Lode Platinum-Group Metals Potential of the Goodnews Bay Ultramafic Complex, Alaska

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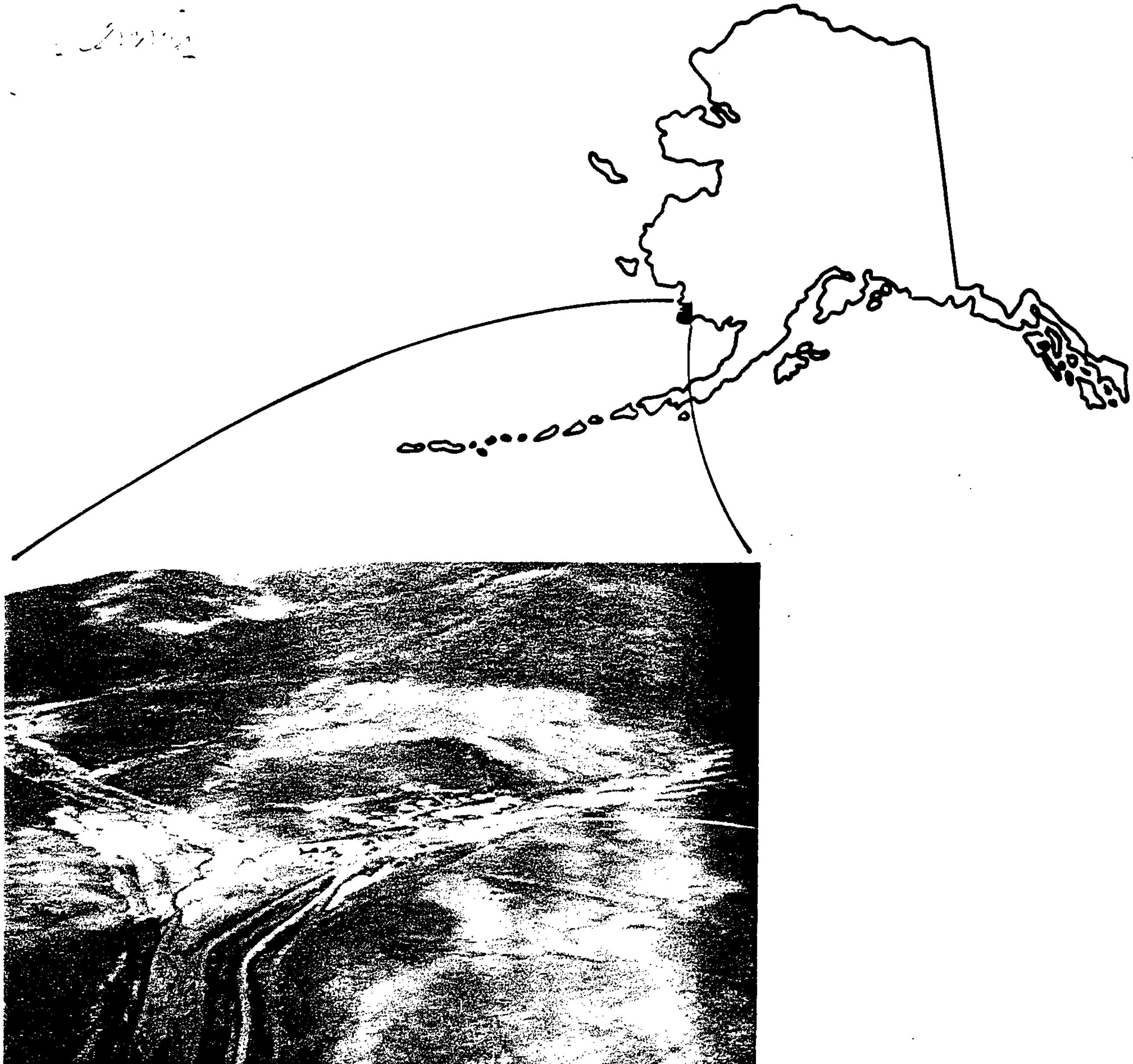

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald P. Hodel, Secretary

BUREAU OF MINES
Robert C. Horton, Director

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

F	Fahrenheit
ft	feet
g	gram
in	inch
lb	pound
mgal	milligal
my	million years
oz	troy ounce
oz/ton	troy ounce per ton
pct	percent
ppm	parts per million
sp gr	specific gravity
yr	year

LODE PLATINUM-GROUP METALS POTENTIAL OF THE GOODNEWS BAY ULTRAMAFIC COMPLEX, ALASKA

By D. D. Southworth[1] and Jeffrey Y. Foley[2]

ABSTRACT

In 1981, 1982, and 1983, the Bureau of Mines examined the potential for lode deposits of platinum-group metals (PGM) in the Goodnews Bay ultramafic complex, Alaska. The complex consists of the Red Mountain, Suzie Mountain, and Smalls River ultramafic bodies and displays concentric zoning of rock types similar to complexes in southeast Alaska, British Columbia, and the Ural Mountains in the U.S.S.R. Results of the study indicate that platinum is preferentially associated with chromite and magnetite in the dunite core of the complex, and palladium is preferentially associated with sulfide minerals in the outer clinopyroxene-rich zones.

The most promising targets for PGM lode deposits are the chromite-rich dunite at the heads of Fox Gulch and Squirrel Creek and iron-nickel and iron-copper sulfide-bearing magnetite clinopyroxenite and hornblende-rich rocks outward of the dunite core, also in the Fox Gulch-Squirrel Creek area. Significant placer reserves are present in the unmined, deeply buried placer ground in the lower Salmon River Valley, and also in tailings from previous dredging.

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INTRODUCTION

The platinum-group metals (PGM) platinum, palladium, iridium, osmium, rhodium, and ruthenium function as catalysts in the automotive, chemical, and petroleum-refining industries. Other U.S. industries rely on the chemical inertness and refractory properties of PGM. The metals are considered critical and strategic commodities and are necessary to the nation's military and economic well-being.

Because the only PGM produced domestically are recovered as trace by-products and by recycling, in 1983, the United States relied on foreign imports for about 84 pct of its PGM supplies. About 16 pct of PGM consumption was recovered from domestic scrap (25)[3]. Most imports were from the Republic of South Africa (56 pct of total imports), the U.S.S.R. (16 pct of total imports), and Canada (11 pct of total imports). The United Kingdom is an important processor of PGM concentrates produced in the Republic of South Africa.

Domestic U.S. PGM production is less than one pct of U.S. consumption and has mostly been as a byproduct of the refining of copper ores; minor production has also come from domestic placer mining operations and other sources. The Goodnews Bay Mining Company, in southwestern Alaska, is the only domestic mine that has produced PGM as its principal commodity. About 650,000 oz of PGM were produced from the Goodnews Bay placers during the period 1928 through 1975 (1). Since 1976 the Goodnews Bay Mining Company has operated only sporadically, mostly reworking tailings from earlier mining.

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[3] Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

As part of its current Alaska-wide assessment of critical and strategic minerals, the Bureau of Mines investigated the potential for PGM lode deposits in the Goodnews Bay area from 1981 through 1983 using a combination of geologic mapping, geochemical sampling, and geophysical surveys to delineate the extent of the ultramafic complex and to better define the distribution of PGM within the complex.

LOCATION

The Goodnews Bay complex is located approximately 10 miles south of the entrance to Goodnews Bay, along Kuskokwim Bay, on the southwest coast of Alaska (fig. 1). The 42-square-mile study area (fig. 2) extends from approximately 161° 36'W and 59° 00'N to 161° 47'W and 58° 52'N.

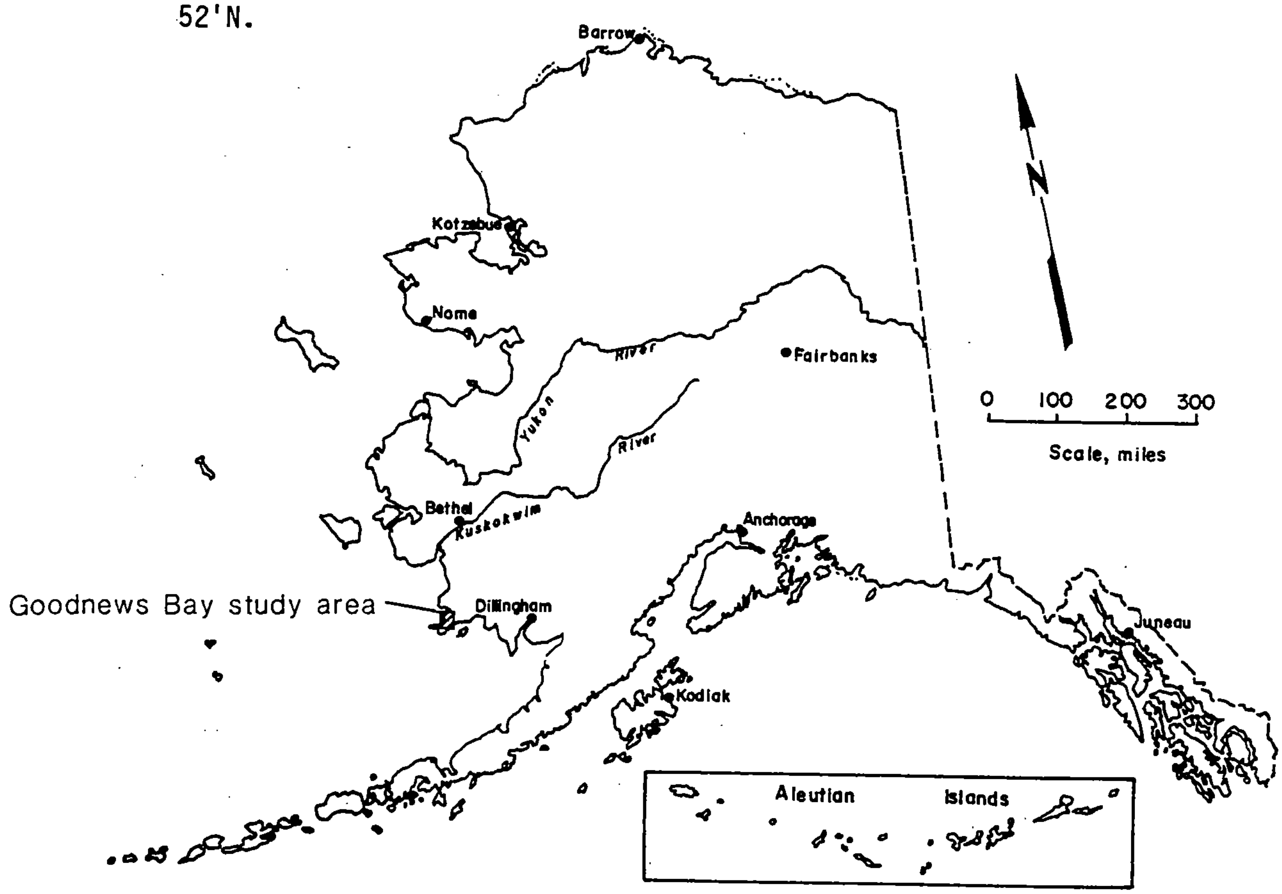


FIGURE 1. - Index map of Alaska.

PREVIOUS INVESTIGATIONS

Geologic data on the Goodnews Bay area are contained in numerous reports. Harrington (16), in 1919, described and mapped the topography and geology of the area immediately around Goodnews Bay at a scale of 1:250,000. A 1933 report by Reed (32), of the Alaska Territorial Department of Mines, detailed the early placer mining efforts in the Goodnews Bay mining district, and described the ultramafic rocks at Red Mountain. During 1937, Mertie (26) prepared geologic maps of the Goodnews Bay area at 1:62,500 scale. In 1940, Mertie (27) described the general geology of the area and reported in detail on the composition of the platinum-group minerals in the placer deposits. The Goodnews Bay placer deposits were summarized by Mertie in 1969 (28) and again in 1976 (29). The latter report contains the most detailed description available of the mineralogy and distribution of PGM in the Goodnews Bay placers. Bird and Clark (4) reported results of electron-microprobe analyses of olivine chromitites from Red Mountain and suggested a similarity of Red Mountain to the Alaska-type zoned complexes. Porter (30) described the glaciation of the area from Goodnews Bay to Chagvan Bay. His findings explain in part the distribution of the placer paystreaks in the Salmon River. Griscom's (15) interpretations of aeromagnetic data from the region help to define the extent of the ultramafic complex. Potassium-argon age determinations of rocks from many of the plutons of southwestern Alaska, including two from Red Mountain (176.4 $\pm$ 5.3 my, 186.9 $\pm$ 5.6 my) were reported by Wilson (40-41).

The potential for placer platinum and gold deposits in beach sands near Red Mountain has also been the subject of several studies. The earliest of these was by Berryhill (3), who, in 1963, investigated the placer potential of beach sands along much of the Bristol Bay coastline. Although Berryhill collected twenty-one samples along the beach adjacent to Red Mountain, he detected greater than trace amounts of PGM or gold in only four samples. The highest values Berryhill obtained were 0.0573 oz/ton Pt and 0.0736 oz/ton Au from "thin sand veneer" collected with a shovel. Reports on the sedimentallogical processes active in the Goodnews and Chagvan Bay areas include several graduate studies (5, 35, 37-39). Bond (5), reported specifically on the distribution of platinum in the beach sands adjacent to Red Mountain. Potential beach placer accumulations and the recovery of PGM are also the subject of current Bureau of Mines investigations.

PROSPECTING AND DEVELOPMENT HISTORY

Reed (31) reports that PGM were first discovered in pan samples from Fox Gulch in 1926. Small-scale mining plants were operated intermittently from 1927 to 1934 on Platinum, Squirrel, and Clara Creeks, and on Fox and Dry Gulches. As the shallower paystreaks were mined out and it was discovered that large-scale, more expensive methods would be necessary to reach the deeper placer concentrations, many of the smaller claim groups were consolidated. Eventually two concerns, the Goodnews Bay and the Clara Creek mining companies, controlled most of the placer claims of the area. The Goodnews Bay Mining Co., the larger of the two, began operating with a dragline excavator in 1934 (27, 32), and the Clara Creek Mining Co. began dragline excavator operations in 1936. By 1941, however, the Clara Creek Mining Co. had ceased operations. The Goodnews Bay Mining Co. eventually acquired title to, or leased, virtually all of the mining claims along the Salmon River and its tributaries (27). In 1937, the Goodnews Bay Mining Company began mining in the Salmon River Valley with a newly installed, 8-cubic-foot bucket-line dredge (fig. 3) (33) that has continued, with several brief hiatuses, to operate up to the present. Mertie (29) described the mining activities in the district through 1976.

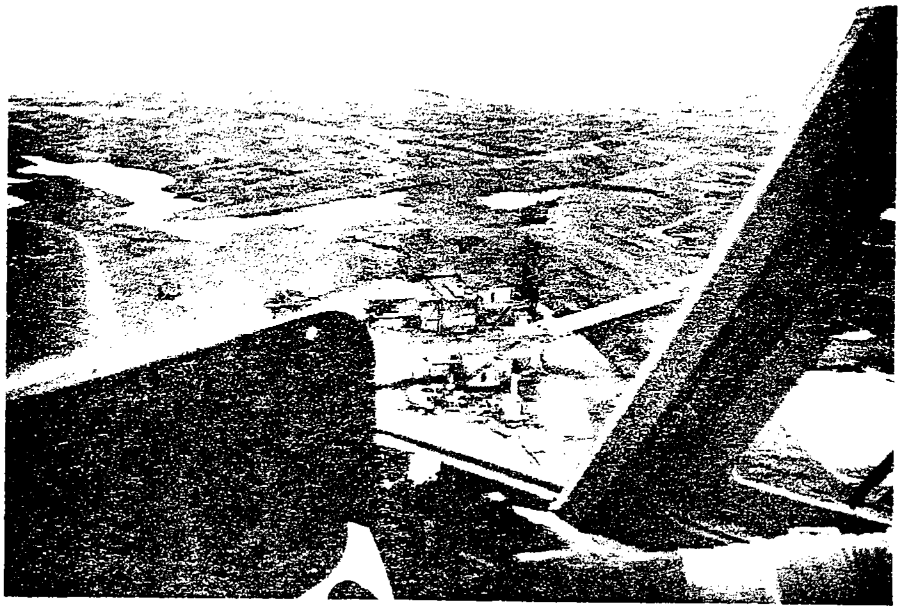


FIGURE 3. - Bucket-line dredge in Salmon River Valley.

Hanson Properties of Spokane, WA, acquired the Salmon River holdings in 1980 and is the present mine operator. The company is currently reworking tailings from previous mining, and is exploring virgin ground for both placer and lode PGM. The company holds lode claims on the east side of Red Mountain, but no hardrock mining has been done. Despite investigations by the mineral industry and government geologists, no economic lode platinum deposits have been discovered in the area.

OWNERSHIP

Virtually all of the placer mining claims in the Salmon River Valley and adjoining tributaries are currently (1985) held or controlled by the Goodnews Platinum Co., a subsidiary of Hanson Properties, of Spokane, WA. A map showing the placer claims in the area is published in the 1976 report by Mertie (29).

ACCESS

Regularly scheduled air service is available from Bethel to the village of Platinum, on Goodnews Bay. A gravel road spans the 10 miles between Platinum and the mine camp at the southeastern end of Red Mountain. The mine also has a gravel airstrip which can accommodate aircraft the size of a De Haviland "Twin Otter". There is no commercial lodging available.

PHYSIOGRAPHY

The report area lies in a region of subdued relief. Elevations range from sea-level to 1,887 ft at the summit of Red Mountain. Thorsen Mountain and Red Mountain together separate the Salmon River Valley from Kuskokwim Bay.

The area around Red Mountain has been extensively glaciated, with evidence of at least four glacial advances ranging in age from 8,910 $\pm$ 110 yr to greater than 45,000 yr (30). The main portion of the Salmon River Valley apparently escaped significant glaciation, however, several small cirques are preserved along the western (seaward) side of the Red Mountain ridgecrest. Mertie (27) reported finding large glacial erratics at elevations as high as 800 ft on the north end of Red Mountain. Extensive deposits of reworked glacial material (fig. 4) are found at the northwestern margin of Red Mountain and in the Salmon River Valley as far south as Dowry and Clara Creeks.

FIGURE 4. - Reworked glacial till at northwestern end of Red Mountain.

The climate in this part of Alaska is usually wet and foggy from April through September. The mean annual temperature is 33° F, although summer temperatures can range from 40° F to 75° F. The mean annual precipitation is 45 in, with the heaviest rainfall occurring in late summer. The effective working season for the dredge is usually limited by freezing temperatures to the period from late April to mid-December.

Vegetation consists principally of a thick tundra mat, except near the mouth of the Salmon River where there are a few alder and willow thickets.

SAMPLING AND ANALYTICAL PROCEDURES

Pan samples were collected to enhance recognition of PGM and gold in alluvium and regolith. In general, pan samples were collected from the silty, poorly sorted material in active stream channels. Several samples of residual soil from the crest of Red Mountain were collected and treated similarly to those from the streams. Each stream sample represents three 16-in pans of material screened to minus 1/4-mesh from an original volume of 6 to 9 pansful. The residual soil samples each represent two pansful of material (no screening was necessary). Each sample was panned in the field and reduced to approximately 40 to 50 g of concentrate, then carefully washed into a plastic bag. Pan concentrate samples were further reduced in the laboratory either by panning to a constant volume (equivalent to a weight of about 30 g) or by concentrating them on a riffle table. Fire assay preconcentration of the samples was done by either the Bureau's laboratory in Juneau or by Bondar-Clegg Laboratories, Inc., of Lakewood, CO. This was followed by either: (1) inductively coupled argon plasma analysis (ICAP), at the Bureau's Reno, NV Research laboratory, or by Neutron Activation Services of Hamilton, Ontario, Canada, or (2) emission spectrographic analysis for Pd, Rh, Ru, Ir, and Os, at the Bureau's Reno laboratory. Because the emission spectrograph procedure utilized a platinum internal standard, no platinum analyses were possible by that technique. Results of analyses of pan concentrate samples are listed in table 1. Pan concentrate sample locations are shown on figure 5.

Stream sediment samples were collected in conjunction with pan concentrate samples from some of the unmined tributaries of the Smalls and Salmon Rivers. The samples were collected from the finer sandy portion of the active channel or deepest part of a dry but recently active stream bed. Samples were air dried before screening at minus

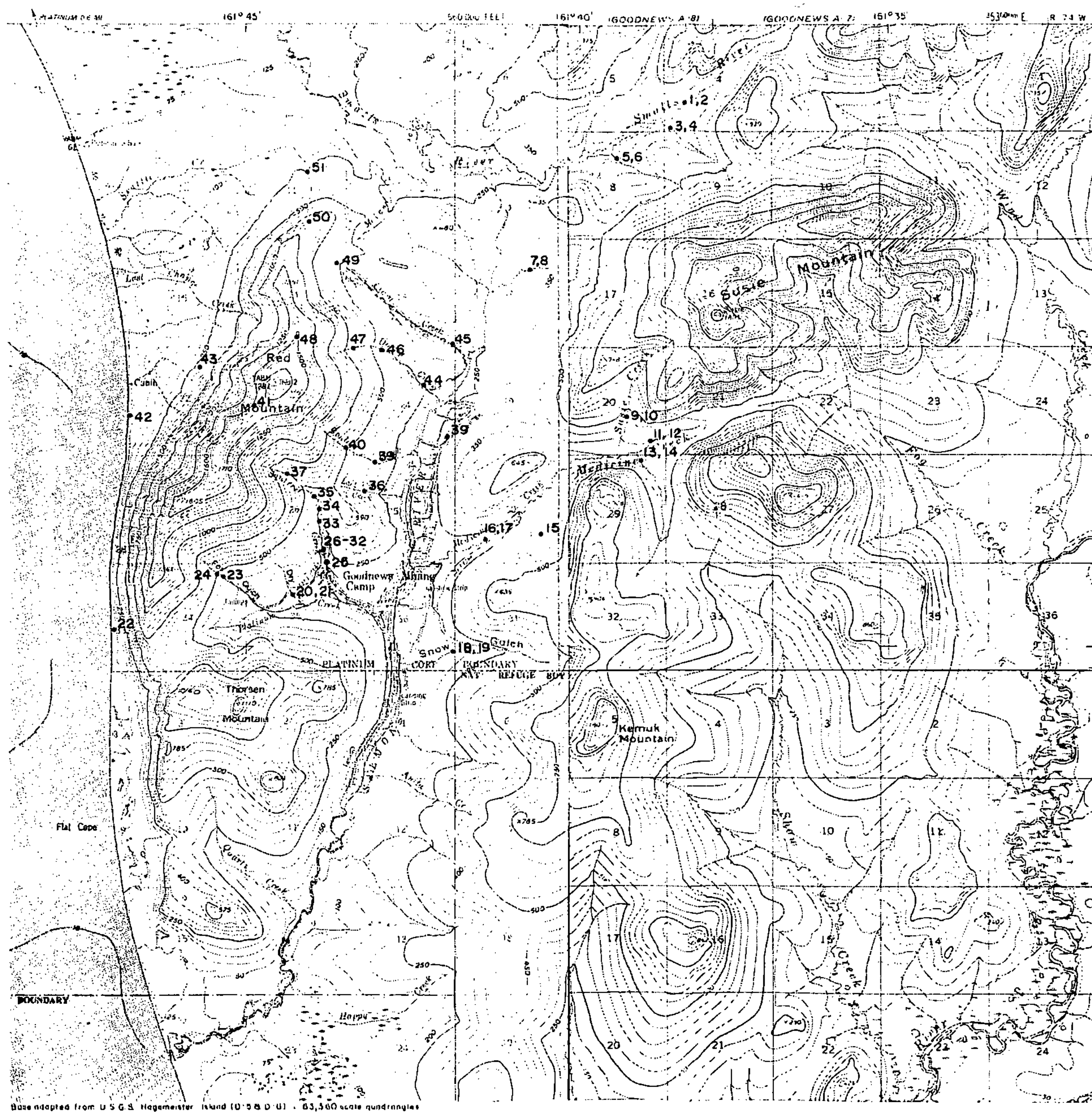
TABLE 1. - Fire assay analyses[1] of pan concentrate samples from the Goodnews Bay study area.

