THE MOUNT GALEN VOLCANICS—A NEW MIDDLE TERTIARY VOLCANIC FORMATION IN THE CENTRAL ALASKA RANGE

BY
JOHN E. DECKER AND WYATT G. GILBERT

GEOLOGIC REPORT 59

STATE OF ALASKA

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Cover photograph - Mount Galen from ridge 1.0 km north of Eielson visitors center. Photo by W.G. Gilbert.

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CONTENTS

ILLUSTRATIONS

TABLES

THE MOUNT GALEN VOLCANICS—A NEW MIDDLE TERTIARY VOLCANIC FORMATION IN THE CENTRAL ALASKA RANGE

By
John E. Decker[1] and Wyatt G. Gilbert[2]

ABSTRACT

The Mount Galen Volcanics are named for a series of andesitic and basaltic lava flows, breccia, and tuff of late Eocene-early Oligocene age in the west-central Alaska Range. These rocks, once considered part of the Cantwell Formation, cover at least 25 square kilometers (km^2) and locally reach a thickness of 1,000 meters (m).

The formation can be divided petrologically into hornblende andesite, two-pyroxene andesite, and basalt. Hornblende andesite with calc-alkaline characteristics is the most common rock type and occurs as tuff, lava flows, flow breccia, and clasts and tuffaceous matrix in volcanic breccia. Two-pyroxene andesite most commonly occurs as lava flows and flow breccia. Basalt occurs as lava flows and typically contains phenocrysts of titanaugite and plagioclase ($\pm$ olivine) and has olivine tholeiite characteristics.

Ten K-Ar mineral ages from seven rock samples range from 32.3 $\pm$ 1.0 m.y. to 43.2 $\pm$ 2.6 m.y. with a mean and mode of 37-38 m.y.

Taken together, the Mount Galen Volcanics and lower Oligocene plutonic rocks of the Alaska-Aleutian Range batholith constitute a middle Tertiary magmatic arc that roughly parallels the southern Alaska continental margin.

INTRODUCTION

This report names and describes the Mount Galen Volcanics, a discontinuous series of andesitic and basaltic volcanic rocks of late Eocene-early Oligocene age in the west-central Alaska Range (fig. 1). These rocks are preserved in the western part of a block-faulted terrane that formed north of the McKinley strand of the Denali fault in late Cenozoic time (Gilbert, 1975).

Field studies of the Mount Galen Volcanics east of Stony Creek were begun by Gilbert in June 1974, and Decker mapped and described the major part of the formation, which lies northwest of Moose Creek and Stony Creek, during July and August 1974. Gilbert extended mapping south to the Thorofare River during 1975, and both authors briefly examined the volcanic rocks in the Gorge Creek area and west of the Muldrow Glacier in 1976.

[1]Geology Department, University of Alaska, Fairbanks, AK 99701; present address: Geology Department, Stanford University, Stanford, CA 94305.
[2]DGGS, P.O. Box 80007, College, AK 99708.

PREVIOUS INVESTIGATIONS

The earliest known reference to rocks belonging to the Mount Galen Volcanics is by Brooks (1911), who noted the presence of volcanic rocks and lignite on his geologic map. In 1919 Capps described the pyroclastic rocks near Stony Creek as sediments containing abundant blocks of extrusive rocks interbedded with columnar lava, and assigned this occurrence to the Coal-Bearing Formation of probable Eocene age. In the Mount Galen area Capps mapped similar rocks as undifferentiated intrusive and extrusive rocks of pre-Ordovician to Tertiary age. Later, Capps (1927, 1932) described this undifferentiated sequence as dikes, sills, stocks, and lava flows of various compositions, mainly of Tertiary age. In 1933 Reed mapped volcanic rocks in the Mount Eielson district that consist dominantly of porphyritic andesite, but include tuff, basalt, dacite, obsidian, and breccia as well. These rocks were considered to be of Eocene age on the basis of correlation with volcanic rocks associated with the Cantwell Formation. In addition, Reed (1933) mapped porphyritic granodiorite of probable Jurassic age that the authors believe are volcanic rocks of the Mount Galen Volcanics. The change in age of the Cantwell Formation from Eocene to Cretaceous (Chaney, 1937) led Capps (1940) to assign the volcanic rocks in the Mounts Galen and Eielson areas to the late Mesozoic. In 1961, J.C. Reed, Jr. included rocks of the Mount Galen Volcanics with the Cantwell Formation. East of the Mount Galen area Paleocene volcanic rocks once considered part of the Cantwell Formation have recently been renamed the Teklanika Formation (Gilbert and others, 1976).

GENERAL DESCRIPTION OF MOUNT GALEN VOLCANICS

The Mount Galen Volcanics are a discontinuous series of andesitic and basaltic volcanic breccia, flow breccia, lava flows, and tuff that covers more than 25 km^2 in a band from the Thorofare River to a point 4 km east of Stony Creek (fig. 2—see centerfold). These rocks unconformably overlie Triassic(?) metabasalt and sedimentary rocks of the Paleocene Cantwell Formation and are conformably overlain by Tertiary lignite-bearing continental sedimentary rocks (fig. 3). The formation is

