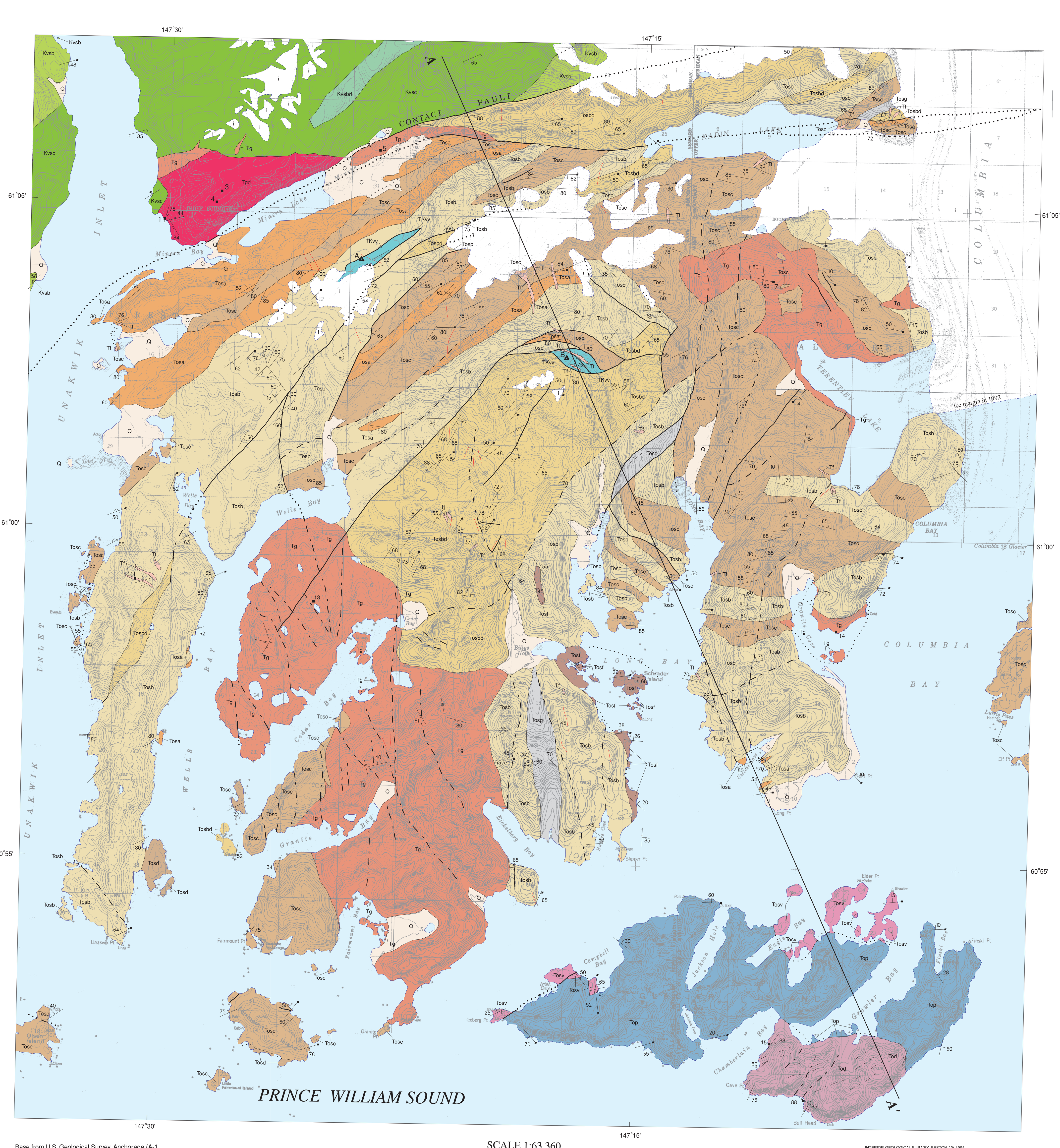
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