Sample	Au, oz/ton	Ir, oz/ton	Os, oz/ton	Pd, oz/ton	Pt, oz/ton	Rh, oz/ton	Ru, oz/ton
1P...	--	--	--	<0.002	<0.002	--	--
3P...	--	--	--	<.002	.006	--	--
5P...	--	--	--	<.002	.021	--	--
7P...	--	--	--	<.002	.010	--	--
10P...	--	--	--	<.002	<.002	--	--
12P...	--	--	--	<.002	<.002	--	--
14P...	--	--	--	<.002	<.002	--	--
17P...	--	--	--	<.002	<.002	--	--
19P...	--	--	--	<.002	<.002	--	--
21P...	--	--	--	<.002	.008	--	--
22P...	0.0028	0.0052	ND	--	.002	ND	ND
23P...	--	--	--	<.002	<.002	--	--
24P...	--	.12	>0.020	--	.028	0.110	0.0040
25P...	ND	.046	ND	ND	.092	.0040	ND
26P...	--	--	--	<.002	.004	--	--
27P...	--	--	--	<.002	.004	--	--
28P...	--	--	--	.011	1.530	--	--
29P...	--	--	--	.009	1.880	--	--
30P...	--	--	--	.002	.681	--	--
31P...	--	--	--	<.002	.039	--	--
33P...	--	>.56	.36	--	--	.056	.042
34P...	.016	--	--	<.007	.058	--	--
35P...	.018	--	--	.009	2.385	--	--
36P...	--	.032	ND	--	.031	.0016	ND
37P...	--	--	--	--	.0374	--	--
38P...	--	--	--	.004	.750	--	--
39P...	ND	.24	.032	ND	.140	.019	.0066
40P...	--	.28	.070	--	--	.011	.010
41P...	.005	--	--	<.003	.020	--	--
42P...	--	--	--	--	.003	--	--
43P...	.002	--	--	<.002	.010	--	--
44P...	.02	.040	ND	.001	.500	.0036	ND
45P...	--	ND	ND	--	.0426	ND	ND
46P...	ND	>.56	.08	.110	19.690	.056	.018
47P...	--	--	--	--	.0084	--	--
48P...	--	--	--	<.001	.0138	--	--
49P...	.003	--	--	<.002	.035	--	--
50P...	--	--	--	.034	--	--	--
51P...	<.002	.18	ND	<.002	.0096	.0020	ND

ND Not detected, no detection limit specified.

[1]See text for description of analytical procedures.

NOTE: -- indicates sample was not analyzed for this element.



LEGEND

• 51 Sample site

N

0 1 2

Scale, miles
Contour interval 50 feet

FIGURE 5. -- Pan concentrate and stream sediment sample location map

80-mesh and undergoing standard atomic absorption analyses for Co, Cu, Ni, and Pb. Results of these analyses are shown in table 2 and sample locations appear on figure 5.

Rock samples were usually collected as random chip samples across an outcrop, suspected mineralized area, or an altered zone. An effort was made while in the field to remove any weathering rind, so that only relatively fresh material was sampled. Rock sample locations are shown on figure 6.

Each rock sample was analyzed by atomic absorption methods for silver, gold, cobalt, chromium, copper, and nickel. Gold, platinum, palladium, osmium, iridium, rhodium, and ruthenium, were analyzed in a manner similar to that described above for the pan concentrate samples. Results of the analyses are listed in table 3; rock sample descriptions are listed in appendix A. Whole-rock oxide analyses were performed by Bondar-Clegg, Inc. of Lakewood, CO, using standard atomic absorption techniques. Results are listed in table 4. A computer program written at the University of Washington was used to calculate CIPW normative mineral abundances and AFM (A = K_2O + Na_2O, F = FeO, M = MgO) oxide ratios.

Splits of 28 rock sample pulps were used in the X-ray diffraction studies of forsterite (Fo) content described later in this report. Three separate scans were made of each sample and the results were averaged. The averages are listed in table 5 and the distribution of Fo content across the Goodnews Bay complex is shown on figure 7.

A number of samples were also collected for petrographic study and visual estimates were made of mineral abundances.

TABLE 2. - Chemical analyses[1] of stream sediment samples from the Goodnews Bay ultramafic complex.

Sample	Co ppm	Cu ppm	Ni ppm	Pb ppm
2.....	35	46	80	<30
4.....	28	24	74	<30
6.....	21	7.8	38	<30
8.....	63	24	270	<30
9.....	40	58	160	<30
11.....	11	41	17	<30
13.....	20	25	30	<30
15.....	15	29	34	<30
16.....	25	64	51	<30
18.....	14	14	26	<30
20.....	61	43	320	<30
32.....	96	60	550	<30

[1]See text for description of analytical procedure.

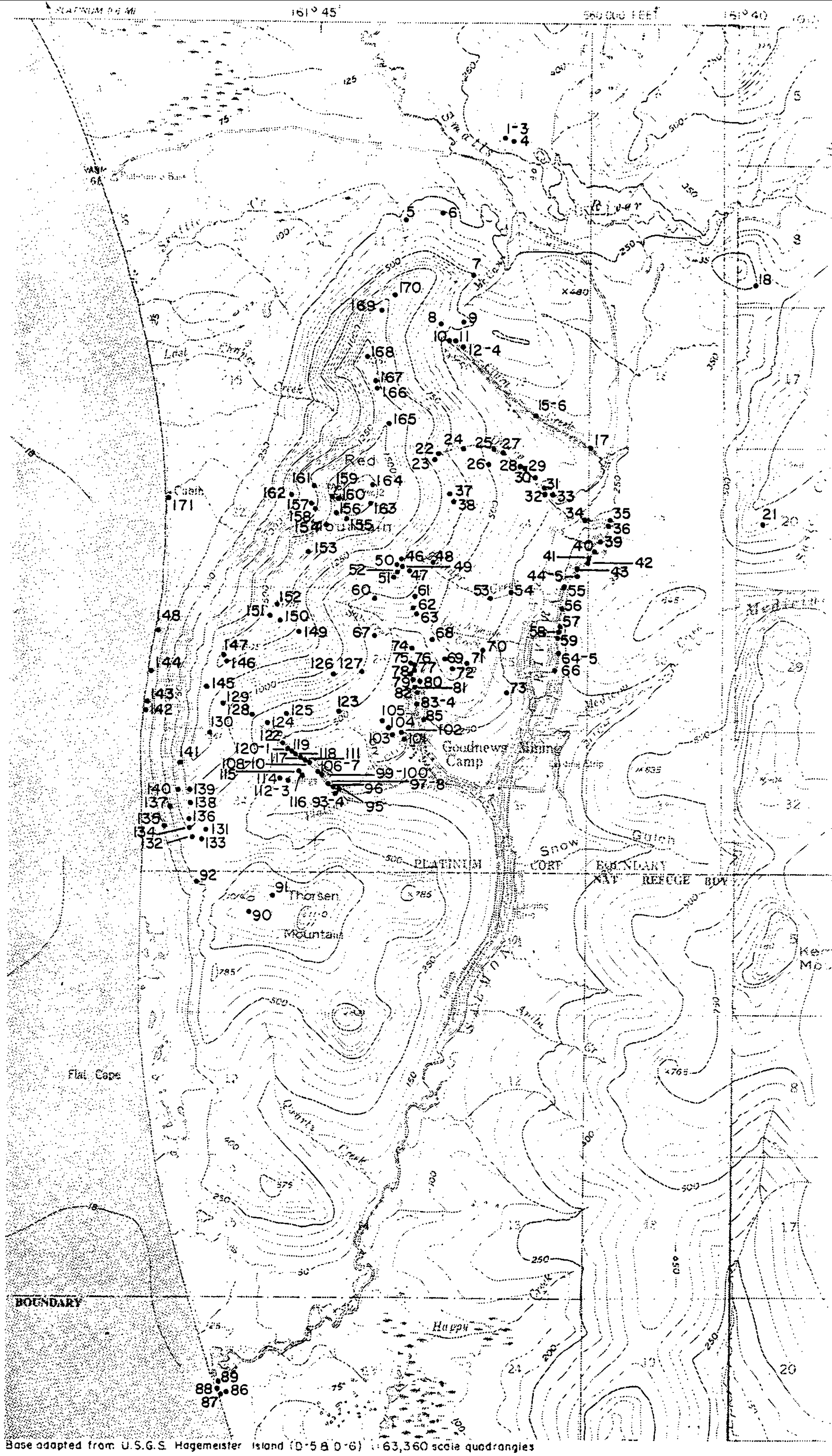


FIGURE 6. -- Rock sample location map

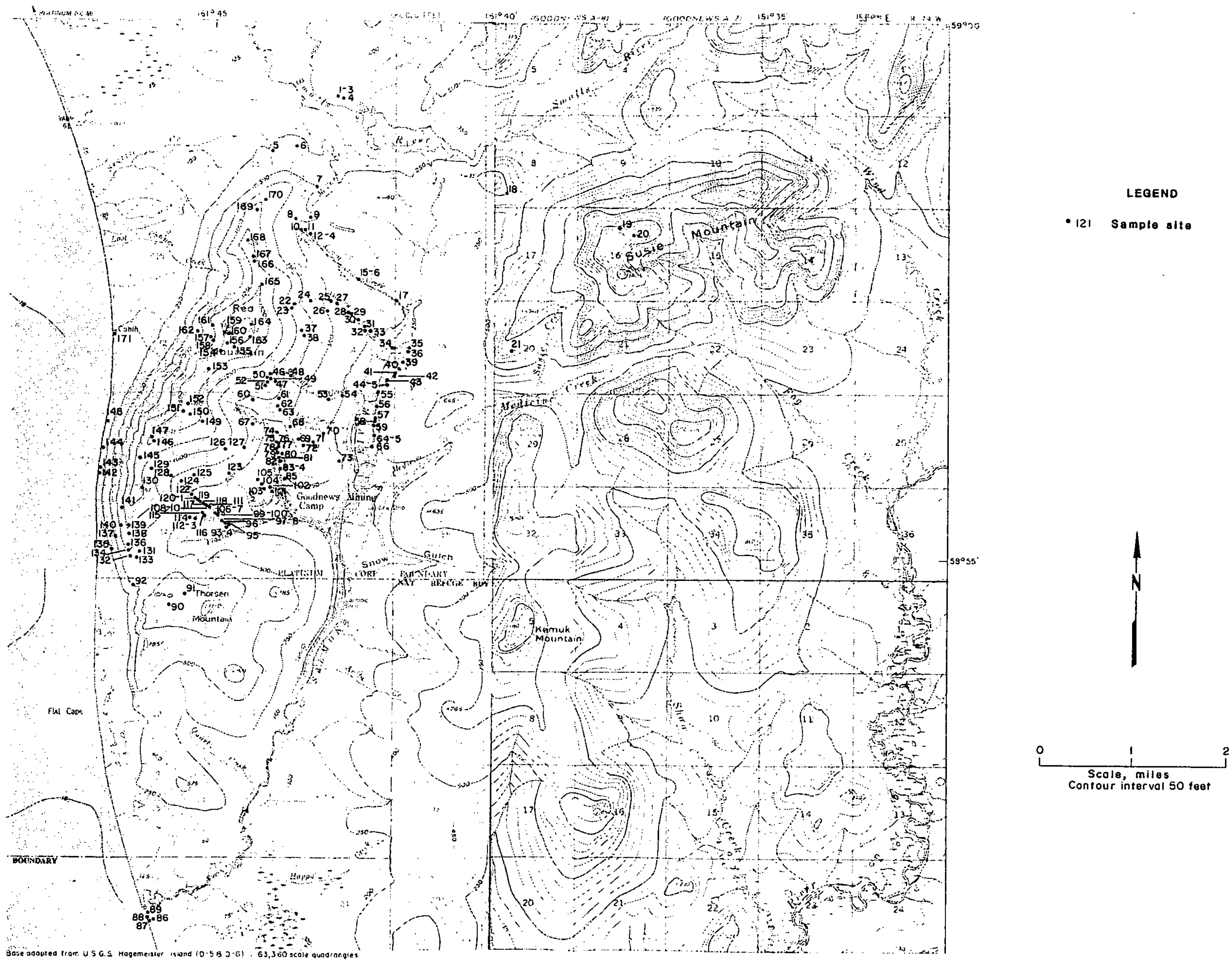


FIGURE 6. -- Rock sample location map

TABLE 3. - Chemical analyses of rock samples from the Goodnews Bay ultramafic complex

Sample	Ag,[1] ppm	Au,[1] ppm	Co,[1] ppm	Cr,[1] ppm	Cu,[1] ppm	Ni,[1] ppm	Au,[2] oz/ton	Ir,[2] oz/ton	Pd,[2] oz/ton	Pt,[2] oz/ton	Os,[2] oz/ton	Rh,[2] oz/ton	Ru, oz/ton
1..	<0.1	<0.03	22	1,700	7	93	<0.007	ND	<0.0003	<0.0003	ND	ND	ND
2..	<.1	<.03	51	1,800	7	260	<.007	ND	<.0003	<.0003	ND	ND	ND
5..	--	--	--	<200	253	96	<.0002	--	<.0003	<.0003	--	--	--
7..	--	--	--	--	--	--	<.0002	--	<.0003	<.0003	--	--	--
9..	--	--	--	3,600	18	2,680	<.0002	--	<.0003	<.0003	--	--	--
10..	--	--	--	<200	54	22	<.0002	--	<.0003	<.0003	--	--	--
11..	--	--	--	400	20	24	<.0002	--	<.0003	<.0003	--	--	--
12..	--	--	125	--	--	1,700	.001	--	<.001	<.001	--	--	--
14..	--	--	35	79	--	57	--	--	--	--	--	--	--
17..	--	--	--	--	--	--	<.01	--	.00032	<.070	--	--	--
19..	--	--	--	2,700	--	--	<.0002	--	<.001	<.001	--	--	--
20..	--	--	--	1,600	--	--	<.007	--	<.030	<.030	--	--	--
23..	--	--	120	3,900	4	610	.0004	ND	<.0003	<.0003	ND	ND	ND
24..	--	--	153	1,400	4	700	.001	ND	<.0003	<.0003	ND	ND	ND
29..	--	--	--	<200	95	28	.001	--	<.0003	<.0003	--	--	--
31..	--	--	125	675	--	--	<.0002	--	<.001	<.001	--	--	--
34..	.7	<.03	62	2,300	26	205	<.01	ND	.00048	.006	ND	ND	ND
35..	--	--	--	--	--	--	<.0002	--	<.001	<.001	--	--	--
36..	.25	<.02	20	240	89	38	<.007	--	<.0003	<.0003	--	--	--
37..	--	--	136	2,100	4	840	.001	--	<.0003	<.0003	--	--	--
38..	--	--	106	3,300	6	900	<.0002	--	<.0003	<.0003	--	--	--
39..	.1	--	64	155	--	150	--	ND	ND	ND	ND	0.0014	ND
40..	<.1	--	230	--	14	2,900	<.0002	--	<.001	<.001	--	--	--
41..	--	--	--	2,100	8	1,050	<.0002	--	<.0003	<.0003	--	--	--
42..	<.1	<.03	22	1,400	15	78	--	ND	.00062	<.0003	ND	ND	ND
43..	.1	--	57	--	175	72	--	--	--	--	--	--	--
44..	<.1	<.03	97	2,050	8	795	--	ND	<.0003	<.0003	ND	ND	ND
45..	<.1	<.03	87	1,500	14	750	.0005	ND	<.0003	.001	ND	ND	ND
46..	--	<.03	115	2,700	4	900	<.0002	ND	<.0003	.013	ND	ND	ND
47..	<.1	<.03	88	2,800	5	740	<.0002	--	<.0003	<.0003	--	--	--
48..	--	--	115	250	4	740	.001	ND	<.0003	<.0003	ND	ND	ND
50..	.15	<.03	87	760	6	630	<.007	ND	<.0003	<.0003	ND	ND	ND

See explanatory notes at end of table.

Table 3. - Chemical analyses of rock samples from the Goodnews Bay Ultramafic Complex--Continued

Sample	Ag,[1] ppm	Au,[1] ppm	Co,[1] ppm	Cr,[1] ppm	Cu,[1] ppm	Ni,[1] ppm	Au,[2] oz/ton	Ir,[2] oz/ton	Pd,[2] oz/ton	Pt,[2] oz/ton	Os,[2] oz/ton	Rh,[2] oz/ton	Ru, oz/ton
51..	<0.1	<0.03	69	2,900	21	980	<0.007	--	<0.0003	<0.0003	--	--	--
52..	<.1	<.03	79	1,550	9	710	<.007	--	<.0003	<.0003	--	--	--
53..	--	--	--	<200	140	59	<.0002	--	<.0003	<.0003	--	--	--
55..	<.1	--	81	--	33	81	--	--	--	--	--	--	--
56..	<.1	<.03	26	130	285	24	<.007	ND	<.0003	<.0003	ND	ND	ND
57..	<.1	<.03	15	525	7	46	<.007	ND	<.0003	<.0003	ND	ND	ND
58..	.2	<.03	20	73	305	21	--	ND	.0010	<.0003	ND	ND	ND
60..	.1	.05	81	3,050	5	735	.048	--	.040	<.0003	--	--	--
62..	<.1	<.03	83	2,900	4	660	--	ND	<.0003	<.0003	ND	ND	ND
63..	.2	<.03	84	2,150	7	760	--	--	<.0003	<.0003	--	--	--
64..	.1	<.03	13	115	44	20	--	ND	<.0003	<.0003	ND	ND	ND
65..	<.1	<.03	18	64	61	21	--	ND	<.0003	<.0003	ND	ND	ND
66..	.3	<.03	19	28	355	33	--	ND	.00088	<.0003	ND	ND	ND
67..	.1	<.03	77	3,250	6	785	<.007	0.0038	.00030	<.030	ND	ND	ND
69..	--	--	28	--	105	49	<.00015	--	<.0003	<.0003	--	--	--
72..	--	--	41	--	79	225	<.0002	--	<.0003	<.0003	--	--	--
73..	<.1	<.03	15	63	44	13	<.007	ND	<.030	<.030	ND	ND	ND
74..	--	--	126	--	2	655	<.0002	--	.004	.002	--	--	--
75..	--	--	--	--	--	--	--	--	--	--	--	--	--
76..	--	--	24	62	89	14	<.0002	ND	.015	<.0003	ND	ND	ND
77..	--	<.03	41	180	20	82	<.0002	ND	.008	<.0003	ND	ND	ND
78..	--	--	15	--	140	11	.001	--	<.001	<.001	--	--	--
79..	--	.10	16	77	77	13	<.0002	--	<.0003	<.0003	--	--	--
80..	.2	<.03	14	130	160	24	<.0007	ND	.002	<.0003	ND	ND	ND
81..	--	--	27	27	130	--	<.002	--	<.001	<.001	--	--	--
82..	--	--	22	22	430	--	<.002	--	<.001	<.001	--	--	--
83..	--	--	--	--	--	--	<.007	--	<.030	<.030	--	--	--
84..	--	--	--	--	--	--	<.0002	--	<.001	.049	--	--	--
85..	--	--	8	--	--	--	<.0002	--	<.001	<.001	--	--	--
86..	--	--	--	--	--	--	.001	--	.003	.009	--	--	--
87..	--	--	--	--	--	--	.026	--	ND	.114	--	--	--
88..	--	--	--	--	--	--	<.001	--	.0002	.001	--	--	--
89..	--	--	--	--	--	--	.0001	--	<.0001	.001	--	--	--

See explanatory notes at end of table.

Table 3. - Chemical analyses of rock samples from the Goodnews Bay Ultramafic Complex--Continued

Sample	Ag,[1] ppm	Au,[1] ppm	Co,[1] ppm	Cr,[1] ppm	Cu,[1] ppm	Ni,[1] ppm	Au,[2] oz/ton	Ir,[2] oz/ton	Pd,[2] oz/ton	Pt,[2] oz/ton	Os,[2] oz/ton	Rh,[2] oz/ton	Ru, oz/ton
93..	--	--	14	<200	38	--	<0.00015	--	<0.00015	<0.0015	--	--	--
95..	--	--	18	<200	76	--	<.00015	--	<.00015	<.0015	--	--	--
96..	--	--	15	<200	52	--	<.00015	--	<.00015	<.0015	--	--	--
98..	--	--	15	<200	64	--	<.00015	--	<.00015	<.0015	--	--	--
99..	--	--	36	73	--	31	<.0002	--	<.001	<.001	--	--	--
100..	--	--	59	910	--	--	--	--	<.030	<.030	--	--	--
101..	0.3	<.03	9	125	35	16	<.007	ND	<.030	<.030	ND	ND	ND
103..	.2	<.03	9	68	100	8	<.007	ND	.00042	<.030	ND	ND	ND
104..	--	<.03	12	63	96	6	.001	ND	<.0003	<.0003	ND	ND	ND
106..	--	--	22	800	29	--	<.00015	--	<.00015	<.0015	--	--	--
107..	--	--	50	9,200	93	--	<.00015	--	<.00015	<.0015	--	--	--
108..	--	--	40	500	640	--	<.00015	--	.00045	<.0015	--	--	--
109..	--	--	31	<200	1,460	--	.0006	--	.0022	<.0015	--	--	--
110..	--	--	48	1,500	5	--	<.00015	--	<.00015	.0027	--	--	--
111..	--	<.03	29	1,200	5	110	.001	ND	<.0003	<.0003	ND	ND	ND
112..	--	--	54	--	--	120	<.0002	--	<.001	.002	--	--	--
113..	--	--	51	--	--	110	<.0002	--	<.001	<.001	--	--	--
114..	--	--	97	--	111	251	.003	--	<.0003	<.0003	--	--	--
115..	--	.05	28	530	420	46	<.000	ND	.00078	.003	ND	ND	ND
117..	--	--	25	1,600	3	--	<.00015	--	<.00015	<.0015	--	--	--
118..	--	--	--	3,900	--	--	<.0002	--	<.001	<.001	--	--	--
119..	--	--	121	2,200	5	--	<.00015	--	.0006	<.0015	--	--	--
120..	--	--	130	2,300	7	--	<.00015	--	<.00015	<.0015	--	--	--
121..	--	--	123	3,200	12	--	<.00015	--	<.00015	<.0015	--	--	--
123..	--	<.03	126	3,100	4	710	<.0002	ND	<.0003	<.0003	ND	ND	ND
124..	--	--	--	81,500	85	570	<.0002	--	<.0003	<.0003	--	--	--
125..	--	--	--	--	--	--	<.0002	--	<.0020	.0230	--	--	--
126..	--	--	--	--	--	--	--	--	<.0020	<.0040	--	--	--
127..	<.1	<.03	78	3,150	5	640	<.007	--	<.0003	.001	--	--	--
128..	--	<.03	94	2,300	3	610	--	--	.007	<.0003	--	--	--
129..	--	--	--	--	--	--	--	--	<.0020	<.0040	--	--	--

See explanatory notes at end of table.

