RECONNAISSANCE STRATEGIC AND CRITICAL MINERAL INVESTIGATIONS IN THE MCGRATH A-3 AND B-2 QUADRANGLES, SOUTHWEST ALASKA

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UNITED STATES DEPARTMENT OF THE INTERIOR

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INTRODUCTION

The Bureau of Mines Alaska Field Operations Center (AFOC) has, since 1981, been investigating reported platinum-group metal (PGM) and cobalt occurrences in Alaska. These investigations are being conducted as part of AFOC's strategic and critical minerals program which includes past and present statewide assessments of minerals that are essential to the nation's defense and industrial well-being; minerals investigated to date include PGM, cobalt, chromium, tin, tantalum, columbium, and rare-earth elements. The results of AFOC's critical and strategic mineral investigations are presented in Bureau publications, open-file reports, unpublished field reports, and outside publications. This report summarizes the Bureau's investigation of selected cobalt, PGM, and other mineral occurrences in 1985, near Farewell, in the USGS McGrath Quadrangle, southwest Alaska (fig. 1). The results of this report and others on cobalt and PGM will, in the future, be included in statewide summary reports for the respective commodities.

GEOLOGY

Rocks in the Farewell area are separated into two lithologically and structurally distinct sequences by the Farewell fault. This fault is the southwestern extension of the Denali-Shakwak fault system and is characterized by 40 mi right-lateral Cenozoic displacement; vertical movement also occurred during the Cenozoic, and Quaternary movement has been entirely vertical, with the southern block uplifted (Bundtzen, Kline, and Clough, 1982 and Bundtzen and Gilbert, 1983).

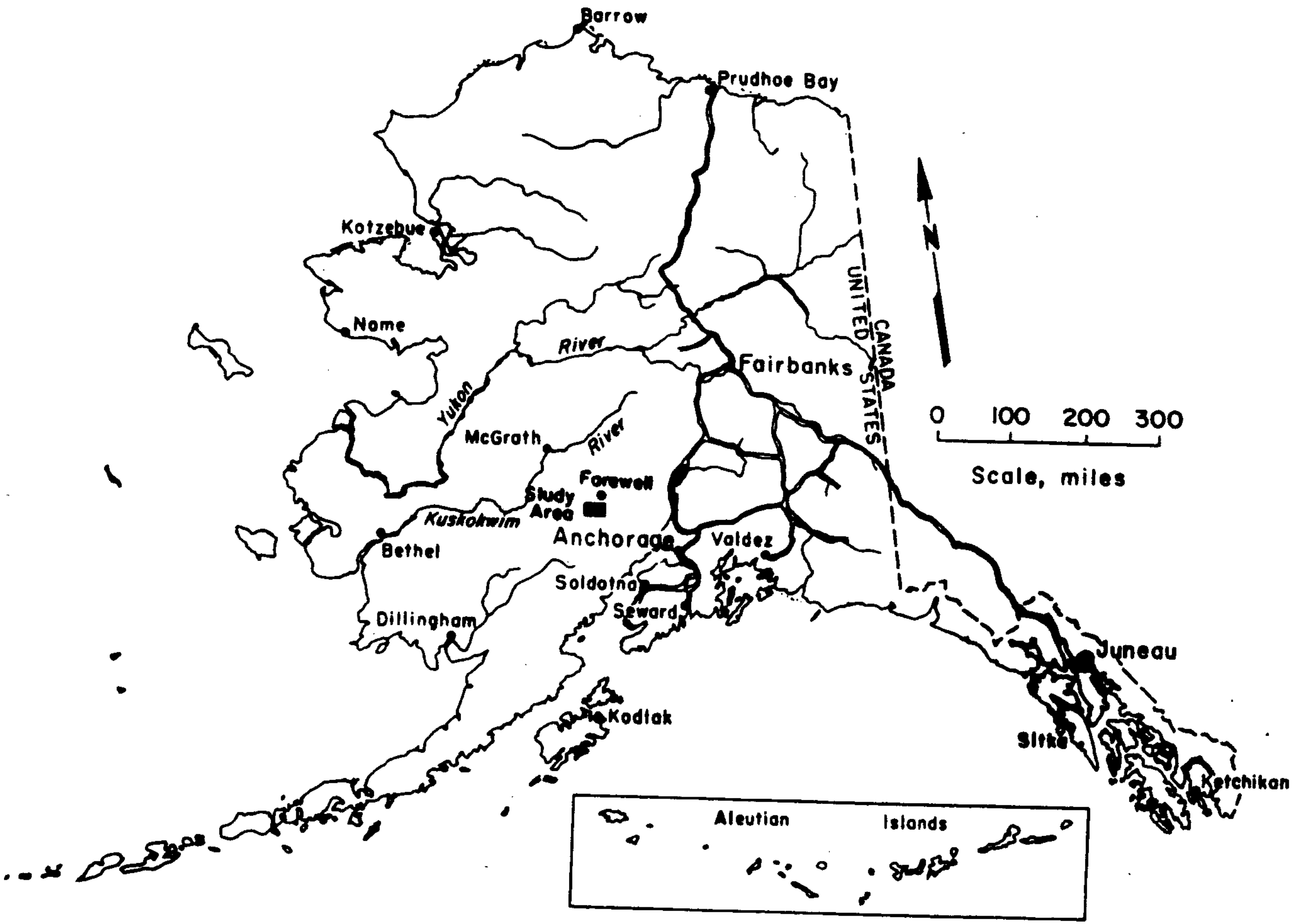


FIGURE 1.- Location map.

North and west of the Farewell fault is a sequence of relatively undeformed, shallow-water sedimentary rocks that are interpreted by Bundtzen and Gilbert (1983) to represent carbonate platform deposits. Immediately north of the Farewell fault, are massive, and locally laminated, Middle to Late Devonian limestones with minor interlayered sandstone (Bundtzen, Kline, and Clough, 1982). These rocks are overlain by Paleozoic to Mesozoic mafic igneous rocks, chert, and conglomerate. The mafic igneous rocks and associated chert are similar to the Silurian Chilakadrotna Greenstone, north of Lake Clark, Paleozoic to Triassic rocks of the Gemuk Group, exposed throughout southwest Alaska, and parts of the Mississippian Innoko Terrane in the USGS Medfra and Ophir Quadrangles (Bundtzen, Kline, and Clough, 1982). The rocks north of the Farewell Fault are provisionally assigned to the Nixon Fork tectonostratigraphic terrane which underlies much of the Medfra Quadrangle to the north.

To the south of the Farewell fault, Ordovician and Silurian deep-water sediments of the Dillinger tectonostratigraphic terrane are overlain by shallow-water Devonian sediments (Bundtzen, Kline, and Clough, 1982). This entire sequence increases in age to the south, and together, the rocks are folded and overturned into northwest-verging nappes (Solie, 1982).

The Ordovician rocks include shale and siltstone that grade upward into darker gray shale, black chert, and thin volcaniclastic sand layers. This sequence is interpreted by Bundtzen and others (1982) to represent initial quiescent, deep-water sediments, that were deposited on an abyssal plain or continental margin.

The Silurian sequence contains rhythmically-layered sandstone, silstone, laminated limestone, and shale that grade upward into fine-grained siltstone and shale (Bundtzen, Kline, and Clough, 1982). This clastic sequence includes Bouma intervals and other sedimentary features indicative of turbidity currents and turbidite deposition (Bundtzen, Kline, and Clough, 1982).

A thick sequence of undated, laminated limestone, dolomitic limestone, calc-sandstone, shale, and minor chert and volcanogenic(?) sedimentary rocks overlies the Silurian sequence (Bundtzen, Kline, and Clough, 1982). This sequence contains sedimentary structures that indicate a depositional environment similar to that interpreted for the Silurian sequence (Bundtzen, Kline, and Clough, 1982).

The stratigraphically highest Paleozoic sequence, south of the Farewell fault, contains algal limestone, shale, chert, mafic and ultramafic flows, sills, and dikes, and a late Middle Devonian clastic chert sequence (Bundtzen, Kline, and Clough, 1982). The sedimentary environments and the presence of chert, and ultramafic to tholeiitic mafic igneous rocks in shale and sandstone intervals indicates an ocean-floor environment.

The area is intruded by a variety of igneous rocks ranging in age from Late Cretaceous to Oligocene (Bundtzen, Kline, and Clough, 1982 and Solie, 1983). Igneous rocks in the area comprise dike swarms, flows, sills, breccia pipes, and small stocks of dominately intermediate composition, with alkaline mafic components. Subparallel dike swarms include basaltic through rhyolitic composition. The dikes resemble and may be genetically analogous to dike swarms described in the eastern Alaska Range (Foley, 1982, 1984, and 1985). Bundtzen and others (1982) suggest that dike swarms like those in the vicinity of the dumbell-shaped intrusion near the Rat Fork prospect may represent the root zones of volcanic centers.

Two major volcanic complexes in the area are described by Bundtzen and others (1982). One of these caps a ridge, west of Veleska Lake, and the other overlies Middle Devonian layered rocks, west and north of Sheep Creek. The Veleska Lake complex ranges from basalt to rhyolite in composition but comprises mostly dacite. The Veleska Lake complex is intruded by Paleocene granodiorite and dacite dikes and sills that resemble the flow rocks of the complex (Bundtzen, Kline, and Clough, 1982) The Sheep Creek complex postdates most of the Paleocene intrusive rocks and is composed of basalt, andesite, and rhyolite-welded(?) tuffs that are overlain by graded airfall tuffs.

Solie (1983) has described, in detail, the Middle Fork plutonic complex, which underlies the southern portion of the McGrath A-3 Quadrangle. That complex comprises granite, quartz monzonite, monzodiorite, syenite, and alkali gabbro and is believed to be part of the late Cretaceous through Tertiary suite of igneous plutons in the much larger Alaska-Aleutian Batholith (Solie, 1983).

Overlying the Paleozoic and Mesozoic rocks in the southeastern McGrath Quadrangle are extensive alluvial and colluvial deposits. Alluvial deposits include extensive gravel deposits, particularly on the piedmont, north of the Farewell fault (Bundtzen, Kline, and Clough, 1982) and in the larger valleys south of the fault. These gravel deposits include glacial drift and extensive terrace deposits. Overlying the gravel deposits, north of the fault, are extensive, permanently frozen, organic-rich, silt deposits. Colluvial cover is abundant on the flanks of the mountains in the southern part of the study area and landslide deposits are locally present. Periglacial phenomenon, such as solifluction and aüfeising, are common in the higher areas. Some glacial ice remains in cirques and alpine valleys at higher elevations.

MINERAL OCCURRENCES AND AREAS INVESTIGATED

The areas examined during this investigation are shown on figure 2; also shown are known prospects in the region. See Bundtzen and Gilbert (1983) and Smith and Albanese (1985) for descriptions of the known prospects.

