State of Washington
MON C. WALLGREN, Governor

Department of Conservation and Development
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DIVISION OF GEOLOGY
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Report of Investigations
No. 14

SOME MAGNETITE DEPOSITS
OF
STEVENS AND OKANOGAN COUNTIES, WASHINGTON

By
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CONTENTS

ILLUSTRATIONS

FOREWORD

The occurrence in Washington of the three essential raw materials for iron manufacture, iron ore, coal, and limestone, has long stimulated interest in possible development of an iron industry here. A report of a thorough study of early furnace installations by Professor Joseph Daniels was published in 1929.[1] As he clearly pointed out, an important factor has been the small size of the known deposits of iron ore.

This situation naturally led to a search for larger and better grade iron deposits. As a consequence there have appeared, either in public or in private distribution, reports which, on the one hand, indicate that Washington has no iron ores of commercial size or grade, and on the other, giving enthusiastic, if somewhat overly optimistic, estimates of both grade and tonnage.

New factors involving both beneficiation and markets have justified reopening, for further study, the whole question of an iron industry in the Pacific Northwest. As a part of this general review of all factors, the Division of Geology, in 1941, began a thorough examination of every occurrence of iron ore in the State, in an attempt to secure more reliable data as to both character and size of deposits than had been made available by earlier, and less detailed work. It is felt that, when completed, these studies will eliminate much of the guesswork in the matter of iron ore resources by providing a better basis for estimates.

To date these studies by the Division of Geology have been carried on in four counties, the results having been published in the current series of reports of investigations. No. 8 on Buckhorn Mountain deposits in Okanogan County appeared in 1943, followed by No. 10 on the Blewett deposit of Chelan County. Two others were published in 1944, No. 11 on the Stratigraphic Aspects and No. 12 on Economic Aspects of the entire Blewett-Cle Elum Iron Zone.

The present report, dealing with certain well-known magnetite deposits in Okanogan and Stevens counties, is thus the fifth in this series on iron ores in Washington. By the application of magnetic methods of examination to these deposits Mr. Broughton has succeeded in fixing their approximate dimensions. Core drilling or other mode of underground work is essential to provide precise facts as to either composition or tonnage. Yet it may be observed that the order of magnitude is established; were the estimates increased by as much as 100 percent the total ore figure would be in hundreds of thousands rather than millions of tons.

—Harold E. Culver, *Supervisor*.

March 15, 1945.

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[1] Daniels, Joseph, Iron and steel manufacture in Washington, Oregon, California, and Utah: Washington Univ. (Seattle) Eng. Exp. Sta. Series, Rept. No. 2, pp. 28-44, 1929.

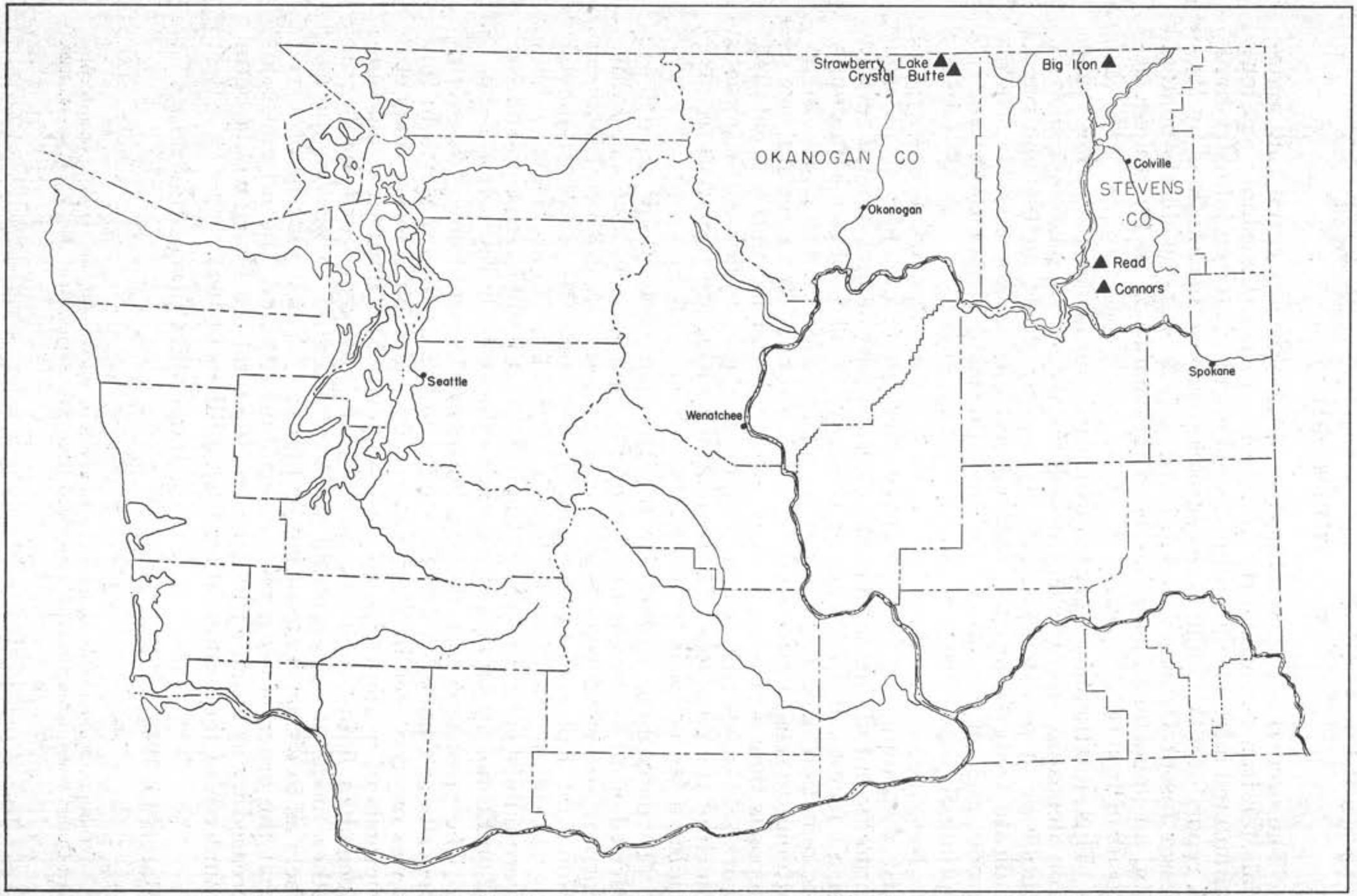

FIGURE 1—Index map of Washington showing the locations of the Big Iron, Read, Connors, Crystal Butte, and Strawberry Lake magnetite deposits.

INTRODUCTION

This report consists of the descriptions, based on detailed magnetic surveys, of five magnetite deposits in northeastern Washington. They are: the Big Iron deposit in the Orient district of northern Stevens County, the Read and Connors deposits in the Cedar Canyon district of southern Stevens County, and the Crystal Butte and Strawberry Lake deposits in the Myers Creek district of northeastern Okanogan County. All of these deposits have at least two things in common. First, they are genetically of the same type, having been formed by replacement of old metasedimentary rocks at or near contacts with intrusive granitic rocks, and they all have similar mineral composition, being composed essentially of magnetite and iron sulphides in varying amounts. Second, they are all of relatively small size when considered as potential supplies of iron ore for support of an iron and steel industry in Washington. All of the deposits are easily accessible by unimproved roads, a situation that may somewhat augment development despite their small size.

Accompanying this report are five detail maps of the various magnetite deposits. They show topography, outcrops, rock formations, structure, isodynamic lines, and possible extent of unexposed ore. The elevation datum for topographic contouring was carried from U. S. Geological Survey and U. S. Coast and Geodetic Survey bench marks by aneroid. As a rule, section corners and lines are not shown on these maps, but the maps are referred to the approximate locations of near-by section corners. Individual mining claims are not shown on any of the maps.

FIELD WORK

Field work on the five magnetite deposits was carried on by the Division of Geology from July 5, 1944 to August 29, 1944. During the course of the field work the writer was assisted by L. T. Teir and R. E. Stevenson, geologists of the Division of Geology, and by A. K. Guard, geologist of the Division of Mines and Mining.

Each of the magnetite deposits was covered by a network of dip needle and sun compass traverses spaced 100 feet apart. Sun compass readings at 50-foot intervals and dip needle readings at 25-foot intervals along the traverses were recorded. Slope angles between the 50-foot stations were recorded. Maps prepared by plotting the sun compass and dip needle traverses and stations served as bases for mapping the topography, outcrops, rock formations, structure, and development work. Plates 1-5 are the maps thus prepared.

ACKNOWLEDGMENTS

The writer sincerely thanks Messrs. W. Buckley, T. Buckley, C. Field, H. W. Bailey, J. W. Glasgow, and S. J. Connors for their splendid aid and cooperation with the field parties. Magnetic instruments were generously loaned by the Geological Survey of Wisconsin through the courtesy of Mr. E. F. Bean, State Geologist.

