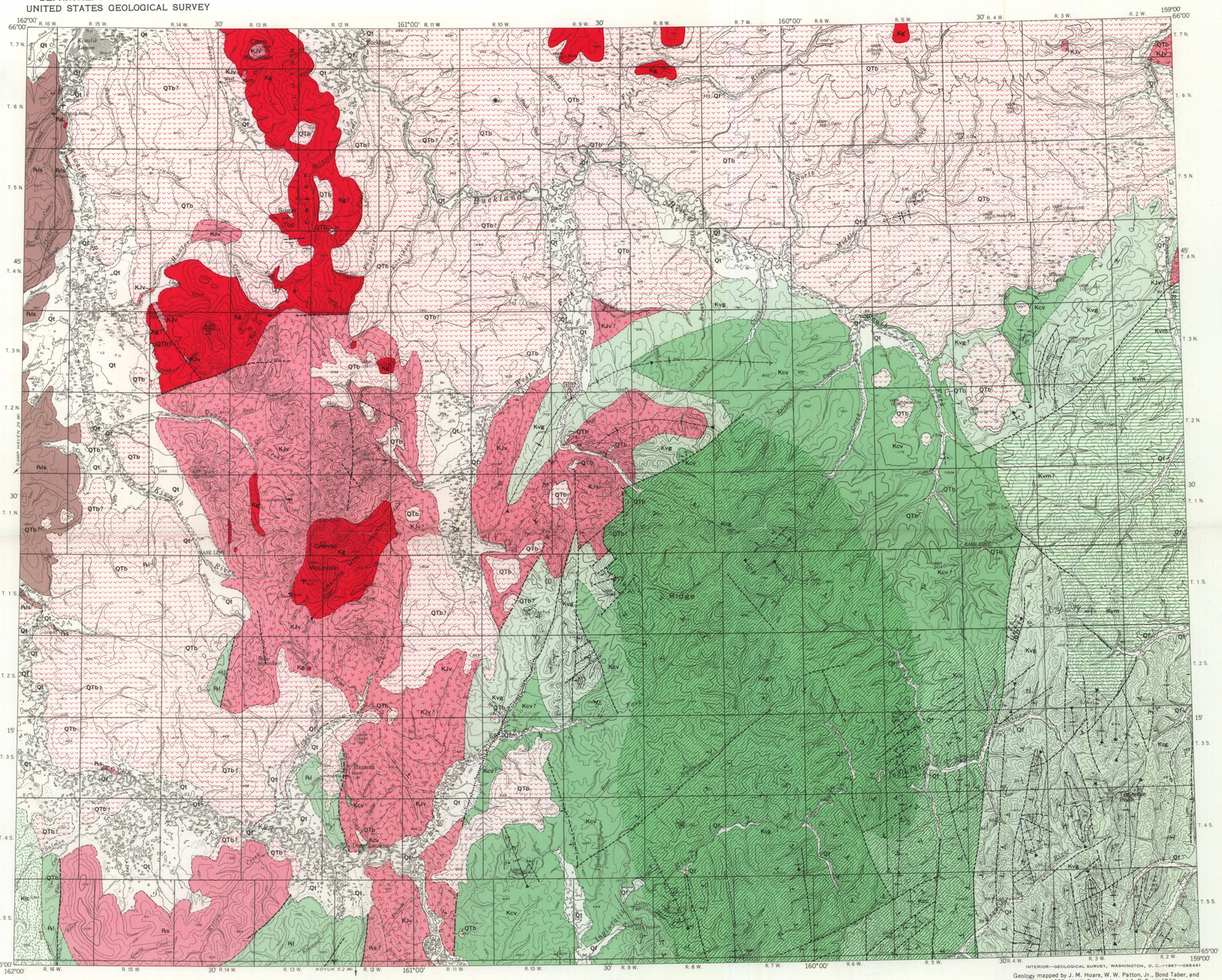


Base from U.S. Geological Survey topographic quadrangles, 1955

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
DOTTED LINES REPRESENT 100-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
1955 MAGNETIC DECLINATION AT SOUTH EDGE OF SHEET VARIES FROM 19°30' TO 21°30' EAST

