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GEOLOGIC REPORT NO. 20

Geological and Geochemical Investigations in the Eureka Creek and Rainy Creek Areas, Mt. Hayes Quadrangle, Alaska

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by Arthur W. Rose

ABSTRACT

The Eureka Creek and Rainy Creek areas are on the south slope of the Central Alaska Range just south of the Denali fault, a major strike-slip fault. The major rock types in both areas include schist, phyllite, slate, and gneiss of uncertain age; andesitic to dacitic volcanics and sediments of Mississippian or Pennsylvanian age; Rainy Creek basalt and associated sediments of Mississippian or Pennsylvanian age; Permian Mankomen formation; and Triassic(?) Amphitheatre basalt, argillite, and limestone. These bedded rocks were intruded by several granitic to dioritic plutons and later by dunite, peridotite, and gabbro. Tertiary Gakona formation and glacial deposits cover the older rocks in parts of the area. Recurrent north-south regional compression in late Mesozoic and Tertiary time resulted in east-west reverse and thrust faults, and northeast tear faults. These structures are modified by north-south and northwest faults, and cut by steep east-west faults along which the Alaska Range was uplifted during Tertiary time.

A magnetite-bearing skarn deposit was found on the east side of the Maclaren Glacier and appears to warrant a magnetometer survey. Numerous copper and copper-nickel shows are present in the area, as well as minor amounts of asbestos. Fifteen groups of stream sediment anomalies are recognized. The most significant seem to be copper-lead anomalies from streams draining dunite near Rainy Creek and copper-lead anomalies between Broxson Gulch and Landslide Creek in a poorly-exposed area bordered by strongly pyritized volcanics. Numerous zinc-molybdenum anomalies are spatially associated with pyritic black slate and argillite. Samples of the slate do not contain anomalous zinc content, and further work is needed to explain the anomalies.

INTRODUCTION

This report covers the results of geologic mapping and stream sediment geochemical sampling during 1965 in the Eureka Creek drainage, and supplements a previous report on mapping and sampling in the adjacent Rainy Creek area (Rose, 1965). These areas lie on the south slope of the central Alaska Range between the Delta River and the Maclaren River, west of the Richardson Highway and northwest of Paxson (figure 1). During July and early August 1965, about 3-1/2 weeks were spent mapping and

and sampling in the Eureka Creek area (between Broxson Gulch and the Maclaren River), plus 2 weeks checking the previous years work in the Rainy Creek area (between the Delta River and Broxson Gulch). The writer was assisted by David O. Bary, who is responsible for most of the stream sediment sampling.

Access to the Rainy Creek area was by small boat across the Delta River at Mile 212-1/2 of the Richardson Highway, and by light plane to an air-strip on the east side of Broxson Gulch. In the Eureka Creek area, natural level spots on the west side of Broxson Gulch and on outwash at the base of the East Maclaren Glacier were slightly improved to allow light plane landings. We are greatly indebted to C.B. McMahon of Gakona, Alaska, for expert and conscientious flying, which greatly facilitated the field work.

REGIONAL GEOLOGY AND PREVIOUS WORK

The Denali fault is the dominant feature of the central Alaska Range. This arcuate strike-slip fault extends the entire length of the central and eastern Alaska Range (figure 1). East of the map area, the fault strikes northwest and separates Precambrian(?) schist and gneiss on the north from Paleozoic and younger sedimentary and volcanic rocks on the south. North of the map area the fault strikes N70W to west and has schist, gneiss, and granitic rocks on both sides. Along the north edge of the Rainy Creek area, the Broxson Gulch thrust fault strikes approximately east-west and forms the boundary between schist and less metamorphosed rocks. This north-dipping thrust fault has been traced from Broxson Gulch eastward to the Delta River, where it intersects or joins the Denali fault (Rose, 1965; Stout, 1965).

A relatively complex geologic history is evident from previous mapping of the region. The schist and gneiss of the high part of the Alaska Range have been generally considered as Precambrian in age and the oldest rock unit in the region. In the Rainbow Mountain area just east of the Delta River, Hanson (1964) distinguished pre-Mississippian meta-sediments and meta-volcanics which he considered younger than the schist and gneiss. Graywacke, andesitic pyroclastics and flows, and minor limestone of Mississippian and Pennsylvanian age are widely exposed in the Rainbow Mountain and Rainy Creek areas (Hanson, 1964; Rose, 1965; Stout, 1965; Bond, 1965). The Permian Menkomen formation is well exposed near the mouth of Eureka Creek and consists mainly of limestone and black shale with some graywacke and tuff. Triassic(?) Amphitheatre basalt is wide-spread in the lower hills south of the Alaska Range. West of the Maclaren River, Triassic(?) argillite and other clastic sediments are reported to overlie the basalt. Lenses of limestone occur near the contact between the basalt and the argillite (Ross, 1933; Kaufman, 1964). Mesozoic ultramafic, mafic, and granitic intrusives are widespread in the region.

The Tertiary Gakona formation, composed of sandstone, shale, and conglomerate derived from erosion of the uplifted Alaska Range, is preserved in several fault blocks along the south slope of the range.

In the Rainy Creek area, schist and gneiss form the exposures north of the Broxson Gulch thrust fault. Black slate, meta-diorite and meta-volcanics in a small thrust slice near Broxson Gulch were included in Group A of the previous report (Rose, 1965). Group B of the previous report consisted of silicic tuffs, limy tuffs, and limestones. Group C was composed of graywacke and andesitic volcanics similar to the Mississippian and Pennsylvanian rocks described by Hanson (1964). A group of rocks called "amphibole serpentinites" was considered to intrude the older rocks. The "amphibole serpentinite" and the older rocks are intruded by one large body and several smaller bodies of dunite, and by dikes and larger bodies of gabbro and mafic gabbro. In addition to the major Broxson Gulch thrust fault, the area is cut by two smaller thrust faults, two large east-west faults (the Airstrip and Pioneer faults) and numerous northwest and northeast cross-faults.

GEOLOGY OF THE AREA EAST OF BROXSON GULCH
(Rainy Creek Area, Figure 2)

Field work in the Rainy Creek area during 1965 consisted of mapping areas not previously covered by Stout (1965) or the writer (Rose, 1965), remapping areas of uncertain structure, additional study of the puzzling "amphibole serpentinites", and collection of additional stream sediment and rock samples in areas shown to be of interest by the previous work.

Figure 2 shows the results of all available mapping in the Rainy Creek area. The larger faults mapped by Stout are shown, but lithologic and stratigraphic correlations with his units have not yet been made. It is hoped that correlations can be made during the 1966 season.

Some minor changes in fault interpretation are shown on Figure 2, but no major changes were made from previous work by the writer. The thrust fault cutting Tertiary and Quaternary conglomerate mapped by Stout (1965) on Ann Creek was examined and it was concluded that the conglomerate is Quaternary (based on striated boulders), but the presumed Paleozoic sediments are probably large blocks that have slid down the hill rather than being the upper plate of a thrust. West of Broxson Gulch (Section 32, T18S, R8E), the black slate, meta-diorite, and meta-volcanic rocks of Group A, mapped in 1964, are now considered a part of the schist, phyllite, and gneiss sequence.

Rainy Creek basalt

As a result of the 1965 field work, the rocks previously shown as "amphibole serpentinite" are now regarded as a mafic-rich basalt of unusual texture, and will hereafter be referred to as the Rainy Creek basalt ("Cr" on figure 2). The andesite flow unit of Stout (1965) appears to correlate in part with the Rainy Creek basalt. The volcanic nature of these rocks in indicated by (1) the fragmental texture of many exposures, now regarded as of pyroclastic or flow breccia origin, (2) the existence of dikes of similar composition, (3) the aphanitic character of most of the rock, and (4) the presence of sediments interlayered with the volcanic rock. As noted in the previous report, the basalt is typically dark gray, mostly aphanitic, but with sparse coarser areas pseudomorphic after original mafic phenocrysts of either olivine or hypersthene. In thin section, very fine-grained pale green actinolite or hornblende makes up 75 to 95% of the rock. Minor amounts of chlorite and magnetite or pyrite are usually present, and up to 15% of a mineral that may be plagioclase. Small amounts of fine-grained epidote are also present in some specimens. Near gabbro and dunite the basalt is metamorphosed to hornfels containing brown hornblende, olivine, orthopyroxene, and possibly plagioclase.

A composition of mafic-rich basalt is indicated by the partial chemical analysis shown in Table 1. A norm calculation, assuming 2.0% TiO_2 and 2.5% Fe_2O_3, indicates 39% plagioclase (An_{76}), 22% hypersthene, 14% olivine, 14% diopside, and 7% opaque oxides. The mafic-rich character of the basalt is indicated by nickel content of 300 to 1200 ppm, averaging about 600 ppm, which is distinctly higher than most (but not all) basalts.

The mode of origin of the Rainy Creek basalt remains puzzling. The combination of fragmental texture with large extent (10 miles by 5 miles) and thickness (at least 1500 feet and possibly several times this), lack of perceptible layering or bedding (but with interlayered or included sediments), and aphanitic character do not seem to fit basalts described elsewhere.

