UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

RECONNAISSANCE GEOLOGIC INVESTIGATIONS IN THE TALKEETNA MOUNTAINS, ALASKA

By

Béla Csejtey, Jr.

74-147
Open-file report

1974

This report is preliminary
and has not been edited or
reviewed for conformity with
Geological Survey standards
and nomenclature

CONTENTS

CONTENTS--continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

In 1972 the U.S. Geological Survey started a long-range program of reconnaissance geologic mapping and geochemical sampling in the geologically little-known Talkeetna Mountains of south-central Alaska. As the initial phase of the program, three separate areas--a few tens of km^2 each--have been mapped and sampled in some detail in the western and central Talkeetnas, all within the Talkeetna Mountains 1:250,000 quadrangle (fig. 1). The present report stresses preliminary geologic descriptions of the three areas. In addition, the report incorporates information on the Talkeetna Mountains batholithic complex and inferences on the tectonic significance of the late Paleozoic rocks in the region.

Geographically, the roughly circular-shaped Talkeetna Mountains are located between the central Alaska Range to the north and the Chugach Mountains to the south. They underlie the Talkeetna Mountains 1:250,000 topographic quadrangle, as well as parts of the Healy 1:250,000 quadrangle to the north and the Anchorage 1:250,000 quadrangle to the south. The central part of the Talkeetna Mountains is extremely rugged and heavily glaciated and contains high peaks between 1,800 and 2,700 m (approximately 6,000 and 9,000 ft) in altitude. The remainder of the talkeetnas form broad rolling uplands with deeply incised river valleys. Most of the upland areas are above timberline, which is approximately at 900 m (about 3,000 ft). No roads or trails lead into the Talkeetnas, and landing areas for small fixed-wing aircraft are sparse. The western flank of the Talkeetna Mountains falls within the Anchorage-Fairbanks developmental zone connecting the two major population centers of Alaska.

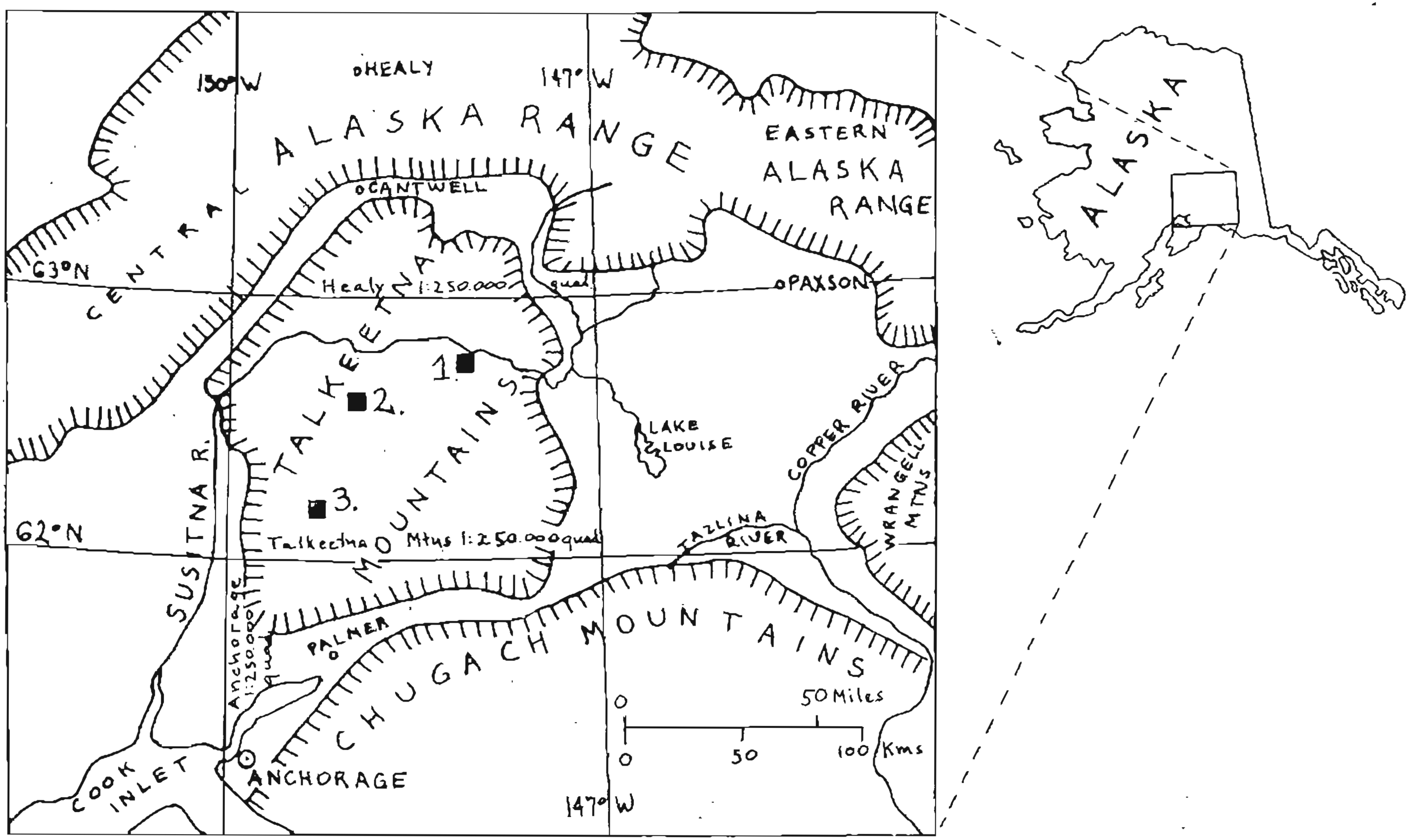
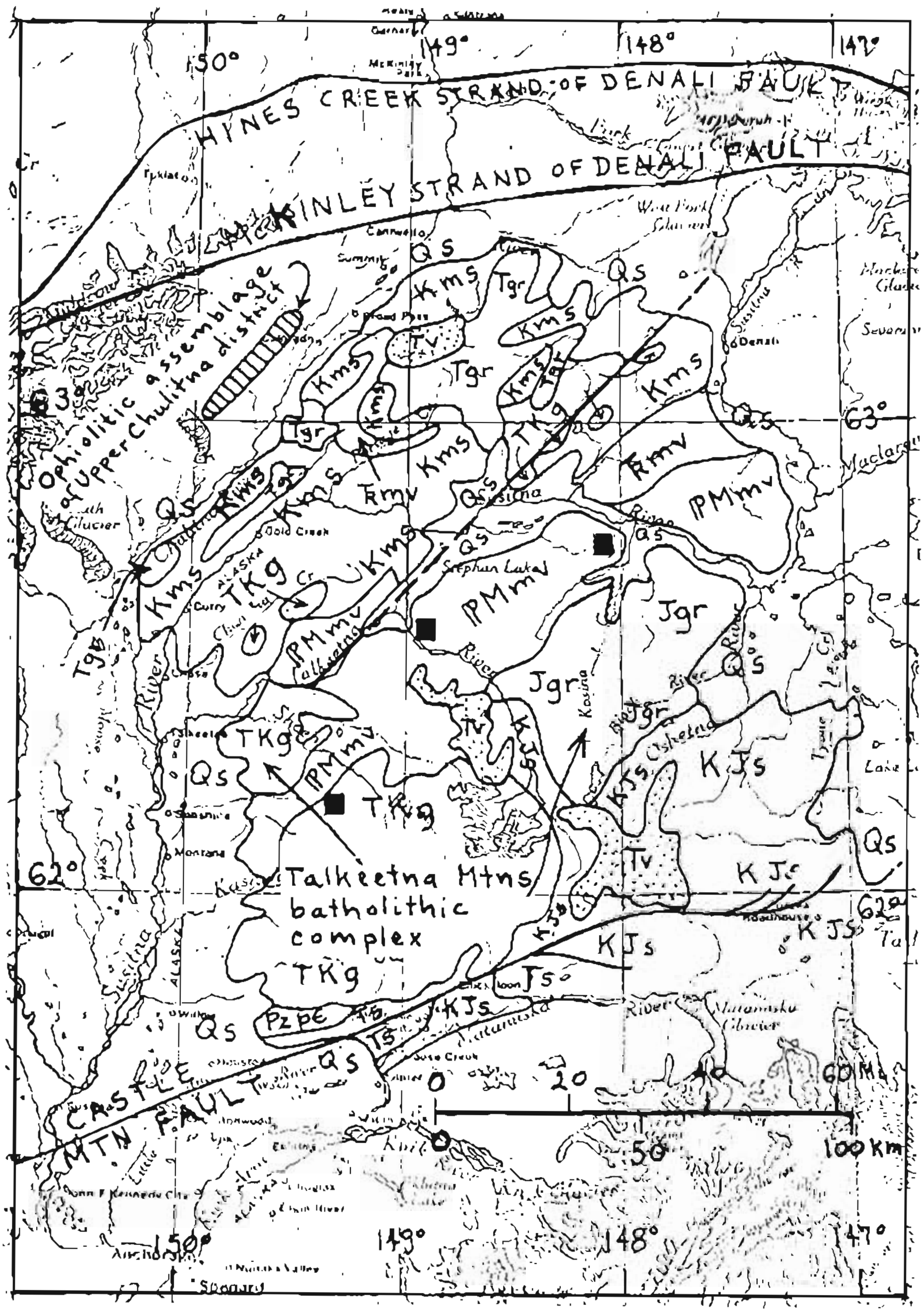


Figure 1.—Index map showing location of the three geologically mapped areas in the Talkeetna Mountains, Alaska.
1.-Watana Lake area.
2.-Area in the Talkeetna Mountains C-4 quadrangle
3.-Area in the Talkeetna Mountains A-5 quadrangle.

All of the Talkeetna Mountains are covered by modern topographic maps at 1:63,360 scale and by good aerial photographs flown by the U.S. Air Force. In addition, ERTS-1 (Earth Resources Technology Satellite) multispectral imagery at various scales is also available.

