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

PRELIMINARY GEOLOGIC MAP OF THE COLD BAY AND FALSE PASS QUADRANGLES, ALASKA PENINSULA

By

Frederic H. Wilson[1], Thomas P. Miller[1], and Robert L. Detterman[2]

OPEN-FILE REPORT 92-545

1992

[1]Anchorage, Alaska, 99508-4667, [2]Deceased

PRELIMINARY GEOLOGIC MAP OF THE COLD BAY AND FALSE PASS QUADRANGLES, ALASKA PENINSULA

Table of Contents

Introduction 3

Acknowledgements 3

Description of Map Units
    Surficial deposits and sedimentary rocks
        Quaternary 3
        Tertiary 4
        Cretaceous 5
        Cretaceous and/or Jurassic 6
        Jurassic 6
    Volcanic rocks
        Quaternary 6
        Quaternary and/or Tertiary 7
        Tertiary 7
    Intrusive rocks
        Quaternary 8
        Tertiary 8

References cited 9

PRELIMINARY GEOLOGIC MAP OF THE COLD BAY AND FALSE PASS QUADRANGLES, ALASKA PENINSULA

By
Frederic H. Wilson, Thomas P. Miller, and Robert L. Detterman

INTRODUCTION

This map of the Cold Bay and False Pass 1:250,000-scale quadrangles on the Alaska Peninsula is a compilation based in part on the mapping conducted as part of the Alaska Mineral Resource Assessment Program (AMRAP) and the Geothermal Energy Program. Field studies by the authors began as early as 1973 in the quadrangles, but systematic mapping was not begun until 1988. Systematic mapping remains to be completed for much of the southwest part of the map area and the vicinity of southeastern Cold Bay. Previous geologic mapping in the region, which constitutes an invaluable data base for our studies, was conducted by Kennedy and Waldron (1955), Waldron (1961), Burk (1965), McLean and others (1978), and DuBois and others, 1989.

Most of the new mapping for this map was done by helicopter-supported foot-traverses and with helicopter spot landings. Coverage of areas between surface observations was made using helicopter overflights and interpretation of vertical aerial photography and Landsat imagery. Field investigations were conducted from bases at Cold Bay (1990), King Cove (1988), and False Pass (1991). In addition, some field work in 1984 was also conducted using the U.S. Geological Survey Research Vessel *Don J. Miller II* in the vicinity of Belkofski Bay.

ACKNOWLEDGEMENTS

Robert L. (Buck) Detterman's death as this map was being compiled left a profound void. His knowledge of and insight into Alaska Peninsula geology was of tremendous value. His friendship, guidance, and contributions to Alaska Peninsula geology will be long remembered.

In addition to the field studies by the authors (F.H. Wilson, 1983, 1988, 1990-91; T.P. Miller, 1973-75, 1977-79, 1981-82, 1986-89; R.L. Detterman, 1984, 1988), the following geologists are gratefully acknowledged for their contributions to the mapping and compilation: S.W. Bie, 1991; G.D. DuBois, 1988, 1990; D.H. Richter, 1986; T.L. Vallier, 1991; W.H. White, 1988, 1990-91; M.E. Yount 1983, 1986-88. F.R. Weber made significant contributions to the mapping of the Quaternary deposits, helping to fill the void left by Bob's death.

D.H. Richter provided an appreciated insightful and thorough review of a draft of this map.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS AND SEDIMENTARY ROCKS

QUATERNARY

Qs **Surficial deposits, undivided (Holocene and Pleistocene)**--Typically unconsolidated, poorly to well-sorted, poorly to moderately well-stratified sand, gravel, and silt. Ranges from coarse, subangular to rounded rock fragments to fine sand and silt; locally includes considerable pumice near Emmons Lake volcanic center. Unit locally incorporates fluvial, colluvial, glacial outwash, lacustrine, beach, estuarine, swamp, and eolian deposits. Large areas are covered by organic-rich silt deposits. Unit includes abundant volcanic ash and volcanic debris in vicinity of Joshua Green River and in vicinity of most volcanoes, particularly those on Unimak Island and those that compose the Emmons Lake eruptive center. Eolian deposits form dunes 10 to 20 m high composed largely of sand and pumice. Locally divided into:

