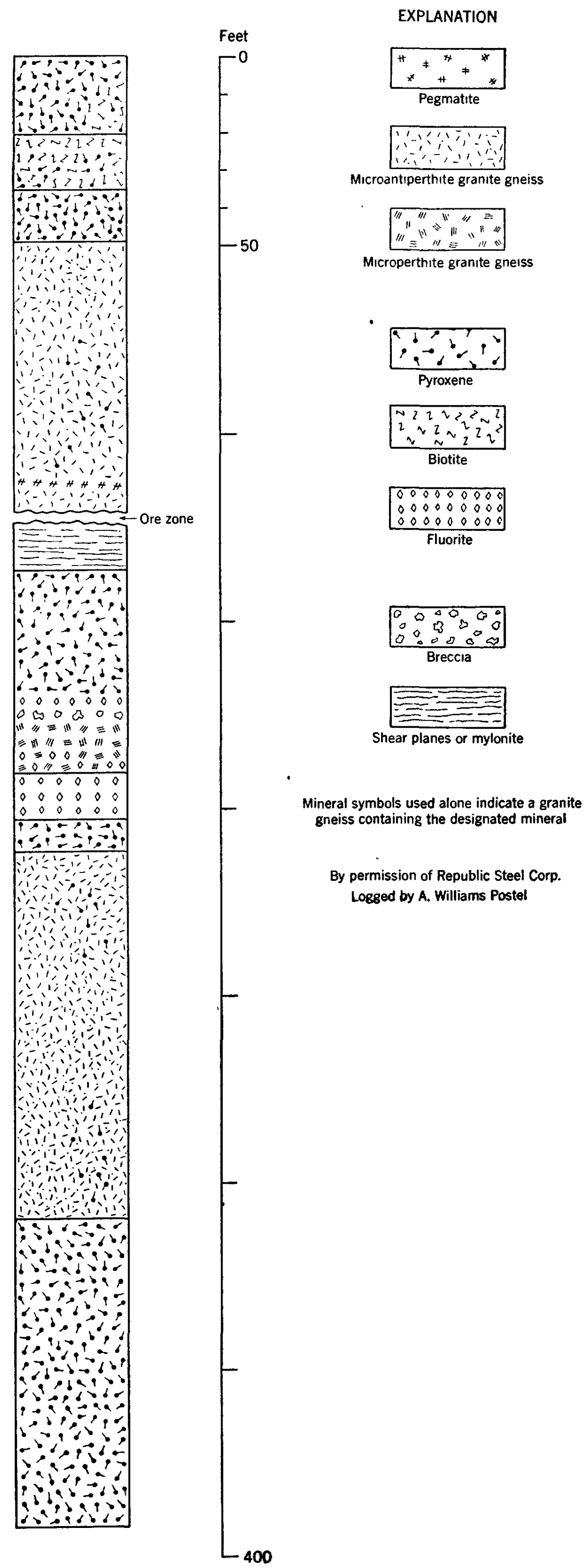

FIGURE 29.—Graphic log of diamond-drill hole 25, Mace mine.

thickness of about 4 feet. Table 37 shows the composition of samples from this hole. An assay of dump material by the United States Bureau of Mines gave the following results. The magnetic fraction contains 97.3 percent of the total iron.

Sample No.	Total Fe	S	TiO_2	SiO_2
994-43	48.30	0.01	0.91	27.68

Nearby outcrops strike N. 10° E. and dip 60° W.

Mitchell prospect.—The Mitchell prospect in the Dannemora quadrangle is represented by two test shafts. The more important of the two shafts is near the east bank of the Little Ausable River, 0.65 mile N. 5° W. from the schoolhouse at "B.M. 1044." Mr. Henry Mitchell, a resident in the vicinity, says the shaft was sunk vertically for 35 feet and a drift was then driven 55 feet to the east.

Magnetite-bearing rocks on the dump near the shaft indicate that the ore is in granitized skarn, quartzose skarn, and sheared quartz. Table 38 gives the compositions of ore and rock material. The rocks that crop out near the shaft are pink granite gneisses that carry pyroxene, hornblende, and biotite in varying amounts.

Outcrops on the hanging-wall side of the shaft strike N. 30° W. and dip 55° E. Outcrops on the footwall side of the shaft strike N. 30° W. and dip 65° E.

Lynch prospect.—The Lynch prospect lies on the crest of a small hill, 1,540 feet above sea level at a distance 1,400 feet N. 57° E. from the head of the Little Ausable River, as shown on the topographic map of the Dannemora quadrangle. It is 13,600 feet south and 2,100 feet east of the intersection of lat. 44°45' and long. 73°40'.

The crest of the hill is composed of a medium-grained pink biotite and pyroxene granite gneiss containing local thick sheets of coarse green pyroxene-garnet skarn. Magnetite occurs as a replacement of this skarn. Some of the magnetite shows interesting secondary quartz rims.

Two shallow test pits have been dug in the magnetite-bearing skarn. The footwall of the ore is a pink pyroxene-contaminated syenite gneiss; the hanging wall is a granitized skarn. Table 39 shows the compositions of these materials.

TABLE 37.—*Modal composition of 5 samples of ore and associated rocks from the Mace mine, diamond-drill hole 25*

[C, cataclastic; Cl, recrystallized cataclastic]

	25–1	25–2	25–3	25–4	25–5
Microcline	...		...	...	...
Microcline and microperthite	...		41.2	44.5	...
Microcline and microantiperthite	42.2		...	...	37.9
Plagioclase	An_{10} 17.5	[1]40.7	An_{12} 28.7	An_7 19.1	An_7 19.1
Quartz	37.3		28.9	33.0	25.9
Biotite	...		...	...	...
Magnetite	...	59.3	...	...	8.6
Accessories	3.0	...	1.2	3.4	8.5
Magnetite	X	...	X	X	...
Sphene	X	...	X	...	...
Chlorite	X	X	...	X	X
Zircon	...	...	X	...	X
Calcite	...	...	...	X	...
Epidote	...	...	...	X	...
Fluorite	...	...	...	X	...
Depth (feet)	72	146.8	151	245.5	320.3
Texture	C	Cl	C	Cl	C

[1] Crushed too fine to separate.

TABLE 38.—*Modal composition of 4 samples of ore and rocks from dump of Mitchell test pit*

[X, present; D, dominant; C, cataclastic; G, xenomorphic-granular]

	Mit–1	Mit–2	Mit–4	Mit–5
Microperthite	...	1.4	...	...
Microcline and microperthite	31.6	...	...	...
Plagioclase	An_{12} 12.9	...	...	...
Quartz	37.4	25.7	89.2	14.1
Clinopyroxene	11.6	39.2	2.4	67.0
Hornblende	...	4.2	...	...
Biotite	Tr.	...	...	...
Magnetite	...	33.6	...	13.8
Accessories	6.4	...	4.2	5.1
Apatite	...	X	...	X
Zircon	...	...	X	...
Calcite	X	...	X	...
Chlorite	...	...	...	...
Magnetite	X	...	D	...
Sphene	X	...	...	...
Chlorite	X	...	...	...
Magnetite (percent by weight)[1]	...	46.5	...	21.4
Iron (percent by weight)[1]	...	33.7	...	15.5
Texture	C	G	C	G

[1] Computed from mode.

Mit. 1. Microperthite granite gneiss.

Mit. 2. Quartzose pyroxene ore.

Mit. 4. Quartz vein material.

Mit. 5. Quartzose pyroxene subore.

TABLE 39.—*Modal composition of 3 samples of ore and associated rocks from the Lynch Prospect*

[X, present; G, xenomorphic granular; Gr, granular]

	617	617A[1]	617B[2]
Microcline	...	...	9.5
Microperthite	...	61.1	...
Plagioclase	...	An_{16} 17.5	An_{17} 33.4
Quartz	2.5	Tr.	11.7
Clinopyroxene	63.2	20.9	17.9
Garnet	1.4	...	22.2
Magnetite	31.6	...	...
Accessories	1.2	.4	5.2
Magnetite	...	X	X
Sphene	X	...	X
Zircon	...	X	...
Magnetite (percent by weight)[3]	44.3	...	...
Iron (percent by weight)[3]	32.0	...	...
Texture	G	G	Gr

[1] Footwall.

[2] Hanging wall.

[3] Computed from mode.

617. Ore.

617A. Pyroxene-contaminated microperthite syenite gneiss.

617B. Pyroxene-contaminated plagioclase granite gneiss.

The rocks of the Lynch prospect strike N. 10°–20° E. and dip 40° W. Small, intricate folds occur on the hanging-wall side of the ore. As exposed in one of the test pits, the ore vein is about 5 feet wide.

A reconnaissance dip-needle survey of the area indicated discontinuous zones of magnetic attraction extending for a distance of 1,800 feet. High magnetic attractions do not exceed 30 feet in length parallel to the strike. The airborne magnetometer survey showed no attraction over this locality.

Rock ore bed.—Witherbee (1916), in his location map of Adirondack iron ore, shows that this ore bed is on the north side of Slush Pond, south of the west peak of Slush Pond Mountain, in the southwest corner of the Dannemora quadrangle. The ore was reported to be 10 feet thick, but the bottom "was not observed."

Field investigation by A. F. Buddington (personal communication) indicates that the magnetite zone is 500 feet south of the "n" of Slush Pond (see plate 1). The dip-needle survey showed two anomalies with maximum lengths between 500 to 700 feet.

A dump by an old pit indicates that the magnetite is in a granite gneiss. A near by outcrop had magnetite in a feldspathic hornblende skarn. This outcrop has a strike of N. 20° W. and a dip of 70° E.

DANNEMORA AREA

The mines of the Dannemora area include the Averill, Ellis, LaMar, and Russia Station magnetite concentrations. The first three are in and near the town of Dannemora in the northwest corner of the Dannemora quadrangle. The Russia Station locality is on the southern end of Johnson Mountain in the Lyon Mountain quadrangle. Ownership of the first three mines is largely in private hands. The largest part of the Russia Station zone is owned by the Republic Steel Corp., though small parts of the area are owned privately.

Newland (1908) included this area in his description of the mines of the Saranac Valley; he stated (p. 35) that to the end of 1906 the Dannemora and Saranac Valley areas produced 500,000 long tons of ore. The Averill, LaMar, and Ellis mines occur on a discontinuous line of magnetic anomaly over a linear distance of about 2.5 miles (Donnerstag, 1945). The overall production from this group was probably small.

Averill mine.—The Averill mine is within the village limits of Dannemora, about 0.1 mile west of the prison walls. It was opened in 1842 (Newland, 1908, p. 126). The working consisted of an open-cut about 300 feet long by 30 feet wide. At the east end of the cut the ore was followed for a short distance underground down the dip. All the workings are now flooded. No ore specimens are obtainable. In the pit the hanging-wall is seen to be composed of a granitized pyroxene amphibolite.

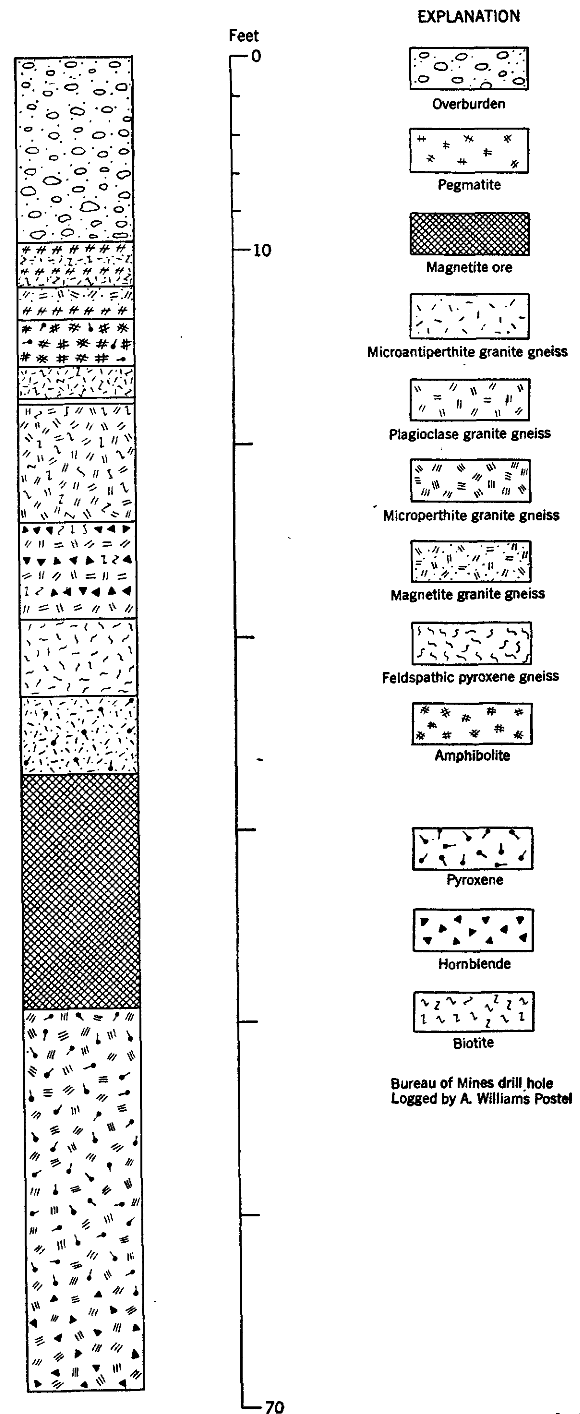

FIGURE 30.—Graphic log of diamond-drill hole 2E, Ellis ore bed.

Modal composition of a sample (No. 303) from the hanging wall, Averill pit

[G, Xenomorphic-granular]

Microcline	13.9	Accessories:	
Quartz	9.2	Apatite	0.3
Plagioclase	15.9 (An_{26})	Magnetite	12.9
Clinopyroxene	10.3		
Hornblende	37.4		
Texture			G

At the northeast end of the pit, a pink pyroxene granite gneiss carrying numerous pyroxene skarn inclusions is exposed. It is probably this rock that was mineralized to form the ore body. The strike of the pit is N. 50° E. and the dip is 10° to 30° NW.

