DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY [Mineral investigations resource map, MR series; text to accomp. map] MR-26.

TO ACCOMPANY MAP MR- 26

CHROMITE IN THE UNITED STATES

(Exclusive of Alaska and Hawaii)

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Introduction

The chromite deposits in the United States (exclusive of Alaska and Hawaii) are shown on the accompanying map. In compiling the map, the deposits were classified in five size categories according to the estimated total quantity of chromite present before mining. The map shows, by different symbols, deposits of chromite in ultramafic rocks, beach sands in which chromite is an important constituent, and lateritic iron ores in which chromium has been concentrated by weathering of peridotite in situ. Although geologically significant amounts of chromium are known to occur in some gabbros and sedimentary rocks other than beach sands and laterite, the data are too fragmentary to show on the map.

Some of the more prominent districts are identified by name on the map and all deposits are numbered to correspond to the locality index. The locality index, arranged alphabetically by States, gives the name and geographical coordinates of each deposit. Both published and unpublished data were used, and at least one reference is given for each locality on which reports have been published.

Geology

Chromium is a lithophile element which occurs principally in spinels, simple silicates, aluminosilicates, and complex salts. Because commercial ores of chromium are limited to chromite, which occurs only in nonalkalic ultramafic rocks or rocks derived from them, the distribution of chromium is best known in peridotites.

Chromite is a spinel whose composition is best stated by the formula $(Mg,Fe^{+2})(Cr,Al,Fe^{+3})_2O_4$. As the mineral crystallizes early from magmas of basaltic or more mafic composition, in equilibrium with the magma and contemporaneously formed silicates, the composition varies widely. (Stevens, 1944; Thayer, 1946). Unaltered chromites from the United States are known to range from 16.4 to 60.4 weight percent Cr_2O_3, and in composition (mol percent) (Thayer, 1956a) as follows: $(Mg_{73-39}Fe_{27-61})(Cr_{77-18}Al_{81-20}Fe_{2.8-12})_2O_4$. Chromites which have been metamorphosed, as in the Red Lodge district, Montana (James, 1946) and at Casper Mountain, Wyoming (Stephenson and Stephenson, 1942) commonly are greatly enriched in both magnetite and hematite. Consistent differences in chromites from various districts reflect differences in the country rock peridotites. For example, in the stratiform deposits of the Stillwater complex the normative composition of the chromite is in the range $Mg_{39-51}(Cr_{52-69}Al_{26-39}Fe_{5-10})$, compared with $Mg_{58-73}(Cr_{38-68}Al_{26-56}Fe_{3-9})$ in the Grant County district in Oregon. The Stillwater complex yields concentrates consistently rich in iron (Cr:Fe ratio about 1.6:1), whereas the Grant County district has yielded mostly lump ores and concentrates averaging 46-48 percent Cr_2O_3 with Cr:Fe ratios of 2.5-3:1. The Grant County deposits contain the only significant reserves of high-alumina chromite in the United States. The chromite in most of the pod deposits is of the high-chromium type which constitutes high- to medium-grade metallurgical ore.

Both major types of chromite deposits, stratiform and podform, are represented in the United States. The Stillwater complex in Montana is a stratiform peridotite-gabbro complex, in whose lower part chromite is interlayered with rocks rich in olivine and pyroxene. The chromite layers range from a few grains thick up to three or four feet of massive ore, or 20 to 25 feet of layers of various grades averaging 25 to 30 percent chromite. Individual layers or chromite-bearing units have been traced thousands of feet. The chromite occurs in poikilitic harzburgite layers which are repeated in approximately 15 cyclical units in the ultramafic zone (Jackson, 1961). It is generally agreed that the stratiform deposits were formed in place by crystal settling from a fluid magma of noritic composition (Hess, 1960; Jackson, 1961).

The podform deposits occur in alpine-type peridotites and peridotite-gabbro complexes as irregular masses scattered more or less at random in the peridotite (Thayer, 1960). In two of the most important districts, the State Line in Pennsylvania and Maryland, and the Grant County district, Oregon (Thayer, 1956b) gabbro or norite forms an essential part of the country-rock complex. Gabbroic rocks are known to occur in other major districts, such as San Luis Obispo, California, but their relations to the peridotites are not as well known. The alpine-type peridotites and related gabbros are believed to have been emplaced as semisolid crystal mushes, after primary differentiation by a stratiform-type process in the crust or mantle.