Sediments interlayered with the Rainy Creek basalt were formerly considered inclusions in an intrusive (Rose, 1965) and were assigned to Group B. The interpretation of these rocks as volcanic implies that the tuffaceous sediments and limestone may be the same age as the basalt, although some might be large blocks rafted by flows. Several lines of evidence discussed in the previous report indicate that the basalt is younger than at least some rocks of Group C ("Cvs" of this report).

Rock and stream sediment sampling in the Rainy Creek area are discussed under Economic Geology and Geochemistry.

Table 1
Analysis of Rainy Creek Basalt Sample

	Sample 5E314	Olivine Basalt, Hawaii
SiO_2	45.12%	49.42
Al_2O_3	12.86	11.83
Fe (as FeO)	13.95	10.53
MgO	13.03	12.04
CaO	9.50	9.28
Na_2O	1.12	2.35
K_2O	<0.2	0.59
Loss of Ignition	1.50	0.16
	97.10	

Analysis by J.G. Smith, Coast Eldridge Engineers and Chemists Ltd. except K_2O by semi-quantitative x-ray fluorescence.

Location: 1.7 miles N10E from junction of West and North Forks and Rainy Creek, on hill just south of dunite exposure. The sample is relatively unmetamorphosed and unaltered compared to other specimens, fragmental in texture and largely aphanitic.

An x-ray diffraction pattern of this sample showed abundant hornblende-actinolite, some plagioclase, minor chlorite, and a possible trace of epidote. Actinolite and chlorite are the only minerals recognized with certainty in the thin section, except for plagioclase in a small fragment of andesite.

Hawaiian basalt analysis from Shepherd, American Journal of Science, V. 35A, p. 335, 1938.

GEOLOGY OF THE AREA WEST OF BROXSON GULCH
(Eureka Creek Area, Figure 3)

In this report, the East Fork of the Maclaren River is abbreviated to East Maclaren River, and the large glacier at the head of this river is referred to as the East Maclaren glacier. The large glacier in Broxson Gulch is called the Eureka glacier, after local usage. Landslide Creek and Compass Creek are names adopted for this report.

Schist and phyllite

The northern third of the area shown on figure 3 is composed of schist, phyllite, and slate. In general, the metamorphic grade, the degree of foliation, and the grain size of the rocks increase northward from the contact with the unfoliated rocks. Four units are recognized within the metamorphic rocks in the map area.

The black slate unit (sl) crops out between Broxson Gulch and Landslide Creek, and is lithologically identical to the black slate of Group A (Rose, 1965). Greenish and light gray phyllite are present locally within the black slate, and some black slate could be considered phyllite. Some quartz veining and considerable iron-staining derived from oxidation of fine-grained pyrite are evident.

The graywacke schist unit (gs) includes relatively fine-grained schist and phyllite originating as poorly-sorted clastic sediments, plus minor amounts of impure limestone as thin beds. Foliation is distinct to well-developed. The color is generally medium to light gray, but locally green, brown, and orange-brown colors are evident. Thin sections show that quartz, ablite, chlorite, and muscovite are the major constituents, along with smaller amounts of actinolite, epidote, and clinozoisite, and traces of graphite, pyrite, and carbonate. This mineral assemblage is indicative of greenschist facies metamorphism. The angular grains of quartz and plagioclase are enclosed in a foliated matrix of finer sericite and chlorite, or the quartz and plagioclase are in thin layers separated by layers rich in micaceous minerals.

Schist with plagioclase porphyroblasts (ps) forms a third unit which was mapped only in the northwest corner of figure 2, but is abundant in the moraine of the larger glaciers. This schist is similar to the graywacke schist but has coarser grain size and obvious porphyroblasts of a black mineral with good cleavage. Thin section examination shows that the black porphyroblasts are poorly-twinned albite filled with graphite in thin bands. Graphite bands are also present in the rest of the rock, but in most porphyroblasts the bands have been rotated up to 30° from their original orientation indicating that movement occurred during growth of the porphyroblasts. Other minerals in the schist are quartz, muscovite, and chlorite, plus minor sphene, apathite, pyrrhotite , tourmaline, and calcite.

A higher grade equivalent of the plagioclase schist is staurolite schist found locally in the moraine of the Eureka and East Maclaren glaciers. The staurolite schist was not seen in outcrop, but is apparently present in the higher mountains north of the area. This schist is brownish gray and contains plagioclase (An_{35}), biotite, quartz, staurolite, and minor garnet, muscovite, graphite tourmaline, rutile(?), and pyrrhotite, indicative of almandine amphibolite facies metamorphism.

The fourth unit, of meta-diorite and meta-volcanic rocks (mdv), is exposed adjacent to the East Maclaren glacier in Section 27, T18S, R7E, and in section 19, T18S, R8E. The two rock types are similar to the diorite and greenstone of Group A described previously (Rose, 1965) in a thrust slice near Broxson Gulch. Where undeformed, the diorite is medium-grained, poorly foliated, and composed of hornblende, saussuritized plagioclase, chlorite, quartz, and epidote. However, within a few feet of such poorly foliated diorite, the rock has commonly been highly sheared and locally mylonitized. Nearby andesite also varies from unfoliated to highly sheared over short distances. Green chlorite schist and phyllite in Section 25, T18S, R7E, adjacent to the Maclaren glacier are included with the meta-diorite and meta-volcanic rocks, although only a small amount of diorite was seen and a considerable amount of the schist and phyllite appears to be of sedimentary origin.

The age of the foliated metamorphic rocks is uncertain, and there is evidence for both a pre-Mississippian and a Mesozoic age for the original sediments. The lack of foliation in the adjacent rocks, the regional extent of the metamorphism, and the highly deformed and well-foliated nature of the schist close to the contact with the unfoliated rocks suggest that the schist and phyllite are pre-Mississippian, possibly Precambrian. This is the interpretation given by previous investigations in the region (Moffitt, 1954, Ragan and Hawkins, 1964). On the other hand, phyllite in Sections 19 and 30, T18S, R7E appears identical to phyllite in Sections 26 and 27, T18S, R6E on the opposite side of the Maclaren glacier. Argillite, schist, and related rocks between the Maclaren glacier and the Susitna River have been considered Triassic or younger on the basis of regional mapping and relations to fossiliferous limestone lenses in the upper part of the underlying greenstone (Moffit, 1912; Ross, 1933, Kaufman, 1964). Lithologic descriptions by these writers fit the phyllite and lower grade schist of the Eureka Creek area, and their description of locally more metamorphosed patches and a general increase in metamorphic grade to the north also matches the Eureka Creek area. The interpretation of the schist and phyllite as metamorphosed Mesozoic sediments appears understandable if it is assumed that the degree of deformation and metamorphism generally increased northward, and that the poorly sorted graywacke and shale were much more readily deformed and foliated than the massive volcanics to the south, causing the distinct break from foliated to unfoliated rocks. There is little if any break in the metamorphic grade, as indicated by the mineralogy, at the contact between foliated and unfoliated rocks. According to this hypothesis, the Mesozoic sediments may have been analogous to the clastic sediments of the Nutzotin Mountains of the eastern Alaska Range, but have been more thoroughly metamorphosed. The present south contact of the metamorphic rocks would be an unconformity or relatively small fault according to this hypothesis. The age of metamorphism would be late Mesozoic or early Tertiary, possibly related to the granitic intrusives of the region.

The evidence does not seem adequate to decide between the alternatives of pre-Mississippian and Mesozoic age, and both should be considered in any further mapping in the region. For convenience in this report, the metamorphic rocks are shown in legends and structural interpretations as pre-Mississippian(?).

Mississippian or Pennsylvanian dacite, andesite, and graywacke (Cvs, Cl)

Between Broxson Gulch and the East Maclaren glacier, the most abundant rock unit is composed of dacite, andesite, and graywacke of dacitic to andesitic composition. Many exposures are dacite agglomerate, and some dacite tuff is undoubtedly present. The rocks are moderately altered to chlorite, epidote, pyrite, quartz, and clay, and a greenish bleached or iron-stained appearance is common. A porphyritic texture is visible in many exposures. Bedding is present in some outcrops. All seven samples examined in thin section have the composition of dacite or quartz-bearing andesite.

Limestone beds up to 20 feet thick were mapped in five localities east of Landslide Creek, but none of the limestone could be traced more than a few hundred feet, either because the beds were originally lens-like, or because of subsequent faulting.

The rocks of this unit are similar to Group C of the Rainy Creek area and to the Rainbow Mountain sequence of Hanson(1964), except for the greater abundance of quartz. An age of Mississippian or Pennsylvanian is tentatively assigned on the basis of lithologic correlation with the above rocks plus the presence of crinoid stems and a poorly-preserved brachiopod in one of the limestone exposures.

