46-14

PRELIMINARY REPORT

IRON DEPOSITS OF RUNNING WOLF DISTRICT JUDITH BASIN COUNTY, MONTANA

1121

by

G. E. Goodspeed

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ILLUSTRATIONS

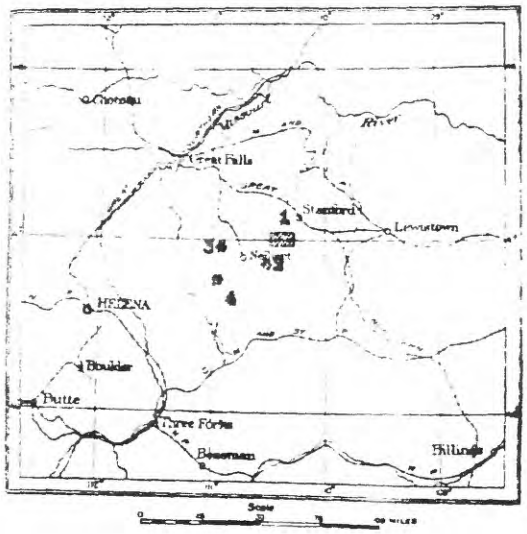

Figure 1: Index map showing general location of Running Wolf Iron deposits, rectangular lined area below "1", from U. S. G. S. Bull. 715-F, p. 85.

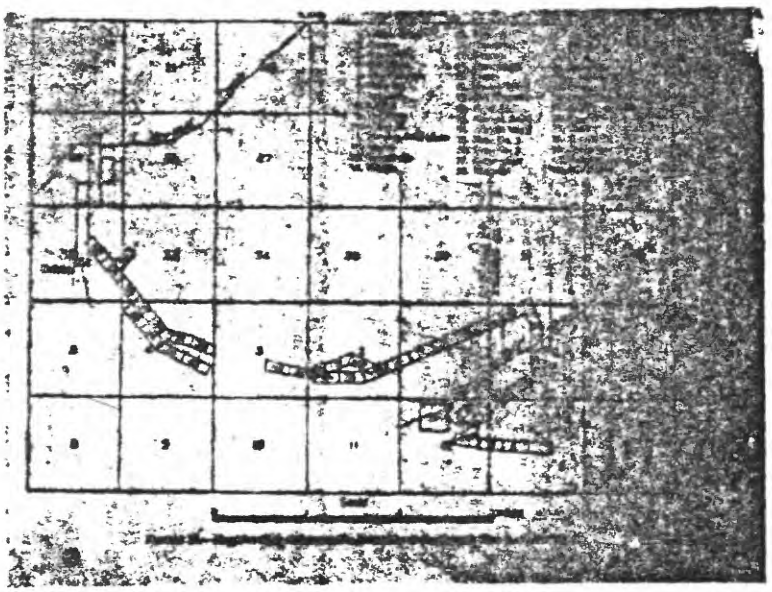

Figure 2: Claim map of Running Wolf iron deposits, from U. S. G. S. Bull. 715-F, p. 88, by Lewis G. Westgate.

readily accessible by county or farm roads, but others are accessible only by trail.

Mr. R. W. Wilson of Great Falls, Montana is the owner of most of the mining claims in the Running Wolf district. The list of patented claims furnished by him in July 1943 is as follows:

R. W. Wilson Mining Claims:

Willow Creek	Dewey	Snow Storm No. 1	Mountain View
Tunnel Site	Crystal Spring	Dorothy	Marjorie
Hill Side	Red Mammoth	Snowbird	Boiler Placer
Rainbow	Big Falls	Republican	Iron Mountain
Homestake	Big Ben	Copper King	Lookout
Bonanza	North Star	Copper Queen	LeRoi
Black Eagle	Snow Storm No. 2	Steamboat	

R. W. Wilson and Frank Whitaker, c/o R. M. Armour, First National Building, Great Falls, Montana, undivided one-half interest:

Ruby No. 1
Ruby No. 2
Ruby No. 3

Other Owners of Patented Claims

Claim	Owner
Ironclad) Iron King)	Alice Albright Shadoan, 206 S. Yellowstone, Livingston, Mont.
Joseph M. Giroux -	Dewey Whitaker, c/o E. J. Stommes, Montana Bank Bldg., Great Falls, Mont.
Iron Crown) Iron Cross)	Great Falls Townsite Company, Great Falls, Mont.

A general geologic study of this area was made by the Geological Survey in the mapping of the Fort Benton and Little Belt Quadrangles 1/. Weed and Pirsson included more detailed geologic and petrographic information in another report published about the same time 2/. In 1918 Lewis C. Westgate of the Geological Survey studied the iron ore deposits near Stanford, Montana 3/. In 1941 E. N. Goddard of the Geological Survey made a brief report on this district in an unpublished letter to the Chief Geologist, G. F. Loughlin.

During July, August, and the first part of September, 1943, the writer, assisted by J. P. Fitzsimmons, examined most of the iron deposits of this district and made a topographic and geologic map of the most promising deposits on the divide between Running Wolf and Willow Creeks. In the latter part of 1943, and the early part of 1944, the Bureau of Mines drilled 4 diamond drill holes at this locality and dug 15 trenches across the contact of the igneous and sedimentary rocks exposing the iron ore bodies on the Giroux, Iron Crown, and Iron Cross claims. The Bureau also made numerous chemical analyses of samples from their exploratory work. During 1943-1944 the writer studied over 75 thin sections and polished ore sections from this district.

GEOLOGY IN RELATION TO THE IRON DEPOSITS

In the Running Wolf district there are two main igneous rock masses. The one composing Woodhurst Mountain has an exposure approximately 3 miles in diameter; the other, about 4 miles west and adjacent to Dry Wolf Creek, about 2 miles in diameter. The Woodhurst Mountain intrusive mass is shown by Westgate to be separated from the igneous body to the south by a narrow band of Madison limestone (Figure 3). This interpretation is probably the correct one in contrast to Weed's map where this body is shown to be the northeastern extension of the Yogo Peak igneous mass. However, it is possible that they are connected in depth. Most of the igneous bodies have been more resistant to erosion than the adjacent sedimentary rocks and, therefore, form individual mountains and peaks such as Woodhurst Mountain.

