REPORT OF A TRIP ON THE UPPER MISSISSIPPI AND TO VERMILION LAKE, MINNESOTA.

By Bailey Willis.

Professor Raphael Pumpelly,
Chief of Division.

Sir: On the 25th of August, 1880, I received your instructions to sample and report upon the iron ores of Minnesota.

Owing to unavoidable delays, I did not enter upon the work until September 10, when I visited the deposit north of Agate bay, on the north shore of Lake Superior.

On the 15th I left Duluth for the Upper Mississippi with Mr. George A. Fay, of Marquette, and a half-breed.

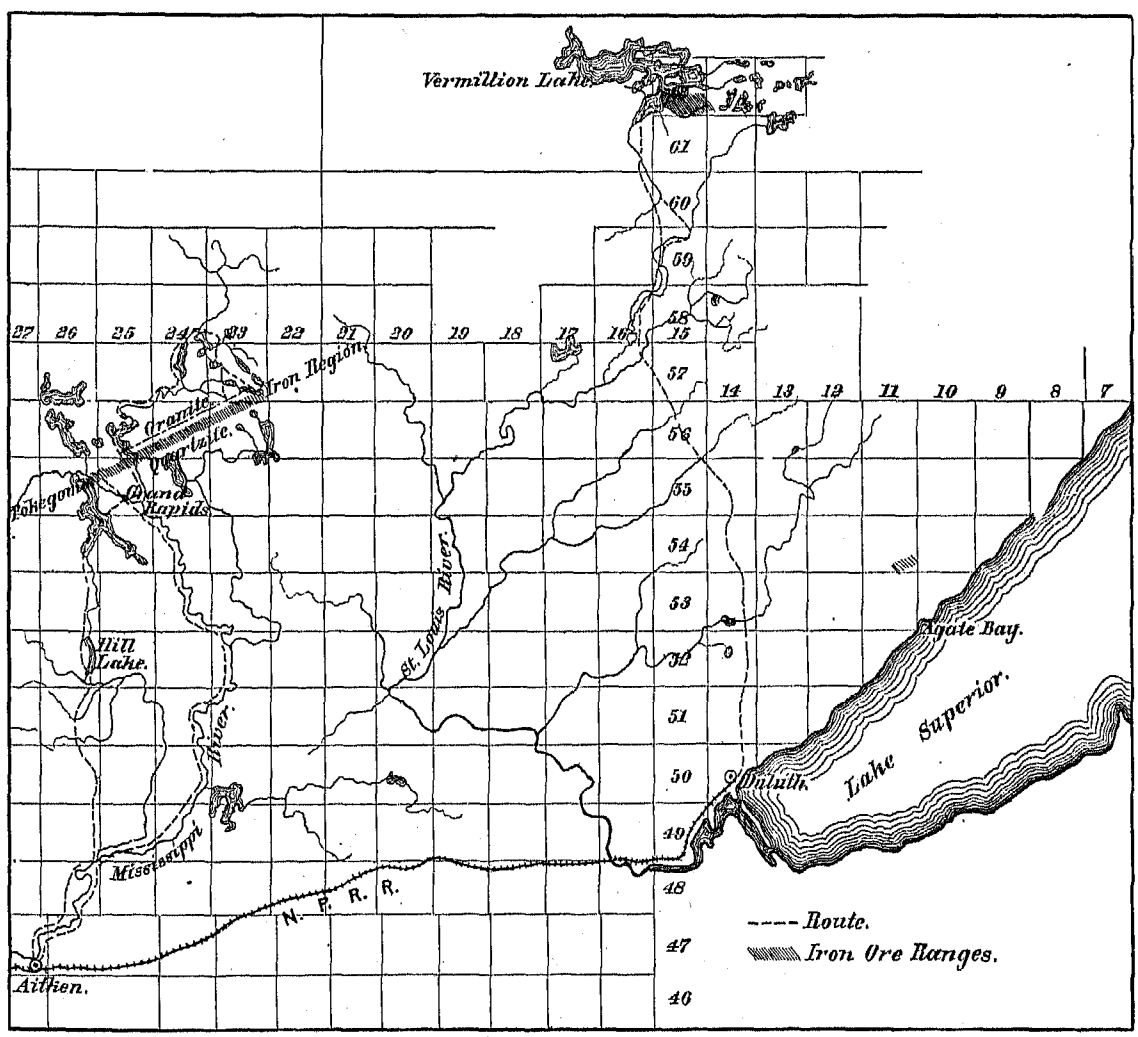


Fig. 203.—Map of a part of Northern Minnesota, showing route traversed.

Mr. Fay's illness obliged me, on the third day, to proceed without him. I was gone two weeks up the Mississippi and Prairie rivers with two Indians, and returned to Duluth on October 1. On the 3d I left Duluth with Mr. Fay and three packers for Vermilion lake. At Esquagama bridge, 65 miles from Duluth, we joined a guide, who had previously been sent up the Saint Louis river with our canoe and provisions. On the 10th we reached the Two

a Rivers range at Vermilion lake. Snow fell to the depth of 3 feet between the 15th and 17th, after which all work was done on snowshoes, during very unfavorable weather. We broke camp on the Vermilion range on November 10, and reached Duluth on the 18th.

Very respectfully, yours,

BAILEY WILLIS,
Special Agent.

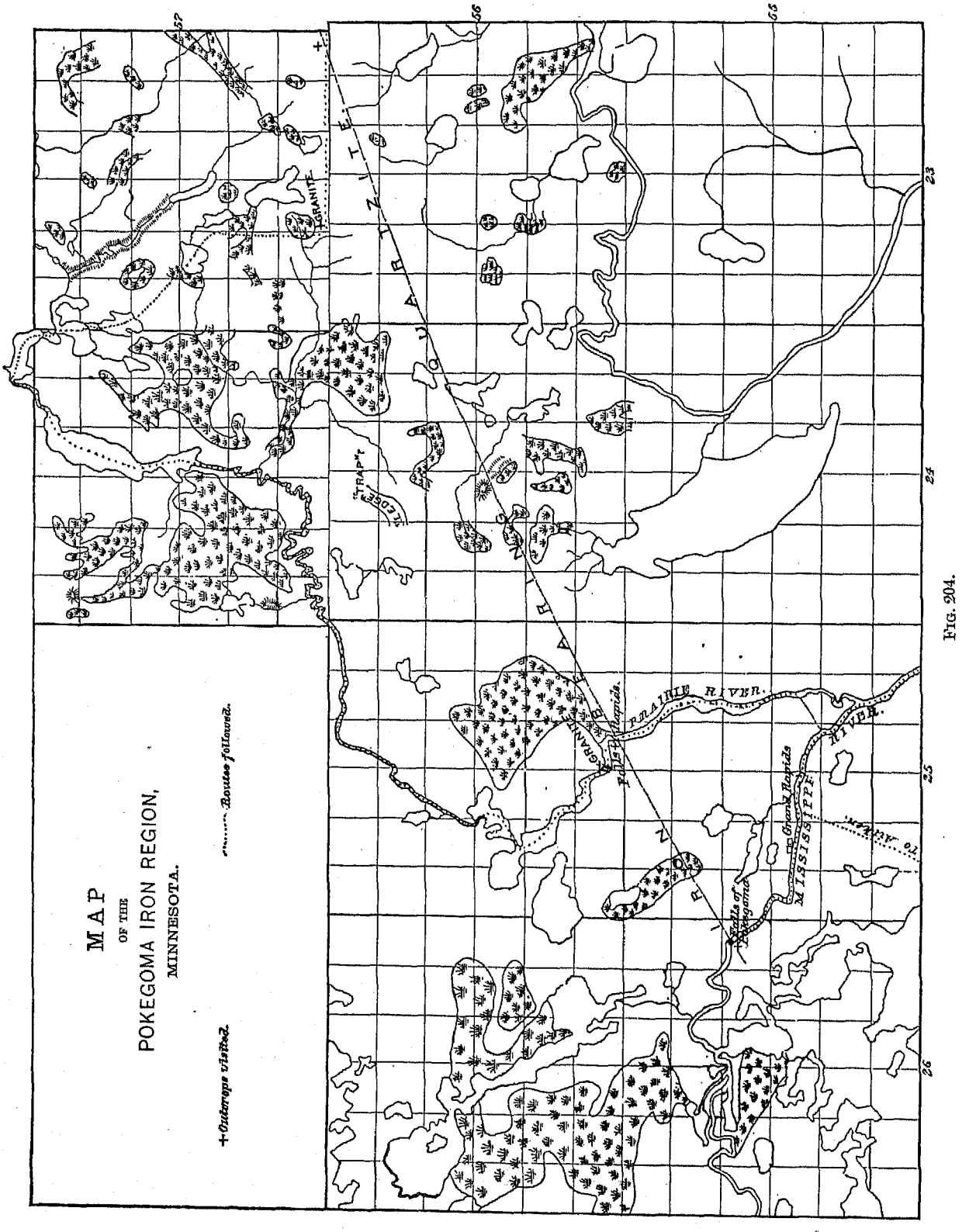


FIG. 204.

The strata forming the north shore of Lake Superior from Duluth eastward belong to the copper-bearing series. At Agate bay the outcrops on the shore consist of amygdaloid and other beds, frequently stained with the

green carbonate of copper. For six miles north of Agate bay the country is flat without any outcrops whatever, a but in Sec. 35, T. 54 N., R. 11 W., there is a small ravine, having a northeast southwest course, with precipitous sides of gabbro.

The northwest wall rises to a height of about 60 feet. It is more coarsely crystalline than the gabbro on the southeast, which only forms low bluffs 15 to 20 feet high. In this latter are little veins of magnetic ore and among the loose blocks at the foot were found several pieces of ore 1 foot to 18 inches thick. This magnetite forms a range that extends several miles northeast and southwest.

Sample 977 was taken from the loose blocks mentioned.

The following is the result of analysis:

b

	AGATE BAY.
	977
	Per cent.
Metallic iron	51.71
Phosphorus	0.027
Phosphorus in 100 parts iron	0.052

Outline of trip on the Mississippi river. c

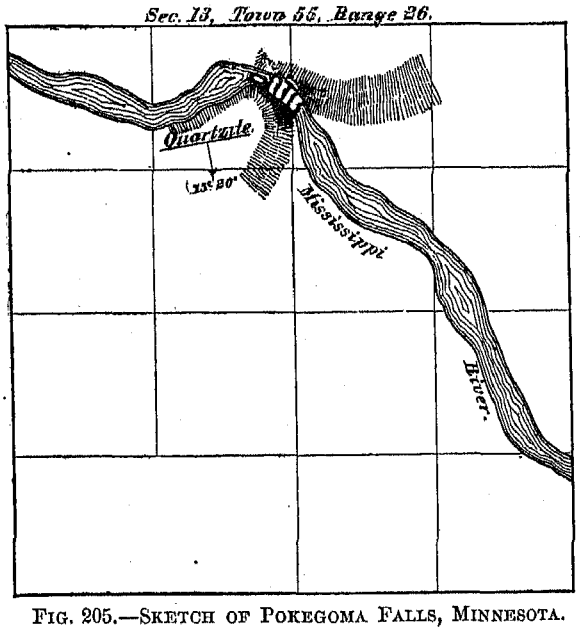
From Aitken to Grand rapids in T. 55 N., R. 25 W., by trail, 65 miles.

From Grand rapids to Sec. 36, T. 57 N., R. 23 W.. by way of Prairie river and Crooked lake, and return.

Grand Rapids to Aitken by canoe down the Mississippi, 155 miles.

From Aitken to Quodenong or Hill lake, about 45 miles, the trail leads through level bottom-lands, which are frequently marshy. The soil is a dark-colored vegetable mold, tough and elastic, like india-rubber, changing at times to a hard, fine, gray clay, without sand or pebbles. West of Hill lake are low drift ridges, and from there northward the surface is covered with boulders. The shores of Pokegoma lake, in places rising abruptly to a height of 25 or 30 feet, consist of sand- and clay-beds.

Three miles above Grand rapids, in Sec. 13, T. 55 N., R. 26 W., are the only outcrops seen on the Mississippi d north of Aitken. A ledge of red quartzite here forms the falls of Pokegoma, 12 feet in vertical height and about 250 feet long. This quartzite crops out along the south bank of the river for about 400 paces, and forms the backbone of a ridge 15 or 20 feet above the common level, which extends in a general course of north 70° to 80° east.



e

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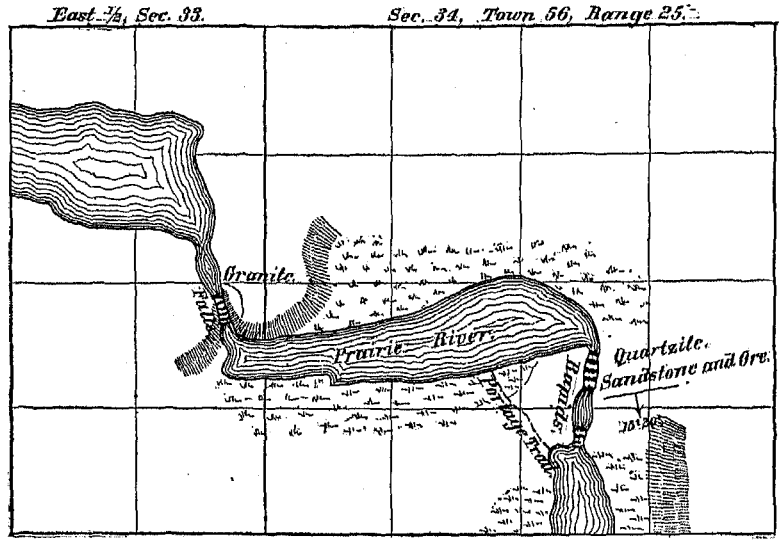
FIG. 205.—SKETCH OF POKEGOMA FALLS, MINNESOTA.

Near the foot of the falls appears an incoherent sandstone, formed of coarse, rounded grains, cemented by oxide of iron, which overlies the quartzite and dips with it 15° to 20° south 10° east.

About 5 miles in a direction of north 60° east from Pokegoma falls are the Lower rapids of Prairie river. The fall is about 5 feet, and a quiet pool divides the two swift rushes of the water.

a The upper edge of the rapids is formed by a ledge of the same quartzite that is so prominent at Pokegoma falls; it also outcrops on the northern end of the portage trail. On both sides of the little basin and part way



b

c

FIG. 206.—SKETCH OF THE LOWER RAPIDS, PRAIRIE RIVER, MINNESOTA.

down the lower half of the rapids are outcrops of coarse-grained sandstone, sometimes metamorphosed to a quartzite, irregularly interstratified with a steel blue, very hard specular ore, some specimens of which are strongly magnetic.

The following section (Fig. 207) was sketched just at the edge of the rapids:

d

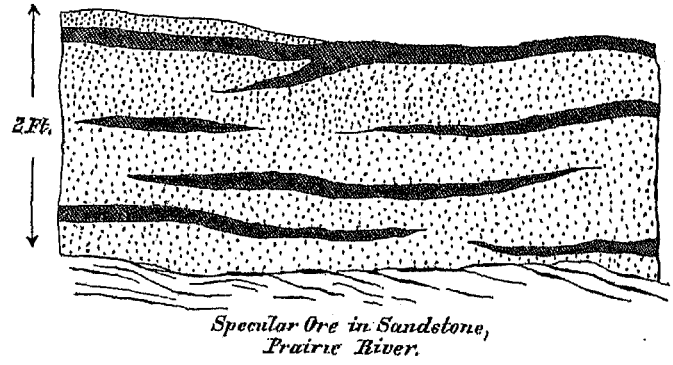


FIG. 207.

e

A hundred feet east of the river is a small test-pit, in which the same sandstone and specular ore are exposed. The thickest layer of pure ore seen was about 3 inches. Sample 978 represents this ore, the associated sandstone not being included in it.

	978.
	Per cent.
Metallic iron	50.94
Phosphorus	0.012
Phosphorus in 100 parts iron	0.024

f

The above-described strata maintain the dip of the quartzite at Pokegoma falls, namely, 15° to 20° south, 10° east.

Prairie river, above the lower rapids, is a broad, quiet reach of water with marshy shores; but three-quarters of a mile west it falls 15 feet through a narrow channel cut in gray granite.

The narrow part of the river, from the foot of the falls to the lake above, is about a quarter of a mile in length. On both sides are bold outcrops of the fine-grained homogeneous gray granite, which shows no bedding, but is cut in all directions by many veins of coarsely crystalline pink feldspar and quartz.

From this point northward up Prairie river, through Crooked lake and across several hilly portages in T. 57, R. 23 W., nothing was seen but sand, clay, and loose boulders.

The first outcrops found consist of coarse red granite, which forms low ridges 15 to 20 feet high, separated by a swamps, on the southern line of T. 57 N., R. 23 W. This granite was not seen east of Sec. 35; and in the SE. corner of Sec. 36 the iron-bearing quartzite of the lower rapids of Prairie river rises in a steep bluff about 15 feet above the swamp.

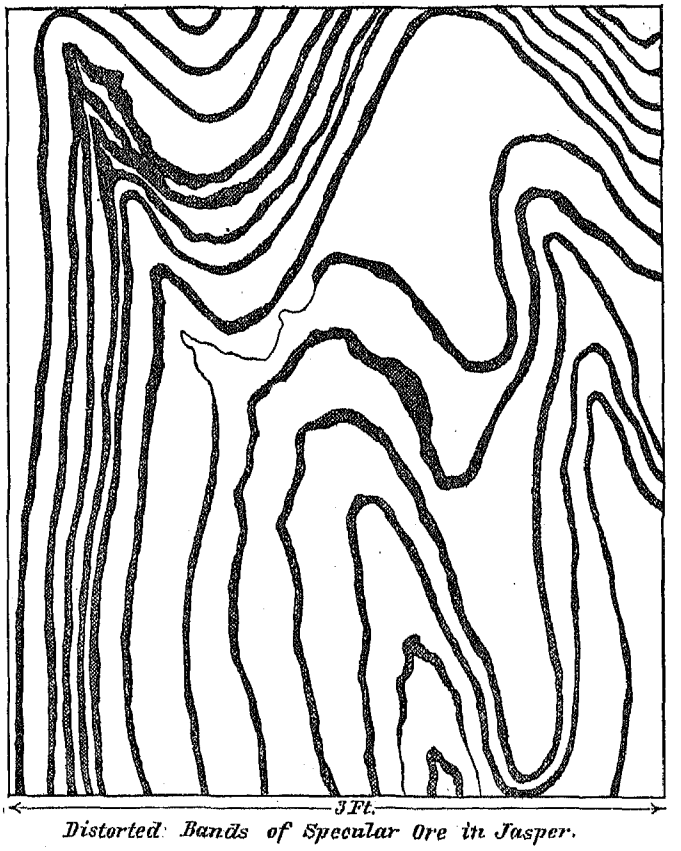
The iron ore occurs in thin layers as at Prairie river, but it is also more evenly distributed through the quartzite. The strata dips slightly to the south.

Outline of trip to Vermilion lake.

Duluth to Esquagama bridge, in T. 58 N., R. 15 W., trail 65 miles; through Esquagama or Embarrass lakes, across Wine portage and up Embarrass river to Big portage, 9 miles; Big portage from Embarrass to Pike river, b 4 miles; down Pike river to Vermilion lake, between 15 and 20 miles, with two portages. Returned by trail; 86 miles.

Narrative.—Between Duluth and the Cloquet river, a distance of 20 miles, there are frequent outcrops of the feldspathic rocks of the copper series. After crossing the Cloquet these disappear, and for 50 miles northward the surface is covered with heavy drift-beds. The abrupt slopes of the ridges descend sharply to swampy hollows, but there are no outcrops of rock in place. Much of the timber has been burnt off, and the huge boulders stand like houses amid the aftergrowth of birch and hazel.

At Wine Portage, 72 miles from Duluth, Embarrass river flows through a gap in Mesaba heights, in a series of rapids, three-quarters of a mile long. A cursory examination of the hill just east of the portage showed nothing c but drift. It is, however, probable that outcrops exist in this neighborhood, as the backbone of the range is said to consist of quartzite and magnetic iron ore, which have been traced by Professor Chester for 30 miles to the northeast.



Distorted Bands of Specular Ore in Jasper.

FIG. 208.

These heights are commonly called the "dividing ridge" between Hudson's bay and Lake Superior waters; but the true divide is the rolling plain of gravel and sand that is crossed by the Big portage between Embarrass and Pike rivers. The banks of the latter are grassy marshes, backed by an even line of tamaracks. As one approaches Vermilion lake outcrops of light-green highly silicious slate, frequently cut by veins of white quartz, are seen in a number of places along the river. They are especially prominent at a rapids about 2 miles from the lake and at Vermilion falls, which are near the mouth of the river. A very similar slate forms the shores of the lake at the Vermilion trading-post and Indian agency, and it rises in bluffs 50 feet above the marshes on the southern line of Sec. 32, T. 62 N., R. 15 W.

a As may be seen from the accompanying maps, the work of the party was confined to that part of this township south of the lake and west of sections 26 and 35. A reconnaissance survey was made with dial compasses* and watches, and pacing for distances. Lines were run thus one-eighth mile apart; all outcrops were noted, and at every 100 paces the variation and dip of the needle were observed. All belts of magnetic attraction discovered were traced.

In this area two interrupted ridges, 300 feet high, extend nearly due east and west, divided by a valley three-quarters of a mile wide. The principal hills consist of hard red jasper, flanked by lower points of black and white banded magnetic quartzite. They are girt by terraces of heavy drift, and the valley is a swamp, surrounding low drift mounds and outcrops of massive metamorphic rock. The northern and more extensive group of ridges is called b the "Vermilion range", the southern, the "Two Rivers range". Southeast from the Vermilion range, and separated from it by swamps, is Chester's peak, the abrupt end of a ridge, 500 feet high, which continues eastward beyond the limits of this survey.

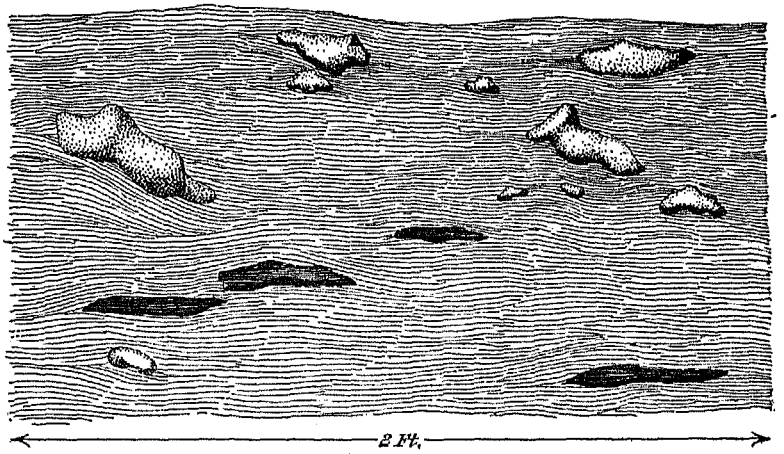
Geology.—Dips throughout this area are between 85° and 90°, except in the northwestern outcrop of jasper on the Vermilion range. Observations at this one point afforded data for determining the relations of seven beds, as follows:

I. The lowest bed observed is a light-green, thinly laminated chloritic schist. It was only exposed at points on the anticlinal axes, and no estimate of its thickness is possible.

II. Jasper, made up of narrow bands of white, gray, brown, and bright red quartzite, interstratified with c layers of very hard blue specular iron ore, which also occurs in ore bodies of considerable superficial extent and in fissures that run across the bedding. The jasper hill summits are striated and highly polished by ice moving in the general direction of the strike. The planed edges of the bands illustrate the distortion suffered by the strata, and represent on a small scale the flexed condition of the entire series. See Fig. 208:

The thickness of the jasper, measured across apparently vertical dips, varies from 200 to 600 feet, or more. The smaller figure is probably nearer the truth.

d



c *Black Slate and Sandstone enclosed in Schist.*

FIG. 209.

III is a chloritic schist, similar to that which underlies the jasper. At points in the synclinal, which is involved in the Two Rivers fold, it is massive, contains triclinic feldspar, and is cut by veins of white quartz. But as a rule I and III are so similar that it is only possible to distinguish them by reference to the adjacent strata. Being softer than the quartzites between which it lies, III varies in thickness according to the pressure it has been subjected to. The original thickness of deposition was probably about 150 feet.

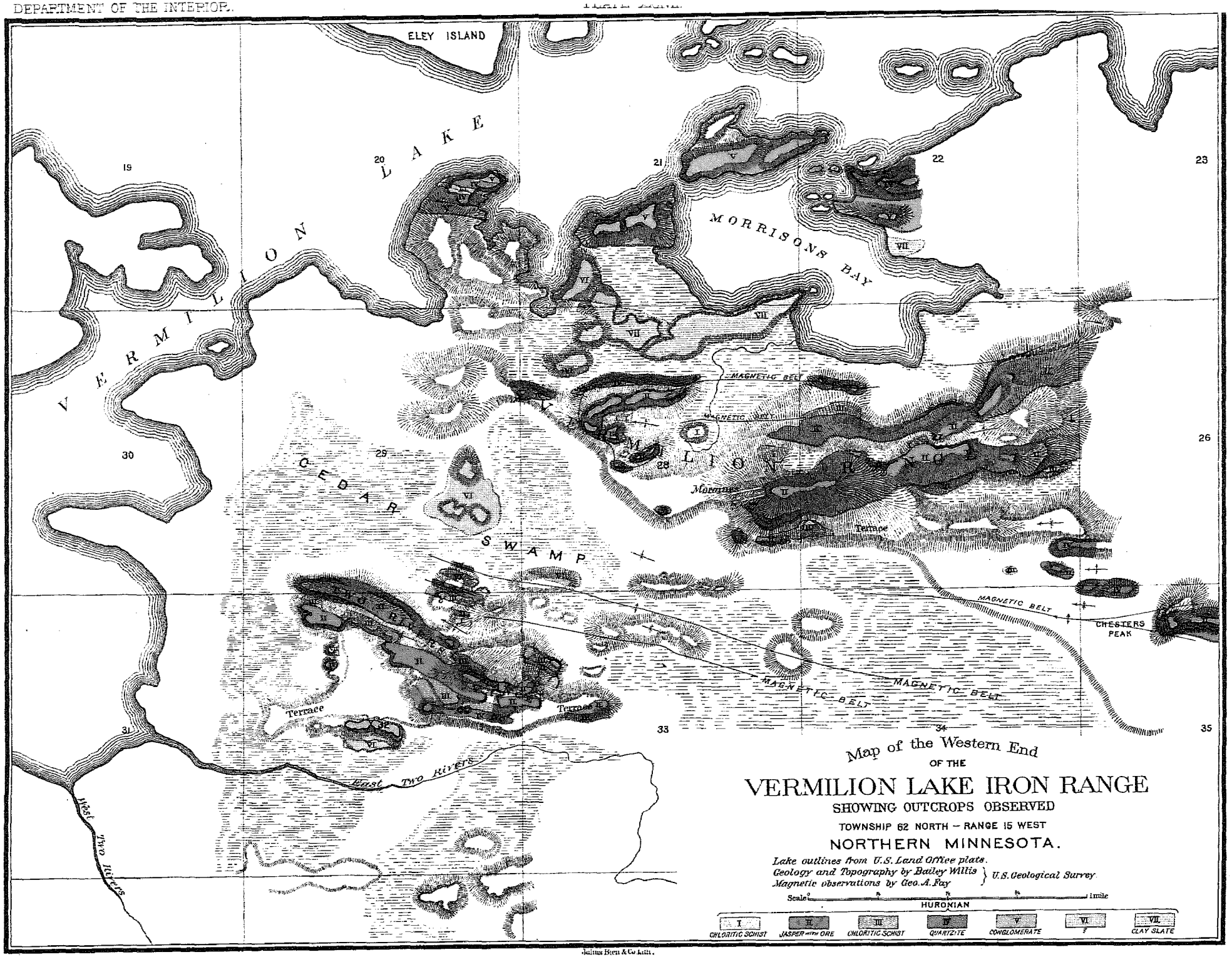
f IV is a quartzite, banded in dark-gray, white, and black, and of saccharoidal texture. It contains grains of magnetite, irregularly distributed through it, which disturb the needle and produce the principal belts of magnetic attraction, indicated on the geological maps, Plates XXVII and XXXVIII, and on the magnetic chart, Plate XXXIX. This quartzite is probably about 200 feet thick. No ore of any value has been found in it.

