State of Washington
Arthur B. Langlie, Governor

Department of Conservation and Development
Ed Davis, Director

DIVISION OF MINES AND MINING
Sheldon L. Glover, Supervisor

Report of Investigations No. 2

WASHINGTON IRON ORES,
A SUMMARY REPORT

By
Sheldon L. Glover

Olympia, Washington
April, 1942
Washington Iron Ores,
A Summary Report

Foreword

Magnetite, hematite, or limonite are known to occur in important amounts in some forty deposits throughout thirteen counties of Washington. These occurrences, considered to be of potential economic value, are briefly described in the following pages. Other deposits are known or are reported to exist, but the information on them is too scant or vague to warrant mention at this time. It is entirely possible that additional bodies will be found as time goes on, but the probability is remote that new discoveries will add appreciably to the commercial availability of iron ore in the State.

The iron minerals have not received the attention that has been given other metallic ores, yet the amount of prospecting that has been done on many of the occurrences is surprising when the scant market is considered. This work has facilitated the geologic investigation of the genesis and habit of the minerals and has aided in determining the areal dimensions of the deposits. Information must be obtained by diamond drilling or other underground exploration before accurate data will be available on the tonnage in the various deposits, but it is possible to make useful estimates of quantity. This has been done for most of the ore bodies through the assumption of a reasonable third dimension (mining depth), based on a knowledge of the structure and nature of the given deposit.

Whittier (reference no. 9), on the basis of data obtained up to 1917, estimated the possible available tonnage of all deposits to range between 10 and 50 million tons. Shedd, Jenkins, and Cooper (reference no. 12) had much more detailed information to guide them in their estimates and reported as follows:

Known ore ("refers to the ore in sight -- that on the dump, in workings, and on the outcrop") – – – – – – – – – – – – – 815,000 tons.
Probable ore ("refers to a conservative estimate of the ore which could probably be mined from a moderate depth") – – – 2,974,000 tons.
Possible ore ("refers to the total amount of ore which could possibly be mined if local characters are continuous throughout the entire properties and if mining is carried to considerable depth") – – – – – – – – – – – – – 7,606,000 tons.

They mention in this connection that, "None of these features (sic) are accurate. They are given merely to present to the reader a general relative impression of conditions existing in the State as far as is known." They have refrained from including in their estimate of tonnage certain deposits where details of size were vague or lacking and, of course, do not include several later discoveries. It would appear that at least a 10 percent increase in their estimates would be conservative and proper, making the total "possible" tonnage, for example, something over 8 million tons, but there is a good possibility that future prospecting, particularly of the Neutral-Aztec property, Okanogan County, and the Balfour-Guthrie property, Kittitas County, may prove these estimates to be far too low.
Fifteen or more reports have been written, based on the various geological investigations that have been made from time to time of the iron ores of the State or of particular deposits. Most of these reports are no longer available for distribution, and, although they may be consulted in the larger libraries, it has been thought desirable to reissue the more essential information for the ready reference of those interested in this resource.

In compiling the following summary of information on iron ores, all reports known to the writer have been freely drawn upon, and some additional data, hitherto unpublished, have been added. Most of the material has been abstracted from the State Division of Geology bulletin no. 27, "Iron ores, fuels, and fluxes in Washington," by Solon Shedd, O. P. Jenkins, and H. H. Cooper, 1922. This is the most comprehensive and useful report dealing with State-wide occurrences, though other accounts may contain more complete data on individual occurrences. A list of references is included, and the more pertinent ones are indicated in the discussions of individual deposits, so that original sources may be consulted for more detailed treatment.

REFERENCES, in chronological order

(The initial numbers correspond to those in the body of this report.)


5. Young, Robert, Report upon Cle Elum iron mines: A private report on investigations for Balfour, Guthrie & Company, Ltd., 1906, a copy of which has been made available to the writer through the courtesy of that company.


7. Zapffe, Carl, Report on the Cle Elum iron ores in the Cle Elum mining district, Kittitas County, Washington: A private report on investigations for the Northern Pacific Railway Company, 1913, a copy of which has been made available to the writer through the courtesy of that company.


17. Mackin, J. H., A private report on investigations for the Northern Pacific Railway Company, 1941, made available through the courtesy of that company and the author.

CHelan County

McCarthy property   Secs. 14, 15, (22-17E) Magnetite  Not concentrated in bodies of commercial importance.

Magnetite occurs as a migmatic segregation in peridotite — in some places as disseminated grains and in others as the principal constituent. The best ore (mostly oxidized to hematite) is in a zone 8 to 10 feet wide and a hundred or so feet long adjacent to a diabase dike. Two or three tunnels have been driven but they show mainly serpentine; some ore has been dug from shallow surface pits.

Distance to railroad at Cashmere, about 17 miles. Elevation, 3,000 or Distance by rail to Seattle, 154 miles. 3,500 feet.

Analysis of specimen of higher grade hematite with some magnetite.

R. P. Cope, Pullman, analyst.

Iron (Fe), 47.98%; silica (SiO₂), 10.81%; phosphorus (P), 0.24%; sulphur (S), 0.009%.

Reference — No. 12, pp. 71, 72.
Magnetite occurs as disseminated grains and small magmatic segregations in peridotite. A 50-foot tunnel exposes patches of the mineral but no extensive bodies.

Distance to railroad at Cashmere, 15 miles. Elevation about 2,600 feet. Distance by rail to Seattle, 154 miles.

Analyses of two samples. R. F. Cope, Pullman, analyst.