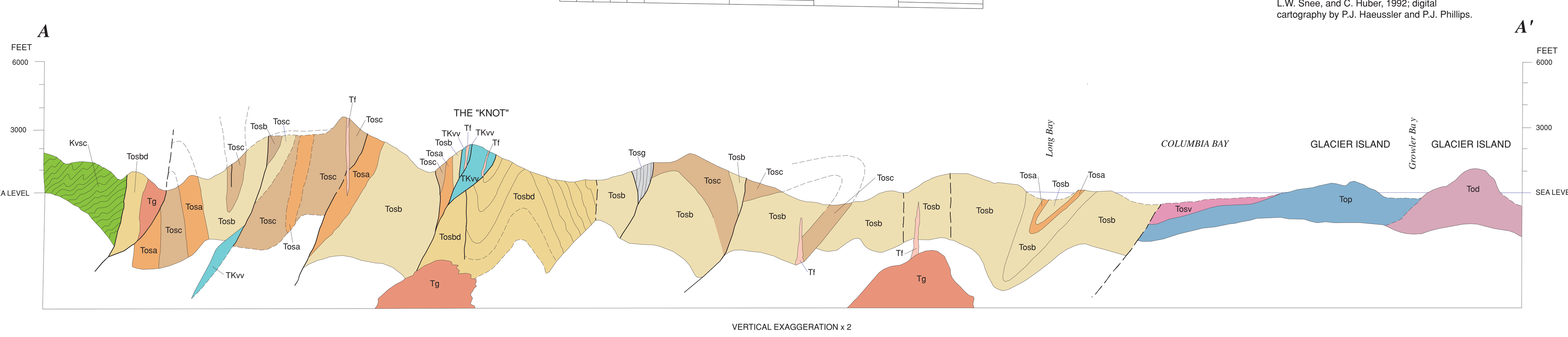
Base from U.S. Geological Survey, Anchorage (A-1 and A-2), 1960 and Seward (D-1 and D-2), 1951.
Universal Transverse Mercator projection

SCALE 1:63,360

KILOMETER

MILES

Geology modified from Tysdal and Case (1979) and Nelson and others (1985); field mapping by S.W. Nelson, 1980-1982, 1992; M.L. Miller, 1980-1982, 1992; J.A. Dumoulin, 1980-1982; G.R. Winkler, 1982; S.M. Karl, 1982; P.J. Haeussler, L.W. Snee, and C. Huber, 1992; digital cartography by P.J. Haeussler and P.J. Phillips.



VERTICAL EXAGGERATION x 2

PRELIMINARY GEOLOGIC MAP OF THE CHUGACH NATIONAL FOREST SPECIAL STUDY AREA, ALASKA

By

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1999

Line Symbols

Contact—Dashed where approximate or inferred; dotted where concealed

Fault—Dashed where approximate or inferred; dotted where concealed

Lineament—Identified from air photos. Possible fault

Quartz vein—Mineralized and unmineralized

Ice contact

STRIKE AND DIP OF BEDS AND FLOWS

Horizontal

Vertical

Inclined—Ball indicates tops of upright beds

Overturned

STRIKE AND DIP OF METAMORPHIC CLEAVAGE

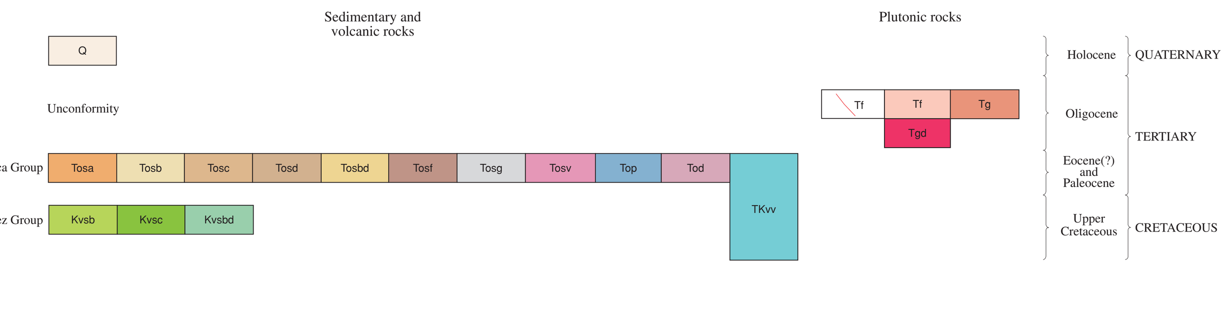
Inclined

Fossil locality—See Table 1

Radiometric age locality—See Table 2

Line of cross section

CORRELATION OF MAP UNITS



INTRODUCTION

In 1990 both the U.S. Geological Survey and U.S. Bureau of Mines were contacted by the Chugach National Forest (CNF) for the purpose of providing mineral resource information for the CNF Master Plan during the planning period fiscal years 1991-1994. This information is to address the terms and requirements of the 1986 Settlement Agreement and to provide mineral and geologic information useful to the CNF for making land-use decisions.

