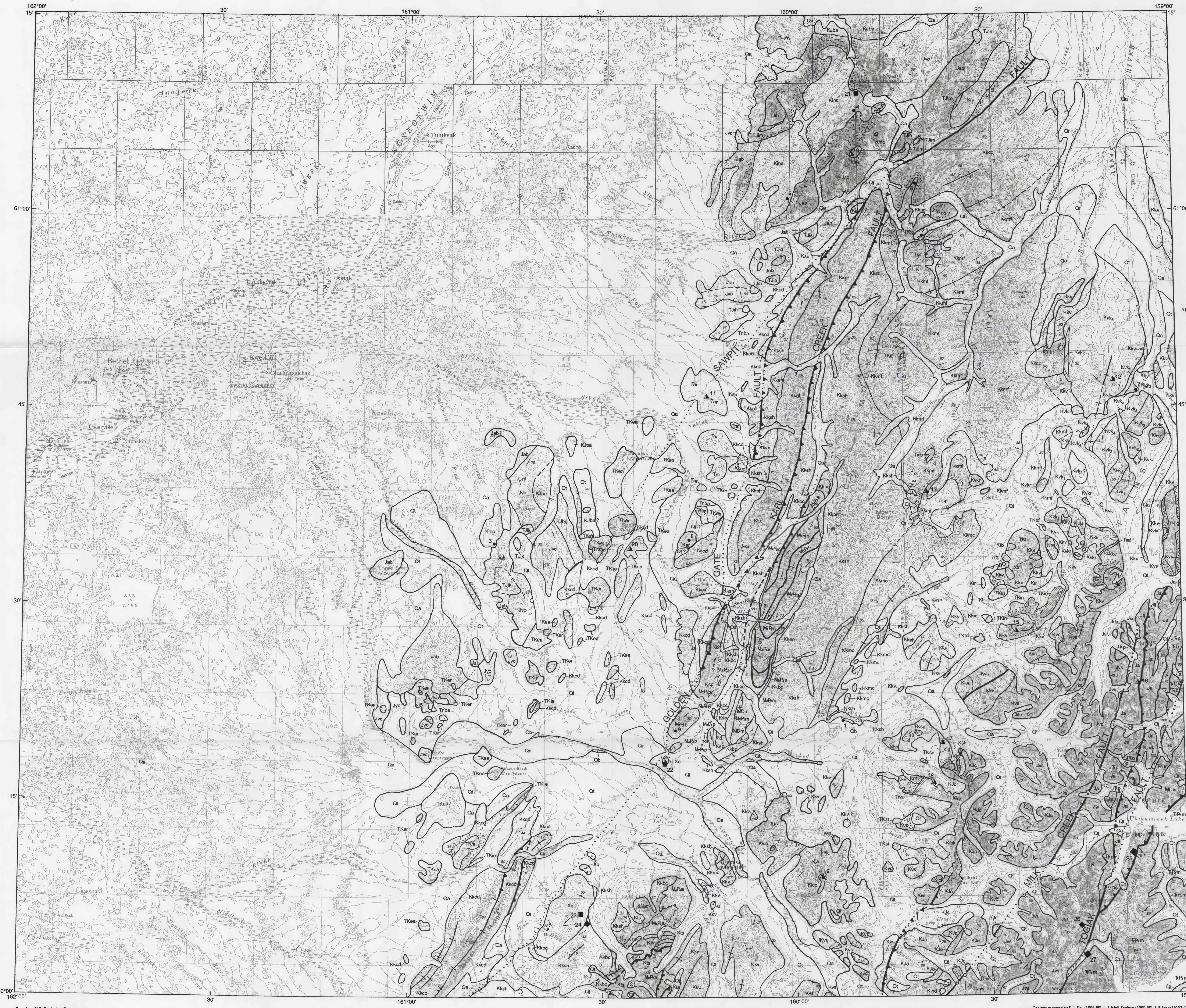
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-2226-A
Explanatory pamphlet accompanies map



Base from U.S. Geological Survey,
Bethel, 1980 (revised 1987), Russian Mission, 1980
Universal Transverse Mercator projection

SCALE 1:250,000

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

AREA OF MAP

Geology mapped by S.E. Box (1986-89), E.J. Moll-Stalcup (1988-89), T.P. Frost (1987-89), J.M. Murphy (1984, 1986-89), J.P. Calzia (1987-89), Greg Grimsich (1989), T.E. Moore (1987), M.W. Mullen (1987-88), W.W. Patton, Jr. (1987), S.M. Roeske (1987), and N.E. Yount (1987).
Data compiled in 1991.

