UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY REPORT ON THE TITANIFEROUS IRON DEPOSITS OF THE LARAMIE RANGE, WYOMING

By

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51-75

This report and accompanying illustrations are preliminary and have not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

I

CONTENTS

ILLUSTRATIONS

Preliminary Report on the Titaniferous Iron Deposits of the Laramie Range, Wyoming

By W. H. Newhouse and A. F. Hagner

Introduction

The investigation of the titaniferous iron deposits and anorthosite of the Laramie Range, Wyoming, by geologists of the U. S. Geological Survey was conducted as a joint project by the U. S. Geological Survey and the Geological Survey of Wyoming. Field work was started during the summer of 1944 and has been carried on intermittently since as a part of the studies of the Laramie Range pre-Cambrian.

The anorthosite series was previously studied by Katherine Fowler (1930), and part of the area is included in the Laramie-Sherman folio (Darton, et al, 1910). The titaniferous iron deposits have been described by a number of investigators and a review of their observations is included by Singewald (1913). Later the deposits were studied in somewhat more detail by Diemer (1941). Results of a core drilling program carried out by the United States Bureau of Mines in 1943 and 1944 are given by Frey (1946, a, b). After the work of Frey, the Bureau of Mines drilled some holes at the Shanton deposit but the results of this work have not been published.

The writers were ably assisted in the field by Max L. Troyer and George W. De Vore. Dr. H. D. Thomas, State Geologist of Wyoming, has encouraged and supported the work from the start and Dr. S. H. Knight has generously provided space and facilities of the Department of Geology,

University of Wyoming. The chemical analysis of massive ore from Iron Mountain, given in Table 2, was made possible by funds from the University of Wyoming.

Location

The anorthosite series and included titaniferous iron deposits are in the southeastern part of Wyoming and form part of the Laramie Range. The area extends northward from about 15 miles northeast of Laramie to a few miles beyond North Sybille Creek. The anorthositic rocks cover a large part of townships 16 to 21 N., ranges 71 and 72 W. in Albany County. Wyoming highway 34 crosses the northern part of the area along North Sybille Creek and two county roads and numerous ranch roads give access to much of the region.

General Geology of the Pre-Cambrian

The oldest rocks in the area are pre-Cambrian quartzites, dolomites, and hornblende schists. Next in age are the anorthositic rocks which have been intruded by masses and dikes of norite. After the crystallization of norite, quartz syenite, gneisses, granites, and "lamprophyre" dikes formed. Following these events there was a long period of erosion and peneplanation. The titaniferous iron ores were introduced after the formation of anorthosite and before the intrusion of granite dikes.

Anorthositic Rocks

The anorthositic series ranges in composition from rocks composed almost entirely of plagioclase to those containing 50 percent or more dark minerals. Anorthosite contains 90 percent or more plagioclase with the remainder ferromagnesian silicates and minor sporadic magnetite-

ilmenite. Noritic anorthosite contains, for the most part, 10 to 20 percent hypersthene, and magnetite-ilmenite as an accessory mineral. Locally, hypersthene constitutes up to 50 percent of the noritic anorthosite. In some places olivine forms 5 or more percent of the anorthosite and locally may reach 40 percent.

Anorthosite is light to medium gray or bluish-gray, medium- to coarse-grained, and generally forms angular, prominent outcrops. In places it grades along strike into darker varieties. The rock commonly exhibits a well-developed parallelism of plagioclase crystals, called platy crystal structure. Pronounced layering is often displayed which is due to different proportions of minerals or to differing grain size. In individual exposures this layering is parallel to the platy crystal structure. Noritic and olivine anorthosite are more massive and platy structure is poorly developed or absent. Outcrops are sub-round to round and weather brown. The plagioclase in the anorthositic rocks ranges in anorthite content from 35 to 65 percent.

Structure of Anorthositic Rocks

A complete section of the anorthosite series is not exposed. The part that is exposed has the form of a folded lens or tabular-shaped mass.

The major structure of the anorthosite is a sharply defined anticline in the east which trends north-south for 25 miles. An offset of this structure is present in the southern anorthosite area. The southern anticline trends N. 60° E. and is about 7 miles long. In the northern area the anorthositic rocks dip, in general, to the west except where modified

by the major anticline. Dips of the platy crystal structure and layering of the anorthosite series on the principal, northern, anticline are from 20° to 60°, the majority being from 40° to 50°. The domal part is in the northeast and the anticline plunges south from this point for 17 miles and north for 8 miles. This structure is modified locally by minor folds on the flanks of the major fold.

Zones of Granulation and Alteration

A zone of granulated anorthosite from 1,000 to 3,000 feet wide and 9 miles long is present along the anticlinal axis in the anorthosite north of Iron Mountain. Here the anorthosite is light gray, granulated, and in general finer-grained than elsewhere. A fractured and altered zone lies west of Iron Mountain along and near the axial portion of the anticline. Another such zone, nearly 8 miles long, begins northeast of Iron Mountain and trends southeasterly across the eastern limb of the fold.

Titaniferous Iron Deposits

Magnetite-ilmenite bodies large enough to be of commercial interest crop out at Iron Mountain. The bodies exposed by erosion at the Shanton and other deposits are smaller. Although massive ore is known to be present at more than 30 other places in the area, most of the exposures are small; only a few lenses are several hundred feet long and up to 20 feet thick.

The deposits in the Laramie Range may be classified under three chief mineralogic types.* One type contains massive magnetite-ilmenite

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*These mineralogic types should not be confused with grades of ore at Iron Mountain.

with minor spinel. A second type contains olivine and occasionally plagioclase in addition to the minerals of the first type. The third type contains magnetite-ilmenite with apatite. Locally these minerals are arranged in bands producing a marked compositional layering of the ore.

The first two types of ore are often associated in the same ore body. Within an ore body olivine is often more abundant in some layers than in others. Thin layers may consist almost entirely of olivine and these adjoin other layers containing almost none. The layering at Iron Mountain appears to be parallel to the plane of platy feldspar structure and layering in the adjoining anorthosite. The magnetite-ilmenite bodies that transect the plane of layering in the anorthosite approximately at right angles do not display olivine layering within the ore.

Deposits of the first two types have a wide distribution, being present at irregular intervals generally near the axial region of the main fold over a distance of about 22 miles. Deposits that contain apatite are small and occur only in the northern part of the anorthosite area. Several of these apatite bearing deposits are near small bodies of dolomite in the anorthosite.

The ore bodies are lenses or tabular-shaped masses frequently arranged in discontinuous and overlapping, en echelon bodies. An individual lens is generally parallel to the compositional layering and plane of platy crystal structure in the anorthosite. This is especially well shown in the Iron Mountain region.

Massive magnetite-ilmenite containing only a small percentage of

silicate minerals is resistant to weathering and forms prominent outcrops. Olivine, the most common silicate in the ore, is largely removed from outcrops by weathering processes to give pitted surfaces. Where olivine or apatite exceeds 20 percent, the ore disintegrates on weathering and outcrops are generally lacking.

Chemical Analyses of "Ore" Specimens from the Anorthosite Area

Partial chemical analyses were made of specimens taken from over 30 occurrences of titaniferous iron "ore". The location of these occurrences is shown on the large map (Plate 1). The specimens came from weathered surface exposures and probably many of them contain higher percentages of iron and titanium dioxide, with lower silicon dioxide than a properly taken sample of fresh "ore". They may be used to obtain approximate ratios of iron to titanium in the fresh "ore".

The partial chemical analyses are shown in Appendix B and more complete analyses are given in Table 1. Many partial analyses of the ore at Iron Mountain and at the Shanton deposit were made by the United States Bureau of Mines (Frey, 1946, a, b).

Relation of Ore to Structural Features

Most of the Laramie Range titaniferous iron occurrences are in the anorthosite within a mile of the anticlinal axis. In townships 18 and 19 the "ores" are in westerly and northwesterly trending zones. One zone includes Wy-26, Wy-27, and Wy-29; another includes Wy-22, Wy-21, and Wy-23 (see Plate 1). In more detail this is indicated on the Iron Mountain map where the northern and southern ore bodies are synclinal in form with southeasterly plunge. Smaller outcrops of titaniferous iron

are exposed west and northwest of the northern ore body. The significant structures that localized the ore are considered to be folds along the zones just mentioned.

Individual ore bodies in the Laramie Range were introduced into the surrounding anorthosite, commonly along the plane of platy crystal structure. Ore containing considerable olivine or apatite generally displays compositional layering which is parallel to this plane.

The ores in townships 18 and 19 are dominantly in regions where the dips of the platy crystal structure and the compositional layering in the anorthosite range from 10° to 50°. This is so whether the ore is parallel to or transects the layering.

The larger titaniferous iron ore bodies all occur in anorthosite with less than 10 percent hypersthene. Ore bodies are small and discontinuous in noritic anorthosite. This is believed to be due to the more brittle nature of anorthosite, to the massive character of noritic anorthosite and the influence of these physical features on the fractures that admitted the ore mineralization.

