Map and tables showing potassium-argon age determinations and selected major-element chemical analyses from the Circle quadrangle, Alaska

by
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This report is part of a potassium-argon age study of igneous and metamorphic rocks undertaken for the Circle quadrangle Alaska Mineral and Resource Assessment Program (AMRAP). Geologic maps and other publications related to this study are being produced under the team leadership of Helen L. Foster of the U.S. Geological Survey (Foster and others, 1983). This report replaces Wilson and Shew (1981), which reported all potassium-argon and fission track dates available at that time. Presented here are 38 potassium-argon age determinations and 1 fission-track age determination for 11 metamorphic rocks and 17 igneous rocks. Analytical data is listed in table 1, rock descriptions are given in table 2, major element chemical analyses of selected samples and CIPW norms are listed in table 3, and sample locations are plotted on the map. Modes in table 2 except for samples MP406 and CHS72X are estimated from thin sections; minor components compose 1 to 5% and accessory components less than 1% of the thin section. Sample descriptions for MP406 and CHS72X are from the original references. Three samples that are not shown on the map are included in the tables. Two of these samples are from the Big Delta quadrangle just south of the Circle quadrangle boundary; one is a granodiorite sample with biotite and hornblende age determinations and the other is a granite sample with a biotite age determination. The third sample is from the southeast Livengood quadrangle, and is a lamprophyre. The longitude for sample 79AWs 75 in Wilson and Shew (1981) was erroneous and has been corrected in this report.

The newly acquired metamorphic age determinations come from the southeastern part of the quadrangle and yield discordant ages ranging from early Cretaceous to early Tertiary (112.0 to 64.8 m.y.). Five of the metamorphic rock samples are gneisses, and two are amphibolites. The four previously dated metamorphic rocks were mica schists. The newly dated gneiss samples are all two-mica bearing augen gneiss except for sample 79AWs 84b which is a biotite gneiss. The metamorphic rocks in the Circle quadrangle range in metamorphic grade from greenschist to amphibolite facies. The metamorphic grade is generally highest in the southeast part of the quadrangle and decreases to the northwest (Foster and others, 1983). "Locally, contact metamorphism associated with the intrusion of Late Cretaceous and early Tertiary granites is superimposed on the regional metamorphism." (Foster and others, 1983).

Plutonic rocks in the Circle quadrangle range in age from 77.6 to 56.5 m.y. and vary compositionally from two-mica granite to hornblende-biotite granodiorite using the Streckeisen (1976) classification system. Four new intrusive rock dates are introduced in this report; these include two-mica granite and tourmaline granite from the southeast Circle quadrangle, granite from the northwest Big Delta quadrangle, and lamprophyre from the southwest Livengood quadrangle. The newly dated two-mica granite is one of three two-mica granite plutons dated in the Circle quadrangle. Plutons in the southeastern portion of the quadrangle have a large proportion of muscovite relative to total mica; towards the northwest, the proportion of muscovite in the granitic rocks decreases. The granite sample 79AWs 85 in the southeastern Circle quadrangle has abundant tourmaline with accessory muscovite and no mafic minerals. The Mt. Prindle, Quartz Creek, and Lime Peak (Rocky Mt.) plutons in the northwest Circle quadrangle have minor to accessory tourmaline in the biotite- and biotite-hornblende granite (Bjarne Holm, personal communication, 1981). The sample location for CHS72X from Chena Hot Springs is approximate as no location is given in the original thesis (Biggar, 1974). Sample 75ASj538 is a biotite-hornblende granite from the Big Delta quadrangle, further information on this sample can be found in Luthy and others (1981).

In the southeastern part of the quadrangle, the ages of the plutonic and metamorphic rocks overlap whereas sparse metamorphic dates in the western part of the quadrangle are significantly older than the nearby igneous rocks. The metamorphic rocks generally have older apparent ages than the plutonic rocks and are commonly analytically discordant. There are 4 plutons with anatectic characteristics emplaced along a southwest to northeast trend, parallel to the metamorphic foliation in the southeastern part of the quadrangle. The plutons in this belt have apparent ages ranging from 60.6 to 72.8 m.y. (Samples 78AWr 287, 288, 79AWs 94a, and 79AFr 583). Biotite ages in the southeastern Circle quadrangle on both igneous and metamorphic rocks are younger than and analytically discordant with age determinations on other coexisting minerals, except for sample 78AWr 287. This suggests that a post-metamorphic thermal event reheated the rocks. Dalrymple and Lanphere (1969) suggest that "In complex metamorphic terranes, biotite ages often are too low, but for this very reason biotite is quite useful as a sensitive indicator of post-formation thermal events". In this particular case, the minimum biotite ages may indicate time of emplacement of the last plutons and thermal resetting of the metamorphic rocks. As such, biotite ages from metamorphic rocks are not related to the age of original metamorphism but rather to reheating caused by emplacement of the plutons. Muscovite is somewhat more resistant to argon loss due to a higher blocking temperature than biotite and therefore yields older apparent ages due to less resetting; it is difficult to determine how significant the reheating effect may have been on the muscovite. However, hornblende is much more resistant to reheating than muscovite. One hornblende age from an amphibolite, sample 79AWs 103, gives an apparent age of 112 m.y. This may be a more appropriate estimate of the time when the high-grade metamorphic event ended. This sample is the most distant of the high-grade metamorphic rocks from this belt of plutons. Sample 79AWs 83c has an apparent age of 66.5 m.y. on amphibole and 64.8 m.y. on biotite with large analytical errors. The relatively low age for the amphibole may have been caused by argon loss and possible potassium gain due to the hydrofluoric acid leaching treatment (M.L. Silberman, personal communication, 1978) which was unfortunately used on this particular sample.