Edited by Dale Russell; prepared by Lori Ghequiere

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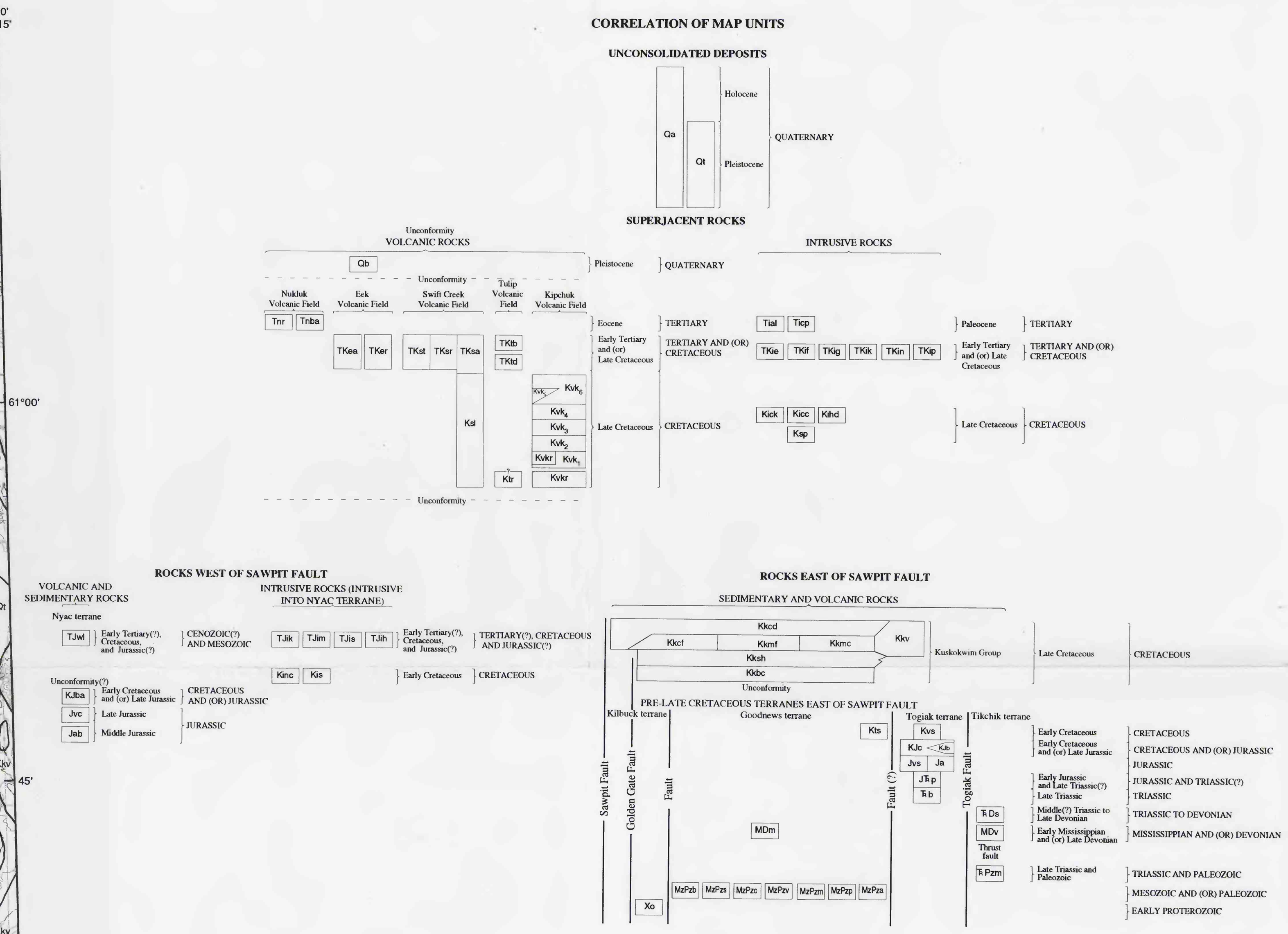
CORRELATION OF MAP UNITS