The border facies of these intrusive bodies are commonly porphyries and have an aphanitic groundmass. The phenocrysts consist mainly of small, white, feldspar crystals; a few mafics, chiefly biotite, and locally a little quartz. Under the microscope the following minerals were noted: plagioclase (oligoclase), orthoclase and sanidine, quartz, biotite, hornblende, a little apatite, and corundum (sapphire). The border facies are quickly cooled phases of syenitic

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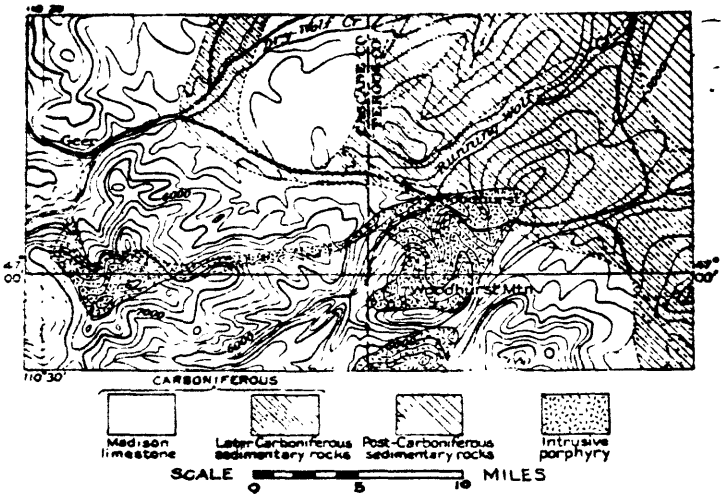
1/ Weed, W. H., U. S. Geol. Survey Geol. Atlas, Fort Benton folio (No. 55), 1899; Little Belt Mountains folio (No. 56), 1899.

2/ Weed, W. H., and Pirsson, L. V., U. S. Geol. Survey 20th Annual Report, Geology of the Little Belt Mountains, 1898-1899.

3/ Westgate, L. V., U. S. Geol. Survey Bull. 715-F, Deposits of Iron Ore near Stanford, Montana, 1920.



Contour interval equals 200 feet

Fig.3: Geologic map of vicinity of Running Wolf iron deposits from U. S. G. S. Bull. 715-F, p. 86, by Lewis G. Westgate.

magmas, and although their aphanitic groundmass suggests the term trachyte, it is perhaps more desirable, owing to their intrusive nature, to call them syenite porphyries.

The iron ore deposits of this district are commonly found adjacent to the contact of the larger intrusive bodies and the sedimentary rocks. Because of this fact it was believed that the iron ores are normal contact deposits and that these deposits might be found anywhere along the contact of the sedimentary and igneous rocks. However, there are many portions of this contact completely barren of ore, and even in the vicinity of ore occurrences the actual contact of the igneous and sedimentary rock commonly does not show any iron mineralization, and may be several feet away from the ore. Furthermore, normal contact metamorphic deposits are characterized by an extensive zone of contact metamorphic minerals. Such zones are lacking in this district, although at one locality a few small, irregular, discontinuous, garnet-calcite veinlets transect the adjacent, partially crystallized limestone.

On the northwestern slope of Woodhurst Mountain, about 600 feet southeast of the Running Wolf Creek road, an exploratory tunnel cuts the contact between the igneous and sedimentary (limestone) rocks. This contact consists of a crushed zone from 3 to 12 inches wide, a pronounced

zone of flow banding in the igneous rock 4 to 5 inches wide, and a fine-grained chilled border zone several feet wide. Thin sections show protoclastic structure in the banded zone, and some alteration in the chilled border. Near this contact the limestone is a compact, banded, gray rock, and the microscope shows it to be partially recrystallized. There are several small veinlets of calcite and garnet transecting the bedding planes.

This particular contact of the Woodhurst Mountain laccolith definitely shows that the syenite porphyry was injected in a partially crystallized state, and that the immediate contact was affected by continuing magmatic pressure which produced the protoclastic border. The alteration of the igneous rock adjacent to the contact shows the effect of deuteric alteration, i. e., the volatiles contained in the magma were released in the late stages of crystallization, and in migrating outward from the main intrusive body they altered the chilled zone.

Some of the volatiles may have penetrated this zone and formed a few garnet-calcite veinlets in the limestone. The small amount of contact metamorphism does not seem to be compatible with the size of the intrusive masses. This may be due to a relatively small volatile content of the magma, and perhaps by the confining effect of the chilled border.

The limestone is only partially recrystallized and contains only small garnet veinlets. In the shale there is a slight indication of metamorphism in the development of authigenic feldspar, i. e., feldspars which have formed in place after the deposition of the sediment. This slight metamorphism of the sedimentary rock suggests that no large amount of he or volatiles escaped rapidly from the magma.

As previously stated, the actual contact of the porphyry and limestone is a crushed zone from 3 to 12 inches wide. This is not only indicative of post-intrusive deformation, but also suggests a possible mechanism by which later hydrothermal solutions rose along this zone and formed the iron deposits. More conclusive data concerning the post-intrusive deformation were seen at a contact near the head of Sage Creek

Here the contact is exposed in the workings of a prospect belonging to J. E. Maeder of Stanford, Montana. It is near the head of Sage Creek just north of Bear Park Hill, and about 1 mile south of the divide between Willow Creek and Running Wolf Creek. This contact strikes east-west and dips steeply to the north with igneous rock on the hanging wall and gently, southerly-dipping limestone on the footwall. A distinct fault breccia is exposed on the north side of a small, 15-foot shaft. This brecciated zone is about 5 feet wide and consists of angular fragments of limestone and igneous rock up to 2 feet in diameter, in a matrix of bluish, clay-like material containing some magnetite, hematite, and sulphides. Fragments of the igneous rock which are surrounded by magnetite are much altered. The light brown of the igneous fragments and the bluish-white of the limestone fragments contrast strikingly with the black magnetite. It is, therefore, clear that the magnetite was formed after the intrusive, and was structurally controlled by post-intrusive deformation.

On the Giroux claim near the eastern end of the iron ore outcrop, the contact between the igneous and sedimentary rocks strikes approximately

trenches and 4 diamond drill holes (Plates I and II). The chemical analyses made by the Bureau of Mines of samples from the trenches and core are given on pages 16-17 of this report. The holes were logged by F. C. Armstrong of the Northwest Regional Office of the Geological Survey, and these records are given on page 18 of this report.

Character of the Ores

Although in most of the exposures the boundaries of the ore are well-defined, in two trenches, 17 and 19, they are said to have the appear ance of replaced limestone. In general, limestone forms the hanging wall of the ore, and altered prophyry the footwall, but the diamond drill holes (see logs) show from 3 to 6 feet of altered limestone below and between the ore and the porphyry. The cores show brecciated limestone in the vicinity of the ore, and the lack of core indicates the probable shattered condition of the rock. The presence of gougey material and altered rock indicates hydrothermal action, as does the common occurrence of jasperoid veinlets. If the alteration were due to weathering, more widespread effects would be expected from the surface downward, and the pyrite which is present in the altered igneous rock would not be expected.

