U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
STATE OF ALASKA DEPARTMENT OF NATURAL
RESOURCES, DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

PROFESSIONAL PAPER 1497-C
PLATE 1

EXPLANATION

The metamorphic scheme used to compile this map (Zwart and others, 1967; fig, 4; table 1) is based on pressure- and temperature-sensitive metamorphic minerals. Metamorphosed rocks are divided into three facies groups based on increasing temperature: (1) laumontite and prehnite-pumpellyite facies (LPP), shown in shades of gray and tan; (2) greenschist facies (GNS), shown in shades of green; and (3) epidote-amphibolite and amphibolite facies (AMP), shown in shades of orange. Where possible, the greenschist-facies and the epidote-amphibolite- and amphibolite-facies groups are divided into three facies series on the basis of pressure. H, I, or L in place of the final letter in the symbol used for a facies group indicates a high-, intermediate-, or low-pressure facies series, respectively. Numerical subscripts are used to differentiate between units that have the same metamorphic grade and age but that are thought to have different metamorphic histories.

USE OF METAMORPHIC COLOR PATTERNS AND SYMBOLS

GNS(eKPz) **Metamorphic-facies designation**—Age, or bracketing ages[1] of metamorphism given in parentheses. Letters preceding age: l, late; m, middle; e, early. (For example, GNS (eKPz) indicates greenschist-facies metamorphism occurred sometime during Paleozoic to Early Cretaceous time)

Undifferentiated facies groups or series—Dominant facies or series given first

GNS,AMP **Undifferentiated greenschist and amphibolite facies**

AMH,I **Undifferentiated high-and intermediate-pressure amphibolite facies**

Transitional between two facies groups or series—Lower grade or pressure facies given first

LPP/GNS **Transitional between prehnite-pumpellyite and greenschist facies**

AMP(eK) **Transitional between low- and intermediate-pressure amphibolite facies**

Polymetamorphism

Two phases

AMP(eKD) + GNS(eK) **Vertical stripes**—Older phase (AMP (eKD))

Horizontal stripes—Younger phase (GNS (eK))

Area of migmatite

Strongly metamorphosed pluton—Metamorphic-facies designation of pluton considered to be that of surrounding metamorphic unit; protolith age of metaplutonic rocks given in text

Weakly metamorphosed pluton—Known to have been or inferred to have been metamorphosed under low-grade metamorphic conditions (prehnite-pumpellyite- or lowermost greenschist-facies grade) along with its wallrocks. Protolith age of metaplutonic rocks given in text

•gl **Location of metamorphic-mineral occurrence**—a, andalusite; c, cordierite; cs, crossite; gl, glaucophane, k, kyanite; l, lawsonite

•22 **Metamorphic-mineral locality and number**—Shown on plate 2 and referred to in table 2

GRANITIC AND OTHER ROCK SYMBOLS

(Areas shown as granitic rocks may include some intrusive rocks of intermediate or mafic composition and some related volcanic and hypabyssal rocks)

Qs **Surficial deposits (Quaternary)**

Tg, TKg, Kg **Postmetamorphic granitic rocks**

Tertiary, Tertiary and (or) Cretaceous, Cretaceous

JTRg **Synmetamorphic granitic rocks**

Latest Jurassic and earliest Triassic late-metamorphic intrusive rocks

TKg, lJg, meJg **Synmetamorphic and synkinematic granitic rocks**

Early Tertiary and Late Cretaceous, Late Jurassic, Middle and Early Jurassic

Jmu **Undivided mafic and ultramafic rocks**

Jurassic Border Ranges mafic and ultramafic complex—After Burns (1985)

Ju, Du, MzPzu **Ultramafic rocks**—Unit may also include minor associated layered gabbroic rocks and pillow basalt

Jurassic, Devonian, Mesozoic and (or) Paleozoic

Area of unmetamorphosed volcanic and (or) sedimentary rocks

LINE SYMBOLS

Contact or boundary between metamorphic-facies units—Dashed where approximately located; dotted where concealed; may cut across premetamorphic faults. Delineation of dotted contacts or boundaries under areas shown as glaciers based on exposure of nunataks and (or) on extension of contacts or boundaries along strike between areas in which bedrock is exposed

High-angle fault—Dashed where approximately located; dotted where concealed. Arrows show relative horizontal movement

Thrust fault—Dashed where approximately located; dotted where concealed. Sawteeth on upper plate

