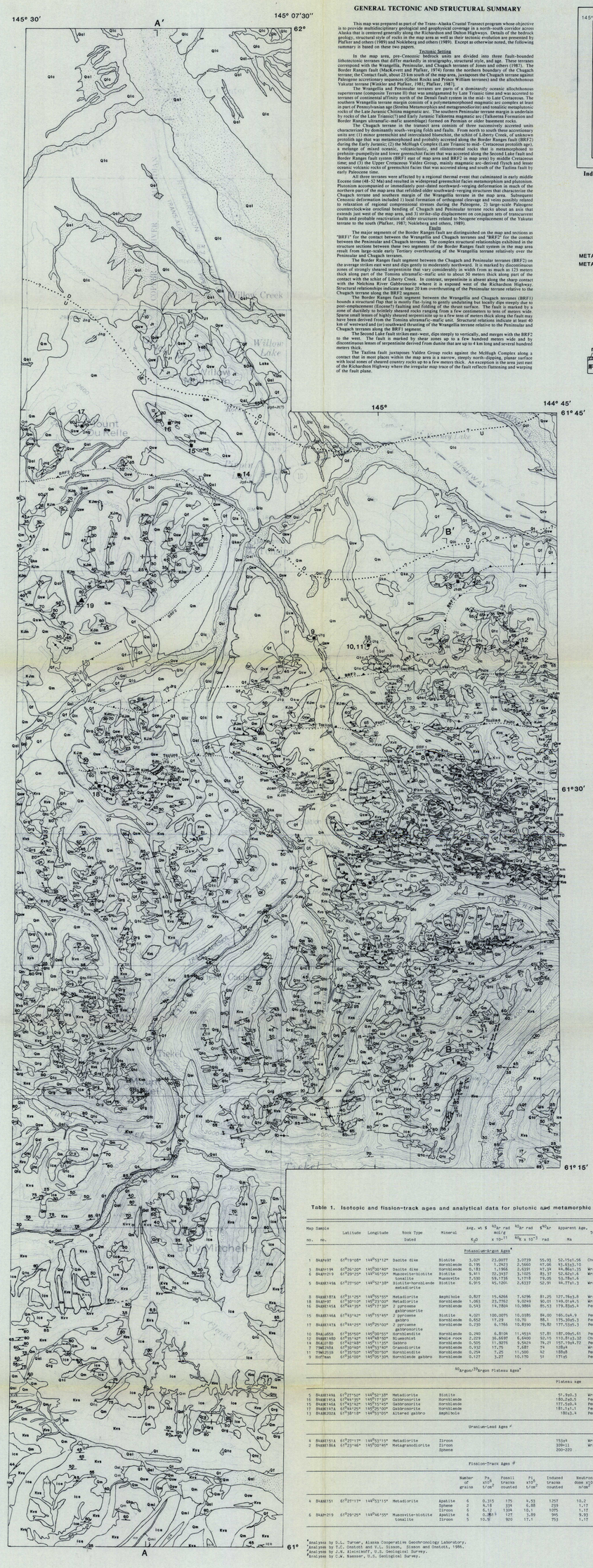


Geology compiled from Winkler and others (1981a), unpublished mapping by Wallace (1981), and mapping by R.G. Coleman (1984), G.W. Crouse (1984), J.S. Lull (1984, 1986), W.J. Nokleberg (1984), T.L. Pavlis, G.H. Pessel (1984), George Plafker (1972, 1984, 1988), R.C. Roback (1984), V.B. Sisson (1984), and W.K. Wallace (1984).

Base USGS topographic series: Valdez, Alaska A-4 (1953), B-3 (1951), B-4 (1951), C-3 (1951), C-4 (1951), D-4 (1949).

GENERAL TECTONIC AND STRUCTURAL SUMMARY

This map was prepared as part of the Trans-Alaska Crustal Transect program whose objective is to provide multidisciplinary geological and geophysical coverage in a north-south corridor across Alaska that is centered generally along the Richardson and Dalton Highways. Details of the bedrock geology, structural style of rocks in the map area as well as their tectonic evolution are presented by Plafker and others (1989) and Nokleberg and others (1989). Except as otherwise noted, the following summary is based on these two papers.