Table 3. - Chemical analyses of rock samples from the Goodnews Bay Ultramafic Complex--Continued

Sample	Ag,[1] ppm	Au,[1] ppm	Co,[1] ppm	Cr,[1] ppm	Cu,[1] ppm	Ni,[1] ppm	Au,[2] oz/ton	Ir,[2] oz/ton	Pd,[2] oz/ton	Pt,[2] oz/ton	Os,[2] oz/ton	Rh,[2] oz/ton	Ru, oz/ton
130..	--	--	--	--	--	--	--	--	<.0020	<0.0003	--	--	--
131..	--	--	118	--	5	930	.00015	--	<.0003	<.0003	--	--	--
135..	--	--	--	--	--	--	<.0002	--	<.0003	<.0003	--	--	--
137..	--	<0.03	114	2,600	5	980	0.001	ND	.001	<.0003	ND	ND	ND
138..	--	--	--	--	--	--	<.0020	0.0001	<.0020	<.0040	ND	ND	ND
140..	--	<.03	84	64,000	4	710	.0005	ND	<.0003	<.0003	ND	ND	ND
142..	--	.03	99	2,300	7	790	.0004	.0013	<.0003	<.0003	ND	ND	ND
145..	--	--	--	--	--	--	<.0020	.0001	<.0020	<.0040	ND	ND	ND
147..	--	--	--	--	--	--	<.0020	--	<.0020	<.0040	--	--	--
148..	--	--	27	355	--	71	.0002	.0015	<.001	<.001	ND	ND	ND
149..	--	--	108	2,600	6	950	.001	--	<.0003	<.0003	--	--	--
150..	--	--	--	--	--	--	--	--	--	--	--	--	--
151..	--	--	110	1,500	5	760	.001	--	<.0003	<.0003	--	--	--
152..	--	--	--	--	--	--	<.0020	--	<.0020	<.0040	--	--	--
153..	--	--	120	1,700	3	930	<.0002	ND	.006	<.0003	ND	ND	ND
154..	--	--	--	135,000	--	--	<.0002	.0068	.00078	.012	--	--	--
155..	--	--	--	--	--	--	--	--	--	--	--	--	--
156..	--	--	--	15,000	--	--	<.002	--	<.001	<.001	--	--	--
157..	--	<.03	76	81,000	4	840	<.0002	.0030	<.0003	<.0003	ND	ND	ND
158..	--	<.03	96	46,000	8	530	.0001	.024	.011	.011	ND	0.0034	ND
159..	--	--	--	3,700	--	--	<.0002	--	<.001	.011	--	--	--
160..	--	--	--	21,000	--	--	<.0002	--	<.001	.004	--	--	--
161..	--	--	--	--	--	--	<.0002	--	<.0003	<.0003	--	--	--
162..	--	--	--	15,000	--	--	.0003	--	<.001	<.001	--	--	--
163..	--	--	--	--	--	--	<.0020	--	<.0020	<.0040	--	--	--
164..	--	--	117	2,800	4	840	.001	ND	<.0003	<.0003	ND	ND	ND
165..	--	--	124	2,700	4	690	<.0002	ND	<.0003	<.0003	ND	ND	ND
166..	--	--	--	5,700	5	955	<.0002	--	<.0003	.001	--	--	--
168..	--	--	128	--	4	815	<.0002	--	<.0003	<.0003	--	--	--
170..	--	--	--	1,400	8	--	<.00015	--	<.0003	<.0003	--	--	--
171..	--	--	--	70,000	--	--	<.0002	--	<.001	<.001	--	--	--

ND Not detected.
[1]Analyzed by Standard atomic absorption techniques (see text for details).
[2]Analyzed by fire assay preconcentration followed by inductively coupled plasma analysis (see text for details).

NOTE. -- indicates sample was not analyzed for this element.

TABLE 4. - Whole-rock major oxide analyses of rocks from the Red Mountain ultramafic body and adjacent area

Sample	Al_2O_3, pct	CaO, pct	CO_2, pct	FeO,[1] pct	Fe_2O_3[1], pct	K_2O, pct	LOI, pct	MgO, pct	MnO, pct	Na_2O, pct	P_2O_5, pct	SiO_2, pct	TiO_2, pct	Total pct
1.	2.10	16.0	0.15	--	7.0	<0.10	2.0	19.7	0.12	0.30	0.11	52.0	0.20	99.68
2.	1.10	12.0	.07	--	9.2	<.10	2.0	26.7	.15	.20	.08	47.5	.15	99.15
49.	14.80	1.10	<.02	--	1.20	1.80	.31	.60	.01	6.20	.10	74.5	.10	100.72
74.	.20	.30	.02	--	11.7	<.10	8.0	40.8	.18	<.10	.08	38.0	.10	99.38
111.	1.60	18.5	.02	--	6.3	<.10	2.0	20.0	.10	.40	.10	51.0	.20	100.22
128.	<.20	.30	.36	--	12.6	<.10	8.0	41.0	.18	<.10	.09	38.0	<.05	100.53
132.	1.30	21.0	.18	3.1	2.7	0.6	1.17	19.3	.10	.60	<.01	50.5	.30	100.85
142.	.20	.55	.02	--	11.0	<.10	8.0	41.0	.17	<.10	.09	39.0	.05	100.08
143.	1.50	18.5	.07	--	6.1	<.10	2.0	20.4	.11	.20	.09	50.0	.15	99.12
149.	.20	.30	.29	--	12.7	<.10	7.0	39.5	.19	<.10	.09	39.0	.05	99.32
151.	<.20	.35	.02	--	13.0	<.10	7.0	41.0	.19	<.10	.10	38.5	.05	100.21
153.	.20	.20	.15	--	12.3	<.10	9.0	41.4	.19	<.10	.09	36.5	.10	100.13
164.	.20	.60	.02	--	12.5	<.10	8.0	40.0	.19	<.10	.10	37.5	.10	99.21
165.	.20	.20	.22	--	13.6	<.10	7.0	39.0	.21	<.10	.06	38.0	.05	98.54
166.	.04	.39	.06	5.75	4.28	.01	11.0	43.41	.27	.02	.10	36.0	<.05	101.33
170.	.19	1.65	.05	7.12	3.96	.01	8.0	41.83	.31	.03	.10	38.0	<.05	101.25
876[2].	5.50	16.3	0.0	4.40	4.45	.45	1.65	16.0	.14	1.00	.10	48.2	.66	98.85
878[2].	4.40	16.3	0.0	7.45	13.5	.10	.65	13.5	.12	.25	.06	40.8	1.55	98.68
881[2].	12.50	12.0	0.0	6.45	5.3	1.1	1.40	12.5	.10	2.2	.39	44.0	1.42	99.36
882[2].	7.6	14.8	0.0	8.2	11.7	.65	.75	12.0	.14	1.1	.12	41.3	1.34	99.70
883[2].	3.7	17.5	0.0	4.9	4.7	.10	2.35	17.7	.12	.25	.02	46.8	.61	98.75

[1]Where FeO is not reported, total iron is reported as Fe_2O_3.
[2]Data courtesy of Anaconda Minerals Company.
NOTE. -- indicates sample was not analyzed for this chemical compound.

TABLE 5. - Forsterite (Fo)[1] content of olivine in selected rock samples from the Goodnews Bay Ultramafic Complex

Sample	Fo content	Sample	Fo content
2.....	79	123....	87
7.....	88	127....	90
23.....	92	128....	92
37.....	90	130....	89
38.....	91	141....	91
42.....	82	146....	87
47.....	88	149....	90
48.....	87	151....	90
50.....	89	153....	88
52.....	90	157....	89
60.....	88	158....	86
74.....	89	164....	91
79.....	86	165....	89
114.....	82	169....	88

[1]Atomic ratio of Mg to total octahedral cations (see text for description of analytical procedure).

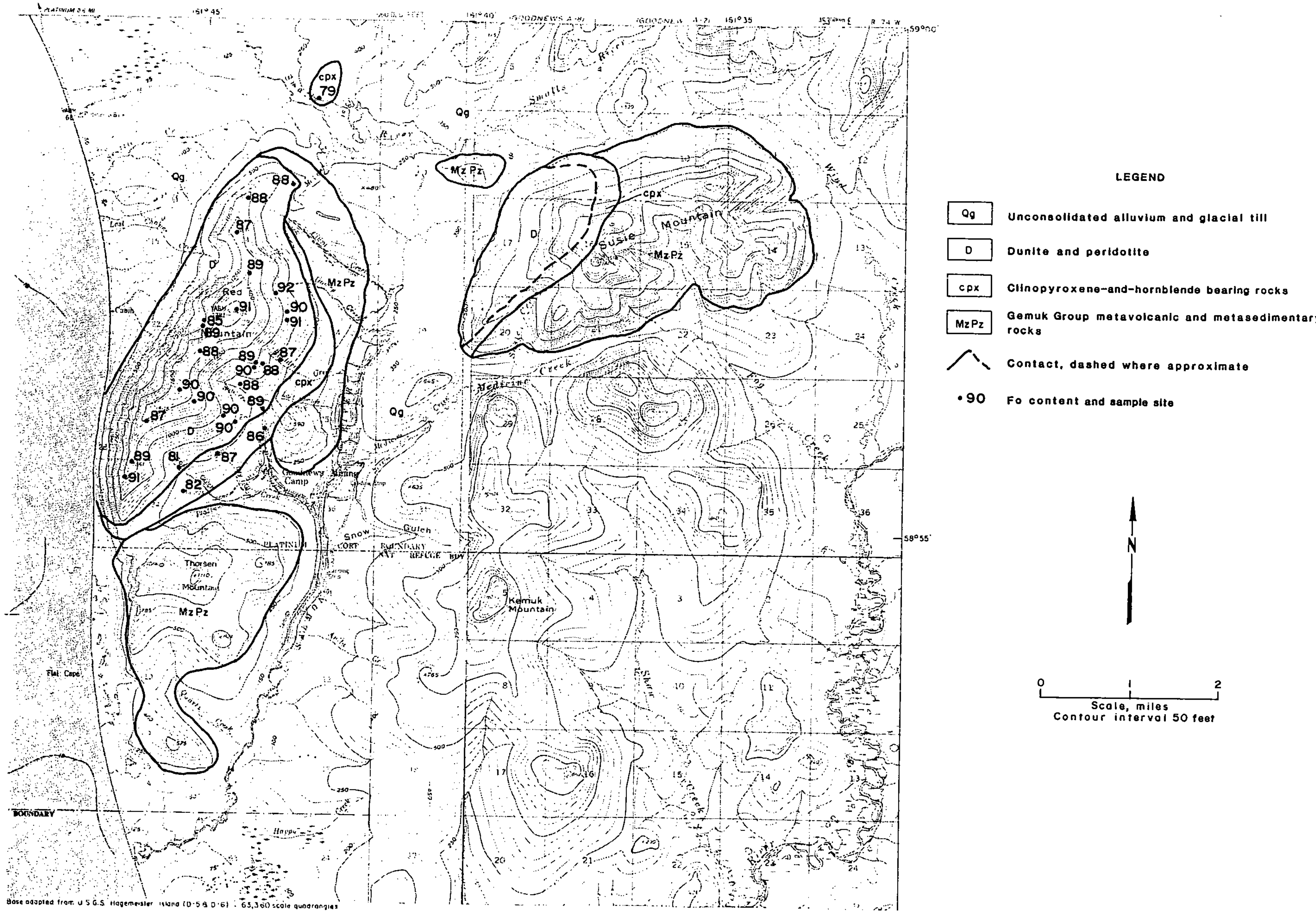


FIGURE 7. -- Distribution of forsterite (Fo) content of olivines in the Goodnews Bay ultramafic complex

REGIONAL GEOLOGY

The Goodnews Bay and surrounding areas in southwestern Alaska are dominated by sedimentary and volcanic rocks assigned to the Gemuk Group, a largely undifferentiated unit that ranges in age from Carboniferous through Early Cretaceous (9). Even though the Gemuk Group has been subdivided elsewhere in southwestern Alaska (17-20) into three unnamed units of Paleozoic to Mesozoic, Jurassic to Early Cretaceous, and early Cretaceous ages, the rocks adjacent to the Goodnews Bay ultramafic complex remain as rocks of undifferentiated Paleozoic and Mesozoic age (MzPz on fig. 2) (20).

LOCAL GEOLOGY

The Gemuk Group, where exposed by dredging and dragline excavation in Platinum and Clara Creeks, consists of light-colored chert, argillite, and volcanic rock, or their metamorphic equivalents. An examination of a limited number of thin sections of rocks of the Gemuk Group revealed them to have been amphibolitized for a distance of at least 200 feet outward from the contact with the ultramafic complex.

Intrusive Igneous Rocks

The main exposed intrusive bodies in the study area crop out on Red Mountain and the northern half of Suzie Mountain. Lesser bodies of intrusive rock are present either as apparent fault slices of the complex or as rare dikes adjacent to Red Mountain. The intrusive rocks are generally ultramafic in composition and have been divided into mappable units of dunite, wehrlite, magnetite clinopyroxenite, hornblende clinopyroxenite, and hornblendite (see figs. 2, 8) based on their relative content of olivine, clinopyroxene, magnetite, and hornblende.

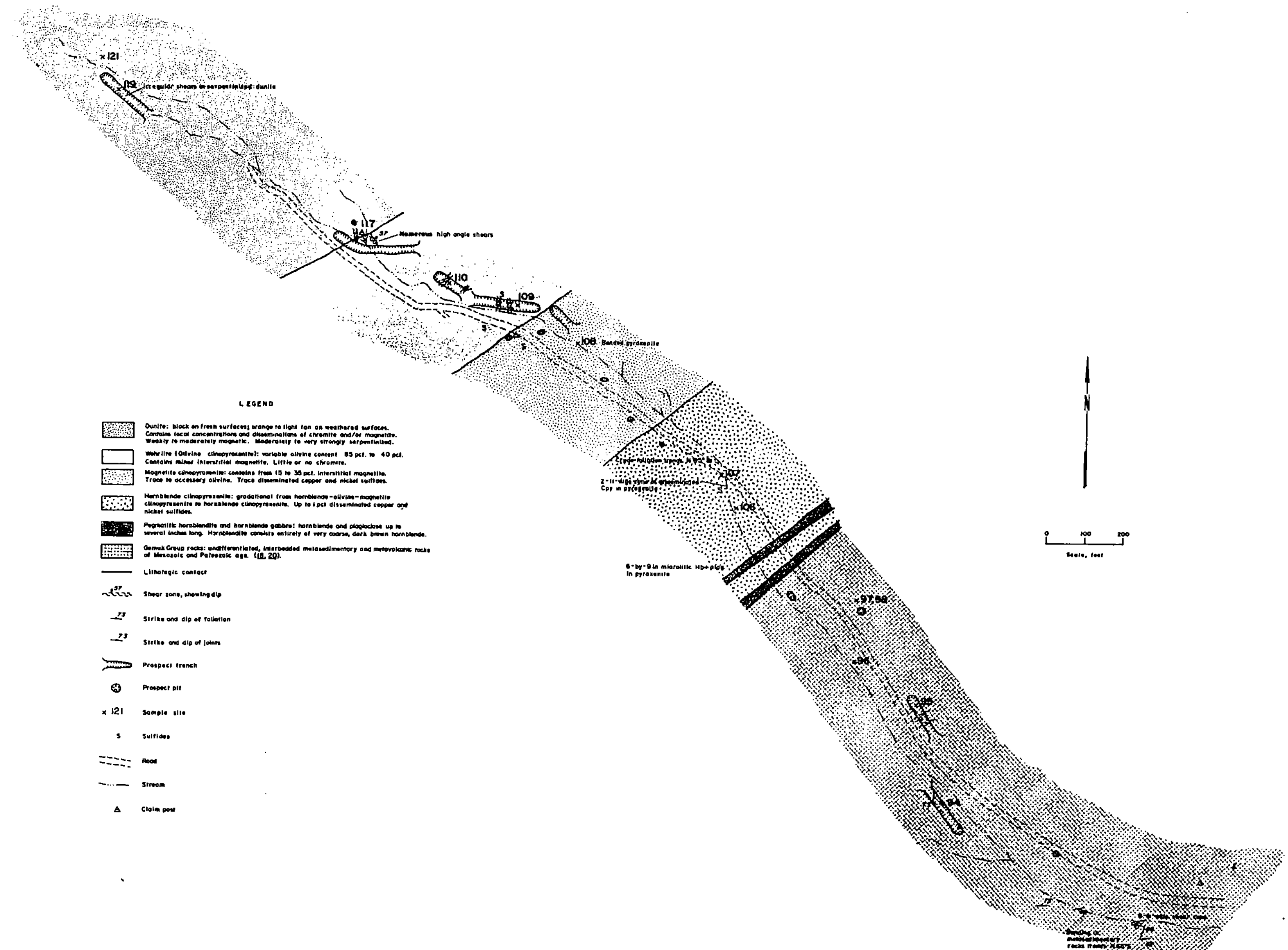


FIGURE 8. -- Geologic map of Fox Gulch

Dunite

Dunite constitutes more than 80 pct of the exposed ultramafic rocks. Along the crest of Red Mountain it forms large blocky outcrops. The dunite is dark green to black on fresh surfaces, but commonly has a tan to yellow-orange weathering rind. The weathering rind is generally from 0.1 to 1.0 in thick. Close inspection of the weathered surface, with the unaided eye, reveals the presence of a fine network of hair-like serpentine veinlets, which stand out in slight relief against the less resistant olivine groundmass. Individual grains of euhedral to subhedral accessory chromite, up to 0.1 in across, are commonly disseminated throughout and usually constitute less than one pct of the rock. Rarely, small pods (fig. 9) or schlieren of massive chromitite, up to 10 in wide by 1.5 ft long have been found. Less frequently, magnetite schlieren (fig. 10) are seen in the dunite. The magnetite and chromite grains are usually subhedral and fairly coarse-grained (0.10 to 0.25 in across).

In thin section, the dunite is composed of medium- to coarse-grained, anhedral olivine grains. In some of the dunite the olivine is recrystallized, resulting in overgrowths of a second generation of olivine over the original olivine grains. The later generation of olivine tends to be from three to ten times coarser than the original olivine, often poikilitically enclosing earlier-formed olivine grains, and only rarely contains chromite. In general, olivine at Red Mountain is untwinned, displays weak undulatory extinction and is not optically zoned. Virtually all of the dunite at Red Mountain is partially serpentinized, with serpentine usually forming from 10 to 60 pct of the rock. Along some minor fault zones olivine is entirely

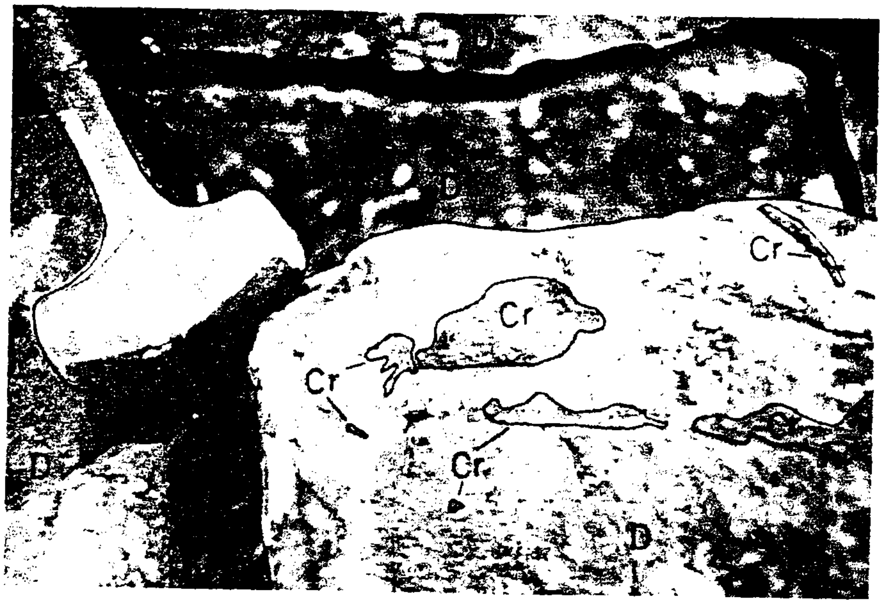


FIGURE 9. - Chromite pods in dunite.