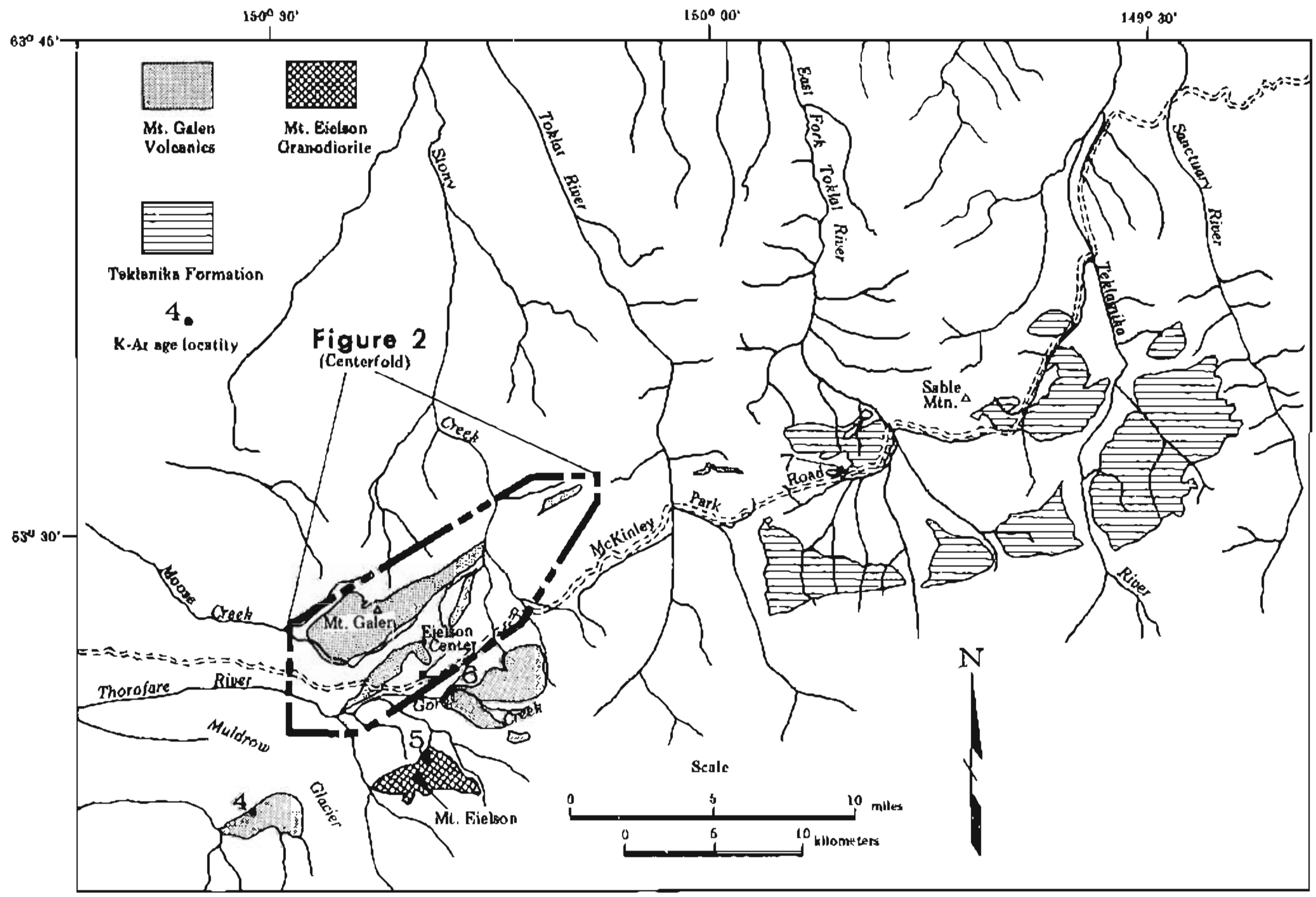


Figure 1. Distribution of Mount Galen Volcanics and location of study area.

overlain unconformably by Quaternary glacial, fluvial, and colluvial deposits. On the northwest the volcanic rocks are generally bounded by high-angle, north-side-up faults. The Mount Galen Volcanics have a minimum thickness of about 1,000 m.

The formation name is taken from its type locality, which extends along a narrow ridge from Stony Creek southwestward to the top of Mount Galen in the northwestern Mount McKinley B-1 quadrangle (fig. 2, cover photograph). At Stony Creek the lower part of the section consists of 250 m of volcanic breccia, tuff, and columnar-jointed basalt flows. Excellent exposures higher in the section on the flanks of Mount Galen are dominantly volcanic breccia, flow breccia, tuff, and andesitic flows. A basal contact is well exposed north of Mount Galen, where volcanic breccia unconformably overlies steeply dipping conglomerate of the Cantwell Formation. Here the basal contact is at a higher stratigraphic horizon than the strata at Stony Creek, indicating that the Mount Galen Volcanics were deposited over a surface of considerable topographic relief.

The Mount Galen Volcanics may have erupted from several centers, but only one probable vent has been identified within the study area. The vent is located about 1.5 km southwest of VABM Thoro, where there are rugged outcrops of volcanic breccia which cuts Triassic(?) metabasalt (fig. 3).

In outcrop four rock types can be distinguished: 1) volcanic breccia, which contains mainly noncognate clasts in a porous, tuffaceous matrix; 2) flow breccia, which contains predominantly cognate clasts in a dense, microcrystalline and vitric groundmass; 3) lava flows; and 4) crystal-lithic tuff and lapilli tuff. Considerable gradation exists between the four rock types, principally between tuff and volcanic breccia, flows and flow breccia, and volcanic breccia and flow breccia. These rock types were not mapped separately.

As a whole the Mount Galen Volcanics are poorly bedded, although from a distance a crude stratification can be observed (fig. 4). Tuff and volcanic breccia are poorly consolidated, whereas lava flows and flow breccia generally exhibit greater induration. Andesitic rocks weather light brown to light gray; basaltic rocks weather grayish black. Lava flows of both compositions display spheroidally weathered surfaces. Columnar jointing occurs within basaltic flows with columns 10 to 30 m long and 1 to 2 m in diameter. The volcanic breccia is composed of subrounded to angular clasts, both cognate, up

Figure 3. Looking northwest from ridge 1.0 km north of Eielson visitors center. Volcanic breccia in foreground cuts Triassic(?) basalt and may represent an eruptive center. Tertiary conglomerate in middle distance conformably overlies Mount Galen Volcanics. Ridge in distance is southwest end of Mount Galen.

to 5 m in diameter and commonly between 1 and 3 m in diameter (fig. 5). Most of the tuff probably originated as volcanic mudflows, but ash flow tuff also occurs.

