Preliminary geologic map of the northeast Dillingham quadrangle (D-1, D-2, C-1, and C-2), Alaska

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Introduction

This map and associated digital databases result from field mapping directed mainly towards bedrock conducted in September 2000 and August 2001. Surficial deposits are mapped largely from photo interpretation aided by limited ground observations. This map was produced as part of a larger compilation effort covering the Dillingham, Taylor Mountains, Lake Clark and Iliamna quadrangles. Previous work in the area is limited; J.N. Platt and E.L. Muller (1957?) prepared an unpublished draft photogeologic interpretation of the Dillingham quadrangle in the mid-1950's. Although some fieldwork was part of their effort, there is no information available to indicate whether either author actually set foot in this map area. Wallace and others (1989) collected dating samples from two of the igneous bodies in the area as part of a regional reconnaissance. Our map area covers roughly 2,350 sq km (900 sq mi); encompasses 4 1:63,360-scale quadrangles in southwestern Alaska and represents approximately 3 weeks of field effort.

Regional geology

The map area lies in a transition zone between the Mesozoic magmatic arc-related geology of the Alaska-Aleutian Range on the east and the accretionary terranes of southwest Alaska to the west. The Alaska-Aleutian Range east of the map area consists of largely Mesozoic rocks equivalent stratigraphically and in lithologic character to the Wrangellia terrane (Jones and others, 1977) of south central Alaska. Included is the Tlikakila Complex of Wallace and others (1989), the Triassic Cottonwood Bay and Chilikradrotna Greenstones and the Triassic Kamishak Formation (limestone and chert). These are intruded and overlain by rocks of the Alaska Peninsula terrane (Wilson and others, 1985) consisting of the Alaska-Aleutian Range batholith, the Talkeetna Formation and younger Jurassic and early Cretaceous sedimentary rocks. Intruding these rocks are middle Cretaceous (~90 Ma) and Late Cretaceous-Early Tertiary (60-70 Ma) plutonic rocks. Finally, volcanic rocks of middle Tertiary (30-45 Ma) and latest Tertiary to Holocene volcanic rocks of the present-day- and paleo-Aleutian magmatic arcs form the highest stratigraphic units.

West of the map area, the geology is not as well-defined. In the northwest Dillingham quadrangle, Mesozoic and Paleozoic volcanic and sedimentary rocks are chaotically mixed in a unit traditionally mapped as the Gemuk Group and having many characteristics of a mega-scale tectonic melange. This is in part overlapped from the north by rocks of the early Late Cretaceous Kuskokwim Group, a thick flysch sequence extensively distributed in southwest Alaska. South of the Gemuk Group exposures, the rocks consist of a poorly defined Jurassic and Cretaceous mixed volcanic and sedimentary package (unit KJvs of Hoare and Coonrad, 1978 and this map), succeeded farther south by rocks of the Late Jurassic graywacke of Kulukak Bay (unit Jk of Hoare and Coonrad, 1978 and Jkw of this map). These rocks of the western Dillingham quadrangle are, similarly to the Alaska-Aleutian Range rock units, all intruded by Late Cretaceous to earliest Tertiary (60-70 Ma) granitic plutonic rocks.

Surficial deposits of the region consist of the deposits of two glacial source areas, the Cordilleran ice sheet of the Alaska-Aleutian Range and the separate ice mass of the Ahklun

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[1] Cover photograph by M.L. Miller, U.S. Geological Survey

Mountains (Briner and Kaufman, 2000; Manley and others, 2001; Kaufman and others, 2001). Glacial advances from both of these source areas advanced toward the map area, with the earliest and most extensive glaciations from the east actually overrunning all but the highest parts of the map area. These events have left a rich tableau of surficial deposits, largely unmapped except through photo interpretation. Surficial mapping of the adjacent Iliamna quadrangle by Detterman and Reed (1973) and the photogeologic interpretation by Platt and Muller (1957?) provided a basis upon which surficial deposits are shown in the map area. The southern part of our map area consists of the type area for the Kvichak advance of the Brooks Lake (late Wisconsin) glaciation (Detterman, 1986).