In general, the iron ore is compact, fine-grained, and fractured The fine-grained ore fractures somewhat like matte; the coarser-grained ore, like cast iron. Local porous structures in the ore are apparently caused by the leaching of included remnants of limestone. Most of the ore is magnetic, although some of it shows a reddish color on grinding. In polished sections it is seen that magnetite is the predominant ore mineral, commonly accompanied by varying amounts of specular hematite and limonitic material, some of which appears to be hypogene, and some supergene in origin. Many of the sections exhibit small, irregular inclusions of limestone in the iron ore aggregate, projections of the iron ore into the carbonate, and well-developed crystal edges of magnetite against the carbonate. Most of the sections show the presence of chalcedony or jasperoid, which appears to be both contemporaneous with and later than the magnetite. A little pyrite seen in many of the sections was earlier than the magnetite. A very little chalcopyrite and green-staining by malachite were observed in one of the cuts.

A specimen of the iron from diamond drill hole No. 4 is brownish-black and contains numerous, irregular cavities which are partially filled with limonite, chalcedony, and carbonate. Some are completely filled with chalcedony. The black iron ore has a hackly fracture. Some has a platy structure resembling specular hematite but has a black streak and is magnetic. A polished section of this specimen when examined by reflected light shows predominantly a very fine-grained aggregate of magnetite with a few specks of specular hematite. Associated with the fine-grained magnetite is very finely granular, reddish, crystalline, limonitic material and a few small irregular masses of chalcedony. The magnetite shows well-formed crystal edges in juxtaposition with the chalcedonic quartz indicating a contemporaneity of formation. A few, small, irregular relics of carbonate are present. Minute, later, roughly parallel veinlets of limonite transect both the magnetite and the chalcedony.

N. 70° W. Portions of it are fairly straight for two or three hundred feet; near the eastern edge of the claim the trace of the contact is wavy, the waves having an amplitude of 25 to 50 feet in a north-south direction. Near the west end of the Iron Crown claim the contact veers to the north. About 150 feet east of the east end of the iron ore outcrop on the Giroux claim, the contact is exposed in Bureau of Mines trench 13; about 300 feet northeast of this point it is exposed in Bureau trench 14. This abrupt change in direction might be explained by a fault, although there is no surface expression of such a feature, or by a locally discordant portion of the contact.

Owing to the paucity of continuous limestone outcrops, it is not possible to determine accurately the attitude of the limestone strata in this area. About 25 feet east of the iron ore outcrop on the Giroux claim the limestone is nearly vertical with an east-west strike; about 250 feet farther to the northeast it has a strike of N. 80° E. and dips 50° S. Approximately 150 feet to the west of the west end of the Giroux outcrop, the limestone strikes N. 70° E. and dips 70° S.; farther west, on the Iron Crown claim, it has a strike of N. 80° W. and dips 37° S. On the Iron Crown claim to the west, readings of similar strike were recorded for the limestone outcrops with more gentle southerly dips, 50° and 37°. It seems evident that the limestone strata dip away from the intrusive mass of Woodhurst Mountain, and that the dips are more steep closer to some portions of the contact. Syenite porphyry outcrops on the hill to the south, but there is no indication of iron ore along the probable contact.

Limestone. Lithologically the limestone, which presumably belongs to the Madison, ranges from a very compact, although locally finely jointed, bluish-gray rock to a more crystalline, white rock. The white limestone is distinctly more coarsely crystalline than the blue-gray limestone, and individual calcite grains are discernible with a hand lens. The outcrops of limestone west of the old shaft on the Giroux claim show lenticular, cherty bands, some of which are about 5 inches wide. These bands are apparently parallel to the bedding.

THE IRON ORE DEPOSITS OF THE RUNNING WOLF-WILLOW CREEK AREA

Most of the iron ore deposits of this area are in the form of narrow, steeply dipping lenses which occur along about 4,200 feet of the contact between the limestone and the igneous rock. Although actually exposed in but a few places this contact, as indicated by float and by old prospect trenches, has a total length of about 6 miles. The 4,200 feet of the contact, which has been systematically explored, has adjacent to it iron ore lenses having a total length of approximately 1,600 feet, and it is believed that this sector contains more iron ore than the average for the total length of 6 miles. This indicates that iron ore lenses are adjacent to less than 36 percent of the contact.

Two of these ore lenses are shown on the accompanying topographic and geologic map, Plate 1. They are located on the Giroux and the Iron Crown and Iron Cross claims. The exploratory work done by the Bureau of Mines during the winter of 1943-1944 consisted of numerous

Another specimen of iron from 126 feet below the collar of diamond drill hole No. 4 is fine-grained, purplish-black, intersected by irregular, discontinuous veinlets of calcite, and contains numerous, small, irregular, carbonate inclusions. A polished section of this specimen shows irregular patches of very fine-grained hematite with finely granular, limonitic material included in slightly darker magnetite, and numerous inclusions of carbonate. A thin section from the same specimen shows that most of the irregular, carbonate masses are probably relics of the limestone which has been replaced by magnetite and hematite. Projections of the iron ore into the carbonate and well-developed crystal edges of the magnetite against the carbonate are common. A little chalcedonic quartz is associated with the carbonate.

Although the previously described core specimens suggest replacement of limestone by the iron ore, the next foot of core is even more suggestive of this process. It has a blotchy appearance with irregular, purplish-black masses of iron ore fading into yellowish-white, altered limestone. Under the microscope the altered limestone is seen to be a fibrous aggregate of anthophylite and tremolite with carbonate, zoisite, a little kaolinitic material, and grains of magnetite and red, limonitic material. There is present a roughly parallel structure formed by minute, anastomosing, turbid carbonate veinlets. A polished section of the iron ore associated with the altered limestone shows a fine-grained aggregate of magnetite and a little hematite which is in gradational contact with finely granular, iron-stained limestone. Relics of the limestone are included in the iron ore, and the iron ore projects into the limestone. The iron ore is transected by minute, carbonate veinlets, and contains several, small, irregular inclusions of a soft, greenish-white, amorphous-appearing material.