GEOLOGIC SETTING OF TALKEETNA MOUNTAINS

The Talkeetna Mountains are part of a geologically critical area of juncture between the Aleutian volcanic island arc system and continental crust. In addition, the Talkeetnas are bracketed by two major, currently active fault systems: the Denali Fault on the north and the Castle Mountain Fault on the south. On the basis of reconnaissance information available so far, the backbone of the Talkeetnas appears to be a northeast-trending batholithic complex, ranging in age from Jurassic to Late Cretaceous-early Tertiary (fig. 2). Bedrock north of the batholithic complex chiefly consists of late Paleozoic andesitic metavolcanic rocks, the remnants of an island arc system, and less abundant late Mesozoic metagraywacke. South of the batholith the bedrock is dominantly Mesozoic sedimentary and volcanic rocks, possibly successor basin deposits. The structural grain of the Talkeetnas appears to trend northeast.



Geology modified after Capps, 1940; Clark and others, 1972; Grantz, 1960a, 1960b, 1961a, 1961b; Beikman, written commun.

Figure 2.—Generalized geologic map of the Talkeetna Mountains, Alaska

EXPLANATION

Sedimentary and volcanic rocks

Qs — Surficial deposits — QUATERNARY

Tv — Subaerial volcanic rocks, chiefly andesitic — TERTIARY

Ts — Clastic sedimentary rocks — TERTIARY

Kms — Metagraywacke and slate — CRETACEOUS(?)

KJs — Sedimentary and volcanic rocks, undifferentiated — JURASSIC AND CRETACEOUS

R̄mv — Metabasalt flows and tuff — TRIASSIC (?)

PMmv — Andesitic to basaltic metavolcanic and metavolcaniclastic rocks. Includes some marble interbeds, and Triassic(?) diabase sills — MISSISSIPPIAN TO PERMIAN

Pzp€ — Mica schist with altered ultramafic bodies — PRECAMBRIAN(?) TO LATE PALEOZOIC

Plutonic rocks

Tgr — Granodiorite and granite — TERTIARY

TKg — Tonalite, quartz diorite, granodiorite — LATE CRETACEOUS — EARLY TERTIARY

Jgr — Granodiorite and tonalite — JURASSIC

Fault, approximately located; dashed where concealed

■ Location of areas mapped for present report

Figure 2.—Generalized geologic map of the Talkeetna Mountains, Alaska—Continued

PREVIOUS WORK

An up-to-date comprehensive geologic report on the Talkeetna Mountains is still lacking. The most complete report (Capps, 1940) summarizes results of early exploratory surveys and includes a 1:250,000-scale geologic map of part of the Talkeetnas. Later reports include several geologic maps at 1:48,000 scales (Grantz, 1960a, 1960b, 1961a, 1961b), and a report on granitic rocks of the southeastern Talkeetna Mountains (Grantz and others, 1963). A geologic map, and a discussion of the Willow Creek mining district, constitute the latest available information for the southern Talkeetnas (Barnes, 1962; Ray, 1954). Several later reports describe the geology and geochemistry of five small areas in the central and northern Talkeetna Mountains (Anderson, 1969a, 1969b; Rose, 1965, 1967; Richter, 1963; Kaufman, 1964; Hawley and others, 1968). Maps showing the known metallic mineral resources of the Talkeetnas have been recently compiled by Cobb (1972a, 1972b), and by Clark and Cobb (1972). Aeromagnetic survey maps at scale 1:63,360 have been recently published by the Alaska Division of Geological and Geophysical Surveys for all but a small northwestern portion of the Talkeetna Mountains. An unpublished reconnaissance geologic map of southern Alaska, including the Talkeetna Mountains, has been compiled recently at 1:1,000,000 scale by Beikman.

GEOLOGY OF THE WATANA LAKE AREA

The area mapped near Watana Lake (fig. 3) comprises approximately 65 km^2 (about 25 mi^2) in the Talkeetna Mountains C-2, C-3. D-2, and D-3 quadrangles. Bedrock consists of a several-thousand-meters-thick, dominantly marine sequence of basaltic and andesitic metavolcanic and metavolcaniclastic rocks with subordinate intercalated beds of black phyllite, fossiliferous cherty marble, and several metadiabase sill-like intrusive bodies. All these rocks have been recrystallized into mineral assemblages of the low-grade portion of the greenschist metamorphic facies of Turner (1968). Poorly preserved crinoid columnals, corals(?), and bryozoans from the cherty marble beds in the middle part of the sequence strongly suggest a late Paleozoic age. However, rocks near the top of the metavolcanic and metavolcaniclastic sequence could possibly be as young as early Mesozoic. On the basis of correlation with similar rocks in the eastern Alaska Range (Richter and Jones, 1973), the metadiabase intrusives are assumed to be early Mesozoic, probably Triassic in age. The age of the greenschist regional metamorphism has been determined by Smith and Turner (1973) in the central Alaska Range to be late Mesozoic. Significant parts of the mapped area are underlain by Quarternary glacial and alluvial deposits.

Metavolcanic and metavolcaniclastic sequence

The metavolcanic and metavolcaniclastic sequence forms an apparently homoclinal succession that dips moderately southward. Its thickness can not be determined accurately because both its base and top are unexposed. The unit's maximum exposed thickness is ~~1,900~~ 5,000 m (about 16,000 ft) in a section that may have partly repeated by faulting.

Exposures of the metavolcanic and metavolcaniclastic sequence range from poor in the topographically low areas to moderately good in the glacially dissected mountains just west of Watana Lake. Outcrops of the metavolcanic and metavolcaniclastic rocks, forming the bulk of the sequence, are characteristically greenish gray.

Rocks of the sequence have been tentatively subdivided into six informal units (fig. 3) with conformable contacts. In order of succession, these units are discussed below.

Basal metavolcaniclastic unit (Pza)

This poorly exposed unit consists of medium- to fine-grained metavolcaniclastic rocks with subordinate intercalated meta-flows of basaltic-andesitic composition and a few interbeds of dark gray phyllite. The base of the unit was not observed; the minimal thickness of the unit appears to be as much as 2,000 m (approximately 6,500 ft). Compositional stratification of the unit is crude; individual layers range in thickness from a few tens to a few hundreds of meters. Much of the unit is pervasively sheared.

Thin section studies show the metavolcaniclastic rocks to be poorly sorted. Slightly metamorphosed clasts of rounded rock fragments and angular crystal fragments as much as 5 mm in diameter, constituting between 20 to 50 percent of the rock by volume, are randomly distributed in a finer grained but thoroughly recrystallized and foliated matrix. Rock clasts consist of fine-grained basalt, andesite, and mudstone; crystal clasts are made up of oligoclase-andesine, hornblende, and subordinate quartz. The larger the clasts, the less metamorphic effects they display. The matrix consists of porphyroblastic textured aggregates of albite, pale green actinolite, chlorite with anomalous blue interference colors, lesser epidote, sericite, calcite, opaques, and some quartz. The original clastic texture is still discernible despite the metamorphic overprint. The results of a chemically analyzed representative sample are given in table 1.

The basaltic-andesitic meta-flows contain sparse relict phenocrysts of cloudy plagioclase in a fine-grained, recrystallized groundmass of chlorite, epidote, albite, sericite, opaques, and some quartz. A chemical analysis of a variolitic textured basaltic flow sample is given in table 1.

The interbedded phyllites are dark gray and fine grained with well-developed slaty cleavage. Thin sections show them to consist of white mica (probably muscovite), chlorite, quartz, calcite, possibly actinolite, and lesser graphite, epidote, and microcline.

Fossiliferous marble unit (Pzb)

The marble unit is approximately 180 m (about 600 ft) thick, and it is made up of thick-bedded to massive, coarse- to medium-grained, medium bluish gray to white marble with subordinate black nodular chert, and a few thin interbeds of black phyllite.

Thin sections indicate the marbles to consist dominantly of calcite with minor amounts of dolomite, white mica, and some quartz. The degree of recrystallization, that is the grain size of the marbles varies. Pockets of medium-grained (between 1 and 2 mm) marble, containing still recognizable bioclasts, such as abundant fossil crinoid columnals and shell fragments, occur irregularly within coarse grained rocks. Apparently

Table 1 - Chemical data of representative bedrock samples, Watana Lake area, Talkeetna Mountains, Alaska

Chemical analyses
[Results in weight percent]

Map unit / Rock type	Pzm - unit		Pzd unit	Pzf - unit			Mzdb		
	Metavolcaniclastic rock	Metabasalt	Metatuff	Metavolcanic rocks			Metadiabase		
	1.	2.	3.	4.	5.	6	7.	8.	9.
SiO_2	67.1	46.8	51.2	49.8	50.3	51.1	49.7	50.5	51.4
Al_2O_3	13.5	16.5	15.8	13.5	14.3	13.0	16.1	15.7	15.5
Fe_2O_3	.50	2.4	3.6	5.9	5.3	4.0	3.1	1.5	2.2
FeO	5.1	8.3	6.6	7.8	6.4	7.6	7.2	6.1	7.8
MgO	3.0	7.8	6.6	5.8	5.9	6.2	5.8	7.6	6.5
CaO	1.9	9.2	10.3	9.0	8.5	10.1	10.6	13.2	9.2
Na_2O	3.6	2.6	2.6	3.3	4.9	3.5	2.4	1.4	3.1
K_2O	.73	.10	.11	.70	.17	.79	.75	.18	.78
H_2O +	2.5	4.7	2.6	2.0	2.2	2.3	2.3	2.3	2.6
H_2O -	.14	.69	.49	.18	.32	.30	0.28	.19	.20
TiO_2	.77	.49	.59	2.0	1.9	1.9	1.5	.39	.72
P_2O_5	.22	.21	.15	.27	.20	.20	.18	.07	.24
MnO	.12	.16	.14	.19	.16	.17	.17	.14	.15
CO_2	.08	.14	.04	.04	.01	.04	.07	.03	.08
SUM	100	100	101	100	100	101	100	99	100

Samples:

1.— 72ACy-47 [Locations of samples are shown in fig.3]
2.— 72ACy-5
3.— 72ACy-36
4.— 72ACy-32
5.— 72ACy-40
6.— 72ACy-44
7.— 72ACy-12a
8.— 72ACy-17
9.— 72ACy-23

Table 1.—Chemical data of representative bedrock samples, Watana Lake area, Talkeetna Mountains, Alaska—Continued

Semiquantitative spectrographic analyses
[Results in parts per million]

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Ba	300	70	70	150	50	50	200	150	300
Co	10	50	30	50	30	30	30	50	30
Cr	30	500	500	100	200	150	150	500	100
Cu	70	150	150	200	150	200	200	150	100
Nb	N	N	N	10	N	10	N	N	N
Ni	20	300	150	100	150	200	150	150	50
Sc	20	50	70	50	50	50	30	70	50
Sr	200	300	150	500	150	200	300	70	500
V	150	300	200	500	300	300	300	200	200
Y	15	10	15	30	30	30	20	10	20
Zr	70	N	20	100	100	100	50	N	50
Ga	10	15	10	15	15	15	7	7	15
Yb	2	1.5	2	3	3	2	1.5	1.5	2

[Rapid rock chemical analyses by Herbert Kirschenbaum and Leonard Shapiro. Semiquantitative six-step spectrographic analyses by Chris Heropoulos; results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12 ... but are reported arbitrarily as mid points of these brackets, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1...; the precision of a reported value is approximately plus or minus one bracket at 68-percent confidence or two brackets at 95-percent confidence. N, not dected at limit of delection.]

the marble beds were derived from bioclastic limestone. The black phyllite interbeds consist of fine-grained aggregates of white mica, quartz, chlorite, and carbonaceous material.