Triassic(?) Amphitheatre basalt (TRa) and dacite (TRd)

Dark green to gray vesicular to massive basalt underlies a large area between the East Maclaren and Maclaren glaciers. This basalt is similar in all respects to the Amphitheatre basalt of probable Triassic age that is widespread to the south of the Eureka Creek and Rainy Creek areas (Moffit, 1912; Rose and Saunders, 1965; Rose, 1966). Most of the basalt appears to have originated as flows, but distinctly layered tuff and agglomerate is present locally in Section 6, T19S, R7E, accompanied by larger amounts of agglomerate with barely discernable layering and a fragmental appearance. Based on regional relationships described by Ross (1933) and Moffit (1912), the Amphitheatre basalt is presumedto dip northward beneath the Triassic(?) argillite. However, the one basalt attitude measured indicates a southward dip, and suggests close attention to the nature of this contact and the relative ages of the basalt and argillite in future mapping.

Porphyritic dacite intrudes the basalt in the lower part of Compass Creek. The dacite contains phenocrysts of plagioclase and fine hornblende needles, and is similar to hornblende andesite mapped near Paxson (Rose and Saunders, 1965).

Triassic(?) argillite (TRs) and limestone (TRi)

Dark gray argillite and slate argillite underlie most of an east-west zone between the East Maclaren and Maclaren glaciers. The argillite contains considerable fine pyrite and exposures of the rock are typically iron-stained. Crumpled bedding and striations along bedding indicate considerable deformation, as does conversion of some argillite to schist near faults in Section 6, T19S, R7E.

Accompanying the argillite are at least four beds of limestone. The most continuous bed extends along most of the contact between the argillite-limestone unit and the intrusive rocks to the north. This limestone bed is 20 to 50 feet thick and in most exposures exhibits a streaky banded appearance apparently resulting from deformation. The grain size in most exposures is fine, and no calc-silicate minerals were recognized, suggesting that the contact with the granitic rocks is a fault. A similar but thinner limestone bed is locally present a few hundred feet south. The most southerly exposure of sedimentary rock on the western fork of Compass Creek is a massive light gray dolomite, which is also poorly exposed on the main fork of Compass Creek. The fourth and thickest limestone bed is exposed in the northwest part of Section 6, T19S, R7E. This limestone is intruded by gabbro and locally replaced by magnetite and various calc-silicate minerals (see Economic Geology).

Minor amounts of arkose and conglomeratic graywacke are interbedded with the argillite in places.

The argillite and limestone are similar to sediments farther west assigned an age of Triassic or younger by Moffit (1912) and Ross (1933), and a tentative correlation with these sediments is made. As discussed previously, the schist and phyllite may be a more metamorphosed equivalent of the argillite.

Granitic and dioritic intrusives

Intrusives of granitic to dioritic composition underlie a considerable proportion of the Eureka Creek map area, in contrast to the Rainy Creek area, where the only plutonic intrusives are mafic and ultramafic in composition. Three relatively large granitic intrusives are present in the Eureka Creek area, plus three smaller bodies, two of which are dioritic.

Landslide Creek granodiorite

The Landslide Creek granodiorite occupies about two square miles between the East Maclaren Glacier and the headwaters of Landslide Creek. Two dikes of similar composition and texture crop out a short distance to the south of the main body, and a large inclusion of the granodiorite was found in peridotite in the southwest part of Section 27, T18S, R8E. The granodiorite is medium-grained, leucocratic, and light gray to buff in color. Biotite is the only mafic mineral. Sample 5E434 in table 2 indicates the typical composition. Most of the body is relatively uniform in character, but a more mafic-rich phase of quartz diorite composition is present near the southwest contact (sample 5E451, table 2). In the western part of the main body, the granodiorite is cut by numerous dikes ranging from diorite to quartz diorite and by a few diabase or dabbro dikes. It is also cut by two relatively large dikes and several smaller bodies of mafic gabbro and peridotite. Adjacent to these bodies of mafic gabbro and peridotite, the granodiorite is highly iron-stained and is partly to completely altered to quartz and an iron-bearing carbonate mineral (silica-carbonate alteration). The southwest contact with dacite and andesite is intrusive and irregular, but no metamorphic effects were noted in the adjacent volcanics other than the widespread pyritization and propylitic alteration. At the northwest corner, the granodiorite appears to intrude the meta-diorite and meta-volcanic unit, but interpretation is complicated by a peridotite dike and a zone of dioritic hybrid rock, plus an apparent necessity for a fault to account for the structure on opposite sides of the East Maclaren glacier.

Quartz monzonite

A very leucocratic pink to orange quartz monzonite crops out in about half a square mile just east of the terminus of the East Maclaren glacier. The composition is indicated by sample 5E461, table 2. Exposures at the southeastern end are more mafic-rich granodiorite with a porphyritic texture (sample 5E462). Most of the quartz monzonite is highly shattered and crumbly, and is exposed only on steep slopes and in gullies. A small amount of pyrite is present in some parts of the intrusive and is apparently responsible for some of the weak iron-staining that gives the orange color.

Table 2. Mineralogical composition of granitic and dioritic rocks

	5E407*	5E434*	5E451	5E454	5E461*	5E462	5E469	5E470	5E472	5E473	5E485	5E486*	5E498
Quartz	35%	42%	20%		35%	15%	10%	20%	2%	tr	20%	32%	12%
Feldspar	27	14	2		32	15					2 ?	8	3
Plagioclase	34	37	65	28	31	50	50	10	43	50	73	44	62
% An	28z	24z	40	5-10?	30	30		5-10?			10-15		65z
Biotite	2	6		5	1	3							5
Hornblende			10	15		15	10	20	20a	48a		7	16
Clinopyroxene				20					35				tr
Chlorite	1	1	2	10		1	3	3			5	8	
Epidote		a	a	10			17	30	a	a	a		
Sericite	a	a	a	10			5	15			a		
Limonite					1								
Magnetite	1	tr	tr	2		2		1	2				tr
Leucoxene					tr					2			
Shpene	tr			tr		tr				tr			
Apatite			tr	tr		tr	tr	tr				tr	tr
Zircon		tr				tr							
Pyrrhotite													2
Grain size (mm.)	2	1-3	1-2	1-2	2-4	2 Porphyritic	2	z-3	1/2	1/2-2	2-5	1	1
Name	Qtz. Monz.	Granodi.	Qtz. Dior.	Diorite	Qtz. Monz.	Granodi.	Qtz. Dior.	Qtz. Dior.	Diorite	Diorite	Soda Granite	Granodi.	Qtz. Dior.

* Composition based on point count of 450 to 500 points.

z Zoned

a Alteration product, assigned to original mineral if no percentage shown

Tabe 2 (Continued)

5E407	Quartz monzonite of Section 4, T19S-R8E.
5E434	Landslide Creek quanodiorite, typical specimen, SE 1/4 Section 30, T18S-R8E.
5E451	More mafic phase of Landslide Creek intrusive, SW 1/4 Section 5, T18S-R7E.
5E454	Diorite of SW 1/4 Section 36, T18S-R7E, a common type.
5E461	Quartz monzonite, NW 1/4 Section 1, T19S-R7E.
5E462	More mafic phase of above, NW 1/4 Section 6, T19S-R8E.
5E469	Compass Creek intrusive granodiorite and quartz diorite phase, on the west fork of Compass Creek.
5E470	Compass Creek intrusive, diorite and quartz diorite phase, SW 1/4 Section 33, T18S-R7E.
5E472	Diorite inclusion in diorite phase of Compass Creek intrusive, NW 1/4 Section 32, T18S-R7E.
5E473	Compass Creek intrusive, diorite phase, NW 1/4 Section 32, T18S-R7E.
5E485	Compass Creek intrusive, soda granite phase, SW 1/4 Section 34, T18S-R7E.
5E486	Compass Creek intrusive, granodiorite phase, SW 1/4 Section 34, T18S-R7E.
5E498	Quartz diorite of Section 6, T19S-R7E.

The adjacent andesite and dacite are strongly pyritized and altered to chlorite and epidote, but are not otherwise metamorphosed. On the south side, sediments of the Gakona formation are faulted against the quartz monzonite.

Compass Creek intrusive

The Compass Creek intrusive is composed of a zoned sequence of granitic to dioritic intrusives in an east-west belt between the Maclaren and East Maclaren glaciers. The southernmost exposures are a leucocratic, medium-grained pink granitic rock shown by a thin section to be a soda granite containing abundant sodic oligoclase but very little potash feldspar (sample 5E485, table 2). The original mafic mineral was apparently biotite, now almost completely altered to chlorite.

A narrow strip north of the soda granite is composed of medium gray, medium-grained quartz diorite and granodiorite, typified by samples 5E 469 and 5E486. The grain size is finer than the granite, and the mafic mineral is hornblende.

The main northern part of the intrusive is composed of diorite and quartz diorite, with variable texture and composition. Samples 5E470 and 5E473 are typical. Hornblende is the main mafic constituent, and in most of this phase, only a small amount of quartz is present. The feldspars are saussuritized and the mafic minerals mainly altered to actinolite. Inclusions of fine-grained diorite and andesite are common.

Exposures are not good enough to determine the nature of the contacts between the major phases of the pluton, but within the diorite phase there are abrupt changes, apparently intrusive in nature, between varieties differing in texture and mafic content. The contacts between granite and quartz diorite and between quartz diorite and diorite can be located within 20 or 30 feet and appear to be relatively planar and dip moderately to the north. These contacts could be either intrusive or faulted.

