DRAWING NUMBER
RAYHO CORPORATION · RIVIERA, CALIFORNIA
RATIO FORMAT 1/8 REDUCTION
SEE LIST OF SHEETS FOR SIZES OF SHEETS USED

# U.S. GEOLOGICAL SURVEY

# OPEN FILE REPORT 80-892-A

## FOLIO OF THE VALDEZ QUADRANGLE, ALASKA

## WINKLER AND OTHERS--GEOLOGY

## Sheet 2 of 2

# GEOLOGIC MAP AND SUMMARY GECHRONOLOGY OF THE VALDEZ QUADRANGLE, SOUTHERN ALASKA

By

G.R.Winkler, M.L. Silberman, Arthur Grantz, R.J. Miller, and E.M. MacKevett, Jr.

1981

## DESCRIPTION OF MAP UNITS

### ALL DOMAINS

#### Surficial Deposits

Q Unconsolidated surficial deposits - diverse Quaternary surficial deposits are widespread in the quadrangle and generally are related to present or former glaciers. The deposits include alluvium, colluvium, talus, glacial till, glaciofluvial, and paludal deposits, and a variety of intermediate, mixed, and reworked deposits that formed during both the latest major glaciation (Wisconsinan) and the younger Alaska glaciation. The distribution and character of these surficial deposits are described by Nichols and Yehle (1965), Williams and Johnson (1980), and Yehle (1980). The complicated chronology of glacial and associated deposits in the Valdez area is briefly made to discussed in detail by Fortuna and Nichols (1965) and by Williams and Johnson (1980).

#### Plutonic rocks

Tdf Felsic to intermediate hypabyssal intrusive rocks - dikes, sills, and small stocks include most pre-Miocene age units. Dikes and sills are very conspicuous in domains 2 and 4; small stocks are most numerous in domain 3, but exist in all domains. The hypabyssal rocks are compositionally diverse; dacite porphyries and felsite dikes are most abundant, but rhyolite and andesite are present locally. Most rocks are porphyritic and contain abundant fine-grained (or less commonly medium-grained) phenocrysts in extremely fine-grained felsic or pilotaxitic groundmass. The phenocrysts consist of plagioclase, mafic minerals (chiefly hornblende, biotite, and pyroxene), quartz and K-feldspar. Hornblende is the mafic phenocryst most commonly present and pseudomorphs or relics and the fulmanr phenocrysts are partially altered or replaced by calcite or sericite. Groundmasses generally are strongly altered also. The hypabyssal rocks form bold, conspicuously light-colored outcrops and weather very light gray or pale tan, generally in contrast to darker-hued country rocks.

The hypabyssal rocks are younger than the latest metamorphism that affected the Chugach terrane and contiguous terranes to the north; that also may post-date major movement on the Pitts Creek-Chugach Mountains fault system. Hypabyssal intrusions both north and south of the fault, ranging from domains 2 and 4 (Table 1, locs. 12 and 28) have been dated at ca. 47 and 42 m.y., indicating no Eocene age for some of the hypabyssal rocks. Altered, mineralized dikes in the Tasnuna quadrangle to the east are cut by Eocene(?) dikes and are unaltered. Intrusions include the Valdez and Orca Groups in the Prince William Sound region (Nedom and others, 1979; Winkler and Plafker, 1981)

Dominantly mafic hypabyssal rocks (domain 3 see below); they are similar to undated rocks in the Schlichter area that are believed to be Eocene (Grantz, 1960) and to undated rocks in the upper Matanuska Valley and the southern Talkeetna Mountains that include rocks as young as the Chickaloon Formation of Paleocene age (Coalyer and others, 1978), Eocene(?) dikes in the Valdez quadrangle (Table 1, locs. 4, 6; Grantz and M. L. Silberman, unpublished data, 1980). To the east in the McCarthy quadrangle, similar rocks in domain 3 have yielded K-Ar ages as young as Miocene (MacKevett and others, 1978) and are believed to represent subvolcanic phases of Wrangell lava volcanism; analogous rocks may be present in the southern Talkeetna Mountains (Coalyer and others, 1978).