Low-angle normal fault—Sawteeth on upper plate

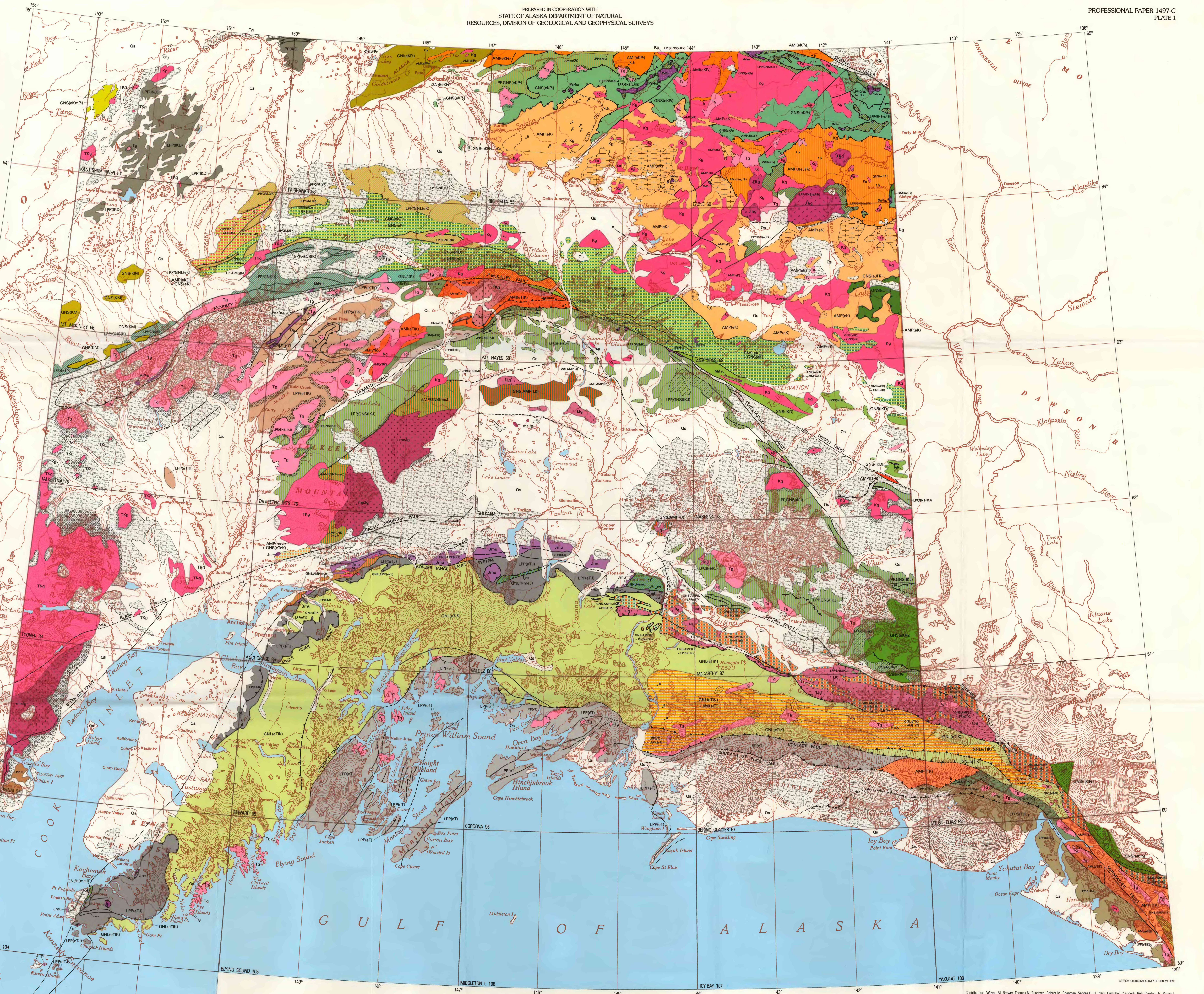
Contact-metamorphic aureole—Approximately 1 km or more in width

Sillimanite isograd—Ticks on high-grade side

VALDEZ 86 **1:250,000-scale quadrangle**—Boundary, name, and map reference number