In early 1992 an Interagency Agreement between the U.S. Geological Survey, the U.S. Bureau of Mines and the Chugach National Forest was signed. In this agreement the U.S. Geological Survey is to provide a report which estimates the undiscovered mineral endowments of the 'special' study area (see Fig. 1) and to identify the potential for mineral discovery and development. The U.S. Bureau of Mines was to prepare a report updating the discovered mineral endowment of the Special Study Area. These reports are now published (Roe and Balen, 1994; Nelson and others, 1994). This geologic map is a component of the U.S. Geological Survey contribution to the overall project.

LOCATION AND GEOGRAPHIC SETTING

The Chugach National Forest, located in the Kenai-Chugach Mountains physiographic province of Alaska (Wahraftig, 1965) is the second largest national forest in the United States and is about 9,000 square miles in area. This area encompasses scenic Prince William Sound, the largest embayment along the coast of Alaska between Cook Inlet and Cape Spencer on the Alaskan panhandle to the southeast.

The Special Study Area is located in the northern part of Prince William Sound (Fig. 1). The Special Study Area is about 400 mi^2 in area and is bounded by Unakwik Inlet on the west and Columbia Glacier and Columbia Bay on the east. The southern part of the area includes Glacier Island and the northern boundary is approximately latitude 61° 07' N. The coastline of the area is indented by fjords that were produced by south-flowing glaciers. The lower slopes are densely vegetated with stands of spruce, cedar, hemlock, alder, and devils club. Timber line is located at about 1500' elevation. Relief in the area ranges from sea level to 4,800' at "X Mountain" (T11N, R12W, Sec. 3, 4).

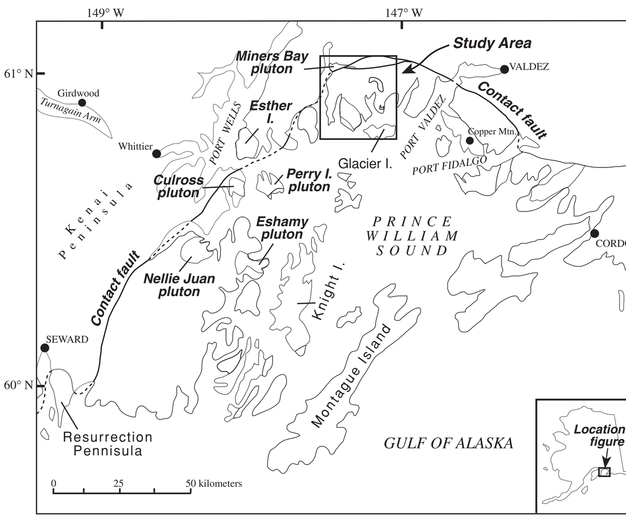


Figure 1. Location of the Special Study area in the Chugach National Forest, northern Prince William Sound.

PREVIOUS GEOLOGIC MAPPING

Most previous geologic mapping efforts by federal agencies in the Chugach National Forest were reconnaissance-scale efforts produced for regional geologic and resource studies. One of the earliest geologic map compilations covering the area was done by Moffit (1954). Nelson and others (1985) published a geologic map of the entire Chugach National Forest.

Most geologic mapping under the U.S. Geological Survey's Alaska Mineral Resource Assessment Program (AMRAP) covered 1:250,000-scale quadrangle maps. Quadrangle maps covering the Chugach National Forest include: Tysdal and Case (1979) for the Seward and Blying Sound Quads., Winkler and others (1981) for the Valdez Quad., Winkler (1992) for the Anchorage Quad., Winkler and Plafker (1993) for the Cordova and Middleton Island Quad. Winkler (1973) published a 1:63,360-scale geologic map covering Hinchinbrook Island in the Cordova Quad.

