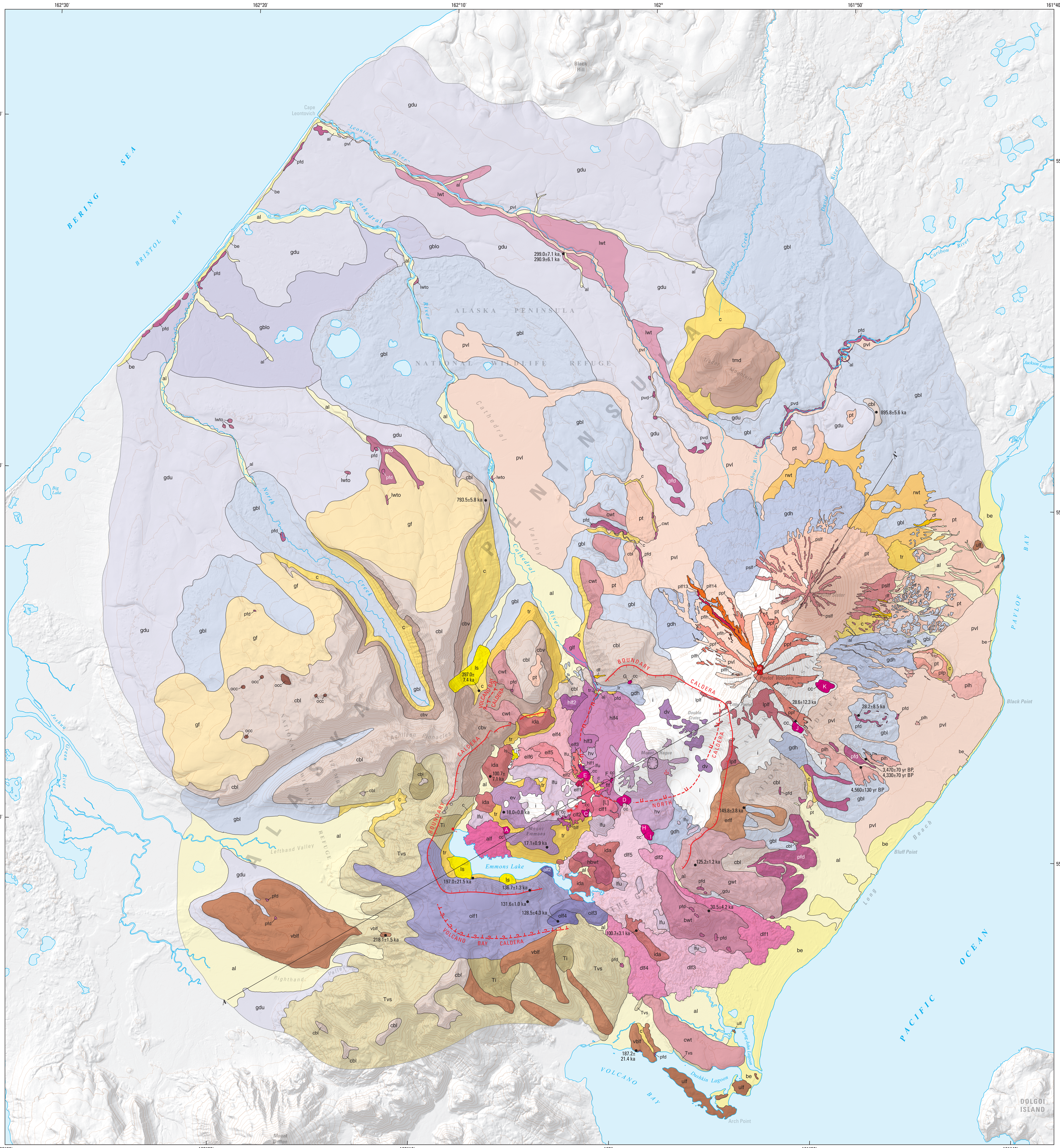
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3519
Pamphlet accompanies map