One of the medium-grained marble pockets (locality marked on fig. 3) yielded a poorly preserved fossil fauna of disarticulated crinoid columnals, bryozoans, brachiopod shell fragments, and a few pieces of corals(?). The crinoid columnals are by far the most abundant, and they all have circular outlines with maximum diameters of 16 mm (0.6 in). None of the fossils could be identified in more detail because of their fragmental nature and poor preservation. According to A. K. Armstrong (personal communication, 1974), the fauna strongly suggests a late Paleozoic (Mississippian to Permian) age as faunas of very similar fossils and occurring in rocks of similar stratigraphic positions have been determined to be of late Paleozoic age in the Wrangell Mountains (Smith and MacKevett, 1970) and in the eastern Alaska Range (Richter and Jones, 1973).

Phyllite unit (Pzc)

This unit consists of dark gray to black, fine-grained, massive phyllite with prominent slaty cleavage. Its total thickness is about 900 m (approximately 3,000 ft), but more than half of the unit is made up of interspersed sills of the early Mesozoic metadiabase (see later). Thin sections show the phyllites to consist of very fine grained granoblastic aggregates of white mica (probably muscovite), quartz, chlorite, carbonaceous material (probably graphite), and subordinate actinolite and epidote.

Metatuff unit (Pzd)

This unit, approximately 500 m (roughly 1,650 ft) thick, consists of fine- to medium-grained metatuff of andesitic-basaltic composition. No stratification was observed in the unit.

Thin sections indicate the rock is a crystal metatuff. Angular and relict crystals of twinned oligoclase-andesine and clinopyroxene are set in a pervasively sheared and recrystallized matrix of zoisite, albite, fibrous actinolite, chlorite, opaques, and some sericite. A chemical analysis of a typical metatuff is given in table 1.

Coarse metavolcaniclastic unit (Pze)

The unit is approximately 300 m (about 1,000 ft) thick. It consists of massive metavolcaniclastic rock with rounded clasts of fine-grained volcanics, as much as 8 cm (about 3 in) in diameter, in a fine- to medium-grained recrystallized matrix. The volcanic clasts constitute more than half of the rock by volume, and in thin section they appear to be andesitic to basaltic in composition. Relict plagioclase laths and microlites in some of the better preserved volcanic clasts indicate trachytic or intergranular textures. The recrystallized matrix contains occasional relict fragments of sericitized oligoclase-andesine and chloritized hornblende, as well as echinoid needle remains now consisting of clinozoisite. The whole rock has been intensively metamorphosed into an assemblage of clinozoisite, chlorite, sericite, fibrous tremolite-actinolite, albite, possibly some talc, and minor strained quartz.

Metavolcanic unit (Pzf)

Only the base of this unit is located within the mapped area, its minimum thickness is calculated to be 1,200 m (about 3,900 ft). The unit is poorly exposed and it consists of massive, fine- to medium-grained metabasalt flows, some of which may be transitional to andesite in composition. The thickness of individual flows could not be determined in the field. Thin sections of these flows consist of sparse, anhedral crystals of relict andesine-labradorite and hornblende in a metamorphic aggregate of epidote, chlorite, actinolite, albite, sericite, opaques, and minor quartz. Relict textures are dominantly intergranular and subophitic and in some flows trachytic. Chemical analyses of three typical samples are shown in table 1.

Origin, age, and correlation

The metavolcanic and metavolcaniclastic sequence is interpreted to have deposited dominantly, if not exclusively, in a submarine environment at moderate to shallow depths. This is suggested by the interbedded fossiliferous marble beds, by the echinoid needles, and by the overall lithologic character of the sequence. The thick compositional layering of the volcaniclastic rocks suggests a fairly rapid rate of deposition. Most constituents of these rocks probably were derived from nearby volcanic centers. The fossiliferous marble beds probably signify deposition of calcareous bioclastic material by high-energy currents on shallow banks of limited areal extent.

On the basis of fossil remains in the marble unit, the metavolcanic and metavolcaniclastic sequence is interpreted to be of late Paleozoic, probably Permian in age, but its basal parts may be Pennsylvanian. In contrast, it is also possible that the uppermost portion of the sequence is slightly younger, that is Triassic in age.

Rocks similar in age and lithologic composition to the sequence near Watana Lake have been described from the eastern Alaska Range by Richter and Jones (1970, 1973) and from the west-central Alaska Range by Clark and others (1972).

In the eastern Alaska Range, the correlative rocks consist of a several-thousand-meter-thick heterogeneous series of Pennsylvanian to Permian andesitic volcanic and volcaniclastic rocks and lesser marine clastic beds and limestones. Richter and Jones (1970, 1973) interpret these rocks as remnants of a late Paleozoic volcanic island arc which were subsequently added to the North American plate.

From the Upper Chulitna district of the west-central Alaska Range, Clark and others (1972) report a Permian(?) ophiolitic assemblage of intermixed serpentinite, gabbro, basalt, and bedded chert (fig. 2). The ophiolitic assemblage is overlain by an approximately 350 m (about 1,000 ft) thick volcaniclastic sequence with a few limestone interbeds ranging in age from Permian to Early Triassic. Clark and his coworkers interpret the ophiolitic sequence as Permian(?) oceanic crust, and the overlying Permian and Triassic volcaniclastic rocks as derivatives of a volcanic island arc built directly on oceanic crust.

Metadiabase (Mzdb)

The metadiabase is a medium to dark greenish-gray, medium- to fine-grained, structureless rock which forms sill-like intrusive bodies as much as 100 m (about 330 ft) thick in the metavolcanic and metavolcaniclastic sequence, especially in the dark phyllite unit (Pzc). Fine-grained border phases, a few meters thick, occur at every contact. Thin sections show the metadiabase to consist of anhedral and partly decomposed relict minerals, constituting as much as one-third of the rock by volume, scattered in a granoblastic aggregate of metamorphic minerals. Relict minerals consist of twinned and progressively zoned labradorite (An65 core to a rim of An35), augite, magnetite, and some interstitial quartz; the metamorphic minerals are chlorite, epidote, sericite, actinolite, and minor albite. Relict textures range from subophitic to intergranular. The metamorphic minerals indicate the metadiabase underwent the same degree of metamorphism as the enveloping country rocks. Chemical analyses of three representative samples are shown in table 1.

As mentioned previously, the age of the metadiabase sills is assumed to be early Mesozoic, probably Triassic, on the basis of correlation with gabbro intrusives in the eastern Alaska Range (Richter and Jones, 1973).

GEOLOGY OF A PART OF THE TALKEETNA MOUNTAINS C-4 QUADRANGLE

The geologically mapped area in the Talkeetna Mountains C-4 quadrangle underlies approximately 36 km^2 (about 14 mi^2) in the southwest part of the quadrangle just north of the Talkeetna River (fig. 4). Topographically, the area is a rolling upland dissected by deep glacial valleys. Exposures are fair to good except in the deep valleys which are mantled by surficial deposits and are heavily timbered.

Bedrock of the mapped area consists of a several-thousand-meter-thick sequence of andesitic to basaltic metavolcanic and metavolcaniclastic rocks with subordinate marble and dark-gray phyllite interbeds, several sill-like bodies and plugs of metadiabase, a small quartz diorite stock, a sequence of dacite porphyry flows, and of two small patches of pyroxene andesite flows. Alluvium and glacial deposits constitute the Quaternary surficial deposits.

On the basis of lithologic correlations with identical rocks in the Watana Lake area, about 48 km (about 30 mi) to the northeast, the metavolcanic and metavolcaniclastic sequence is interpreted to be of late Paleozoic age, and the metadiabase of Triassic age. The origin and regional correlations of these rocks have already been discussed in the Watana Lake area section and will not be repeated here. The quartz diorite is probably a satellite of the Late Cretaceous-early Tertiary batholithic mass in the southern and central Talkeetna Mountains (see later). The dacite porphyry and pyroxene andesite both are interpreted to be Tertiary in age, the andesite being the younger of the two, as similar Tertiary volcanic rocks occur in various parts of the Talkeetna Mountains (Chapin, 1918; Capps, 1940).

Rocks of the metavolcanic and metavolcaniclastic sequence and the metadiabase intrusives have been metamorphosed into mineral assemblages of the low-grade portion of the greenschist facies of Turner (1968). In contrast, the quartz diorite, dacite porphyry, and pyroxene andesite have not been affected by the regional metamorphism which, in the central Alaska Range, was determined by Smith and Turner (1973) to be of late Mesozoic age.

Several normal faults of unknown displacement are marked by linear features on aerial photos. These faults cut rocks as young as the pyroxene andesite and they probably represent a late Tertiary or possibly younger period of deformation.

The only indications of mineral deposits in the area are a few pyrite-bearing veinlets.

In the following section, each rock type of the mapped area will be briefly described.

Metavolcanic and metavolcaniclastic sequence

The metavolcanic and metavolcaniclastic sequence is fairly well exposed in small, characteristically greenish-gray cliffs. Rocks of the sequence are massive and crudely layered, thus the structure and thickness of the sequence are not known with certainty. Based on the attitude of one marble interbed, the sequence appears to be a southeastward dipping monocline with a minimal thickness of several thousand meters, as neither the base nor the top are exposed. In the field the metavolcanic and metavolcaniclastic sequence has been informally subdivided into a basal metavolcanic unit (Pza) with a marble interbed (Pzm), and an overlying metavolcaniclastic unit (Pzb) (fig. 4).