EARLIER INVESTIGATIONS

Of the five magnetite deposits included in this report only the Big Iron and the Read have been described and the Crystal Butte briefly mentioned in published reports. From time to time technical journals have briefly mentioned mining activities and development at the Big Iron and Read deposits. Several published reports on the geology of the regions including the iron deposits are available. The important published reports are as follows:

1897. Hodges, L. K., Mining in the Pacific Northwest: The Post Intelligencer, Seattle, Washington, pp. 106, 110.
The report includes a brief description of the Big Iron magnetite deposit in the Orient district and of mining activities in the Myers Creek district. The ore is reported to crop out over an area 450 feet long and 250 feet wide and is said to contain one-half to one and one-half ounces of gold, 2 to 5 ounces of silver, and 3½ to 5 percent copper. These figures undoubtedly show an exaggeration of the value of the ore. No mention is made of magnetite deposits in the Myers Creek district.

1911. Umpleby, J. B., Geology and ore deposits of the Myers Creek mining district: Washington Geol. Survey Bull. 5, pt. 1, pp. 11-52.
A detailed description of the geology and some of the ore deposits of the district. The Crystal Butte deposit is briefly mentioned. No indication as to the extent of the deposit or the grade of the ore is given.

1914. Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 64-91.
A detailed account of the geology and ore deposits of the Orient district. The Big Iron deposit is described as a zone of sulphide impregnation and replacement over 100 feet wide and at least several hundred feet long. Pyrite and chalcopyrite are the only ore minerals reported. No mention is made of the magnetite.

1920. Weaver, Charles E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, pp. 256-294.
The bulletin includes a discussion of the geology and mineral deposits of the Orient district. The Big Iron deposit is briefly described. No mention is made as to the presence of magnetite in the ore.

1922. Shedd, Solon; Jenkins, Olaf P.; and Cooper, Herschel H., Iron ores, fuels and fluxes of Washington: Washington Div. Geology Bull. 27, pp. 43-46, 57.
The Read iron deposit is described. The ore body is described as being roughly tabular in shape with a length of 3,000 feet and a width from a few inches to 50 feet. It is estimated to contain 500,000 tons of possible ore, but no indication is given as to the grade of ore.

1936. Culver, Harold E., The geology of Washington: Washington Div. Geology Bull. 32, pt. 1, General features of Washington geology (with preliminary geologic map).
Includes a brief discussion of rock formations in areas including the magnetite deposits.

1940. Melrose, J. W., Summary of information on iron ore deposits of Washington: Washington Div. Mines and Mining Inf. Circ. 6, p. 10.
Includes a brief summary of previously published information on the Read deposit.

1942. Glover, Sheldon L., Washington iron ores, a summary report: Washington Div. Mines and Mining Rept. of Inv. 2, pp. 18, 19, 21.
Includes a brief summary of previously published information on the Big Iron and the Read deposits.

STEVENS COUNTY

The three Stevens County deposits described in this report are probably the largest known magnetite deposits in the county. These three deposits were chosen for detailed magnetic study since it is believed that they are the most likely magnetite deposits in Stevens County to contribute to an iron industry in Washington. The magnetic studies give a much more accurate picture as to the extent of the deposits than has hitherto been available. There are other similar magnetite deposits in the county. Some of these have been examined by magnetic methods and were found to be too small to be considered as sources of iron ore. Yet unknown magnetite deposits will doubtless be found along the numerous granite-metasedimentary contacts in the county.

BIG IRON MAGNETITE DEPOSIT

The Big Iron magnetite deposit, owned by Mr. W. Lon Johnson and associates of Colville, consists of nine claims (Big Iron 1-9) in the Orient mining district of northern Stevens County. It is about 14 miles by road northeast of Orient in the SW¼SW¼ sec. 24 (40-37 E.)* on the east side of Sulphide Mountain at an elevation of about 3,750 feet above sea level. The nearest railroad shipping point is at Rock Cut on Kettle River about 3 miles north of Orient.

According to U. S. Bureau of Mines Mineral Yearbook statistics the Big Iron mine produced about 35,000 tons of iron ore intermittently from 1924 to 1937. There has been no recorded production since 1937. The ore, extracted from a large open pit on the property, was all hand sorted and consisted essentially of magnetite with minor amounts of iron sulphides. It averaged about 56 percent metallic iron.[①] The ore was shipped to Chewelah where it was used in making ferromagnesite.

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* T. 40 N., R. 37 E.

① U. S. Bureau of Mines Mineral Yearbook. 1924-1937.

The main development work is a large open pit about 200 feet long and 100 feet wide with an average depth of about 25 feet. A 30-foot shaft (shaft no. 2, pl. 1) is located 215 feet N. 50° W. of the west end of the open pit and another shaft (shaft no. 1, pl. 1) is about 100 feet farther north. The exact depth of this shaft is not known for it is filled with water up to 20 feet from the collar. Five long trenches have been dug between the open pit and the shafts. Other development work consists of several old caved shafts, numerous small open cuts, and several hundred feet of diamond drilling the records of which are not available. Considerable drifting was done from the bottoms of the old, now caved, shafts, but the materials encountered are unknown. About 700 feet south of the open pit and hence outside of the mapped area are several open cuts and a deep shaft that is now caved, but there are no indications of iron ore on the dumps of these workings.

Improvements consist of two large cabins in excellent condition, several dilapidated cabins and sheds, and one large ore bunker in serviceable condition. There are ample supplies of timber and water on the property for both domestic and mining purposes.

General geology

The oldest rock formation in the vicinity of the Big Iron deposit is a series of metasedimentary rocks of Paleozoic age (Weaver),[1] composed essentially of quartzite interbedded with minor amounts of limestone and argillite and containing some greenstone dikes and sills. Limestone is exposed in the two shafts northwest of the open pit and a large greenstone sill is exposed in the north face of the pit. For the most part the beds of this series strike east and west and are nearly vertical, but in places have dips as low as 15° to the south and 30° to the north due to minor folding and faulting.

Diabase dikes, which due to their relatively fresh appearance can readily be distinguished from the earlier greenstone dikes and sills, cut the metasedimentary series. Small diabase dikes several inches across can be seen in the west pit face and a larger 3-foot diabase dike is exposed in the south edge of the pit. This dike has been altered by hydrothermal action to a yellowish-brown, friable rock. Monzonite- and granite-porphyry dikes considered by Weaver[2] to be apophyses from underlying granitic masses of Tertiary age cut the older rocks. Several of these dikes are exposed just north of the mine pit. It is thought that these dikes are genetically related to the granitic mass that furnished the solutions causing the formation of the Big Iron deposit.

Ore body

The Big Iron ore body is within an elongate zone of contact or hydrothermal replacement trending N. 55° W. through the metasedimentary rocks. This replacement zone is best exposed in the

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(1) Weaver, Charles E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, pp. 52 and 257.

(2) Idem, p. 258.

mine pit, but can also be seen in a narrow stripped area on the west, south, and east sides of the pit; and in the shafts, trenches, and open cuts north and northwest of the pit. As exposed by the workings it is about 480 feet long, 130 feet wide, and has a maximum depth of about 45 feet. Within this zone the quartzite and limestone beds have been partially replaced by pyrite, pyrrhotite, and magnetite with minor amounts of chalcopyrite and scheelite. The ore is reported to carry up to three or four dollars in gold per ton. The best exposures of magnetite are in the south and west faces of the pit. Here the ore is irregularly banded with the bands striking east and west, dipping about 75° S., ranging from a fraction of an inch to several feet across, and being separated by thin bands of unreplaced quartzite. This banding effect is probably caused by selective mineralization of the metasedimentary beds. In the northwest corner of the pit the banding, or bedding, dips about 30° to the north and the ore minerals are predominantly sulphides. The north face of the pit shows very little magnetite and the central part of this face is occupied by a large greenstone sill that dips about 50° to the south. At the east end of the pit the metasedimentary rocks have been heavily mineralized with sulphides, but very little magnetite is present. The scheelite crystals are scattered through the ore, but are most abundant in the south and west sides of the pit. They range in size from mere specks to crystal clusters up to 3 inches across. However, at no place were they found to be abundant enough to constitute tungsten ore.

Small quartz veins from 1 to 6 inches across cut at various angles the beds exposed in the pit. It is believed that these quartz veins were formed prior to the sulphide and magnetite mineralization, for the ore minerals fill fractures cutting the veins.

Around the edges of the mine pit, a zone of oxidation that is from 2 to 10 feet thick overlies the ore. Although this oxidized zone resembles good iron ore it is made up of hematite and limonite including a large quantity of magnetite, sulphides, and quartzite. It is probably too thin and impure to be considered as a source of iron ore.