Tectonic Setting

In the map area, pre-Cenozoic bedrock units are divided into three fault-bounded lithotectonic terranes that differ markedly in stratigraphy, structural style, and age. These terranes correspond with the Wrangellia, Peninsular, and Chugach terranes of Jones and others (1987). The Border Ranges fault (MacKevett and Plafker, 1974) forms the northern boundary of the Chugach terrane; the Contact fault, about 25 km south of the map area, juxtaposes the Chugach terrane against Paleogene accretionary sequences (Ghost Rocks and Prince William terranes) and the allochthonous Yakutat terrane [Winkler and Plafker, 1981; Plafker, 1987].

The Wrangellia and Peninsular terranes are parts of a dominantly oceanic allochthonous superterrane (composite Terrane II) that was amalgamated by Late Triassic time and was accreted to terranes of continental affinity north of the Denali fault system in the mid- to Late Cretaceous. The southern Wrangellia terrane margin consists of a polymetamorphosed magmatic arc complex at least in part of Pennsylvanian age (Seitsina Metamorphics and metagranodiorite) and tonalitic metaplutonic rocks of the Late Jurassic Chitina magmatic arc. The southern Peninsular terrane margin is underlain by rocks of the Late Triassic(?) and Early Jurassic Talkeetna magmatic arc (Talkeetna Formation and Border Ranges ultramafic-mafic assemblage) formed on Permian or older basement rocks.

The Chugach terrane is a complex assemblage of Paleozoic and Mesozoic oceanic rock units characterized by dominantly south-verging folds and faults. From north to south these accretionary units are: (1) minor greenschist and intercalated blueschist, the schist of Liberty Creek, of unknown protolith age that was metamorphosed and probably accreted along the Border Ranges fault (BRF2) during the Early Jurassic; (2) the McHugh Complex (Late Triassic to mid- Cretaceous protolith age), a melange of mixed oceanic, volcaniclastic, and olistostromal rocks that is metamorphosed to prehnite-pumpellyite and lower greenschist facies that was accreted along the Second Lake fault and Border Ranges fault system (BRF1 east of map area and BRF2 in map area) by middle Cretaceous time; and (3) the Upper Cretaceous Valdez Group, mainly magmatic arc-derived flysch and lesser oceanic volcanic rocks of greenschist facies that was accreted along and south of the Taylina fault by early Paleocene time.

All three terranes were affected by a regional thermal event that culminated in early middle Eocene time (48-52 Ma) and resulted in widespread greenschist facies metamorphism and plutonism. Plutonism accompanied or immediately post-dated northward-verging deformation in much of the northern part of the map area that refolded older southward-verging structures that characterize the Chugach terrane and southern margin of the Wrangellia terrane in the map area. Subsequent Cenozoic deformation included 1) local formation of orthogonal cleavage and veins possibly related to relaxation of regional compressional stresses during the Paleogene, 2) large-scale Paleogene counterclockwise rotational bending of Chugach and Peninsular terrane rocks about an axis that parallels the Pacific margin of the Chugach terrane, and 3) Neogene faulting mainly on conjugate sets of transcurrent faults and probable reactivation of older structures related to Neogene emplacement of the Yakutat terrane to the south (Plafker, 1987; Nokleberg and others, 1989).

Faults

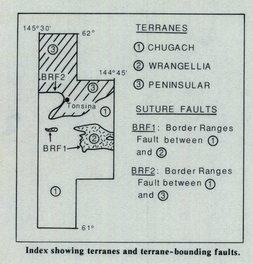
The major segments of the Border Ranges fault are distinguished on the map and sections as "BRF1" for the contact between the Wrangellia and Chugach terranes and "BRF2" for the contact between the Peninsular and Chugach terranes. The complex structural relationships exhibited in the structure sections between these two segments of the Border Ranges fault system in the map area result from large-scale early Tertiary overthrusting of the Wrangellia terrane relatively over the Peninsular and Chugach terranes.

