STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

702 Woodlark Building
Portland, Oregon

G M I SHORT PAPER

NO. 12

Preliminary Report

on

HIGH ALUMINA IRON ORES

in

WASHINGTON COUNTY, OREGON

by

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Department of Geology and Mineral Industries

1944

PRICE 15 CENTS

FOREWORD

Occurrence of sizeable bauxitic iron deposits within 30 miles of Portland and within 10 miles of the Columbia River should prove to be of considerable importance to the Portland area and the State. Two products - iron and alumina - may be produced from this ore, and a market exists for both products in the lower Columbia River area. It is seldom that mineral deposits are so favorably situated as regards markets.

Although much testing work needs to be done in order to obtain full knowledge both of the extent and value of the deposits and the most economical method of treatment, it should be pointed out that a large amount of pioneer work on ore treatment has already been done in Norway and in the United States.

This report was prepared and is being issued while investigation work by the Department is still being done. The reason for doing this is because of the urgent need for setting up post-war industrial projects. It is felt that development of and production from these ores might well be such a project, and that this report may point the way.

Although the report is definitely preliminary, sufficient facts have been obtained to show the potential importance of the deposits, and the Department wishes to make these facts immediately available. Even though further exploration may change some conclusions, it is believed that any such changes will be along the lines of enlarging and defining ore reserves rather than detracting from their importance. For example, after the manuscript was first prepared, some bauxite minerals were discovered in places in the horizon immediately below the hard ore. This discovery, the economic importance of which is not yet known, necessitated some additions to the report.

Supplemental statements or news releases will be issued when they are warranted by additional facts obtained in the investigation work.

F. W. Libbey, Director
August 4, 1944.

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ILLUSTRATIONS

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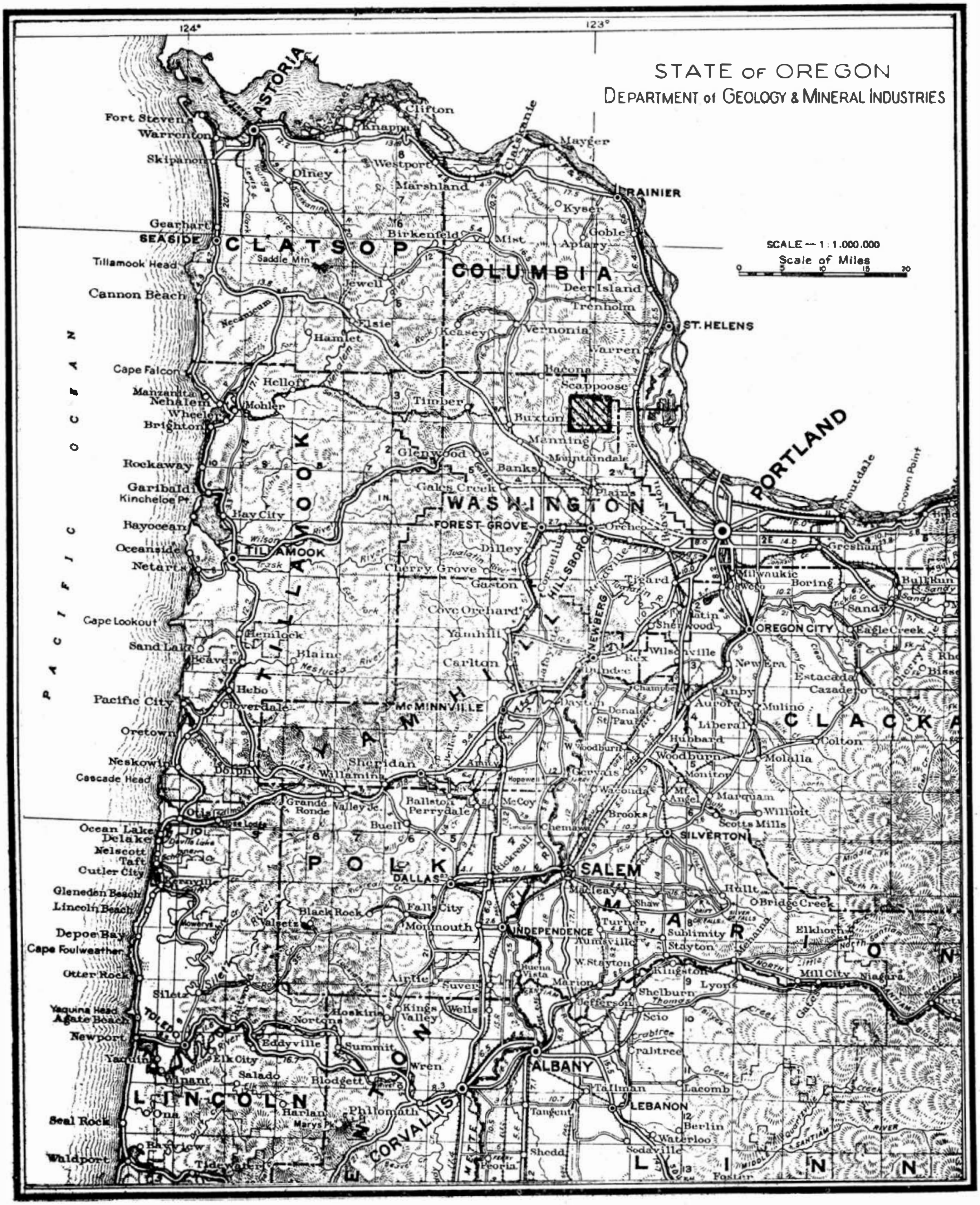


Index Map of Northwestern Oregon
Showing Location of High-Alumina Iron Ore Deposits
Northern Washington County

ABSTRACT

Bauxitic iron ore is found in scattered deposits in northern Washington County, Oregon, over an area comprising roughly four townships. Although these deposits are separated by only a few miles from the limonite deposits of Columbia County, their composition is distinctly different in that the Washington County ores contain about 25 percent iron, generally over 30 percent alumina, and about 0.15 percent phosphorus, compared to about 50 percent, 4 percent, and 0.70 percent respectively for Columbia County ores.

The ores are generally oölitic or pisolitic and magnetic, and occur in flat-lying beds 6 to 15 feet or more thick under a silt overburden. Topography determines the outline of the deposits, and their locations are confined to the more or less flat-topped hills and spurs. The ore is of lateritic origin and was apparently formed by the weathering of Columbia River basalts after their final outpouring in the Miocene and prior to the folding and accompanying uplift of the region which is believed to be Pliocene.

The main exploratory work was done in the Hendrickson locality where over 2,000,000 long tons of ore (natural) is indicated. Various other deposits were sampled, but insufficient work was done by which tonnage estimates on them may be based.

Both iron and alumina could be produced from this ore to supply a local market. The Pederson process has been used to treat similar material in Norway to produce both these products commercially.

INTRODUCTION

High-alumina iron ore or ferruginous bauxite has in the past been reported to occur in northern Washington County, Oregon. In April 1944, the Department started an investigation in order to obtain definite information concerning the extent and value of these deposits. At the Hendrickson locality more than 100 acres has been mapped on a scale of 200 feet to the inch with a 10-foot contour interval. In sampling, 49 auger holes, totaling 922 feet, have been drilled and more than 90 samples have been analyzed.

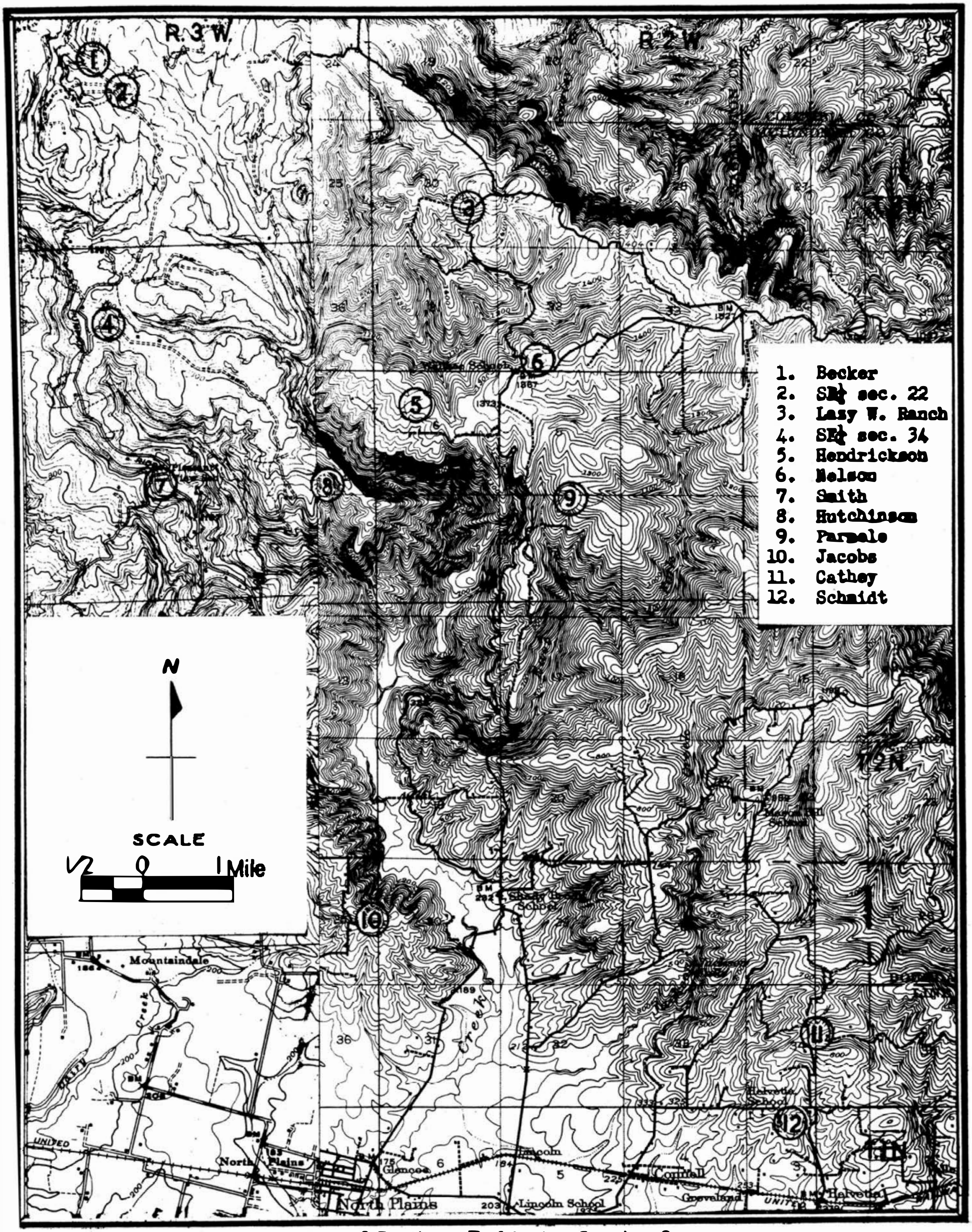
A large part of the land investigated is privately owned and some of it is under cultivation. There is some Oregon and California Railroad revested lands in the area, but the extent and location of Government land has not been determined. A considerable portion is cut-over land; some of this contains second growth timber and a heavy brush cover.