The pod-type deposits and their alpine-type hosts are distributed along the eugeosynclinal parts of major mountain chains. In the Eastern United States peridotites are scattered along the Appalachian Mountains from the Canadian boundary to Alabama; related gabbroic rocks have been recognized in Pennsylvania, Maryland, and Virginia. Peridotites likewise occur the length of the Cordilleran eugeosyncline from northern Washington to southern California; related gabbroic rocks are known in several districts. Although peridotite probably is more abundant along the Cordilleran eugeosyncline than along the Appalachian, the amount of chromite in the West seems disproportionately greater. The Appalachian ultramafic rocks are believed to be Middle Ordovician in age; those along the Pacific Coast are Triassic and Jurassic.

The chromite deposits in Texas, Montana, and Wyoming are in Precambrian rocks whose broader relations are mostly concealed under younger rocks. The larger deposits, near Red Lodge, Montana, and Casper, Wyoming, are in inclusions of peridotite caught up in extensive younger granites and have been highly metamorphosed. The relative ages of the Stillwater complex and the podform deposits in Montana and Wyoming are not known.

The chromite in the beach sand deposits along the coast of southern Oregon and northern California was derived ultimately from the peridotites in the Klamath Mountains. The concentrates obtainable are rich in iron (Cr:Fe ratio about 1.5:1), and contain about 40 percent Cr_2O_3. The major reserves are in raised beach deposits. The black sands are believed (Griggs, 1944) to have been reworked from Tertiary sedimentary rocks that lie on the ultramafic rocks, rather than directly from them.

The lateritic iron ores in Washington lie at the base of the Eocene Swauk formation, are lenticular, and in part bouldery.

Locality Index

CALIFORNIA

Mostly podform deposits; some beach placers. (General references: Cater, 1948a, 1948b; Cater, Rynearson and Dow, 1951; Diller, 1921; Dow and Thayer, 1946; Jenkins, 1942; Rynearson, 1948, 1953; Smith and Griggs, 1944; Walker and Griggs, 1953; Wells and Cater, 1950; Wells, Cater and Rynearson, 1946.)

	Lat. N.	Long. W.
1. Crescent City beach sands.	41°44'	124°10'
2. Crescent City beach sands.	41°42'	124°09'
3. High Plateau and Bonanza mines. Wells and others, 1946, p. 33.	41°56'	123°56'
4. High Dome (4 deposits). Wells and others, 1946, p. 43.	41°57'	123°52'
5. French Hill mine (2 deposits). Wells and others, 1946, p. 46.	41°49'	123°59'
6. Soldiers Well (8 deposits). Wells and others, 1946, p. 69.	41°42'	123°57'
7. Old Doe (4 deposits). Wells and others, 1946, p. 70.	41°41'	123°56'
8. Cyclone Gap. Wells and Cater, 1950, p. 122.	41°52'	123°37'
9. Seiad Creek (Mountain View). Wells and others, 1949, p. 48;	41°54'	123°08'