The Border Ranges fault segment between the Chugach and Peninsular terranes (BRF2) on the average strikes east west and dips gently to moderately northward. It is marked by discontinuous zones of strongly sheared serpentinite that vary considerably in width from as much as 125 meters thick along part of the Tonsina ultramafic-mafic unit to about 50 meters thick along part of the contact with the schist of Liberty Creek. In contrast, serpentinite is absent along the sharp contact with the Nelchina River Gabbronorite where it is exposed west of the Richardson Highway. Structural relationships indicate at least 20 km overthrusting of the Peninsular terrane relative to the Chugach terrane along this fault segment.

The Border Ranges fault segment between the Wrangellia and Chugach terranes (BRF1) bounds a structural flap that is mostly flat-lying to gently south-dipping and consists of a complex post-emplacement (Eocene?) faulting and folding of the thrust surface. The fault is marked by a zone of ductilely to brittlely sheared rocks ranging from a few centimeters to tens of meters wide. Sparse small lenses of highly sheared serpentinite up to a few tens of meters thick along the fault may have been derived from the Tonsina ultramafic-mafic unit. Structural relations indicate at least 40 km of westward and (or) southward thrusting of the Wrangellia terrane relative to the Peninsular and Chugach terranes along the BRF1 segment.

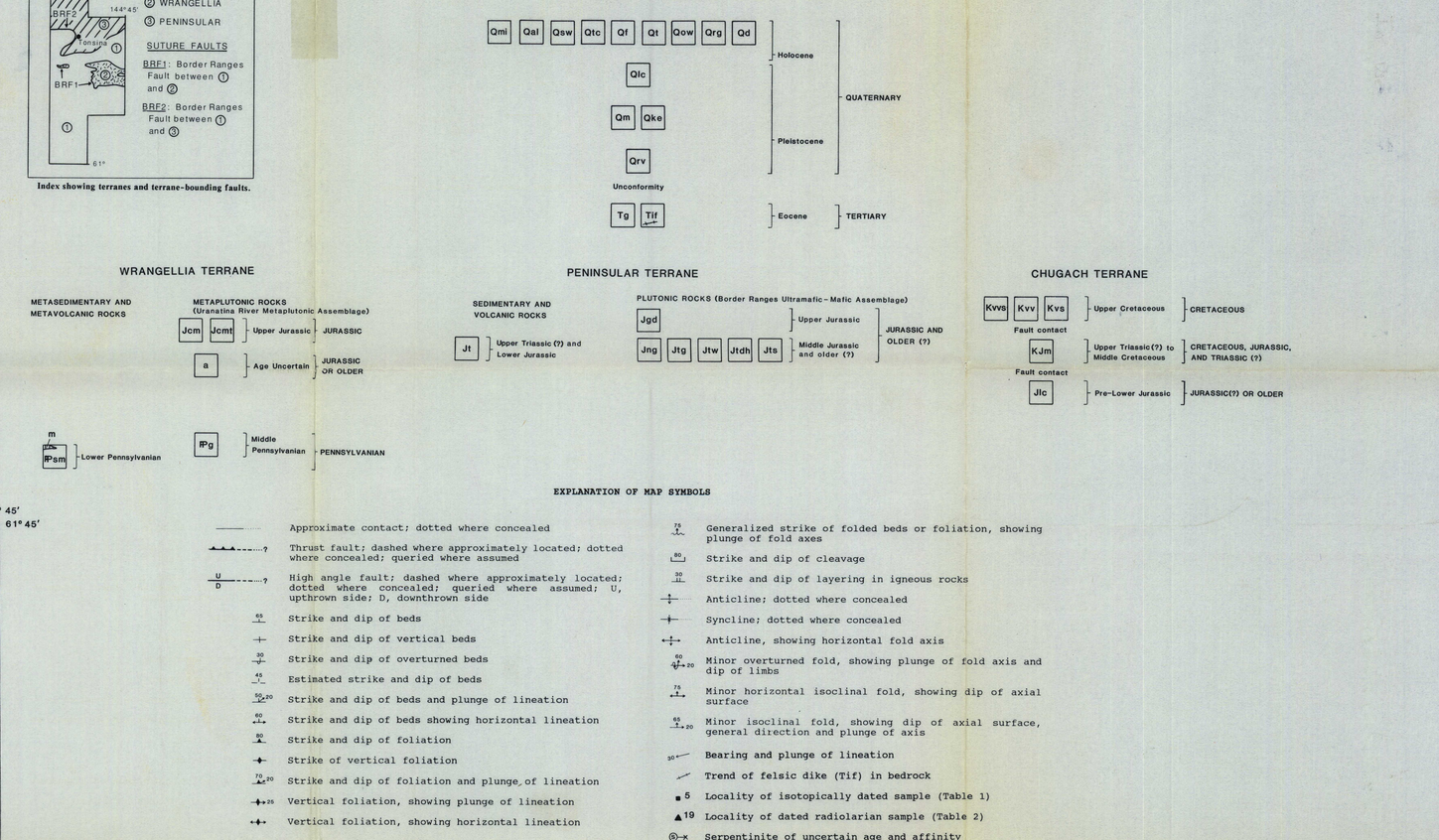
The Second Lake fault strikes east-west, dips steeply to vertically, and merges with the BRF2 to the west. The fault is marked by shear zones up to a few hundred meters wide and by discontinuous lenses of serpentinite derived from dunite that are up to 4 km long and several hundred meters thick.