TABLE 1

Chemical Analyses of Massive Ore

	1	2	3
	Iron Mountain	Shanton Wy 25	Taylor Wy 5
SiO_2	none	.26	.36
Al_2O_3	8.12	5.13	3.01
Fe_2O_3	26.26	38.34	26.15
FeO	41.80	32.66	36.31
MgO	3.62	2.93	1.85
CaO	none	.10	.21
Na_2O	nd	.54	.20
K_2O	nd	.40	.22
H_2O-	nd	.02	.03
H_2O+	.58	.34	.43
TiO_2	19.30	19.56	30.84
MnO	.09	.14	.08
S	nd	.03	.01
P_2O_5	nd	<.01	<.01
V_2O_5	nd	.40	.27
	99.77	100.86	99.98

(1) Fresh massive magnetite-ilmenite core from drill hole 10 at 209 feet. Analyst, F. A. Gonyer.

(2), (3) Weathered massive magnetite-ilmenite. Magnetite partly replaced by hematite. Analysts, Norman Davidson (2) and I. Warshaw (3).

Introduction of Ore

Although most of the ore lenses are essentially parallel to the layering and platy crystal structure of the anorthosite, some cut across this structure at nearly right angles. At a number of places in the Laramie Range the ore-bearing zones transect the layering and platy crystal structure of the anorthosite, although individual lenses lie parallel to it. This en echelon is believed to be due to the introduction of ore along zones of shear fracturing that deviate toward the direction of tensional fractures. Layering in the southern ore body at Iron Mountain strikes more easterly than the trend of the ore lens. The layering thus bears the same relation to the lens as a whole as do the en echelon lenses just described. This is considered to be complete replacement along a zone of en echelon fractures. In contrast with this, the layering in some ore bodies is essentially parallel to the major plane of the lens. The halo of low-grade mineralization containing olivine and magnetite-ilmenite developed principally along the hanging wall of the ore zone at Iron Mountain; it transects and greatly modifies the host anorthosite.

The ores are considered to have formed by replacement of anorthosite. The replacement theory is believed to be supported by the marked change in mineralogy along the strike, dip, and plunge of an ore body, and of its individual layers whether a fraction of an inch or tens of feet thick. These variations of mineralization, which range from almost pure anorthosite or pure olivine to massive magnetite-ilmenite, are difficult to explain in any other manner than by replacement.

The proportion of magnetite-ilmenite to olivine, as well as the proportion of these to the older anorthosite, appear to be related to structural features. One aspect of this is that when magnetite-ilmenite is present with olivine the "ore" minerals are concentrated along the most pronounced part of a fold, whereas the olivine extends into the limbs and on the more gently folded portions.

Hand specimens and microscopic sections indicate replacement of anorthosite by olivine and magnetite-ilmenite. The criteria used are essentially those set forth by Bastin, et al (1931).

Iron Mountain Deposit

Introduction.—Iron Mountain is 47 miles northeast of Laramie by road, and is located near the eastern margin of the anorthosite area, in secs. 22, 23, 26, and 27, T. 19 N., R. 71 W., Albany County, Wyoming. The nearest railroad station is at Farthing on the Colorado and Southern Railroad 9 miles to the southeast. Bosler, on the Union Pacific Railroad, is about 31 miles west.

Iron Mountain is a rugged northward-trending ridge which is breached near the southern end by North Chugwater Creek. The ridge rises to an elevation of approximately 7,450 feet which is about 660 feet above the creek level. Titaniferous magnetite ore crops out principally along the ridge crest. Where the ore consists mostly of massive magnetite-ilmenite with little olivine and anorthosite, it stands up above the surrounding anorthosite in prominent outcrops. The major ore zone extends about 5,000 feet along and near the crest of the ridge.

A number of tons of ore have been shipped from the deposit at various

times for experimental purposes, but no commercial production has been made. Previous reconnaissance work in the area dates back to the surveys of Stansbury (1853), Hayden (1870), and King (1878). Further work was done by Knight (1893), Kemp (1899, 1905), Lindgren (1902), Ball (1907), Singewald (1913), Diemer (1941), and Frey (1946, a, b). The work of these men, with the exceptions of Diemer and Frey, is summarized by Singewald.

The geologic and topographic map (Plate 2) was made with plane table and alidade and covers an area of 6,000 feet by 2,000 to 3,000 feet. The elevation was established by aneroid barometer and checked by carrying in a line from a known elevation with plane table and alidade.

Lithologic Types.--The rocks at Iron Mountain include several types of anorthosite and granite. The ore bodies lie within a major anorthosite layer. Two minor layers or broad bands of noritic anorthosite are present in the Iron Mountain map area (Plate 2). Each of these is several hundred feet wide and is parallel to the platy crystal structure of the adjoining anorthosite. Other noritic anorthosite layers are present in the map area but these are small and were not mapped. The anorthosite and noritic anorthosite have been profoundly modified in the central part of the map area by the introduction of olivine and magnetite-ilmenite. This alteration has left small masses of the original rocks but these are not widespread enough so that contacts of the noritic layers can be traced across the mineralized zone.

The hanging wall and footwall of the deposits is mineralized anorthosite. The mineralized zone varies considerably in width. The width

is related to the size of the ore bodies, the strike and dip of the layering and also the topography. The mineralized rock has been divided into two types. One contains grades 2 and 3 "ore" and olivine in high concentrations but the bulk of the rock consists of 85 to 95 percent plagioclase with olivine and magnetite-ilmenite distributed throughout. This type could not be subdivided because of insufficient exposures. The second type has less abundant mineralization. About 75 percent of the rock contains 5 to 15 percent olivine and 2 to 7 percent magnetite-ilmenite; the remainder is anorthosite. Olivine exposed at the surface has been changed to serpentine minerals and other alteration products. In drill cores the olivine is commonly fresh. The areal extent is shown on the Iron Mountain map (Plate 2).

Grade of Ore.—The Iron Mountain ore bodies have been divided into 3 grades on the basis of volume percentage of silicates present. The TiO_2 percentage of these grades was obtained from assays made by the U. S. Bureau of Mines.

Grade 1 consists of massive magnetite-ilmenite with from 0 to 35 percent by volume of silicates, mostly olivine and minor spinel. The TiO_2 percentage ranges from 16 to 23 inclusive.

Grade 2 consists of magnetite-ilmenite with 35 to 65 percent by volume of silicates, chiefly olivine and minor spinel, plagioclase and hypersthene. The TiO_2 percent ranges from 10 to 16. "Ore" of this grade rarely crops out and is therefore shown on the geologic sections but not on the geologic map of Iron Mountain.

Grade 3 consists of magnetite-ilmenite with 65 to 85 percent by

volume of silicates, largely plagioclase with minor olivine and hypersthene. The TiO_2 percent ranges from 5 to 10. Grade 3 "ore" is shown on the geologic sections but not on the geologic map of Iron Mountain.

Grain Size of Magnetite-Ilmenite and Olivine.—The magnetite-ilmenite grains are commonly between .2mm and 1cm in diameter. In massive ore magnetite generally occurs in larger grains than ilmenite, but where considerable silicates are present ilmenite tends to form larger grains. The ilmenite lamellae range in size from those observable only under high magnification to others which can be seen with the naked eye. Olivine is commonly in rounded grains which range in size from a fraction of a mm. to several millimeters across.

Mineralogic Variations in Olivine and Magnetite-Ilmenite.—Olivine and magnetite-ilmenite vary in composition. Olivine ranges from about 40 percent fayalite in the heavy mineralization to 50 percent in sparse mineralization. Although there are exceptions to this, detailed work by George W. DeVore has established this generalization.

In a detailed study of polished surfaces of the ores from Iron Mountain by Gregory Turner (1947), it was found that the ratio of magnetite to ilmenite in the massive ore is approximately 4:1, and in the sparse mineralization it is about 4:5. Chemical analyses of the massive ores, when compared with those of the magnetite-ilmenite of the sparse mineralization, do not show the shifts in iron-titanium ratios expected with these observations. Individual grains of magnetite and ilmenite are present in both the massive ore and in the sparse mineralization. Exsolved lamellae of ilmenite are abundant in the magnetite in the sparse mineralization

and rare in massive ore with less than 5 percent silicates. In table 1 the analysis Wy-19 is of magnetite-ilmenite concentrated from a drill core estimated to contain 10 percent magnetite-ilmenite, 60 percent olivine, and 30 percent plagioclase by volume. The concentrate contained an estimated 70 to 90 percent magnetite-ilmenite. Analysis Wy-20 was made of magnetite-ilmenite from core estimated to contain 20 percent magnetite-ilmenite, 30 percent olivine, and 50 percent plagioclase by volume. The concentrate contained 80 to 90 percent magnetite-ilmenite. Analysis Wy-39 was made of massive magnetite-ilmenite with only a few percent silicate. The chemical analyses and microscopic observations can be reconciled by assuming changes in the composition of the ilmenite or magnetite or both. The writers suggest that the ilmenite probably contains a higher percent of iron relative to titanium in the sparse mineralization than it does in the massive ore. The exsolution textures of magnetite-ilmenite vary in the massive ore and in ore containing silicates. In the latter, ilmenite is present as individual grains and as exsolution lamellae in magnetite. In massive ore lacking silicates the two minerals occur principally as distinct grains. An intermediate texture is found where appreciable silicates are present. In this texture ilmenite forms rims around magnetite grains. Our interpretation is that exsolution of ilmenite, i.e., titanium, from the magnetite solid solution was most complete in the massive ore. Some titanium may still be present because Turner describes a network of ilmenite or hematite in magnetite observable only at high magnifications.