Ellis ore pits.—A detailed descripton of the Ellis ore bed (pl. 3) has already been published (Donnerstag, 1945). The pits may have been opened about the same time as the Averill mine. The Ellis ore pits, three in number, are near the Ellis road, about 1.7 miles from the intersection of the Ellis road with the Rand Hill road. In all the pits, the ore occurs in a medium-grained, foliated, feldspar-pyroxene rock interpreted as granitized skarn. The color ranges from dark green to pink, depending upon whether green pyroxene or pink feldspar predominates. Local pegmatitization produces very coarse aggregates of pyroxene and feldspar. As seen at outcrops, the footwall side of the ore body is underlain by amphibolite and a complex of plagioclase granite gneiss and pyroxene granite gneiss. The hanging-wall side of the ore body is a low-mafic microcline granite gneiss.

Where cut by two short diamond-drill holes by the United States Bureau of Mines, the immediate hanging-wall and footwall are composed of a pyroxene-contaminated microantiperthite quartz syenite gneiss and a pyroxene-microperthite granite gneiss, respectively. The texture of the rocks from the diamond-drill holes is strongly indicative of recrystallized cataclastic minerals. Table 41 gives the petrographic analyses of material from the two holes.

Diamond-drill hole 1E was abandoned at a depth of 26.5 feet, when the drilling hit underground workings. Diamond-drill hole 2E (fig. 30) cut 12.2 feet, true thickness, of ore. The assay of this material by the Bureau of Mines gave 20.7 percent metallic iron over an apparent thickness of 15.1 feet.

The following tables show the composition of materials collected from the old workings (table 40). The assays of channel samples (fig. 31) (table 42) and diamond-drill cores (table 43) from the ore zone are reproduced from the Bureau of Mines Report of Investigation 4002 (Bardill, 1947a).

TABLE 40.—*Modal composition in volume percent of 5 samples of Ellis ore and barren rock*

[X, present; Cl, recrystallized cataclastic; G, xenomorphic-granular; Grl, local shearing]

	P285[1]	P285C[1]	P285A[1]	P288[2]	P290[3]
Microcline	....	Tr.	....	....	....
Microperthite	27.1	46.6	....	[4]69.2	[4]33.3
Microantiperthite	....	....	53.7	....	....
Plagioclase	An$_9$ 10.2	An$_7$ 13.9	An$_6$ 23.2	9.9	1.6
Quartz	....	Tr.	....	Tr.	....
Hornblende	....	....	....	....	14.2
Clinopyroxene	39.1	26.9	10.4	19.4	32.1
Biotite	Tr.	....	11.8	Tr.	Tr.
Magnetite	20.9	9.6	.9	9.5	18.7
Accessories	2.7	2.9	....	....	....
Apatite	X	X	X	X	X
Zircon	X	X	X	X	X
Calcite	X	X	....	....	....
Sphene	....	....	....	X	....
Magnetite (percent by weight)[5]	32.0	15.6	....	....	29.1
Iron (percent by weight)[5]	23.2	11.1	....	....	21.0
Texture	G	G	Cl	Grl	Cl

[1] Old ore pit at 100 feet N, 250 feet W base-line coordinates.
[2] Old ore pit at 900 feet N, 320 feet W base-line coordinates.
[3] Old ore pit at 700 feet N, 270 feet W base-line coordinates.
[4] Some microcline present.
[5] Computed from mode.

P285. Pyroxene-contaminated microperthite syenite gneiss.
P285C. Pyroxene-contaminated microperthite syenite gneiss.
P285A. Biotite-pyroxene-microantiperthite syenite gneiss.
P288. Pyroxene-contaminated microperthite syenite gneiss.
P290 .Pyroxene-hornblende-contaminated microperthite syenite gneiss.

TABLE 41.—*Modal composition of 11 rock samples from Ellis ore bed, diamond-drill holes 1E and 2E*

[D, dominant; X, present; Cl, recrystallized cataclastic; Gr, granular; G, xenomorphic granular]

	1E–1	1E–2	2E–1	2E–2	2E–3	2E–4	2E–5	2E–6	2E–7	2E–8	2E–9
Microcline	....	....	....	....	....	....	Tr.	....	....	39.7	50.4
Microantiperthite	86.2	29.6	55.3	....	50.5	Tr.	Tr.	....	68.6		
Microperthite	....		....			....				....	....
Plagioclase	7.1	2.2	8.2	An$_{22}$ 67.8	An$_{11}$ 10.3	An$_{10}$ 71.9	An$_{10}$ 70.6	An$_{12}$ 65.1	7.1	An$_{11}$ 20.5	10.8
Quartz	Tr.	Tr.	34.4	Tr.	35.6	25.6	10.2	30.2	2.2	20.8	23.8
Clinopyroxene	....	48.8	....	....	....	....	....	....	[1]18.1	5.9	....
Hornblende	1.8	....	....	[2]14.8	....	....	13.8	2.7	....	....	[2]2.5
Biotite	1.3	.8	.5	.8	1.2	.8	2.8	Tr.	....	Tr.	....
Magnetite	....	18.5	....	9.2	....	....	....	....	....	6.4	.5.9
Accessories	3.6	....	1.6	7.3	2.4	1.7	2.5	1.9	4.0	.3	.7
Magnetite	D	X	D	X	D	D	D	D	D	....	....
Apatite	....	....	X	D	....	X	....	....	....	D	X
Sphene	....	....	X	X	....	....	....	....	X	X	X
Zircon	X	....	X	X	X	X	X	X	X	X	X
Chlorite	....	....	....	....	X	X	X	X	....	....	D
Calcite	X	....	....	....	....	....	X	....	X	....	....
Depth (feet)	....	....	11.3	17.1	17.7	24.6	28.0	30.2	43.0	62.4	72.5
Texture	Cl	Gr	Cl	Gr	Cl	Cl	Cl	Gr	Cl	Gr	Cl

[1] Some hornblende present.
[2] Some pyroxene present.

1E–1. Microantiperthite syenite gneiss.
1E–2. Microantiperthite syenite gneiss.
2E–1. Microantiperthite granite gneiss.
2E–2. Hornblende-plagioclase granite gneiss.
2E–3. Biotite-microperthite granite gneiss.
2E–4. Plagioclase granite gneiss.
2E–5. Hornblende-plagioclase granite gneiss.
2E–6. Hornblende plagioclase granite gneiss.
2E–7. Pyroxene-microantiperthite-quartz syenite gneiss.
2E–8. Pyroxene-microantiperthite granite gneiss.
2E–9. Hornblende-microantiperthite granite gneiss.

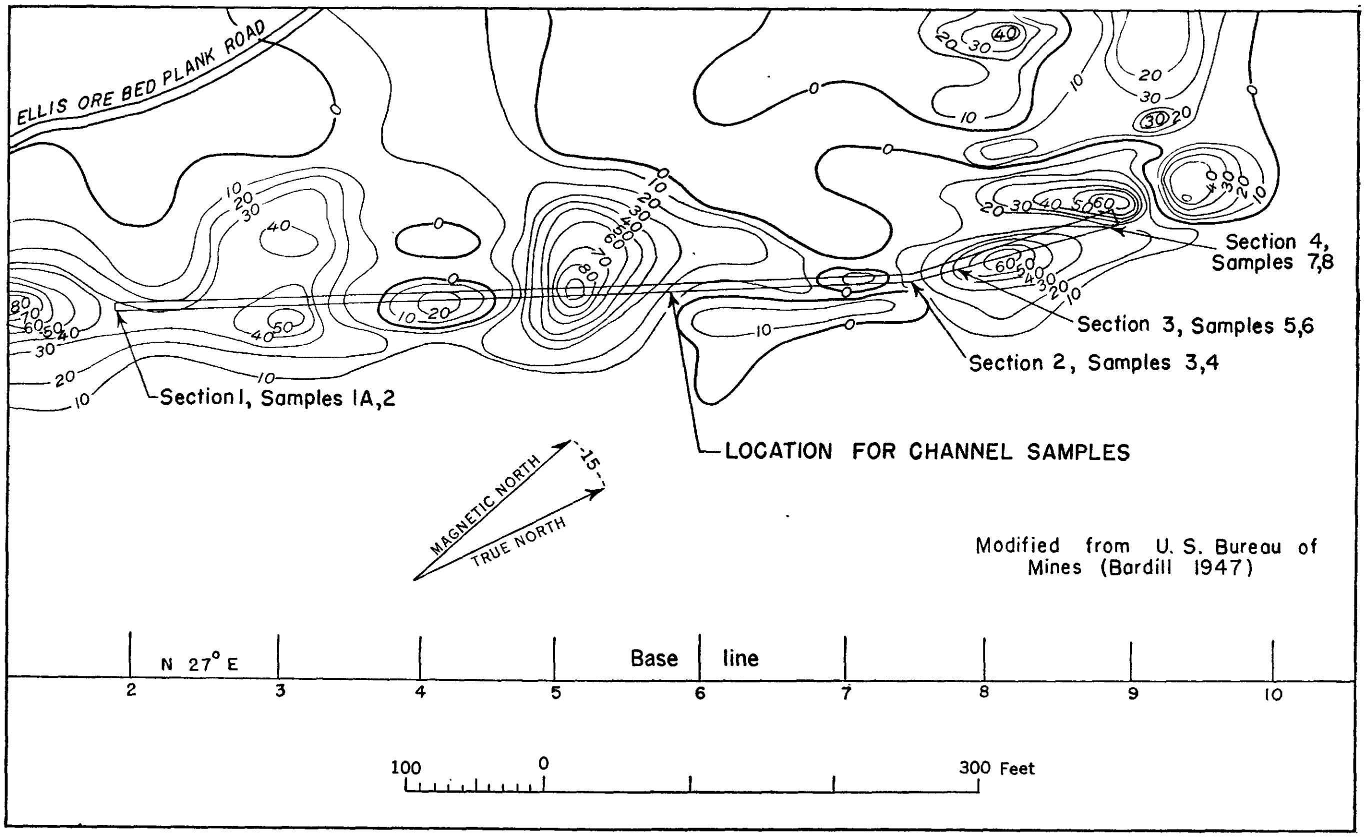

FIGURE 31.—Magnetic-anomaly map and assay section of the Ellis ore bed.

TABLE 42.—*Assays of 9 channel samples from the Ellis ore bed*

Sample No.	Length (feet)	Soluble Fe (percent)	Magnetic Fe (percent)	P (percent)	S (percent)	TiO_2 (percent)	Insol. (percent)
Section 1:							
994-1....	1.0	50.70	49.70	0.17	0.060	0.48	31.30
994-1a...	5.0	47.00	44.20	1.15	.090	.43	24.30
994-2....	5.0	41.90	39.70	2.30	.160	.38	21.40
Section 2:							
994-3....	5.0	36.60	34.70	.36	.018	.48	43.00
994-4....	5.0	29.20	25.80	.10	.008	.53	54.80
Section 3:							
994-5....	3.0	37.50	35.00	.90	.022	.40	38.90
994-6....	5.0	22.70	19.00	1.03	.018	.35	57.70
Section 4:							
994-7....	3.3	20.70	18.40	.31	.022	.53	65.70
994-8....	5.0	15.70	13.70	.42	.022	.48	71.90

A typical test on the composite sample of samples 994-3 through 994-8 crushed to minus 65-mesh showed:

	Total Fe percent	Soluble Fe percent	Magnetic Fe percent	P percent	S percent	TiO_2 percent	Insol. percent	Ratio of conc.
Heads......	31.00	27.50	24.00	0.77	0.06	0.46	62.40	......
Concentrates	67.00	66.8	....	.05	.06	.66	4.30	2.5
Tailings.....	7.0	2.80	....	1.15	.10	1.60	85.7	......

Iron recovery based upon total-iron analysis was 86.6 percent.

TABLE 43.—*Assays of 4 samples from hole 1E and 16 samples from hole 2E*

Hole 1E

[Coordinates: N. 10,213, E. 9,804. Elevation, 1,791 feet]

Sample No.	Depth in feet: From—	Depth in feet: To—	Total Fe (percent)	Magnetic Fe (percent)	Insol. (percent)
54................	0.0	5.0	10.10	....	78.6
55................	5.0	7.5	17.80	14.10	71.8
56................	7.5	12.5	15.20	10.60	75.1
57................	12.5	17.6	22.50	18.15	67.0

Hole 2E

[Coordinates: N. 10,243, E. 9,747. Elevation, 1,790 feet]

Sample No.	Depth in feet: From—	Depth in feet: To—	Total Fe (percent)	Magnetic Fe (percent)	Insol. (percent)
4................	0.0	9.5	....	....	....
58................	9.5	12.3	6.33	....	89.6
59................	12.3	15.3	8.50	....	83.3
60................	15.3	17.1	11.10	....	78.4
61................	17.1	21.0	5.55	....	89.8
62................	21.0	22.9	6.20	....	87.4
63................	28.9	31.1	9.50	....	85.2
64................	34.1	40.8	20.00	16.30	72.8
65................	40.8	45.9	13.40	....	78.0
66................	45.9	50.0	20.40	15.95	68.9
67................	50.0	55.0	26.10	21.40	62.6
68................	55.0	61.0	30.20	25.00	51.9
69................	61.0	65.0	11.00	....	82.7
70................	65.0	72.7	8.85	....	84.5
71................	72.7	78.0	7.70	....	85.7
72................	78.0	87.0	6.80	....	86.0