PETROLOGY

At its type locality the Mount Galen Volcanics can be divided petrographically into three groups: 1) hornblende andesite, 2) two-pyroxene andesite, and 3) basalt. Plagioclase and orthopyroxene compositions were determined optically.

Figure 4. Photograph showing crude stratification of light-colored volcanic breccia overlain by darker flow.

HORNBLENDE ANDESITE

Hornblende andesite (fig. 6) is the most common rock type and occurs as tuff, lava flows, flow breccia, clasts, and tuffaceous matrix in volcanic breccia. Hornblende-andesite lava flows and clasts derived from flows have a porphyritic texture with a glassy to microcrystalline flow-oriented groundmass. Strongly zoned, fragmental plagioclase (An_{52} to An_{65}) up to 10 mm long is the most abundant phenocryst, constituting from 15 to 20 percent of the rock. Zonation is commonly oscillatory, although reversed and normal zonation also occur. Euhedral to subhedral grains are frequently broken and contain a network of subparallel fractures filled with devitrified glass. Plagioclase is generally unaltered and inclusion free, but it occasionally contains finely disseminated glass inclusions, which occur along crystal margins and in bands within grains parallel to crystal outlines.

Hornblende occurs as euhedral to subhedral phenocrysts up to 20 mm long and constitutes approximately 10 percent of the rock. Most phenocrysts are zoned and strongly pleochroic (X = pale yellow, Y = greenish brown, and Z = dark green).

Occasionally, grain margins of both plagioclase and hornblende are clouded by glass inclusions and are altered by resorption to the point where many phenocrysts appear rounded. Partially resorbed fragmented grains and high An content of the plagioclase indicate that the phenocrysts are not in equilibrium with the groundmass. The groundmass contains, in order of decreasing abundance, colorless to brown glass, flow-oriented plagioclase microlites, cryptocrystalline material and devitrified glass, and magnetite. Vugs, either with euhedral to subhedral outlines (probably vacated by phenocrysts) or, more rarely, vesicles, are lined with