Several percent or more of spinel are present as blebs in magnetite,

and in ilmenite grains accompanied by exsolved ilmenite lamellae. It also occurs as exsolved blebs in exsolved ilmenite lamellae. The spinel contains some iron and one refractive index determination gave 1.76n to 1.77n.

The above are tentative conclusions since work has not been completed. They are intended to indicate certain possibilities to anyone considering mechanical concentration as an ore dressing possibility.

Post-ore-Faults.—At several places the ore is offset by faults which appear to have only a few tens of feet displacement; however, the fault along the southwestern part of the southern ore body has a greater offset. Numerous small slickensided surfaces are present along and near the footwall of the massive ore.

Tonnage Estimates.—Table 2 gives the estimated ore reserves at Iron Mountain in short tons. Data are based on the geologic map and on diamond drilling and assays by the U. S. Bureau of Mines. The principal tonnage is found in two blocks designated the northern and southern areas. All of the ore estimated in the northern area is above 6,900 feet elevation; all the ore in the southern area is above 6,600 feet elevation.

There are approximately 9,150,000 short tons of indicated and inferred titaniferous magnetite "ore" in the main ore zone. Of this total, 8,650,000 tons are found in the northern and southern blocks; the remaining 500,000 tons occur in small lenses and masses.

Suggested Prospecting Areas in the Iron Mountain Region

Deeper ore may be present on the structures occupied by the northern and southern ore bodies at Iron Mountain.

On the Iron Mountain map two areas are of particular interest for magnetic prospecting. One of these is along the southeastern extension of the southern ore body bounded by coordinates 1200N. to 2400N. and 1200E. to 2000E. This ore would probably be deep. The subsidiary fold to which the southern ore body appears to be related extends eastward for about one-half mile. The other area is bounded on the west by a line from coordinates 2400N., 1000E. to 5600N., 2600E. and extends 1200 feet east of this line.

Other known deposits of titaniferous iron ore in the Laramie Range are small compared with the Iron Mountain deposit. The most extensive mineralization elsewhere is present at the Shanton property and at Wy-21, also near the northern part of the anorthosite area at Wy-1 and Wy-3 (see Plate 1). If ore is needed to supplement an operation at Iron Mountain, magnetic prospecting might locate some near the surface in the area outlined in orange on plate 1. This area includes anorthosite with low to moderate dips and other structural features with which ore appears to be related (see section on Relation of Ore to Structural Features).

Date: November 14, 1950 Signed: W. H. Newhouse

A. F. Hagner

TABLE 2

ESTIMATED ORE RESERVES AT IRON MOUNTAIN, WYOMING

	Short Tons		
	Grade 1	Grade 2	Grade 3
	TiO_2 16 to 23% incl. Fe 42 to 50% V_2O_5 .50	TiO_2 10 to 16% Fe 30 to 42% V_2O_5 .36	TiO_2 5 to 10% Fe 18 to 30% V_2O_5 .17
Northern Area			
Indicated	1,200,000	1,280,000	700,000
Inferred	70,000	780,000	1,170,000
Southern Area			
Indicated	1,700,000	320,000	200,000
Inferred	430,000	430,000	370,000
Small Miscellaneous Masses			
Indicated	100,000		
Inferred	100,000	100,000	200,000
Totals			
Indicated	3,000,000	1,600,000	900,000
Inferred	600,000	1,310,000	1,740,000

Based on geologic map by U. S. Geological Survey and Wyoming Geological Survey and on diamond drilling and assays by U. S. Bureau of Mines. The principal tonnage is found in two blocks, designated the northern and southern areas. All the ore estimated in the northern area is above 6,900 feet elevation; all the ore estimated in the southern area is above 6,600 feet elevation. In converting cubic feet of ore to tons, 8 cubic feet was used for one ton of Grade 1, 9 cubic feet for Grade 2 and 10 cubic feet for Grade 3.

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Appendix A

DIAMOND DRILL HOLE LOGS

HOLES 1-17

IRON MOUNTAIN,

WYOMING

by

W. H. NEWHOUSE AND A. F. HAGNER

(Holes not surveyed)

Iron Mountain, Wyoming

D. D. Hole 1

Core
BX 0-3
AX 3-10
EX 10-656

Coordinates 5518N, 2293E
Elev. of Collar 7358.0
Length 656 feet
Angle - 45°
Bearing N 32° 30' W

From Ft.	To Ft.	Core Recovery Ft.	
0	3	1	Massive magnetite-ilmenite.
3	32	0.8	Analysis of sludge by Bureau of Mines indicates a mixture of magnetite-ilmenite-silicate. Average of sludge analyses - Fe 35.18, TiO_2 9.34. Cemented hole 0 - 20 feet. 0 - 32 ft. = Fe 36.3%, TiO_2 10.6%.
32	44	3	The same with analysis of 3 ft. of core recovered. With such poor recovery the core analyses are probably too high. The sludge analyses are probably too low. Core not seen by U. S. Geological Survey. Sludge 38.75 Fe, TiO_2 12.48 Core 45.8 Fe, TiO_2 18.1 Lost water at 39 feet.
44	131	22.5	Anorthosite, 20% ferromagnesian silicate, mostly olivine, variable grain size and distribution. Poor core recovery probably due to poor drilling. Less than 1% magnetite-ilmenite. Lost water at 55 ft., twice 64-74 ft., frequently 74-84 ft., lost some 108-115 ft., slowly 121-124 ft., cemented 124-129 ft.
131	148	10	Anorthosite, very minor ferromagnesian silicate. Lost much water 142-148 feet.
148	178	15	Anorthosite, considerable ferrogmagnesian silicate. Altered to chlorite. Cemented hole 148-162 feet.
178	182	good	Anorthosite, very minor ferromagnesian silicate.
182	195	good	Anorthosite, considerable ferromagnesian silicate.
195	294	good	Anorthosite, very minor ferromagnesian silicate. Cemented hole 190-214 feet.
294	325	good	Anorthosite, 20% ferromagnesian silicate, some is olivine.
325	331	good	Anorthosite, very minor ferromagnesian silicate. Angle of compositional banding at 328-329 is 60°-70° to core axis, also angle of platy feldspars.

Iron Mountain, Wyoming

D. D. Hole 1

From Ft.	To Ft.	Core Recovery Ft.	
331	474	good	Anorthosite, 20% ferromagnesian silicate, most is olivine, irregularly distributed.
474	477	good	Granite, fine grained, biotite.
477	501	Fair	Anorthosite, 20% ferromagnesian silicate, most is olivine. Compositional banding and platy feldspar structure 60° to core axis at 481. (See lavender feldspar crystal when core is wet, spec. 484.)
501	524	fair	Anorthosite, very minor ferromagnesian silicate. Platy feldspar structure is 45°-50° to core axis at 511.
524	532	good	Anorthosite, considerable ferromagnesian silicate.
532	597	fair	Anorthosite, very minor ferromagnesian silicate.
597	601	good	Granite, fine grained, biotite.
601	613	good	Anorthosite, considerable ferromagnesian silicate.
613	646	fair	Granite, biotite, fine grained. Pink and white.
646	656	good	Anorthosite, moderate % of ferromagnesian silicates. Platy feldspar structure 55° to core axis at 653.

End of hole

Iron Mountain, Wyoming

D. D. Hole 2

Core
3 in. Stand Pipe 0-3
BX 3-60
AX 60-122
EX 122-300

Coordinates 4328N, 1830E
Elev. of Collar 7333
Length 300 feet
Angle - 45°
Bearing N 75° W

From Ft.	To Ft.	Core Recovery Ft.	
1	98	26	Anorthosite 10-15% ferromagnesian silicate, mostly olivine but considerable hypersthene, 3-5% magnetite-ilmenite. Lost water at 92 ft. Cemented hole 97-122 ft.
98	118	18	Anorthosite-olivine-magnetite-ilmenite mixture. Estimated 10% olivine and 5% magnetite-ilmenite well distributed as irregular masses usually less than 1 inch across.
118	261	130	Core missing, has been analyzed by Bureau of Mines. Averages of core analyses furnished by Bureau of Mines:

118 - 127	9.9% Fe,	3.4% TiO_2
127 - 136	48.4% Fe,	18.5% TiO_2
136 - 160	19.9% Fe,	5.2% TiO_2
160 - 180	43.1% Fe,	14.3% TiO_2
180 - 208	21.8% Fe,	5.6% TiO_2
208 - 253	35.9% Fe,	11.8% TiO_2
253 - 261	2.9% Fe,	.55% TiO_2

261	300	37

Anorthosite, fine grained.