Analytical data

Major- and trace-element chemical analyses and radiometric dates are important in helping us establish the map units, particularly the plutonic rock units of this map area. Major-element chemical analyses were by Joe Taggert and trace-element analyses were by Dave Siems of the USGS in Denver using methodology described in Arbogast (1996) and Taggert (2002). ^{40}Ar-^{39}Ar age analyses were completed by Alex Iriondo and Mick Kunk of the USGS in Denver. Full analytical data, as well as more detailed interpretations for both types of analyses will be released in companion publications. A note on the radiometric ages; both conventional K-Ar and ^{40}Ar-^{39}Ar analyses of plutonic rocks in southwestern Alaska have commonly yielded ages where co-existing hornblende is younger than biotite (see for example, Wilson, 1977; Wallace and others, 1989; and Iriondo and others, in press). A good explanation for this has not been developed. The occurrence is common enough that there may be some broad-scale regional process operating; however, what this process is has not been determined.

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Description of map units

Quaternary

Qs Undifferentiated surficial deposits—Mainly unsorted gravel, sand, and silt produced, deposited, and reworked by action of wind, water, glaciers, and frost, including solifluction. Locally subdivided into:

Qa Alluvium—Mainly gravel and sand, consists in part of glacial and glaciofluvial material reworked by postglacial streams. Forms floodplains along major streams and rivers

Qaf Alluvial fan deposits—Gravel, sand, and silt, commonly deposited at mouth of small tributary canyons to main drainages. Includes some colluvial deposits

Qc Colluvial deposits—Chiefly rubble, gravel, sand, silt, and clay. Consists of talus and other slope debris deposits, also includes alluvium of minor streams, and locally glacial, rock glacier, and mass-wasting deposits. May include older glacial drift and locally grades into glacial deposits

Qls Landslide deposits—Chiefly rubble, gravel, sand, silt, and clay. Mapped chiefly through airphoto interpretation

Qt Terrace deposits—Gravel, sand, and silt underlying terraces adjacent to and above modern floodplains. Largely mapped through air photo interpretation

Qt2 Older terrace deposits—Gravel, sand, silt underlying higher-level terraces above younger terraces on modern floodplains. Largely mapped through air photo interpretation

Qac Abandoned channel deposits—Consist of gravel, sand, and silt originally deposited as alluvium. Abandoned channel landforms indicate drainage routes resulting from the melting of massive Pleistocene glaciers. Cut older surficial deposits and commonly the landforms contain small lakes or underfit streams. Largely mapped through air photo interpretation

Ql Lacustrine deposits—Well-sorted, well-stratified clay, silt, and fine sand deposited in ephemeral glacial and postglacial lakes. Typically covered by several feet of muck and peat. Largely mapped through air photo interpretation

Qsw Swamp deposits—Silt, sandy silt, and bog deposits, interpreted from air photos. May in part represent old lake beds

Qd Eolian sand—Well-sorted sand, forming active and stabilized dunes on outwash plains and raised beaches

Qsf Solifluction deposits—Solifluction mantle, interpreted from air photos. Based on the characteristics of solifluction deposits elsewhere, probably consist of poorly sorted rock rubble, gravel, sand, silt, clay, and organic deposits derived from local upslope sources

Qm Glacial deposits—Undifferentiated glacial and related deposits consisting of silt, sand, gravel, and boulders. Includes end and recessional moraine deposits as well as ground moraine. Also, locally includes colluvium and talus, landslide debris, alluvium, and wind-blown silt. Locally subdivided into:

Qmrg Active and recently active rock glaciers—Chiefly rubble and coarse rock debris, interpreted from air photos

Qme Esker deposits—Sand and gravel deposited in sinuous ridges, typically associated with older glacial deposits, interpreted from air photos

Qmc Till, cirque glaciations—Consist of unsorted boulder to clay-size particles. Moraine forms locally present, restricted to or just outside of cirques. These deposits primarily reflect glaciers of Holocene and latest Wisconsin age. No age control is available

Qmbu Undifferentiated glacial deposits of the Brooks Lake glaciation (Detterman, 1986) of Late Wisconsin age—Includes morainal deposits of all types. In the southeastern part of the map area, largely consists ground moraine behind (up-glacier) of the Kvichak glacial limit. Deposits tend to be low relief and marked by large remnant lakes. Locally subdivided into:

Qmbk Brooks Lake, Kvichak moraine—End moraine of the Kvichak advance (Detterman and Reed, 1973) of the Brooks Lake glaciation. On the surface, consists of wind-winnowed lag deposits of well-rounded pebbles and cobbles. Small kettle lakes are common and there is a prominent transition outward to outwash deposits. The southeastern part of map area is the type area of this advance surrounding Iliamna Lake. Another small area of deposits occurs in the northeast corner of the map area

Qmbo Outwash deposits of the Brooks Lake glaciation—Stratified gravel and sand of outwash aprons and plains of the Brooks Lake glaciation outboard of the Kvichak glacial limit. Forms graded, typically well-drained surfaces of low relief

Qmm Glacial deposits of the Mak Hill glaciation—Glacial moraine deposits immediately outboard of the Kvichak advance. Consists of a number of prominent end moraine deposits and limited ground moraine. Limited morphological evidence suggests multiple advances may be associated with the Mak Hill glaciation. Similar evidence is found on the southern Alaska Peninsula northeast of Cold Bay (Wilson and others, 1997). Largely consists of end moraine deposits, composed chiefly of gravelly till of the Mak Hill glaciation (Platt and Muller, 1957?). Age control is lacking; Detterman (1986) reports a radiocarbon date suggesting a minimum age of 40 ka for deposits on the Alaska Peninsula. Locally subdivided into:

Qmmg Ground moraine of the Mak Hill glaciation—Ground moraine; includes some organic and lacustrine material

Qmmo Outwash deposits of the Mak Hill glaciation—Stratified gravel and sand of outwash aprons and plains. May include ground moraine of older glacial advances

Qmu Glacial deposits of an unnamed glaciation of Platt and Muller (1957?)—Consists of ground moraine and subtly developed end moraine. Composed chiefly of glacial and glaciofluvial materials. Extensively mantled by colluvium, silt, muck, and peat. Morainal topography, where recognizable is subdued and modified by subsequent erosion

Qmuo Outwash deposits of an unnamed glaciation of Platt and Muller (1957?)—Stratified gravel and sand of outwash aprons

Bedrock deposits

bu Possible bedrock of unknown character—Shown in a small area along the Stuyahok River that interpretation of air photos suggests may be bedrock

Sedimentary rocks

Cretaceous

Kk Kuskokwim Group—Well-bedded, rhythmically interbedded dark siltstone and sandstone. Found only north of the Koktuli River in the northern part of the map area

Early Cretaceous (?) to Middle Jurassic (?)

KJvs Volcanic and sedimentary rocks—Low-grade metamorphic or contact metamorphosed volcanic and lesser sedimentary rocks. Altered volcanic breccia is relatively abundant; however in the southwestern part of T.4 S., R.40 W., unit consists largely of vertically standing beds of contact-metamorphosed shale, siltstone, and lesser sandstone. In its southwestern outcrop area, locally includes unaltered fragmental volcanic rocks. Contact metamorphism evidenced in outcrop by recrystallization where weathered surfaces show textures and structures but fresh surfaces appear aphanitic. In thin-section, mafic minerals are largely replaced by chlorite and feldspars are altered in part to sericite. Inferred to correlate with a thick marine unit (KJvs) consisting of volcanic and sedimentary rocks mapped by Hoare and Coonrad (1978) in the western Dillingham and adjacent Goodnews Bay quadrangles. According to Hoare and Coonrad (1978), "the volcanic rocks range in composition and type from mafic pillow basalts to more abundant andesitic and trachytic flows, tuff, and breccia. Interbedded with the volcanic rocks are tuffaceous siltstone, tuffaceous chert, and massive or thin-bedded argillite." Radiolaria of Late Jurassic to Early Cretaceous age and fragmentary ammonites of Jurassic age have been collected from this unit in the Goodnews Bay quadrangle to the west (Hoare and Coonrad, 1978)

Middle to Late Jurassic(?)