The trenches and open cuts north and northwest of the pit reveal considerable hematite, limonite, and partially oxidized magnetite and sulphides, but unoxidized ore is not exposed in this area except in the two shafts (pl. 1). Because of its dilapidated condition shaft no. 1 was not entered, but the dump is composed largely of quartzite, limestone, and sulphides. Only a very small amount of magnetite is present. The beds at the collar strike east and west and dip about 45° S. In the upper half of shaft no. 2 the metasedimentary rocks are only slightly mineralized and show little sign of oxidation. However, the rocks exposed in the lower half of the shaft are heavily oxidized and are crisscrossed by numerous joints and planes of movement. Here the rock is made up of about 25 percent magnetite. About halfway down the shaft the rocks dip 40° to the north and at the bottom of the shaft they dip 60° to the south. It is quite possible that the lower half of the shaft has exposed a zone of major faulting cutting the ore.

The Big Iron deposit is believed to have originated by mineralizing solutions rising along a zone of fracturing from some underlying and unexposed granitic mass, and replacing the impure quartzites and limestones with the ore minerals. The numerous monzonite- and granite-porphyry dikes in the vicinity suggest the presence of a near-by granitic mass, and the mineral association is typical of deposits formed at or near the contact between intrusive granitic rocks and metasedimentary rocks. The original composition of the metasedimentary beds controlled, to some extent, the degree of mineralization, but the location of the zone of replacement was probably controlled largely by a zone of fracturing that trended about N. 55° W. Evidence for this fracturing is the divergence between the trend of the mineralized zone and the strike of the beds, and the abrupt changes in the dips of the beds exposed in the mine pit and in the shafts.

Taken as a whole the zone of replacement constitutes a low-grade magnetite deposit. The mineralization is extremely irregular and the sulphides are definitely more abundant than the magnetite. Some beds have been almost entirely replaced by the ore minerals, whereas adjacent beds often show very little evidence of replacement. The total amount of sulphides and magnetite ranges from a few scattered crystals disseminated in the quartzite to masses several feet across where replacement has been nearly complete. For the most part the magnetite is intimately mixed with the sulphides, and with the exception of small bodies of nearly pure magnetite the mineralized zone as a whole can hardly be considered as iron ore. From exposures in the mine pit and in shaft no. 2 it is estimated that the ratio of sulphides to magnetite is about 60 to 40 with not over half of the country rock being replaced by the ore minerals. A rough concept as to the grade of the ore encountered in the mine pit may be obtained by recalling that shipped ore averaged about 56 percent metallic iron and that it was hand sorted, and then by comparing the size of the large mine dump with the size of the pit (pl. 1). The dump covers about as much area as does the pit and is about as high as the pit is deep. The calculated volume of the shipped ore is approximately 225,000 cubic feet, and the volume of the pit is about 500,000 cubic feet. Thus the shipped ore constituted about one-half of the material removed from the pit and the 56 percent metallic iron content of the hand-sorted ore is therefore reduced to about 28 percent metallic iron in terms of unsorted ore.

Estimation of ore reserves

The Big Iron deposit, as exposed by the workings, is about 480 feet long, 130 feet wide, and has a maximum depth of about 45 feet. Because of the very irregular distribution of magnetite in the present exposed parts of the deposit it is extremely difficult to make any estimation of ore reserves that is anything other than a mere guess. However, the magnetic data give some further clues as to the extent and shape of the mineralized zone and to areas within the zone that are most likely to contain minable bodies of magnetite.

Preliminary magnetic traverses were run over all of the nine mining claims in order to determine which areas were to be covered by detailed magnetic traverses. Three areas of local magnetic attraction were located, but only one warranted detailed work. The largest area of attraction is in the vicinity of the mine pit. A small area (100 to 200 feet across) of very weak magnetic attraction (1° to 2°) is located about 1,200 feet southwest of the mine pit and another similar area is about 1,400 feet southeast of the pit. The outcrops of quartzite in these last two areas show no magnetite mineralization, and since the areas are small and the magnetic attraction is slight it is not probable that any commercial body of magnetite ore can reasonably be expected.

The detailed magnetic data disclose an irregular pear-shaped area of local magnetic attraction trending northwestward from about 400 feet southeast of the mine pit to about 800 feet northwest of the pit (pl. 1). It has a maximum width of about 400 feet in the vicinity of the pit and narrows abruptly to the southeast and gradually to the northwest. Two hundred and thirty-five feet northwest of the west end of the pit is a definite offset in the area of attraction. This offset indicates the presence of a fault trending about N. 20° E. with the northwest block having been displaced about 50 feet southwestward.

As a whole, this major magnetic area shows only slight attraction, but it does include four areas of positive magnetic attraction (pl. 1). The location, average length and width, area, and degree of maximum positive vertical magnetic attraction for each of these four areas follow.

Location of positive magnetic area	*Average length*	*Average width*	*Approximate area*	*Maximum positive vertical magnetic attraction*
West end of mine pit and including the trenches....	260 ft.	100 ft.	26,000 sq. ft.	54°
270 feet northwest of the mine pit.............	100 ft.	30 ft.	3,000 sq. ft.	20°
East end of mine pit.........	80 ft.	80 ft.	6,400 sq. ft.	22°
80 feet southeast of the mine pit............	130 ft.	30 ft.	3,900 sq. ft.	9°

The total area showing positive vertical magnetic attraction is about 39,000 square feet as compared to about 14,000 square feet for the area of the mine pit. All of these areas of positive vertical attraction are relatively small. This small size and the general high intensity of the attraction indicate that the magnetite causing the disturbance is located at or very near the surface. The magnetite ore should not be expected to extend to great depth. This depth can not be definitely established without diamond drilling or some other form of underground development work, but it is not likely to be greater than 100 feet and is probably less.

Considering the sizes of the three smallest areas of positive vertical magnetic attraction (it must be remembered that the actual length and width of a buried magnetite body are less than the length and width of the area of attraction) and the probability that the degree of mineralization in them is similar to that in the exposed parts of the mine pit, they are not expected to contain a total of more than a few thousand tons of magnetite ore that could be hand sorted to a product containing 56 percent metallic iron (the grade of ore that was shipped from this deposit). According to the magnetic data the largest reserve of magnetite lies beneath that area of positive vertical attraction including the west half of the mine pit and the trenches northwest of the pit. This area is about 26,000 square feet as compared to 14,000 square feet for the area of the pit. Assuming that the degree of mineralization throughout this area of attraction is the same as it is in the mine pit, it should be possible to mine and hand sort about twice as much magnetite ore containing 56 percent metallic iron as has already been produced from the pit, provided a mining depth equal to that of the present pit is maintained. This would be about 70,000 short tons. The ground surface rises about 30 feet from the southeast end of the area to the northwest end, or a little over half the depth of the pit. If the ore underlying the area of attraction extends uniformly in depth to the elevation of the present pit floor about half again as much ore might be present, thus making a total of about 100,000 short tons.

The tonnage figure presented here is only an estimation based on assumptions supported by reliable magnetic data and should not be accepted as absolute fact. It is presented here merely to give some idea as to the amount and grade of iron ore that might be expected from this deposit. Diamond drilling or other underground development work will have to be done before any more accurate tonnage estimations can be made.

READ MAGNETITE DEPOSIT

The Read magnetite deposit, owned by Mr. J. W. Glasgow of Hunters and Mr. Henry Becker of Fruitland, consists of two claims, the Granite and the Magnetite, trending in an east-west direction through the north half of sec. 14 (30-37 E.) in the Cedar Canyon mining district of southwestern Stevens County. The property is on the divide between the Hunter Creek and Alder Creek drainages at an elevation of about 2,700 feet above sea level. The old Fruitland-Springdale road cuts the east end of the property, thus making it accessible by truck. The nearest railroad shipping points are Springdale, Davenport, and Kettle Falls; respectively about 30, 40, and 45 miles from the deposit. The haul to Springdale would necessitate crossing the Huckleberry Mountains. The truck haul from the deposit to Columbia River at Hunters is about 10 miles.

No commercial shipments of iron ore have been made from this property, however it is reported that years ago a few tons of the ore were smelted in a small furnace erected at Fruitland.[1] Development work consists of five shallow prospect shafts, two short adits, and several open cuts (pl. 2). The two adits and three of the shafts are caved. Shaft no. 1 at the east end of the deposit is open to a depth of 30 feet and shaft no. 5 at the west end has been opened to a depth of 10 feet. An old road roughly connects the workings. There are very few trees on the property, but timber for mining purposes is available on the hill just east of the property. There is a small spring near the deposit, but it is doubtful that it could furnish an ample supply of water for both mining and domestic uses.

General geology

Limestone and quartzite belonging to Weaver's[2] undifferentiated Stevens series of Paleozoic age constitute the oldest rocks of the Read magnetite deposit. Of the two rock types the limestone, containing thin quartzite beds, predominates and extends westward from shaft no. 1 to shaft no. 5 (pl. 2). In general the limestone strikes about N. 50° E. and dips from 80° to 90° NW. However, at the west end of the deposit, near shaft no. 5, the strike changes to about N. 10° W. and the dip is about 85° NE., indicating the presence of a syncline trending about N. 35° E. and pitching northeastward. West of shaft no. 5 beds of massive quartzite are exposed. They appear to underlie the limestone beds conformably. A few hundred feet west of the limestone the quartzite beds strike from N. 80° W. to N. 70° E. with corresponding northeast and northwest dips and apparently lie in a strong anticlinal fold adjacent to the syncline shown by the limestone beds.