Rynearson and Smith, 1940.		
10. Fairview. Wells and others, 1949, p. 52.	41°48'	123°06'
11. McGuffy Creek group (8 deposits). Wells and others, 1949, p. 55; Wells and Cater, 1950, p. 117.	41°43'	123°03'
12. Gazelle Mountain (2 deposits). Wells and Cater, 1950, p. 108.	41°25'	122°36'
13. Coggins. Hawkes and others, 1943.	41°11'	122°17'
14. Railroad Lease (5 deposits).	41°09'	122°31'
15. Forest Queen group (7 deposits).	41°03'	122°24'
16. Little Castle Creek. Hawkes and others, 1943.	41°11'	122°18'
17. Grau mine (3 deposits). Rynearson, 1946, p. 203.	40°02'	122°40'
18. Noble Electric Steel group (10 deposits). Rynearson, 1946, p. 206.	40°02'	122°39'
19. Black Diamond (Grey Eagle) group (23 deposits). Rynearson and Wells, 1944; Dow and Thayer, 1946, p. 9.	39°44'	122°35'
20. Lambert. Rynearson, 1953, p. 267.	39°47'	121°37'
21. Boiler Pit (30 deposits). Rynearson, 1953, p. 214.	39°08'	120°45'
22. Dobbas (2 deposits). Cater and others, 1951, p. 146.	38°48'	121°06'
23. Pillikin (6 deposits). Wells and others, 1940a; Cater and others, 1951, p. 131.	38°47'	121°06'
24. Murphy (2 deposits). Cater and others, 1951, p. 123.	38°32'	120°57'
25. Peoria Flat area (12 deposits). Cater, 1948a, p. 23.	37°55'	120°30'
26. McCormick (6 deposits). Cater, 1948a, p. 21.	37°52'	120°30'
27. Marshs Flat group (7 deposits). Cater, 1948a, p. 15.	37°48'	120°22'
28. Number 5 and Adobe Canyon groups (30 deposits). Hawkes and others, 1942.	37°25'	120°24'
29. Butler Estate (Mistake). Walker and Griggs, 1953, p. 54.	36°19'	120°33'
30. Clara H., Lacey (13 deposits). Rynearson, 1948, p. 78.	36°57'	119°25'
31. Jack Spratt (9 deposits). Rynearson, 1948, p. 87.	36°54'	119°19'
32. Holston. Rynearson, 1948, p. 98.	36°02'	118°56'
33. Sweetwater-Norcross group (15 deposits). Smith and Griggs, 1944; Walker and Griggs, 1953.	35°25'	120°45'

34. Castro group (10 deposits). Smith and Griggs, 1944; Walker and Griggs, 1953. 35°23' 120°42'

35. Trinidad-Pick and Shovel group (6 mines). Smith and Griggs, 1944; Walker and Griggs, 1953. 35°22' 120°41'

36. Sousa Ranch. Walker and Griggs, 1953. 35°15' 120°42'

MARYLAND

Podform deposits. (General references: Knopf, 1921; Singewald, 1928).

1. Reed (Wilkins) mine. Singewald, 1928. 39°37' 76°27'

MONTANA

(General references: Hess, 1960; Jones and others, 1960; Jackson, 1961; Shafer, 1937).

Red Lodge district. Podform deposits in metamorphosed inclusions of peridotite in Precambrian gneissic granite.

1. Gallon Jug claims. James, 1946, p. 183. 45°02' 109°28'

2. Drill, North Star, Pick, and Shovel claims. James, 1946, p. 180. 45°03' 109°27'

3. Highline claim. James, 1946, p. 185. 45°02' 109°25'

Stillwater Complex. Stratiform deposits in the lower parts of poikilitic harzburgite layers in the ultramafic zone.

4. Benbow mine. Jackson and others, 1954; Peoples and Howland, 1940, 398. 45°22' 109°48'

5. Mouat mine. Peoples and others, 1954; Peoples and Howland, 1940, p. 413. 45°23' 109°54'

6. Central Stillwater deposits. Irregular, thin layers of chromite. Howland, 1955. 45°25' 110°05'

7. Gish deposit. Howland and others, 1949. 45°29' 110°12'

NORTH CAROLINA

Podform deposits. (General reference: Lewis, 1921).

OREGON

(General reference: Allen, 1938; Diller, 1921; Griggs, 1944; Thayer, 1940; Twenhofel, 1943; Westgate, 1921).

Podform deposits.

1. Dry Camp (and 5 others). High grade metallurgical ore. Thayer, 1940, p. 100. 44°22' 118°47'

2. Chambers mine (5 deposits). High alumina refractory-type ore. Thayer, 1940, p. 96. 44°21' 118°50'

3. Haggard and New (and 4 deposits). High grade metallurgical ore. 44°21' 118°53'

4. Iron King mine (and 3 deposits). High-alumina refractory-type ore. Thayer, 1940, p. 98. 44°21' 118°56'

5. Chollard (Golconda). Allen, 1938, p. 47. 42°05' 123°33'

6. Sordy mine. Allen, 1938, p. 52a. 42°26' 123°44'

7. Oregon mine. Allen, 1938, p. 43. 42°21' 123°46'

8. Chrome King mine (and 2 others). Allen, 1938, p. 44. 42°19' 123°49'

9. McCaleb group. 42°16' 123°51'

10. Sour Dough mine. Wells and others, 1940b, p. 463-476. 42°02' 123°57'

Beach placer deposits.