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<tr>
<td>Iron (Fe)</td>
<td>42.67%</td>
<td>49.74%</td>
<td>Manganese (Mn)</td>
<td>1.29%</td>
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<tr>
<td>Silica (SiO₂)</td>
<td>18.54</td>
<td>9.57</td>
<td>Phosphorus (P)</td>
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<td>Aluminum (Al)</td>
<td>8.55</td>
<td>5.32</td>
<td>Sulphur (S)</td>
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<td>Chromium (Cr)</td>
<td>1.08</td>
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<td>Titanium (Ti)</td>
<td>0.14</td>
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<tr>
<td>Calcium (Ca)</td>
<td>1.28</td>
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<td>Loss on ignition</td>
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<tr>
<td>Magnesium (Mg)</td>
<td>8.66</td>
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Reference.— No. 12, pp. 70, 71.

Washington Nickel Mining & Alloys Co. Secs. 11,13,14, property

Magnetite, hematite

No tonnage estimates available, but the amount may be very large.

This may be, at least in part, the same as the McCarthy and Rothert properties (q.v.). The magnetite is in sec. 13, where it has been reported to occur as small segregations or masses in peridotite. A tunnel crosscuts several of the bodies. The hematite is in secs. 11, 13, and 14 and is exposed in several open cuts.

Mackin (reference no. 17) has concluded that field evidence indicates the ore bodies to be of sedimentary origin and that they lie on the serpentinite-peridotite at the base of the Swauk formation. This would make them corollaries of the Cle Elum ores of Kittitas County (see page 10, Balfour-Guthrie property) and suggests a far greater extent than would be expected if they were segregations in the peridotite. He mentions three formational phases or members with a total width of 150 to 250 feet, probably continuous for at least 3,000 feet, and with a vertical range of at least 1,500 feet. The phases include: (1) a breccia made up of serpentine in an iron-rich matrix which may or may not be ore; (2) a 22-foot bed of massive brown ore that is exposed in numerous cuts for at least 800 feet; and (3) another poorly exposed zone similar to No. 2 but with some peridotite-pebble intermixture.

Distance to railroad at Dryden, 15 miles. Elevation, 1,500 feet or so. Distance by rail to Seattle, 140 miles.
CHELAN COUNTY (continued)

Analyses of channel samples from the 22-foot (No. 2) member

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<tr>
<td>Iron (Fe)</td>
<td>26.21%</td>
<td>36.06%</td>
<td>Sulphur (S)</td>
<td>0.02%</td>
<td>0.018%</td>
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<tr>
<td>Alumina (Al₂O₃)</td>
<td>2.54</td>
<td>4.64</td>
<td>Manganese (Mn)</td>
<td>0.44</td>
<td>0.42</td>
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<td>Silica (SiO₂)</td>
<td>25.30</td>
<td>19.68</td>
<td>Nickel (Ni)</td>
<td>0.57</td>
<td>0.76</td>
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<td>Lime (CaO)</td>
<td>1.97</td>
<td>1.52</td>
<td>Chromium (Cr)</td>
<td>1.36</td>
<td>2.41</td>
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<td>Magnesia (MgO)</td>
<td>19.18</td>
<td>8.86</td>
<td>Water (H₂O)</td>
<td>2.88</td>
<td>1.81</td>
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<tr>
<td>Phosphorus (P)</td>
<td>0.018</td>
<td>0.023</td>
<td>Loss</td>
<td>11.26</td>
<td>10.41</td>
</tr>
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</table>

Reference.—No. 16, p. 8; No. 17.

FERRY COUNTY

Copper Key mine 10 miles NE. of Republic Magnetite and other minerals. Amount undetermined. Possibly of economic importance.

This deposit is near the summit of Belcher Mountain and is an irregular replacement of (principally) limestone or dolomite adjacent to intrusive sheets of monzonite porphyry. A large quantity of magnetite is present — in some places accompanied by pyrite, pyrrhotite, and some chalcopyrite, in other places remarkably free from these minerals. Development work shows one ore body to extend at least 100 feet horizontally and for more than 100 feet down its dip. It has a width of approximately 25 feet, and a considerable additional extent is indicated.

Distance to railroad at Gurlew Lake, 7 miles. Elevation, 4,650 feet. Distance by rail to Seattle, 495 miles.


Iron (Fe), 63.21%; silica (SiO₂), 0.61%; lime (CaO), 8.78%; magnesia (MgO), 1.10%; phosphorus (P₂O₅), 0.11%; sulphur (S), 0.08%; arsenic (As), none.

References.—No. 12, pp. 58, 59; No. 8, pp. 173-175.

Oversight mine 10 miles NE. of Republic Magnetite and other minerals. Amount undetermined. Of doubtful value.

The Oversight mine, on Cocke Mountain, is a replacement deposit in dolomitic limestone similar to the Copper Key occurrence. The ore body is chiefly magnetite and pyrite, with lesser amounts of pyrrhotite and small amounts of chalcopyrite.
FERRY COUNTY (continued)

Distance to railroad at Torboy, 9 miles. Elevation about 4,650 feet. Distance by rail to Seattle, 499 miles.


"This is not a general average of the ore ---. Some of it is nearly pure magnetite."

Iron (Fe), 26.97%; lime (CaO), 14.71%; magnesia (MgO), 12.91%; phosphorus pentoxide (P₂O₅), 0.164%; sulphur (S), 8.90%; arsenic (As), none.

References.—No. 12, p. 59; No. 8, pp. 170-173.

Belcher mine 10 miles NE. of Republic Pyrite and magnetite Size of body not determined. Of doubtful value.

The Belcher mine is on Belcher Mountain, about one-half mile north-east of the Copper Key mine. The ore is an irregular replacement of limestone and dolomite adjacent to intrusive dikes of monzonite porphyry. Magnetite occurs but is less abundant than at the Oversight and Copper Key properties, iron sulphides are common, and various contact metamorphic minerals are present. A drift on No. 2 level follows an ore body for 75 feet — 40 feet through solid ore and 35 feet through more-or-less replaced country rock — and various other workings show ore, but insufficient work has been done to determine the size of the body. An estimate is made that the deposit is 5 to 20 feet thick and extends down the dip for considerable distance; the length along the strike is not determined.