Mode of Formation of the Iron Ore Deposits on the Giroux, Iron Crown and Iron Cross Claims

Although the position of these deposits adjacent to a contact between porphyry and limestone suggests that they are genetically contact deposits, the lack of zones of high-temperature, lime silicates, as well as the presence of a few feet of limestone between sections of ore and the syenite porphyry, are indicative of the inadequacy of this interpretation. However, the alteration and the intimate association of jasperoid quartz with the ore, an association to be seen under the microscope in the very fine-textured ore from the surface and at depth, strongly suggest that the ore was formed by ascending hydrothermal solutions.

The fracturing observed in some of the surface exposures, the considerable amount of deformation indicated in the drill holes, as well as the brecciation of nearby localities previously described, suggest that the hydrothermal solutions were controlled by a fracture system which approximately paralleled only portions of the contact between the igneous and sedimentary rocks.

These fracture systems provided the channel ways for the ascending hypothermal solutions and, although some filling took place, it is probable that replacement played the dominant role in the formation of

these deposits. Many features, including numerous relics of limestone in the ore, are indicative of replacement.

The shape of these iron ore deposits and the dominance of magnetite as an ore mineral seems to place them in the hypothermal vein zone. However, the presence of chalcedony and jasperoid, as well as apparently hypogene limonitic minerals and the lack of high-temperature lime silicates, would indicate a not too elevated temperature of formation. It is possible that the iron-rich hydrothermal solutions which formed the ore came as the later products of a basic magma crystallizing at depth. It appears very doubtful that these solutions came from the adjacent Woodhurst Mountain laccolith.

Two important economic deductions may be based upon the data and interpretations as outlined above. First, that the fracture system and not the intrusive contact is the controlling structure; therefore, the ore cannot be expected to continue uninterruptedly along the contact. Secondly, it appears unlikely that the ore body at depth would show any greater tonnage per vertical foot than is shown on and near the surface. Moreover, the presence of earlier pyrite in core of the deepest drill hole may indicate a radical change in the mineral character of the ore at greater depth. However, on the Iron Cross claim the presence of pyrite in the surface exposures and not at depth is of interest because since pyrite is the earlier mineral, greater concentrations might be expected at depth. The available data with regard to this deposit are too few to furnish accurate interpretations as to the cause of this seeming anomaly. It is possible, of course, that pyrite was not originally evenly distributed, either vertically or laterally.

Reserves on Giroux, Iron Crown and Iron Cross Claims

Because the Running Wolf iron ores are largely replacement deposits, an estimate of the reserves based on the small amount of data available is liable to be in error. There are insufficient data to warrant an estimate of measured ore on these claims. However, it is believed that the figures given below are of the correct order of magnitude and that it can be positively stated that the deposits are small--too small to be considered a source of iron under existing economic conditions.

Specific gravity determinations were made on several specimens of the Running Wolf iron ores and an average of these proved that a factor of 8 cubic feet of ore per ton was accurate for tonnage estimates.

On the Iron Cross and Iron Crown claims it is estimated that the ore body shown in vertical longitudinal projection E-E' (Plate 2) is 16.1 feet wide and contains 550,000 tons of indicated ore and 200,000 tons of inferred ore which averages 59.96 percent Fe, 0.018 percent P, 0.104 percent S, 6.77 percent Insoluble, 0.023 percent Cu, and 0.01 percent TiO_2. Because of the inclusion of sample No. 125 (See Page 16) in the estimate, the width and tonnage may be slightly high and the grade slightly low. Trenching has shown that neither end of the ore body is open at surface, and it is assumed that the ends of the ore down dip are the same as those indicated by surface trenching. Indicated ore is

assumed to extend 50 feet down dip below the diamond drill hole intersections. Inferred ore is assumed to extend 100 feet down dip below the lower limit of the indicated ore.

On the Giroux claim it is estimated that the ore body shown in vertical longitudinal projection F-F' (Plate 2) is 5.9 feet wide and contains 80,000 tons of indicated ore and 40,000 tons of inferred ore which averages 55.37 percent Fe, 0.025 percent P, 0.124 percent S, 15.27 percent Insoluble, 0.006 percent Cu, and 0.01 percent TiO_2. These tonnage figures are based on a down dip projection of 50 feet below diamond drill hole No. 2 for indicated ore, and an additional 100-foot projection for inferred ore. The presence of only 1.4 feet of ore in diamond drill hole No. 1 may indicate a rake of the ore to the west as shown on Plate 2. However, if this means that the ore body is the bottom portion of a lens as shown by the dashed line on Plate 2, then the above tonnage estimate must be revised. In this case there are only 60,000 tons of indicated ore and no inferred ore.

Logs of Diamond Drill Holes

Log of Diamond Drill Hole No. 1

Elev. of Collar	Inclination	Bearing	Depth in Feet	Coordinates North	Coordinates East
6,151	-43°	N. 22° 30' E.	111	19817	17929

Size: AX 0 to 101 feet; EX 101 to 111 feet.

Footage	Description and Remarks
0 - 26	No core.
26 - 48	Light gray to white, massive, limestone. 26 - 35 Slightly iron stained. 38 - 40 Darker gray, denser. 45 - 48 Darker gray, slightly sheared (30° to core). 17 feet recovered.
48 - 68	Decomposed, brecciated limestone, moderately iron stained and some green coloration in gougey material. Few chips solid limestone in decomposed material. 4 feet recovered.
68 - 78	White to light gray, finely crystalline limestone, locally slightly iron stained. 68 - 71 Moderately iron stained and decomposed. Core in chips. Some mud. 6-inch dense gray bed near 74 feet. 6-foot core recovered. Probably most lost 68 - 71
78 - 91.5	Limestone similar to 68 - 78. 3-foot core recovered. Probably most lost near 78 feet and 91.5 feet.
91.5 - 93	Iron formation. Some bands of heavily iron stained limestone at start, then magnetite, limonite, and probably some hematite in chips. Less than 1 foot recovered. Representative sample at 92.5 feet.
93 - 99	Decomposed limestone and syenite. Effervesces near start, gradually decreasing and disappearing near end. Moderately iron stained. 93 - 96. 1½ feet recovered.
99 - 111	Syenite, white, moderately coarse. Little scattered pyrite. Representative sample at 108 feet. 96 - 101 1½ feet recovered. 101 - 111 2 feet recovered.

Log of Diamond Drill Hole No. 2

Elev. of Collar	Inclination	Bearing	Depth in Feet	Coordinates North	East
6150	-49°	N. 22° 30' E.	134	19828	17664

Size: AX 0 to 112.5 feet; EX 112.5 to 134 feet.