The Taylina fault juxtaposes Valdez Group rocks against the McHugh Complex along a contact that in most places within the map area is a narrow, steeply north-dipping, planar surface with local zones of sheared country rocks up to a few meters thick. An exception is the area just east of the Richardson Highway where the irregular map trace of the fault reflects flattening and warping of the fault plane.



Index showing terranes and terrane-bounding faults.

CORRELATION OF MAP UNITS



EXPLANATION OF MAP SYMBOLS

- Approximate contact; dotted where concealed
- Thrust fault; dashed where approximately located; dotted where concealed; queried where assumed
- High angle fault; dashed where approximately located; dotted where concealed; queried where assumed; U, upthrown side; D, downthrown side
- 65 Strike and dip of beds
- Strike and dip of vertical beds
- 30 Strike and dip of overturned beds
- 45 Estimated strike and dip of beds
- 50 20 Strike and dip of beds and plunge of lineation
- 60 Strike and dip of beds showing horizontal lineation
- 80 Strike and dip of foliation
- Strike of vertical foliation
- 70 20 Strike and dip of foliation and plunge of lineation
- 25 Vertical foliation, showing plunge of lineation
- Vertical foliation, showing horizontal lineation
- 75 Generalized strike of folded beds or foliation, showing plunge of fold axes
- 80 Strike and dip of cleavage
- 30 Strike and dip of layering in igneous rocks
- Anticline; dotted where concealed
- Syncline; dotted where concealed
- Anticline, showing horizontal fold axis
- 60 20 Minor overturned fold, showing plunge of fold axis and dip of limbs
- 75 Minor horizontal isoclinal fold, showing dip of axial surface
- 60 20 Minor isoclinal fold, showing dip of axial surface, general direction and plunge of axis
- 30 Bearing and plunge of lineation
- Trend of felsic dike (Tif) in bedrock
- 5 Locality of isotopically dated sample (Table 1)
- 19 Locality of dated radiolarian sample (Table 2)
- Serpentinite of uncertain age and affinity