Glacier—Shown with color or symbol of unit inferred to underlie it based on exposure of nunataks and (or) on extension of contacts or boundaries along strike between areas in which bedrock is exposed. Areas shown as unmetamorphosed volcanic and (or) sedimentary rock within the boundaries of the Bering and Malaspina glaciers probably also include Quaternary surficial rocks

[1]Standard abbreviations for metamorphic ages are: T, Tertiary; Mz, Mesozoic; K, Cretaceous; J, Jurassic; TR, Triassic; Pz, Paleozoic; M, Mississippian; D, Devonian



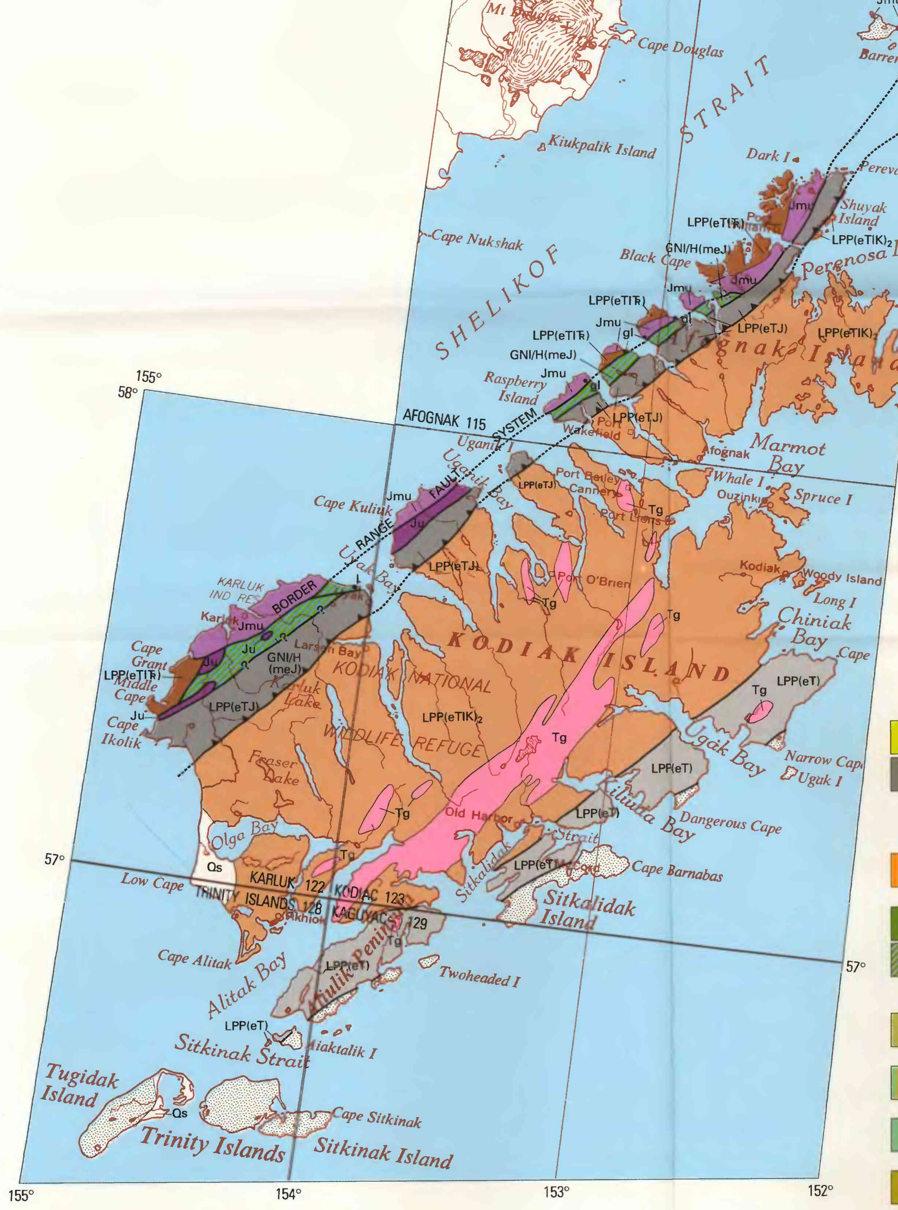
SCALE 1 : 1 000 000

25 0 25 50 75 100 MILES

25 0 25 50 75 100 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

INTERIOR-GEOLOGICAL SURVEY, RESTON, VA-1993



Base from U.S. Geological Survey, 1: 2,000,000 National Atlas series; Central Alaska, sheet 38-39; Northern Alaska, sheet 40-41; Southwestern Alaska, sheet 42-43; Aleutian Islands, sheet 44-45, 1967 (revised 1973)

Albers Equal Area Projection

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Dusel-Bacon, Cynthia, Csejtey, Béla, Jr., Foster, H.L., Doyle, E.O., Nokleberg, W.J., and Plafker, George, 1993. Distribution, facies, ages, and proposed tectonic associations of regionally metamorphosed rocks in east- and south-central Alaska: U.S. Geological Survey Professional Paper 1497-C.

