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RECONNAISSANCE GEOLOGY AND GEOCHEMISTRY OF THE WILLOW CREEK-HATCHER PASS AREA, ALASKA

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This public data file represents data collected during July-August, 1981 in conjunction with a surficial geological study of the area.

EXPLANATION OF UNITS

Q: Undifferentiated Quaternary deposits

Ti: Intermediate to felsic intrusives. These are small irregular light gray rhyolite to dacite dikes and sills which intrude the Jps and Kar units. Intrusives are composed of very fine-grained quartz, plagioclase and minor potassium feldspar with varying amounts of subsequent alteration. Locally the intrusives contain disseminated pyrite. Chloritized reaction rims frequently occur within the country rock bordering these intrusive bodies.

TKt: Tonalite. Mineralogy consists of plagoclase, blue green hornblende, and quartz with trace biotite which increases in abundance to the north. Minerals show slight to moderate stress. Minor potassium feldspar occurs as interstitial and vein material. Csejetey et al, (1978) report hornblende K-AR ages of 73.1 to 74.4 million years. Exposures of contact zones between the tonalite and the schist unit Jps at Hatcher Pass reveal a predominantly intrusive contact with subsequent localized shearing at the contact.

TKg: Gossan. This unit represents numerous localized altered shear zones within the schist and migmatite units composed of orange-brown gossans with varying amounts of disseminated to massive sulfide minerals. An examination of 14 sulfide bearing polished sections (prepared by T. Bundtzen) indicates that associated sulfides include varying amounts of pyrrhotite, pyrite, arsenopyrite, chalcopyrite, ilmenite, marcasite, and sphalerite, with minor amounts of stibnite, tetrahedrite (?), chalcocite(?), bismuth(?), chromite(?), covellite, tetrahedrite(?), and hematite. Most of the sulfides examined formed at a minimum of 250°C based on the presence of chalcopyrite-sphalerite exsolution pairs. A generalized paragenetic sequence includes:

1) early formation of pyrite or arsenopyrite $\pm$ ilmemite
2) subsequent formation of sphalerite, chalcopyrite, and pyrrhotite
3) later formation of marcasite, covellite, chalcocite (?) and stibnite.

Geochemical analyses of selected grab samples from this unit yield values up to 5.2% copper and 1.24% zinc (see table 1).

Kum: Serpentinized ultramafic bodies. These rocks consist of greenish gray to black highly sheared serpentinite group minerals, talc, chlorite, actinolite-to-tremolite, and opaque minerals which intrude the Jps schist unit. Zones of altered actinolitic schist up to 15' wide surround many of these serpentinized ultramafic bodies as a result of high temperature of emplacement. Original textures have been completely destroyed. Small pods and discontinuous lenses (up to a few feet long) of fuchsite-bearing schist sporadically occurs near these serpentized bodies. Csejtey et al (1978) report semi-quantitative chromium contents of up to 1,000 - 5,000 ppm, nickel content of 1,000 - 2,000 ppm, and fire assay analyses which show platinum and palladium content ranging from 0.0 to 0.03 ppm with an average platinum/palladium radio of 3:1 on selected grab samples from the serpentinized ultramafic bodies.

Kar: Arkose, graywacke, sandstone, and shale of the Arkose Ridge Formation. Csejetey et al (1978) report a biotite K-Ar age date of 67.5 million years from a basalt dike intruding the Arkose Ridge Formation. The Arkose Ridge Formation contains a basal conglomerate unit. The conglomerate clasts consist predominantly of highly stressed hornblende-biotite-quartz-plagioclase assemblages with amphiboles altering to chlorite and plagoclase. The matrix naterial between these clasts is similar in grain size, and mineral assemblages to the clasts. These assemblages are similar in mineralogy and texture to plutonic rocks to the north.