#### DOMAIN 1

#### Sedimentary and volcanic rocks

QTw Wrangell Lava - The Nikolai Lava (Moxham(1), 1955) consists of at least 2,000 m of flows, tuffs, and minor sedimentary rocks in the southeastern part of the quadrangle. The volcanic rocks issued chiefly from Mt. Wrangell (4317 m), an active shield volcano, which emits small volumes of ash and occasionally flows; a prominent crater on the east side of its summit (about 1 km in diameter) is surrounded by Quaternary and older rocks; hydrothermal plume and ditas (may unit QTi) genetically related to Wrangell lava extensive out parts of the volcanic sequence; and columnar jointed to massive flows and tuffs are interstratified with Neogene ash and debris-flows so far as the Yakutat Quadrangle (Winkler and Plafker, 1981; Table 1, Table and Nichols, 1965). The Wrangell lava ranges in composition from basalt to dacite, but mainly is pyroxene andesite. The flows are essentially diverse: porphyritic rocks with fine-grained interstratal groundmasses are characteristic, but subordinate intermediate to felsic rocks with aphanitic groundmasses range from basaltic to sub and are dominantly lithic-crystal tuff. Widespread but volumetrically minor and mafic flows and pyroclastic rocks (Table 1) are exposed beneath flow in river canyons that drain southeastward from Mt. Wrangell.

The Wrangell lava is part of a calc-alkaline volcanic province that extends throughout the Wrangell Mountains and discontinuously eastward into the Yukon Territory (MacKevett, 1978). Probable correlatives occur in the Talkeetna Mountains, the Alaska Peninsula, and the Aleutian Islands. Most Wrangell Lava in the Valdez quadrangle is thought to be Quaternary in age (Richter and others, 1978; Nelson and others, 1978) but Moxham and Nichols (1965) report K-Ar ages ranging between 10 and 2.7 m.y. for Wrangell Lava in the Nabesna quadrangle to the northeast. The youngest Wrangell Lava in the Valdez quadrangle is not well dated, but probably is Holocene inasmuch as lapies of the courses of several rivers in the southern Copper River Basin appear to have been influenced by Wrangell lava flows which lie above dated ash and debris-flows that have a minimum C-14 age of only 1760 ± 200 years (Miller and Smith, 1976).

Kb Berg Creek Formation - Lower Cretaceous marine clastic rocks are exposed in three separate areas of domain 1: (1) at the eastern edge of the quadrangle capping a ridge between the Chitina and Copper Rivers; (2) near the confluence of the Chitina and Copper Rivers; and (3) two small upland patches west and south of Marshia Creek. The Lower Cretaceous rocks rest with angular unconformity upon Paleozoic and Lower Mesozoic bedded rocks and upon Upper Jurassic plutonic rocks dated by K-Ar ages of 153 ± 5 m.y. (Table 1, loc. 8) in the Eureka River, the Lower Cretaceous rocks consist of at least 200 m of diverse calcareous conglomerate, conglomeratic sandstone, and sandstone. Conglomerate clasts are well rounded, the sand sandstones generally are pebbly, cobbly, and boulder conglomerate consisting of clasts that were derived from Paleozoic rocks. Overlying strata are very lenticular, and many sandstone beds have steeply inclined cross-stratification. Fossils are rare but include pelecypod molds and casts of Buchiaceae. The type section of the formation is very light gray calcarenite that is largely bioclastic. These rocks probably formed in a high-energy near shore bar or shoal. They are Neocomian (Grantz and others, 1964) and correlate with the Berg Creek Formation of the Valdez quadrangle and of the McCarthy quadrangle (MacKevett and others, 1978). Near the mouth of the Chitina River, the Lower Cretaceous rocks consist of at least 400 m of partly calcareous siltstone, sandstone, and conglomerate (Moffit, 1954) and are similar to the Berg Creek north of the Katalla River. The conglomerate contains clasts of nearby bedrock, with prominent clasts of Paleozoic limestone and of Upper Jurassic porphyry. Some of these sequentiions. Near the mouth of the Chitina River, dark-gray fossiliferous glauconitic siltstone is more abundant than it is north of the Katalla River, although layers of thick limestone shells and calcareous sandstone crowded with pelecypods are also conspicuous in the section. The fossil assemblages of siltstones probably indicate that the rocks were deposited farther from shore than the thinner and coarser equivalent rocks to the north. Remnant upland patches of Lower Cretaceous rocks less than 30 m thick are present west and south of Marshia Creek. They consist of dark brownish-gray siltstone, sandstone, and conglomerate similar to lithologies in the Berg Creek Formation elsewhere. The rocks form small sections of considerable relief locally. No fossils were collected from these patches, but they are presumed to be distal facies of the Berg Creek Formation, as are the more extensive outcrops near the mouth of the Chitina River. Lithologic and chronologic correlatives of the Lower Cretaceous clastic rocks are present in domain 3 to the west of the Valdez quadrangle and in the Talkeetna Mountains. Locally the Berg Creek is intruded by Upper Jurassic rocks.