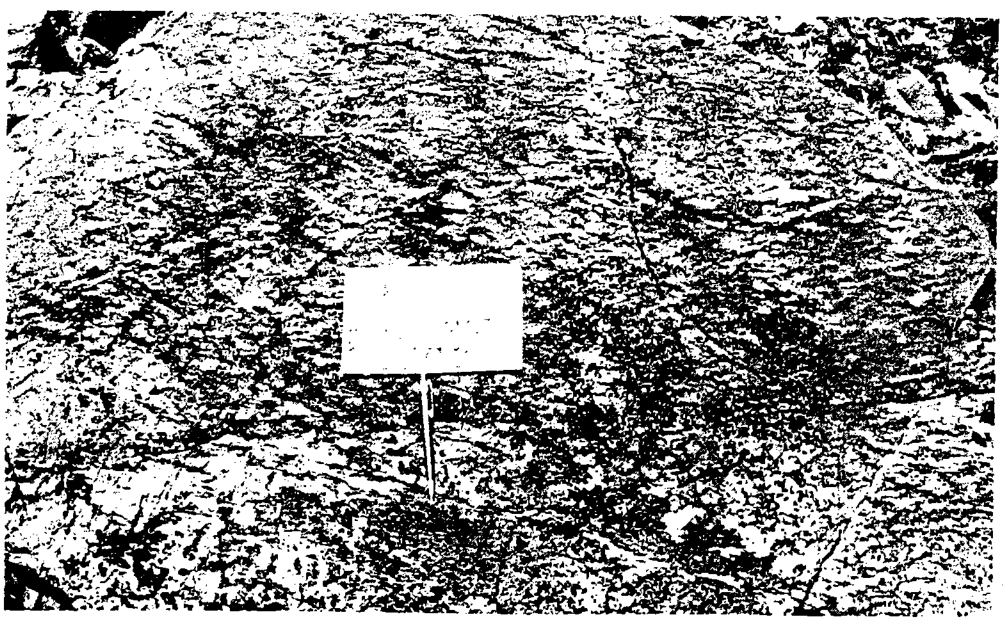


FIGURE 10. - Magnetite schlieren in dunite.

replaced by serpentine minerals. The serpentine veinlets within the dunite are commonly 0.004 to 0.04 in wide and cross olivine grain boundaries. Magnetite that formed during serpentinization occurs as very-finely disseminated grains within the serpentine veinlets and gives the dunite an overall weakly magnetic character. Late-stage veins or dikes of very coarse-grained (>0.4 in) clinopyroxene cut the dunite in many places. On the west side of Red Mountain, a swarm of clinopyroxenite dikes is particularly well exposed in a seacliff (fig. 11). In places, the coarse clinopyroxenite dikes have a core of dark-green to black hornblendite. Clinopyroxene is not as completely serpentinized as olivine in the enclosing dunite, and serpentine veinlets often terminate at clinopyroxene grain boundaries.

FIGURE 11. - Clinopyroxenite dike swarm exposed in dunite along beach on west side of Red Mountain.

Wehrlite

Wehrlite is rare at Red Mountain. It was observed only in limited outcrops in upper Fox Gulch and to the north of the high saddle at the head of Platinum Creek Pass. In figure 2, wehrlite and other ultramafic units that are marginal to the dunite and peridotite core are shown schematically; their distribution is interpreted on the basis of geophysical traverses and limited outcrop and rubblecrop. Although primary wehrlite may be present at Red Mountain, unequivocable examples of it were not observed. At Red Mountain, the "wehrlite" appears to be a product of mixing, as outcrops of wehrlite are characterized by irregular streaks and patches of light gray-green pyroxene-rich inclusions an inch or so across, in a matrix of tan-weathering olivine. Wehrlite is the dominant rock type in the Smalls River body and is also abundant in the Suzie Mountain body.

In thin section (fig. 12), wehrlite is composed of 10 to 40 pct, smooth, anhedral, clinopyroxene grains that are 0.01 to 0.08 in across. Occassionally, round clinopyroxene grains are poikilitically enclosed in larger olivine crystals. Clinopyroxene is commonly twinned. The textural relationship of olivine and clinopyroxene is ambiguous, but is interpreted that olivine replaces clinopyroxene. Olivine occurs not only as large crystals up to 0.2 in across, but also occurs as irregular patches interstitial to clinopyroxene. As in the dunite, olivine is selectively serpentinized. Where interstitial olivine is seen, it is nearly completely replaced by serpentine, and there may be no serpentine in the surrounding clinopyroxene. Chromite is a rare constituent of the wehrlite, and magnetite is restricted to dusty inclusions within the serpentine minerals.

Clinopyroxenite

Outward from the wehrlite, olivine content of the rocks gradually decreases, and both magnetite and hornblende content increases. It

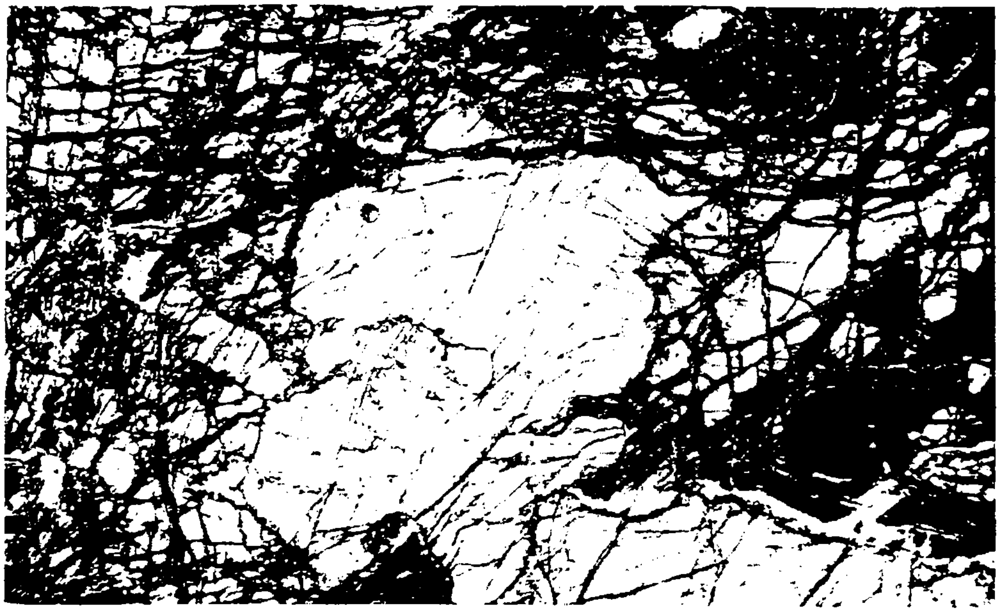


FIGURE 12. - Photograph of wehrlite. High-relief olivine is criss-crossed by serpentine veinlets, while the clinopyroxene characteristically appears relatively unaffected by serpentinization. Plane polarized light. Distance across bottom of photo is approximately 0.1 in.

was impractical to map these gradational variations, therefore they appear as one unit (cpx) on the geologic maps (figs. 2 and 8). Within this unit, combined magnetite and clinopyroxene content is greater than 80 pct. Magnetite clinopyroxenite is best exposed in the stream beds of Fox Gulch and Squirrel Creek. This unit is characteristically grayish-green, medium-grained, and contains 5 to 20 pct disseminated, steel-gray magnetite. In Fox Gulch some clinopyroxenite boulders contain 3- to 4-in-wide crudely-defined bands. Close inspection reveals that the bands are a result of subtle grain size variations and minor differences in olivine content. These banded clinopyroxenites were not observed in outcrop. Magnetite clinopyroxenite with high magnetite content has a dull, metallic gray color. Minor olivine is sometimes seen in hand specimen, and from less than 1 to 2 pct sulfide minerals, including chalcopyrite, pyrrhotite, and pentlandite are common. Although it is not well exposed in outcrop, the very strong magnetic signature of this unit makes the magnetite clinopyroxenite readily traceable with a magnetometer in covered areas.

The magnetite clinopyroxenite, in thin section (fig. 13), is composed of 65 to 85 pct irregular, anhedral clinopyroxene grains, usually 0.01 to 0.08 in across, but as large as 0.2 in. The clinopyroxene is commonly twinned. Magnetite occurs as large irregular, interstitial patches, up to 0.2 in across, that may entirely surround several smaller clinopyroxene grains. Olivine is a minor constituent, usually less than 5 pct, of the magnetite clinopyroxenite and occurs as isolated grains up to 0.08 in across.

FIGURE 13. - Photomicrograph of magnetite clinopyroxenite. The black areas are magnetite; light areas are clinopyroxene. The distance across bottom of photograph is approximately 0.1 in.

In most cases the olivine in magnetite clinopyroxenite has been partially to completely replaced by serpentine. Hornblende is rarely present when magnetite is abundant, and is only observed as irregular patches less than 0.004 in across that have partially replaced clinopyroxene. Serpentine similarly is present only as a replacement mineral in olivine. Epidote and minor calcite occur in late, fracture-filling veinlets up to 0.04 in wide. Sulfide minerals occur as small (0.002 in), irregular patches within clinopyroxene grains and as aggregates of anhedral grains marginal to interstitial magnetite.

Hornblende clinopyroxenite

Hornblende clinopyroxenite, where it is exposed by mining in lower Fox Gulch, is a transitional unit that grades, over a distance of approximately 500 ft, from hornblende-olivine-magnetite clinopyroxenite to hornblende clinopyroxenite. The rock is dark gray-green, medium-grained, and equigranular, with a weakly to strongly magnetic character. Olivine and magnetite contents of the unit decrease gradually towards the margins of the complex with olivine disappearing first. Thin section examination reveals that the olivine content in this unit varies from 0 to 4 pct and the olivine is serpentinized. Magnetite occurs as disseminated irregular and round grains, about 0.008 in across. Hornblende is yellow-green to dark olive-green in plane polarized light. Near the magnetite clinopyroxenite unit, the hornblende content is relatively low (less than 5 pct). It first occurs as small patches less than 0.004 in across within, and as irregular fringes on, clinopyroxene grains. As the hornblende content increases, hornblende entirely replaces and forms pseudomorphs of the original clinopyroxene grains (fig. 14). Rare, interstitial

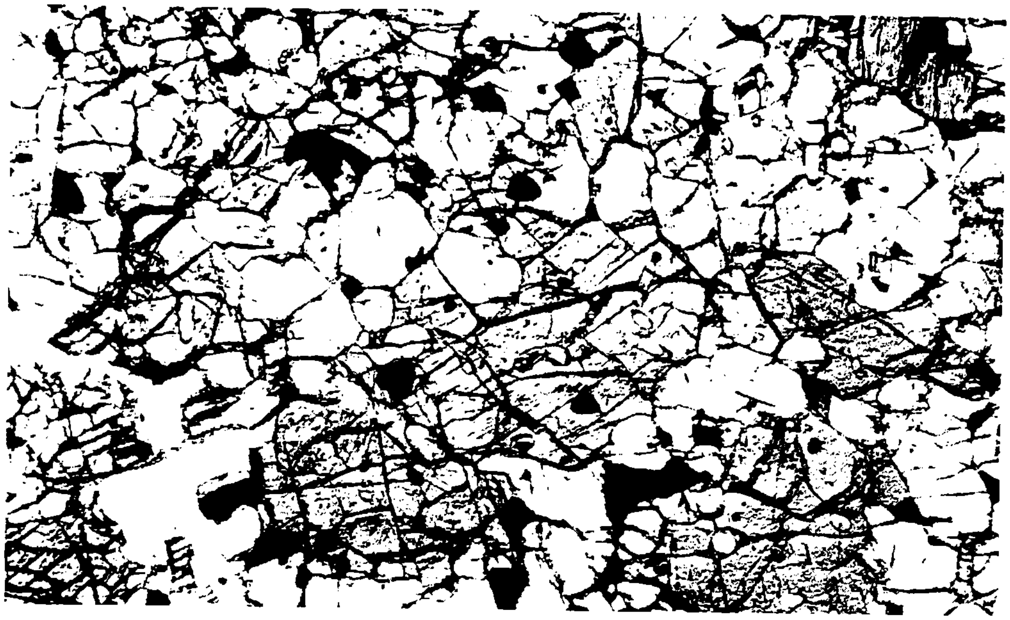


FIGURE 14. - Photomicrograph of magnetite-hornblende clinopyroxenite. Magnetite is black, hornblende appears medium gray, clinopyroxene appears white. Plane polarized light. Distance across bottom of photograph is approximately 0.1 in.

plagioclase feldspar is present, commonly surrounded by coarse-grained hornblende. Serpentine occurs only in olivine grains. Chromite was not observed in this unit, and the sulfide minerals pyrrhotite, pentlandite, and chalcopyrite are present only in trace amounts.

Hornblendite and Hornblende Gabbro

Hornblendite and pegmatitic hornblende gabbro occur as dike rocks near the contact of the intrusive complex with the surrounding rocks of the Gemuk Group. They are best exposed in the stream beds of Fox Gulch and Squirrel and Dowry Creeks. Although grouped here for convenience, the hornblendite and pegmatitic hornblende gabbro probably represent different crystallization episodes, with the hornblende gabbro being the later event.

The hornblendite is characterized by very coarse-grained crystals (up to 6 in long) of dark-green to greenish-black hornblende. In thin section, the randomly oriented hornblende crystals are strongly colored (light-green to dark-green), and are usually broken.

The hornblende gabbro contains very coarse-grained, euhedral hornblende crystals, with 40 to 50 pct interstitial and anhedral plagioclase. Microscopically, the hornblende is similar in color to that in the hornblendite. Plagioclase is very strongly altered to epidote and prehnite. Coarse-grained (to 0.08 in) sphene crystals and finely disseminated magnetite are present in trace amounts.

The abundant pegmatitic hydrous mineral phase (hornblende) in hornblendite at the contact of the outer zone of the intrusive complex, coupled with the abundant, late hornblende in the country rock suggests that the hornblende probably formed by contact metasomatism during emplacement of the clinopyroxenites. Other workers (4, 27, 40-41) have previously suggested this and Irvine (22) reports that similar pegmatitic hornblendites occur at or near the intrusive contacts of the Duke Island ultramafic complex in southeastern Alaska.

Leucocratic Tonalite

Leucocratic tonalite occurs as rubble near a dunite outcrop above the divide between Squirrel and Boulder Creeks. Tonalite was not observed in outcrop, but was seen only as small, angular to subangular boulders and cobbles scattered along the hillside for a few tens to hundreds of feet. It is beige on weathered surfaces and white on fresh surfaces. The rock is composed of medium to coarse grains of plagioclase and quartz, with 3 to 5 pct disseminated, irregularly shaped, fine-grained biotite.

Thin section examination (fig. 15) revealed that the leucocratic tonalite is composed of subhedral and euhedral plagioclase and quartz crystals, 0.04 to 0.08 in across. Plagioclase forms roughly 60 pct of the rock, and has a composition of An_{45}. It is only slightly altered to white mica or clay minerals. Quartz makes up about 35 pct of the rock. Biotite usually occurs as irregular grains interstitial to quartz and feldspar. The biotite has a fibrous or shredded habit and is apparently psuedomorphic after pyroxene, amphibole, or an earlier generation of biotite. Trace amounts of sphene are also present.

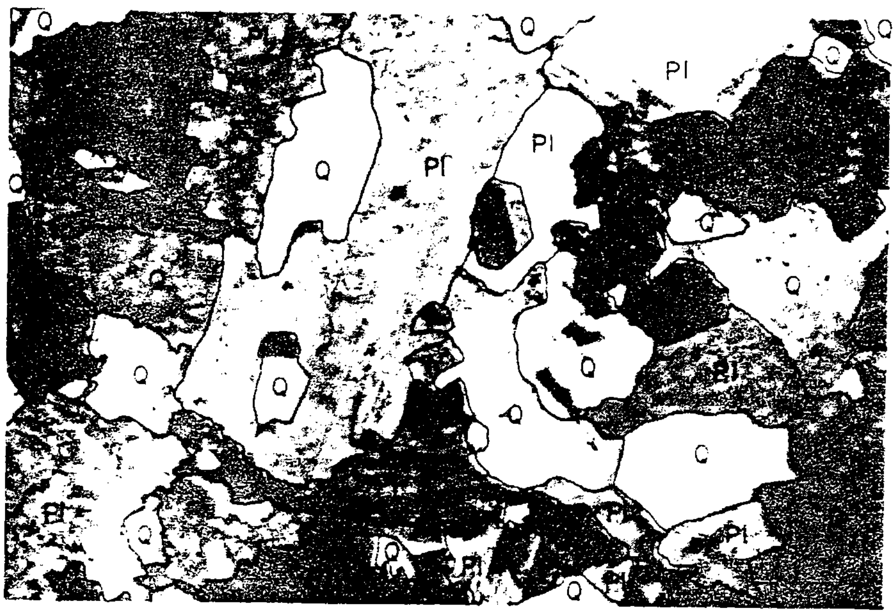


FIGURE 15. - Photomicrograph of leucocratic tonalite (Pl - plagioclase, Q - quartz, B - biotite). Crossed nichols. Distance across bottom of photograph is approximately 0.1 in.

CHEMISTRY AND OLIVINE MINERALOGY OF ULTRAMAFIC ROCK SUITE

Introduction

Whole-rock major oxide analyses and olivine mineralogy were done to establish the similarity or dissimilarity of the Goodnews Bay complex with the platiniferous, Alaskan-type ultramafic complexes or ophiolitic rocks.

Major Oxides

Twenty-one rock samples from the ultramafic complex and immediately adjacent rocks were collected for whole-rock chemical analyses of major oxides (table 4).

Figure 16 is a plot of the AFM ratios for rocks from the Goodnews Bay complex, the Alaskan-type Duke Island complex (34), and two ophiolite complexes (12). Comparison of these plots indicates that rocks from the Goodnews Bay complex follow an iron-enrichment trend very similar to that of rocks from Duke Island.

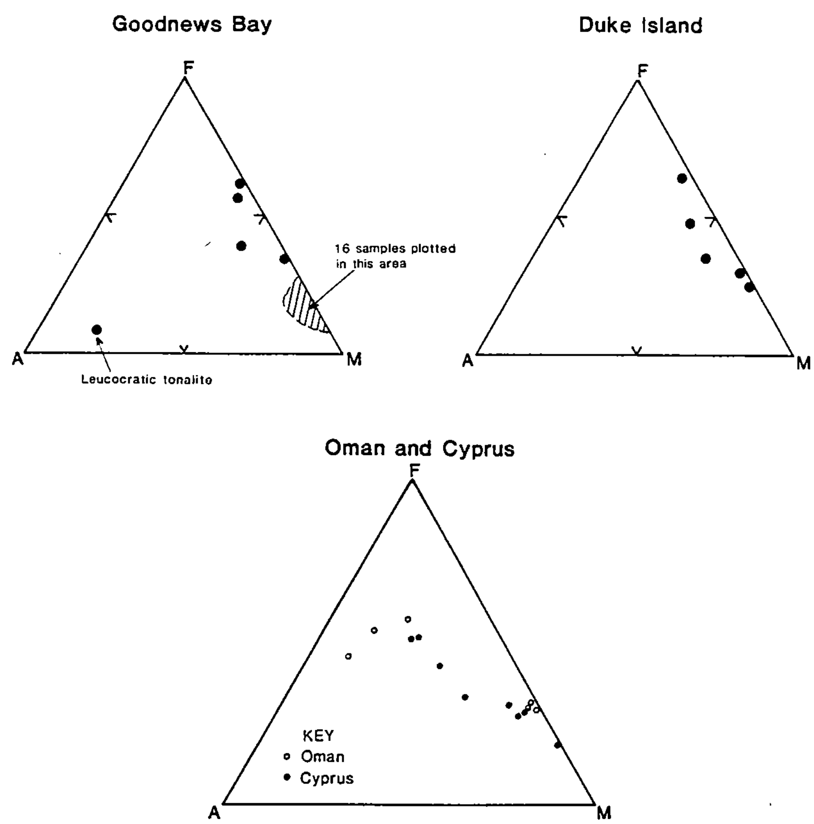


FIGURE 16. - Alkalies-FeO-MgO diagram of rocks from the Goodnews Bay complex and comparative rock suites.

Olivine Mineralogy

X-ray diffraction studies of olivine from 28 samples of the various rock types in the complex were made to determine if significant olivine compositional variations exist within the complex. The analytical results are listed in table 5, and the distribution of forsterite content is shown on figure 7.

Olivines in the Goodnews Bay ultramafic suite range from Fo_{79} (79 pct forsterite [Mg_2SiO_4]), in hornblende-olivine clinopyroxenite, to Fo_{92}, in dunite from the central portion of the complex. In general, olivine in the more olivine-rich rocks tends to have higher Fo content than olivine in rocks containing pyroxene or hornblende.

ECONOMIC MINERALS

Gold

The dredging operation in the Salmon River Valley recovers placer gold in addition to PGM. Historically, the ratio of gold to PGM in the concentrates has been roughly 1:10 (29). Most of the gold recovered from the Salmon River Valley is well-rounded and worn and was probably derived from glacial material near the divide between the Salmon and Smalls Rivers (30). However, at least a small portion of the gold is apparently derived from Red Mountain itself, as indicated by: (1) the chemical analyses of dunite and other rocks reported in table 3; (2) intergrown PGM alloy and gold in placer concentrates; and (3) by the occasional, though rare, presence of gold in panned concentrates (table 1) collected from creeks on Red Mountain above their confluence with the Salmon River.

Chromite

Podiform segregations of chromian spinel in the Goodnews Bay ultramafic complex are erratically distributed throughout the dunite and are typically small. Microprobe analyses of chromian spinels were performed by the Bureau's Reno Research Center and indicate that the spinel is an Fe-rich chromite, with average Fe/Fe+Mg ratios of about 0.90 and Cr/Cr+Al ratios of about 0.78. Dunites contain from less than 1 to 2 pct chromite as disseminated grains and rare pods and schlieren (fig. 9). Occassionally massive chromite schlieren up to a foot long were observed, and one sample (154, table 3) high-graded from a chromite pod contained 13.5 pct Cr; chromite is slightly more abundant in dunite rubble and float at the heads of Fox Gulch and Squirrel Creek. Even in times of national emergency, however, concentrations such as these would probably not constitute a domestic chromite resource, as numerous larger, higher-grade sources of chromite are available in Alaska (14) and elsewhere in the U.S.

Copper and Nickel Sulfide Minerals

Disseminated copper and iron-nickel sulfide minerals including chalcopyrite, pyrrhotite, and pentlandite were observed in the narrow clinopyroxene- and hornblende-bearing outer zones at the southern end of the ultramafic complex. This mineral association is best observed in the Fox Gulch-Squirrel Creek area. The two highest Cu values obtained from rock samples, 1,460 and 640 ppm, (table 3, samples 108 and 109, respectively) were from samples of magnetite clinopyroxenite with accessory pyrrhotite, pentlandite, and chalcopyrite. Although these anomalous Cu values are associated with anomalous Pd values (.0005 and .0022 oz/ton), even in combination they do not approach economic concentrations. Similarly, nickel sulfides do not represent economic nickel concentrations even though they may be associated with slightly anomalous levels of PGM in some of the rock samples from Red

Mountain. A 30-lb sample of sulfide-bearing magnetite-hornblende clinopyroxenite was collected from rubble crop between Fox Gulch and Squirrel Creek to determine if PGM are associated with copper and iron-nickel sulfides at that location. Head analyses indicated that 0.05 pct Cu, 15.7 pct Fe, 0.026 pct Ni, and no detectable PGM were present. Because of the low grade, no attempts were made to concentrate sulfide minerals and PGM in the laboratory. Chemical analyses of the few stream sediment samples (table 2) collected in the study area did not indicate anomalous levels of Cu or Ni. It is possible that in the Fox Gulch-Squirrel Creek area Cu, Ni, and PGM grades increase beneath the surface in more sulfide-rich and unweathered magnetite clinopyroxenite and hornblendite.

Magnetite

Volumetrically, magnetite clinopyroxenite constitutes a very small portion of the Goodnews Bay ultramafic complex. Very rarely did magnetite constitute twenty percent of any sample, and generally it makes up less than 5 percent of the magnetite clinopyroxenite. Magnetite concentrations in dunite, such as that shown in figure 10, are very rare and are insignificant as a potential source of iron.