METAMORPHIC FACIES MAP OF EAST- AND SOUTH-CENTRAL ALASKA

Compiled by

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1993

ABBREVIATED DESCRIPTION OF METAMORPHIC MAP UNITS

(See text for more detailed information)

AREA NORTH OF THE McKINLEY AND DENALI FAULTS

Kantishna River area (Nixon Fork, Minchumina, and White Mountains terranes

GNS(eKmPz) **Greenschist-facies phyllite, schist, quartzite, greenstone, and marble**—Protoliths are Proterozoic(?) to middle(?) Paleozoic in age. Metamorphism is bracketed between middle Paleozoic and Early Cretaceous time

LPP(lKD) **Prehnite-pumpellyite-facies argillite, semischist, quartzite, metalimestone, and metachert**—Protoliths are Ordovician to Devonian in age. Metamorphism is bracketed between Devonian and early Late Cretaceous time

Yukon-Tanana upland (Yukon-Tanana and Seventymile terranes)

AMH,I(eJlTR) **High-and Intermediate-pressure amphibolite-facies gneiss, schist, amphibolite, marble, and quartzite**—Protoliths include at least some Paleozoic rocks. Metamorphism is thought to have taken place during Late Triassic through Early Jurassic time

GNS(eJlTR) **Greenschist-facies schist and minor phyllite and metavolcanic rocks**—Protoliths are thought to be of Paleozoic age. Metamorphism is thought to have taken place during Late Triassic through Early Jurassic time

LPP/GNS(eJlTR) **Transitional prehnite-pumpellyite- to greenschist-facies greenstone and associated metasedimentary and metavolcanic rocks**—Most protolith ages are unknown but sparse radiolarians and (or) conodonts are Mississippian, Early Permian, and Late Triassic in age. Metamorphism took place during Early Jurassic time and may have begun in latest Triassic time

LPP(eKPz) **Prehnite-pumpellyite-facies quartzite, phyllite, metalimestone, and grit**—Protoliths are Proterozoic and (or) Paleozoic in age. Metamorphism is bracketed between Paleozoic and late Early Cretaceous time and may have occurred during Early Cretaceous time

LPP,GNS(eKPz) **Undifferentiated prehnite-pumpellyite- and greenschist-facies quartzite, argillite, phyllite, and minor metalimestone**—Protoliths are Proterozoic and (or) Paleozoic in age. Metamorphism is bracketed between Paleozoic and late Early Cretaceous time and may have occurred during Early Cretaceous time

GNS(eKPz) **Greenschist-facies schist, semischist, quartzite, marble, greenstone, and phyllite**—Sedimentary protoliths are Paleozoic in age; volcanic protoliths are in part Devonian in age. Metamorphism is bracketed between Paleozoic and late Early Cretaceous time

GNI(eKPz) **Intermediate-pressure greenschist-facies quartzite, pelitic schist, felsic schist, mafic schist, calc-silicate rocks, and rare marble**—Protoliths are Proterozoic(?) and Paleozoic in age; volcanic protoliths are in part Devonian in age. Metamorphism is bracketed between Paleozoic and late Early Cretaceous time and may have occurred during Early Cretaceous time

AMI(eKPz) **Intermediate-pressure amphibolite-facies pelitic schist and gneiss, quartzite, orthogneiss, calc-silicate rocks, marble, and amphibolite**—Plutonic protoliths are Late Proterozoic and Mississippian in age. Metamorphism is bracketed between Paleozoic and late Early Cretaceous time and may have occurred during Early Cretaceous time

AMP(eK) **Amphibolite-facies schist, gneiss, augen gneiss, amphibolite, quartzite, and minor marble**—Volcanic protoliths are

Alaska Range (Yukon-Tanana, Pingston, McKinley, Windy, and Dillinger terranes)