LIST OF MAP UNITS

(See pamphlet for Description of Map Units)

UNCONSOLIDATED DEPOSITS

- Qa — Alluvium (Holocene and Pleistocene)
- Qt — Glacial till (Pleistocene)

SUPERJACENT ROCKS

VOLCANIC ROCKS

- Qb — Basalt (Pleistocene)

Nukluk Volcanic Field

- Tnr — Rhyolite (Eocene)
- Tnba — Basalt and andesite flows (Eocene)

Eek Volcanic Field

- TKea — Andesite flows and porphyry (Paleocene and Cretaceous?)
- TKer — Rhyolite (Paleocene and Cretaceous?)

Swift Creek Volcanic Field

- TKst — Rhyolite ash-flow tuff (early Tertiary and (or) Late Cretaceous)
- TKsr — Rhyolite (early Tertiary and (or) Late Cretaceous)
- TKsa — Andesite flows (early Tertiary and (or) Late Cretaceous)
- Ksl — Lithic air-fall tuff (Late Cretaceous; Campanian)

Tulip Volcanic Field

- TKtb — Block and ash flow (early Tertiary and (or) Late Cretaceous)
- TKtd — Dacite and andesite flows and dacite tuff (early Tertiary and (or) Late Cretaceous)
- Ktr — Rhyolite domes and flows (Late Cretaceous)

Kipchuk Volcanic Field

- Kvk_6 — Andesite and basalt flows (Late Cretaceous; Maestrichtian)
- Kvk_5 — Fine-grained tuff, crystal-vitric tuff, and tuffaceous sandstone (Late Cretaceous; Maestrichtian)
- Kvk_4 — Upper black andesitic lithic tuff (Late Cretaceous; Maestrichtian)
- Kvk_3 — Andesite flows (Late Cretaceous)
- Kvk_2 — Lower black andesitic lithic tuff (Late Cretaceous)
- Kvk_1 — Basal andesite flows (Late Cretaceous)
- Kvkr — Rhyolite domes and flows (Late Cretaceous)

INTRUSIVE ROCKS

Intrusive rocks, undivided—Divided into

- Tial — Aniak Lake pluton (Paleocene)
- Ticp — Cripple Mountains pluton (Paleocene)
- TKie — Eek River pluton and related plutonic rocks (early Tertiary and (or) Late Cretaceous)
- TKif — Fisher Dome and Marvel Creek plutons, undivided (early Tertiary and (or) Late Cretaceous)
- TKig — Gemuk Mountain pluton (early Tertiary and (or) Late Cretaceous)
- TKik — Quartz monzodiorite of Kipchuk River (early Tertiary and (or) Late Cretaceous)
- TKin — North Fork pluton (early Tertiary and (or) Late Cretaceous)
- TKip — Mt. Plummer pluton (early Tertiary and (or) Late Cretaceous)
- Kick — Crooked Mountain pluton (Late Cretaceous)
- Kicc — Canyon Creek pluton (Late Cretaceous)
- Kihd — Hornblende diorite stocks and dikes (Late Cretaceous)
- Ksp — Serpentinite (Late Cretaceous)

ROCKS WEST OF SAWPIT FAULT

VOLCANIC AND SEDIMENTARY ROCKS

Nyac terrane

- TJwl — Whitefish Lake Volcanic Field (early Tertiary?, Cretaceous, and Jurassic?)
- KJba — Basaltic and andesitic lava flows (Early Cretaceous and (or) Late Jurassic)
- Jvc — Volcaniclastic conglomerate, sandstone, and shale (Late and Middle Jurassic)
- Jab — Andesitic and basaltic lava flows and marine epiclastic rocks (Middle Jurassic)

INTRUSIVE ROCKS
(Intrusive into Nyac terrane)

