



Bureau of Mines
Report of Investigations 4578

INVESTIGATION OF THE McCORMICK
CHROMITE MINE, TUOLUMNE COUNTY, CALIF.

BY JOHN R. SHATTUCK AND SPANGLER RICKER

BUREAU OF MINES

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A Century of Conservation

1849



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UNITED STATES DEPARTMENT OF THE INTERIOR

J. A. Krug, Secretary

BUREAU OF MINES

James Boyd, Director

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John R. Shattuck^{1/} and Spangler Ricker^{1/}

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INTRODUCTION AND SUMMARY

Preliminary examination of the McCormick chromite property was made by the Federal Geological Survey and the Bureau of Mines during the spring and summer of 1943. In October 1943 an exploratory project was undertaken by the Bureau in cooperation with the Survey and was completed in February 1944. The urgent need during the war for high-grade lump chromite such as produced at the McCormick mine, was one of the pertinent reasons for the project.

The McCormick mine is situated about 12 miles southwest of the town of Sonora, in the foothill belt of the Sierra Nevada Mountains, Tuolumne County, Calif. The chromite occurs as irregularly shaped lenses in masses of dunite contained in a steeply dipping, sheared, serpentinized zone of peridotite, near a contact with granodiorite.

The mine was first worked about 1870 by an English syndicate. The south workings were subsequently extended down to the 216 foot level. It was worked during 1917 and 1918 and remained idle from 1918 to 1931, then worked for

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about a year. It was last worked by a lessee from 1941 to the spring of 1944. Total production, excluding the period before World War I, is estimated to be between 2,000 and 4,000 long tons of chromite that averaged about 46 percent chromic oxide.

The work performed by the Bureau of Mines embraced 190 feet of drifting and cross cutting, 10 feet of raising, 680 feet of jackhammer prospect holes, 67 feet of surface trenches, and drilling 11 diamond-drill holes totaling 1521 linear feet.

ACKNOWLEDGMENTS

Special acknowledgment is due to F. W. Cater, of the Federal Geological Survey, for his assistance in planning the work, doing the geological mapping, and logging the diamond drill cores.

Analytical work was done under the supervision of A. C. Rice, of the Metallurgical Branch.

PHYSICAL FEATURES

The McCormick mine (fig. 1) is in sec. 2, T. 1 S., R. 13 E., Mount Diablo base and meridian, in western Tuolumne County, Calif., about 12 miles southwest of Sonora. It is readily accessible from that town by traveling southwesterly on State Highways 108 and 120 for 11 miles to the Copperopolis road junction, thence 1 mile westerly on the surfaced Copperopolis road, thence 0.6 mile southeasterly on a dirt road to the mine. From Oakdale, Calif., it is 25 miles via Highway 120 to the Copperopolis road junction. The nearest rail shipping point is at Chinese Station on the Sierra Railroad, 4.5 miles southeast of the mine.

The property lies less than 1 mile south of Table Mountain, so named because it is formed of flat-lying lava flows. It is in an area of moderate relief on the eastern watershed of the Stanislaus River at an altitude of about 1,100 feet. Two small southwesterly flowing creeks drain the immediate vicinity and supply ample water for the livestock that grazes here during the year, except in summer, when the creek usually runs dry. Hot summers, pleasant springs and autumns, and a rainy season are typical of the foothill belt of the Sierra Nevada Mountains. An average annual precipitation of about 30 inches normally lasts from the latter part of November to March. Vegetation consists of brush, grass, and occasional oak and pine trees.

HISTORY

The property was first worked about 1870 by an English syndicate. The ore is said to have been mined principally from open cuts on both the northern and southern ore bodies, and the extent of these workings indicates that about 1,000 tons may have been produced. With the increase in cost of strategic minerals during World War I, operations were resumed, and a considerable tonnage of high-grade ore was shipped during 1917 and 1918. The mine remained idle from 1918 to 1931. During 1931 and 1932, 500 to 2,000 tons of ore was produced from the southern deposit between the 88- and 170-foot levels.