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1967—G66441

Geology mapped by J. M. Hoare, W. W. Patton, Jr., Bond Taber, and I. L. Tailleur, 1958; W. W. Patton, Jr. and A. R. Tagg, 1960; W. W. Patton, Jr., N. W. Rutter, and A. R. Tagg, 1961 Petrographic studies by T. P. Miller and D. W. Hinckley

EXPLANATION

SEDIMENTARY ROCKS

Qf — Flood-plain deposits

Gravel, sand, and silt along flood-plains of major stream valleys. Characterized physiographically by bars, oxbow lakes, meander scrolls, abandoned channels, and other evidence of recent flood-plain building. Locally includes alluvial terrace and fan deposits along narrow valleys. Mapped almost entirely from aerial photographs

Qt — Terrace deposits

Terraced alluvial silt deposits in the Koyuk, Kiwalik, and Buckland lowlands. Some peat and gravel. Characterized by thermokarst topography and many small lakes. Mapped almost entirely from aerial photographs

Klc — Limestone conglomerate

Poorly sorted, locally derived nonmarine conglomerate overlying metamorphic rocks of Paleozoic age in southwestern corner of quadrangle. Conglomerate composed of pebble to boulder-size clasts chiefly of recrystallized limestone but also including some schist, greenstone, phyllite, and quartz. Interbedded micaceous sandy limestone (calcarenite). Plant fossils of Cretaceous age reported by Smith and Eakin (p. 56, 1911). Conglomerate may be a marginal facies of calcareous graywacke and mudstone (units Kcg, Kcv, Kcc *)*

Kcg, Kcv, Kcc — Calcareous graywacke and mudstone

Kcg, *rhythmically interbedded medium gray, yellowish-orange weathering, fine grained to gritty, highly calcareous graywacke (table 1, 58ATr108, 110) and micaceous, calcareous mudstone. Abundant carbonized plant debris. Mudstone characterized by fine, locally convolute, cross laminations and current-rippled partings. Unit appears to coarsen westward; abundance of detrital carbonate, quartz, mica, and metamorphic rock fragments suggests it was derived chiefly from the terrane of Paleozoic metasedimentary rocks in contrast to the underlying volcanic graywacke, conglomerate, and mudstone (units* Kvg, Kvm) *which were derived mainly from the terrane of Mesozoic volcanic and plutonic rocks. Crops out along Inglutalik River but elsewhere in the quadrangle exposures are confined to scattered patches of frost-riven rubble along ridge tops. Weathers more or less homogeneously and is expressed topographically by broad, even sloping, nearly flat topped interfluves. Estimated to be more than 5,000 feet thick in northwest-plunging syncline which crosses Inglutalik River 3 miles above Nigkimigoon River.*

Kcv, *mixed sequence of calcareous graywacke, calcareous mudstone, volcanic graywacke, and volcanic conglomerate. Lithologically transitional between units* Kvg *and* Kcg. *On Inglutalik River, chiefly medium gray to pale olive, yellowish-orange weathering, micaceous, highly calcareous graywacke (table 1, 58ATr92) with lenses of volcanic granule to cobble conglomerate. On Buckland River, dark greenish gray to pale olive, hard, slightly calcareous, volcanic graywacke (table 1, 61APa75) interbedded with medium to dark gray, fine to medium grained, calcareous graywacke and mudstone; volcanic graywacke conspicuously graded and sole marked. Unit appears to overlap the volcanic graywacke and conglomerate unit (*Kvg*) along western edge of Cretaceous sedimentary basin and near Dime Landing rests on andesitic volcanic rocks (*KJv*). Contact with* Kcg *gradational; distinguished from* Kcg *by presence of volcanic graywacke. Carbonized plant material abundant throughout locally forming thin coaly layers. Unit probably correlative with coal-bearing beds near Koyuk in the adjoining Norton Bay quadrangle, which have been assigned a Cretaceous age on the basis of pollen study by E. B. Leopold (written communication, 1963). Poorly exposed; outcrops confined chiefly to cutbanks.*