Beds I to IV, inclusive, form the ridges. The sharp, conical outcrops of IV rise from the drift terraces which bound the swamps, and the contact between IV and V was only seen on the rocky point which extends into section 20.

V, VI, and VII are the valley rocks, and are intimately related.

V is a conglomerate, consisting of sandstone pebbles and bits of black slate inclosed in silicious chloritic schist (see Fig. 209). The major axes of the fragments lie parallel to the bedding of the schist. No very distinct line

* The form and method planned by Major Brooks for the Michigan geological survey.



Map of the Western End
OF THE
VERMILION LAKE IRON RANGE
SHOWING OUTCROPS OBSERVED
TOWNSHIP 62 NORTH – RANGE 15 WEST
NORTHERN MINNESOTA.

Lake outlines from U.S. Land Office plats.
Geology and Topography by Bailey Willis } *U.S. Geological Survey*
Magnetic observations by Geo. A. Fay }

Scale 0 ¼ ½ ¾ 1 mile

HURONIAN

I	II	III	IV	V	VI	VII
CHLORITIC SCHIST	JASPER with ORE	CHLORITIC SCHIST	QUARTZITE	CONGLOMERATE	?	CLAY SLATE

Julius Bien & Co. Lith.

of contact was observed between V and VI, which is a compact homogeneous rock, composed of round quartz **a** grains, chlorite and hornblende, plagioclase feldspar, and a little calcite. It cleaves into pyramidal and prismatic blocks, is a light-gray color on the weathered surface, and but little darker on the fresh fracture. Should this rock be proved eruptive it belongs to the quartz diorites; but I consider it a metamorphosed sedimentary bed of transition from the conglomerate below.

VII. A black clay slate. This slate is very fissile and sonorous. It occupies a broad area north of the Vermilion range; was not seen in the valley south of it, but forms a singular outcrop on the western end of the Two Rivers range, in close proximity to a peak of the quartzite IV. Its presence here implies a sudden downward pitch of the axes of the Two Rivers fold, but is difficult to explain with only the facts now known. The layers of slate in this outcrop are pierced with square holes left by the decomposition of crystals of pyrite, which are lined by a deposit **b** of silica, apparently formed around a smaller crystal, as the holes within are sharply angular.

The Vermilion and Two Rivers ranges are anticlinal ridges, eroded to the soft, chloritic schist, I. In the former range the spring of the jasper arch is thus left on either side, the southern being the higher, and the schist forming a hollow or gentle slope north of it.

Through Sec. 28 huge masses of jasper from the crown of the arch remain imbedded in the green schist, with which they agree in strike and vertical dip. These jasper blocks are rectangular and several hundred feet long; the ends of the bands come out squarely to the contact with the schist, as to a fault. These contacts represent, in fact, short fractures at right angles to the axis, between which blocks from the crown of the arch were bent downward, forming cut-off synclinals in the top of the anticlinal. The depressed portions of the jasper have thus **c** escaped the erosion suffered by the crown. A similar inlaying of III in II was observed in the Two Rivers range. The outcrop of the jasper arch, where it pitches westward under the surface, forms a hook-shaped ridge and gave the key to the structure, as may be seen on examining the dips on the magnetic chart in the NW. ¼ of Sec. 28. West of this the quartzite, IV, forms the ridge, and the intermediate schist, III, presumably underlies the drift

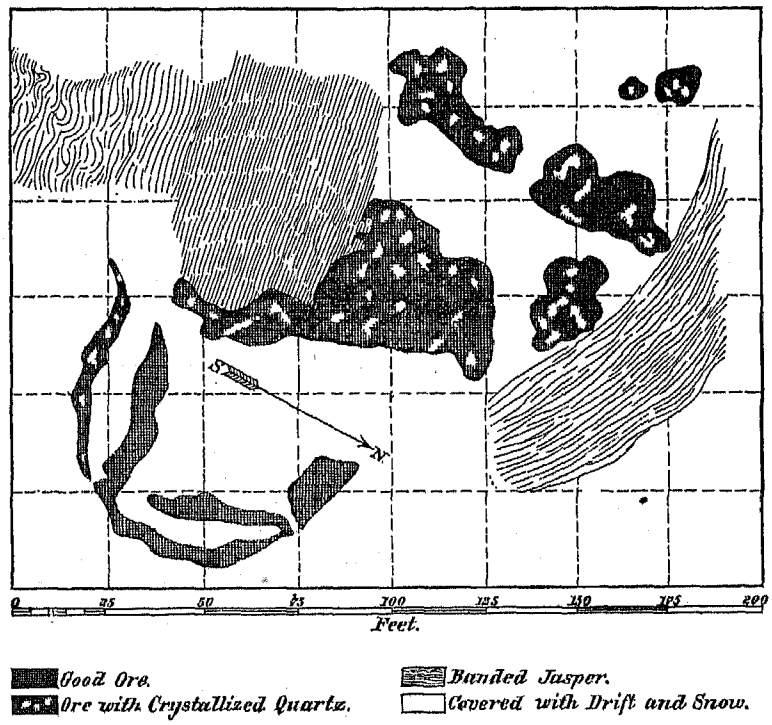


FIG. 210.—SKETCH-MAP OF AN ORE BODY ON THE TWO RIVERS RANGE, MINNESOTA.

between the outcrops. On the south side of the Vermilion range a small fold brings the jasper to the surface **f** through the overlying schist, and it contains a large ore-body at this point. Near the line between Secs. 27 and 28 the jasper is very much contorted, and the great thickness, which here forms the highest part of the Vermilion range, is due to crumpling of the bed. On the north side of the arch the jasper ridge is low and the outcrops are not continuous, being frequently drift-covered. South of Morrison's bay there are cliffs of "slate ore", a variety of jasper which cleaves readily parallel to the bedding into thin sheets, and is lined with specular ore on the cleavage planes.

The Two Rivers range consists almost wholly of the flexed jasper on the southern side of the main anticlinal, the northern being represented by but two narrow outcrops in the valley. The lower schist, I, was identified as such by inlaid masses of jasper similar to those on the axis of the Vermilion range. The jasper lip of the involved synclinal, just west of the line between Secs. 32 and 33, contains a considerable body of specular ore. South of

a it is the subordinate anticlinal, and beyond that the jasper ridge, with its outlying pinnacles of the black quartzite, IV, which stand on the edge of the drift terrace. The two lines of IV north of the range were each located by a single outcrop and by magnetic attraction, traced through the swamp. The dislocation of the more southerly of these belts, proven by sudden change of strike, is accompanied by a corresponding jump of the belt of magnetic attraction. The northern line of attraction follows the crown of an arch, which separates the area between the Two Rivers and Vermilion ranges into two troughs of unequal widths.

Plate XXXVII gives the outcrops observed, the spaces left white having been covered with deep snow and drift.

Plate XXXVIII shows the structure deduced from these observations.

Plate XXXIX gives Mr. Fay's magnetic notes in detail, and illustrates the relation of the principal lines of b magnetic attraction to the quartzite, IV, and in a less degree to the jasper, as well as the fact that they are in no way connected with the known bodies of valuable ore.

I was told by the surveyors at work in the townships east of Vermilion—namely, T. 62 N., R. 13 and 14 W.—that the variation changes rapidly from point to point, as it does in T. 62 N., R. 15 W., and that the only outcrops seen consist of jasper and quartzite. The surface is covered with a dense growth of pine, and the strata are hidden under moss and thick underbrush. Burnside lake, 12 miles east of Vermilion, is said to contain many rocky islets, consisting principally of jasper.

NOTES ON THE OCCURRENCE OF IRON ORE.

c During the summer of 1880 the iron ores of this locality had been examined by Professor A. H. Chester, who stripped the jasper beds wherever the outcrops showed a considerable proportion of ore. Many of these trenches were filled with water and could not be examined. The following notes state what could be ascertained:

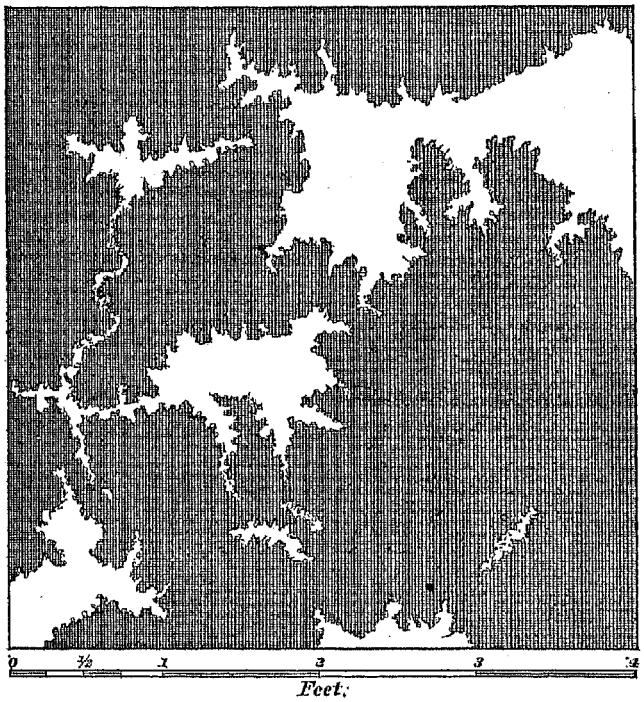


FIG. 211.—CRYSTALLIZED QUARTZ IN SPECULAR ORE, TWO RIVERS RANGE, MINNESOTA.

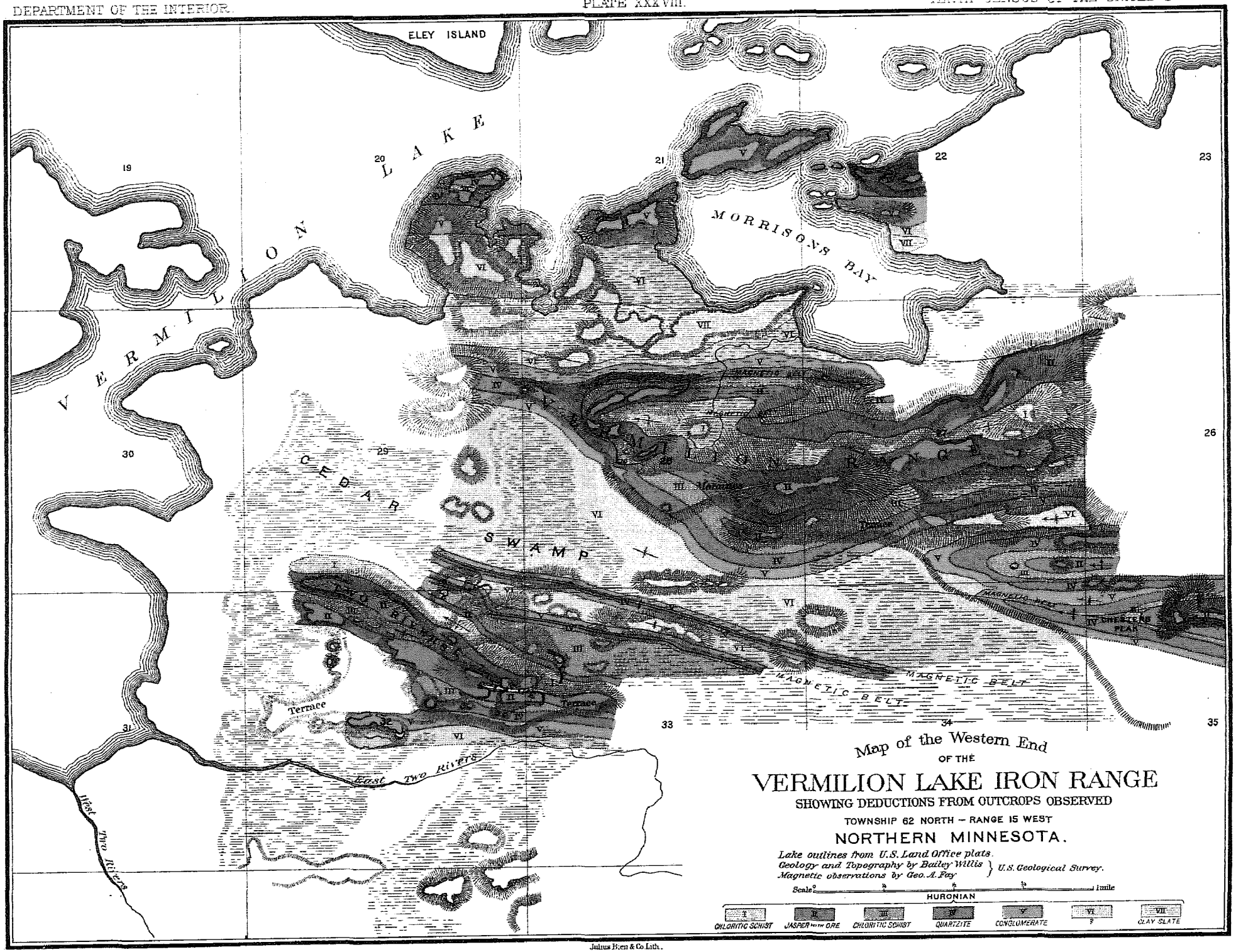
The ore-bodies of the Two Rivers range are confined to its eastern end. In Sec. 33, on the eastern slope of jasper, six trenches exposed a surface 100 paces long, east and west, by 20 to 60 paces wide, north and south. The southern end of these trenches was sunk to the contact with the chloritic schist, III. But one of these test-pits exposed any good ore d free from large admixtures of jasper and crystallized quartz, and that was of small surface area. It is a slaty, specular ore, softer and less crystalline than that found elsewhere in the range. The analysis of sample 980, taken by chipping along the trench, gives—

	980.
	Per cent.
Metallic iron	65.89
Phosphorus	0.044
e Phosphorus in 100 parts iron	0.067

The largest body of ore seen in the Two Rivers range lies in the fold of the synclinal in Sec. 33, near the line of Sec. 32. Fig. 210 shows its association, the white areas having been covered with drift or snow. The ore is a homogeneous steel-blue specular, inclosing many cavities lined with brilliant micaceous crystals. It is exceedingly hard, and associated with crystallized quartz. In that marked good ore in Fig. 210 no quartz could be detected by the eye. The character of the other portions of the ore is indicated in Fig. 211.

Sample 979 was taken by chipping in three lines across the outcrop of good ore. The other parts would yield f similar results if carefully hand-picked:

	979.
	Per cent.
Metallic iron	66.46
Phosphorus	0.044
Phosphorus in 100 parts iron	0.066



Map of the Western End
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SHOWING DEDUCTIONS FROM OUTCROPS OBSERVED
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Lake outlines from U.S. Land Office plats.
Geology and Topography by Bailey Willis } U.S. Geological Survey.
Magnetic observations by Geo. A. Fay

Scale 0 ¼ ½ ¾ 1 mile

HURONIAN

I	II	III	IV	V	VI	VII
CHLORITIC SCHIST	JASPER with ORE	CHLORITIC SCHIST	QUARTZITE	CONGLOMERATE	?	CLAY SLATE

Julius Bien & Co. Lith.

This ore was followed westward in a number of test-pits. Near the section line it has a width of 24 feet, with but little quartz. A hundred paces west of the section line a bluff exposes a vertical section given in Fig. 212. A little farther westward three trenches cross an ore-body 75 feet long and from 2 to 16 feet wide.

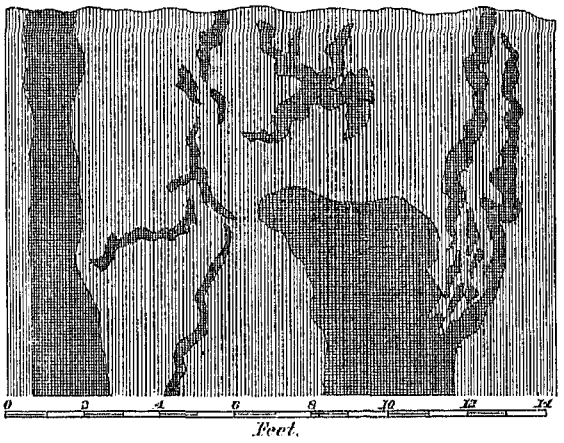

FIG. 212.—VERTICAL SECTION IN THE TWO RIVER RANGE, MINNESOTA, SHOWING SPECULAR ORE IN BANDED JASPER.

On the southern slope of the Vermilion range, in the southeast corner of Sec. 28, a large body of ore forms a prominent bluff. It lies in the synclinal, where the jasper appears through the schist, III, and the ore crops out

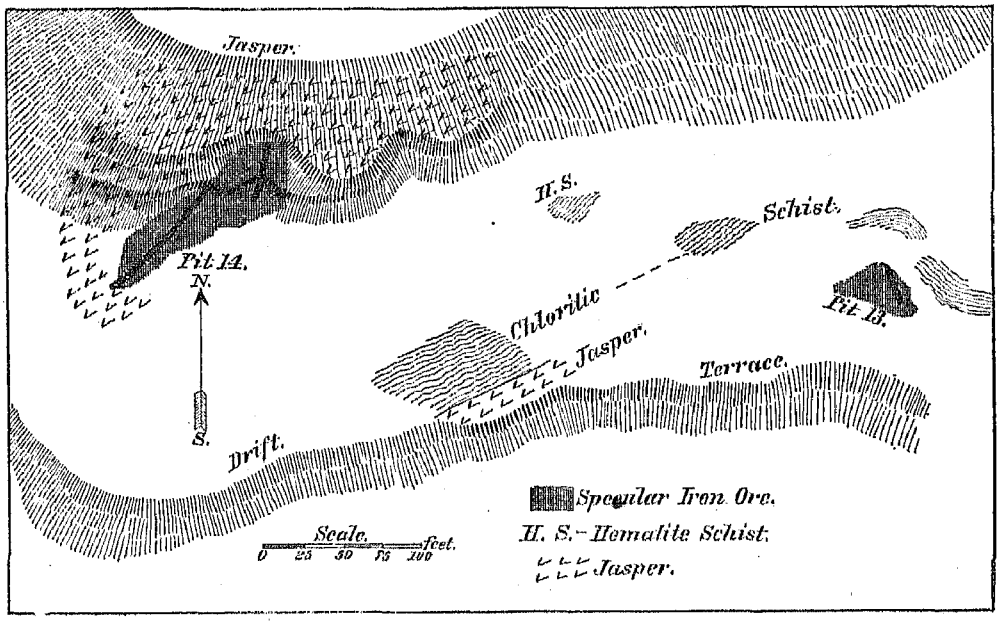

FIG. 213.—SKETCH MAP OF AN ORE BODY ON THE VERMILLION RANGE, MINNESOTA.

north and south of the schist as shown in Fig. 213. It may probably be continuous between pits 13 and 14.

Sample 981 represents the average composition of the very hard, crystalline, steel-blue ore:

	981.
	Per cent.
Metallic iron	68.05
Phosphorus	0.056
Phosphorus in 100 parts iron	0.082

The hill 200 paces west of this, which is probably in the same fold, contains curious masses of ore in angular fragments cemented by pyrite. These have no commercial value.

The other ore-deposits of consequence in the Vermilion range, three in number, occur in the jasper, south of the anticlinal, in Sec. 27.

The first of these is near the line between Secs. 27 and 28. It is opened in two trenches 75 feet apart, and has a width of about 25 feet. The ore is schistose and softer than that of the other deposits, and is mingled with jasper.

a Sample 982 represents the average ore from both pits:

	982.
	Per cent.
Metallic iron	64.55
Phosphorus	0.035
Phosphorus in 100 parts iron	0.054

An eighth of a mile farther east the much-contorted jasper contains a large proportion of ore, which led to
b digging the trench shown in Fig. 214. The extent of this ore-body was hidden by the snow, but the width in the

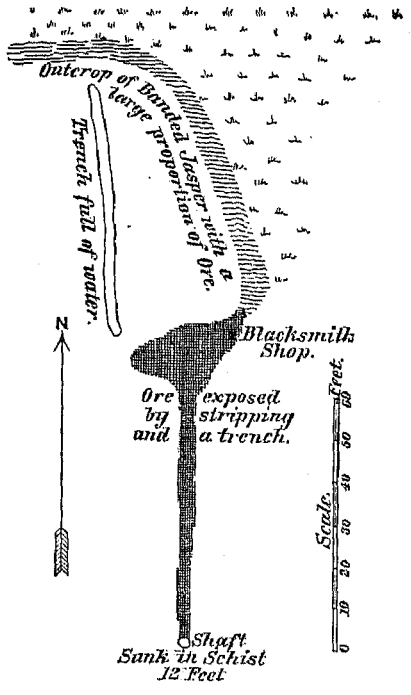

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FIG. 214.—SKETCH MAP IN THE VERMILLION RANGE, MINNESOTA.

trench was 70 feet. Sample 983 represents this ore:

	983.
	Per cent.
Metallic iron	67.28
Phosphorus	0.050
Phosphorus in 100 parts iron	0.088

Still eastward from this pit the jasper outcrops contain a large proportion of ore, and the most eastern test-pits expose the largest area of good ore seen on the range (see Fig. 215).

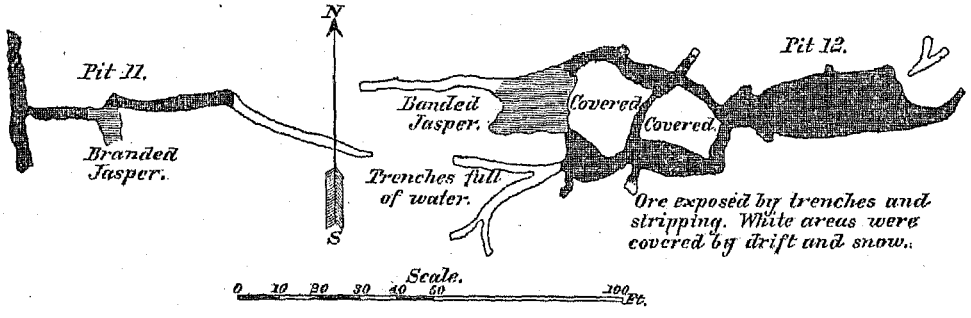

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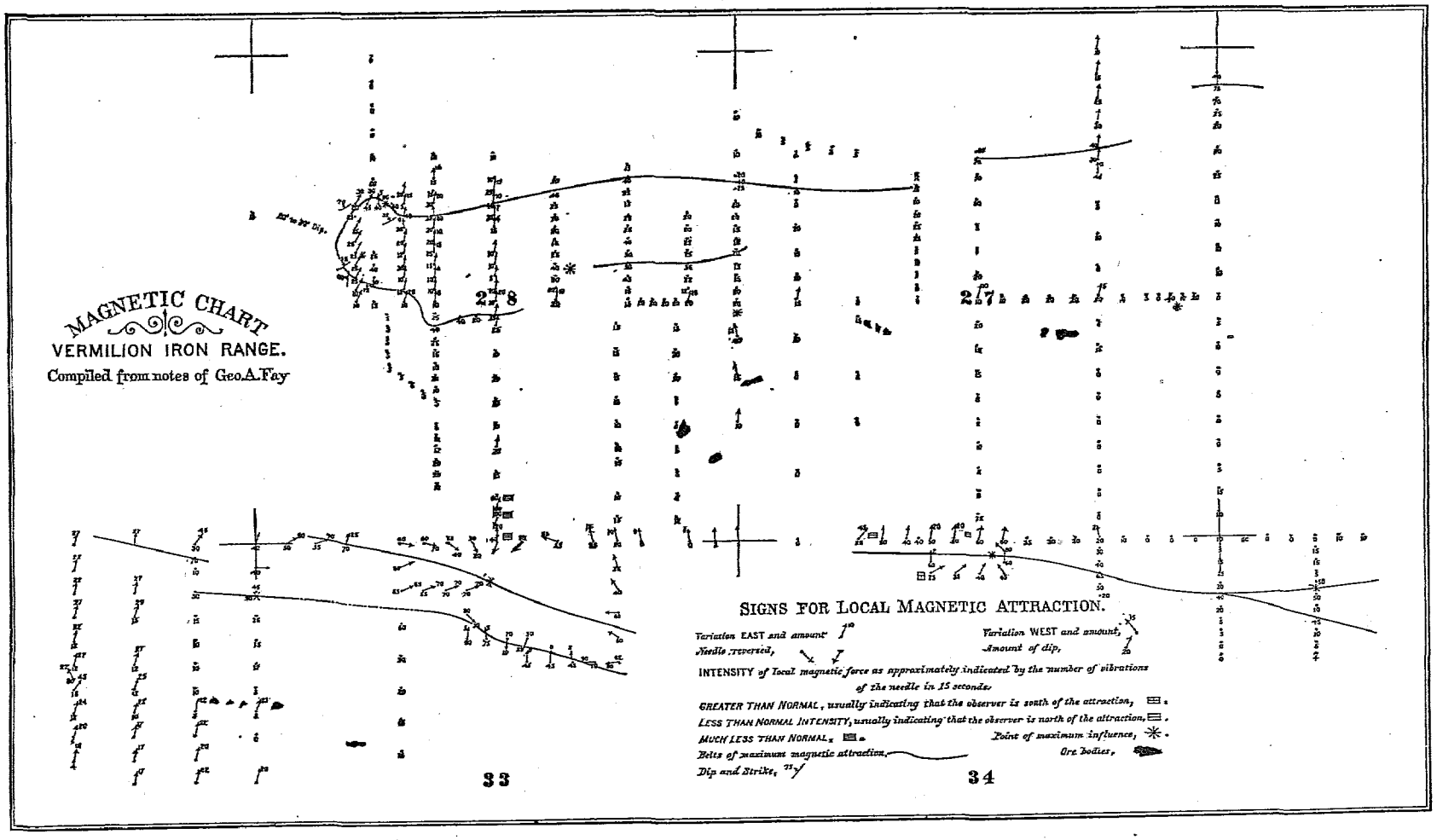
FIG. 215.—SKETCH OF AN ORE BODY OF THE VERMILION RANGE, MINNESOTA.


MAGNETIC CHART
VERMILION IRON RANGE.
Compiled from notes of Geo.A.Fay
SIGNS FOR LOCAL MAGNETIC ATTRACTION.
Variation EAST and amount
Needle reversed,
Variation WEST and amount,
Amount of dip,
INTENSITY of local magnetic force as approximately indicated by the number of vibrations of the needle in 15 seconds.
GREATER THAN NORMAL, usually indicating that the observer is south of the attraction,
LESS THAN NORMAL INTENSITY, usually indicating that the observer is north of the attraction,
MUCH LESS THAN NORMAL,
Point of maximum influence,
Belts of maximum magnetic attraction,
Ore bodies,
Dip and Strike,
33
34

The ore is hard, crystalline, and free from quartz-masses. Sample 984 represents the average of the entire ore-surface:

	984.
	Per cent.
Metallic iron	65.73
Phosphorus	0.067
Phosphorus in 100 parts iron	0.102

The ore-bodies described all appear to lie in folds or crumpled portions of the very much disturbed strata. The suggestion they thus give may serve as a hint to prospectors able to unravel the complicated structure of this iron-bearing series in its eastward extension.

Drift phenomena do not properly belong to this paper, but I wish to call attention to the two parallel drift-ridges that lie on the western slope of the main Vermilion ridge, in the southeast part of Sec. 28. They are about one-eighth mile long, perhaps 20 feet high, and between them is a hollow not much larger than one of the ridges.