Distance to railroad at Curlew Lake, about 11 miles. Elevation, 4,100 feet. Distance by rail to Seattle, 495 miles.

References.—No. 12, pp. 59, 60; No. 8, pp. 175-179.

Other deposits, reported but not investigated.


2. Iron ore; in Deadman Creek district near Boyds. Spokane Chronicle, March 29, 1937.

GRAYS HARBOR COUNTY

Elma (Dennis) deposit  Sec. 28, (16-5W.)  Titaniferous magnetite  Tonnage estimate
Known ---- 5,000
Probable-10,000
Possible-20,000

The deposit has 3 to 8 feet of overburden and consists of a stratified bed of consolidated black sand and intermixed sand and gravel. It is 1 to 4 feet thick and 2 or 3 acres in extent, though the lateral boundaries have not been well defined. Prospecting is by several open cuts and pits. One carload was shipped to Bilrowe Alloys Company, Tacoma, and 1,000 pounds to Rothery Process Steel Company, Seattle, for experimental purposes.

Distance to railroad at Elma, 3½ miles. Elevation, 400 (?) feet.
Distance from Seattle, 110 miles.

Analysis (indicative).  R. P. Cope, Pullman, analyst.

Iron (Fe), 50.02%; silica (SiO₂), 0.80%; phosphorus pentoxide (P₂O₅), 0.18%; sulphur (S), 0.062%; titanium dioxide (TiO₂), 22.23%.

References.—No. 12, pp. 107-109; No. 14, pp. 8-11.

Other deposits, reported but not investigated.

Black sand deposits, reported to occur at Damon's Point, were considered to be economic. Mining and Scientific Press, vol. 92, p. 78, 1906. Northwest Mining News, vol. 1, no. 9, p. 17, 1907. See also: Mining and Scientific Press, vol. 88, p. 70, 1904.

JEFFERSON COUNTY

Limonite from a deposit in the Chimacum Valley was used at one time, but it is reported that the iron produced was of rather poor quality and the deposit proved to be very limited in quantity. One report suggests 75,000 tons to be available.

Analysis (indicative).  E. Fulmer, Pullman, analyst.

Iron (Fe), 53.67%; phosphorus (P), 1.09%; insoluble, 9.67%; alumina (Al₂O₃), none; manganese (MnO), 0.29%; calcium (CaO), 0.95%.

References.—No. 2, pp. 5, 10; No. 15, p. 29.
KING COUNTY

Denny property
Sec. 6, (22-11E.), 2 miles NE. of Snoqualmie Pass

The ore body, a contact metamorphic deposit between limestone and intrusive granodiorite, occurs as mineralized bands and isolated masses of magnetite with which are associated characteristic contact minerals. Considerable pyrite is present in some places. The largest bodies are ovoid lenses, 20 feet or more across, which lie approximately parallel to the surface of the ground and thus exhibit a maximum exposure of ore. The principal exploration work consisted of a 53-foot tunnel and some open cuts and pits, now inaccessible.

Distance to railroad at Rockdale, 1½ miles, but the nearest feasible loading point would probably be farther. Elevation, 3,500 feet. Distance by rail to Seattle, 58 miles.

Analyses (from 3, probably fairly representative).
S. Shedd, Fullman, and Booth, Garrett, and Blair, Philadelphia, analysts.

Iron (Fe), 55.48% to 68.54%; silica (SiO2), 1.89% to 7.99%; phosphorus (P), 0.021%; sulphur (S), 0.089% to 0.25%.

References.—No. 12, pp. 86-90, 94; No. 9, pp. 25, 26; No. 2, pp. 26, 27; No. 3, p. 13; No. 17.

Guye property
Secs. 29, 31, (23-11E.), (NE4 SW4, sec. 28?)

The deposits are of contact-metamorphic origin and very similar to those of the Denny property, which is only 2 miles distant, but are, in general, wider and more continuous. Pyrite does not appear to be common, but garnet is intimately intermixed with the magnetite. Development work consists of one tunnel and four or five open cuts and pits.

Distance to railroad at Rockdale, about 2½ miles. Elevation, 4,600 feet. Distance by rail to Seattle, 58 miles.

Analyses (representative). From Northern Pacific Railway Company

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<tr>
<td>Iron (Fe)</td>
<td>59.94%</td>
<td>64.31%</td>
<td>Sulphur (S)</td>
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<tr>
<td>Alumina (Al2O3)</td>
<td>2.54</td>
<td>2.0</td>
<td>Titanium (TiO2)</td>
<td>0.24</td>
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<td>Silica (SiO2)</td>
<td>6.71</td>
<td>4.07</td>
<td>Manganese (Mn)</td>
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<td>Lime (CaO)</td>
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<td>0.32</td>
<td>Water (H2O)</td>
<td>0.60</td>
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<tr>
<td>Magnesia (MgO)</td>
<td>0.39</td>
<td>0.37</td>
<td>Loss</td>
<td>2.43</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.019</td>
<td>0.020</td>
<td>*Not to exceed</td>
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</tbody>
</table>
ANDERSON PROPERTY  Sec. 11, (26-10E.)  Magnetite  Tonnage estimate
Known -- 2,000
Probable-- 5,000
Possible--10,000

This ore body is in limestone and is presumably a contact-replacement deposit. The exposure is a more-or-less lenticular mass 25 to 30 feet in height and 15 feet in width. Some mining development has been done, and, when visited, 200 tons of ore lay on the dump. One carload is said to have been shipped.

Distance to railroad at Baring, 1 mile. Elevation, several hundred feet above the Skykomish River.

Distance by rail to Seattle, 77 miles.

Analyses (indicative).
E. H. Rothert, Seattle, and R. P. Cope, Pullman, analysts.