Immediately north of the area discussed in this report, limonite deposits occur northwest of the town of Scappoose in Columbia County. The Scappoose ores so far developed, however, are different in certain characteristics from those in Washington County. The Oregon Bureau of Mines and Geology published a report on the Limonite Iron Ores of Columbia County, Oregon in 1923, and recently the U.S. Bureau of Mines published War Minerals Report 186, Scappoose Mine, Columbia County, Oregon, describing results of exploration work done in 1942.

For purpose of comparison, typical analyses of the ore (dry basis) of the two areas are given below:

		Washington County	Scappoose Area
Iron	(Fe)	24.6 %	49.0 %
Alumina	(Al_2O_3)	32.8	4.3
Silica	(SiO_2)	9.5	5.3
Titania	(TiO_2)	3.5	0.4
Phosphorus	(P)	0.150	0.73

Only part of the Washington County area has been examined by the writers. Some reconnaissance work is still being done by the Department (July 1944) but a large amount of exploration and sampling would be necessary in order to delimit and determine the value of all the known occurrences.



Index Map of Northern Washington County, Oregon
Showing Generalized Location of Deposits Examined
Topog. Base by U.S.G.S. and 29th Engineers, U.S. Army

ACKNOWLEDGEMENTS

The topographic mapping on the Hendrickson deposit and the drilling and sampling of the various deposits were done by Mr. J. F. Cleaver and Mr. L. C. Swanson. The chemical analyses were made by Mr. L. L. Hoagland, and the spectrographic work was done by Miss Esther W. Miller.

The early reconnaissance work was greatly facilitated by Dr. R. P. Nixon, Forest Grove, whose knowledge of the area and deposits was of great assistance in this preliminary work. Owners of the various properties examined were uniformly cooperative and in this connection the writers wish to express appreciation of help given by Messers. Hendrickson, Nelson, Schmidt, Leitzel, Cathey, McKnight, Dudley, Baldwin, and Parmele.

LOCATION

The location of the area is shown on the index map of northwestern Oregon, opposite page 1; that of the deposits, on the county index map, opposite page 3. These deposits occur in an area roughly 25 to 35 miles northwest of Portland in T. 1 N., R. 2 W. and in Tps. 2 and 3 N., Rs. 2 and 3 W. From Portland, the area may be reached either from the north via Skyline Blvd. (or U.S. 30) and Dixie Mtn. Road; or from North Plains on the south via Dixie Mtn. Road or Pumpkin Ridge Road. Branch roads lead to various parts of the area. The western part is most easily reached from the south by the Pumpkin Ridge Road; the eastern part by the Dixie Mtn. Road.

TOPOGRAPHY

A gently sloping upland surface, having an elevation of more than 1600 feet, drops gradually southward in a distance of 7 miles to an elevation of about 400 feet where it approaches the Tualatin Plain. The crest of the surface forms the drainage divide between northern Washington County and southern Columbia County. This surface is dissected over much of the area by many gulches and canyons whose steep slopes are characteristic of youthful topography, the gulches separating the more or less flat-topped hills and spurs. The area south of the divide is drained by McKay Creek and the East Fork of Dairy Creek, which have fairly steep gradients in their upper reaches.

GENERAL GEOLOGY

In 1941 as a project of the Department's state geological survey, Wilkinson[1] mapped the St. Helens quadrangle in Columbia County which lies immediately north of the area described in this report. Many of his descriptions and conclusions, particularly those concerning geologic history, are applicable to northern Washington County. Extracts from Wilkinson's report are as follows:

"<u>Geologic History</u>:

"The geologic history of this region began with the deposition of sediments in an Oligocene sea. The shoreline, or tidal-flat area, was in part within the quadrangle, since leaves are found in several places intermingled with marine fossils. . ."

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[1]Wilkinson, W. D., Geology of the St. Helens Quadrangle (1941), State Department of Geology and Mineral Industries, in manuscript.

". . .At the end of the Oligocene there was a general uplift, which resulted in the shoreline being moved to the west. The new surface was subjected to continual erosion until middle Miocene time . . .The surface at the end of this period was possibly one of early or middle maturity.

"During Miocene time a series of basaltic lavas flowed out over this surface filling many of the valleys and ultimately forming a flat uniform plain, except possibly for occasional areas of the original hilltops or ridges of Oligocene sediments which stood above this new surface as steptoes. The inundation by the Miocene basalts occurred at varying time intervals since some flows have soil well developed upon surfaces, which were buried by later flows. The final surface was almost a plain, having only irregularities incident to the mode of origin or remnants of the old surface. Upon this surface a new drainage pattern developed, which is expressed in the present topography.

"Sometime during the period between late Miocene and the present, the entire region was subjected to climatic conditions which resulted in deep weathering and which produced a heavy soil mantle of a lateritic type."

The formations mentioned by Wilkinson[2] in the preceding paragraphs are also present in Washington County. Disregarding a silt covering, the Columbia River basalts form most of the surface of the area concerned in this report. The sedimentary rocks, which unconformably underlie the Columbia River basalts, were assigned to the Oligocene by Wilkinson. They are exposed at only a few known localities in this part of Washington County. Similar sediments are believed to be exposed in one of the cuts on the Dixie Mtn. Road between the Shady Brook School and Wallace School, and are found in numerous cuts on the road leading from Rocky Point on U.S. 30 to Skyline Blvd. No attempt was made to map their attitude but casual observations showed them to be more folded than the overlying basalts. Oligocene sediments are not known to occur along U.S. 30 south of Rocky Point, where Columbia River basaltic flows are exposed dipping several degrees to the east. Thus the Oligocene sediments found along the Rocky Point Road seem to occur in a window cut near the crest of an anticlinal fold in stratigraphically younger basalts. The axis of the fold trends roughly northwest and appears to lie near the divide separating the drainage of northern Washington County and southern Columbia County. As mentioned by Treasher[3] the course of the Willamette River appears to have been determined more by the attitude of the Columbia River basalts than by faulting. Treasher[4] mapped the structure of the Miocene lavas of the Portland Hills, which lie east of Washington County, as a northerly-trending anticline.

Basalts similar in character and age to the Columbia River lavas of both the Portland area and St. Helens quadrangle are exposed in the valley of McKay Creek west of the Hendrickson deposit where this series of basalts, in places vesicular, is as much as 400 feet thick. The strike of these flows is about N. 65° W. and the dip, several degrees to the south. The much steeper southwest wall of the valley of McKay Creek is believed to be further evidence bearing out the southwest dip of the lavas. As will be pointed out later, the attitude of these basalts is very similar to that of the Hendrickson deposit.

Although the structure of the flows underlying the deposits treated in this report has been determined at a limited number of localities only, the basalts are thought to form the southwest limb of an anticline whose axis trends roughly northwest, and whose northeast limb has helped to determine the western side of the Willamette-Columbia River valley. The crest of the anticline nearly coincides with the drainage divide in northern Washington County. The basalts of the southwest limb of this anticline, on which the ore deposits are located, dip several degrees to the south, and apparently extend southward under the fill of the Tualatin River Valley to reappear in the Chehalem hills.

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[2]Wilkinson, W. D., op. cit.

[3]Treasher, R. C., Geologic History of the Portland Area, GMI Short Paper, No.7, State Department of Geology and Mineral Industries, 1942.

[4]Treasher, R. C., Geologic Map of the Portland Area, State Department of Geology and Mineral Industries, 1942.

These hills appear to be largely basalts, supposedly of the same age, whose dip, where measured, is several degrees to the north. They are also thought to occur north of the Chehalem hills in Cooper Mountain and Bull Mountain, where they appear to form a northwest-trending anticline which disappears to the northwest under the valley fill. Boring lavas[5] of late Pliocene or early Pleistocene age were poured out in the area northeast of Bull Mtn., as in the vicinity of Tigard, filling structural as well as erosional depressions.

The Miocene basalts in this part of Washington County thus seem to have been folded into rather broad anticlines and basins. The Tualatin River Valley appears to be a good example of such a basin. Although Wilkinson fails to mention any major folding of the Columbia River lavas in the St. Helens quadrangle in Columbia County, he does not state that it did not occur and it seems likely that that area may have been affected by the same folding. In the St. Helens quadrangle the difference in elevation of the Columbia River basalts is more than 1600 feet, and Wilkinson states that their maximum thickness is about 700 feet. The highest elevations of these lavas are in the southern part of the St. Helens quadrangle just north of the area treated in this report; the lowest elevations are several miles to the northeast along the Columbia River. As Wilkinson pointed out that the final surface of these lavas was nearly a plain, this difference in elevation might be due entirely to displacements along northwest-striking faults mapped by him; however, present elevations of these basalts might also be attributed largely to broad gentle folding. Weaver[6] stated that the basalts in Columbia County rest with marked unconformity on the underlying marine Oligocene shales and sandstones, and that the basalts have been subjected to minor folding which has given them a general easterly or northeasterly dip. He stated also that they pass beneath the valley of the Columbia River and reappear on the northern side in the State of Washington, forming the major Columbia River syncline.

The age of the folding which produced the regional structures could not be determined from observations within the Washington County area. However, the folding is believed to have occurred in Pliocene time and is thought to be directly related to, or a part of, the deformation which produced the latest major folding of the Coast Range.

Silt, buff to brown to red in color and in places as much as 40 feet thick, overlies most of the Hendrickson and Nelson deposits. It also occurs west of McKay Creek such as that near the Hutchinson deposit. Where exposed in cuts, it is massive and unconsolidated. The grain size of the component minerals ranges from 0.3 mm to that of clay which constitutes about 10 percent of the silt. Nearly all of the silt is minus 50-mesh, and the minus 200-mesh fraction constitutes about 70 percent of the sand fraction. Besides clay and some volcanic glass, the silt includes such minerals as plagioclase, microcline, quartz, biotite, muscovite, hypersthene, and magnetite. Similar silts are found in many road cuts along Skyline Blvd. where they have been mapped as Powell silt loam[7]. The massive unconsolidated nature, mineralogic composition, fineness of grain size, light color, stratigraphic position and topographic distribution of the silt strongly suggest it was wind-laid.