For samples dated by the authors, potassium was determined by flame photometry using a lithium metaborate fusion technique (Engels and Ingamells, 1970). Potassium analysts were Byron Lai, D. Vivit, Paul Klock, J. Marinenko, and S. Neil. Argon extraction and measurement was accomplished using standard techniques of isotope dilution mass spectrometry, essentially as described by Dalrymple and Lanphere (1969). The analytical error assigned to each age newly reported here is an estimate of the standard deviation of analytical precision using the method of Cox and Dalrymple (1967) together with the authors calculated estimates of uncertainties in the concentration of ^{38}Ar tracer and potassium measurements. Sample preparation, argon extraction and data reduction was by the authors with assistance from Rita Taylor, Brian Ho, and Leda Beth Gray. M.A. Lanphere and G.D. Eberlein generously contributed data on samples collected and analyzed by themselves in the early 1960's. Three samples (79AWs 83c, 79AWs 102, and 79AWs 104) were analyzed by Krueger Enterprises, Inc, and the analytical errors associated with these were calculated using the reported variance in potassium and ^{40}Ar and are not calculated using the method of Cox and Dalrymple (1967).

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Table 2.--Rock descriptions.

78AWr 286, Salcha River. Fine- to medium-grained muscovite-biotite granite. Estimated mode: 35% microcline, 35% quartz, 10-15% plagioclase, 10% biotite, and 5% muscovite. Minor chlorite from alteration of biotite, very minor amounts of clay minerals from alteration of feldspar. Hypidiomorphic-granular texture.

78AWr 287, Big Windy Creek East. Fine- to medium-grained muscovite-biotite granite. Estimated mode: 35% strained quartz, 30% potassium feldspar, 20% plagioclase, 5-10% biotite, and 5% muscovite. Sparsely scattered areas of myrmekite. Muscovite is primary and secondary. Hypidiomorphic-granular texture.

78AWr 288, Big Windy Creek West. Fine- to medium-grained hornblende-biotite granite. Estimated mode: 25% microcline, 25% plagioclase, 15% quartz, 15% perthitic feldspar, 10% biotite, 5-10% hornblende, and minor chlorite after biotite, and calcite. Some areas of myrmekite and very fine myrmekite. Feldspar is generally unaltered though hornblende has intergrown biotite. Hypidiomorphic-granular texture.

79AWs 75, Victoria Mountain. Coarse- to medium-grained hornblende-biotite granite with coarse phenocrysts of pink potassium feldspar. Estimated mode: 50-60% potassium feldspar partly altered to sericite, 10-15% quartz, 10% plagioclase (approximately An 20), 10% very slightly chloritized biotite and 5-10% hornblende, pleochroic in shades of green. Accessory zircon. Hypidiomorphic-granular texture.

79AWs 76, Lime Peak (Rocky Mt.). Coarse-grained biotite granite. Euhedral crystals of biotite and tourmaline in a groundmass of quartz and feldspar. Estimated mode: 80-85% perthitic feldspar, 10% quartz, 5% biotite pleochroic in shades of green, amd minor muscovite and tourmaline. Tourmaline in clusters. Hypidiomorphic-granular texture.

79AWs 77, Quartz Creek. Medium- to fine-grained biotite granite. Estimated mode: 80-85% perthitic feldspar, 5-10% quartz, 5-10% slightly chloritized biotite, trace plagioclase (An 20) and muscovite, and accessory zircon. Minor alteration of some feldspar grains to sericite. Hypidiomorphic-granular texture.