Kcc, *cyclically interbedded sequence of medium gray, yellowish-orange weathering, fine to coarse grained, calcareous graywacke, hard dark gray, fine to medium grained, carbonaceous, volcanic graywacke (table 1, 58ATr119); and dark carbonaceous mudstone. Graywacke typically graded and sole marked. Abundant carbonized plant debris. Unit appears to grade upward into* Kcg *and laterally into* Kcv; *probably distal facies of* Kcv. *Distinguished from* Kcg *and* Kcv *by abundance of dark fine-grained graywacke and mudstone. Well exposed in cutbanks on Inglutalik and Ungalik Rivers but poorly exposed elsewhere*

Pzl, Pzs — Limestone and schist

Pzl, *chiefly light gray, massively bedded, recrystallized limestone and dolomite. Subordinate calcareous mica schist and dark phyllite. Tentatively assigned a middle Paleozoic age based on possible correlation with fossiliferous carbonate rocks in the Solomon quadrangle (Smith and Eakin, 1911)*

Pzs, *chiefly quartz mica schist, mica schist, and quartzite. Locally includes calcareous, graphitic, and feldspathic schists, amphibolite schist, phyllite, and thin limestone. Age and stratigraphic relationship with limestone (*Pzl*) uncertain; contact gradational?*

Pzls, *undivided limestone and schist in areas of poor exposure*

IGNEOUS ROCKS

QTb — Basalt

Flows of gray to dark red vesicular olivine basalt. Some black, dense glassy basalt. Flows extruded over terrain of moderate relief; range in elevation from sea level to over 1,800 feet. More than 500 feet thick along incised tributaries of Buckland and Tagagawik Rivers. In Buckland, Kiwalik, and Koyuk lowlands generally covered by thick mantle of wind-blown silts. Flows horizontal or nearly horizontal; locally tilted as much as 35° on Buckland-Kiwalik divide and folded into several small flexures on Middle Fork of Buckland River. Mafic alkaline basalt with abundant peridotite inclusions forms partly dissected cone 10 miles SE of Buckland village and several prominent knobs at Sugar Top on Buckland-Kiwalik divide. Fine to medium crystalline trachybasalt intrusive (?) at VABM Boulder near head of Fish River and along axis of small anticlinal flexure on Middle Fork of Buckland River. Bulk of flows believed to correlate with Imuruk Volcanics (early ? and middle Pleistocene) in adjoining Bendeleben quadrangle (Hopkins, 1963); some flows may be as old as Tertiary. Mapped almost entirely from aerial photographs

Kvg, Kvm — Volcanic graywacke, conglomerate, and mudstone

Kvg, *volcanic graywacke and conglomerate; composed chiefly of andesitic volcanic rock detritus but locally includes notable amounts of granitic rock detritus and fine-grained tuffaceous material. In the drainage areas of the Buckland and Koyuk Rivers chiefly massive, poorly stratified, pebble to boulder conglomerate interbedded with dark greenish-gray to pale olive graywacke (table 1, 61APa23) and subordinate dark gray finely laminated mudstone. Conglomerate composed of well-rounded clasts of andesitic volcanic and granitic rocks in a poorly sorted gritty matrix of assorted volcanic rock debris and potash feldspar. Many granitic clasts are lithologically identical with granitic rocks (*Kg*) of Granite Mountain and Hunter Creek plutons. Near contact with andesitic volcanic rocks (*KJv*) conglomerate and graywacke are hard and tuffaceous and seem to grade into volcanic breccias and agglomerates of unit* KJv. *In eastern part of quadrangle unit consists of mixed sequence of dark greenish gray to pale olive, fine to coarse grained graywacke (table 1, 58APa93); medium gray, calcareous, fine to medium grained graywacke; and dark gray laminated mudstone. Thin lenses of feldspar, chert, and quartz grit. Some graywacke is tuffaceous and characterized by conspicuous mottling due to partial zeolitization of volcanic material (Hoare and others, 1964). Thin beds of grayish yellow to pale olive felsic tuff locally in northeastern part of quadrangle. Unit well exposed in cutbanks on West Fork of Buckland and Ungalik Rivers; forms prominent rubble-covered ridges between West Fork of Buckland and East Fork of Koyuk and in southeastern corner of quadrangle. Age uncertain; believed to be approximately correlative with volcanic graywacke of late Early Cretaceous (Albian) age in Hughes (Patton and Miller, 1966) and Selawik (Patton, unpublished field data) quadrangles. Granitic boulders in conglomerate yield lead-alpha and potassium-argon ages of 90± 10 m.y. to 100± 15 m.y. (tables 2 and 3) and indicate that enclosing rocks are probably no older than late Early Cretaceous.*