Jkw Graywacke and conglomerate—Typically dark-green or gray massive sandstone, although coarse-pebble conglomerate is locally present. Rare fragmentary fossils are found within map area; a sample we collected in 2001 yielded fragments of *Buchia*, suggesting a Late Jurassic or Early Cretaceous age (fossil report by Robert B. Blodgett, 2002). These rocks are correlated with a thick marine sedimentary unit referred to as the "Weary graywacke" by Hoare and others (1975) and later referred to as the "Graywacke of Kulukak Bay" by Hoare and Coonrad (1978). This unit is widely exposed in the southern Goodnews Bay and the Nushagak Bay quadrangles as well as the southeastern Dillingham quadrangle (Hoare and Coonrad, 1978). Rocks in the map area correlated with this unit are also correlated with unit KJs of the adjacent Iliamna quadrangle (Detterman and Reed, 1980). In the Goodnews Bay and Nushagak Bay quadrangles, *Buchia*, *Inoceramus*, belemnites, and rare ammonite fragments ranging from Middle to early Late Jurassic age have been found. A report of

Jurassic(?) fossils found by Unocal in 1959 in the map area appears to have erroneous sample locations; these samples actually appear to have come from a part of the Taylor Mountains quadrangle, immediately north of the map area

Igneous rocks

Volcanic rocks

Tertiary

Tvu Volcanic rocks, undivided—Andesite, dacite, and basalt lava flows, tuff, lahar deposits, volcanic breccia, and hypabyssal intrusions. Age determinations range from approximately 41 to 54 Ma (Table 1), indicating these rocks represent a distinct event, separate in time from the plutons and "ignimbrite." In part mapped based on photo correlation with areas of known volcanic rocks of unit Tv of Detterman and Reed (1980) having similar outcrop and erosion patterns. Locally subdivided into:

Tva Andesite plug—Small andesite plug that has intruded contact metamorphosed siltstone just south of the Koktuli River (sec. 1, T.3 S., R. 40 W.). (The contact metamorphism of the siltstone is not associated with this plug and appears to be associated with an earlier nearby pluton, the alaskite of unit TKga.) Also includes an isolated andesitic plug in southeast corner of the D-1 quadrangle (T.5 S., R.40 W.). ^{40}Ar-^{39}Ar isochron age on this isolated plug was 47.93 +/- 1.39 Ma

Tvf Felsic hypabyssal rocks—Occur as dikes and small plugs. In the valley of Pike Creek, unit consists of porphyritic, quartz-eye and feldspar phenocrystic felsic rocks that are variably hydrothermally altered. In general, unit appears to represent the roof area of plutons of the map area. Only the larger of scattered occurrences of felsic hypabyssal rocks are shown

Tertiary, Eocene and older?

Tmv Volcanic rocks, undivided, basalt and andesite—Dark-gray to green, glassy to porphyritic basaltic andesite and andesite lava flows. The unit description is inferred from the adjacent Iliamna quadrangle geologic map (Detterman and Reed, 1980) and rocks of this unit are only present on the extreme eastern edge of our map area in the southern part of T.3 S., R.39 W. Most likely correlative, in part, with volcanic rock units below:

Ttv Tuffaceous felsic volcanic rocks—Cream, light-gray, and green layered, tuffaceous volcanic rocks. Exposed in the northern part of the map area on both sides of the Koktuli River. Rocks are distinctive relative to other nearby volcanic rocks of units KJvs and KJmv in not showing evidence of contact metamorphism

Bimodal volcanic suite, subdivided into:

Tbb Olivine basalt—Massive columnar-jointed olivine basalt flows part of a bimodal volcanic sequence in the area east of the Stuyahok Hills. The sequence consists of interlayered basalt flows and felsic tuff. Flows range from 3 to 10 m thick. Basalt yields ^{40}Ar-^{39}Ar ages of about 44 Ma (Table 1). SiO_2 content is approximately 48 to 49 percent (dry)

Tbr Rhyolitic and dacitic tuff—Distinctive light colored horizons of felsic tuff interlayered with olivine basalt in the Stuyahok Hills. Tuff composed largely of altered glass and very fresh phenocrysts of plagioclase. Tuff layers approximately 10 to 30 m thick. Age (^{40}Ar-^{39}Ar) is approximately 44 Ma (Table 1). SiO_2 content is approximately 75 percent (dry)