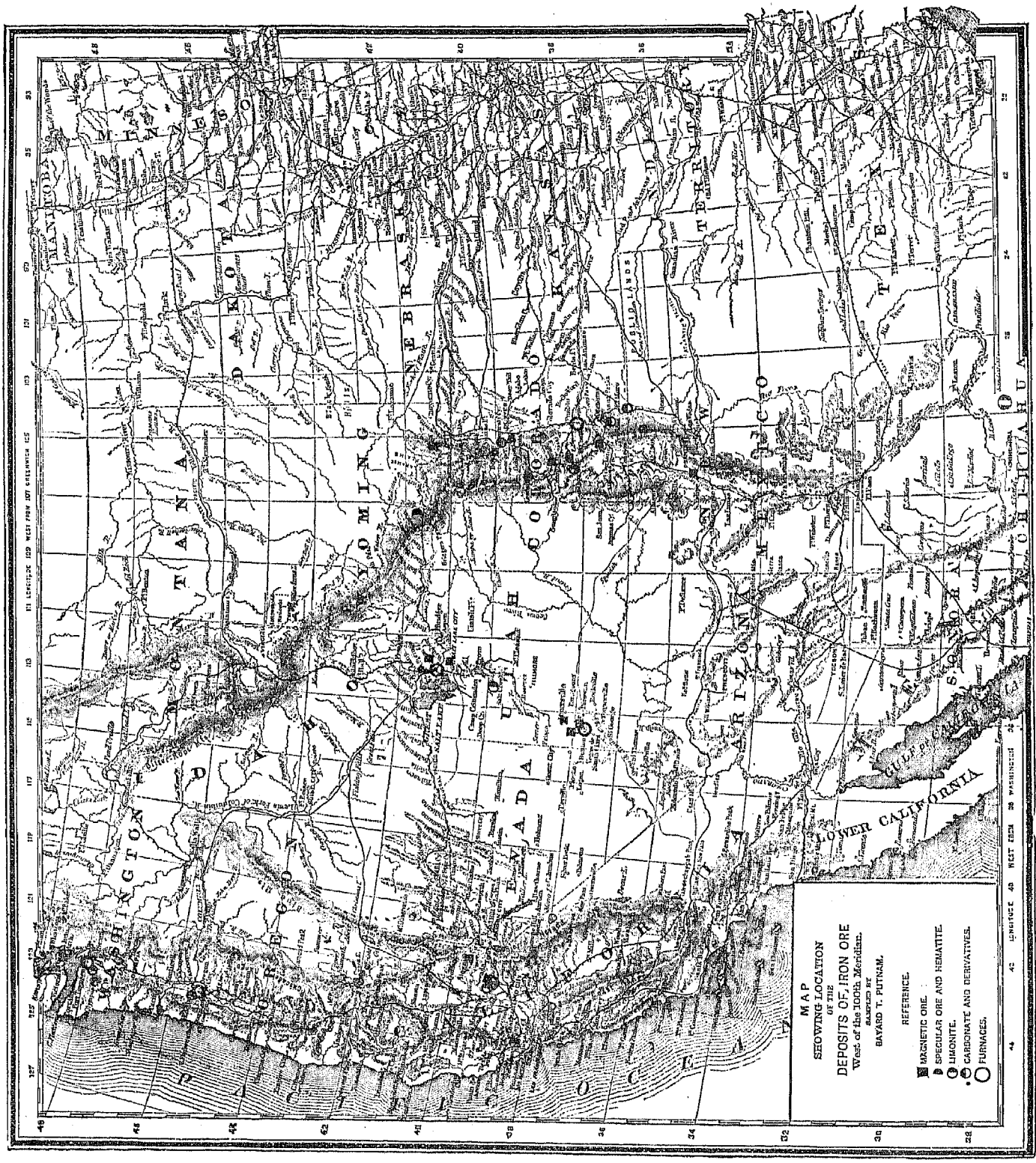

MAP
SHOWING LOCATION
OF THE
DEPOSITS OF IRON ORE
West of the 100th Meridian.
BAYARD T. PUTNAM.
REFERENCE.
MAGNETIC ORE.
SPECULAR ORE AND HEMATITE.
LIMONITE.
CARBONATE AND DERIVATIVES.
FURNACES.
MANITOBA
MINNESOTA
DAKOTA
NEBRASKA
WYOMING
COLORADO
NEW MEXICO
TERRITORY
TEXAS
INDIAN TERRITORY
KANSAS
MONTANA
IDAHO
WASHINGTON
OREGON
NEVADA
UTAH
ARIZONA
CALIFORNIA
LOWER CALIFORNIA
GULF OF CALIFORNIA
PACIFIC OCEAN
MEXICO

FIG. 216.

NOTES ON THE SAMPLES OF IRON ORE COLLECTED WEST OF THE ONE HUNDREDTH MERIDIAN.

By Bayard T. Putnam.

In a country so sparsely settled as is that portion of the United States west of the 100th meridian, and one in which, moreover, transportation is so expensive, and suitable fuel as a rule is so scarce, it is not strange that little has thus far been done to develop the iron resources of the region or even to determine the extent of those resources. In the published reports of the government surveys, etc., of the West, iron-ore is but seldom mentioned, and the references made to it are as a rule either to masses of ore, such as those found in southwestern Utah, Sierra county, California, etc., which must of necessity at once have attracted the attention of the traveler, or to the seams of partially-altered carbonate ore, usually associated with beds of lignite and coal. d

The smelting of iron ore has not, however, been left entirely untried. Lesley, (*a*) in 1859, speaks of a reported forge in Utah, using ore found in the mountains east of Salt Lake City, and also says: "One or more forges are spoken of on the West coast, but nothing is known of them." The report of a forge near Salt Lake City is probably an error, and the rumor is doubtless explained by the fact that a few pounds of ore were there worked into iron in a blacksmith's forge. The California forges I have been able to find no other reference to.

The extraordinary masses of ore in Iron county, Utah, are situated but a few miles from the old Mormon settlement of Cedar City, and must therefore have been known to the first immigrants. Iron is said to have been produced from this ore as early as 1852, but nothing beyond the mere statement of the fact appears in any of the reports of that region which I have seen. Iron City was founded about 1869, and a small charcoal blast-furnace, puddling-furnace, foundery, etc., erected there by the Great Western Iron Company, of which John W. Young was e president. Some iron was made between 1869 and 1875, but the experiment was not financially a success, and since the latter date (or possibly 1876) the works have been idle. In December, 1880, the population of Iron City consisted of one family. The blast-furnace is 19 feet high, 4 feet wide at the boshes, and was planned to make 5 tons of pig-iron daily. The fuel used was charcoal, made from the cedar which covers the surrounding hills. It was burnt in piles. Two large beehive kilns were built near the furnace, during the last year that the latter was in operation, but they have never been used. The iron made was used principally for shoes and dies for stamp-mills, and was teamed to different parts of the territory and to Nevada, where it is said to have given good satisfaction. I was unable to obtain any detailed statement in regard to the working of the furnace, but I understand that difficulty was experienced in puddling the iron, and but little if any soft iron was made. Something like $150,000 was expended before the works were abandoned. The property is now owned by Thomas Taylor, of Salt Lake f City. The ore will be described hereafter.

Probably the honor of making the first pig-iron west of the 100th meridian belongs to Colorado. In 1864 a small blast-furnace was built by Mr. Marshall, near what is now the Marshall coal mine, on South Boulder creek, Boulder county, 5 miles south of the town of Boulder, to smelt the nodular pieces of partially-altered carbonate, derived from a thin seam in the coal formation through the erosion and degradation of the inclosing rock, which here covered the plains in large quantities. The stack which was built from the sandstone overlying the coal was designed to make 5 tons of pig iron a day. The fuel was charcoal made from the pine, etc., in the foot-hills 4 miles away. Limestone was also brought from the foot-hills. The blowing-engine was of wood, and was driven by a 25-foot overshot water-wheel. The furnace was in operation for about two and a half months in the summer of 1864,

a *The Iron Manufacturer's Guide*, p. 217.

a and made some 200 tons of pig-iron, which was used for mill purposes with good results; but the cost of producing the iron was too great, and the furnace has been idle since its first run. The stack is still standing, and the blowing-machinery has not been disturbed, and is in good condition.

In Oregon a company was incorporated in February, 1865, under the name of the Oregon Iron Company. In 1866 the erection of a furnace and the necessary buildings was commenced at Oswego, Clackamas county, a small village on the west bank of the Willamette river, 7 miles above (south of) Portland. The stack is of stone, and was erected under the direction of Mr. G. D. Wilbur, of Connecticut, after the plan of the Lime Rock furnace, in Litchfield county of that state. The rock used is basalt, from the neighborhood. The furnace was completed in June, 1867, but did not immediately go into blast on account of some difficulty in obtaining a sufficient quantity of
b charcoal. The destruction of some of the buildings by fire on the night of July 2d further delayed matters, and it was not until the 24th of August (1867) that the first cast of pig-iron was made. The stack as originally built was 32 feet high and 9½ feet in diameter at the boshes. Its height was increased to 42 feet in 1869. The blast-producing machinery was driven then, as it is now, by a turbine water-wheel. The blast was heated. In the first run the furnace produced from 6 to 8 tons of pig iron a day. By the 1st of October 224 tons (gross) had been made at an average cost of $28 98 per gross ton, the cost being distributed as follows: (a)

166 bushels of charcoal, at 8 cents, $13 28; 884 pounds lime, at 40 cents, $3 53; 4,970 pounds ore, at $2 50 a ton, $5 50; labor, etc., $6 67; total, $28 98.

The ore was obtained chiefly from the Prosser mine (see samples 1165 and 1167), 2½ miles distant, whence it
c was teamed to the furnace. A little Patton ore (sample No. 1166) was also used. The conditions for a commercial success so far as natural advantages were concerned seemed to be here well fulfilled, but the project was not financially remunerative, and after sinking several hundred thousand dollars the Oregon Iron Company put the furnace out of blast. It was idle for some years, but was bought for a fraction of its original cost in 1878 by its present owners, who are known as the Oswego Iron Company. The stack was raised to 44 feet, and in the spring of 1880 a new blowing-engine (horizontal, two cylinders, each 4 feet in diameter and 5-foot stroke, built in Portland) and a new turbine-wheel were put in. Arrangements were also made to complete a canal, begun by the old company from the Tualitin river to Sucker lake. It is from the latter that the water is drawn to drive the turbine, and in some seasons of the year the lake is too low to supply the necessary head. When the canal is completed the lake can probably be kept full at all times. A narrow-gauge railroad was completed to the Prosser mine in August,
d 1880, and the cost of the ore at the furnace will, therefore, be much reduced hereafter. The company owns about 3,000 acres of timber-land, principally fir, which, it is said, will cut on an average 100 cords to the acre. The charcoal has been heretofore all made in heaps, but kilns are now being constructed. Estimating the value of the stumpage at 10 cents per cord, and the price of cutting at 90 cents, the total cost of the coal delivered at the furnace is between 6 and 7 cents a bushel. Much of the wood, it is claimed, will make 50 bushels of coal to the cord.

No limestone is found in the neighborhood, and this is the most serious drawback which the furnace company has to meet. That now used is brought from Puyallup valley, in Washington territory, and costs at the furnace $5 50 to $6 per ton.

The ore, as will be more fully mentioned hereafter, is a limonite. Its yield in the furnace is indicated by the
e following statement: On January 12, 1881, the furnace-charge was—

Prosser ore (see samples Nos. 1165 and 1167)	pounds..	1,000
Patton ore (see sample No. 1166)	do....	100
Limestone	do....	55
Charcoal	bushels..	25

There are 112 charges every twenty-four hours; hence in that time there are used in the furnace 61.60 tons (2,000 pounds) of ore, 3.08 tons of limestone, and 2,800 bushels of charcoal. The product is about 24 net tons of pig-iron. Hence, first, the mixture of ores yields about 40 per cent. pig-iron in the furnace; second, it takes 128 bushels of charcoal to make 1 ton of pig-iron. The latter figure appears to be higher than is the average rate of charcoal consumption for the year. The present yield of the furnace per twenty-four hours is also greater than it has heretofore been. The production of pig-iron in 1880 was 5,000 net tons.

f A furnace was built at Ogden, Utah, in 1875, by the Ogden Iron Manufacturing Company, and was lighted in the fall of that year. It froze up, however, before the iron came down, and has been idle since. The stack is of the crinoline pattern, 45 feet high and 12 feet in diameter at the boshes, and is provided with a water-balance elevator. The blast-producing machinery consists of three horizontal blowing-cylinders, each 21 inches in diameter, with a 72-inch stroke. The original plans included a puddling furnace, rolling-mill, foundery, etc., and much of the necessary machinery is now on the ground, but has never been set up. Power for the whole works was to have been supplied by two 48-inch turbine water-wheels.

I could not learn definitely the cause of the failure of this enterprise, but it is evident that the plan of using the raw Wyoming coals, which was the fuel proposed, could not have been successfully carried out. My own

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a Report of J. Ross Browne on the Mineral Resources of the States and Territories West of the Rocky Mountains, 1868.

impression is, too, that the ores used in the experiment were lean and silicious, and would work with some difficulty **a** in any event. That there was ignorant management somewhere is too apparent to require mention. The furnace and other property of the old company has been purchased by the Equitable Iron and Coal Company, incorporated under the laws of Utah January 1, 1878, but, so far as known to me, the works still remain idle.

The year 1880 witnessed the beginning of three blast-furnaces in the West—one in Colorado, one in California, and one in Washington territory.

The Washington territory furnace was started after the other two, but went into blast first. It is located at "Irondale", on the west shore of Port Townsend bay, about 3½ miles in a direct line from the town of Port Townsend. The foundation of the furnace was laid in August, 1880, fire was started in January, 1881, and the first cast was made on January 25, 1881. The campaign lasted until November 10, 1881, during which time about 1,300 **b** tons of pig-iron were made. The stack is of brick bound with 15 iron hoops and 8 vertical braces. Its dimensions are as follows: Height, 32 feet; diameter at the boshes, 9½; diameter at throat, 3 feet; diameter at hearth, 2 feet; section of hearth, square; height of boshes above bottom of crucible, 12 feet; angle of boshes, 65°. Top of furnace is covered with stack 28 feet high (above charging floor). There are three tuyeres, each having a 4-inch aperture at nozzle. The height of center of tuyeres above bottom of crucible is 23 inches. The gases are taken off through four openings, each 9 inches by 15 inches, connecting with a flue which passes entirely around the upper part of the furnace. They are conveyed by a 20-inch iron pipe to the oven, which is built on the ground. The oven contains 32 6-inch pipes, each 5½ feet long. There were used in the furnace-stack alone 120,000 red brick and 21,000 fire brick, and in the works altogether 165,000 red brick and 30,000 fire-brick. **c**

The ore is of two kinds, a bog-ore dug in Chimicum valley, 2½ miles from the furnace (sample No. 1168), and magnetic ore from Texada island, British Columbia (sample No. 1169). Limestone is obtained from Orcas island, at a cost of $2 a ton. Charcoal is made near the furnace. The works are the property of the Puget Sound Iron Company.

The California Iron Company commenced the erection of a charcoal furnace in the spring of 1880, in Placer county, 3 miles from Clipper gap, and 7 miles from Auburn (both stations on the Central Pacific railroad, in the western foot-hills of the Sierra Nevada mountains). The stack is 47 feet high, 10 feet diameter at the boshes, and is inclosed in an iron shell supported on iron pillars. It is provided with a water jacket and six tuyeres, and is modeled after a furnace in Menominee, Michigan. The first cast was made on April 24, 1881. The works are located within a few hundred feet of a deposit of manetite ore of unknown extent (samples No. 1170 and 1171), **d** and within a few miles of what appears to be a large mass of limonite (sample No. 1172). The latter is referred to in *Whitney's Report of the Geological Survey of California*, Vol. I, p. 284, and the remark is there made that this locality is perhaps more favorably situated than any yet discovered in the state for trying the experiment of iron-smelting. The foot-hills are plentifully supplied with wood for charcoal. The company has erected twenty beehive kilns in which to burn the coal.

The extensive iron- and steel-works of the Colorado Coal and Iron Company were begun in the spring of 1880, and one stack was completed and put into blast in September of the following year. The works are situated on the mesa at South Pueblo, near the main track of the Denver and Rio Grande railroad. The full plans include two blast-furnaces (crinoline pattern), each 15 by 65 feet, two Bessemer converters, a complete rail- and merchant-mill plant, foundery, etc. If finished according to these plans, this will be as complete an iron establishment as **e** any in the country. Coke manufactured at El Moro, by the company, is used as fuel. The ores are brought from different parts of the mountains. Limestone occurs in the foot-hills near by.

In 1873 a furnace was projected by the Sierra Iron Company of California, to work the large masses of magnetic ore existing in Sierra and Plumas counties, but the works were never really begun, owing in part at least to the failure to build a proposed railroad from Reno, Nevada, to Oroville, California, which would have passed near the iron mines.

The Norway Iron Mining and Manufacturing Company of Utah was incorporated under the laws of that territory in November, 1879. The company owns property in Morgan county, 10 miles from Weber station, on the Union Pacific railroad, where, it is claimed, deposits of good iron ore have been discovered. The company propose to erect a 10-ton furnace near the mines, but have not as yet begun actual building. **f**

The following list of the iron-smelting establishments west of the 100th meridian contains some data omitted from the foregoing brief sketch:

California.—California Iron Company, Clipper Gap, Placer county. One stack 47 by 10 feet; iron shell; water-jacket; six tuyeres. Begun in 1880. First cast of iron on April 24, 1881; fuel, charcoal; ore, magnetite and limonite from vicinity of furnace. Manager, P. Fitzhugh.

Colorado.—Colorado Coal and Iron Company, South Pueblo, Pueblo county. One stack 65 by 15 in blast, and plans made for a second. Complete Bessemer rail-mill plant in process of construction. First cast of pig-iron, September, 1881. Fuel, coke. Officers of company: President, William J. Palmer; vice-president, Charles B. Lamborn; secretary and treasurer, Walter B. Gaskill; general agent, W. G. Brown.

a *Oregon.*—Oswego furnace, Oswego Iron Company, Oswego, Clackamas county. One stone stack 44 by 9½ feet; open-top hot blast; water-power; fuel, charcoal. The furnace was built in 1866–1867 by the Oregon Iron Company. First cast, August 24, 1867. The present owners came into possession in 1878. The officers of the Oregon Iron Company were: President, W. S. Ladd; vice-president, H. G. Leonard; secretary, H. D. Greene. The officers of the Oswego Iron Company are: President and treasurer, S. H. Brown, 220 Front street, Portland; secretary and superintendent, E. W. Crichton, Oswego; agent, L. B. Seeley, Main and Folsom streets, San Francisco.

Utah territory.—Great Western Iron Works, Iron City, Iron county. One small charcoal stack, puddling furnace, etc. Built about 1869. Idle since 1875 (or 1876). Now owned by Thomas Taylor, of Salt Lake City.

Equitable Iron and Coal Company, Ogden. One stack 45 by 12; built in 1875, but has made no iron. Officers
b of company: President, E. H. Orth; general manager, James D. Kase; secretary, George F. Brown.

Norway Iron and Manufacturing Company, Salt Lake City. Projected charcoal furnace in Morgan county. Officers of company: President, John F. Lynch; vice-president, Charles Popper; treasurer, Frederick G. Lynberg; secretary, B. A. M. Froiseth.

Washington territory.—Puget Sound Iron Company, Irondale, Port Townsend bay. One brick stack 32 by 9½ feet; begun in 1880. First cast January 25, 1881. Fuel, charcoal. Ores, bog-ores found in vicinity of furnace, and magnetite from Texada island, British Columbia. Officers of the company: President, John A. Paxtine; vice-president, John H. Redington; treasurer, Charles H. Simpkins; secretary, A. Holsey.

In the autumn of 1880 the writer was directed by Professor Pumpelly to visit and sample, so far as time would
c permit, the known deposits of iron ore west of the 100th meridian. The following notes embrace descriptions of the samples collected: (*a*)

IRON ORES IN COLORADO.

Magnetite in the Archæan.—Magnetite exists in the Archæan rocks throughout the Rocky mountains. All the samples collected contain titanic acid, in some cases in such large quantities as to render the ore unfit for use in the blast-furnace, excepting when mixed in small amounts with other ores. The attempts which have been made at several points to use this ore for flux in lead-smelting have proved failures.

The largest mass of magnetite thus far discovered in Colorado is known as *Iron mountain.* It is a hill about
d 800 feet long, 500 feet wide, and 60 feet high, situated in Wet Mountain valley, Fremont county, about 1 mile north of the upper end of Pine Creek cañon. Pine creek is a tributary to Grape creek, and the latter empties into the Arkansas river near Cañon City. A branch of the Denver and Rio Grande railroad has recently been completed between Cañon City and Silver Cliff, which passes along Grape creek, and from this Iron mountain is but about 4½ miles distant. Preliminary surveys have already been made for a spur-track through Pine Creek cañon to the ore-deposit. By this route the distance to Cañon City is about 22 miles, and to the steel-works at South Pueblo 65 miles. By road from Cañon City, through Grape Creek cañon, across Webster park, and through Webster cañon (sometimes called Copper gulch), the distance to Iron mountain is about 21 miles. Iron mountain is 8,000 feet above the level of the sea, and 2,500 feet above Cañon City. On the proposed railroad route there is a continuous down-grade from the former to the latter point (see Fig. 217).

e The existence of iron ore here has been known for many years. It was referred to by Mr. Endlich, (*b*) in 1873, who states that the ore was then being mined. In 1875 the locality was visited by M. Chaper, ex-secretary of the Geological Society of France. Extracts from his report, with analyses of the ore made at the School of Mines, Paris, were printed in the *Fifth annual report of the board of directors of the Colorado Improvement Company* (1877–1878). A United States patent for the land was obtained in 1872. The property now belongs to the Colorado Coal and Iron Company. On the accompanying sketch-map (Fig. 218), which indicates closely the general size and shape of the hill, are recorded the results of a series of dip-needle observations. A line was marked out over the hill in the most convenient locality, and along it stakes were placed at intervals of 100 feet. From each of these stakes lines were run in either direction at right-angles with the main line, and along these cross-lines the angle of the dip was noted at points five paces apart. The "base-line" was measured with a tape. Its direction (true) is
f about north 6° east. The cross-lines are numbered on the map from 1 to 9, beginning at the south. The day the magnetic survey was made the hill was covered with 3 or 4 inches of snow. Much of this had melted by the following morning, so that the outcrops of ore could be located. The direction of the two main ridges of the hill is

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a Montana, Idaho, and eastern Washington territory were not visited owing to the difficulty of transportation in that region in the winter season at that time. The work of the Northern Transcontinental survey has since proved the existence of extensive deposits of iron ore in the mountain region of Montana. Notable amongst these is a mass of magnetic ore in crystalline rocks on East Boulder creek, Gallatin county, and one in Lower Palæozoic quartzites(?) on Cable mountain, Deer Lodge county. The ore from the outcrop at the latter locality will average from 55 to 60 per cent. metallic iron, is low in phosphorus and sulphur, and practically free from titanium. It is therefore an excellent Bessemer ore. As situated it is not difficult of access, and as soon as there is a sufficient demand for iron in Montana it will doubtless prove valuable.

b *Annual Report Geological and Geographical Survey of the Territories for* 1873, by F. V. Hayden, p. 333.

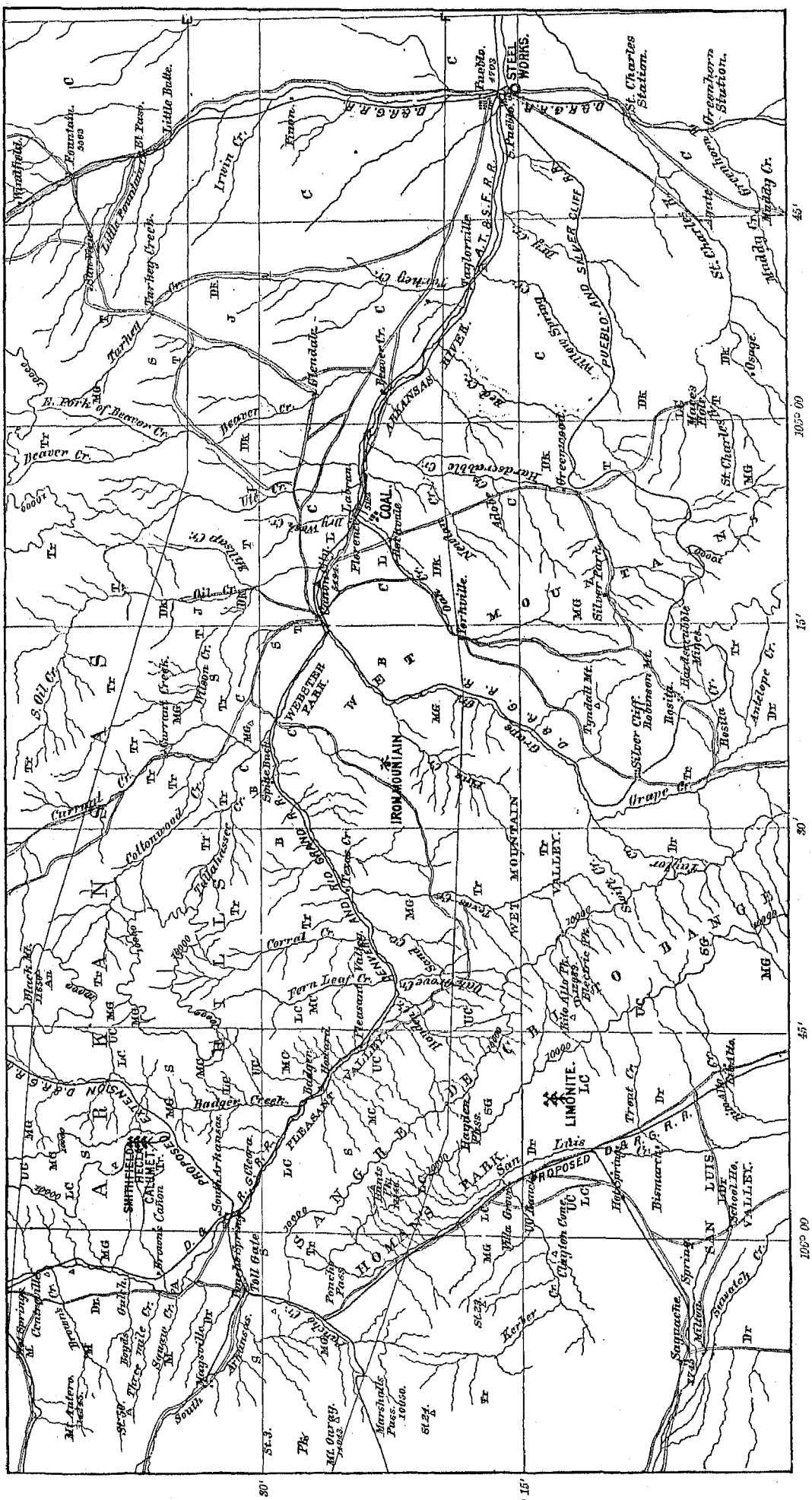
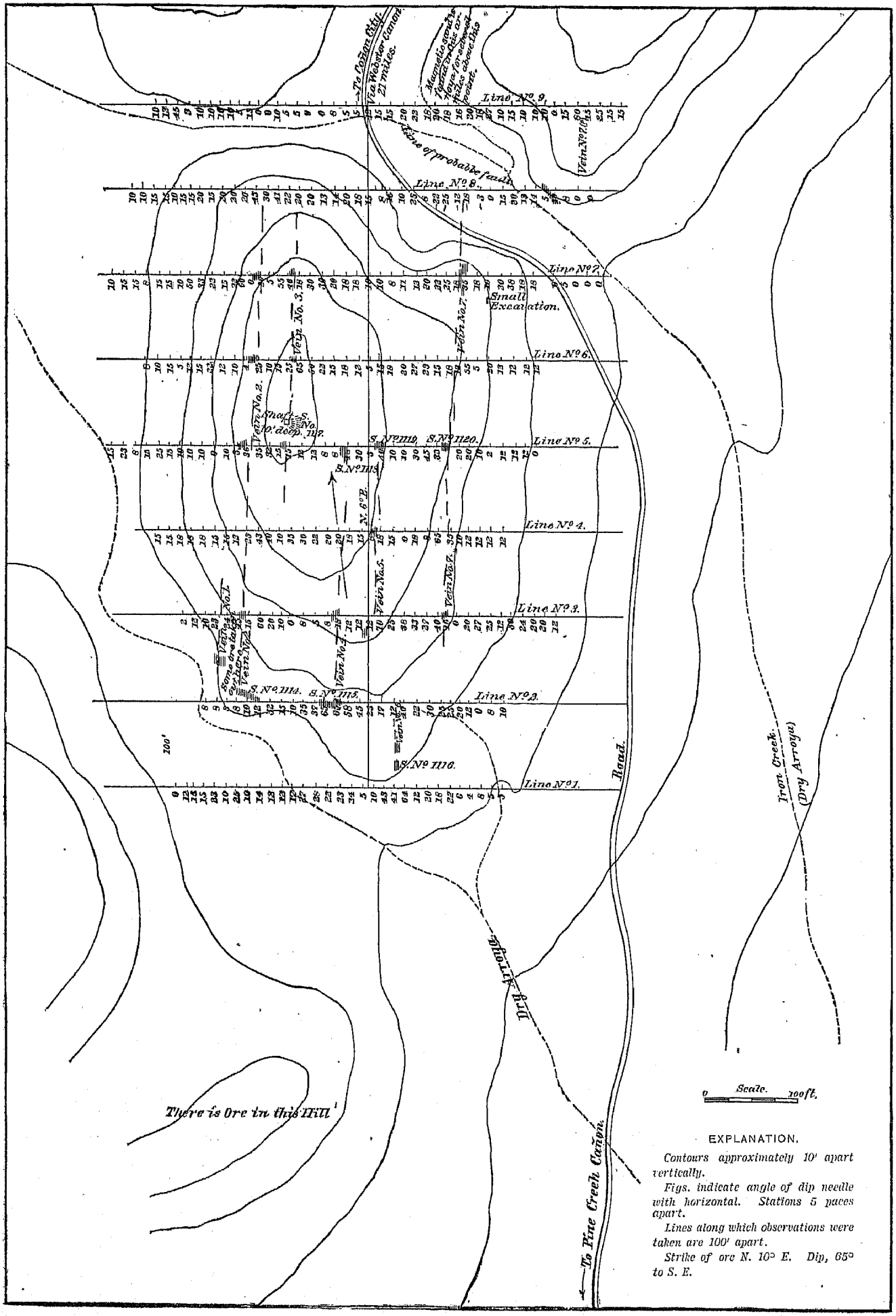


FIG. 217.—MAP OF A PORTION OF COLORADO, SHOWING THE POSITION OF SOME OF THE IRON-ORE DEPOSITS SAMPLED.