Shaded relief and contours from U.S. Geological Survey 10-meter digital data, 2019. Hydrography from U.S. Geological Survey National Hydrography Dataset

Universal Transverse Mercator projection, zone 4N

Shorelines and glacier outlines may not coincide with mapped unit boundaries because these features are dynamic and can differ from when units were mapped. Because these differences were considerable in places along the Pacific Coast, some shorelines there have been modified to match the mapping extent

TRUE NORTH — MAGNETIC NORTH 9½°
APPROXIMATE MEAN DECLINATION, 2026

SCALE 1:100 000
1 0 1 2 3 4 5 6 7 8 MILES
1 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS
CONTOUR INTERVAL 200 FEET
NORTH AMERICAN DATUM OF 1927

ALASKA
MAP LOCATION

Geology mapped by T.P. Miller, C.F. Waythomas, M.T. Mangan, F.A. Trusdell, A.T. Calvert, and C.J. Nye, 1999–2004; minor revisions, 2005–2017. Reconnaissance sampling and mapping by T.P. Miller, D.H. Richter, and M.E. Yount, 1986–1991. Potassium-argon geochronology by M. Lanphere from samples collected in 1974. Argon-argon geochronology by P. Layer and A.T. Calvert from samples collected in 1999–2004

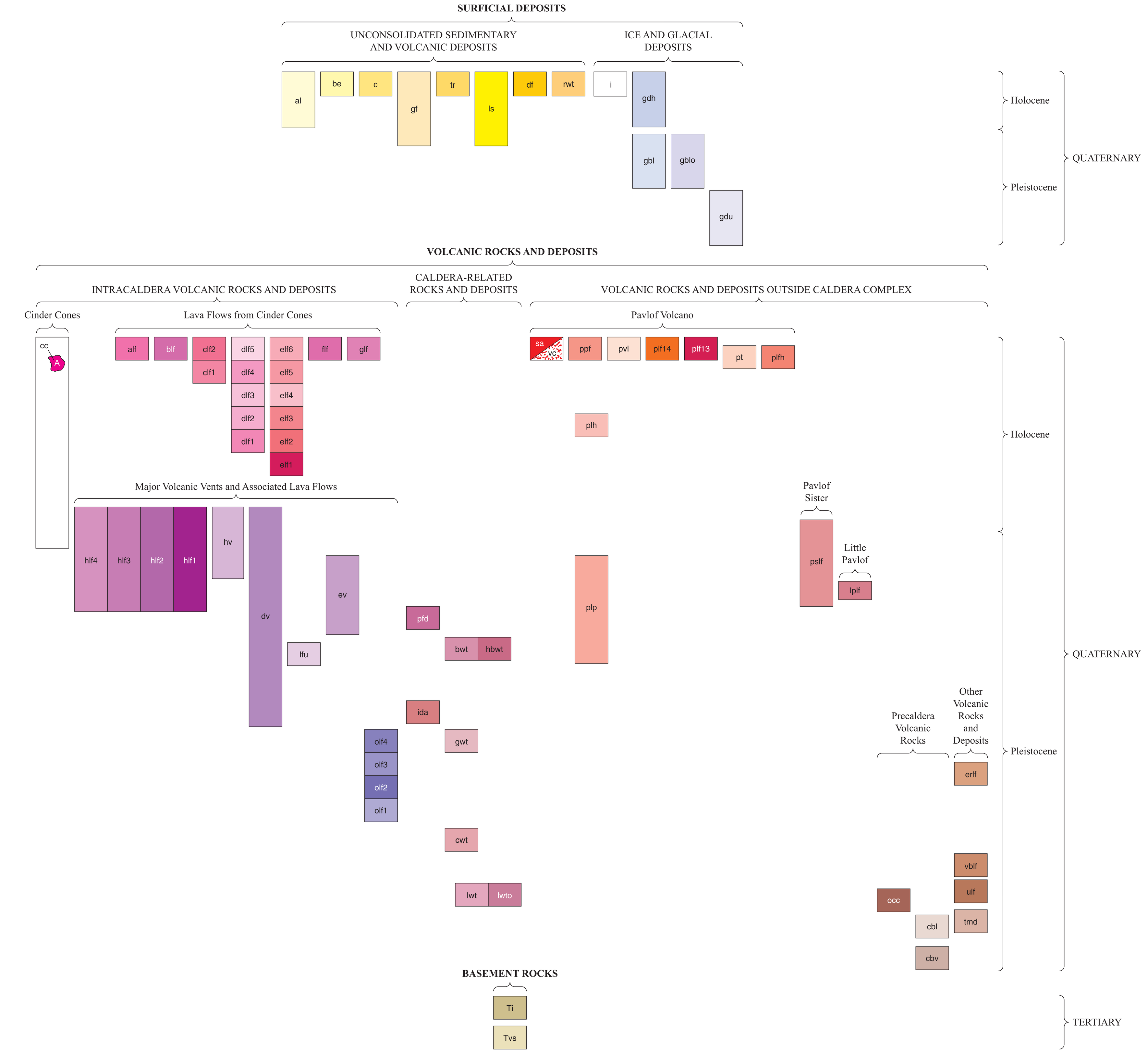
GIS database and digital cartography by E. Thoms and J. McIntire