DESCRIPTION AND INTERPRETATION OF MAP UNITS

ALL TERRANES

Unconsolidated Deposits (Quaternary)-- Diverse unconsolidated surficial deposits of modern origin, except for deposits of glacial Lake Atna and coarse morainal deposits that formed during both the latest major glaciation (Wisconsin) and the younger Alaska glaciation and lahar deposits from the Wrangell Mountains. The distribution and character of these deposits is taken mainly follow Nichols and Yehle (1969) and Williams and Johnson (1980) with minor modifications of ice-bedrock contacts within the map area. The chronology of glacial and glaciolacustrine sequences in the Copper River Basin was discussed in detail by Williams and Johnson (1981) and Ferrians and others (1983). Consist of:

- Qal Alluvium (Holocene)
- Qf Alluvial fan deposits (Holocene)
- Qd Deltaic deposits (Holocene)
- Qlc Terrace gravel (Holocene)
- Qtc Talus cone deposits (Holocene)
- Qsw Slope wash deposits (Holocene)
- Qm Morainal moraine (Holocene)
- Qrg Rock glaciers (Holocene)
- Qow Outwash deposits (Holocene)
- Qt Cataract deposits (Pleistocene)
- Qke Kame deposits (Pleistocene)
- Qd Delta and esker deposits (Pleistocene)
- Qrv Lahar deposits (Pleistocene)

Tg Tonalite (Eocene)-- Discordant hypabyssal tonalite stock about 1/2 km^2 that intrudes the Uranatina River metatonalite assemblage. Age is a quality no. 6). Lithologically similar stocks and plugs are located just to the east of the map area within both the metaplutonic assemblage and McHugh Complex. The intrusive rocks form bold, conspicuously light-colored outcrops. The stock in the map area is very light gray, fine- to medium-grained, inequigranular, hypidiomorphic granular, massive tonalite. Variants to the east include quartz diorite and granodiorite in which either biotite or hornblende may be the dominant mafic mineral. Accessory minerals are euhedral biotite or form from alteration of plagioclase (Winkler and others, 1981a).

Age data-- The rock is intrusive into tonalite has nearly concordant biotite and muscovite ages of 52.6 and 53.8 ± 1.6 Ma that are probably close to the emplacement age (no. 5, Table 1). Fission-track data are nearly concordant and indicate rapid cooling through the annealing temperatures of these minerals (Lull and others, 1986, no. 5, Table 1). The 52.6 Ma K-Ar biotite age indicates a pronounced Eocene uplift of the northern Chugach Mountains. Isotopically-dated pre-Tertiary metamorphic rocks with ages of ca. 45 to 52 Ma in the same general area suggest widespread thermal metamorphism related to the Tertiary plutonism (no. 5, Table 1). The tonalite stock and associated plutonic rocks are inferred to have caused the widespread contact metamorphism of pelitic schist (Tts) on the basis of their distribution, lithology, geochemistry, and age. Probable correlative hypabyssal rocks are a very abundant vein of the map area along the southern margin of the Wrangellia and Peninsular terranes in the northern Chugach Mountains. Tonalite dikes and sills are also abundant in the Wrangellia terrane and eastern part of the Prince William terrane (Sanak-Baranof belt of Hudson, 1983). Their distribution, coupled with that of dike unit (Tv), suggest that all these terranes were in absolute present relative positions by Eocene time (Plafker and others, 1989).

Tif Intermediate dikes (Eocene)-- Andesite and dacite dikes that extensively intrude the Uranatina River metamorphic unit of the southern margin of the Wrangellia terrane. The Talkeetna Formation and Jurassic metatonalite are absent north of the Chugach terrane. Mainly steeply dipping dikes and dike swarms a few meters to 10 m thick, the largest of which are shown schematically on the map and sections. Dikes tend to be emplaced parallel to regional joint sets, the most prominent of which generally trend approximately east-northeast to northwest. Typically fine- to medium-grained porphyritic of plagioclase and hornblende ± sparse quartz phenocrysts a very fine-grained to aphanitic groundmass. Some of the dikes exhibit flow banding. Plagioclase phenocrysts generally euhedral albite of about 5 mm in diameter. Plagioclase phenocrysts are generally fresh with well-developed oscillatory zoning.