GEOLOGY

REGIONAL GEOLOGY

The geology of the National Forest is dominated by two major lithologic units, the Valdez Group (Late Cretaceous) and the Orca Group (Paleocene and Eocene) (Schrader, 1900). The Valdez Group is part of a 2,200-km-long by 100-km-wide belt of Mesozoic accretionary complex rocks called the Chugach terrane (Jones and others, 1987). This terrane extends along the Alaska coastal margin from Baranof Island in southeastern Alaska to Sanak Island in southwestern Alaska. The Orca Group is part of an accretionary complex of Paleogene age called the Prince William terrane that extends across Prince William Sound westward through the Kodiak Island area, underlying much of the continental shelf to the west (Plafker, 1969, 1971; Tysdal and Case, 1979). Both groups consist largely of graywacke, siltstone and shale; the finer grained rocks commonly display a slaty fabric. Petrographic study of the clast composition from the graywackes has suggested that the sediments represent the progressive unroofing of a volcanic arc to its plutonic core (Dumoulin, 1987). A recent petrographic study Phillips (1996) concluded the composition does not vary with turbidite facies units. Framework modes of Orca Group sandstones from the Special Study Area range from 19 to 53 percent quartz grains, 25 to 70 percent feldspar grains, and 5 to 74 percent total lithic fragments (Phillips, 1996). The compositional variations reflect differences in the proportions of lithic fragments, derived from volcanic cover of the arc, versus quartz and feldspar, derived from deeper roots of the arc. Additional isotopic and petrographic studies of the sedimentary rocks from the two groups indicate the major source of these clasts was likely the Coast Mountains provenance in Canada (Farmer and others, 1993) and that a secondary input may have come from the Wrangellia and Peninsular terranes (Phillips, 1996).

Both groups also contain thick sections of mafic volcanic rocks (Nelson and others, 1985). In the Orca Group the mafic rocks comprise an ophiolite section that contains, from base to top, ultramafic rocks, gabbro, sheeted dikes, and pillow basalt (Crowe and others, 1992; Nelson and others, 1985; and Nelson and Nelson, 1993). The volcanic section in the Valdez Group also contains thick pillow basalt, lesser sheeted dikes, gabbro, and ultramafic rocks. These units are spatially associated with each other. Both volcanic sections host massive sulfide deposits that were worked primarily for copper (Crowe and others, 1992). These volcanic sections can be distinguished geochemically because those in the Valdez Group are more alkaline than those in the Orca Group (Crowe and others, 1992).

The contact between the Orca and Valdez Groups is designated as the Contact fault (Winkler and Plafker, 1981). In eastern Prince William Sound the location of the Contact fault is based on the change in structural trend in the two groups. Between the Copper River and Port Fidalgo the regional strike of the Orca Group is northeast. The Valdez Group in this area exhibits an east-west regional strike. In western Prince William Sound the regional strike of the two groups is parallel. This coupled with the close lithologic similarities of the two groups, makes location of the contact problematic in western Prince William Sound (Bol and Gibbons, 1992).

Plutonic rocks in the forest were emplaced during two main intrusive episodes. The earliest intrusive episode has been dated by potassium-argon methods as 50 to 53 Ma (Plafker and Lanphere, 1974; Nelson and others, 1985) and at around 53-54 Ma by $^{40}Ar/^{39}Ar$ (Haeussler and others, 1995). Rocks of this age are found in eastern Prince William Sound and to the west of Prince William Sound. These plutons have been assigned to the Sanak-Baranof plutonic belt (Hudson and others, 1979) are thought to have formed from large melt fractions of the graywacke host (Barker and others, 1992) during subduction of a spreading center beneath the accretionary complex (Bradley and others, 1993 and references therein). The younger plutonic episode has been dated by both potassium-argon and $^{40}Ar/^{39}Ar$ methods (Lanphere, 1966; Nelson and others, 1985; this study). Potassium-argon dates of hornblende and biotite for the younger intrusive episode in Prince William Sound lie between 32.2±1.6 Ma and 38.4±1.9 Ma (Nelson and others, 1995).

Rocks of both the Orca and Valdez Groups are found in the Special Study Area. The Valdez Group is represented by low-grade metamorphosed turbidites found north of the Contact fault. Rocks of the Orca Group are found to the south of the Contact fault and consist of both turbidites and mafic volcanic rocks.

Geologic mapping at 1:63,360-scale of both groups has focused on the distribution of the depositional facies (Mutti and Ricci Lucchi, 1978) in turbidites both for structural interpretation and controls for mineralization (Haeussler and Nelson, 1993).

Two volcanic rock-associations are found in the study area. One association is the volcanic rocks found on Glacier Island that consist of pillow basalt and sheeted dikes typical of an ophiolite association (Crowe and others, 1992). The ophiolite of Glacier Island is part of a 100 km-long belt of ophiolite that extends from Elrington Island in the south, north through Glacier Island and east to Ellamar (Crowe and others, 1992). These ophiolitic rocks are inferred to have formed around 57 Ma, which is the radiometrically determined age of the Resurrection Peninsula ophiolite near Seward (Nelson and others, 1989). We obtained a $^{40}Ar/^{39}Ar$ plateau on plagioclase from the Glacier Island sequence in the study area of 37.6±0.6 Ma. We interpret this age as being reset during intrusion of the 32-38 Ma plutons.