Edited by Taryn A. Lindquist; digital cartographic production by Katie Sullivan

Manuscript approved for publication January 26, 2024

CORRELATION OF MAP UNITS

[Cinder cones on map are labeled with letters (for example, cone A is labeled "A"); approximate locations of cones outside of unit cc are indicated by letters in square brackets. See Description of Map Units (in pamphlet) for precise unit ages]



LIST OF MAP UNITS

[Cinder cones on map are labeled with letters (for example, cone A is labeled "A"); letters in square brackets are placed at approximate location of cone. See Description of Map Units (in pamphlet) for full unit descriptions]

SURFICIAL DEPOSITS

UNCONSOLIDATED SEDIMENTARY AND VOLCANIC DEPOSITS

- al — **Alluvial deposits (Holocene)**
- be — **Beach and eolian deposits, undifferentiated (Holocene)**
- c — **Colluvial and talus deposits, undifferentiated (Holocene)**
- gf — **Geliflucton deposits (Holocene and Pleistocene)**
- tr — **Talus and rockfall deposits, undifferentiated (Holocene)**
- ls — **Landslide deposits (Holocene and Pleistocene)**
- df — **Debris-flow deposits (late Holocene)**
- rwt — **Reworked tephra and slopewash deposits, undifferentiated (late Holocene)**

ICE AND GLACIAL DEPOSITS

- i — **Modern glacier ice (Holocene, modern)**
- gdh — **Young glacial drift (Holocene, modern)**
- gbl — **Drift of Brooks Lake glaciation (late Pleistocene)**
- gblo — **Outwash deposits of Brooks Lake glaciation (late Pleistocene)**
- gdu — **Older glacial drift (Pleistocene)**