Treasher[8] states that a fine-grained silt cover which is usually brown or tan occurs in the Portland area, and is made up largely of quartz grains. The structure of the silt is described as massive with loessial characteristics. He further states that it is as much as 100 feet thick and occurs at elevations ranging from 25 to 1200 feet, stratigraphically overlying everything except recent alluvium. He stated that it was probably deposited in late Pleistocene or early Recent time.

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5 Treasher, R. C., Geologic Map of the Portland Area, State Department of Geology and Mineral Industries, 1942.

6 Weaver, Charles E., Tertiary Stratigraphy of Western Washington and Northwestern Oregon, Univ. of Wash. Pub., vol. 4, June 1937.

7 Ruzek, C. V., et al, Soil Survey of Multnomah County, Oregon, U.S. Dept. of Agric., Bur. of Soils, 1922.

8 Treasher, R. C., op. cit.

The fact that erosion has failed to remove large masses of the silt in the Washington County area suggests its comparatively recent geologic age, and thus the silt probably was deposited after the area had been considerably dissected. Auger drilling shows that the Hendrickson and Nelson deposits are not connected. Erosion prior to the deposition of the silt is believed to have cut through the ore sheet, forming a saddle between Wallace School and the Grange Hall, to the south. The present topography there as well as elsewhere in the area is for the greater part the result of erosion of the silt cover which masks the true character of the pre-silt topography. In several places the present drainage appears to coincide with that established prior to the deposition of the silt. This suggests that the pre-silt topography, though modified, may correspond in part with that of the present day.

Recent terrace deposits occur along the upper valleys of McKay Creek and the East Fork of Dairy Creek.

GEOLOGY OF THE DEPOSITS

Shape and attitude:

High-alumina iron ore outcrops in a few places where the silt cover is thin or lacking near the tops of the hills. Pieces of the iron ore float have been found in many places throughout the area on the surface, and embedded in soil. The ore occurs in flat-lying and more or less isolated beds apparently governed in their location by topography.

The topsoil in most places contains numerous pellets which may be either weathered oölites, weathered basalt fragments, or cemented soil. Above the ore, the silt varies in color from deep red to dark reddish-brown.

A typical section of the iron formation would be: 2 feet of reddish-brown clay (under 10 feet or more of silt overburden), 8 or more feet of oölitic, pisolitic, or pebbly, usually hard, high-alumina iron ore, underlain by mottled or vari-colored clay-like material.

In places this clay-like material has been found to be bauxitic. At the cut near Hole No. 7 on the Hendrickson farm the bottommost material is a mixture containing gibbsite, limonite, and magnetite. In Hole 32 at the Hutchinson locality the horizon underlying the oölitic ore contains cliachite - an amorphous bauxite.

As it occurs at the Hendrickson locality, the high-alumina iron ore is a blanket from 5 to more than 17 feet thick, many acres in areal extent. The bottom of the ore bed, as indicated by test holes, is quite smooth and regular. The thickness of the bed as well as the overburden, appears to be related to the present drainage which at least in part corresponds to that prior to deposition of the silt.

All the holes drilled through the hard ore sheet at the Hendrickson site, with one exception, were bottomed in a clay-like material. The one exception (Hole 18) showed the underlying material to be much altered basalt. The attitude of the Hendrickson deposit was determined from the elevations of the bottom contact of the hard ore. The strike is approximately N. 75° W. and the dip 1° - 2° to the south. This attitude is very similar to that of the basaltic flows in the valley of McKay Creek. A sufficient number of holes to determine the attitude of the other ore deposits were not drilled. Like the Hendrickson deposit, they are thought to correspond to the regional structure. The thickness of the material underlying the hard ore is unknown. The rock underlying the clay-like material is probably flow basalt although no contact has been found. A well-developed terrace, probably produced by the erosion of the less resistant clay-like stratum underlying the hard ore and covered with "shot" soil, lies directly southwest of and at a somewhat lower elevation than the Hendrickson deposit. This terrace extends a short distance southwestward where it terminates at the edge of the youthful valley of McKay Creek. Near the top of the eastern valley wall and just under the soil which covers the terrace, numerous large, dark gray, massive basaltic boulders are exposed which give way below to a thick series of basaltic flows.

Character of the ore:

Of several textural varieties present, the oölitic or pisolitic type is most common and probably most important. A pebbly, somewhat nodular and porous variety is common in some places.

The oölites and pisolites are variable in size and may be nearly round, ovoid, or quite irregular in shape. They range from less than 1/16 inch in diameter to nearly 3/4 inch. The fresh or unweathered fracture surfaces of most oölites have a dark gray to nearly black color and a submetallic luster, weathering concentrically to a brownish color. Hardness is somewhat variable but for most oölites is probably 5 to 5.5. The streak is reddish-brown.

The matrix is usually softer and lighter in color than the oölites. It has an earthy limonitic appearance. Some specimens contain numerous small cavities sometimes containing earthy material.

Thin sections of the oölitic ore from the Hendrickson deposit show that both the oölites and matrix may be colloform. Some of the larger oölites enclose a number of smaller ones. Residual grains of magnetite, and possibly some of ilmenite, as much as 0.55 mm in size are contained in the oölites as well as in the colloform matrix and are irregular in outline for the most part. They are possibly an important minor constituent. With the exception of silica, which in some thin sections fills small cracks in the oölites and matrix and thus may be secondary, all the material is isotropic. A thin section of the porous pebbly type of ore shows it to be made up of colloform, limonite-like material containing numerous residual magnetite grains. Analyses, however, show its similarity of composition to the typically oölitic material.

Spectrographic analysis of the oölites obtained from a sample at the Hendrickson locality reveals that they contain more than 10 percent of both iron and aluminum with the percentage of iron much the greater, approximately 4 percent silica, and about 3 percent titanium. Analysis of the matrix shows the same elements to be present, and although the aluminum and iron are both more than 10 percent, the percentage of aluminum is slightly greater than the iron. The concretions as well as the matrix contain water of hydration.

The oölitic texture of the ore, the colloform nature together with the hydrous isotropic character and mixed and variable composition of both the oölites and matrix, as well as the inclusions of residual minerals strongly indicate a colloidal origin. These characteristics suggest that both oölites and matrix are mixtures of hydrous iron and aluminum oxides with some impurities.

The oölites possess various degrees of magnetism; most of them are strongly magnetic. The matrix is generally much less magnetic than the oölites and in one instance nearly half of a sample, finely crushed, from the Hendrickson deposit consisted of pieces of matrix either very weakly magnetic or non-magnetic.

On the Hutchinson place southwest of McKay Creek a bed of massive dark-brown limonite more than 2 feet thick crops out near the bottom of a gully. This limonite is weakly magnetic, has no oölites, and is typical of the limonite ribs of the Scappoose area. A sample returned 51.34 percent iron, 5.64 percent alumina, and 4.53 percent silica. The outcrop is apparently stratigraphically below a bed of oölitic, high alumina ore.

Origin of the ore:

Concerning the origin of the Scappoose iron ores in Columbia County, Wilkinson[9] states:

". . .In the field, the iron occurs in ribs from a few inches to several feet in thickness. These ribs vary in structure. They are characterized by small concretions of varying diameter. In these masses the pisolites have formed a compact hard layer which is composed of high grade iron ore. In other places the pisolitic structure is not present but a porous honeycomb structure of compact limonite occurs. The open spaces contain ocherous limonite. At the Apple

[9] Wilkinson, W. D., op. cit.

Valley locality and the Anderson property farther north, the iron ribs are massive, compact, high-grade iron ore. Only a few pits were open enough to allow examination.

"Throughout most of the area where deep weathering has taken place, the surface is covered with small pellets ranging in size up to half an inch in diameter. These are frequently limonite concretions. In the saddle, the entire road cut is composed of these concretions embedded in clay of high iron content. Similar concretions are common to all of the soils covering basaltic areas. In fact these pellets were so common to the soil mantle that in mapping the soils, the term 'shot soil' was used by Harper and Torgerson[10].

"Two possibilities suggest themselves regarding the origin of the iron ore bodies: (1) that the basalts were extruded and that the iron was leached from these basalts, transported and deposited in bogs, and (2) that the basalts were extruded, weathered, and leached and the iron actually deposited within the underlying lavas and near the contact of the lavas and sediments."

The origin of the Washington County ores is different from that of the Scappoose limonite ores in Columbia County to the north. The Scappoose ores contain more phosphorus and much less alumina and somewhat less titania. The association of sedimentary material and petrified wood with some of them and their stratigraphic position are evidence that they were formed in a different environment and prior to the Washington County ores. Possible further evidence of the greater age of the limonites is shown at the Hutchinson place where massive limonite, typical of the Scappoose ores, lies stratigraphically below a bed of the oölitic ore. The oölitic structure of the Washington County ore together with the mixed composition and colloform texture of the oölites as well as the matrix, suggest their colloidal nature and a lateritic origin.

As Miocene basalts are common in Washington County and as the ore is a mixture of hydrous iron and aluminum oxides with low phosphorus and some titania, it seems fairly certain that the ores were formed by the laterization of basalts.

The basalts which stratigraphically underlie the Hendrickson deposit and which are exposed by McKay Creek are dark gray in color and fine-grained. Thin sections show that they are hemicrystalline. The phenocrysts are plagioclase, augite, and magnetite. The groundmass is either a gray or brown glass which forms some 20 to 25 percent of the rocks. The texture of two of the rocks sectioned tends to be intersertal with the spaces between the divergent plagioclase laths occupied by augite, magnetite, and glass.

The plagioclase is labradorite in the form of laths, averaging 0.4 to 0.5 mm in length and as much as 1.5 mm long. They show albite twinning and a number of them are fractured. Labradorite constitutes about 50 to 55 percent of the rocks. Augite, in many instances in the form of fractured anhedral aggregates, makes up some 25 percent of the sections. Most of the magnetite grains have either anhedral or very irregular outlines and constitute a few percent. The groundmass is either a gray or brown glass, in some places partially devitrified, and in the three rocks examined averages about 20 to 35 percent.

A weathered portion of one thin section shows that the glassy matrix alters much more readily than the plagioclase and augite. The magnetite was apparently unaltered. The differential alteration of the glassy groundmass, the fractured nature of nearly all the augite and some of the labradorite, and the intersertal-like texture of the basalts favor their rather rapid and continuous alteration.

Although the underlying basalts did not give rise to the ore, it is very likely that similar but younger representatives of the same series were the parent rocks.

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[10] Harper and Torgerson, Soil Survey of Columbia County, Oregon, U.S. Dept. of Agric. in cooperation with Oregon Agricultural Exp. Sta., 1929.