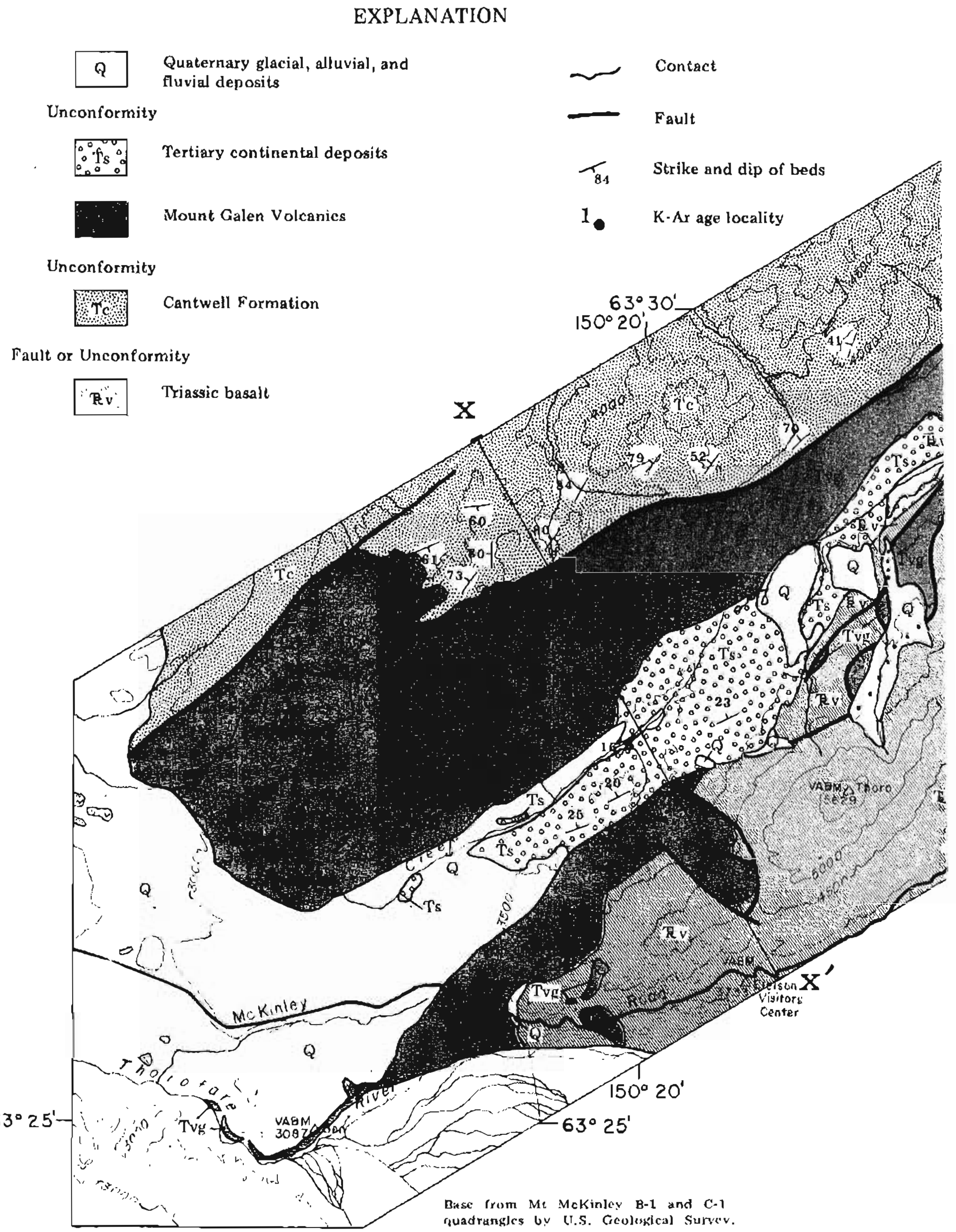
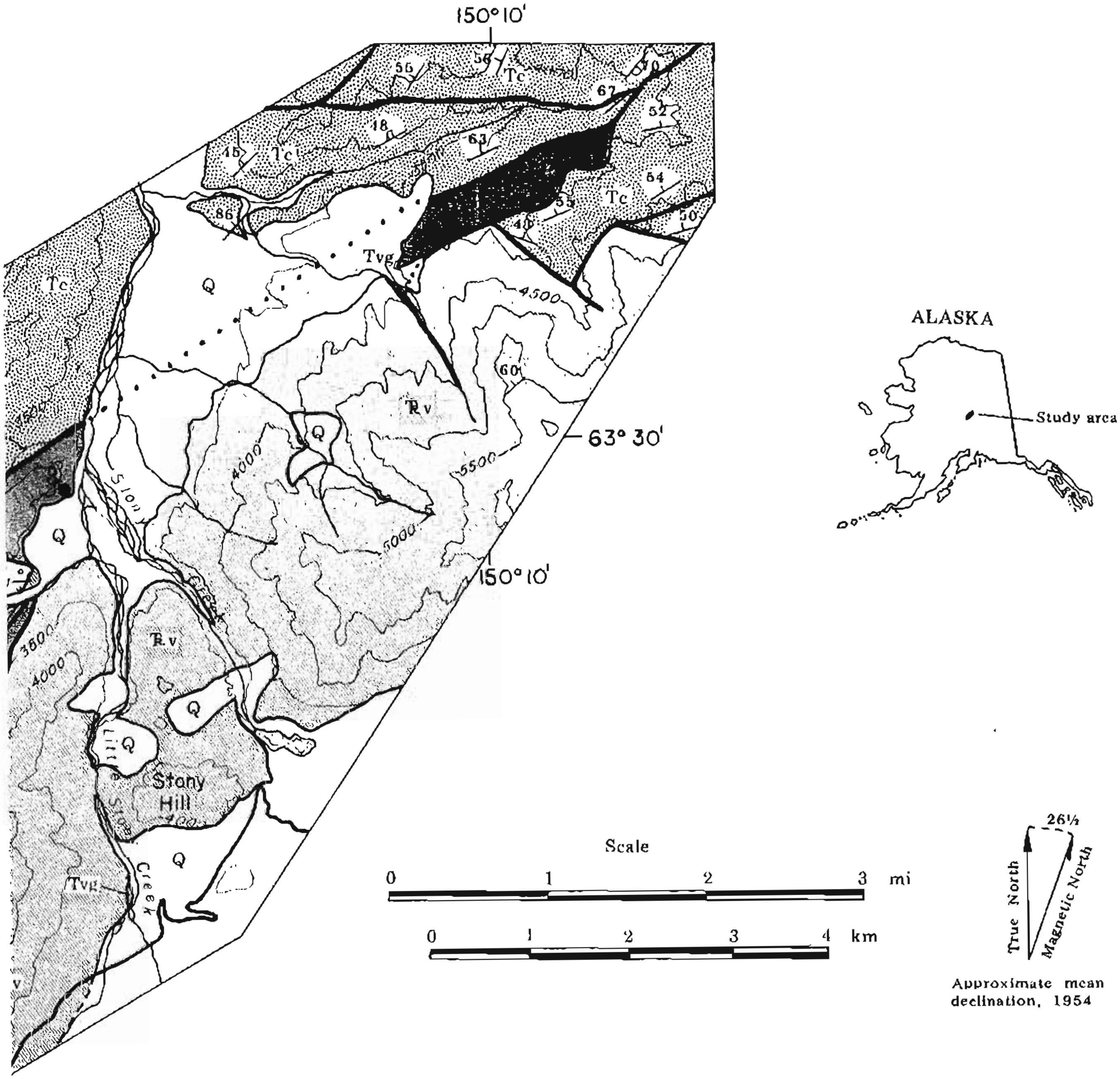