Jm Unnamed Jurassic marine sedimentary rocks - Marine clastic rocks of probable Late Jurassic age crop out in the bluffs of the Copper River between the mouths of Marshia and Rivers. The rocks are at least 300 m thick and consist mostly of shale, stone, siltstone and mudstone, which contain many interbeds of pebble- and cobble-conglomerate (Grantz and others, 1964). Neither the top nor the base of the sequence is exposed, but the sequence may gradationally to or transition from nearby outcrops of the Kotsina and resembles it closely in color and degree of induration. Conglomeratic sandstones predominate in the lower part of the sequence; in many places it is calcareous and cross-stratified. Pebbles contain abundant clasts of subolivic and basaltic lithic clasts with subordinate plagioclase, amphibole, and quartz. Cobbles are mainly of porphyritic rocks. Clasts in interbedded conglomerate mostly are intermediate or mafic volcanic rock types, but scattered clasts of felsic and mafic plutonic rocks, limestone, and sandstone occur. Dark greenish-gray siltstone and mudstone predominate in the upper part of the section and are very similar to rocks of the Chichina River. The highest rocks in the sequence include rust-gray weathering limey siltstone interbeds and concretions. Rocks in the Chitina River are slightly folded into southeast-striking cherrons and brachyclines (Grantz and others, 1964). Apparently the strata were deformed during the Late Jurassic and Early Cretaceous orogeny that affected all pre-Albian rocks in the Matanuska-Wrangell terrane (MacKevett, 1978).

Sparse fossils from outcrops in the Chichina River indicate a probable early Late Jurassic (Callovian) age for the unnamed rocks (Grantz and others, 1964). They are coeval with Upper Jurassic rocks in the Chichina River and in the Talkeetna Mountains (Imlay, 1973) and with the Hitchin Mountain Formation of the eastern Wrangell Mountains (MacKevett, 1969).

Ka Kotsina Conglomerate - The Kotsina Conglomerate (Moho, 1900) crops out extensively both north and south of the Kotsina River and also occurs on the north side of the Chuchatna River. It is lithologically similar to the Berg Creek and Chichina Formation, but its top is nowhere exposed. Most outcrops of the Kotsina are cut by numerous high-angle faults, so its reported maximum thickness of 300 m is only approximate. The Kotsina consists of bold, craggy outcrops of well-indurated pebble- and cobble-conglomerate and coarse sandstone with some buisiers clasts. Olive-gray lithic and feldspathic sandstone, siltstone, and carbonaceous shale are interbedded in many places, and increase in proportion west of Long Glacier. Clasts in the conglomerate are principally dark volcanic rocks of local origin derived from the Nikolai Greenstone, but the clasts allered volcanic rocks in the Chulai Group, but the clasts are mainly of fine-grained felsic volcanic rocks, sandstone, argillite and chert, and a few felsic and mafic plutonic rocks.

No fossils were found in the Kotsina Conglomerate in the Valdez quadrangle, and only plant scraps have been found elsewhere. The Middle or Late Jurassic age assignment was given by Grantz and others (1964) who bracketed the absolute age of the formation by K-Ar dating (Table 1, loc. 1). Biotite from a crosscutting microdiorite dike was dated at 145 ± 5 m.y. The microdiorite dike is truncated by the angular unconformity at the base of the Berg Creek Formation. Plutons of these ages are widespread in the Wrangell Mountains (MacKevett, 1978) and in the Chugach Mountains (Winkler and Plafker, 1981) also (this study). The Kotsina probably results from local accelerated uplift and erosion initiating regional Late Jurassic-Early Cretaceous orogeny (MacKevett, 1978). Unnamed possibly correlative rocks from the Talkeetna Mountains (Imlay, 1980) are much thinner and contain only subordinate conglomerate.

JPzs McCarthy Formation - After several revisions in nomenclature, MacKevett (1963) divided the McCarthy Formation into a lower and an upper member. Only the lower member is present in the Valdez quadrangle, where it forms the westernmost outcrops of a belt of Upper Triassic and Lower Jurassic marine limestone, argillite, and chert, extending southeastward from the type area in southern Wrangell Mountains (MacKevett, 1978). The lower member of the McCarthy gradationally overlies Upper Triassic limestone and is overlain unconformably by the Kotsina Conglomerate or the Berg Creek Formation. The lower member is intruded by numerous felsic to intermediate stocks and sills (Table 1, locs. 2) Upper Triassic at its base (Smith and Tozer, 1972) and generally forms schoiled outcrops that are characterized by numerous small- and large-scale irregular folds. The deformation precludes reliable estimates of thickness; maximum thickness in the McCarthy quadrangle to the east is on the order of 1,000 m (MacKevett, 1978). The lower member is westward, probably because of pre-Kotsina erosion. The lower member consists of interbedded finely-laminated, dark-gray, impure limestone, subordinate flaxlike shale, and minor chert. In many places, the limestone and shale are carbonaceous, and they also contain abundant aspectinid pelecypods, the genus Monotis and both calcareous and siliceous microfossils.