Metavolcanic unit (Pza)

Crudely layered and massive andesitic to basaltic metatuffs and metaflows make up this unit. Individual layers appear to be as much as 100 m thick.

Thin section studies indicate rocks of the unit have been metamorphosed into fine-grained, moderately schistose assemblages of epidote, chlorite, actinolite, albite, lesser quartz, clinozoisite, and some magnetite. Original textural features have been largely obliterated, only in a few thin sections were outlines of clastic plagioclase crystals or remnant porphyritic-trachytic textures observed. Chemical analysis of a basaltic sample is shown in table 2.

Marble interbed (Pzm)

The marble interbed is approximately 100 m (about 330 ft) thick and consists of massive, coarsely crystalline, medium-gray marble with a few thin beds of dark-gray phyllite. No fossils were found in the unit. One thin section of the marble showed no other minerals but calcite, and all primary textural features have been obscured.

Metavolcaniclastic unit (Pzb)

The unit is made up by coarse volcaniclastic rocks and by subordinate dark-gray phyllite in a few interbeds as much as 5 m (about 16 ft) thick.

Lithologically, all of the metavolcaniclastic rocks are very similar. They are massive and greenish gray and contain subangular to subrounded lithic fragments as much as 10 cm (about 4 in) in maximum dimension in a finer grained, poorly sorted matrix. The lithic clasts constitute more than half of the rock by volume, and thin sections indicate that they consist of fine-grained volcanic rocks, probably andesite, and subordinate siltstone and mudstone. Relict constituents of the finer grained matrix include small lithic fragments, angular grains of quartz, twinned plagioclase (probably andesine), hornblende, and minor opaques. The bulk of the matrix has been metamorphosed into moderately schistose granoblastic aggregates of chlorite, epidote, albite, actinolite, lesser quartz, and calcite.

The subordinate dark-gray phyllites contain fine-grained and schistose aggregates of white mica, chlorite, quartz, albite, and finely disseminated carbonaceous material, probably graphite.

Metadiabase (Mzdb)

The metadiabase is a dark greenish-gray medium- to coarse-grained, massive rock which forms small irregular stocks or large sill-like bodies, possibly as much as 500 m (about 1,700 ft) thick, within the metavolcanic and metavolcaniclastic sequence. Chilled border phases were observed at every exposed contact. Thin section studies indicate the metadiabase to consist of anhedral relict and granoblastic metamorphic minerals. The relict minerals are twinned and zoned labradorite (An60 to An40), augite, magnetite, apatite, whereas the metamorphic minerals are chlorite, actinolite, white mica, calcite, minor epidote, and albite. Recognizable relict textures range from intergranular and subophitic to ophitic in some of the coarse-grained samples. The chemical analyses of three representative samples are shown in table 2.

Quartz diorite (TKqd)

The quartz diorite is a medium-gray, medium- to fine-grained, granitic textured structureless rock which forms a small epizonal intrusive stock of approximately 1 km^2 (about 0.3 mi^2) in area. The stock has a border phase of fine-grained quartz diorite and is in discordant contact with the metavolcanic country rocks. Three thin sections and one modal count of the quartz diorite indicate the rock-forming minerals and their volume percentages to be plagioclase--63.5%, quartz--12.0%, hornblende--15.2%, biotite--6.8%, and interstitial K-feldspar--1.0%. Magnetite, apatite, sphene, and zircon constitute the accessory minerals—1.5% in volume. The plagioclase is twinned and strongly zoned from An60 cores to An25 rims and has the mean composition of andesine.

Table 2.—Chemical data of representative bedrock samples from a part of the Talkeetna Mountains C-4 quadrangle, Talkeetna Mountains, Alaska

Chemical analyses.
[Results in weight percent]

Map unit	Pza	Mzdb			TKqd		Tdp		Tpa	
Rock type	Metabasalt	Metadiabase			Quartz diorite		Dacite porphyry		Pyroxene andesite	
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
SiO_2	50.5	52.0	45.9	50.0	56.3	56.2	70.7	68.2	60.3	52.0
Al_2O_3	18.0	14.8	14.8	13.6	22.7	17.8	14.2	15.1	17.2	16.5
Fe_2O_3	5.6	2.8	2.6	3.6	1.9	3.4	3.0	2.7	2.2	3.8
FeO	5.8	7.2	10.4	9.7	1.3	4.7	1.9	.36	4.2	5.8
MgO	4.4	6.0	6.2	5.9	1.0	3.7	1.4	3.4	3.0	4.0
CaO	12.5	12.1	5.5	9.8	9.4	6.8	3.8	2.8	5.6	7.8
Na_2O	1.1	2.7	2.5	3.1	3.6	3.2	4.2	3.2	3.4	3.2
K_2O	.07	.17	.20	.57	.27	.90	.12	2.6	1.4	.80
H_2O +	.90	1.7	5.0	2.2	1.0	1.0	1.2	1.2	.48	1.7
H_2O −	.20	.28	.81	.20	.38	.27	.08	1.0	.52	1.2
TiO_2	.54	1.5	2.1	2.2	.44	.91	.40	.52	.82	1.4
P_2O_5	.08	.16	.09	.26	.10	.23	.16	.17	.08	.25
MnO	.25	.16	.12	.19	.03	.12	.13	.02	.11	.11
CO_2	.07	.07	2.9	.08	.09	.09	.03	.02	.08	.08
SUM	100	101	99	101	99	99	101	101	99	99

Samples:

1. — 72ACy-73
2. — 72ACy-63b
3. — 72ACy-68a
4. — 72ACy-77
5. — 72ACy-74
6. — 72ACy-76
7. — 72ACy-63a
8. — 72ACy-87
9. — 72ACy-83
10. — 72ACy-85

[Locations of samples are shown on fig. 4.]

Table 2. - Chemical data of representative bedrock samples from a part of the Talkeetna Mountains C-4 quadrangle, Talkeetna Mountains, Alaska — Continued

Semiquantitative spectrographic analyses

[Results in parts per million]

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Ba	20	50	100	100	200	500	30	700	500	300
Be	N	N	N	N	N	N	N	1.5	N	N
Co	30	30	50	50	7	15	3	3	20	30
Cr	30	100	200	20	N	30	2	10	30	50
Cu	300	150	100	200	1.5	70	7	15	50	100
Nb	N	7	7	10	N	N	N	7	N	7
Ni	30	150	150	100	N	3	N	5	30	100
Pb	N	N	N	N	N	N	N	15	10	N
Sc	70	50	50	50	10	20	20	10	20	30
Sr	700	300	200	300	700	700	100	200	300	500
V	300	300	300	500	30	200	30	50	100	150
Y	10	20	20	30	20	20	30	10	20	30
Zr	N	70	50	100	30	70	50	150	70	100
Ga	15	15	10	20	15	20	10	15	15	15
Yb	1.5	2	2	3	1	2	3	1.5	1.5	3

[Rapid rock chemical analyses by Herbert Kirschenbaum and Leonard Shapiro. Semiquantitative six-step spectrographic analyses by Chris Heropoulos; results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12 ... but are reported arbitrarily as midpoints of these brackets, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1 ...; the precision of a reported value is approximately plus or minus one bracket at 68-percent confidence or two brackets at 95-percent confidence. N, not detected at limit of detection.]

Minor amounts of chlorite and sericite constitute the deuteric alteration products. The chemical analyses of two quartz diorite samples are given in table 2.

Dacite porphyry (Tdp)

This unit comprises a sequence of subaerial flows of dacite porphyry with a minimal aggregate thickness of several hundred meters. As the dacite porphyry flows are massive and structureless, thicknesses of individual flows are imperfectly known but they probably are on the order of several tens of meters.

In hand specimen the dacite porphyry is tan and has a porphyritic texture with corroded phenocrysts of plagioclase, quartz, and altered hornblende as much as 7 mm in maximum dimension, evenly distributed in a fine-grained holocrystalline matrix. Thin sections show that the plagioclase phenocrysts are subhedral to anhedral, twinned, slightly sericitized, and are normally zoned from calcic andesine to sodic oligoclase. The quartz phenocrysts have rounded and resorbed habits. The hornblende phenocrysts have been partly replaced by magnetite, possibly hematite, and some chlorite. The very fine grained matrix consists of quartz, plagioclase, and some K-feldspar. Chemical analyses of two dacite porphyry samples are given in table 2.

Pyroxene andesite (Tpa)