Figure 2: Geologic map of Mount Galen area, Mount McKinley National Park, Alaska.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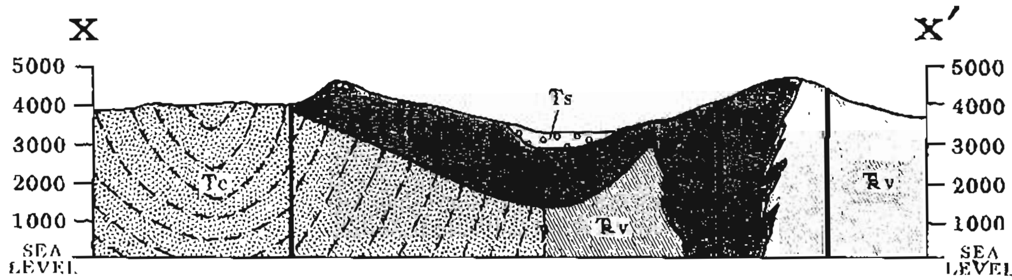
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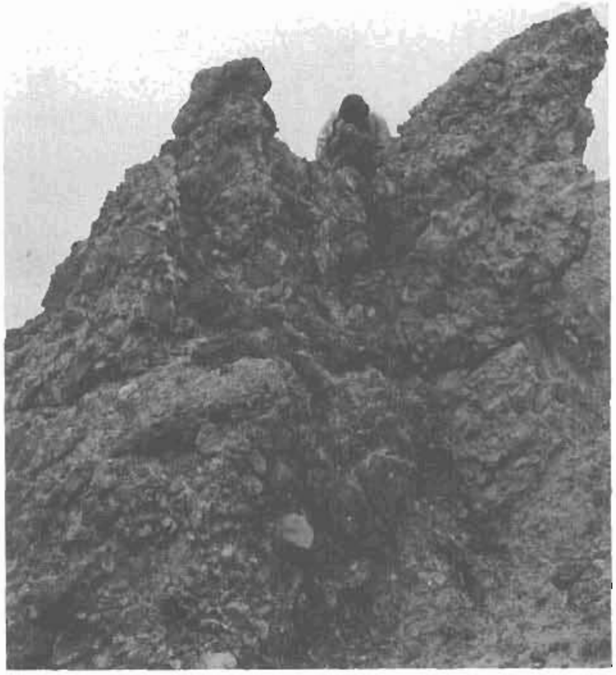

Figure 5. Volcanic breccia composed of rounded to subangular clasts with a tuffaceous matrix.

Figure 6. Photomicrograph of hornblende andesite from Mount Galen Volcanics. H = hornblende, white crystals are plagioclase, and the groundmass is glass. 8X.

parallel acicular crystals of yellow to red geothite(?). Centers of vugs and vesicles where not totally occupied by goethite(?) contain analcime(?) in radial aggregates. Apatite is a ubiquitous accessory.

Crystal-lithic tuff and tuffaceous volcanic breccia of hornblende andesite composition have a hypocrystalline porphyritic texture. Hornblende and plagioclase phenocrysts predominate and appear as described above. The groundmass consists of colorless to brown glass, crudely oriented plagioclase laths, and axiolitic devitrified glass. Xenoliths observed in thin section include metabasalt, oxyhornblende-bearing basalt, two-pyroxene andesite, hornblende andesite, glass, pumice, crystalline flow-oriented groundmass, glassy flow-oriented groundmass, and noncognate plagioclase and hornblende.

TWO-PYROXENE ANDESITE

Two-pyroxene andesite (fig. 7) most commonly occurs as lava flows and flow breccia with a hypocrystalline to holocrystalline porphyritic texture. Euhedral to subhedral plagioclase (An_{55} to An_{64}) up to 4 mm long is the most common phenocryst, constituting about 30 percent of the rock. Zonation in the plagioclase is commonly oscillatory and less commonly normal or reversed. The phenocrysts are generally clear but occasionally contain abundant glass inclusions, resulting in a honeycomb structure. Resorption effects are common along grain margins. Broken grains are also common.

Pink to green pleochroic hypersthene (En - 50, -2V = 50^{0}) makes up 5 to 10 percent of the rock. It occurs as zoned euhedral to subhedral phenocrysts up to 2 mm long, as cores in augite phenocrysts, and as anhedral grains in the groundmass.

Colorless to pale-green weakly pleochroic augite forms euhedral to subhedral phenocrysts up to 2 mm long and constitutes between 5 to 10 percent of the rock. Polysynthetic and simple twinning (001 = twin plane) are common. Phenocrysts are frequently zoned, often with hypersthene cores.

The groundmass is predominantly holocrystalline, although brown or colorless glass was observed in a few thin sections. Flow-oriented plagioclase laths up to 0.1 mm long form the dominant feature of the groundmass, magnetite and apatite are common accessories.

BASALT

Basalt occurs as several distinct flows up to 30 m thick, typically exhibiting columnar jointing. The texture is holocrystalline and porphyritic, with a groundmass dominated by flow-oriented plagioclase microlites and equant magnetite grains.

The clinopyroxene in these rocks is brown titanaugite. It makes up about 25 percent of the rock and occurs as anhedral grains in glomeroporphyritic aggregates with subordinate plagioclase and magnetite.

Zoned plagioclase phenocrysts (An_{55} to An_{60}) up to

15 mm long make up 10 to 15 percent of the rock. Zoning is typically normal or oscillatory. Plagioclase phenocrysts are clear and relatively free of inclusions; however, alteration along fractures is common. Subhedral plagioclase laths up to 1 mm long constitute 50 to 65 percent of the groundmass. In hand specimen the plagioclase is characteristically amber colored and translucent.

Magnetite forms euhedral to anhedral grains up to 0.2 mm in diameter and composes 10 to 15 percent of the rock, indicating that these rocks crystallized under a high partial pressure of oxygen (Osborn, 1962).

Olivine, when present, occurs as euhderal to subhedral microphenocrysts generally less than 0.4 mm in diameter and constitutes up to 10 percent of the rock. It is often completely altered to yellow or red-brown geothite(?), brown iddingsite, and green chlorite.

Trace amounts of secondary biotite occur as subhedral crystals associated with geothite(?) and chlorite alteration.