Iron (Fe), 55.00% to 60.70%; silica (SiO2), 10.20% to 9.51%; alumina (Al2O3), 0.75%; lime (CaO), 4.53%; magnesia (MgO), 1.15%; phosphorus (P), 0.065%; sulphur (S), 0.09%; titanium dioxide (TiO2), Tr. to 0.94%.

References.-- No. 12, pp. 92, 93, 95; No. 14, pp. 11-14.

WILLIAMS-SMITH PROPERTY  Secs. 35, 36, (26-10E.)  Magnetite  Tonnage not estimated.

The ore bodies are probably contact replacements of limestone. Magnetite crops out in three places, the largest exposure being 51 feet across. A 257-foot tunnel is said to have been driven into one of the bodies.

Distance to railroad at Miller River, 5 miles. Elevation, 2,900 feet. Distance by rail to Seattle, 85 miles.


Iron (Fe), 66% to 67%; silica (SiO2), 2.70% to 4.10%; phosphorus (P), 0.0264% to 0.37%; sulphur (S), none.

References.-- No. 12, pp. 93-95; No. 14, pp. 11-14.
KING COUNTY (continued)

Other deposits, reported but not investigated:


2. Iron ore at the Kelley prospect on Chair Peak. Second Ann. Rept. of First State Geologist, p. 41, 1892. Also, Hodges, L. K., Mining in the Pacific Northwest, p. 41, Seattle, 1897.


KITTITAS COUNTY

Balfour-Guthrie property Secs. 26, 34, 35, (23-11E.), 1, 2, (22-14E.) Magnetite and some hematite Tonnage estimate Known — 500,000 (?) Probable-2,000,000 Possible-5,000,000

The ore is a mixture of hematite and magnetite, occurring in three forms — massive, laminated, and oolitic, and lies on a serpentinized peridotite at the base of the folded Swauk formation. It probably originated as a concentration of iron minerals derived from the weathered and altered peridotite prior to the deposition of the Swauk series. The ore bodies crop out at the contact of the two formations as a series of discontinuous lenses, usually from a few feet to 30 feet thick; they are exposed for 1½ miles along the Cle Elum River, again for a mile at a short distance east of the river, and in the mountains still farther east, for a total distance of about 5 miles. Some prospecting by tunnels, shafts, pits, and trenches was done prior to 1903 and later, and 4 diamond drill holes (70, 106, 397, and 448 feet in depth) were put down in 1903. (See, also, page 4, Washington Nickel Mining & Alloys Co. property.)

Robert Young (reference no. 5) states, "a conservative approximation of the ore lying above water level would be about eight million tons."

Carl Zapffe (reference no. 7) mentions that, "in the present state of developments there is insufficient data available for a determination of the likely depth of the ores, to satisfactorily make a tonnage estimate. ... in a few places it is quite certain that the ores were from 200 to 400 feet deep, that generally not more than from 1 to 10 feet were visible, that possibly the ores might extend downward several thousand feet, and that all important increases in tonnages depended almost entirely on this dimension, because the lengths and widths of the deposits are already well defined." On varying assumptions he makes estimates of 295,000 tons, 2,264,000 tons, or 12,754,000 tons as the amount of available ore.
Distance to railroad at Lakeside, 16 miles. Elevations, 2,770 to 5,020 feet. Distance by rail to Seattle, 110 miles.

Analyses (representative)

Many analyses by various analysts are available. The ore varies from low percentages of iron to more than 68%, averaging between 40 to 50% for the whole body — not merely specimens; phosphorus, generally less than 0.05%; sulphur, 0 to 0.17%; titanium, generally not present; alumina is commonly high (7% to 36%). The average weighted chemical composition of 46 samples (A. McCullough, analyst) shows for the whole district: iron (Fe), 41.12%; alumina (Al₂O₃), 21.51%; silica (SiO₂), 16.31%.

References.—No. 12, pp. 73-79; No. 2, pp. 27-36; No. 7; No. 5; No. 3, pp. 13, 14.

Teanaway deposits  Probably sec. 12, "Iron ore"  Amount unknown.
                        (22-15E.)

These deposits, included in the Iron Mountain and Devine groups of claims, are on Beaver (Beverly?) Creek, about 3 miles south of Mount Stewart, east of Teanaway River. Except for a series of 13 analyses nothing is known about these occurrences.

Approximate distance to railroad at Teanaway, 27 miles. Elevation, 5,000 to 6,000 feet. Distance by rail to Seattle, 90 miles.

Average composition, from 13 analyses. J. C. Beneker, Seattle, analyst.

Iron (Fe), 50.13%; silica (SiO₂), 11.71%; alumina (Al₂O₃), 9.63%; manganese (Mn), 0.84%; nickel (Ni), 1.09%; chromium (Cr), 1.65%; phosphorus (P), 0.27%; sulphur (S), none.

Reference.—No. 12, pp. 84, 85.

Durrwachter property  Secs. 9, 10, (19-15E.)  Hematite  Tonnage estimate
                      Known — 1,000
                      Probable—40,000
                      Possible—50,000

The ore body consists of two roughly parallel zones of hematite-bearing garnetiferous gneissophane schist of sedimentary origin, not unlike the Hamilton (Skagit County) occurrence. Some magnetite is also present. The upper, or better-paying showing, varies from extremely narrow to several feet in thickness, extends for more than 2,000 feet, and dips 30 or 35 degrees into the mountain side.
DISTANCE TO RAILROAD AT SOUTH CLE ELUM, 2 MILES. ELEVATION, 2,800 FEET. DISTANCE BY RAIL TO SEATTLE, 90 MILES.

ANALYSIS (INDICATIVE, AFTER ELIMINATION OF GARNET).
R. P. Cope, Pullman, analyst.

IRON (Fe), 26.56%; silica (SiO₂), 29.49%; phosphorus (P), 0.24%; sulphur (S), 0.09%.

REFERENCE.—No. 12, pp. 79-81.