The south contact of the intrusive with the country rock is believed to be a fault, based on the lack of metamorphism of adjacent limestone and the sheared character of the limestone, plus a zone of brecciated conglomeratic graywacke adjacent to the East Maclaren glacier. Several faults offset the south contact.

The north contact, with the metamorphic rocks, was not examined in detail.

Quartz monzonite, Section 4, T19S, R8E

A small area of biotite quartz monzonite crops out near the center of this section. Much of this body is moderately altered and pyritized, but the composition of a relatively unaltered specimen is shown in table 2 (sample 5E407). This quartz monzonite intrudes highly pyritized dacite and andesite on the north, and is faulted against Tertiary sediments on the south.

Diorite, Section 36, T18S, R7E

Dark fine-grained diorite and related rocks are exposed just north of the quartz monzonite in this area. The intrusive is quite variable in composition. Pyroxenite was seen in one area, and very fine-grained gabbro cut by coarser gabbro or diorite in another. Sample 5E454, table 2, is a relatively widespread phase. The contact of the quartz monzonite extends without interruption across the trend of the diorite, suggesting that the quartz monzonite is younger than the diorite.

Quartz diorite, Section 6, T19S, R7E

An elongate body of mafic-rich quartz diorite, typified by sample 5E 498, has intruded pyritized argillite at this location.

Diabase (g)

At least two dikes of diabase or gabbro have intruded limestone and slaty argillite in Section 6, T19S, R7E. The limestone near the northern dike is metamorphosed to clinopyroxene, garnet, magnetite, and coarse calcite, and the dike is highly altered. The age of the diabase relative to other intrusive rocks is not known.

Ultramafic rocks (d, p)

Dunite, peridotite, and mafic gabbro similar to that reported from the Rainy Creek area occur as dikes up to 1/4 mile wide in an east-west trending zone approximately through the center of the map area. Within this belt the ultramafic rocks are most abundant in the eastern part of the area, between Broxson Gulch and the East Maclaren glacier, and seem to finger out and become less abundant in the western part of the map area. The three rock types grade into each other and also occur as narrow dikes of gabbro or mafic gabbro in peridotite or dunite, so it was not possible to completely separate them on the map. In general, dunite is the predominant type in the eastern part of the map area, but was not found west of the East Maclaren glacier. Between Broxson Gulch and Landslide Creek, dunite, peridotite, and minor mafic gabbro separate the slate and phyllite of the metamorphic sequence from the dacite-andesite sequence. The ultramafic rocks were evidently intruded along a fault or unconformity. Farther west, ultramafic rocks occur mainly within the granitic intrusives. However, one thick dike of dunite and peridotite almost coincides with the contact between the Landslide Creek granodiorite and the metamorphic rocks.

Dunite also forms a large area just north of Eureka Creek, and was observed from the air to form the north slopes of a large hill in Sections 21, 22, and 26, T19S, R8E.

The larger bodies of dunite are relatively unaltered, but the smaller bodies and most of the peridotite and mafic gabbro are moderately to severely altered to serpentine, actinolite, and saussurite.

Age of intrusive rocks

The age of the intrusive rocks can be given only as Mesozoic(?). Among the intrusive types, the ultramafic rocks clearly intrude the Landslide Creek and Compass Creek plutons. The diorite of Section 36 appears to be younger than the quartz monzonite. The intrusives of the eastern part of the map area intrude the Mississippian-Pennsylvanian andesite-dacite sequence, and diabase and quartz diorite of Section 6 are younger than Triassic(?) argillite and limestone. The Compass Creek pluton is probably younger than the Triassic(?) sediments. In the Rainy Creek area, gabbro sills and dikes intrude the Permian limestones and shale. From regional evidence, the intrusives appear to be older than the Tertiary sediments. Based on this information, the granitic and ultramafic intrusives are concluded to be Jurassic, Cretaceous, or early Tertiary in age, with the ultramafic intrusives being younger than the granitic intrusives. A Jurassic or Cretaceous age is in agreement with reconnaissance mapping of the U.S. Geological Survey (Capps, 1940).

Tertiary Gakona formation (Tg)

Coal-bearing sandstones, shales, and conglomerates of the Tertiary Gakona formation (Mendenhall, 1905) are poorly exposed along lower Landslide Creek and some of its tributaries. Careful search would probably disclose additional exposures. Similar sediments were also found in the lower part of Broxson Gulch. Although carbonaceous material was found in almost every exposure of the Gakona formation, the thickest coal beds noted were only about six inches thick.

Tertiary conglomerate (Tc)

Two exposures of conglomerate between Landslide Creek and the East Maclaren glacier may be facies of the Gakona formation, but are unusual enough to merit special attention. The more southerly of these (just south of Hill 5460) is composed of about 95% dunite and 5% gabbro as boulders and cobbles. The fragments show very little evidence of weathering before deposition. The conglomerate appears to occur as a bed about 100 feet thick dipping to the south of about 10 degrees. However, the dunite conglomerate bed has subsequently broken up into blocks up to 25 feet in diameter that have slid eastward down the slope toward Landslide Creek, and the entire slope is now covered by these huge blocks of conglomerate (see picture by Moffit, 1912, plate Iv A, p. 32). The present stream has cut a sharp valley about 100 feet deep into alluvial fans which extend from the opposite side of the valley, and the layer of dunite conglomerate blocks can be seen to extend beneath the fans, indicating that the sliding occurred before the present erosional epoch, possibly during the waning stages of Pleistocene glaciation.

The northerly conglomerate body lies just south of the granodiorite stock, and is composed of dunite and granodiorite boulders, cobbles, and sand. Crude bedding is locally visible, dipping moderately southwest. This body of conglomerate appears to be thicker than the dunite conglomerate, but exposures are too poor to determine its base.

Both conglomerates are interpreted to have formed by rapid erosion of newly-exposed rocks along the fault scarp, possibly the fault just north of the more northerly conglomerate exposure. The abundance of dunite in the more southerly block may be explained by a greater abundance of dunite in the eroded portion of the fault block. The proposed origin is thus analogous to the "mega-breccias" of Longwell (1951) and the debris-flow accumulations of Noble and Wright (1954).

STRUCTURAL GEOLOGY

In the unfoliated rocks of the area, faulting is the most important kind of deformation recognized. The faults of the area appear to fall into five main groups. These are: east-west faults with moderate dips to the north, east-west faults with steep or vertical dips, northwest faults, northeast faults, and north-south faults.

East-west faults with moderate dips to the north are probably of thrust or reverse nature and are found along the contacts of and within the Triassic(?) argillite-limestone sequence. They are probably also present within the schist and phyllite but are not obvious because they are parallel to the foliation. Faults of this nature may form the north contacts of the two largest granitic plutons, or alternatively, the granitic rocks may have been intruded along pre-existing faults of this type.

An east-west fault of steep dip separates the Tertiary Gakona formation from older rocks to the north. At least one and probably two smaller faults of this type are present between Landslide Creek and the East Maclaren glacier, forming a graben occupied by the northerly body of Tertiary conglomerate. Movement on the fault forming the north side of this graben and on the large fault forming the north contact of the Gakona formation has been north side up. At least part of the Tertiary uplift of the Alaska Range has probably taken place on these faults. Movement on the second small fault, which is inferred to account for the restricted area occupied by the conglomerate, would be opposite in direction.

Northwest-striking faults are mapped in Broxson Gulch and near Landslide and Compass Creeks. A fault in Broxson Gulch is required by the large discontinuity between the geology east and west of Broxson Gulch (figure 1). In the Rainy Creek area, unfoliated rocks extend north to the Broxson Gulch thrust fault. However, west of Broxson Gulch in the Eureka Creek area, the contact between foliated and unfoliated rocks, although still trending east-west, is about two miles farther south. The exposures in Broxson Gulch allow two possible locations for the fault evidently responsible for this discontinuity. One alternative is an approximately north-south fault, possibly extending from Landmark Gap (about 7 miles south of the map area) through Broxson Gulch and up the glacier in Section 13, T18S, R8E. A second alternative, and the one favored here, is a northwest-striking fault forming the contact between the Gakona formation and older rocks in the East Fork of Broxson Gulch, and extending up the lower part of the Eureka Glacier. This alternative is favored because of the presence of several small faults of northwest strike both east and west of Broxson Gulch, and because the exposures of Gakona formation along the East Fork seem more reasonably placed with other exposures of Gakona formation on the west side of the fault. This large northwest fault will be called the Eureka Fault. It appears likely that the Broxson Gulch thrust is later than the Eureka Fault, and that it cuts off the Eureka Fault and passes into the foliation of the schist west of their intersection under the Eureka glacier.

Movement on the small northwest fault near Compass Creek appears to be either right lateral strike slip or up on the southwest. The northwest fault near Landslide Creek may have had similar movement, but is postulated to have moved up on the northeast during Tertiary movement on the steep east-west faults. The direction of movement on the Eureka fault is uncertain because the attitude of the contact between foliated and unfoliated rocks is uncertain.