79AWs 80, Chena River. Medium- to coarse-grained biotite granite. Estimated mode: 40% quartz, 40% potassium feldspar, 15% plagioclase, 5% biotite, with accessory chlorite, actinolite and apatite. Plagioclase is partially altered to sericite and has oscillatory zoning. On the basis of albite and Carlsbad-albite twinning, plagioclase composition is approximately An 38. Biotite has been partially replaced by chlorite and actinolite. Perthitic texture in potassium feldspar. Hypidiomorphic-granular texture with some grain boundaries defined by accumulations of fine-grained quartz in a mosaic texture.

79AWs 82, Birch Creek South Fork. Fine- to coarse-grained weakly foliated garnet-biotite-muscovite gneiss. Estimated mode: 30% plagioclase, 20% garnet, 15% biotite, 15% muscovite, 10% quartz, 10% orthoamphibole, and minor chlorite associated with the biotite. Lepidoblastic texture. Plagioclase is albite-twinned, extinction angles vary from 10 to 35° corresponding to a possible compositional variation of An 30 to An 60. Clusters of plagioclase grains tend to have a common crystallographic orientation over portions of the rock.

79AWs 83c, Caribou Creek. Fine- to medium-grained amphibolite. Estimated mode: 60% amphibole, 15% quartz, 10% plagioclase, 10% biotite, and 5% opaque minerals. Folded weak foliation defined by layers of biotite, quartz, and plagioclase with alternating layers of amphibole. Plagioclase grains are typically albite twinned with small extinction angles.

79AWs 84b, Yukon Fork. Fine- to medium-grained augen gneiss. Estimated mode: 80-90% quartz, 5-10% biotite, 5% garnet, 1-3% opaque minerals, and 1% plagioclase. Folded lepidoblastic texture defined by biotite and fine-grained quartz with rare plagioclase in a medium-grained quartz groundmass. Skeletal garnet with infilling quartz forms core of augen.

79AWs 85, Caribou Creek. Fine- to medium-grained, light-gray, tourmaline granite. Estimated mode: 40% microcline, 25% plagioclase (An 10), 25% quartz, 5% tourmaline, and minor garnet and muscovite, and accessory zircon. Some feldspar grains have minor alteration to sericite. Allotriomorphic-granular texture.

79AWs 89, Chena Hot Springs. Medium-grained biotite granite or granodiorite. Estimated mode: 30-35% plagioclase (oligoclase), 25-30% orthoclase, 20-25% quartz, 10% slightly chloritized biotite, minor muscovite, and accessory zircon. Hypidiomorphic-granular texture.

79AWs 94A, Yukon Fork. Medium-grained biotite granite. Estimated mode: 35% strained quartz, 30% microcline and perthitic feldspar, 20% plagioclase (An 40), 10% biotite with minor chlorite, 5% muscovite, and accessory garnet and zircon. Zircon in two populations, 1. prismatic with strong birefringence and, 2. oval, rounded with low birefringence.

79AWs 101, O'Brien Creek. Medium- to coarse-grained lamprophyre. Estimated mode: 40-45% deep green pyroxene (aegirine or aegirine-augite), 20-25% biotite, 20-25% potassium feldspar, 2-3% apatite, and 2-3% opaque minerals. Biotite very deep brown, weakly pleochroic. Possible relict olivine. Panidiomorphic--granular texture.

79AWs 102, Salcha River. Fine- to medium-grained augen gneiss. Estimated mode: 70% quartz, 20% potassium feldspar, 10% muscovite, 5-10% biotite, and 1% opaque minerals. Minor potassium feldspar with perthitic texture. Weakly developed lepidoblastic texture. Augen composed of large composite potassium feldspar crystals.

79AWs 103, Gulch Creek. Fine-grained amphibolite. Estimated mode: 60% amphibole, 20% quartz, 10% biotite, 9% opaque minerals, and 1% chlorite. Strongly developed foliation defined by actinolitic amphibole laths, biotite, and opaque minerals. Foliation cross-cut at 80° by later quartz, amphibole, and chlorite filled fractures.

79AWs 104, Salcha River. Medium-grained augen gneiss. Estimated mode: 50-60% quartz, 15-20% biotite, 15% muscovite, 5-10% plagioclase, 5% chlorite, and 5% sillimanite. Biotite is partially replaced by muscovite and chlorite. Sillimanite and mica define folded foliation. Lepidoblastic textured rock. Quartz augen.

79AWs 105a, Salcha River. Medium- to coarse-grained, potassium feldspar-rich augen gneiss. Estimated mode: 50% potassium feldspar, 40% quartz, 10% biotite, <5% muscovite, and trace apatite. Potassium feldspar augen with perthitic texture defined by mica and zones of granulated quartz.

79AFr 583, VABM "Dex". Medium- to coarse-grained two-mica granite. Estimated mode: 40% potassium feldspar, 20% biotite, 20% muscovite, 10% plagioclase, 5% apatite, 5% quartz, and minor chlorite. Oscillatory zoned plagioclase. Large subhedral to anhedral muscovite and potassium feldspar crystals. Potassium feldspar is in microcline twinned and perthitic varieties. Weakly developed mortar structure or subporphyritic texture.