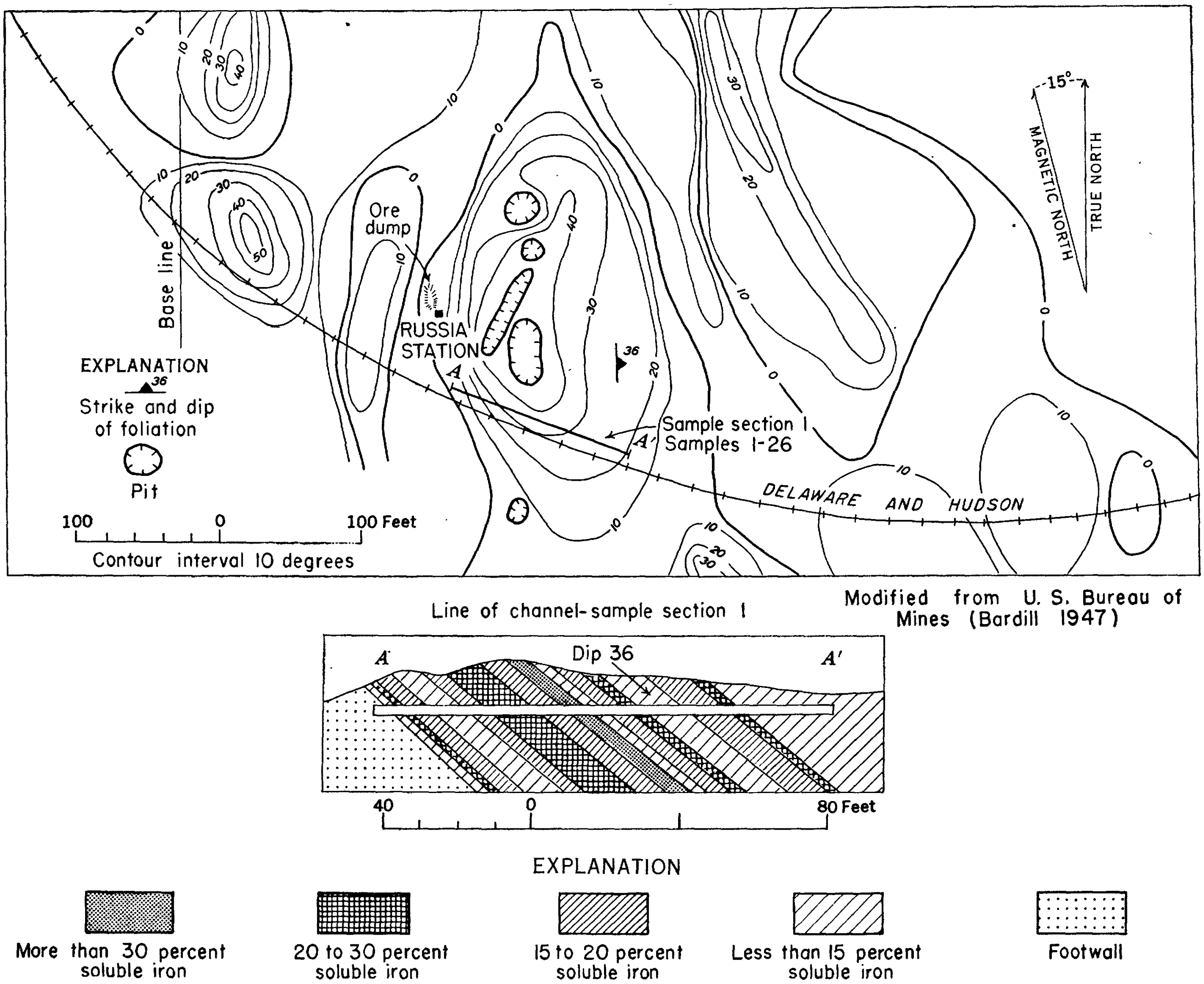

FIGURE 32.—Magnetic-anomaly map and assay section of the Russia Station ore bed.

It is not possible to give a complete detailed interpretation of the structural picture of the Dannemora area. Actual contacts are generally covered. Dips and strikes, particularly dips, change abruptly, and the abandoned ore pits are partly flooded.

The major structural feature of the area is a relatively broad and shallow syncline that plunges to the southwest. Within the syncline are numerous small anticlinal and synclinal flexures, which cause the abrupt change in dips and strikes typical of the region.

The Ellis ore occurs on the southeast limb at the extreme northeastern end of the syncline. The ore zone strikes N. 30° E. and dips moderately to the northwest. In diamond-drill hole 2E the foliation at the surface dips about 40°; at a depth of 80 feet the dip decreases to 15°. Magnetic work indicates that the ore occurs only on the southeast limb and part way around the heel of the syncline. The tonnage of ore in the Ellis zone is probably small.

LaMar pit.—The LaMar pit is about a mile S. 30° W. from the Ellis mine. The anomaly on which the LaMar pit is situated is not continuous with the Ellis anomaly. Though more or less parallel with it, the LaMar anomaly is offset about 500 feet to the west. The ore (table 44) occurs in a granitized pyroxene amphibolite somewhat similar to the host rock of the Ellis magnetite deposit. The footwall is amphibolite underlain by biotite granite gneiss and low-mafic granite gneiss. The hanging-wall is a magnetite granite gneiss. The LaMar zone strikes N. 55 E. and dips 36° NW.

Russia Station.—The Russia Station magnetite crops out along the road bed of the Delaware and

TABLE 44.—*Modal composition of subore (sample 294) from LaMar pit[1] (in volume percent)*

[D, dominant; X, present; G, xenomorphic-granular]

Microperthite and microantiperthite[2]	30.0	Magnetite	11.3
Plagioclase (An_{12})	24.1	Accessories	1.0
Quartz	1.0	Apatite	D
Clinopyroxene	6.1	Zircon	X
Hornblende	26.4	Biotite	X
Magnetite (percent by weight)[3]			18.1
Metallic iron (percent by weight)[3]			13.1
Texture			G

[1] At 4,200 feet south, 600 feet west from the anomaly base line.
[2] Some microcline present.
[3] Computed from mode.

Hudson Railroad at the southern end of Johnson Mountain. The old shaft, now flooded, is said to have a depth of about 50 feet. The mine was opened in 1852 and was closed in 1872. Peter Tremblay is credited with having located this mine for Jerry Phillips. (Written personal communication from Daniel Tremblay of Redford, N. Y.) Production must have been small.

Marginal magnetite concentration occurs in a pyroxene-contaminated granite gneiss and in a pyroxene-plagioclase granite gneiss (table 45). About 130 feet of these mineralized rocks is exposed in the railroad cut. The Republic Steel Corp. in 1948 was directing a diamond-drilling program to explore the Russia Station magnetic anomalies. The United States Bureau of Mines took 26 channel samples (fig. 32) for assay over a distance of 132 feet (78

TABLE 45.—*Modal composition of 6 samples of ore and gangue rock from Russia station*

[Samples were collected from east to west and numbered consecutively as given. Symbols: X, present; Cl, recrystallized cataclastic; G, xenomorphic-granular; Gr, granular]

	399	399A	399B	399C	399E	399F
Microcline	67.1	......	......	......	......	......
Microperthite		[1,2] 54.1	[1,2] 52.4	......	......	......
Microantiperthite	......	......	......	......	......	[2] 51.8
Plagioclase	6.0	4.6	14.4	An_6 52.7	An_{12} 62.7	An_8 10.3
Quartz	19.3	3.0	6.6	9.1	Tr.	13.7
Clinopyroxene	X	34.3	16.1	14.7	7.1	14.0
Hornblende	X	......	......	5.2	16.7	......
Biotite	X	......	......	X	......	X
Magnetite	2.3	2.5	10.0	11.8	11.5	7.3
Accessories	5.2	1.5	.5	6.4	2.0	2.9
Sphene	X	X	X	......	......	......
Zircon	X	X	X	X	X	X
Calcite	......	X	X	......	......	......
Chlorite	X	......	X	X	X	......
Apatite	......	......	......	......	X	X
Magnetite (percent by weight)[3]	......	......	18.07	20.92	20.44	13.22
Metallic iron (percent by weight)[3]	......	......	13.10	15.15	14.80	9.5
Texture	Cl	G	G	G	Gr	Cl

[1] Some microantiperthite.
[2] Orthoclase microperthite.
[3] Computed from mode.

399. Microperthite granite gneiss.
399A. Pyroxene-contaminated microperthite-quartz syenite gneiss.
399B. Pyroxene-contaminated microperthite-quartz syenite gneiss.
399C. Pyroxene-hornblende-contaminated plagioclase granite gneiss.
399E. Hornblende-pyroxene-plagioclase syenite gneiss.
399F. Pyroxene-microantiperthite granite gneiss.

feet, true thickness). The following assay information (table 46) is reprinted from Bureau of Mines Report of Investigations 4008 (Bardill 1947c).

TABLE 46.—*Partial analysis (in percent) of 26 samples from ore zone at Russia Station*

Sample No.	Soluble Fe	Magnetic Fe	P	S	TiO_2	Insol.
1	5.40	......	0.170	0.05	1.03	88.6
2	19.90	......	.150	.04	.53	67.2
3	15.80	......	.160	.05	.73	73.6
4	9.10	......	.650	.04	1.88	83.1
5	10.60	......	.340	.06	1.18	82.5
6	17.50	......	.024	.06	.43	73.0
7	23.30	......	.074	.05	.68	64.0
8	22.00	......	.076	.05	.48	65.8
9	19.50	......	.044	.08	.58	68.9
10	16.40	......	.065	.04	.43	74.1
11	16.90	......	.043	.01	1.08	72.6
12	31.10	......	.040	.00	.98	53.1
13	11.50	......	.046	.00	1.40	79.3
14	15.00	......	.045	.01	1.28	75.0
15	24.00	......	.056	.01	1.18	63.1
16	13.90	......	.043	.00	1.38	80.9
17	10.90	......	.012	.01	1.48	83.2
18	9.53	......	.060	.00	1.53	69.4
19	17.70	......	.054	.02	1.28	68.9
20	16.90	......	.043	.01	1.08	63.0
21	20.90	......	.062	.02	1.43	63.8
22	4.32	......	.043	.00	1.75	78.9
23	9.48	......	.098	.00	1.35	73.8
24	15.30	......	.049	.00	1.28	78.5
25	12.10	......	.075	.00	1.68	78.1
26	12.60	......	.045	.03	1.63	78.8
Av. assay	15.45	13.6	0.099	0.025	1.14	73.20

Selection from the foregoing analyses gives a continuous true thickness of 22 feet of 21 percent soluble iron to be taken near the center of the ore zone. The richest part of the zone has a true thickness of 3 feet and assays 31 percent soluble iron.

The foliation in the rocks near Russia Station generally strike north, although they deviate 25° both to the east and to the west. It will be seen that easterly deviations from the general north strike lie on the east side of a reference line at about long. 73° 46' and that westerly deviations lie west of it. The main ore zone follows the westerly deviation. All dips in the Russia Station are moderate to the east. Small recumbent folds, the limbs of which are separted by a few inches, overturned to the west may be seen in the area. The axial planes of such folds are parallel to the dip of the foliation. These folds occasionally pass into small overthrust faults in which the overthrust member rides up the fault plane to the west. This structural pattern prevails for some 2 miles north and south of Russia Station. It is suggestive of a major, tight, northward-plunging syncline overturned to the west (fig. 33).

The Russia Station ore zone is on the central magnetic anomaly, the so-called Phillips anomaly, of three parallel anomalies which have already been described. Old workings also lie on the eastern anomaly, the Kimball anomaly, and on the western anomaly, the Dorothy anomaly.

On the Kimball anomaly an old open-cut, now filled with water, may be seen on the Miner farm,

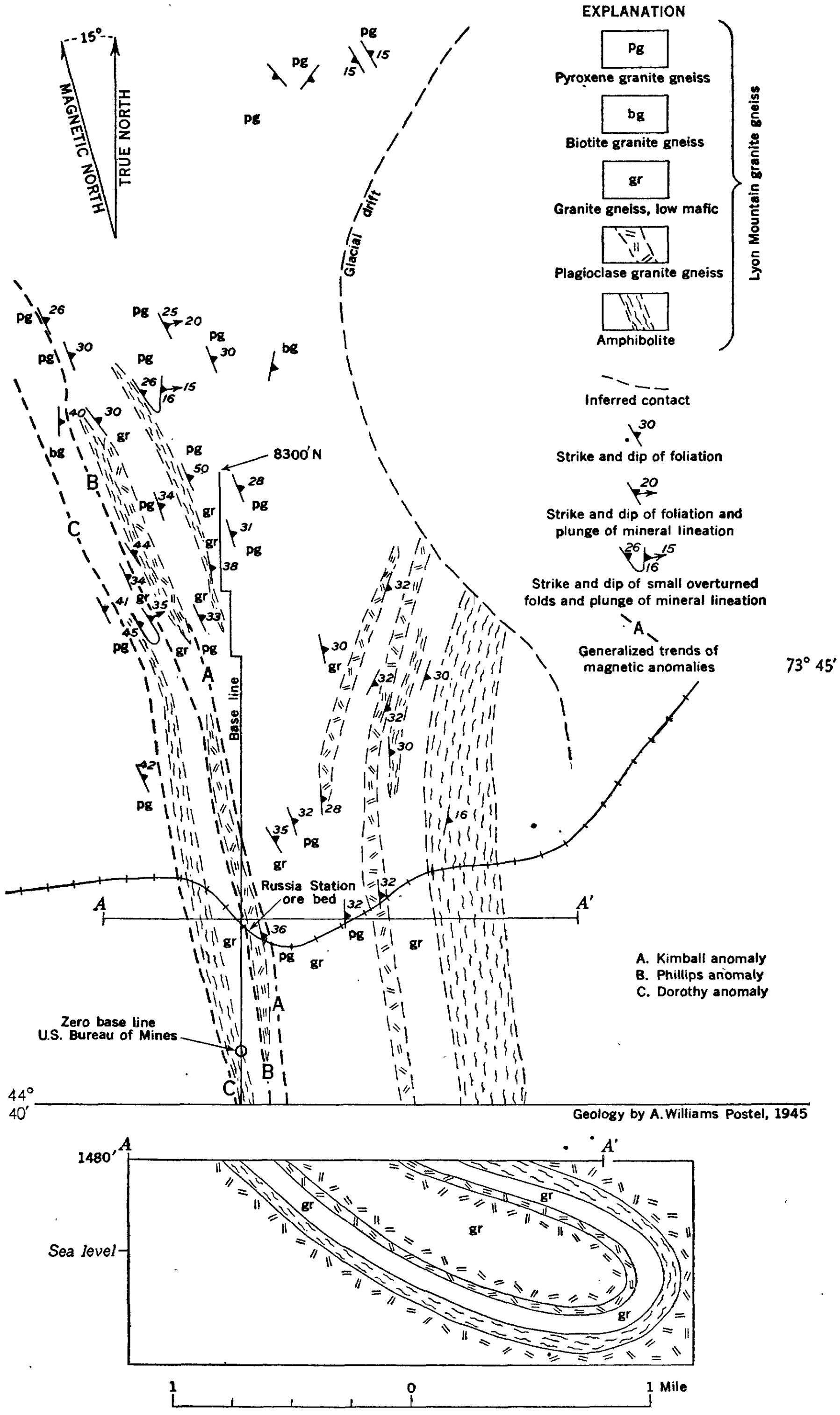

FIGURE 33.—Geologic map of the Russia Station ore bed.