A northeast-striking fault offsets the contact of the Compass Creek intrusive adjacent to the East Maclaren glacier. This fault may be related to several northeast-striking faults in the Rainy Creek area. Faults of this trend previously mapped by Stout (1965) and the writer are left lateral tear faults related to thrusting.

A north-south fault may exist down the East Maclaren glacier. A fault of this type appears to be required by the discontinuity of pre-intrusive rock types across the glacier. The apparent continuity of units in the metamorphic sequence indicates that this fault is cut off by an east-west fault.

In the area between Broxson Gulch and Landslide Creek, the wide ultramafic dike separating foliated and unfoliated rocks apparently intruded a pre-existing fault (or an unconformity if the foliated rocks are Mesozoic). The dike has a steep or vertical dip and an east-west trend for about two miles west from Broxson Gulch, suggesting that the controlling structure was a normal fault. Farther west, the dike dips northeast at a moderate angle and strikes about N60W, suggesting a thrust fault or an unconformity for the controlling structure. The moderate northward dip of most of the ultramafic dikes cutting the Landslide Creek and Compass Creek intrusives suggests that structures of this attitude existed prior to ultramafic intrusion.

In the Rainy Creek area, bedding dips south in most fault blocks. Bedding in the Triassic sediments near the Maclaren glacier and to the west dips northward. The structural feature responsible for this change in dip has not been identified.

GEOLOGIC HISTORY OF THE AREA

As discussed previously, the age of the parent rocks of the schist and phyllite is uncertain. Assuming they are pre-Mississippian, they were also metamorphosed prior to Mississippian time. The Mississippian and Pennsylvanian sediments and volcanics were deposited next, followed by Permian Mankomen formation, Triassic(?) Amphitheatre basalt and intercalated sediments, and Triassic argillite, limestone, and other sediments. Taken overall, the deposition was under eugeosynclinal conditions, but the Triassic(?) argillite and related sediments may be clastic wedge deposits in basins marginal to areas of Mesozoic uplift. The moderately-dipping east-west faults apparently were formed by north-south compression during the Mesozoic, and were the structural control for intrusion of granitic and dioritic rocks. Some folding probably took place during this period, accounting for the northward dip of the Triassic rocks near the Maclaren glacier and the southward dip of most Mississippian through Triassic rocks in the Rainy Creek area. Intrusion of the granitic to dioritic rocks was followed by further development of the moderately-dipping east-west faults and intrusion of the ultramafic rocks. The area was then cut into blocks by the northwest and north-south faults. The relative age of these two sets of faults is uncertain. Thrusting was the next major event, and may have included some renewed movement on the moderately dipping east-west faults in addition to the thrusting in the

Rainy Creek area and the movement on the associated northeast tear faults. The era of north-south compression apparently ended with the thrusting, and was followed by predominantly vertical movements which uplifted the Range along the steep east-west faults. The Gakona formation was deposited adjacent to the range during this period, followed by further uplift which may still be continuing.

The above sequence fits the Eureka Creek area and most relationships in the Rainy Creek area. The main exception is the Airstrip fault, which is a steep east-west fault and according to the above interpretation should be later than faults of other trends, yet it is cut off by the Eureka fault. An older period of movement on the steep east-west faults is necessary to account for this, or movement on the Eureka fault during Tertiary uplift.

ECONOMIC GEOLOGY

Although several of the localities discussed below are probably not of commercial interest, they are included in this report to show the type of mineralization occuring in the area.

Locality 1 (Figure 2)

A sample collected in 1964 from iron-stained black slate in the small thrust block east of the East Fork of Broxson Gulch contained 0.1 ounce per ton gold and small amounts of silver and nickel, according to an assay made at that time. An assay of $3.50 per ton seemed interesting enough to encourage further work. However, re-assay of the sample during 1965 showed no gold and silver, and nine additional samples of slate, some of which were high-graded for quartz veins and iron-staining, contained nil to 0.01 ounce per ton gold and nil or trace silver. The slate samples were also analyzed for various base metals by geochemical methods with the following results: 5 to 75 parts per million copper, 60 to 135 parts per million zinc, 0 to 5 parts per million lead, 2 to 21 parts per million molybdenum, 20 to 90 parts per million nickel and 5 to 45 parts per million arsenic. The slate no longer appears of any interest for its mineral content.

Locality 2 (Figure 2)

A smaple of gossan from this locality in the Rainy Creek drainage collected in 1964 was analyzed in 1965 and found to contain 2350 ppm copper, 50 ppm zinc, 215 ppm lead, and 7 ppm molybdenum. The gossan has developed from pods of sulfide-rich material replacing limestone adjacent to a gabbro dike. A moderate size fault cuts the rocks a few tens of feet to the south and some limestone has been altered to skarn. The locality may be of interest for the high copper content of the gossan, although the observed gossan zone was only about ten feet wide, and did not appear to be present in outcrops a few tens of feet away. Other sulfide-rich replacements were found a few hundred feet away and described previously (Rose, 1965, Locality 4).

Locality 3 (Figure 3)

Occasional small veins of chrysotile asbestos up to 1/4 inch wide are present in dunite of this vicinity, and samples of coarser asbestos were found in the nearby abandoned camp of a prospector. Although not all outcrops were visited, it seems unlikely that any appreciable tonnage of asbestos ore is present in this vicinity.

Locality 4 (Figure 3)

A deposit of limonite-cemented talus crops out at this locality. An old pit into the material does not appear to have reached bedrock, which is inferred to be black slate. The limonite-rich material contains 1,000 ppm zinc, 375 ppm lead, 12 ppm molybdenum, and 115 ppm copper. Transported limonite commonly originates by oxidation of pyrite-rich rocks, and the anomalous content of zinc and other metals both in the gossan and in nearby stream sediments suggests that some base metal sulfides probably accompany the pyrite. Further prospecting is necessary to determine the location, grade, and character of the source material.

Locality 5 (Figure 3)

A sheared zone in dacite agglomerate contains pyrite, chalcopyrite, and malachite. The sheared zone strikes N85W and dips 35SW. It has been prospected by a shallow trench and several small pits, and was staked in 1964 by a prospector for Moneta-Porcupine but apparently never recorded. A sample across a width of one foot contained 2.95% copper, 2.2 ounce per ton silver, and no gold. The shear zone and sporadic iron-staining can be traced up the hill for several hundred feet.

Locality 6, (Figure 3)

Dunite of this vicinity is cut by sporadic veins and lenses of opal, calcite, brittle chrysotile, magnetite, chromite, and an unidentified green glassy mineral. No concentrations of economic grade were noted.

Locality 7 (Figure 3)

This small gully draining westward into the Maclaren glacier follows a fault. On the south side of the fault, Triassic(?) limestone is cut by a diabase dike and altered to skarn. Magnetite is present in amounts of 10 to 20 percent in some exposures of skarn. Other minerals include diopside, garnet, and coarse calcite. The exposures are largely covered by gravel, so the extent of the magnetite could not be determined. Skarn was found over a length of about 1/2 mile, but magnetite was noted only in the eastern half of this distance. A magnetic survey should allow an appraisal of the size of the magnetite-bearing area, and possibly give an idea of its grade.

Locality 8 (K-M prospect, Figure 3)

The K-M prospect has been described by several previous workers (Chapman and Saunders, 1954; MacKevett, 1964; Kaufman, 1964). The prospect is on a north-striking quartz vein containing chalcopyrite and bornite which cuts Amphitheatre basalt. At the discovery point, a sample across 10.75 feet contained 10.9% copper. The vein has been explored by 800 feet of underground workings, and by trenches on the surface, both of which indicate that the width of the vein and the copper content of the vein decrease northward. Little or no work has been done since the visit of MacKevett in 1960. MacKevett states that the faulted southern extension of the vein had not been found, but several quartz veins, one of them several feet wide, are now exposed just above the portal of the adit. These veins (shown on the sketch map of Kaufman) may represent the southern extension. Very little copper is evident in these veins.

Other copper occurrences

Minor occurrences of copper were noted in the following locations:

1. Headwaters of Ann Creek, figure 2. Copper staining in metamorphosed limestone cut by numerous dikes and adjacent to a thrust.

2. Section 35, T18S, R8E. Copper stain and quartz veining in graywacke adjacent to an andesite dike.

3. Section 33, T18S, R8E. Fine chalcopyrite disseminated near fractures in graywacke. Estimated grade 0.2% copper across 5 feet.

4. Section 31, T18S, R8E. Local copper staining in a highly fractured zone in pyritized andesite.

5. Section 25, T18S, R7E. A vein of limonite about 6 inches wide with an adjacent zone of copper staining in a mafic gabbro dike.

6. Section 4, T18S, R7E. Vesicles in basalt filled by opal, chlorite, pyrite and minor chalcopyrite.

Silica-carbonate veins and alteration

Throughout the area, veins and patches of rock containing quartz and an iron-bearing carbonate mineral have weathered to obvious stained patches. No valuable minerals were noted in any of these, but they are similar to gold-bearing veins of the Valdez Creek district and to lead-silver veins of the Slana area, and may be worthy of some attention in any future prospecting of the area.