At the Hutchinson Locality the earthy material immediately beneath the hard oölitic ore contains less silica than in the ore above. This earthy material also contains bauxite minerals, especially cliachite as mentioned previously. Spectrographic analyses show that the silica content of the horizon under the hard ore increases markedly with depth, indicating admixture of clay. Description of the section drilled and sampled is given in the part which discusses individual deposits.

As noted at the Hutchinson and some other localities, the material beneath the hard ore contains bauxite minerals in some places at least. At still other places in the area basaltic-like pebbles are present. These pebbles are dark gray in color and some have a vesicular texture. However, examination shows they are nearly completely altered. It is believed that the ferruginous bauxite grades downward into a clayey horizon which gives way in depth to altered basaltic parent rock.

The exact time of origin of the deposits is not known. However, they were formed after the basalts of the area were extruded in Miocene time and before the deposition of the overlying silt which has been assigned by Treasher[11] to the late Pleistocene or early Recent. The laterization responsible for the formation of the ores probably occurred before the basalts were folded and somewhat elevated; the rate of formation of laterite would have had to exceed the rate of its removal by erosion. As it is now generally agreed that the formation of lateritic aluminum hydroxides is caused simply by the long continued action of ordinary ground waters under special conditions of moisture and heat[12], it appears that erosion was relatively inactive during the formation of the Washington County ores. The association of Miocene basalts with the marine Astoria formation to the west of the area suggests that the lavas were poured out when Washington County had a lower average relief than now. Laterization may have been active in forming the deposits from the time of the final outpouring of the Miocene lavas to the time of their folding, and may have produced a relatively continuous blanket of laterite over the area. The folding is believed to have occurred in the Pliocene. Treasher states that the Miocene basalts and the overlying gravels of the Troutdale formation, which he gave a middle Pliocene age, are essentially parallel in the Portland area. As Troutdale gravels were mapped at elevations as much as 1200 feet and are distributed over a wide area, Treasher concluded that they were deposited as a piedmont fan and were deformed at the same time as the Miocene basalts. Boring lavas of late Pliocene or early Pleistocene age are undeformed and occur southeast of the area apparently occupying structural as well as erosional depressions in the Columbia River basalts.

Erosion following the folding and accompanying uplift had somewhat dissected the Washington County ore deposits when a thick blanket of silt was laid down, probably by wind action, over much of the area in possibly late Pleistocene or early Recent time. Erosion has since removed part of this cover.

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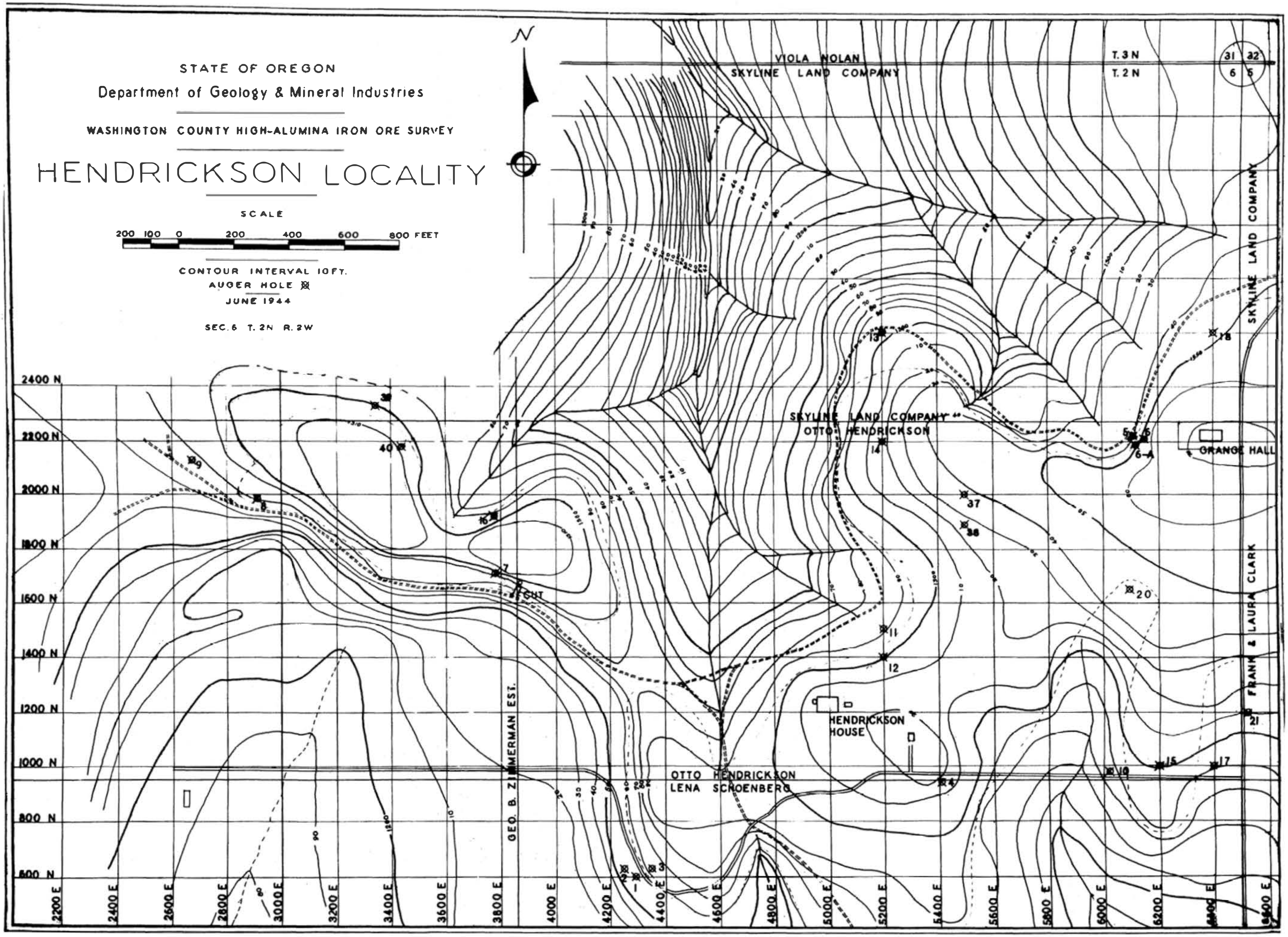
[11] Treasher, R. C., op. cit. (Geologic Map).

[12] Lindgren, Waldemar, Mineral Deposits, p. 375, McGraw-Hill, 1933.


STATE OF OREGON
Department of Geology & Mineral Industries
WASHINGTON COUNTY HIGH-ALUMINA IRON ORE SURVEY
HENDRICKSON LOCALITY
SCALE
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CONTOUR INTERVAL 10 FT.
AUGER HOLE
JUNE 1944
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VIOLA NOLAN
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SKYLINE LAND COMPANY
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GRANGE HALL
FRANK & LAURA CLARK
HENDRICKSON HOUSE
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6600 E

INDIVIDUAL PROPERTIES

Three of the seven localities discussed in the following section of the report - the Hendrickson, Hendrickson Extension, and the Nelson - contain the bulk of the indicated ore reserves in the area so far explored. At the other properties mentioned, considerable exploration work is necessary before tonnage estimates may be made.

Hendrickson Deposit:

The Hendrickson farm on Dixie Mtn. Road (see index map opposite page 3) was selected because of its accessibility and also because exposures of the ore formation along an old logging railroad grade indicated a possible tonnage. Preliminary sampling of the exposures which represented only the top of the ore bed gave the following results:

(Analyses by Lerch Bros., Hibbing, Minnesota)

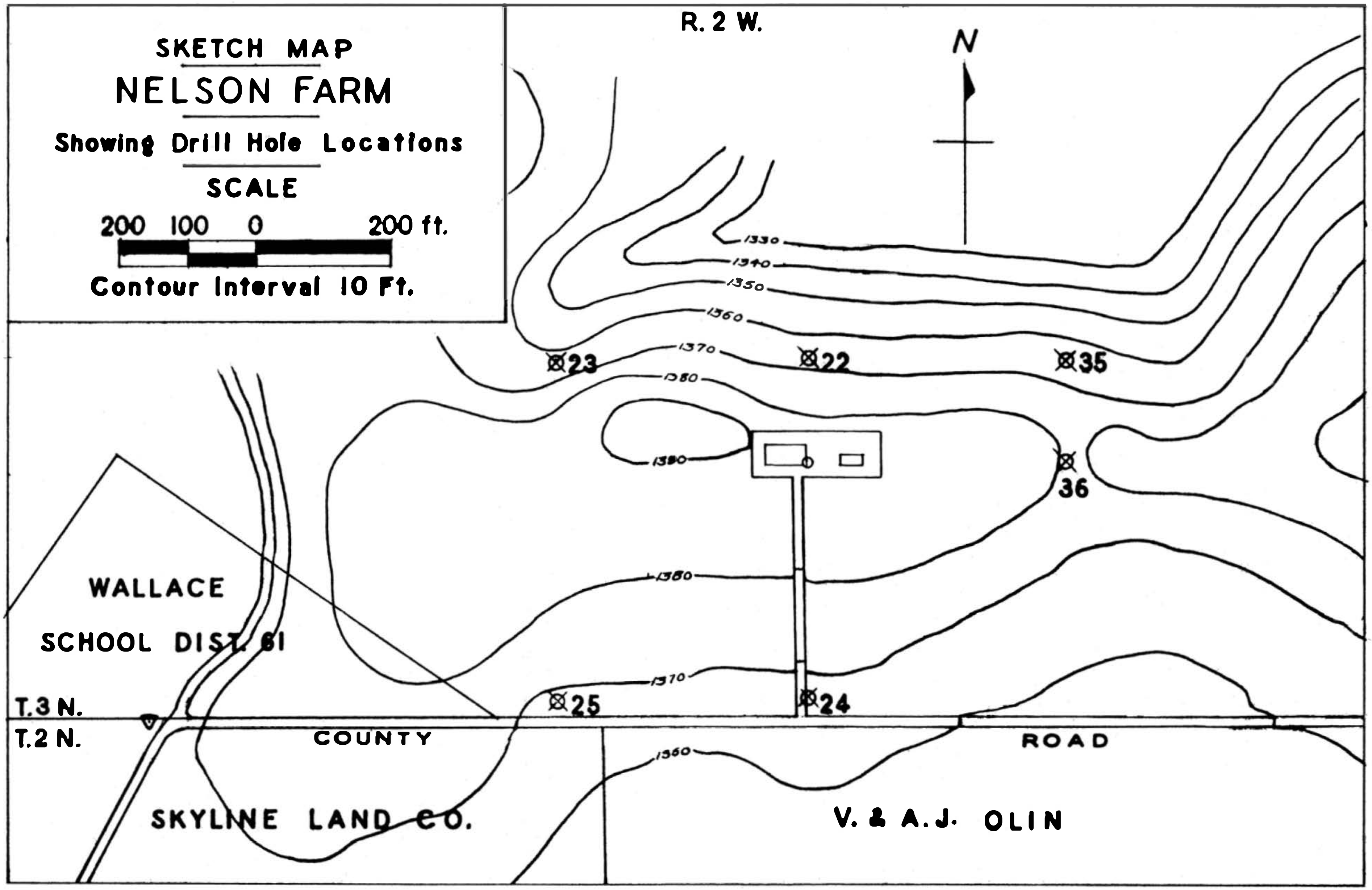
(A)	Railroad cut NW of the Hendrickson house (1500 N - 4000 E). A 4-ft. channel sample of pebbly type ferruginous bauxite.	Iron	(Fe)	28.26	%
		Alumina	(Al_2O_3)	34.60	
		Silica	(SiO_2)	6.22	
		Phosphorus	(P)	0.170	
		Titania	(TiO_2)	-----	
(B)	Railroad cut N. of the Hendrickson house (1900 N - 5100 E). Top foot of the oölitic ore bed sampled.	Iron	(Fe)	40.92	%
		Alumina	(Al_2O_3)	24.59	
		Silica	(SiO_2)	3.58	
		Phosphorus	(P)	0.092	
		Titania	(TiO_2)	4.02	
(C)	Same location as (B). A 4-ft. channel sample of red silty clay overlying (B).	Iron	(Fe)	14.13	%
		Alumina	(Al_2O_3)	23.41	
		Silica	(SiO_2)	38.27	
		Phosphorus	(P)	0.098	
		Titania	(TiO_2)	3.22	