Stratigraphic fossils from the lower member of the McCarthy Indicate the Norian stage of the late Triassic, but they are restricted to the lower part of the member; hence perhaps the upper part of the member may be as young as Early Jurassic (MacKevett, 1971).

Jc Chitina Valley batholith - Weakly to strongly foliated, compositionally diverse Jurassic plutonic rocks crop out north of the Tebay fault in the Chugach Mountains, in the southeastern part of the Valdez quadrangle, and throughout the length of Wrangell Mountains. The plutons include rocks as young as the Middle or Upper Jurassic Kotsina Conglomerate and are overlain unconformably by the Lower Cretaceous Berg Creek Formation or the Wrangell Lava. The dominant lithology is fine- to medium-grained biotite granodiorite and granodiorite; hornblende and quartz monzonite, and granodiorite are nearly as common as biotite granodiorite in the dominant occurrency. Biotite is present commonly, and in some places is more abundant than hornblende; sphene and epidote occur sporadically. Sphene is generally abundant in the small plutons which is exposed along the Chitina River in T.4S, R.6E; and epidote is conspicuous in some of the large plutons centered in T.2N, R.3E.

K-Ar ages of hornblende from five of the plutons range between 147 ± 7 and 157 ± 8 m.y. (Table 1, locs. 3-7); Rb-Sr ages of three of the plutons are between 147 and 157 m.y. (Table 2). The dated hornblende and biotite are commonly chlorite altered. Hornblende ages are consistently older than biotite ages in the Chitina Valley batholith, which probably reflects the better argon retention characteristics of hornblende. Similar patterns are observed in other plutons of northern Chugach and Kenai Mountains (Decker and others, 1980; Winkler and Plafker, 1981). The Chitina Valley batholith and Bering Glacier quadrangles (MacKevett, 1978), and forms the western end of the Tonsina-Chitnagat belt of Hudson (1979a). Batholithic compositions are uniform to the west in the Talkeetna Mountains, but they are in part older than the Chitina Valley batholith and, unlike it, they contain extensive iron(Tonalite Sodium (Carter and others, 1978; Hudson, 1979b). The Chitina Valley batholith is similar to the Sanford Pluton in the Talkeetna Mountains, but a direct correlation is possible but cannot be demonstrated at present (Hudson, 1979b).

Gabbro and Leucogabbro - Gabbroic rocks are subordinate in the Chitina Valley batholith. Small gabbroic plutons are only the larger masses are shown. They consist of medium- to coarser-grained, massive to foliated, altered gabbro, leucogabbro, and minor diorite, that is composed predominantly of plagioclase and hornblende. The gabbro has local pegmatitic phases, and in a few places has the texture of a dike to be seen to be replacing earlier pyroxene.

These plutons are coarsewise with layered gabbros in the McCarthy quadrangle, which are interlayered with quartz monzodiorite and granodiorite (MacKevett, 1978). Unnamed possibly correlative rocks from the Talkeetna Mountains (Imlay, 1980) are much thinner and contain only subordinate conglomerate.

Jg1 Hornblende Gabbro and Leucogabbro - Layered gabbro and leucogabbro are associated spatially with ultramafic rocks near the Tebay fault in the Chugach Mountains, in the southeastern part of the Valdez quadrangle. Layering in the Tonsina River 8 km west of Lower Tonsina. Gabbro is interlayered with clinopyroxenite and the west end of the Tebay fault. Hornblende lenses of clinopyroxenite; elsewhere contacts between gabbro and ultramafic rocks are not exposed or are faulted. The layered gabbros are dominantly of hornblende gabbro, hornblende-augite gabbro is common, however, with the hornblende replacing or mixed upon the augite; and layers and lenses of hornblendite occur at several places. Hoffman (1974) has described a lens of augite gabbro with mafic veins near the east side of the Bernard Mountain ultramafic body, which we have mapped as part of the Tebay fault. Layering is defined by gabbroic rocks in comparison in many places, and contains alternating layers rich in hornblende or pyroxene and in plagioclase. Orientation of the gabbro and associated ultramafic rocks is seaven in a few places.

Although the layered fabric and stratigraphy of the gabbroic rocks lad Hagan and Grybeck (1964) and Hoffman (1974) to describe them as hornblende-bearing anorthosites, and gabbro and diorite gneiss, the basic character of the rocks is plutonic. They may be related to the layered mafic plutonic body in domain 1 that extends more than 100 km westward from near the Chitina River to the Copper River. Hornblende-bearing ultramafic rocks may be a large tectonic fragment bounded entirely by faults and similar to the roughly circular tectonic inclusion in the Bond Creek Formation between the McHolme and Tasline Glaciers (domain 4; may unite Jlg, Jm, Jmg). K-Ar age determinations on the gabbroic rocks have not been made in the Valdez quadrangle, however, the gabbroic rocks have been emplaced at a time or after level near the base of rocks that are equivalent to the Lower Jurassic Bond Creek Formation. The rocks are considerable range in emplacement ages of gabbroic rocks may be indicated.