Chip Loy Prospect

The Chip Loy prospect is named after its discoverers, Ed Chip and Robert Loy. The deposit is located on the east side of a north-flowing tributary of the the Middle Fork of the Kuskokwim River (fig. 2). The north-flowing tributary was informally named Straight Creek by Gordon Herreid, who described the prospect during a geological and geochemical survey of the area in 1966 (Herreid, 1968). The deposit was later sampled by the Bureau of Mines in 1981 (Roberts, 1985), during an examination of prospects in the area by the Alaska Division of Geological and Geophysical Surveys (Smith, and Albanese, 1985), and during the present investigation.

The Chip Loy prospect crops out between the 2,900- and 4,000-ft elevations in a steep, west-facing cliff and contains disseminated and massive pyrrhotite along the contact of a steeply-dipping diabase mass that has intruded banded limestone and slate (Herreid, 1968 and Smith and Albanese, 1985). The diabase mass was described by Herreid (1968)

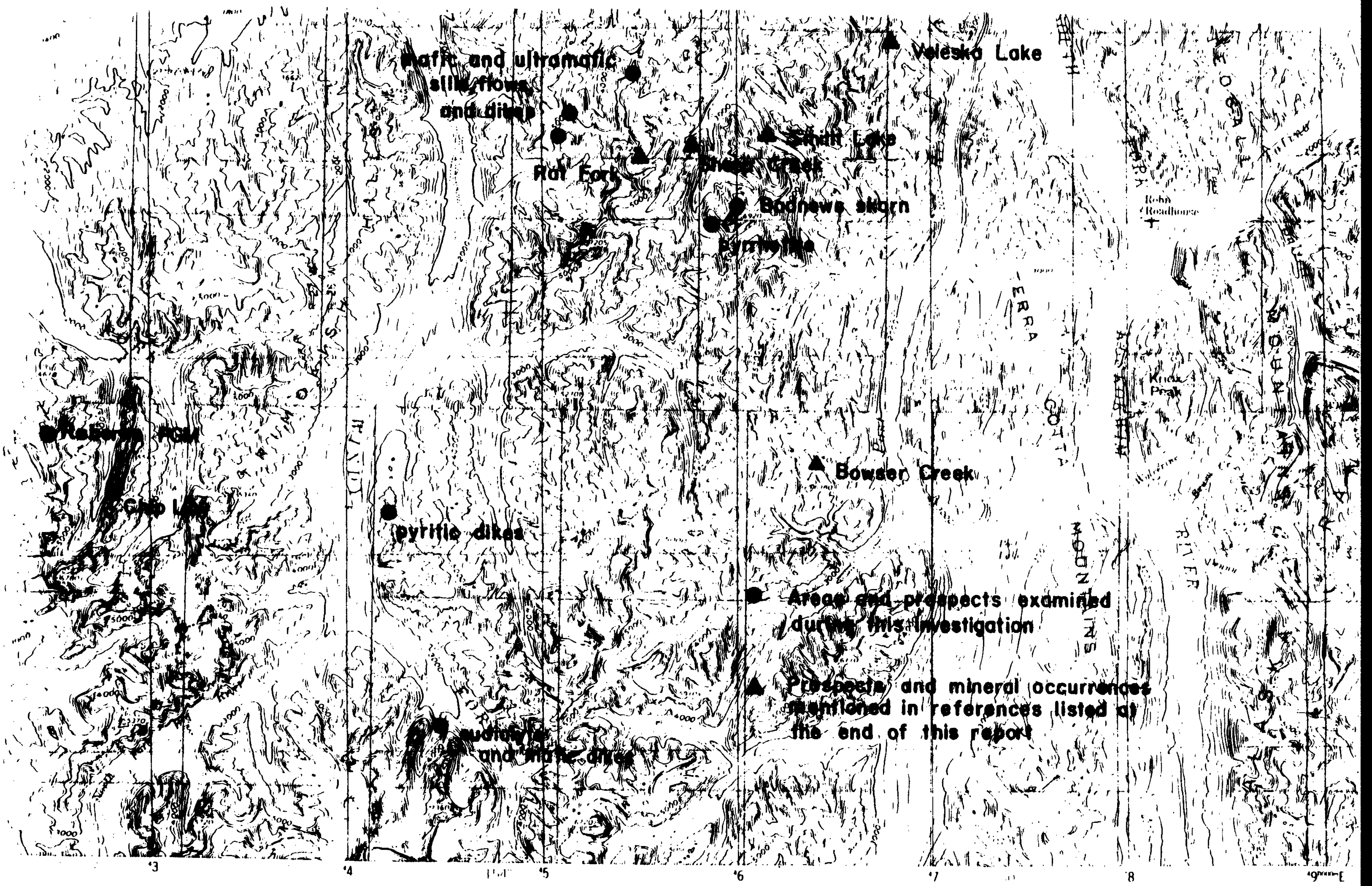
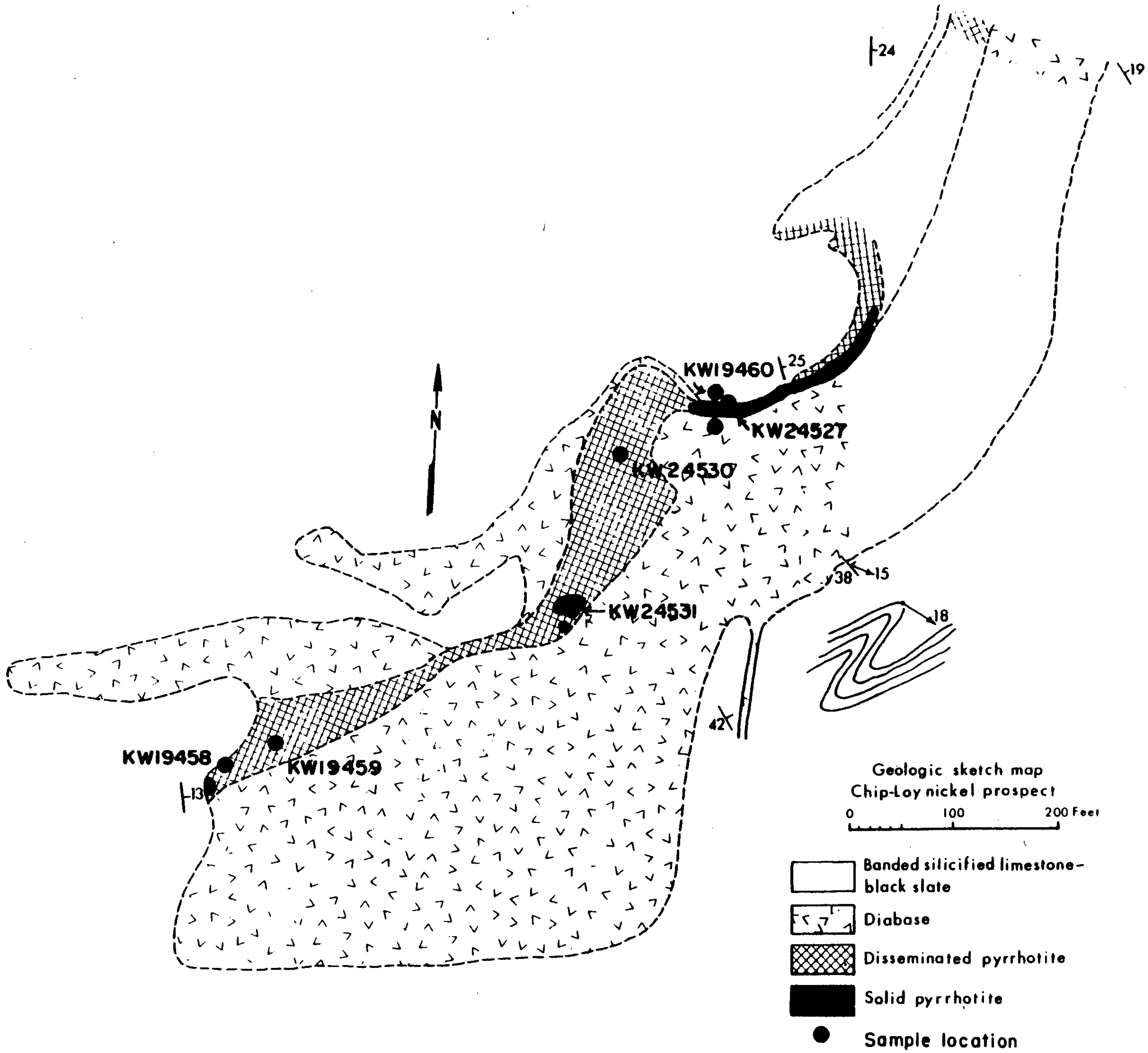


FIGURE 2.- Prospects and areas investigated in the southeastern McGrath Quadrangle.


N
24
19
KW19460
25
KW24527
KW24530
KW24531
38
15
18
42
KW19458
KW19459
13
Geologic sketch map
Chip-Loy nickel prospect
0
100
200 Feet
Banded silicified limestone-black slate
Diabase
Disseminated pyrrhotite
Solid pyrrhotite
Sample location

as a pipe(?) and by Smith and Albanese (1985) as a dike(?). The diabase body is elongate to the northeast, generally conforming to the layering in the sedimentary country rock and has an irregular width and outline, with shoots obliqiuely cutting the country rock. Pyrrhotite, the most abundant sulfide mineral, is present as disseminated grains, blebs, and aggregates, irregular veins, and as massive segregations. Polycrystalline pyrrhotite masses locally contain pyrrhotite crystals up to 2 in across. Pyrite, the second most abundant sulfide mineral, occurs along pyrrhotite grain boundaries, as disseminated grains and aggregates, and as flames in pyrrhotite. Chalcopyrite is locally present as a minor constituent along grain boundaries and fractures in pyrrhotite-pyrite aggregates. As observed at the surface, throughout and on either side of the mineralized area, the sulfide-rich rock is stained a deep, brick-red color with goethite and other oxides coating the weathered rock. James Sjoberg, Bureau of Mines Mineralogist at Reno (NV) Research Center, observed bravoite (violarite), pyrite, chalcopyrite, magnetite, hematite, and trace galena during scanning-electron microscope examination of pyrrhotite-rich rock collected by William Roberts from the Chip Loy prospect. No pentlandite was observed and it was concluded that nickel and cobalt are present in bravoite which, along with carrolite and violarite, is in the linnaeite [(Co,Ni)S] mineral group.

According to Smith and Albanese (1985), from 0.25 million to 2.0 million short tons of sulfide-bearing material may exist at the Chip Loy prospect. Based on reported analyses (table 1), grades ranging from 0.05 to 0.5 pct copper, 0.1 to 1.0 pct nickel, 0.02 to 0.1 pct Co, and trace gold and silver might be expected to be recovered from the Chip Loy prospect.