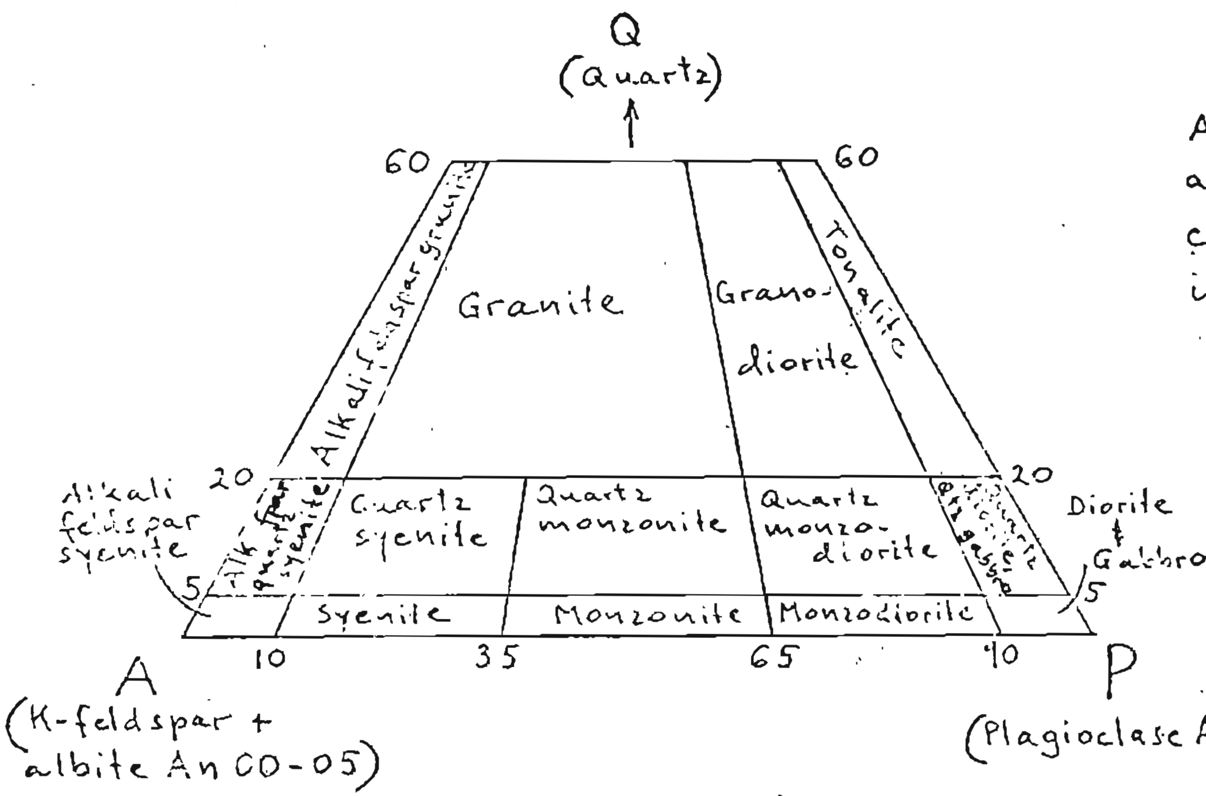
The pyroxene andesite occurs in two small patches, the erosional remnants of a formerly more extensive sequence of subaerial flows. Both exposures comprise several superimposed flows with individual thicknesses of 10 to 15 m (about 33 to 50 ft).

In hand specimen the andesite is dark gray to black and aphanitic with sparse plagioclase phenocrysts as much as 5 mm long (about 0.2 in.). The rock fractures conchoidally. Thin section studies show the plagioclase phenocrysts to be anhedral to subhedral, twinned, zoned from An55 to about An40 with an average composition of calcic andesine. The matrix consists of fine-grained crystals of elongated calcic andesine, rounded augite, magnetite, minor anhedral quartz, and abundant dark brown to black interstitial glass. Subordinate alteration products comprise chlorite, limonite, and clays. The texture is trachytic. Chemical analyses of two pyroxene andesite samples are shown in table 2.

GEOLOGY OF A PART OF THE TALKEETNA MOUNTAINS A-5 QUADRANGLE

The area mapped in the Talkeetna Mountains A-5 quadrangle underlies approximately 29 km^2 (about 19 mi^2) in the central portion of the quadrangle (fig. 5). Its topography is typically alpine and characterized by serrate ridges and glacially carved valleys; local relief is as much as 800 m (about 2,600 ft). Because the area is above timberline, exposures are generally good.

The mapped area lies athwart the border zone of a large batholithic complex; bedrock consists of plutonic rocks and their associated late-stage rocks and, to lesser extents, a sequence of mafic metavolcanics and interbedded marble. The plutonic rocks form the western portion of the informally named Talkeetna Mountains batholithic complex. They consist dominantly of quartz diorite and tonalite (see fig. 6 for plutonic rock nomenclatures), are of Early Tertiary age, and represent two epizonal to mesozonal intrusive members of the same plutonic period. A more detailed description of the Talkeetna Mountains batholithic complex



Alaskite: a granitic rock with a color index of less than 5, commonly with an irregular texture.

Figure 6. - Plutonic rock nomenclature used in this report.

will be given in a subsequent section. The mafic, that is, andesitic to basaltic, metavolcanic rocks and interbedded marble had been regionally metamorphosed into apparent greenschist assemblages and subsequently were contact metamorphosed into assemblages as high as the hornblende hornfels facies (Turner, 1968). The width of the contact metamorphosed zone is at least 1.5 km (almost 1 mi). These rocks are correlated with the metavolcanic and metavolcaniclastic sequences in the Watana Lake area and in the C-4 quadrangle, and thus are interpreted to be of late Paleozoic age. (The origin and regional correlation of these volcanogenic sequences has been discussed in the section on the Watana Lake area.) The correlation further suggests that the greenschist regional metamorphism took place in late Mesozoic time.

Mineralization within the mapped area comprises scattered malachite-bearing veinlets and locally derived float of hydrothermal quartz containing appreciable amounts of copper, silver, and gold.

Plutonic rocks

Geologic setting

The plutonic rocks of the mapped area comprise parts of two intrusive bodies of the same plutonic episode, as well as dikes and plugs of associated late-stage rocks. The two intrusive members are lithologically identical. They are separated by an approximately 400-m- (about 1,300-ft) wide mixed zone of gneissose protoclastic border phases, screens of contact schists, and plugs of late-stage felsic rocks. On the accompanying geologic map of the area (fig. 5), the two intrusive members are informally designated as the western pluton and the eastern pluton. Contacts between the plutonic rocks and the metavolcanic rocks are sharp and steep, and appear to be discordant.

Petrography

Tonalite-quartz diorite.--The two intrusive members consist of lithologically similar tonalite which occasionally ranges into quartz diorite (fig. 7).

In hand specimen, the typical tonalite of both plutons is medium gray, coarse to medium grained, and has a granitic texture. A fair flow foliation is conspicuous in all samples. No fine-grained border phases were observed at contacts with the metavolcanic rocks.

Thin section studies indicate that the tonalites consist of andesine, quartz, hornblende, and subordinate orthoclase. The andesine is generally twinned and has an average composition of about An38. Some of the andesine crystals are normally zoned from about An44 to about An34. Quartz invariably has undulating extinction and frequently forms composite grains with sutured boundaries between the individual quartz crystals. Hornblende is pleochroic from light brownish green to medium green. Biotite generally forms large irregular flakes and is pleochroic from light yellowish brown to dark greenish brown. Both hornblende and biotite tend to occur in clusters. Orthoclase is always institial. Sphene, magnetite, apatite, and zircon constitute the accessories. Alteration products consisting of epidote, chlorite, and sericite were observed in minute amounts in a few thin sections.

Thirteen chemical and spectrographic analyses and eleven modal counts have been obtained on the tonalite-quartz diorite of the two plutons

Table 3.—Chemical and modal data of representative bedrock samples from a part of the Talkeetna Mountains A-5 quadrangle, Talkeetna Mountains, Alaska

Chemical analyses. (Results in weight percent)

Map unit	TKwp						TKep							TKbz		TKep*
Rock type	Tonalite-quartz diorite of western pluton						Tonalite-quartz diorite of eastern pluton							Late stage aplite-alaskite, alaskitic granite		
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
SiO_2	58.9	60.3	58.2	61.2	62.0	63.2	61.1	62.5	62.0	60.8	60.8	61.3	53.5	71.1	75.1	75.2
Al_2O_3	17.2	17.5	17.9	16.7	17.2	16.8	16.7	15.6	16.6	16.8	14.5	16.8	17.7	15.2	13.8	13.3
Fe_2O_3	3.1	2.6	2.9	2.6	2.4	2.3	2.6	2.0	2.3	2.5	5.1	2.1	2.5	.91	.27	.39
FeO	3.4	3.0	3.4	3.0	2.6	2.6	3.4	3.1	3.4	3.4	5.0	3.2	3.8	.72	.56	.32
MgO	3.2	2.9	3.4	3.0	2.5	2.4	2.6	2.8	2.6	2.8	2.0	3.0	3.4	.70	1.0	.20
CaO	6.0	5.8	6.6	5.4	5.2	5.3	5.1	5.5	5.4	5.4	6.5	5.4	6.5	2.9	2.7	1.4
Na_2O	3.4	3.6	3.4	3.5	3.3	3.6	3.4	3.6	3.3	3.7	3.3	3.6	3.7	3.6	4.2	2.8
K_2O	1.6	1.6	1.2	1.8	1.6	1.5	2.0	2.0	1.4	1.9	.52	1.9	1.5	3.9	.60	5.0
H_2O+	1.2	.87	.90	.75	.83	1.0	.71	.80	.86	.63	.64	.90	1.2	.75	.90	.76
H_2O-	.14	.08	.10	.19	.27	.17	.15	.06	.14	.09	.07	.09	.09	.09	.06	.05
TiO_2	.76	.66	.71	.65	.61	.53	.92	.73	.78	.80	1.3	.81	.85	.21	.09	.30
P_2O_5	.29	.23	.26	.21	.20	.13	.29	.23	.25	.27	.35	.17	.24	.12	.05	.02
MnO	.11	.10	.12	.10	.09	.09	.12	.08	.09	.05	.21	.08	.10	.11	.00	.00
CO_2	.01	.02	.06	.06	.03	.05	.03	.02	.03	.03	.03	.08	.03	.03	.02	.03
SUM	99	99	99	99	99	99	99	99	99	99	100	99	100	100	99	99

* Sample 16. is from an aplite-alaskite dike within TKep unit.

Table 3.--Chemical and modal data of representative bedrock samples from a part of the Talkeetna Mountains A-5 quadrangle, Talkeetna Mountains, Alaska--Continued

Samples:

1.--72 ACy - 127	9.--72 ACy - 132
2.--72 ACy - 125	10.--72 ACy - 107a
3.--72 ACy - 148	11.--72 ACy - 98
4.--72 ACy - 100	12.--72 ACy - 114
5.--72 ACy - 136	13.--72 ACy - 117
6.--72 ACy - 137	14.--72 ACy - 128
7.--72 ACy - 106	15.--72 ACy - 97b
8.--72 ACy - 152	16.--72 ACy - 107b

[Locations of samples are shown in fig. 5]

Table 3.-Chemical and modal data of representative bedrock samples from a part of the Talkeetna Mountains A-5 quadrangle, Talkeetna Mountains, Alaska-Continued.