GNS(eKD) + GNS(eK) **Polydeformed and partly or totally polymetamorphosed greenschist-facies metasedimentary and metavolcanic rocks**—Unit includes schist, quartzite, phyllite, lesser amounts of greenstone, marble, and metachert(?), and singly metamorphosed metadiorite and metagabbro dikes and sills. Protoliths include Devonian volcanic rocks, probable Paleozoic sedimentary and volcanic rocks, Upper Triassic carbonaceous and calcareous rocks and limestone, and Late Triassic to late Early Cretaceous gabbro. Ages of the metamorphic episodes are poorly known. The first episode is bracketed between Devonian and late Early Cretaceous time; the second is probably late Early Cretaceous in age

AMP(eKD) + GNS(eK) **Amphibolite-facies schist, quartzite, amphibolite, and granitic gneiss that have been retrograded to greenschist-facies assemblages**—Protoliths and metamorphic age constraints are the same as those described immediately above

LPP/GNL(eK) **Prehnite-pumpellyite-facies semischist, metavolcanic rocks, schist, phyllite, slate, metalimestone, and metaconglomerate**—Protoliths are Ordovician(?) to Early Mississippian in age. Metamorphism is thought to have occurred during late Early Cretaceous time

GNS(KM) **Greenschist-facies metasedimentary and metavolcanic rocks**—Protoliths include Proterozoic and (or) Paleozoic basement and overlying middle Paleozoic rocks. Metamorphism is bracketed between Mississippian and late Early Cretaceous time

GNS(lKD) **Greenschist-facies phyllite, metaconglomerate, schist, quartzite, metalimestone, greenstone, and metavolcanic rocks**—Metalimestones contain Middle Devonian fossils. Metamorphism is bracketed between Middle Devonian and early Late Cretaceous time

LPP/GNS(K) **Prehnite-pumpellyite- and (or) greenschist-facies metasedimentary rocks, greenstone, and metachert**—Protoliths range in age from middle Paleozoic to mid-Cretaceous. Metamorphism occurred during Cretaceous time

GNL/I(K) **Transitional low- to intermediate-pressure greenschist-facies phyllite, quartzite, metaconglomerate, metavolcanic rocks, metalimestone, and minor metagabbro**—Protoliths are proposed to be Jurassic and Cretaceous in age. Metamorphism occurred during Cretaceous time

AML/I(K) **Transitional low- to intermediate-pressure amphibolite-facies schist, marble, quartzite, and minor amphibolite and metaplutonic rocks**—Unit also includes weakly metamorphosed plutonic rocks. Protoliths include Triassic calcareous rocks and gabbroic dikes and sills of presumed Jurassic and Cretaceous age; weakly metamorphosed (late-kinematic) plutonic rocks are of Late Cretaceous age. Metamorphism occurred during Cretaceous time

AREA SOUTH OF THE MCKINLEY AND DENALI FAULTS AND NORTH OF THE BORDER RANGES FAULT SYSTEM

Medium-grade rocks of the Peninsular, Wrangellia, and Alexander terranes

AMP,GNS(meJ) **Undifferentiated amphibolite- and greenschist-facies metavolcanic and metaplutonic rocks and subordinate marble and pelitic schist**—Protolith ages are unknown but presumably are late Paleozoic to Early Jurassic. Metamorphism was probably associated with Early and (or) Middle Jurassic plutonism

AMP(meJ) + GNS(eTeK) **Amphibolite-facies pelitic schist that has been retrograded to greenschist-facies assemblages**—Protolith ages are unknown but presumably are late Paleozoic to Early Jurassic. Amphibolite-facies metamorphism was probably associated with Early and (or) Middle Jurassic plutonism. Retrograde metamorphism occurred sometime during Early Cretaceous to Paleocene time

GNS,AMP(eKJ) **Undifferentiated greenschist- and epidote-amphibolite-facies tectonized oceanic rocks and blocks of metachert and metabasalt in argillite matrix**—Oceanic rocks include argillite, metachert, schist, amphibolite, marble, and

GNS,AMP(lJ) **Undifferentiated, locally mylonitic greenschist- and amphibolite-facies mafic schist and lesser amounts of pelitic and psammitic schist, metachert, greenstone, marble, and metagranodiorite**—Metagranodiorite is of Pennsylvanian protolith age. Metamorphism is interpreted to have been associated with the intrusion of synkinematic plutons of presumed Late Jurassic age