Table 1. - Analytical results and descriptions of Chip Loy prospect and Straight Creek samples.

Analytical results

Sample	Ag, ppm	As, ppm	Au, oz/st	Co, ppm	Cu, ppm	Fe, pct	Ni, ppm	Pd, oz/st	Pb, ppm	Pt, oz/st
2542		10	<0.1	43	83	3.91	72	NA	7	NA
2543		378	<.1	496	5,546	16.30	8,200	NA	23	NA
2544		111	<.1	291	2,300	14.70	5,320	NA	35	NA
2545		105	<.1	14	579	15.00	456	NA	18	NA
2546		22	<.1	863	4,670	43.20	14,400	NA	10	NA
2547		<10	<.1	930	3,340	26.20	13,500	NA	29	NA
2548		<10	<.1	182	2,820	9.73	2,590	NA	36	NA
2549		<10	<.1	101	2,250	6.79	1,810	NA	27	NA
2550		<10	<.1	55	627	4.88	747	NA	28	NA
KW19457[1]		NA	<.1	NA	50	NA	150	NA	NA	NA
KW19458[1]	NA	49	NA	49	590	NA	540	NA	55	NA
KW19458[2]	NA	NA	<.0002	NA	NA	NA	NA	<0.001	NA	<0.001
KW19459[1]	NA	NA	NA	860	11,500	NA	8,000	NA	57	NA
KW19459[2]	NA	NA	.001	NA	NA	NA	NA	<.001	NA	<.001
KW19460[1]	NA	NA	NA	1,050	700	NA	11,500	NA	29	NA
KW19460[2]	NA	NA	<.0002	NA	NA	NA	NA	<.001	NA	<.001
KW19460[3]	NA	NA	NA	595	970	NA	>25,000	NA	NA	NA
KW24527[2]	7.2	NA	NA	1,800	1,400	NA	26,000	NA	110	NA
KW24530[2]	2.6	NA	.097	77	710	NA	1,200	NA	<10	NA
KW24531[2]	6.1	NA	.003	2,500	10,000	NA	33,000	NA	110	NA
KW24532[2]	13.5	NA	.002	640	21,000	NA	8,500	NA	<10	NA
KW24560[2]	NA	NA	.001	270	95	NA	72	<.0003	<10	<.0003

Note- Samples 2542-2550 are chip samples collected across mineralized interval in 1982 by Smith and Albanese. Analyses reported in ADDGS Public-data File 85-54 (Smith and Albanese, 1985). Samples KW19457-19460 collected in 1981 by Roberts (written communication, 1981).

[1] Atomic absorption analyses by Technical Services Laboratories, Spokane, WA.
[2] Inductively coupled-plasma analyses by Bureau of Mines Reno Research Center: Ag, Au, Pd, and Pt preconcentrated by fire-assay.
[3] Atomic absorption analyses by Bondar-Clegg, Inc., Lakewood, CO; Au, Pd, and Pt preconcentrated by fire-assay.

Descriptions

KW19457	Stream sediment sample from Straight Creek.
KW19458	Goethite gossan.
KW19459	Massive pyrrhotite with minor chalcopyrite.
KW19460	Massive pyrrhotite.
KW24527	Massive pyrrhotite with minor chalcopyrite.
KW24530	Diabase with disseminated pyrrhotite and chalcopyrite.
KW24531	Very coarse-grained, massive pyrrhotite with chalcopyrite stringers
KW24532	Chalcopyrite-rich massive and semi-massive pyrrhotite in fine-grained diabase.
KW24560	Pan-concentrated heavy mineral concentrate from Straight Creek (also contains 430 ppm Nb).

A 25-lb sample of pyrrhotite-rich rock was collected at sample location KW24527. This sample was crushed and blended at the Bureau's Albany (OR) Research Center and splits taken for head analyses by the Bureau's Reno Research Center and Bondar-Clegg, Inc., Lakewood, CO. Results of those analyses are listed in table 2.

Table 2. - Head analyses from high-grade Chip Loy sulfide sample (KW24527)

	Ag, ppm	Au, ppb	Co, ppm	Cu, ppm	Fe, pct	Ni, pct	Pb, ppm	Pd, ppb	Pt, ppb	S, pct
1	NA	<7	1,300	4,100	43.1	3.10	NA	<10	<10	31.2
2	2.6	20	590	5,000	NA	>2.00	27	10	<15	NA

[1] Inductively-coupled plasma analyses by Reno Research Center. Au, Pd, and Pt preconcentrated by fire-assay.

[2] Atomic absorption analyses by Bondar-Clegg, Inc. Ag, Au, Pd, and Pt preconcentrated by fire-assay.

Robert's PGM Occurrence

A mafic dike strikes northeast and cuts phyllite, siliceous mudstone and limestone at the crest of a northwest-striking ridge, 1.5 mi west of Straight Creek (figs. 2 and 4). The dike is sheared, shattered, serpentenized, and heavily-stained with iron oxide. Malachite and minor azurite locally coat the weathered rock and are concentrated along fractures. The rock contains pods and stringers of sulfide minerals including abundant pyrrhotite, with minor chalcopyrite and traces of sphalerite. The sulfide-bearing, iron-stained outcrop is about 20 ft by 60 ft in areal extent and is bounded by faulted intrusive contacts at its northeast and southeast margins. Sulfide minerals are most abundant along the contacts between the dike and the country rock and may represent skarn mineralization. Undulating shear surfaces throughout the exposed mass have slickensides on them and the mass may have been mostly crystallized upon emplacement into its present position.

Roberts reported anomalous copper, nickel, platinum, and palladium in sulfide-bearing pyroxenite and peridotite from this location in 1982, and samples collected during the present investigation confirmed the presence of those metals. Significant gold was also detected in the samples collected during the present investigation. Analytical results for samples collected by Roberts and during the present investigation are presented in table 3.

A 11.8-lb sample of pyrrhotite- and chalcopyrite-rich material was collected from Robert's PGM occurrence and forwarded to ALRC for mineralogical characterization, head analyses, and concentration of sulfide minerals by flotation. Results of those tests are not yet available.

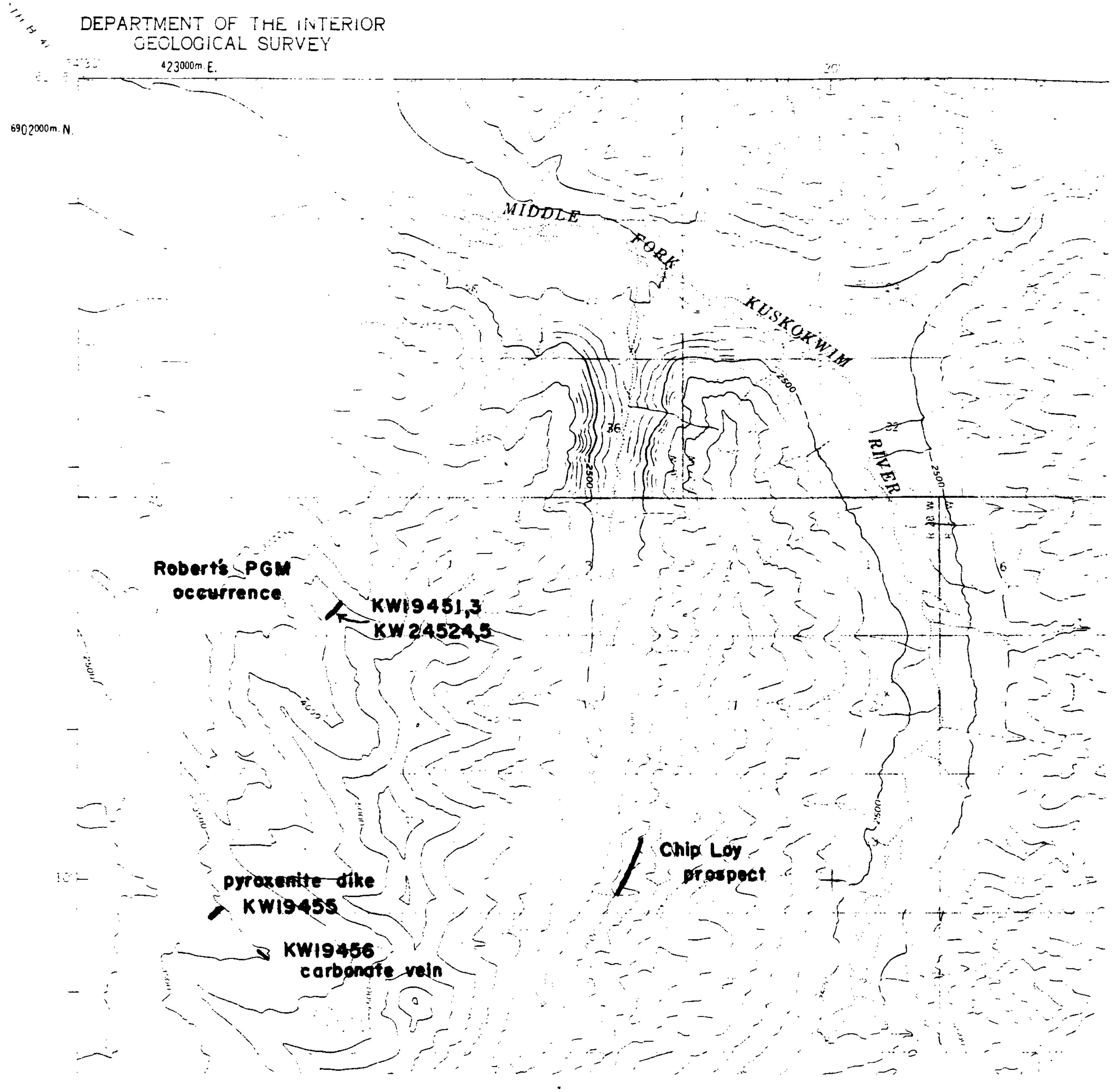


FIGURE 4. - Robert's PGM occurrence (base map from McGrath A-3 Quadrangle).

Table 3. - Analytical results and descriptions of samples from Robert's PGM occurrence and adjacent area

	Analytical results								
Sample	Ag, oz/st	Au, oz/st	Co, ppm	Cu, ppm	Ni, ppm	Pb, ppm	Pd, oz/st	Pt, oz/st	Zn, ppm
KW19451[1]	NA	<0.0002	140	3,100	5,330	NA	0.011	0.009	NA
KW19451[2]	NA	NA	110	3,500	4,200	11	NA	NA	81
KW19453[1]	NA	<.0002	67	435	1,565	NA	.001	<.001	NA
KW19453[2]	NA	NA	76	365	1,250	14	NA	NA	51
KW19454[1]	NA	<.0002	NA	NA	NA	NA	<.001	<.001	NA
KW19454[2]	NA	NA	73	67	800	15	NA	NA	50
KW19455[2]	NA	NA	58	18	205	13	NA	NA	76
KW19456[2]	NA	NA	23	3	26	37	NA	NA	29
KW24524[3]	LD	.030	150	3,300	5,500	<10	.014	.012	180
KW24525[3]	LD	.163	440	12,000	27,000	<10	.018	.058	330

[1] Atomic absorption analyses for Co, Cu, and Ni by Bondar-Clegg, Inc. and Au, Pd, and Pt by Reno Research Center using inductively-coupled plasma procedures after fire-assay preconcentration.
[2] Atomic absorption analyses by Technical Services Laboratories, Spokane, WA.
[3] Inductively-coupled plasma analyses by Reno Research Center. Au, Pd, and Pt preconcentrated by fire-assay.
NA- Not analyzed
LD- Less than detection limit.