Semiquantitative spectrographic analyses
[Results in parts per million]

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15	16.
B	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1500	N
Ba	500	500	500	700	700	500	700	700	700	700	150	700	500	1500	150	2000
Be	N	N	N	N	N	N	N	N	N	N	N	N	N	2	N	N
Co	20	15	15	15	15	10	15	10	15	15	10	15	20	N	N	N
Cr	20	15	15	15	10	7	10	15	10	15	3	30	30	N	2	N
Cu	300	100	100	70	150	70	50	150	30	150	50	200	100	7	30	15
Ni	15	10	15	10	7	5	5	7	7	10	N	20	20	N	N	N
Pb	10	10	N	10	7	7	15	N	7	N	N	N	10	20	30	30
Sc	15	10	20	15	15	15	15	15	15	20	50	15	20	N	N	N
Sr	1000	1000	1000	700	700	700	500	700	500	500	500	700	700	700	100	300
V	150	100	150	100	100	100	150	100	150	150	50	150	150	10	15	N
Y	20	15	15	10	10	10	20	20	20	20	20	10	15	10	20	N
Zr	150	70	50	100	70	50	100	150	50	100	70	100	70	100	10	70
Ga	20	20	15	15	15	15	20	15	20	20	15	20	20	15	7	10
Yb	1.5	1	1	1.5	1	1	2	1.5	1.5	1.5	2	1.5	2	1	5	N

Table 3.—Chemical and modal data of representative bedrock samples from a part of the Talkeetna Mountains A-5 quadrangle, Talkeetna Mountains, Alaska—Continued.

[Rapid rock chemical analyses by Herbert Kirschenbaum and Leonard Shapiro. Semiquantitative six-step spectrographic analyses by Chris Heropoulos; results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12 ... but are reported arbitrarily as midpoints of these brackets, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1 ...; the precision of a reported value is approximately plus or minus one bracket at 68-percent confidence or two brackets at 95-percent confidence. N, not detected at limit of detection.]

31

Modes

[Results in volume percent]

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Quartz	16.2	18.0	15.4	15.7	None available	None available	20.2	21.1	22.6	14.2	22.7	15.4	12.8	29.0	None available	33.8
Plagioclase	56.4	55.6	57.6	58.3			51.6	51.9	54.5	57.0	53.4	57.1	56.5	37.6		34.0
K-feldspar	2.5	5.2	3.5	3.0			5.4	5.0	0.5	5.0	0.2	4.1	1.3	27.6		28.2
Biotite	10.2	11.6	8.8	11.2			10.0	12.0	16.5	18.0	1.2	20.9	14.0	4.8		2.8
Hornblende	14.3	9.0	13.4	10.5			11.6	8.8	5.0	4.7	20.5	1.5	15.0	0.0		0.0
Accessories	1.4	0.6	1.3	1.3			1.2	1.2	0.9	1.1	2.0	1.0	0.4	1.0		0.6
Total	100	100	100	100			100	100	100	100	100	100	100	100		100

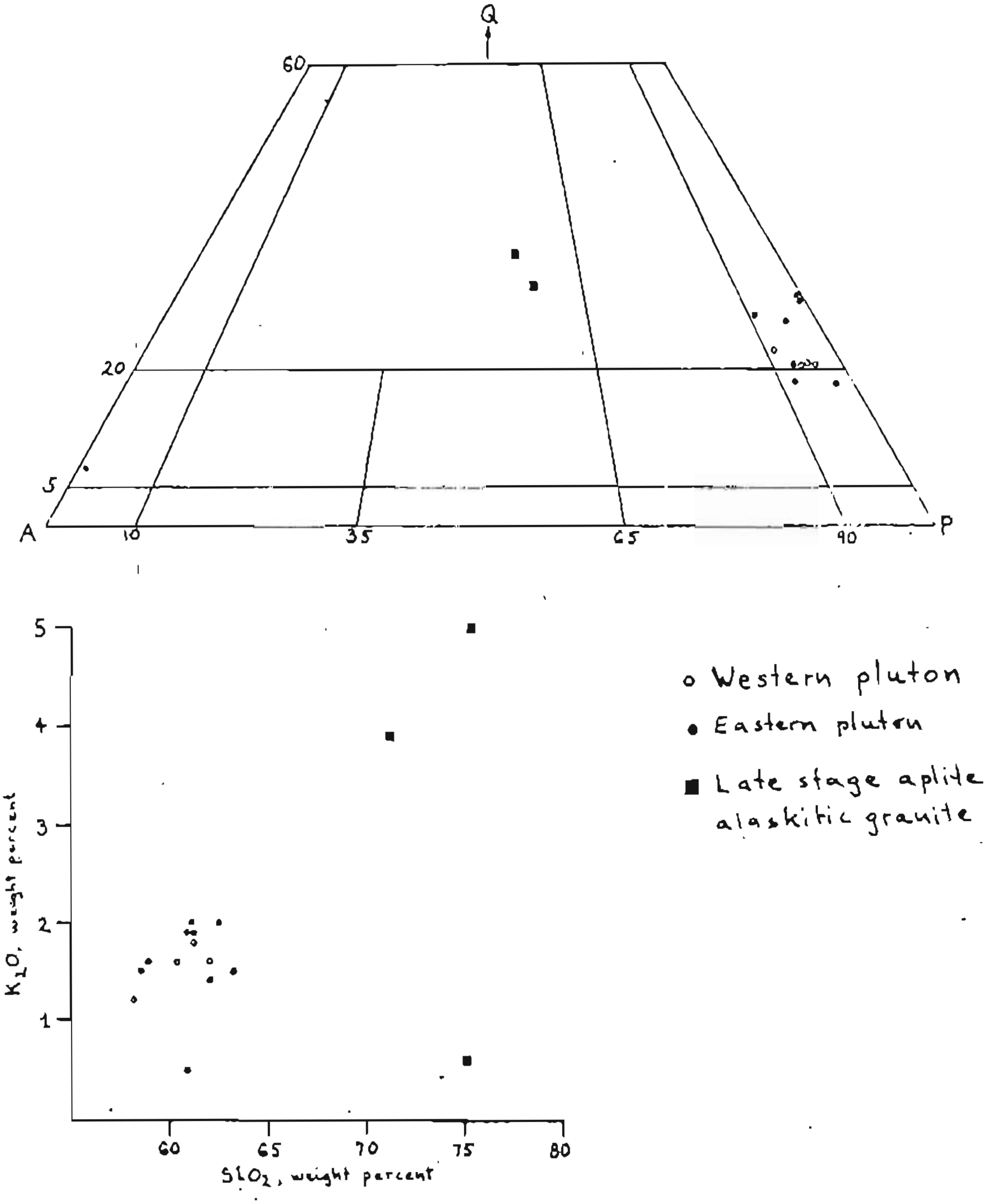


Figure 7. — Modal diagram, and plots of K_2O against SiO_2 for plutonic rocks of the Talkeetna Mountains A-5 quadrangle, Talkeetna Mountains, Alaska.

(table 3 and fig. 7). The narrow range of the chemical and modal analyses further indicate that the intrusive members are lithologically uniform and identical. The color index of the tonalites ranges from 21 to 30 with an overall average of about 24. There is a fair agreement between the chemistry of these tonalites and that of the hornblende-biotite tonalite of Nockolds (1954).

The gneissose and protoclastic border phases of the tonalites are compositionally similar to the main rock body, but they have diverse grain sizes, and their constituent minerals have been intensely granulated.

The late-stage rocks consist of aplite-alaskite dikes as much as 0.4 m (about 16 in.) thick. In the border zone between the two tonalite plutons, these rocks locally grade into small irregular bodies of alaskitic granite and granodiorite.

The late-stage rocks are light to medium gray, dominantly medium to fine grained, and, rarely, coarse grained. Texture varies from irregular and aplitic in the dikes to granitic in the cores of the larger bodies. The color index is generally below 5.

Thin section studies show the late-stage rocks to consist of twinned and zoned oligoclase, microcline, strained quartz, biotite, and subordinate hornblende. Accessories are apatite, magnetite, and sphene. Myrmekitic intergrowths of oligoclase and K-feldspar are common. In some rocks the feldspars have been moderately sericitized and the mafic minerals chloritized.

Chemical analyses and/or modal counts of three late-stage rocks are shown in table 3.

The contact schists, occurring as large screens in the border zone between the two intrusive members, are dark gray and medium grained, have schistose texture, and are composed of biotite, quartz, plagioclase, K-feldspar, and minor hornblende.

Structural features and pluton emplacement

The most characteristic structural feature of both intrusive members is a fairly well developed foliation, readily marked by the flow alignment of biotite (fig. 5). Elongate prismatic crystals of hornblende in places form a distinct lineation within the foliation plane. Generally, the foliation is regular except in and near the border zone between the two intrusives where it becomes swirly and irregular.

Xenoliths are scarce in either intrusive, but where present they are elongate, with a maximum dimension of 0.3 m (about 12 in.), and are completely recrystallized.

The prevailing structure and petrography of the two intrusives suggest that they were emplaced at relatively moderate depths in the earth's crust. According to the classification of Buddington (1959), the characteristics of the two plutons appear to be transitional between the mesozone and the epizone. The foliation and lineation, the lack of chill-border phases, and the greenschist facies metamorphism of the country rock tend to ally the intrusives with the mesozone. On the other hand, the sharp and apparently discordant contacts with the country rock, the numerous undeformed aplite-alaskite dikes, and the early Tertiary ages of the intrusives (see later) are indicative of the epizonal conditions.

The similar ages, identical lithologies, and the spatial juxtaposition of the two plutons indicate that they were emplaced by successive injections of consanguineous magmas of identical compositions. As only parts of the two plutons and their country rocks have been mapped, there is no information on the methods of magma emplacement.

<u>Age and correlation</u>

Available stratigraphic evidence suggest a post-late Mesozoic age for the two plutons. On the basis of regional correlation, the intruded metavolcanic country rock is assumed to be of late Paleozoic age. Greenschist facies regional metamorphism of the country rock, which predates the emplacement of the plutons, is postulated to have taken place in late Mesozoic time, as an apparently correlative metamorphic event was so dated by Smith and Turner (1973) in the central Alaska Range.

A concordant K-Ar age determination on coexisting hornblende and biotite was obtained for each of the two plutons (table 4). The calculated ages of either mineral pairs differ by less than 5 percent. These age determinations indicate that the plutons were emplaced within a short period of each other in very early Tertiary time.