Age data-- Yield K- Ar ages of 52 Ma and 44 Ma, respectively, suggest that the Eocene plutonic rocks (no. 1 and 3, Table 1). They are younger than the major displacements on the Border Ranges fault and intrusive in the map area because they intrude rocks both north and south of these faults, and one small dike intrudes directly across the fault contact. They are widely distributed in the Valdez Group west of the map area in the Valdez and Anchorage quadrangles (Winkler and others, 1981a; Nelson and others, 1985). K-Ar ages of the dikes north of the Peninsular terrane to the Kodiak Islands comparable age ranges from about 55 to 44 Ma (Nelson and others, 1985)

WRANGELLIA TERRANE

Metamorphic rocks and metamorphic rocks

IPsm Strelna Metamorphic of Plafker and others (1989) (Early Pennsylvanian and older?)-- Variably metamorphosed and deformed, low grade metamorphic assemblage of schistose metasedimentary and metavolcanic rocks with minor metaplutonic rocks, exposed mainly east of the map area. Rocks in the map area are dominantly pelitic schist and minor marble. Forms the older part of the Liberty Creek metamorphic assemblage of Plafker and others (1989); informally referred to as the Little Tonsina River Assemblage by Winkler (1981). Metamorphic grade is lower greenschist facies; however, grade increases to amphibolite facies adjacent to Late Jurassic metaplutonic rocks of the Uranatina River metatonalite and Late Cretaceous hypabyssal intrusion (Nokleberg and others, 1989). Rocks commonly fine grained with folded and crenulated foliation. Local mylonitic fluxion texture. Quartz is commonly segregated into bands and lenses. Second strong deformation, primary textures have not been obliterated. Protoliths are rocks except for primary bedding, graded bedding, and relict clastic texture are absent.

Consists mainly of small outcrop areas of metamorphosed and variably foliated ultramafic and gabbroic rocks, too small to be delineated on the map, that are mainly serpentinite. Rocks are commonly sheared and foliated. Some of these rocks have a juxtaposed sheets of Wrangellian rocks relatively over rocks of the Chugach terrane. The most common types are coarse-grained hornblendite, hornblende gabbro, clinopyroxenite, and olivine hornblende pyroxenite ± chromite ± serpentine ± antigorite.

Quartz-feldspar mica schist and quartz mica schist, in zones to 1 km wide, comprise most of the rocks in the map area. The two lithologic types are commonly interlayered and the local contacts are gradational to sharp. The unit locally includes undivided metaplutonic rocks which strongly resemble the quartz-feldspar mica schist in outcrop which is apparently derived from the quartz-feldspar mica schist typically shows subtle, centimeter- to meter-scale layering that appears to reflect original bedding. Though mostly recrystallized, a few samples appear to have a relict clastic texture. Quartz-rich segregations commonly parallel layering. Mineral assemblages are alkali feldspar, fine grained quartz, and variably albitized and altered plagioclase, ± garnet, white mica, epidote, chlorite, sphene, and calcite. The quartz-mica schist is characterized by thinly laminated (1-10 mm) layers of quartz-schist and quartz-rich mica schist. The rock consists of 60-90% strained, granoblastic quartz (mainly the smaller 0.2 mm grains) with varying amounts of biotite, white mica, chlorite, epidote, garnet, and calcite; segregation bands and veins(?) of coarsely crystallized quartz (~1 cm) are common. The rock commonly has a shear-folded appearance, local fluxion texture, moderate segregation of felsic minerals, and local crosscutting shear zones of cataclasite.

White to gray marble(m) forms conspicuous deformed and folded bands and pods throughout the Liberty Creek metamorphic belt. Compositional layering is a conspicuous marker in the metamorphic complex. Individual marble beds vary markedly in thickness and lateral extent; most are on the order of 200 m, indicating amounts of recrystallization. Individual layers are continuously trackable for up to 3 km. Only the largest and most continuous layers are shown on the map. Most marble is coarse-grained, equigranular, granoblastic, and nonfoliated. Some marble layers contain rare calcite veins predominantly phyllitic schist or as inclusions within metaplutonic rocks. The marble is massive to strongly schistose and locally contains small amounts of recrystallized. Commonly composed of 95% or more strongly dynamically recrystallized calcite ± minor opaque minerals in thin stringers, pods, remobilized sphene, graphite, and white mica. Locally, calc-schists are associated with the marable beds that consist of 50-70% calcite, with quartz, chlorite, white mica, epidote and albite ± tremolite, actinolite, and sphene.