Descriptions	
KW19451	Oxidized, sheared, blocky pyroxenite with pyrrhotite, pyrite, and trace chalcopyrite collected by Roberts.
KW19453	Very coarse-grained peridotite float with pyrrhotite and slickensides collected by Roberts.
KW19454	Sheared serpentinite collected by Roberts.
KW19455	Biotite pyroxenite collcted by Roberts
KW19456	Carbonate vein collected by Roberts
KW24524	Random chip sample collected during present inverstigation over entire mineralized outcrop.
KW24525	High-graded Pyrrhotite-chalcopyrite rock collected during present investigation from mineralized contact.

Serpentenized mafic and ultramafic rock with associated sulfide minerals like those described here were not observed anywhere else in the immediate vicinity of Robert's occurrence. Coarse-grained pyroxenite, locally cut by carbonate veins was observed by Roberts about 2.5 mi south of the present occurrence, at sample locations KW19455 and KW19456 (fig. 4). No sulfide minerals or anomalous metal concentrations were detected in these two samples (table 3).

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Table 3. - Analytical results and descriptions of samples from Robert's PGM occurrence and adjacent area

	Analytical results								
Sample	Ag, oz/st	Au, oz/st	Co, ppm	Cu, ppm	Ni, ppm	Pb, ppm	Pd, oz/st	Pt, oz/st	Zn, ppm
KW19451[1]	NA	<0.0002	140	3,100	5,330	NA	0.011	0.009	NA
KW19451[2]	NA	NA	110	3,500	4,200	11	NA	NA	81
KW19453[1]	NA	<.0002	67	435	1,565	NA	.001	<.001	NA
KW19453[2]	NA	NA	76	365	1,250	14	NA	NA	51
KW19454[1]	NA	<.0002	NA	NA	NA	NA	<.001	<.001	NA
KW19454[2]	NA	NA	73	67	800	15	NA	NA	50
KW19455[2]	NA	NA	58	18	205	13	NA	NA	76
KW19456[2]	NA	NA	23	3	26	37	NA	NA	29
KW24524[3]	LD	.030	150	3,300	5,500	<10	.014	.012	180
KW24525[3]	LD	.163	440	12,000	27,000	<10	.018	.058	330

[1] Atomic absorption analyses for Co, Cu, and Ni by Bondar-Clegg, Inc. and Au, Pd, and Pt by Reno Research Center using inductively-coupled plasma procedures after fire-assay preconcentration.
[2] Atomic absorption analyses by Technical Services Laboratories, Spokane, WA.
[3] Inductively-coupled plasma analyses by Reno Research Center. Au, Pd, and Pt preconcentrated by fire-assay.
NA- Not analyzed
LD- Less than detection limit.

Descriptions

KW19451	Oxidized, sheared, blocky pyroxenite with pyrrhotite, pyrite, and trace chalcopyrite collected by Roberts.
KW19453	Very coarse-grained peridotite float with pyrrhotite and slickensides collected by Roberts.
KW19454	Sheared serpentinite collected by Roberts.
KW19455	Biotite pyroxenite collcted by Roberts
KW19456	Carbonate vein collected by Roberts
KW24524	Random chip sample collected during present inverstigation over entire mineralized outcrop.
KW24525	High-graded Pyrrhotite-chalcopyrite rock collected during present investigation from mineralized contact.

Serpentenized mafic and ultramafic rock with associated sulfide minerals like those described here were not observed anywhere else in the immediate vicinity of Robert's occurrence. Coarse-grained pyroxenite, locally cut by carbonate veins was observed by Roberts about 2.5 mi south of the present occurrence, at sample locations KW19455 and KW19456 (fig. 4). No sulfide minerals or anomalous metal concentrations were detected in these two samples (table 3).

Mafic and Ultramafic Sills, Flows, and Dikes

Mafic to ultramafic sills, flows, and dikes cap ridges and are intruded into late Middle Devonian siltstone, shale, and chert in the west-central portion of the McGrath B-2 Quadrangle (Bundtzen, Kline, and Clough, 1982). As described by Bundtzen and others (1982), these rocks include dark green to gray, fine- to coarse-grained, equigranular gabbro to diorite sills, gabbro and basalt dikes, and sheared pillow(?) basalt with minor chert confined to, and generally parallel to the underlying and enclosing sedimentary rocks. Up to 50 pct magnetite and up to 25 pct olivine are reported in the sills which are differentiated, with gabbro and ultramafic basal zones that grade upward into dioritic rocks. Bundtzen and others (1982) also report that cumulate fabrics were observed in olivine- and pyroxene-bearing rocks from these igneous bodies.

Mafic volcanic rocks of this group were examined in the Sheep Creek area during the present investigation (fig. 5) and sampled rocks are tentatively classified on the basis of hand specimen descriptions as basalt and basaltic-andesite. Associated rocks include dacite, rhyodacite, and rhyolite. In places, the mafic flow rocks are nearly 1,000 ft thick and have chilled contacts. Samples containing trace to accessory sulfide minerals, including pyrite, pyrrhotite, and chalcopyrite were collected for geochemical analyses and results and descriptions of those samples are listed in table 4. It was observed during this investigation that the mafic rocks are typically fine- to medium-grained phaneritic with a high color index ($\geq$ 70) and containing about 20 pct interstitial plagioclase that is altered to a bluish-green colored mineral, probably epidote. Although these rocks are not strongly magnetic, very fine-grained, disseminated magnetite grains

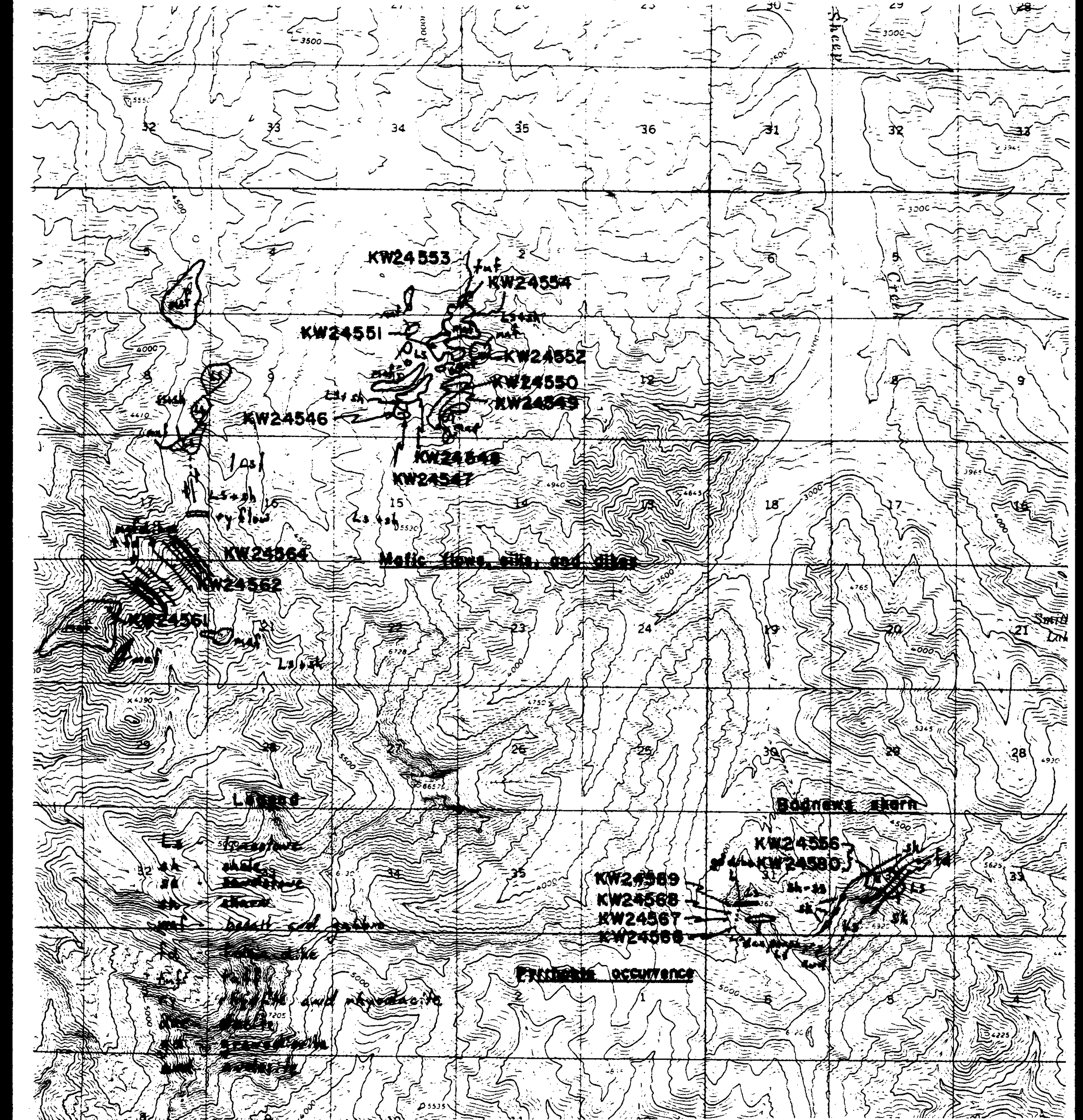

FIGURE 5. - Mafic and ultramafic flows, sills, and dikes, Badnews skarn, and pyrrhotite occurrence (base map from McGrath B-2 Quadrangle).