TANEUM DEPOSIT 12 MILES SE. OF "IRON ORE" AMOUNT UNKNOWN

Easton

This deposit, on the north fork of Taneum Creek, is said to be 10 feet thick and to show 60% iron on analysis.

DISTANCE BY RAIL FROM EASTON TO SEATTLE, 78 MILES.

BIG CREEK DEPOSIT 5 MILES SE. OF "IRON ORE" AMOUNT UNKNOWN

Easton

The exact location and geology of this deposit is not known.

DISTANCE BY RAIL FROM EASTON TO SEATTLE, 78 MILES.

AVERAGE COMPOSITION, FROM 5 ANALYSES. PROF. JAMES A. DODGE, MINNEAPOLIS, ANALYST.

IRON (Fe), 44.73%; silica (SiO₂), 27.35%; lime (CaO), 3.18%; magnesia (MgO), 0.35%; manganese (Mn), 2.79%; phosphorus (P), 1.29%; sulphur (S), 0.02%; copper (Cu), 0.08%; combined oxygen with Fe, Mn, and P, 20.33%.

REFERENCE.—No. 12, p. 86.

OKANOGAN COUNTY

NEUTRAL-AZTEC MINE SECS. 13, 24, 40-30E. MAGNETITE TONNAGE ESTIMATE

Known —— 200,000
Probable — 375,000
Possible — 500,000

The ore bodies, on Buckhorn Mountain, are irregularly shaped lenticular masses of magnetite, enclosed in calcareous metamorphic rocks adjacent to a quartz-bearing hornblende syenite intrusive. The largest body is 400 feet
long and 50 to 100 feet wide; the depth is not known, but the difference in elevation between the two ends of the deposit is more than 200 feet. Associated minerals are pyrite and a little pyrrhotite and chalcopyrite. The several tunnels and large open cuts are not adequate to outline the ore bodies, and it is thought that the deposit is much larger than is indicated by the actual exposures. In fact, unsubstantiated reports of detailed exploration, involving diamond drilling and conducted by a British Columbia company many years ago, suggest a total tonnage many times in excess of the amount that is based on natural exposures.

Shipments from open cuts on the main ore body amounted to some 8,000 tons prior to 1920; small amounts were shipped intermittently during succeeding years; and lately the production (to the Northwest Magnesite Company) has amounted to about 8,000 tons annually.

Distance to railroad at Curlew, 22 miles. Elevation, 4,800 feet. Distance by rail to Seattle, 483 miles.

<table>
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<td>Iron (Fe)</td>
<td>70.17%</td>
<td>70.15%</td>
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<td>Silica (SiO₂)</td>
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<tr>
<td>Manganese (Mn)</td>
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<td>1.70</td>
<td>1.85</td>
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<tr>
<td>Alumina (Al₂O₃)</td>
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<td>0.09</td>
<td>---</td>
<td>7.60</td>
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<td>Phosphorus (P)</td>
<td>0.009</td>
<td>0.11</td>
<td>0.15</td>
<td>0.028</td>
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<tr>
<td>Sulphur (S)</td>
<td>0.21</td>
<td>1.50</td>
<td>1.40</td>
<td>0.012</td>
</tr>
<tr>
<td>Titanium oxide (TiO₂)</td>
<td>---</td>
<td>Nil</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Combined water, etc.</td>
<td>---</td>
<td>1.50</td>
<td>---</td>
<td>---</td>
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<tr>
<td>Cobalt (Co)</td>
<td>---</td>
<td>Tr.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Nickel oxide (NiO)</td>
<td>---</td>
<td>1.00</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Chromic oxide (Cr₂O₃)</td>
<td>---</td>
<td>2.00</td>
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<tr>
<td>Alkalies, oxygen, etc.</td>
<td>15.85</td>
<td>18.75*</td>
<td>22.23</td>
<td></td>
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</tbody>
</table>

*Undetermined, moisture, etc.

A. Indicative. R. P. Cope, Pullman, analyst; B. Indicative; C. Picked sample; D. One-ton mine-run sample; analyses by a Portland, Oregon chemist and supplied by Mr. Archie Wilson, owner of the property.

References. — No. 12, pp. 61-65; No. 6, p. 48.

MacLean (Roosevelt, Grant) property

- Secs. 24, 25, (40-30E.)
- Magnetite, with pyrite and chalcopyrite
- Quantity indeterminate

This is a contact-metamorphic deposit very similar to the Neutral-Aztec property, which is only a mile to the north. It was originally

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OKANOGAN COUNTY (continued)

opened as a copper property, and developments consist of surface work and an 800-foot tunnel, stopes, and crosscuts. The workings are inaccessible, but it is known that magnetite bodies occur and that some 2,000 tons were mined.

Distance to railroad at Curlew, 20 miles. Elevation, 4,700 feet.
Distance by rail to Seattle, 483 miles.

References.—No. 12, pp. 65-67; No. 6, pp. 44-46.

Fuller property Sec. 26, (30-23E.) Magnetite Tonnage estimate
Known —— 2,000
Probable— 10,000
Possible— 20,000

This mineral is an intimate intermixture of coarse-grained magnetite with hornblende and actinolite. It occurs in veins and thin lenses in a steeply dipping body of hornblende, biotite, and actinolite, that varies from a few feet to 15 feet in thickness. The exposure along the strike is 400 or 500 feet. The wallrocks are syenite gneiss.

Distance to railroad at Pateros, 1 mile. Elevation, 2,300 feet.
Distance by rail to Seattle, 224 miles.

Analysis of better than average grade ore. R. P. Cope, Pullman, analyst.

Iron (Fe), 57.02%; silica (SiO₂), 4.51%; phosphorus pentoxide (P₂O₅), 0.05%; sulphur (S), 0.097%; titanium dioxide (TiO₂), 3.25%.

Reference.—No. 12, pp. 68, 69.