The greenschist is mainly albite, epidote, chlorite, and actinolite ± quartz, calcite, white mica, sphene, leucoxene (two samples), chlorite, hornblende, magnetite, and possible remnant hornblende. Protolith is mainly volcanic rocks that may have been derived from the nearby Pennsylvanian to Early Permian Skolai magmatic arc that underlies much of the Wrangellia terrane (MacKevett, 1978; Richter, 1975; Jones and others, 1981).

Age data--Unit underlain in the map area; predates the Middle Pennsylvanian and Late Jurassic metaplutonic rocks of the Uranatina River metatonalite unit. Considered to be at least as old as Early Pennsylvanian by correlation along strike with strata containing age-diagnostic fossils approximately 10 km east of the Copper River (Plafker and others, 1985). Corresponds in general with the metamorphosed Skolai Group (MacKevett, 1978), undivided Skolai Group (Winkler and others, 1981a), nonplutonic rocks of the Chitina Valley Group of Richter and others (1975), Little Tonsina River and Station Creek assemblages of Plafker and others (1985), and nonplutonic part of the Seitsinha metamorphic complex of Winkler and others (1981a)

Metaplutonic rocks

Uranatina River metaplutonit unit (Jurassic and Pennsylvanian)-- Compositionally diverse, strongly schistose to locally blastomylonitic metaplutonic rocks metamorphosed to low greenschist facies. Forms younger part of the Liberty Creek metamorphic assemblage of Plafker and others (1989); informally referred to as the Uranatina River metaplutonic assemblage by Wallace (1981). Unit comprises about 80% of the Wrangellia terrane in the map area, and is widely distributed along strike to the east of the Tarsal fault in the upper Chitina River valley (Winkler and others, 1981a). Includes volumetrically minor amounts of Pennsylvanian metagranodiorite with more abundant compositionally variable Mesozoic metaphitonic rocks that range in composition from ultramafic to tonalitic. Protoliths are estimated 80% gabbroic hornblende diorite, quartz diorite, and tonalite. Deformation took place under hornblende to lower greenschist facies metamorphic conditions. Cataclastic flow in the more siliceous rocks and by brittle cataclastic failure in adjacent more mafic rocks (Nokleberg and others, 1989; Pavlis and Crouse, 1989). Consists of:

Jcm Mafic and intermediate metaplutonic rocks (Late Jurassic)-- Foliated to mylonitic plutonic rocks, dominantly diorite, but including quartz diorite and tonalite, comprise an estimated 80% of the unit. Mineral assemblages of the diorites (<5% quartz), quartz diorites (5-20% quartz), and tonalites (>20% quartz) are essentially hornblende and albitized plagioclase ± quartz, biotite, and chlorite. Unit recrystallized and altered to varying degrees with partial to complete replacement of hornblende by actinolite, epidote, and chlorite and of plagioclase by epidote, sericite, and calcite. Accessory minerals include apatite, sphene, and zircon(?)

Jcmt Trondhjemite (Late Jurassic?)-- Two small plutons and numerous highly deformed pods, stringers, and dike of leucocratic metaigneous rocks of dominantly trondhjemitic composition within the Haley Creek metamorphic assemblage in the and near the Border Ranges fault in the map area and east of the map area near the Copper River. Rocks are uniformly white and consist of 75-90% plagioclase that is pervasively albitized, and 10-25% quartz with from 0-10% muscovite ± sparse epidote and chlorite. Generally strongly foliated and (or) lineated. Primary textures strongly modified or obliterated by intensive ductile deformation and recrystallization with trondhjemite bodies commonly flattened into the foliation, or into pods and lenses aligned with the foliation ad lineation of enclosing rocks. In local low-strain zones, trondhjemite preserves a hypidiomorphic granular texture. Contacts commonly segregated into bands and lenses. Second strong deformation, primary textures have not been obliterated. Protoliths are rocks except for primary bedding, graded bedding, and relict clastic texture stone locality.