The Paleozoic limestone and quartzite have been intruded by a large mass of relatively coarse-grained granite that was mapped by Weaver[3] as a part of the Loon Lake batholith of Mesozoic age. The contact between this granite and the Paleozoic rocks trends about N. 85° E., roughly corresponding with the line of prospect shafts. At the only place where it is actually exposed, in shaft no. 1, the contact dips 75° NW.

Small granitic dikes, probably apophyses of the large granite mass, cut the Paleozoic rocks. One of these dikes can be seen about 350 feet northwest of shaft no. 5. One small basic dike, cutting the quartzite at the west end of the deposit, was also observed in the mapped area.

Ore body

The Read ore body lies within a narrow, irregular zone of alteration along the limestone-granite contact in which the limestone beds have been partially replaced by contact metamorphic minerals. The zone of replacement, as exposed by the workings, extends along the granite-limestone contact for a distance of 3,000 feet, ranges

[1] Shedd, Solon; Jenkins, Olaf P.; and Cooper, Herschel H., Iron ores, fuels and fluxes of Washington: Washington Div. Geology Bull. 27, p. 44.

[2] Weaver, Charles E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, pp. 82-84.

[3] Idem, pp. 87-89.

in thickness from a few inches to possibly 40 feet, and has a maximum vertical range of about 200 feet. The contact metamorphic minerals in the replaced zone have been reported ① to be magnetite, chalcopyrite, wollastonite, tremolite, and fluorite. In addition to these relatively abundant minerals there are occasional minute crystals of scheelite, a small amount of garnet, and considerable ludwigite in the zone of replacement. Small fractures occasionally show stains of malachite and azurite.

Because of the lack of outcrops and the caved condition of the workings very little knowledge of the character and degree of mineralization can be obtained. Shaft no. 1 at the east end of the deposit (pl. 2) exposes the granite-limestone contact to a depth of 30 feet. The limestone along the contact has been hydrothermally bleached and mineralized with a few scattered grains and pods of magnetite up to several inches across. The altered zone has a maximum exposed thickness of 2 feet. The only indications of iron ore at shaft no. 2 and the adjacent adit are a few small pieces of magnetite on the dumps. The dump of the open cut 350 feet N. 40° E. of shaft no. 3 shows numerous pieces of altered limestone heavily mineralized with disseminated magnetite. Some of the pieces contain up to 80 percent magnetite. The cut opened across the strike of the beds 100 feet northeast of shaft no. 3 exposes 10 feet of the mineralized zone. The beds here are thin, seldom over 6 inches thick, and appear to have originally been impure limestone and quartzite. They have been partially replaced with magnetite, and all degrees of replacement from a few disseminated grains to solid bands of magnetite several inches across are displayed. It is estimated that the magnetite content of the exposed face is not over 40 percent. Shaft no. 4 and the adjacent adit show a few pieces of disseminated magnetite ore on their dumps. The open cut just east of shaft no. 4 exposes 3 feet of a very cherty brown rock containing much opal and a few disseminated grains of magnetite. The open cut just west of shaft no. 4 is badly caved, but shows some very rotten granite and some limy beds containing a small amount of disseminated magnetite. Shaft no. 5 and the adjacent open cut expose a 6-foot section of thin limy and quartzitic beds slightly mineralized with magnetite, most of which occurs as scattered disseminated grains. Only one bed, 3 inches thick, appeared to contain over 50 percent magnetite. Nowhere along the granite-limestone contact zone are there any exposed bodies of reasonably high-grade magnetite ore. The exposures indicate that replacement of the limestone beds by magnetite was very irregular and, on the whole, slight.

Estimation of ore reserves

It has been reported by Shedd, Jenkins, and Cooper ② that the Read magnetite deposit may contain 500,000 tons of possible ore. No indication is given as to the grade of these 500,000 tons except that mention is made of a specimen of ore, probably hand selected,

① Op. cit. (Bull. 27), p. 45.
② Op. cit., p. 46.

that was shown by analysis to contain 60 per cent metallic iron. Visual inspection of the ore exposures and dump materials does not suggest that a large amount of even 30 percent iron ore is present. Although there are signs of magnetite scattered along a 3,000-foot strip of the contact zone it is impossible, on the basis of present exposures, to estimate the amount of any particular grade of iron ore that might be present. All that can safely be said is that exposures indicate that it might be possible to economically mine and hand sort a few thousand tons of high-grade magnetite ore. It is imperative that a considerable amount of development work be done before any attempt is made at mining. A well-planned trenching program supplemented by diamond drilling where indications of commercial ore are favorable is recommended.

Although it is impossible to determine, from exposures, the amount and grade of ore in the deposit, the results of the detailed magnetic survey are a great aid in determining the extent and possibly the degree of magnetite mineralization. The magnetic data at least show the areas that should and those that should not receive development work.

There are three separate areas of local magnetic anomalies along the granite-limestone contact (pl. 2). The smallest area, about 250 feet long and 75 feet wide, is in the vicinity of shaft no. 1 at the east end of the deposit. Within this area the maximum positive vertical attraction is only one degree. There are no exposed indications of iron ore in shaft no. 1, and since the magnetic area is small and the attraction is extremely weak it is doubtful that any commercial body of magnetite exists in this place. It is believed that further development work in this area will be a waste of time and money.

A large area of local magnetic anomalies, about 400 feet long and 200 feet wide, is in the vicinity of shaft no. 2. The maximum positive vertical attraction is 8 degrees. The dimensions of this magnetic area may give the inexperienced observer the impression that the magnetic anomalies are caused by a large body of magnetite ore. However, it must be remembered that the area of magnetic anomalies is necessarily wider and longer than the attracting body of magnetite and that the width and length of the area increases as the distance of the magnetite below the surface increases. The body of attracting magnetite should even be expected to be shorter and narrower than the area of positive vertical attraction. The width of this area and the relatively weak attraction could be caused by either a small, massive body of deeply buried magnetite or a large mass of low-grade disseminated magnetite near the surface. As indicated by the material on the dumps of shaft no. 2 and the adjacent adit this latter possibility is the more logical. It is possible that this area contains a small amount of magnetite ore that can be economically mined and hand sorted. One or two vertical diamond drill holes located within the area of high positive vertical attraction, from 50 feet to 250 feet southwest of shaft no. 2, should indicate the presence or absence of commercial ore.

The largest area of local magnetic anomalies covers the western half of the deposit and is about 1,700 feet long and 350 feet wide. It contains three distinct areas of positive vertical attraction adjacent to and on the limestone side of the limestone-granite contact. The position of these areas indicates that the contact dips steeply underneath the limestone, and the narrowness of the area of anomalies suggests that the attracting magnetite does not extend to great depths. Two of the areas of positive vertical attraction are small, relatively weak, and probably do not contain commercial bodies of ore. One of these areas is 400 feet N. 25° E. of shaft no. 3. It is about 90 feet long and 15 feet wide with a maximum positive vertical attraction of only 2 degrees. The other is 300 feet west of shaft no. 5. It is about 150 feet long and 100 feet wide with a maximum positive vertical attraction of 8 degrees. The third area of positive vertical attraction lies between the other two. It is about 1,200 feet long, averages about 200 feet in width, and is extremely irregular in shape. On the whole, the positive vertical magnetic atraction within this area is weak, but as shown on the map, plate 2, there are four areas of relatively high positive vertical magnetic attraction, two near shafts no. 3 and no. 4 and two near shaft no. 5. The largest and strongest area of attraction includes shafts no. 3 and no. 4. It is roughly 450 feet long and 150 feet wide with a maximum positive vertical attraction of 24 degrees. It is suggested that the initial development work on the entire deposit should be confined to this area of positive attraction and should be in the form of trenching and diamond drilling. If systematic development work does not prove a body of commercial magnetite ore within this area it is extremely unlikely that a commercial body of magnetite ore will be found elsewhere on the property.

CONNORS MAGNETITE DEPOSIT

The main part of the Connors magnetite deposit is 8 miles by road south of Fruitland in the SW¼ sec. 16 (29-37 E.) at an elevation of about 2,400 feet above sea level. The land is leased from the State of Washington by Mr. S. J. Connors for ranching purposes. A relatively unimportant part of the deposit extends southwestward into the northwest corner of sec. 21 (29-27 E.). The Connors ranch road is within a few hundred feet of the deposit, thus making it accessible to truck haul. The nearest railroad shipping points are Springdale, Davenport, and Kettle Falls; respectively about 45, 40, and 55 miles from the deposit. The haul to Springdale would necessitate crossing the Huckleberry Mountains. The distance by road from the deposit to Columbia River at Gerome is about 8.5 miles.