261 - 277 5-15% olivine, several % hypersthene, part of the olivine is altered to chlorite, 5% magnetite-ilmenite.

277 - 282 Very minor ferromagnesian silicate.

282 - 300 Contains 10-20% olivine, much altered to chlorite, 5%+ of magnetite-ilmenite. 283-286 layering 80°-90° to core axis of ferromagnesian silicate and magnetite-ilmenite.

End of hole.

Iron Mountain, Wyoming

D. D. Hole 3

Coordinates 5180N, 1487E
Elev. of Collar 7338
Length 390 feet
Angle - horizontal
Bearing S 63° E

Core
BX 15-61
AX 61-390

From Ft.	To Ft.	Core Recovery Ft.		
1	15	0	Overburden.	
15	20	2	Granite, light gray, biotite.	
20	210.5		Anorthosite	
		6	20-51	dark gray, broken core, 5-15% chloritized olivine. Weathered. Some dendritic magnetite-ilmenite.
		5	51-61	gray, with poorly defined platy feldspar structure at large angles to core axis. Patches of dendritic magnetite-ilmenite. 5-15% olivine partly chloritized.
		6	61-80	gray, poorly defined platy feldspar structure at large angles to core axis. Very scanty magnetite-ilmenite and 5-15% olivine.
			20-80	2-5% magnetite ilmenite.
			80-82	altered, core broken, weathered.
		1	82-87.5	gray, platy feldspar structure at 85 ft. is approximately 60°-65° to core axis. Minor yellow titanite ?
		5	87.5-93	altered, core broken, weathered.
		31	93-124	gray, minor magnetite-ilmenite and 15-20% olivine. Platy feldspar structure at 103 ft. is approximately 55° to core axis, at 114 ft. 55°-60°.
		53	124-177	10-15% olivine. Angle of ferromagnesian silicate streaks at 174 is approximately 50° to core axis. 2-3% magnetite-ilmenite.
		6	177-201	with 5-10% olivine, 2-5% magnetite-ilmenite.
		11	190-201	gray, very little ferromagnesian silicate. Platy structure not well developed. Coarse grained.
		8.5	201-210.5	gray, like 190-201 but becomes finer grained or more granulated toward the ore. This whole footage contains finely disseminated epidote ? The several feet adjoining the ore contains scattered streaks or seams of chlorite ? and magnetite-ilmenite. These form angles with the core axis, one set at 35°, another set at 45°.

Iron Mountain, Wyoming

D. D. Hole 3

From Ft.	To Ft.	Core Recovery Ft.	
210.5	255	44.5	Massive magnetite-ilmenite, one-eighth to one-quarter inch diameter grains. Several % silicate (olivine) by volume. Olivine present as large grains. No banding. Several small calcite veins at 35° and more to core axis. 210.5-256 contains 92-94% magnetite-ilmenite by vol. when recalculated.
255	278	22	Magnetite-ilmenite ore with 10-20% olivine by volume. Ore grains one-eighth to one-quarter inch in diameter. Olivine grains vary up to one-half inch in diameter. No banding. Core broken and 2 feet lost 271-276. Probably fractured or fault. 256-329 contains 51-59% magnetite-ilmenite by volume when recalculated.
278	329	38	Magnetite-ilmenite-silicate ore with 20-40% olivine by volume. Grain size like 255-278. No banding.
329	350	31	Massive magnetite-ilmenite ore, grains one-eighth to one-quarter inch diameter. Less than 10% silicate by volume. No banding. 329-335 1% olivine by volume when recalculated.
350	356	3	Magnetite-ilmenite-silicate "ore" with 20-30% olivine. Grains size like others in this hole.
356	359	2	Massive magnetite-ilmenite ore. Less than 10% silicate. Few thin carbonate seams.
359	368	4	Magnetite-ilmenite silicate "ore" with 30-40% or more olivine. Core much broken and lost.
368	390	2	Anorthosite, with olivine, magnetite-ilmenite, minor pyrite, and mica. Very poor core recovery. Anorthosite apparently fractured and with magnetite-ilmenite, etc., along fractures but core pieces too small to be certain. Not certain whether fracturing was all pre-mineral.

End of hole.

Iron Mountain, Wyoming

D. D. Hole 4

Coordinates 1965N, 1000E
Elev. of Collar 6848
Length 199 feet
Angle - 45°
Bearing N. 75° W

Core
BX 10-40
AX 40-199

From Ft.	To Ft.	Core Recovery Ft.	
1	10	0	Anorthosite strongly weathered. Friable. Some disseminated magnetite-ilmenite and olivine.
10	27	8.9	Magnetite-ilmenite-silicate ore estimated 20-30% silicate by volume. Silicate mostly olivine. Grain size; magnetite-ilmenite 1/8 to 1/4 inches diameter, olivine 1/16 inch to 1/4 inch. Angle of core axis to silicate layering 70°-75°.
27	73.5	42.8	Massive magnetite-ilmenite. 27-69 Minor silicate, several % by volume. Magnetite-ilmenite grain size 1/8 to 1/4 inch diameter. 69-73.5 Silicate estimated at 15-25% by volume.
73.5	80		Anorthosite, altered with chlorite and epidote? Friable broken 73.5-75, also 78-80. Few small specks rutile?
80	83.5	3.5	Magnetite-ilmenite-silicate with 40-50% silicate. Silicate-olivine, chlorite and anorthosite. Minor hematite along 1/4 inch calcite vein.
83.5	104.5	20.5	Anorthosite, fine grained and altered? Chlorite. Minor titanite? Minor ferromagnesian silicate. 3 inches ore at 91.5.
104.5	116.5	12	Magnetite-ilmenite-silicate. 104.5-114 Massive magnetite-ilmenite with 10-20% silicate chiefly olivine. 114-116.5 With 50-70% silicate chiefly olivine.
116.5	129.8		Anorthosite, fine grained, minor ferromagnesian silicate.
129.8	145.5		Anorthosite-olivine-magnetite-ilmenite mixture. Estimated 10% of magnetite-ilmenite. About equal % of anorthosite and olivine. Olivine coarse grained. Recalculated to 15-20% magnetite-ilmenite.
145.5	149	1.5	Granite, biotite, fine grained.
149	160		Anorthosite, with chlorite and some minor biotite and magnetite-ilmenite.

Iron Mountain, Wyoming

D. D. Hole 4

From Ft.	To Ft.	Core Recovery Ft.	
160	174		Anorthosite-olivine-magnetite-ilmenite mixture. 160-173 With 5-10% magnetite-ilmenite by volume. 163-167.5 Magnetite-ilmenite-silicate ore with 15-20% silicate. Silicate mostly olivine, some anorthosite. 167.5-174 With 5% magnetite-ilmenite by volume. Silicate mainly anorthosite with minor olivine.
174	199		Anorthosite, contains much more ferromagnesian silicate than is in the anorthosite that is with the mineralization. Some alteration to chlorite. 175-199 20-30% olivine.

End of hole.

Iron Mountain, Wyoming

D. D. Hole 5

Core
BX 0–50
AX 50–183

Coordinates 2075N, 1025E
Elev. of Collar 6897
Length 183 feet
Angle – 50°
Bearing N 22° W

From Ft.	To Ft.	Core Recovery Ft.	
0	28	0	Anorthosite-magnetite-ilmenite mixture, weathered, friable, estimated at 15–30% magnetite-ilmenite. Ore minerals present as small vein-like masses and as small disseminated masses. Little if any olivine. Information from drill hole collar pit.
28	39.5	11	Magnetite-ilmenite-olivine, with 15–20% olivine by volume. Good compositional layering at 60–65° to core axis.
39.5	59	19	Magnetite-ilmenite with less than 5% silicate. Compositional layering at 70° to core axis.
59	87	good	Anorthosite with considerable ferromagnesian silicate estimated at 5–10% by volume. The ferromagnesian silicate was probably olivine now altered to chlorite?
87	90	3	Magnetite-ilmenite-olivine-anorthosite. Olivine 5–10% by volume, anorthosite 2% by volume.
90	95	5	Anorthosite with 5% ferromagnesian silicate.
95	119.1	34	Magnetite-ilmenite-olivine. Olivine 15–20% by volume.
119.1	138	good	Anorthosite, with 5–15% ferromagnesian silicate which is part hypersthene and part olivine altered to chlorite.
138	160.5	good	Anorthosite-olivine-magnetite-ilmenite. Anorthosite 40%, olivine 35%, magnetite-ilmenite 25% by volume. Olivine coarse grained.
160.5	180	good	Anorthosite, with 5–20% ferromagnesian silicate, chiefly olivine, some hypersthene. 6 inch granite dike at 162 feet.
180	183		Anorthosite, highly altered, chloritic, dark green. Numerous small calcite veinlets at large angle to core axis.
			End of hole.