According to Reed and Lanphere (1969, 1973), emplacement of granitic plutons in southern Alaska has occurred in three distinct plutonic epochs. These epochs are: Early and Middle Jurassic, from about 176 to 154 m.y. ago; Late Cretaceous and early Tertiary, from about 83 to 58 m.y. ago; and a middle Tertiary epoch between 38 to 26 m.y. ago. The K-Ar age determinations on the two plutons of this report clearly indicate that they belong to the Late Cretaceous-early Tertiary plutonic epoch. Comparing the chemistry and petrography of the two Talkeetna Mountains plutons with that of coeval plutons elsewhere in southern Alaska, the Talkeetna plutons are markedly similar to the Summit Lake plutonic series of Reed and Lanphere (1973, p. 2596).

Table 4.—Potassium-argon age determinations on biotite and hornblende mineral pairs for plutonic rocks of the Talkeetna Mountains A-5 quadrangle, Talkeetna Mountains, Alaska.

[Argon analyses and age calculations by J.C. Von Essen and A.H. Atkinson; potassium analyses by L.B. Schlocker. Decay constants for K^{40}: $\lambda_e = 0.585 \times 10^{-10}$ year^{-1}; $\lambda_\beta = 4.72 \times 10^{-10}$ year^{-1}. Atomic abundance of $K^{40} = 1.19 \times 10^{-4}$ atom percent.]

Pluton and rock type	Map designation on fig. 5	Location		Field No.	Mineral	K_2O (percent)	Ar^{40}_{rad} (10^{-10} moles/gr)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Apparent age (millions of years)
		Lat (N.)	Long (W.)						
Western pluton; tonalite	A.	62°08'	149°19'	72ACy-127	Biotite	9.30	9.055	0.87	64.8±2
					Hornblende	0.781, 0.783 (avg. 0.782)	7.371	0.78	62.7±2
Eastern pluton; quartz diorite	B.	62°09'	149°13'	72ACy-117	Biotite	9.33	9.207	0.79	65.6±2
					Hornblende	1.043, 1.042 (avg. 1.042)	9.869	0.77	63.0±2

Metavolcanic and marble sequence

The metavolcanic and marble sequence of the mapped area lies within the contact aureole of the plutonic rocks, thus its preplutonic lithology and regional metamorphic gradient is imperfectly known. Attitudes of these rocks appear to be nearly vertical. The apparent minimal thickness of the sequence is 1,500 m (about 4,800 ft).

Within about 1 km (about 0.6 mi) of the plutonic contacts, the massive and dark-greenish-gray metavolcanic rocks have been completely recrystallized into fine-grained, xenomorphic-granular textured assemblages of hornblende, sodic labradorite, and some opaques. These rocks clearly belong to the hornblende hornfels facies of Turner (1968).

Beyond about 1 km from the plutonic contact, the metavolcanic rocks underwent only partial thermal recrystallization. The metavolcanics in this zone are still fine grained and dark greenish gray, but have a foliated fabric. Thin section studies show these rocks to consist of schistose aggregates of quartz, fibrous amphibole, albite, and subordinate epidote, granoblastic hornblende, chlorite, and opaques. The fibrous amphibole also occurs in needle-like habits, is pleochroic from light green to medium green, has maximum extinction angles less than 20 degrees, and it is provisionally identified as actinolite. Some thin sections contain an occasional clast, as much as 5 mm in maximum dimension, of altered basalt or andesite, indicating a clastic origin for at least part of the metavolcanic section. The granoblastic hornblende crystals are interpreted as products of thermal recrystallization, whereas the fibrous actinolite(?), along with the schistose texture, appears to indicate an earlier greenschist facies regional metamorphism (Turner, 1968).

The marble interbed is approximately 150 m (about 490 ft) thick and is nearly vertical. The marble is massive, medium grained, has a light gray to white color, and consists of equigranular granoblastic aggregates of calcite and subordinate olivine, probably forsterite. The presence of forsterite indicates that the marble interbed too has been recrystallized into hornblende hornfels.

The mineral assemblages, the occasional relict volcanic rock clasts and schistose textures, and the overall field aspects of these mafic hornfelsic rocks suggest that they have evolved from a mafic, that is, a basaltic to andesitic, metavolcanic and metavolcaniclastic sequence of apparent greenschist facies metamorphism. On the basis of lithologic similarities, the metavolcanic rocks and the interbedded marble are correlated with the late Paleozoic metavolcanic and metavolcaniclastic sequences of the Watana Lake and the C-4 quadrangle areas.

TALKEETNA MOUNTAINS BATHOLITHIC COMPLEX

The plutonic rocks mapped in the A-5 quadrangle are part of an inadequately known batholithic complex, herein named the Talkeetna Mountains batholithic complex, which underlies a northeast elongate area of approximately 6,500 km^2 (about 2,500 mi^2) in the core of the Talkeetna Mountains (fig. 2). Emplacement of the complex appears to have been controlled by the northeast-trending regional structural grain. Country rock contacts, however, are dominantly discordant and steep, and are always sharp.

Country rocks northwest of the batholithic complex consist of strongly deformed Paleozoic metavolcanic and metavolcaniclastic rocks which have been regionally metamorphosed, apparently in late Mesozoic time, into greenschist facies, locally amphibolite facies assemblages. On the southeast the intruded country rocks comprise deformed Mesozoic volcanic and sedimentary rocks which only locally have undergone low grade, not higher than prehnite-pumpellyite facies regional metamorphism.

Thermal metamorphic effects extend as much as 2 km (about 6,500 ft) into the country rocks. As far as 1 km from plutonic contacts, the country rocks have been recrystallized into hornblende hornfels facies assemblages.

The batholithic rocks are chiefly tonalite, quartz diorite, granodiorite, and granite (K-feldspar ≅ plagioclase), but they include subordinate diorite and gabbro. Dominant grain sizes are medium and coarse. The bulk of the batholithic rocks display flow-foliation and sparse lineation. The batholithic complex is obviously composite, but the number and areal extent of its constituent plutons are not yet known. Late-stage rocks of aplite-alaskite, and thin to moderately thick quartz veins are common throughout the complex.

Presently available structural and petrographic information provisionally suggest that the plutons of the complex were emplaced as magma intrusions at depths transitional between the epizone and mesozone of Buddington (1959). The widespread foliation and the apparent lack of chill zones are indicative of the mesozone, whereas the domonantly discordant and sharp contacts and the numerous undeformed aplitic dikes are suggestive of the epizone. Geologic information obtained so far is inadequate to postulate on the methods of magma emplacement.

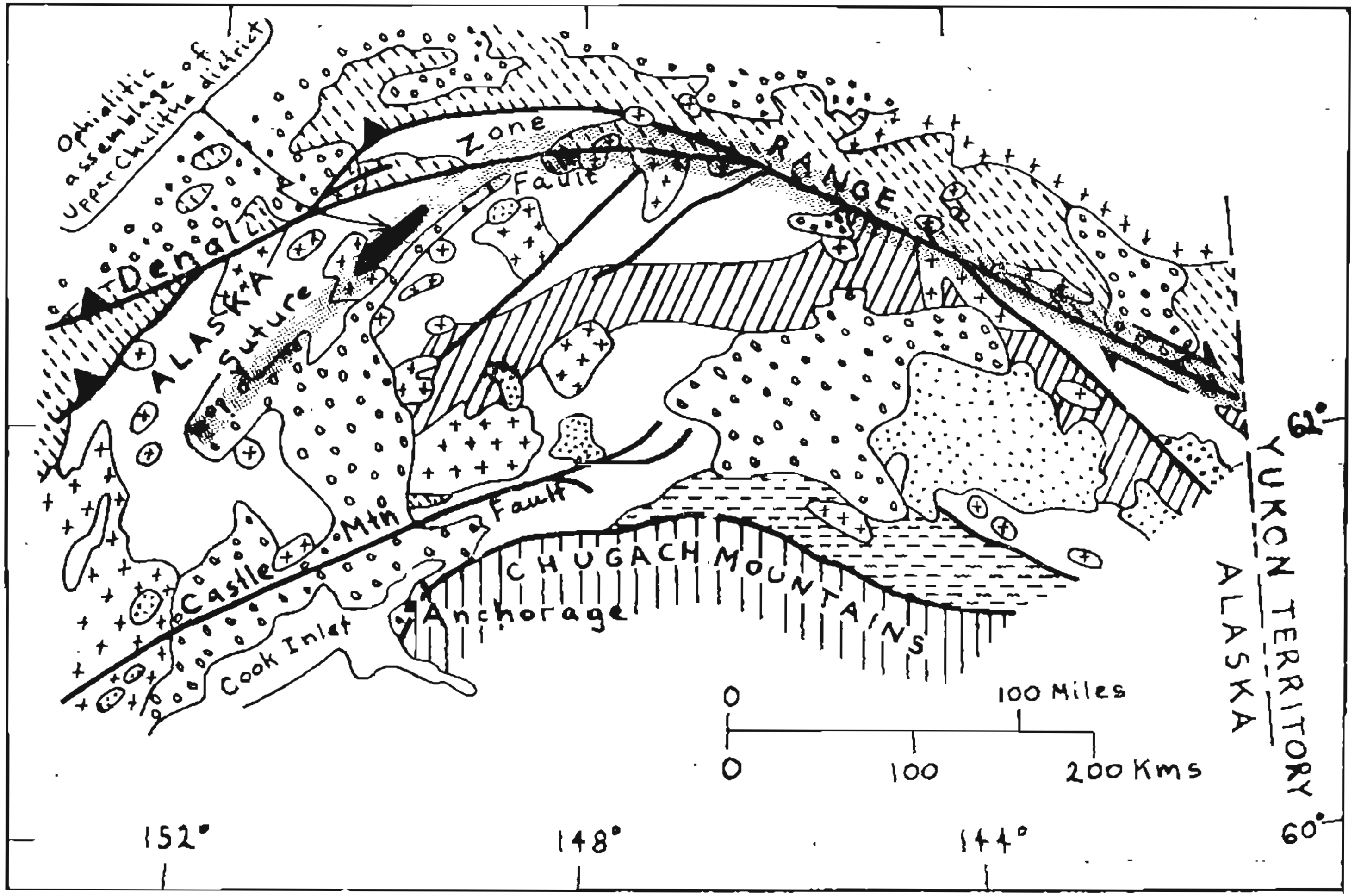
The new K-Ar age determinations from the Talkeetna Mountains A-5 quadrangle (described previously), and another obtained by Grantz and

Lanphere (in Reed and Lanphere, 1969) from the southwest portion of the Talkeetna Mountains batholithic complex indicate a Late Cretaceous-early Tertiary age for the western two-thirds of the complex. In contrast, K-Ar and Pb-α age determinations by Grantz and others (1963) from the Kosina pluton, forming the easternmost part of the Talkeetna Mountains batholithic complex, yielded Jurassic ages. Thus, intrusives of at least two plutonic epochs are present in the batholithic complex. Earlier workers (Paige and Knopf, 1907; Capps, 1916, 1940) postulated that most if not all of the complex was made up by Jurassic rocks.