Footage	Description and Remarks
0 - 48	Limestone. White to light gray, finely crystalline. Locally, moderately iron stained.
	19 - 20 Darker, denser bed.) Distances only approximate because of lost core between runs.
	22 - 27 Darker, denser bed.)
	30 - 32 Darker, denser bed.)
	46 - 48 Darker, denser bed.)
	37 - 41 Decomposed, slightly iron stained limestone; somewhat gougey.
	40 - 45 Fairly well banded (bedding?), 60° to core.
	0 - 20 Lost core 12'.
	20 - 33 Lost core 5'.
	33 - 37 Lost core 2'.
	37 - 48 Lost core 3'.
48 - 101.5	Limestone. Similar to above.
	48 - 65 Moderately iron stained. 6" dark gray bed near 61'.
	65 - 72 Medium gray, denser bed.
	72 - 92 Predominantly white limestone, little gray near 80'. Slightly iron stained after 85'. 4" quartz after 90'.
	92 - 96 Light gray, slightly iron stained.
	96 -101.5 Similar to 48 - 65.
	48 - 65 9' lost core.
	65 - 85 11' lost core.
	85 -101.5 10' lost core.
101.5 - 112.5	Brecciated, gray and white, slightly iron stained limestone. Bedding (?) at 65° to core.
	111.5 - 112.5 Quartz. 7' lost core.
112.5 - 118	First foot of recovered core dark gray limestone, fine-grained, massive. Next foot of recovered core iron formation. 3½' lost core. Representative sample near 117'.
118 - 126.5	Iron formation. Magnetite, limonite and probably some hematite. 4½' lost core. Representative sample near 120'?
126.5 - 134	Syenite, decomposed, with some limestone present to 130' then less decomposed to near 134'. Last few inches of hole in fresh syenite. 50 percent lost core.

Log of Diamond Drill Hole No. 4

Elev. of Collar	Inclination	Bearing	Depth in Feet	Coordinates North	Coordinates East
5995	-50°	N. 19° E.	141	20277	16228

Size: AX 0 to 141 feet.

Footage	Description and Remarks
0 - 24	Limestone, light gray to white, medium- to fine-grained. Locally slightly iron stained. 22' recovered.
24 - 28	Limestone, white, slightly iron stained.
28 - 35	Predominantly light brown (iron stained) limestone.
35 - 50	Brecciated gray and light brown limestone. Mostly gray after 48'.
50 - 56	Light gray and brown, fine-grained, banded limestone. Gougey and brecciated portion near 55'--fault (?).
56 - 86	Limestone, predominantly fine-grained, white, slightly iron stained. More staining toward 80 - 86' and some gray sections. Bedding (?) at 58' at 65° to core.
86 - 106	Limestone, white to light gray, fine-grained, massive. Locally slightly brecciated with slight iron staining along fractures. 99 percent recovery.
106 - 126	Magnetite and hematite. Numerous solution cavities. Central portion more predominantly hematite. Near 126 feet small remnants of limestone.
126 - 129	Limestone, fine-grained, medium gray, altered. Some magnetite and hematite in irregular patches--replacing limestone? 98 percent recovery.
129 - 136	Syenite porphyry. Decomposed. Locally little decomposed limestone. Few short sections of undecomposed syenite. 71 percent recovery.
136 - 141	Syenite porphyry. Fresh. 80 percent recovery.

Log of Diamond Drill Hole No. 5

Elev. of Collar	Inclination	Bearing	Depth in Feet	Coordinates North	East
6010	-50°	N. 50° E.	214	20503	15586

Size: AX 0 to 188.5 feet; EX 188.5 to 214 feet.

Footage	Description and Remarks
0 - 54.5	Limestone, light gray, fine-grained, massive. Locally iron stained. Few small vugs. 67 percent recovery.
54.5 - 93.5	Highly brecciated and decomposed material. Slightly iron stained.
	54.5 - 72 Predominantly decomposed syenite with few limestone fragments. 57 percent recovery.
	72 - 93.5 60 percent decomposed limestone fragments and 40 percent decomposed syenite. 88 percent recovery.
93.5 - 133	Limestone similar to 0 - 54.5. 50 percent recovery.
133 - 164	Limestone, greatly decomposed with short sections of limestone similar to 0 - 54.5 feet. Slightly iron stained in decomposed sections. 58 percent recovery.
164 - 188	Limestone similar to 0 - 54.5 feet. 42 percent recovery.
188 - 203.5	Magnetite and hematite iron formation. Numerous small cavities with some quartz in them. Some square corners in cavities--pyrite? R. S. at 190 feet. Water lost in iron formation. Badly broken. Difficult drilling. 14 percent core recovered by weight. Approximately 4 feet of core recovered. 26 percent recovery estimated from amount of core in the box.
203.5 - 206.5	Decomposed material. Approximately 80 percent syenite, 20 percent limestone. 50 percent recovered.
206.5 - 214	Syenite porphyry. 13 percent recovery.

Note: Total depth of hole, 214 feet.
Total footage cemented, 287 feet.

Bureau of Mines Analyses of Trench Samples--the Giroux, Iron Crown, Iron Cross Claims

Sample No.	Trench No.	True Thickness	Percent Iron	Percent Phosphorous	Percent Sulphur	Percent Insoluble	Percent Copper
117	1	5.4	55.65	0.018	0.080	16.21	
118	2	5.4	54.23	0.016	0.180	16.70	
119	3	6.2	46.71	0.014	0.070	25.90	
120	6	8.5	57.81	0.073	0.110	13.08	
121	4	4.6	53.79	0.011	0.030	18.18	
141	Giroux Discovery	4.2	60.84	0.016	0.110		0.002
122	15	8.6	53.60	0.016	0.064	20.48	0.010
123	15	5.2	61.01	0.012	0.036	11.80	0.019
Trench Av.		13.8	56.39	0.015	0.053	17.21	0.013
126	17	8.6	59.11	0.011	0.070	13.28	0.021
127*	17	7.0	10.39		0.076		0.008
Trench Av.		8.6	59.11	0.011	0.070	13.28	0.021
128	18	2.6	58.00	0.046	0.020	8.06	0.005
129	18	2.3	55.11	0.045	0.022	2.35	0.005
130	18	3.7	64.72	0.026	0.766	2.09	0.021
131	18	4.3	65.03	0.036	0.398	3.36	0.014
132	18	4.3	64.66	0.024	0.456	3.28	0.016
133	18	4.3	65.99	0.020	0.148	0.90	0.011
134	18	4.3	66.80	0.014	0.034	1.82	0.002
135	18	3.5	44.18	0.021	0.018	1.66	0.002
Trench Av.		29.3	61.44	0.027	0.254	2.74	0.010
124	16	4.3	53.10	0.029	0.124	4.73	0.090
125	16	4.3	27.13		0.048		0.019
Trench Av.		8.6	40.11	0.029	0.086	4.73	0.054