Limited exposure of the contact between the Arkose Ridge Formation basal conglomerate and the Jmi migmatite unit to the north reveal highly sheared contacts. Slickensides along these contacts and the presence of at least one klippe of Arkose Ridge formation rock which occurs north of the contact) (one mile north of Eska Ridge) suggest possible northward thrusting. Northward thrusting in the general area is supported by Fuchs (1980) who reports that Eocene uplift involving tilting and northward thrust faulting near the Castle Mountain fault is suggested by paleomagnetic evidence.

Csejetey et al (1978) proposed a dominantly plutonic provenance for the Arkose Ridge formation based on the composition and texture of the clasts within the Arkose Ridge formation. The similarity of the clasts of diortic and sheared chloritic amphibole-rich rock within the Arkose Ridge formation to the tonalite (Tkt) and Urn-bearing migmatites (Jmi) suggest probable sources for the Arkose Ridge Formation.

Jmi: The migmatite unit Jmi consists **precominantly** of assemblages of plagioclase, quartz, hornblende and occasionally biotite in varying proportions along with marble zones that appear to have been mixed by thermally mixed forming randomly oriented ptigimatically deformed bands of leucocratic and melanocratic rocks. The unit was previously described by

Csjetey et al, (1978) as intricately intermixed amphibolite and quartz diorite of lower to Middle Jurrasic metamorphic and plutonic ages. The migamtite contains local zones up to several meters wide of schistose amphibolites and qtz-plag-bio-chlorite schists very similar to those of the Jps unit to the west. Chemical similarities of the schistose zones within the Jmi unit and the pelitic schist of the Jps unit is shown in table 2 (compare sample 2 with samples 7A and 7B) and in figure 1 (AMP, AFC, and AFK diagrams).

The schistose zones in the migmatite also contain crenulations similar in appearance, magnitude, and attitude (striking S80W and plunging 30" SW) as those crenulations of the Jps schist unit to the west. It is not clear at present whether these schistose zones

1) represent xenolithic blocks of schist from the Jps unit or

2) suggest that the Jmi unit represents a lateral equivalent (higher grade metamorphism) of the Jps unit.

Jqg: Quartz diorite to quartz diorite gneiss. This unit borders the Jmi unit. Textures range from equigranular to strongly gneissic. The mineralogy of this unit consists mianly of plagioclase with 30% quartz, 0-5% potassium feldspar, minor white micas, and trace sphene and epidote. Petrographic-. analyses reveal cataclastic textures with highly sheared and deformed microstructures within various areas of this rock unit. This unit may represent an aluminum rich phase of the Jmi unit.

J?ps: Pelitic schist. This unit is composed of medium to dark gray quartz, muscovite, albite and chlorite schist. Minor constituents include chloritized garnet and biotite. Locally the schist contains thin laminae of carbonaceous material. The schist is indicative of the greenschist metamorphic facies which has probably undergone retrograde metamorphism from a possible amphibolite facies (Csejtey et al, 1978). Major oxide whole rock geochemistry of a typical sample of the schist unit is given in table 2. Foliation attitudes vary greatly within the schist unit which suggests that complex deformation occurred within the unit after the development of schistosity. However, a uniform, dominant low angle crenulation alignment striking S70-80°W and plunging 0-12" to the SW throughout the unit suggests a later, regional metamorphic event. The schist was considered to be of probable lower to Middle Jurassic metamorphic age by Csejtey et al, (1978). However, considering the occurance of the schist zones within the Jurassic migmatic unit and the polymetamorphic history of the schist, the primary metamorphic age of the schist unit could be considerably older than Jurassic.

Table 1. Trace Element rock geochemistry. In ppm unless stated otherwise. Cu, Pb, Zn, Au, Ag, Mo and Sb analyzed by spectrophotometry. All remaining elements analyzed by semiquantitative emission spectrophotometry. ND = not dectected. If no analysis is reported, the sample was not analyzed for that element.