In 1941, the mine was leased, and a small amount of developing was done. Thirty tons of ore, robbed from pillars, was shipped, after which the lease was abandoned. Late in 1942, E. A. Kent acquired a lease on that portion of the property lying within a 350-foot radius of No. 1 shaft. This encompassed all the productive portion of the McCormick property. Active prospecting and development were continuous in the south workings with a crew of about 5 men from 1942 until the spring of 1944. Production during that period was several hundred tons.

Excluding the uncertain yield before the first World War, 2,000 to 4,000 long tons of chromite had been produced that assayed 44 to 49 percent chromic oxide and having a chromium-to-iron ratio ranging from 3 to 1 to 4 to 1. The following is believed to be a typical analysis of the ore:

	<u>Percent</u>
Chromic oxide	46.74
Silica	7.81
Iron	10.25
Phosphorus	.039
Sulfur024
Aluminic oxide	16.49
Magnesium oxide	17.67
Chromium-to-iron ratio	3.12 to 1

The mine is owned by Robert McCormick and his two sisters, Mrs. E. O'Conner and Mrs. F. Winn. McCormick, whose address is R. F. D., Sonora, Calif. lives on his ranch less than 1 mile from the property.

DESCRIPTION OF DEPOSIT AND MINE WORKINGS

The chromite occurs as irregular lenses in masses of dunite contained in a sheared serpentized zone of peridotite near its western contact with granodiorite. Weathering of the sheared and serpentized rock makes it difficult to differentiate the types of peridotite derivatives. Diamond drilling disclosed that the largest lenses of chromite were associated with the largest masses of dunite.

Two deposits, known as the North and South mines, account for more than 90 percent of the production. Their relationship is shown on figure 3. Several smaller lenses have been found and mined but produced inappreciable amounts of ore. The ore lenses strike from N. 20° W. to N. 40° W. and dip from 75 degrees to vertical.

The principal deposit is on the southerly end of the property and is developed by three shafts 34 to 220 feet deep and over 700 feet of accessible drifts, crosscuts, raises, and winzes. A production of 3,000 to 5,000 tons of ore is credited to the deposit, and but a few hundred tons remained to be stoped at the time of termination of the project. The lens is 30 to 165 feet in length, averaging about 98 feet, and has been developed for 200 feet in depth. Considerable variations in thickness occur along both strike and dip and range from a barren seam to a maximum of 14 feet. The pinches never persist more than a few feet along the strike or dip within the deposit. Above the 129-foot level, the mined width averaged about 4.5 feet in thickness, whereas below this level the average thickness of ore is less than 2 feet.

Post-mineral faults offset the ore in several places, with a maximum horizontal displacement of 12 feet, but generally such movements have not exceeded 4 feet. Shearing is general along the ore zone. Altered diorite dikes of later age than the ore parallel or cut across the deposit at a slight angle. Frequently, the mineral uvarovite, and occasionally kammererite, is found at the contacts of the dike with the chromite.

The North workings, particularly the stopes, are filled with waste or are partly caved. They were unwatered to a depth of 90 feet by the operator during the Bureau of Mines project, and all accessible openings were inspected and surveyed. As nearly as could be determined, the productive portion of the lens was 40 to 50 feet long, over 90 feet deep, and ranged to 5 feet in thickness. A shaft 90 feet deep was sunk in 1941 about 2 feet west of the stopes, but it was abandoned before it reached the bottom of the old workings. The 57- and 89-foot levels are open but do not show more than a seam of chromite, which swells to a maximum thickness of 4 inches at one point.

Two smaller lenses lie 300 to 400 feet east of the northern workings. About 100 feet to the east are outcrops of metamorphic rocks in contact with the serpentized peridotites, but this contact does not represent the limit of the peridotite mass, which outcrops several thousands of feet to the east. The metamorphic rocks are understood to be part of the Amador formation and are small inclusions in the ultra-basic intrusives.

DEVELOPMENT BY BUREAU OF MINES

Development by the Bureau of Mines was designed to develop the area between the North and South mines for new ore bodies and to increase the ore reserves in mine workings.

The work consisted of 190 feet of drifting and crosscutting, 10 feet of raises, 680 feet of jackhammer prospect holes, (fig. 2) 67 feet of surface trenches, and 1,521 feet of diamond drilling.