Kvm, *chiefly medium- to dark-gray mudstone and medium-gray to dark greenish gray, calcareous and noncalcareous, fine to medium grained, volcanic graywacke (table 1, 58AHr62). Mudstone finely cross laminated. Unit poorly exposed. No fossils found in this unit in Candle quadrangle but possibly correlative rocks in the Nulato quadrangle contain* Gastroplites *of Early Cretaceous (Albian) age (Patton, 1968), (Bickel and Patton, 1957)*

Kg — Granitic rocks

Chiefly hornblende and pyroxene monzonite and syenite. Some biotite quartz monzonite. Rocks from Hunter Creek and Granite Mountain plutons are assigned a mid-Cretaceous age based on lead-alpha age determinations of 90± 10 and 100± 15 m.y. and on a potassium-argon age determination of 102± 5 m.y. (tables 2 and 3). Granitic rocks in the north-central part of the quadrangle belonging to the Selawik Hills pluton are also assigned a mid-Cretaceous age based on a potassium-argon age determination of 100± 5 m.y. from a sample collected in the adjoining Selawik quadrangle (Miller and others, 1966)

KJv — Andesitic volcanic rocks

Includes a wide variety of andesitic flows and volcaniclastic rocks. Chiefly andesitic and trachyandesitic crystal and lithic tuffs, tuffaceous volcanic graywacke, massive andesitic breccia, agglomerate, and conglomerate, and intercalated flows of porphyritic pyroxene andesite and basalt. Dark basalt flows (?) with exceptionally large phenocrysts of hornblende and augite occur abundantly on West Fork of Buckland River. In vicinity of granitic plutons volcanic rocks characteristically hornfelsic and propylitically altered to a hard, pale green aggregate of chlorite, epidote, calcite, and sodic plagioclase. Unit includes many small unmapped intrusive bodies of hybrid diorite, syenite, and monzonite in vicinity of granitic plutons. Bulk of unit believed to be of earliest Cretaceous (Neocomian) age and correlative with Buchia*-bearing andesitic volcanic rocks of the adjoining Kateel River quadrangle (Patton, 1966). A poorly preserved ammonite with ornamentation pattern strongly suggesting* Simbirskites *of Early Cretaceous (Hauterivian) age (D. L. Jones, personal communication, 1966) found on West Fork of Buckland River. A potassium-argon determination from basalt porphyry flow near West Fork of Buckland River also yields an Early Cretaceous age of 130± 3 m.y. (table 3). Some tuffs and breccias on West Fork of Buckland River appear to grade laterally into volcanic conglomerate and graywacke (Kvg) and may be mid-Cretaceous in age. Unit may also include rocks as old as Jurassic and correlative with altered mafic volcanic rocks recently reported in the Hughes quadrangle (Patton and Miller, 1966)*

Contact
Dashed where approximately located, inferred, or indefinite

Fault
Dashed where approximately located or inferred; dotted where concealed; queried where doubtful

Anticline
Showing creatline and direction of plunge. Dashed where approximately located or inferred

Syncline
Showing troughline and direction of plunge. Dashed where approximately located or inferred

Overturned syncline
Showing troughline, direction of dip of limbs, and direction of plunge. Dashed where approximately located or inferred

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds determined by field observation

Strike of vertical or near vertical beds based on photointerpretation

Strike and dip of beds based on photointerpretation
Probably includes some overturned beds