No.	Rock Unit	Cu	Pb	Zn	Au	Ag	Mo	Sb	W	Hg (ppb)	B	Be	Ni	Co	Fe	Cr	Mn	Bi	Sn	V	Ca	Y	Sc	Ti	Cd
1	Qtz vein in Jps	84	17	4	3.1	1.6	5	8	<10				10	20											
2	Kum	41	6	8	<0.1	0.3	3	<2	<10				0.2%	100		500									
3	Kum	31	8	21	<0.1	0.1	3	<2	<10				0.5%	100		0.2%									
4	Ti ?	54	9	25	<0.1	0.1	3	<2	<10				20	<20											
5	Ti ?	28	5	27	<0.1	<0.1	3	<2	<10				10	<20											
6	Altered Jps	113	17	78	<0.1	0.1	5	<2	<10				20	20											
7	Altered Ti	69	18	43	0.1	0.2	4	<2	<10				10	20											
8	tremolitic Jps	42	29	89	<0.1	0.2	6	<2	<10				200	70											
9	Calcic Jps	77	11	97	<0.1	0.1	6	<2	<10				20	50											
10A	TKt	240	10	47	<0.1	0.1	8	<2	<10				20	50											
10B	Jps	104	14	43	0.1	0.3	12	<1	2	60			10	<20		20									
11A	Ti	88	7	49	<0.1	0.1	3	<2	<10				10	<20											
11B	Altered Jps	194	8	123	<0.1	0.2	5	<2	<10				15	20											
12	Kum	29	7	19	0.1	0.2	2	3	<10				0.5%	100											
13	Kum	14	34	99	<0.1	0.4	7	<1					>0.5%	50											
14A	Ti	61	12	20	0.1	0.3	4	<1	2	50			10	<20		<20			ND						
14B	Ti	65	5	8	<0.1	0.1	4	<2	<10				10	<20											
15	Kar ?	0.17%	19	7%	0.06	1.8	3	ND	<20		10	<1	19	30	7%		0.3%	<20	<20	300	15%	<100	<10	0.2%	<100
16	Jmi	0.28%	12	5%	0.05	0.5	4	ND	<100		10	<1	87	70	5%	<20	0.3%	<20	<20	500	10%	<100	<10	0.7%	<100
17	TKg	261	47	31	0.04	0.5	3	ND	<20		20	<1	23	70	7%	<20	0.2%	<20	<20	500	15%	<100	<10	0.5%	<100
18	Jmi	234	8	42	0.2	0.3	7	<1	2	105			20	70		500			ND						
19	TKg	329	25	39	0.02	0.3	6	ND	<20		10	<1	30	20	5%	<20	0.1%	<20	<20	500	15%	<100	<10	0.7%	<100
20	Jmi	148	4	17	<0.1	0.2	5	<2	<10				10	50											
21	Jmi	0.18%	16	44	ND	0.7	5	0	<20		10	<1	20	70	5%	<20	0.2%	<20	<100	200	3%	<100	<10	0.3%	<100
22	Kar	100	17	500	<0.1	0.4	5	<1	3	90			10	20		<20									
23	TKg	1.6%	59	0.7%	0.1	14.6	54	14	<20		15	<1	10	30	7%	<20	500	<20	<20	70	1%	<100	<10	0.1%	<100
24	TKg	5.2%	30	1.2%	1.1	40.3	73	<2	<10				10	70											
25	mafic zone in Jmi	27	36	41	0.2	0.2	7	<1	<2	110			20	100		<20									
26	TKg	119	9	137	<0.1	0.2	10	<1					10	50		<20									
27	Vein in Jmi	740	8	64	<0.1	0.4	5	<2	10				10	50											
28	TKg	63	6	20	<0.1	<0.1	4	<1						50											
29	TKg	83	9	24	0.01	0.3	4	17	<20		10	<1	7	<10	2%	<20	300	<20	≤20	150		<100		0.5%	<100
30	TKg	214	5	12	<0.1	0.4	42	<1	2	>0.05%		10	70						ND						
31	TKg	0.9%	10	786	0.02	3.0	35	ND	<20		10	<1	25	70	7%	<20	500	<20	<20	70	5%	<100	<10	700	<100

Table 1. Contd.