Intrusive rocks, undivided—Divided into

- TJik — Little Kasigluk River pluton (early Tertiary?, Cretaceous, and Jurassic?)
- TJim — Altered mafic plutonic rocks (early Tertiary?, Cretaceous, and Jurassic?)
- TJis — Slate Creek pluton (early Tertiary?, Cretaceous, and Jurassic?)
- TJih — Hypabyssal felsic intrusive rocks (early Tertiary?, Cretaceous, and Jurassic?)
- Kinc — Nyac, Bonanza Creek, and Columbia Creek plutons, undivided (Early Cretaceous)
- Kis — Sawpit pluton (Early Cretaceous)

ROCKS EAST OF SAWPIT FAULT

SEDIMENTARY AND VOLCANIC ROCKS

Kuskokwim Group—Divided into:

Chert-clast provenance rocks (Late Cretaceous; Turonian)

- Kkcd — Deltaic facies
- Kkcf — Outer-fan turbidite facies

Mixed provenance rocks (Late Cretaceous; Turonian)

- Kkmf — Outer-fan turbidite facies
- Kkmc — Inner-fan-channel facies
- Kkv — Volcanic provenance rocks (Late Cretaceous; Turonian)
- Kksh — Shale and siltstone (Late Cretaceous; early Turonian and (or) late Cenomanian)
- Kkbc — Basal conglomerate (Late Cretaceous; Cenomanian?)

PRE-LATE CRETACEOUS TERRANES EAST OF SAWPIT FAULT

Kilbuck terrane

- Xo — Amphibolite-facies orthogneiss and amphibolite with minor intercalated pelitic schist (Early Proterozoic)

Goodnews terrane

- Kts — Turbiditic sandstone, conglomerate, and phyllite (Early Cretaceous)
- MDm — Marble with metabasaltic dikes (Early Mississippian and (or) Late Devonian)
- MzPzb — Metabasalt and minor metachert (Mesozoic and (or) Paleozoic)
- MzPzs — Arkosic sandstone and slate (Mesozoic and (or) Paleozoic)
- MzPzc — Chert and argillite (Mesozoic and (or) Paleozoic)
- MzPzv — Volcaniclastic sandstone and argillite (Mesozoic and (or) Paleozoic)
- MzPzm — Metachert and phyllitic metachert (Mesozoic and (or) Paleozoic)
- MzPzp — Chloritic phyllite (Mesozoic and (or) Paleozoic)
- MzPza — Argillaceous melange with blocks of limestone, basalt, and chert (Mesozoic and (or) Paleozoic)

Togiak terrane

- Kvs — Marine volcaniclastic sandstone, conglomerate, shale, and interbedded tuff (Early Cretaceous)
- KJc — Argillite and tuffaceous chert (Early Cretaceous and (or) Late Jurassic)
- KJb — Pillow basalt (Early Cretaceous and (or) Late Jurassic)
- Jvs — Marine volcaniclastic sandstone, conglomerate, and argillite (Jurassic)
- Ja — Marine arkosic sandstone and argillite (Jurassic)
- JTRp — Phyllite and chert (Early Jurassic and Late Triassic?)
- TRb — Pillow basalt and minor interbedded chert (Late Triassic)

Tikchik terrane

- TRDs — Marine sandstone, shale, limestone, and conglomerate (Middle? Triassic to Late Devonian)
- MDv — Massive volcanic and volcaniclastic rocks (Early Mississippian and (or) Late Devonian)
- TRPzm — Melange (Triassic and Paleozoic)

Map symbols

- **Contact**—Dashed where approximately located dotted where concealed
- **Fault**—Dashed where inferred, dotted where concealed. U, upthrown block; D; downtown block
- **Thrust fault**—Sawteeth of upper plate. Dashed where inferred, dotted where concealed
- **Folds**—Showing trace or axial plane, arrowhead indicates direction of plunge. Dashed where inferred, dotted where concealed
  - **Anticline**
  - **Syncline**
  - **Overturned anticline**
  - **Overturned syncline**
- **Axial trend of fold**—Too small to show individually at scale of map
- **Strike and dip of bedding or flows**
  - 19 **Inclined**
  - **Vertical**
  - 52 **Overturned**
- 26, 6 **Strike and dip of foliation**—Arrow indicates plunge of mineral lineation
- 31 **Strike and dip of cleavage**
- **Hornfels**
- **Mafic phase of felsic pluton**
- 7 ● **K/Ar sample locality**—Number refers to sample number in table 1
- 11 ▲ **$^{40}Ar/^{39}Ar$ sample locality**—Number refers to sample number in table 2
- 21 ■ **U/Pb sample locality**—Number refers to sample number in table 3
- 25 ◆ **Apatite fission-track sample locality**—Number refers to sample number in table 4