EXPLANATION.

Contours approximately 10' apart vertically.

Figs. indicate angle of dip needle with horizontal. Stations 5 paces apart.

Lines along which observations were taken are 100' apart.

Strike of ore N. 10° E. Dip, 65° to S. E.

north 10° east, and this apparently is the strike of the ore-veins. The dip of the latter is to the southeast at a high a angle. The surface of the hillside and that of the valley near its foot are covered with small pieces of ore, which cause the needle to be deflected from a horizontal for some distance away from the ore-mass.

On the southwest side of the hill there is a small opening on an outcrop of a vein of ore, from which a little ore has been taken. This vein (marked No. 1) does not outcrop again to the northward, nor does the dip-needle indicate its extension in that direction, unless the dips on line No. 7 be due to it. About 20 feet east of the above opening there is an outcrop on a second vein. This seems to be the most regular and persistent if not the widest vein in the hill, excepting, perhaps, No. 7. Its outcrop can readily be traced for 600 feet or more, and near line No. 2 it is exposed for a width of 20 to 25 feet. At line No. 3 it seems to unite with the third vein. This latter outcrops on lines Nos. 5, 6, 7, and the dip-needle indicates its extension to line No. 8, though at this latter point it probably forms one with No. 2. It is possible that No. 2 and No. 3 are practically one vein, separated in places by a "horse" b of rock. Between No. 2 and No. 4, on line No. 2 there is a gully in which a gray granite (?) outcrops, and although this was the only rock outcrop seen, the configuration of the hill would seem to indicate that the rock extends northward through the hill, and has been more eroded than the ore-mass. Vein No. 4 is fully 50 feet wide on line No. 2, but it narrows toward the north, and the last outcrop—a small one—is seen a few feet south of line No. 5. The needle does not indicate its extension as far as line No. 6. The next vein, No. 5, first outcrops on the "base-line", a few feet south of line No. 3. Its northernmost outcrop is a little north of line No. 5. The sixth vein outcrops on line No. 1 and between it and No. 2. No outcrop was seen north of No. 2, but the vein appears to extend at least to line No. 3. The seventh vein was first discovered outcropping on line No. 3; it was traced northward to line No. 7. For some distance this vein forms the edge of the hill-top or ridge. The slope of the surface changes c immediately east of it. A short distance north of line No. 7 the eastern ridge of the hill terminates quite abruptly, and the vein is not traceable farther in this direction. To the northwest, on the north side of Iron creek, ore again outcrops, however, and the strike of the vein is here about the same as in the Iron hill. It appears probable, therefore, that vein No. 7 has been faulted about on the line of Iron creek, and thrown to the *right*. This supposition is strengthened by the negative attraction of the needle along line No. 8.

Whether the seven veins of ore thus traced out are all distinct and separate, is, of course, not possible to say without actual cross-cutting; but, with the exception of veins Nos. 2 and 3, such seems to be the case. The behavior of the needle might appear to indicate that magnetite is distributed in some quantities through the entire hill. It must be remembered, however, that the surface of the hill is covered with float-ore. The rock outcropping on line No. 2, both east and west of vein No. 4, contains little if any magnetite, yet the needle was deflected when held d immediately over this outcrop.

Excepting that the ore from the southern part of the hill is more weathered, the feldspar gangue being in some cases kaolinized, giving the mass a mottled appearance, all the ore examined is remarkably alike, considering the extent of the deposit. The ore from the small shaft on vein No. 3 is jet-black in color on weathered surface, compact in texture, shows a well-developed prismatic structure, and is very heavy. On fresh fracture it has a peculiar luster, which is perhaps best described by the word "graphitic".

I learned from the analyses of M. Chaper's samples, before visiting the locality, that part of the ore at least contained a large percentage of titanic acid. As the titanium-carrying ore cannot be hand-picked from the ore free from that element, it seemed important to determine if the latter was not concentrated in one or more bands, leaving the others comparatively free from it. Samples were therefore collected from the outcrop of each vein. These e samples contained—

	1114.	1115.	1116.	1117.	1118.	1119.	1120.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	48.89	48.18	46.61	48.85	46.05	47.01	47.42
Phosphorus	0.025	0.026	0.037	0.011	0.040	0.030	0.026
Titanic acid	11.99	12.92	11.61	12.73	13.84	14.86	13.04
Phosphorus in 100 parts iron	0.051	0.054	0.079	0.023	0.087	0.083	0.055

Sample 1114 is from outcrop of vein No. 2 at the southwestern side of the hill. Sample No. 1115 is from outcrop f of vein No. 3 on line No. 2. Sample No. 1116 is from outcrop of vein No. 6, between lines Nos. 1 and 2. Sample No. 1117 is from a small pile of ore thrown out from a test-shaft on vein No. 3, near the top of the hill north of line No. 5. Sample No. 1118 is from outcrop of vein No. 4, near line No. 5.

The analyses indicate that all this ore contains too much titanium to be used alone in the blast-furnace. The low contents in phosphorus of the different samples is noticeable, as is also the nearly uniform percentage of metallic iron. The samples consisted of series of chippings across the different outcrops.

a The following analyses of this ore were published in the report of the Colorado Improvement Company, previously referred to.

	A.	B.	C.
	Per cent.	*Per cent.*	*Per cent.*
Silica	8.60	18.60	2.75
Alumina	4.00	7.00	7.70
Lime	1.60	1.30	None.
Magnesia	2.30	1.60	3.20
b Titanic acid	14.00	10.00	.....
Peroxide of iron	70.50	62.00	.....
Magnetic oxide of iron	.....	.....	67.76
Sulphuric acid	.....	.....	Trace.
Phosphoric acid	.....	.....	Trace.
Oxide of manganese	.....	.....	Trace.
Total	101.00	100.50	.....

Samples A and B were collected by M. Chaper, and analyzed at the School of Mines, Paris. Sample A is a c "compact titaniferous magnetite with feldspathic gangue, from Iron mountain (Grape creek), Fremont county, Colorado". Sample B, "an oxidized iron sand, forming the bed of Iron creek for several miles above Iron mountain. A portion of the iron exists in the state of protoxide, which is all converted into peroxide, whereby the increase in weight results." C is an analysis of a sample of the ore by Charles S. Hinchman, made in 1871. The titanic acid was not determined.

The iron sand represented by analysis B is a noticeable feature of the surface geology near Iron creek, above Iron mountain. It is widely distributed through the surface material, and the ant-hills, of which there are many, are in a great measure made of it. Many of the grains are too large to be properly called sand, being $\frac{1}{8}$ inch or more in diameter. Their edges are all rounded. They have evidently been derived by the alteration and erosion of a rock containing much feldspar and magnetite.

A mass of titaniferous magnetite occurs in *Caribou hill*, near the Caribou and other silver mines, in Boulder d county. Caribou is 20 miles from Boulder, near the Continental divide. Its elevation above tide is 9,000 feet. Two small openings were made at the western end of the outcrop some years since, and a little ore was taken out and teamed to Boyd's smelter at Boulder. The pits are 8 to 10 feet deep and 6 to 8 feet wide. The ore exposed in them and seen on the dump varies greatly in richness, the mass being made up of little seams of rich compact magnetite, lying in a silicious magnetic rock. The outcrop extends along the crest of the hill, and is about 400 feet in length. The north side of the hill is completely covered with float-ore. All the ore is very magnetic, and exhibits polarity to so marked a degree that the dip of the needle changes from +90° (north end down) to −50° (south end down) in the distance of ten paces. There is undoubtedly a large amount of iron-ore in the hill, but it is probable that the rich ore is too irregularly distributed through the rocks to permit of its being economically mined, even if other circumstances were favorable. Sample No. 1105 consists of selected pieces of the rich ore. Sample No. 1106 e is an average of a small pile of ore near the western opening. The samples contained—

	1105.	1106.
	Per cent.	*Per cent.*
Metallic iron	59.04	35.35
Phosphorus	0.017	0.022
Titanic acid	Present.	Present.
Phosphorus in 100 parts iron	0.029	0.062

On Strain creek, in the foot-hills, near Morrison, Jefferson county, a discovery of what was supposed to be a f valuable deposit of iron-ore was made in the spring of 1880. The "claim" is known as the *Jefferson County Iron mines*. The question of its ownership is now before the courts. If the locality which I visited was the right one, and I was assured by my guide that it was, the "ore" is of no value as an ore of iron. The deposit is situated about three-eighths of a mile above the mouth of Strain creek gulch, which latter is 1¼ mile south of Morrison, and consists of an amphibole schist with magnetite. Three pits have been made in this rock at the upper (western) opening. The "vein" (or seam of amphibole schist) is about 75 feet wide, but it narrows toward the east, and at the lower opening, some 500 feet distant from the upper one, it is not more than 10 feet in width where exposed at the surface. The strike is such that the schist crosses the gulch between the openings above referred to and is exposed along the north side of the creek for some distance. At the west, red granite, containing a large amount of feldspar and but little mica, lies on either side of the schist. Outside of the granite is gneiss. The granite thins out toward the

east, and at the eastern opening the schist lies wholly in the gneiss. The percentage of magnetite in the "ore" **a** appears to be greater at the western opening than elsewhere, and here sample No. 1107 was taken. The sample contained—

	1107.
	Per cent.
Metallic iron	20.56
Phosphorus	0.069
Phosphorus in 100 parts iron	0.336

b

In the Arkansas hills, about 9 miles from South Arkansas station (at the junction of the South Arkansas and Arkansas rivers), in Chaffee county, a vein of magnetic ore was being explored in February, 1881, by the Colorado Coal and Iron Company. The vein, striking northeasterly and dipping southeasterly, has been traced with the compass along the west slope of a mountain ridge for a distance of over 4,000 feet, and three claims have been staked on it. These are, in order from south to north, the *Calumet*, the *Hecla*, and the *Smithfield*.

The surface of this and the neighboring ridges is covered with eruptive rock (the trachorheite of Hayden's map), which masks the underlying geology. The immediate associate of the ore is a soft, whitish material composed chiefly of carbonate of lime. This contains, besides the seams of magnetite of varying widths, crystals of green epidote and quartz. **c**

At the Calumet mine a trench 53 feet long has been cut across the formation, exposing a band of fine-grained magnetite, 12 feet wide, lying in the above-mentioned rock. A slope has also been sunk immediately under this band of ore for a depth of 68 feet, at an angle of 46°, following the depth of the vein. Ore forms the roof of this slope from the surface down. It is the intention of the company to drive a tunnel eastward across the ore-belt at a depth of 75 feet below the surface.

At the Hecla claim only a small opening has been made into the side of the hill. It has exposed an irregular mass of ore lying in the calcareous rock.

At the Smithfield claim a shaft was sunk, but it was filled with *débris* when visited. No ore was seen on the dump, but the compass-needle was deflected near the shaft.

A sample of the ore (No. 1176) was taken at the bottom of the slope on the Calumet claim, and in the prospect **d** cut on the Hecla claim (No. 1176 x). These samples contained—

	No. 1176.	No. 1176 x.
	Per cent.	*Per cent.*
Metallic iron	40.23	48.03
Phosphorus	0.026	0.008
Phosphorus in 100 parts iron	0.053	0.017

Titanic acid was not determined, but it is reported to be present only in small quantities. **e**

Magnetite in Carboniferous(?) limestone.—The *Ainsworth* and *Stoddard* mines (so called) are situated in Costilla county, in the Sangre de Cristo mountains, on the east side of Grayback gulch, about 5 miles north of Placer (a station on the Denver and Rio Grande railroad), and 4½ miles from Veta pass. Both mines are on the Trinchera land grant, and are owned by the railroad company and others. They are leased to the Colorado Coal and Iron Company, and are now being explored by it. The discovery of iron ore at this point must have been made soon after the discovery of the placer deposits, for which Grayback gulch was at one time noted, as pebbles and small boulders of magnetite occur in considerable numbers through the sand and gravel. The tracing of these pebbles to their source in the bed of magnetic ore was easily done. In 1877 an opening was made at the Ainsworth mine, by H. T. Sefton and F. Proctor, and between 1,000 and 1,500 tons of ore are said to have been mined and shipped for flux, principally to Mather & Geist, at Pueblo. A survey for a spur-track to the mines has already been made, **f** which, if built, will be 4½ miles long, and will connect with the main road 2 miles east of Placer station. From this junction to the summit of Veta pass is 9 miles; beyond the latter point there is a continuous down grade. The distance from the mines to the steel-works at South Pueblo by this route will be 81 miles.

The Ainsworth opening is in the hillside, about 740 feet above Grayback creek, while the Stoddard opening, on the same side of the hill, is only 180 feet above the same point. The ore at both places is a fine-grained magnetite, carrying calcite and occasionally a crystal of pyrite, bedded in the limestone. This limestone is colored on Hayden's map as Upper Carboniferous. At the Stoddard mine active explorations were begun in August, 1880. An incline was built and a tunnel was started into the outcrop of ore along the strike of the vein (about north 80° east). After passing through 26 feet of ore, a vertical face of rock (limestone) was encountered, which was penetrated for a distance of 30 feet before the drift was abandoned. This break in the vein is due to a fault, and it seems probable

a that the rock to the east of the line of fault has been lifted to a height of over 500 feet. Under this supposition the relation of the Ainsworth and Stoddard deposits is readily accounted for, as is indicated in Fig. 219. The

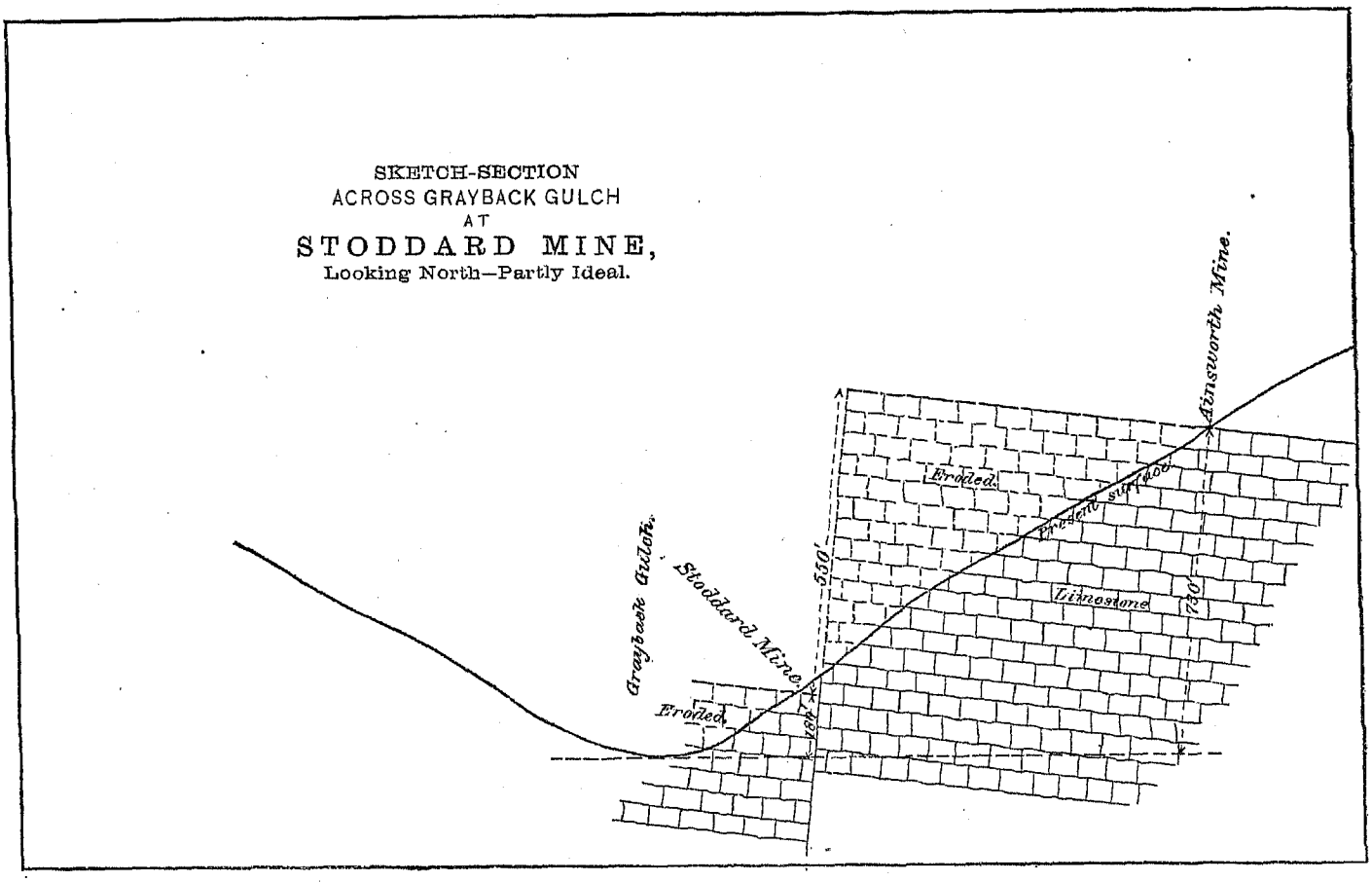


FIG. 219.

direction of the fault is at a slight angle with that of the gulch. In consequence of this, and of the dip of the vein causing the outcrop to pitch toward the south, the wedge-shaped mass of ore remaining increases in width toward the latter direction. But I understand that later explorations south of the first opening have developed the fact that the vein there becomes so thin and "pockety" as to be practically unworkable. Sufficient work had not been done at the Ainsworth mine when visited to prove the extent of the deposit. From what I could see, however, I e infer that the ore will be found to lie in pockets rather than in any well-defined regular vein.

Near the outcrop at both openings, but more especially at the Stoddard mine, the ore is largely peroxidized. The samples of the ore collected yielded, on analysis—

	No. 1108.	No. 1108*a*.	No. 1109.	No. 1110.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	59.23	47.74	55.50	52.58
Phosphorus	0.016	0.008	0.039	0.059
Phosphorus in 100 parts iron	0.027	0.017	0.070	0.112

f Sample No. 1108 is from the face of the lower drift at the Ainsworth mine. Sample No. 1108*a* is from the upper drift in the same opening. Sample No. 1109 is from a pile of weathered ore from the lower drift at the Stoddard mine. Sample No. 1110 is from a pile of 500 tons of ore at the bottom of the incline; all from the tunnel

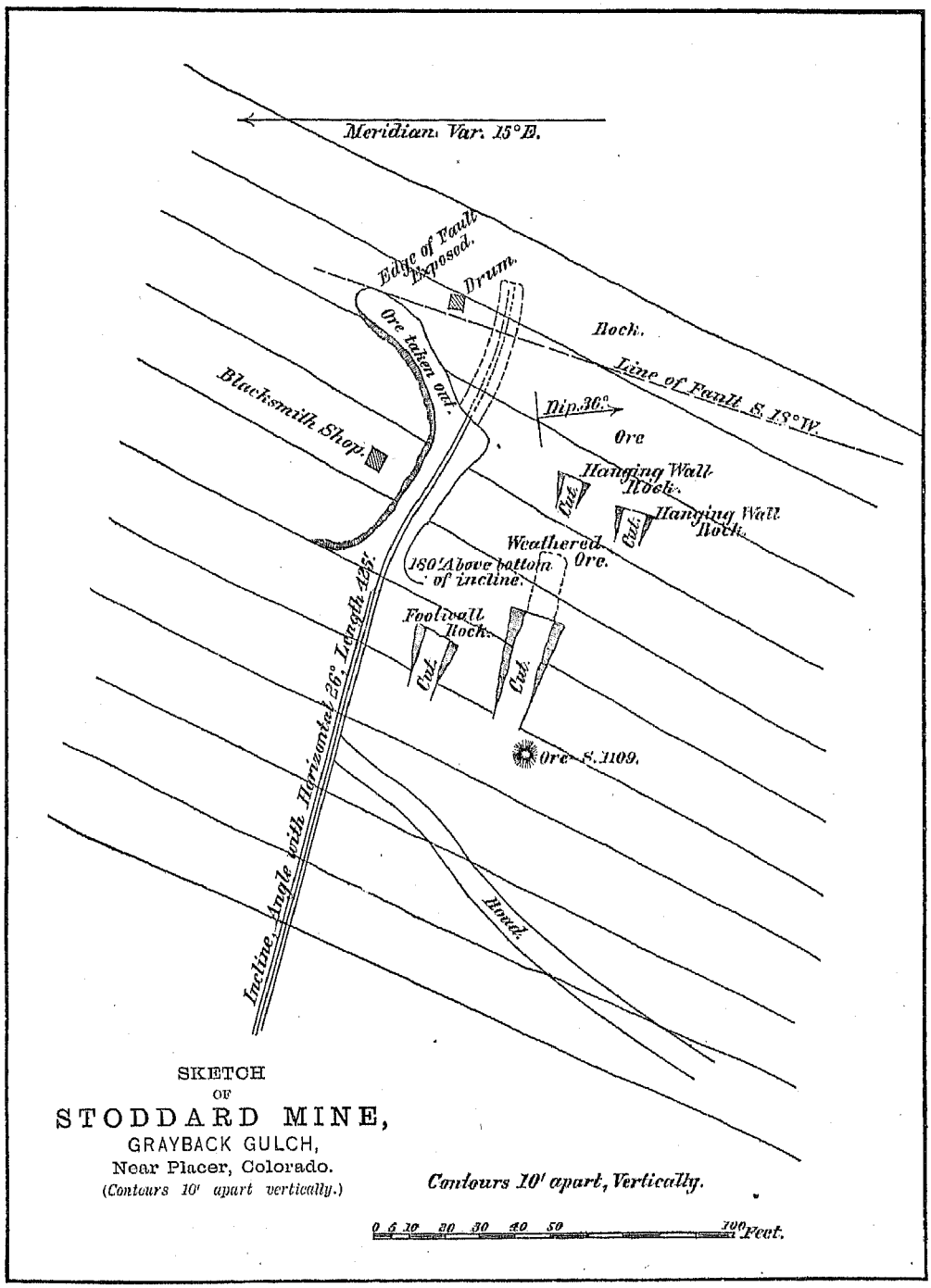

Meridian. Var. 15° E.
Edge of Vault Exposed.
Drum.
Ore taken out.
Rock.
Line of Vault S. 18° W.
Blacksmith Shop.
Dip 36°
Ore
Hanging Wall Rock.
Cut.
Hanging Wall Rock.
Weathered Ore.
150' Above bottom of incline.
Footwall Rock.
Cut.
Cut.
Ore S. 3109.
Incline. Angle with Horizontal 26° Length 425'.
Band.
SKETCH
OF
STODDARD MINE,
GRAYBACK GULCH,
Near Placer, Colorado.
(Contours 10' apart vertically.)
Contours 10' apart, Vertically.
0 5 10 20 30 40 50 100 Feet.

FIG. 220.

a of the Stoddard mine. This last sample represents, therefore, a fair average of the probable shipping product of the mine. Other analyses of the Stoddard ore, kindly furnished me by the vice-president of the Colorado Coal and Iron Company, were as follows:

	A.	B.	C.
	Per cent.	*Per cent.*	*Per cent.*
Silica	11.90	8.60	3.53
Oxide of iron (Fe_2O_3)	82.10	81.20	.....
Alumina	3.00	2.20	1.70
Lime	0.20	2.80	0.83
b Magnesia	Trace.	0.38	0.91
Phosphoric acid	0.096	0.102	.....
Manganese	.....	.....	0.11
Titanic acid	.....	.....	None.
Moisture	.....	.....	None.
Volatile matter	4.20	4.60	.....
Total	102.396	99.882	.....
Metallic iron	57.50	56.84	67.30
Phosphorus	0.04	0.045	0.007
c Sulphur	.....	.....	0.03

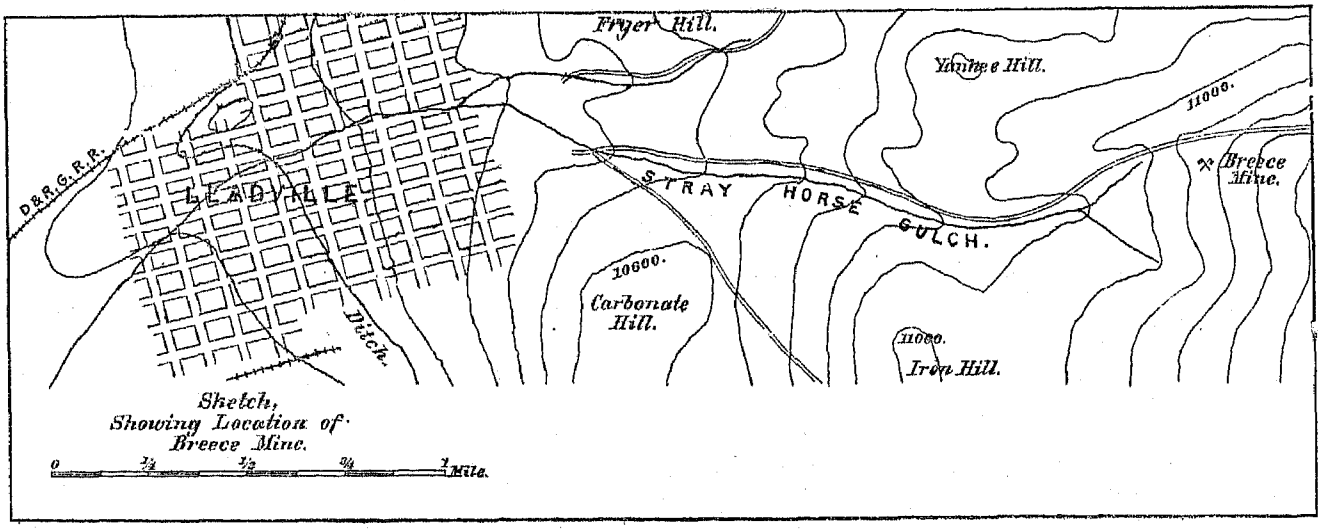
Analyses A and B were made at the North Chicago rolling mill, January 24, 1880. A note on the report states that "both samples were somewhat magnetic, especially No. 1" (A). Analysis C was made by Mr. H. L. Wells, the chemist of the Colorado Coal and Iron Company. The "sample" was evidently a picked specimen.

A sample of magnetic ore was sent me by Mr. T. W. Robinson, of Fairplay, with a letter stating that it had been mined near Hamilton, Park county, and used at one time in the Holland smelter for flux. The sample was taken from a pile of about 25 tons of crushed ore at the latter place. The following is the result of its analysis:

	1132.
	Per cent.
d Metallic iron	63.01
Phosphorus	0.040
Titanic acid	Absent.
Manganese	Present.
Phosphorus in 100 parts iron	0.053

Owing to deep snow the locality was not visited by me. At the date of Mr. Robinson's letter the Holland smelter was idle, and no work was being done at the mine.

Hematite.—Several specimens of hematite were shown to me as having come from the Arkansas hills, but the only mass of the anhydrous peroxide seen in Colorado was at the *Breece Iron* mine, near Leadville. This is a e specular ore, which in powder is largely lifted by the magnet, but in mass has little effect on the compass-needle. It resembles the hard specular ores of the Marquette region, Michigan. The mine is located on the western slope of Breece hill, overlooking Adelaide park, and is distant from Leadville, via Stray Horse gulch, about 2½ miles. Its elevation is about 1,000 feet above the railroad depot in Leadville, and 11,150 feet above tide-level (see Fig. 221).



f

FIG. 221.