No.	Rock Unit	Cu	Pb	Zn	Au	Ag	Mo	Sb	W	Hg (ppb)	B	Be	Ni	Co	Fe	Cr	Mn	Bi	Sn	V	Ca	Y	Sc	Ti	Cd
32	TKg	149	13	51	<0.1	0.3	364	<2	<10				10	20											
33	Kar	85	9	74	0.1	0.2	2	<1	2	80			15	50		50			ND						
34	TKg	0.17%	10	1.01%	0.1	0.9	163	<1	2	280			20	70											
35	TKg	0.66%	4	0.3%	0.1	3.3	85	<1	2	340			15	70					ND						
36	Jmi?	47	3	65	<0.1	<0.1	3	<1																	
37	Jag	49	10	102	<0.1	0.1	4	<1	<10				10	20		50			ND						
38	Jag	87	37	20	<0.1	0.2	47	<2	<10				10	220											
39	Jmi	134	2	3	0.1	0.2	265	<1	2	35			10	30		<20			ND						
40	Marble-rich Jmi	187	2	32	0.1	0.2	63	<1	2	260			10	20		<20			ND						
41	Jmi	154	2	36	0.1	0.6	25	<1	2	80			15	50		20			ND						
42	Jmi	44	2	21	<0.1	<0.1	6	<1	2	120			15	30		20			ND						
43	Jmi	122	2	14	0.1	0.3	12	<1	2	90			15	20		20			ND						
44	mafic zone in Jmi	153	12	93	<0.1	0.6	5	6	>10				10	50											
45	Kum?	477	3	11	0.1	0.5	9	<1					10	50		50									
46	Jag	57	3	37	0.1	0.1	6	<1	2	110			5	<20		<20			ND						
47	Jag	51	7	32	<0.1	0.6	19	<1	2	50			15	30		20			ND						
48	Jmi	54	5	16	0.1	<0.1	7	<1	2	85			10	20		<20			ND						
49	Jmi	532	3	46	0.1	0.2	8	<1	2	165			10	70		<20			ND						
50	Jmi	91	4	55	0.1	0.1	8	<1	2	1350			15	70		100			ND						
51	Jmi	71	1	3	<0.1	0.1	48	<1	2	80			15	<20		<20			ND						
52	Jmi	222	2	43	0.1	0.1	9	<1	2	75			20	100		<20			ND						
53	Jmi	305	3	10	<0.1	0.1	3	<2	<10				20	70											
54	Jmi	90	28	92	<0.4	0.4	7	<2	<10				20	50											
55	Jmi	144	5	32	<0.1	0.1	2	<2	<10				20	50											

Table 2. Major oxide whole rock geochemistry analyses.

No.	Rock Unit	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI	H_2O	FeO	Σ
1	Kum	42.01	13.13	1.85	0.21	15.75	12.17	0.88	0.03	0.41	0.08	3.61	0.02	10.17	100.32
2	Jps	68.82	14.34	1.81	0.06	2.18	0.76	1.76	2.17	0.73	0.26	3.14	0.00	4.14	100.17
3a	Altered Jmi	42.74	14.39	7.77	0.29	6.77	1 . 6	2.38	0.04	4.32	0.40	0.17	0.02	9.10	99.55
3b	Altered Kar	33.38	14.77	3.17	0.29	7.77	8.03	0.18	0.00	5.42	0.35	10.52	0.05	15.40	99.33
4	Mafic zone in Jmi	48.38	19.96	3.69	0.14	5.28	10.20	2.87	0.24	0.87	0.21	2.55	0.00	5.34	99.73
5	Mafic zone in Jmi	48.17	13.47	6.72	0.21	4.90	15.15	0.83	0.07	2.61	0.30	1.70	0.02	5.53	99.68
6	Ultramafic clast from conglomerate in Kar	48.25	15.56	3.41	0.18	7.12	10. 1	2.89	0.16	1.87	0.23	2.39	0.01	8.34	100.52
7a	schist within Jmi	58.6	5.3	3.37	0.	5.03	4.72	3.07	0.32	0.51	0.15	3.21	0.07	5.08	99.61
7b	schist within Jmi (duplicate sample)	68.7	13.55	1.97	0.10	4.67	3.16	.68	1.01	0.44	0.14	2.30	0. 0	3. 0	00.94
8	Jmi	51.15	14.01	3.99	0. 23	6.06	9.26	2.57	0.50	2.17	0.21	0.42	0.01	8.94	99.52
9	Jmi	40.30	23.30	2.93	0.10	8.62	12.19	1.44	0.08	0.16	0.07	5.45	0.08	5.13	99.85
0	TKg	58.85	15.89	1.15	0.10	1.68	4.70	3.45	2. 8	0.55	0.22	4.7	0.	.42	97.0
1	Jmi	44.98	18.54	10.60	0.15	1.81	5.34	0.27	0.19	0.97	0. 5	2.58	0.66	2.11	98.35
2	Mafic zone from Jmi	51.74	17.42	2.05	0.15	4.78	5.86	4.01	0.40	0.99	0.20	5.22	0.02	6.70	99.54