The principal underground work was confined to the 129- and 216-foot levels of the South workings and consisted of 190 feet of drifting and cross cutting, 10 feet of raising, and 680 feet of jackhammer prospect-hole drilling. All of the work was done by contract. Figures 2 and 3 show the plan and section of the South workings and the location of the work done by the Bureau. The work outlined the edges of the ore body, but the limit in depth had not yet been reached.

Surface work consisted of trenching and diamond drilling. The lay-out of the surface, showing location of trenches and drill holes in respect to the mine workings, is shown on figure 1. Plan of work was designed to search for extension of the known ore bodies and to prospect for virgin chromite lenses between them.

The trenches, totaling 67 feet, averaged 2 feet in width and 1 foot in depth and were excavated a short distance northwest of the principal deposit.

Eleven diamond drill holes (fig. 1) ranging in depth from 95 to 233 feet and totaling 1,521 feet were drilled. All but one was collared near the

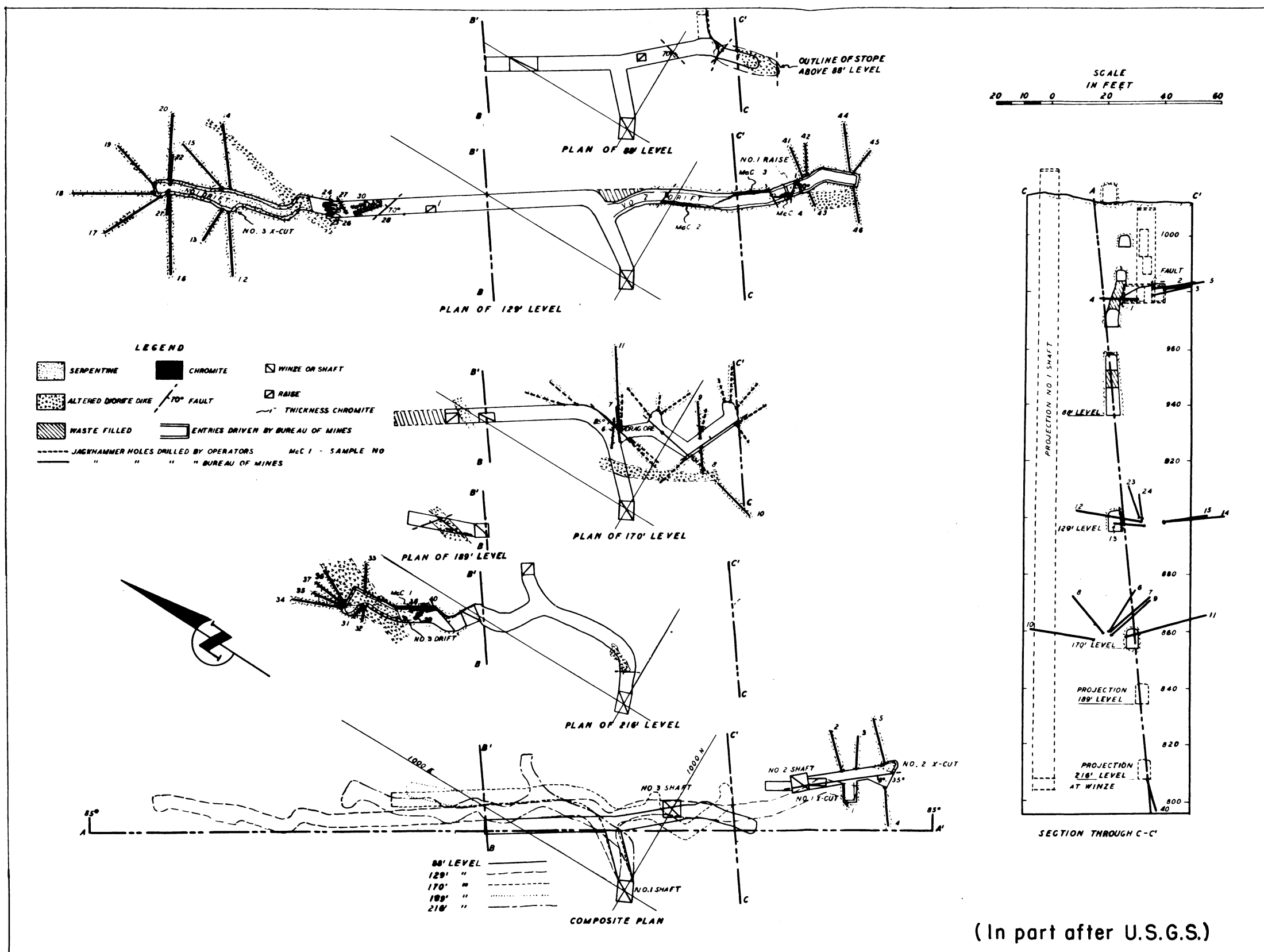


Figure 2. - Plan of south workings, McCormick chromite mine.

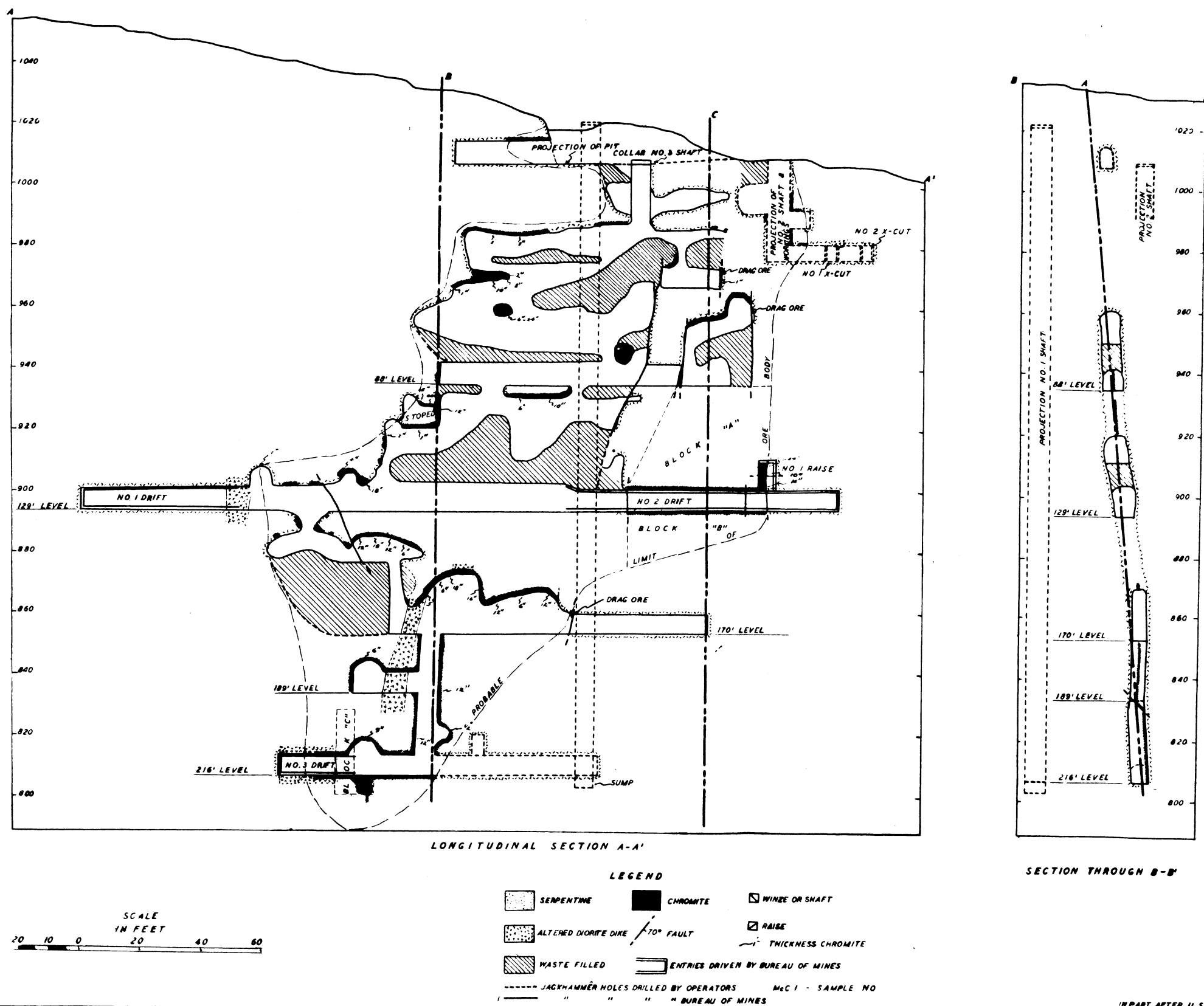


Figure 3. - Sections of south workings, McCormick chromite mine.