STREAM SEDIMENT SAMPLING

A total of 227 stream sediment samples were collected in the Rainy Creek and Eureka Creek areas during 1964 and 1965 and are plotted on figures 2 and 3. The analytical data for these samples are listed in table 3. The samples consist of fine sediments from below the water level, and were screened to -80 mesh before the laboratory analyses for total copper, zinc, lead, molybdenum and nickel were done. Analyses for readily extractable heavy metals and copper were done in the field before screening.

Background for copper is mainly in the range of 50 to 150 parts per million (figure 4), but because certain rock types appear to have slightly higher background, a value of 200 ppm is selected as a threshold for anomalies (see Rose, 1965, for further data on copper content of rocks in the area). For zinc, a threshold of 220 ppm is used, for lead 30 ppm, and for molybdenum 6 ppm (but values below 10 are regarded as questionable anomalies). Sediments containing more than 400 ppm copper, 500 ppm zinc and 100 ppm lead are considered strong anomalies. The nickel background for most rocks in the area is less than 100 ppm; however, the ultramafic and mafic rocks contain several hundred to several thousand ppm nickel, and streams draining these rocks give correspondingly higher values. Nickel values over 200 ppm are considered anomalous only if no ultramafic rocks, dunite conglomerate or Rainy Creek basalt are present in the drainage.

Discussion of anomalies

Samples 4 through 12, 23, and 24.

Discussed in the previous report (Rose, 1965). If Stout's andesite flow unit correlates with the Rainy Creek basalt, the nickel anomalies can be discounted. A moderate copper anomaly and two weak zinc anomalies remain.

Samples 27, 28, 29, 32, 33, 34, and 35.

Discussed in the previous report. A half-day reconnaissance in this

Table 3

Analyses of Stream Sediments

Map No.	Field No.	Cu ppm	Zn ppm	Pb ppm	Mo ppm	Ni ppm	Readily Extractable H. M. ml.	Readily Extractable Cu ml.
1	4WP134*	100	120	5			4	
2	4WP135*	90	125	5			5	
3	4WP259*	150	135	0	0	180	1	
4	4WP260	415	210	5	3	175	7	
5	4WP261	155	300	15	2	85	4	
6	4WP258	145	140	5	2	135	1	
7	4WP262	110	115	5	2	175	1	
8	4WP257*	70	95	0	0	420	3	
9	4WP263	150	150	10	3	260	5	
10	4WP264	130	140	10	3	350	3	
11	4WP256*	100	90	0	0	550	3	
12	4WP265	180	100	5	3	260	4	
13	4WP136*	100	125	10			7	
14	5N79	100	135	5	2	400	5	
15	4WP255						5	
16	4WP267	130	80	10	2	360	5	
17	4WP268	130	95	10	2	60	3	
18	4AR457	125	145	5	2	115	4	
19	4AR458						2	
20	4WP271	70	85	10	2	80	2	
21	4WP269	65	45	5	1	60	6	
22	4WP270	120	150	5	3	500	13	
23	4AR459	135	125	5	2	240	4	
24	4AR460	105	90	5	2	460	7	
25	4AR455	170	200	5	3	740	7	
26	4AR461	160	105	10	3	1100	3	
27	4AR462	235	235	5	3	835	10	
28	4AR463	215	200	0	3	1700	8	
29	4AR464	230	310	10	3	145	19	
30	4AR467	110	100	5	3	130	6	
31	4AR469	135	130	5	3	105	5	
32	4AR466	240	140	5	3	120	20	
33	4AR470	300	135	5	4	130	11	
34	4AR471	305	140	5	3	130	7	
35	4WP272	200	125	5	2	120	4	
36	4AR454	130	110	5	3	835	1	
37	4WP266	65	80	10	3	240	2	
38	4WP137*	85	125	0			2	
39	4WP138	50	85	5	1	120	2	
40	5N78	60	110	5	2	220	4	

Map No.	Field No.	Cu ppm	Zn ppm	Pb ppm	Mo ppm	Ni ppm	Readily Extractable H. M. ml.	Readily Extractable Cu ml.
41	5N61	50	85	5	2	190	1	
42	5N77	50	80	5	2	330	2	
43	4WP139*	40	145	5			2	
44	5N76	50	100	5	2	130	0	
45	5N63	65	175	5	3	220	2	
46	4WP140*	55	150	0			1	
47	4WP141*	50	105	5			1	
48	5N75	65	120	10	2	650	0	
49	5N74	55	100	10	3	200	0	
50	4WP155*	90	110	0	0	1000	1	
51	5N73	80	110	10	3	930	5	
52	5N62	65	90	5	2	320	1	
53	4WP146*	115	140	10			1	
54	4WP154*	95	100	0	0	1050	1	
55	5N72	80	135	10	3	720	1	
56	4WP153*	145	100	0	0	1100	1	
57	4WP152*	80	90	0	0	870	1	
58	4WP151*	170	95	5	1	520	1	
59	5N71	130	160	15	3	+1000	3	
60	4WP156*	85	120	0	1	780	1	
61	4WP163	85	105	0	0	460	3?	
62	4WP162*	70	85	0	0	800	1	
63	5N68	290	205	35	(5)	+1000	9	
64	5N70	135	135	10	2	+1000	2	
65	5N68	520	270	80	3	+1000	12	
66	4WP157	330	145	25	3	1500	5	
67	5N67	120	170	320	(8)	+1000	2	
68	4WP158	370	110	5	3	2300	2	
69	5N69	290	190	15	(6)	+1000	7	
70	4WP159*	135	145	0	1	1300	1	
71	4WP160*	40	90	0	0	40	1	
72	4WP161*	60	190	0	0	2100	1	
73	WP147*	105	130	10			1	
74	WP148*	175	110	0			1	
75	4AR356	750	125	5	4	500	3	
76	4WP172*	70	90	0	1	210	1	
77	4WP173*	45	105	0	0	55	1	
78	4WP175*	75	135	0	0	225	1	
79	4WP215*	50	180	0	0	70	1	
80	4WP214*	55	210	0	2	75	5	
81	4WP212	170	750	35	2	175	5	
82	4WP229	70	90	5	2	260	1	
83	4WP228#	70	110	0	0	340	1	
84	4WP226#	90	115	0	0	260	2	
85	4WP225#	145	100	0	0	330	1	

Map. No.	Field No.	Cu ppm	Zn ppm	Pb ppm	Mo ppm	Ni ppm	Readily Extractable H. M. ml.	Cu ml.
86	4WP224#	115	95	0	1	530	1	
87	4WP223#	305	210	5	0	40	1	
88	4WP222#	105	30	0	0	240	1	
89	4WP221#	185	60	0	0	435	1	
90	4WP220*	2500	125	0	1	400	10	
91	4WP219#	325	85	0	0	615	9	
92	4WP211*	140	65	0	0	420	1	
93	4WP210*	120	200	0	4	330	2	
94	4WP236*	75	90	0	0	270	1	
95	4WP237	185	150	0	2	280	1	
96	4WP238	215	270	5	3	290	5	
97	4WP231#	160	90	0	0	615	3	
98	4WP232#	165	95	0	0	375	1	
99	4WP233	135	70	5	2	250	1	
100	4WP234*	105	130	0	3	45		
101	4WP235*	140	85	0	0	270	1	
102	4WP184#	120	170	0	3	100	1	
103	4WP185#	70	115	0	0	210	1	
104	4WP183*	45	110	0	0	240	2	
105	4WP182*	135	135	0	0	240	2	
106	4WP186*	70	60	0	0	420	2	
107	4WP193*	145	150	0	0	300	2	
108	4WP192*	70	150	0	0	1200	1	
109	4WP187*	105	145	0	1	320	1	
110	4WP188	185	105	5	2	340	1	
111	4WP191*	65	120	0	0	1200	1	
112	4WP190*	45	125	0	0	80	2	
113	4WP189	55	125	5	1	50	3	
114	4WP303						3	
115	4WP304*	85	145	15	1	75	2	
116	4WP307	65	85	5	1	40	12	
117	4WP311	55	105	5	1	50	8	
118	4WP310*	65	125	20	1		4	
119	4WP309*	70	125	15	1		7	
120	4WP308	70	125	10	1	75	1	
121	4WP306	65	125	5	1	45	8	
122	4WP305						2	
123	4WP301*	70	125	0	0	70	4	
124	4WP285	55	70	5	1	35	14	
125	4WP286	50	95	5	1	40	21	
126	4WP287*	55	60?	15	0	80	5	
127	4WP312	100	205	10	4	200	1	
128	4WP289	245	150	5	2	435	3	
129	4WP288*	175	40?	15	0	550	14	
130	4WP284	140	160	5	3	410	6	