MP406, Mt. Prindle. Medium-grained biotite granite. Mode: 38% quartz, 30% potassium feldspar, 18% plagioclase (oligoclase-andesine), trace muscovite, 1% opaque minerals, and 1% fluorite. Hypidiomorphic-granular texture (Holm, 1973).

CHS72X, Chena Hot Springs. Fine-grained biotite granite with poikiolitic grains of potassium feldspar and quartz to 4mm in size. Estimated mode: 35% plagioclase (An 40-25), 30% potassium feldspar, 15% quartz, 15% biotite, 2% sphene, 2% opaque minerals, 1% chlorite, trace apatite, epidote, and allanite. Feldspar is extensively altered to kaolinite and sericite along minute parallel fractures (Biggar, 1974).

Table 3.--Major element chemistry

Sample#	79AWs 75	79AWs 76	79AWs 77	79AWs 80	79AWs 85	79AWs 89	79AWs 94A	79AWs 101
SiO_2	64.3	76.3	72.4	72.4	75.2	66.3	71.0	42.0
Al_2O_3	15.9	12.2	13.7	14.2	14.4	16.2	14.3	6.99
Fe_2O_3	1.86	0.38	0.41	0.41	0.85	0.66	0.42	5.90
FeO	2.16	1.19	1.66	1.74	0.85	3.22	2.03	9.45
MgO	1.16	0.12	0.50	0.36	0.11	1.26	0.55	8.25
CaO	2.59	0.49	1.07	2.85	0.24	3.43	2.70	12.7
Na_2O	3.68	2.84	2.86	2.69	5.50	2.96	1.83	1.23
K_2O	5.78	5.15	5.28	3.85	3.25	3.35	4.86	4.25
TiO_2	0.49	0.08	0.28	0.16	0.00	0.53	0.29	1.81
P_2O_5	0.30	0.00	0.12	0.06	0.09	0.28	0.08	2.86
MnO	0.06	0.02	0.05	0.04	0.20	0.05	0.03	0.32
CO_2	0.13	0.14	0.12	0.27	0.00	0.00	0.41	0.14
H_2O+	0.48	0.85	0.43	0.43	0.30	0.78	0.72	1.18
H_2O-	0.18	0.09	0.12	0.07	0.01	0.08	0.10	0.27
Total	99.07	99.85	99.00	99.53	101.00	99.10	99.32	97.35

CIPW NORMS

Qtz	14.035	38.511	32.336	35.909	29.586	26.20	34.70	--
Cor	--	1.076	1.649	0.875	1.602	2.177	1.337	--
Or	34.753	30.811	31.730	21.479	19.073	20.150	29.278	26.226
Ab	31.682	24.329	24.610	23.109	46.217	25.494	15.785	0.997
An	9.967	2.461	4.602	13.957	0.599	15.460	13.123	1.044
Hy	4.260	2.101	3.646	3.618	1.494	7.861	4.411	--
Di	0.907	--	--	--	--	--	--	36.621
Ol	--	--	--	--	--	--	--	10.330
Ne	--	--	--	--	--	--	--	5.347
Mg	2.744	0.558	0.605	0.604	1.224	0.974	0.621	8.933
Ilm	0.947	0.154	0.541	0.309	--	1.025	0.562	3.590
Ap	0.707	--	0.283	0.141	0.207	0.660	0.189	6.916
Hem	--	--	--	--	--	--	--	--
%An	23.93	8.28	15.75	37.65	1.23	37.75	45.39	9.53

Table 1.--Circle quadrangle K-Ar age determinations and fission track date.