In the abstract of his report on the geology of Leadville in the *Annual Report of the United States Geological Survey* for 1881, Mr. S. F. Emmons thus refers to the ore-body.

The Breece Iron mine has a remarkable deposit of red hematite, mixed with magnetite, which occurs at the contact of the main sheets of white and gray porphyry. Its ore is found at the surface in two bodies, having a maximum thickness of nearly 30 feet each, the lower of which is underlaid by white porphyry; while between it and the upper body, which is apparently an offshoot from the main body, is a sheet of decomposed porphyry which has certain resemblances both to the pyritiferous and the gray porphyry. This deposit is apparently due to the oxidation of a mass of iron pyrites which were brought to their present position in solution in a similar manner to the other ore-deposits of that region. Indications of iron are found along the contact line between the white and gray porphyry to the eastward, but as yet no considerable bodies of iron have been developed. West of the Breece mine the Superior and the Mountain Boy, on the ridge connecting Breece and Yankee hills, have also struck a considerable body of iron between gray and the white porphyries. This may be a continuation of the Breece iron body, the intermediate portion having been removed by erosion of the head of Stray Horse gulch, which has brought to the surface the white porphyry underlying the gray. On the other hand, while the Breece iron is an anhydrous red hematite, the material developed in these shafts consists of brown hematite, limonite, and bluish-gray chert, the usual replacement material of sedimentary beds. Moreover in the neighboring shaft of the Theresa mine, shales belonging to the Weber series have been found in the same relative position, for which reason the outcrop is indicated on the map by the color of that formation.

On page 43 of Hayden's report for 1873, this deposit of ore is mentioned, and it is there stated that a similar ore-mass, presumably a part of the same vein, was observed in Iowa gulch, 6 miles south of Stray Horse gulch.

The Breece mine has been worked for some years to supply the Leadville smelters with flux, but during the past summer the demand for the ore has fallen off, owing to the discovery that the second-grade silver ores from the Amie mine would give good results in the furnace, and possessed the advantage of containing a few ounces of silver to the ton. The mine was idle at the date of my visit, November 15, 1880. The sketch (Fig. 222) indicates

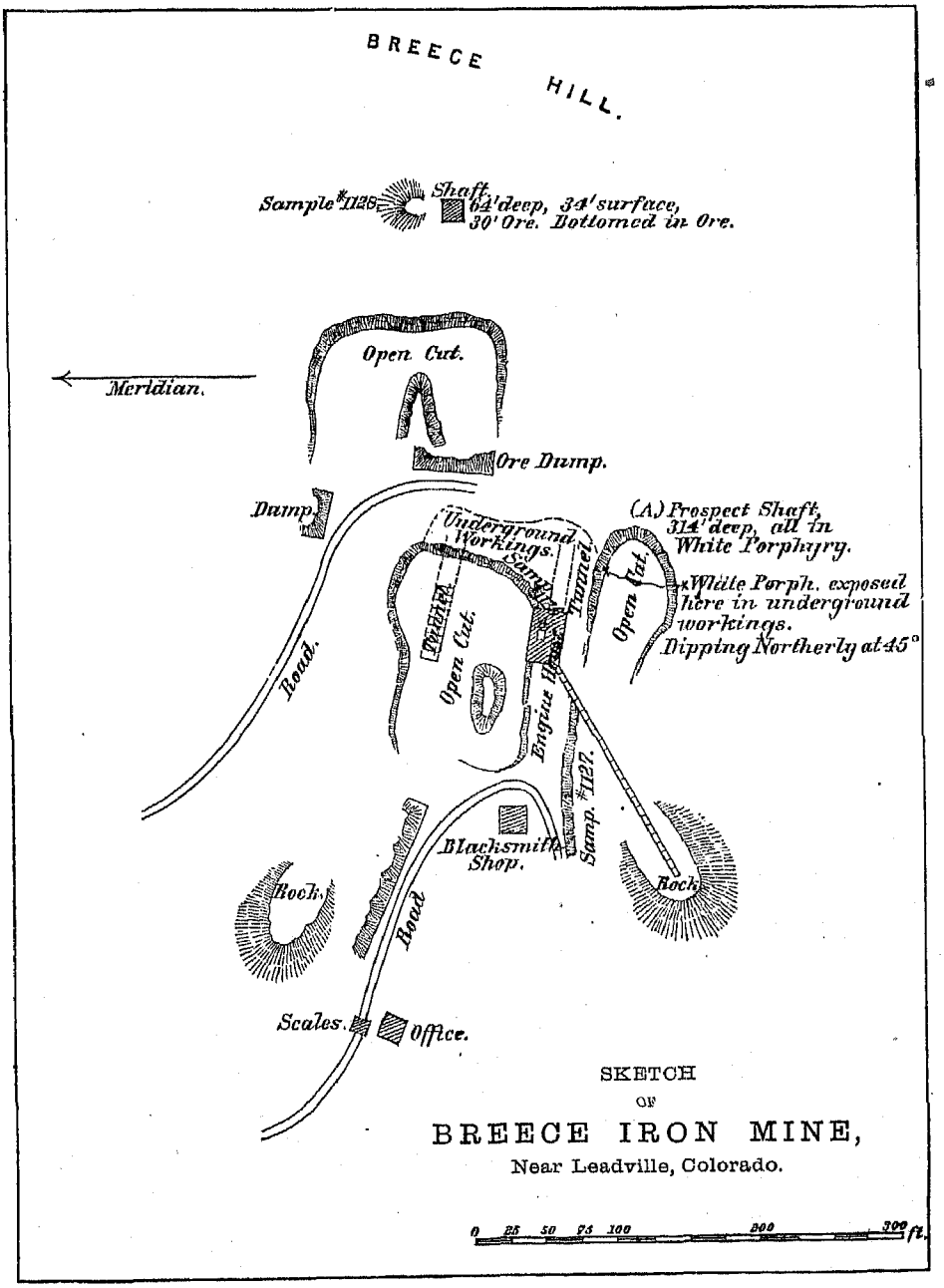


FIG. 222.

a the extent of the developments at that time. It also shows the location of the samples, which were found to contain—

	1126.	1127.	1128.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	64.35	61.51	63.25
Phosphorus	0.017	0.038	0.024
Phosphorous in 100 parts iron	0.026	0.062	0.038

b Sample No. 1126 is from a pillar between two stopes in the underground workings in the lower ore-body. Sample No. 1127 is from a pile of about 100 tons on the dock near the south slope. Sample No. 1128 is from a pile of ore thrown from a new shaft east of the upper cut. This shaft is 64 feet deep, and the lower 30 feet of it are in ore, in which it is bottomed. This ore-body seems to be a portion of the upper bed.

Copies of the following analyses of Breece ore were furnished by Colonel Lamborn:

	A.	B.
	Per cent.	*Per cent.*
Oxide of iron	.....	98.57
Silica	1.605	0.60
Titanium	None.	None.
Sulphur	.....	0.247
Phosphorus	0.008	None.
Manganese and lime	Traces.	None.
Loss	.....	0.583
	.....	100.00
Metallic iron	66.299	69.00

c

Analysis A was made by Booth, Garrett & Blair December 10, 1879. Analysis B was made at the United d States assay office, New York, February 1, 1880.

Limonite.—Although containing too much lead and silver to be in a commercial sense an ore of iron, samples were taken from the low-grade ore of the *Amie* mine. This mine is situated on Fryer hill, near the Little Pittsburgh and Chrysolite mines, and is the first mine about Leadville that has been able to sell its low-grade ore. This ore appears to be much less silicious than the low-grade ores of the neighboring mines, and makes, I am told, a very good flux. It is reported to carry from 10 to 30 ounces of silver to the ton.

During the summer the owners of the Amie mine have sold all the old dumps, and they are now raising 75 tons of low-grade ore a day. The ore seen was partly brown in color and partly dark blue or black. The former is known as "red" and the latter as "black" ore. The red ore is probably a mixture of the hydrous and anhydrous e oxides; the color of the black ore seems to be due to manganese. The samples contained—

	1129.	1130.	1131.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	40.95	50.20	44.38
Phosphorus	0.058	0.076	0.049
Phosphorus in 100 parts iron	0.142	0.151	0.110

Manganese and lead are present in, and titanic acid is absent from, all the above samples.

Sample No. 1129 consists of selected chippings of the black ore. Sample No. 1130 of selected chippings of the f red ore. Sample No. 1131 is from a pile of 500 tons of ore at the Grant smelter. The latter represents a fair average of the "run of the mine".

Perhaps the most remarkable body of iron ore seen by me in Colorado is a deposit of limonite situated in the western foot-hills of the Sangre de Cristo mountains, overlooking the San Luis valley, about 5 miles south of the western end of Hayden's pass. It was noted by Mr. Endlich in 1873 (Hayden's *Report*, etc., 1873, p. 333), but I believe has nowhere been described. The largest outcrop is in what is locally known as Smith's gulch, 8 miles southeasterly from Villa Grove, and 4 miles northwesterly from the now abandoned post-office of Bismarck. From Poncho Springs, the present terminus of the Gunnison extension of the Denver and Rio Grande railroad, the distance to this deposit via Poncho pass, is 30 miles; and it is 25 miles from the point where the railroad, on its way to Marshall pass, will leave Poncho Creek gulch. This, then, is the distance to the nearest point on any railroad in process of construction. On Neil's map of Colorado a "proposed" railroad is laid down, running over Poncho pass through Villa Grove and Saguache to Alamosa. Such a road would pass within 6 or 7 miles of the ore.

One mile south of the ore-deposit are a number of hot springs, which furnish sufficient water to wash several a hundred tons of ore a day, should washing be found desirable. The largest outcrop of the ore is on the north side of the gulch. It is over 100 feet in width, and from a distance it resembles more a mass of magnetite than one of limonite, for its surface is jet black in color, due probably to the presence of manganese. The ore lies in a blue limestone, apparently within the area colored on Hayden's map as Lower Carboniferous. Higher up on the mountain side a white, highly silicious, slaty limestone or calcareous quartzite, containing dendritic manganese, was observed. A great deal of exploring has been done on both sides of Smith's gulch in search of silver-bearing copper ore. At the contact of the iron ore and the limestone there is sometimes a narrow seam of copper-bearing minerals—copper pyrite, copper carbonates, and gray copper. Generally, however, this band is represented simply by a green streak. Assays of the copper ore show only from8 to 20 ounces of silver to the ton; and thus far not more than a few b hundred pounds of this "mineral" have been mined. But it has been with the hope of striking a rich vein that a number of shafts have been sunk and tunnels driven, which now serve to prove the extent of the deposit of iron ore. The relative position of the claims referred to is shown on the accompanying sketch (Fig. 223). There are

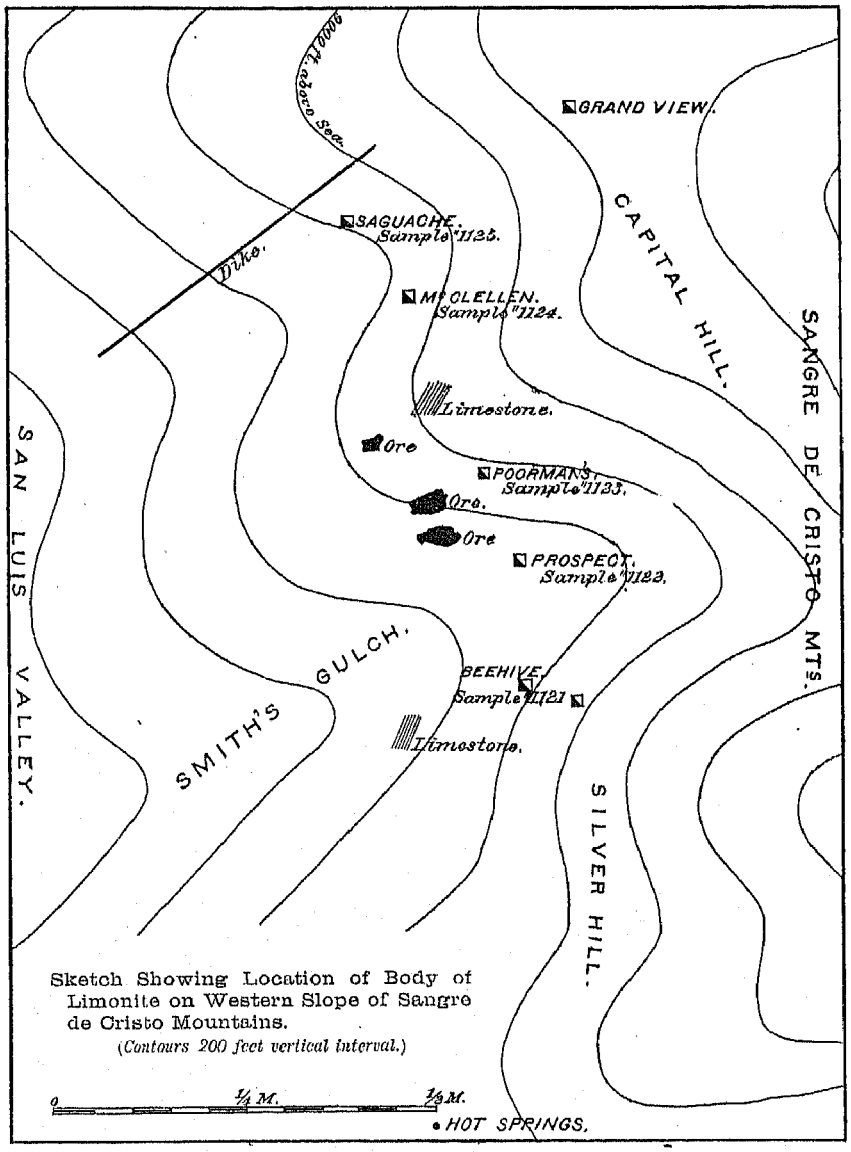


FIG. 223.

two shafts on the Beehive claim on the south side of the gulch. The more easterly of these is nearly 100 feet in depth, and is near the eastern side of the body of iron ore, at the contact of the latter with the limestone. One side of the shaft is limestone; the other three sides are principally yellow and red ochers. Very little good iron ore was seen on the dump. At the western opening a shaft has recently been started from the end of a tunnel, which penetrates the hillside to a distance of 70 feet. The bottom of the shaft is now 20 feet below the tunnel level, and its sides are all good iron ore. On the dump there are many tons of an excellent looking cavernous limonite, which could be used in the furnace without washing. Sample No. 1121 was taken from the dump. On

a the north side of the gulch, east of the outcrop above mentioned, a shaft 74 feet deep has been sunk on the Prospect claim. This shaft is apparently all in iron ore, as the dump shows no rock. The ore in the dump is represented by sample No. 1122. A little gully, filled with surface *débris*, lies between the Prospect shaft and the outcrop of ore.

The *Poorman's* shaft is a small prospect pit situated some 500 feet north of the Prospect, higher up on the side of the mountain spur. A portion of the ore seen here contains considerable red ocher. Sample No. 1123 consists of selected chippings from those lumps of ore which were comparatively free from this substance.

The *McClellan* lode is located in a "wash" north of Smith's gulch. Here a tunnel 40 feet long has been driven into the hillside, the first 25 feet through limestone, the last 15 feet in ore. The end of the tunnel is ore. A slope b of about 50 feet in length has also been sunk along the contact of the limestone and ore (which has an easterly dip of 55°), and a cross-cut begun from the bottom of this slope. The slope is sunk partly in limestone, so that the dump contains a large amount of rock, but the ore exposed along the sides of the tunnel is rich and of good quality. Its principal gangue seems to be carbonate of lime, which often occurs crystallized. Sample No. 1124 consists of a series of chippings taken along the sides of the tunnel, and is believed to represent a fair average of this part of the ore-body.

The *Saguache* claim is northwest of the McClellan. The shaft was filled with snow, but the size of the dump indicates that it is not deep. Part of the ore thrown out from the shaft is a compact red hematite, and contains considerable baryte. A dike-like ridge cuts across the mountain spur north of this claim, which probably explains c the occurrence at this point of anhydrous ore. Sample No. 1125 was taken from a few lumps of ore on the dump near the above shaft.

At a small opening on the Grand View claim, northeast of the McClellan tunnel, and about 10,000 feet above tide-water, there is a small seam of comparatively compact limonite, 1 foot thick, with a strike nearly at right angles with the line of the chief outcrops. Both walls are limestone.

The *Beehive* shaft is over 3,000 feet from the Saguache shaft. How much good ore there is between these two openings now covered with surface *débris* can only be determined by exploration. As a rule limonite occurs in pockets of no very great depth, and there is no evidence to indicate that this rule does not hold in this case. At the same time it is, I think, safe to say that there are here many thousands of tons of ore "in sight". This lies in such a position that it can be cheaply mined, and although it may be desirable to wash a portion of the ore to d separate the ocher, the greater part can probably be used in the furnace as it comes from the ground. Gottlieb Swaltzreade is the owner of the Beehive claim, the Saguache Mining Company of the Prospect and Saguache claims, and the Milwaukee Mining Company of the McClellan claim. The first mentioned was the only one upon which work was being done at the time of my visit.

The following are the analyses of the samples mentioned above:

	1121.	1122.	1123.	1124.	1125.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	54.47	55 56	51.04	55.01	45.39
Phosphorus	0.026	0.058	0.055	0.034	0.045
Phosphorus in 100 parts iron	0.048	0.104	0.106	0.061	0.099

e

Manganese is present in and titanic acid is absent from all of these samples. Large tabular masses of barite occur in the specimen from the Beehive mine (sample 1121).

Carbonate ore and its derivatives.—In connection with the coal-bearing strata of Colorado there often occurs a bed of carbonate of iron, which, through loss of carbonic acid and absorption of oxygen, changes into limonite on exposure to the ordinary atmospheric influences. The fresh carbonate, associated with silica, alumina, etc., is found usually in nodular concretions or "kidneys" in the shales and sandstones. These hard concretions have resisted disintegration more successfully than the material inclosing them, and are found to-day covering the surface of the plains (probably often to some depth) in the neighborhood of the coal strata. Reference has already f been made to the occurrence of this ore near Marshall, Boulder county, where a small furnace was built to work it. Near Walsenburg many tons were seen during a short drive. At Trinidad a small seam was observed a few feet above the coal of the El Moro mine, and at Cañon City the ore also exists in some quantity. The nodular pieces are, as heretofore found, however, too widely distributed, and the seams of the ore are too small to be of much economic importance. The unaltered ore is, moreover, quite lean. The character of the ore as regards iron and phosphorus is shown by the following analyses:

	1104.	1111.	1112.	1113.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	47.89	51.46	27.71	15.63
Phosphorus	0.305	0.047	1.190	0.556
Phosphorus in 100 parts iron	0.637	0.091	4.258	3.557

Sample No. 1104 was collected near the Marshall coal mine, Boulder county. Sample No. 1111 is from near a
the El Moro coal mine. Samples 1112 and 1113 are from near Walsenburg. No. 1112 represents the oxidized
coating of a nodule of ore, and No. 1113 the unaltered kernel.

IRON ORE IN WYOMING.

Magnetite.—Iron mountain, near the headwaters of the Chugwater creek, about 40 miles northwest of Cheyenne, 20 miles northeast of Laramie City, is thus described by Mr. Arnold Hague: (*a*)

" Iron mountain, to which reference has already been made, is a mass of titaniferous magnetite or ilmenite, and is situated just north of the Chugwater creek, about 1½ mile above the point where the stream leaves the hills. The mountain rises about 600 feet above the stream-bed, is irregular in form, but has a somewhat oval-shaped outline. It occurs intercalated in granite, standing nearly vertical, b
with the walls in places sharply defined. This is the case in the cañon, where the dark iron body resembles a broad dike, which rises to the top of the cañon wall. Frequently large masses of granite are nearly incased in the iron, and again the iron body puts out into the surrounding granite. The main deposit of iron is nearly a quarter of a mile in length, with a strike a little to the west of north and east of south. To the north the main deposit terminates somewhat abruptly, but southward it crosses the cañon and may be traced cropping out through the granitoid rocks, with the same general strike for nearly 2 miles in the direction of Pebble creek. These outcrops vary much in size, mostly mere narrow seams and small irregular patches of iron which disappear in the surrounding granite. Still farther south, just above Horse creek, considerable deposits again make their appearance, but much smaller than Iron mountain, and, like the latter, have been held for valuable mineral bodies; they are probably only a continuation of the larger one. The ilmenite occurs chiefly as a compact, massive deposit, iron black in color, with a submetallic luster. It is frequently found, however, with a coarse, granular structure. It is accompanied by small amounts of magnetite and hematite, which decompose, and give portions of the mass a brownish red appearance. Prof. O. D. Allen, of Yale College, examined specimens of the Iron Mountain ore, and found it to contain a mixture of c
ferrous and ferric oxides, which gave 50.83 per cent. of metallic iron combined with 22.32 per cent of titanic acid. Other samples of the ore, analyzed by Professor Richards, of the Institute of Technology in Boston, gave the following results:

	Per cent.
Ferrous oxide	24.55
Ferric oxide	48.97
Titanic acid	23.18
Sulphur	0.03
Residue insoluble in acid	2.15
Total	98.88
Metallic iron	53.33

d

Samples of the coarse, granular variety, collected from the deposits south of Iron mountain, yielded Mr. R. W. Woodward the following:

	Per cent.
Metallic iron	34.29
Titanic acid	40.47

e

All the samples examined gave a very high, although a varying, amount of titanic acid. This high percentage of so refractory a substance as titanic acid renders the vast deposit of iron of but little use for practical purposes in iron smelting, which is to be regretted, as the beds in the Laramie hills could be easily mined, and are so well located in reference to a market, and the known sources of iron in Wyoming are so limited.

The titanic-iron deposits of Canada and Norway would appear to possess very much the same characters, with equally varying amounts of titanic acid in their composition. An analysis of a specimen from Krageröe, in Norway (*Dana, Min.*, 1868, p. 143), gave as high as 46.92 per cent. in titanic acid, and Dr. T. Sterry Hunt (*Geological Survey of Canada*, 1863, p. 501) found 48.60 per cent. from similarly situated beds at Bay Saint Paul, Canada. The ilmenite from château Richer gave titanic acid 39.86 per cent. This occurrence of ilmenite and gabbro so intimately associated together in the Laurentian rocks in widely separated parts of the globe, each with the same physical habits, and in the case of the gabbros of Wyoming and Norway, with the same minute microscopical structure and peculiarities, is most remarkable, and the causes evidently deep-seated.

Hematite.—Two and one-half miles north of Rawlins station there is a deposit of soft, reddish hematite in the f
red sandstone, which, according to Mr. Emmons (*Geol. Expl. 40th Par.*, Vol. II, p. 161), underlies the lower limestone bed (Carboniferous), and is probably "in the lower Palæzoic series of the Laramie hills".

Two mines were opened here in 1871, and were worked until 1877. It is said that over 17,000 tons of ore were shipped from one of these openings, and, judging from the size of the pits, nearly the same amount was taken from the other. The ore was all used by the Utah smelters for flux. Since 1877 a few tons have been dug each year for paint, but no regular mining has been done. The two openings, known from the names of their respective owners as the *Shaw* and the *Friend* mines, are about 500 feet apart. When visited the pits were partly filled with snow and ice, and but little idea could be obtained as to the form of the deposit. The ore seen, however, appears

a Geological Exploration, 40th Parallel, Vol. II, p. 14 *et seq.*

a to be in more or less irregular pockets in the sandstone, and it seems probable that the pockets opened upon are practically exhausted. There is no very sharp line of separation between the ore and the sandstone, and I am told that the last ore shipped to Utah was very silicious. Specimens of the ore from each opening contained—

	1133.	1134.
	Per cent.	*Per cent.*
Metallic iron	56.96	63.29
Phosphorus	0.046	0.593
Phosphorus in 100 parts iron	0.081	0.937

b Carbonate ore of the coal strata, and limonite derived therefrom, is found at Evanston and elsewhere in the territory.

IRON ORE IN DAKOTA.

In his report on the *Geology of the Black Hills of Dakota*, p. 57, Mr. Newton refers to the occurrence of hematite as follows:

In several localities the silicious slates (Archæan) contain, interlaminated with them, immense quantities of iron, almost always specular oxide. On Box Elder creek a ridge some 400 feet in height is composed of a vast deposit of silicious hematite, which was estimated to be from 800 to 1,000 feet in thickness across the upturned strata. Occasionally, bands of almost pure specular hematite several inches in thickness are found in the mass, with frequent layers of highly crystallized micaceous hematite. The body of the c ferriferous strata, however, is highly siliciferous, and entirely useless as an iron ore, consisting of thin strata, an inch or less in thickness, of specular hematite, alternating with silicious slates or with pure white quartz in seams or irregular masses, the whole presenting a remarkable resemblance to the silicious banded hematite of the Huronian of the Lake Superior region. In other localities on the same creek hematites were also found, but nowhere of any practical value, because of their highly silicious character.

Mr. Jenney, on page 295 of the same volume, reports that—

Blue-block iron ore (siderite), weathering to limonite, was found of good quality in the black clay shales of the Cretaceous on Beaver creek. The deposit covered quite an area, and consisted of three horizontal layers, respectively, 8 inches, 3 inches, and 5 inches thick, separated by a few feet of clay shales. The ore closely resembles the block ores of the coal measures of Kentucky and Pennsylvania, which are worked in the small charcoal iron furnaces scattered through the timbered districts.

d

IRON ORES IN UTAH.

In the extent of its iron-ore deposits Utah may be considered the most favored region west of the 100th meridian.

Probably the largest masses of iron ore in the whole west are located in the western part of Iron county, about 225 miles a trifle west of south of Salt Lake city. The ore occurs in a subordinate ridge of the Wahsatch mountains known as the Iron mountains. This ridge is separated from the main range by Rush Lake valley, and overlooks the Escalante valley on the west. Attaining its greatest height in the rim of the Great basin at the south, the Iron mountains break gradually down toward the northeast into a series of rounded hills. The general direction of the range is northeast and southwest.

The ore deposits are in two distinct groups, *i. e.*, the Iron Springs group and the Iron City (or Oak Springs) group. The former is the most northerly. It is about 8 miles between the most southerly outcrop in the Iron e Springs group and the most northerly one in the Iron City group, but it is possible that future explorations may discover ore in this apparently barren belt. There is also iron ore in one of the two hills called the Desert mounds, which rise directly from the desert, a couple of miles west of the main ridge of the Iron mountains and 5 miles from Iron Springs.

The Iron Springs group.—Iron springs is 10 miles north of west from Cedar City, a Mormon settlement on the stage route from Milford (the present terminus of the Utah Southern railroad) and Silver Reef, and is distant 60 miles from the former and 36 miles from the latter place. At the springs the mountain ridge is cut in two by a broad transverse valley, which subdivides the group of deposits into two groups. On the north of this valley the following claims have been entered: Marshall, War Eagle, Great Western, Lost Horse, Othello, Desdemona, Atkins, Western Extension of Atkins, McGary, Norvell, Lillian, Sundown, Cumberland, and Martin. The three f first named are nearest the springs, and are by far the largest of the group. The northernmost claim is about 2 miles from the Great Western, and the others are at various intermediate points.

Of the three large outcrops, the *Marshall* is the farthest eastward. The ore forms the crest of a hill, 75 to 100 feet in height, and outcrops for 300 feet in a north 55° east direction. The dip is at a high angle, probably toward the southeast. The vein is about 50 feet wide at the middle of the outcrop, but it narrows slightly toward either end. The ore is very magnetic, and deflects the compass needle strongly, and yet attempts made to trace it from the outcrop in the direction of the strike with the dip-compass were unsuccessful. This seemed to me so curious that observations were repeated at various points, but always with negative results. It would appear from this that the ore-masses outcrop their full length and terminate quite abruptly. The different iron deposits seem to be entirely isolated from each other. The ore is compactly crystalline, often porous, and contains little scales of brown mica, and occasionally bunches or groups of minute octahedral crystals of magnetite. Sample No. 1141 consists of a series of chippings across the outcrop.