Iron Cap claim Sec. 9, (31-30E.) Limonite No tonnage estimate available.

Massive to earthy limonite, 20 feet or more in width at the surface, occurs near the west line of sec. 9. It is probably a decomposition product of magnetite.

Reference.—No. 10, p. 83.

PACIFIC COUNTY

McGowan property Sec. 22, (9-10W.) Magnetite-bearing black sands No tonnage estimate made.
PACIFIC COUNTY (continued)

The occurrence is a Recent bedded deposit of unconsolidated black sand in a low terrace adjacent to the Columbia River at McGowan. Test pits show the sand to be at least 4 feet thick in places and to extend over several acres. It is reported that a considerable acreage has been proved by drilling.

Distance to railroad at Astoria, Oregon, 5½ miles by water.
Distance by rail to Seattle, 282 miles.

Reference.—No. 16, p. 3.

SKAGIT COUNTY

Iron Mountain (Hamilton) deposits
Secs. 23, 24, (35-6E.) and eastward
Hematite and magnetite
Tonnage estimate
Known —— 20,000
Probable— 100,000
Possible— 500,000

These deposits are presumably of sedimentary origin and occur as discontinuous beds or lenses in a fine-grained glaucophane-garnet schist of pre-Chuckanut (Mesozoic ?) age. Five of these beds, more or less parallel, are known in the six miles between Hamilton and Birdsviwe, two are known at Marblemount, and others are reported in the 22-mile interval between Marblemount and Birdsviwe on the south side of the Skagit River. They vary from a few feet to 30 feet in thickness and mostly dip about 55 degrees to the southwest. The mineralization is hematite with and without magnetite; the relative proportions have not been determined except in some deposits of better grade, which appear to be about one-half hematite and one-half magnetite. In some beds the walls are sharply defined; in others the ore grades insensibly into the country rock.

Considerable prospecting and development work was done after the discovery of these beds in 1881, and some 5,000 tons of ore have been mined, but most of the old openings are now inaccessible. A W.P.A. mineral investigation project, sponsored by the Department of Conservation and Development, showed by trenching that one bed in sec. 30, (35-7E.) extended for more than 600 feet and had a thickness varying from 0 to 15 feet, averaging a little over 3 feet. Samples taken here contained: Iron (Fe), 31.6%; silica (SiO2), 33.1%; manganese (Mn), 6.6%; phosphorus (P), trace; and sulphur (S), trace.

Distance to railroad, immediately adjacent or within a mile or so. Elevation, 100 to several hundred feet.
Distance by rail to Seattle, 89 miles.
SKAGIT COUNTY (continued)

Representative composition (from 15 analyses).

Highest percentage of:                      Lowest percentage              Average percentage
Iron (Fe) ................................ 46.60                      29.11                      37.79
Silica (SiO₂) ................................ 32.94                      17.00                      24.73
Alumina (Al₂O₃) ............................ 9.54                        None                       6.01
Calcium carbonate (CaCO₃) .................. 9.77                        3.78                       6.56
Manganese oxide (Mn₃O₄) .................... 14.28                      0.19                       9.75
Phosphorus (P) .............................. 1.06                        Tr.                        0.49
Sulphur (S) .................................. 0.25                        0.06                       0.16

References.—No. 12, pp. 95-102; No. 2, pp. 19-25; No. 9, pp. 27-29;
No. 14, pp. 18-22; No. 16, pp. 4, 5.

SNOHOMISH COUNTY

Coe deposit  Sec. 36, (32-5E.)  Limonite  Tonnage estimate
(bog iron)                      Known —— 3,000
                                      Probable—10,000
                                      Possible—15,000

This is a Recent deposit of bog iron, 2 to 3 feet thick, covering 2 or 3 acres (possibly 10 acres). Some of this ore appears to contain a considerable amount of manganese dioxide. It is thought to be of too low grade to be of any particular economic importance.

Distance to railroad at Arlington, 1½ miles. Elevation, about 200 feet.
Distance by rail to Seattle, 61 miles.

References.—No. 12, p. 103; No. 14, p. 23.

Jefferson deposit  Sec. 29 or 30, (32-6E.)  Limonite  Tonnage estimate
(bog iron)                      Known —— 1,000
                                      Probable—3,000
                                      Possible—5,000

A Recent deposit of bog iron covers 3 or 4 acres. Most of the ore has been mined, but there may be a few thousand tons remaining. It is too low in grade to be considered of special economic importance.

One account (reference no. 14 below) says that the limonite is reported to underlie about 30 acres and to have an average thickness of overburden of 3 feet. On the assumption of a 2-foot average thickness of ore an estimate of available tonnage is given as 250,000 tons.
SNOHOMISH COUNTY (continued)

Distance to railroad at Arlington, 5 miles. Elevation, about 100 feet. Distance by rail to Seattle, 61 miles.

References.—No. 12, p. 103; No. 14, pp. 23-25.

Pilchuck Creek area T. 32 N., R. 5 E. Magnetite Available tonnage not known

Basal and near-basal sediments of the Chuckanut formation (Eocene) crop out along the banks of Pilchuck Creek (Little Pilchuck River) for a mile or so upstream from where State Highway 1-A crosses the creek, about 6 miles northwest of Arlington. In some places they dip steeply, in others they are relatively flat lying and pre-Eocene igneous and metamorphic rocks are exposed. Dean Milnor Roberts, College of Mines, University of Washington, reports that some of these beds contain magnetite, together with rutile and possibly other titanium minerals; that the content of iron is not high, but the sandstone crushes readily and the iron minerals can be concentrated by tabling; that the beds have been excavated to depths of a few feet to expose fresh surfaces for testing; and that probably a large acreage is underlain by these beds, though the content of iron has not been determined at many places.

Darrington area Location vague "Iron ore" Details not known

Iron ore has been reported to occur about 5 miles southeast of Darrington, on a mountain south of the Sauk River.