Jt Metagabbro (Middle Pennsylvanian)--Underlies an area estimated to be <1 km^2 in a cirque just east of the Richardson Highway (map locality no. 2). Foliated metagranodiorite is a remnant of a larger pluton engulfed in younger plutonic rocks. Distribution and contact relationships are unknown. Consists of an estimated 45% plagioclase, 30% quartz, 15%potassic feldspar, and 10% epidote with <1% hornblende altered to epidote, and accessory tourmaline, sphene, and oilipsomelane.

Age data--The Pennsylvanian biotite-tonalitic granodiorite is dated by U-Pb zircon ages of 310 ± 3 and 312 ± 3 Ma (no. 1, Table 1). Intrudes Pennsylvanian and variably metamorphosed to intermediate plutonic rocks, metagranodiorite, monzonite and syenite plutons are widely distributed to the east and north in the Chitina Valley and southern Nutzotin and Mansfield Mountains (Aleinikoff and others, 1981; Richter and others, 1988; Plafker and others, 1989).

The metadiorite has Late Jurassic emplacement age of 153 ± 4 Ma based on U-Pb zircon analysis (no. 4, table 1); K-Ar dates on hornblende from the diorite and tonalite stock in the same field complex yielded ages but with a wider spread due to partial resetting (no. 5, 8, 1, Table 1). Early Cretaceous K-Ar ages of 110 Ma from a granodiorite (no. 7, Table 1) in the map area and 133 Ma from a trondhjemite just east of the map area (Winkler and others, 1981a) are tentatively interpreted as most probably reset by Late Cretaceous deformation and by early Tertiary plutonism; however, a Cretaceous igneous event is an alternative possibility (Plafker and others, 1989). Fission-track data on a metadiorite sample (no. 4, Table 1) yields closely similar ages for sphene (48 ± 8.4 Ma), zircon (42.3 ± 3.8 Ma), and apatite (42.4 ± 7.0 Ma) which suggests rapid uplift and cooling through the annealing temperatures of the plutonic suite in the eastern part of the Chugach Mountains. Rocks in the Chitina Valley batholith to the east (Plafkerand others, 1989). Late Jurassic plutonic rocks (Jgd) of the Talkeetna Mountains are the closest known exposures to the southern margin of the Peninsular terrane in the mapare and to the west in the Valdez quadrangle (Winkler and others, 1981a), may abide part of this magmatic belt. If so, the Wrangellia and Peninsular terranes were juxtaposed by at least Late Jurassic time

PENINSULAR TERRANE

Sedimentary and volcanic rocks

Jt Talkeetna Formation (Early Jurassic and Late Triassic?)-- Dominantly andesitic volcaniclastic rocks and associated hypabyssal rocks that are poorly exposed at Stuck Mountain and in isolated wooded hills just west of the Richardson Highway in the northern part of the map area. Formerly mapped as part of the Chitina Valley Group by Mountain (Martin, 1926) and geographically extended into the Valdez quadrangle to include lithologically and compositionally equivalent strata (Winkler and others, 1981a; Plafker and others, 1989)

Consists of well-bedded and locally faulted with general northeast dips at angles of 35-55°. Unit 2-3 km thick. Well and seismic reflection data from within the Copper River Basin indicate that it is overlain by Middle and Upper Jurassic and Cretaceous bedded sedimentary and lesser volcanic rocks (Plafker and others, 1989; Alaska Geological Society, 1969). In the map area, the contact with the Nelchina River Gabbronorite is not exposed but is inferred to be a steep fault zone that separates the Talkeetna Formation from the Peninsular terrane. The rocks are intruded by the Nelchina River Gabbronorite