Qaf **Alluvial fan and landslide deposits**--Deposits are poorly sorted rock fragments ranging in size from coarse, meter-sized, subangular fragments to fine sand and silt. Alluvial fans have a typically well-developed cone-shaped or coalescing cone-shaped morphology. Landslide deposits have poorly to well-developed lobate morphology. Only larger fans and landslide deposits are mapped separately

Qb **Marine beach and estuarine deposits**--Moderately well stratified and sorted sand and gravel on beaches, and mud and silt in estuaries

Qm **Moraines and other glacial deposits**--Poorly sorted, nonstratified, rock fragments ranging in size from coarse, meter-sized, subrounded to rounded fragments to fine sand and silt. Mainly forms end, lateral, and ground moraines but, locally includes moderately well-sorted and stratified ice-contact and outwash deposits. Morphologically distinctive drift units are indicated by dashed and dotted internal contacts shown within unit

Qmt **Marine terrace deposits**--Stratified and moderately well-sorted sand and gravel. Forms nearly level plains, locally ending at prominent wave-cut scraps

TERTIARY

Tvs **Volcanic sedimentary rocks and agglomerate (Pliocene?)**--Unit is of variable thickness and consists of volcanogenic, nonmarine sedimentary rocks and interlayered agglomerate, flows and sills. Included in this unit in the area northwest of the Emmons Lake eruptive center are rocks mapped as the Agglomerate of Cathedral Valley by Kennedy and Waldron (1955); a thick sequence of agglomerate beds and subordinate tuff beds and lava flows that are well exposed in Cathedral Valley. According to Kennedy and Waldron (1955), the rocks are predominantly basalt and basaltic andesite and dip north toward the Bering Sea. Kennedy and Waldron (1955) suggested that they are probably comparable in age to the Belkofski Tuff (renamed the Belkofski Formation); we suggest here a better lithologic and stratigraphic correlation is with the Milky River Formation (see Detterman and others, in press)

Tta **Tachilni Formation (late Miocene)**--Named by Waldron (1961) for roughly 100 meters of marine sedimentary rocks at Morzhovoi Bay. Formation is composed of gray to brown, poorly-consolidated, crossbedded, subgraywacke sandstone commonly interbedded with volcanic-pebble conglomerate and siltstone (Detterman and others, in press). Sandstone is composed of 30-35 percent angular quartz, 30 percent volcanic rock fragments, 10-15 percent feldspar, and 5 percent pyroxene and amphibole, in a clay matrix. McLean (1979b) reported a thickness of about 460 m for the Tachilni and designated a reference section, 130 m thick at South Walrus Peak; the reference section as measured is incomplete as the basal part was not examined. In determining thickness of the entire unit, Detterman and others (in press) suggested structural complications and poor exposure preclude measurement of a complete section. A considerable part of the unit as mapped by McLean and others (1978) is included on this map in the Belkofski Formation. The Tachilni Formation is richly fossiliferous, including 36 genera of bivalves and 11 genera of gastropods (Detterman and others, in press). Marincovich (1983) showed that these fossils have a close correlation with the Wishkahan Stage of the late Miocene, resulting in a late Miocene age assignment for the unit, in contrast to the late Miocene and early Pliocene age reported by McLean (1979a, b). The Tachilni is unconformably overlain by late Tertiary and Quaternary volcanic and volcaniclastic rocks. The contact of the Tachilni and the Morzhovoi Volcanics is generally structurally conformable though locally unconformable where volcanic flows fill former stream valleys cut into the Tachilni. A lower contact exposed on the coast between Morzhovoi Bay and False Pass is conformable with the underlying Belkofski Formation

Tu **Unga Formation (middle Miocene to late Oligocene)**--Originally named the Unga Conglomerate by Dall (1882, 1896) for exposures west of Zachary Bay on Unga Island (Port Moller B-2 and B-3 1:63,360-scale quadrangles); later redefined a number times and finally made the Unga Formation (see Detterman and others, in press). Section on Unga Island is 275-m-thick, and consists of volcanic rocks (lahar deposits, debris flow deposits, and tuff), sandstone, conglomerate, and carbonaceous shale and coal (restricted to lower part). Sandstone and conglomerate are composed of poorly-sorted, and typically loosely consolidated, volcanic debris. Unit had been restricted to Unga Island, the Pavlof Islands, and along Pacific coast of Alaska Peninsula adjacent to