The second association of volcanic rocks consists of volcaniclastic rocks and pelagic limestone. These rocks are found in two fault-bounded areas within the Orca Group turbidites. Volcanic mudstone with broken pillow breccia, purple or green calcareous shale, and thin beds of gray, green, and purple limestone are characteristic of the unit. These rocks are unusual because they contain fossils older than the enclosing Orca Group and older than the Valdez Group that lies to the north of the Contact fault. These rocks are younger than the McHugh Complex of (Clark, 1973), are age-correlative with the 'Cape Current terrane' of Connelly (1978), and thus they are probably correlative, even though structurally they appear dissimilar. These rocks also contain mid-Eocene fossils, which may be explained by tectonic mixing of sediments of dissimilar ages.

DESCRIPTION OF MAP UNITS

Q — **Surficial deposits, undivided (Holocene)**—Predominantly glacial moraine and outwash deposits and beach and terrace deposits. Consists of sand and gravel; terminal, lateral, moraine composed of unsorted deposits of boulders, cobbles, gravel, and sand left by retreat of alpine and valley glaciers; and talus consisting of coarse angular rock debris derived from bedrock

Orca Group (Eocene and Paleocene)—Named by Schrader (1900) for a widespread, thick and complexly deformed sequence of flysch and mafic volcanic rocks. The depositional facies of the Orca Group turbidites suggest deposition on the continental slope as well as on deep-sea fans. No diagnostic fossils have been collected in the Orca Group from the Special Study Area. Locally near the Tertiary plutons the Orca Group has been thermally metamorphosed to the albite-epidote hornfels facies as indicated by metamorphic biotite and amphibole. In this area, the Orca Group has been divided into seven lithofacies of sedimentary rocks, based on the classification of Mutti and Ricci Lucci (1978), and volcanic rocks:

Tosa — **Conglomerate (Lithofacies A)**—Dark gray, poorly-bedded to massive, matrix-supported pebbly mudstone and sandstone to pebble, cobble, and boulder conglomerate. Minor lenses of sandstone and lessor amounts of siltstone. Clasts are usually well-rounded and predominately sandstone and siltstone. Only one felsic igneous rock clast was observed. The thickest occurrence of conglomerate is found on the east side of Unakwik Inlet just of Miners Bay. Here the conglomerate unit nearly 1,000-m-thick and the outcrops are part of a large northeast-trending fold. Depositional environment probably in submarine landslides on unstable slopes and large channel deposits on the slope and upper parts of deep-sea fans (Winkler and Tysdal, 1977)

Tosb — **Massive sandstone (Lithofacies B)**—Gray to tan, massive bedded, fine to medium grained sandstone. Beds range in thickness from 2 m to over 5 m. Locally contains interbedded interval of well bedded turbidites of lithofacies C (Mutti and Ricci Lucchi, 1978). Massive sandstone is predominant in a belt that extends from the Special Study Area to the southwestern part of the Chugach National Forest. Dish structures are locally common

Tosc — **"Typical" turbidites (Lithofacies C)**—Gray, well bedded, fine to medium grained, alternating layers of sandstone, siltstone, and shale. Beds are in layers less than or equal to 2 m thick. This lithologic association led to the original definition of turbidites (Mutti and Ricci Lucchi, 1978). Commonly displays nearly complete Bouma sequences (Bouma, 1962). Primary sedimentary features are common and include well-developed graded bedding, cross-bedding, load and flute casts, dish structures, and fine-scale laminations. Probably deposited in the middle part of a deep sea fan that had local inner fan deposits representing feeder and distributary channels with the fan complex

Tosd — **Rythmite (Lithofacies D)**—Dark gray, well bedded, fine grained, siltstone, and shale in beds 5 cm or less in thickness. Probably represents a distal facies of Tosc. Occurs in local map scale outcrops on the southern side of Fairmount Island and the west side of Wells Bay

Tosbd — **Massive sandstone and rythmite (Lithofacies B and D)**—Interbedded intervals, undivided at map scale, of tan, massive channel sandstones and rythmite. Rythmite interval probably represents overbank deposits

Tosf — **Chaotic deposits (Lithofacies F)**—Dark gray, contorted, fine grained shale. Irregular blocks of rythmite and sandstone in a chaotically folded shale host. Probably represent deposition of large slump blocks along submarine canyon walls or the slope environment. The outcrops along the west side of Long Bay are the only known occurrence of this lithofacies in the Orca Group (Nelson and others, 1985)