Platinum-Group Minerals

Platinum-group metals have chemical affinity for some oxide minerals, notably magnetite and chromite (8). Mertie reports (28, p. 53) that on one property in the Ural Mountains in the U.S.S.R. a mass of high-grade chromite-platinum ore, only about 7 feet long, produced 965 oz of native platinum metals. The following evidence suggests a preferential association of PGM with chromite and magnetite at Red Mountain. Mertie (27-28) noted that some of the larger PGM nuggets

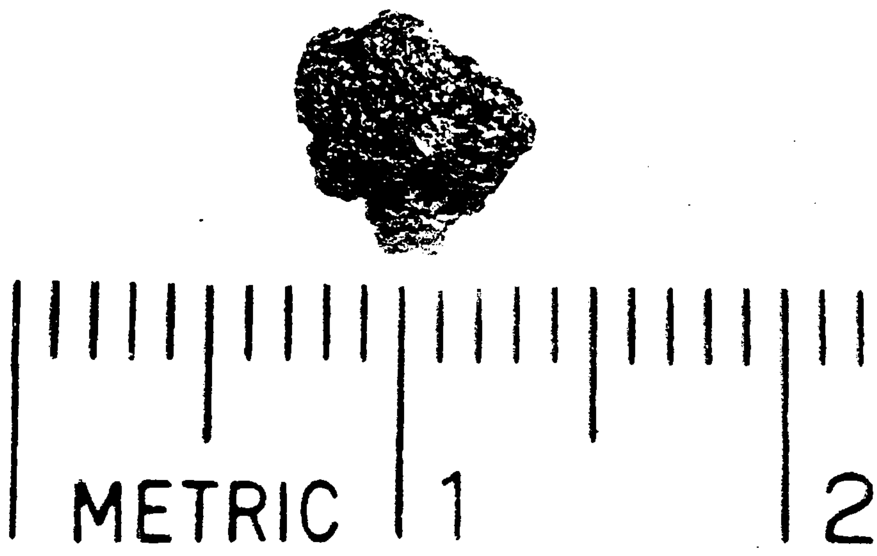


FIGURE 17. - Placer nugget from Salmon River, showing intimate intergrowth of crystalline PGM (light gray) and chromite (black). Labeled scale units are millimeters (0.039 in) divided into tenths.

found in the placers are intergrown with chromite (fig. 17) and chromite from the Goodnews placer concentrates contains about 0.05 oz of PGM/ton (27). Bird and Clark (4) reported a platinum alloy inclusion in chromite in a sample of dunite from Red Mountain, and Ulrich (35) reported a PGM grain in olivine from Red Mountain, occurring immediately adjacent to a chromite grain. Scanning electron microscope and spectrographic studies by the U.S. Geological Survey (36) on magnetite and magnetic concentrates from placer deposits in the Goodnews Bay district confirm the presence of PGE with magnetite.

During the present investigation chromite segregations were sampled and analyzed for PGM. Of all the rock samples analyzed (table 3) the seven samples containing the greatest PGM were either high-graded from chromite segregations or were samples of dunite with large amounts of disseminated chromite. Other circumstantial evidence linking PGM and chromite at Red Mountain are: (1) the presence of small chromite pods and stringers in dunite rubble above the heads of Fox Gulch and Squirrel Creek, the two richest PGM producing creeks draining Red Mountain; (2) the presence of PGM in eluvial material (samples 42P, 43P, table 1) adjacent to a relatively chromite-rich area on the Red Mountain ridge crest; and (3) the above-mentioned intergrowths of PGM and chromite in nuggets found in the local placers. The correlation is not perfect, however, because samples with elevated levels of chromite do not always contain higher levels of PGM.

Even though there is an association of PGM (especially platinum) with chromite at Red Mountain, chromite and associated PGM are not sufficiently concentrated in exposed rock in the ultramafic complex to constitute a viable lode source of PGM. Relatively chromite-rich dunite at the head of Fox Gulch and Squirrel Creek may be underlain by anomalously chromite- and PGM-rich dunite.

There is also evidence of a PGM-magnetite association at Red Mountain. This is suggested by: (1) observed placer nuggets with intergrown magnetite and PGM (fig. 18); (2) high PGM content of magnetite nuggets (samples 17, 34, and 84, table 3) collected from tailings piles near the Goodnews Mine camp; (3) PGM content of black sands (samples 85-89, table 3) collected along the beach adjacent to Red Mountain; and (4) the historic liberation of PGM from magnetite by crushing and milling the "iron ores" (28).

The greatest concentrations of magnetite in dunite were observed as wisps or schlieren up to 3 ft long (fig. 10) in the central portion of the complex. Within the dunite, however, magnetite concentrations

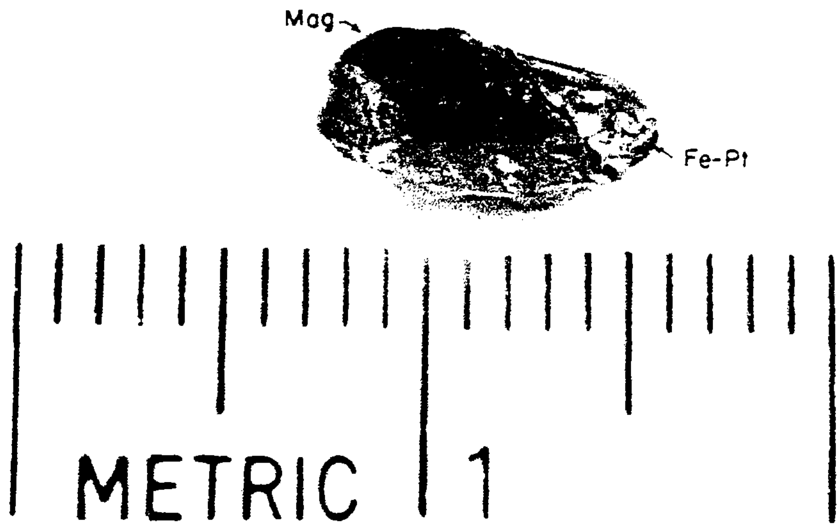


FIGURE 18. - Placer nugget with intergrown magnetite (Mag) and ferroplatinum alloy (Fe-Pt). Labeled scale units are millimeters (0.039 in) divided into tenths.

distinct from chromite are extremely rare. The likelihood of such concentrations constituting significant PGM deposits is very low. Although a number of magnetite clinopyroxenite samples contain significant levels of PGM, it is suspected that the PGM in those cases are associated with sulfide minerals.

Disseminated sulfide minerals, notably chalcopyrite and pyrrhotite with minor exsolved pentlandite, are present at Red Mountain in clinopyroxenite and hornblendite border phases. Because PGM are known to be associated with copper sulfides elsewhere (eg., Sudbury, Ontario and Salt Chuck, Alaska), a number of sulfide-bearing rock samples were analyzed. As shown by the results of the analyses (table 3), many of the clinopyroxenites contain PGM. The sulfide-bearing rocks that contain detectable PGM tend to have higher Ir:Pt and Pd:Pt ratios than do the PGM from the dunite. Cabri (8, p. 61) notes an almost universal tendency of some sulfides to concentrate Pd. The preferential enrichment of Ir and Pd in sulfides, as compared to chromite, and the association of sulfides with the clinopyroxenites and hornblendites at Red Mountain may explain why, as noted by Mertie (29, p. 88), the ratio of Ir:Pt in the placer gravels increases as one moves from the northern end of the Salmon River paystreaks to the southern end (fig. 19). Those creeks which contain relatively higher levels of Ir and Pd in the platinum minerals are creeks which flow over the relatively sulfide-rich clinopyroxenite and hornblende-bearing outer zones of the complex. Although there is an apparent association of anomalous PGM values (especially palladium) with sulfides, no concentrations of sulfide minerals approaching economic grade were observed.

Comparison of PGM in the Goodnews Bay Complex With Other Mafic-Ultramafic Complexes in Alaska

Table 6 summarizes the PGM content of rocks from the Goodnews Bay complex and eight other mafic-ultramafic complexes in Alaska. All but the Seldovia complex contain PGM, and palladium was produced from the Salt Chuck complex in southeast Alaska. The following discussion is based on data contained in tables 6 and 7, which show the distribution of samples containing Pt, Pd, Rh, and Ir among the various complexes. For purposes of comparison, these tables include data from the Seldovia and Eklutna complexes, both of which are interpreted by Burns (7) to represent cumulate fractionates of a volcanic island arc. Similarly, Findlay (13), Irvine (23), and Clark (11) interpret

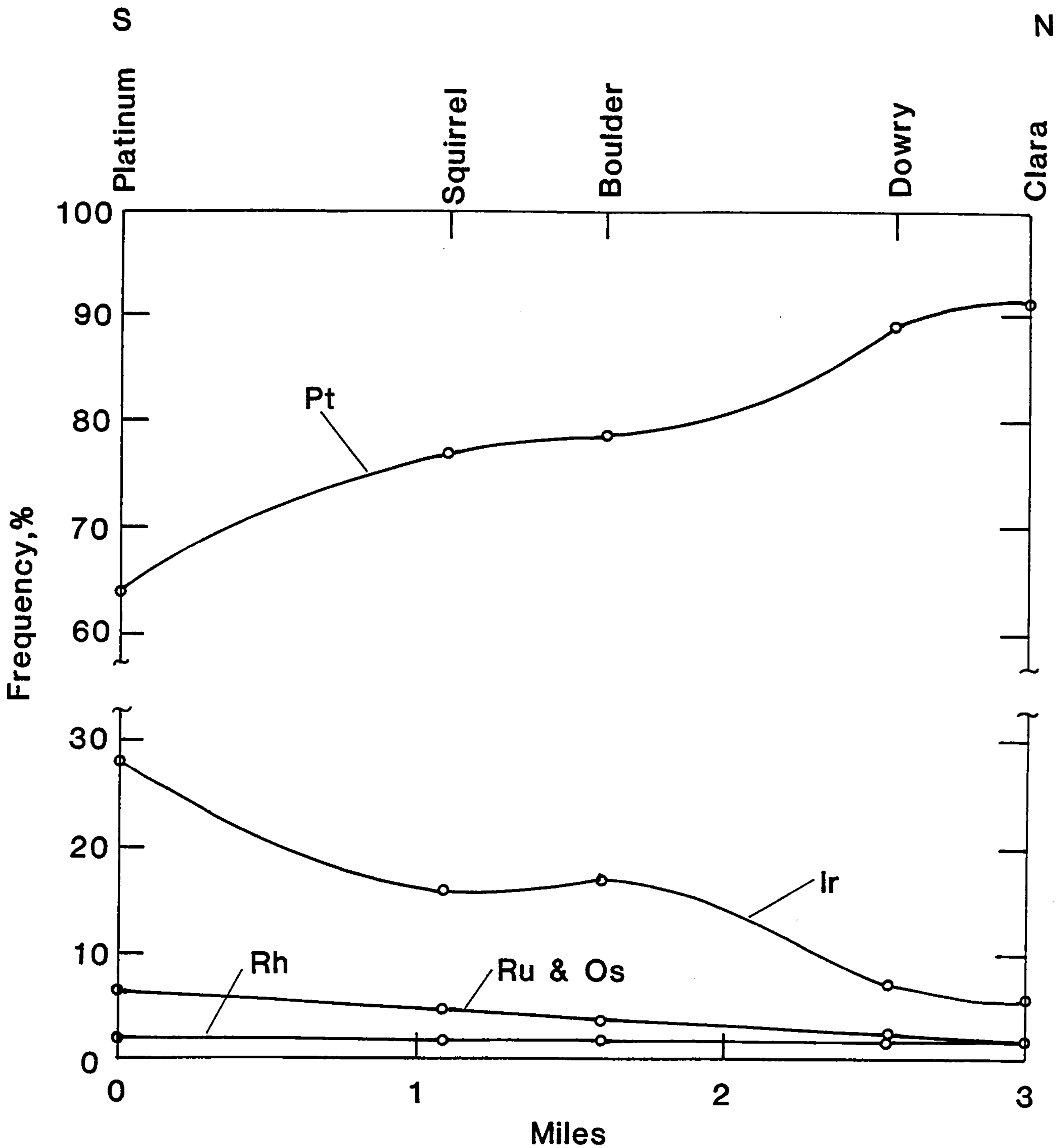


FIGURE 19. - Variation in composition of platinum metals in streams that drain Red Mountain ridge, adapted from Mertie (28).

Table 6. - Concentrations, in parts per million, of platinum, palladium, rhodium, and iridium in some mafic-ultramafic complexes in Alaska.

Locality	Platinum		Palladium		Rhodium	Iridium	
	Max	Avg	Max	Avg	Max	Max	Avg
1. Duke Island[1]	0.200	0.037	0.140	0.033	0.010	--	--
2. Union Bay[1]	1.600	.093	.200	.023	.062	0.215	--
3. Blashke Island[1]	.200	.010	.020	.010	--	--	--
4. Eklutna[1]	.100	.042	.140	.060	--	--	--
5. Salt Chuck[1]	.160	.057	2.900	1.010	--	--	--
6. Mount Fairweather[1]	.170	.040	.184	.036	--	--	--
7. Klukwan[1]	.100	.046	.100	.040	--	--	--
8. Goodnews Bay[2]	1.400	.16	.020	.040	.030	.300	--
8. Goodnews Bay[3]	1.681	.047	.515	.034	.117	.823	.037
9. Seldovia[2]	0	0	0	0	0	0	0

[1]Data from Clark and Greenwood (10).
[2]Data from Bird and Clark (4).
[3]Data from samples collected by BOM.

Pt + Pd avg (this report)

.081

Pt/Pt + Pd = 0.58

Table 7. - Distribution of platinum-, palladium-, rhodium-, and iridium-bearing samples from some mafic-ultramafic complexes in Alaska.

Location	Number of samples containing				Total number of samples
	Platinum	Palladium	Rhodium	Iridium	
1. Duke Island[1].......	10	16	6	0	22
2. Union Bay[1].........	21	22	6	2	50
3. Blashke Islands[1]...	8	10	0	0	10
4. Eklutna[1]...........	12	12	0	0	16
5. Salt Chuck[1]........	6	6	0	0	6
6. Mount Fairweather[1].	6	6	3	0	7
7. Klukwan[1]...........	7	7	0	0	10
8. Goodnews Bay[2]......	9	4	6	2	19
8. Goodnews Bay[3]......	14	18	1	8	102[4]
9. Seldovia[2].........	0	0	0	0	51

[1]Data from Clark and Greenwood (10).
[2]Data from Bird and Clark (4).
[3]Data from samples collected by BOM.
[4]Of these, 37 were analyzed for Rh and Ir.

Alaskan-type complexes as crystallized magma chambers of individual volcanoes. Disagreement exists on the interpretation of specific complexes. Bird and Clark (4) imply that the Eklutna complex is of the Alaskan-type and attribute the absence of PGM in the Seldovia complex to an origin different from all of the other complexes.

Data show that anomalous PGM concentrations are variably associated with specific rock types, oxide and sulfide minerals, and major and trace elements in mafic-ultramafic complexes in Alaska. Clark and Greenwood (10) examined the platinum-group metals concentrations of 121 rock samples from seven mafic-ultramafic complexes in southern and southeastern Alaska and found that Pd was associated with bornite in hornblendite at Salt Chuck, and Pt was associated with magnetite in dunite at Union Bay. Bird and Clark (4) analyzed 40 rock samples from the Goodnews Bay complex and concluded that at least some of the PGM at Goodnews Bay is derived from olivine chromitites. Analyses of 102 rock samples from the Goodnews Bay complex during this investigation support Bird and Clark's conclusions regarding the complex. An average of 0.047 ppm Pt in the 102 samples analyzed is comparable to the averages calculated by other workers for other mafic-ultramafic complexes (average 0.010 to 0.093 ppm) in Alaska. The average palladium content (0.034 ppm) in rocks of the Goodnews Bay complex is also comparable to Pd values in the other complexes (average .010 to .060 ppm). This comparison does not include data from the Salt Chuck copper-palladium mine. Both the Bird and Clark study (4) and the present investigation, however, have found that the rocks of the Goodnews Bay complex contain levels of palladium comparable to those of platinum and iridium (table 6). Mertie reported that of the six platinum-group elements (PGE), the placer mining operations at Goodnews Bay have primarily produced platinum, with lesser amounts of iridium and osmium. Historically, combined palladium, rhodium, and ruthenium have constituted less than two percent of the PGM recovered by the Goodnews Bay placer operations. The fact that palladium is not a significant constituent of the placer concentrates is not unusual, even though it is present in the rocks. Jolly (24, p. 687) reports that, worldwide, placer deposits of the platinum-group metals are characterized by the nearly complete absence of palladium. He notes that palladium, and to a lesser extent platinum, rhodium, and ruthenium, go into aqueous solution during placer formation. This results in an apparent depletion in Pd in placer PGM deposits, and a corresponding apparent enrichment of Ir and Os. Although the Goodnews Bay complex may be relatively anomalous in Ir (average .037 ppm), comparisons of Ir with the other complexes are not valid due to the high detection limit for Ir in the Clark and Greenwood study (.100 ppm) compared to the Ir detection limit in the present study (.0034 ppm). Detection limits for the other elements were comparable between the studies.

GEOPHYSICAL INVESTIGATIONS

Introduction

Geophysical investigations were undertaken along the flanks of Red Mountain and in the valleys of the Smalls and Salmon Rivers. The location of the geophysical traverse lines are shown on figure 20. The objectives were two-fold: (1) first, to determine if the apparent zonal arrangement of rock types, suggested by bedrock outcrops in Fox Gulch and Squirrel Creek, are continuous between these two widely

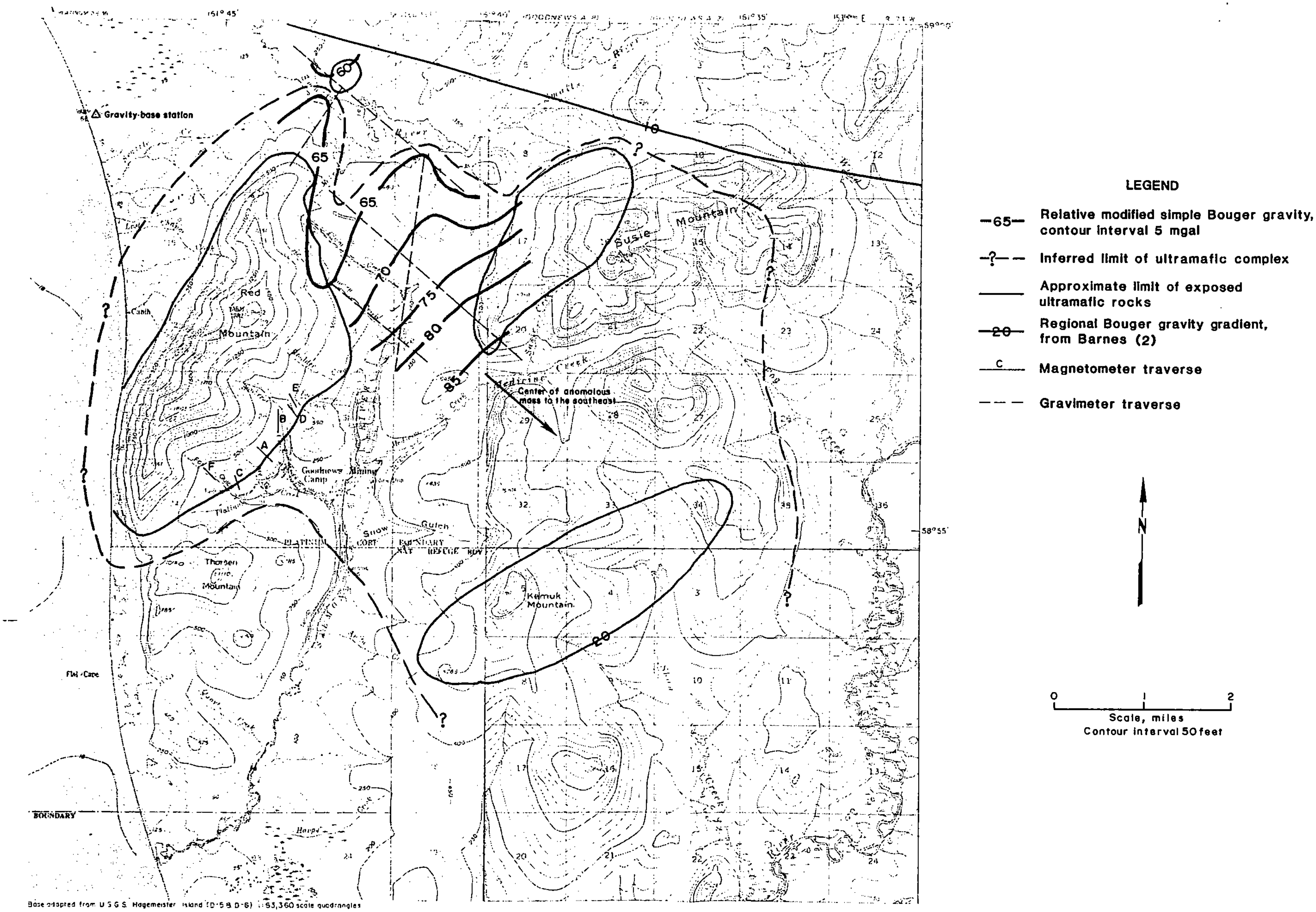


FIGURE 20. -- Location of geophysical traverses and gravity contour map of the Goodnews Bay Complex

separated exposures and (2) to determine whether or not the Red Mountain body is continuous with either the Smalls River ultramafic body or the Suzie Mountain body. Because the magnetite clinopyroxenite and other boundary lithologies have distinct magnetic signatures, they were found to continue beneath the cover between Fox Gulch and Squirrel Creek. The gravity data is less conclusive, two interpretations are presented, and it appears that more of the Salmon River Valley, than previously thought, is underlain by ultramafic rock.