Table 4. - Analytical Results and Descriptions of Mafic, Ultramafic and associated rocks.[1]

Analytical Results

Sample	Ag, oz/st	Au, oz/st	Co, ppm	Cu, ppm	Nb, ppm	Ni, ppm	Pb, ppm	Pd, oz/st	Pt, oz/st	Zn, ppm
KW24544	0.015	0.001	45	350	71	83	22	<.002	<.002	190
KW24545	.012	.001	43	350	47	86	<10	<.002	<.002	110
KW24546	.015	.001	45	180	55	180	<10	<.002	<.002	130
KW24547	LD	LD	48	200	<10	130	<50	<.002	<.002	150
KW24548	LD	LD	31	88	30	84	70	<.002	<.002	240
KW24549	LD	LD	55	300	54	100	74	<.002	<.002	270
KW24551	LD	LD	35	540	<10	36	<50	<.002	<.002	<20
KW24552	LD	LD	54	270	34	87	<50	<.002	<.002	180
KW24553	LD	LD	67	160	60	180	180	<.002	<.002	450
KW24554	LD	LD	63	180	43	190	170	<.002	<.002	330
KW24555	.012	.001	44	180	54	210	<10	<.002	<.002	110
KW24561	LD	LD	61	210	29	200	110	<.002	<.002	230
KW24562	.033	.001	5	100	48	75	17	<.002	<.002	72
KW24564	LD	LD	56	70	43	110	160	<.002	<.002	280

[1] Inductively-coupled analyses by Reno Research Center; Ag, Au, Pd, and Pt preconcentrated by fire-assay.
LD- Less than detection limit.

Descriptions

KW24544	Fine-grained mafic dike with very fine, disseminated pyrite.
KW24545	Do.
KW24546	Phaneritic, blue-green basaltic andesite with accessory magnetite and very fine-grained sulfide minerals.
KW24547	Dark blue-green phaneritic basaltic andesite with 5 pct 4 to 6-mm hornblende phenocrysts and accessory pyrite and chalcopyrite.
KW24548	Buff-colored silica-carbonate-altered basaltic andesite.
KW24549	Dark black mafic basalt with blue-green, interstitial, epidotized plagioclase.
KW24551	Blue-green, phaneritic, sub-ophitic basalt with accessory chalcopyrite.
KW24552	Fine-grained phaneritic basalt with accessory pyrite.
KW24553	Pink to buff-weatering silica-carbonate-altered basalt.
KW24554	Medium-grained phaneritic basalt with blue-green interstitial feldspar.
KW24555	Medium-grained basaltic andesite with blue-green interstitial feldspar and accessory pyrite.
KW24561	Fine-grained, blue-green basaltic andesite with accessory sulfide minerals.
KW24562	Pink-weathering, pyrite-bearing, ankeritic quartzite.
KW24564	Dark brown,fine-grained, phaneritic basalt.

are typically present and fine-grained sulfide minerals, although ubiquitous, are not very abundant and generally constitute less than .5 pct of the rock Other than traces of silver and gold, both near the lower detection limits for those metals, no anomalous metal concentrations were detected in any of the analyzed rocks.

A swarm of pyrrhotite-bearing mafic dikes was also observed in the southeast corner of section 20 and in the northwest corner of section 28, T23N, R26W, McGrath A-3 Quadrangle (fig. 6). Samples KW24544 and KW24545 from this area contained no anomalous metal concentrations (table 4).

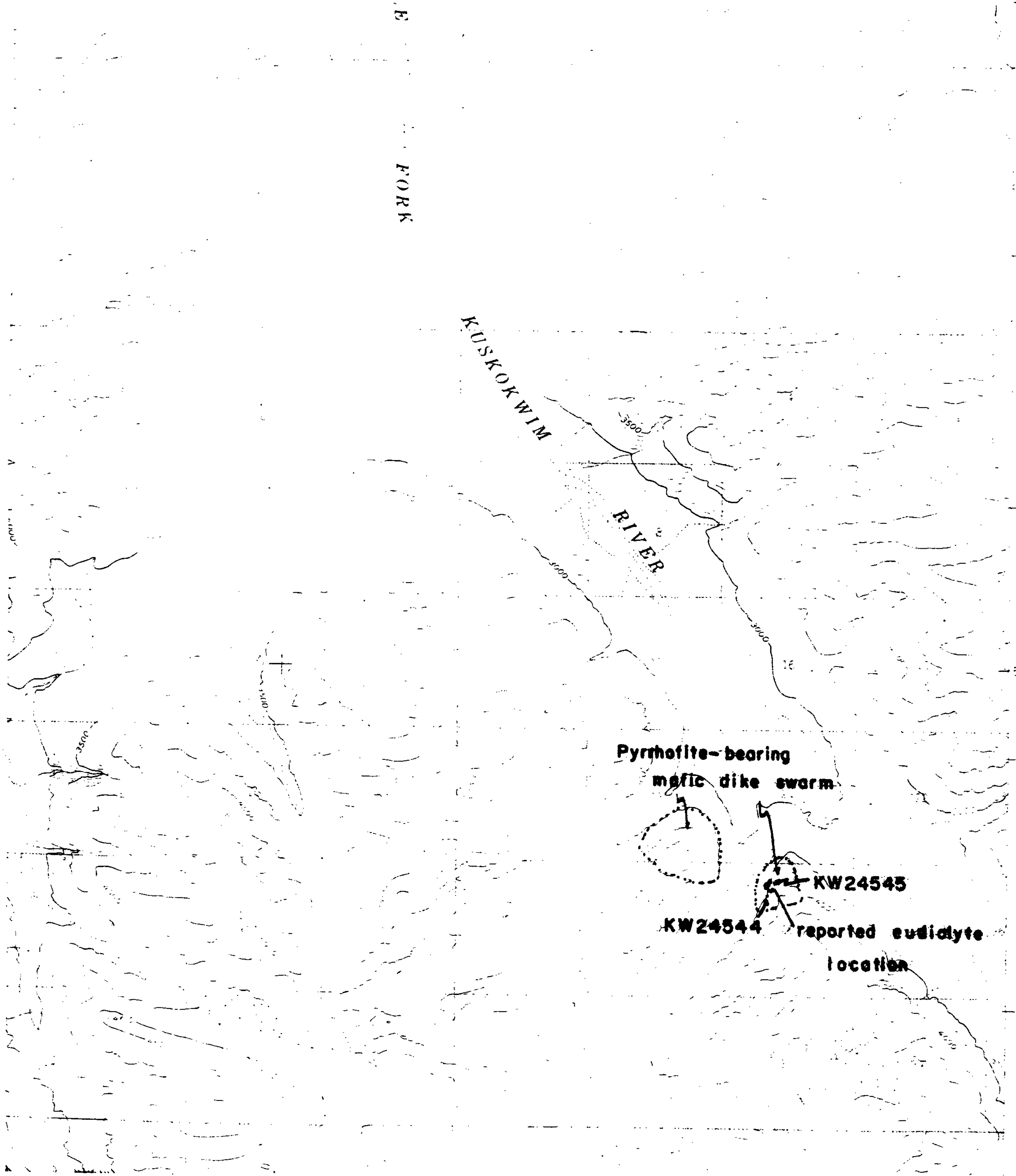

FIGURE 6. - Pyrrhotite-bearing mafic dikes and reported eudialyte location (base map from McGrath B-2 Quadrangle).

Badnews Skarn Prospect

The Badnews prospect, named by R. Burleigh during mineral investigations conducted in 1979 by Placid Oil Co., is a Cu-Pb-Zn skarn deposit in tightly-folded limestone, siltstone, and argillite (fig. 5). Limestone at the prospect has been preferentially replaced by skarn minerals, whereas, the siltstone and argillite are hornfelsed and bleached to light purplish-green and off-white colors. East-northeast-striking dacite dikes intrude the limestone in the area. Locally, the siltstone and argillite contain sulfide and calcite veins proximal to dacite dikes and massive skarn in limestone. It is suggested on the basis of field observations that later, and possibly related, hydrothermal fluids altered the dacite dikes and concentrated the skarn-forming metals. A post-skarn breccia occurs at the contact of a dacite dike in limestone and as breccia veins that cross-cut relatively fresh limestone. Late quartz-calcite veins that contain coarse-grained pyrrhotite-chalcopyrite-sphalerite-galena aggregates that parallel the dike and cleavage surfaces in the enclosing rock are up to 2 ft wide. By contrast, pyrrhotite-rich masses that contain little of the other sulfide minerals are up to 6 ft wide. Skarn mineralization in the limestone is varied in appearance. A buff-colored alteration assemblage is often observed in strata that are bounded above and below by relatively unaltered gray limestone. The buff-colored rock commonly grades into dark green to brownish-green rock characterized by the presence of epidote, garnet, fine-grained biotite and amphibole. Copper-, lead-, and zinc-sulfide mineral abundance is greatest in the darker-colored rock but chalcopyrite is locally present in the massive pyrrhotite pods. Also observed at this prospect is magnetite-garnet assemblage in fine-grained, yellow-green, calcite-garnet rock .

Table 5. - Analytical results and descriptions of samples from the Badnews skarn prospect.[1]

			Analytical results				
Sample	Ag, oz/st	Au, oz/st	Co, ppm	Cu, ppm	Pb, ppm	Ni, ppm	Zn, ppm
KW24556	0.070	0.001	290	2,800	93	84	160
KW24580	.420	.001	280	4,400	<10	120	92,000

1 Inductively-coupled plasma analyses by Reno Research Center; Ag and Au preconcentrated by fire assay.

Descriptions

KW24556 Massive pyrrhotite with minor chalcopyrite and trace sphalerite.

KW24580 Pyrrhotite, chalcopyrite, and sphalerite in dark-green skarn assemblage.

Pyrrhotite Occurrence

One mile southwest of the Badnews skarn prospect (fig. 6), massive pyrrhotite is reported by Bundtzen (1985). This location was examined during the present investigation and pyrrhotite, along with pyrite, was found to occur in carbonate-altered andesite dikes that cut the limestone country rock. The sulfide minerals are widely distibuted as very fine-grained, disseminated grains and less frequently are observed in fine veinlets and coarse clots and crystals up to 1 in across. Also observed in the area were a 20-ft-wide granodiorite dike and a small plug of dacite porphyry. Sample analyses and descriptions from this area are listed in table 6.

Table 6. - Analytical results and descriptions of pyrrhotite samples

Analytical Results

Sample	Ag, oz/st	Au, oz/st	Co, ppm	Cu, ppm	Nb, ppm	Ni, ppm	Pb, ppm	Pd, ppb	Pt, ppb	Zn, ppm
KW24566	.012	.001	19	38	44	28	<10			130
KW24567			7	45	32	44	<10			89
KW24568			7	23	88	23	10			91
KW24569			17	32	43	21	<10			130
KW24571			22	140	64	180	<10			180
KW24572			8	180	58	57	<10			140

[1] Inductively-coupled analyses by Reno Research Center; Ag, Au, Pd, and Pt preconcentrated by fire-assay.

Descriptions

KW24566	Carbonate-altered andesite with disseminated pyrrhotite and trace chalcopyrite.
KW24567	Do.
KW24568	Dark gray massive limestone with coarse pyrrhotite aggregate.
KW24569	Pyritic, gray limestone.
KW24571	Carbonate-altered hornfels with disseminated pyrrotite.
KW24572	Gray-green pyrrhotite-bearing volcaniclastic rock cut by calcite veins.