(Continued)

(Continued)

Sample No.	Trench No.	True Thickness	Percent Iron	Percent Phosphorous	Percent Sulphur	Percent Insoluble	Percent Copper
136	19	5.2	44.95	0.018	0.036		0.002
137*	19		18.40		0.088		0.002
Trench Av.		5.2	44.95	0.018	0.036		0.002
138	20	6.8	67.20	0.012	0.020		0.002
139	20	6.8	61.91	0.014	0.088		0.015
140	20	4.1	63.78	0.007	0.086		0.165
Trench Av.		17.7	64.38	0.012	0.061		0.045
144	21	6.1	67.85	0.011	0.062		0.002
145	21	6.1	66.11	0.019	0.106		0.057
146	21	6.1	63.11	0.012	0.122		0.011
147	21	6.1	59.37	0.011	0.128		0.002
148	21	3.5	59.42	0.011	0.142		0.002
Trench Av.		27.9	63.52	0.013	0.109		0.016

* These samples not used in calculating averages.

Bureau of Mines Analyses of Drill Hole Samples--Giroux, Iron Crown, Iron Cross Claims

Footage and Type Sample	Hole No.	True Thickness	Percent Iron	Percent Phosphorous	Percent Sulphur	Percent Insoluble	Percent Copper	Percent TiO_2
Core 92-93	1	1.0[a]	52.98	0.019	0.032	20.38	0.012	0.01
Core 116.5-122	2	5.2	56.88	0.011	0.320	15.06	0.010	0.01
Core 122-126	2	3.8	58.38	0.016	0.058	12.26	0.002	0.01
Av. for Hole		9.0[b]	57.51	0.013	0.210	13.88	0.006	0.01
Core 106-111	4	4.7	67.26	0.010	0.018	2.07	0.010	0.01
Core 111-115	4	3.8	67.42	0.006	0.014	1.82	0.012	0.01
Core 115-120	4	4.8	57.30	0.012	0.046	11.67	0.186	0.01
Core 120-125	4	4.8	59.52	0.009	0.020	7.97	0.002	0.01
Core 125-128	4	2.9	41.72	0.032	0.024	13.92	0.002	0.01
Sludge 107-112*	4		58.88	0.017	0.064	3.18	0.002	0.06
Sludge 112-117*	4		58.80	0.011	0.046	8.39	0.212	0.02
Sludge 117-122*	4		56.90	0.012	0.052	8.87	0.002	0.01
Sludge 122-127*	4		62.00	0.015	0.060	3.96	0.010	0.01
Sludge 127-129*	4		32.22	0.041	0.076	17.55	0.002	0.02
Av. for Hole (core only)		21.0[c]	59.72	0.013	0.025	7.20	0.048	0.01
Core 188-195	5	5.9	65.84	0.024	0.052	1.85	0.002	0.01
Core 195-203.5	5	7.1	66.25	0.021	0.054	2.19	0.002	0.01
Sludge 189.5-195	5		53.27	0.049	0.128	9.84	0.002	0.01
Av. for Hole (core only)		13.0[d]	66.06	0.022	0.053	2.04	0.002	0.01

*These samples not used in calculating averages.

a. In estimates of tonnage and grade, 1.4' used as true thickness.
b. In estimates of tonnage and grade, 11.9' used as true thickness.
c. In estimates of tonnage and grade, 18.8' used as true thickness.
d. In estimates of tonnage and grade, 14.6' used as true thickness.

Other Analyses from the Running Wolf District

The following analyses are taken from United States Geological Survey Bulletin 715-F, p. 91, by L. G. Westgate:

Analysis No.	Claim and map No.	Iron	Phosphorus	Silica	Sulphur	Lime
1)		(66.05	0.015	1.90		
2)		(65.01	.014	3.90		
3)	Iron Crown (3)	(64.00	.0028	6.50		
4)	and Iron Cross	(66.50	.0028	4.20		
5)	(4)	(64.30	.005	5.90		
6)		(65.30	.006	5.53		
7)		(64.00	.014	6.10		
8	Snowbird (39)	67.90	.0028	2.80		
9	do	65.60	.0	2.50		
10	do	66.20	Trace.	2.20		
11	Iron Mountain (5)	64.20	Trace.	4.20		
12	Iron King (9)	66.90	Trace.	2.00		
13	Crystal Spring (20)	63.20	Trace.	5.40		
14	Snowbird (39) and Dewey (19)	64.00	.014	6.10		
15	Snowbird (39)	67.00	.010	4.50	None	
16	do	61.50	.010	5.70	None	
17	Geroux (2)	63.69	.020	6.18		
18	Iron Crown (3)	56.52	.025	5.07		
19	Iron Cross (4)	37.41	.107	3.17		8.87
20	Iron King (9)	56.51	.021	4.10		
21	Carrie M. (10)	56.00	.019	12.95		
22	Dewey (19)	63.09	.035	5.71		
23	Iron King (9)	58.44	.022	4.55		
24	Snowstorm No. 1 (37)	34.88	.021	3.90		High
25	Snowbird (39)	50.14	.026	6.60		
26	do	58.03	.020	7.86		

1-7, 14-16 by Colorado Fuel & Iron Co.; 8-13 by Anaconda Copper Mining Co.; 17-26 by Dwight E. Woodbridge, Duluth, Minn.

LE ROI (IROQUOIS) AND IRON KING CLAIMS

The Le Roi (Iroquois) and Iron King claims are located on the northwestern slope of Woodhurst Mountain in the south-central portion of Sec. 6, T. 14 N., R. 11 E. The principal workings are about 600 feet southeast of Running Wolf Creek road. A few pieces of iron ore float may be seen in the road, and a few small pits are nearby. The workings consist of a tunnel 65 feet long. About the first half of it is driven in a southeasterly direction (S. 37° E.), and the remainder in a southwesterly direction. There is a short tunnel and a few cuts just above and to the southeast of the longer tunnel.