peridotite-granodiorite contact. Spaced at fairly regular intervals between and beyond the North and South deposits, the hole intersected the most favorable geologic area along the prolongation of the general strike of the known bodies or shear zones. One hole was drilled under the more promising of the two small chromite outcrops.

No samples were analyzed from any of the drill holes. In holes 7, 9, and 11, a sheared seam of chromite up to 1/4 inch maximum thickness was cut. Analyses of samples from south workings (fig. 2) are shown in table 1.

The drilling was all in serpentinized peridotite. Several small masses of dunite were indicated, but none nearly as large as those containing the principal known masses of chromite.

Logs of diamond-drill holes are shown at the end of this report.

TABLE 1. - Analyses of samples, south workings

Sample ^{1/}	Percent			
	Cr ₂ O ₃	Fe	SiO ₂	Cr/Fe
McC 1	42.00	10.67	6.74	2.7/1
McC 2	46.81	7.80	3.94	2.7/1
McC 3	49.18	9.62	3.32	3.5/1
McC 4	46.47	9.91	3.68	3.2/1

^{1/} Locations shown in figure 2.

BUREAU OF MINES DIAMOND DRILL-HOLE LOGS

Hole 1

Location: N. 1139.5, E. 834.5
Elevation of collar: 1,056.0 feet
Depth: 233 feet

Bearing: N. 56° E.
Dip: -55°

Footage		Core recovery, percent	Description
From-	To-		
0	2.0	0	Overburden.
2.0	9.0	0	Granodiorite, badly weathered throughout; grain size smaller near contact.
9.0	18.0	28	Sheared serpentine, somewhat altered and indurated near contact. Some pyrite and limonite after pyrite found in seams at depth of 16 to 18 feet.
18.0	19.0	83	Serpentine altered and soaked by diorite dike.
19.0	21.0	56	Altered diorite; hornblende crystals in fine-grained matrix are oriented at angle to core.
21.0	23.0	56	Sheared serpentine.

Hole 1 (Cont'd.)

Footage		Core recovery, percent	Description
From-	To-		
23.0	33.0	84	Altered diorite dike, cut by numerous seams of white material, sometimes contains a pink mineral in seams. Some crystals of pyrite present.
33.0	34.0	95	Highly sheared serpentine.
34.0	68.5	67	Sheared serpentine possessing a peculiar mottled appearance. Serpentine is light green and swirls around small dark areas of serpentine up to 3/16 inch across. Shearing and schistosity at 30° to length of core.
68.5	128.0	92	Schistose, greenish-black, mottled serpentine. Mottling has texture similar to that found in the lighter-colored serpentine described above, which is probably an altered and weathered phase of the dark, mottled serpentine. Some shearing at 99.0 to 101.0 feet and 116.0 to 117.0 feet.
128.0	141.0	73	Dense, greenish-black, unmottled serpentine; 3 inch white dike at 136 feet.
141.0	147.0	69	Dark, mottled serpentine.
147.0	178.0	94	Dense, unmottled serpentine with some schistosity.
178.0	185.0	89	Slightly sheared, mottled serpentine.
185.0	207.0	81	Schistose, dense serpentine, somewhat sheared at 198 feet.
207.0	208.5	100	White dike with injection contacts into surrounding serpentine.
208.5	228.0	93	Schistose serpentine; 4 inch white dike at 220 feet.
228.0	233.0	90	Diorite dike, somewhat bleached near contacts and contains several serpentine splits.