No shipments of iron ore have been made from this deposit. The main development work has been done on the low bench about one-eighth of a mile southeast of the Connors' ranch buildings and consists of a caved adit, an 8-foot prospect shaft, and four open cuts. Two other open cuts are respectively 950 feet S. 70° E. and 850 feet S. 25° E. of the prospect shaft. The southwest extension of the deposit has been prospected by two shafts, both caved, and two open cuts located about 2,000 feet S. 25° W. of the main workings. There is an ample supply of timber for mining purposes in the vicinity, but an adequate surface supply of water on the property is lacking.

General geology

The oldest rock formation in the vicinity of the Connors magnetite deposit is limestone, containing thin quartzite and chert beds, mapped by Weaver ① as undifferentiated limestone of the Paleozoic Stevens series. Outcrops are scarce, but this limestone is exposed in the open cut S. 70° E. of the prospect shaft and on the hill southeast of the shaft. No structure readings were obtained from these exposures. Chert and quartzite beds striking about northeast and dipping 25° SE. are exposed in the shaft. This limestone formation has been intruded by Loon Lake granite of Mesozoic age (Weaver).② Granite outcrops are also scarce, occurring in the prospect shaft and the open cut 100 feet to the south, and in two small outcrops along the southwest extension of the deposit.

The main limestone-granite contact trends about N. 40° E. and since the granite lies to the northwest, on the downhill side, the contact can be roughly traced, despite the scarcity of outcrops, by the change from decomposed granite soil to limestone soil. It was found that the change from granite to limestone bedrock was indicated by the magnetic readings and the mapping of the contact (pl. 3) is based on such data. The magnetic readings also indicate that the contact dips steeply to the northwest underneath the granite. At no place was this main contact observed.

The chert and quartzite beds in the vicinity of the prospect shaft appear to be surrounded by granite. Granite is exposed a few hundred feet to the northwest (outside of the mapped area), in the bottom of the prospect shaft, and in the open cut 70 feet south of the shaft. Magnetic readings support this by indicating that the chert and quartzite beds are as an island completely surrounded by granite. This may be caused by post-granite faulting, but since no supporting evidence for this could be found it is believed more likely that these beds represent a small roof pendant detached from the main limestone mass at the time of the granite intrusion.

Ore body

The magnetite of the Connors deposit is confined to the roof pendant-like mass at the north end of the mapped area and to the main granite-limestone contact. The important ore body, as indicated by exposures, is in the small roof pendant-like mass. Here, cherty limestone and quartzite beds have been partially replaced by magnetite. Other contact metamorphic minerals may be present, but only magnetite was observed. The prospect shaft exposes 8 feet of cherty and quartzitic beds dipping 25° SE. and containing not over 40 percent magnetite. These beds are very porous and heavily stained with limonite suggesting that unreplaced limestone or some other soluble material in the beds has been leached out. Decomposed granite underlies the ore, and the largest concentration of magnetite is just above the granite where a 6-inch bed has been

① Weaver, Charles E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, pp. 82-84.

② Idem, pp. 87-89.

almost entirely replaced by coarse-grained, friable magnetite. The open cut just west of the shaft exposes 15 feet of ore across the strike of the beds. The ore in this cut is similar to that in the shaft. The other open cut and adit are caved and expose no bedrock. The dump of the open cut 100 feet southwest of the shaft shows pieces of cherty magnetite ore.

The caved shafts at the southwestern extension of the main granite-limestone contact expose no ore, but the dumps contain a few fragments of magnetite-bearing chert. The open cut just northeast of the shafts exposes a small amount of chert with some disseminated magnetite.

Estimation of ore reserves

The best known and most easily mined ore body of the Connors magnetite deposit is that one in the small roof pendant-like mass at the north end of the mapped area. Exposures show chert and quartzite beds containing about 40 percent magnetite, striking northeast and dipping 25° SE. The workings indicate the presence of ore for 120 feet along the strike of the beds, with a width of 15 feet across the strike, and with a stratigraphic thickness of 8 feet. Thus the workings indicate a block of ore 120 feet long the cross section of which is the shape of a right triangle. The hypotenuse of the triangle is 15 feet long and the short leg is 8 feet long. This block should contain about 700 short tons of about 40 per cent magnetite ore. This and other tonnage figures for the deposit are based on a specific gravity of 3.7 which is the average of several samples collected from the prospect shaft and adjacent open cut.

The area of local magnetic anomalies in the vicinity of the roof pendant-like mass is 600 feet long and has a maximum width of 160 feet. As shown on the map (pl. 3) the northern edge of the magnetic area is closer to the ore exposures than is the southeast edge, thus indicating that the ore body dips to the southeast. Within the magnetic area are two small areas of positive vertical attraction along the strike of the ore body. For the most part the magnetic attraction is slight with a maximum positive vertical attraction of 8 degrees. Since the area of anomalies is small and the attraction is weak except in a narrow zone along the strike of the ore body, it is quite probable that the body of magnetite causing the attraction is narrow and continues to a very shallow depth. Granite is exposed in the open cut 70 feet south of the shaft and therefore the width of the ore body must be less than 70 feet. Based on magnetic data the length of the ore body can be extended to about 350 feet. Using a length of 350 feet, a maximum stratigraphic thickness of 10 feet, and a width of 50 feet (arbitrary distance down the dip of the beds to the granite) there would be in the neighborhood of 20,000 short tons of ore present.

Magnetic data show a narrow elongate area of local anomalies in the vicinity of the caved shafts along the granite-limestone contact at the southwest end of the mapped area. The area of anomalies is about 850 feet long and 150 feet wide, and contains an area of positive vertical attraction about 700 feet long and 50 feet wide with a maximum positive vertical attraction of 3 degrees. These magnetic data are interpreted as indicating a very thin (less than 50 feet) zone of replacement along the granite-limestone contact. Fragments of lean ore on the dumps of the old shafts and the very weak magnetic attraction suggest only slight replacement of the limestone by magnetite. It is extremely doubtful that there is even a small body of magnetite ore of minable grade within this area of magnetic attraction. One or two short diamond drill holes within the area should confirm or disprove this.

The largest area of local magnetic anomalies is along the granite-limestone contact in the central part of the mapped area (pl. 3). It is roughly 1,700 feet long and 250 feet wide. The largest part of this area shows extremely weak positive vertical magnetic attraction the maximum of which is 2 degrees. It is impossible to determine, from magnetic data alone, the size or grade of the magnetite body causing this attraction, but since the area is relatively wide and the attraction is very weak the magnetite body is believed to be at considerable depth below the surface. However, the weak attraction may be caused by sparsely disseminated magnetite in a relatively thick zone along the contact. A few diamond drill holes spaced along the northwest side of the area of attraction and directed toward the limestone at steep angles should confirm the presence or absence of minable ore.

OKANOGAN COUNTY

No attempt is made in this report to describe all of the magnetite deposits of Okanogan County. Several of the known deposits have been examined by reconnaissance magnetic surveys and were found to be too small to be considered as sources of iron ore. The Crystal Butte and Strawberry Lake deposits described in this report are in the vicinity of the Buckhorn magnetite deposit that was described in the Division of Geology Report of Investigations No. 8. The Buckhorn deposit, estimated to contain about 18,000,000 tons of iron ore, would probably form the nucleus of any magnetite iron ore industry in Washington. The Crystal Butte and Strawberry Lake deposits were chosen for detailed magnetic study in view of the possibility that they might contain sufficient tonnages of good magnetite ore to appreciably increase the magnetite supply in northeastern Okanogan County. From the magnetic studies it was learned that they can not be expected to contribute more than a small amount of magnetite ore.

CRYSTAL BUTTE MAGNETITE DEPOSIT

The Crystal Butte magnetite deposit, owned by Mr. Speadon of Seattle, is about 5 miles by road southeast of Chesaw, Okanogan County, in the SW¼SE¼ and the SE¼SW¼ sec. 35 (40-30 E.). It is at an elevation of about 4,300 feet above sea level on the south slope of Buckhorn Mountain, a quarter of a mile east of the old Crystal Butte mine. The property is accessible by an old wagon road along the southern edge of section 35. The nearest railroad shipping point is Curlew, about 30 miles from the deposit.

No shipments of ore have been made from this property. Development work consists of five prospect shafts, a 350-foot adit, two trenches totaling 420 feet in length, and three small open cuts (pl. 4). All of these old workings are badly caved, but the adit can be entered and bedrock is still exposed around the edges of four of the shafts, one of the trenches, and two of the open cuts. A small cabin is about 1,000 feet south of the workings. There is no surface supply of water on the property, but springs can no doubt be located at no great distance. There is an ample supply of timber for mining purposes in the vicinity of the deposit.

General geology

Quartzite and argillite of Carboniferous (?) age (Umpleby) [1] makes up the only rock formation exposed at the Crystal Butte magnetite deposit. This formation is exposed on the property by numerous small outcrops and by some of the old workings. The beds exposed in the adit strike N. 20° E. and dip 25° SE., and are intensely sheared parallel to the strike and dip. At the most northerly shaft (pl. 4) the beds strike N. 30° E. and dip 23° SE., and in the open cut 200 feet south of the adit they strike N. 20° W. and dip 25° NE.