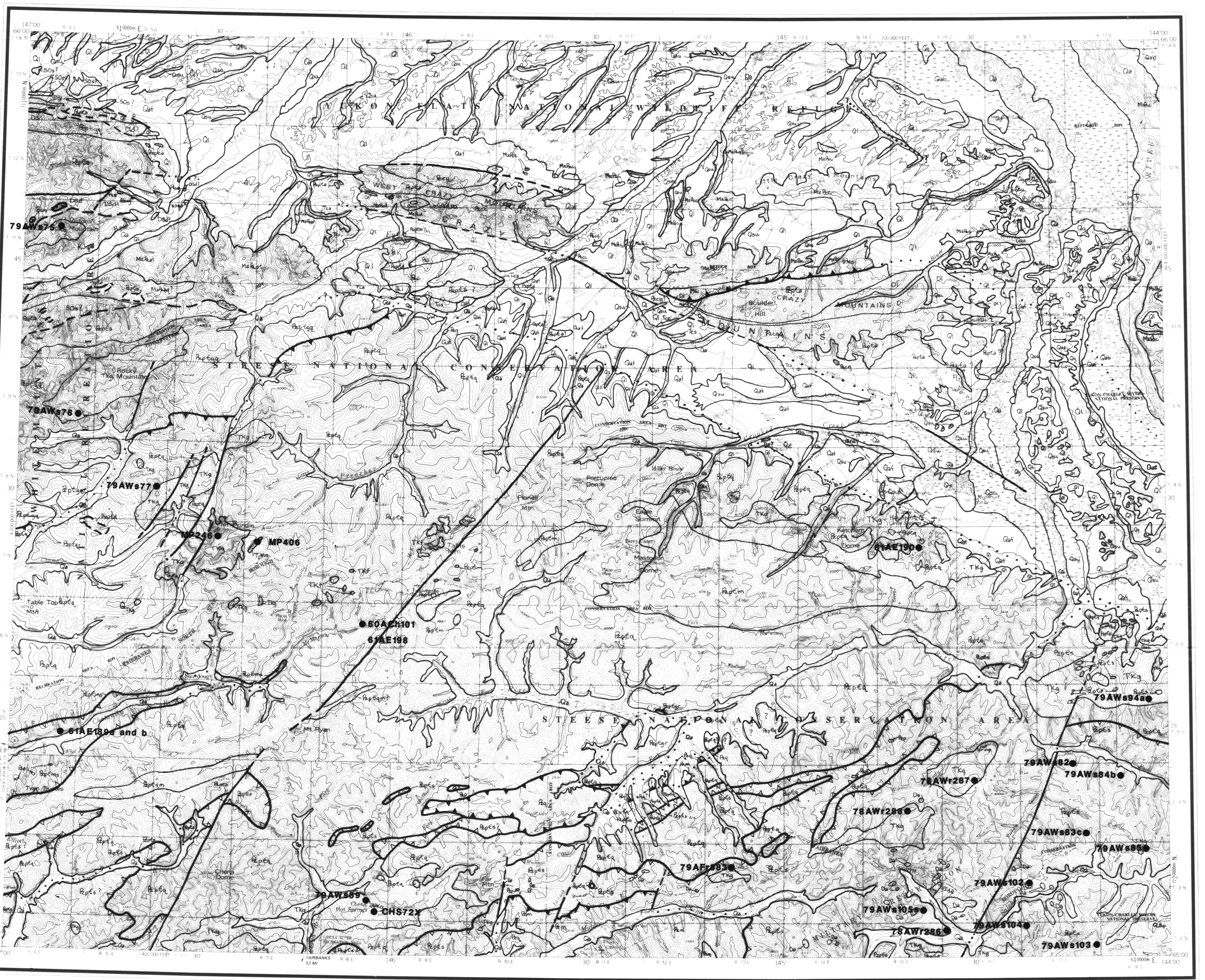
Sample Number and locality name	Location	Rock Type	Mineral	$\%K_2O$		$^{40}Ar_{rad}$ $\times 10^{-10}$ moles/gm	$\%^{40}Ar_{rad}$	Apparent age (m.y.) ± 1	Reference
78AWr 286 Salcha River	Circle A2 65°01.8'N 144°35.0'W	Two-mica Granite	Bio	8.51 8.63 8.51 8.63	>8.57	9.265	79.7	73.5 ± 2.5	This report
			Mus	10.90 10.91 10.89 10.94	>10.91	12.45	81.6	77.6 ± 2.0	This report
78AWr 287 Big Windy Creek East	Circle A2 65°11.7'N 144°30.2'W	Two-mica Granite	Bio	9.10 9.09 9.21 9.21	>9.15	8.123	71.1	60.6 ± 0.6	This report
			Mus	10.99 10.89 10.91	>10.93	9.654	61.8	60.5 ± 0.6	This report
78AWr 288 Big Windy Creek West	Circle A2 65°09.6'N 144°40.4'W	Hornblende-biotite granite	Bio	9.28 9.30	>9.29	8.796 8.744	79.3 80.3	64.4 ± 0.48	This report
79AWs 75 Victoria Mountain	Circle D6 65°47.3'N 146°56.0'W	Hornblende-biotite granite	Bio	9.37 9.37 9.37 9.36	>9.37	8.965	58.0	65.3 ± 0.65	This report
			Hbl	1.073 1.069 1.066 1.078	>1.072	1.038 1.018	70.0 72.2	65.5 ± 1.03	This report
79AWs 76 Lime Peak	Circle C6 65°35.1'N 146°51.6'W	Biotite granite	Bio	7.76 7.64 7.85 7.77	>7.76	6.432 6.416	65.90 76.42	56.65 ± 0.95	This report
79AWs 77 Quartz Creek	Circle C6 65°30.4'N 146°39.3'W	Biotite Granite	Bio	8.96 9.00 8.98 8.98	>8.98	8.552 8.804	76.04 75.32	65.92 ± 1.38	This report
79AWs 80	Big Delta D6 64°54.3'N 146°22.0'W	Granite	Bio	7.96 7.98	>7.97	10.549 10.500	94.10 96.00	89.5 ± 1.4	This report
79AWs 82 Birch Creek South Fork	Circle A1 65°12.6'N 144°15.4'W	Gneiss	Bio	8.47 8.44	>8.46	8.1486	92.00	66.16 ± 0.76	This report
			Mus	9.00 9.00	>9.00	9.3595 9.1757	90.778 89.820	70.16 ± 1.48	This report
79AWs 83c Caribou Creek	Circle A1 65°08.0'N 144°13.5'W	Amphibolite	Bio	5.89 5.69	>5.79	5.500	62.50	64.80 ± 6.0	This report
			Amp (HF)*	0.437 0.413	>0.425	.4142	19.65	66.50 ± 9.6	This report
79AWs 84b Yukon Fork	Circle A1 65°11.9'N 144°07.9'W	Augen Gneiss	Bio	8.66 8.62 8.59 8.62	>8.62	8.0159 7.9930	80.28 83.39	63.40 ± 1.5	This report
			Mus	9.66 9.59 9.65 9.67	>9.64	10.215 9.880	81.39 83.445	71.00 ± 2.00	This report
79AWs 85 Caribou Creek	Circle A1 65°06.9'N 144°04.5'W	Tourmaline Granite	Mus	10.37 10.33 10.30 10.37	>10.34	11.96 11.566	94.6 93.6	77.5 ± 2.3	This report
79AWs 89 Chena Hot Springs	Circle A5 65°03.6'N 146°04.2'W	Biotite Granite	Bio	9.10 9.07 9.07 9.06	>9.08	7.754 7.730 7.911	73.03 73.42 72.68	58.73 ± 0.85	This report
79AWs 94a Yukon Fork	Circle B1 65°16.7'N 144°03.1'W	Biotite Granite	Bio	7.74 7.66 7.63 7.58	>7.65	6.9109 7.0786	61.37 61.10	62.41 ± 1.34	This report