Map No.	Field No.	Cu ppm	Zn ppm	Pb ppm	Mo ppm	Ni ppm	Readily Extractable H. M. ml.	Readily Extractable Cu ml.
131	4WP283	110	45	5	1	220	7	
132	4WP282	80	130	25	2	180	7	
133	4WP318	45	110	5	2	45	14	
134	4WP319	80	175	10	3	85	2	
135	4WP281	110	290	70	2	105	1	
136	4WP326*	50	110	5	0	35		
137	4WP325*	45	60	5	0	35		
138	324	60	110	15	2	40	10+	
139	5N109	65	95	5	3	90	7	
140	5N108	75	235	10	3	80	14	13
141	4WP323*	80	200?	5	0	55	3	
142	4WP322*	60	200?	5	0	60	4	
143	4WP321	35	50	5	1	25	9	
144	4WP320*	60	100?	10	0	45	4	
145	5N137	60	185	20	2	100	2	
146	5N106	90	320	10	6	70	3	
147	5N107	110	600	15	8	100	20	
148	5N105	110	380	10	6	90	6	
149	5N104	140	170	15	3	80	8	
150	5N103	115	185	10	3	80	3	13
151	5N102	65	115	10	2	70	2	0
152	5N101	85	130	15	3	70	0	
153	5N100	70	380	5	13	70	8	
154	5N81	100	330	10	4	210	13	17
155	5N88	110	190	10	2	570	4	
156	5N89	100	145	15	2	140	3	
157	5N82	95	320	10	4	140	1	
158	5N90	140	175	5	3	820	5	
159	5N91	190	145	5	3	+1000	0	
160	5N92	95	190	5	3	400	7	
161	5N99	85	160	10	3	120	3	
162	5N94	110	485	10	(7)	600	19	15
163	5N93	85	290	10	3	80	12	0
164	5N98	90	290	15	4	80	7	
165	5N97	65	130	15	3	60	1	
166	96	80	170	5	3	60	0	
167	5N95	95	445	10	6	80	10	8
168	5N110	95	145	20	3	220	4	
169	5N136	100	135	20	2	170	3	
170	5N135	120	185	35	3	200	1	
171	5E408	160	190	25	2	80	10	
172	5N159	155	185	50	4	90	2	
173	5N160	60	145	10	3	210	0	
174	5N161	485	170	75	2	130	18	
175	5N158	430	235	65	3	70	17	

Map No.	Field No.	Cu ppm	Zn ppm	Pb ppm	Mo ppm	Ni ppm	Readily Extractable H. M. ml.	Readily Extractable Cu ml.
176	5N157	210	140	20	4	80	2	
177	5N165	100	90	5	3	90	3	
178	5N166	80	160	5	2	100	1	
179	5N168	60	95	5	2	180	0	
180	5N170	110	105	5	2	90	1	
181	5N156	100	310	10	(5)	370	4	
182	5N164	65	135	10	2	220	2	
183	5N163	70	115	10	(4)	610	1	
184	5N149	65	140	20	(4)	700	2	
185	5N150	70	100	10	3	210	2	
186	5N151	50	60	5	2	180	2	
187	5N152	60	90	10	4	370	3	
188	5N153	80	175	10	3	60	4	
189	5N154	65	145	5	4	80	2	
190	5N155	105	310	10	4	410	17	
191	5N162	115	320	10	(5)	490	7	
192	5N183	260	105	5	7	120	2	
193	5N184	65	90	10	4	40	0	
194	5N185	215	115	10	4	90	1	
195	5N172	35	50	15	17	30	1	
196	5N173	240	210	20	3	80	1	
197	5N174	75	95	10	2	180	0	
198	5E458	95	115	10	3	300	0	
199	5E452	65	85	10	3	150	0	
200	5E448	60	80	5	3	330	0	
201	5E450	65	105	5	3	80	9	
202	5N220	65	110	~5	2	170	11	
203	5N219	50	55	~5	2	40	2	
204	5N218	65	80	~5	2	60	9	
205	5N217	100	125	-5	3	80	5	
206	5N216	180	120	5	2	80	6	
207	5N215	80	100	5	3	70	4	
208	5N221	65	100	5	3	120	3	
209	5N206	60	100	5	2	70	4	
210	5N198	75	235	10	4	70	18	
211	5N194	80	320	10	7	90	2	
212	5N191	25	70	10	2	60	3	
213	5N193	55	80	5	2	70	0	
214	5N192	80	115	10	2	90	0	
215	5N214	110	140	10	3	70	3	
216	5N197	50	110	5	2	80	1	
217	5E196	105	175	10	4	100	0	
218	5E195	50	170	5	5	70	+20	
219	5E203						3	
220	5E210	55	130	5	2	80	11	

Map No.	Field N No.	Cu ppm	Zn ppm	Pb ppm,	Mo ppm	Ni ppm	Readily Extractable H. M. ml.	Readily Extractable Cu ml.
221	5E199	80	100	-5	3	60	3	
222	5E200	85	340	5	7	100	13	
223	5E201	80	260	10	8	80	4	
224	5E202	80	105	10	2	40	0	
225	5E232	80	135	5	3	60	0	
226	5E235	250	105	-5	3	90	7	
227	5E236	220	100	5	2	80	8	

* Analysis for Cu, Zn, Pb, and Mo by Division of Mines and Minerals. All other Cu, Zn, Pb, and Mo analyses and all Ni analyses by Rocky Mountain Geochemical Laboratories.

\# Cu and Ni analysis by Rocky Mountain Geochemical Laboratories. Zn, Pb, and Mo analyses by Division of Mines and Minerals.

( ) Cr interference with Mo determination resulting in higher values.

-5 Less than 5 ppm.

+1000 Greater than 1000 ppm

Analyses for readily extractable heavy metals on samples prefixed 4WP and 4AR by University of Alaska method 1 (Mukherjee and Mark Anthony, 1957). Analyses for readily extractable heavy metal and readily extractable copper on samples prefixed 5N and 5E by procedures of Hawkes (1963). The Hawkes procedure for heavy metals is very similar to the USGS procedure described by Mukherjee and Mark Anthony (1957).

area during 1965 did not turn up any obvious source of these copper-zinc anomalies, but snow cover was still extensive. Pyritization is moderate to intense in many parts of the drainage, and further prospecting and geochemical sampling is suggested.

Samples 63 through 69.

Discussed in the previous report. Snow cover in late June, 1965, was too extensive to allow geologic work, but stream sediments in the lower part of the area were recollected and give a higher copper value on one stream, and indicate moderately to strongly anomalous lead values in several samples. Other copper-iron sulfide occurrences in the area are near the borders of dunite and gabbro bodies, and these anomalies may be derived from a similar but larger source. Further geochemical sampling, mapping and prospecting of these drainages is strongly recommended.

Samples 75 and 81.

Discussed in the previous report. Sample 75 is a strong copper anomaly derived from a known copper prospect. Sample 81 is a moderate zinc anomaly of unknown source. Both are in relatively small drainages.

Samples 87, 90, 91, and 96.

Discussed in the previous report. A nickel anomaly in Sample 91 is now discounted owing to the presence of gabbro and Rainy Creek basalt in the drainage. No source is known for the other anomalies, but pyritization is widespread in the area. Note that Sample 90 is a white encrustation from around a small spring, not a stream sediment. Further prospecting is suggested.

Samples 105, 107, and 108.

Discussed in the previous report. A reconnaissance through this area during 1965 failed to turn up any ultramafic or mafic rocks as a source of these nickel anomalies. The lack of associated copper anomalies detracts from the likelihood of important nickel mineralization.

Samples 128 and 135.

These lead-zinc and copper anomalies were discussed in the previous report. The copper anomaly (128) combined with other indications of mineralization make this a favorable area for further prospecting.

Samples 153, 154, 157, 162, 163, 164, and 167.

These samples are weakly to moderately anomalous in zinc and lie along the outcrop of the black slate unit. Weak molybdenum anomalies are present in two samples and a zinc-rich gossan is present in this area (see Economic Geology). Field anomalies were obtained on many of these samples, and because the black slate contained considerable syngenetic pyrite and was locally highly iron-stained two samples of black slate were collected and analyzed. The analyses are shown in table 4. The molybdenum and arsenic contents are somewhat higher than background for most rocks, but are probably not unusual for black shales. On the basis of these analyses, the normal black slate does not appear to be the source of the zinc anomalies. However, several other groups of stream sediment samples in or near black slate outcrops also show zinc and molybdenum anomalies, so it seems likely that the anomalies are somehow related to the slate. Possibly restricted units in the slate contain abundant zinc, or there are epigenetic concentrations of zinc-rich sulfides locally within the unit. Further investigation is needed to determine the source of these anomalies.

Samples 140, 146, 147, and 148.

These samples are weakly to moderately anomalous in zinc, and possibly anomalous in molybdenum. Some dark gray slate and phyllite are present in the vicinity of samples 146, 148, and sample 140 is a relatively small stream, probably derived largely from the small streams draining into the west side of the Eureka Glacier, which include 146-148. The anomalies may be related to the dark slate and phyllite in a manner similar to samples 153, 154, etc. If so, the lack of anomalies in samples 149, 150, 151, 152, 158, and 159 is perplexing because dark slate and phyllite are also present in these drainages.

Sample 170.

A weak lead anomaly of unknown origin.

Samples 172 to 176.