GNS,AMP(lJ) + GNS(eTlK) **Undifferentiated, locally mylonitic greenschist- and amphibolite-facies mafic schist, calcareous schist, pelitic or psammitic schist, marble, metachert, and metagranodiorite that have been retrograded to greenschist-facies assemblages**—Metagranodiorite is of Pennsylvanian protolith age; bedded rocks are probably of Early Pennsylvanian protolith age. Initial metamorphism was synkinematic with the intrusion of Late Jurassic plutons. Retrograde metamorphism occurred primarily during Late Cretaceous and (or) early Tertiary time

GNS,AMP(lJ) + LPP(eTlK) **Undifferentiated greenschist- and amphibolite-facies phyllite, pelitic schist, calcareous schist, mafic schist, amphibolite, compositionally variable metaplutonic rocks, marble, and metachert that have been retrograded to prehnite-pumpellyite facies**—Protoliths include Lower Pennsylvanian bedded rocks, Pennsylvanian intrusive rocks, and Upper Triassic volcanic and carbonate rocks. Initial metamorphism was synkinematic with the intrusion of Late Jurassic plutons. Retrograde metamorphism occurred primarily during Late Cretaceous and (or) early Tertiary time

GNS(eKlPz) **Greenschist-facies marble, phyllite, metavolcanic rocks, mica schist, and metaplutonic rocks**—Marble is, in part, Devonian in age and may be as old as Cambrian; metaplutonic rocks are late Paleozoic in age. Metamorphism may have occurred during late Paleozoic and (or) during Late Jurassic to Early Cretaceous time

AMP(lTPz) **Amphibolite-facies heterogeneous assemblage of orthogneiss, amphibolite, metaplutonic rocks, schist and phyllite**—Unit consists of a fault sliver of unknown origin. Metamorphism bracketed between Paleozoic and late Tertiary time

Low-grade rocks of the Peninsular and Wrangellia terranes and low- to high-grade flyschoid rocks inboard of the Wrangellia terrane

LPP(J) **Laumontite-facies metagraywacke and metavolcanic rocks**—Protoliths are Jurassic volcaniclastic sedimentary rocks and volcanic rocks. Metamorphism probably was associated with and primarily preceded Jurassic plutonism

LPP(eTlTR) **Prehnite-pumpellyite-facies greenstone and volcaniclastic turbidites**—Protoliths are Late Triassic in age. Metamorphism bracketed between Late Triassic and early Tertiary time

LPP,GNS(lKJ) **Undifferentiated prehnite-pumpellyite- and greenschist-facies metavolcanic rocks, metalimestone, argillite, metachert, greenstone, metasedimentary rocks, and intermediate metaplutonic rock**—Sedimentary and volcanic protoliths are late Paleozoic, Triassic, and Mesozoic in age; plutonic protoliths are Pennsylvanian in age. Age of metamorphism may have varied within this unit. Metamorphism occurred sometime during Early Jurassic to Late Cretaceous time

LPP(eTlK) **Prehnite-pumpellyite-facies metamorphosed flyschoid rocks and tectonically interleaved fragments composed of various metaigneous and metasedimentary rocks**—Flysch consists of metagraywacke, semischist, and argillite of Late Jurassic to early Late Cretaceous age. Tectonic fragments consist of metachert, metalimestone, metasedimentary rocks, and mafic to intermediate metavolcanic rocks; protolith ages range from Devonian to Jurassic. Metamorphism occurred sometime during early Late Cretaceous to early Tertiary (latest Paleocene) time

LPP(eTlK)₁ **Prehnite-pumpellyite-facies argillite, metagraywacke, metaconglomerate, metagabbro, and volcaniclastic metasedimentary rocks**—Unit forms lowest grade part of the Maclaren metamorphic belt. Protoliths are Jurassic and Cretaceous flysch. Metamorphism occured during Late Cretaceous and early Tertiary time

GNI(eTlK) **Intermediate-pressure greenschist-facies phyllite, metagraywacke, marble, quartzite, and greenstone**—Unit forms medium-grade part of the Maclaren metamorphic belt. Protoliths are Jurassic and Cretaceous flysch and Triassic carbonaceous sedimentary rocks, limestone, and mafic igneous rocks. Metamorphism occurred during Late Cretaceous and early Tertiary time