79AWs 101 O'Brien Creek	Livengood B1 65°29.0'N 147°06'W	Lamprophyre	Bio	9.04 9.04 9.05 9.07	>9.05	11.973 12.067	81.3 80.6	90.00 ± 0.8	This report
79AWs 102 Salcha Creek	Circle A1 65°04.7'N 144°22.3'W	Augen Gneiss	Bio	8.99 8.96 8.98	>8.98	10.560 10.068	62.5 71.2	78.1 ± 3.0	This report
			Mus	10.98 10.90	>10.94	14.973 14.775	76.0 72.7	92.0 ± 5.0	This report
79AWs 103 Gulch Creek	Circle A1 65°00.7'N 144°11.5'W	Amphibolite	Hbl	0.419 0.418 0.419 0.415	>0.418	.69217 .7734 .61911	65.89 66.41 75.31	112.0 ± 12.3	This report
79AWs 104 Salcha River	Circle A1 65°02.0'N 144°22.5'W	Augen Gneiss	Bio	8.64 8.60	>8.62	10.573 10.258	65.2 75.6	82.0 ± 3.1	This report
			Mus	8.95 8.97	>8.96	11.883 11.788	75.9 59.1	89.5 ± 3.3	This report
79AWs 105a Salcha River	Circle A2 65°03.1'N 144°38.7'W	Augen Gneiss	Bio	9.34 9.23 9.30 9.19	>9.27	10.310 10.482 10.548	48.31 79.37 80.30	76.7 ± 1.5	This report
			Mus	10.42 10.37 10.38 10.46	>10.41	12.976 12.253	91.9 92.9	82.3 ± 3.5	This report
79AFr 583 VABM "Dex"	Circle A3 65°05.9'N 145°0.72'W	Two-mica Granite	Bio	8.90 8.89 8.91 8.94	>8.91	9.415 9.632	85.6 82.9	72.8 ± 1.6	This report
75ASj 538	Big Delta D1 64°52.6'N 144°04.5'W	Granodiorite	Bio	8.85 8.90	>8.88	11.79	96.5	90.0 ± 2.0	This report
			Hbl	0.858 0.862 0.862 0.863	>0.861	1.182	67.5	92.9 ± 2.0	This report
CHS72X Chena Hot Springs	Circle A5 65°02.9'N 146°02.8'W	Biotite Granite	Bio	8.641 8.628	>8.634	7.538	82.9	59.7 ± 1.8**	Biggar, 1974
			Sphene	Fission-track Spontaneous tracks = $8.424 \times 10^5/cm^2$ (936 tracks) Induced tracks = $17.237 \times 10^5/cm^2$ (958 tracks)				58.9 ± 2.7	Holm, 1973 Biggar, 1974
MP246 Mt. Prindle	Circle B5 65°27.1'N 144°27.8'W	Pegmatite	Mus	10.106 10.112	>10.109	8.570	76.4	58.0 ± 1.8**	Holm, 1973
MP406 Mt. Prindle	Circle B5 65°26.7'N 146°21.2'W	Biotite Granite	Bio	8.975 8.970	>8.972	7.806	72.5	59.5 ± 1.8**	Holm, 1973
61AE 189A Grouse Creek	Circle B6 65°14.1'N 146°51.8'W	Fine-grained mica schist	Mus	8.93(2)		21.12	88	178 ± 5.3	M.A Lanphere and G.D. Eberlein, written commun., 1981
61AE 189b Grouse Creek	Circle B6 65°14.1'N 146°51.8'W	Coarse-grained mica schist	Mus	9.28(2)		23.32 23.16	86 92	166 ± 3.5	M.A. Lanphere and G.D. Eberlein, written commun., 1981
61AE 190 Circle Hot Springs	Circle B2 65°26.6'N 144°39.2'W	Granite	Bio	7.90(2)		7.003	82	60.5 ± 1.8***	Wasserburg and others, 1963
61AE 198 Montana Creek	Circle B5 65°21.6'N 146°05.4'W	Mica schist	Mus	1.12(2)		1.930	54	116 ± 3.5***	Wasserburg and others, 1963; Forbes and Weber, 1975
60ACh 101 Montana Creek	Circle B5 65°21.6'N 146°05.4'W	Mica schist	Mus	9.14(2)		14.92	90	110 ± 3.3***	Wasserburg and others, 1963