Iron Mountain, Wyoming

D. D. Hole 6

Coordinates 1828N, 947E
Elev. of Collar 6792
Length 149 feet
Angle - 50°
Bearing N 62° W

Core
BX 0-29
AX 29-149

From Ft.	To Ft.	Core Recovery Ft.	
0	11	2	Magnetite-ilmenite-silicate, with less than 20% silicate by volume. Silicate chiefly olivine. Compositional layering at large angles to core axis, approximately 75°-90°. 0-11 contains 68-75% magnetite-ilmenite by volume recalculated.
11	25	2	Two ft. biotite, fine grained, pink and white. 11-25 contains 15-20% magnetite-ilmenite by volume recalculated. See sludge analyses.
25	89	63	Massive magnetite-ilmenite. Less than several % silicate by volume. Crystals of magnetite-ilmenite elongated or somewhat lenticular with longest dimension 70-90° to core axis. Small silicate masses or crystals are also elongated nearly at right angles to core axis.
89	107		Anorthosite with 5-15% ferromagnesian silicate. Mostly olivine, some hypersthene.
107	126.5	good	Anorthosite-olivine-magnetite-ilmenite. Anorthosite 70-85%, olivine 10-20%, magnetite-ilmenite 5-10%, by volume.
126.5	129	good	Magnetite-ilmenite with less than 5-10% silicate.
129	149	good	Anorthosite fine grained. 134-149 20-30% olivine.

End of hole.

Iron Mountain, Wyoming

D. D. Hole 7

Coordinates 1867N, 1129E
Elev. of Collar 6803
Length 240 feet
Angle - 54°
Bearing N 41° W

From Ft.	To Ft.	Core Recovery Ft.	
0	17	1.5	Partly anorthosite, partly magnetite-ilmenite with 30-50% silicate which is mostly feldspar.
17	37	0	No core.
37	65	23.5	Anorthosite-olivine-magnetite-ilmenite mixture with 50% feldspar, 35% olivine, 15% magnetite-ilmenite by volume. Coarse grained, no platy feldspar structure, but at 43 ft. coarse layering at right angles to core axis.
65	119	30	Granite, fine grained, biotitic at 71 ft. rock much broken chloritic, probably fault breccia. At 76 ft. iron ore 2 inches. Core recovery 65-76 ft., 1.3 ft. Biotite crystals arranged parallel along planes at 55-65° to core axis.
119	129.4	10.4	Massive magnetite-ilmenite. Less than 5% silicate. Grain size one-eighth to one-quarter inch in diameter.
129.4	134.6	4.8	Anorthosite, coarse grained with minor olivine altered to chlorite.
134.6	182.6	43.6	Massive magnetite-ilmenite with less than 5% silicate except 137.7-138.3 and 145-145.5 which sections of core are anorthosite partly altered to chlorite. Granite 151-152, 163-164 about 10% olivine. Magnetite-ilmenite grains show some elongation or lenticularity at right angles to core axis.
182.6	184.6	2	Anorthosite, coarse grained some chloritic streaks.
184.6	194	9.4	Magnetite-ilmenite-olivine with 10-15% olivine by volume. Coarse grained olivine.
194	204.5	good	Anorthosite coarse grained. Ferromagnesian silicate 5%.
204.5	205.7	good	Massive magnetite-ilmenite with minor chorite. Several inches of chloritic anorthosite on each side of the ore.
205.7	240	good	Anorthosite, coarse grained and bleached with 5-10% ferromagnesian silicate chiefly chloritized olivine and 1-2% magnetite-ilmenite as one-quarter to one-half inch irregular shaped masses. Small granite dikes at 228.5-230 and 232-233. Compositional layering at 238-239 at 80° to core axis, but not very good. Considerable number of small calcite veins. 203-225 5-10% chloritized olivine. End of hole.

Iron Mountain, Wyoming

D. D. Hole 8

Core
BX

Coordinates 2263N, 1075E
Elev. of Collar 6967
Length 175 feet
Angle - 60°
Bearing N 26° W

From Ft.	To Ft.	Core Recovery Ft.	
0	62	4	Magnetite-ilmenite-silicate, with 40% silicate by volume. Silicate mainly anorthosite.
62	93.2	23.5	Magnetite-ilmenite-olivine with 25% olivine by volume.
93.2	103.4	8	Anorthosite, very minor ferromagnesian silicate. Core broken.
103.4	108.3	4.5	Magnetite-ilmenite-olivine, with 15% olivine by volume.
108.3	120	12	Anorthosite, medium grain size, olivine 5-10%, a few % hypersthene.
120	126.5	6	Magnetite-ilmenite-silicate, with 10% anorthosite and 5-15% olivine by volume. 5-10% magnetite-ilmenite. A few % hypersthene.
126.5	130.5	3	Anorthosite, fine grained, olivine 5-10%, 5-10% magnetite-ilmenite.
130.5	136	4.5	Magnetite-ilmenite-anorthosite, with 30% anorthosite by volume.
136	175	37	Anorthosite fine grained, olivine and magnetite-ilmenite as dendritic masses. These masses form layering 70°-80° to core axis. Olivine and hypersthene 5-15%, magnetite-ilmenite 2-3%. The olivine is partly chloritized.
			End of hole.

Iron Mountain, Wyoming

D. D. Hole 9

Core
BX 0-25
AX 25-240

Coordinates 1603N, 748E
Elev. of Collar 6856
Length 240 feet
Angle - 60°
Bearing N 57° E

From Ft.	To Ft.	Core Recovery Ft.	
0	67	25	Anorthosite, minor ferromagnesian silicate. More ferromagnesian silicate 32-60 than elsewhere in the section. Core much broken, no platy feldspar structure. Lost water in hole at 62.5 and 68 ft. - fault? Note poor core recovery 0-68 ft.
67	176.5	109	Magnetite-ilmenite-silicate. Silicate, olivine and chlorite. Compositional banding of olivine and ore minerals as follows: 72 ft., 50°-55° angle to core axis 75 ft., 45°-50° " " " " 79 ft., 55° " " " " 86 ft., 50° " " " " 90 ft., 50°-55° " " " " 92 ft., 40°-45° " " " " 102 ft., 45°-55° " " " " 111 ft., 45°-50° this is an especially good one 137 ft., 40°-45° 139 ft., 40° 158 ft., 45°-55° (on banded and elongated magnetite-ilmenite crystals) 166 ft., 50° 67- 77 olivine 20% by volume. 77- 97 olivine 15-20% by volume plus several % anorthosite. 97-176 olivine 5% or less. Lost water in hole at 121 ft. - probably small fault.
176.5	181.5	5	Anorthosite, 5-10% ferromagnesian silicate, considerable chlorite. 178 ft. platy feldspar structure at 15°-20° to core axis, the same at 180 ft. 15°.
181.5	240	58	Magnetite-ilmenite with 5% silicate. Silicate is mainly chlorite. Compositional banding of ore with olivine at 190 ft. is 45°-50° to core axis, at 197 ft. 40°. Last two feet in hole core is much broken and apparently some minor solution cavities. End of hole.

Iron Mountain, Wyoming

D. D. Hole 10

Core
BX 0-70
AX 70-212

Coordinates 1542N 872E
Elev. of Collar 6914
Length 212 feet
Angle - 60°
Bearing N 44° 30'W

From Ft.	To Ft.	Recovery Ft.	
0	15	2.5	Anorthosite, 5-10% ferromagnesian silicate, except near 15 feet where it is feldspathic.
15	20	0	
20	71	9.5	Magnetite-ilmenite-olivine-anorthosite mixture. Silicate 50-60% by volume. Core much broken and silicate altered. Poorest recovery was in the altered silicate zones. This section is probably not as rich as the core assays will indicate. Sludge assays will be more accurate. Lost water at 71 ft. - fault?
71	109.7	35	Magnetite-ilmenite-olivine-anorthosite mixture. Magnetite-ilmenite 10-12%, olivine 25%, anorthosite 60% by volume. This ore is quite uniform throughout, each foot of core would assay about the same as any other foot of core except that 107-109.7 is richer. Feldspar is mostly platy but not oriented. Very poor core recovery to 89 ft. 15-109.7 contains 20-25% magnetite-ilmenite by volume recalculated.
109.7	115.3	5	Anorthosite, feldspathic medium grained.
115.3	137	20	Magnetite-ilmenite-olivine-anorthosite mixture. Magnetite-ilmenite 10%, olivine 30%, anorthosite 60% by volume. Uniform except for 130.5-132.2 which is pure anorthosite except for 2-3% magnetite-ilmenite. Ore banding with anorthosite at 131 is 50°-55°. Lost water at 137-138 ft.
137	139.4	2.4	Anorthosite, feldspathic, with 10% scattered olivine and several % ore.
139.4	160.2	19	Magnetite-ilmenite-olivine-anorthosite mixture. Magnetite-ilmenite 60%, olivine 25%, anorthosite 15% by volume. Chloritized silicate at 159-160.2. At four different places in this section excellent compositional banding at 55° to core axis. Two examples show 70° to core axis. Lost water at 160-165 ft.