Table 1. *Conventional K/Ar isotopic age determinations from Bethel and southern Russian Mission quadrangles, southwestern Alaska*

Map No.	Sample No.	Latitude, Longitude	Material dated(a)	Lithology (map unit)	K_2O (wt. %)	Radiogenic ^{40}Ar (mol/g)	Radiogenic ^{40}Ar (% of total ^{40}Ar)	Age(b) (Ma)	Analyst(c)
1	86ASB9a	60°21'18" 159°51'48"	WR	Olivine basalt (Qb)	1.136	6.83×10^{-13}	19.6	0.418±0.016	1
2	87ACz61	60°56'27" 159°39'33"	bt	Quartz diorite (TKip)	8.105	7.73×10^{-10}	85.2	65.1±2.0	2
3	87ATf30	60°34'40" 160°47'15"	bt	Granodiorite (Kinc)	7.90	1.353×10^{-9}	53.4	115.0±3.5	2
4	82MR300	61°07'52" 159°49'44"	bt	Granodiorite (Kinc)	8.575	138×10^{-11}	82.2	108.5±3.3	4
			hbl		0.55	8.23×10^{-11}	51.2	101.1±3.0	4
5	63CO414	61°02'00" 160°00'00"	bt	Granodiorite (Kinc)	8.52	152×10^{-11}	89	120.0±3.6	3
6	82MR307	61°02'21" 159°40'32"	bt	Granodiorite (TKip)	6.099	59.6×10^{-11}	87.1	66.6±2.0	4
7	82JD435a	60°46'13" 159°06'26"	pl	Andesite (Kvk_4)	2.56	25.9×10^{-11}	96.7	69.0±2.1	4
			WR		1.51	15.8×10^{-11}	90.9	71.4±2.1	4
8	82JD450B	60°35'02" 160°16'17"	WR	Rhyolite (TKer)	4.159	35.8×10^{-11}	85.5	59.3±1.8	4
			bt		8.332	76.2×10^{-11}	67.4	62.5±1.9	
9	B78-1213	60°20'30" 160°18'48"	act	Actinolite schist (MzPzb)	0.0679	0.000722 ppm	16.8	146.0±15.0	5

(a) Abbreviations: bt = biotite, hbl = hornblende, act = actinolite, pl = plagioclase, WR = whole rock.
(b) Decay Constants: $\lambda_\beta = 4.92 \times 10^{-10}$ year^{-1}; $\lambda_\varepsilon = 0.572 \times 10^{-10}$ year^{-1}; $\lambda_\varepsilon' = 8.78 \times 10^{-10}$ year^{-1}; $^{40}K/K = 1.167 \times 10^{-4}$ atom percent.
(c) Analysts: (1) Nora Shew, (2) Marvin Lanphere, (3) Marvin Lanphere [Wilson, 1977], (4) Don Turner [Robinson and Decker, 1986], (5) Krueger Enterprises, Inc. (W. Connelly, AMOCO, written commun., 1978).

Table 2. *Age determinations by $^{40}Ar/^{39}Ar$ total-fusion method from Bethel and southern Russian Mission quadrangles, southwestern Alaska*
[Analyses by Marvin Lanphere]