The quartzite-argillite formation has been intruded by quartz-bearing hornblende syenite of Mesozoic age (Umpleby).[2] Although the syenite is not exposed on this property it does crop out just north of the old Crystal Butte mine a quarter of a mile to the west. It is believed that this intrusive syenite underlies the Crystal Butte magnetite deposit at no great depth and was responsible for the introduction of the ore minerals in the quartzite and argillite beds.

Ore body

There is not as much evidence to support a contact metamorphic origin for the Crystal Butte magnetite deposit as there is in the cases of the other magnetite deposits discussed in this report. However, syenite intrusive into the quartzite-argillite formation is exposed only a quarter of a mile distant and could underlie the deposit at shallow depth. Also, the suite of ore minerals consisting of pyrite, pyrrhotite, magnetite, chalcopyrite, and scheelite suggest contact-metamorphic origin. This deposit should probably be referred to as an iron sulphide deposit rather than a magnetite deposit, for by far the most prominent ore minerals are pyrite and pyrrhotite. The magnetite occurs as small crystals disseminated through the iron sulphides. The chalcopyrite appears to make up less than one per cent of the ore and the scheelite occurs as occasional minute crystals in the ore.

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[1] Umpleby, J. B., Geology and ore deposits of the Myers Creek mining district: Washington Geol. Survey Bull. 5, pt. 1, pp. 17-22.

[2] Idem, pp. 23-26.

The ore body, as exposed by the workings (pl. 4), is roughly 900 feet long and 300 feet wide, and trends about N. 20° E. It appears to be a zone of incomplete and very irregular replacement of the quartzite and argillite beds by ore minerals. In most cases the ore minerals are sparsely and unevenly disseminated through the beds, but occasionally a single thin bed shows almost complete replacement. The type and degree of mineralization is well shown in the adit where a 15-foot bed of mineralized quartzite striking N. 20° E. and dipping 25° SE. is exposed. The bed consists mainly of pyrite, pyrrhotite, and unreplaced quartzite, with minor amounts of disseminated magnetite and chalcopyrite and traces of scheelite. It is quite apparent that mineralization has been confined to certain beds or zones of beds, and may have been controlled by differences in fracturing and chemical composition of the beds.

Estimation of ore reserves

As stated above, if based on exposures alone this deposit would be properly classed as an iron sulphide deposit rather than a magnetite deposit. Although the replaced beds carry a small amount of fine-grained disseminated magnetite no high-grade ore is exposed, and it is extremely doubtful that more than a few tons of good grade magnetite ore could be accumulated by careful methods of hand sorting without mining an excessive amount of waste material.

Nevertheless, the detailed magnetic data suggest that some small bodies of commercial magnetite ore may be present. The area of local magnetic anomalies, roughly 800 feet long and 350 wide, includes all of the workings and is elongated in a north-south direction (pl. 4). It contains two areas of positive vertical magnetic attraction, the largest of which roughly covers the east half of the area of anomalies. On the whole, the attraction within this large positive area is slight, from 1 to 2 degrees. However, at the extreme north end of the large positive area, positive vertical attraction from 5 to 17 degrees is revealed over an area about 100 feet long and 30 feet wide. Also, in the west-central part of the large positive area, positive vertical attraction from 5 to 10 degrees is revealed over an area about 200 feet long and 50 feet wide. Just west of this small area of high positive vertical attraction is an area of intense (35 degrees maximum) negative vertical attraction.

The smaller area of positive vertical attraction, about 130 feet long and 50 feet wide, is just south of the adit portal and has a maximum positive vertical attraction of only 2 degrees.

The pyrrhotite of this deposit is strongly magnetic and together with the small amount of fine-grained disseminated magnetite no doubt accounts for most of the magnetic anomaly. It is not known how strong a positive vertical magnetic attraction should be expected from such a body of pyrrhotite, but an attraction of several degrees is probably not unreasonable. It is possible that the two small areas of high positive vertical attraction are caused by ore containing a much higher magnetite content than is found in the exposed parts of the replaced zone. A few short diamond drill holes put down within these two areas should indicate the presence or absence of commercial magnetite ore. However, large bodies of high-grade magnetite ore are not to be expected within these two areas or elsewhere in the deposit.

STRAWBERRY LAKE MAGNETITE DEPOSIT

The Strawberry Lake magnetite deposit owned by Messrs. W. Buckley and T. Buckley of Chesaw is a quarter of a mile west of Strawberry Lake, about 3 miles by road northwest of Chesaw in northeastern Okanogan County. It is in the SE¼ sec. 7 (40-30 E.) at an elevation of about 4,000 feet above sea level. An old road passes within 100 feet of the deposit, thus making it accessible to truck haul. The nearest railroad shipping point is Oroville, about 20 miles distant.

No shipments of iron ore have been made from this deposit. Development work consists of five shallow prospect shafts, all more or less caved, and several old open cuts (pl. 5). Two short adits southwest of the deposit have been driven on narrow quartz veins and have not developed the iron body. There is an adequate supply of timber for mining purposes just south of the deposit. The nearest source of water for mining is Strawberry Lake, about a quarter of a mile east of the deposit.

General geology

Numerous outcrops of argillaceous quartzite and four small exposures of siliceous limestone occur within the mapped area (pl. 5). Due to the lack of recognizable bedding in these metasedimentary rocks, no structure readings were obtained and the true relationship of the limestone to the quartzite is not clear, but the limestone appears to occur as thin beds or small lenses interbedded with quartzite. Umpleby[1] maps these rocks as a part of the Carboniferous (?) series of northeastern Okanogan County. These old quartzites and limestones have been intruded by granite of Mesozoic age (Umpleby).[2] Although no granite can be seen at the magnetite deposit a large area of granite does occur about a quarter of a mile to the north and east, and at an old mine about an eighth of a mile to the south there is considerable granite on the dumps of the old workings. It is believed that the intrusive granite underlies the magnetite deposit at shallow depth and was responsible for the mineralization of the quartzite and limestone beds.

Ore body

As shown by the exposures the Strawberry Lake magnetite deposit consists of a central core of high-grade magnetite ore that grades outward through lower grade ore into country rock containing only scattered disseminated crystals of the ore minerals. The central core of high-grade ore is well exposed by the large outcrop,

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[1] Umpleby, J. B., Geology and ore deposits of the Myers Creek mining district: Washington Geol. Survey Bull. 5, pt. 1, pp. 17-22.

[2] Idem, pp. 23-26.

70 feet long and 50 feet wide (pl. 5), and consists of about 80 percent magnetite with minor amounts of pyrite and unreplaced quartzite, and occasional minute crystals of scheelite and garnet. The shaft sunk in this outcrop to a depth of about 10 feet shows that the ore continues to at least that depth. Two of the three shafts northwest of this large outcrop and the small outcrop to the southeast expose low-grade ore consisting mainly of pyrite and unreplaced quartzite with only minor amounts of magnetite. The other workings still farther away show only quartzite and limestone containing numerous small disseminated crystals of pyrite and occasional small crystals of magnetite and scheelite.

The structure of the ore body is not determinable from the exposures present, but it appears to trend about N. 65° W. and may have a possible length of about 165 feet and a width of about 75 feet.