#### DOMAIN 2

#### Sedimentary and volcanic Rocks

QTw Wrangell Lava - Andesitic tephra, lava flows, and debris flows, presumably emanating from Mt. Wrangell during Late Pleistocene and Holocene time, are exposed in the Valdez quadrangle. The rocks are at least 300 m thick and consist mostly of shoulder stone, siltstone and mudstone, which contain many interbeds of pebble- and cobble-conglomerate (Grantz and others, 1964). Neither the top nor the base of the sequence is exposed, but the sequence may gradationally to or transition from nearby outcrops of the Kotsina and resembles it closely in color and degree of induration. Conglomeratic sandstones predominate in the lower part of the sequence; in many places it is calcareous and cross-stratified. Pebbles contain abundant clasts of subolivic and basaltic lithic clasts with subordinate plagioclase, amphibole, and quartz. Cobbles are mainly of porphyritic rocks. Clasts in interbedded conglomerate mostly are intermediate or mafic volcanic rock types, but scattered clasts of felsic and mafic plutonic rocks, limestone, and sandstone occur. Dark greenish-gray siltstone and mudstone predominate in the upper part of the section and are very similar to rocks of the Chichina River. The highest rocks in the sequence include rust-gray weathering limey siltstone interbeds and concretions. Rocks in the Chitina River are slightly folded into southeast-striking cherrons and brachyclines (Grantz and others, 1964). Apparently the strata were deformed during the Late Jurassic and Early Cretaceous orogeny that affected all pre-Albian rocks in the Matanuska-Wrangell terrane (MacKevett, 1978).

Sparse fossils from outcrops in the Chichina River indicate a probable early Late Jurassic (Callovian) age for the unnamed rocks (Grantz and others, 1964). They are coeval with Upper Jurassic rocks in the Chichina River and in the Talkeetna Mountains (Imlay, 1973) and with the Hitchin Mountain Formation of the eastern Wrangell Mountains (MacKevett, 1969).

Ka Kotsina Conglomerate - The Kotsina Conglomerate (Moho, 1900) crops out extensively both north and south of the Kotsina River and also occurs on the north side of the Chuchatna River. It is lithologically similar to the Berg Creek and Chichina Formation, but its top is nowhere exposed. Most outcrops of the Kotsina are cut by numerous high-angle faults, so its reported maximum thickness of 300 m is only approximate. The Kotsina consists of bold, craggy outcrops of well-indurated pebble- and cobble-conglomerate and coarse sandstone with some buisiers clasts. Olive-gray lithic and feldspathic sandstone, siltstone, and carbonaceous shale are interbedded in many places, and increase in proportion west of Long Glacier. Clasts in the conglomerate are principally dark volcanic rocks of local origin derived from the Nikolai Greenstone, but the clasts allered volcanic rocks in the Chulai Group, but the clasts are mainly of fine-grained felsic volcanic rocks, sandstone, argillite and chert, and a few felsic and mafic plutonic rocks.

No fossils were found in the Kotsina Conglomerate in the Valdez quadrangle, and only plant scraps have been found elsewhere. The Middle or Late Jurassic age assignment was given by Grantz and others (1964) who bracketed the absolute age of the formation by K-Ar dating (Table 1, loc. 1). Biotite from a crosscutting microdiorite dike was dated at 145 ± 5 m.y. The microdiorite dike is truncated by the angular unconformity at the base of the Berg Creek Formation. Plutons of these ages are widespread in the Wrangell Mountains (MacKevett, 1978) and in the Chugach Mountains (Winkler and Plafker, 1981) also (this study). The Kotsina probably results from local accelerated uplift and erosion initiating regional Late Jurassic-Early Cretaceous orogeny (MacKevett, 1978). Unnamed possibly correlative rocks from the Talkeetna Mountains (Imlay, 1980) are much thinner and contain only subordinate conglomerate.