Magnetometer Traverses

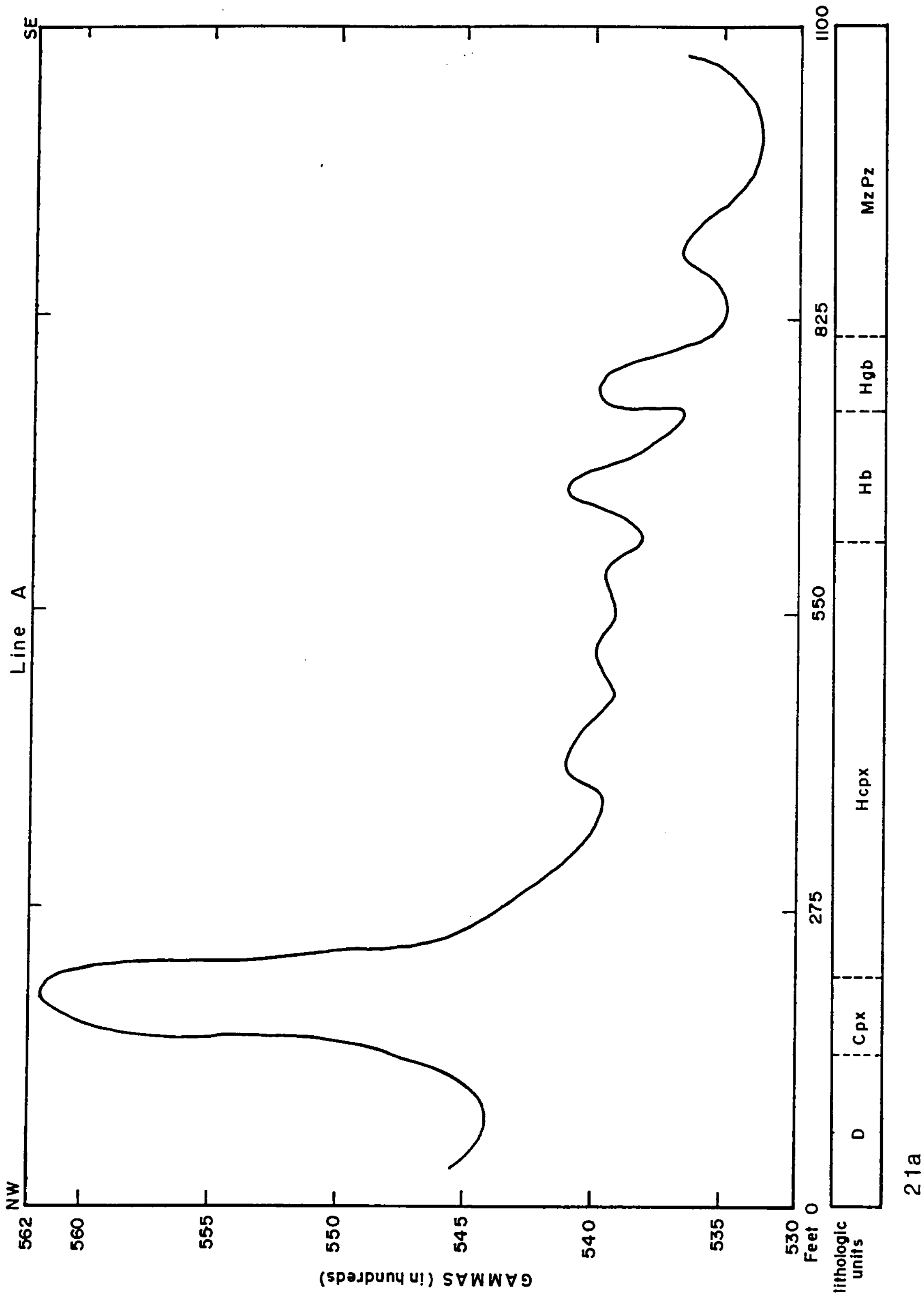
A series of magnetometer traverses was made across the flanks of Red Mountain to trace lithologic contacts in covered areas. The magnetometer surveys were made with a Geometrics[4] proton precession magnetometer. Readings were taken at 25-ft-intervals along northwest-striking lines. Profiles corresponding to each of the magnetometer traverses are shown on figures 21 a-f.

[4]Reference to specific products does not imply endorsement by the Bureau of Mines.

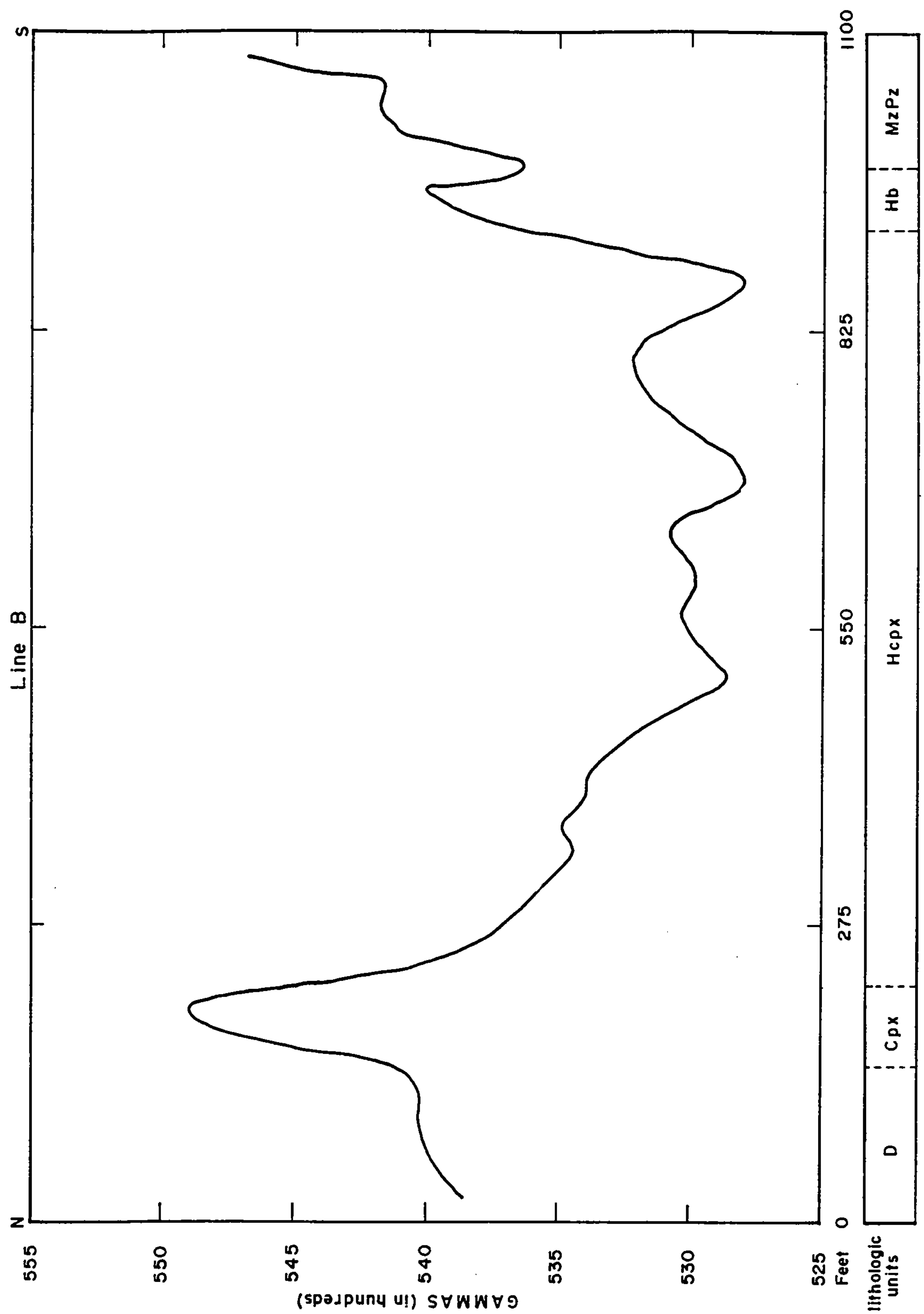
The lithologies of the ultramafic suite are interpreted to have fairly distinct magnetic signatures and are arranged in a regular, roughly concentric, manner, at least on the southern and southeastern margins of Red Mountain.

Gravimeter Traverses

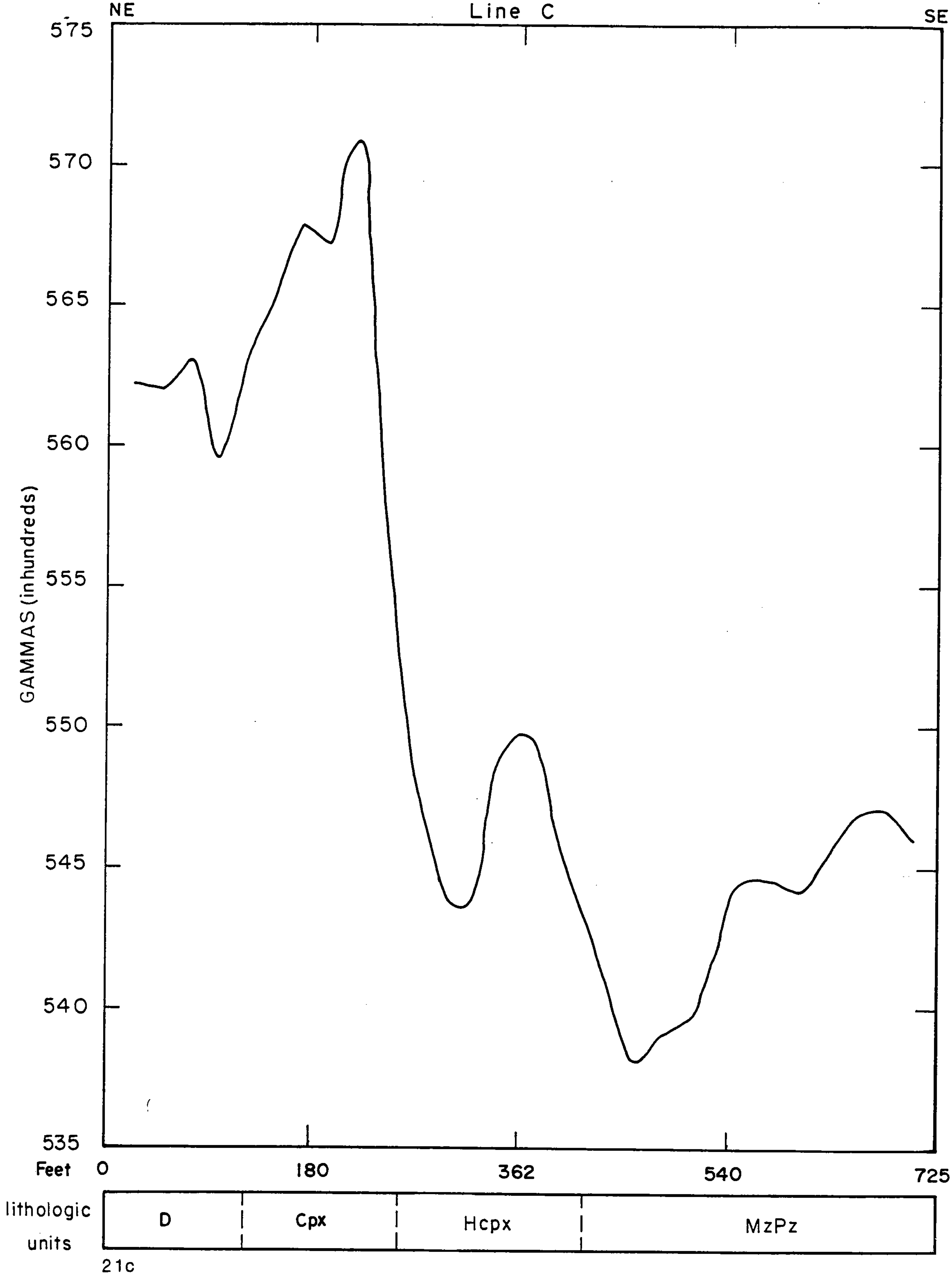
Previous investigations by industry have concluded that both the Smalls River body and the ultramafic portion of Suzie Mountain are probably faulted slivers of the Red Mountain complex. Griscom's (15) aeromagnetic interpretation of the Hagemeister and Goodnews Quadrangles also suggests that Suzie Mountain is a faulted fragment of Red Mountain.



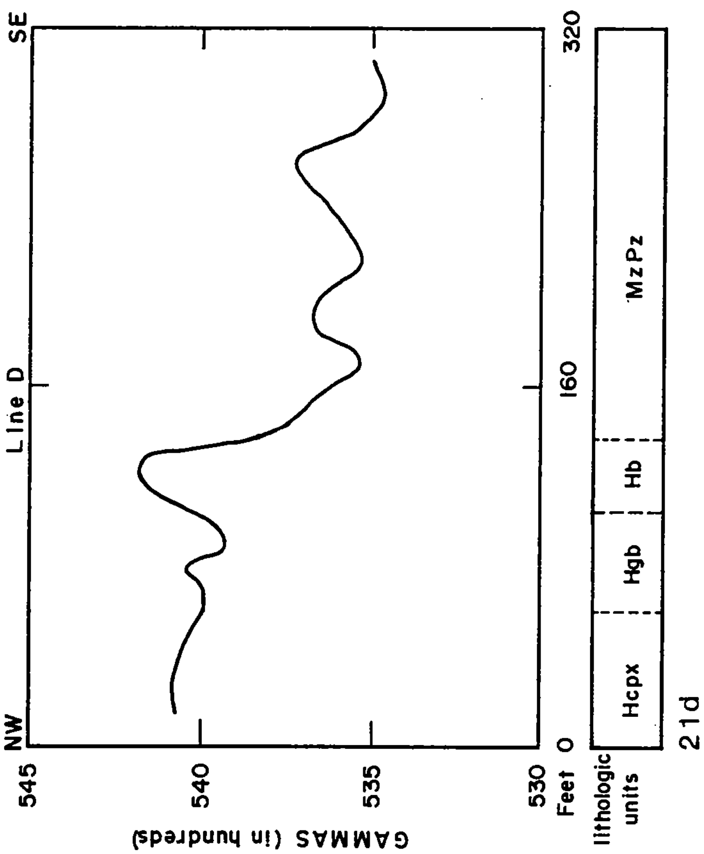
FIGURES 21a-21f. -- Magnetometer profiles with intrpreted geology


Line B
N
S
GAMMAS (in hundreds)
555
550
545
540
535
530
525
Feet
0
275
550
825
1100
lithologic units
D
Cpx
Hcpx
Hb
MzPz

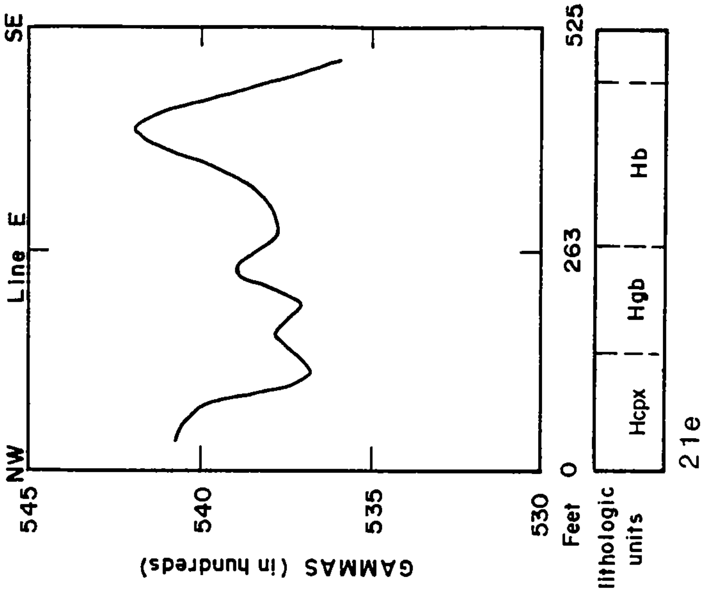
21b



NE
Line C
SE
575
570
565
560
555
550
545
540
535
GAMMAS (inhundreds)
Feet 0
180
362
540
725
lithologic units
D
Cpx
Hcpx
MzPz
21c


GAMMAS (in hundreds)
545
540
535
530
NW
Line D
SE
Feet
0
160
320
lithologic units
Hcpx
Hgb
Hb
MzPz

21d


GAMMAS (in hundreds)
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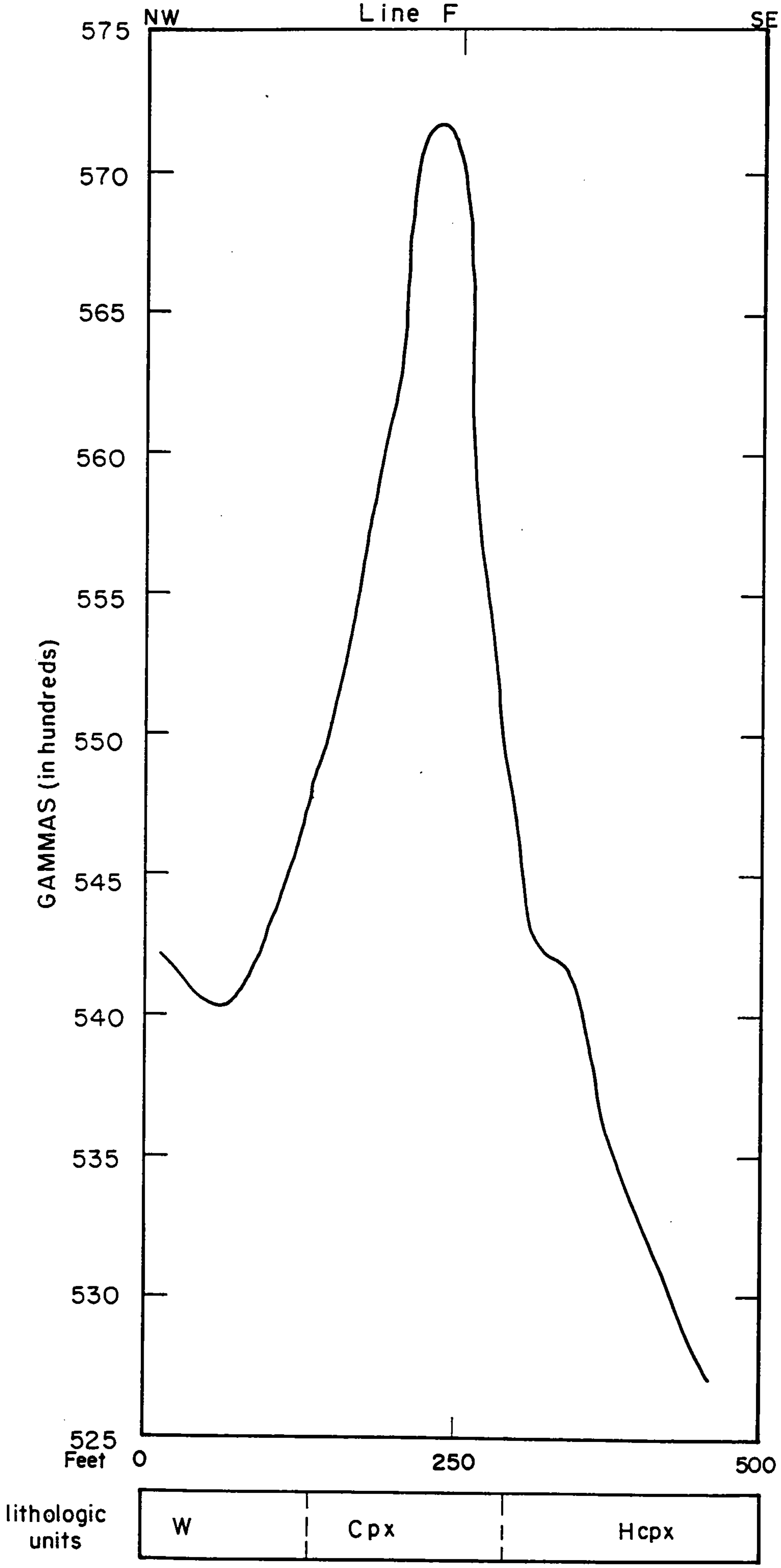
540
535
530
NW
Line E
SE
Feet
0
263
525
lithologic units
Hcpx
Hgb
Hb

21e



Line F
NW
SE
GAMMAS (in hundreds)
575
570
565
560
555
550
545
540
535
530
525
Feet
0
250
500
lithologic units
W
Cpx
Hcpx

21f

To determine if the ultramafic complex extends out from Red Mountain and underlies all or a portion of the Salmon River and Smalls River valleys, a series of gravimeter lines (see fig. 20) was run between the three ultramafic bodies.

Relative gravity data is contoured on figure 20. The data suggest at least two possible interpretations. The first is that the gravity increase is simply due to a general regional gradient. The second explanation suggests that rocks of the Gemuk Group form only a relatively thin sheath over ultramafic rocks, from the eastern side of Red Mountain across the Salmon River Valley to the western side of Suzie Mountain. Because ultramafic rocks crop out in the Salmon River Valley and on Thorsen Mountain, the second interpretation is more likely than the first, and, this second interpretation suggests that, although possibly cut by one or more faults, the Smalls River body and Red and Suzie Mountains represent exposed portions of a single, larger, intrusive mass. Although the gravity survey was not extensive enough to permit geophysical modeling, the steady increase in gravity toward the southeast suggests that the center of the anomaly lies somewhere immediately to the north of Kemuk Mountain. Barnes' 1:2,500,000-scale bouger gravity map of Alaska (2) also indicates a 10 to 15 mgal anomaly in that vicinity.

Perhaps of more importance in evaluating the potential for lode deposits of PGM is that a much larger portion of the Salmon River Valley may be underlain by ultramafic rock than has been previously thought.

PLACER PGM SOURCE, LODE PGM POTENTIAL, AND PLACER RESERVES

Potential PGM resources in the Goodnews Bay complex include: (1)

lode sources in host rock like that from which the placers were derived, (2) tailings from previous years' placer mining, (3) unmined, deeply buried placers in the lower Salmon River Valley, and (4) yet unrecognized placer PGM resources to the east of Salmon River.

The dunite core of Red Mountain contains low levels of PGM. Mertie (29) assumed that the present Red Mountain represents half of the original exposed intrusive body, and estimated that a mean tenor of 0.00040 oz per ton would have provided about one million oz of PGM to the placers. Present calculations based on the assumption that the average (0.00236 oz per ton) of PGM in the samples collected during this study, although biased by high-graded chromite and magnetite samples, also indicate that a pluton of the size hypothesized by Mertie would have provided sufficient PGM to account for all of the PGM thus far recovered by mining, that still unrecovered, and that lost to erosion. Because of the low grade, a homogeneous body of this tenor would not, however, be economical to mine as a lode source of PGM.

The size of PGM grains identified in rock samples from the Goodnews Bay ultramafic complex does not approach the maximum size of PGM segregations that are intergrown with chromite and magnetite euhedra found in placer concentrates from the Salmon River Valley and its tributaries (figs. 17-18). Nuggets up to 0.2 in across and consisting of PGM intergrown with chromite and magnetite euhedra are common in placer concentrates and indicate that these mineral grains formed together during magmatic processes and were later eroded and deposited in placers. Although coarser nuggets are not uncommon, most PGM in placer concentrates is much finer, and the failure to find segregations of nugget-size PGM segregations in the small volume of rock samples collected is not surprising. It is possible that upper levels of the Goodnews Bay ultramafic complex were more enriched in PGM, chromite, and magnetite than are the presently uneroded portions, but, except for a slight PGM enrichment towards the center of the complex (4), no systematic variations in the abundance of these minerals has been observed within the relatively homogeneous dunite and peridotite portions of the complex.