Unga Island, however rocks on the west side of Deer Island which consist of green to brown mudstone, volcanic breccia and lahar deposits, carbonaceous shale are here referred to the Unga Formation. Nowhere is the relation of the Unga to other units is well defined, as neither the top nor base of formation is exposed

Tbe **Belkofski Formation (middle Miocene? to late Oligocene?)**--Originally named the Belkofski Tuff by Kennedy and Waldron (1955); later renamed the Belkofski Formation by Burk (1965; see also, McLean, 1979a). McLean (1979a, b) gave a generalized description of a section about 1,830 m thick along northwest shore of Belkofski Bay; it consists of gray or greenish-gray to gray-brown, tuffaceous, volcaniclastic sandstone, siltstone, and conglomerate containing interbeds of tuff and volcanic breccia. On the Pavlof Islands (Port Moller 1:250,000-scale quadrangle) and on the peninsula between Morzhovoi Bay and False Pass and Unimak Island, rocks of unit are dominantly red, pink, and purple and are very well indurated. This unit is conformably overlain by the Tachilni Formation; and based on lithologic similarity and apparent stratigraphic position is likely correlative with the Unga Formation (unit Tu; Detterman and others, in press). Lower contact of the Belkofski Formation is nowhere exposed. Potassium-argon age determination on a clast from volcanic agglomerate overlying Belkofski Formation on Dolgoi Island (Port Moller 1:250,000-scale quadrangle) is 11.79±0.41 Ma (Wilson and others, in press "A")

Ts **Stepovak Formation (early Oligocene and late Eocene)**--Originally called the Stepovak Series by Palache (1904) for rocks exposed on east side of Chichagof Bay; later renamed the Stepovak Formation by Burk (1965; see also, Detterman and others, in press); and divided into two informal members by Detterman and others (in press). Lower member is a deep-water turbidite deposit composed of dark-brown laminated siltstone and shale, and interbedded sandstone that commonly shows graded bedding and rip-up clasts. Upper member, rich in unaltered volcanic debris, was deposited in a shallow-water shelf environment; megafauna distributed throughout the upper member are characteristic of water depths no greater than 30 to 50 m (Louie Marincovich, Jr., written commun., 1983-86). In the map area, rocks exposed in the vicinity of Indian Head on Belkofski Bay, in part originally mapped as the arkose unit of Kennedy and Waldron (1955, unit Ta) are herein assigned to the Stepovak Formation, presumably the upper member. They consist of dusky-yellow-green to green, very-fine to coarse grained, angular to subrounded, volcaniclastic sandstone containing minor interbeds of dark-gray to olive-gray siltstone. Some sandstone layers are mottled green and white, suggesting they are laumontitic and tuffaceous. Unit is faintly bedded, having low-angle tabular crossbeds. Locally, it contains considerable pebble conglomerate and dark-olive-gray siltstone containing plant debris; the siltstone itself is locally highly bioturbated. Assignment of the rocks at Indian Head to the Stepovak Formation considerably extends the known geographical range of the unit

CRETACEOUS

Ks **Shumagin Formation (Late Cretaceous; Maestrichtian)**--Named and defined by Burk (1965; see also, Moore, 1974a) for typical exposures at Falmouth Harbor on Nagai Island (Port Moller 1:250,000-scale quadrangle) which was later designated as type area of unit by Moore (1974a). In map area unit only occurs in Sanak Islands. The Shumagin Formation consists of interbedded sandstone, siltstone, mudstone, and shale at least 3,000 m thick (Burk, 1965). Sandstone is dominantly medium-light-gray to medium-dark-gray, very fine to medium-grained, highly indurated lithic graywacke (Moore, 1974a, b). Sandstone beds range in thickness from 2 cm to 20 m, are graded, and contain abundant shale and siltstone chips (Moore, 1974a, b; Detterman and others, in press). Thin (less than 10 cm) grayish-black mudstone layers are interbedded with sandstone; however, in some areas mudstone forms the dominant lithology. Thin-bedded siltstone, mudstone, and sandstone sequences are rhythmically bedded and have sharp upper and lower contacts indicative of turbidity current deposition in deep-sea-fan and abyssal-plain environments. Only contact of the Shumagin with a younger unit is observed where the early Tertiary Sanak Island batholith have intruded (Kienle and Turner, 1976; Detterman and others, in press), at this contact, the Shumagin has been metamorphosed. The Shumagin depositionally overlies a structurally conformable chert and volcanic rock sequence (KJcv). Fossils are uncommon in the Shumagin, but existing collections indicate an early

Maestrichtian age for the formation (J.W. Miller, written commun., 1983-88; oral commun., 1991).