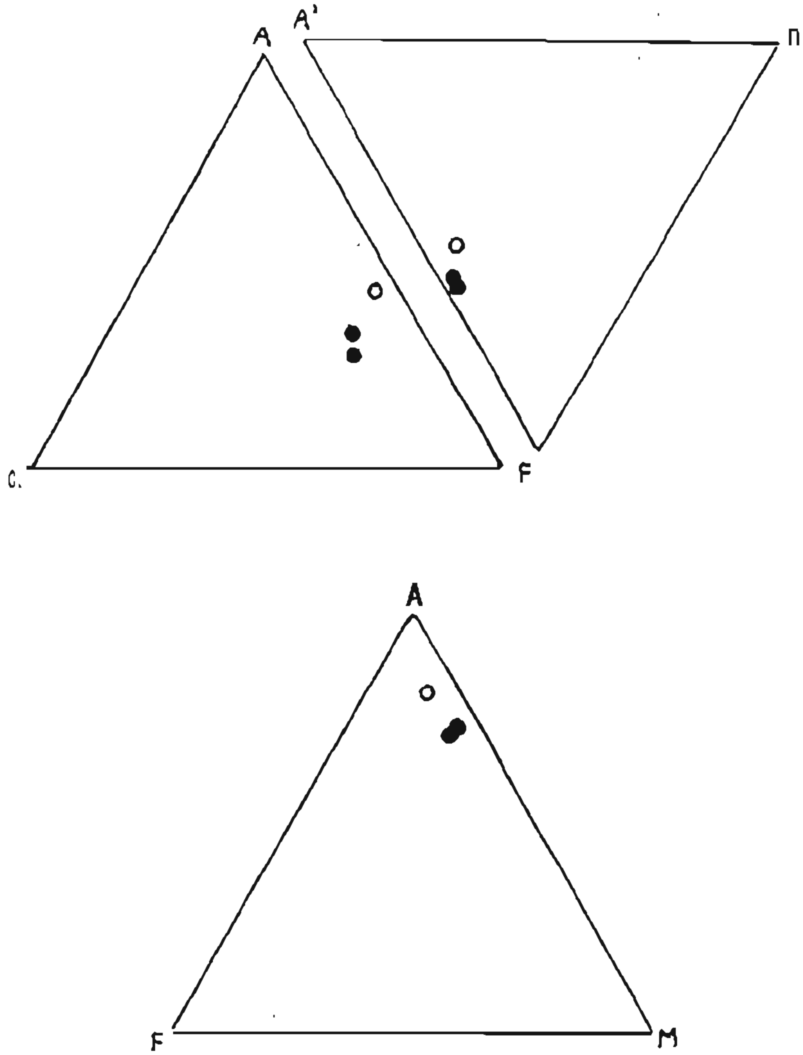

Figure 1. ACF, AFK, and AFM diagrams of samples from Jps pelitic schist (o) and schist pod within Jmi migmatite (●). Calculations based on Winkler 1974 after Eskola.

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