According to Reed and Lanphere (1969), most mineral deposits in southern Alaska are associated with plutons of Late Cretaceous-early Tertiary age. Thus, the new age determinations from the largely unexplored Talkeetna Mountains batholithic complex suggest that the western two-thirds of the complex is a geologically favorable area for mineral exploration.

TECTONIC SIGNIFICANCE OF THE LATE PALEOZOIC METAVOLCANIC AND METAVOLCANICLASTIC ROCKS OF THE TALKEETNA MOUNTAINS

Results of the present investigations indicate that the late Paleozoic metavolcanic and metavolcaniclastic rocks form a broad, northeast-trending belt in the central and northern Talkeetna Mountains. The structural grain of these rocks also trends northeastward. These volcanogenic rocks are interpreted to constitute the remnants of the same late Paleozoic volcanic island arc system as in the eastern Alaska Range (Richter and Jones, 1970, 1973), and in the west-central Alaska Range (Clark and others, 1972). Thus, remnants of this island arc underlie considerably larger areas than previously recognized (fig. 8).



Geology modified after King, 1969; Clark and others, 1972; and Beikman, in press.

Figure 8. — Generalized tectonic map of south-central Alaska

EXPLANATION

Tertiary and Quaternary non marine basinad deposits

Quaternary and Tertiary terrestrial volcanic rocks

Early Mesozoic to Early Tertiary sedimentary and volcanic rocks deposited on continental crust

Late Mesozoic eugeosynclinal deposits

Plutonic rocks, mostly Mesozoic to Tertiary

Late Paleozoic volcanic island arc rocks, developed on an unidentified oceanic plate

Late Paleozoic eugeosynclinal deposits

Mid Paleozoic or older cratonic rocks

Contact, approximately located

Fault.
Arrows indicate where primary displacement is lateral.
Teeth indicate where primary displacement is interpreted to be vertical.

Late Paleozoic suture zone between North American plate (to the north) and unidentified oceanic plate (to the south).

Figure 8.—Generalized tectonic map of south-central Alaska—Continued

Richter and Jones (1970, 1973) postulate that the late Paleozoic volcanic island arc system has originally developed on an oceanic plate in connection with the southward subduction of the dominantly continental North American plate which had a leading edge of oceanic crust. By Late Permian time, most of the leading edge of oceanic crust had been consumed, and the volcanic island arc began to collide with the continental portion of the North American plate. As a result of reversal in the direction of plate subduction in Early Triassic time, the remnants of the island arc were added to, and became part of, the North American plate. In the eastern Alaska Range, the zone of suture between island arc rocks and those of the continental North American plate coincides with the mid-Tertiary right-lateral Denali Fault (fig. 8).

In the central Alaska Range, the location of the suture zone, that is the edge of the original North American plate, is imperfectly known. The ophiolitic sequence and the island arc rocks in the west-central portion of the Range trend about northeast at an acute angle to the Denali Fault (Clark and others, 1972), as do all the correlative rocks in the Talkeetna Mountains. The northeast trend of the late Paleozoic rocks in the west-central Alaska Range and in the Talkeetna Mountains is interpreted to be parallel with the edge of the continental portion of the North American late, against which the late Paleozoic island arc rocks were molded. The ophiolitic sequence of the Upper Chulitna district, which contains altered ultramafic bodies, could very well represent the actual zone of suture. In that case the zone should diverge in a southwesterly direction from the northward convex course of the Denali Fault system somewhere near the northernmost segment (fig. 8). Thus, west of the area of divergence the course of the Denali Fault, as shown by King (1969), is within continental rocks of the original North American plate.

Richter and Jones (1970, 1973) interpret the Denali Fault in the eastern Alaska Range as a strike-slip fault, having formed by renewed northwestward plate motion in the northern Pacific since mid-Tertiary time. In accordance with this concept, the western portion of the Denali Fault--the portion west of the northward apex--by virtue of its southwesterly direction and apparent position within the continental North American plate should splinter and eventually die out, or at least change into a fault system of different character. Accordingly, strike-slip displacement along this portion of the Denali Fault is minimal and large-scale earthquakes apparently are unlikely.

REFERENCES CITED

Anderson, R. E., 1969a, Preliminary geochemistry and geology of the Little Falls Creek area, Talkeetna Mountains quadrangle, Alaska: Alaska Div. Mines and Geology Geochem. Rept. 19, 16 p.

_____ Geology and geochemistry of the Diana Lakes area, western Talkeetna Mountains, Alaska: Alaska Div. Mines and Geology, Geol. Rept. 34, 27 p.

Barnes, F. F., 1962, Geologic map of lower Matanuska Valley, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-359.

Buddington, A. F., 1959, Granite emplacement with special reference to North America: Geol. Soc. America Bull., v. 70, p. 671-747.

Capps, S. R., 1915, The Willow Creek district, Alaska: U.S. Geol. Survey Bull. 607, 86 p.

_____ 1940, Geology of the Alaska Railroad region: U.S. Geol. Survey Bull. 907, 201 p.

Chapin, Theodore, 1918, The Nelchina-Susitna region, Alaska: U.S. Geol. Survey Bull. 668, 67 p.

Clark, A. L., Clark, S. H. B., and Hawley, C. C., 1972, Significance of upper Paleozoic oceanic crust in the Upper Chulitna district, west-central Alaska Range, _in_ Geological Survey Research 1972: U. S. Geol. Survey Prof. Paper 800-C, p. C95-C101.

Clark, A. L., and Cobb, E. H., 1972, Metallic mineral resources map of the Healy quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF 394.

Cobb, E. H., 1972a, Metallic mineral resources map of the Talkeetna Mountains quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-370.

_____ 1972b, Metallic mineral resources map of the Anchorage quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map MF-409.

Grantz, Arthur, 1960a, Geologic map of the Talkeetna Mountains A-1 quadrangle, and the south third of the Talkeetna Mountains B-1 quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-314, scale 1:48,000.

_____ 1960b, Geologic map of the Talkeetna Mountains A-2 quadrangle, Alaska and the contiguous area to the north and northwest: U.S. Geol. Survey Misc. Geol. Inv. Map I-313, scale 1:48,000.

_____ 1961a, Geologic map of the north two-thirds of Anchorage D-1 quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-343, scale 1:48,000.

_____ 1961b, Geologic map and cross sections of the Anchorage D-2 quadrangle and northernmost part of the Anchorage D-3 quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-342, scale 1:48,000.

Grantz, Arthur, Thomas, Herman, Stern, T. W., and Sheffey, N. B., 1963, Potassium-argon and lead-alpha ages for stratigraphically bracketed plutonic rocks in the Talkeetna Mountains, Alaska, in U.S. Geological Survey Research 1963: U.S. Geol. Survey Prof. Paper 475-B, p. B56-B59.

Hawley, C. C., Meier, A. L., and Miller, R. L., 1968, Geochemical investigation at Antimony Creek antimony prospect, northern Talkeetna Mountains, Alaska: U.S. Geol. Survey open-file rept., 9 p.

Kaufman, M. A., 1964, Geology and mineral deposits of the Denali-Maclaren River area, Alaska: Alaska Div. Mines and Minerals Geol. Rept. 4, 15 p.

King, P. B., 1969, Tectonic map of North America: U.S. Geol. Survey, scale 1:5,000,000.

Nockolds, S. R., 1954, Average chemical compositions of some igneous rocks: Geol. Soc. America Bull., v. 65, p. 1007-1032.

Paige, Sidney, and Knopf, Adolph, 1907, Geologic reconnaissance in the Matanuska and Talkeetna Basins, Alaska: U.S. Geol. Survey Bull. 327, 71 p.

Ray, R. G., 1954, Geology and ore deposits of the Willow Creek mining district, Alaska: U.S. Geol. Survey Bull. 1004, 86 p.

Reed, B. L., and Lanphere, M. A., 1969, Age and chemistry of Mesozoic and Tertiary plutonic rocks in south-central Alaska: Geol. Soc. America Bull., v. 80, p. 23-44.

______ 1973, Alaska-Aleutian Range batholith: geochronology, chemistry, and relation to Circum-Pacific plutonism: Geol. Soc. America Bull., v. 84, p. 2583-2610.

Richter, D. H., 1963, Geology of the Portage Creek-Susitna River area, Alaska: Alaska Div. Mines and Minerals Geol. Rept. 3, 2 sheets.

Richter, D. H., and Jones, D. L., 1970, The structure and stratigraphy of the eastern Alaska Range [Alaska], in 2nd International Arctic Symposium Proc.: Am. Assoc. Petroleum Geologists Bull., v. 54, p. 2502.

_____ 1973, Structure and stratigraphy of eastern Alaska Range, Alaska: Am. Assoc. Petroleum Geologists Mem. 19, p. 408-420.

Rose, A. W., 1965, An aerial reconnaissance in the northern Talkeetna Mountains, Alaska: Alaska Div. Mines and Minerals Ann. Rept. for 1965, p. 57-59.

_____ 1967, Geology of an area on the upper Talkeetna River, Talkeetna Mountains quadrangle, Alaska: Alaska Div. Mines and Minerals Geol. Rept. 32, 7 p.

Smith, E. T., and Turner, D. L., 1973, Geochronology of the Maclaren metamorphic belt, south-central Alaska: a progress report: Isochron/West, no. 7, p. 21-25.

Smith, J. G., and MacKevett, E. M., Jr., 1970, The Skolai Group in the McCarthy B-4, C-4, and C-5 quadrangles, Wrangell Mountains, Alaska: U.S. Geol. Survey Bull. 1274-Q, p. Q1-Q26.

Turner, F. J., 1968, Metamorphic petrology, mineralogical and field aspects: New York, McGraw-Hill, 403 p.