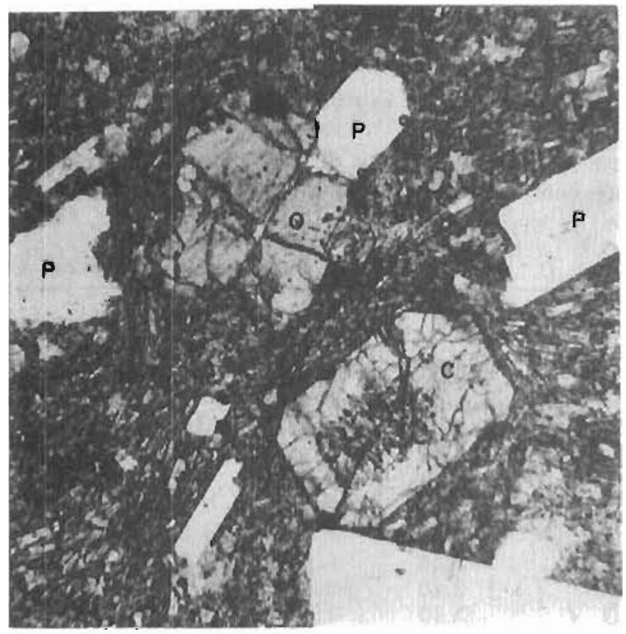

Figure 7. Photomicrograph of two-pyroxene andesite from the Mount Galen Volcanic sequence. C = clinopyroxene, O = orthopyroxene, P = plagioclase, and the groundmass is composed of oriented plagioclase laths and glass. 20X.

GEOCHEMISTRY

A 13-oxide chemical analysis was performed on seven rocks from the Mount Galen Volcanics--two basalts, three hornblende andesites, and two twoproxene andesites. CIPW norms (table 1) were calculated from 11 of the oxides (omitting H_2O+ and CO_2 and recalculating the total to 100 percent) following the procedure outlined by Kelsey (1965). These data are plotted on figures 8-11 which are used simply for classification and comparison and are not intended to show variation or trends within the Mount Galen Volcanics. Analyses 5 and 6 are suspect because of high H_2O+ content and low K_2O values.

Most of the Mount Galen Volcanics were classified as andesites both petrographically and in the field, although their high silica content would probably cause many of them to be classified as dacites on some classification schemes. The classification followed here is based on normative plagioclase vs normative color index after Irvine and Baragar (1971) (fig. 8), and the five Mount Galen andesites that were analyzed all plot within the andesite field. The alkali content (fig. 9), lack of iron enrichment (fig. 10), and high Al_2O_3 content (fig. 11) of the Mount Galen andesite samples suggest that they are part of a calc-alkali series. The SiO_2 values of the Mount Galen andesites range from 58.6 to 64.8 weight percent, all of which are higher than the average Cenozoic andesite (SiO_2 = 58.17 wt %) of Chayes (1969). Ray (1967) and Forbes and others (1969) have reported similar high-silica andesites from continental settings in other parts of southern Alaska. Ray has proposed that the high-silica andesites from the Mount Trident Volcano were differentiated from a slightly undersaturated olivene-normative parent magma with alkalic affinities.

The presence of titanaugite in the Mount Galen basalt samples and their high ratio of total iron to magnesium suggest alkaline affinities. When plotted on an alkali-vs-silica diagram the basalts fall in the alkaline field (fig. 9). The 'MacDonald and Katsura' line on figure 9 has been suggested to approximate the trace of the critical plane of silica undersaturation of Yoder and Tilley (1962) (MacDonald and Katsura, 1964). The Mount Galen basalts, however, are not nepheline-normative and plot in the olivine tholeiite field on the Yoder and Tilley basalt tetrahedron. Chayes (1966) has suggested that nepheline-normative basalts represent the only unquestionably alkaline variety, whereas opx-normative basalts (normative nepheline = 0) may also show distinct alkaline tendencies. The Mount Galen basalts are probably transitional, possessing both alkaline and subalkaline characteristics.

AGE AND CORRELATION

The Mount Galen Volcanics were extruded in late Eocene-early Oligocene time. Potassium-argon dates from plagioclase and hornblende separates from a hornblende andesite flow yield ages of 40.1 ± 1.2 m.y. and 38.0 ± 1.1 m.y., respectively (fig. 2; table 2). In addition, three plagioclase ages from two basalt flows are 38.0 ± 1.4 m.y., 34.8 ± 1.4 m.y. and 38.6 ± 1.2 m.y. (fig. 2; table 1); because of the alteration of these rocks, these must be considered minimum ages.

A porphyritic hornblende andesite flow in the southern Healy C-6 quadrangle (fig. 1) (Gilbert and Redman,

1975) yields a radiometric age of 43.2 ± 2.6 m.y. (table 2) (Gilbert, 1976). These rocks probably represent the easternmost exposure of the Mount Galen Volcanics.

Just west of the terminus of the Muldrow Glacier is a little-known series of volcanic rocks that include purple-weathering glassy felsite, green felsic lapilli tuff, and basalt. These rocks are 5.0 km southwest of the Mount Galen Volcanics exposed along the Thorofare River and are probably correlative with them. A plagioclase minimum age from a basalt in the Muldrow Glacier area is 32.3 ± 1.0 m.y. (fig. 1; table 2).

Table 1. *Geochemical analyses and CIPW norm calculations (in percent).*[a]