* Sample has been treated with hydroflouric acid.
** Recalculated with constants given below.

$\lambda_\beta = 4.963 \times 10^{-10}$ year^{-1}, $\lambda_\epsilon = 5.72 \times 10^{-11}$ year^{-1}, $\lambda_{\epsilon'} = 8.78 \times 10^{-13}$ year^{-1}, $^{40}K/K = 1.167 \times 10^{-4}$ atom percent.

$\lambda = 6.85 \times 10^{17}$ year^{-1}, thermal neutron dose = 1.97×10^5 neutrons/cm^2.

***Location and analytical data furnished by M.A. Lanphere and G.D. Eberlein, 1981.



Base from U.S. Geological Survey, 1955

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology from Menzie and others, 1983

DEFINITION OF MAP UNITS

UNCONSOLIDATED DEPOSITS

- Qa — Alluvium and colluvium
- Qaf — Alluvial fan deposits
- Qs — Silt and peat
- Qsu — Silt, undifferentiated and organic material
- Qg — Gravel
- Ql — Loess

SEDIMENTARY ROCKS

- Tcs — Conglomerate and sandstone

UNMETAMORPHOSED IGNEOUS ROCKS

- TKg — Granite
- TKf — Felsic igneous rock

NORTHWEST CIRCLE QUADRANGLE

- KJqa — Quartzite, argillite, conglomerate, and hornfels
- MzPzat — Argillite, tuff, quartzite, and conglomerate
- MzPzaq — Argillite and quartzite
- Pzug — Ultramafic and mafic rocks and greenstone
- DSd — Dolomite and argillite
- DSl — Limestone, dolomite, and shale
- SOs — Siltstone, dolomite, chert, and mafic igneous rocks
- Old — Livengood Dome(?) Chert
- Pzp€a — Argillite, grit, and quartzite
- Pzp€gq — Grit, quartzite, and argillite

AREA NORTH OF TINTINA FAULT ZONE

- MzPzc — Circle Volcanics and associated rocks
- PMc — Chert, argillite, and quartzite
- MzPzd — Diorite
- Pzcg — Chert pebble conglomerate
- Pzcc — Chert, conglomerate, and limestone
- Pzc — Chert and argillite
- Dl — Limestone
- Pzl — Limestone and chert
- Pzp€a — Argillite, grit, and quartzite
- Pzp€b — Basalt and limestone

AREA SOUTH OF TINTINA FAULT ZONE

- Da — Augen gneiss
- Pzq — Quartzite, meta-argillite and phyllite
- Pzm — Phyllite, calcareous phyllite, and marble
- Pzp€s — Pelitic schist
- Pzp€ms — Garnet-muscovite schist
- Pzp€d — Dolomite and marble
- Pzp€q — Quartzite and quartzitic schists (includes magnetic chlorite schist subunit (Pzp€qm))
- Pzp€m — Mafic schist
- Pzp€gr — Grit and quartzite