Weak to moderate copper and lead anomalies are present in this group of samples from streams draining an area covered by glacial gravels. Adjacent dacite and andesite are moderately to highly pyritized and altered, and a quartz monzonite intrusive crops out just to the south. Several exposures of brecciated dacite cemented by pyrite were noted in the vicinity. All these features recommend the area for further prospecting. Additional stream sediment samples should be collected below the quartz monzonite, and the area should be carefully prospected, possibly including geochemical soil sampling in the covered areas.

Table 4

Analyses of black slate from west of Broxson Gulch

Sample	Copper	Zinc	Lead	Molybdenum	Nickel	Arsenic
5E387	10	95	5	12	30	20
5E388	30	120	5	6	30	25

Values in parts per million (ppm)

Analyses by Rocky Mountain Geochemical Laboratories.

Sample 5E387. Chip sample across 100 feet of typical black slate with moderate iron-staining and some quartz veining. Location near sample 159.

Sample 5E388. Grab sample of highly pyritized and iron-stained black slate from selected points across several hundred feet of black slate near sample 159.

Samples 181, 190, and 191.

Weakly anomalous in zinc. These samples drain areas of black slate and the discussion under samples 153, 154, etc. probably applies.

Samples 192, 194, 195, and 196.

Weak to moderate anomalies in copper and molybdenum, including one value of 17 ppm molybdenum. These samples are in or near the quartz monzonite intrusive. Further sampling and prospecting in this area may be justified, although the drainages are quite small and it is doubtful that any large deposit exists here.

Samples 210, 211, 222, and 223.

Weakly anomalous in zinc and possibly molybdenum. The streams drain pyritic slaty argillite and an explanation similar to that for smaples 153, 154, etc., may apply.

Samples 226 and 227.

Sample 227 is from Discovery Creek on which the K-M prospect is located (Chapman and Saunders, 1953; MacKevett, 1964), and probably provides the best available evidence of the strength of anomaly that is interesting. The value of 220 ppm copper is only slightly above the threshold value selected for this report, and a number of samples from elsewhere in the area show stronger anomalies. The fact that the dump of the underground workings extends into the stream bed and is being eroded by the stream probably has accentuated the anomaly. These considerations must be tempered by the fact that Discovery Creek is a moderate-size stream, with a drainage basin somewhat over one square mile, and has a small glacier in its headwaters. Nevertheless, stronger anomalies elsewhere in the area are believed to be of some interest by comparison.

Spray Creek, from which sample 226 was taken, is slightly smaller than Discovery Creek in discharge. The copper content of the sediment sample is slightly higher than Discovery Creek. One or two small copper showings are known on Spray Creek, but the strength of the anomaly suggests that further prospecting and sediment sampling are justified in the drainage.

Panning samples

Samples of sand from near the surface of the stream bed were panned at sites 45, 52, 81, 182, 185, 187, 188, and the main eastern branch of Compass Creek. Samples 45 and 52 contained some magnetite and chromite along with abundant olivine, some pyroxene, and small amounts of other igneous and metamorphic minerals. Samples from site 81, 182, 187, and Compass Creek contained moderate to abundant pyrite, along with some magnetite and other minerals. Samples 185 and 188 contained small amounts of pyrite, moderate magnetite, and silicates. Semi-quantitative analyses for copper, zinc, lead, and molybdenum showed only traces (a few hundred parts per million) of copper and zinc in sample 81, trace copper in Sample 187, and none of these elements in the others. The presence of readily-oxidized pyrite in these samples indicates both the abundance of pyrite in the bedrock of these drainages and the dominance of physical erosion over chemical weathering in the alpine environment.

SUGGESTIONS FOR PROSPECTING

The moderate copper and lead anomalies of samples 63 through 69 should be investigated by further stream sediment sampling, prospecting, and geologic mapping of these drainages. The anomalies occur in two moderate-sized streams draining a large dunite body and its contacts. Small magnetite-pyrite-chalcopyrite replacement deposits were found elsewhere in the Rainy Creek area near the contacts of dunite (localities 11, 12, 18, and 20 of Rose, 1965) and gabbro (localities 4 and 19). The relatively strong stream sediment anomalies in these samples may indicate similar but considerably larger bodies of mineralized rock.

The size and grade of the magnetite mineralization at locality 7 of this report are not known because of poor exposure. A ground magnetic survey of the locality is suggested as an inexpensive means of deciding whether further work on the occurrence is justified. Note that several other magnetite occurrences have been reported in the region by Kaufman (1964) and Rose (1966).

Prospecting and sampling of exposed mineralization is suggested to investigate stream sediment anomalies in samples 27 through 35, 87, 90, 96, 128, 172 through 176, and 226. Further stream sediment sampling and some soil geochemical sampling may be useful in several of these areas. Simple electrical methods such as self-potential may be useful to explore in the area of samples 81 and 128, but at the other localities disseminated pyrite is probably too extensive for geophysical methods to be definitive.

Further work on the zinc-molybdenum anomalies of samples 153, 154, etc. might consist of additional sampling of exposed black slate to determine if certain parts of the slate contain unusual amounts of zinc, and soil sampling to further localize the source of the anomalies. Conclusions reached on this group of anomalies will probably apply to the other zinc anomalies associated with black slates.

The reader is also referred to the previous report on the Rainy Creek area (Rose, 1965) for a discussion of the numerous mineral occurrences in that area.

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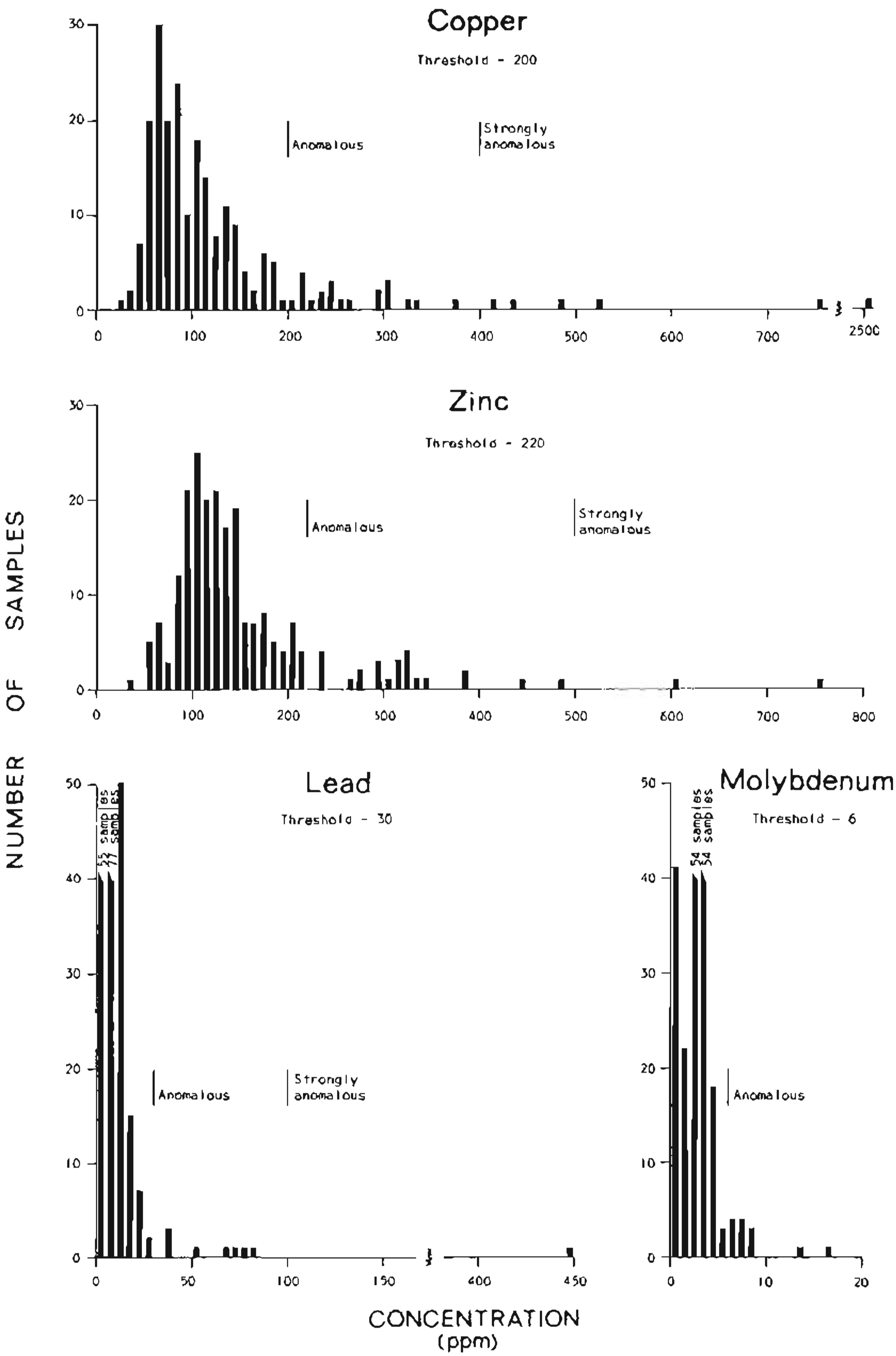

Figure 4. Histograms of copper, zinc, lead and molybdenum content of stream sediments.