which on the map is 1.5 miles S. 13° E. from the numeral "9" in "B.M. 1489." A pillar of ore left in the open-cut indicates a true thickness for the ore zone of about 8 feet. The ore is low to medium in grade and is mixed with pyroxene, hornblende, and plagioclase. The footwall is a pyroxene-microantiperthite granite gneiss and the hanging-wall is a hypersthene amphibolite; see table 47. An area, 300

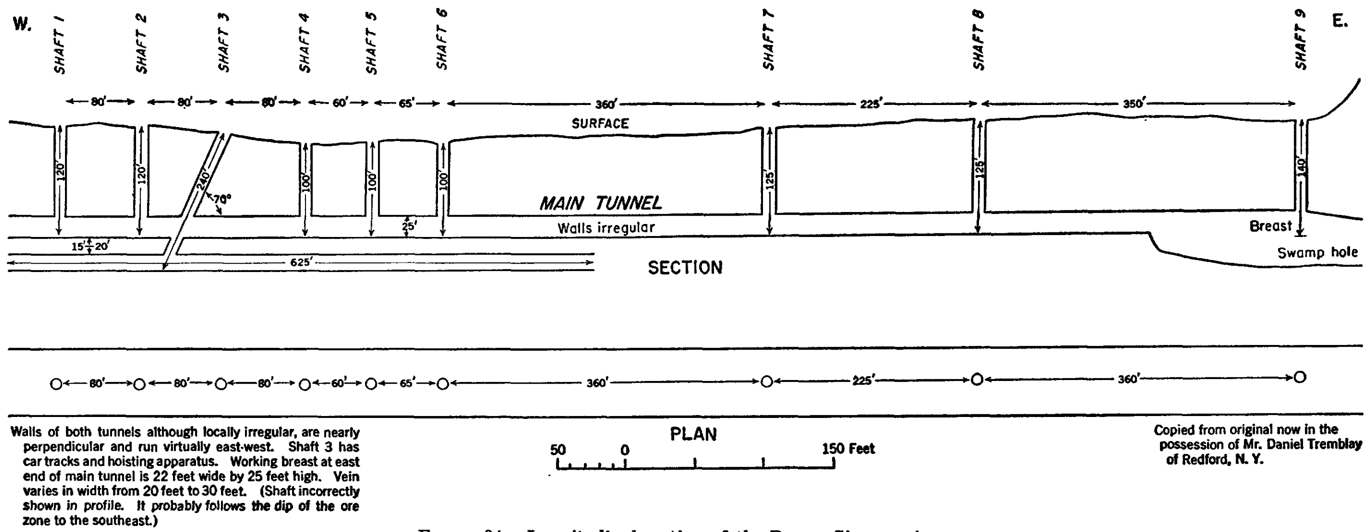

FIGURE 34.—Longitudinal section of the Bowen-Signor mine.

feet by 30 feet, of high magnetic anomaly surrounds this ore belt, which strikes N. 15° W. and dips 40° E. An assay (sample 994-35) of this ore by the United States Bureau of Mines gave 38.80 percent total iron (Fe) and 10.54 percent silica (SiO_2).

The material on a waste pile from an old test pit (about lat. 44° 41', long. 73° 47') on the Dorothy anomaly contains magnetite in pyroxene granite gneiss. The magnetite content ranges from 30 percent to 40 percent by volume. There is no outcrop near the pit, but the structure probably conforms to that near Russia Station.

TABLE 47.—*Composition (percent by volume) of hanging wall and footwall of magnetite body on Miner farm, Lyon Mountain quadrangle*

[X, present; D, dominant; G, xenomorphic-granular]

	P350A	P350B
Microantiperthite		50.0
Plagioclase	An_{40} 43.4	An_{20} 24.6
Quartz		Tr.
Hypersthene	6.8	
Clinopyroxene		11.2
Hornblende	43.3	
Magnetite		13.9
Accessories	6.5	0.2
Apatite	X	X
Zircon	X	X
Biotite	X	
Magnetite	D	
Texture	G	G

P350A, hanging-wall amphibolite.
P350B, footwall pyroxene-microantiperthite granite gneiss.

SARANAC VALLEY ORE BELT

The Bowen-Signor, Clayburg, and Tremblay mines lie along a curved mineralized belt in the Saranac Valley about a mile south of Redford in the Lyon Mountain quadrangle. An old magnetic map cited by Newland (1908, p. 126) and recent work of the United States Bureau of Mines indicate that this curved belt is about 6 miles long, extending some 2 miles northeast from the Bowen-Signor mine and also some 4 miles west from it. The discovery of this belt is credited to Peter Tremblay, who started mining from four pits just west of the Bowen-Signor mine in 1844. Tremblay opened the present Bowen-Signor mine in 1854 and worked it until 1867, when he sold the property to Bowen and Williams (Hurd, 1880).

Bowen-Signor mine.—The Bowen-Signor mine, which is 0.8 mile due south of Redford, produced some 260,000 tons of ore (Newland, 1908, p. 127); it was operated from 1854 until 1885. According to an old mine plan now in the possession of Daniel Trembley of Redford, the working breast of ore had a width of about 22 feet when mining ceased. The ore had been mined for a distance of about 1,600 feet parallel to the strike. The mining operations (fig. 34) involved two levels, 100 feet and 175 feet below the surface. The lower level had been driven for a distance of 625 feet.

Samples obtained from the old dumps (table 48) show magnetite in plagioclase granite gneiss, quartzose pyroxene skarn, and pyroxene skarn. Associated gangue rocks include pyroxene-scapolite gneiss, feldspathic pyroxene gneiss, quartzose pyroxene skarn, and microperthite granite gneiss. The composition of rocks that crop out at the mine are given in table 49.

Putnam (1886, p. 120) gives the following ore analyses:

	1313	1314
Metallic iron	34.28	66.78
Phosphorus	.124	.037

1313 from 400 tons of crude ore.
1314 from 100 tons of separated ore.

TABLE 48.—*Modal composition of 12 samples of ore and gangue rock from dumps of Bowen-Signor mine*

[D, dominant; X, present; G, xenomorphic-granular; C, cataclastic; Gn, gneissic; Gr, granular]

	BS–2	BS–3	BS–4	BS–5	BS–6	BS–7	BS–10	BS–11	BS–13	BS–14	BS–15	BS–16
Microperthite	41.9	6.1	....	2.8	....	Tr.	....	....	....	....	7.1	....
Plagioclase	An_{23} 28.9	....	....	An_{20} 80.4	57.6	....	....	An_{10} 38.9	....	An_{10} 80.2	An_{10} 57.2	....
Quartz	Tr.	3.4	37.4	....	....	Tr.	62.1	34.4	20.5	7.3	5.7	59.8
Clinopyroxene	19.9	81.2	47.0	7.3	14.3	88.5	[1]34.1	1.0	67.6	....	13.3	[1]31.2
Hornblende	....	....	....	6.2	....	....	2.3	....	....	5.2	....	2.1
Scapolite	4.6	....	....	....	....	....	....	....	....	....	....	....
Magnetite	....	9.3	15.5	....	28.1	10.4	....	24.1	....	....	10.0	....
Accessories	4.6	....	....	3.2	....	1.1	1.5	1.6	11.8	7.4	6.6	6.8
Magnetite	D	....	....	X	....	....	D	....	....	D	....	D
Apatite	X	....	....	X	X	X	....	X	....	X	....	....
Zircon	X	....	....	X	X	....	X	X	....	X	X	X
Sphene	X	X	....	D	....	D	....	X	....	....	X	....
Chlorite	....	....	....	....	....	....	....	....	D	X	....	....
Calcite	....	....	....	....	....	....	....	....	X	....	X	....
Metallic iron (percent by weight)[2]	....	14.8	23.4	....	40.0	16.1	....	39.0	....	....	18.0	....
Magnetite (percent by weight)[2]	....	10.7	16.9	....	29.0	11.7	....	28.1	....	....	13.1	....
Texture	G	G	G	G	C	Gr	C	Gr	C	G	C	Gn

[1] Largely replaced by calcite.
[2] Computed from mode.

BS–2. Pyroxene-contaminated microperthite syenite gneiss.
BS–3. Granitized pyroxene skarn.
BS–4. Quartzose pyroxene skarn.
BS–5. Pyroxene-hornblende plagioclase gneiss.
BS–6. Pyroxene-contaminated microperthite granite gneiss.
BS–7. Pyroxene skarn.
BS–10. Quartzose pyroxene skarn.
BS–11. Pyroxene-plagioclase granite gneiss.
BS–13. Quartzose pyroxene skarn.
BS–14. Hornblende-plagioclase granite gneiss.
BS–15. Pyroxene-plagioclase granite gneiss.
BS–16. Altered quartzose pyroxene skarn.

When the mine was operating, 2 to 3 tons of crude ore was needed to produce a ton of concentrate. Data from the diamond-drilling program carried out by the Saranac Iron Mining Co. in 1905 show an iron content ranging from 4.5 percent to 47.7 percent, with phosphorus ranging from 0.02 percent to 1.78 percent. Assays by the United States Bureau of Mines of composite samples taken from the old dumps gave the following results (adapted from Reed and Cohen 1949):

Product	Percent by weight	Chemical analysis of magnetic and nonmagnetic fractions (percent)						Total sample Fe (percent)	Total Fe (percent)
		Fe	SiO_2	S	P	Mn	TiO_2		
C–55:									
Magnetic	22.5	67.9	3.70	0.002	0.02	0.07	0.34	15.3	84.9
Nonmagnetic	77.5	3.5	.....	.....	.....	.....	.....	2.7	15.1
Total	100.0	.....	.....	.....	.....	.....	.....	18.0	100.0
Ratio of concentration									4.35 : 1
C–56:									
Magnetic	29.8	68.6	2.96	0.002	0.01	0.06	0.34	20.4	89.3
Nonmagnetic	70.2	3.5	.....	.....	.....	.....	.....	2.5	10.7
Total	100.0	.....	.....	.....	.....	.....	.....	22.9	100.0
Ratio of concentration									3.34 : 1

C-55. From dump on Saranac River near Redford.
C-56. From dump at Bowen-Signor mill pond.

Rocks exposed near the old workings strike N. 40° E. and dip 70° NW. This strike conforms to the trend of the magnetic anomaly. The diamond-drilling data show, however, that underground the mineralized zone dips 50° to 70° SSE., the opposite of the direction of dip of the exposed rocks. This difference in dip is characteristic of the region and may be seen in nearby outcrops. The old logs from diamond-drilling indicate that the ore body ranges in thickness from 6 feet to 22 feet. Two of the holes drilled cut two ore zones, and one hole cut four mineralized zones. There is some indication from the drill logs that the ore zones decrease in thickness and iron content with depth. The irregular thickness of the ore zone may be caused by a pencil-shaped or cigar-shaped ore body.

TABLE 49.—*Modal composition of two samples of outcrop material from the Bowen-Signor mine*

[D, dominant; X, present; Gr, granular; Cl, recrystallized cataclastic]

	453	453A
Microcline and microperthite	....	48.0
Plagioclase	An_{22} 61.5	An_{17} 23.1
Quartz	Tr.	23.4
Clinopyroxene	23.7	....
Hornblende	4.0	....
Accessories	10.8	5.4
Magnetite	D	X
Epidote	X	....
Zircon	X	X
Sphene	....	D
Apatite	....	X
Texture	Gr	Cl

453. Plagioclase-pyroxene gneiss.
453A. Microperthite granite gneiss.

TABLE 50.—*Modal composition of 19 samples from Bowen-Sign or mine (diamond-drill hole 1), Lyon Mountain granite gneiss*

[Gn, gneissic; G, xenomorphic-granular; Gl, xenomorphic-granular with mylonite channels; Cl, recrystallized cataclastic; C, cataclastic; Cm, cataclastic with mylonite; X, present]

	BS1-1	BS1-2	BS1-3	BS1-4	BS1-5	BS1-6	BS1-7	BS1-8	BS1-9	BS1-11	BS1-14	BS1-15	BS1-16	BS1-17	BS1-18	BS1-19	BS1-20	BS1-21	BS1-22
Microcline	46.1	...	...	...	...	...	...	Tr.	48.0	5.6	25.8	...	55.9	...	...	...	53.2	...	4.7
Microperthite		18.4	52.8	...	...	51.5	...	...	...	...	...	...		50.4	...	53.1	...	58.8	...
Microperthite and microantiperthite	...	...	...	...	...	42.9	...	...	...	...	...	...	...	...	...	...	...	...	...
Microantiperthite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11.5
Plagioclase	An_7 13.6	An_{10} 30.3	An_{11} 19.7	An_{30} 32.0	An_{28} 46.5	An_{10} 13.9	An_{10} 7.3	An_7 63.3	An_7 11.0	An_{10} 58.8	An_8 32.5	...	An_7 11.0	An_{10} 8.8	An_{20} 40.6	An_8 10.5	An_{10} 10.9	An_{12} 7.5	An_{12} 41.8
Quartz	26.1	45.8	19.3	...	...	33.0	39.1	35.1	37.7	33.2	37.5	19.3	24.9	23.8	...	24.8	37.5	22.0	34.6
Clinopyroxene	...	...	...	...	...	...	...	...	...	...	...	31.1	...	3.6	...	5.4	...	1.7	...
Hornblende	...	...	...	41.7	42.0	...	...	...	...	...	...	...	...	...	30.6	...	...	...	...
Biotite	...	...	...	4.0	2.2	...	4.0	Tr.	...	...	...	...	...	...	18.5	...	...	...	...
Garnet	...	...	...	...	...	...	...	...	...	...	...	...	6.0	7.4	...	...	...	3.7	2.6
Scapolite[1]	...	...	...	13.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Apatite	...	...	...	...	...	...	...	...	...	...	...	46.4	...	...	...	...	...	...	...
Accessories	14.1	5.5	8.2	8.9	9.2	1.5	6.6	1.5	3.3	2.4	4.1	3.2	2.1	5.9	10.2	6.1	3.3	6.2	4.7
Magnetite	X	X	X[2]	X	X	X	X[2]	X[2]	X	X	X	X	X[2]	X	X	X[2]	X	X	...
Apatite	...	...	...	X	X	...	...	X	...	...	X	...	...	X	...	...	...	X	...
Zircon	X	X	X	X	X	...	X	X	X	...	...	...	X	...	...	X	...	...	...
Sphene	...	...	...	X	X	...	...	...	...	...	X	X	X	X	X	X	X	X	...
Calcite	X	X	...	...	...	X	...	...	...	...	X	...	X	...	X	...	...	...	...
Chlorite	X	...	X	X	...	X	...	...	X	...	...	...	...	X	X	...	...	...	...
Depth (feet)	24.7	41.9	55.2	69.4	98.9	103	123.6	141.3	162.9	179.7	246	269	280.5	296.5	300.7	334.9	393	432.4	468.7
Texture	Gl	Cl	G	G	G	G	G	G	Cl	Cm	Cm	G	G	G	Gn	G	Cm	Cl	Cl

[1] Completely altered.