VOLCANIC ROCKS AND DEPOSITS

INTRACALDERA VOLCANIC ROCKS AND DEPOSITS

Cinder Cones

- cc — **Cinder cones (Holocene to late Pleistocene)**—Letters identify cones

Lava Flows from Cinder Cones

- alf — **Cone A lava flow (Holocene)**
- blf — **Cone B lava flow (Holocene)**
- **Cone C lava flows (Holocene)**
  - clf2 — **Cone C lava flow 2**
  - clf1 — **Cone C lava flow 1**
- **Cone D lava flows (Holocene)**
  - dlf5 — **Cone D lava flow 5**
  - dlf4 — **Cone D lava flow 4**
  - dlf3 — **Cone D lava flow 3**
  - dlf2 — **Cone D lava flow 2**
  - dlf1 — **Cone D lava flow 1**
- **Cone E lava flows (Holocene)**
  - elf6 — **Cone E lava flow 6**
  - elf5 — **Cone E lava flow 5**
  - elf4 — **Cone E lava flow 4**
  - elf3 — **Cone E lava flow 3**
  - elf2 — **Cone E lava flow 2**
  - elf1 — **Cone E lava flow 1**
- flf — **Cone F lava flow (Holocene)**
- glf — **Cone G lava flow (Holocene)**

Major Volcanic Vents and Associated Lava Flows

- **Volcanic rocks of Mount Hague (early Holocene? to late Pleistocene)**
  - hlf4 — **Volcanic rocks of Mount Hague, subunit 4**
  - hlf3 — **Volcanic rocks of Mount Hague, subunit 3**
  - hlf2 — **Volcanic rocks of Mount Hague, subunit 2**
  - hlf1 — **Volcanic rocks of Mount Hague, subunit 1**
- hv — **Volcanic rocks and pyroclastic deposits of Mount Hague (early Holocene? to late Pleistocene)**
- dv — **Volcanic rocks and pyroclastic deposits of Double Crater (early Holocene? to late Pleistocene)**
- ev — **Volcanic rocks of Mount Emmons (late Pleistocene)**
- lfu — **Lava flows and pyroclastic deposits, undifferentiated with respect to source volcano (Pleistocene)**
- **Lava flows on south caldera rim (Pleistocene)**
  - olf4 — **Lava flow 4 on south caldera rim**
  - olf3 — **Lava flow 3 on south caldera rim**
  - olf2 — **Lava flow 2 on south caldera rim**
  - olf1 — **Lava flow 1 on south caldera rim**

CALDERA-RELATED ROCKS AND DEPOSITS

- pfd — **Rhyolite pyroclastic-flow deposits (late Pleistocene)**
- bwt — **Dacite rheomorphic tuff and agglutinate of "The Butte," undivided (late Pleistocene)**
  - hbwt — **Subglacial or subaqueous phase**
- ida — **Dacite to andesite lava domes, flows, coulees, and welded tuff (Pleistocene)**
- gwt — **Rhyodacite rheomorphic tuff, agglutinate, and ignimbrite of "The Gap" (late Pleistocene)**
- cwt — **Rhyolite rheomorphic tuff, agglutinate, and breccia of upper Cathedral River drainage (middle Pleistocene)**
- lwt — **Rhyolite welded tuff of "Leontovich River," undivided (middle Pleistocene)**
  - lwto — **"Otter Den" tuff subunit**

VOLCANIC ROCKS AND DEPOSITS OUTSIDE CALDERA COMPLEX

Pavlof Volcano

- sa — **Spatter, agglutinate, cinders, and ash of Pavlof Volcano summit (late Holocene)**
- vc — **Inferred volcanic conduit (late Holocene)**—Shown in cross section only
- ppf — **Pyroclastic-flow deposits of 2016 eruption of Pavlof Volcano (late Holocene)**
- pvl — **Lahar deposits of historically recorded eruptions of Pavlof Volcano (late Holocene)**
- plf14 — **Basaltic andesite lava flow of 2014 eruptions of Pavlof Volcano (late Holocene)**
- plf13 — **Basaltic andesite lava flow of 2013 eruption of Pavlof Volcano (late Holocene)**
- pt — **Tephra deposits of historically recorded eruptions of Pavlof Volcano (late Holocene)**
- plfh — **Clastogenic lava flows of historically recorded eruptions of Pavlof Volcano (late Holocene)**
- plh — **Basalt to andesite lava flows of Pavlof Volcano (Holocene)**
- plp — **Andesite lava flows of Pavlof Volcano (Pleistocene)**