Estimation of ore reserves

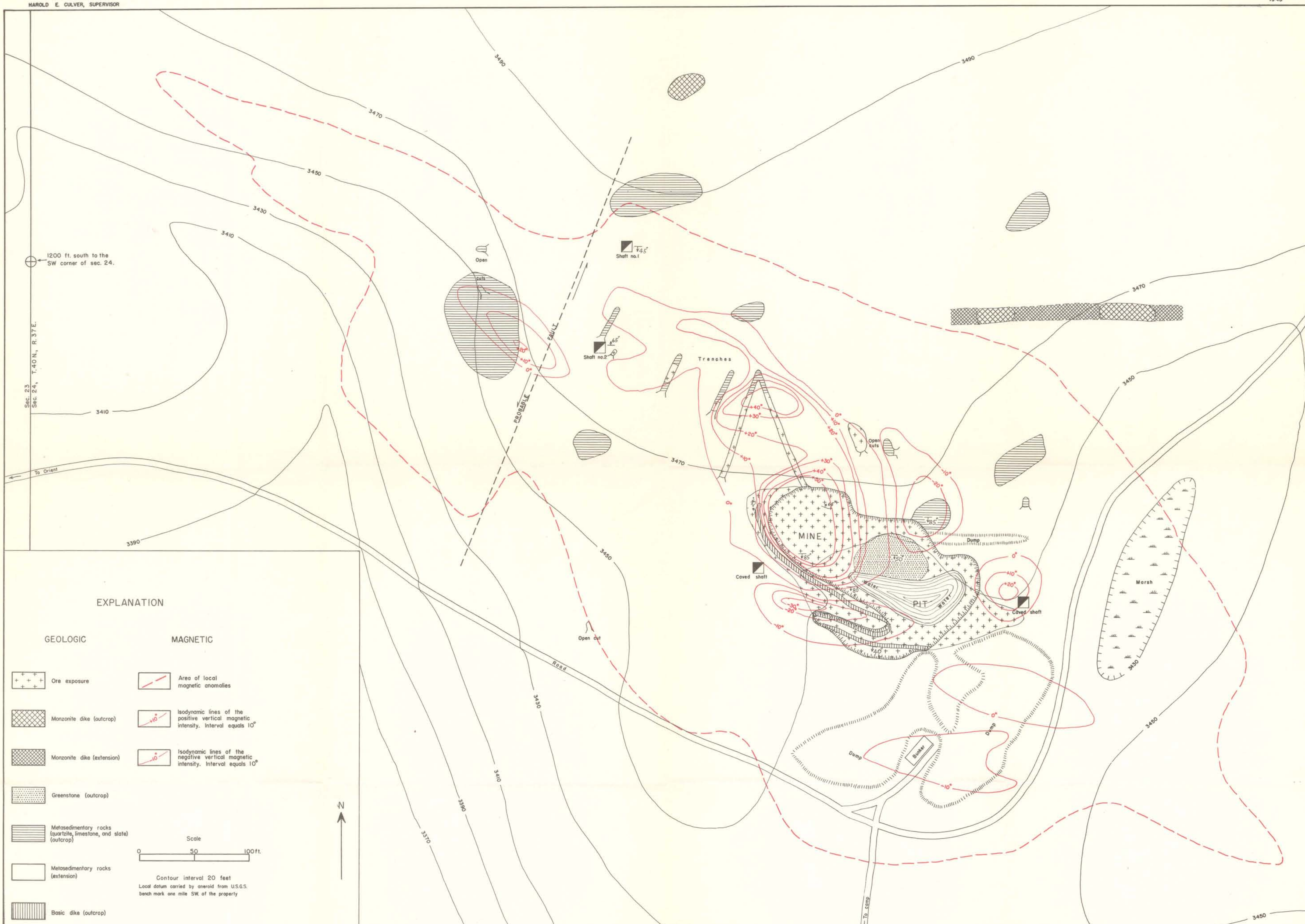
The exposures show a body of high-grade ore about 70 feet long, 50 feet wide, at least 10 feet deep, and containing about 80 percent magnetite. A block of ore with these dimensions and grade would contain about 4,500 tons of magnetite. This can be regarded as more or less proven ore. The horizontal dimensions and especially the vertical dimensions of this block can no doubt be increased somewhat, but this is not safe without information other than that furnished by the exposures.

The detailed magnetic data indicate that the Strawberry Lake magnetite deposit is definitely small and can not be considered as a source of a large amount of magnetite ore. The area of local magnetic anomalies is roughly circular and about 250 feet in diameter (pl. 5), and contains one area of positive vertical magnetic attraction about 165 feet long and 65 feet wide located along the southwest edge of the large outcrop of high-grade ore. The maximum positive vertical attraction is 22 degrees. Just northeast of this area of positive vertical attraction is an area of negative vertical attraction of comparable size and having a maximum negative attraction of 43 degrees.

The magnetic data indicate that the ore body trends northwestward and dips southwestward under the area of positive vertical attraction at an unknown, but relatively gentle angle. The magnetic data also show that the magnetite body causing the attraction must be less than 165 feet long and 65 feet wide. With the data on hand it is impossible to calculate the tonnage or grade of magnetite ore available. However, it would be worth while to have some knowledge as to the possible maximum amount of magnetite within the known dimensions. It is known from magnetic data that the block of ore dips to the southwest. Let us assume that the angle of dip is 45 degrees. The block of ore can have a maximum length of about 150 feet and a thickness of about 45 feet. The exact distance that this block of ore can be extended down its dip is not known, but a distance of 100 feet is probably reasonable. The grade of the ore within this block is not known, but it can be expected to be considerably less than the 80 percent magnetite estimated for the high-grade outcrop. Probably an average of 45 percent magnetite is more nearly correct. Thus the block of ore as outlined may contain a maximum of about 50,000 tons of magnetite. It must be remembered that this figure is a possible maximum for the deposit. Since it is based on assumptions as well as facts it should not be accepted as final until the exact dimensions and grade of the ore body are established by diamond drilling or other method of development. However, a much larger tonnage of magnetite should not be expected from this deposit.