AMI(eTlK) **Intermediate-pressure amphibolite-facies schist, gneiss, amphibolite, and metaplutonic rocks**—Unit forms highest

AREA SOUTH OF THE BORDER RANGES FAULT SYSTEM

Chugach terrane

GNI/H(meJ) **Transitional intermediate-pressure greenschist-facies to high-pressure greenschist- (blueschist-) facies metabasalt, metachert, mica schist, marble, and fine-grained clastic rocks**—Unit occurs as fault-bounded and commonly internally imbricated blocks. Protolith ages are unknown. Metamorphism occurred during Early and Middle Jurassic time

LPP(eTJ) **Prehnite-pumpellyite-facies argillite, metagraywacke, greenstone, metatuff, and metachert**—Unit is a mélange and also includes minor amounts of metalimestone, mafic metaplutonic rocks, serpentinite, and slices of exotic blueschist-facies rocks. Metamorphism occurred during Jurassic to early Tertiary time

LPP(eTlK)₂ **Prehnite-pumpellyite-facies flyschoid metasedimentary rocks**—Unit includes slate, phyllite, metasandstone, and metaconglomerate of the Upper Cretaceous Kodiak Formation. Metamorphism occurred during latest Cretaceous and (or) early Tertiary time

GNL(eTlK) **Low-pressure greenschist-facies flyschoid metasedimentary rocks and oceanic metabasaltic rocks**—Unit includes metagraywacke, slate, phyllite, semischist, schist, and, locally, metaconglomerate, metatuff, greenstone, metagabbro, greenschist, and serpentinite of the Upper Cretaceous Valdez Group. Metamorphism occurred during latest Cretaceous and (or) early Tertiary time

GNL(eTlK) + AML(eT) **Polymetamorphosed low-pressure amphibolite-facies quartz-mica schist and gneiss**—Protoliths and timing of initial low-pressure greenschist-facies metamorphism are the same as those described immediately above. Subsequent amphibolite-facies metamorphism was associated with Eocene plutonism. Equivalent to (informal) Chugach metamorphic complex of Hudson and Plafker (1982)

GNS/AMP(lTK) **Transitional greenschist- to amphibolite-facies schist, semischist, and amphibolite**—Protoliths are interpreted to be turbidites and tholeiite of Cretaceous, probably Late Cretaceous, age. Metamorphism occurred, perhaps more than once, sometime during Cretaceous to Miocene time

AMP(lTK) **Amphibolite-facies biotite gneiss, hornblende schist, and amphibolite**—Protoliths and protolith and metamorphic age constraints are the same as those described immediately above

Yakutat terrane

LPP(eTlK)₃ **Laumontite- and prehnite-pumpellyite-facies metasandstone, argillite, and metaconglomerate and structurally disrupted lenses**—Protoliths of metasedimentary rocks were deposited in Late Cretaceous time. Lenses (mélange) consist of Upper Jurassic(?) and Lower Cretaceous metachert, argillite, and sedimentary and volcanic rocks and olistostromal blocks of older rocks. Unit is lowest grade part of a low-pressure-facies series. Metamorphism occurred during latest Cretaceous and (or) early Tertiary time

GNL(eTlK)₁ **Greenschist-facies slate, phyllite, and semischist**—Unit is intermediate-grade part of a low-pressure-facies series. Protoliths and protolith and metamorphic age constraints are the same as those described immediately above

AML(eTlK) **Amphibolite- and epidote-amphibolite-facies metavolcanic rocks, schist, and minor metaconglomerate and marble**—Unit is highest grade part of a low-pressure-facies series. Protoliths and protolith and metamorphic age constraints are the same as those described above for unit LPP(eTlK)₃

Ghost Rocks and Prince William terranes

LPP(eT) **Prehnite-pumpellyite-facies metagraywacke, argillite, metaconglomerate, metalimestone, greenstone, and greenschist**—Unit locally includes zones of mélange. Protoliths in the Kodiak area (Ghost Rocks Formation of Moore and others, 1983) are Late Cretaceous to early Paleocene in age; protoliths in the rest of the unit (Orca Group) are late Paleocene through early middle Miocene in age. Metamorphism occurred during early Tertiary time

LPP(eT) + AML(eT) **Polymetamorphosed low-pressure amphibolite-facies metasedimentary rocks**—Protoliths and timing of initial