[2] Euhedral.

BS1-1. Microperthite granite gneiss.
BS1-2. Microperthite granite gneiss.
BS1-3. Microperthite granite gneiss.
BS1-4. Biotite scapolite amphibolite.
BS1-5. Biotite amphibolite.
BS1-6. Microperthite granite gneiss.
BS1-7. Biotite-microantiperthite granite gneiss.
BS1-8. Plagioclase granite gneiss.
BS1-9. Microcline granite gneiss.
BS1-11. Plagioclase granite gneiss.
BS1-14. Microcline granite gneiss.
BS1-15. Quartzose apatite-pyroxene gneiss.
BS1-16. Garnet-microperthite granite gneiss.
BS1-17. Garnet-pyroxene-microperthite granite gneiss.
BS1-18. Biotite amphibolite.
BS1-19. Pyroxene-microperthite granite gneiss.
BS1-20. Microcline granite gneiss.
BS1-21. Garnet-pyroxene microperthite granite gneiss
BS1-22. Garnet-plagioclase granite gneiss.

Conservative estimates indicate that a few million tons of low-grade ore still remains in the Bowen-Signor mine.

During the summer of 1947 the Bureau of Mines drilled three holes on the Bowen-Signor belt, two of them on the Bowen-Signor mine and one on the westward extension of the Bowen-Signor magnetic anomaly between the Clayburg and Tremblay mines, a section which the Bureau of Mines called the Earl anomaly.

The first hole on the Bowen-Signor workings was opposite number 3 shaft (counting from west to east) and 250 to the southeast. The bearing was perpendicular to the center line of the workings. The second hole was 400 feet northeast of the first hole. Neither of these holes intersected ore, which may be an indication that the ore lies in narrow elongate shoots. Figure 35*A* is the graphic log of these two holes; tables 50 and 51 show the mineralogic compositions of samples taken from the drill core. The hole on the Earl anomaly was located some 2.4 miles west of the Bowen-Signor mine, about halfway between the old Tremblay mine and the Clayburg mine. This hole intersected 12.3 feet of magnetite ore (9.6 feet, true thickness). The magnetite replaces a pyroxene-contaminated plagioclase granite gneiss. The hanging-wall of the ore zone is a pyroxene-microperthite granite gneiss, and the footwall is a plagioclase skarn migmatite underlain by a pyroxene-hornblende-plagioclase granite gneiss. Both the footwall and the hanging-wall contain subore zones adjacent to the main ore zone. The main ore zone has a weighted average of 35.7 percent of metallic iron over an apparent thickness of 12 feet (based on assays by the Bureau of Mines). If the footwall and hanging-wall subore zones are included with the main ore zone a weighted average of 23.4 percent of metallic iron over an apparent thickness of 35.1 feet is obtained.

Figure 35*B* is the graphic log of the hole, and table 52 shows the mineralogic composition of samples taken from the drill core. Table 53 gives the results of assays made by the United States Bureau of Mines.

No polished sections of this ore were made, but the high TiO_2 content of the magnetic fraction indicates ilmenite in the magnetite. The high iron content in the nonmagnetic fraction may be due to martite.

TABLE 51.—*Modal composition of 18 samples obtained from Bowen-Signor mine (diamond-drill hole 2), Lyon Mountain granite gneiss*

[X, present; G, xenomorphic-granular; Cl, cataclastic recrystallized; Cm, cataclastic with mylonite; C, cataclastic; Gn, gneissic]

	BS2-1	BS2-3	BS2-4	BS2-5	BS2-6	BS2-7	BS2-8	BS2-10	BS2-11	BS2-12	BS2-13	BS2-14	BS2-15	BS2-16	BS2-17	BS2-18	BS2-19	BS2-20
Microcline	51.0	28.8	Tr.	.....	Tr.	.....	.....	13.2	54.6	.....	62.0	.....	.....	.....	66.4	50.4	.....	.....
Microperthite			.....	.....	.....	42.5	.....	.....						65.0		.....	.....	64.6
Microantiperthite	.....	Tr.	.....	.....	.....	.....	22.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	32.1	.....
Microantiperthite and microperthite	.....	.....	24.5	64.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Plagioclase	An_{10} 13.1	An_{8} 32.2	An_{8} 39.1	An_{10} 6.0	An_{26} 20.0	An_{10} 19.7	An_{11} 36.6	An_{10} 59.5	An_{10} 29.7	[1]20.3	An_{11} 6.3	An_{23} 49.4	An_{80} 40.5	An_{8} 17.8	An_{10} 8.7	An_{8} 20.0	An_{11} 30.5	An_{10} 4.1
Scapolite	.....	.....	.....	.....	25.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Quartz	22.9	28.6	33.5	28.6	.....	34.4	35.3	25.1	12.2	4.9	21.7	.....	.....	10.7	18.1	16.2	1.8	15.3
Clinopyroxene	8.8	.....	.....	.....	.....	.....	.....	.....	.....	37.6	.5	.....	Tr.	.....	.4	.....	7.1	4.4
Hornblende	.....	.....	.....	.....	44.2	.....	.....	.....	.....	.....	.....	16.0	32.3	.....	.....	.....	12.8	.....
Biotite	.....	2.0	Tr.	Tr.	Tr.	Tr.	2.0	.....	.....	.....	.....	16.3	.....	.....	.....	.....	.....	.....
Sphene	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.1	17.9	.....	.....	.....	.....	.....
Garnet	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.8	6.9	.....	.....	.....	2.9	10.4	.....	5.3
Magnetite	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.0	.....	.....	.....	.....	.....	.....
Accessories	4.1	8.3	2.8	1.0	10.0	3.3	3.9	2.1	3.4	10.3	2.5	1.2	9.2	[2]6.4	3.5	2.9	2.2	6.3
Magnetite	X[3]	X	X[3]	X	X	X	X	X	X[3]	X	X	X	X	X	X	X[3]	13.4	X
Apatite	.....	.....	X	.....	X	X	X	.....	X	X	X	X	X	X	.....	.....	X	X
Zircon	X	X	X	.....	X	X	X	X	.....	X	X	X	.....	.....	.....	X	X	.....
Sphene	.....	.....	.....	.....	X	.....	.....	.....	X	X	X	X	X	X	X	X	X	X
Calcite	X	.....	.....	X	.....	X	.....	.....	.....	.....	.....	.....	.....	X	.....	.....	.....	.....
Chlorite	.....	X	.....	.....	.....	X	X	X	.....	.....	.....	.....	.....	.....	.....	.....	.....	X
Depth (feet)	52.6	90.6	90.7	100	122.8	190.2	201.7	224	267.2	280.8	290.1	324.8	344.8	360.9	403.7	448.1	492.2	557.9
Texture	Cm	C	Cl	G	Gn	Cl	Cl	C	Cm	G	G	Gn	Gn	Cl	Cl	Cl	G	G

[1] Altered.
[2] Some white mica.
[3] Euhedral.

BS2-1. Pyroxene-microperthite granite gneiss.
BS2-3. Biotite-microperthite granite gneiss.
BS2-4. Microantiperthite granite gneiss.
BS2-5. Microantiperthite granite gneiss.
BS2-6. Scapolite amphibolite.
BS2-7. Microperthite granite gneiss.
BS2-8. Biotite-microantiperthite granite gneiss.
BS2-10. Plagioclase granite gneiss.
BS2-11. Microperthite granite gneiss.
BS2-12. Plagioclase-pyroxene quartz syenite gneiss.
BS2-13. Garnet-microperthite granite gneiss.
BS2-14. Biotite amphibolite.
BS2-15. Amphibolite.
BS2-16. Microperthite granite gneiss.
BS2-17. Garnet-microperthite granite gneiss.
BS2-18. Garnet-microcline granite gneiss.
BS2-19. Hornblende-pyroxene-microantiperthite quartz syenite.
BS2-20. Garnet-pyroxene-microperthite granite gneiss.

948752—52—6

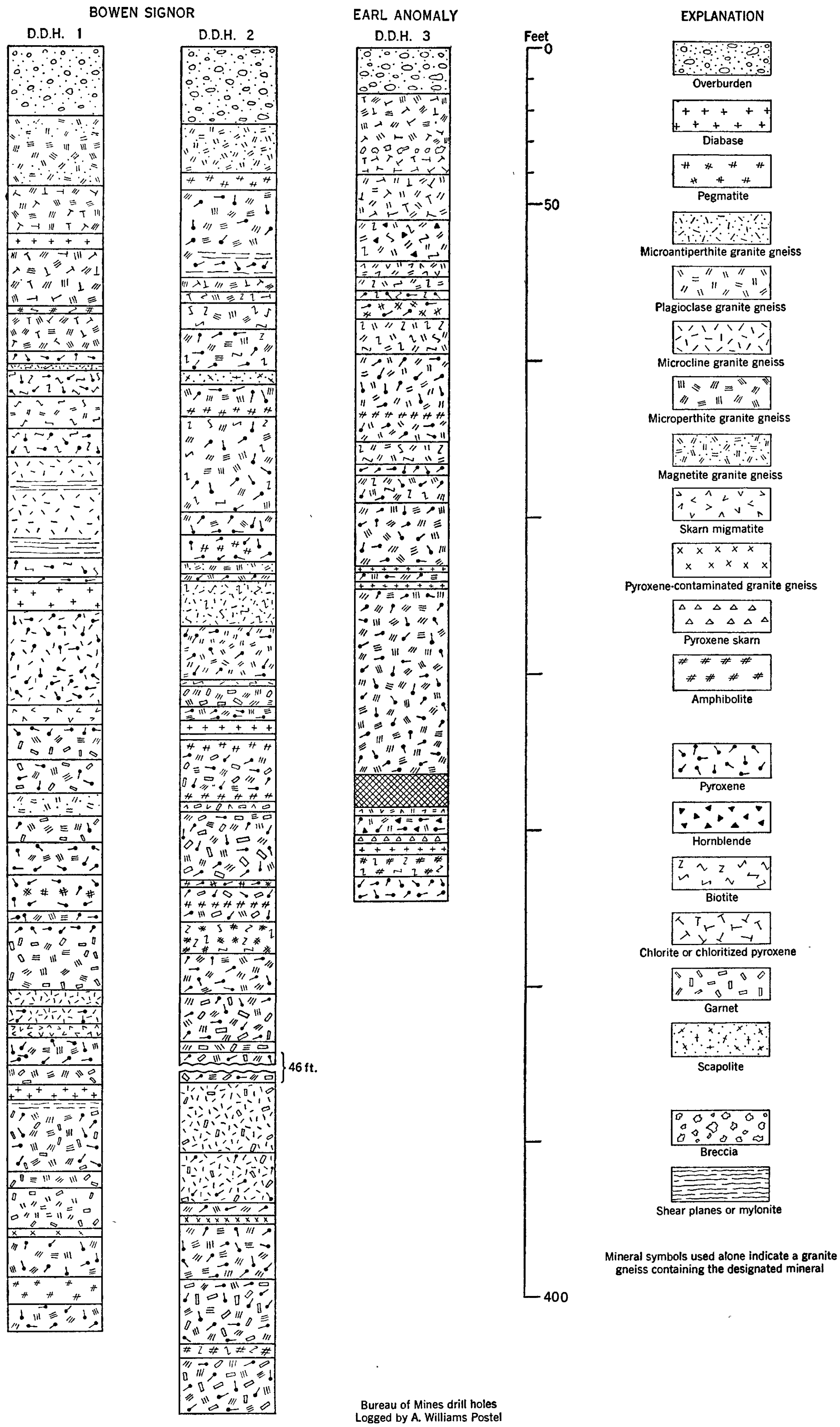

FIGURE 35.—Graphic logs. *A*, Diamond-drill holes 1 and 2, Bowen-Signor mine. *B*, Diamond-drill hole 3, Earl anomaly.

TABLE 52.—*Modal composition of 11 samples from the Earl anomaly (diamond-drill hole 3)*

[C, cataclastic; Cl, recrystallized cataclastic; Cm, cataclastic with mylonite channels; G, xenomorphic-granular]

	BS3–1	BS3–2	BS3–3	BS3–4	BS3–5	BS3–6	BS3–7	BS3–8	BS3–9	BS3–11	BS3–12
Microcline	....	....	....	....	....	7.6	10.5	46.6	65.2	....	....
Microperthite	38.4	25.8	23.3	....	....	....	....			....	....
Microantiperthite	....			17.1	13.0	....	....	....	....	....	....
Plagioclase	An_{10} 19.1	An_{6} 35.9	An_{11} 26.2	An_{6} 57.8	An_{10} 55.5	An_{10} 55.6	An_{10} 50.6	2.8	An_{9} 8.1	....	An_{30} 46.2
Quartz	41.3	36.1	45.4	11.4	23.8	18.3	33.4	44.8	24.6	0.8	....
Clinopyroxene	....	....	....	....	....	....	....	....	....	87.5	....
Hornblende	....	....	1.3	.9	....	....	....	....	....	9.9	32.5
Biotite	....	....	3.7	....	6.5	17.9	....	....	....	....	14.0
Chlorite	....	....	....	8.5	....	....	....	....	....	....	....
Accessories	1.1	2.1	....	4.2	1.1	.5	5.4	5.7	2.0	1.7	7.2
Magnetite	X	X	X	X	X	....	X	X[1]	X[1]	X	X
Apatite	....	....	....	....	....	....	X	X	X	....	X
Zircon	X	....	X	X	X	X	X	....	X	....	....
Sphene	....	....	....	X	....	....	....	X	....	....	X
Epidote	X	X	....	....	....	....	....	....	....	....	....
Chlorite	....	X	X	X	X	....	X	X	X	X	....
Calcite	....	....	X	X	....	X	X	X	....	X	X
Depth (feet)	38.2	63.9	75.9	80.6	86.6	112.5	126.7	202.9	249	344.4	355.8
Texture	Cm	Cl	C	Cl	Cm	C	Cl	Cl	Cl	G	G

[1] Euhedral.