Tob Older olivine basalt—Massive columnar jointed olivine basalt flows in the southwestern D-1 quadrangle (T.4 S., R.41 W.); overlies alaskite (unit TKga) and graywacke of probable Jurassic age (unit Jkw). Lithologically identical to rocks of unit Tbb. Unit appears to be overlain by contact-metamorphosed rocks of unit KJvs; we suggest that locally, the unit may be a shallow sill rather than flows to explain this unusual outcrop pattern. ^{40}Ar-^{39}Ar isochron age is 53.70 +/- 0.62 Ma. SiO_2 content is approximately 48 to 49 percent

Tertiary, Paleocene

Tig Ignimbrite—Crystal tuff containing variable amounts of biotite and feldspar crystals in a tuffaceous matrix. Unit is widespread in the western Stuyahok Hills and varies in texture from fine-grained porphyritic tuff to coarse-grained, crystal-rich tuff. The proportion of tuffaceous groundmass seems to decrease east to west. Wallace and others (1989) report a K-Ar age of 57.9 +/- 1.7 (hornblende) and 58.6 +/- 1.8 (biotite) for this unit. New ^{40}Ar-^{39}Ar age determinations (table 1) on biotite indicate a tight age range between 59.25 +/- 0.05 and 59.69 +/- 0.05 Ma

Cretaceous or Jurassic?

KJvm Olivine basalt flows and fragmental mafic volcanic rocks—Ranges in apparent composition from andesite to basalt based on field calls. Locally distinguished part of unit KJvs above. Contact metamorphosed

Triassic (?)

Trv Mafic igneous rocks—Fine-grained, mildly altered basaltic volcanic rocks. Unit is exposed in a small area of outcrop in the extreme northeastern corner of map area and extends westward. Age inferred based correlation with Chilikradrotna Greenstone of Wallace and others (1989) and Cottonwood Bay Greenstone of Detterman and Reed (1980). SiO_2 content is about 45 percent

Plutonic rocks

Tertiary and Cretaceous

Granitic rocks, undivided—Fine-, medium-, and coarse-grained, light- to dark-gray, rarely pink granitic rocks. Chiefly granite, quartz monzonite, and quartz monzodiorite. In general, alkali content of these rocks is high relative to normal for their SiO_2 content (LeMaitre, 1976). K-Ar and ^{40}Ar-^{39}Ar ages range from 61 to 67 Ma. Virtually all of the plutonic rocks of the map area fall on a common chemical trend; as they are of generally similar age, we suggest that they may represent a single magmatic system. Subdivided into:

TKgs Granitic rocks of the eastern Stuyahok Hills—Largely medium- to coarse-grained, light-gray to pinkish biotite monzogranite. Large pluton widely exposed in the eastern part of the Stuyahok Hills. Typically contains large (2cm) phenocrysts of potassium feldspar (orthoclase). Biotite is dominant mafic mineral; biotite to hornblende ratio is approximately 3:1. A number of thin sections show disequilibrium mineral assemblages suggesting formation by interaction of a granitic melt with a great deal of included material. K-Ar ages reported by Wallace and others (1989) are 61.2 +/- 1.8 Ma (biotite) and 54.5 +/- 1.6 Ma (hornblende, minimum age). Ten newly determined ^{40}Ar-^{39}Ar ages on biotite are tightly grouped between 60.90 +/- 0.04 and 61.70 +/- 0.06 Ma and an ^{40}Ar-^{39}Ar hornblende is 60.06 +/- 0.25 Ma. Based on chemistry, rocks of this pluton cluster about the intersection of the quartz monzonite, monzogranite, granodiorite, and quartz monzodiorite fields of Streckeisen (1975); however, visually estimated modes place the rock unit primarily in the monzogranite field

TKge Eastern granitic rocks—Hornblende quartz monzonite. Texturally similar to the granitic rocks of the eastern Stuyahok Hills in having large (2 cm) feldspar phenocrysts, however hornblende is the more common mafic mineral in these rocks. An ^{40}Ar-^{39}Ar age of 61.3 +/- 0.2 Ma on hornblende is coeval with the granitic rocks of the eastern Stuyahok Hills and with some parts of the Pike Creek pluton