Map No.	Sample No.	Latitude, Longitude	Material dated(a)	Lithology (map unit)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$*	$^{36}Ar/^{39}Ar$	$^{36}/Ar_{Ca}$** (wt. %)	$^{40}Ar_R$** (wt. %)	Age (Ma)
10	88ATf32	61°06'18" 159°46'28"	bt	Granodiorite (Kinc)	6.350	0.0526	0.00208	0.67	90.4	110±3.3
11	87ACz75M	60°45'56" 160°13'48"	rb	Alkali rhyolite (Tnr)	7.003	0.5910	0.0145	1.08	39.5	54.7±1.6
12	88ASB99a	60°46'55" 159°10'10"	bt	Dacite flow (Kvk_6)	4.542	0.0244	0.00347	0.19	77.5	69.5±2.1
13	87ATf72	60°38'38" 159°39'41"	bt	Granite (Ticp)	7.497	0.0492	0.00325	0.40	87.1	62.2±1.9
14	88ATf62	60°31'15" 159°09'50"	bt	Granite (Tial)	4.976	0.0685	0.00639	0.28	62.1	60.8±1.8
15	88ATf56	60°28'04" 159°24'32"	bt	Granite (Tkin)	4.879	0.0386	0.00529	0.19	68.0	64.3±1.9
16	87AJm271B	60°23'37" 159°07'03"	hbl	Diorite (Kihd)	13.35	8.595	0.0359	6.32	25.6	68.0±2.0
17	86ASB1	60°19'24" 159°37'36"	WR	Andesite (Ksl)	7.156	8.146	0.0130	16.6	55.2	74.3±2.2
18	87ATf51	60°16'29" 159°38'00"	bt	Granite (Kick)	4.436	0.126	0.00265	1.26	82.5	69.8±2.1
19	87AJm36a	60°09'08" 159°56'11"	bt	Granodiorite (Kicc)	7.761	0.1636	0.00102	4.25	96.2	70.3±2.1 #
20	88AML12	60°34'32" 160°25'36"	pl	Andesite (TKea)	51.20	13.97	0.1663	2.26	6.16	59.5±12.3

(a) Abbreviations: bt = biotite, hbl = hornblende, pl = plagioclase, rb = riebeckite, WR = whole rock.
* Corrected for ^{37}Ar decay, half-life = 35.1 days.
** Subscripts indicate radiogenic (R) and calcium-derived (Ca) argon.
\# sample analysed by laser fusion.

Table 3. *U-Pb zircon ages for Bethel and southern Russian Mission quadrangles, southwestern Alaska*
[analyses by Joe Wooden]

Map No.	Sample No.	Latitude, Longitude	Lithology (map unit)	Age (Ma) (upper Concordia intercept)
21	88ATF24d	61°09'28" 159°49'18"	Granodiorite (Kinc)	104-129
22	87ASB125b	60°17'59" 160°20'02"	Trondjheimitic gneiss (Xo)	2070±16
23	88ML22b	60°05'35" 160°36'00"	Granitic gneiss (Xo)	2040±74