A plane-table survey of the Hendrickson Locality was made and 29 holes were drilled using hand augers and chopping bits for the purpose of sampling the deposit. The topography and the location of drill holes and cut is shown on the map opposite page 11.

It is believed that some of the holes in ore showed relatively high silica results because too much of the overlying reddish-stained clayey silt was included in the samples.

The material near the bottom of the cut near Hole 7 contains gibbsite in addition to limonite and a minor amount of magnetite. The silica content of this earthy material is somewhat lower than that of the average ore. Analyses of samples from this cut were not included in the calculations. The cut near Hole 7 was made to determine the characteristics of a section of the ore and was sampled to obtain the volume-weight factor for tonnage calculations. Analyses and description of the material in the cut follows:

Sample No.	Fe.	Al_2O_3	SiO_2	Moisture	Ignition Loss	Sample Width	Description
	(Not Sampled)					0' - 3'	Red clay
P-2473	23.25	36.48	5.70	17.5	19.8	3' - 9'	Hard reddish brown ore.
P-2474	15.81	42.92	5.74	21.2		9' - 12'7"	Dark reddish brown ore with gray nodules and white specks.


SKETCH MAP
NELSON FARM
Showing Drill Hole Locations
SCALE
200 100 0 200 ft.
Contour Interval 10 Ft.
R. 2 W.
N
1330
1340
1350
1360
1370
1380
1390
1380
1370
1360
23
22
35
36
25
24
WALLACE
SCHOOL DIST. 61
T. 3 N.
T. 2 N.
COUNTY
ROAD
SKYLINE LAND CO.
V. & A. J. OLIN

An arithmetical average analysis of samples of ore from holes so far drilled on the Hendrickson place is:

Iron	(Fe)	25.95	%
Alumina	(Al_2O_3)	31.85	
Silica	(SiO_2)	8.95	
Phosphorus	(P)	0.140	
Titania	(TiO_2)	4.5	
Moisture		19.0	
Ignition Loss		18.0	

The area underlain by ore on the Hendrickson farm is approximately 64 acres. The volume-weight factor for the ore has been determined as 17 cu. ft. per long ton in place. Using this factor, the Hendrickson farm would contain in round figures 2500 tons per acre-foot. The average arithmetical thickness of the ore sampled, using 11 holes in ore, is approximately 11 feet; therefore, 1,760,000 long tons of ore is indicated for the Hendrickson property alone. The earthy material underlying the hard ore was thought to be largely clay at the time most of the sampling was done. Since then it has been found that in places this material is bauxitic, and it is possible that further drilling will prove a greater thickness of ore than that used in the calculations.

Any discussion of the economics of this deposit should take into consideration the two adjacent bodies located on the Nelson farm to the northeast and the so-called Hendrickson Extension to the northwest, both of which are described in the following paragraphs. These three areas contain the bulk of the indicated ore reserves discussed in this report.

Five of the holes were also drilled just south of the Hendrickson farm on the Schoenberg property which adjoins it. Results of this drilling indicate that the same ore body underlies a portion of the Schoenberg farm, although the areal extent is small because of the nature of the terrain.

Hendrickson Extension:

This locality lies to the northwest of the Hendrickson deposit and is separated from it by a narrow saddle.

Oölitic type ore is exposed at Hole 26. Analysis of 13 feet of ore from this hole gave the following values:

Iron	(Fe)	23.49	%
Alumina	(Al_2O_3)	36.60	
Silica	(SiO_2)	6.94	

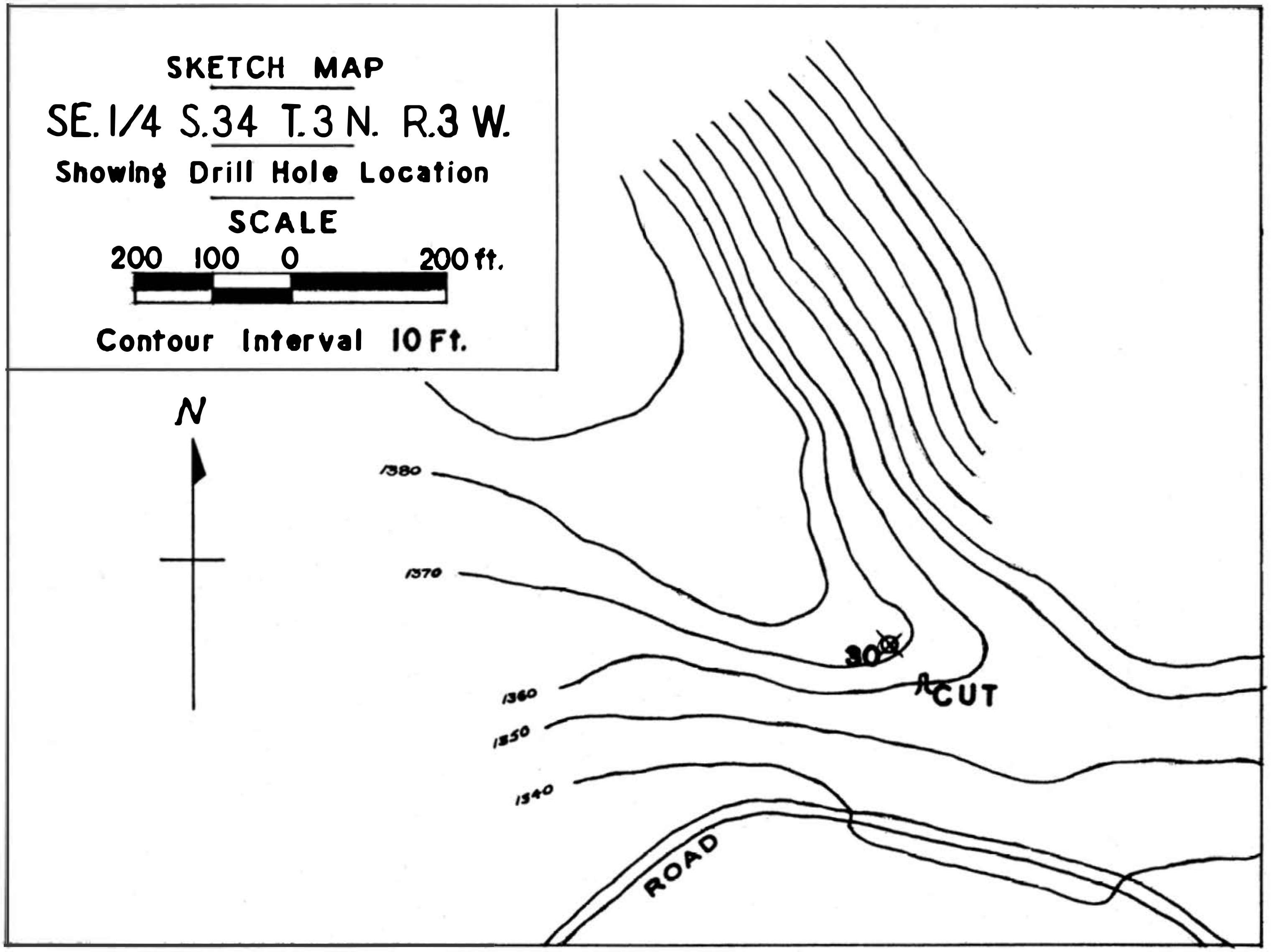
Any estimate of the extent of this ore body is difficult due to insufficient exploration. However, a flat-topped area possibly 50 acres or more in extent may be underlain by ore.

Nelson Deposit:

A quarter of a mile northeast of the Hendrickson locality at a somewhat greater elevation six auger holes were put down on the Nelson farm. The iron formations at these two farms, although not connected, could easily be served by one mining operation. A sketch showing the topography and locations of the holes is opposite page 13.

Average analysis of ore from Holes 22, 23, and 24 is as follows:

Iron	(Fe)	21.66	%
Alumina	(Al_2O_3)	32.52	
Silica	(SiO_2)	12.97	


SKETCH MAP
SE. 1/4 S. 34 T. 3 N. R. 3 W.
Showing Drill Hole Location
SCALE
200 100 0 200 ft.
Contour Interval 10 Ft.
N
1380
1370
1360
1350
1340
30
CUT
ROAD

Reserves, based on a 10-foot average thickness of ore for the area lying between Holes 22, 23, and 24 are estimated to be 175,000 long tons. By deepening Holes 25, 35, and 36 additional tonnage might be proved. Increase in areal extent might also be shown by additional drilling. A well at the Dudley house southwest of the Nelson farm and 200 feet southeast of the Wallace School, cut several feet of oölitic ore at a depth of about 25 feet. No accurate measurements could be made due to inaccessibility of the well. A petrographic examination of a sample of clay-like material from the well dump showed the material to be largely a mixture of gibbsite and limonite. Spectrographic analysis showed the material was mainly alumina and iron with about 5 percent each of silica and titania.