Pavlof Sister

- pslf — **Basaltic andesite lava flows, breccia, and scoria of Pavlof Sister (Holocene to late Pleistocene)**

Little Pavlof

- lplf — **Basalt of Little Pavlof (Pleistocene)**

Precaldera Volcanic Rocks

- occ — **Basaltic andesite cinder cones (Pleistocene)**
- cbl — **Andesite of ancestral Mount Emmons (middle to early Pleistocene)**
- cbv — **Andesitic volcaniclastic rocks of ancestral Mount Emmons (middle to early Pleistocene)**

Other Volcanic Rocks and Deposits

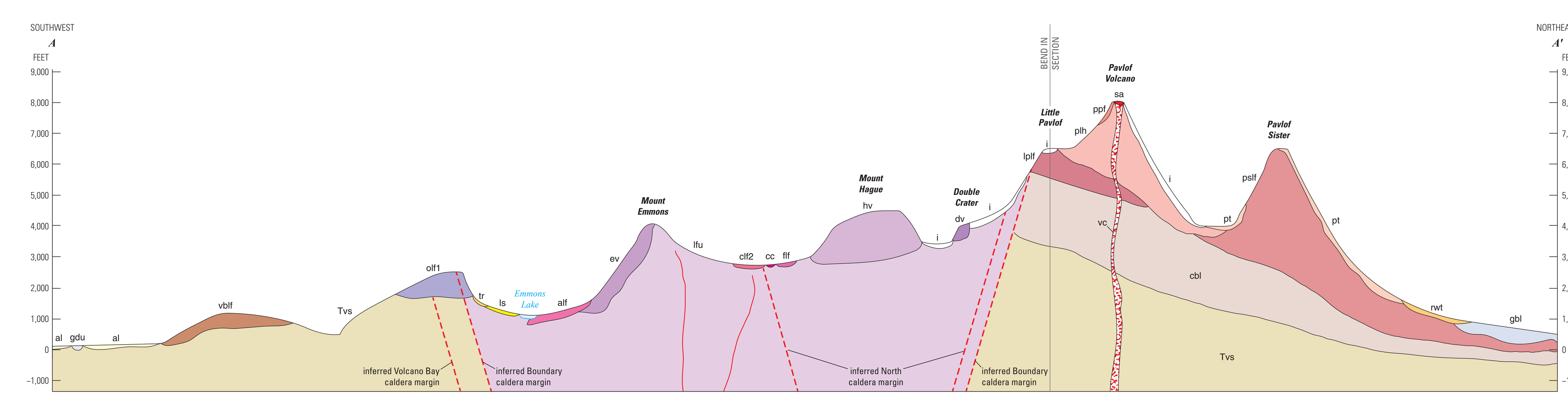
- erlf — **Andesite of east caldera rim (middle Pleistocene)**
- vblf — **Andesite of Volcano Bay area (middle? Pleistocene)**
- ulf — **Basalt and basaltic andesite lava flows (Pleistocene)**
- tmd — **Hypabyssal dacite of Trader Mountain (early Pleistocene)**