URANIUM-LEAD ISOTOPIC DATA FOR ZIRCON SAMPLES

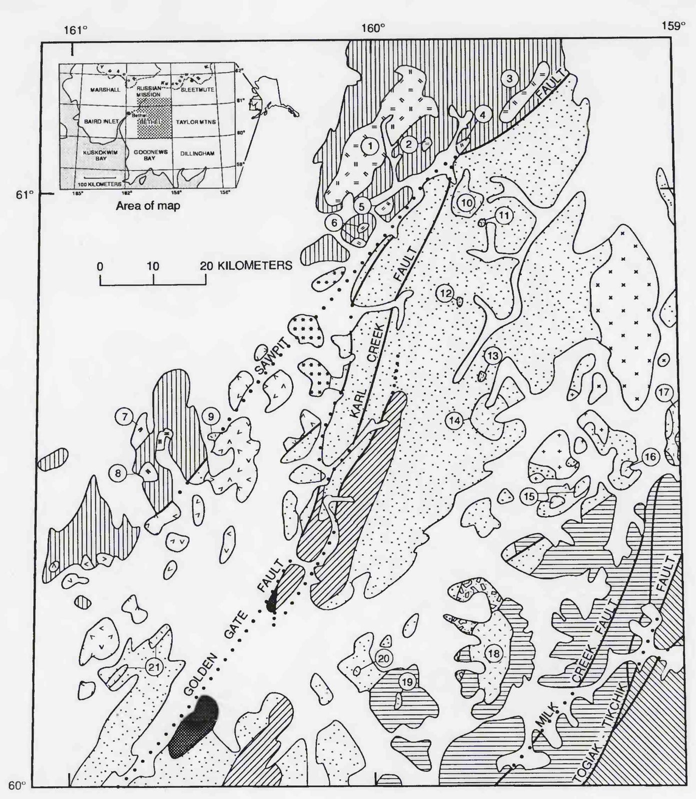
Sample No. (fraction no.*)	U+ (ppm)	Pb+ (ppm)	Atomic ratios§ $^{206}Pb/^{238}U$	Atomic ratios§ $^{207}Pb/^{235}U$	Atomic ratios§ $^{207}Pb/^{206}Pb$	Apparent ages# (Ma) $^{206}Pb/^{238}U$	Apparent ages# (Ma) $^{207}Pb/^{235}U$	Apparent ages# (Ma) $^{207}Pb/^{206}Pb$	Measured ratios $^{206}Pb/^{204}Pb$	Measured ratios $^{208}Pb/^{206}Pb$
88ATF-024d										
(NM-63)	761	12.7	0.01629	0.10826	0.04819				2892	0.13230
			104.2	104.4	108.7					
(NM63-102)	631	10.8	.01642	.10989	.04853				1459	.14329
			105.0	105.9	125.0					
(M63-102)	678	12.2	.01685	.11296	.04861				924	.15503
			107.7	108.9	129.0					
(M102-163)	461	8.4	.01696	.11282	.04824				740	.17386
			108.4	108.5	111.2					
87ASB125b										
(+102)	343	127	0.34209	5.9657	0.12648	1897	1971	2050	10870	0.1276
(63-102)	278	105	0.35089	6.1470	0.12706	1939	1997	2058	16230	0.1215
(-63)	240	93	0.35886	6.2913	0.12715	1977	2017	2059	12660	0.1322
88ML22b										
(9)	1589	330	0.19283	3.1690	0.11919	1137	1450	1944	2139	0.1193
(8)	726	214	0.26590	4.4977	0.12268	1520	1731	1996	2645	0.1552
(7)	386	122	0.28387	4.8445	0.12377	1611	1793	2011	1715	0.1470

* All fractions are nonmagnetic splits at 1.7 amps on a Franz Isodynamic separator; sizes are in micrometres; 88ML22b is a bulk-size fraction split into increasingly more nonmagnetic fractions.
\+ Concentrations for total element determined on split of dissolved sample using a mixed ^{235}U-^{208}Pb spike.
§ Corrected for analytical blank of 0.3 ng Pb and 0.01 ng U and common Pb by using measured $^{206}Pb/^{204}Pb$ and Pb isotopic composition from Stacey and Kramers (1975) for an age of 2,100 Ma; measured Pb isotopicratios corrected for 0.10 percent per mass unit fractionation; all isotopic ratios measured in static mode on a multicollector Finnigan-MAT mass spectrometer in the Pb lab at U.S. Geological Survey, Menlo Park, California.
\# Calculated using the decay constants and $^{238}U/^{235}U$ recommended by Steiger and Jager (1977).
ppm=parts per million.

Table 4. *Apatite fission-track cooling ages for Bethel and southern Russian Mission quadrangles, southwestern Alaska*
[Analyses by John Murphy]

Map No.	Sample No.	Latitude, Longitude	Lithology (map unit)	Elevation (ft)	N	ρs (N_s) ($10^6 cm^{-2}$)	ρi (N_i) ($10^6 cm^{-2}$)	ρD (ND) ($10^6 cm^{-2}$)	$P(\chi^2)$%	r	$N_s/N_i \pm 1\sigma$ (mean ratio)	Pooled age Ma±1σ
24	88ML22b	60°05'35" 160°36'00"	Granite gneiss Xo	1,750	19	0.2071 (347)	0.6224 (1043)	1.150 (5214)	83.0	0.974	0.333±0.021	66.6±4.6
25	89ASB101	60°10'42" 159°07'40"	Dacite MDv	2,600	20	0.06096 (62)	0.2596 (264)	1.160 (5214)	99.6	0.658	0.235±0.033	47.5±6.9
26	89ASB38	60°05'18" 159°16'08"	Sandstone Jvs	2,450	8	0.1287 (40)	0.3410 (106)	1.380 (5618)	52.2	0.741	0.377±0.070	90.5±17.0
27	89AJM34	60°03'17" 159°15'28"	Sandstone TRPzm	700	21	0.106 (60)	0.7228 (392)	1.113 (5214)	73.1	0.713	0.159±0.022	29.7±4.2