11. South Slough area, unexplored deposit. Griggs, 1944, p. 128. 43°19' 124°18'

12. South Slough area (8 deposits). Griggs, 1944, p. 128-129. 43°16' 124°18'

13. Seven Devils Terrace (12 deposits). Griggs, 1944, p. 130-137. 43°15' 124°22'

14. Pioneer Terrace and Lagoons (6 deposits). Griggs, 1944, p. 137-141. 43°12' 124°22'

15. Unexplored deposits (2). Griggs, 1944, p. 143. 43°04' 124°33'

16. Present beach. Griggs, 1944, p. 147. 43°05' 124°26'

17. Butler mine (3 deposits). Griggs, 1944, p. 144. 42°51' 124°28'

18. Present beach. 42°49' 124°32'

19. Ophir beach. Griggs, 1944, p. 147. 42°34' 124°23'

20. Present beach. 42°28' 124°25'

21. Rogue River beaches. Griggs, 1944, p. 147. 42°25' 124°25'

PENNSYLVANIA

Podform deposits. (General references: Frazer, 1880; Gordon, 1922; Knopf, 1921).

1. Line, Red, and Jenkins pits (6 deposits). Gordon, 1922, p. 450; Knopf, 1921, p. 96. 39°43' 76°10'

2. Wood mine (3 deposits). Steep, pipelike body of massive ore. 39°44' 76°06'

PENNSYLVANIA (cont'd.)

Gordon, 1922, p. 450; Knopf, 1921, p. 97; Frazer, 1880, p. 192.

TEXAS

Podform deposits. (General reference: Barnes, Shock, and Cunningham, 1950).

WASHINGTON

(General references: Huntting, 1956; Pardee, 1921).

Podform deposits.

1.	Lambert.	48°41'	121°59'
2.	Three Lakes (3 deposits). Thayer and others, 1943.	48°38'	121°54'

Lateritic iron ores.

3.	Cle Elum River deposits. Eocene; average grade 2-3 percent Cr_2O_3. Lamey and Hotz, 1952.	47°26'	121°04'
4.	Blewett deposits. Eocene; bouldery, low grade. Lamey, 1950.	47°25'	120°40'

WYOMING

Podform deposits. (General reference: Osterwald and Osterwald, 1952).

1.	Casper Mountain. Disseminated chromite in talc-tremolite schist; 5-10 percent Cr_2O_3, Cr:Fe ratio very low. Horton and Allsman, 1949; Stephenson and Stephenson, 1942.	42°45'	106°18'

Selected References

Allen, J. E., 1938, Chromite deposits in Oregon: Oregon Dept. Geology and Mineral Industries Bull. 9.

Barnes, V. E. Shock, D. A., and Cunningham, W. A., 1950, Utilization of Texas serpentine: Texas Univ. Bur. Econ. Geology, Pub. 5020, p. 8, 10.

Cater, F. W., Jr., 1948a, Chromite deposits of Tuolumne and Mariposa Counties, California: California Div. Mines Bull. 134, pt. 3, chap. 1, p. 1-32.

____________, 1948b, Chromite deposits of Calaveras and Amador Counties, California: California Div. Mines Bull. 134, pt. 3, chap. 2, p. 33-60.

Cater, F. W., Jr., Rynearson, G. A., and Dow, D. H., 1951, Chromite deposits of Eldorado County, California: California Div. Mines Bull. 134, pt. 3, chap. 4, p. 107-167.

Diller, J. S., 1921, Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey Bull. 725-A, p. 1-35.

Dow, D. H., and Thayer, T. P., 1946, Chromite deposits of the northern Coast Ranges of California: California Div. Mines Bull. 134, pt. 2, chap. 1, p. 1-38.

Frazer, Persifor, Jr., 1880, The geology of Lancaster County, Pennsylvania: Pennsylvania Geol. Survey, 2d, Rept. CCC, 350 p.

Gordon, S. G., 1922, The chromite deposits of the State line serpentines: Acad. Nat. Sci. Philadelphia, Proc., v. 73, pt. 3, p. 449-454.