Trace of conspicuous bed

Location of lead-alpha age sample
Number refers to sample list in table 2

Location of potassium-argon age sample
Number refers to sample list in table 3

Placer gold mine

Volcanic cone

Thermal spring

QUATERNARY — Qf, Qt
TERTIARY(?) AND QUATERNARY — QTb
CRETACEOUS — Kg
CRETACEOUS — Kvg, Kvm, Kcg, Kcv, Kcc, Klc
JURASSIC(?) AND CRETACEOUS — KJv
PALEOZOIC — Pzl, Pzs, Pzls

Structure

The pre-Cenozoic rocks of the Candle quadrangle are nearly everywhere highly deformed. Only locally, however, can the folds and faults be mapped at a regional scale owing to the scarcity of exposures and extensive frost riving. Most of the structural features shown on the map have been interpreted from aerial photographs. In the southeastern part of the quadrangle, where the Cretaceous sedimentary rocks are best exposed, the structure is characterized by tight north-trending folds locally overturned to the east. Some synclinal axes can be traced for several miles or more but anticlinal axes generally are faulted out by pervasive north-trending high angle faults. The fold axes are offset by numerous closely spaced northeast- and east-trending faults, only a few of which are shown on the map. In the Buckland and Tagagawik drainages exposures of Cretaceous sedimentary rocks are sparse but the general distribution of map units suggests the presence of several broad east- and northeast-trending flexures. Aeromagnetic data (Zietz and others, 1959) indicate that the northern margin of the Cretaceous sedimentary basin extends east-northeast beneath the cover of Cenozoic volcanic rocks from the West Fork of the Buckland River to the Tagagawik River near lat. 65°50'N

TABLE 1. MINERALOGICAL COMPOSITION (IN PERCENT) OF 8 CRETACEOUS GRAYWACKE SAMPLES FROM THE CENTRAL AND EASTERN PART OF THE CANDLE QUADRANGLE

[Based on modal analyses; counts of 600 points per thin section]

Sample No.	58ATr108	58ATr110	58ATr92	61APa75	58ATr119	61APa22	58APa93	58AHr62
Unit	Kcg	Kcg	Kcv	Kcv	Kcc	Kvg	Kvg	Kvm
Quartz, quartzite	20	15	15	10	7	8	4	7
Chert	<1	<1	2	2	2	<1	3	2
Feldspar	7[1]	13[2]	10[2]	25[1]	28[2]	44[2]	16[2]	26[1]
Volcanic rock fragments	<1	8	10	16	19	9	15	24
Sedimentary rock fragments	---	1	<1	3	<1	<1	1	1
Metamorphic rock fragments (except carbonate and quartzite)	5	8	8	2	3	---	2	1
Granitic rock fragments	---	<1	---	2	2	<1	---	<1
Mica	3	2	4	---	---	---	---	---
Carbonate (including detrital fragments)	51	36	43	4	2	---	---	5
Argillaceous material (<.02mm.)	6	12	5	32	31	30	44	27
Miscellaneous[3]	6	6	4	5	6	9	16[4]	6

[Analyses by T. P. Miller]
[1]Chiefly plagioclase, less than one third potash feldspar
[2]Estimated to be between one third and two thirds potash feldspar
[3]Chiefly detrital ferromagnesium and heavy minerals
[4]Approximately half zeolite

TABLE 2. LEAD-ALPHA AGES OF ZIRCON FROM GRANITIC ROCKS (Kg) AND FROM BOULDERS IN CONGLOMERATE (Kvg)

Sample localities are shown on map as ⊡

Sample No.	Field No.	Lat. and Long.	Unit	α/mg-hr	Pb (ppm)	Age (m.y.)
1	61ARu24	65°27'N 161°13'W	Kg	489	19.7	100±15
2	61ATg40	65°41'N 161°31'W	Kg	707	25.4	90±10
3	61APa58	65°41'N 161°31'W	Kg	750	26.0	90±10
4	61APa59a	65°36'N 160°35'W	Kvg	1341	65.6	120±15
5	61APa59b	65°36'N 160°35'W	Kvg	433	15.0	90±10
6	61APa60	65°24'N 160°39'W	Kvg	533	19.7	90±10