JPzs McCarthy Formation - After several revisions in nomenclature, MacKevett (1963) divided the McCarthy Formation into a lower and an upper member. Only the lower member is present in the Valdez quadrangle, where it forms the westernmost outcrops of a belt of Upper Triassic and Lower Jurassic marine limestone, argillite, and chert, extending southeastward from the type area in southern Wrangell Mountains (MacKevett, 1978). The lower member of the McCarthy gradationally overlies Upper Triassic limestone and is overlain unconformably by the Kotsina Conglomerate or the Berg Creek Formation. The lower member is intruded by numerous felsic to intermediate stocks and sills (Table 1, locs. 2) Upper Triassic at its base (Smith and Tozer, 1972) and generally forms schoiled outcrops that are characterized by numerous small- and large-scale irregular folds. The deformation precludes reliable estimates of thickness; maximum thickness in the McCarthy quadrangle to the east is on the order of 1,000 m (MacKevett, 1978). The lower member is westward, probably because of pre-Kotsina erosion. The lower member consists of interbedded finely-laminated, dark-gray, impure limestone, subordinate flaxlike shale, and minor chert. In many places, the limestone and shale are carbonaceous, and they also contain abundant aspectinid pelecypods, the genus Monotis and both calcareous and siliceous microfossils.

Stratigraphic fossils from the lower member of the McCarthy Indicate the Norian stage of the late Triassic, but they are restricted to the lower part of the member; hence perhaps the upper part of the member may be as young as Early Jurassic (MacKevett, 1971).

Ja Chitistone and Nizina Limestones - light- to medium-gray Upper Triassic carbonate rocks that are so conspicuous along the southern flank of the Wrangell Mountains (MacKevett, 1978) extend in multiple thrust sheets westward into the Valdez quadrangle as far as the Cheshina River. Upper Triassic carbonate rocks also are present on both sides of the Chitina River valley in the eastern part of the Valdez quadrangle. In the McCarthy quadrangle, these carbonate rocks aggregate up to about 1,100 m in thickness, and have been subdivided into a lower, thicker-bedded sequence - the Chitistone Limestone - and an upper, thinner-bedded sequence - the Nizina Limestone (Martin, 1926). Similar lithologic subdivisions of the limestone in the Chitistone and Nizina Limestones in the McCarthy quadrangle are given by Armstrong and others (1970). In the Valdez quadrangle, equivalent carbonate rocks are attenuated greatly, and have thicknesses ranging from only about 25 m along Elliott Creek (Moffit and Nelson, 1923) to about 250 m east of Long Glacier. In addition, thin-bedded limestone similar to the Nizina Limestone is present in structural slices in the Chitina Valley, the two formations have been mapped as one in the Valdez quadrangle. The Upper Triassic carbonate rocks disconformably overlie the Nikolai Greenstone and grade upward into the lower member of the McCarthy formation. North of the Cheshina and in the Chitina Valley, the carbonate rocks are overlain by a thin section of Middle Jurassic Dagnino Conglomerate and by the Berg Creek Formation. The carbonate rocks consist chiefly of limestone of diverse textural varieties, but include minor dolomite low in the sequence, and nodules and lenses of dark-gray chert high in the sequence.

No new paleontologic information on the Upper Triassic carbonate rocks has been obtained from the Valdez quadrangle, but the carbonate rocks span most of the Karnian and Norian stages of the Late Triassic in the McCarthy quadrangle (see MacKevett, 1978).

Nbm Nikolai Greenstone - In the Wrangell Mountains and near the mouth of the Chitina River, outcrops of altered tholeiitic basalt correlative with the Nikolai Greenstone of the McCarthy quadrangle are discontinuously between Upper Triassic carbonate rocks. Additional outcrops of the Nikolai are present north of Canyon Creek, where they are in tectonic contact with Upper Triassic rocks. The Nikolai outcrops in Marsh and south of the Kotsina River, where the Nikolai occurs in slipes above rocks as young as an Upper Jurassic Kotsina Conglomerate and by the Berg Creek Formation. The carbonate rocks consist chiefly of limestone of diverse textural varieties, but include minor dolomite low in the sequence, and nodules and lenses of dark-gray chert high in the sequence.

The Nikolai consists of weakly metamorphosed slightly porphyritic tholeiitic basalt that characteristically is amygdaloidal and poorly bedded. The alteration of the Nikolai to the prehnite-pumpellite facies is very widespread, but rarely has it masked the original mineralogy. Primary igneous clinopyroxene is the chief mafic mineral in the Nikolai; it likely has formerly also suspended in fine-grained intergranular groundmasses rich in plagioclase, but it now contains chlorite, epidote, and lesser amounts of iron and titanium oxides and relictus relictus. Amygdules generally are filled with calcite, chlorite, quartz, or epidote, but some contain zeolites, prehnite, or native copper.