Eudialyte Occurrence

Eudialyte is reported by Gilbert and Solie (1983) and Bundtzen (1985) to occur in peralkaline arfvedsonite granite of the Windy Fork pluton in the southeast quarter of section 28, T23N, R26W, McGrath A-3 Quadrangle (fig. 6). A brief search for the reported occurrence was unsuccessful.

Tertiary Dikes

Near-vertical Tertiary dikes, showing a wide range of compositions, occur throughout the southeastern McGrath Quadrangle and are locally sheeted, constituting up to 50 pct of outcrops. The dikes range in composition from basaltic to rhyolitic, with abundant intermediate compositions. East-west strikes are typical among these dikes which appear to have intruded the older rocks in response to regional stresses that resulted in planes of weakness that parallel are slightly oblique to the northeast-striking Farewell fault. It is noteworthy that the compositional variation among the dikes, their structural style of emplacement, and the presence of ocellar and amygdaloidal textures are strikingly similar to features that characterize two suites of alkaline mafic and ultramafic rocks described in the eastern Alaska Range (Foley, 1982, 1984, and 1985). In those cases, the presence of widely-varied compositions, and more specifically, the presence of both alkaline and subalkaline compositions, was attributed to crustal contamination of varied magmas that originated within an heterogeneous mantle and were emplaced at shallow depths in the crust as result of deep-seated faults that propagated along the Denali and Farewell faults (Foley, 1985). Furthermore, available radiometric age dates indicate that all these dikes were emplaced at progressively younger times going from east to west along the Denali fault. Summaries of petrographic descriptions of dikes in the McGrath B-2 and A-3 Quadrangles are provided by Bundtzen and others (1982) and Gilbert and Solie (1983).

During the present investigation, six samples of pyritic rhyolite and rhyodacite dikes were collected along the north-south-striking ridge in sections 18 and 19, T24N, R26W, McGrath A-3 Quadrangle. Fire-assay atomic absorption analyses detected no gold in five of the samples and only 9ppb in a sixth sample from a 60-ft-wide rhyolite dike.

Bundtzen and others (1982) note that contact mineralization and thermal effects are generally lacking proximal to these dikes. Near the Veleska Lake and Sheep Creek areas, however, contact and breccia pipe mineralization is reported (Bundtzen and others, 1982).

CONCLUSIONS AND RECOMMENDATIONS

Among the prospects and mineral occurrences examined during this investigation, the Chip Loy prospect has the best potential for containing significant strategic and critical mineral reserves. Based on the potential size of the Chip Loy prospect, as determined by Smith and Albanese (1985), and the range of cobalt grades that might be encountered, as estimated in this report, from 100 thousand to 4 million lb of cobalt may be present there. Uncertainties exist, however, regarding the recoverability and extent of these resources.

Cobalt at the prospect is intimately associated with iron and nickel in minerals of the linnaeite group and procedures that will selectively concentrate these minerals, so that cobalt can be recovered, must be determined. It is recommended that samples weighing upwards of several hundred pounds be collected for beneficiation tests by Salt Lake Research Center from relatively unweathered rock representing the different types of mineralization present, including massive and disseminated sulfide-bearing rock. Collection of these samples will require either overland access by snowmachine when the ground is frozen and snow-covered or considerably more helicopter time than was allocated to the present investigation.

Much more detailed and quantifiable data is needed to determine the true extent of sulfide minerals and metal content at the prospect. Because of the friable character of the rock and the steepness of the outcrop at the prospect, comprehensive and detailed surface mapping and sampling will be very tedious, considerably dangerous, requiring the careful experienced use of technical rock climbing gear and techniques, and because of the weathered sulfide minerals near the surface will even then be of limited benefit. Definative assessment of the prospect's potential can only be achieved by diamond drilling and perhaps some underground exploration. Diamond drilling from the surface will probably require substantial casing to prevent circulation loss in the badly fractured rock. Drilling equipment other than that currently on hand at AFOC will be rquired.

Although cobalt was reported by Smith and Albanese (1985) at several of the sulfide mineral occurrences and prospects in the area, only the Chip Loy prospect appears to constitute a significant cobalt resource. It is recommended that any efforts in the area by the Bureau be concentrated on evaluation of the Chip Loy prospect and that this evaluation be funded and conducted at a level equal or greater to that typically done by AFOC in the last several years.

REFERENCES

Bundtzen, T.K., J.T. Kline, and J.G. Clough, 1982, Preliminary Geology of McGrath B-2 Quadrangle, Alaska. Alaska Division of Geological and Geophysical Surveys open-file report 149, 22pp., 1 sheet, 1:63,360.

Bundtzen, T.K. and W.G. Gilbert, 1983, Outline of Geology and Mineral Resources of Upper Kuskokwim Region, Alaska. Journal of the Alaska Geological Society, pp. 101-117.

Bundtzen, T.K., 1985, Personal communication, 3 1:63,360-scale map sheets.

Foley, J.Y., 1982, Alkaline Igneous Rocks in the Eastern Alaska Range in Short Notes on Alaskan Geology, 1981: Alaska Division of Geological and Geophysical Surveys Report 73, pp. 1-5.

__________ 1984, Petrography and Petrology of Alakaline Igneous Rocks in the Eastern Alaska Range, in Abstracts with Programs, 1984, 80th Annual Meeting, Cordilleran Section: Geol. Soc. Amer. vol. 16, no. 5, pp.283-284.

__________ 1985, Petrology, Geochemistry, and Geochronology of Alkaline Dikes and Associated Plutons in the Eastern Mount Hayes and Western Tanacross Quadrangles, Alaska. M.S. Thesis, University of Alaska, Fairbanks, 95 pp., 1 sheet, 1:63,360.

Gilbert, W.G. and D.N. Solie, 1983, Preliminary Bedrock Geology of McGrath A-3 Quadrangle, Alaska. Alaska Division of Geological and Geophysical Surveys Report of Investigations 83-7, 1 sheet, 1:63,360.

Herreid, G., 1968, Geological and Geochemical Investigations Southwest of Farewell, Alaska. Alaska Division of Mines and Minerals Geologic Report 26, 24 pp.

Roberts, W.S., 1985, Personal Communication, 18 pp.

Solie, D.N., 198~~2~~3, The Middle Fork Plutonic Complex, McGrath A-3 Quadrangle, Southwest Alaska. Alaska Division of Geological and Geophysical Surveys Report of Investigation 83-16, 17 pp.

Smith, T.E. and M.D. Albanese, 1985, Preliminary Prospect Examinations in the McGrath A-2, A-3, and B-2 Quadrangles, Alaska. Alaska Division of Geological and Geophysical Surveys Public Data File 85-54, 19 pp.

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130 Pemberton Ave.
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Phone: (604) 985-0681
Telex: 04-352667

BONDAR-CLEGG

Geochemical Lab Report

Incomplete report

REPORT: V88-03351.0 PROJECT: AK/KUSKOKWIM PAGE 1

SAMPLE NUMBER	ELEMENT UNITS	Au PPB	Pt PPB	Pd PPB	Ag PPM	Co PPM	Cu PPM	Ni PPM	Hg PPB
* Camp concentrated rocks									
C2 AK 24265C-CON	assays forthcoming PGE				0.4	74	520	120	1200
C2 AK 24265D-CON					0.6	130	781	200	1900
C2 AK 24392C-CON					0.3	22	136	30	>5000
C2 AK 24392D-CON					0.2	42	220	60	2200
C2 KW 24524B-CON	Robert's PGM float conc.				22.0	853	>20000	>20000	1050
*									
C2 AK 24265C-TAIL		876	40	25					
C2 AK 24265D-TAIL		82	40	30					
C2 AK 24392C-TAIL		322	20	15					
C2 AK 24392D-TAIL		208	30	20					
C2 KW 24524B-HEAD		237	960	940	Robert's PGM 80g split from 5.9Kg sample				
C2 AK 25210-MAG		>10000	>20000	200					
C2 AK 25209-SLIMES		570	30	35					

assays requested 7/22

copies for
Howard
Robert's file
KW field report
M'Gold
PGM file

5

For your information and to insert in your copy of Kuskokwim field report.

U.S. Bureau of Mines
AFOC Fairbanks

Field No. KW 24524

Sampler Foley
Project STRAIGHT CK
Quadrangle McGrath A-3
Elevation 3350

Date 7/25/86
Prospect Roberts Plgm
SE 1/4 sect. 5 T 24N R 28W
Meridian Seward

Sample type
- ○ representative
- ⊗ chip, random
- ○ pan concentrate
- ○ high-grade
- ○ chip, continuous
- ○ sluice box
- ⊗ bedrock
- ○ grab
- ○ stream sediment
- ○ rubble
- ○ channel
- ○ stream pebble
- ○ float
- ○ soil, depth ____
- ○ water

Sample weight 20 lb

other split submitted for Geochem

○ TS ○ PS ○ PTS ○ slab ○ office specimen

NOTES (see list) portion analyzed by Reno contained .030 oz Au, .018 Pd .01 oz/t, .012 Pt

Random chip collected over 3 x 10 ft outcrop of cpy, po-pn, sphal-bearing diabase. Serpentinized margins and abundant malachite w/ minor azurite. Small, 30 x 60 ft faulted mass (dike?) in Ls, phyllite, and interlayered siliceous mudstone and Ls. Looked around, but no similar rocks outside this immediate area.

Teaser.

Sulfides are cs and Cu, disseminated. See 24525

50g flot. conc. split received from Bill O'Connor in ALRC.
PS made, remainder sent to Bondar-Clegg for INAA PGE, Au, Cu, Ni, Zn, Pb

Also 2, 200gm head splits
1 pulverized — split / 120g arch, 80g to ALRC
1 not pulv. recd.

Lab instructions: 24524B - 5.9 kg chip sent to ALRC

FIRE ASSAY: Au Ag Ir Os Pd Pt Rh Ru

ASSAY (ore grade)	Ag	Ba	Cu	Mo	Pb	Zn	Al	Cr	Fe	Mg	Nb	Sn	Ta	W	U	Th	REO
	Co	Mn	Ni	As	Hg	Sb	other										
GEOCHEM	Ag	Ba	Cu	Mo	Pb	Zn	Al	Cr	Fe	Mg	Nb	Sn	Ta	W	U	Th	REO
	Co	Mn	Ni	As	Hg	Sb	other										

MAJOR OXIDES ○ other ____

lab no. AF6-003

United States Department of the Interior

BUREAU OF MINES

1450 QUEEN AVENUE SW
ALBANY, OREGON 97321-2198

TAKE PRIDE IN AMERICA

May 25, 1988

Memorandum

To: Jeff Foley, Geologist, Alaska Field Operations Center, Fairbanks

From: Group Supervisor,, Minerals Engineering

Subject: Samples from Robert's PGM occurrence

The analyses on the subject samples requested in your memo of December 1987, have been completed. The results are described in the attached petrographic report that was prepared by Bill O'Connor. Splits of the heads and concentrates are being sent to you for future reference.