STEVENS COUNTY

Kulzer property Sec. 20, (31-4IE.) Limonite and hematite Tonnage estimate

Known — 4,000

Probable— 15,000

Possible— 50,000

This deposit is a mineralized zone, varying in width from a few feet to 30 feet or more, in which iron oxides, hydroxides, and carbonates occur as residuary segregations in a decomposed porphyry and as a replacement of the limestone that was intruded. Extensive prospecting and development work has been done, and some 9,000 tons have been shipped.

Distance to railroad at Valley, 5 miles. Elevation, 2,200 feet.
Distance by rail to Seattle, 395 miles.
STEVENS COUNTY (continued)

Analysis (indicative). R. P. Cope, Pullman, analyst.

Iron (Fe), 53.56%; silica (SiO₂), 6.45%; phosphorus (P), 0.14%; sulphur (S), 0.004%.

References.—No. 12, pp. 37-40, 57; No. 9, pp. 29, 30.

Hill property  Secs. 17, 20, (31-39E.)  Hematite, magnetite, and martite  Available amount unknown. Less than 1,000 tons on dump.

The minerals occur as, probably, metasomatic replacement deposits in dolomite. Extensive development and prospecting (which included diamond drilling) were carried on many years ago, but the workings are caved and the results unknown. No information is available on the shape or size of the ore body.

Distance to railroad at Valley, about 9 miles. Elevation, 3,050 feet. Distance by rail to Seattle, 395 miles.

Analysis (indicative). R. P. Cope, Pullman, analyst.

Iron (Fe), 68.57%; silica (SiO₂), 1.69%; phosphorus (P), 0.024%; sulphur (S), 0.006%.

References.—No. 12, pp. 40-43, 57; No. 9, pp. 31, 32.

Read property  Sec. 14, (30-37E.)  Principally magnetite; amount of impurities large.  Tonnage estimate

Known — 5,000
(minus)

Probable—100,000
Possible—500,000

This is a roughly tabular contact-metamorphic deposit in limestone adjacent to granite. The mineralized zone varies from a few inches to 50 feet or more in width, dips 80 degrees, and may be traced for 3,000 feet. At the surface the magnetite is coarsely granular and the interstices between grains are filled with earthy silicates and with calcium and magnesium carbonates; at depth the magnetite is massive and contains considerable chalcopyrite. Other associated minerals are wollastonite, tremolite, quartz and fluorite. The property has been developed by 4 or 5 shafts, 10 to 50 feet in depth, and a 56-foot tunnel; but these do not delimit the ore body.

Distance to railroad at Springdale, 25 miles; 4 miles from Coulee Dam backwater.
Distance by rail to Seattle, 386 miles.
STEVENS COUNTY (continued)

Analysis (indicative). R. P. Cope, Pullman, analyst.

Iron (Fe), 60.40%; silica (SiO₂), 3.23%; phosphorus (P), 0.07%; titanium (Ti), trace; sulphur (S), 0.048%. The presence of pyrite and chalcopyrite in the ore indicates a high sulphur content for the mass as a whole.

Reference. No. 12, pp. 43-46, 57.

Clugston Creek (Chloride Queen and other) properties

Secs. 11, 23, 24, Limonite Available tonnage not known, but deposits very limited.

The ore occurs as discontinuous veins and irregular masses in limestone and is probably very limited in extent. Some development work has been done, and a few hundred tons of ore were shipped many years ago.

Distance to railroad at Colville, 15 miles or so. Elevation, 3,200 to 4,000 feet or so.

Distance by rail to Seattle, 426 miles.

Analyses (indicative). S. Shedd, Pullman, analyst.

Iron (Fe), 50.45% to 56.58%; silica (SiO₂), 4.45% to 14.90%; alumina (Al₂O₃), 2.00% to 2.48%; phosphorus (P), 0.30% to 0.31%; sulphur (S), 0.32%.

References. No. 12, pp. 46, 47; No. 9, pp. 30-32; No. 4; No. 2, pp. 37-39.

Bechtol property Sec. 27, (39-41E.) Limonite Tonnage estimate

Known ---- 1,000

Possible- 20,000

Probable- 75,000

The mineral occurs as an irregular steeply dipping vein in limestone, with a width of 6 to 25 feet and a traceable length along its outcrop of 1,000 feet. The limonite is probably a surface alteration product of siderite, suspected of occurring at depth. It is developed by tunnels and open cuts, from which approximately 300 tons of ore have been mined.

Distance to railroad at Boundary, 13 miles. Elevation, 2,850 feet.

Distance by rail to Seattle, 477 miles.

Reference. No. 12, pp. 48-50.
STEVENS COUNTY (continued)

Thompson property  Sec. 23, (39-41E.)  Limonite  Tonnage estimate
Known  --  50,000
Probable  --  250,000
Possible  --  500,000

Limonite occurs as a moderately steeply dipping vein in dolomitic limestone. The vein is continuous for 800 feet, where it has an average width of 30 feet, then pinches out and reappears 500 feet to the north, where its width is 15 feet, thereafter it is traceable for 1,000 feet with an average width of 10 feet. Branching veins occur that are mostly narrow, though one has a width of 20 feet for a short distance. The limonite is a surface alteration of siderite and is accompanied by goethite. Exploration is by numerous pits and trenches and by an 85-foot tunnel and other underground work.

Distance to railroad at Boundary, 12 miles. Elevation, 3,075 feet.
Distance by rail to Seattle, 477 miles.

Analysis (above-average mine run). R. P. Cope, Pullman, analyst.

Iron (Fe), 59.99%; silica (SiO₂), 2.23%; phosphorus (P), 0.048%; sulphur (S), 0.023%.

Reference.—No. 12, pp. 51-54, 57.

Napoleon mine  Sec. 3, (37-37E.)  Some magnetite  Hardly considered
but chiefly  iron ore.
pyrite.