The silt overlying the ore body is the same as that on the adjoining Hendrickson farm. The horizon of the ore in the drill holes on the Nelson farm is nearly the same as would be obtained by projecting the 1° - 2° dip of the hard ore northeastward from the Hendrickson ore body. Although these two ore bodies were undoubtedly connected originally, they are now separated by the saddle which crosses the road between Wallace School and the Grange Hall. A hole drilled just east of the road at the lowest point in the saddle struck silt which was deposited after erosion had removed the ore. Another hole drilled 120 feet south of a point midway between Holes 24 and 25 was likewise barren.

Locality No. 4:

This deposit is shown on the index map, opposite page 3. It is located in SE¼ sec. 34, T. 3 N., R. 3 W. on a logging road, a quarter of a mile east of the Pumpkin Ridge Road. General topographic features of the area together with the location of Hole 30 and an open cut are shown on the sketch map opposite page 15. Hole 30 penetrated 11 feet of ore. The lower 7 feet assayed as follows:

Iron	(Fe)	22.70	%
Alumina	(Al_2O_3)	33.65	
Silica	(SiO_2)	8.41	

A 20-foot cut 6 feet deep, located 50 feet southeast of Hole 30, exposes about 4½ feet of pebbly type ore.

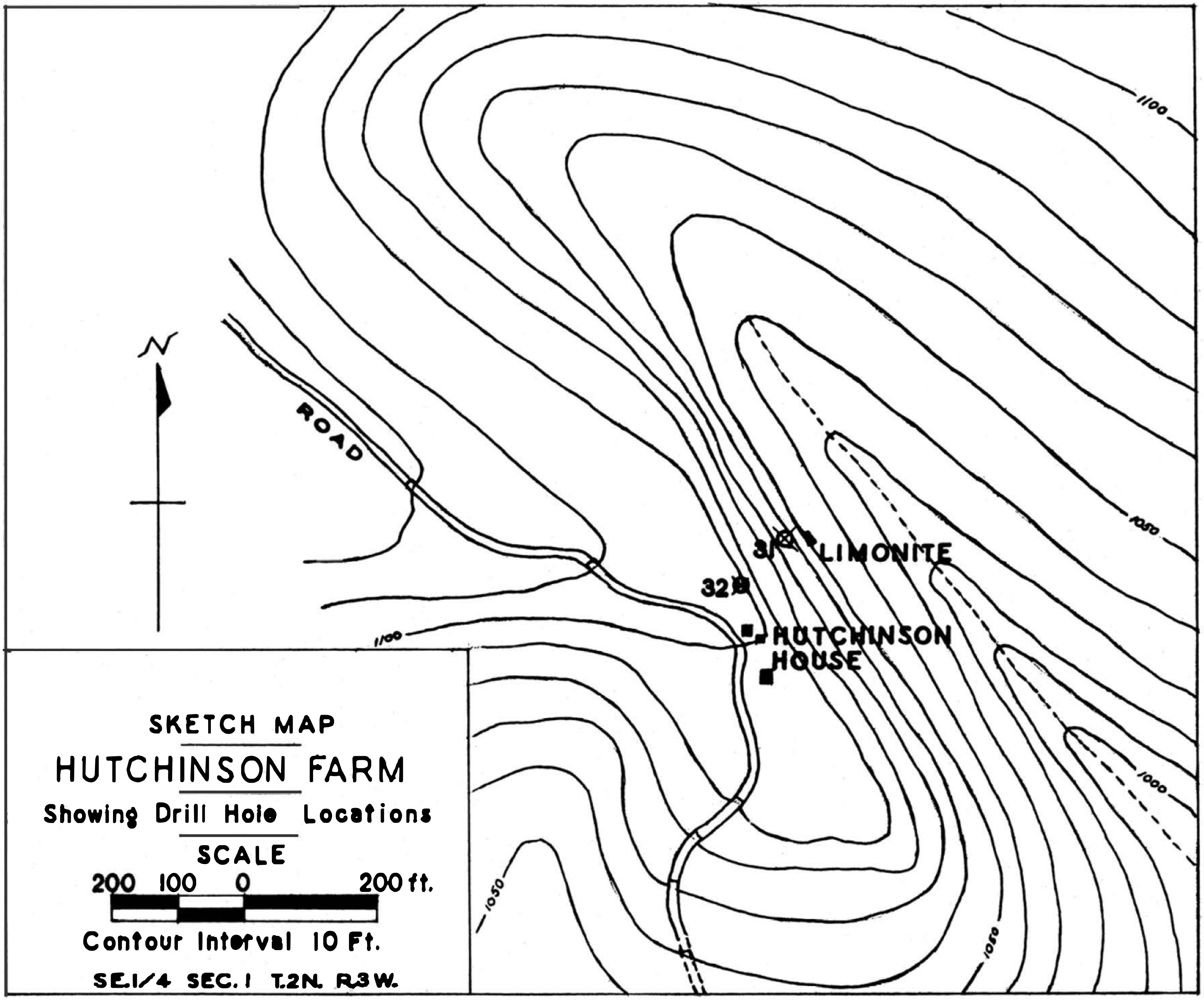
Without additional holes to delimit the ore body accurately, no tonnage estimates may be made. The topography of the area to the south and east indicates that the ore has been eroded away. However, exposure of the same type of ore in a road cut on Pumpkin Ridge Road about a quarter of a mile to the northwest suggests the extension of the ore body to the northwest from the open cut and Hole 30.

Hutchinson place:

This locality, designated No. 8 on the index map, is 2½ miles by road southeast of Locality No. 4, at an elevation of about 1100 feet. Topography and the locations of the limonite outcrop and Holes 31 and 32 are shown on the sketch map opposite page 17. Hole 31 encountered hard limonite and the hole was abandoned. Hole 32 was drilled through 14 feet of ore having a weighted average analysis as follows:

Iron	(Fe)	24.84	%
Alumina	(Al_2O_3)	33.54	
Silica	(SiO_2)	7.62	

The ore body has been removed by erosion on the south and east but may extend for some distance to the northwest in the direction of Locality No. 4. Analysis and description of the section drilled follows:


N
ROAD
31
LIMONITE
32
HUTCHINSON
HOUSE
1100
1050
1000
SKETCH MAP
HUTCHINSON FARM
Showing Drill Hole Locations
SCALE
200 100 0 200 ft.
Contour Interval 10 Ft.
SE.1/4 SEC. 1 T.2N. R.3W.

Sample No.	Fe	Al_2O_3	SiO_2	Moisture	Sample Width	Description
		(Not Sampled)			0' - 4'	Top soil.
		" "			4' - 8'	Red clay.
P-2455	22.83	33.12	12.96		8' - 10'	Oölitic iron (hard).
P-2456	32.68	25.72	8.62		10' - 12'	" "
P-2457	25.91	32.88	5.28		12' - 13'	Yellow clay-like material with white specks.
P-2538	21.80	34.08	4.78	20.2	13' - 14'6"	Dark red-brown clay-like material - few oölites.
P-2539	24.16	37.24	5.00	21.22	14'6" - 16'6"	Yellow brown clay-like material with white fragments and occasional oölites.
P-2540	22.80	42.12	5.34	20.8	16'6" - 17'6"	Very few, if any, oölites.
P-2541	22.36	42.00	4.00	20.8	17'6" - 19'6"	Brown and yellow-brown pebbly, clay-like material.
P-2542	23.48	30.08	5.62	21.8	19'6" - 20'	No change.
P-2543	25.26	26.12	12.44	30.6	20' - 22'	Mottled, varicolored and clay-like, white streaks.
P-2544	23.03	27.64	18.64	34.04	22' - 24'	Little apparent change.

The material below the hard ore at a depth of 12 - 13 feet was described in the field as a yellow clay with white specks of decomposed feldspar. Chemical analyses showed that the material contained relatively high iron and alumina and low silica. Petrographic analysis of the white specks showed that they were probably cliachite with some gibbsite. Spectrographic analysis confirmed their bauxitic character, as they contained more than 10 percent aluminum, less than 5 percent silica, less than 1 percent iron, and less than 1 percent titanium. Chemical analysis of the same picked material returned 1.28 percent silica.

Schmidt Farm:

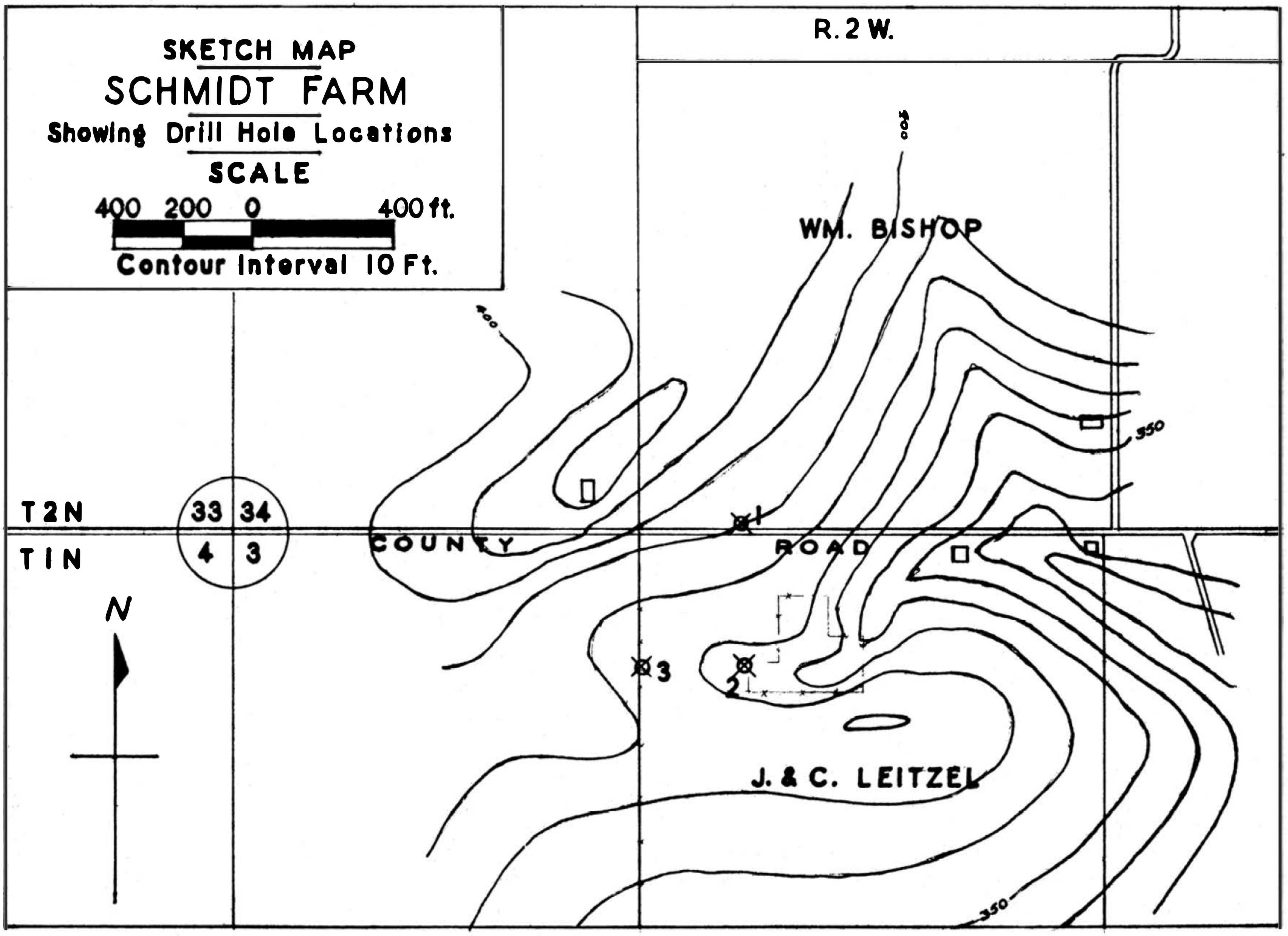
In the southern part of the area in sec. 3, T. 1 N., R. 2 W., at an elevation of about 350 feet, an outcrop of oölitic material occurs south of the Helvetia Road on the Schmidt farm approximately three-quarters of a mile north of Helvetia. A preliminary sample of the outcrop gave the following analysis:

Iron	(Fe)	18.51	%
Alumina	(Al_2O_3)	45.87	
Silica	(SiO_2)	8.16	
Phosphorus	(P)	0.150	

Three auger holes were put down at this farm as shown on the sketch opposite page 19. Analytical results of samples from Holes 1 and 2 give the following average analysis:

Iron	(Fe)	19.32	%
Alumina	(Al_2O_3)	42.08	
Silica	(SiO_2)	8.30	

The topography of this area is such that a considerable acreage might be underlain by ore. Additional holes to determine the extent of the ore body are needed before any tonnage estimates may be made, and to give information concerning average thickness of overburden.


SKETCH MAP
SCHMIDT FARM
Showing Drill Hole Locations
SCALE
400 200 0 400 ft.
Contour Interval 10 Ft.
R. 2 W.
WM. BISHOP
J. & C. LEITZEL
COUNTY ROAD
T2N
T1N
33
34
4
3
N
400
500
350
350
1
2
3

Cathey Farm:

Half a mile north of the Schmidt farm on the county road in sec. 34, T. 2 N., R. 2 W., three auger holes were drilled as shown on the sketch map, opposite page 21.

Average analyses of samples taken from Holes 4 and 6 gave the following results:

Iron	(Fe)	15.93	%
Alumina	(Al_2O_3)	22.33	
Silica	(SiO_2)	40.35	

Hole 5 failed to reach the ore.

From the analysis it is apparent that the silica content of this deposit is much too high for the material to be classed as ore.

MISCELLANEOUS PROPERTIES

The following properties were examined for surface indications, and two of them were tested by single drill holes. Although ore deposits in these properties appear to be somewhat restricted in size, further exploration work may show that some of them contain ore in economic amounts.

Becker Locality (1):

This deposit is 4.6 miles north of the Pleasant View School on the Pumpkin Ridge Road at an elevation of about 1625 feet. Owing to the uncertainty of the location of various branch roads as shown on maps of the area, the locations of Deposits 1 and 2 were not exactly determined. Locality 1 may actually be as far south as Locality 2, and Locality 2 may be in sec. 26. Hole 33 drilled through 9 feet of reddish brown material having the following analysis:

Iron	(Fe)	13.54	%
Alumina	(Al_2O_3)	28.48	
Silica	(SiO_2)	16.80	

Pebbly type ore was found on the surface near the road.

Railroad Cut Locality (2):

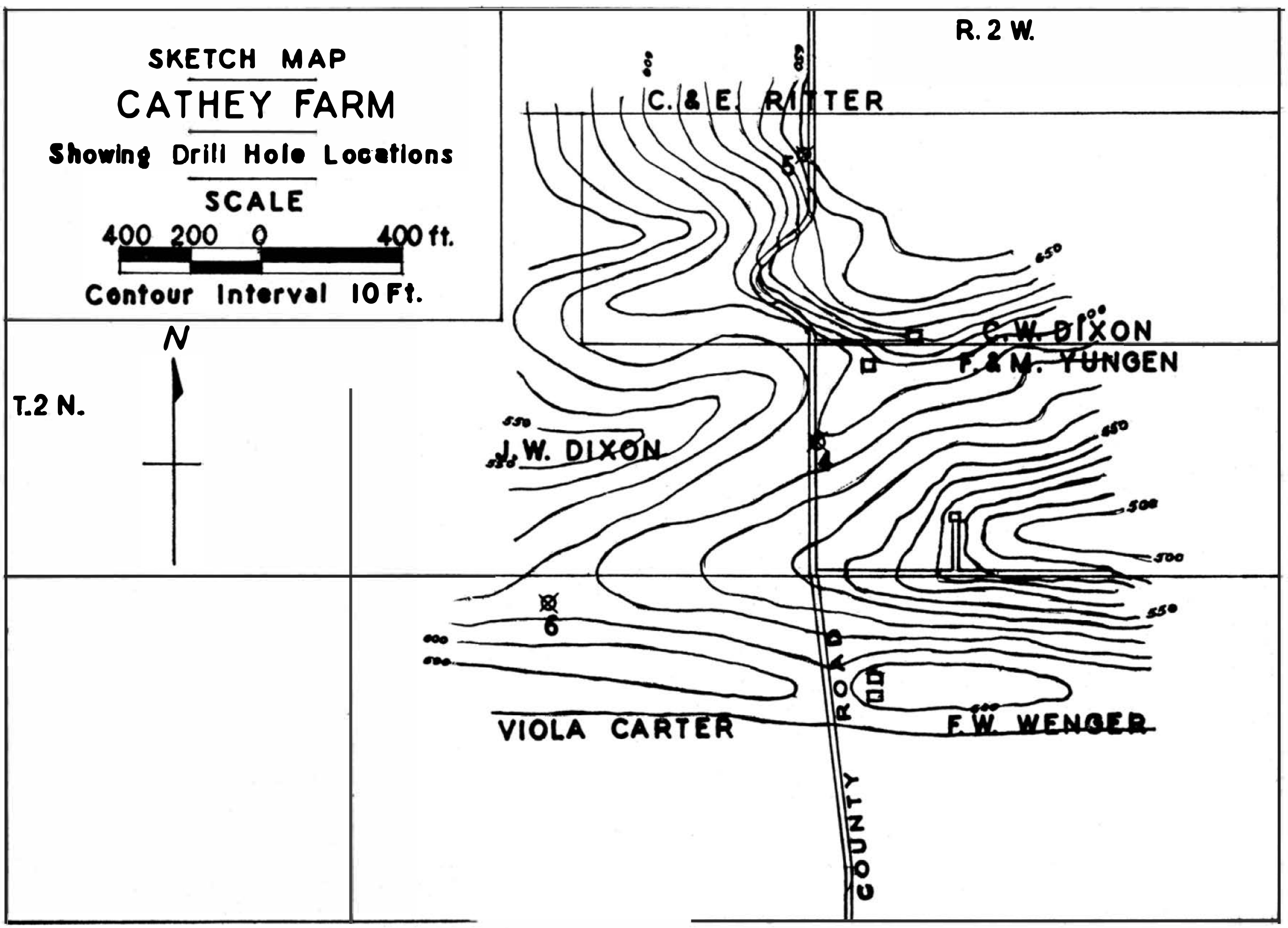
This locality, 4.0 miles north of Pleasant View School by the way of the Pumpkin Ridge Road, is at an elevation of 1550 feet. The bottom of an old railroad cut, about 15 feet deep shows a 3-foot layer of reddish brown clay-like material containing pieces of typical oölitic ore as much as 4 inches in diameter. No analysis of the material has been made.

Lazy W Ranch (3):

Oölitic type ore occurs as float in the saddle west of the house in the SE¼ sec. 30, T. 3 N., R. 2 W., at an elevation of about 1540 feet. Large chunks of limonite, very similar to the Scappoose ores, have been found in prospect holes nearly half a mile west of the house at an elevation of 1530 feet and near the head of the drainage of a creek which flows southwest.

Smith Locality (7):

This occurrence is on the Pumpkin Ridge Road 0.45 mile north of the Pleasant View School, at an elevation of 1175 feet. Oölitic type float is found both north of the Smith house and in a draw a short distance to the southwest. A well has been dug back of the house at the old Epler place on the other side of the road from, and a short distance north of, the Smith house. Oölitic type ore was found on the dump and may be seen also on the walls of the well shaft.


SKETCH MAP
CATHEY FARM
Showing Drill Hole Locations
SCALE
400 200 0 400 ft.
Contour Interval 10 Ft.
N
T.2 N.
R. 2 W.
C. & E. RITTER
C.W. DIXON
F. & M. YUNGEN
J. W. DIXON
VIOLA CARTER
F. W. WENGER
COUNTY ROAD
5
4
6
650
600
550
500

Parmele Locality (9):

Hard pebbly type ore occurs in S$\frac{1}{2}$ sec. 5, T. 2 N., R. 2 W., 0.27 mile east of Dixie Mtn. Road. The ore is exposed in a road cut at the top of the hill at an elevation of about 1240 feet. Hole 29 penetrated 10 feet of ore having the following weighted average analysis:

Iron	(Fe)	24.22 %
Alumina	(Al_2O_3)	32.62
Silica	(SiO_2)	8.52

The silica content of the lower 6 feet of ore is somewhat less than that given. Petrographic analysis shows that the white particles in the firm red clay-like material of this lower portion is gibbsite with some limonite.

Jacobs Farm (10):

This locality is 0.2 mile east of the Pumpkin Ridge Road and 4.45 miles south of the Pleasant View School, at an elevation of about 525 feet. Pieces of typical oölitic ore occur scattered over portions of the W. O. Jacobs farm and the ore may have considerable areal extent in that general vicinity.

ECONOMICS AND ORE TREATMENT

The near-surface position, blanket form, and generally low stripping ratio make the deposits so far examined susceptible of surface mining methods. On the Hendrickson deposit thickness of overburden averages about 21 feet which allows a stripping ratio of 2 to 1. There is some evidence that the average thickness of ore is greater than 11 feet, the figure used, so that the stripping ratio may be less than that given. The silt overburden should be easily handled. The ore itself is friable, and mining and crushing to the size required for smelting could be done cheaply.