The best exposure of iron ore is seen in the long tunnel and raise above it, about 23 to 30 feet from the portal. The ore occurs chiefly as bands of magnetite and subordinate pyrite, parallel to the original bedding of the limestone which dips about 30 degrees to the southwest; the same direction, but not so steeply as the contact between the igneous rock and the limestone. The actual contact, which is a crushed zone from 3 to 12 inches wide, strikes N. 70° W. and dips 41° SW. The contact, which probably is in nearly the same position as the original intrusive contact, is not perfectly conformable to the bedding planes of the limestone but transects them at a small angle.

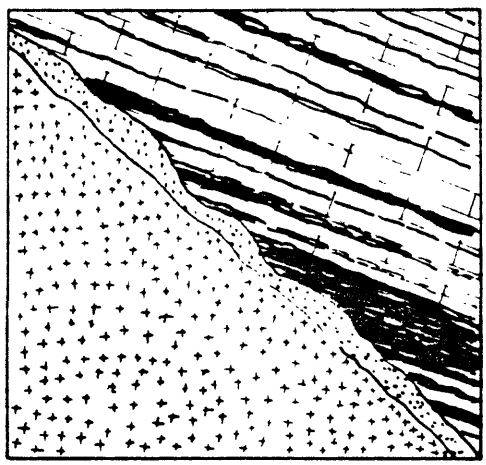


Figure 4: Sketch of contact of igneous rock (4) and limestone (ls) showing crushed zone (stippled) and banded ore (black) replacing limestone. Approximate size of section 10 by 12 feet. From tunnel and raise on Le Roi claim.

The bands of ore range from a fraction of an inch to about 2 feet wide and, as exposed in the tunnel and in the short raise, there appears to be an aggregate stratigraphic thickness of approximately 20 feet. It exhibits all gradations from massive magnetite with considerable amounts of pyrite to nearly pure limestone with small vein-like bands of ore. In addition to pyrite, there are local occurrences of specular hematite. Although the ore is exposed for several feet in the tunnel and raise, there is no direct evidence as to its extent down the dip of the limestone. The dip needle gave evidence of attraction for about 50 feet east and 50 feet west of the tunnel.

Polished sections about 2 inches square of this ore show nearly solid bands of finely granular magnetite over half an inch wide, separated by bands of grayish-green limestone. The bands of magnetite are, in general, parallel to the bedding with fairly well-defined borders, but locally are lenticular. They show considerable variation in width, and may break into parallel, lenticular veinlets connected by very narrow veinlets. Some of the wider bands of ore contain tabular, elongated, lenticular inclusions of limestone.

Minute, rounded protrusions of the magnetite into the limestone, as well as minute, irregular veinlets of magnetite surrounding calcite grains in the limestone, are seen in the thin and polished sections. The polished sections also show numerous, irregular grains and well-formed crystals of early pyrite in the limestone. Magnetite is clearly later than this pyrite as it surrounds and transects the latter. There are, however, a few, minute, transecting veinlets of pyrite and associated carbonate which are apparently later than the magnetite. There are also minute, irregular cavities which have apparently resulted from the solution of included limestone; some of these are stained with limonite suggesting the former presence of pyrite. Locally there are conspicuous plates of specular hematite in joint cracks in the altered limestone and in the igneous rock adjacent to the contact. Platy crystals of specular hematite are also noticeable in a few of the finer grained bands of ore. Polished sections from one of these bands show the hematite plates extending into the very fine-grained portions and including minute grains of magnetite. There also appears to be an intricate network of hematite, recognizable by its slightly lighter color in polished section, surrounding grains of magnetite.

The evidence seen in this deposit indicates that replacement was the dominant mechanism of formation. It is probable that hydrothermal solutions rich in iron rose through fracture or fault zones adjacent to the igneous contact, replacing the limestone and penetrating it along bedding planes and fractures. There is no definite evidence as to either the stratigraphic extent or the extent along the bedding planes of such penetration. The dip needle, however, does not indicate a large body of ore. Although the iron ore minerals are high grade, the amount of pyrite, 10 percent, in the ore makes this deposit unattractive as an iron deposit. There is no evidence to indicate whether the amount of pyrite might be expected to increase or decrease with depth.

There is insufficient exploratory work and sampling to make an estimate of measured ore for this deposit. The exposures on the ore body show a stratigraphic thickness of 20 feet. Assuming, on the basis

of exposures and a dip needle traverse, that the ore extends over an area approximately 100 by 100 feet and is 20 feet thick, it is estimated that there are 25,000 tons of indicated ore on the property. As much again, or another 25,000 tons, is estimated as inferred ore.

ALBRIGHT CLAIMS

The Albright claims are in Sec. 2, T. 14 N., R. 10 E., approximately 3 miles southwest of Dry Wolf Creek, and less than 1 mile northeast of Running Wolf Creek. They are located on the northern slope of the ridge separating Running Wolf and Dry Wolf Creeks and can be reached by wood road and trail from the Dry Wolf Creek road.

Many of the cuts on these claims, as examined in July 1943, were filled with debris due to slumping; and geologic relationships were further obscured by the tree growth and thick cover. In one cut the iron ore is from 8 to 10 feet wide with an approximately east-west strike and a nearly vertical dip. Blue and white limestone rubble were present in this cut. The iron ore is similar to that which has been previously described in the Running Wolf-Willow Creek area.

The ore from the central portion of this cut is brownish-black and fine-grained, with roughly parallel, coarser grained bands which are in rough alignment with partially filled veinlets of limonite-stained chalcedony. There are several, small (1/8 to 1/4 inch), irregular, and rounded masses of chalcedony included in the iron ore. The ore in the coarser bands has a distinctly platy character, and might easily be mistaken for specular hematite. However, it is highly magnetic. A polished section shows irregular and rounded areas of very finely granular, dark magnetite and a little hematite, surrounded and traversed by veinlets of a very fine-grained aggregate consisting of black magnetite, gray, anisotropic hematite, and a reddish anisotropic mineral, perhaps lepidocrocite. The relative proportions of these minerals vary considerably in different portions of the section. Later veinlets of chalcedony transect the fine-grained magnetite and exhibit cup-like projections into the magnetite, thus indicating a replacement of the iron ore by chalcedony. Along the borders of some of these veinlets are narrow rims of red lepidocrocite, and portions of the veinlets are also stained with yellow limonite.

Since the iron ore on the Albright claim has a mineralogy similar to the Running Wolf-Willow Creek deposits, an assumption of a strike length of 200 feet, a dip length of 100 feet, and a width of 10 feet may be inferred. An ore body of these dimensions contains 25,000 tons of inferred ore.