Ultramafic, Mafic, and Eclogitic Rocks

- Pzp — Serpentinized peridotite
- Pzg — Greenstones
- Pze — Eclogite

GEOLOGIC SYMBOLS

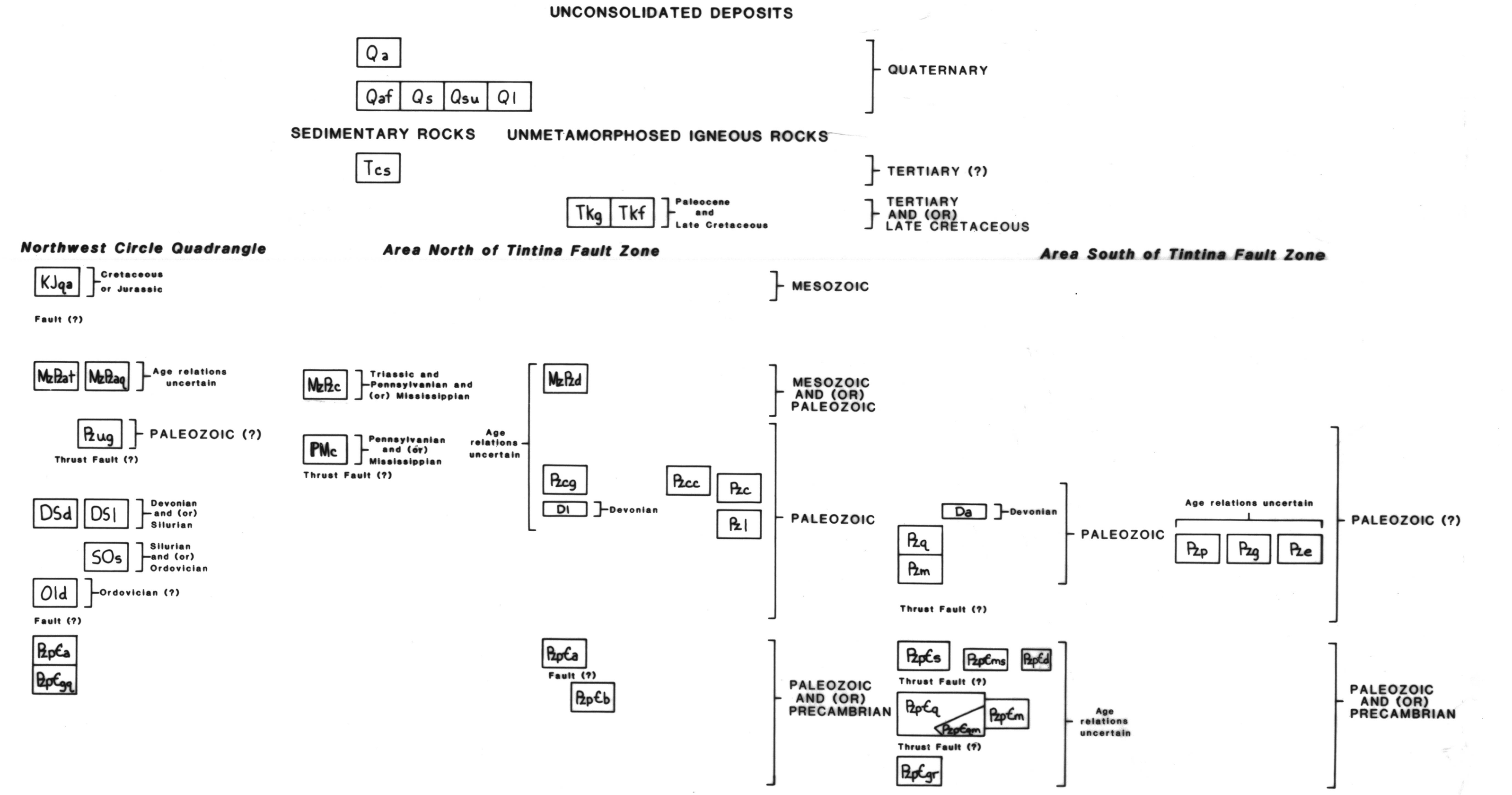
Contact
Approximately located, and inferred

Fault
Dashed where existence or kind of fault uncertain or where approximately located; dotted beneath covering deposits; arrows indicate apparent direction of offset
U, upthrown side
D, downthrown side

Thrust fault
Postulated, dotted beneath covering deposits

Premetamorphic thrust fault
Postulated; predates major regional metamorphism. Dotted beneath covering deposits

CORRELATION OF MAP UNITS



Map and tables showing potassium-argon age determinations and selected major-element chemical analyses from the Circle quadrangle, Alaska

by Gregory D. DuBois, Frederic H. Wilson, and Nora Shew

1986