Griggs, A. B., 1944, Chromite-bearing sands of the southern part of the coast of Oregon: U. S. Geol. Survey Bull. 945-E, p. 113-150.

Hawkes, H. E., Jr., Wells, F. G., and Wheeler, D. P., Jr., 1942, Chromite and quicksilver deposits of the Del Puerto area, Stanislaus County, California: U. S. Geol. Survey Bull. 936-D, p. 79-110.

Hawkes, H. E., Jr., Wheeler, D. P., and Livermore, J. S., 1943, Chromite deposits of Little Castle Creek area, Shasta and Siskiyou Counties, California: U. S. Geol. Survey, prelim. maps.

Hess, H. H., 1960, Stillwater igneous complex, Montana: Geol. Soc. America Mem. 80.

Horton, F. W., and Allsman, P. T., 1949, Investigation of Casper Mountain chromite deposits, Natrona County, Wyoming: U. S. Bur. Mines, Rept. Inv. 4512.

Howland, A. L., 1955, Chromite deposits in central part Stillwater complex, Sweet Grass County, Montana: U. S. Geol. Survey Bull. 1015-D, p. 99-121.

Howland, A. L., Garrels, R. M., and Jones, W. R., 1949, Chromite deposits of Boulder River area, Sweetgrass County, Montana: U. S. Geol. Survey Bull. 948-C, p. 63-82.

Huntting, M. T., 1956, Inventory of Washington minerals: Washington Div. Mines and Geology Bull. 37, pt. 2, Metallic Minerals.

Jackson, E. D., 1961, Primary textures and mineral associations in the ultramafic zone of the Stillwater complex, Montana: U. S. Geol. Survey Prof. Paper 358.

Jackson, E. D., Howland, A. L., Peoples, J. W., and Jones, W. R., 1954, Geologic maps and cross sections of the Benbow chromite deposits and the undeveloped deposits in Nye Basin: U. S. Geol. Survey open-file report.

James, H. L., 1946, Chromite deposits near Red Lodge, Carbon County, Montana: U. S. Geol. Survey Bull. 945-F, p. 151-189.

Jenkins, O. P., 1942, Outline geologic map of California showing locations of chromite properties: California Div. Mines Econ. Mineral Map no. 3, scale 1:1,000,000.

Jones, W. R., Peoples, J. W., and Howland, A. L., 1960, Igneous and tectonic structures of the Stillwater complex, Montana: U. S. Geol. Survey Bull. 1071-H, p. 281-337.

Knopf, E. B., 1921, Chrome ores of southeastern Pennsylvania and Maryland: U. S. Geol. Survey Bull. 725-B, p. 85-99.

Lamey, C. A., 1950, The Blewett iron-nickel deposit, Chelan County, Washington: U. S. Geol. Survey Bull. 969-D, p. 87-103.

Lamey, C. A., and Hotz, P. E., 1952, The Cle Elum River nickeliferous iron deposits, Kittitas County, Washington: U. S. Geol. Survey Bull. 978-B, p. 27-68.

Lewis, J. V., 1921, Deposits of chrome ore in North Carolina: U. S. Geol. Survey Bull. 725-B, p. 101-139.

Osterwald, F. W., and Osterwald, D. B., 1952, Wyoming mineral resources: Wyoming Geol. Survey Bull. 45, p. 22.

Pardee, J. T., 1921, Chromite ores in Washington:U. S. Geol. Survey Bull. 725-A, p. 61-66.

Peoples, J. W., and Howland, A. L., 1940, Chromite deposits of the eastern part of the Stillwater complex, Stillwater County, Montana: U. S. Geol. Survey Bull. 922-N, p. 371-416.

Peoples, J. W., Howland, A. L., Jones, W. R., and Flint, D. F., 1954, Geologic maps, sections, and map of underground workings of the Mt. View Lake area, Stillwater County, Montana: U. S. Geol. Survey open-file report.

Rynearson, G. A., 1946, Chromite deposits of the North Elder Creek area, Tehama County, California: U. S. Geol. Survey Bull. 945-G, p. 191-210.

__________, 1948, Chromite deposits of Tulare and eastern Fresno Counties, California: California Div. Mines Bull. 134, pt. 3, chap. 3, p. 61-104.