Iron Mountain, Wyoming

D. D. Hole 10

From Ft.	To Ft.	Recovery Ft.	
160.2	206.8	40	Magnetite-ilmenite-olivine-anorthosite mixture. Magnetite-ilmenite 30% by volume, anorthosite 30%, olivine 40% by volume.
			160.2-163 Silicates strongly chloritized and core broken and friable. Fault at 161.
			163 -182.4 Contains anorthosite in the mixture, also olivine.
			182.4-206.8 Richer than 163-182.4 and only minor anorthosite.
			183-184 Excellent compositional banding at 65°-70° to core axis.
			198-200 Excellent compositional banding with olivine at 65°-70° to core axis, same angles at 204, 206.
206.8	212	6	Magnetite-ilmenite massive. Not over several % silicate by volume. Hole stopped in massive ore since this section is near that cut by hole 9.

End of hole.

Iron Mountain, Wyoming

D. D. Hole 11

Coordinates 4829N 1953E
Elev. of Collar 7332
Length 283 feet
Angle -40°
Bearing N 64° 0' W

Core
NX 0-20
BX 20-50
AX 50-283

From Ft.	To Ft.	Recovery Ft.	
0	112	22	Magnetite-ilmenite-anorthosite-olivine mixture, magnetite-ilmenite 30-40%, silicate mainly olivine. Silicates weathered and altered, core much broken and poor recovery. Core likely richer in Fe-Ti than the section drilled.
112	143.1	23	Magnetite-ilmenite-anorthosite-olivine mixture. Magnetite-ilmenite 10-15%, anorthosite 60%, olivine 25-30%. 112-122 silicates weathered, principally the olivine, core broken. As usual the olivine is coarse-grained when feldspar is present.
143.1	173.2	28	Magnetite-ilmenite-anorthosite-olivine mixture. Magnetite-ilmenite 30%, feldspar 40%, olivine 30% by volume. Olivine coarse grained.
173.2	177	2.5	Anorthosite, broken, chloritic.
177	225	48	Magnetite-ilmenite-olivine, anorthosite. Magnetite-ilmenite 50%, olivine 45%, feldspar 1-5% by volume. 177-184 Broken and with calcite veins. Minor pyrite. May be fault. 184-189 Magnetite-ilmenite 85%, olivine 15%, feldspar 1-2%. 189-194.6 Massive ore with several % olivine. 194.6-214 Olivine 50-60% by volume. 214-225 Olivine 25% by volume. Olivine coarse grained. No compositional banding.
225	248		Anorthosite with 5-15% olivine, 1-2% magnetite-ilmenite. 234 layering at 40°-50° to core axis.
248	269		Anorthosite, feldspathic, medium to fine grained.
269	283		Anorthosite, feldspathic, but with olivine and magnetite-ilmenite, 5-8% each by volume 272-278. Olivine 5% elsewhere. Angles of olivine and ore streaks to core axis. 274 50°-60°. 282 50°-60°.
			End of hole.

Iron Mountain, Wyoming

D. D. Hole 12

Coordinates 4917N, 2104E
Elev. of Collar 7309
Length 282 feet
Angle - 55°
Bearing N 63° W

Core
BX 0-56
AX 56-

From Ft.	To Ft.	Core Recovery Ft.	
0	14	1.5	Magnetite-ilmenite with 5% silicate by volume. Silicate mostly olivine. Core much broken. Silicate oxidized to limonite.
14	20		No core.
20	36	1.6	Magnetite-ilmenite-olivine. Olivine 25-40% by volume. Several % plagioclase feldspar. Oxidized.
36	66	5.6	Magnetite-ilmenite-silicate layers alternating with anorthosite layers. Magnetite-ilmenite-silicate layers average 30-40% magnetite-ilmenite by volume and over whole section average 10-15% by volume. 56-61 gouge-fault.
66	71	3.1	Anorthosite, some ferromagnesian silicate, probably olivine. Core altered with some limonite stain. 71 Hole lost water.
71	75	2	Magnetite-ilmenite-anorthosite-olivine. Anorthosite 85-90% by volume. Olivine several %.
75	99	23	Magnetite-ilmenite-olivine-plagioclase feldspar. Olivine 20-30% by volume. Plagioclase feldspar 2-3%. Olivine coarse grained. No compositional layering but platy feldspar structure at 99 feet is 70°-75° to core axis.
99	136.8	37	Anorthosite-olivine-magnetite-ilmenite. 5-10% magnetite-ilmenite, 20% olivine, 70% anorthosite by volume. Coarse grained. Lost water 122 ft.
136.8	140	3.2	Anorthosite fine grained and streaked with chlorite or olivine.
140	149.5	9.5	Magnetite-ilmenite-olivine-anorthosite. 25-35% magnetite-ilmenite, 45-60% olivine, 15-20% anorthosite.
149.5	159.4	9.9	Anorthosite, with 5-10% disseminated olivine. Platy feldspar structure excellent at 158-159 is 55°-60° to core axis.

Iron Mountain, Wyoming

D. D. Hole 12

From Ft.	To Ft.	Core Recovery Ft.	
159.4	175	15.6	Magnetite-ilmenite-olivine-anorthosite. Magnetite-ilmenite 60-70%, olivine 25-35%, anorthosite 5%. Anorthosite one 6 inch section, one ½ inch section of core. Sharp contacts of local massive magnetite-ilmenite with 6 inches of fine grained anorthosite at 162. Several 1/16 - 1/8 inch thick calcite veins at varying angles to core axis.
175	187	good	Magnetite-ilmenite-olivine-anorthosite. Magnetite-ilmenite 20-30%, olivine 65-76%, anorthosite 5% by volume.
187	210.5	good	Anorthosite with mineralization olivine. Olivine 15-25% by volume. Many feldspar crystals platy at large angles, 80°-90° to core axis. Olivine also elongated at same angle. Disseminated pyrrhotite.
210.5	283	good	Anorthosite, with 10-20% ferromagnesian silicate by volume. Ferromagnesian silicate hypersthene and some olivine. Granite 243-244. 6 inches massive ore at 211. Hypersthene apparently fresh in 250-280. Hypersthene and feldspar form a rude alignment at right angles to core axis.
			End of hole.

Iron Mountain, Wyoming

D. D. Hole 13

Core

Coordinates 5176N, 2080E
Elev. of Collar 7375
Length 151 feet
Angle - 50°
Bearing N 48° W

From Ft.	To Ft.	Core Recovery Ft.	
0	32		No core.
32	75	5	Magnetite-ilmenite-anorthosite-olivine. 32-55 15-20% magnetite-ilmenite by volume. Remainder chiefly anorthosite. 55-75 Magnetite-ilmenite 70%, olivine 25%, feldspar 5%, by volume. Core much broken. This estimate too high. See sludge analysis.
75	108	29	Magnetite-ilmenite-olivine-anorthosite. Magnetite-ilmenite 40-50%, olivine 40-50%. Feldspar 10% by volume. 85-86, 100-102 fine grained anorthosite. 75-85 Magnetite-ilmenite 80% volume. 86-108 excepting 100-102, magnetite-ilmenite 25-35%, olivine bulk of remainder. Olivine discolored by oxidation.
108	127	15	Magnetite-ilmenite-olivine. Magnetite-ilmenite 80-90%, olivine remainder except for 1-2% feldspar. Olivine less discolored by oxidation.
127	151	good	Anorthosite, feldspathic, fine grained. 132.6-133 Massive ore, with pyrite or pyrrhotite along calcite vein. 140-142, 146.5-148.5 sheared and chloritized.
			End of hole.