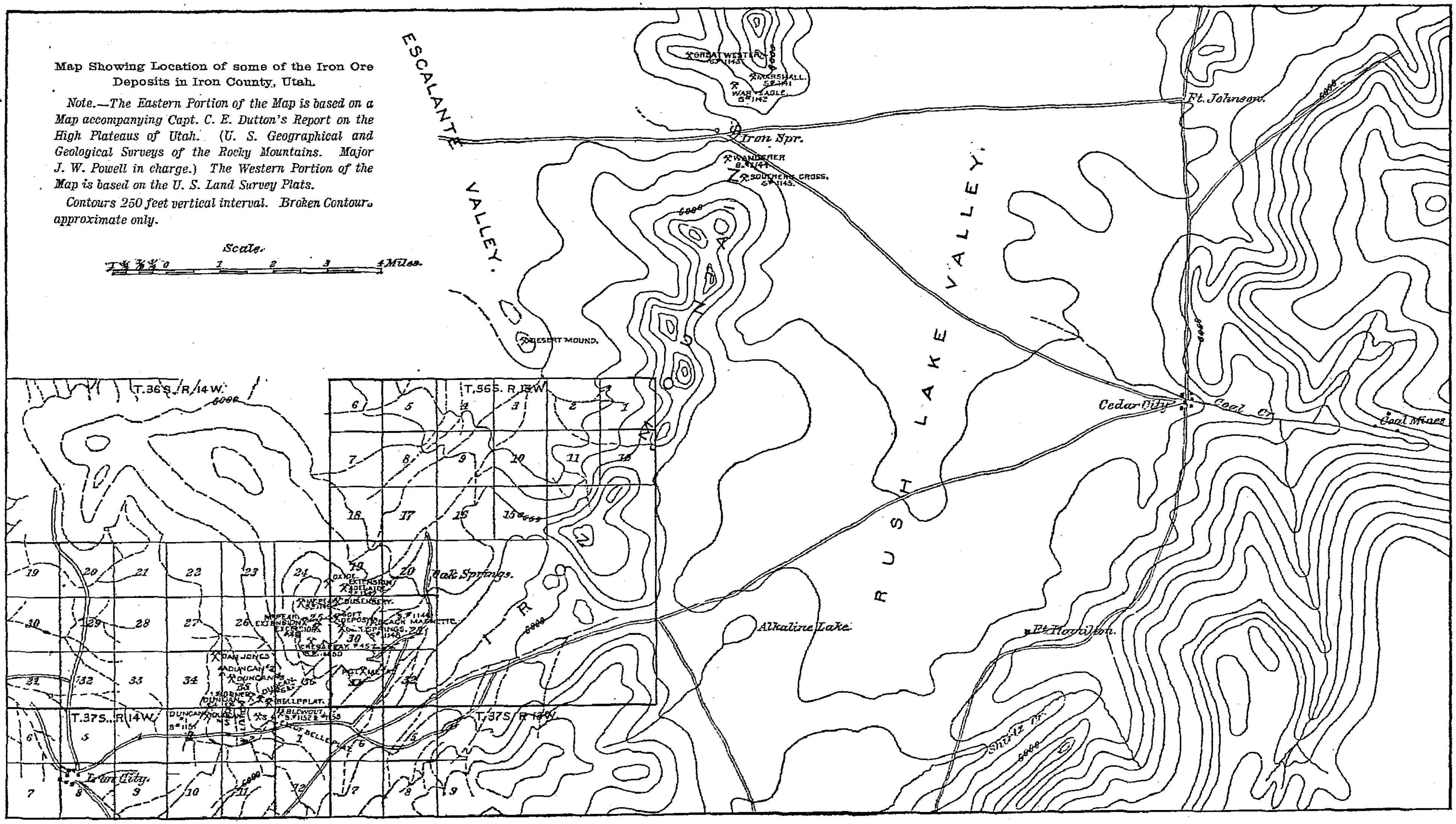

Map Showing Location of some of the Iron Ore Deposits in Iron County, Utah.
Note.—The Eastern Portion of the Map is based on a Map accompanying Capt. C. E. Dutton's Report on the High Plateaus of Utah. (U. S. Geographical and Geological Surveys of the Rocky Mountains. Major J. W. Powell in charge.) The Western Portion of the Map is based on the U. S. Land Survey Plats.
Contours 250 feet vertical interval. Broken Contour approximate only.
Scale.
4 Miles.
ESCALANTE VALLEY.
RUSH LAKE VALLEY.
Iron Spr.
Ft. Johnson.
Cedar City
Coal Cr.
Coal Mines
Alkaline Lake
Ft. Hamilton.
Desert Mound.
Oak Springs.
Iron City.
T.36 S. R.14 W.
T.36 S. R.13 W.
T.37 S. R.14 W.
T.37 S. R.13 W.

Fig. 224.

a The *War Eagle* (sample No. 1142) is about 750 feet west of the Marshall. It also forms the crest of the hill. The outcrop is perhaps 300 feet long by 150 to 200 feet wide, and in shape is approximately oval. The direction of the longer axis is about north 35° or 40° east. The height of the hill is about 100 feet. Blue limestone covers the south side of the hill, and outcrops within 20 or 30 feet of the ore. The north side of the hill is covered with trachyte(?). The ore resembles that from the Marshall claim. The specimen sent in is, however, more porous, and suggests at once a metamorphosed limonite. Groups of magnetite crystals occur in many of the cavities.

The *Great Western* (sample No. 1143) is about a quarter of a mile from the War Eagle, in a direction a trifle north of west. The ore outcrops along the crest of a trachyte(?) covered hill, about 200 feet high. At the top of the hill the rock is hard and solid, but around the base, and especially on the northeast side, it is much decomposed. b A drift enters the hill at one point for 50 feet, entirely in this decomposed, kaolin-like material. There are four parallel outcrops on the hill. The largest of these is 750 feet long and 12 feet wide. The inclosing rock has been eroded on either side, and the top of the outcrop is, at some points, 25 feet above the surface. This immense ridge or "comb" contains at least 20,000 tons of ore. It dips at an angle of 75° to the north (the strike is nearly east and west), and the south side of the hill is completely covered with boulders of ore of all sizes. I should estimate the ore above ground on this hill at between 25,000 and 30,000 tons. The other three veins are shorter and smaller in every way; still they undoubtedly contain a large amount of ore. The character of the ore is as remarkable as the deposit itself. There are numerous seams or cracks parallel with the strike of the ore, the sides of which are completely covered with crystals of magnetite. These crystals are chiefly octahedra, and vary in size from less c than one-sixteenth to three-quarters of an inch in length. I found several clusters of rhombic-dodecahedra, but this form was comparatively rare, although the octahedral crystals were often modified with dodecahedral faces. Narrow crystals of apatite, almost white in color, and sometimes 2 or 3 inches in length, occur through portions of the ore.

On the mountains south of the springs the following claims have been located: Wanderer (sample No. 1144), Southern Cross (sample No. 1145), Pioche, Little Mormon, Vermilion, Eclipse, Prince, Lindsay, Game Cock, and Little Allie. The first two named overlook the springs, and are said to be the largest of the group. They contain an immense quantity of ore, as each deposit forms an essential portion of the mountain spur in which it lies. The ore is, as a whole, leaner than that north of the springs. The gangue is chiefly white quartz. Apatite occurs in considerable quantities. The general appearance of the ore is the same as that from the War Eagle and Marshall d outcrops, excepting that a portion of it, especially at the Southern Cross claim, is partly peroxidized. It is, however, strongly magnetic. Several of this group of claims are on so-called "soft deposits". The Vermilion is so named on account of the color of the ore and the earth near it.

The Desert mounds were not visited.

The accompanying map (Fig. 224) shows the position of all the claims in the Iron City group. Of these the following were visited and sampled:

The *Black Magnetic* (sample No. 1146) includes two parallel veins of ore near Oak springs. The ore is of good quality and contains but little gangue.

The *Adelaide* (sample No. 1147), one of the so-called "soft deposits", is situated a half mile northwest of the Black Magnetic. It seems to form the principal portion of a low hill. A drift enters the hill 25 or 30 feet, and is e all in ore. The ore is quite soft (in the drift it can be picked down readily). It gives a yellow to dark brown powder, which is largely taken up by the magnet, and in mass the ore deflects the compass-needle.

The *Oak Springs* claim (sample No. 1148) is on a vein of magnetic ore which outcrops on a mountain spur in a general northeasterly and southwesterly direction. Much of the ore is largely mixed with white quartz, but there is a large quantity of rich ore in the deposit. The ore is remarkable for its magnetic energy, furnishing excellent specimens of lodestone.

The *Mountain Peak* vein (sample No. 1149) outcrops along a shoulder of Mountain peak to its summit. It is 8 to 10 feet thick, very regular, strikes N. 6° W., and has been traced for 800 or 1,000 feet. It is too inaccessible to be of any immediate value.

The *Excelsior* and *Chesapeake* veins (sample No. 1150) are on the southern slope of Mountain peak. The last f named is about 10 feet thick, and outcrops for several hundred feet, the ore in many places standing 12 or 15 feet above the surface. It is very free from gangue. The ores represented by samples Nos. 1146, 1148, 1149, 1150 are very much alike in general appearance. The magnetite is, as a rule, very compactly crystalline.

Blowout mountain, or the Big Blowout, as it is sometimes called, southwest of Mountain peak, is generally spoken of as being the largest mass of ore in Utah. It is an isolated hill or butte, 600 or 700 feet long, 350 to 400 feet wide, and about 200 feet high. It is 21 miles from Cedar city and 5 miles from Iron city, near the road between the two places. Trachyte(?) outcrops on the northern and limestone on the southern slope of the hill, but its main mass appears to be magnetic ore. Portions of the ore-mass contain considerable quartz, but there is here, apparently, an immense quantity of rich, pure ore, capable of being mined by the simplest operations, and located very conveniently for transportation. A railroad could be built directly to the hill, and the cars could be run into an open quarry, in which there would be a breast of ore over 100 feet high and possibly 250 to 300 wide. Occurring at many points on the hill, but especially near the top, are masses of ore, with a concretionary and

radiated structure similar to limonite, which show, as suggested by Dr. Newberry, the sedimentary origin of the a ore-body. Sample No. 1153 consists of numerous chippings of this variety of ore. Sample No. 1152 consists of a series of chippings taken at uniform intervals across 150 feet of the outcrop, where the ore is freest from quartz intermixture. It represents a fair average of a large portion of the ore-mass.

West of Blowout mountain there are several so-called "soft deposits", the largest of which, known as *Duncan No.* 1, is located a few rods north of the Iron City road. The southern part of the hill is limestone (which also covers the valley to the south). The top of the hill is mainly a lean, partially-weathered, although quite hard, magnetite. Two drifts have been driven into the hillside above the limestone, one 50 feet and one 25 feet in length. The former passes through 15 feet of soil and 35 feet of soft ore; the latter through the same amount of surface material and 10 to 12 feet of ore. The ends of both drifts are ore. The ore resembles that of the Adelaide (sample No. 1147). The powder is nearly all lifted with the magnet. Sample No. 1151 was taken along the sides of the b drifts. The samples contained—

	1141.	1142.	1143.	1144.	1145.	1146.	1147.	1148.	1149.	1150.	1151.	1152.	1153.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	57.55	61.43	67.81	64.09	61.64	67.09	63.21	65.48	67.09	68.06	60.41	67.31	68.44
Phosphorus	0.248	0.198	0.113	0.264	0.425	0.080	0.182	0.064	0.093	0.059	0.066	0.057	0.038
Phosphorus in 100 parts iron	0.431	0.312	0.167	0.412	0.689	0.119	0.288	0.098	0.139	0.087	0.111	0.085	0.055

Two analyses of the ore from this region by Captain C. E. Dutton, of the Ordnance Corps, U. S. A., were c published in Vol. III of Lieutenant Wheeler's *Report on Explorations and Surveys West of the 100th Meridian.* They are as follows:

	Red hematite ore.	Magnetic ore.
	Per cent.	*Per cent.*
Insoluble residue (silica and silicates)	3.34	3.81
Magnetic oxide of iron (Fe_3O_4)	5.64	67.68
Peroxide of iron (Fe_2O_3)	82.97	28.00
Water	6.06	0.10
Alumina	1.35	0.38
Manganese	.....	Trace.
Sulphur	0.06	None detected.
Phosphoric acid	0.19	None detected.
Lime	0.33	.....
Total	99.94	99.97
Metallic iron	62.16	68.61

d

As to the age of these deposits nothing definite is known, and the solution of the problem will necessarily be greatly complicated by the overflows of eruptives, which cover the sedimentary rocks near almost all of the outcrops. e Limestone occurs in the lower valleys, and at Iron springs sandstone and conglomerate were observed, apparently overlying the limestone.

Professor Newberry visited this locality in 1879, and in a paper on the "Genesis of Our Iron Ores" (*School of Mines Quarterly*, November, 1880) he briefly describes them. He says: "As to the age of this remarkable series of iron-ore deposits I cannot speak with absolute certainty, though they are apparently Lower Silurian."

In the Wah-Wah mountains in Beaver county, 35 or 40 miles west of north from Iron springs, magnetite oxidized at the outcrop to limonite has been mined, and teamed to Frisco for flux. Samples of the ore were collected at the Horn Silver smelter at Frisco. Sample No. 1135 is from a pile of 25 tons of ore from *Bowen's* mine, a small opening on the east slope of the Wah-Wah mountains, about 22 miles southwest from Frisco and 15 miles northeast of Sulphur springs. The ore sampled was all peroxidized. Sample No. 1136 was also taken f at the Horn Silver smelter, from 15 tons of ore, from *Money's* mine, on the ridge of the Wah-Wah mountains, 6 miles west of Bowen's mine and about 20 miles from Frisco. The ore is a mixture of the per- and magnetic oxides.

The samples contained:

	1135.	1136.
	Per cent.	*Per cent.*
Metallic iron	60.63	57.84
Phosphorus	0.012	0.015
Phosphorus in 100 parts iron	0.020	0.026

a A deposit of hematite, probable the croppings of a vein of magnetite, has recently been opened upon on the west side of the Frisco mountains, about 6 miles from Frisco. The ore will be teamed to the lead smelters.

In the Star mining district, in the Picacho mountains, between Frisco and Milford, there are several deposits of iron-ore. The *Vulcan* mine, on the east side of the range, about 7 miles from Milford, has sent some ore to Frisco. The ore is a limonite, and is reported to carry a small amount of silver. Sample No. 1137, from a few tons at the smelter, represents this ore. The analysis shows it to be fairly rich in iron, but it is said to make a poor flux, and but little of it has been used in the furnace. A portion of the pile was certainly very silicious.

The *Lake Superior* mine, at the north end of the district, about 7 miles from Milford and 3 miles from the railroad between Milford and Frisco, was entered for copper by Forgie Brothers, of Frisco. The claim includes an b irregular deposit of magnetic ore, 80 feet wide at one place, with an outcrop 500 feet long, lying between quartzite and granite. The strike of the ore is northeast and southwest. Toward the southwest it can be traced up a little ravine, between a spur of granite on the northwest and one of quartzite on the southeast, but within 500 feet of the widest part of the ore-belt outcrops of granite and quartzite were observed, only a few feet apart. On the side of this ravine two shafts have been sunk, in search of copper ore, to depths of about 60 feet each. The dumps near these shafts consisted of quartzite stained with iron oxide and copper carbonate. In some specimens a little copper oxide could be seen. In a prospect shaft 150 to 200 feet northeast of the widest part of the ore outcrop a lean magnetite ore was seen; but a short distance beyond this, and in the line of the strike, there are several outcrops of granite and quartzite. The ore contains a great deal of carbonate of lime, and the average of the vein would probably not yield over 30 per cent. of metallic iron, but there are numerous little seams, a few c inches in width, which will run perhaps 60 per cent. in iron. Sample No. 1140 represents the better quality of the ore. It consists of numerous chippings from different parts of the outcrop. The high percentage of phosphorus is a noticeable feature. No apatite was noted in the ore.

The Rocky mining district is about 3 miles northeast of the north end of the Star district, in the same general range of hills, which latter are, however, cut by a broad transverse valley between the two districts. The railroad from Milford to Frisco passes through this valley. In the southern end of the Rocky district, 4 miles from Milford, and about 1 mile from the railroad, many claims have been located on supposed copper veins, and some magnetic ore has been mined and teamed to Frisco. The largest opening on the iron ore is on the eastern slope of a spur of the hills overlooking the Beaver river, and was worked by the Frisco Mining and Smelting Company. The d excavation is partly open cut and partly underground, but is not more than 15 or 20 feet deep. The body of ore is very irregular and different parts of it appear to vary greatly in richness. The mine has been idle for some months; a sample of the ore (No. 1139) was collected at the Frisco smelter. The rock in the immediate vicinity of the mine is quartzite; granite outcrops a few rods to the east, lower down the hillside. A few hundred feet west of the opening there is an outcrop on a vein of ore, which from its direction appears to be an extension of the Lake Superior belt in the Star district. This vein also is very irregular, and much of the ore is too lean to be valuable.

In the Bradshaw mining district, in the Mineral range of mountains, an argentiferous limonite occurs. From the *Cave* mine in this district, 7 miles southeast of Milford, worked by the Frisco Mining and Smelting Company, an ore is obtained which is said to average $20 75 in gold and silver to the ton. Sample No. 1138 is from a pile of 20 tons of this ore at the smelter.

e The above-mentioned samples contained:

	1137.	1140.	1139.	1138.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	49.61	57.25	62.23	39.31
Phosphorus	0.139	0.237	0.014	0.044
Phosphorus in 100 parts iron	0.280	0.414	0.022	0.112

The East Tintic mining district, in the dividing ridge between Goshen and East Tintic valleys, contains important deposits of limonite, which have been worked for several years past to supply the lead smelters at Sandy f with flux. The mines are situated on both sides of the divide. Those on the east of the ridge are about 16 miles west of Santaquin. Much of the surface of Goshen valley is only a few feet above Utah lake, and the bottom lands, over which the road to the mines passes, are sometimes flooded and often very muddy. This mud is largely adobe, so that the teaming is at times very heavy and difficult. A railroad could probably be built around the southern rim of the old Utah lake basin quite easily, and I understand such a road has been talked about. The ore occurs in irregular deposits at the contact of limestone and a much decomposed rock locally known as "porphyry". The explorations of the Fortieth Parallel did not extend so far south as this, and I believe the district has never been studied geologically.

The Oquirrh mountains, of which the Tintic mountains are a southern extension, are, however, mainly composed (according to the Fortieth Parallel maps) of Carboniferous rocks, and it is not improbable that the limestone found in contact with the ore is of Carboniferous age.

The conditions surrounding the ore-deposits resemble in many particulars those at the Breece mine, near Leadville. The mines are chiefly worked in open cut, but a few of the larger ones are now partly underground. No timbering is used in any of the openings and no machinery. In many cases the carts can be backed directly to the face of the ore; where this is not possible the ore is wheeled in barrows to the dump. The openings are all in the hillside, and generally some distance above the bottom of the gulch, so that all surface-water drains off naturally and no pumps are required.

The following is a list of the mines, with their respective owners:

Name of mine.	Location.	Owner.	Operator.	No. of men employed.
East of divide.				
Black Stallion	Black Stallion gulch	Oliver Durant	Henry Dieterle	12
Red Chief	do	Henry Dieterle	do	6
Billings	do	John Snell	Thomas Clayson	3
Red Stallion	Burriston gulch	Henry Dieterle and Riter	Henry Dieterle	2
Hematite	do	William Fall	William Fall	3
Sailor Boy	do	Henry Dieterle	Henry Dieterle	3
Queen of the West	do	do	do	3
Iron Queen	Black Stallion gulch	A. Peryon	A. Peryon	6
Mountain Chief	do	A. Noon	A. Noon	3
Raven	Noon's hollow	do	do	3
Double Cave	do	do	do	3
Vulture	do	do	do	6
West of divide.				
Le Bonde	Ruby hollow	Henry Dieterle and Riter	Henry Dieterle	2
Southern Extension Dragon	Dragon's hill	W. Huntington	do	12
Iron Clad	do	A. Peryon and Green	Peryon and Green	2
Reverse	do	Green	Green	2
Eliza	do	do	do	2
Total				61

The Black Stallion was opened in 1873 or 1874; the Billings in 1874; the Iron Queen and the Mountain Chief in 1875. West of the divide, the Le Bonde was opened in 1873; the Southern Extension of the Dragon late in 1877. All the other mines have been opened since 1878. The Dragon mine proper is a silver mine. No patents have thus far been obtained. The claims are held by assessment work only, and as there is no machinery, there has been practically no investment either in property or in plant.

The peculiarity of most of the ore is its dark color, due probably to the presence of manganese. The Black Stallion ore (sample No. 1155) is especially noticeable in this respect, but the ore from nearly all the mines is dark, and much of it is almost black. The ore in the stopes is quite soft, and is picked down readily. With the exception of pockets of white and gray clay, the ore-mass is quite free from gangue matter. The walls, however, are so irregular that mining to any great depth will be expensive on timber account. The mines west of the divide were idle at the date of my visit, as there was too much snow in the mountains to permit teaming the ore across them; but a sample (No. 1160) was taken from 50 tons of ore from the Southern Extension of the Dragon, piled near the stage-station. The samples collected from this district contained—

	1155.	1156.	1157.	1158.	1159.	1160.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	52.47	48.21	61.18	51.40	46.46	59.30
Phosphorus	0.043	0.096	0.142	0.420	0.052	0.259
Phosphorus in 100 parts iron	0.082	0.199	0.232	0.817	0.112	0.437

Sample 1155 is from 30 tons of *Black Stallion* ore; color of ore blue-black, of powder dark brown. Sample No. 1156 is from face of stope and from small pile of broken ore in *Hematite* mine; color of ore reddish brown, of powder dark brown. Sample No. 1157, from broken ore and face of stope in *Sailor Boy* mine; color of ore almost blue-black, of powder dark brown. Sample No. 1158, from face of stope in *Queen of the West* mine; color of ore reddish-brown, of powder yellowish-brown. Sample No. 1159, from 50 tons of ore from *Billings* mine; color of ore blue-black, of powder dark brown. Sample No. 1160, from 50 tons of ore from *Southern Extension of the Dragon* mine; color of ore blue-black, of powder brown.

The variation in the percentage of phosphorus is great. With the exception of No. 1160, the samples were collected from mines all within an area of an eighth of a mile radius. It may be noted that the Queen of the West (sample No. 1158) is a small opening, so that the sample is taken almost from the outcrop.

At Ogden I was told that there were numerous deposits of excellent iron ore in the Wahsatch mountains,

a within a radius of 10 or 12 miles of the city. Ogden cañon was said to be especially rich in this ore, and several so-called iron mines were visited, but I did not see anything which seemed to me of importance. Several localities on the mountains I was unable to go to, however, on account of deep snow.

The *Vulcan* mine is on the south side of Ogden cañon, about 2½ miles from the city of Ogden. It is a mere prospect pit on a quartz seam impregnated with oxide of iron (sample No. 1161). A few specimens of a silicious hematite were seen in the dump, but I saw nothing to indicate the presence of a workable body of ore. Two or three claims have been located on this same quartz seam, which appears to extend along the side of the cañon for some distance.

On the east side of Cold creek, a tributary to Ogden river, about 7 miles from Ogden city, there is a layer of
b red ferruginous rock lying between quartzite (Ogden?) and slate, which it has been supposed was a valuable iron ore. I am told that some of this "ore" was used in the Ogden blast furnace. The vein is thin; at no point where it has been opened upon is it more than 6 inches in width, and the ore is seen from the analysis (1162) of selected chippings to be worthless as an ore of iron.

On the western side of Willard peak, overlooking Great Salt lake, and about 2¾ miles from the town of Willard, a station on the Utah and Northern railroad, 14 miles from Ogden, is a deposit of micaceous specular ore. It is owned by J. M. Barker, and Harden Brothers, of Willard, and was opened in 1870, and between that date and 1873 some 7,000 tons of ore were mined, and about 5,000 tons were shipped to the lead smelters for flux. The remaining 2,000 tons are stocked at the foot of the mountain, back of Mr. Barker's house, 1¼ mile from Willard
c station. Since 1873 assessment work only has been done at the mine. The mine was not visited owing to snow, but the ore is said to lie between slaty limestone and quartzite; it is probably therefore in the Cambrian. The ore in the pile was very silicious, and the quartz material was so thoroughly intermixed with the ore that it would be difficult to "cob" it successfully. Sample No. 1163 is better than the average of the pile, and yet it contains only about 50 per cent. of metallic iron.

The three samples last mentioned contained—

d

	1161.	1162.	1163.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	45.94	9.89	51.31
Phosphorus	0.026	0.130	0.038
Phosphorus in 100 parts iron	0.057	1.315	0.074

IRON ORES IN MONTANA AND IDAHO.

As mentioned in a foot note on p. 472, neither Montana nor Idaho were visited in the winter of 1880–'81, and no definite information regarding the iron ore resources of that region were then obtained. Since then the work of the Northern Transcontinental Survey has proved the existence of numerous, and in some instances, important iron-ore deposits. A deposit at Cable mountain, Deer Lodge county, Montana, and one on East Boulder creek, Gallatin
e county, are referred to in the note.

IRON ORE IN NEVADA.

I learned very little about iron ore in Nevada, but it is not improbable that it exists, and in workable quantities, at many points in the state.

On pages 585 and 586 of Vol. II, *Geological Explorations Fortieth Parallel*, Mr. S. F. Emmons describes a body of ore near the line of the Central Pacific railroad as follows:

In the neighborhood of Palisade cañon, the andesite core of the range has been overflowed and mostly concealed by a flow of trachyte, which in its turn is covered by extensive flows of rhyolite, which mask the greater portion of the range north of the river. * * * Apparently inclosed in this trachyte, on the south bank of the river, at the mouth of a little side-cañon, is a hill a few hundred feet in height, containing a large mass of iron ore, remarkably fine-grained, and having a thoroughly conchoidal fracture. At a little distance it might be mistaken for a basaltic rock. An analysis of this ore, made by Mr. B. E. Brewster, gave the following results:

f

	Per cent.
Ferric oxide	84.217
Alumina	0.178
Manganous oxide	1.454
Magnesia	0.472
Water	1.713
Insoluble residue	12.518
Total	100.552

Which would give a percentage of metallic iron 58.95. The occurrence of such a body of iron ore in the midst of volcanic rocks is an interesting phenomenon, though it is probably too far from any source of fuel-supply to be of practical value. It is, however, a remarkably pure ore, being entirely free from phosphorus or sulphur, though containing a rather high percentage of silica.

At Humboldt station Mr. C. S. Wright, the proprietor of the Humboldt house, gave me a large specimen of a magnetic ore, which he told me was found in the Jackson mountains, about 40 miles northwest of Humboldt, where "a vein of ore 15 feet wide can be traced for several thousand feet". Chippings from the specimen contained—

	1164.
	Per cent.
Metallic iron	66.75
Phosphorus	0.320
Phosphorus in 100 parts iron	0.479

The ore is a massive magnetite, free from pyrite, but containing numerous long, whitish crystals of apatite. b

IRON ORE IN CALIFORNIA.

In Blake's *Report of a Geological Reconnaissance in California* (New York, 1858), in Whitney's *Report of the Geological Survey of California*, Vol. I (1865), in J. Ross Browne's *Report on the Mineral Resources of the States and Territories West of the Rocky Mountains* (Washington, 1868), and in several of the volumes of Raymond's *Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains*, mention is made of the occurrence of iron ore at a number of localities in the state of California. A list of these will be given hereafter. With the exception of the deposits of chromic iron ore, valuable for its chromium, there appear to be, however, but two groups of deposits which have thus far attracted much attention as a probable source of iron. One of these lies c in the foot-hills of the Sierra Nevada, in Placer county, the other higher up in the mountains, partly in Sierra and partly in Plumas county.

The latter is owned by the Sierra Iron Company, and was reported on by Baron F. von Richthofen in 1865, and by Clarence King and James D. Hague, conjointly, in 1873. Von Richthofen's report was published in pamphlet form at Virginia City, Nevada, November, 1865. Messrs. King and Hague's report has, I believe, never appeared in print in entirety, but a long abstract was published in Raymond's report for 1874, pp. 44 *et seq.* Von Richthofen described the geographical and geological position of the deposits and the character of the ore as follows:

Locality.—California, though rich in many other metals, has heretofore proven poor as to the occurrence of the ores of iron. The rumor of the discovery of valuable deposits in 1864–'65 in the higher parts of Sierra county appeared, therefore, to offer a subject worthy d of exact examination. During repeated visits to these places from May to October, 1865, I have found that the deposits, so far as explored till then, are situated on the headwaters of the North and Middle forks of the North Yuba river, about 12 miles east-northeast of the city of Downieville, and a few miles north of the culminating rocky summits of the Sierra buttes. The country is mountainous; its waters escape to the west through ravines. Near their sources these ravines expand to basins and valleys, often filled by lakes and separated from each other by ridges of little elevation above their level. Communication, therefore, is comparatively easy between the different parts of these highlands, as well as with the adjacent eastern valleys, such as Mohawk valley and Sierra valley, which again are connected by excellent roads with the state of Nevada. The iron deposits are situated near the high parts of these mountains, along a line of about 2 miles in length, which connects some of the above-mentioned basins, its southerly end starting from Gold valley, on the Middle fork, while its northerly end extends to a depression on the headwaters of the North fork, and the central part runs through a gap between both forks. Gold valley is a fine basin with good meadows on the bottom-lands and timber on the surrounding hillsides. Its altitude is from 6,000 to 6,200 feet above the level of the sea, while the iron-ore deposits at the northern extremity of the line may have an elevation of 6,500 feet. The timber extends far above this altitude. Winter in these mountains is severe, but will not interrupt e smelting-works if sufficient supplies of ore and fuel are provided.