Plutons of the Pike Creek area. A large complex of granite to monzodiorite plutons, widely distributed in the hills in the southcentral part of the D-1 quadrangle. Subdivided into:

TKpnw Northwestern unit—Medium-grained, light-gray hornblende-biotite monzogranite to quartz monzodiorite. Locally contains large phenocrysts of orthoclase; biotite to hornblende ratio approximately 2:1. Two major element chemical analyses have 67.8 and 68.2 percent SiO_2. ^{40}Ar-^{39}Ar biotite ages are 65.72 +/- 0.04 and 66.49 +/- 0.07 Ma

TKpsw Southwestern unit—Medium- to coarse-grained, light-gray biotite monzogranite or quartz monzodiorite. Equigranular and contains more pyroxene than unit TKpnw. Clinopyroxene, some of which contains pinkish orthopyroxene cores is common in some samples, whereas others have no pyroxene but contain sodic amphibole. Minor development of string perthite texture in orthoclase. Two major element chemical analyses have 61.5 and 61.9 percent SiO_2. ^{40}Ar-^{39}Ar biotite ages are 61.11 +/- 0.07 and 61.67 +/- 0.05 Ma

TKpe Eastern unit—Medium-grained, light-gray biotite monzogranite to quartz monzonite. Hornblende to biotite ratio approximately 6:4; may contain orthoclase phenocrysts and hornblende may have relict clinopyroxene cores. Major element chemical analysis indicates 63.2 percent SiO_2 and very high K_2O (4.70 percent). Separated from the western units of pluton complex by an inferred fault. ^{40}Ar-^{39}Ar biotite age of 63.09 +/- 0.05 Ma

TKpd Monzodioritic rocks of Pike Creek—Largely medium-grained quartz monzodioritic and dioritic rocks in the southeast D-1 quadrangle. Rocks are typically dark green, have sparse biotite and abundant amphibole and clinopyroxene, and locally show evidence of contact metamorphism. SiO_2 content ranges between 57.4 and 61.4 percent; as with other rocks in this region, alkalis tend to be higher that normal for rocks of this silica content (LeMaitre, 1976). ^{40}Ar-^{39}Ar age on biotite of 64.42 +/- 0.04 Ma and on hornblende of 61.1 +/- 0.7 Ma. The hornblende age is essentially the same as the surrounding monzogranite and quartz monzodiorite. As the surrounding rocks show no evidence of contact metamorphism, this hornblende age should be considered a minimum or suspect

TKgn Northern pluton—Medium-grained biotite monzogranite to syenogranite found in the mountains immediately south of the Koktuli River. Biotite is the only mafic mineral and orthoclase has moderate development of string perthite. SiO_2 of analyzed samples has a narrow range of 65.5 to 65.7 percent and K_2O is relatively high (>4.80 percent) relative other plutons in the map area. ^{40}Ar-^{39}Ar ages range between 65.50 +/- 0.05 and 66.24 +/- 0.08 Ma on biotite. Chemistry suggests rock unit is high-potassium granodiorite, a number of samples are corundum normative

TKgm Granitic rocks and mixed hornfels and dikes—Fine-, medium-, and coarse-grained, light- to dark-gray, plutonic granitic rocks mixed with felsic dikes and contact metamorphosed volcanic or sedimentary rocks. Outcrop area is south of the Northern pluton, at much lower elevation, suggesting that it may indicate the roof area of another pluton. However SiO_2 (67.5 percent), K_2O (4.50 percent), and other characteristics, including age (^{40}Ar-^{39}Ar 65.26 +/- 0.06 Ma on biotite) are similar to the Northern pluton

TKgnw Northwest pluton—Porphyritic amphibole-bearing monzonite. Outcrops on isolated low-relief ridge south of the Koktuli River and west of the Northern pluton. Consists of plagioclase, amphibole (kaersutite?), and clinopyroxene phenocrysts in a fine-grained groundmass. SiO_2 content ranges from 63.6 to 64.1 percent on the two samples analyzed. Alkalis are consistently high at 7.32 to 7.48 percent. ^{40}Ar-^{39}Ar plateau age on amphibole is 63.76 +/- 0.27 Ma