CRETACEOUS and/or JURASSIC

KJcv—Chert and volcanic sequence (Early Cretaceous or Jurassic)—Unit was originally described by Moore (1974b) for rocks that occur on the northeast coast of Long and Clifford Islands in the Sanak Islands. Moore's (1974b) description of these rocks is as follows: "Reddish-brown, light-gray, and grayish-green bedded chert; dark-greenish-gray pillow lavas and tuffs, thin (5-10 cm) medium-gray, medium- to fine-grained sandstone interbedded with dark-gray mudstone". The maximum exposed thickness reported by Moore (1974b) is 250 m; however as no base of the unit is exposed the total thickness of the unit is unknown. Clasts of chert, presumably derived from this unit, are found in the depositionally overlying massive sandstone of the Shumagin Formation (Ks), hence the assignment of a Jurassic or Early Cretaceous age for these rocks (Moore, 1974b) as no fossil or radiometric age-control exists. No other locality on the Alaska Peninsula or adjacent islands has similar lithologies, except for parts of the Early Cretaceous Uyak Formation (Moore, 1969; Fisher, 1979) on Kodiak Island, with which Moore (1974b) made only a lithologic correlation

JURASSIC

Jn Naknek Formation, Northeast Creek Sandstone Member (Late Jurassic; Oxfordian)--Originally named Naknek Series by Spurr (1900, p. 169-171, 179, 181) for exposures at Naknek Lake at the northeast end of the Alaska Peninsula. Detterman and others (in press; see also, Detterman and Hartsock, 1966; Martin and Katz, 1912) have subdivided unit into five members. Megafossils, particularly the pelecypod *Buchia* (Detterman and Reed, 1980, p. B-38; John W. Miller, written commun., 1982-88), are common and the fauna, which also includes ammonites, indicate an age range of Oxfordian to late Tithonian (Late Jurassic). The only member of the Naknek Formation exposed in the map area is the Northeast Creek Sandstone Member. The sandstone is typically thick-bedded, crossbedded, and contains magnetite laminae and thin beds of conglomerate. Fossils are uncommon in the unit although carbonaceous debris is common in parts. Depositional environment is mainly nonmarine. Some sand beds are channeled with lag gravel at the bases of channels. According to Detterman and others (in press), "Crossbedding is mostly high-angle and variable directional eolian type, some is small-scale, tabular crossbedding with clay drapes characteristic of point bar deposits." Unit is unconformably overlain by Quaternary deposits in the map area; no lower contact is exposed. Elsewhere on the Alaska Peninsula, the Naknek is conformable with the overlying Staniukovich Formation and unconformably overlies the Middle Jurassic Shelikof Formation (see Detterman and others, in press). The Alaska-Aleutian Range batholith (Reed and Lanphere, 1969, 1972, 1973) was the main source of sedimentary debris for the Naknek Formation

VOLCANIC ROCKS

QUATERNARY

Qv,Qfp,HvVolcanic rocks (Holocene and Pleistocene)--Mainly andesite, dacite, and leucobasalt lava flows, volcanic breccia, lahar deposits, and debris-flow deposits. Unit also includes basaltic, basaltic andesite, and dacite parasitic cinder and spatter cones. Lava flows and clasts in the other deposits are typically gray to black, porphyritic, and commonly vesicular. Clasts are highly scoriaceous to vitrophyric; range in size from cinder-size fragments to bombs 1 m long. Andesite is the principal composition and probably constitutes 60 percent or more of the unit. Individual flows are locally as thick as 30 m and laterally continuous over large areas. Unit typically forms volcanic edifices. Also occurs as isolated outcrops which cap or form ridges, providing a good example of topography reversal due to erosion. Includes basalt of Frosty Peak Volcanics (Waldron, 1961), shown on map as unit Qfp and lava flows of Holocene age at Shishaldin Volcano and Emmons Lake eruptive center shown as unit Hv