BS3–1. Microperthite granite gneiss.
BS3–2. Microantiperthite granite gneiss.
BS3–3. Biotite-hornblende microantiperthite granite gneiss.
BS3–4. Hornblende-microantiperthite granite gneiss.
BS3–5. Biotite-plagioclase granite gneiss.
BS3–6. Biotite-plagioclase granite gneiss.
BS3–7. Plagioclase granite gneiss.
BS3–8. Microperthite granite gneiss.
BS3–9. Microperthite granite gneiss.
BS3–11. Pyroxene skarn.
BS3–12. Biotite amphibolite.

TABLE 53.—*Assays by United States Bureau of Mines of material from Earl anomaly (diamond-drill hole 3)*

Sample No.	Interval	Fe (percent)	Sample No.	Interval	Fe (percent)
102–760	309—313.4	11.7	102–764	327.0—330.8	[1]33.7
102–761	313.4—318.8	6.83	102–765	330.8—333.0	17.4
102–762	318.8—323.5	[1]39.7	102–766	333.0—338.0	22.5
102–763	323.5—327.0	[1]34.1	102–767	338.0—344.1	25.8

[1] Main ore zone.

Following are the results of a Davis tube test (adapted from Reed and Cohen, 1949) at minus 100-mesh on composite sample 102-762 to 102-767, inclusive. The test engineer was F. D. Lamb.

Product	Percent by weight	Chemical analysis of magnetic and nonmagnetic fractions						Total sample Fe	Percent total Fe
		Fe	SiO_2	S	P	Mn	TiO_2		
Magnetic	34.8	69.5	0.60	0.12	0.04	0.15	1.37	24.2	87.7
Nonmagnetic	65.2	5.3	......	......	......	......	......	3.4	12.3
Total	100.0	......	......	......	......	......	......	27.6	100.0

Clayburg mines.—The Clayburg mines are on the south branch of the Saranac River about half a mile south of Clayburg. The workings consist of an adit near the west bank of the river and an open pit on the east bank of the river. The west-bank adit is now flooded and can be examined only by raft or over the ice in the winter.

The ore in the east open pit is in a pyroxene-microantiperthite granite gneiss. The magnetite content runs about 30 percent by volume. The ore zone has a true thickness of about 8 feet. The footwall is composed of a plagioclase pyroxene gneiss; the hanging-wall is a pyroxene-contaminated granite gneiss (table 54). Numerous pegmatites with pyroxene skarn inclusions cut the complex.

TABLE 54.—*Modal composition of samples from the hanging-wall and footwall, Clayburg mine*[1]

[D, dominant; X, present; Gr, xenomorphic-granular; Gr_1, xenomorphic-granular with mild cataclastic channels]

	473	473A
Microantiperthite	An_{8} 58.4	....
Plagioclase	....	An_{25} 56.8
Quartz	16.3	....
Clinopyroxene	23.6	27.9
Hornblende	X	8.8
Accessories	1.6	6.5
Magnetite	D	D
Apatite	X	X
Chlorite	X	....
Sphene	....	X
Texture	Gr_1	Gr

[1] Pit on east side of Saranac River.

473. Pyroxene-contaminated microantiperthite granite gneiss. From hanging-wall.
473A. Plagioclase-pyroxene gneiss. From footwall.

At the top surface of the pit the strike of the ore zone is east and the dip vertical. In a descent of 40 feet to the bottom of the pit the dip changes to 70° N. Outcrops to the north of the pit dip steeply to the north; those to the south of the pit dip to the south.

Tremblay mine.—The Tremblay mine is on the south side of the main highway about a mile east of Riverview. Operations on this deposit began about 1858 and ceased in 1880. (Daniel Tremblay, written personal communication.) At the present time the workings are badly overgrown and flooded. The main pit is about 150 feet by 15 feet and according to Smock (1889, p. 40) was worked to a depth of 80 feet.

Inspection of the material still remaining on the dumps indicates that the magnetite is in quartzose pyroxene skarn, microperthite granite gneiss, and granular quartz. There is some associated skarn and amphibolite. Table 55 indicates the composition of samples from the dump.

Putnam (1886, p. 121) cites the following assays:

	1315	1316
Metallic iron	28.62	65.01
Phosphorus	.017	.004
Titanic acid	....	Present

1315. Burnt ore from crusher.
1316. Separated ore.

The ore zone strikes N. 65° W. and dips 75° NE. Putnam (1886) says that the ore mass is irregular in shape.

Table 55.—*Modal composition of ore and skarn from dump of Tremblay mine*

[X, present; C, cataclastic; Cl, recrystallized cataclastic; Gr, xenomorphic granular]

	Trm-1	Trm-2	Trm-2A	Trm-3
Microperthite	....	....	....	56.7
Plagioclase	....	....	Tr.	4.9
Quartz	49.0	0.9	34.6	20.7
Clinopyroxene	....	71.6	[1]18.6	Tr.
Hornblende	2.2	25.7	....	....
Magnetite	48.4	....	46.7	16.3
Accessories	.4	1.7	....	1.3
Apatite	X	X	....	....
Zircon	X	....	....	X
Chlorite	X	....	....	X
Magnetite	....	X	....	....
Magnetite (percent by weight)[2]	65.0	....	63.5	27.8
Iron (percent by weight)[2]	47.0	....	45.0	20.1
Texture	C	Gr	C	Cl

[1] Chloritized. [2] Computed from mode.

Trm-1. Quartzose ore. Trm-2A. Quartzose skarn ore.
Trm-2. Skarn. Trm-3. Microperthite granite gneiss subore.

Tremblay pits.—The Tremplay pits are on the westward extension of the Bowen-Signor anomaly, about a quarter of a mile southwest from the most westerly shaft of the Bowen-Signor mine. These pits, four in number, represent the first workings in the Bedford area. They were opened in 1844 (written communication, Daniel Tremblay).

The pits were worked as a small hand operation, and the material produced was sold to the local forges.

The magnetite ore as seen on the dumps is of two types: a quartzose pyroxene skarn ore and a microperthite granite gneiss ore. Table 56 gives the composition of two samples obtained from the dumps.

There are no outcrops in the vicinity of the pits, but the structure is probably conformable to the Bowen-Signor mine.

LYON MOUNTAIN ORE BELT

The Lyon Mountain ore belt consists of a series of northeasterly trending ore bodies extending over a distance of 4 miles near the towns of Standish and Lyon Mountain in the northwest corner of the Lyon Mountain quadrangle. From southwest to northeast there are four major ore bodies: the 81 mine, the Phillips vein, the Chateaugay mine, and the Parkhurst mine. These properties are now owned by the Republic Steel Corp. Only the 81 and the Chateaugay mines were being operated in 1951. These four bodies probably form parts of one continuous ore belt with local breaks.

Table 56.—*Modal composition of ore from dumps of Tremblay pits*

[D, dominant; X, present; C, cataclastic; Gr, granular]

	TrP-1	TrP-2
Microperthite	....	14.6
Plagioclase	....	An_{12} 6.8
Quartz	15.4	31.4
Clinopyroxene	56.8	....
Magnetite	27.5	28.2
Accessories	.2	8.7
Apatite	....	9.5
Zircon	X	....
Chlorite	X	D
Calcite	....	X
Texture	Gr	C
Magnetite (percent by weight)[1]	39.5	43.7
Iron (percent by weight)[1]	28.5	31.7

[1] Computed from mode.

TrP-1. Quartzose skarn ore.
TrP-2. Microperthite granite gneiss ore.

Chateaugay mine.—The Chateaugay mine of the Republic Steel Corp. is in the village of Lyon Mountain. A general description of the mine installation and operation has recently been given in Skillings' Mining Review (July 10, 1948). This mine and the 81 mine were in 1951 the only producing mines in Clinton County. Mr. Paul W. Zimmer, geologist for the Republic Steel Corp. at Lyon Mountain, plans a detailed description of this mine and the 81 mine. Part of the information given here for these two mines is due to the helpful cooperation of Mr. W. J. Linney, District Manager, and Mr. Zimmer.

Gallagher (1937, p. 10) states that the ore deposits at Lyon Mountain Village probably were known as early as 1850. Mining was undertaken by 1867 but not extensively until 1871. Production from 1871 to the present time has been approximately 15,000,000 tons of ore. In 1948 the mine had an annual output capacity of 1,500,000 long tons of crude ore (Skillings' Mining Review, July 10, 1948).

Magnetite in the Chateaugay mine is a replacement of a pyroxene-contaminated microcline-microperthite granite gneiss and plagioclase granite gneiss. The ore lies in two parallel zones designated

TABLE 57.—*Estimated modal composition of 10 samples from Chateaugay mine*[1]

[C, cataclastic; Gr, granular; WC, water course]

	[2]444	[2]445	[3]271	[4]271A	[5]270	[6]270A	[7]306	[8]306A	A	B
Orthoclase	25	.....	.....	.....	.....	.....	.....	.....	.....	.....
Microcline and microperthite	.....	[9]35	60	70	.....	45	35	60	20	40
Plagioclase[10]	15	.....	10	.....	70	.....	15	10	10	20
Quartz	Tr.	5	20	20	.....	20	15	25	.....	.....
Clinopyroxene	20	30	5	5	20	30	30	.....	40	20
Magnetite	40	30	.....	.....	.....	.....	.....	.....	30	20
Sphene	.....	.....	.....	.....	10	5	5	5	.....	.....
Level	.....	.....	600	600	600	600	1263	1263	WC	600
Texture	C	C	C	C	Gr	C	C	C	C	C

1 Compositions were estimated visually from thin section at mine office of Republic Steel Corp.
2 Parkhurst mine.
3 20 feet in footwall of footwall vein. Diamond-drill hole.
4 10 feet in footwall of footwall vein. Diamond-drill hole.
5 80 feet in hanging wall of footwall vein. Diamond-drill hole.
6 100 feet in hanging wall of footwall vein. Diamond-drill hole.
7 1 foot in hanging wall of hanging-wall vein. Diamond-drill hole.
8 1 foot in footwall of hanging-wall vein. Diamond-drill hole.
9 Microcline absent.
10 Plagioclase in oligoclase range.

444. Pyroxene-contaminated orthoclase granite-gneiss ore.
445. Pyroxene-contaminated microperthite granite-gneiss ore.
271. Pyroxene-microperthite granite gneiss.
271A. Pyroxene-microperthite granite gneiss.
270. Pyroxene-contaminated plagioclase syenite gneiss.
270A. Pyroxene-contaminated microperthite granite gneiss.
306. Pyroxene-contaminated microperthite granite gneiss.
306A. Magnetite-microperthite granite gneiss.
A. Pyroxene-contaminated microperthite syenite-gneiss ore.
B. Pyroxene-contaminated microperthite syenite-gneiss ore.

as the footwall vein and the hanging-wall vein. Included masses of pyroxene skarn are prominent in the granite gneiss and may be seen both underground and in surface outcrop (fig. 36). Cataclastic texture is evident in many thin sections of the rocks that were replaced by magnetite and of those associated with the mineralized zones.

Table 57 gives compositions of materials in the mineralized zones and the associated contact rocks.

FIGURE 36.—Skarn boudinage replaced in part by magnetite. Outcrop of the footwall vein, Chateaugay mine, Lyon Mountain, N. Y.

The ore forms cigarlike shoots in two synclinal structures that plunge in a general northeasterly direction. The ore-bearing limbs have a strike of N. 30° E. and at the surface outcrop have a dip of 60°–65° NW. The limbs show minor anticlinal rolls. The ore is in five shoots that are connected along the strike by mineralized stringers. The shoots plunge northeastward parallel to the plunge of the mineral

TABLE 58.—*Modal composition of eight samples from 81 mine, Republic Steel Corp. (diamond-drill hole 481)*

[X, present; D, dominant; G, xenomorphic-granular; C, cataclastic; Ck, weakly cataclastic; Gl, xenomorphic-granular gneissic; Gn, gneissic; Gr, granular]

	1	2	4	5	6	8	9	10
Microcline	.....	.....	.....	.....	.....	} 56.9		
Microperthite	57.6	58.6	.....	.....	} 49.6		.....	55.9
Microantiperthite	.....	.....	.....	.....		.....	.....	.....
Plagioclase	An_{18} 13.4	7.6	An_8 61.8	An_{10} 65.5	An_{11} 9.2	17.1	An_{22} 47.2	13.5
Quartz	25.6	3.1	21.3	14.7	17.9	23.7	.....	28.2
Clinopyroxene	Tr.	.....	7.2	8.2	2.1	Tr.	.....	.....
Hornblende	Tr.	6.1	5.3	8.6	9.8	.9	44.2	.....
Biotite	.....	Tr.	.....	.....	.....	.....	.....	.....
Magnetite	.....	.....	.....	.....	10.4	.....	.....	.....
Accessories	3.3	24.5	4.3	2.9	.9	1.3	8.5	2.3
Magnetite	D[1]	X	X[1]	.....	X	X[1]	.....	D[1]
Apatite	X	X	.....	X	.....	X	X	.....
Sphene	X	.....	D	D	.....	D	D	X
Zircon	X	.....	X	X	.....	X	X	X
Chlorite	X	X	.....	.....	D	.....	.....	.....
Calcite	.....	D	.....	.....	.....	.....	.....	.....
Depth (feet)	15.1	45.8	208.3	219.9	266.1	272.7	277.9	296
Interval (feet)	11.0–20.3	20.3–191.0	205.4–229.3	205.4–229.3	265.6–267.5	267.5–272.7	277.9–292.8	292.8–302.6
Texture	GCl	G	Gl	Gn	C	C	G	G

1 Euhedral.

1. Microperthite granite gneiss.
2. Hornblende-microperthite-quartz syenite gneiss.
4. Pyroxene-hornblende-plagioclase granite gneiss.
5. Hornblende-pyroxene-plagioclase granite gneiss.
6. Hornblende-pyroxene-microantiperthite gneiss.
8. Hornblende-microperthite granite gneiss.
9. Amphibolite.
10. Microperthite granite gneiss.

lineation in the surrounding rocks. The plunge of the mineral lineation at the surface is 45° N.