TKga Alaskite—Coarse- to fine-grained white to off-white alaskite (or alkali-feldspar granite) consisting of white feldspar and smoky quartz. Mafic minerals and mica are exceedingly sparse in this large (7 km in diameter) body on the southwestern edge of the D-1 quadrangle. Where present, biotite appears late or secondary, rare amphibole is sodic, locally cyan-blue pleochroic. Smoky quartz and pegmatitic zones are common throughout unit. SiO_2 content is high, ranging from 74.8 to 75.4 percent. An ^{40}Ar-^{39}Ar age determination on biotite yielded 66.64 +/- 0.08 Ma whereas two plateau ages on potassium feldspar were 58.2 +/- 0.2 Ma, slightly older that the overlying olivine basalt (unit Tbo, 53.7 Ma) suggesting extended cooling or resetting associated with the volcanism

TKqd Monzonitic rocks—Coarse- to fine-grained monzogranitic to monzodioritic rocks in the southeast D-1 quadrangle. Rocks are typically dark green, have sparse clinopyroxene, and locally show evidence of contact metamorphism. Amphibole is the dominant mafic mineral and tends to be green pleochroic and partially altered to chlorite

Table 1 Radiometric ages

[All dates are ^{40}Ar-^{39}Ar total fusion ages unless otherwise noted. Abbreviations: bio = biotite, hbl = hornblende, plag = plagioclase, k-spar = potassium feldspar, iso = isochron, WR = whole rock matrix
* Section, Township, and Range for samples 82BB 421 and 422 from Wallace and others (1989)
K-Ar constants: $\lambda_{\varepsilon+\varepsilon'} = 0.581 \times 10^{-10}$/yr, $\lambda_\beta = 4.962 \times 10^{-10}$/yr, $^{40}K/K_{total} = 1.167 \times 10^{-10}$ mol/mol.]

Map number	Sample number	Rock unit	Rock type	Latitude (dec. º N) Longitude (dec. º W)*	Mineral	Age and error (Ma)	Source and notes
1	01AH 70	TKga	Alaskite	59.837, 156.351	bio	66.64 +/- 0.08	Iriondo and others, in press, emplacement age?
1	01AH 70	TKga	Alaskite	59.837, 156.351	k-spar plateau	58.2 +/- 0.2	Iriondo and others, in press, cooling age?
2	01AH 80	TKga	Alaskite	59.805, 156.377	k-spar plateau	58.2 +/- 0.2	Iriondo and others, in press, cooling age?
3	01AWs 60	Tbb	Basalt	59.601, 156.323	WR, iso	44.35 +/- 0.39	Iriondo and others, in press
4	01AWs 67	Tbb	Basalt	59.610, 156.310	WR, iso	44.45 +/- 0.42	Iriondo and others, in press
4	01AWs 67b	Tbr	Rhyolite	59.610, 156.310	Plag, iso	44.75 +/- 0.83	Iriondo and others, in press
5	00AWs 38	TKgs	Granite	59.606, 156.159	bio	61.15 +/- 0.04	Iriondo and others, in press
6	01AWs 24	TKgs	Granite	59.607, 156.321	bio	61.70 +/- 0.06	Iriondo and others, in press
7	01APc 18	TKgs	Granite	59.606, 156.223	bio	61.28 +/- 0.05	Iriondo and others, in press
8	01APc 20	TKgs	Granite	59.604, 156.254	bio	61.30 +/- 0.05	Iriondo and others, in press
9	01APc 23	TKgs	Granite	59.589, 156.240	bio	61.64 +/- 0.05	Iriondo and others, in press
10	01AWs 57	TKgs	Granite	59.618, 156.122	bio	61.57 +/- 0.06	Iriondo and others, in press
11	01AWs 80	TKgs	Granite	59.630, 156.190	bio	61.63 +/- 0.05	Iriondo and others, in press
12	01APc 25	TKgs	Granite	59.579, 156.240	bio	61.26 +/- 0.05	Iriondo and others, in press
13	01AWs 59	TKgs	Granite	59.581, 156.332	bio	61.65 +/- 0.05	Iriondo and others, in press
14	01AWs 78	TKgs	Granite	59.566, 156.263	bio	60.90 +/- 0.04	Iriondo and others, in press
15	82BB 421	TKgs	Granite	Sec. 3, T.7S., R. 41W.	K-Ar, bio	61.15 +/- 1.8	Wallace and others (1989)

Table 1 Radiometric ages (cont.)