Hole 2

Location: N. 1187.0
 Elevation at collar: 1,066.0 feet
 Depth: 148 feet

Bearing: N. 56° E.
 Dip: -40°

Footage		Core recovery, percent	Description
From-	To-		
0	9.0	10	Granodiorite.
9.0	42.0	50	Light-green, schistose, mottled serpentine. Matrix is light-green and swirls around darker patches up to 1/4 inch across.
42.0	44.0	4	Shear zone? Cuttings are slickentite serpentine.
44.0	86.0	41	Mottled, light-green, schistose serpentine; schistosity from 20° to 30° with length of core.
86.0	90.0	0	Shear zone? No core.
90.0	90.5	48	Altered diorite.
90.5	94.5	48	Sheared serpentine with much talc.
94.5	96.0	48	Diorite.
96.0	103.0	39	Brecciated serpentine.
103.0	148.0	78	Dark greenish-black, dense, slightly schistose serpentine. Schistosity at 30° to 45° to length of core. Slight mottling in places.

Hole 3

Location: N. 1271.5, E. 720.0
 Elevation of collar: 1,074.5 feet
 Depth: 152 feet

Bearing: N. 56° E.
 Dip: -43°

Footage		Core recovery, percent	Description
From-	To-		
0	2	0	Overburden
2	14	0	Granodiorite
14	43	4	Badly sheared, mottled serpentine.
43	44	22	Altered diorite dike.
44	57	13	Sheared, mottled serpentine.

Hole 3 (Cont'd.)

Footage		Core recovery, percent	Description
From-	To-		
57	111	46	Mottled serpentine with sheared spots at 59, 64, 78, and 84 feet. Schistosity at 45° to core. Serpentine to 111 feet is bleached; a few scattered grains of accessory chromite, and occasional grains of limonite after pyrite along fractures. Core all badly broken.
111	131	79	Dark, greenish-black, mottled, schistose serpentine.
131	134	68	Unmottled, dense, only slightly schistose serpentine; about 1 percent accessory chromite.
134	145	77	Schistose, slightly mottled serpentine.
145	147.7	100	Only slight schistosity; probably saxonite.
147.7	149	100	Schistose, mottled serpentine. Dark.
149	150	100	White dike, probably altered diorite.
150	152	100	Dark, schistose, mottled serpentine.

Hole 4

Location: N. 1358.2, E. 666.5
Elevation of collar: 1,080.5 feet
Depth: 150 feet

Bearing: N. 56° E.
Dip: -41°

Footage		Core recovery, percent	Description
From-	To-		
0	2	13	Overburden.
2	16	17	Weathered, light-green, mottled, schistose, serpentized saxonite. Schistosity at 45° to length of core.
16	17	50	Shear zone with gouge and slickentite.
17	34	31	Saxonite; same as 2 to 16 feet.
34	42	14	Core virtually absent. Shear zone.
42	57	52	Serpentinized saxonite.
57	59	75	Slickentite; small shear zone. Considerable asbestos (slip fiber).

Hole 4 (Cont'd.)

Footage		Core recovery, percent	Description
From-	To-		
59	63.5	89	Slightly darker, mottled, serpentized saxonite; considerable talc and magnetite in seams.
63.5	65	100	Altered dike cut by seams of a light-pink mineral. Serpentine on contact indurated and considerable chlorite formed.
65	86	98	Dark, mottled, serpentized saxonite. Schistosity at 45° to length of core. Sheared at 67 to 68 feet, 71.5 to 72 feet, 78.5 to 79 feet. Open fractures filled with opal and limonite.
86	90	100	Dense, unmottled, serpentized dunite with only slight schistosity. 1 percent accessory chromite.
90	94	100	Mottled, serpentized saxonite. Opal in open fractures.
94	96	100	Slightly schistose, serpentized dunite with 1 percent accessory chromite.
96	128	34	Dark, mottled, serpentized saxonite; sheared at 99 feet and 102 feet. 4 inch dike at 110 feet.
128	129	44	Serpentized dunite.
129	131.5	93	Serpentized, mottled saxonite.
131.5	132.4	93	Serpentized dunite.
132.4	136	93	Serpentized, mottled saxonite.
136	146	92	Serpentized dunite.
146	150	91	Serpentized saxonite.