This deposit is a body of amphibolite, probably of contact-metamorphic origin, mineralized with pyrrhotite, pyrite, some magnetite, and a little chalcopyrite. Extensive underground workings show the mineralized zone to be 60 feet wide, 300 feet long, and at least 250 feet deep. A rather large tonnage was formerly mined and shipped to smelters where it was used as a flux.

Distance to railroad at Boyds, 1½ miles. Elevation, 2,500 feet.
Distance by rail to Seattle, 445 miles.

Analysis (Approximate mine run). Analyst not known.

Iron (Fe), 33%; sulphur (S), 1.2%; lime (CaO), 10%; silica (SiO₂), 30%; copper (Cu), 0.3%; silver (Ag), trace; gold (Au), 0.05 to 0.10 ounces per ton.

References.—No. 12, pp. 55, 56; No. 8, pp. 89-91.

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Big Iron (Sheep Creek)  Secs. 23, 24,  Magnetite  Estimated 500,000
mine  (40-37E.)  tons available.

This property contains a series of lenses of magnetite, with pyrite
and chalcopyrite, in metamorphosed sedimentary rocks. The mineralized zone
forms a belt variously reported as 100 to 130 feet wide and 500 to 1,000
feet long. It is developed by several shafts and surface pits and trenches.
The property was formerly operated for gold and copper but more recently
for magnetite, which has been shipped to Chewelah. Analyses of the ore
are said to show an iron (Fe) content of 60%.

Distance to railroad at Orient, 15 miles. Elevation, 3,600 feet.
Distance by rail to Seattle, via Spokane, 448 miles.

References.—No. 8, pp. 82, 83; U. S. Bur. Mines Minerals Yearbook, 1934,
and other years; No. 14, table, p. 26.

THURSTON COUNTY

Lake St. Clair deposit  Sec. 6, (17-1E.)  Limonite  An estimated 75,000
(bog iron)  tons has been ex-
posed by pits and trenches.

The limonite occurs as a Recent bedded deposit that probably extends
beyond the limits of the area prospected. Earlier work showed a thickness
of 2 to 6 feet, later work as much as 14 feet in some places. A small
amount was formerly mined for use as mineral pigments.

Distance to railroad at Union Mills, 5 miles. Elevation, 75 feet.
Distance from Seattle, 64 miles.

Analysis (indicative). Analyst not known.

Iron oxide (Fe₂O₃), 54.05%; silica (SiO₂), 14.90%; alumina (Al₂O₃), 7.25%;
organic matter, 2.80%; moisture, 18.20%.

References.—No. 11, p. 109; No. 16, p. 2.

WHATCOM COUNTY

Church Mountain deposits  Approx. sec. 35,  Hematite  Tonnage not esti-
(40-7E.) and to mated, probably small.
the south.

Further investigation is required to ascertain the geology and economic
value of these occurrences. From a preliminary examination it appears that
WHATCOM COUNTY (continued)

the ore is, in part, an impure hematite formed by the dehydration of clayey and sandy limonite, and in part a surficial concentration of iron oxide derived from the weathering of a ferruginous sandstone. It occurs on and in a steeply dipping series of fossiliferous (probably Mesozoic) sediments. A similar material occurs in probably small amount on the south side of the Nooksack Valley, opposite Church Mountain.

Distance to railroad at Glacier, 4 miles or so. Elevation, 1,300 feet plus. Distance by rail to Seattle, 143 miles.

Reference.—State Division of Geology field notes.

<table>
<thead>
<tr>
<th>Sturman and Herringa deposits</th>
<th>Sec. 8, 17, (40-3E.)</th>
<th>Limonite (bog iron)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tonnage estimate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Known — 5,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Probable— 20,000</td>
<td></td>
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<tr>
<td></td>
<td>Possible— 30,000</td>
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</table>

Several deposits of bog iron occur in the vicinity of Bellingham, Ferndale, and Lynden, but they are generally small. The Sturman and Herringa deposits, near Lynden, are the most extensive. The Sturman deposit covers an acre or so to an average depth of 2 feet under only a few inches of soil. The Herringa deposit may cover 5 acres and varies in thickness from 0 to 2 or 3 feet.

Distance to railroad, within 2 miles or so. Elevation, about 100 feet. Distance by rail to Seattle, 139 miles.

Analysis (indicative). R. P. Cope, Pullman, analyst.

Iron (Fe), 39.67%; silica (SiO₂), 19.43%; phosphorus (P), 0.153%; sulphur (S), 0.013%.

Reference.—No. 12, pp. 103-105.

<table>
<thead>
<tr>
<th>Sumas Mountain deposit</th>
<th>Sec. 2, (39-4E.) and sec. 35, (40-4E.)</th>
<th>Ferruginous mudstone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Doubtful value.</td>
<td>Amount not estimated</td>
</tr>
</tbody>
</table>

A ferruginous mudstone or low-grade hematite occurs here as a blanket deposit on a pre-Tertiary basic igneous rock (altered peridotite) and underlying a basal conglomerate of the Chuckanut formation (Eocene). It probably represents a residual product, resulting from the weathering of the peridotite. Exposures of the fairly compact brownish material vary in thickness up to 20 feet and extend for 1,500 feet or so up the west side of Sumas Mountain. The lateral extent is unknown, and exposures are chiefly confined to one stream channel that crosses the bed.

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WHATCOM COUNTY (continued)

Distance to railroad at Nooksack, 4 miles. Elevation, 700 to 1,600 feet. Distance by rail to Seattle, 121 miles.

Analysis of picked specimen. R. P. Cope, Pullman, analyst.

Iron (Fe), 37.31%; silica (SiO2), 20.83%; phosphorus (P), 0.20%; sulphur (S), 0.008%.

References.—No. 12, pp. 105-107; No. 14, pp. 14-17.