Iron Mountain, Wyoming

D. D. Hole 14

Coordinates 4239N, 2110E
Elev. of Collar 7229
Length 291 feet
Angle - 55°
Bearing N 59° W

Core
BX 15-52
AX 52-

From Ft.	To Ft.	Core Recovery Ft.	
0	15		No core.
15	30	1.5	Granite, fine grained, biotite, recovery poor and footage of granite not known.
30	40.5	1.5	Anorthosite, medium grain size, some ferromagnesian silicate, hypersthene core much broken.
40.5	77	32	Anorthosite, medium to fine grain size, 3-5% magnetite-ilmenite, 5-10% ferromagnesian silicate, chiefly olivine. Minor hypersthene and chlorite. 40.5-62 Medium grain size and more olivine, 5-10%. 62 -77 Finer grain and 3-5% olivine. Platy feldspar structure plane forms at large angles to core axis 40.5-77, at 49 it is 50°-60° to core axis and at 55 and 89 it is 80°-90° to core axis. 68-71 Magnetite-ilmenite and ferromagnesian silicate layering at 65°-90° to core axis along plane of platy feldspar structure. 47 - Lost water. 68 - Lost water.
77	120	good	Anorthosite, fine grained, with ferromagnesian silicates 5-10%, chiefly chlorite derived from olivine and magnetite-ilmenite 2-5%. Layering or banding of small masses or crystals of ferromagnesian silicates is along and parallel to the plane of platy feldspar structure, with angle to core axis 75°-90°. 77- 90 5-8% olivine, some hypersthene. 89- 90 Feldspathic, coarse grained. 92-120 102 - Lost water.
120	147		Like 77-120 but only about 2-5% total of olivine silicate and 2-3% magnetite-ilmenite. Grain size and angles of platy feldspar about the same.

Iron Mountain, Wyoming

D. D. Hole 14

From Ft.	To Ft.	Core Recovery Ft.	
147	159.5		Anorthosite, fine grained, with disseminated fine grained olivine and magnetite-ilmenite. Feldspar 50%, olivine 25%, magnetite-ilmenite 25% by volume except for 149-152. 149-152 coarse grained, with 40% coarse grained feldspar, magnetite-ilmenite 40, olivine 20% by volume.
159.5	193.4	very good	Feldspar coarse grained 60%, magnetite-ilmenite 15%, olivine coarse grained 22% by volume. Chlorite 3% mainly derived from olivine. 159.5-160.5 and 164.5-165.5 chloritic core broken.
193.4	207	good	Anorthosite, fine grained, with 5-15% olivine, chlorite and magnetite-ilmenite as clusters or dendritic masses. Platy feldspar plane indistinct but not at 90° to core axis.
207	215	8	Olivine coarse grained 75-80%, magnetite-ilmenite 15-20%, feldspar 5% by volume.
215	237.5	21	Anorthosite fine to medium grained, olivine disseminated medium grained 30-35%, magnetite-ilmenite. Platy feldspar structure plane 50°-55° to core axis.
237.5	244.5	8	Magnetite-ilmenite 60%, olivine 30%, feldspar 10% coarse grained.
244.5	291	44	Anorthosite medium grain size. Olivine disseminated medium grain size 15%, magnetite-ilmenite 1-2%, by volume. Platy feldspar structure plane 60°-90° to core axis. 286-291 chloritic and with magnetite-ilmenite 3-5% by volume. Some fractures with light limonitic stain.
			End of hole.

Iron Mountain, Wyoming

D. D. Hole 15

Coordinates 3882N, 1963E
Elev. of Collar 7243
Length 298 feet
Angle - 60°
Bearing N 36° W

Core
BX C-75

From Ft.	To Ft.	Core Recovery Ft.	
0	22	1.5	Granite, core much broken, probably a dike 1.5 ft. thick.
22	95	68	Anorthosite, fine grained with 5-15% ferromagnesian silicate partly altered olivine partly hypersthene and 2-5% magnetite-ilmenite disseminated. Platy feldspar structure and chlorite (?), planar at 80°-90° to core axis.
95	133	good	Anorthosite, fine to medium grain size, with olivine and chlorite 10-20%, magnetite-ilmenite 2-5%. 101 platy feldspar structure 60° to core axis, 114 angle 65°-35°, 125 angle 80°-90°.
133	218	good	Anorthosite, fine to medium grain size, ferromagnesian silicate 15-25% mainly olivine, some pyroxene, some chlorite. Magnetite-ilmenite 3-8% by volume. Angle of ferromagnesian silicate planar structure and platy feldspar 70°-80° to core axis. Pyrite a small fraction of 1%. 166-167 Granite fine grained, biotite. 216-218 Rich in ferromagnesian silicate, very fine grained, olivine. Likely crushed and replaced.
218	267	46	Anorthosite, fine grain size, feldspathic, considerably granulated, crushed and recrystallized. Epidote disseminated.
267	298		Anorthosite medium grain size, hypersthene 10-20%, some olivine in part altered to chlorite. Platy feldspar structure plane at 272 is 60°-80° to core axis. Pyrite very small fraction of 1%. End of hole.

Iron Mountain, Wyoming

D. D. Hole 16

Coordinates 3150N, 1666E
Elev. of Collar 7252
Length 308 feet
Angle -50°
Bearing N 35° W

Core
BX 0-103

From Ft.	To Ft.	Core Recovery Ft.	
0	20	0	No core
20	129	32	Anorthosite, coarse grain, hypersthene 5-10%, magnetite-ilmenite 1%. 113-129 Hypersthene altered to chlorite? This is adjoining the granite dike. Core much broken.
129	153.5	15.5	Granite, pink and white feldspar, fine grained, biotite, altered, core broken.
153.5	257		Anorthosite, coarse grain, hypersthene, 15-20% or more, minor olivine, some chlorite. Locally the hypersthene masses are elongated at large angles to core axis. 153.5-156 Very heavy chloritization, friable, core broken.
257	308		Like 153.5-257 except the hypersthene is partly altered to chlorite and olivine. Olivine 5-15%, magnetite-ilmenite 2-5% by volume. Platy feldspar structure and elongation of hypersthene and ore grains 45° to core axis. 295-308 not as coarse grain as 257-295. End of hole.

Iron Mountain, Wyoming

D. D. Hole 17

Coordinates 1561N, 1018E
Elev. of Collar 6884
Length 410 feet
Angle -50°
Bearing N 25°30' W

Core
EX 0-20
BX 20-50
AX 50-410

From Ft.	To Ft.	Core Recovery Ft.	
0	30	1.5	Core recovered is coarse-grained feldspar.
30	40		No core but sludge contains magnetite-ilmenite.
40	50	3.7	Magnetite-ilmenite with 5-10% olivine, layering with coarse-grained olivine at 70° to core axis.
50	57	1.2	Granite, fine-grained, biotite, white or light gray.
57	88	15	Magnetite-ilmenite with 5% coarse-grained olivine. Minor chlorite seams. No core 62-72, some magnetite-ilmenite reported in sludge.
88	122	27	Magnetite-ilmenite-olivine-feldspar (except for 96.4-98.6 which is altered olivine and anorthosite plus 2-5% magnetite-ilmenite). Magnetite-ilmenite 25%, olivine 60%, feldspar 15%, by volume. Olivine coarse-grained. Layering of ore with olivine at 45°-60° to core axis. Lost water frequently 55-124 feet.
122	130	10	Magnetite-ilmenite, massive with 5% olivine, coarse-grained.
130	136	5.5	Magnetite-ilmenite-feldspar-olivine-chlorite. Magnetite-ilmenite 15%, feldspar 50%, olivine coarse-grained 30%, chlorite 5%, by volume.
136	139.3	3.3	Like 122-130.
139.3	143	3.7	Like 130-136 but at 142.5-143 the feldspar is fractured and contains phlogopite?
143	154	3	Granite fine-grained, biotite, white feldspar.

Iron Mountain, Wyoming

D. D. Hole 17

From Ft.	To Ft.	Core Recovery Ft.	
154	195	38.4	Anorthosite with 15-20% coarse-grained olivine and 5-10% magnetite-ilmenite. Fairly gradual decrease in magnetite-ilmenite and olivine from 154-169. 169-195 fairly uniform with 3-5% magnetite-ilmenite and 10-15% olivine. Fair platy feldspar structure at 45°-60° to core axis.
195	236	39	Anorthosite with 55-65% feldspar, 25-35% olivine, 10-20% magnetite-ilmenite, by volume. Olivine coarse-grained. Feldspar platy, but not oriented in a planar structure. The percentage of constituents in general constant for this footage but any one of the three minerals is locally dominant over 6 inch lengths.
236	254	18	Magnetite-ilmenite-olivine-feldspar. Magnetite-ilmenite 50-60%, olivine 25%, feldspar 25%, by volume. Layering of olivine and ore minerals at 75°-90° to core axis.
254	293	39	Magnetite-ilmenite with 5% olivine, which more heavy at 260-264. 262-263 chlorite 75% by volume.
293	299	3	Granite, fine-grained, biotite, white feldspar.
299	311	12	Magnetite-ilmenite with 2-3% olivine, chlorite less than 1%.
311	343	31	Granite fine-grained biotite, gray feldspar. Becomes coarser grained 337-343.
343	346	3	Anorthosite, with uralitization typical of that adjoining granite.
346	351	2.5	Olivine-magnetite-ilmenite feldspar. Olivine 75-80%, magnetite-ilmenite 15-20%, feldspar 5% by volume. Olivine coarse-grained.
351	357.5	6	Anorthosite, fine-grained. Feldspar 60%, olivine 25%, magnetite-ilmenite 10%, chlorite 5% by volume. At 355 platy feldspar structure plane 45°-50° to core axis.