N, Number of individual crystals dated; ρs, spontaneous track density; N_s, Number of spontaneous tracks counted; ρi, induced track density; N_i, Number of induced tracks counted; ρD, track density measured in external mica dectector adjacent to SRM612 dosimetry glass after irradiation; ND, Number of tracks counted in determining ρD; r, Correlation coefficient between individual crystal spontaneous and induced counts; $P(\chi^2)$%, Chi square probability; $N_s/N_i \pm 1\sigma$, Mean ratio of individual crystals N_s/N_i±one standard deviation); Pooled age-calculated using sample ρs/ρi and 350 zeta; error is one standard deviation.



EXPLANATION

- Surficial deposits (Quaternary) undivided

PLUTONIC ROCKS
Early Cretaceous plutons (some units may be Jurassic or Late Cretaceous) (west of Sawpit fault)

- Plutons indicated by number: 1. Nyac, 2. Bonanza Creek, 3. Sawpit, 4. Fox Creek, 5. Slate Creek, 6. Dry Creek, 7. Columbia Creek, 8. Little Kasigluk River

Late Cretaceous to early Tertiary plutons (mostly east of Sawpit fault)

- Plutons indicated by number: 9. Shining Dome, 10. Mt. Plummer, 11. Marvel Creek, 12. Fisher Dome, 13. Loco Creek, 14. Cripple Mountains, 15. North Fork, 16. Aniak Lake, 17. Gemuk Mountain, 18. Crooked Mountains, 19. Canyon Creek, 20. west Canyon Creek, 21. Eek River

VOLCANIC FIELDS

- Nukluk volcanic field (Eocene)—Alkalic rhyolite and basalt flows, and rhyolitic ash-flow tuffs
- Eek volcanic field (Paleocene and Late Cretaceous?)—Calc-alkaline andesite and dacite flows; subordinate rhyolite domes
- Kipchuk volcanic field (Late Cretaceous)—Calc-alkaline andesite flows and tuff; subordinate rhyolite domes
- Tulip volcanic field (early Tertiary and (or) Late Cretaceous)—Calc-alkaline dacite and andesite flows, pyroclastic rocks, and rhyolite domes
- Swift Creek volcanic field (early Tertiary and (or) Late Cretaceous)—Calc-alkaline andesite flows and breccias and rhyolite ash-flow tuffs

SEDIMENTARY ROCKS

- Kuskokwim Group (Late Cretaceous)—Shallow- to deep-marine sandstone, shale, and minor conglomerate

TERRANES

- Nyac terrane (Early Cretaceous? and Jurassic)—Volcanic, volcaniclastic, and plutonic rocks of volcanic arc afffinity
- Goodnews terrane (Mesozoic and Paleozoic)—Structurally disrupted assemblage of metabasalt, argillite, chert, marble, and minor clastic rocks
- Togiak terrane (Early Cretaceous to Late Triassic)—Volcaniclastic and minor volcanic rocks of volcanic arc affinity
- Tikchik terrane (Mesozoic and Paleozoic)—Structurallly disrupted assemblage of volcanic rocks, chert, clastic rocks, argillite, and marble
- Kilbuck terrane (Early Proterozoic)—Amphibolite-facies orthogneiss and paragneiss
- Contact
- Fault, dotted where inferred

Figure 1. Generalized bedrock geologic map of the Bethel and southern Russian Mission quadrangles, southwestern Alaska, emphasizing pre-Late Cretaceous terranes, Cretaceous and Tertiary plutonic bodies (numbers refer to pluton names in explanation), and Late Cretaceous-early Tertiary volcanic fields.

PRELIMINARY GEOLOGIC MAP OF THE BETHEL AND SOUTHERN RUSSIAN MISSION QUADRANGLES, SOUTHWESTERN ALASKA

By

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