Hole 5

Location: N. 1424.5, E. 592.2
 Elevation at cellar: 1,078.0 feet
 Depth: 156 feet

Bearing: N. 56° E.
 Dip: -40°

Footage		Core recovery, percent	Description
From-	To-		
0	2	5	Overburden.
2	21	4	Highly sheared slickentite; very little core.
21	70	45	Schistose, mottled, serpentized saxonite. Leached and weathered. Schistosity 30° to length of core.

Hole 5 (Cont'd.)

Footage		Core recovery, percent	Description
From-	To-		
70	96	31	Dark-green, schistose, mottled saxonite. Serpentinized.
96	104.5	47	Serpentinized, schistose dunite; minor accessory chromite. Schistosity at 75° to length of core.
104.5	106.2	50	Mottled, serpentinized saxonite.
106.2	109.5	89	Serpentinized, schistose dunite.
109.5	130	91	Mottled, serpentinized, schistose saxonite.
130	130.5	83	Altered diorite dike; contacts sheared.
130.5	146	79	Schistose, mottled, serpentinized saxonite.
146	151	77	Diorite and altered, indurated serpentine in alternating bands. Dikes 3 to 10 inches thick.
151	156	77	Serpentinized, mottled, schistose saxonite.

Hole 6

Location: N. 1479.5, E. 490.0
Elevation of collar: 1,067.3 feet
Depth: 152 feet

Bearing: N. 72° E.
Dip: -44°

Footage		Core recovery, percent	Description
From-	To-		
0	2	0	Overburden.
2	30	14	Granodiorite; weathered and decomposed; fine-grained from 2 to 19 feet. Several serpentine inclusions.
30	31	42	Altered slickentite.
31	50	44	Medium-grained granodiorite.
50	52	50	Indurated, altered serpentine.
52	53.5	50	Diorite? Dike; no quartz.
53.5	66	34	Sheared slickentite; a few jasperoid seams.
66	67	24	Diorite dike.

Hole 6 (Cont'd.)

Footage		Core recovery, percent	Description
From-	To-		
67	104.5	41	Slickentite serpentine, some fragments of mottled saxonite. 4 inch diorite dike at 85 feet.
104.5	110	68	Dike of coarse-grained material not similar to altered diorite dikes. Probably considerable alteration. Solution cavities scattered through dike.
110	113.5	72	Slickentite.
113.5	116.5	85	Dike similar to 104 to 110 feet.
116.5	128	10	Sheared serpentine; slickentite.
128	131	24	Brecciated, mottled, serpentized saxonite.
131	138	64	Brecciated, serpentized, dunite.
138	152	46	Schistose, mottled, serpentized saxonite

Hole 7

Location: N. 1561.5, E. 454.0
 Elevation of collar: 1,068.0 feet
 Depth: 100 feet

Bearing: N. 76° E.
 Dip: -56-1/2°

Footage		Core recovery, percent	Description
From-	To-		
0	2	0	Overburden.
2	5	0	Decomposed granodiorite.
5	27	16	Core very fragmental; fragments of slickentite and saxonite. Schistosity at from 0° to 20° with length of core.
27	29	21	Brecciated dunite.
29	35	7	No core; probably sheared.
35	37	50	Brecciated dunite.
37	40.5	50	Highly sheared slickentite with a small amount of chromite gouge at 39 feet.
40.5	41	50	Diorite dike.

Hole 7 (Cont'd.)

Footage		Core recovery, percent	Description
From-	To-		
41	44	22	Sheared slickentite.
44	46	22	Brecciated dunite.
46	47.5	100	Saxonite; schistosity at 40° to length of core.
47.5	49	100	Diorite dike.
49	70	14	Dunite and slickentite fragments.
70	75	29	Slickentite.
75	91	20	Brecciated saxonite and slickentite fragments.
91	92.5	32	Schistose serpentized dunite.
92.5	100	24	Schistose saxonite; schistosity at 45° to length of core.