Iron Mountain, Wyoming

D. D. Hole 17

From Ft.	To Ft.	Core Recovery Ft.	
357.5	370.5		Magnetite-ilmenite-olivine-feldspar. Magnetite-ilmenite 40%, olivine 25%, 35% feldspar by volume.
			364-366 Anorthosite with 30% olivine and 5% ore.
			368-370 Like 364-366.
370.5	410		Anorthosite, very fine grain with 25-35% very fine olivine well disseminated. Probably a thoroughly granulated anorthosite with olivine either original or replacement, 2-5% magnetite-ilmenite.
			402-410 coarser grain.
			End of hole.

Appendix B

Chemical Analyses of "Ore" Specimens from Anorthosite Area

After Drying*

Sample	Total Iron %	(TiO_2) %	(V_2O_5) %	(SiO_2) %	(P_2O_5)
by					
1	26.10	24.72	0.11	0.66	10.39
2	50.38	29.92	0.21	0.82	None
3	51.34	22.64	0.25	0.13	None
4	36.42	32.31	0.18	0.59	4.95
6	51.66	19.84	0.23	0.29	None
7	52.26	21.75	0.23	0.28	None
9	50.56	21.79	0.23	1.53	None
10	50.48	22.32	0.32	0.30	None
11	48.58	21.29	0.21	1.96	0.53
12	41.06	9.90	0.04	17.86	1.30
13	33.18	8.12	0.02	24.16	2.06
14	60.00	0.56	Trace	4.02	0.14
15	53.48	17.97	0.32	0.28	None
16	49.46	21.90	0.34	0.34	None
17	50.04	21.96	0.25	0.50	None
18	36.48	43.97	0.21	2.04	None
19	56.70	9.26	0.29	3.24	None
20	49.46	17.26	0.23	3.60	0.02
21	51.54	19.74	0.25	1.08	None
22	50.64	21.62	0.25	0.75	None
23	52.70	20.19	0.29	0.34	None
24	50.80	24.90	0.29	0.36	None
26	52.40	19.92	0.29	0.38	None
27	52.50	19.80	0.21	0.36	None
28	50.35	20.31	0.21	0.56	None
29	52.30	20.54	0.20	0.22	None
30	51.25	20.24	0.21	0.31	None
31	52.15	19.19	0.21	0.40	None
32	53.40	17.82	0.36	0.28	None
33	53.10	20.02	0.34	0.60	None
34	52.35	19.41	0.29	0.38	None
35	52.00	18.39	0.32	0.27	None
36	51.95	18.79	0.25	0.39	None
37	48.70	20.08	0.12	2.80	1.51
39	50.10	20.13	0.23	0.16	None
40	37.80	10.75	0.07	17.64	None
	49%	18%	.20%		

*Analyst: Ledoux & Company, Inc.

Appendix B

Description of Analyzed "Ore" Specimens from Anorthosite Area"

Wy-1 Magnetite-ilmenite-apatite from west end of deposit. Apatite estimated to be about 50%.

Wy-2 Massive magnetite-ilmenite (with several olivine crystals showing only on seam surface) from a lens one to two feet thick and 20 to 40 feet long that lies within magnetite-ilmenite-apatite rock at west end of deposit.

Wy-3 Massive magnetite-ilmenite; several small rounded (oxidized brown) crystals of silicate that may have been olivine.

Wy-4 Ilmenite-magnetite-apatite. Apatite estimated at 50%.

Wy-6 Massive magnetite-ilmenite with some limonite.

Wy-7 Massive magnetite-ilmenite.

Wy-9 Massive magnetite-ilmenite. Highly weathered and oxidized with considerable limonite stain.

Wy-10 Magnetite-ilmenite.

Wy-11 Magnetite-ilmenite with apatite and possibly some olivine and hypersthene.

Wy-12 Magnetite-ilmenite 30%, olivine and other silicates 70%. Olivine oxidized brownish.

Wy-13 Magnetite-ilmenite, olivine, and considerable other silicate.

Wy-14 Magnetite-ilmenite with 10-20% silicate.

Wy-15 Magnetite with large blades of ilmenite and only minor ilmenite grains. Spinel? 5-8%.

Wy-16 Magnetite-ilmenite with 5-10% olivine and 5-10% spinel.

Wy-17 Magnetite-ilmenite with 5-10% spinel.

Wy-18 Magnetite-ilmenite with 40% silicate that is highly oxidized, limonitic, and friable.

Wy-19 DD Hole 17 at 202-205 feet. Magnetite-ilmenite concentrated from core containing 10% magnetite-ilmenite, 60% olivine, and 30% feldspar to a concentrate with an estimated 70-90% magnetite-ilmenite.

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*Mineral percentages estimated by volume from hand specimens, except spinel.

Wy-20 DD Hole 14 at 150 feet. Magnetite-ilmenite concentrated from core containing 20% magnetite-ilmenite, 30% olivine, and 50% feldspar to a concentrate having 80-90% magnetite-ilmenite.

Wy-21 Magnetite-ilmenite with several percent silicate and 5-10% spinel. Magnetite largely oxidized to hematite.

Wy-22 Magnetite-ilmenite with 5-10% spinel. Magnetite much replaced by hematite.

Wy-23 Magnetite-ilmenite with 5-10% spinel. 1/3 to 1/4 of the magnetite is replaced by hematite.

Wy-24 Magnetite-ilmenite, much oxidized. 20-30% voids containing some limonite and altered silicate, probably olivine, now mostly leached out.

Wy-26 Magnetite-ilmenite much replaced by hematite, some spinel, and 5% silicate. Silicate weathered brown.

Wy-27 Magnetite-ilmenite with 5-10% spinel and silicate (mostly spinel). Much hematite replaces the magnetite.

Wy-28 Magnetite-ilmenite with about 10% altered silicate, probably olivine. Limonitic. 5-10% spinel.

Wy-29 Magnetite-ilmenite with 5-10% spinel. About 60% of the magnetite is altered to hematite.

Wy-30 Magnetite-ilmenite with 5-10% spinel. Much magnetite oxidized to hematite.

Wy-31 Magnetite-ilmenite with 5-10% spinel and 5% oxidized silicate.

Wy-32 Magnetite-ilmenite, 5-10% spinel, 5-10% voids, probably from leached silicates. Much magnetite replaced by hematite.

Wy-33 Magnetite-ilmenite, 5-10% spinel, 5-10% oxidized silicate. Magnetite partially oxidized to hematite. Not plotted on map; location - sec. 36, T. 18 N., R. 72 W.

Wy-34 Magnetite-ilmenite, 5-10% spinel, 5% oxidized silicate. Some oxidization to hematite.

Wy-35 Magnetite-ilmenite, 5-10% spinel.

Wy-36 Magnetite-ilmenite, 5-10% spinel.

Wy-37 Magnetite-ilmenite with olivine and hypersthene (?).

Wy-39 DD Hole 9 at 232 feet. Magnetite-ilmenite with 2-4% silicate.

Wy-40 DD Hole 9 at 75 feet. Magnetite-ilmenite 40% by volume, olivine 40%, and plagioclase 20%.

EXPLANATION OF SECTIONS

Alluvium

Biotite Granite. Gray or pink, fine- to medium-grained, locally pegmatitic.

"Ore"

Grade 1. Massive magnetite-ilmenite containing from 0-35% silicates by volume, mostly olivine. TiO_2 16-23% incl.

Grade 2. Magnetite-ilmenite containing from 35-65% silicates by volume, chiefly olivine. TiO_2 10 to 16%.

Grade 3. Magnetite-ilmenite with 65-85% silicates by volume, chiefly plagioclase with minor olivine. TiO_2 5 to 10%.

Mineralized Anorthosite and Noritic Anorthosite.

Type 1. Contains grades 2 and 3 "ore" and olivine in high concentrations but the bulk of the rock consists of 85-95% plagioclase with olivine and magnetite-ilmenite throughout. Type 1 is not subdivided because of insufficient exposures.

Type 2. About 75% of the rock contains 5-15% olivine and 2-7% magnetite-ilmenite; the remainder is anorthosite.

Altered and Bleached Anorthosite and Granite. Rocks are fractured, granulated, and fine-grained.

Noritic Anorthosite. Gray, weathers brown, coarse-grained. Platy crystal structure poorly developed or absent. Hypersthene 5-20%.

Anorthosite. Light gray, fine- to coarse-grained with well developed platy crystal structure.

Dip of platy crystal structure and of compositional layering in anorthosite and of compositional layering in ore.

Platy crystal structure and compositional layering.

Contact

Fault

Diamond drill hole.