The analyses presented in table 3 also indicate that PGM at Goodnews Bay are preferentially associated with chromite concentrations within the dunite core. Even though chromite concentrations with PGM have occasionally proven to be very rich, such as in the Ural Mountains of the U.S.S.R., these zones are typically small and erratically distributed. Rarely are they of sufficient tonnage to constitute a viable mine. Samples of sulfide-bearing clinopyroxenite and hornblendite from the Goodnews Bay complex contain low, but anomalous, levels of PGM and although no significant concentrations of sulfides were observed at the surface, nor were there indications that they might be present in the subsurface, the possibility of economic deposits cannot absolutely be ruled out.

There are significant placer PGM reserves present in the yet unmined, but deeply (100 to 200-ft) buried, placer ground in the lower Salmon River Valley and also in tailings from previous years' dredging. During the 1975 season, the Goodnews Mining Company dredge processed clay-rich tailings from some earlier mining of the bench paystreak and recovered PGM equivalent to approximately 10.8 pct of the original operation's production. An engineer for the Goodnews

Platinum Co. estimates that, at best, the second operation was only 50 percent efficient in recovering fine-grained PGM from the clays. He suggests that recovery during the more recent operation was highest among the oldest tailings, because the clays had more time to oxidize, break down, and liberate PGM.

Appendix B contains a series of tables showing the results of churn drilling carried out in the Salmon River valley by the mine operators during the late 1950's and early 1960's. The drill locations are keyed to the sketch map of the placer claims in figure 22. Maps of the 1,517 drill hole locations are not reproduced here, but they are available for inspection at U.S. Bureau of Mines, Fairbanks.

The churn drill results outline several areas of anomalous concentrations of platinum in the Salmon River channel and along the bench paystreak. The anomalous areas are shown on figure 22, superimposed on a geologic sketch map of the Goodnews Bay complex. The anomalous areas were defined on the basis of churn drill samples that contained platinum values in excess of ten cents per cubic yard, calculated at the 1960 platinum price of $27 per ounce. Serpentinized ultramafic bedrock has been exposed by mining immediately upstream of the two anomalous areas just below the mouth of Dowry Creek. Bedrock samples (44, 45, table 3) from this location contain only low Pt concentrations (.001 oz/ton), but it is possible that the bedrock could be the source of the churn drill anomalies there. The mile-long anomalous area beginning at the confluence of Snow Gulch and Salmon River suggests the possibility of an unrecognized PGM source somewhere in Snow Gulch. The results of the gravity survey suggest that the ultramafic complex may extend beyond the currently-defined boundaries to the east and southeast and may be a source for the placer deposits. There are, however, other possibilities that could account for the anomalous areas including paleochannels, differences in stream or streambed morphology, the effects of glaciation, or other factors.

SUMMARY AND RECOMMENDATIONS

The Goodnews Bay ultramafic complex is an Alaskan-type zoned complex similar to those of southeastern Alaska, British Columbia, and the Ural Mountains of the U.S.S.R., some of which have produced PGM from lode and placer deposits.

Platinum at Red Mountain is preferentially associated with concentrations of chromite and magnetite in dunite, but no economic lode concentrations of PGM-bearing chromite or magnetite are exposed. It is possible that undiscovered, platiniferous, chromite-rich pods or lenses exist at Red Mountain, or have existed there in the geologic past. Minor palladium is associated with sulfide minerals (pyrrhotite, pentlandite, and chalcopyrite) disseminated within the clinopyroxene- and hornblende-bearing rocks of the outer zones of the complex at the southern end of Red Mountain. Although the sulfide-bearing units tend to be more consistently anomalous in PGM (especially Ir and Pd), where exposed Cu, Ni, and PGM content do not approach economic grades. Where present, sulfide minerals constitute no more than half a percent by volume of the magnetite clinopyroxenite. A correlation of higher Pd levels with relatively lower Pt levels in the outer zones of the complex explains the variation, noted by Mertie (29), in the composition of the platinum minerals recovered from the streams that drain the Red Mountain ridge. Gravity surveys of the Salmon River Valley suggest that the Smalls River body and Red and Suzie Mountains may represent exposed portions of a single intrusive mass and that a significant portion of the valley may be underlain by ultramafic rock.

Buried PGM-rich chromite pods within the dunite core of Red Mountain are the most promising (exploration) targets for locating PGM lode deposits in the Goodnews Bay complex. With the goal of locating such chromite pods, a detailed magnetometer survey over the Red Mountain body is recommended as an initial step. A diamond-drilling program would be the logical next step. Drill targets should be (1) any anomalies encountered by the magnetometer survey, (2) the chromite-rich areas above the heads of Fox Gulch and Squirrel Creek, (3) the relatively sulfide-rich clinopyroxene- and hornblende-bearing outer zones of the Red Mountain body, and (4) drilling might also be considered on Suzie Mountain, to test whether it, as a less deeply eroded analog of Red Mountain, still contains PGM-rich chromite masses not yet bared to erosion.

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APPENDIX A. - Description of rock samples collected in the vicinity of the Goodnews Bay Ultramafic Complex

Sample	Field description
1...	Olivine clinopyroxenite. Minor secondary hornblende.
2...	Peridotite. Trace chlorite.
5...	Pegmatitic hornblende-grabbro.
7...	Dunite.
9...	Porphyritic andesite.
10...	Volcaniclastic rock.
11...	Quartz vein in volcaniclastic rock.
12...	Serpentinized, magnetic peridotite.
14...	Pegmatitic hornblende gabbro.
17...	Magnetite-rich pebbles from Clara Creek.
19...	Dunite from Suzie Mountain. Trace Chlorite.
20...	Do.
23...	Dunite from Red Mountain.
24...	Strongly serpentinized peridotite.
29...	Hornblende plagioclase dike rock.
31...	Serpentinized peridotite.
34...	Magnetite-rich pebbles from Salmon River tailings.
35...	Do.
36...	Hornblende-olivine pyroxenite.
37...	Dunite.
38...	Dunite with disseminated chromite.
39...	Strongly weathered punky gabbro (?).
40...	Residual soil overlying serpentinized dunite.
41...	Serpentinized dunite.
42...	Olivine clinopyroxenite.
43...	Serpentinized peridotite bedrock exposed in Salmon River tailings.
44...	Serpentinized dunite.
45...	Do.
46...	Do.
47...	Do. Disseminated chromite euhedra.
48...	Do.
49...	Leucocratic tonalite.
50...	Serpentinized dunite.
51...	Do.
52...	Do. Disseminated chromite.
53...	Volcaniclastic rock.
55...	Hornblende gabbro.
56...	Meta-amphibolite.
57...	Olivine clinopyroxenite.
58...	Magnetite-hornblende gabbro with chalcopyrite.
60...	Dunite. Disseminated chromite.
62...	Do.
63...	Do.
64...	Altered gabbroic rock from Salmon River tailings.
65...	Do.
66...	Hornblende gabbro with trace sulfides.
67...	Serpentinized dunite. Disseminated chromite.
68...	Epidotized volcaniclastic rock.

APPENDIX A. - Description of rock samples collected in the vicinity of the Goodnews Bay Ultramafic Complex--Continued

Sample	Field description
69...	Amphibolite.
72...	Hornblende clinopyroxenite.
73...	Meta-andesite. Trace pyrite.
74...	Serpentinized dunite. Accessory chromite.
75...	Magnetite-hornblende clinopyroxenite with sulfide. High-graded sample.
76...	Magnetite clinopyroxenite with disseminated chalcopyrite.
77...	Coarse hornblende-magnetite clinopyroxenite.
78...	Epidotized meta-volcanic.
79...	Do.
80...	Hornblende gabbro with disseminated sulfides.
81...	Banded diorite with disseminated sulfides.
82...	Coarser variety of same rock as sample 81.
83...	Chromite-rich pebbles from tailings piles.
84...	Magnetite-rich pebbles from tailings piles.
85...	Altered meta-volcanic with minor disseminated pyrite.
86...	Black sand veneer from beach.
87...	Do.
88...	Do.
89...	Do.
93...	Amphibolitized volcaniclastic rock.
95...	Do.
96...	Do.
98...	Do.
99...	Pegmatic hornblende with accessory chalcopyrite.
100...	Olivine-hornblende clinopyroxenite.
101...	Volcaniclastic rock.
103...	Porphyritic andesite.
104...	Do.
106...	Serpentinized olivine-hornblende clinopyroxenite. Trace chalcopyrite.
107...	Magnetite clinopyroxenite.
108...	Olivine-magnetite clinopyroxenite.
109...	Magnetite clinopyroxenite with accessory chalcopyrite.
110...	Olivine-clinopyroxenite.
111...	Do.
112...	Magnetite clinopyroxenite.
113...	Olivine-magnetite clinopyroxenite with disseminated sulfides.
114...	Hornblende cliopyroxenite.
115...	Olivine clinopyroxenite.
117...	Olivine clinopyroxenite. Trace chlorite.
118...	Serpentinized dunite with minor chromite.
119...	Do.
120...	Do.
121...	Do.
123...	Serpentinized dunite.
124...	High-graded chromite in dunite.
125...	Do.
126...	Do.

APPENDIX A. - Description of rock samples collected in the vicinity of the Goodnews Bay Ultramafic Complex--Continued

Sample	Field description
127...	Serpentinized dunite with minor disseminated chromite.
128...	Serpentinized dunite with abundant disseminated ferrit-chromite.
129...	High-graded chromite in dunite.
130...	Do.
131...	Serpentinized dunite with minor disseminated chromite.
135...	Dunite with minor disseminated chromite.
137...	Do.
138...	Select sample of cm-sized iron-stained areas from dunite surface.
140...	High-graded samples of chromite pod in dunite.
142...	Serpentinized dunite with minor chromite.
143...	Select sample of clinopyroxenite dike in dunite.
145...	Select sample of cm-sized iron-stained surface areas in dunite.
147...	High-graded sample of chromite pods in dunite.
148...	Fine grained amphibolitized meta-basite.
149...	Dunite with minor disseminated chromite.
150...	High-graded sample of magnetite-rich pod in dunite.
151...	Serpentinized dunite.
152...	High-graded chromite in dunite. Composite sample.
153...	Serpentinized dunite with very minor disseminated chromite.
154...	High-graded chromite pods. Composite sample.
155...	Do.
156...	Chromite and magnetite disseminated in dunite.
157...	High-graded chromite concentrations in dunite. Composite sample.
158...	High-graded magnetic concentrations in dunite. Composite sample.
159...	Dunite with 1-3 pct disseminated chromite. Composite sample.
160...	High-graded chromite and magnetite segregations in dunite. Composite sample.
161...	Dunite with minor disseminated chromite.
162...	High-graded sample of magnetite pod in dunite.
163...	High-graded sample of chromite in dunite.
164...	Dunite.
165...	Do.
166...	Serpentinized dunite with minor disseminated chromite.
168...	Serpentinized dunite.
170...	Serpentinized dunite with minor disseminated magnetite.
171...	Beach sand with magnetite and chromite.
876...	Olivine hornblende clinopyroxenite.
878...	Olivine clinopyroxenite. Fine-grained.
881...	Hornblende pegmatite.
882...	Spotted hornblende clinopyroxenite.
883...	Olivine clinopyroxenite (dike).

APPENDIX B

Churn drill results from Salmon River Valley

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
6A (9)	1	23	2.0
	2	42.5	0.9
	3	47.5	8.4
	4	18	17.8
	5	12	10.8
	6	10	TR
	7	12.5	4.9
	8	14.5	14.2
	9	44.5	8.8
	10	35	13.0
	11	22	4.2
	12	40	3.6
	13	18	3.8
	14	24	22.6
	15	30	22.1
	16	41.5	3.1
	17	44	4.8
	18	18	4.5
	19	8	1.9
	20	23.5	4.5
	21	44	2.6
	22	11.5	2.2
	23	47.5	2.9
	24	9	TR
	25	19	TR
	26	19	TR
	27	17	TR
	28	40.5	21.3
	29	41	16.4
	30	48	9.3
	31	32	1.9
	32	25.5	TR
6A 1 TLLB (10)	1	10	10.7
	2	9.5	0.0
	3	7	37.3
	4	8	212.0
	5	11	59.9
	6	17	263.0
	7	16	44.5
	8	18	28.8
	9	18	TR
	10	11	15.2
	11	13	38.8
	12	19	TR
	13	15	TR
	14	13	15.3
	15	16	8.1
6A 1 TLLB (10) (con't)	16	16	TR
	17	15	TR
	18	13	TR
	19	14	TR
	20	36	2.6
	21	33	6.3
	22	18	6.8
	23	17	6.1
	24	18	51.3
	25	15	217.5
	26	11	4.8
	27	14	19.4
	28	14	30.6
	29	19	TR
	30	18	TR
	31	22	TR
6A 2 TLLB (11)	1	13	TR
	2	22	117.0
	3	23	19.3
	4	26	TR
	5	24	TR
	6	27	TR
	7	25	TR
	8	18	0.0
	9	25	129.5
5A (12)	1	10	5.3
	2	27.5	3.3
	3	38	3.4
	4	61	5.8
	5	39	7.8
	6	25	1.8
	7	38.5	17.3
	8	41	31.8
	9	42	19.0
	10	39	14.3
	11	33.5	8.3
	12	17	TR
	13	10.5	219.0
	14	20	18.4
	15	10.5	11.4
	16	21	TR
	17	30	TR
5A 1 TLLB (13)	1	19	27.1
	2	14	42.0
	3	40.5?	--
	4	13	53.4
	5	14	43.1

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
5A 1 TLLB (13) (con't)	6	11	113.8
	7	12	TR
	8	8	TR
	9	12	11.5
	10	15	57.5
	11	11	TR
	12	8	TR
	13	7	TR
	14	8.5	TR
	15	15	TR
	16	19	TR
	17	12.5	TR
	18	11.5	TR
5A 2 TLLB (14)	1	25	10.1
	2	39	6.8
	3	21	29.8
	4	22	77.7
	5	36	3.2
	6	22	14.9
	7	27	17.8
	8	31	26.4
	9	24	TR
	10	18	15.2
	11	11	7.6
	12	21	215.6
	13	31	5.9
	14	15	0.0
	15	20	22.0
	16	17	TR
	17	21	108.3
	18	20	22.7
	19	25	39.4
	20	29	51.5
	21	30	3.4
	22	19	54.5
	23	16	TR
	24	13.5	16.4
	25	20	36.2
	26	21	13.4
	27	25	6.4
	28	12	8.5
	29	14	74.2
	30	32	77.9
	31	30	TR
	32	21	TR
	33	24	TR
5A 2 TLLB (14) (con't)	34	27	113.2
	35	24	45.5
	36	25	52.3
	37	27	3.4
4A 2 TLLB (15)	1	30	7.4
	2	41	TR
	3	18	TR
	4	22	1.3
	5	27	7.6
	6	31	31.0
	7	35	3.4
	8	41	TR
	9	37	1.3
	10	41	17.1
	11	40	4.4
	12	39	96.7
	13	38	41.5
	14	32	TR
	15	39	3.3
	16	39.5	12.2
	17	41	46.3
	18	42.5	14.6
	19	43	1.4
	20	21	TR
	21	31	106.8
	22	33	21.8
	23	37	3.9
	24	40.5	19.1
	25	41	TR
	26	43	TR
	27	27	4.2
	28	32	1.7
	29	35.5	1.5
	30	39	6.9
	31	41.5	7.5
3A 2 TLLB (16)	1	14	48.5
	2	21	14.2
	3	25	11.9
	4	31	2.9
	5	37	21.5
	6	37	TR
	7	38	5.8
	8	25	TR
	9	24	7.6
	10	29	52.6
	11	30	159.0

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
3A 2 TLLB (16) (con't)	12	28.5	5.9
	13	29	2.1
	14	34	2.4
	15	18	18.3
	16	19	8.0
	17	14	7.1
	18	19	5.3
	19	13	4.7
	20	10	54.3
	21	6	0.0
	22	16	6.7
	23	20	0.0
	24	18	8.5
Bobby Bench (17)	1	12	0.0
	2	12	0.0
	3	13	0.0
	4	20	5.3
	5	22	TR
	6	20	0.0
	7	26	0.0
	8	28	0.0
	9	19	TR
	10	14	0.0
	11	14	0.0
	12	17	TR
	13	15	0.0
	14	16	0.0
	15	13	8.2
	16	11	TR
	17	22	13.9
	18	14	0.0
	19	13	TR
	20	--	8.7
	21	10	6.9
	22	13	18.2
	23	21	0.0
	24	19	0.0
	25	17	TR
	26	10	TR
	27	12	TR
	28	18	0.0
	29	11	2.7
	30	20	1.5
4A (18)	1	18.5	TR
	2	5	16.8
	3	9.5	6.4
3A (19)	1	21	TR
	2	7	12.7
	3	8	1.0
	4	14	0.0
	5	14	9.0
	6	10	TR
	7	52	6.0
	8	37	6.2
	9	8	0.0
2A (20)	1	21	4.2
	2	31	1.2
	3	35	2.0
	4	40	4.2
	5	12.5	9.2
	6	13	95.8
	7	8	11.4
	8	7	0.0
	9	11	13.0
	10	21	TR
Medicine Fraction (21)	1	33	TR
	2	26	0.0
	3	17	0.0
	4	4	0.0
	5	22	1.4
	6	21	TR
	7	25	TR
	8	18	TR
	9	17	0.0
Palladium Bench (22)	1	18	7.4
	2	19	58.2
	3	16	6.7
	4	22	TR
	5	18	219.3
	6	19	37.0
	7	22	8.0
	8	29.5	TR
	9	24	124.3
	10	22	7.3
	11	20	1.9
	12	18	2.9
	13	23	25.9
	14	25	26.6
	15	29	217.0
	16	29	6.8
	17	26	34.8

See footnote at end of table.

APPENDIX B
Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd	Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Osmium	1	26	6.6	Ethel	27	18	4.3
Bench	2	26	0.0	Bench	28	13	7.1
(23)	3	24.5	16.4	(24)	29	12	13.4
	4	34	252.0	(con't)	30	12	2.5
	5	29	48.7		31	13.5	0.0
	6	39	144.0		32	21	30.6
	7	47	TR		33	20.5	59.0
	8	41	13.1		34	18	48.1
	9	45	TR		35	19	66.5
	10	31	5.6		36	17	TR
	11	39	1.6		37	15	3.6
	12	37	50.0		38	28	143.0
	13	49	25.7		39	13	6.5
	14	--	10.9		40	8	1.9
	15	24	5.2		41	7	TR
	16	35	9.8		42	7	5.7
	17	42	8.5		43	5.5	3.8
	18	47	58.9		44	10	TR
	19	45	8.1		45	10	6.9
	20	54	70.7		46	8	0.0
	21	57	92.8		47	10	TR
Ethel	1	14.5	15.3	Ethel	1	16	5.2
Bench	2	16	21.5	Fraction	2	17	12.1
(24)	3	19	2.4	(25)	3	13	TR
	4	19	95.2		4	15	16.7
	5	19	34.8		5	15	9.7
	6	20	8.1		6	9	TR
	7	18	4.2		7	14.5	0.0
	8	29	8.4		8	8	2.9
	9	13	45.3		9	10	5.3
	10	17	52.3		10	3	12.9
	11	17	37.1		11	6.5	5.5
	12	21	32.4		12	4	5.5
	13	15	21.4		13	6.5	53.3
	14	33	TR		14	6	12.7
	15	33	3.5	1 Above	1	18	4.7
	16	21	15.3	Discovery	2	31.5	7.1
	17	21	7.3	(26)	3	32.5	3.1
	18	21	TR		4	32	11.9
	19	23	38.3		5	9	2.3
	20	27	7.1		6	11	TR
	21	25	1.2		7	15	TR
	22	15	12.0		8	14	TR
	23	20.5	TR		9	20	TR
	24	19	8.4		10	18	TR
	25	17	17.0		11	33	10.6
	26	14	TR		12	8	6.8

See footnote at end of table.