Oxides	1[b]	2	3	4	5	6	7	8
SiO_2	46.00	47.00	63.20	61.50	59.20	58.60	64.80	69.0
TiO	3.00	2.90	0.66	0.90	0.90	0.75	0.46	0.46
Al_2O_3	17.00	17.00	16.60	18.10	17.20	17.20	15.70	15.50
Fe_2O_3	5.80	5.30	3.60	1.60	2.50	4.30	{ 4.00	{ 3.00
FeO	8.10	7.70	1.20	2.00	2.80	2.10		
MnO	0.04	0.21	0.09	0.18	0.05	0.04	0.84	0.77
MgO	5.00	4.40	2.10	2.40	3.60	2.80	1.70	1.30
CaO	8.20	8.10	5.40	6.00	5.70	5.90	4.10	3.80
Na_2O	3.40	3.80	3.80	4.20	3.10	3.20	3.60	3.60
K_2O	1.10	1.20	1.90	1.60	0.96	0.84	2.20	2.30
P_2O_5	0.35	0.45	0.10	0.15	0.10	0.09	0.08	0.10
H_2O^+	0.70	0.20	0.20	0.90	2.20	2.30	1.70	0.60
CO_2	0.80	0.80	0.80	0.60	0.80	0.80	---	---
Total	99.49	99.06	99.65	100.13	99.11	98.82	99.18	100.43
Norms								
Q	---	---	20.43	15.23	19.98	21.70	22.42	27.87
or	6.62	7.24	11.41	9.57	5.90	5.18	13.36	13.58
ab	29.37	32.83	32.57	36.03	27.27	28.16	31.20	30.52
an	28.46	26.29	22.95	26.18	28.76	28.71	20.28	18.39
di	8.65	9.48	2.75	2.42	---	---	---	---
hy en	4.27	2.28	4.02	5.10	9.32	7.27	4.34	3.23
hy fs	1.78	1.12	---	1.03	2.32	---	5.67	3.56
ol fo	3.84	4.08	---	---	---	---	---	---
ol fa	1.76	1.72	---	---	---	---	---	---
mt	8.60	7.83	2.29	2.34	3.37	4.93	1.46	1.46
il	5.83	5.61	1.27	1.73	1.79	1.49	0.90	0.88
hm	---	---	2.06	---	---	1.08	---	---
C	---	---	---	---	0.98	1.00	0.15	0.37
ap	0.83	1.06	0.24	0.35	0.24	0.21	0.20	0.24
Total	100.01	99.51	99.98	99.97	99.93	99.73	99.98	100.10
Normative plagioclase composition	An 48	An 43	An 38	An 40	An 45	An 46	An 39	An 37
Normative color index	30.49	28.35	9.86	10.60	15.75	13.49	12.37	9.13

[a]Rapid rock technique by Skyline Labs., Wheatridge, CO.
[b]Explanation of column headings:
1 - Field No. 75WG9. Alkali-olivine basalt.
2 - Field No. JD71-74. Alkali-olivine basalt.
3 - Field No. 75WG8. Hornblende andesite flow.
4 - Field No. JD66A-74. Two-pyroxene andesite matrix in volcanic breccia.
5 - Field No. JD 66B-74. Two-pyroxene andesite tuff.
6 - Field No. JD70-74. Hornblende andesite tuff.
7 - Field No. 76WG107. Hornblende andesite from Gorge Creek.
8 - Field No. 76JD-69. Granodiorite of Mount Eielson.

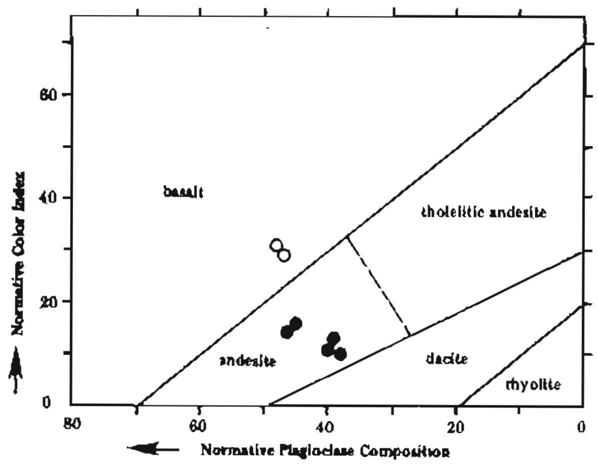

Figure 8. Plot of normative color index versus normative plagioclase composition for seven rocks from the Mount Galen Volcanics. Basalts are indicated by open circles, andesites by solid dots. Boundary lines after Irvine and Baragar (1971).

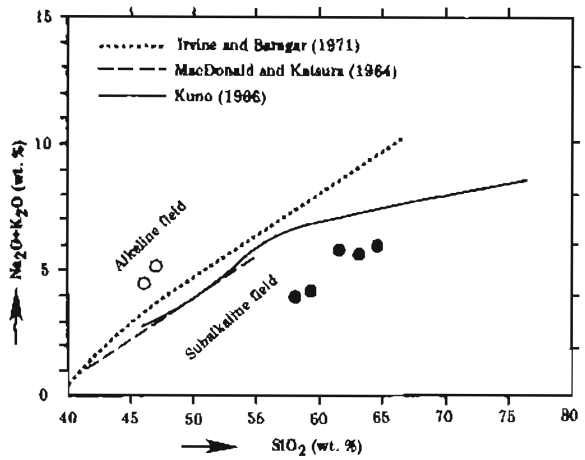

Figure 9. Alkali-silica diagram with seven rocks from Mount Galen Volcanics, showing three different alkaline-subalkaline dividing lines. Basalts are indicated by open circles, andesites by solid dots.

A layered sequence of porphyritic hornblende andesite and porphyritic hornblende dacite in the Gorge Creek area is probably part of the Mount Galen Volcanics. These rocks were mapped by Reed (1933) and Reed, Jr. (1961) as porphyritic granodiorite. Hornblende from a porphyritic hornblende andesite in Gorge Creek yields a K-Ar age of 37.7 ± 1.1 m.y. (fig. 1; table 2).