In the McCarthy quadrangle, the Nikolai is bracketed stratigraphically by Upper Triassic limestone and Upper Jurassic (Callovian) pelecypods beneath and late Triassic (Karnian) ammonites above (MacKevett, 1978). In the Valdez quadrangle, we have found similarity in be middle Jurassic (see Table 1). The Nikolai is correlative with the Nikolai of the McCarthy quadrangle, and with the Chitistone Limestone in the Chitina Valley and in the Talkeetna Mountains (Carter and others, 1978). The Nikolai is also correlative with the Tetelna Volcanics of the Mount Jarvis quadrangle, an allochthonous terrane which extends discontinuously along the spine of the Coast Mountains of North America at least as far south as Vancouver Island (Jones and others, 1977). Paleomagnetic data indicate that the Tetelna Volcanics and the Nikolai formed at latitudes within 15° of the Upper Triassic equator. Hence Wrangellia is believed to have been transported northward rectilinearly to its present position. Three K-Ar whole rock ages of the Nikolai Greenstone (Table 1, locs. 8, 9) fall on a 112 ± 5 m.y. (Early Cretaceous) isochron which may indicate the time of accretion of Wrangellia to North America (Jones and others, 1980).

Pzs Skolai Group - diverse Upper Paleozoic volcanic, volcaniclastic, and marine sedimentary rocks are widespread in the Wrangell Mountains and the Chugach Mountains north of the Tebay fault. The Skolai Group in the Valdez quadrangle is subdivided into a dominantly volcaniclastic Station Creek Formation and a dominantly volcanogenic Station Creek Formation (Smith and MacKevett, 1970; MacKevett, 1978). The volcanic and subordinate sedimentary rocks of the Skolai Group in the Valdez quadrangle are strongly altered and slightly metamorphosed to the prehnite-pumpellite facies and mafic equivalent to part of the Station Creek (see unit Pzs), they have not been subjected to the

The Skolai is overlain unconformably by the Nikolai Greenstone; its base is commonly exposed but the Skolai is believed to rest directly on Upper Paleozoic oceanic crust (MacKevett, 1978). Rocks of the Skolai are intruded by Upper Triassic plutonic rocks; large blocks above the Kotsina Conglomerate in the vicinity of the Chitina River, the Skolai is intruded by Upper Permian and Triassic plutons, some of which (Table 1, loc. 10) be dated by K-Ar at 244 ± 12 m.y., and by compositionally varied Upper Triassic plutons (Table 1, locs. 11, 12) which are dated by K-Ar at 216 ± 11 m.y. and 215 ± 11 m.y. On its southern margin, the Skolai is juxtaposed with amphibolite facies metamorphic rocks along the Tebay fault.

In the Valdez quadrangle, the Skolai is persuasively folded and faulted, hence its thickness cannot even be estimated. In the McCarthy quadrangle to the east, the Skolai is 3,000 m thick (MacKevett, 1978). Smith and Tozer (1972) report K-Ar ages ranging between 10 and 2.7 m.y. for Wrangell Lava in the Nabesna quadrangle to the northeast. The youngest Wrangell Lava in the Valdez quadrangle is not well dated, but probably is Holocene inasmuch as lapies of the courses of several rivers in the southern Copper River Basin appear to have been influenced by Wrangell lava flows which lie above dated ash and debris-flows that have a minimum C-14 age of only 1760 ± 200 years (Miller and Smith, 1976).

Kb Berg Creek Formation - Lower Cretaceous marine clastic rocks are exposed in three separate areas of domain 1: (1) at the eastern edge of the quadrangle capping a ridge between the Chitina and Copper Rivers; (2) near the confluence of the Chitina and Copper Rivers; and (3) two small upland patches west and south of Marshia Creek. The Lower Cretaceous rocks rest with angular unconformity upon Paleozoic and Lower Mesozoic bedded rocks and upon Upper Jurassic plutonic rocks dated by K-Ar at 153 ± 5 m.y. (Table 1, loc. 8). North of Eureka River, the Lower Cretaceous rocks consist of at least 200 m of diverse calcareous conglomerate, conglomeratic sandstone, and sandstone. Conglomerate clasts are well rounded, the sand sandstones generally are pebbly, cobbly, and boulder conglomerate consisting of clasts that were derived from nearby bedrock. Overlying strata are very lenticular, and many sandstone beds have steeply inclined cross-stratification. Fossils are rare but include pelecypod molds and casts of Buchiaceae. The type section of the formation is very light gray calcarenite that is largely bioclastic. These rocks probably formed in a high-energy near shore bar or shoal. They are Neocomian (Grantz and others, 1964) and correlate with the Berg Creek Formation of the Valdez quadrangle (MacKevett and others, 1978). Near the mouth of the Chitina River, the Lower Cretaceous rocks consist of at least 400 m of partly calcareous siltstone, sandstone, and conglomerate (Moffit, 1954) and are similar to the Berg Creek north of the Katalla River. The conglomerate contains clasts of nearby bedrock, with prominent clasts of Paleozoic limestone and of Upper Jurassic porphyry. Some of these sequentiions. Near the mouth of the Chitina River, dark-gray fossiliferous glauconitic siltstone is more abundant than it is north of the Katalla River, although layers of thick limestone shells and calcareous sandstone crowded with pelecypods are also conspicuous in domains 2 and 4; small stocks are most numerous in domain 3, but exist in all domains. The hypabyssal rocks are compositionally diverse; dacite porphyries and felsite dikes are most abundant, but rhyolite and andesite are present locally. Most rocks are porphyritic and contain abundant fine-grained (or less commonly medium-grained) phenocrysts in extremely fine-grained felsic or pilotaxitic groundmass. The phenocrysts consist of plagioclase, mafic minerals (chiefly hornblende, biotite, and pyroxene), quartz and K-feldspar. Hornblende is the mafic phenocryst most commonly present and pseudomorphs or relics and the fulmanr phenocrysts are partially altered or replaced by calcite or sericite. Groundmasses generally are strongly altered also. The hypabyssal rocks form bold, conspicuously light-colored outcrops and weather very light gray or pale tan, generally in contrast to darker-hued country rocks.