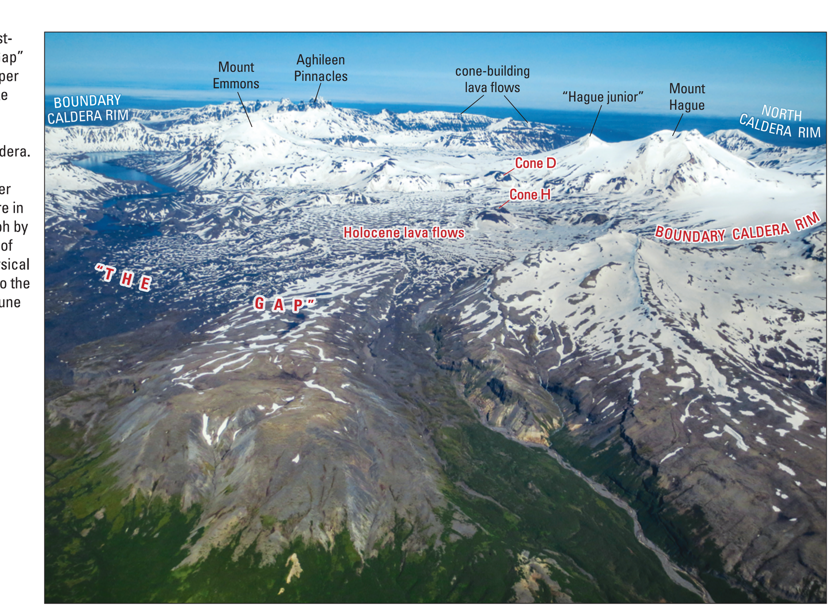
BASEMENT ROCKS

- Ti — **Hypabyssal quartz diorite (late Tertiary)**
- Tvs — **Volcanic and sedimentary rocks, undifferentiated (late Tertiary)**

EXPLANATION OF MAP SYMBOLS

- **Contact**—On map, solid where accurately located. In cross section, solid where location is inferred
- **Volcanic crater rim**—Accurately located. Hachures point into crater
- **Caldera rims**—On map, solid where accurately located; dashed where location is inferred; queried where existence is uncertain. Hachures point into caldera (hachures shown on map only). In cross section, dashed where location is inferred
  - **North caldera rim**
  - **Boundary caldera rim**
  - **Volcano Bay caldera rim**
- **Dikes**—Shown in cross section only
- A——A' **Cross-section line**
- **Extent of geologic mapping**
- **Volcanic vent**
- **Thermal spring**
- **Active fumarole**
- 30.5±4.2 ka **Age-sample locality**





Aerial photograph (to west-northwest) across "The Gap" toward Emmons Lake (upper left) and into Emmons Lake volcanic center, showing caldera rims and various volcanic peaks within caldera. Partly snow covered lava flows and numerous cinder cones of Holocene age are in middle ground. Photograph by Max Kaufman, University of Alaska-Fairbanks Geophysical Institute, under contract to the U.S. Geological Survey, June 7, 2016.

Aerial photograph (to east) toward Aghileen Pinnacles. Along left skyline are (from right to left) volcanoes Little Pavlof, Pavlof Volcano, and Pavlof Sister. Photograph by Matt Loewen, U.S. Geological Survey, July 23, 2024.

Photograph (to southeast) showing U.S. Geological Survey geologists Betsy Yount and Tom Miller preparing to sample the Cathedral welded tuff (cwt). Along skyline are volcanoes Pavlof Sister (left) and Pavlof Volcano (right), with Little Pavlof on its right (southwest) flank. Photograph by Rick Farish, Alaska Helicopters, under contract to the U.S. Geological Survey, August 1987.

Geologic Map of the Emmons Lake Volcanic Center, Alaska

By

Thomas P. Miller, Christopher F. Waythomas, Margaret T. Mangan, Frank A. Trusdell, and Andrew T. Calvert

2026

ISSN 2329-132X (online)
https://doi.org/10.3133/sim3519

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Suggested citation: Miller, T.P., Waythomas, C.F., Mangan, M.T., Trusdell, F.A., and Calvert, A.T., 2026, Geologic map of the Emmons Lake volcanic center, Alaska: U.S. Geological Survey Scientific Investigations Map 3519, scale 1:100,000, pamphlet 59 p., https://doi.org/10.3133/sim3519.

Associated data for this publication: Waythomas, C.F., Miller, T.P., Mangan, M.T., Trusdell, F.A., Calvert, A.T., and Sullivan, K., 2026, Geospatial database of the geologic map of the Emmons Lake volcanic center, Alaska: U.S. Geological Survey data release, https://doi.org/10.5066/P1HUP9CA.