Hole 8

Location: N. 1740.0, E. 412.0
 Elevation of collar: 1,077.0 feet
 Depth: 105 feet

Bearing: N. 69° E.
 Dip: -54-1/2°

Footage		Core recovery, percent	Description
From-	To-		
0	2	0	Overburden.
2	6	11	Somewhat sheared serpentine of unknown derivation.
6	9	22	Schistose dunite with schistosity at 20° to length of core.
9	45	37	Somewhat mottled; schistose serpentine of unknown derivation; core very fragmental.
45	70	33	Core very fragmental; serpentine probably derived from dunite.
70	73	41	Slickentite.
73	80	47	Probably derived from dunite; is somewhat sheared serpentine with marked schistosity.
80	105	90	Serpentine of obscure derivation but probably saxonite.

Hole 9

Location: N. 1596.0, E. 915.5
Elevation of collar: 1,096.0 feet
Depth: 100 feet

Bearing: S. 21° W.
Dip: -49-1/2°

Footage		Core recovery, percent	Description
From-	To-		
0	2	0	Overburden.
2	24	31	Sheared serpentine with fragments of both dunite and saxonite. 1/4 inch of chromite gouge at 15 feet in highly sheared serpentine. Core very fragmental and mixed up.
24	25	35	Diorite dike.
25	29	39	Schistose, somewhat sheared saxonite.
29	37	50	Schistose, somewhat sheared dunite.
37	61	36	Brecciated and sheared serpentine of undetermined origin. Core very fragmental.
61	63.5	34	Schistose dunite.
63.5	64	34	Altered diorite dike.
64	67	67	Schistose dunite.
67	68	67	Highly sheared slickentite. Probably a shear zone.
68	83	11	Brecciated dunite and fragments serpentine of undetermined origin. Core very fragmental.
83	100	25	Sheared and brecciated serpentine probably in large part derived from saxonite. Core very fragmental.

Hole 10

Location: N. 845.0, E. 1110.0
Elevation of collar: 1,014.5 feet
Depth: 130 feet

Bearing: N. 7° E.
Dip: -49-1/2°

Footage		Core recovery, percent	Description
From-	To-		
0	4	0	Overburden.
4	9	9	Sheared slickentite.
9	11	23	Granodiorite.

Hole 10 (Cont'd.)

Footage		Core recovery, percent	Description
From-	To-		
11	38	16	Sheared slickentite; no core from 16 to 28 feet.
38	38.5	77	Diorite dike (altered).
38.5	43	77	Sheared slickentite.
43	52	84	Sheared and schistose mottled serpentine probably derived from saxonite.
52	54	100	Brecciated dunite.
54	55.5	100	Altered diorite dike.
55.5	57	57	Dunite with schistosity at 40° to length of core. Dark and dense.
57	59	36	Black, slightly mottled, schistose saxonite.
59	68	36	Schistose dunite with minor amounts of accessory chromite.
68	69	36	Saxonite, mottled and schistose.
69	70	36	Schistose dunite; minor accessory chromite.
70	78	55	Zone of serpentine probably of dunitic origin but with small amounts of pyroxene in places.
78	78.5	55	Altered diorite dike.
78.5	118	71	Schistose dunite with schistosity at 45° to length of core. Minor accessory chromite in grains 1/4 to 1 mm. in diameter.
118	119.5	82	Schistose, mottled saxonite.
119.5	125	53	Dunite; accessory chromite.
125	125.5	50	Schistose saxonite.
125.5	128	50	Dunite; a few specks of chromite.
128	130	50	Schistose, mottled saxonite.

Hole 11

Location: N. 842.0, E. 1108.5
Elevation of collar: 1014.5 feet
Depth: 95 feet

Bearing: N. 41° E.
Dip: -44°

Footage		Core recovery, percent	Description
From-	To-		
0	6	0	Overburden.
6	7	18	Highly sheared slickentite.
7	9	18	Granodiorite; rather fine-grained and not much quartz.
9	16	25	Highly sheared slickentite; 1/4 inch of chromite at 11 feet.
16	29	0	No core; slickentite cuttings.
29	41	53	Fragments of slickentite and schistose saxonite.
41	42.5	100	Schistose, serpentized dunite.
42.5	45	100	Schistose saxonite.
45	57	56	Schistose dunite.
57	57.5	76	Diorite dike.
57.5	58	76	Schistose dunite; small amount of accessory chromite.
58	73	50	Schistose saxonite.
73	76	24	Dunite.
76	91	20	Saxonite.
91	93	25	Dunite.
93	95	25	Saxonite.