CLAIMS EAST OF REPUBLICAN CREEK

The claims east of Republican Creek are located along the summit of a ridge east of the creek at elevations between 6,750 and 7,100 feet. They may be reached by trail from Republican Creek, a

tributary of Dry Wolf Creek. The old workings include trenches and shafts, most of which are slumped or inaccessible. A soil cover obscures the bedrock geology. However, it is probable that the occurrence of the iron deposits on these claims is similar to the other deposits of the Running Wolf district.

At an elevation of 7,100 feet about 5 feet of ore is exposed in an inclined shaft. This does not represent the full width of the ore. It strikes approximately north-south and dips 68° W. Fine-grained porphyry forms the hanging wall on the west; limestone, the footwall on the east. In this particular deposit, as well as in the other deposits in the near vicinity, the ore appears to be chiefly a fine-grained, somewhat banded magnetite with a few, platy crystals of specular hematite. The gangue, which is chiefly jasperoid containing vugs lined with small quartz crystals, and some banded ore in altered limestone, is indicative of replacement. One specimen shows a few, subhedral, greenish, garnet crystals disseminated in a silicified limestone. A thin section of this specimen shows later calcite and quartz veinlets transecting the garnet and silicified limestone.

Many of the old workings in this vicinity have iron ore on their dumps. However, because of the inaccessibility of most of the workings, actual measurements of widths were possible in only a few cases. One working showed banded iron ore and altered limestone over a thickness of approximately 20 feet.

The lack of exposures renders it impossible to make an estimation of indicated ore. On the assumption that two of the ore bodies have widths of 10 feet, strike lengths of 200 feet, and dip lengths of 100 feet, it is estimated that each contains 25,000 tons of inferred ore.

MISCELLANEOUS DEPOSITS

During the summer of 1943 numerous deposits were examined in the Running Wolf district, in addition to those which have been previously described in this report. Several of these were gossans formed by the weathering of sulphides which replaced limestone. Many of those which were primarily iron ore deposits did not have sufficient exposures, either natural or artificial, on which to base tonnage estimates or any accurate statement as to lateral or vertical extent.

Sage Creek

The geology of one deposit situated near the head of Sage Creek is briefly discussed on Page 6 of this report. At this locality the iron ore appears to be limited to the matrix of a crushed zone about 5 feet wide, and is associated with a considerable amount of gouge and sulphides. Two to three miles east of this deposit are several old trenches which have iron ore on their dumps but not exposed in place. The ore is predominantly magnetite similar to the Running Wolf-Willow Creek ore. Geologic relations also appear to be similar in that the ore

is bounded on the northwest by the igneous mass of Woodhurst Mountain, and on the south and east by limestone.

Wolf Butte

About 8 miles to the northwest of the principal Running Wolf deposits and about half a mile east of Wolf Butte, there are several trenches which have locally exposed impure limonitic and manganiferous material. They are in carbonaceous shales presumably belonging to the Quadrant formation. Owing to the condition of the cuts, no measurements of widths could be made. Some of the carbonaceous shale contains numerous veins of gypsum from 1 to 2 inches wide. The prevailing dip of the shales is to the east, but in one cut it is to the west.

Wolf Butte is a partially eroded laccolith, the igneous rock of which is exposed for 4 miles in a northeast direction and 1½ miles in a northwest direction. The igneous rock, Wolf porphyry, is strikingly porphyritic, with numerous phenocrysts of feldspar (20 mm.) and rounded quartz phenocrysts (5 mm.) in an aphanitic groundmass containing a few flakes of biotite and a few prisms of hornblende. Under the microscope the feldspar phenocrysts are seen to be plagioclase (oligoclase) and sanidine. The sanidine resembles orthoclase, but differs optically in that 2 V is nearly 0. The hornblende is altered to chloritic material. Although the contact between the granite porphyry and the sediments to the east is not exposed, there is a fine-grained, chilled zone several feet in width. It is thought that this zone is not far from the contact. In the zone are a few limonitic veinlets up to an inch in width, on which there are a few prospect pits.

CONCLUSIONS AND RECOMMENDATIONS

The field and laboratory data recorded in this report on the Running Wolf iron deposits suggest that:

1. The deposits are too small to be considered a possible source of iron under existing economic conditions.

2. For the principal deposits which were examined during the summer of 1943, the estimated total of indicated ore is 655,000 (635,000) tons; of inferred ore, 340,000 (300,000) tons. (See detailed summary on Page 26.)

3. Future prospecting may be expected to find iron ore along less than 38 percent of the contact between the limestone and syenite porphyry.

4. The deposits are of hydrothermal origin and probably should be classed in the hypothermal vein zone, due to the preponderance of magnetite, and their lenticular form. However, the widespread occurrence of chalcedony is indicative of a relatively low temperature of formation.

5. The prevailing mechanism of formation is the replacement of limestone by magnetite from iron-rich hydrothermal solutions.

6. The structural controls are local fracture systems adjacent and parallel to contacts between igneous intrusive bodies and sedimentary rocks.

7. The tabular, lenticular, steeply-dipping ore bodies are not continuous along particular contacts, but occur discontinuously along these contacts.

8. In most of the deposits the ore is high grade and would probably average close to 60 percent iron.

9. The shape and size of the deposits would necessitate underground mining methods.

If at some future date, because of changed economic conditions, it becomes advisable to do additional exploratory work, it is recommended that systematic magnetometer surveys be made on traverses normal to the probable contacts between the igneous and sedimentary rocks, in order to locate possible lenses of ore larger than those already explored.

SUMMARY OF TONNAGE ESTIMATES OF RUNNING WOLF IRON ORE DEPOSITS

Claims	Indicated Ore	Facts	Assumptions	Inferred Ore	Facts	Assumptions	Percent Iron	Remarks
Giroux	80,000 or 60,000	Outcrop Trenches 2DD holes Width-5.9'	Essentially tabular	40,000 or 0	Outcrop Trenches 2DD holes Width-5.9'	Additional 100' of depth on dip	55.37	Essentially magnetite with some hematite
Iron Crown Iron Cross	550,000	" Width-16.1'	"	200,000	Same Width-16.1'	Additional 100' of depth on dip	59.96	"
Le Roi (Iroquois)	25,000	Tunnel, raise, pits, ore 20' thick	Horizontal extent by dip needle	25,000	Same	Additional stratigraphic extent	55-60	Magnetite, some hematite, and 10% pyrite
Albright				25,000	Outcrop	Strike length 200'. Dip length 100'. Width-10'	55-60	Essentially magnetite
Claims east of Republican Creek				50,000	"	"	55-60	"
Total for all claims	655,000 or 635,000			340,000 or 300,000				