Qpd **Pyroclastic and debris-flow deposits (Holocene and late Pleistocene?)**--Dacite and rhyolite ash-flow tuff, debris-flow, block-and-ash-flow deposits, explosion debris, and air-fall deposits in the vicinity of Pavlof Volcano (Emmons Lake center), Mount Dutton, Roundtop Mountain, Isanotski Peaks, and Frosty Peak. According to Miller and Smith (1977, p. 174), pyroclastic deposits "typically are composed of pumice and scoria bombs.... and subordinate lithic fragments in a matrix of fine to coarse ash, pumice, and lithic material." Miller and Smith (1977) also reported that composition ranges from basaltic andesite to rhyolite although most are dacite. Map unit is interbedded with, and overlies, Quaternary glacial debris (Qm). The unit records multiple, late Pleistocene and Holocene eruptions, particularly at Roundtop and Emmons Lake volcanic centers and at other volcanic centers. Where known, individual pyroclastic flow deposits are shown by internal contacts

QUATERNARY and/or TERTIARY

QTv **Volcanic rocks (Quaternary and Pliocene?)**--Andesite and basalt lava flows, agglomerate, lahar deposits, sills, and plugs. These primarily extrusive rocks typically cap ridges. A potassium-argon age from south of Kelp Point was 2.94±0.15 Ma (Nora Shew, written commun., 1991, Age report no. 261). Includes the basalt flows of Mount Simeon of Waldron (1961)

QTm **Morzhovoi Volcanics (early Quaternary?, Pliocene, and late Miocene?)**--Named by Waldron (1961) for a sequence of lava flows, interbedded pyroclastic rocks, and minor volcanic sedimentary rocks that overlie the Tachilni and Belkofski Formations. Unit comprises "the eroded remnants of an ancient large composite cone, ... called Morzhovoi volcano, in the area south of Frosty Peak" (Waldron, 1961, p. 688). Waldron (1961, p. 688) designated a type locality along the Pacific coast south and east of Reynolds Head (sec. 5, T. 59S., R. 90W., Cold Bay A-3 1:63,360-scale quadrangle). At the type locality, the unit consists of poorly consolidated dark sandy shale, sandstone, and fine- to coarse-grained conglomerate composed of subrounded to rounded fragments of volcanic debris. These are conformably overlain by interbedded lava flows, coarse agglomerates, and volcanic breccias of light- to pinkish-gray porphyritic basalt. Total thickness of the unit is at least 900 m. Olivine, which is not common in Alaska Peninsula volcanic rocks in general, occurs in small amounts in nearly all rocks of the Morzhovoi Volcanics examined (Waldron, 1961). The age of the Morzhovoi Volcanics is not well controlled. Waldron (1961) inferred an age of no older than latest Tertiary nor younger than middle Pleistocene. Detterman and others (in press) reported that "The upper part of the Tachilni Formation contains several ash beds that were possibly derived from the Morzhovoi volcano." From this they inferred an earlier age limit of late Miocene for the Morzhovoi Volcanics. Unit is correlative with parts of unit QTv elsewhere in the map area

QTdv **Volcanic breccia proximal to Dora Peak (Quaternary?, Pliocene?, and late Miocene?)**--Felsic volcanic breccia, agglomerate, lithic and crystal-lithic tuff, and minor lava flows on Ikatan Peninsula. Unit includes massive volcanic breccia more than 100-m-thick as well as thick intervals of agglomerate and tuff. Composition is more siliceous than other volcanic rocks units. Unit is hornfelsed, showing development of epidote, and cut by locally numerous quartz veins, where near granodiorite pluton of the Ikatan Peninsula (unit Tiu)

TERTIARY

Tvu **Volcanic rocks, undivided (Tertiary)**--Andesite, dacite, and basalt lava flows, tuffs, lahar deposits, volcanic breccia, and hypabyssal intrusions, all locally hydrothermally altered or hornfelsed. No potassium-argon ages are available and there is little stratigraphic control for these rocks. Outcrop and erosional patterns are similar to other Tertiary volcanic rocks