APPENDIX B
Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd	Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
1 Above Discovery (26) (con't)	13	11	TR	Discovery Bench (31) (con't)	26	15	TR
	14	7	8.7		27	10	3.9
	15	9	8.5		28	7	TR
					29	7	TR
Discovery Salmon River (28)	1	6	39.0		30	11	TR
	2	7	TR		31	11	TR
					32	21	36.4
					33	7	30.0
1 Below (30)	1	8.5	0.0		34	5	0.0
	2	8	0.0		35	11.5	TR
	3	4	0.0		36	7	0.0
	4	11	0.0		37	11	TR
	5	9	0.0		38	11	TR
	6	10	0.0		39	10	9.1
	7	11	0.0		40	11	TR
	8	15.5	12.5		41	12	TR
	9	16	2.2		42	12.5	3.1
	10	18.5	2.4		43	11	4.5
	11	10	TR		44	14.5	1.5
	12	19	TR		45	17.5	41.2
	13	19.5	TR		46	21	2.2
	14	19	46.2		47	14	4.4
Discovery Bench (31)	1	11.5	20.2		48	27	17.2
	2	5	7.6		49	17	1.8
	3	32	15.3		50	13	7.0
	4	7	18.2		51	11	3.8
	5	7	18.5		52	14	10.5
	6	7	0.0		53	14	TR
	7	7	TR		54	25	TR
	8	14	51.5		55	27	3.7
	9	26	10.5		56	31	4.7
	10	37.5	115.0		57	21	7.6
	11	9	TR		58	30	4.6
	12	9	5.1		59	30	11.3
	13	9.5	4.0		60	32.5	0.9
	14	9	9.9		61	28	33.6
	15	16	0.0		62	26.5	38.6
	16	22	16.3		63	22	12.2
	17	8	TR		64	27	298.5
	18	8	22.1		65	24	136.7
	19	15	3.1	Ruthenium Bench (32)	1	56	10.1
	20	15	4.1		2	53	109.0
	21	19	17.3		3	44	28.3
	22	8	TR		4	49	50.8
	23	10	TR		5	--	36.0
	24	10.5	5.1		6	57	54.3
	25	11.5	TR		7	50	26.4

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Ruthenium Bench (32) (con't)	8	61	11.0
	9	53	--
	10	40	47.9
	11	42	26.4
	12	47	22.8
	13	52	36.5
Rhodium Bench (33)	1	55	5.8
	2	51	4.5
	3	56	1.2
Platinum Bench (34)	1	53	1.7
	2	55	4.6
	3	52	4.3
	4	45	4.0
	5	48	30.2
	6	53	18.8
	7	58	1.8
Iridium Bench (35)	1	42	43.6
	2	38	5.4
	3	50	18.8
	4	33	11.3
	5	36	19.7
	6	38	8.6
	7	33	1.8
	8	41	TR
	9	30	94.2
	10	20	45.5
	11	26	5.6
	12	31	10.0
2 Below (36)	1	15	TR
	2	26	211.8
Pankin Bench (37)	1	22	2.7
	2	28	33.6
	3	26	78.2
	4	28	53.2
	5	29	70.1
	6	26	40.8
	7	27	4.5
	8	29	1.3
	9	25.5	23.6
	10	24	8.8
	11	21	4.7
	12	22	2.0
	13	19	1.6
	14	21	7.6
	15	17	9.0
	16	28	TR
	17	16	4.3
Pankin Bench (37) (con't)	18	39	4.9
	19	39	1.8
	20	28	45.0
	21	19	1.2
	22	34.5	1.5
	23	26	6.5
	24	27	32.5
	25	28	21.0
	26	31	32.0
	27	31	3.5
	28	34	2.9
	29	35	4.8
	30	35	4.8
	31	41	7.5
	32	46	0.6
	33	43	37.0
	34	43	100.2
	35	44	3.0
	36	47	0.6
	37	51.5	27.0
	38	41	1.1
	39	37	TR
	40	39	5.9
	41	43	TR
	42	35.5	3.9
	43	40.5	33.4
	44	42	61.9
	45	43	25.1
	46	45	7.8
	47	44	13.7
	48	43	TR
	49	45	TR
	50	48	6.7
	51	48	5.9
	52	51	1.0
	53	49	1.2
	54	38	8.6
	55	36	0.8
	56	35	5.2
	57	39	TR
	58	40	2.3
Discovery Snow Gulch (38)	1	34	26.8
	2	30	13.2
	3	33	5.0
	4	27	4.2
	5	24	5.3
	6	27	10.7

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Discovery Snow Gulch (38) (con't)	7	25	33.3
	8	25	8.5
	9	25	62.1
	10	25	21.4
	11	27	4.8
	12	27	10.2
	13	24	TR
	14	22	2.4
	15	20	5.3
	16	20	191.8
	17	24	2.3
	18	29	22.6
	19	21	12.4
	20	23	24.9
	21	23	13.5
	22	18	2.5
	23	19	TR
	24	18	10.6
	25	23	26.3
	26	26	7.9
	27	31	7.4
	28	24	2.5
	29	22	5.9
	30	37	8.7
	31	30	0.2
	32	37	1.4
	33	35	3.7
	34	31	1.0
	35	45	TR
	36	30	2.0
	37	30	1.2
	38	49	0.0
	39	47	TR
	40	42	TR
	41	41	0.0
	42	42	0.0
	43	40	0.0
	44	37	TR
	45	35	1.5
	46	38	0.4
3 Below (39)	1	14	0.0
	2	14	0.0
Margeret Bench (40)	1	52	3.7
	2	41	27.7
	3	49	13.1
	4	53	72.8
	5	48	1.5

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Margeret Bench (40) (con't)	6	40	5.9
	7	42	3.3
	8	44	TR
	9	48	16.0
	10	53	12.1
	11	47	14.8
	12	41	3.2
	13	47	TR
	14	43	TR
	15	43	TR
	16	37	1.2
	17	34	TR
	18	40	1.0
	19	39	1.0
	20	42	3.1
	21	45	3.1
	22	34	TR
	23	40	119.4
	24	39	TR
	25	43	3.2
	26	46	8.3
	27	33	62.5
	28	35	3.1
	29	23	1.8
	30	25	3.7
	31	27	10.2
	32	35	2.6
	33	42	9.5
	34	41	6.9
	35	35	7.2
	36	36	1.9
	37	38	4.9
	38	36	12.7
	39	37	6.6
	40	36	7.6
	41	36	12.7
	42	38	9.2
	43	26	8.1
	44	33	5.2
	45	33	7.6
	46	32	13.4
3 Below 2 TLLB (41)	1	34	TR
	2	31	TR
	3	22	3.8
	4	19	TR
	5	22	TR
	6	27	2.5

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
3 Below 2 TLLB (41) (con't)	7	26	1.0
	8	44	TR
	9	48	16.0
	10	53	12.1
	11	47	14.8
	12	41	3.2
	13	47	TR
	14	43	TR
	15	43	TR
	16	37	1.2
	17	34	TR
	18	40	1.0
	19	39	1.0
	20	42	3.1
	21	45	3.1
4 Below (42)	1	32.5	2.9
Sarah Bench (43)	1	41	28.4
	2	28	5.5
	3	31	1.3
	4	29	10.0
	5	35	3.7
	6	30	6.6
	7	30	14.5
	8	34	108.0
	9	39	17.6
	10	40	2.9
	11	48	1.4
	12	37	5.0
	13	47	19.9
	14	40	2.3
	15	31.5	1.0
	16	33	2.8
	17	33	3.9
	18	30	6.6
	19	31	8.1
	20	32	3.1
	21	28	19.1
	22	31	20.7
4 Below 2nd TLLB (44)	1	43	7.3
	2	44	0.5
	3	46	3.2
	4	49	0.8
	5	50	5.9
	6	49	1.6
	7	59	9.9
	8	65	1.9

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
4th of July Bench (46)	1	28.5	9.6
	2	30	1.3
	3	30	3.6
	4	31	TR
	5	31	77.8
	6	42	32.6
	7	45	13.4
	8	52	2.6
	9	56	36.6
	10	55	37.9
	11	57	1.0
	12	60	TR
	13	30	5.6
	14	30	5.3
	15	31	1.3
	16	34	4.2
	17	35	4.1
	18	34	3.4
	19	34	2.0
	20	32	1.9
	21	36	18.7
	22	38	7.8
	23	38	21.9
	24	37	44.6
	25	55	45.8
	26	56	19.1
	27	55	1.0
	28	25	TR
	29	39	4.5
	30	36	6.9
	31	42	9.6
	32	43	7.3
	33	43	11.4
	34	46	25.6
	35	48	26.1
	36	27	1.1
	37	39	TR
	38	40	1.8
	39	41	3.5
	40	44	TR
	41	52	8.5
	42	60	3.7
	43	60	5.9
	44	62	283.0
	45	59	14.1
	46	45	1.0
	47	48	15.4

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
4th of July Bench (46) (con't)	48	47	47.3
	49	48	30.7
	50	51	34.3
	51	57	16.2
	52	19.5	1.5
	53	32	TR
	54	28	TR
	55	36	TR
	56	45	1.0
	57	44	6.2
	58	50	3.8
	59	58	18.5
6 Below Discovery (48)	1	19.5	3.1
	2	23	3.7
	3	21	TR
	4	28	1.4
	5	36	7.2
	6	25	2.7
	7	31	TR
	8	31	8.9
	9	30	3.6
	10	30	16.5
	11	31	14.8
	12	31.5	14.8
	13	28	4.4
	14	23	11.1
	15	29.5	7.2
	16	27	TR
	17	27	1.0
	18	20	15.7
	19	20	1.5
Mukluk Bench (49)	1	59	12.2
	2	58	76.8
	3	63	80.2
	4	57	6.7
	5	55	8.9
	6	55	4.6
	7	18	TR
	8	27	TR
	9	34	TR
	10	36	TR
	11	55	TR
	12	56	3.0
	13	55	2.7
	14	62	27.9
	15	60	57.8
	16	40	13.8
Mukluk Bench (49) (con't)	17	60	1.8
	18	52	1.0
	19	53	4.9
	20	53	9.7
	21	61	3.9
	22	59	10.3
	23	63	18.8
	24	63	14.2
	25	58	2.4
	26	73	8.9
	27	78	27.0
	28	59	2.5
	29	61	3.9
	30	63	8.8
	31	--	TR
	32	--	TR
	33	--	TR
	34	--	TR
	35	--	TR
Reindeer Fraction (50)	1	26	20.3
	2	--	1.6
	3	--	7.2
	4	--	11.0
	5	27	7.6
	6	20	1.9
	7	19	1.6
Kilbuck Fraction (51)	1	77	8.7
	2	13	8.2
	3	14	8.2
	4	75	8.9
	5	84	2.5
	6	88	1.0
	7	104	1.8
7 Below Discovery (52)	1	23	1.3
	2	17	3.1
	3	19	3.2
	4	19	2.0
	5	25.5	3.6
	6	25	6.7
	7	28	11.3
	8	27.5	15.8
7 Fraction (53)	1	13	6.5
	2	17	1.3
	3	17	TR
	4	21	2.2
	5	20	4.9
	6	21	4.7

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd	Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
7 Fraction	7	21	5.1	8 Below	13	46	32.1
(53)	8	26	1.1	Discovery	14	46	7.3
(con't)	9	37	TR	(55)	15	47	1.8
	10	26	11.5	(con't)	16	42.5	14.0
	11	26	3.5		17	29	2.1
	12	24	9.2		18	28	5.5
	13	21	1.8		19	28	2.7
	14	30	1.0		20	29	1.8
	15	33	1.1		21	32	1.0
	16	33	1.6		22	43	4.8
	17	33	1.0		23	41.5	22.2
	18	30	5.3		24	27.5	2.2
	19	31	0.9		25	27.5	4.1
	20	42	3.4		26	31	7.1
	21	40	4.2		27	26	3.5
	22	39	2.6		28	25	7.5
	23	30	3.1		29	27	4.7
	24	30	2.0	Happy	1	37	2.5
7 Below	1	67	1.0	Bench	2	43	4.3
2nd TLLB	2	74	3.3	(56)	3	35	1.6
(54)	3	74	1.7		4	32	6.9
	4	97	4.3		5	37	2.9
	5	75	1.0		6	46	2.0
	6	81	8.4		7	57	2.1
	7	103.5	3.0		8	33	2.3
	8	104	6.2		9	31	TR
	9	107	2.9		10	26	2.7
	10	76	3.6		11	28	1.7
	11	80	6.3		12	30	0.0
	12	108	4.9		13	27	4.7
	13	68	6.3		14	27	2.6
	14	73	4.7		15	27	TR
	15	79.5	7.4		16	30	7.6
	16	110	4.2		17	26	1.5
	17	111	2.2	8 Below	1	73	1.4
8 Below	1	34	11.2	2nd TLLB	2	72	5.3
Discovery	2	40.5	14.6	(57)	3	67.5	4.2
(55)	3	44.5	18.4		4	71	8.3
	4	43.5	46.2		5	73	1.0
	5	43	20.6		6	79	5.5
	6	36	3.6		7	109	7.8
	7	49	5.0		8	75	1.0
	8	43	20.9		9	80.5	TR
	9	45	14.3		10	109	16.7
	10	47	13.7		11	109	3.5
	11	39	6.3		12	74	1.0
	12	36	1.0		13	79	2.8

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
8 Below 2nd TLLB (57) (con't)	14	103	5.3
	15	103.5	4.9
	16	103	4.2
	17	134	1.1
	18	109	1.0
	19	78	1.1
	20	101	9.9
	21	101	1.3
9 Below Discovery (58)	1	47	1.0
	2	48	27.4
	3	48	6.8
	4	49	54.1
	5	45	21.1
	6	31	4.9
	7	29.5	4.7
	8	28	TR
	9	23	7.9
	10	27	4.2
	11	46	8.4
	12	49.5	41.4
	13	49	48.3
	14	48	51.9
	15	32	1.0
	16	38.5	6.7
	17	34	1.6
	18	28	4.6
	19	31	17.5
	20	28	9.0
	21	26	1.1
	22	26	94.0
	23	48.5	1.0
	24	47	6.6
	25	48	24.5
	26	47	5.7
	27	44	2.4
	28	42.5	16.5
	29	36	8.1
	30	29	1.3
	31	30	18.0
	32	27	1.7
	33	26	5.8
	34	45.5	1.6
	35	49.5	20.1
	36	49	105.6
	37	46	22.7
	38	38	37.8
	39	26.5	5.5
9 Below Discovery (58) (con't)	40	28	8.1
	41	33	5.0
	42	46.5	1.1
	43	50	3.8
	44	44	16.5
	45	43	4.8
	46	34	15.3
	47	29.5	1.0
	48	31	17.2
Ptarmigan Bench (59)	1	26	4.9
	2	26	0.0
	3	77	9.2
	4	79	1.0
	5	27	4.7
	6	24	4.9
	7	22	9.3
	8	82	8.6
	9	29	28.9
	10	26	3.6
	11	27	6.9
	12	81	1.7
	13	82	1.2
	14	30	1.0
	15	23	TR
	16	26	7.3
	17	26	2.4
	18	77	2.5
	19	81	3.8
	20	90	1.0
	21	88	2.1
Spencer Bench (60)	1	96.5	1.4
	2	96	6.2
	3	94	2.3
	4	92	1.4
	5	95	2.2
	6	93	5.3
	7	101	6.3
	8	100	8.8
	9	95	3.6
	10	96	2.6
10 Below (61)	1	24.5	2.5
	2	44	1.7
	3	49	13.9
	4	43	76.4
	5	45	30.6
	6	41.5	41.2
	7	40	13.6

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
10 Below (61) (con't)	8	38.5	30.1
	9	27	1.0
	10	40.5	1.0
	11	49	11.2
	12	53	18.6
	13	47	7.3
	14	39	9.2
	15	38	5.6
	16	37.5	10.0
	17	37	8.1
	18	42	1.8
	19	56	35.6
	20	51.5	19.0
	21	47	11.5
	22	35.5	41.3
	23	33	5.1
	24	39	5.6
	25	50	1.1
	26	51	4.5
	27	50	14.2
	28	51	5.4
	29	48	10.2
	30	39	8.9
	31	38	20.4
	32	34	2.1
11 Below (62)	1	12	0.0
	2	26	1.0
	3	46	1.0
	4	49	8.8
	5	49	49.3
	6	49	57.3
	7	40.5	8.2
	8	34	8.2
	9	17	TR
	10	46	2.3
	11	52	16.9
	12	49.5	35.9
	13	49	7.5
	14	41	6.3
	15	30	TR
	16	55	26.0
	17	35	26.1
	18	52	30.8
	19	51	9.4
	20	50	TR
	21	51	14.7
	22	56	14.7
11 Below (62) (con't)	23	57.5	52.7
	24	56	4.2
	25	52	7.9
	26	50	6.8
	27	48	1.3
Lucky Bench Assn (63)	1	36	19.1
	2	36	2.3
	3	35	10.0
	4	24	8.8
	5	32.5	1.4
	6	52	TR
	7	38	10.1
	8	35	2.6
	9	38	3.7
	10	36	1.6
	11	30	0.0
	12	25	4.3
	13	30	TR
Olson Bench (64)	1	100	4.1
	2	102	76.3
	3	103	12.5
	4	105	35.1
	5	102	4.5
	6	128	2.3
	7	133	5.0
	8	134	6.9
	9	135.5	4.5
	10	157.5	4.0
	11	153	TR
	12	152	7.6
	13	160	2.1
	14	160	2.7
	15	158	3.5
Johnstone Bench (65)	1	164	2.3
	2	167	16.4
	3	166	1.0
	4	49	TR
	5	63	TR
	6	112	TR
	7	96	1.0
	8	150	2.4
Anna Bench (66)	1	168	3.0
	2	169	3.9
	3	172	3.7
	4	173.5	1.0
	5	154	10.5
	6	137	9.3

See footnote at end of table.

APPENDIX B
Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Anna Bench (66) (con't)	7	158	24.8
	8	151	2.7
	9	159.5	3.7
	10	163.5	1.1
	11	168	1.3
Hannah Bench (68)	1	155	4.8
	2	156	13.3
	3	162.5	14.6
	4	170	18.2
	5	173	25.0
	6	176	5.6
	7	183	1.0
	8	180.5	1.3
	9	186	1.6
	10	187	3.1
	11	195	11.1
	12	194	3.0
	13	199	0.5
Martha Bench (69)	1	142	1.0
	2	145.5	1.0
	3	153	15.6
	4	140	1.0
Weeks Bench (70)	1	90	TR
	2	121	TR
	3	198	TR
Wild Goose Bench Assn (71)	1	28	TR
	2	21	0.8
	3	32	1.0
	4	30	TR
	5	44	0.4
	6	44	2.5
	7	46	TR
12 Below (72)	1	63	30.2
	2	53.5	16.9
	3	56.5	18.3
	4	36.5	13.6
	5	36	9.5
	6	46.5	2.0
	7	55.5	25.5
	8	55.5	19.6
	9	40	7.8
	10	36	8.9
	11	54.5	5.9
	12	58.5	43.4
	13	50	7.6
	14	41	20.7
	15	36	13.2

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
12 Below (72) (con't)	16	62.5	1.1
	17	59	14.8
	18	55.5	6.9
	19	49	9.7
	20	36	1.9
	21	30	2.3
	22	62	16.5
	23	59	17.9
	24	57.5	10.5
	25	45	8.7
	26	58	10.3
	27	56.5	18.3
13 Below (73)	1	55	3.7
	2	60.5	6.4
	3	59	13.6
	4	55	2.4
	5	46.5	3.8
	6	48	4.8
	7	60.5	4.4
	8	60	8.1
	9	50.5	5.5
	10	65	0.0
	11	60.5	2.5
	12	54	1.0
	13	43	11.6
	14	38	TR
	15	27	0.0
	16	31	TR
	17	50	3.2
	18	61	13.4
	19	61	4.8
	20	51	4.3
	21	32	0.0
14 Below (74)	1	31	1.2
	2	48	1.0
	3	60	1.6
	4	65.5	19.8
	5	51.5	16.6
	6	36	TR
	7	31	TR
	8	60.5	3.2
	9	62.5	11.7
	10	66	5.7
	11	50	2.3
	12	61	3.1
	13	66	6.9
	14	69	3.4

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
14 Below (74) (con't)	15	52	2.3
	16	56	2.3
	17	65	18.2
	18	65	14.4
	19	65	1.3
	20	48	1.1
	21	49	2.8
	22	71	8.9
	23	67.5	34.4
	24	67	4.4
	25	56	1.0
15 Below (76)	1	48	38
	2	70	11.1
	3	70	13.0
	4	67	19.1
	5	67	1.9
	6	50	3.6
	7	63.5	23.1
	8	68	1.0
	9	68.5	3.8
	10	71	14.8
	11	71	4.3
	12	71	11.1
	13	62	2.2
	14	69.5	4.4
	15	71	7.5
	16	73	9.6
	17	71	4.8
	18	72	5.3
	19	69.5	2.7
	20	69.5	2.9
	21	74	6.5
	22	76	17.5
	23	73	5.3
	24	73	2.8
	25	71	3.2
	26	74	1.9
	27	73	3.9
	28	73	1.3
	29	72	4.2
	30	74	2.5
	31	72	0.9
	32	71	1.7
	33	74	1.2
15 Below 1st TLLB (77)	1	46	0.6
	2	58	0.5
	3	66	0.5
	4	69	0.0
16 Below (78)	1	73	1.2
	2	75	2.2
	3	73	6.8
	4	79	1.4
	5	79	3.4
	6	73	5.1
	7	74	2.6
	8	78	TR
	9	78	TR
	10	86	TR
	11	87	TR
	12	82	TR
	13	89	TR
	14	63	TR
	15	65	TR
	16	60	9.8
	17	57	1.0
	18	53	1.0
	19	56	TR
	20	62	TR
	21	55	TR
	22	61	TR
	23	63	TR
	24	69	0.0
17 Below (79)	1	54	TR
	2	53.5	TR
	3	57	TR
	4	61	TR
	5	63	TR
	6	72	TR
	7	48	TR
	8	26	0.0
	9	18	0.0
	10	18.5	0.0
18 Below (80)	1	59	TR
	2	58	TR
	3	61	TR
19 Below (81)	1	55	0.0
20 Below (82)	1	55	0.0
Ronny Assn (84)	1	196	7.0
	2	201	4.8
	3	205	6.5
	4	212	2.2
	5	214	0.4
	6	223	7.9
	7	224	3.9

See footnote at end of table.

APPENDIX B
Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Ronnie Assn (84) (con't)	8	211	0.9
	9	216.5	0.3
	10	218	5.8
	11	223	6.0
	12	225	2.2
	13	227	TR
	14	228	0.9
	15	229	6.3
	16	221	1.9
	17	225.5	TR
Euphoria Assn (85)	1	200	1.4
	2	202	TR
	3	206	0.6
	4	206	0.9
	5	209	20.9
	6	208	4.3
	7	214.5	2.5
	8	184.5	1.1
	9	187	6.4
	10	182.5	0.3
	11	193	13.4
	12	189.5	1.8
	13	192	0.4
	14	191	TR
	15	193	TR
Alice Assn (86)	1	155	TR
	2	157	0.3
	3	159	18.8
	4	162	5.6
	5	163	11.0
	6	167.5	TR
	7	169	TR
	8	166	4.4
	9	168	12.6
	10	165.5	1.2
	11	169	0.6
	12	171.5	0.3
	13	171	0.9
	14	171	TR
	15	173	0.2
	16	146	2.7
	17	152	TR
	18	150	7.0
	19	155	3.0
	20	158	25.6
	21	156	4.5
	22	157	1.5

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Alice Assn (86) (con't)	23	157	15.5
	24	157	0.4
	25	150	1.3
	26	147	--
	27	146	1.9
	28	146	--
	29	146	0.5
	30	147	TR
Christina Assn (87)	1	139	TR
	2	142	1.3
	3	143	2.2
	4	144	10.9
	5	145	9.3
	6	147.5	6.9
	7	143	--
	8	148	--
	9	147	8.4
	10	148	--
	11	149	4.2
	12	149	7.2
	13	147	TR
	14	149	3.2
	15	151	2.5
	16	153	1.3
	17	154	3.1
	18	145	6.1
	19	144	TR
	20	155	0.9
	21	156	0.6
Judith Assn (88)	1	154	1.0
	2	152	1.2
	3	149	0.1
	4	154	0.6
	5	155	0.6
	6	156	1.6
	7	159	0.7
	8	156	9.6
	9	158	1.2
	10	157	0.4
	11	157	TR
	12	160	0.2
	13	155	0.4
	14	168	TR
	15	153	4.5
Karen Assn (89)	1	156	40.2
	2	156	10.8
	3	160	2.1

See footnote at end of table.

APPENDIX B

Churn drill results from Salmon River Valley--Continued

Claim name (map no.)	Drill Hole Number	Depth to Bedrock (ft)	Cents[1]/ Cu Yd
Sonny Assn (90)	1	155	3.7
	2	159	TR
	3	165	8.0
	4	160	2.9
	5	166	2.1
	6	169	2.1
	7	169	0.8
Faye Assn (91)	1	165	0.0
	2	168.5	TR
	3	160	1.1
	4	165	2.9
	5	166	2.5
	6	169	8.0
	7	171	0.8
	8	170	3.3
Joanne Bench (92)	1	188	0.4
	2	189	0.4
	3	191	1.0
	4	189	2.3
Bubble Assn. (93)	1	186	2.1
	2	181	1.3
	3	193	2.7
	4	200	2.3
	5	201	2.1
	6	199	1.0
	7	200	0.8

[1]Values are from the Goodnews Mining Company records and indicate the value of PGM in cents per cubic yard based on the 1957 price for platinum of $27.00 per troy ounce. These figures are offered here as a convenient means of comparison only.