81 mine.—The 81 mine is located in the northwest corner of the Lyon Mountain quadrangle, 1.1 miles, N. 25° E. from the town of Standish.

According to Newland (1908, p. 115) this mine was opened as early as 1840, though systematic mining was not started until 1878. The mine was finally shut down in 1902. During the late 1940's an active diamond-drilling program was undertaken by the Republic Steel Corp. to investigate the potentialities of this ore deposit.

In 1948 the Republic Steel Corp. commenced stripping operations preparatory to open-cut mining of the 81 ore body and the closely associated Standish Road ore shoot. Ore production commenced in the spring 1949. Contracts were let to construct a six-compartment vertical shaft that would eventually reach a depth of 2,500 feet (Skillings' Mining Review, August 28, 1948).

During the course of the stripping an interesting placer magnetite deposit was uncovered. The concentration is approximately 4 feet thick and 200 feet long. The magnetite is mixed with clay and surrounded by drift. The iron tenor of the deposit was high enough to permit profitable milling of the material.

The bulk of the ore is a replacement of plagioclase granite gneiss. Diamond drilling also indicated magnetite zones in pyroxene skarn included in the plagioclase granite gneiss. The magnetite concentration is weaker in the skarn zones than in the sur-

TABLE 59.—*Modal composition of 21 samples from diamond-drill hole 486 of the 81 mine, Republic Steel Corp.*

[D, dominant; X, present; C, cataclastic; Cl, mild cataclastic; Cg, cataclastic gneissic; G, xenomorphic granular; Gl, xenomorphic granular gneissic]

	1	2	3	4	5	6	7	8	9	10	11
Microcline	...	...	...	...	...	...	...	Tr.	...	...	...
Microperthite	59.4	49.2	31.9	...	68.6	...	...	...	...	...	65.1
Microantiperthite	...			...	...	60.0	61.8	...	70.5	67.6	...
Plagioclase	Tr.	An_{11} 15.0	An_{12} 17.9	An_{16} 50.1	5.4	...	An_{12} 3.0	An_{22} 59.4	...	...	...
Quartz	35.4	9.3	3.9	...	18.3	15.9	16.1	Tr.	20.9	16.0	28.9
Clinopyroxene	2.0	10.9	13.2	...	2.8	...	...	9.7	Tr.	Tr.	...
Hornblende	...	5.6	18.2	35.3	...	10.7	7.1	21.7	2.1	14.0	1.1
Biotite	Tr.	...	...	8.7	...	4.5	4.2	...	Tr.	Tr.	Tr.
Magnetite	...	...	13.6	...	...	...	...	...	...	...	...
Apatite	...	...	1.2	...	...	...	...	...	...	...	...
Accessories	3.2	9.9	1.2	5.8	4.9	8.9	7.7	9.1	6.4	2.4	4.8
Magnetite	D[1]	D	X	D	D	D	D	D	D	D	D
Apatite	X	X	X	X	X	X	...	X	X	X	X
Sphene	X	...	...	...	...	...	...	...	...	...	X
Zircon	X	X	...	X	X	X	...	X	X	...	X
Chlorite	...	...	...	...	...	X	...	...	...	...	...
Calcite	...	...	...	...	...	...	X	...	...	...	...
Depth (feet)	32.7	34.7	43.4	50.0	52.9	60.2	61.7	68.9	72.0	74.0	111.2
Interval (feet)	28.5–34.1	34.1–35.3	42.2–49.9	49.9–52.7	52.7–55.2	55.2–60.8	60.8–64.5	66.0–70.9	70.9–72.2	72.2–77.5	103.0–137.0
Texture	Cl	Cg	G	G	G	Gl	G	Gl	G	Gl, Cl	G

	12	14	15	16	17	18	19	20	21	22
Microcline	...	...					...	...	...	...
Microperthite	66.3	...	65.5	59.5	68.3	27.7	63.0	...	...	...
Microantiperthite	...	68.8	...	...	...	...	...	...	...	36.7
Plagioclase	3.0	3.2	...	An_{10} 3.0	1.7	1.7	An_{10} 12.4	An_{27} 43.4	An_{22} 61.0	An_{11} 5.7
Quartz	26.3	8.0	18.5	5.9	...	...	21.3	...	...	5.6
Clinopyroxene	...	...	5.1	26.4	29.4	66.8	...	...	Tr.	...
Hornblende	1.0	Tr.	1.1	Tr.	...	2.0	...	47.6	31.1	33.3
Biotite	Tr.	17.7	2.8	...	...	Tr.	...	2.0	Tr.	3.0
Magnetite	...	...	...	...	...	...	...	...	...	8.6
Accessories	3.3	2.3	6.9	5.1	.5	1.9	3.3	7.0	7.8	7.1
Magnetite	D	D	D	X	X	X	D	...	D	X
Apatite	X	X	...			X	...	X	X	D
Sphene	X	...	X	D	D	D	X	D	X	X
Zircon	X	X	X	X	X	X	X	X	X	X
Chlorite	...	...	...	...	X	...	...	...	...	...
Calcite	...	...	...	...	...	...	...	...	...	...
Depth (feet)	121.6	175.1	294.5	321.5	330.8	377.5	406.8	407.3	435.4	517.4
Interval (feet)	103–137.0	150.5–331.0	150.5–331.0	150.5–331.0	150.5–331.0	376.9–389.6	389.6–433.9	389.6–433.9	433.9–443.0	517.0–518.3
Texture	G	GCl	Gr	Cg	Gl	G	G	Gl	G	Cg

[1] Euhedral.

1. Pyroxene-microperthite granite gneiss.
2. Pyroxene-hornblende-microantiperthite granite gneiss.
3. Hornblende-pyroxene-microantiperthite-quartz syenite gneiss.
4. Biotite amphibolite.
5. Pyroxene-microperthite granite gneiss.
6. Hornblende-biotite-microantiperthite granite gneiss.
7. Hornblende-biotite-microantiperthite granite gneiss.
8. Pyroxene amphibolite.
9. Hornblende-microantiperthite granite gneiss.
10. Hornblende-microantiperthite granite gneiss.
11. Hornblende-microperthite granite gneiss.
12. Hornblende-microperthite granite gneiss.
14. Biotite-microantiperthite granite gneiss.
15. Pyroxene-biotite-hornblende-microperthite granite gneiss.
16. Pyroxene-contaminated microperthite granite gneiss.
17. Pyroxene-contaminated microperthite syenite gneiss.
18. Pyroxene-contaminated microperthite syenite gneiss.
19. Microperthite granite gneiss.
20. Biotite amphibolite.
21. Amphibolite.
22. Hornblende-biotite-microantiperthite granite gneiss.

rounding plagioclase granite gneiss. One diamond-drill hole exposed magnetite in a pink pyroxene-microperthite granite gneiss with included zones of magnetite-bearing pyroxene skarn and plagioclase granite gneiss. The hanging-wall and footwall of the ore zone vary in mineralogical composition. Examination of thin sections from the mine and from diamond-drill holes showed pyroxene-microperthite granite gneiss, skarn migmatite, amphibolite, and pyroxene-plagioclase granite gneiss in the hanging-wall. The footwall zone was composed of hornblende - pyroxene - microperthite - microantiperthite granite gneiss and pyroxene-contaminated microperthite syenite gneiss.

The compositions of rocks associated with the ore zone from two diamond-drill holes are given in tables 58 and 59. The composition of samples collected from the old mine workings is given in table 60. Figure 37A shows the graphic logs of the two diamond-drill holes for which petrographic data are given.

Table 60.—*Modal composition of samples from No. 2 drift of the 81 mine, Republic Steel Corp.*

[X, present; G, xenomorphic-granular; Cl, recrystallized cataclastic]

	632	632A	632B[1]	632D[1]
Microperthite	....	62.7	....	....
Plagioclase	An_{10} 19.0	An_{8} 7.2	An_{10} 11.8	An_{10} 18.5
Quartz	20.4	17.2	48.7	45.6
Clinopyroxene	Tr.	9.7	1.4	Tr.
Biotite	Tr.	....	....	Tr.
Magnetite	60.6	X[2]	37.5	35.6
Accessories	....	3.2	.5	.3
Apatite	....	....	X	....
Zircon	X	X	....	X
Sphene	....	X	....	....
Chlorite	....	X	....	....
Magnetite (percent by weight)[3]	75.0	....	53.2	51.7
Metallic iron (percent by weight)[3]	54.3	....	38.6	37.4
Texture	G	Cl	G	G

[1] The high quartz content of these samples probably represents a late introduction of quartz.

[2] Euhedral.

[3] Computed from the mode.

From hanging wall exposed at entrance to No. 2 drift.

632. Plagioclase granite gneiss ore.

632A. Pyroxene microperthite granite gneiss.

632B. Plagioclase granite gneiss ore.

632D. Plagioclase granite gneiss ore.

Assays from the recent drilling program on this ore body indicates very lean magnetite to a lean but economic magnetite. Putnam (1886, p. 122) gave the following assays of samples 1320 and 1321:

	1320	1321
Metallic iron	65.14	34.81
Phosphorus	.017	.041
Titanic acid	Present	....

1320. From 150 tons of separated ore.

1321. From 300 tons of crude ore.

Newland (1908, p. 116) cites an average assay of metallic iron of 41.87 percent, and phosphorus of 0.025 percent as obtained by H. H. Hindshaw from 33 samples of drill core taken from an old drilling program.

The ore of the 81 mine lies along the heel and northwest limb of a syncline. The limb has a strike of N. 45° E. A small anticlinal fold lies between the southeast limb of the syncline and the Chateaugay mine (see plate 2 structure map). The ore in the central part of the old mine dips 80° SE. However, the dip at the extreme northeastern end of the old mine is 60° NW. This variation of the dip through the vertical is also encountered in the recent diamond-drilling. The width of the syncline is approximately 2,000 feet. A relatively thin zone of sillimanite granite gneiss crops out near the center of the syncline on the crest of Second Mountain. The southeast limb of the syncline joins, to the northeast, the southwest workings of the Phillips vein and the Chateaugay mine at Lyon Mountain. Magnetic surveys and diamond-drilling indicated magnetite along this limb, but it is either too thin or too lean for exploitation. The magnetite on the southeast limb is associated with sheared and brecciated rock on the footwall side. Figure 37B is a graphic log of a diamond-drill hole put down on this limb. Table 61 indicates the mineral composition of samples obtained from this hole.

The host rocks in the old mine have a strong mineral lineation, plunging 20° NE. Drilling indicates that the plunge of the keel of the syncline is 30° NE., with a possible steepening at depth.

Evidence obtained from the mine workings, the magnetic measurements, and the drilling would indicate that the ore body is not a tabular body conforming to the shape of the syncline but is rather a series of cigarlike shoots (see fig. 38) that trend parallel to the strike of the surrounding rocks and plunge parallel to the mineral lineation and the axis of the syncline. The shoots are not completely separated from each other but are connected by magnetite stringers.

Phillips vein.—The old Phillips vein lies about half a mile southwest of the Chateaugay mine. The ore does not crop out. Information on this ore zone is very meager.

Newland (1908, p. 117) stated that there are in this zone two parallel ore bodies with a thickness of 50 feet. The dip was reported as 80° NW. It was Newland's opinion that the Phillips vein represented a fault-displaced segment of the Chateaugay ore body. It seems more probable now that the apparent displacement is caused by a fold bewteen the Phillips vein and the Chateaugay ore body.

Parkhurst mine.—The Parkhurst mine is on the north side of a small hill near the railroad tracks

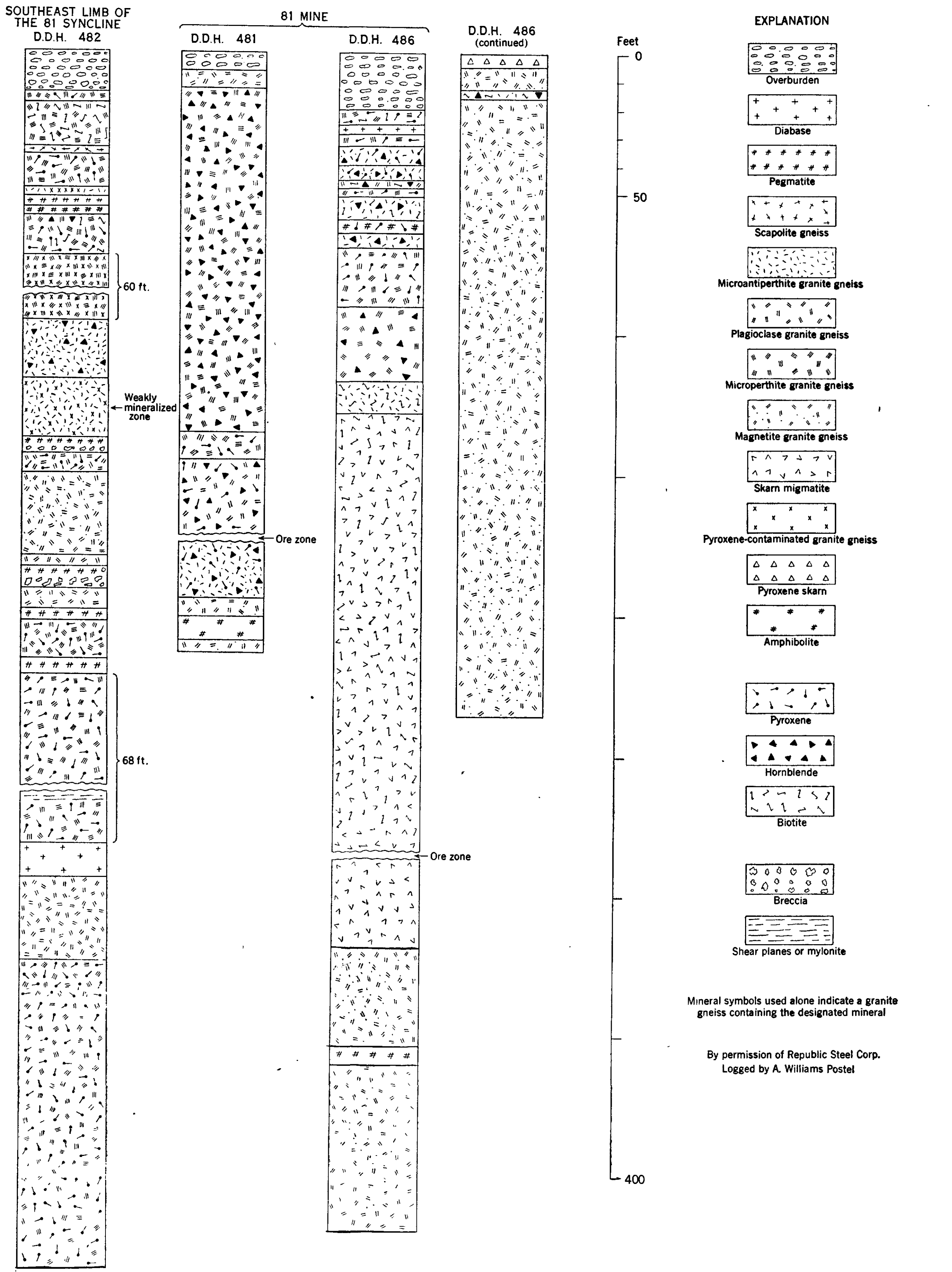

Figure 37.—Graphic logs. *A*, Diamond-drill holes 481 and 486, 81 mine, northwest limb of the syncline. *B*, Diamond-drill hole 482, southeast limb of 81 syncline.