Geological formation.—The deposits of iron-ore occur along a line bearing about NNW.-SSE. in an equally directed belt of a certain class of metamorphic rocks, which is bounded east by granite and west by metamorphic slate, and extends over 4 miles in width, by several times this amount in length. It consists of hard rocks, distinguished by their silicious and often ferruginous character, the constant presence of hornblende and chlorite as ingredient parts, a great variety of stratification, which frequently is missing. It is well known as one of the richest gold-bearing belts in California, the veins being among the widest and most continuous which are worked to profit, and containing the precious metal remarkably equally dispersed, while the slate to the west and the granite to the east contain generally but poor or barren veins of quartz. Some gold-bearing veins are being worked profitably close to the deposits of iron ore.

Parallel to the western boundary line of this belt, and a little distant from it, runs a series of small bluffs of yellow crystalline limestone, bounded on both sides by chlorite slate. The iron ore accompanies this limestone in the shape of abrupt deposits of varying extent. Neither the limestone nor the iron ore forms a continuous band, but either of them occurs in apparently disconnected bodies along one and the same well-defined line. It therefore happens that the iron ore in places is connected with the lime, while at others it f is imbedded in and forms part of the chlorite slate. The shape of these deposits is what is called in German "Erzstock".

Character of the ore.—These mines can boast of the best quality of iron ore which is known to exist. They consist altogether of magnetic ore, the same from which the celebrated Swedish and Russian iron is manufactured. Practically, this ore occurs at your mines in three different conditions:

First, massive magnetic iron ore of remarkable purity. It is very fine-grained, and reminds one of the appearance of steel. Its yield in iron is from 60 to 65 per cent.

Second, a mixture of pure magnetic ore with carbonate of lime. The latter is in a state of calcspar, or marble, and fills cavities in the former. If not present in too large quantity, it rather improves the ore by serving as a flux. Different bodies present different gradations of the combination of the two substances, from pure magnetic iron to limestone, with an admixture of the same, the proportion of iron being occasionally as low as one-fifth in bulk and one-third in weight. Such quantities, by being added to the others, will form an eminently good flux. The ores of this second class may in general be considered as rich as those of the first class, as the latter have necessarily to be mixed with the only impurity of the former in order to be prepared for smelting.

a Third, chloritic and talcose slate, containing innumerable crystals of magnetic iron, the relative bulk of which to that of the other mineral substances varies from 3:1 to ½:1, and less. The impurities are the same which are frequently combined with magnetic iron, principally the silicates of alumina, magnesia, and protoxide of iron. As magnesia is present in the form of silicates (varieties of hornblende, especially asbestos and some talc), it will not be injurious to smelting. None of those substances which, by the smallest admixture, deteriorate the quality of iron, such as phosphorus or sulphur, appear to be present. The yield of iron of those ores of this third class, which form the bulk of the deposits, will not be short of 50 per cent.

Mr. King and Mr. Hague thus refer to the mode of recurrence of the ore, its probable quantity, and its quality:

Mode of occurrence.—From the northernmost outcrop in Spencer's ravine the iron deposits appear as an irregular detached chain of bodies, trending south-southeast across the Four Hill valley and reappearing over a low divide on approximating the same line, a mile farther south, in Gold valley.

Following as they do the strike of the inclosing rocks, it is most probable that these isolated outcrops represent a single zone of b lenticular deposits of ore, and that those portions visible above ground are but a small portion of the whole mass. While it is not to be expected that there is anything like a continuous vein of ore along the whole length of the line, yet it is fair and reasonable to expect greater quantities under the surface than appear above it. Accompanying the bodies throughout their entire occurrence is a stratum of limestone, standing nearly vertical, and representing a variety of metamorphic stages, from a compact gray form to highly crystallized, marbleized varieties, and extensive masses of calcspar. The iron deposits appear as bold bluffs, vein-like outcrops, and broad, dome-like bodies, as will be more particularly described below.

Four Hill group comprises eight or ten different outcrops. Of these the northern, and perhaps the most important, is a bold knob about 40 feet in height and 40 in diameter, rising from the northern slope to the ravine. It is comparatively a solid mass of remarkably pure magnetic oxide of iron, having a fine grain, like the texture of steel. Along its western side it is curiously intermixed with calcspar, which mineral occurs freely in the neighborhood. From this one outcrop alone may be quarried several thousand tons. Southward, on the line indicated, throughout a distance of half a mile, occur similar, though smaller, outcrops, having the form of large branches, except on the southern end and near the Gold Valley divide, where the outcrops are more linear and vein-like. At this end also the ore is more c highly oxidized, approaching hematite in composition. From the topography of the Four Hill region, which is generally a rough, rapidly-rising flank of Spencer's ravine, there are good facilities for getting the ore down to the ravine bottom, where a road or tramway will afford connection with the proposed site of the works. By simply quarrying the surface-ore it is estimated that twenty or twenty-five thousand tons may be made available, and this without making any allowance for the downward continuation of the bodies, nor for those masses exploration is sure to develop.

The Gold Valley deposits first appear nearly or quite a mile distant from the Four Hill deposits, but preserving about the same general direction. The main body in this series lies near the bottom of the valley, presenting a smooth, glacier-worn, and rounded surface, standing out prominently above the inclosing rock and soil. The superficial area of this outcrop is hardly less than 60,000 square feet, and the slope of the surface and its projection above the contiguous soil indicate a thickness of, say, 40 feet. This would give about 300,000 tons as the quantity of ore available in this bed alone for quarrying. About 500 feet farther south a similar but smaller outcrop appears, and there is a probability that the two are connected beneath the surface.

Quantity.—We think it safe to say that the aggregate amount of ore in sight in the Gold Valley and Four Hill deposits is not less than d 350,000 tons. This estimate is based on surface measurements of the outcrops, and on such assumed average thickness or depth for each outcrop as its projection or elevation above its inclosing rock would fairly indicate, not taking into account any probable continuation of the ore in depth or any connected deposits extending beneath the surface-soil and concealed from view. It is quite probable that a much larger quantity than the amount named will be found, since it is not likely that the whole of this deposit is exposed to view. Baron von Richthofen, the eminent geologist, who carefully examined this deposit several years ago, estimated 1,400,000 tons as the probable quantity available for quarrying, and although we do not place the amount "in sight" at more than 350,000 or 400,000, we still think it quite probable that his estimate will be fully confirmed and exceeded by actual development.

Quality.—These deposits consist chiefly of magnetic iron ore of excellent quality. In some bodies of the Four Hill group the ore is almost pure magnetic oxide, presenting when freshly broken a clean, shiny, iron-black fracture, free from any impurity, and containing about 70 per cent. of metallic iron. Other portions of these deposits contain the magnetic ore mixed with calcspar and dolomite, the intermingled mineral being desirable as a flux; this character of ore although containing less per cent. of metallic iron, say 50 per cent., is more valuable for smelting than the first. The mass of the deposits in Gold valley contains more silicious ore which carries from 40 to e 60 per cent. of iron.

The following is from an analysis made by Professor H. Schrother, of Vienna, to whom a specimen of the Gold Valley ore was sent for examination. He reports the quantitative determinations as follows:

	Per cent.
Protoxide of iron	*26.40
Peroxide of iron	*57.40
Silicic acid	15.87
Carbonate of lime and loss	0.33
Total	100.00

f

* Equal to 60.687 metallic iron.

We have also caused examinations to be made by Professor Thomas Price of specimens of ore from the various deposits. He reports that he finds nothing practically deleterious in the composition of the ore. Tests made for sulphur, phosphorus, and titanium show only the most minute traces, too slight to be practically considered, while the per cent. of iron in the poorest selected specimen was 34 (34.70) per cent., and in the better pieces 41, 55, and 70. He regards the ores as of excellent quality, and capable of being mixed to great advantage for smelting purposes. It is probable that the average yield of all the ores, when mixed for smelting, will be not less than 40 per cent. of metallic iron.

The deposits of ore in Placer county, to which reference has already been made, consist both of magnetite and of limonite. The body of magnetite is located on Sec. 15, T. 13 N., R. 8 E., 4 miles from Clipper Gap station and 7 miles from Auburn. Like that in Sierra county this deposit occurs in the metamorphic (auriferous?) slate

series, associated with limestone. Its outcrop is, however, small, and the developments had not, atthe date of a my visit, progressed far enough to prove the size of the ore-body. The vein appears to extend in an east and west direction along the north side of a low ridge, and to dip at a high angle towards the south. A cut has been driven into the hillside through the gravel and decomposed rock which forms the hanging-wall of the ore, thus exposing a face of the latter. The vein has not been cross-cut, but a small trench through the surface-soil apparently at a right angle with the strike, has uncovered a width of 36 feet of ore. A pile of about 30 tons of ore from the cut is on the bank. It is represented by sample No. 1170. The California Company, the owners of the ore-deposit, began building a 40-ton furnace in the spring of 1880, a few hundred feet north of the above opening. West of this ridge is a small valley, where limestone outcrops at several points, and beyond this is another low ridge in which there is an outcrop of magnetite. A short cut has been made into the hillside also, and a few tons of ore taken out. Sample b No. 1171 came from this opening. The strike of the vein is nearly east and west, but the outcrop is southwest of the one near the furnace, so that this is either on a distinct vein or the one vein has been faulted along the valley between the ridges. The distance from one opening to the other is about a quarter of a mile.

Limonite exists at several localities within a radius of 2 or 3 miles of the furnace. The most important deposit thus far opened upon is situated in Sec. 24, T. 13 N., R. 8 E., about 2 miles from the furnace. It is owned by the California Iron Company, and is probably the deposit referred to on page 284, of Vol. I, *Geological Survey of California* (Whitney). The ore lies along the west side of a ridge, and a number of openings have been made into the hill, cutting the ore-body. The largest of these is about 50 feet long, and exposes a breast of ore 10 or 12 feet high. Two drifts, one 6 and the other 12 feet in length, enter the ore-body at right angles with its c strike without crossing it. A pile estimated to contain 350 tons of ore was on the bank. Sample No. 1172 represents an average of this pile. The above-mentioned samples contained—

	1170.	1171.	1172.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	67.68	64.98	53.41
Phosphorus	0.068	0.047	0.178
Phosphorus in 100 parts iron	0.100	0.072	0.333

The magnetite represented by samples Nos. 1170 and 1171 is partially weathered and contains no pyrite. The d analyses proved it to be a rich ore, and probably sufficiently pure to be used for the manufacture of Bessemer steel. For this latter purpose, however, the limonite is not adapted. Analyses of specimens of ores from this region were made by Mr. Hauk, the state mineralogist, with results as follows:

	Magnetite.	Limonite.
	Per cent.	*Per cent.*
Silica	3.23	33.10
Sesquioxide of iron	80.05	55.25
Protoxide of iron	17.06	.....
Lime	.....	1.65
Sulphur	.....	Trace.
Phosphorus	.....	Trace.
Water, hygroscopic	.....	2.90
Water, combined	.....	6.45
Total	100.34	99.35
Metallic iron	69.29	38.68

e

The specimen of limonite analyzed by Mr. Hauk probably did not come from the same deposit as my sample No. 1172. The percentage of water shows the ore to be a mixture of the hydrous and anhydrous oxides.

A deposit of hematite has long been known to exist 3½ miles westwardly from Saint Helena, Napa county, f in portions of Secs. 3, 4, and 9, all in T. 7 N., R. 6 W., and several hundred tons of ore have been mined at different times for use as flux. In the spring of 1880 a few tons were mined for use in an experimental petroleum furnace. A few pounds of iron were made, but the experiment was not a success. The property belongs to Edson Adams, esq., of San Francisco. The ore lies in various sized pockets, in a band of red jasper, which appears to be a local variety of the metamorphic rock of this region. Five or six openings have been made in the hillside on as many pockets of ore, but these proved to be small, and were soon exhausted. Near the ore-bodies the jasper is often covered with a thin scale of specular hematite, which gives to a lump of it, when viewed in one direction, the appearance of being a solid piece of excellent ore. Many little seams of specular ore (a sixteenth of an inch or less in thickness) were seen penetrating the quartz-mass, evidently filling previously formed cracks. While it is possible that there is altogether a considerable quantity of ore in the hill, the pockety and irregular form of the deposit is such that it appears doubtful whether it can be mined economically. A large amount of dead

a work, in removing inclosing rock, etc., would necessarily have to be done, and the uncertainty of finding new pockets when the old ones were exhausted would probably make mining operations hazardous. All the openings were filled with *débris* washed in from the sides of the pits, so that only a little ore was seen in place. A few specimens were taken for analysis from a couple of sacks of the ore in Mr. Adams's office. These contained—

	1173.
	Per cent.
Metallic iron	47.45
Phosphorus	1.870
Phosphorus in 100 parts iron	3.940

b

Other analyses of selected specimens of the ore gave results as follows:

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Ferric oxide	90.05	89.85	80.50	87.79
Manganese oxide	0.88	0.25	0.15	0.14
Alumina	0.14	0.30	1.08	1.80
Lime	0.06	0.65	4.20	1.05
Magnesia	0.20	0.10	.....	.....
Potash and soda	0.12	0.15	0.40	1.18
Silica	7.90	7.70	12.55	6.85
Phosphoric acid	0.09	Trace.	0.17	0.07
Sulphuric acid	Trace.	.....	Trace.	0.16
Water (by difference)	0.56	1.00	0.95	0.96
Total	100.00	100.00	100.00	100.00
Metallic iron	63.03	62.89	56.35	61.45

c

Analysis No. 1 was made at the Smithsonian Institution (?); No. 2, by Dr. Hood, San Francisco; No. 3, at the
d Royal School of Mines, London; No. 4, by the state assayer of Massachusetts.

Copies of the above were kindly furnished me by Mr. Adams.

The difference in the per cent. of phosphorus in my sample and in that of the specimens analyzed elsewhere is so great that Mr. Whitfield made a duplicate determination of the phosphorus in sample No. 1173, resulting in phosphorus 1.890 per cent.

IRON ORE IN OREGON.

In the southwestern part of the state, in the Sierra Nevada mountains, near the California state line, magnetite is reported to have been found, and it probably exists at various points in the Cascades. Bog-ore occurs in the valleys of the Columbia and Willamette rivers in considerable quantities, and this ore may prove an important
e source of iron on the Pacific coast.

Two and a half miles from the Oswego blast-furnace, the location of which has already been described, is a very peculiar body of ore, consisting of a bed of bog-ore intercalated in basalt. It is known as the *Prosser* mine. The foot-wall rock is vesicular, and was evidently the uppermost layer of an overflow. The ore was deposited in a depression in this rock, and was then covered by another basaltic flow. Afterward the whole formation was tilted up to its present position (Fig. 225). The vein dips northwesterly at an angle of about 20°, and outcrops along the

f

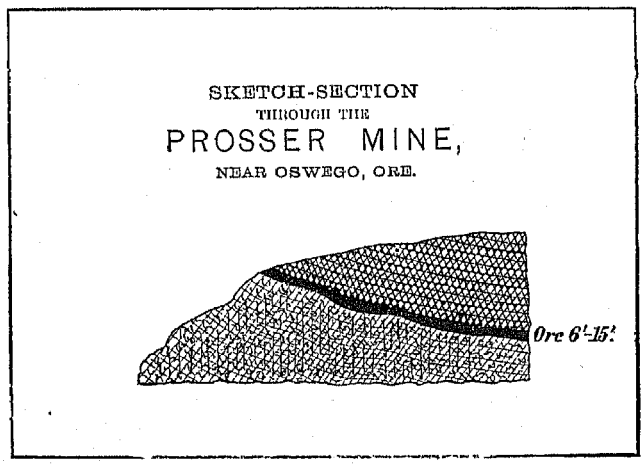


FIG. 225.

a north side of a valley for three-quarters of a mile or more. Many openings have been made along the outcrop, and the ore has been taken out in some places to a depth (on the vein) of 100 feet. The principal opening now consists of a slope 600 feet long on the dip of the vein, from which stopes have been driven westward for a distance of 150 feet. The foot-wall or floor of the mine is very rolling, but the roof is quite regular and even. The thickness of the ore varies from 6 to 15 feet. Between the ore and the roof there is often a layer of very argillaceous material which softens on exposure to the air and scales off. Above this the rock is generally firm, and very little timbering is required. The ore is exploited cheaply. From the mine-cars it is dumped into pockets, from which it is loaded directly on the cars for transportation to the furnace.

A quarter of a mile east of the main opening preparations are being made to drive another slope, but no ore b has yet been mined here.

With present developments the Oswego Iron Company estimates the capacity of the mine at 20,000 tons a year. It has never been worked, however, for twelve consecutive months, as the furnace has not required so much ore. During the census year the mine was in operation but 3⅔ months (*i. e.*, from June 16 to October 3, 1879), and in this time 6,225 tons of ore were raised.

The ore is a limonite, earthy in texture in the main, but containing bunches of a solid, dark-colored, crystallized ore. The latter forms but a small proportion of the mass. Samples of the ore yielded, on analysis—

c

	1165.	1167.
	Per cent.	*Per cent.*
Metallic iron	44.71	54.10
Phosphorus	0.666	0.392
Phosphorus in 100 parts iron	1.490	0.723

Sample No. 1165 is from a pile of 150 tons of ore in the stock-house at the furnace. Sample No. 1167 consists of selected chippings of the crystallized ore.

Within a half mile of the furnace, on land belonging to Mr. Patton, several thousand tons of ore were mined for the old furnace company. This ore was a bog-ore also, and it was deposited probably comparatively recently. It lies horizontally, and is covered with a few feet of sand and gravel only. A sample was taken from a pile of about d 50 tons of this ore near the furnace. It contains—

	1166.
	Per cent.
Metallic iron	45.40
Phosphorus	0.576
Phosphorus in 100 parts iron	1.269

e

IRON ORE IN WASHINGTON TERRITORY.

Deposits of bog-ore are quite numerous near the shores of Puget sound. In Chimicum valley, 2½ miles from the Irondale furnace, on Port Townsend bay, quite an extensive mass of this ore occurs, which has been exploited to some extent for the use of the furnace. Many acres of the valley bottom appear to be covered with a layer of ore from 10 to 20 inches in thickness, lying immediately under the grass roots. Estimating 14 cubic feet of ore to the ton, there are about 4,500 tons of ore on each acre of land. Mr. Moor, the superintendent of the furnace, told me that he had measured over 75,000 tons of ore in this valley, the mineral right of which is leased to the Puget Sound Iron Company for a term of fifty years on a royalty of 25 cents per ton of ore mined. The ore can be delivered by team to the furnace at $1 20 per ton. By building a tram road, it is estimated that this price can be reduced to 75 cents. The ore is porous, but sufficiently solid to permit of its being dug in large lumps. A portion of the f powdered ore is lifted by the magnet. A sample taken from a pile of 300 tons at the furnace contained—

	1168.
	Per cent.
Metallic iron	41.83
Phosphorus	0.751
Phosphorus in 100 parts iron	1.795

a A copy of an analysis of this ore by Mr. Regis Chauvenet, of Saint Louis, was given me by Mr. Charles Simpkins, treasurer of the Puget Sound Iron Company. It is as follows:

	Per cent.
Water	21.42
Silica	8.54
Phosphoric acid	1.433
Sulphur	0.005
Metallic iron	46.02
Phosphorus	0.624
Ratio of iron to phosphorus	100: 1.355

b

Magnetite is reported in the Snoqualmie pass, and on Cypress and San Juan islands. A sample of ore from the latter locality was analyzed by Mr. Regis Chauvenet in April, 1880, with results as follows: (*a*)

	Per cent.
Water	4.38
Silica	21.85
Phosphoric acid	5.177
Sulphur	0.042
Metallic iron	46.56
Phosphorus	2.255
Ratio of iron to phosphorus	100: 4.843

c

The percentage of phosphorus is large and renders the ore of little value.

BRITISH COLUMBIA.

There is an important deposit of magnetite ore on Texada island, in the straits of Georgia, between Vancouver island and the mainland of British Columbia, 120 miles from Port Townsend, which, although in British territory, d is of interest to the United States, as the ore will probably be smelted within its borders. The Puget Sound Iron Company, it is said, has a lease of the mines for three years, at a royalty of 25 cents per ton, agreeing to take not less than 5,000 tons per year. Texada island was visited by Mr. James Richardson in 1873, and mention is made of the iron-ore deposits in the *Report of Progress for* 1873–1874 *of the Geological Survey of Canada*, p. 99. Mr. Richardson finds the ore to be, in some places, associated with a coarse-grained epidotic rock and gray diorite, in others with a gray crystalline limestone, with which it is interstratified. Mr. George Hargreaves, civil engineer, of Victoria, British Columbia, who surveyed this property in 1874, estimated that there were 11,250,000 tons of ore on the island in four deposits.

Mr. D. W. Moor, the superintendent of the Puget Sound Iron Company, reports (*b*) the following measurements e of ore outcrops:

No. 1, *Vein*, commences 600 feet from the sea; width of ore from 15 to 20 feet; runs 200 feet uncovered; the depth can only be told by working.

No. 2, *Hill*, 900 feet from the sea; foot 300 feet perpendicular above water-line; at the base measures 50 feet front; runs 300 feet at a rise of 60° to top, thence 350 feet on level, with width of 90 feet on top; measured thickness of 14 feet; with 8 cubic feet to the ton, this hill shows 100,000 tons in sight.

No. 3, *Hill*, 1 mile from sea; has face 280 feet; runs uncovered 400 feet; thickness, 20 feet. Two knobs come in within 100 feet of this deposit, with 100 feet face, 300 feet long, with thickness of 24 feet; 300,000 tons on No. 3 in sight.

No. 4, *Hill*, 1 mile from the sea, consists of two veins with rock formation; ore 10 to 20 feet in each vein; covered with loose black ore, estimated at 100,000 tons.

I can safely say that there are 500,000 tons of ore in sight, besides the place that we are working now, which is within 300 feet of the f sea, and has a face 20 to 30 feet. A large portion of the above ore can be carried to the sea with double track, the loaded car returning the empty one.

About 600 tons of ore have been brought to Irondale, and are piled on the wharf. A sample from this pile contained—

	1169.
	Per cent.
Metallic iron	65.53
Phosphorus	0.013
Phosphorus in 100 parts iron	0.020

a I am indebted to Mr. Simpkins for a copy of this analysis.

b *Prospectus of the Puget Sound Iron Company*, p. 3.

The ore sampled is a fine granular black magnetite, and contains considerable pyrite. It would appear, however, from the following analyses of other samples, that some of the ore on the island is free from the latter mineral:

	By E. J. Chapman (a).	By Regis Chauvenet. (b)
	Per cent.	*Per cent.*
Protoxide of iron	28.33	.....
Peroxide of iron	67.31	.....
Oxide of manganese	Trace only.	.....
Titanic acid	0.11	.....
Phosphoric acid	0.07	0.128
Sulphuric acid	0.09	.....
Silica and siliceous matter	3.07	1.44
	99.88	.....
Metallic iron	69.00	66.96
Phosphorus	0.030	0.056
Sulphur	0.036	Trace.

a Report on Texada Iron Mines, p. 14.
b Copy given me by Mr. Charles Simpkins.

b

IRON ORE IN ARIZONA.

c

Professor Newberry (*a*) reports the occurrence of specular ore in Monument and Mojave cañons, near the Colorado river, and limonite and magnetite have been found at several localities in the southern part of the territory near Dos Cabezas. Mr. J. G. Gilbert (*b*) observed the latter ore, "probably in quantity to give it economic value," in the schists underlying Paleozoic strata. Iron ore probably exists in many parts of the territory, and will doubtless become known as soon as it is considered of any economic value. It is possible that the gossans of many metalliferous veins will make excellent Bessemer ore.

IRON ORES IN NEW MEXICO.

d

Iron ores occur in beds and as float-boulders in the form of carbonate and hematite in the Coal Measures; as magnetic iron ores they accompany the gold-bearing formation. Every gulch and river in this formation contains magnetic iron sand, the "marmaje" of the Mexicans, and pebbles and boulders of great purity, the "tepurtite" or "la guia del oro" of the native miner. Large lodes of it with huge croppings are found together, with gold veins at the Moreno mines (Nacita gulch); at the south side of the Old Placer mountains the Mammoth lode contains such ore. In the New Placer mountains, east of Tuerto, are very extensive croppings of pure magnetite; and immense quantities of it exist at the Hanover copper mines near Pinos Altos, while a large lode of specular iron ore has been found of late near Embudo (between Taos and Santa Fé).—(Raymond, *Mining Statistics, etc.*, 1870, p. 417.)

At Santa Fé I was told that there were large deposits of iron ore in Los Cerrillos, a low range of mountains 18 miles south of Santa Fé, and between it and Galisteo. I found there several outcrops of narrow veins of magnetite in granite. The largest one seen, near the "Union shaft", is 18 inches wide. The surface is covered with soil, so that its longitudinal extent was not apparent. Sample No. 1174 consists of chippings from this outcrop. The ore e is a rather fine-grained, partly-weathered magnetite, with layers of carbonate of lime. Just before leaving the camp I was shown a piece of limonite of good appearance, a body of which I was informed had been found in these mountains. It is probably the gossan of a sulphuret vein.

North of Santa Fé, in the eastern part of Rio Arriba county, on the Santa Cruz creek, east of the town of Santa Cruz, a 2- to 4-foot vein of magnetic ore is reported.

On the mountains east of Santa Fé creek, about 3 miles from Santa Fé, there is said to be a vein of magnetite 2 feet wide in red granite (?), which is traceable for several hundred yards. A specimen of this ore consists of one-half of magnetite and the other half chiefly of quartz, and is of no value as an ore of iron. It is interesting, however, as indicating the kind of rock which has been the source of the magnetic sands of the gulches. These sands have in all probability been derived from a magnetite-bearing rock, through its disintegration, and not from f a solid body of ore of commercial value.

On the Maxwell land grant, near Elizabethtown, about 30 miles from Cimarron, is a hill locally known as "Iron mountain". Its sides are said to be covered with float-ore, and it has always been supposed to contain a large deposit of magnetite. The locality was examined, however, by Professor St. John (of Topeka, Kansas) during the summer of 1880, who reported (*c*) that the hill contained only a narrow vein 2 to 3 feet in thickness, and the quantity of ore was too small to be practically valuable. I am indebted to Mr. Springer for some specimens of this ore, collected by Professor St. John. Sample No. 1175 consists of these specimens.

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a In *Report on the Geology of Lieutenant Ives' Colorado Exploring Expedition* (Washington, 1861).
b Geological and Geographical Survey West of the 100th Meridian, George M. Wheeler in charge, Vol. III, p. 510.
c So I was told by Mr. Springer, agent of the Maxwell Land Grant Company.

a A small vein of magnetite is also reported on Cimarron Cito creek, but it is believed to be of no value. Carbonate of iron and its weathered product exist, associated with the coal at many points on the grant; but whether in a sufficiently thick seam to be of value I did not learn. A similar ore occurs near Galisteo, and elsewhere in the territory wherever coal has been found.

The samples of ore collected in New Mexico contained—

	1174.	1175.
	Per cent.	*Per cent.*
Metallic iron	65.59	56.80
Phosphorus	0.008	0.051
Phosphorus in 100 parts iron	0.012	0.090

b

In the following table the deposits of ore which were not visited, and opposite which no authority is mentioned, were reported to me in conversation, and no definite information in regard to them was obtainable. It is more than probable, therefore, that the list contains some localities where workable bodies of ore do not exist. Undoubtedly, also, there are many deposits of considerable size, known to prospectors, of which I have no reports. I am indebted to Mr. D. A. M. Froiseth, of Salt Lake City, for much information in regard to the iron ores of Utah. The following contractions have been used in the column headed "*Authority and general remarks*":

c "Ives Report."—*Report upon the Colorado River of the West*, explored in 1857 and 1858, by Lieutenant J. C. Ives, Corps of Topographical Engineers, Washington, U. S. A., 1861.