[Alpha-activity measurements by T. W. Stern; spectrographic analyses of lead by Harold Westley and I. H. Barlow, U.S. Geological Survey, 1963]

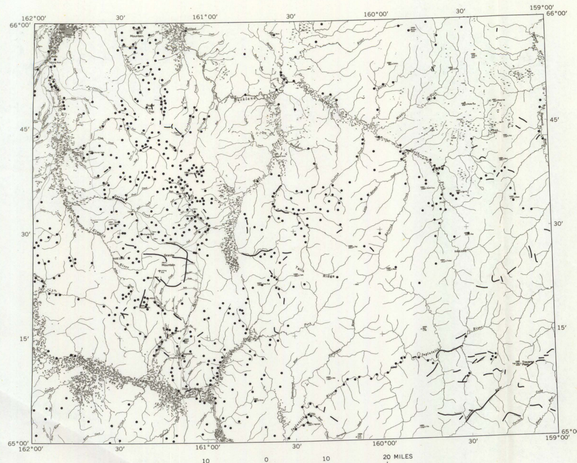
Pb—α ages (rounded to nearest 10 m.y.) were calculated from the equation: $t = \frac{C}{\alpha}Pb$, where t is the calculated age, in millions of years; C is a constant based upon the ratio Th/U, which was assumed to be 1 in the zircon samples dated, and has a value of 2,485; Pb is the lead content, in parts per million, and α is the alpha counts per milligram per hour

TABLE 3. POTASSIUM-ARGON AGE DETERMINATION FOR GRANITIC ROCKS (Kg). FOR BOULDERS IN CONGLOMERATE (Kvg). AND FOR BASALT PORPHYRY FROM ANDESITIC VOLCANIC UNIT (KJv)

Sample localities are shown on map as △

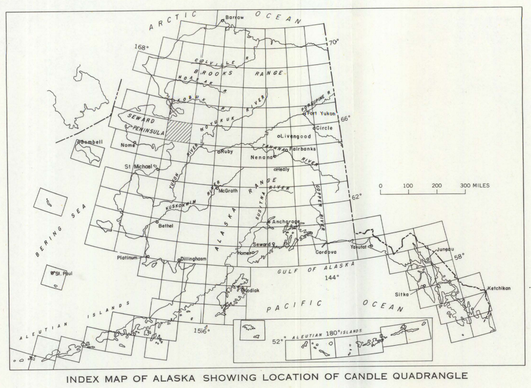
Sample No.	Field No.	Mineral	Lat. and Long.	Unit	K_2O percent	Moles Ar^{40}_{rad}/gm.	Ar^{40}_{rad} (percent)	Age (m.y.)
2[1]	61ATg40	hornblende	65°41'N, 161°31'W	Kg	1.54	2.38441×10^{-10}	94	102±5
7[1]	61APa59	biotite	65°36'N 160°35'W	Kvg	5.30	8.80704×10^{-10}	95	110±5
8[2]	58ATb129	hornblende	65°30'N 160°45'W	KJv	0.733	1.41423×10^{-10}	86	120±3

[1] H. H. Thomas, R. F. Marvin, Paul Elmore, analysts, U.S. Geological Survey, 1963, 1964
[2] M. A. Lanphere, analyst, U.S. Geological Survey, 1966
Constants: $K^{40}\ \lambda_\epsilon = 0.585\times10^{-10}$/yr; $\lambda_\beta = 4.72\times10^{-10}$/yr; K^{40}/K total $= 1.19\times10^{-4}$ mole/mole



MAP OF CANDLE QUADRANGLE SHOWING LOCATION OF FIELD OBSERVATION POINTS AND CONTINUOUS FOOT TRAVERSES

Geology extended between field stations by aerial reconnaissance and by interpretation of aerial photographs



INDEX MAP OF ALASKA SHOWING LOCATION OF CANDLE QUADRANGLE

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REGIONAL GEOLOGIC MAP OF THE CANDLE QUADRANGLE, ALASKA

By
William W. Patton, Jr.
1967

For sale by U.S. Geological Survey, price $1.00