Map number	Sample number	Rock unit	Rock type	Latitude (dec. ° N) Longitude (dec. ° W)*	Mineral	Age and error (Ma)	Source and notes
15	82BB 421	TKgs	Granite	Sec. 3, T.7S., R. 41W.	K-Ar, hbl	54.5 +/- 1.6	Wallace and others (1989), minimum age
16	01AWs 39	TKgs	Quartz monzonite	59.726, 156.204	bio	61.10 +/- 0.09	Iriondo and others, in press
16	01AWs 39	TKgs	Quartz monzonite	59.726, 156.204	hbl, plateau	60.06 +/- 0.25	Iriondo and others, in press
17	01AH 63	TKgm	Hypabyssal dacite	59.870, 156.165	bio	65.26 +/- 0.06	Iriondo and others, in press
18	00AWs 16	Tig	Dacite tuff	59.675, 156.605	bio	59.69 +/- 0.05	Iriondo and others, in press
19	01AM 109a	Tig	Dacite tuff	59.691, 156.531	bio	59.25 +/- 0.05	Iriondo and others, in press
20	01AWs 61	Tig	Dacite tuff	59.608, 156.395	bio	59.34 +/- 0.03	Iriondo and others, in press
21	82BB 422	Tig	Dacite	Sec. 21, T. 6S., R. 42W.	K-Ar, hbl	57.9 +/- 1.7	Wallace and others (1989)
21	82BB 422	Tig	Dacite	Sec. 21, T. 6S., R. 42W.	K-Ar, bio	58.6 +/- 1.8	Wallace and others (1989)
22	01AH 62	TKgn	Quartz monzonite	59.900, 156.198	bio	65.75 +/- 0.03	Iriondo and others, in press
23	01AWs 46	TKgn	Quartz monzonite	59.898, 156.193	bio	66.24 +/- 0.08	Iriondo and others, in press
24	01AH 59	TKgn	Quartz monzonite	59.914, 156.182	bio	65.50 +/- 0.05	Iriondo and others, in press
25	01AWs 2	TKgnw	Monzonite	59.891, 156.250	hbl, plateau	63.76 +/- 0.27	Iriondo and others, in press
26	01AH 69	TKpd	Quartz diorite	59.804, 156.155	bio	64.42 +/- 0.04	Iriondo and others, in press
27	01AH 65	TKpd	Diorite	59.793, 156.143	hbl, iso	61.1 +/- 0.7	Iriondo and others, in press
28	00AWs 37	TKpe	Quartz monzonite	59.789, 156.088	bio	63.09 +/- 0.05	Iriondo and others, in press
29	01AWs 48	TKpnw	Quartz monzonite	59.842, 156.171	bio	65.72 +/- 0.04	Iriondo and others, in press
30	01AH 64	TKpnw	Monzogranite	59.822, 156.201	bio	66.49 +/- 0.07	Iriondo and others, in press
31	00AWs 35a	TKpsw	Quartz monzonite	59.778, 156.134	bio	61.67 +/- 0.05	Iriondo and others, in press
32	01AWs 50	TKpsw	Quartz monzonite	59.769, 156.133	bio	61.11 +/- 0.07	Iriondo and others, in press
33	01AH 67	TKge	Quartz monzonite	59.802, 156.028	hbl, plateau	61.3 +/- 0.2	Iriondo and others, in press
34	01AWs 55	Tob	Basalt	59.790, 156.298	WR, iso	53.70 +/- 0.62	Iriondo and others, in press
35	01AWs 49	Ta	Andesite	59.762, 156.011	WR, iso	47.93 +/- 1.93	Iriondo and others, in press