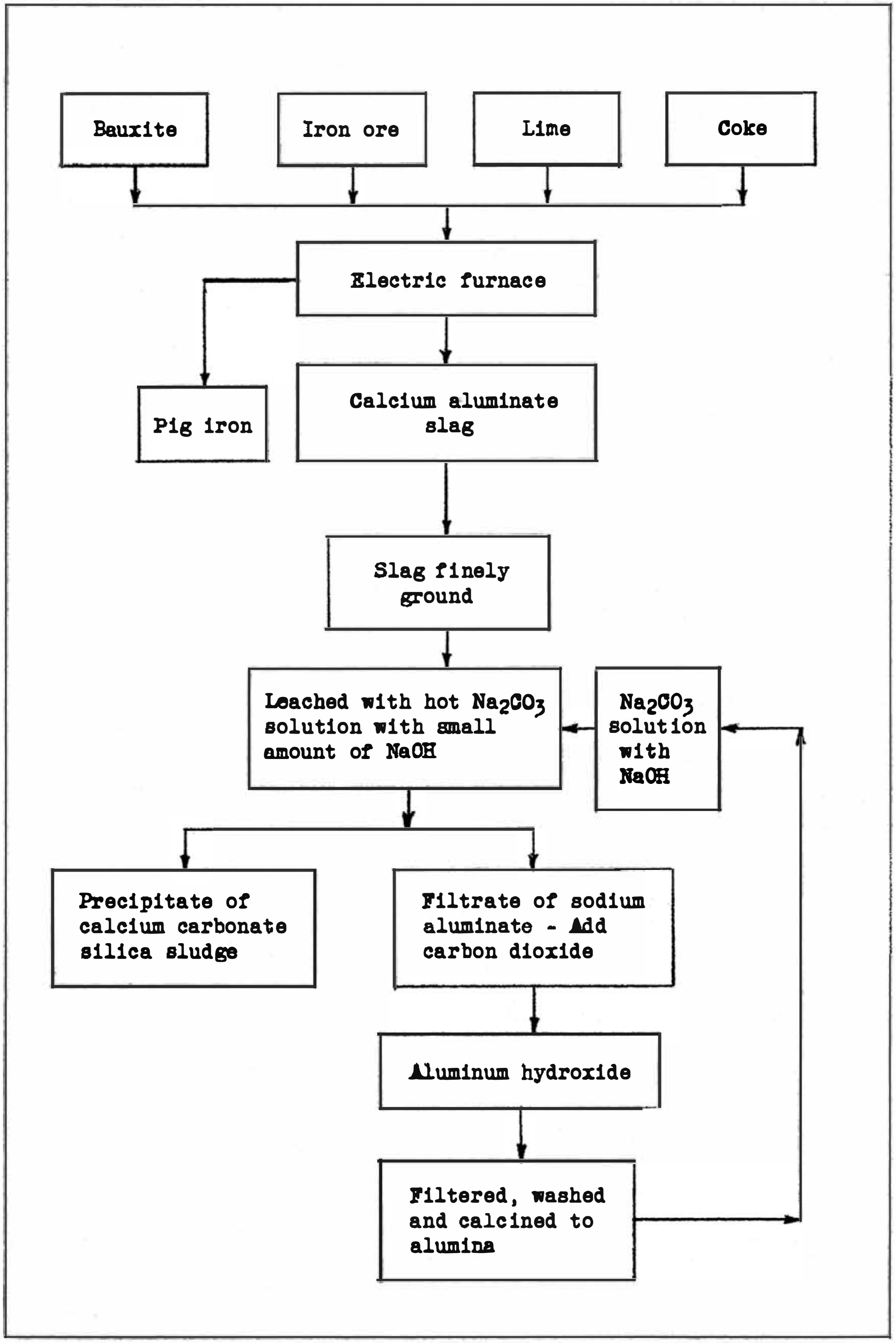
In order to be commercial, this ore would need to be treated to recover both iron and alumina. A market for both of these products exists in the Northwest with a considerable part of the demand concentrated in the lower Columbia River area.

The U. S. Bureau of Mines has been carrying out testing work in treatment of ferruginous and siliceous bauxites to recover iron (either as pig iron or ferro-silicon) and alumina, but no commercial operation for the treatment of this type of ore in this country has been reported.

The Pedersen process has been used in Norway to treat material analogous to the Washington County ore. A commercial operation started in 1928. Essentially the process consists of smelting iron ore, coke, lime, and aluminous material to produce pig iron and calcium aluminate slag. The slag is crushed and leached with hot sodium carbonate solution containing some sodium hydroxide. The resulting solution contains the alumina as aluminum hydroxide; calcium carbonate and silica are left in the sludge and may be filtered off. The solution is treated with carbon dioxide (CO_2) gas in order to precipitate aluminum hydroxide which is filtered off and calcined to obtain anhydrous alumina. The filtrate containing sodium carbonate and sodium hydroxide is recirculated for further slag treatment. A graphical representation of the flow sheet is outlined opposite page 23.

The smelting operation is preferably carried out in the electric furnace. Power consumption is reported to be approximately 3600 kwh per ton of iron produced.

In Norway it is reported that French ferruginous bauxite was smelted with Norwegian iron ore, and that silica in the raw materials should be under 8 percent. A low-sulphur high grade basic iron is produced as well as calcined alumina.



PEDERSEN PROCESS FOR PRODUCTION OF PIG IRON AND ALUMINA

From the evidence now available, it would appear that the Pedersen process would be applicable to the treatment of the Washington County deposits. Some modifications or adaptations might be necessary; at least, thorough metallurgical testing should be done, and pilot plant testing would be essential for design of a commercial plant. It is essential also to do more intensive exploration of the ore deposits to detemine quantity and quality of ore available. Obviously from an operating standpoint one large deposit or a closely spaced group of smaller deposits would be more valuable than many widely scattered small deposits.

Favorable factors relating to investigation and production from these deposits are: (1) their proximity to the Portland area which means favorable operating conditions as regards transportation, labor, and supplies; (2) cheap electric power for smelting; (3) favorable near-by market for the products produced; (4) cheap exploration cost per unit of ore developed; (5) cheap mining cost, as surface mining methods appear to be applicable; (6) relatively high gross value of the ore because two commercial products would be produced.

****

APPENDIX

Bauxite - An amorphous mineral or mixture of minerals having an approximate composition of $Al_2O_3 \cdot 2H_2O$. Now it is more generally applied commercially to aluminous lateritic rocks in which aluminum hydroxides, amorphous or crystalline, predominate over other lateritic constituents.

Cliachite - An amorphous hydrous aluminum oxide, $Al_2O_3(H_2O)_x$. It is the main constituent of some bauxites.

Colloform - The rounded, more or less spherical form assumed by amorphous or metacolloidal minerals or mineral gels in open spaces.

Gibbsite - A hydrous aluminum oxide, $Al_2O_3 \cdot 3H_2O$ or $Al(OH)_3$. It is the major constituent of some bauxites and a minor one in others.

Laterite - A residual deposit, often concretionary, formed as a result of the decomposition of rocks by weathering and ground waters, and consisting essentially of aluminum and ferric hydroxides, which may be crystalline or amorphous.

Laterization - The process which forms laterite.

Limonite - One of the hydrous iron oxide series, $2Fe_2O_3 \cdot 3H_2O$.

Magnetite - The magnetic oxide of iron, Fe_3O_4 or $FeO \cdot Fe_2O_3$.

Oölites - Rounded, concretionary grains usually considered to be smaller than a pea.

Oölitic - A textural term for rocks consisting of small round grains or concretions (oölites), resembling the roe of a fish, cemented together.

Pisolitic - A texture coarser than oölitic, the concretions being about the size of, or larger than, a pea.

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PUBLICATIONS

State Department of Geology and Mineral Industries, 702 Woodlark Building, Portland 5, Oregon

BULLETINS	Price Postpaid
1. Mining Laws of Oregon, 1942, rev. ed., contains Federal placer mining regulations	$0.20
2. Progress Report on Coos Bay Coal Field, 1938: F.W.Libbey	0.10
3. Geology of Part of the Wallowa Mountains, 1938: C.P.Ross	0.50
4. Quicksilver in Oregon, 1938: C.N.Schuette	0.50
5. Geological Report on Part of the Clarno Basin, 1938: Donald K. MacKay	(out of print)
6. Prelim. Rpt. on Some of the Refractory Clays of W. Ore.,'38:Wilson & Treasher	(out of print)
7. The Gem Minerals of Oregon, 1938: H.C.Dake	0.10
8. The Feasibility of a Steel Plant in the Lower Columbia Area near Portland, Oregon: Revised edition, 1940: R.M.Miller	0.40
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10. Placer Mining on the Rogue River, Oregon, in Relation to Fish and Fishing in that Stream, 1938: Henry Baldwin Ward	(out of print)
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12. Geology and Physiography of Northern Wallowa Mtns.,'41:W.D.Smith, J.E.Allen & Others	0.65
13. First Biennial Report of the Department, 1937-1938	(out of print)
14. Oregon Metal Mines Handbook: by the staff	
A. Baker, Union, & Wallowa Counties, 1939	0.50
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C. Vol. I, Coos, Curry, Douglas Counties, 1941	(out of print)
Vol.II, Section 1, Josephine County, 1942	0.75
Section 2, Jackson County, 1943	0.75
15. Geology of the Salem Hills & North Santiam River Basin, Oregon, '39:Thos.P.Thayer	(out of print)
16. Field Identification of Minerals for Oregon Prospectors and Collectors, Second edition, 1941: compiled by Ray C. Treasher	0.50
17. Manganese in Oregon, 1942: by the staff	0.45
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19. Dredging of Farmland in Oregon, 1939: F.W.Libbey	(out of print)
20. Analyses & Other Properties of Oregon Coals, 1940: H.F.Yancey and M.R.Geer	0.35
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8.Strategic & Critical Minerals, A Guide for Oregon Prospectors, 1942:Lloyd W. Staples	0.15
9.Some Manganese Deposits in the Southern Oregon Coastal Region, 1942:Randall E. Brown	0.10
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12.Prelim. Rpt. on High-Alumina Iron Ores in Wash. County. Ore.,'44: Libbey, Lowry, & Mason	0.15

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1. Geologic Map of the Wallowa Lake Quad., 1938: W.D.Smith & Others (also in Bull. 12)	0.45
2. Geologic Map of Medford Quadrangle, 1939: F.G.Wells & Others	0.40
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MISCELLANEOUS PUBLICATIONS	
THE ORE.-BIN: issued monthly by the staff, as medium for news items about the Department, mines, and minerals. Subscription price per year	0.25
Sampling of Small Prospects and New Discoveries	Free
The Spectrographic Laboratory of the State Dept. of Geology & Mineral Industries, 1942	Free
Oregon Mineral Localities Map	0.05
Landforms of Oregon: a physiographic sketch, (17 by 22 inches) 1941	0.10

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