Tv **Volcanic rocks (late Miocene)**--Andesite and basalt flows, sills, and plugs. The extrusive rocks of unit typically cap ridges and consist of massive lava flows, agglomerate, and lahar deposits; unit also includes minor small intrusive bodies. Minor propylitic alteration is characteristic of these rocks. Includes the volcanic rocks of Thinpoint Lagoon of Waldron (1961). A single potassium-argon age from the volcanic rocks at

Thinpoint Lagoon was 5.23±0.66 Ma; another from Fox Island was 8.89±0.12 Ma (Nora Shew, written commun., 1991, Age reports no. 265 and 245)

INTRUSIVE ROCKS

QUATERNARY

Qi **Intrusive rocks (Holocene and Pleistocene)**--Hypabyssal dacite plugs and domes at Quaternary volcanic centers, particularly Frosty Peak, Walrus Peak, and Roundtop

TERTIARY

Ti **Intrusive rocks (Pliocene and late Miocene)**--Medium- to coarse-grained, equigranular, granodiorite to quartz diorite plutons and stocks containing hornblende, biotite, and pyroxene as mafic minerals and typically surrounded by well-developed hornfels zones and sporadic hydrothermal alteration in country rocks. Intrusive bodies are generally located along Pacific coast and include the large pluton on the east side of Belkofski Bay (Moss Cape pluton) and at King Cove. A potassium-argon age on the Moss Cape pluton was 3.21±0.14 Ma (DuBois and others, 1987)

Tiu **Intrusive rocks, undivided (Tertiary)**--Small dikes, sills and stocks of andesite, quartz diorite, or diorite, typically hypabyssal and containing phenocrysts of pyroxene or hornblende in a fine-grained groundmass. No reliable potassium-argon ages are available for these rocks; unit may include rocks of other Tertiary intrusive rock units

Tg **Granodiorite (Paleocene)**--Medium-grained biotite granodiorite, pluton of Sanak Island containing hypidiomorphic granular texture and locally containing potassium feldspar phenocrysts as much as 1 cm in length. Potassium-argon ages reported by Moore (1974b) and Kienle and Turner (1976) range from 62.0±3.3 to 61.4±1.8 Ma when recalculated using currently accepted constants (Steiger and Jager, 1977). A rubidium-strontium mineral isochron was 62.7 Ma and a whole-rock isochron was 49.5 Ma (Hill and others, 1981)

REFERENCES CITED

Burk, C.A., 1965, Geology of the Alaska Peninsula - Island arc and continental margin: Geological Society of America Memoir 99, 250 p., scales 1:250,000 and 1:500,000, 3 sheets.

Dall, W.H., 1882, Notes on Alaska Tertiary deposits: American Journal of Science, 3d series, v. 24, p. 67-68.

Dall, W.H., 1896, Report of coal and lignite of Alaska: U.S. Geological Survey 17th Annual Report, Part 1, p. 771-914.

Detterman, R.L., and Hartsock, J.K., 1966, Geology of the Iniskin-Tuxedni region, Alaska: U.S. Geological Survey Professional Paper 512, 78 p.

Detterman, R.L., and Reed, B.L., 1980, Stratigraphy, structure, and economic geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Bulletin 1368-B, 86 p., 1 map, scale 1:250,000.

Detterman, R.L., Miller, J.W., Case, J.E., Wilson, F.H., and Yount, M.E., in press, Stratigraphic framework of the Alaska Peninsula: U.S. Geological Survey Bulletin 1969-A.

DuBois, G.D., Wilson, F.H., Detterman, R.L., and Hopkins, R.T., Jr., 1989, Reconnaissance geology and exploration geochemistry of King Cove, Alaska Peninsula: U.S. Geological Survey Open-File Report 89-350, 23 p.

DuBois, G.D., Wilson, F.H., and Shew, Nora, 1987, Potassium-argon age determinations from the Port Moller and Stepovak Bay quadrangle, Alaska Peninsula: U.S. Geological Survey Open-File Report 87-191, scale 1:250,000.

Fisher, M.A., 1979, Structure and tectonic setting of continental shelf southwest of Kodiak Island, Alaska: American Association of Petroleum Geologists Bulletin, v. 63, no. 3, p. 301-310.

Hill, M.D., 1979, Volcanic and plutonic rocks of the Kodiak-Shumagin shelf, Alaska: Subduction deposits and near-trench magmatism: Santa Cruz, California, California University, Ph.D. dissertation, 274 p.