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

REPORT OF INVESTIGATIONS
NUMBER 14, PLATE I
1945



DETAILED MAGNETIC TRAVERSES APPROXIMATELY COVERED MAPPED AREA

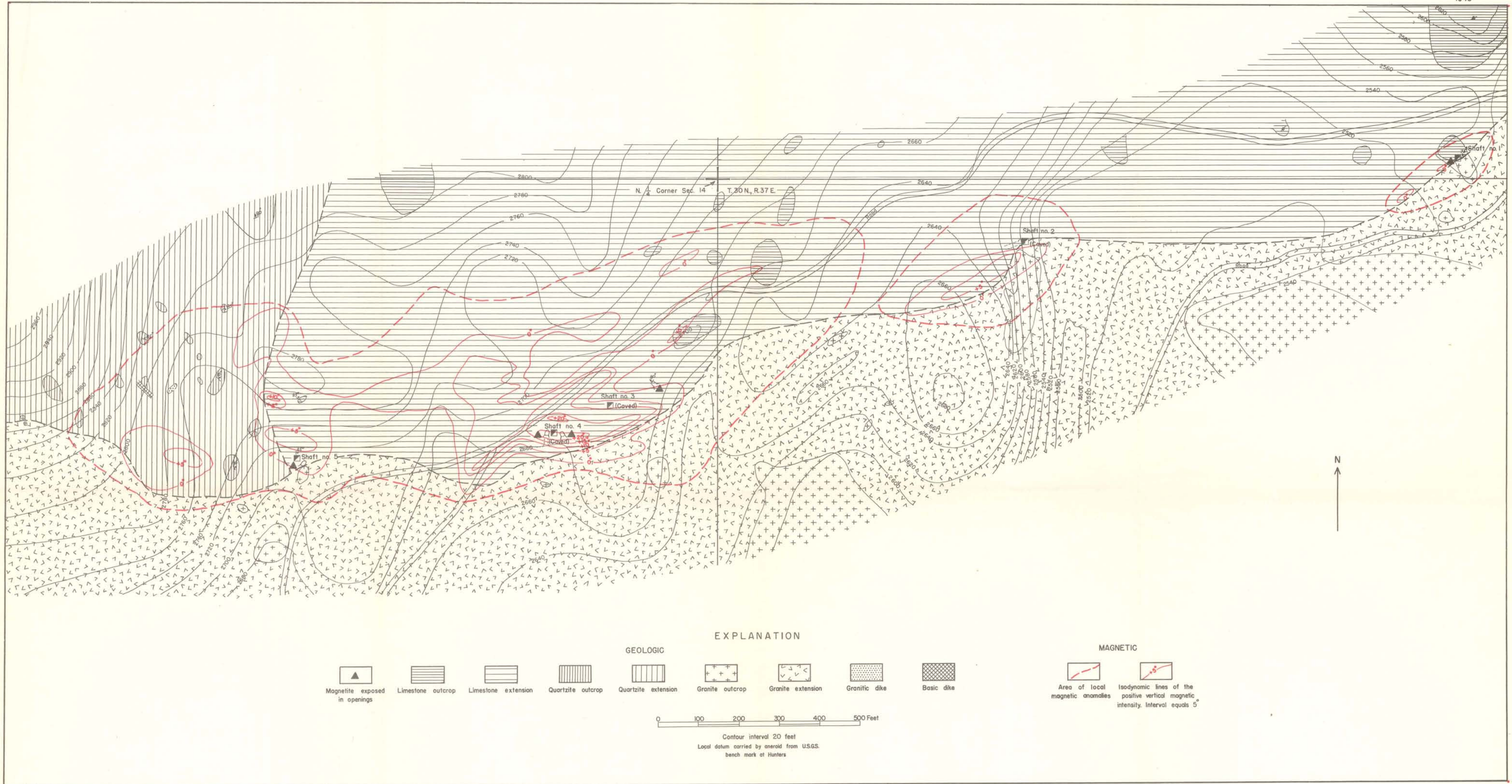
GEOLOGY BY W. A. BROUGHTON

GEOLOGIC MAP OF THE BIG IRON DEPOSIT STEVENS COUNTY, WASHINGTON

SHOWING MAGNETIC DATA

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

REPORT OF INVESTIGATIONS
NUMBER 14, PLATE 2
1945



DETAILED MAGNETIC TRAVERSES APPROXIMATELY COVERED MAPPED AREA

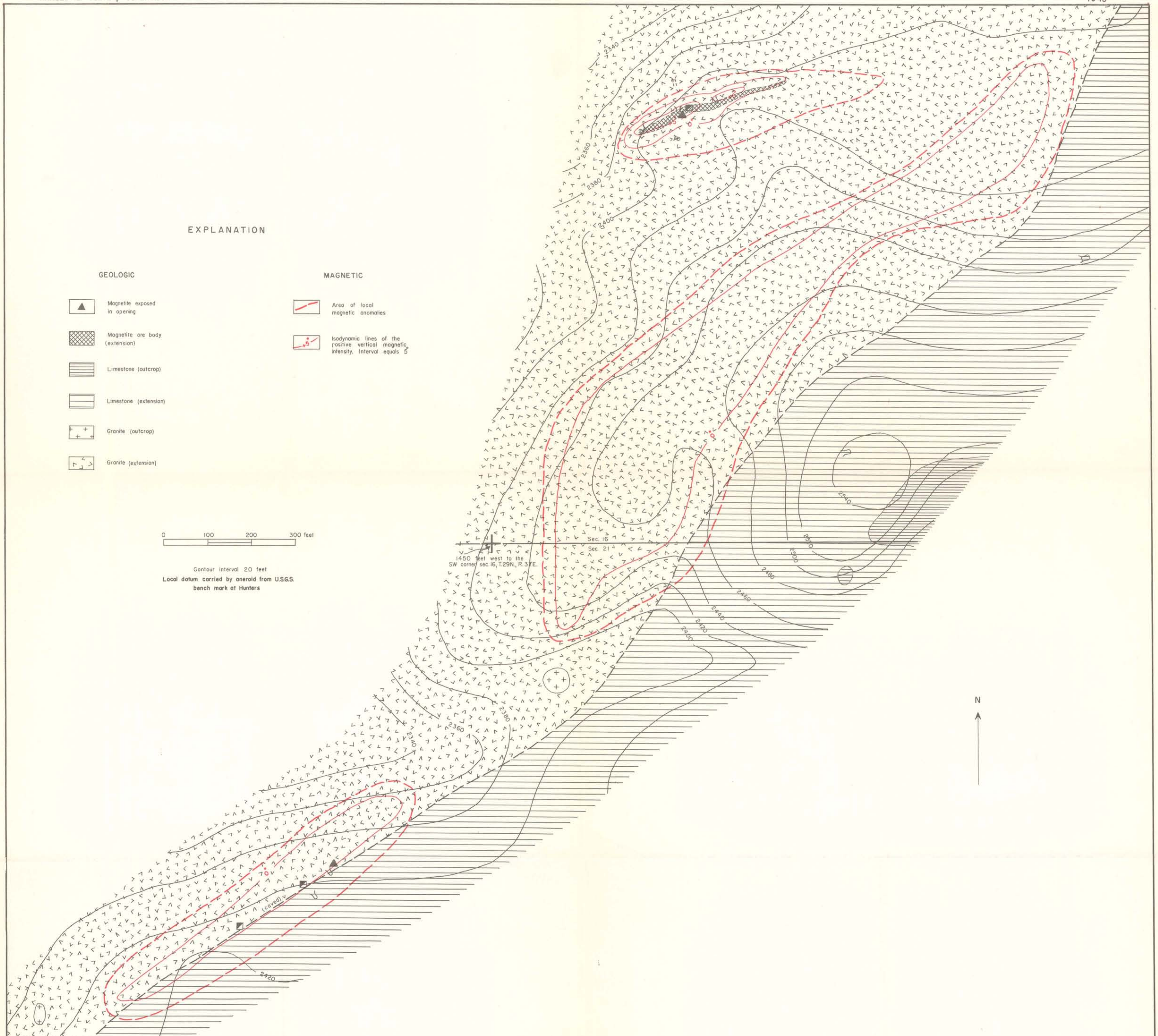
GEOLOGY BY W. A. BROUGHTON

GEOLOGIC MAP OF THE READ IRON DEPOSIT STEVENS COUNTY, WASHINGTON

SHOWING MAGNETIC DATA

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

REPORT OF INVESTIGATIONS
NUMBER 14, PLATE 3
1945



DETAILED MAGNETIC TRAVERSES APPROXIMATELY COVERED MAPPED AREA

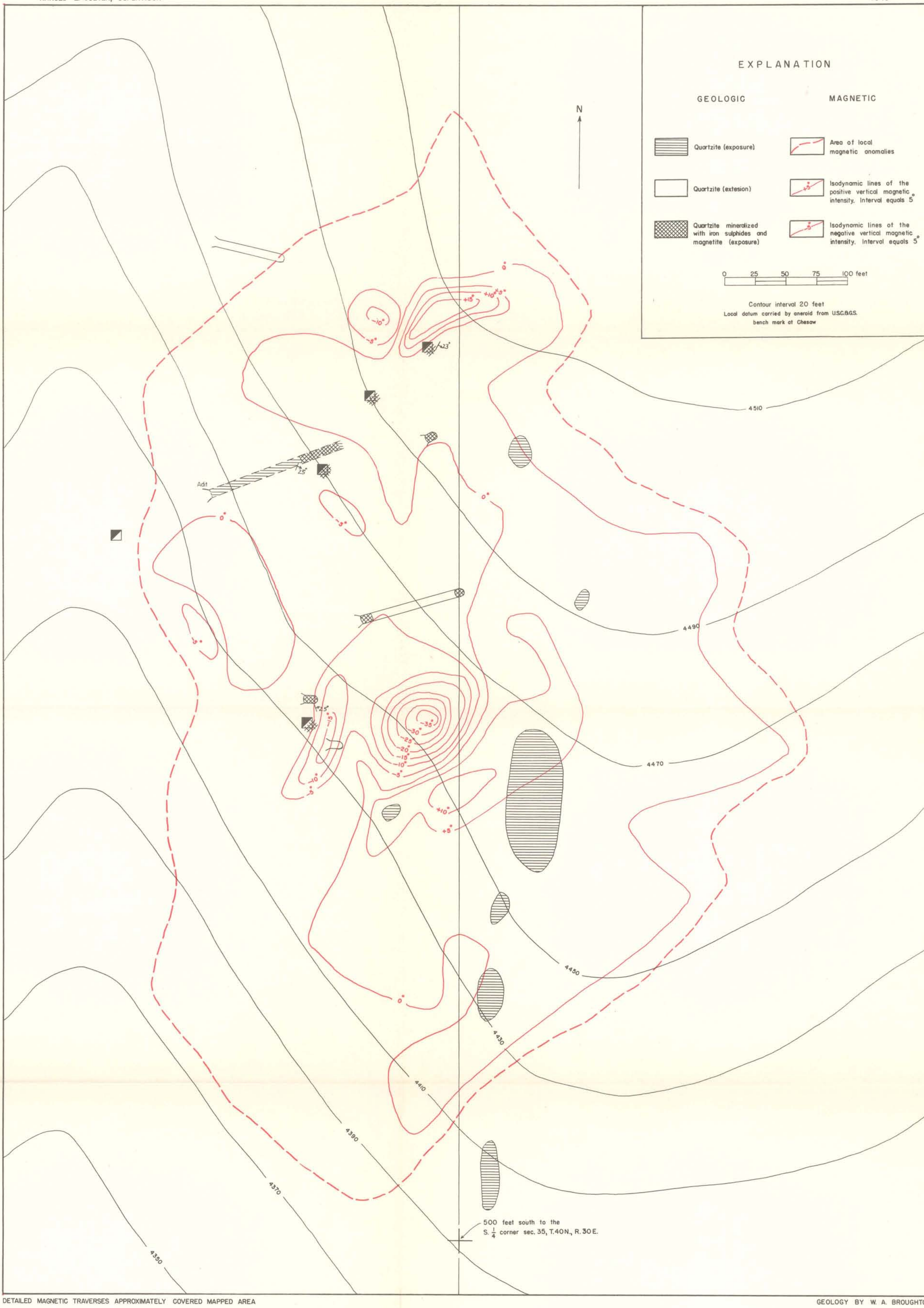
GEOLOGY BY W. A. BROUGHTON

GEOLOGIC MAP OF THE CONNORS IRON DEPOSIT STEVENS COUNTY, WASHINGTON

SHOWING MAGNETIC DATA

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

REPORT OF INVESTIGATIONS
NUMBER 14, PLATE 4
1945



DETAILED MAGNETIC TRAVERSES APPROXIMATELY COVERED MAPPED AREA

GEOLOGY BY W. A. BROUGHTON

GEOLOGIC MAP OF THE CRYSTAL BUTTE IRON DEPOSIT OKANOGAN COUNTY WASHINGTON

SHOWING MAGNETIC DATA

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

REPORT OF INVESTIGATIONS
NUMBER 14, PLATE 5
1945

DETAILED MAGNETIC TRAVERSES APPROXIMATELY COVERED MAPPED AREA

GEOLOGY BY W. A. BROUGHTON

GEOLOGIC MAP OF THE STRAWBERRY LAKE IRON DEPOSIT OKANOGAN COUNTY, WASHINGTON

SHOWING MAGNETIC DATA