__________, 1953, Chromite deposits in the northern Sierra Nevada, California--Placer, Nevada, Sierra, Yuba, Butte, and Plumas Counties: California Div. Mines Bull. 134, pt. 3, chap. 5, p. 171-323.

Rynearson, G. A., and Smith, C. T., 1940, Chromite deposits in the Seiad quadrangle, Siskiyou County, California: U. S. Geol. Survey Bull. 922-J, p. 281-306.

Rynearson, G. A., and Wells, F. G., 1944, Geology of the Grey Eagle and some nearby chromite deposits in Glenn County, California: U. S. Geol. Survey Bull. 945-A, p. 1-22.

Shafer, P. A., 1937, Chromite deposits of Montana: Montana Bur. Mines and Geology Mem. 18.

Singewald, J. T., Jr., 1928, Notes on feldspar, quartz, chrome, and manganese in Maryland: Maryland Geol. Survey, v. 12, pt. 2, p. 91-194.

Smith, C. T., and Griggs, A. B., 1944, Chromite deposits near San Luis Obispo, San Luis Obispo County, California: U. S. Geol. Survey Bull. 945-B, p. 23-44.

Stephenson, E. L., and Stephenson, H. K., 1942, Chromite deposits of Casper Mountain, Natrona County, Wyoming: U. S. Geol. Survey, prelim. maps.

Stevens, R. E., 1944, Composition of some chromites of the Western Hemisphere: Am. Mineralogist, v. 29, p. 1-34.

Thayer, T. P., 1940, Chromite deposits of Grant County, Oregon, a preliminary report: U. S. Geol. Survey Bull. 922-D, p. 75-113.

__________, 1946, Preliminary chemical correlation of chromite with the containing rocks: Econ. Geology, v. 41, p. 202-217.

__________, 1956a, Mineralogy and geology of chromium, in Udy, M. J., ed., Chromium: Am. Chem. Soc., Mon. 132, v. 1, p. 14-52.

__________, 1956b, Preliminary geologic map of the John Day quadrangle, Oregon: U. S. Geol. Survey Mineral Inv. Field Studies Map MF 51, scale, 1:62,500.

__________, 1960, Some critical differences between alpine-type and stratiform peridotite-gabbro complexes: Internat. Geol. Cong., 21st, Copenhagen 1960, Petrog. Provinces, Igneous and Metamorphic Rocks, pt. 13, p. 247-259.

Thayer, T. P., Griggs, A. B., Cater, F. W., Jr., Gros, F., 1943, Chromite deposits of the Twin Sisters Mountains, Washington: U. S. Geol. Survey prelim. map, scale about 1:75,000.

Twenhofel, W. H., 1943, Origin of the black sands of the coast of southwest Oregon: Oregon Dept. Geology and Mineral Industries Bull. 24.

Walker, G. W., and Griggs, A. B., 1953, Chromite deposits of the southern Coast Ranges of California: California Div. Mines Bull. 134, pt. 2, p. 39-88.

Wells, F. G., and Cater, F. W., Jr., 1950, Chromite deposits of Siskiyou County, California: California Div. Mines Bull. 134, pt. 1, chap. 2, p. 77-127.

Wells, F. G., Cater, F. W., Jr., and Rynearson, G. A., 1946, Chromite deposits of Del Norte County, California: California Div. Mines Bull. 134, pt. 1, chap. 1, p. 1-76.

Wells, F. G., Page, L. R., and James, H. L., 1940a, Chromite deposits of the Pillikin area, California: U. S. Geol. Survey Bull. 922-O, p. 417-460.

__________, 1940b, Chromite deposits in the Sour Dough area, Curry County, and the Briggs Creek area, Josephine County, Oregon: U. S. Geol. Survey Bull. 922-P, p. 461-476.

Wells, F. G., Smith, C. T., Rynearson, G. A., and Livermore, J. S., 1949, Chromite deposits near Seiad and McGuffy Creeks, Siskiyou County, California: U. S. Geol. Survey Bull. 948-B, p. 37-60.

Westgate, L. G., 1921, Deposits of chromite in eastern Oregon: U. S. Geol. Survey Bull. 725-A, p. 37-60.

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