The hypabyssal rocks are younger than the latest metamorphism that affected the Chugach terrane and contiguous terranes to the north; that also may post-date major movement on the Pitts Creek-Chugach Mountains fault system. Hypabyssal intrusions both north and south of the fault, ranging from domains 2 and 4 (Table 1, locs. 12 and 28) have been dated at ca. 47 and 52 m.y., indicating no Eocene age for some of the hypabyssal rocks. Altered, mineralized dikes in the Tasnuna quadrangle to the east are cut by Eocene(?) dikes and are unaltered. Intrusions include the Valdez and Orca Groups in the Prince William Sound region (Nedom and others, 1979; Winkler and Plafker, 1981)

Dominantly mafic hypabyssal rocks (domain 3 see below); they are similar to undated rocks in the Schlichter area that are believed to be Eocene (Grantz, 1960) and to undated rocks in the upper Matanuska Valley and the southern Talkeetna Mountains that include rocks as young as the Chickaloon Formation of Paleocene age (Coalyer and others, 1978), Eocene(?) dikes in the Valdez quadrangle (Table 1, locs. 4, 6; Grantz and M. L. Silberman, unpublished data, 1980). To the east in the McCarthy quadrangle, similar rocks in domain 3 have yielded K-Ar ages as young as Miocene (MacKevett and others, 1978) and are believed to represent subvolcanic phases of Wrangell Lava volcanism; analogous rocks may be present in the southern Talkeetna Mountains (Coalyer and others, 1978).

#### DOMAIN 3

#### Sedimentary and volcanic rocks

Wrangell Lava - see description for Domain 2.

Matanuska Formation - Upper Lower and Upper Cretaceous marine clastic rocks are exposed in the southeastern part of the Valdez quadrangle and in the Talkeetna Mountains, where they have been mapped as the Matanuska Formation (Grantz, 1960). Cretaceous rocks are widespread in the south in the Southern Wrangell Mountains, where they consist of the Kennicott, Nonvieux, Jumbine, Chitistone, and McCarthy Formations (Jones and MacKevett, 1969). The Matanuska has been subdivided into several units in the Valdez quadrangle and in the Talkeetna Mountains, but it has been mapped as one unit in the southern Wrangell Mountains, where they consist of the Kennicott, Nonvieux, Jumbine, Chitistone, and McCarthy Formations (Jones and MacKevett, 1969). The Matanuska has been subdivided into several units in the Valdez quadrangle and in the Talkeetna Mountains, but it has been mapped as one unit in the southern Wrangell Mountains, where they consist of the Kennicott, Nonvieux, Jumbine, Chitistone, and McCarthy Formations (Jones and MacKevett, 1969). The Matanuska has been mapped separately (Tuc). The sedimentary rocks are very lenticular and have been intensely folded and faulted; they are dominantly of the Valdez Group and Chugach terrane, and are diagnostic of deposition by sediment-gravity flow processes (primarily turbidity currents) in a deep-water basin. Argillite and siltstone are more abundant than coarser-grained rocks, and they are dark gray, dark brownish gray, and olive gray (Jones and MacKevett, 1969).

Distinctive associations of turbidite facies in sedimentary rocks of the Orca Group indicate that they were deposited on a submarine fan (Winkler and Plafker, 1981). Most of the rocks are dominated by thick-bedded turbidites of Bouma sequence, but several thousand meters of the upper Level of sedimentary rocks are dominated by thin-bedded turbidites of the Bouma sequence, but the uppermost part of the section is dominated by coarse-grained