"Browne."—Report of J. Ross Browne, *on the Mineral resources of the States and Territories West of the Rocky Mountains* (Washington, 1868).

"Blake."—*Report of a Geological Reconnaissance in California*, by William P. Blake (New York, 1858).

"Whitney."—*Geological Survey of California.* J. D. Whitney, State Geologist, Vol. I (1865).

"Raymond."—*Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains*, by Rossiter W. Raymond, U. S. Commissioner of Mining Statistics.

Iron ores in Colorado.

d

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Huerfano county: Grayback gulch, 5 miles from Placer station; 4 miles from Denver and Rio Grande railroad.	Colorado Coal and Iron Company.	*Ore:* Magnetite (oxidized near outcrop). *Rock:* Limestone.	Carboniferous (Hayden).	1108 1108*a* 1109 1110	Ore has been taken from two openings, known as the Ainsworth and the Stoddard mines.
Huerfano county: On plains near Walsenburg.	.....	*Ore:* Carbonate and derivatives.	Cretaceous	1112 1113	Nodules of partially weathered carbonate of iron, derived from the coalseries by erosion and degradation of the inclosing rock, are found in considerable quantities on the surface of the plains near the coal seams.
c					
Las Animas county: Coal mine near El Moro; on railroad.	Colorado Coal and Iron Company.	*Ore:* Carbonate and derivatives. *Rock:* Shale and sandstone.	Cretaceous	1111	Seam of ore 6 inches thick.
Fremont county: On Pine creek, near Grape creek, 22 miles from Cañon City; 4½ miles from Cañon City and Silver City branch of Denver and Rio Grande railroad.	Colorado Coal and Iron Company.	*Ore:* Magnetite (titaniferous). *Rock:* Granite.	Archæan	1114 to 1120	
Saguache county: Western foot-hills of the Sangre de Cristo mountains, 5 miles south of Hayden's Pass, 8 miles southeast of Villa Grove, 25 miles from Gunnison extension of Denver and Rio Grande railroad.	.....	*Ore:* Limonite ..... *Rock:* Limestone.	.....	1121 to 1125	
Saguache county: On road between Saguache and Lake City, about 20 miles west of Saguache.	.....	*Ore:* Limonite (?)	.....	.....	Reported to me by a teamster.
f					
Chaffee county: In Arkansas hills, 9 miles from South Arkansas via Ute Pass; 9 miles from railroad.	Colorado Coal and Iron Company.	*Ore:* Magnetite ..... *Rock:* Trachyte.	.....	1176 and 1176*x*	Three claims have been entered under the following names: Calumet, Hecla, Smithfield.
Chaffee county: Near Garfield and near Cleora.	.....	*Ore:* Magnetite and hematite.	.....	.....	Reported to me in conversation. No developments have been made, and extent of deposits are not known.
Park county: Near Hamilton	.....	*Ore:* Magnetite	.....	1132	Reported to me by letter. Sample of the ore was mailed to me from the Holland smelter; locality was not visited.
Park county: Near Buffalo park, 15 miles west of salt-works.	.....	*Ore:* Limonite (?)	.....	.....	Reported to me in conversation. No definite information obtainable.
Lake county: Breece mine, near Leadville; 2½ miles from railroad.	.....	*Ore:* Specular hematite... *Rock:* Porphyry.	Mesozoic (Emmons).	1126 to 1128	

Iron ores in Colorado—Continued.

a

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Jefferson county: "Jefferson County" Iron mines, near Morrison; 2 miles from railroad.	.....	*Ore:* Magnetite in amphibole. *Rock:* Amphibole schist, granite, and gneiss.	Archæan	1107	
Boulder county: Near Caribou; 20 miles from railroad (at Boulder).	.....	*Ore:* Magnetite..... *Rock:* Granite.	Archæan(?).....	1105 and 1106	
Boulder county: Near Marshall Coal mine, 5 miles south of Boulder; on railroad.	.....	*Ore:* Carbonate and derivatives. *Rock:* Shale and sandstone.	Cretaceous	1104	b See note to 1112 and 1113.
Routt county: In Coal mountain, on the White River divide, south of Yampa peak.	.....	*Ore:* Carbonate and derivatives.	Cretaceous	.....	*Geological Explorations Fortieth Parallel*, Vol. II, p. 270. 6-inch seam.

Specimens of specular ore have been found in Plum and Elk creeks, Cheyenne mountain (near Colorado Springs), and on Pike's Peak, but no mass of het ore is known to exist in the vicinity.

Iron ores in Wyoming.

c

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
In the Laramie hills, 40 miles northwest of Cheyenne; 20 miles from Laramie City, on Union Pacific railroad.	.....	*Ore:* Titaniferous magnetite and ilmenite. *Rock:* Granite.	Archæan	.....	*Geological Exploration Fortieth Parallel*, Vol. II, pp. 15 and 16.
Two and one-half miles from Rawlins station; 2½ miles from Union Pacific railroad.	Messrs. Shaw & Friend.	*Ore:* Hematite ..... *Rock:* Sandstone.	Lower Palæozoic ...	1133 and 1134	*Geological Exploration Fortieth Parallel*, Vol. II., p. 161.
Near Evanston coal-mines; on railroad ..	.....	*Ore:* Carbonate and derivatives. *Rock:* Shales and sandstone.	Cretaceous	.....	Ore in thin layers and in nodules, as in Colorado. Of no commercial value. d
Along Bitter creek, near Leucite hills ...	.....	*Ore:* Carbonate and derivatives. *Rock:* Shales and sandstone.	Cretaceous	.....	*Geological Exploration Fortieth Parallel*, Vol. II, p. 233. Fragments of concretionary brown hematite.
Two miles west of Salt wells, at the Vandyke (coal) mines.	.....	*Ore:* Carbonate and derivatives. *Rock:* Shales and sandstone.	Cretaceous	.....	*Geological Exploration Fortieth Parallel*, Vol. II, p. 234. Four feet of coal is overlaid by a red iron-stained sandstone containing thin beds of limonite.

Iron ores in Dakota.

Slim seams of specular ore were found by Newton in the Archæan slates of the Black Hills, and nodular pieces of carbonate were observed associated with the Cretaceous coals, but no workable deposits of ore in the territory have been reported.

e

Iron ores in Utah.

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Iron county: Near Iron City and Iron Springs, in Ts. 35, 36, 37 S., Rs. 12, 13, 14 W., 7 to 20 miles west from Cedar City; 40 miles from railroad (at Milford).	Thomas Taylor	*Ore:* Magnetite and "hematite". *Rock:* Trachyte, granite, and limestone.	Lower Silurian (?) (Newberry).	1141 to 1154	Some of the ore was smelted in Iron City between 1869 and 1875.
Beaver county: In the Wah Wah mountains, 20 to 25 miles SW. of Frisco, [about T. 30 S., R. 15 W.]; 22 miles from railroad (at Frisco).	.....	*Ore:* "Hematite and magnetite. *Rock:* Granite (?).	.....	1135	Reported to me at Frisco. Bowen's mine (sample No. 1135) is on the east slope of the Wah Wah mountains, 22 miles from Frisco, and was opened in the fall of 1880, and some ore (hematite) was shipped to the Frisco smelters for flux. A little ore has also been sent from Mooney's mine, 6 miles west of the above and on the ridge of the mountains. The localities were not visited. f
Beaver county: On west slope of Frisco mountains, 6 miles from the town of Frisco, about T. 27 S., R. 13 W.	.....	*Ore:* "Hematite".....	.....	.....	Reported to me at Frisco. Explorations were begun here in November, 1880, in search of a good flux for the smelters.
Beaver county: Star district; Vulcan mine, in southern part of district, 7 miles southwest of Milford, about T. 27 S., R. 13 W.	.....	*Ore:* Limonite	.....	1137	Sample collected at Frisco smelter. Ore is reported to contain silver.
Beaver county: Lake Superior mine, in northern part of district, about 7 miles from Milford, about T. 28 S., R. 11 or 12 W.; 3 miles from railroad.	Forgie Brothers (of Frisco).	*Ore:* Magnetite..... *Rock:* Quartzite and granite.	.....	1140	Explorations made and claim entered for copper ore. A little iron ore has been teamed to the Frisco smelters.

a

Iron ores in Utah—Continued.

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Beaver county: Rocky district; the Frisco Mining and Smelting Company's mine, 4 miles from Milford [about T. 27 S., R. 11 W.]; 1 mile from railroad.	Frisco Mining and Smelting Company.	*Ore:* Magnetite ..... *Rock:* Quartzite and granite.	.....	1139	Searching for copper ore is the chief work of the camp, but several hundred tons of iron ore have been mined and teamed to Frisco.
Beaver county: Bradshaw district; Cave mine, 7 miles southeast of Milford, [about T. 29 S., R. 9 (or 10) W.]. b	Frisco Mining and Smelting Company.	*Ore:* Limonite.....	.....	1138	Ore carries about $20 worth of silver and gold to the ton. It is not, therefore, commercially speaking, an ore of iron. It is used for flux at Frisco, where sample was taken. The locality was not visited.
Sevier county: In Castle valley, about T. 22 S., R. 6 E.	.....	.....	.....	.....	Ore is reported to occur near the coal, and is probably, therefore, an altered carbonate of Cretaceous age.
Juab county: On west slope of divide between east and west Tintic valleys, in T. 11 S., R. 3 W.	.....	.....	.....	.....	Reported to me at Tintic.
Utah county: East Tintic district; 16 to 24 miles west of Santaquin station, in divide between Goshen and East Tintic valley, in T. 10 S., Rs. 2 and 3 W.; 16 to 24 miles.	See description of mines.	*Ore:* Limonite..... *Rock:* Limestone and porphyry (?).	.....	1155 to 1160	Mining operations have been carried on here for two or three years. Ore used for flux; chiefly at Sandy.
Utah county: Cedar Valley district; about 15 miles west of Lehi station, in T. 4 S., R. 2 (or 3) W.; 15 miles from railroad. c	.....	.....	.....	.....	
Tooele county: Columbia district; about T. 9 S., R. 6 (or 7) W.	.....	.....	.....	.....	
Tooele county: West of the above, in T. 9 S., R. 6 W.	.....	*Ore:* Specular.....	.....	.....	
Tooele county: Stockton or Rush Valley district; in T. 4 S., R. 4 West; about 3 miles from railroad.	.....	.....	.....	.....	
Tooele county: On the east slope of the Onaqui mountains, near Grantville, in T. 2 (or 3) S., R. 6 (or 7) W.; about 15 miles from railroad.	.....	.....	.....	.....	
Tooele county: Skull district; on the west side of Skull valley, near the Onaqui mountains, 2 miles east of Hooper's ranch; about 20 miles by nearest road, over the Onaqui mountains. d	.....	.....	.....	.....	Marked "Iron mountain" on Froiseth's Map of Utah (1878).
Salt Lake county: Adams district; in City Creek cañon, 10 miles from Salt Lake City, in T. 1 N., R. 2 E.	.....	.....	.....	.....	
Salt Lake county: Antelope district; on Antelope or Church island, about 18 miles northwest of Salt Lake City, in T. 2 (or 3 N.), R. 3 W.	.....	.....	.....	.....	
Salt Lake county: Cottonwood district; in Flagstaff mine [T. 2 S., R. 2 E.].	.....	*Ore:* Limonite.....	.....	.....	A low-grade silver ore; has been used for flux. Mine is now idle.
Morgan county: Mill Creek district; 10 miles south of Weber station, on Union Pacific railroad), and 21 miles from Salt Lake City [T. 3 N., R. 2 W.].	Norway Iron Mining and Manufacturing Company.	.....	.....	.....	Ore is reported to contain gold.
Weber county: In Ogden cañon, 2½ miles north from Ogden City [T. 6 N., R. 1 W.]. e	.....	*Ore:* Hematite..... *Rock:* Quartz.	Archæan? Cambrian?	1161	
Weber county: In Cold Creek cañon, 7 miles north from Ogden City, via Ogden cañon [T. 6 N., R. 1 E.].	.....	*Ore:* Hematite..... *Rock:* Quartzite and slate.	Devonian?.....	1162	
Weber county: In Strong's cañon, 3 miles from Ogden City, near top of mountains overlooking Salt lake.	.....	*Ore:* Specular	.....	.....	
Weber county: 3 miles east of Huntsville, and 14 miles east of Ogden City, via Ogden cañon [T. 6 N., R. 2, E.]. f	.....	*Ore:* Hematite.....	Cambrian?.....	.....	The Cambrian plateau extends "across Logan, Blacksmiths, and Muddy cañons, as far south as Ogden river, occupying a belt 6 to 8 miles in width." "The presence of iron in considerable amounts would appear to be highly characteristic of the Cambrian formation. It occurs disseminated through the rock in thin seams or cracks, and in small concretionary masses, usually, however, decomposed into yellow ochreous earth. In the stream-beds of the North fork of the Muddy, and on the lower slopes of the ridges, were found fragments and rounded pebbles of specular iron; also, in the Cambrian quartzite on Mill creek, which runs to Morgan valley, similar fragments were found. It is not improbable that future explorations may discover iron masses of considerable economic importance." (*Geological Exploration Fortieth Parallel*, Vol. II, pp. 412 and 413.)
Box Elder county: On Willard mountain, 2¼ miles from Willard station, on Utah and Northern railroad [T. 8 N., R. 1 W.]; about 3½ miles by road.	.....	*Ore:* Specular	Cambrian?.....	1163	About 7,000 tons of ore have been taken out from this mine.
Box Elder county: In Willow creek cañon, 3 miles from Willard station; 3 miles from railroad.	.....	*Ore:* Hematite (limonite)? *Rock:* Limestone.	Silurian?.....	.....	A pocket of hematite in limestone was discovered some five or six years ago and worked out. The ore was shipped to Sandy for flux.

Iron ores in Utah—Continued. a

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Box Elder county: In the Idaho and other mines, opposite the city of Corinne; 2 miles from the Utah and Northern railroad.					
Caché county: Mineral Point district; about 75 miles north of Salt Lake City [T. 10 N., R. 2 and 3 E].					b

NOTE.—Also traces of iron ore have been found in Melville, Logan, and Dry Lake mining districts, all in Caché county.

Iron Ores in Nevada.

Eureka county.—In Palisade cañon, 3 miles west of Palisade station. Magnetite in trachyte *Geological Explorations 40th Parallel*, Vol. II, p. 585, 586.

Lander county.—About 15 miles south of Battle mountain a small vein of magnetic (?) ore is reported.

White Pine county.—In Robinson mining district deposits of "hematite" and magnetite are said to exist near road between Pioche and Eureka.

Humboldt county.—In Jackson mountains, 40 miles northwest of Humboldt station. Magnetic ore (see sample No. 1104).

Churchill county.—Near White Plains specular hematite is reported.

In the Mineralogical tables, in Vol. III, *U. S. Geographical Surveys West 100th Meridian*, Lieutenant George M. Wheeler in charge, p. 654, the occurrence of hematite and limonite at "Lone mountain", of menaccanite (titaniferous oxide of iron) at Carlin, Eureka, Morey, Belmont, and of magnetite at Iron springs, Wheeler's peak, and Railroad district is noted. c

"The surveyors employed by the Central Pacific Railroad Company report the discovery of extensive beds of magnetic iron ore within a short distance of the line of the road, near Crystal Springs; also at Neilsbury, within a mile of the road, and at Long valley. There are many other districts in Nevada which contain iron ore. There is a series of regular veins of specular ore from 8 to 20 feet thick, near the East fork of Walker's river, in Esmeralda county."—*Mineral Resources of States and Territories West of Rocky Mountains.* By J. Ross Browne, 1868, p. 225.

Iron Ores in California (Exclusive of Chromic Ores).

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks. d
San Diego county: Purple hills, near the Colorado river.		*Ore:* Specular			Newberry, in Ives' Report, p. 21.
San Diego county: Near San Diego					Newberry in Ives' Report, p. 151.
San Diego county: On ranch belonging to Sisters of Charity, 16 miles from city of Los Angelos.	Sisters of Charity	*Ore:* Specular and magnetite. *Rock:* Clay slate.			Brown, p. 224. "The ore presents itself on the surface for nearly a mile in a stratum averaging 15 feet thick, inclosed in hard metamorphosed clay slate."
Los Angelos county: Williamson's pass					Blake, p. 289. "Large rolled masses of magnetite were picked up in the bed of one of the streams entering the valley of Williamson's pass, on the east side. The ore is very pure and crystalline, and is associated with hornblende, cinnamon-colored garnets, and chlorite. It probably exists in a considerable vein between the pass and the Cajon." e
San Bernardino county: In the Coast range.		*Ore:* Specular			Brown, p. 222.
Kern county: In the Cañada de las Uvas, in the Sierra de Rafael mountains, near Fort Tejon.		*Ore:* Magnetite *Rock:* Limestone.			Blake, p. 289. "Magnetic iron ore occurs in a vein about 3 feet thick in a low ridge of white crystalline limestone, in the valley of the pass known as the Cañada de las Uvas. This ridge is near the highest point of the pass, and the débris of the ore rolls down close to the trail. The vein or bed of ore is nearly vertical, its trend is nearly east and west, and the outcrop is traceable for about 30 feet. The ore is much mixed with carbonate of lime, but no other minerals of association were observed. It is compact, but not crystalline. When broken, it shows a brilliant fracture, with a granular surface, and does not cleave with broad, flat faces, as in the massive ores of New York and New Jersey." f
					Whitney, pp. 104. "Several miles down the valley, southwest of the summit of the pass of the Cañada de las Uvas, the limestone belt is in places accompanied by a belt of ferruginous metamorphic rock containing magnetic oxide of iron, and a similar rock was seen associated with the limestone of the San Emidio Cañon." Referred to also on p. 189.
Kern (or *Los Angeles*) *county:* On shore of lake Castecа, southwest of fort Tejon.		*Ore:* Magnetite *Rock:* Limestone.			Blake, p. 210. There is a vein of iron ore intercalated in one of the limestone ridges bordering the lake.
Santa Barbara county: In the Santa Iñez valley.		*Ore:* Magnetite			Brown, p. 224.
Santa Cruz county: In the coast range near the sea, a few miles north of town of Santa Cruz.					Brown, p. 222.

Iron Ores in California (Exclusive of Chromic Ores)—Continued.

Location and distance from the nearest railroad or navigable stream.	Owner's or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Merced county: Near Burns creek, a tributary of the San Joaquin river.	.....	*Ore:* Limonite ..... *Rock:* Quartz.	.....	.....	Blake, p. 14. Blake reports this vein of ferruginous quartz to be 25 feet thick. From his description it probably is too silicious to make an ore of iron.
Calaveras county: Near Murphy's	.....	*Ore:* Hematite ..... *Rock:* Limestone and slate.	Mesozoic	.....	Whitney, p. 259. "Near the line of contact between the limestone and slates are quite extensive deposits of hematite iron ore, which have not been opened or worked at all, and whose exact extent cannot therefore be known. Were fuel abundant and labor cheap, this deposit might become of importance."
Calaveras county: Five miles from Calaveras.	.....	.....	.....	.....	Raymond, 1870, p. 29. "The discovery of extensive iron-ore deposits 5 miles from Calaveras is reported."
Amador county: Near Ione City	.....	*Ore:* Hematite (?), limonite (?). *Rock:* Sandstone.	Tertiary (?)	.....	Whitney, p. 270. "This member of the formation contains so much iron in places as to become a tolerable ore; in other localities it forms a quartzose breccia, cemented by brown oxide of iron."
Eldorado county: Near Volcanoville, on the Middle fork of the American river.	.....	.....	.....	.....	Blake, p. 269. "Large masses of magnetic iron ore occur in a slight ravine among boulders of quartz and other rocks, near the great vein of auriferous quartz at Volcanoville. Their source is not known, but it is probably in the vicinity. It must form a thick bed, judging from the size and number of the transported masses."
Placer county: Four miles from Clipper Gap station, on Central Pacific railroad.	California Iron Company.	*Ore:* Magnetite and limonite. *Rock:* Limestone, slate, and diorite (?).	Mesozoic	1170 1171 1172	The pioneer blast-furnace of California has just been completed to smelt these ores.
Sierra and Plumas counties: In Gold valley, near Downieville; 47 miles from Truckee, on Central Pacific railroad.	Sierra Iron Company.	*Ore:* Magnetite ..... *Rock:* Limestone and slate.	Mesozoic	.....	Baron von Richthofen, Clarence King, H. D. Hague, quoted by Raymond, 1873, p. 91, and 1874, p. 44. Richthofen estimated the different deposits to contain 1,400,000 tons of ore.
Butte county: Near Chapparal hill, near the Grizzly creek, a tributary to Butte creek, 46 miles miles from Oroville on the Susanville road.	.....	*Ore:* Magnetite ..... *Rock:* Slate and granite.	.....	.....	Brown, p. 224.
Napa county: 3½ miles from Saint Helena; 3½ miles from railroad.	Edson Adams.....	*Ore:* Hematite ..... *Rock:* Jasper schist.	Mesozoic (?).....	1173	
Shasta county: Near the head of Spring creek, north of Shasta City.	.....	*Ore:* Hematite ..... *Rock:* Slate.	Mesozoic	.....	Whitney, p. 322. "Near the head of Spring creek large bodies of hematite iron ore occur [in the metamorphic slates], pure and of good quality, of which numerous boulders have been washed down the cañon. Under favorable circumstances as to fuel and labor, these deposits would be very valuable. The quantity and quality of the ore seem to be all that could be desired."
Shasta county: Potter's iron mine, 2 miles northeast of United States salmon fishery on the McCloud river.	.....	.....	.....	.....	California State Mineralogical Museum.

Specimens of float magnetite have been sent to the State Mineralogical Museum from Sutter river, Amador county, near Tres Pinos, San Benito county, and from points in Butte and Yuba counties. Hematite is reported in the Kelsey tunnel, 14 miles from southeast of Crescent City, Del Norte county. Magnetic sand is known to exist at many points along the coast in large quantities.

Chromic iron ore in California.

Chromic iron ore has been found in pockets in serpentine rocks, of Mesozoic (Lower Cretaceous or Jurassic) age, at different localities along the Coast range and east of it. The body of ore occurring at any one point is usually small, so that a "mine" is soon exhausted. The following list of localities, which is doubtless very incomplete, is taken chiefly from the labels of specimens in the State Mineralogical Museum, San Francisco:

San Luis Obispo county.—Near the city of San Luis Obispo a large amount of ore has been mined from numerous openings; also near San Juan.

Fresno county.—Five deposits, within 20 miles of Fresno city.

Monterey county.—"Extensive beds of massive chromic iron ore are said to exist in the mountains of Monterey county" (Blake, p. 303), near Monterey. "Chromic iron may, however, be discovered sufficiently near to a place of shipment to become of value in time." (Whitney, p. 114.)

Santa Clara county.—Five miles east of San José, and near Los Gatos.

Alameda county.—East of San Antonio "considerable masses of chromic iron ore occur in this position, one of which was formerly worked to some extent." (Whitney, p. 19.)

Sonoma county.—Near Cloverdale; near Litton Springs; near Healdsburg.

Del Norte county.—Near Crescent City (probably the largest deposit of chromic iron ore thus far discovered in the state).

Calaveras county.—"On the south side of San Diego gulch, Calaveras county, on the crest of the highest hill, opposite the Noble copper mine, there is an isolated mass of this ore that will weigh thousands of tons." (Brown, p. 225.)

Amador county.—Near Jackson.

Sacramento county.—Seven miles east of Folsom.

El Dorado county,—Northwest of Shingle Springs.

Iron ores in Oregon.

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Josephine county: On Althouse creek, 4 miles north of California state line, in (about) T. 40 S., R. 7 W.	.....	*Ore:* Magnetite	.....	.....	
Coos county: In (about) T. 27 S., R. 10 W., near Coaledo.	.....	*Ore:* Magnetite	.....	.....	
Marion county: On Butte creek, in T. 6 S., R. 1 E.	.....	*Ore:* Titaniferous magnetite.	.....	.....	b
Clackamas county: North of Clackamas river, in T. 4 S., R. 5 E.	.....	*Ore:* Float limonite	.....	.....	
Clackamas county: 2½ miles from Oswego furnace, in T. 2 S., R. 1 E. Prosser mine. Railroad to mine.	Oswego Iron Company.	*Ore:* Bog-ore ..... *Rock:* Basalt.	.....	1165 1167	Bed of bog-ore intercalated between two basaltic flows.
Clackamas county: Half mile from Oswego furnace, in T. 2 S., R. 1 E. Patton mine.	M. Patton	*Ore:* Bog-ore	.....	1166	
Multnomah county: Near Rooster rock, in T. 1 N., R. 5 E.	.....	*Ore:* Magnetite (?)	.....	.....	
Columbia county: 3 miles northwest of Saint Helen's, in T. 5 N., R. 1 W.	.....	*Ore:* Bog-ore (?)	.....	.....	
Clatsop county: 15 miles south of Astoria, in T. 6 N., R. 9 W.	.....	*Ore:* Bog-ore (?)	.....	.....	c
Clatsop county: 6 miles south of Astoria, in T. 7 N., R. 10 W.	.....	*Ore:* Bog-ore (?)	.....	.....	

Iron ores in Washington Territory.

Location and distance from the nearest railroad or navigable stream.	Owners or lessees.	Character of ore and associated rock.	Probable geological horizon of ore.	If sampled, the number of sample.	Authority and general remarks.
Thurston county: Southwest of Olympia, in (about) T. 17 N., R. 2 W.	.....	*Ore:* Bog-ore	.....	.....	d
Jefferson county: Southwest of Port Ludlow, on the head of Dabop bay, in (about) T. 28 N., R. 1 W.	.....	*Ore:* Bog-ore	.....	.....	
Jefferson county: Chimicum valley, 2½ miles from Irondale, in (about) T. 29 N., R. 1 W.	.....	*Ore:* Bog-ore	.....	1168	Used in furnace at Irondale.
Clallam county: In Gray's marsh, near Squim bay, in (about) T. 30 N., R. 3 W.	.....	*Ore:* Bog-ore	.....	.....	
King county: In the Snoqualmie pass, in (about) T. 22 N., R. 10 E.	.....	*Ore:* Magnetite	.....	.....	
Snohomish county: On the Skykomish river, in (about) T. 27 N., R. 8 E.	.....	*Ore:* Bog-ore	.....	.....	
Snohomish county: Near town of Snohomish, in (about) T. 28 N., R. 5 E.	.....	*Ore:* Bog-ore	.....	.....	
Whatcom county: On Nookaahk river, in (about) T. 39 N., R. 2 E.	.....	*Ore:* Bog-ore (?)	.....	.....	e
Whatcom county: On Birch point, near Bire'a bay, in (about) T. 40 N., R. 1 W.	.....	*Ore:* Bog-ore (?)	.....	.....	
San Juan county: On east side Cypress island, 200 yards from Bellingham straits, in (about) T. 36 N., R. 1 E.	.....	*Ore:* Magnetite	.....	.....	
San Juan county: On Topez island, in (about) T. 35 N., R. 2 W.	.....	*Ore:* Hematite ..... *Rock:* Jaspery quartz.	.....	.....	
San Juan county: San Juan, in (about) T. 35 N., R. 3 W.	.....	*Ore:* Magnetite	.....	.....	See analysis of ore in text.

Iron ores in Arizona.

Professor Newberry found specular ore in Monument and Mojave cañons, and hematite in the Diamond River cañon, also near the Colorado river.—*Geological Report of Colorado Exploring Expedition*, Lieutenant J. C. Ives in charge (1857–'58). f

In the mineralogical tables of Vol. III of the Geological Surveys west of the 100th meridian, Lieutenant George M. Wheeler in charge, mention is made of the occurrence of hematite on the Rio Francisco; of limonite on Rocker creek, a tributary to the Colorado river in the northern part of the territory; and near the town of Dos Cabezas (in the southeastern portion of the territory), and of titaniferous magnetite in the Dragoon mountains (southeast of Tucson); magnetite also occurs near Dos Cabezas.

Iron ores in New Mexico.

"Hematite has been found in the Burro mountains, near Silver City, and in the Placer mountains; limonite exists in the Madelina and Nacimiento mountains." (Wheeler, Vol. III, p. 65.)

Magnetite occurs in the Los Cimarron mountains, 22 miles south of Santa Fé (sample No. 1174), in the Placer and Los Dcos mountains, on the Maxwell land grant near Elizabethtown (Colfax county), and near the Cimarron cito (sample No. 1175), and in the mountains near Santa Fé. Carbonate and limonite derived from it is found in the coal series near Galisteo (San Miguel county), and in the Raton mountains in Colfax county, near the Colorado State line.