/ R Rule

A. R. Rule

Enclosure

Petrographic Report: Robert's PGM Occurrence, Alaska

by W. K. O'Connor

The 5.9 kg sample from the Robert's PGM occurrence was crushed, weighed, and concentrated by sulfide flotation. Analyses for Au, Pt, Pd, Cu, Co, and Ag were conducted on splits of the head and the concentrate. Polished sections were prepared from the ore sample, and from each of the concentration products (rougher concentrate, scavenger concentrate, and flotation tailings). These were initially examined by reflected light microscopy to identify the general sulfide mineralogy. The sections were then examined by SEM for identification of particularly rare and/or fine grained constituents. Characterization determinations from the ore and the concentration products follow.

Ore Samples

Characterization of the ore sample was initiated on the reflected light microscope. Pyrrhotite was identified as the major sulfide constituent, followed by chalcopyrite. Sphalerite and pyrite, while significant phases in the concentrate, were not present in the selected ore sample. Several of the pyrrhotite grains were rimmed by a phase exhibiting a peculiar "skeletal" texture (figure 1). The structure consisted of dark outlines with lighter cores, and was not positively identified in reflected light. Difficulty in discerning the transition between the light and dark zones made the general analytic techniques ineffective. Possibilities ranged from pyrrhotite making up the outline of the skeleton with chalcopyrite in the core, to a single phase exhibiting a zonation phenomenon.

Subsequent examination of the ore sample on the SEM led to positive identification of the phase. Chemistry, determined by x-ray analysis, included Fe, Ni, and Co. The peculiar skeletal framework is due to variations in Ni content within the phase, bravoite (Fe,Ni,CoS_2). Light areas (on SEM photomicrograph) are zones of higher Ni concentration, with zones of lower Ni content appearing darker (figure 2). The presence of the bravoite explains the values of Co reported in the chemical analyses.

The polished section of the ore was also scanned by the SEM for PGMs. A few tiny (10 microns) grains were located. Each grain consistently contained palladium, with varying amounts of bismuth, tellurium, and/or antimony (these will be described in somewhat more detail in the ensuing section). Within the ore sample, these grains were observed to occur as free particles within the matrix and as inclusions in the pyrrhotite.

Concentration Products

Initial characterization of the flotation products determined the primary sulfide phase present in the products is again pyrrhotite, as in the ore sample. Pyrite occurs in minor abundance. Much of pyrrhotite is rimmed with a blue-gray phase (in reflected light), goethite. Chalcopyrite is the next most abundant phase, often containing inclusions of or middled with sphalerite. However, sphalerite occurrence is minor. Despite the middling of chalcopyrite and sphalerite, overall liberation is very good. Grade is very low, even in the flotation concentrate, as illustrated in the chemical analyses.

The tailings sample contains several extremely fine (10 microns), highly reflectant (70 pct), white grains, with very low Vicker's microhardness (100, compared with 1500 for pyrite). Galena was ruled out as a possible identification, and subsequent examination on the SEM led to identification of similar grains as a palladium-bismuth-telluride (figure 3). A specific mineral name may be difficult to establish, but palladium-bismuthide or some similar phase is likely.

The limited number of samples studied makes identification of all the elements that were chemically analyzed difficult. The concentration of Ag, at 0.2 oz/ton in the head and 0.36 oz/ton in the concentrate, indicates a fairly significant occurrence. However, identification of any Ag phases was not successful. A more complete study of a greater volume of material might lead to the successful identification of the source of the silver, whether it be present as a separate phase or in solid solution with one of the other sulfide phases. Gold values were rather low, but further study might prove beneficial for Au characterization as well.

Bill O'Connor

Bill O'Connor
Metallurgist
Albany Research Center

REPORT # : 3338E8 c ANALYTICAL REPORT
NAME.....: O'Connor
DATE.(IN): ~~02/17/88~~ (OUT): 03/03/88 CHART : PRIORITY :

SAMPLE #	DESCRIPTION-*-*-*-*DESCRIPTION-*-*-*-*DESCRIPTION	RECALL #
3338E8	..... 2536 PS2276 Roberts PGM, ro sulf flot con	
3339E8	..... 2537 " scav sulf flot con	
3340E8	..... 2538 " float tails	
3341E8	..... 2539 " head	

SAMPLE #	cCu	cCo	cNi
3338E8	4.71%	0.16%	4.68%
3339E8	0.59%	0.05%	1.35%
3340E8	0.054%	0.02%	0.26%
3341E8	0.31%	0.02%	0.54%

REMARKS : CORRECTED REPORT 3-4-88
ANALYST : Jerry SUPERVISOR : [illegible] VALUES REPORTED AS %

United States Department of the Interior
BUREAU OF MINES
RENO RESEARCH CENTER
1605 EVANS AVENUE
RENO, NEVADA 89512-2295

March 6, 1988

Memorandum

To: W. K. O'Connor, Metallurgist, ALRC

From: Research Supervisor, RERC

Subject: Sample Analysis

Enclosed are the analytical results on the samples you submitted February 15, 1988.

Kenneth G. Broadhead

Kenneth G. Broadhead

SAMPLE ANALYSIS REPORT

Submitted by BROADHEAD
BZ-225

Date of Request 2 /22/88
Date Received by Fire Assay 2 /22/88
Month Day Year

Sample#	Au	Ag	Sample#	Au	Ag	Sample#	Au	Ag
2536	0.14	0.6	minus	.24 for Pd.	0.36 oz/ton Hg		.	.
2537	0.08	—.		.	.		.	.
2538	—.	—.		.	.		.	.
2539	0.02	0.2		.	.		.	.
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Remarks: 2536: Ro. Sulf. Flot. Con 2537: Scav. Sulf. Flot. Con.
2538: Flotation Tails 2539: Head

Reported as: A. g/l B. mg/ml C. % D. ppm E. oz/ton
element unless otherwise noted
oxide

Analyst F. Godsey Date Completed 2 / 25 / 88
Month Date Year

SAMPLE ANALYSIS REPORT

Samples submitted by: Broadhead BZ-225 Date 2/23/88

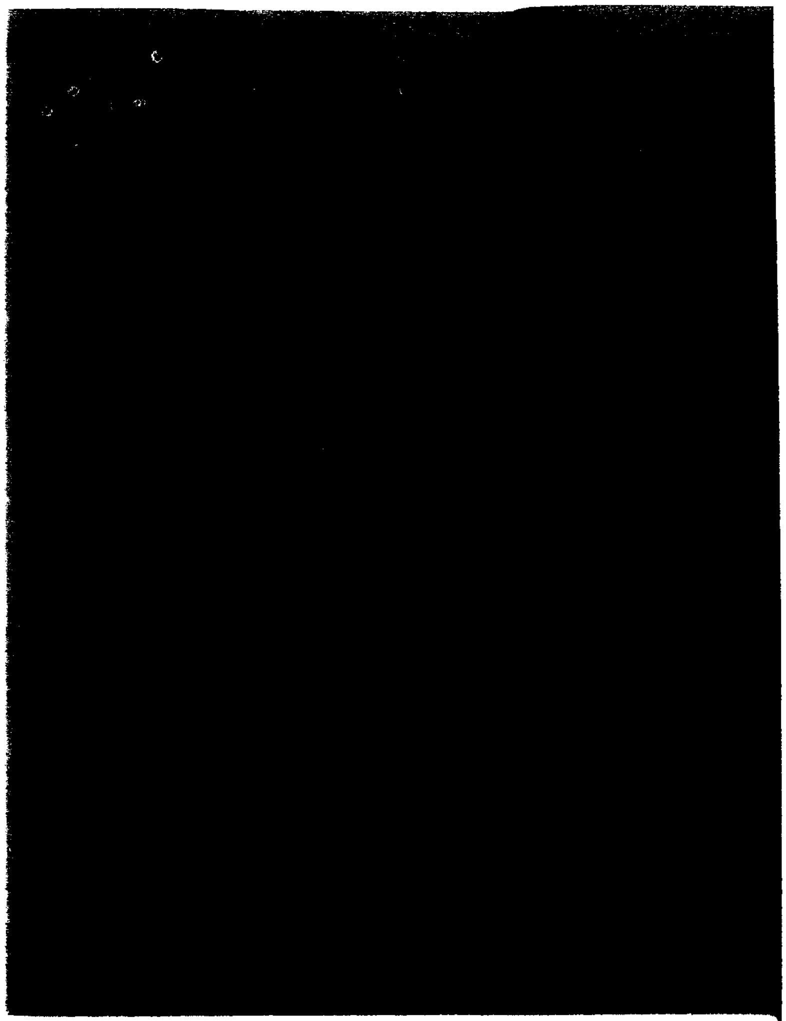
Sample No.	Pt	Pd	Rh	Au			Pt	Pd	Rh	Au
2536	.168	.236	<.02	.07			.180	.226	<.02	.05
2537	.078	.052	<.02	<.02			.096	.050	<.02	<.02
2538	<.02	<.02	<.02	<.02			<.02	<.02	<.02	<.02
2539 (2276)	.024	<.02	<.02	<.02			<.02	<.02	<.02	<.02

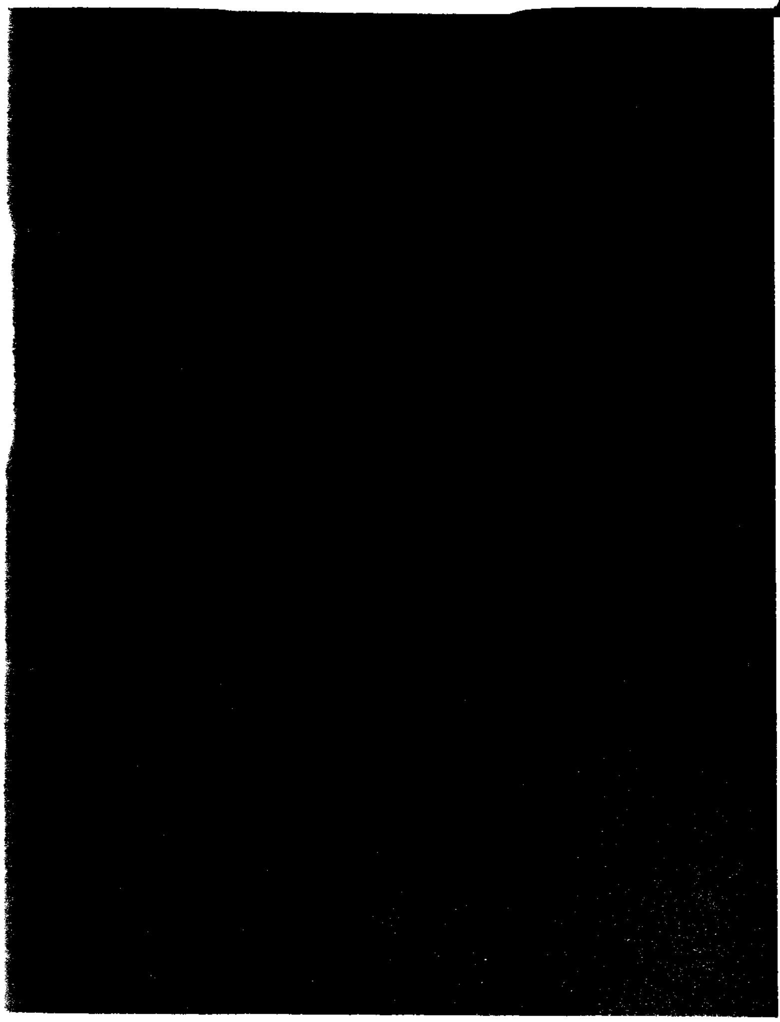
Remarks: Sample Size = 0.1 A.T.