The Mount Galen Volcanics are probably genetically related to nearby plutonic rocks. On the north side of Mount Eielson, equigranular hornblende-biotite granodiorite of the Mount Eielson pluton intrudes and incorporates porphyritic rocks similar to those found in Gorge Creek. Co-existing biotite and hornblende from the Mount Eielson granodiorite yield concordant K-Ar ages of 37.9 ± 1.1 and 37.6 ± 1.1 m.y., respectively (fig. 1, table 2). The Mount Eielson pluton is probably a continuation of the larger Foraker and McGonagall plutons to the southwest (Reed and Lanphere, 1974). These three plutons are virtually indistinguishable on the basis of age, petrology, and major oxide chemistry. Five samples from the Foraker pluton and three samples from the McGonagall pluton yield K-Ar hornblende

Table 2. *Analytical data for K-Ar age determinations.*[a]

Map No.	Sample	Rock type	Mineral dated	K_2O (wt %)	Sample weight (g)	$^{40}Ar_{rad}$ (moles/gm) X 10^{-11}	$^{40}Ar_{rad}$/^{40}K X 10^{-2}	$^{40}Ar_{rad}$/^{40}Ar total	Age ± 1σ (m.y.)
1	75WG8	Andesite	Plagioclase	0.0205	3.5738	1.229	2.373	0.652	40.1 ± 1.2
			Hornblende	0.391	3.5285	2.214	2.245	0.554	38.0 ± 1.1
2	75WG9	Basalt	Plagioclase	0.279	3.3773	1.412	2.007	0.734	34.0 ± 1.4 (min. age)
	75WG9 (replicate)		Plagioclase	0.279	3.773	1.444	2.052	0.743	34.8 ± 1.4 (min. age)
3	75WG19	Basalt	Plagioclase	0.209	3.2529	1.209	2.284	0.481	38.6 ± 1.2 (min. age)
4	76WG110	Basalt	Plagioclase	0.284	4.0713	1.366	1.904	0.586	32.3 ± 1.0 (min. age)
5	76JD59	Granodiorite	Biotite	8.209	1.0736	46.438	2.239	0.871	37.9 ± 1.1
	76JD59	Granodiorite	Hornblende	0.463	1.7119	2.596	2.222	0.271	37.6 ± 1.1
6	76WG107	Andesite	Hornblende	0.390	1.5680	2.197	2.230	0.435	37.7 ± 1.1
7	(Age from hornblende separate from hornblende andesite flow reported by Gilbert, 1976.)								43.2 ± 2.6

[a]Constants used in age calculations:
$\lambda_\epsilon = 0.585 \times 10^{-10}$/yr.
$\lambda_\beta = 4.72 \times 10^{-10}$/yr.
$^{40}K/K_{total} = 1.19 \times 10^{-4}$ mol./mol.

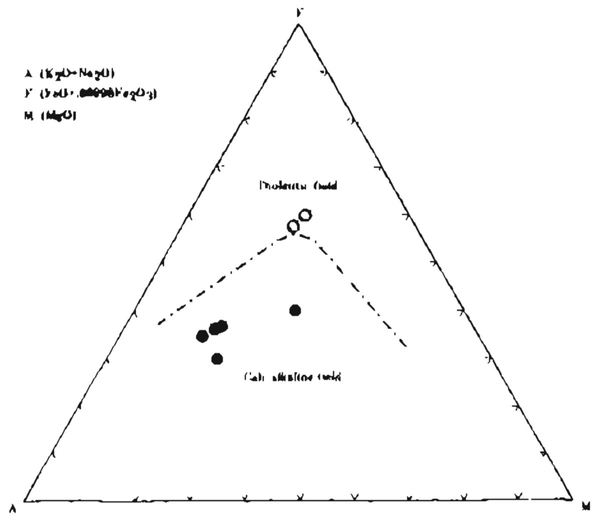

Figure 10. AFM diagram with seven rocks from Mount Galen Volcanics. Dividing line after Irvine and Baragar (1971). Basalts are indicated by open circles, andesites by solid dots.

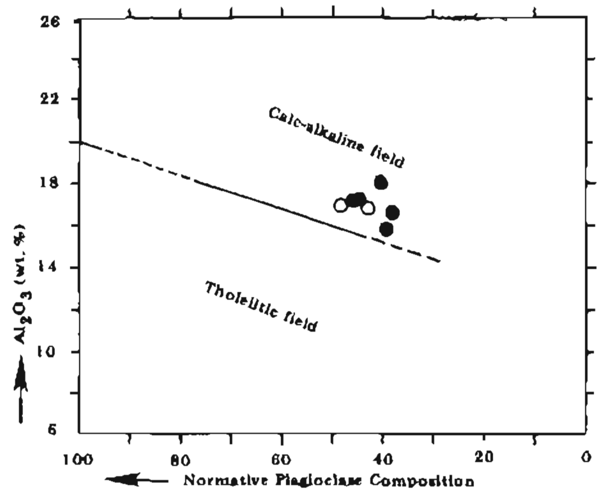

Figure 11. Al_2O_3 - normative plagioclase diagram after Irvine and Baragar (1971) showing seven volcanic rocks from Mount Galen Volcanics. Basalts are indicated by open circles, andesites by solid dots.

ages ranging from 35.2 ± 1.4 m.y. to 38.8 ± 1.6 m.y. with concordant or slightly discordant ages on coexisting biotite (Reed and Lanphere, 1974).

CONCLUSION

The Mount Galen Volcanics is probably the extrusive manifestation of the first of two middle Tertiary plutonic events (40 to 34 m.y. ago) defined by Reed and Lanphere (1973) from the Alaska-Aleutian Range Batholith to the southwest. To the east in the central Alaska Range, Wilson and Turner (1975) have reported additional middle Tertiary plutonic rocks in the 40- to 30-m.y. interval. Taken together, these volcanic and plutonic rocks constitute an upper Eocene-lower Oligocene magmatic arc extending from the Alaska Peninsula through the central Alaska Range. This arc roughly parallels the southern Alaska continental margin and is probably genetically related to the subduction of the Pacific or Kula plates.

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