Table 61.—*Modal composition of 20 samples from 81 mine, Republic Steel Corp. (diamond-drill hole 482)*

[D, dominant; X, present; C, cataclastic; Ck, weakly cataelastic; G, xenomorphic-granular; Gl, xenomorphic-granular gneissic]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	·17	18	19	22	24
Microcline	...	...	...	...	...	65.0	...	...	40.5	12.4	51.9									
Microperthite	...	...	...	53.3	68.1		...	47.6		...		47.6	53.7	43.0	4.6	47.1	56.2	54.4	50.0	55.4
Microantiperthite	...	34.7	...	...	...	...	38.8		...	...	...	...	...	...	...	...	...	...	...	...
Plagioclase	An_{22} 8.2	An_{16} 14.5	An_{22} 57.3	An_{7} 5.2	...	An_{7} 3.1	An_{10} 19.5	An_{10} 11.5	An_{10} 24.2	An_{15} 40.1	An_{5} 16.1	An_{10} 18.1	An_{8} 17.5	An_{8} 26.0	An_{12} 14.9	An_{11} 23.6	An_{9} 22.2	An_{6} 17.4	An_{10} 23.8	An_{10} 16.3
Quartz	...	...	...	34.8	19.1	3.8	29.4	12.1	29.9	28.9	28.5	31.6	25.0	24.9	56.5	25.3	17.5	22.3	17.7	17.5
Clinopyroxene	33.5	11.4	...	...	2.1	25.4	...	23.2	...	[1]14.9	...	...	...	...	[1]10.1	...	...	...	...	6.4
Hornblende	...	22.1	35.3	.4	...	...	5.6	4.5	.3	...	...	...	...	Tr.	Tr.	...	...	...	...	...
Biotite	...	...	Tr.	4.0	3.3	...	...	...	Tr.	...	...	...	Tr.	...	...	...	...	...	...	...
Scapolite	52.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Magnetite	...	11.7	...	...	...	...	...	...	...	...	...	...	...	...	[2]10.2	...	...	...	...	...
Apatite	...	5.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Accessories	6.3	...	7.4	2.3	7.3	2.6	6.6	1.1	5.1	3.6	3.4	2.6	3.9	6.1	3.6	3.9	4.1	5.8	8.5	4.3
Magnetite	X	X	D	D	D	X	D	X	D[2]	D[2]	D[2]	D[2]	D[2]	D[2]	X[2]	D[2]	D[2]	D[2]	D	D
Sphene	D	...	...	X	...	D	X	D	X	X	X	X	X	X	X	X	X	X	X	X
Zircon	...	...	X	X	...	X	X	X	...	...	X	X	X	X	X	X	X	X	...	X
Chlorite	...	...	...	...	...	...	...	...	...	X	...	...	...	...	X	X	X	...	X	...
Apatite	X	X	X	X	X	...	X	...	X	...	...	X	X	X	D	X	X	X	X	X
Calcite	...	...	...	...	...	...	...	...	...	X	...	...	...	...	...	...	...	...	...	...
Depth (feet)	40.8	56	66	74.6	87	123.3	153.3	176.6	206	212.8	217.2	237	240.5	244.9	248.6	285.1	313.2	332.1	433.3	550.3
Interval (feet)	38.8–41.0	55–58.1	62.4–66.4	66.4–84.4	84.4–99.9	99.9–125	152.9–176.5	176.5–193.6	202.5–207.3	207.3–240.5	207.3–240.5	207.3–240.5	240.5–243.3	243–246.9	246.9–253	276.3–286.9	296.2–387.8	296.2–387.8	425.9–438.9	518–559.6
Texture	G	Gl	Gl	Cl	Cl	Gl	C	Cl	G	C	C	G	Cl	G	C	C	C	G	C	...

[1] Altered to calcite.

[2] Euhedral.

1. Scapolite-pyroxene skarn.
2. Hornblende-pyroxene-microantiperthite granite gneiss.
3. Amphibolite.
4. Biotite-microperthite granite gneiss.
5. Biotite-pyroxene-microperthite granite gneiss.
6. Pyroxene-contaminated quartz syenite gneiss.
7. Hornblende microantiperthite granite gneiss.
8. Pyroxene-hornblende-microantiperthite granite gneiss.
9. Microperthite granite gneiss.
10. Pyroxene-plagioclase granite gneiss.
11. Microperthite granite gneiss.
12. Microperthite granite gneiss.
13. Microperthite granite gneiss.
14. Microperthite granite gneiss.
15. Quartzose pyroxene-plagioclase gneiss.
17. Microperthite granite gneiss.
18. Microperthite granite gneiss.
19. Microperthite granite gneiss.
22. Microperthite granite gneiss.
24. Pyroxene-microperthite granite gneiss.

about 2½ miles from Lyon Mountain village. The shaft is flooded.

Newland (1908, p. 122) said that the ore body was walled by schist. He described the ore as being coarse-grained with a gangue of quartz, feldspar, and apatite. Diamond-drilling indicated an ore body with an apparent thickness of 48 feet.

Newland gave the following partial analyses of ore obtained from the dumps:

	Rich ore	Lean ore
Iron	56.10	34.20
Silica	13.85	34.08
Titanic oxide	.0	.20
Sulfur	.015	.035
Phosphorus	.156	.031
Manganese	.05	.04

Between 1889 and 1892 about 40,000 tons of ore were produced.

FRANKLIN COUNTY

Two areas containing magnetite ore bodies in Franklin County near the Clinton County line should be mentioned to complete the description of the area as a whole. These additional localities are known as the Duncan Mountain prospect and the Bannerhouse mine.

Duncan Mountain prospect.—The Duncan Mountain prospect is on the south slope of Duncan Mountain in the Lyon Mountain quadrangle. The prospect, consisting of three shallow pits, lies 0.6 mile N. 50° W. from the dam at Union Falls.

The magnetite is associated with a metagabbro. Examination of a polished ore sample exhibited an unusually high content of granular ilmenite, which is not characteristic of the ores of the Lyon Mountain granite gneiss. A biotite-pyroxene amphibolite forms the hanging-wall of the ore zone; the footwall is composed of a magnetite-microperthite granite gneiss. The modal compositions of these rocks is given in table 61.

An assay made by the United States Bureau of Mines on a channel sample from the east pit gave the following results:

Fe	P	S	TiO^2	Insol.
33.40	0.46	0.20	3.80	43.1

The titanium and phosphorus content of the ore is obviously high. The titanium is present in ilmenite, and the phosphorus is present in apatite.

Exposures in the prospect pits indicate that the ore zone has an eastward strike and a dip of 40°–60° N. The thickness of the magnetite concentration is between 3 and 4 feet. Outcrops some 500 feet down grade have a strong mineral lineation that plunges down the dip.

A reconnaissance dip-needle survey of the area made by the Bureau of Mines showed a moderate anomaly over a distance of 600 feet in the vicinity of the three test pits. The airborne magnetometer survey gave no attraction over this area, though an anomaly was recorded 0.6 mile to the west.

Bannerhouse mine.—The Bannerhouse mine is on the western flank of Sanburn Hill just south of the 44° 50' latitude line on the extreme eastern side of the Chateaugay quadrangle. The mine consists of three pits and a timbered shaft, now flooded, that was driven down the dip of the ore zone.

At this mine magnetite occurs in a pink medium-grained pyroxene syenite gneiss or quartz syenite gneiss of the Lyon Mountain granite gneiss. Schlieren and knots of green pyroxene are common in the ore-bearing rock. The ore zone is cut across at low angles by quartz veins and pegmatites that carry coarsely crystallized magnetite. Both the hanging-

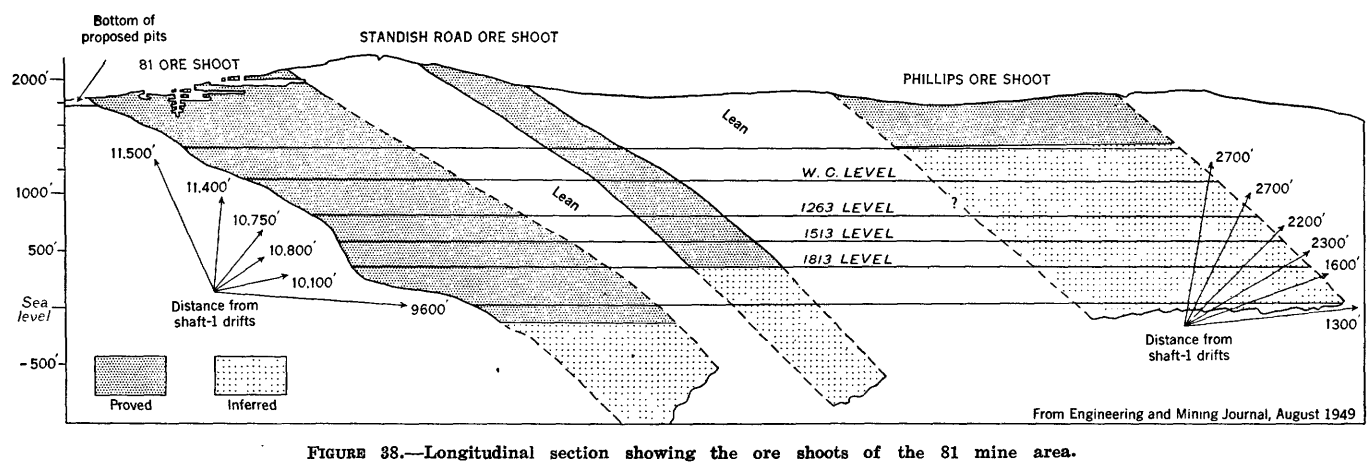

FIGURE 38.—Longitudinal section showing the ore shoots of the 81 mine area.

TABLE 61.—*Modal composition of magnetite and associated rocks from the Duncan prospect east pit*

[X, present; G, xenomorphic-granular; C, cataclastic]

	[1]1096	[2]1096A	[3]1096C
Microperthite		44.0	
Plagioclase	An_{27} 41.4	An_{10} 6.6	An_{17}
Plagioclase and microperthite			29.4
Quartz		38.6	19.1
Clinopyroxene	6.9		
Hornblende	15.6		
Biotite	32.7		.5
Magnetite			[4]51.0
Accessories	3.3	10.7	
Magnetite	X	X	
Apatite	X	X	
Zircon	X	X	
Epidote		X	X
Chlorite		X	
Magnetite (percent by weight)			67.4
Metallic iron (percent by weight)			48.7
Texture	G	G	C

[1] Hanging wall.
[2] Footwall.
[3] Ore from vein.
[4] Titaniferous.
[5] Computed from mode.

1096. Pyroxene amphibolite.
1096A. Microperthite granite gneiss.
1096C. Microantiperthite titaniferous ore.

walls and the footwalls of the magnetite zone are composed of pink medium-grained syenite gneiss. Table 62 shows the modal compositions of samples collected from the old dump.

The ore zone has a strike of N. 80° E. and a dip of 55° S. The mineralized zone may be on the northwest limb of a syncline that plunges to the northeast. Inspection of the abandoned shaft sunk on the ore zone shows a possible thickness of about 10 feet for the ore.

Reconnaissance dip-needle surveys indicate that high attraction is confined to the immediate vicinity of the old workings. It is therefore probable that the ore zone has no great extent.

TABLE 62.—*Modal composition of ore and associated rock from the dump of the Bannerhouse mine*

[D, dominant; X, present; G, xenomorphic-granular; Gl, xenomorphic-granular with recrystallized cataclastic texture]

	P528	P528C	P528F	P528G
Microperthite	68.8	54.7	66.3	61.6
Oligoclase	1.9		1.5	2.0
Quartz		6.5	2.0	
Clinopyroxene	11.8	12.7	22.4	16.2
Biotite			3.0	Tr.
Magnetite	16.5	21.3	4.7	19.5
Accessories	.9	4.8		.7
Apatite		D		X
Zircon	X	X	D	X
Sphene				X
Chlorite	X	X		
Magnetite (percent by weight)[1]	28.1	39.1	9.4	32.3
Iron (percent by weight)[1]	20.3	25.4	1.8	23.3
Texture	G	Gl	Gl	G

[1] Computed from mode.

P528. Pyroxene-contaminated microperthite granite-gneiss subore.
P528C. Pyroxene-contaminated microperthite granite-gneiss ore.
P528F. Pyroxene-contaminated microperthite granite gneiss.
P528G. Pyroxene-contaminated microperthite granite-gneiss ore.

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