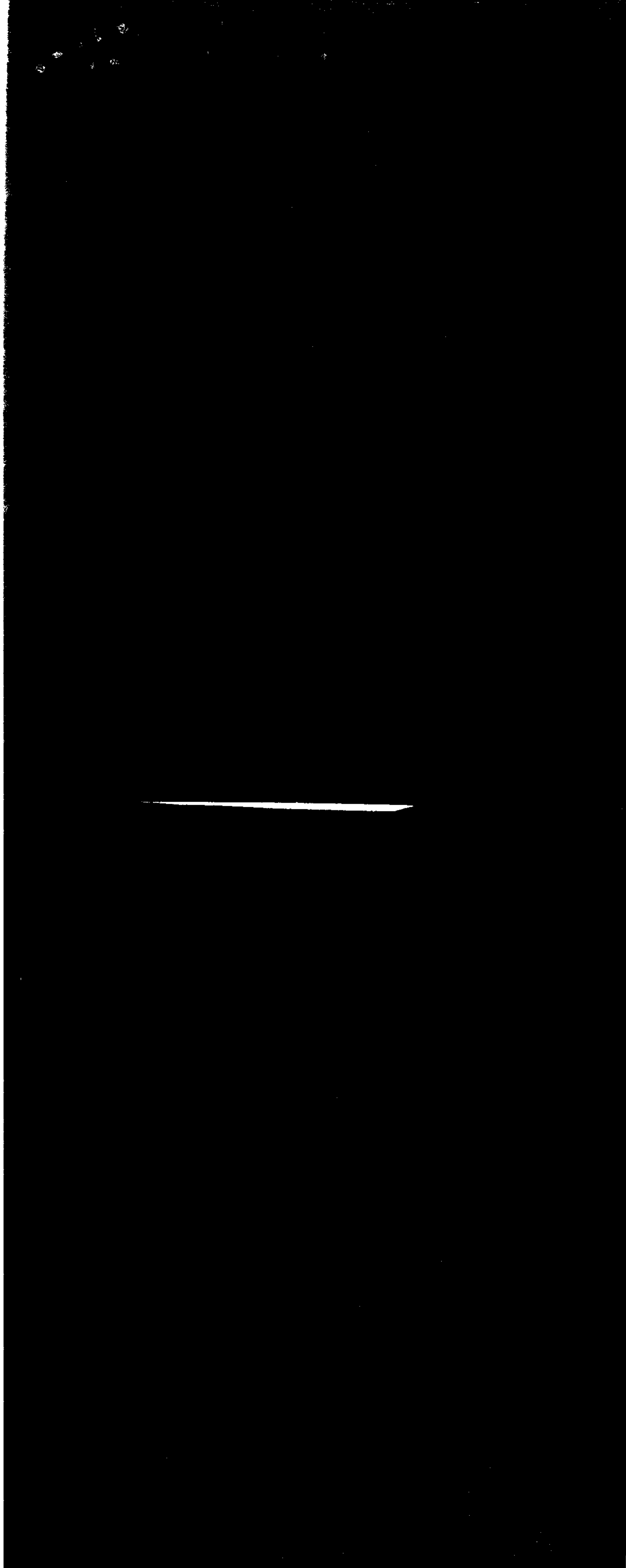
Reported as:
- A. g/l
- B. μg/ml
- C. %
- D. ppm
- E. oz/ton
- F. wt/%
- G. element
- H. oxide

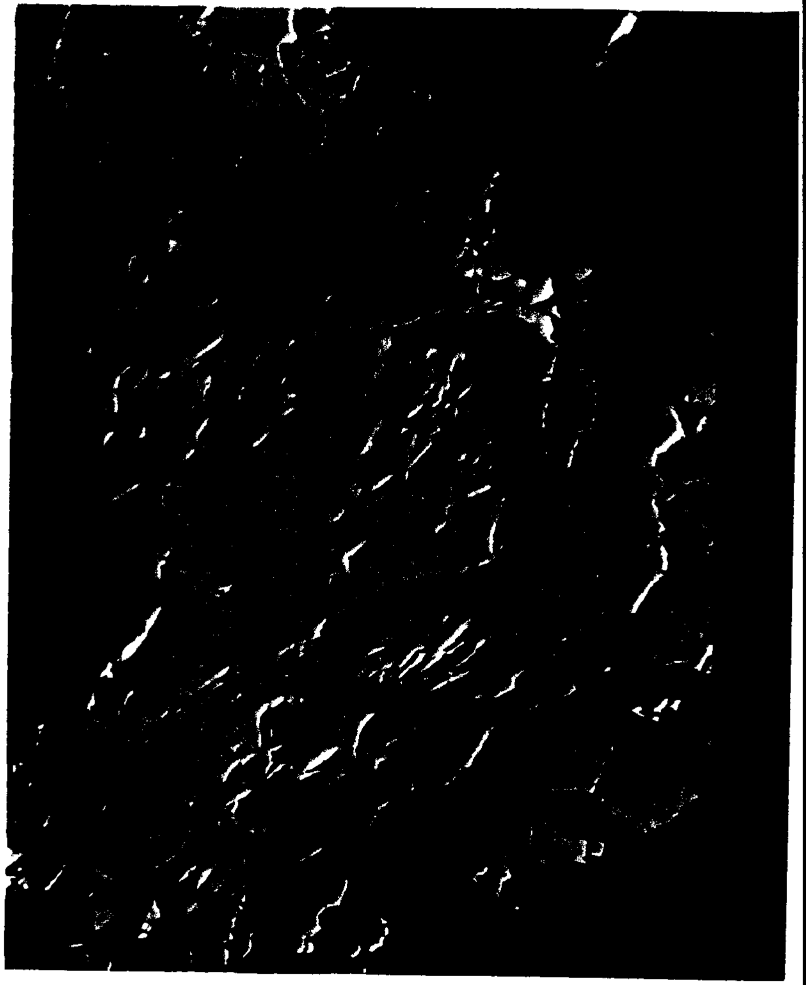
(unless otherwise noted)

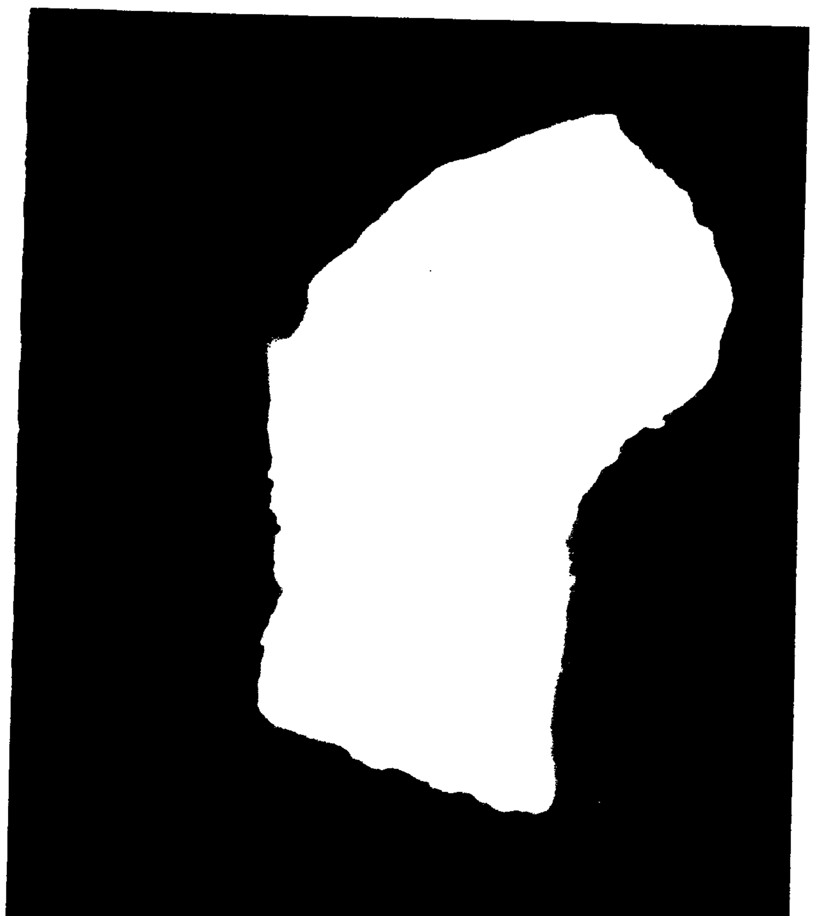
Analyst WBay Date 2/29/88









INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1984

250000

0 5 20 25 MILES

10 15 20 25 KILOMETERS

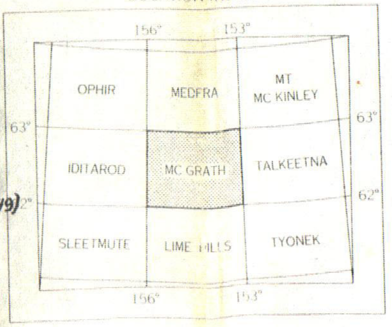
VAL 200 FEET
T 100 FOOT CONTOURS
TICAL DATUM OF 1929
DGE OF SHEET VARIES 22° TO 23°30' EAST

mDg mafic to ultramafic sills, flows and dikes (Bundtzen et al, 1982 - DGGS OFR 149)

Pb-Zn ± Ag skarn, vein & stratabound occurrences. Note many are po-rich (Bundtzen, pers. comm, Smith & Albanese, 1982 DGGS PD-file)

EOLOGICAL SURVEY
RADO 80225, OR RESTON, VIRGINIA 22092
S AND SYMBOLS IS AVAILABLE ON REQUEST

LOCATION INDEX



ROAD CLASSIFICATION

LIGHT DUTY . . . . . UNIMPROVED DIRT

MC GRATH, ALASKA
62153-A1-TF-250

1958
LIMITED REVISION 1984