Hill, M.D., Morris, Julie, and Whelan, Joseph, 1981, Hybrid granodiorites intruding the accretionary prism, Kodiak, Shumagin, and Sanak Islands, southwest Alaska: Journal of Geophysical Research, v. 86, no. 11, p. 10,569-10,590.

Kennedy, G.C., and Waldron, H.H., 1955, Geology of Pavlof Volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028-A, 19 p., scale 1:100,000.

Kienle, Juergen, and Turner, D.L., 1976, The Shumagin-Kodiak batholith, a Paleocene magmatic arc?: Alaska Division of Geological and Geophysical Surveys Geologic Report 51, p. 9-11.

Marincovich, Louie, Jr., 1983, Molluscan paleontology, paleoecology, and North Pacific correlations of the Miocene Tachilni Formation, Alaska Peninsula, Alaska: Bulletin of American Paleontology, v. 84, no. 317, 155 p.

Martin, G.C., and Katz, F.J., 1912, A geologic reconnaissance of the Iliamna region, Alaska: U.S. Geological Survey Bulletin 485, 138 p.

McLean, Hugh, 1979a, Tertiary stratigraphy and petroleum potential of the Cold Bay-False Pass area, Alaska Peninsula: American Association of Petroleum Geologists Bulletin, v. 63, no. 9, p. 1522-1526.

McLean, Hugh, 1979b, Observations on the geology and petroleum potential of the Cold Bay - False Pass area, Alaska Peninsula: U.S. Geological Survey Open-file Report 79-1605, 34 p.

McLean, Hugh, Englehardt, C.L., and Howell, D.G., 1978, Reconnaissance geologic map of the Cold Bay and False Pass quadrangles, Alaska: U.S. Geological Survey Open-file Report 78-323, scale 1:250,000.

Miller, T.P., and Smith, R.L., 1987, Late Quaternary caldera-forming eruptions in the eastern Aleutian arc, Alaska: Geology, v. 15, p. 434-438.

Moore, G.W., 1969, New formations on Kodiak and adjacent islands, Alaska, *in* Changes in stratigraphic nomenclature by the U.S. Geological Survey 1967: U.S. Geological Survey Bulletin 1274-A, p. A27-A35.

Moore, J.C., 1974a, Geologic and structural map of part of the Outer Shumagin Islands, southwestern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-815, scale 1:63,360.

Moore, J.C., 1974b, Geologic and structural map of the Sanak Islands, southwestern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-817, scale 1:63,360.

Palache, Charles, 1904, Geology about Chichagof Cove, Stepovak Bay; with notes on Popof and Unga Islands (Alaska): Harriman Alaska Expedition, v. 4, p. 69-88.

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

_____, 1972, Generalized geologic map of the Alaska-Aleutian Range batholith showing potassium-argon age of the plutonic rocks: U.S. Geological Survey Miscellaneous Field Studies Map MF-372, 2 sheets, scale 1:1,000,000.

_____, 1973, Alaska-Aleutian Range batholith: Geochronology, chemistry, and relations to circum-Pacific plutonism: Geological Society of America Bulletin, v. 84, no. 8, p. 2583-2610.

Spurr, J.E., 1900, A reconnaissance in southwestern Alaska in 1898: U.S. Geological Survey 20th Annual Report, Part 7, p. 31-264.

Steiger, R.H., and Jager, E., 1977, Subcommission on Geochronology: Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Wilson, F.H., Shew, Nora, DuBois, G.D., and Bie, S.W., in press, Map and table showing locations and analytical data for potassium argon age determinations in the Port Moller, Stepovak Bay, and Simeonof Island quadrangles, Alaska Peninsula: U.S. Geological Survey Miscellaneous Field Studies Map MF-2155-_, 8 ms. p., 2 tables, 1 map, scale 1:250,000.

Wilson, F.H., Detterman, R.L., and DuBois, G.D., in press, Geologic framework of the Alaska Peninsula and the Alaska Peninsula terrane: U.S. Geological Survey Bulletin 1969-B, 1 map, scale 1:500,000.

Waldron, H.H., 1961, Geologic reconnaissance of Frosty Peak volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028-T, p. 677-708.