Tosg — **Shale or argillite (Lithofacies G)**—Dark gray, massive argillite or thin bedded shale. Outcrop occur in a north-trending band north of Eickelberg Bay

Ophiolite of Glacier Island

Tosv — **Volcaniclastic rocks**—Dark gray to green, moderate to well bedded volcanic mudstone and sandstone, poorly sorted, broken pillow breccia with angular clasts of pillow basalt, ranging in size from a few centimeters to 15-cm across, in a volcanic mudstone matrix, and rare pillow basalt flows up to 2-m thick. Forms the upper part of the ophiolite and is depositional on pillow basalt unit

Top — **Pillow basalt**—Dark gray or green pillow basalt flows and minor massive basalt flows. Basalts are fine to medium grained, porphyritic with phenocrysts of plagioclase and clinopyroxene; olivine is present but not abundant. Pillows average 0.3 m in diameter. Altered brown volcanic glass makes up much of the inter-pillow matrix. Vesicles are usually filled with calcite and/or chlorite. This unit is gradational into sheeted dike unit

Tod — **Sheeted dikes**—Mafic sheeted dikes are basaltic in composition and form the lower oceanic-crust part of the ophiolite of Glacier Island. The dikes are diabasic, equigranular, and porphyritic. Phenocrysts of plagioclase and clinopyroxene are common. Facings on chilled margins and other field observations indicate that the dikes were intruded into, between, and across pre-existing dikes. Most dikes are vertical in orientation. The chemistry from typical midocean-ridge basalt (Crowe and others, 1992) and the ophiolite is part of a 80 km-long belt of ophiolitic rocks that starts at Elrington Island to the south and includes Knight Island, Glacier Island, and the Ellamar area

Valdez Group (Upper Cretaceous)—The Valdez Group was named by Schrader (1900) for a sedimentary unit several thousand feet thick. Presently the Valdez Group is considered the outboard part of a belt of Mesozoic rocks 100-miles long and as much as 60-miles wide that extends along the Alaska coastal margin from Chatham Strait in southeastern Alaska to Kodiak and Shumagin Islands in southwestern Alaska (Plafker and others, 1977; Plafker and Campbell, 1979). The Valdez Group is strongly folded and metamorphosed to grades ranging from zeolite to lower greenschist and to amphibolite facies. Within the Special Study Area the Valdez Group crops out north of the Contact fault and commonly displays a slaty fabric. Mafic submarine volcanic rocks that are found elsewhere in the Valdez Group are not found in the Special Study Area. In the Special Study Area the Valdez Group has been divided into three lithofacies based on the classification of Mutti and Ricci Lucchi (1978):

Kvsb — **Massive Sandstone (Lithofacies B)**—Gray, massive bedded, fine to medium grained sandstone. Beds range in thickness from 2 m to over 5 m. Locally contains interbedded interval of well bedded, penetratively deformed, turbidites of lithofacies C (Mutti and Ricci Lucchi, 1978)

Kvsc — **"Typical" Turbidites (Lithofacies C)**—Gray, well bedded, fine to medium grained, alternating layers of sandstone, siltstone, and shale with moderate to well developed slaty fabric. Beds are in layers less than or equal to 2-m thick. This lithologic association led to the original definition of turbidites (Mutti and Ricci Lucchi, 1978). Commonly displays nearly complete Bouma sequences (Bouma, 1962). Primary sedimentary features are not common due to metamorphism and deformation

Kvsbd — **Massive Sandstone and Rythmite (Lithofacies B and D)**—Interbedded intervals, undivided at map scale, of gray, massive channel sandstones and rythmite. Rythmite interval probably represents overbank deposits. Forms narrow, northeast trending belt, north of Miners Lake

TKvv — **Volcanic and Sedimentary Rocks, undivided (Late Cretaceous and Tertiary)**—This unit consists of four lithologic units occurring in two fault bounded areas; one area is north of Long Bay and the second area is southeast of Miners Lake. Lithologic units are: (1) volcanic mudstone with broken pillow breccia, (2) purple or green calcareous shale, (3) thin bedded gray, green, and purple pelagic limestone, and (4) sedimentary rocks with outcrop-scale folds and (or) stratally disrupted bedding (Haeussler and Nelson, 1993). Nannoplankton from the interbedded limestone have been identified as Cenomanian, Turonian, and Coniacian in age (Table 1; R. Rosen, written commun., 1993) whereas planktonic foraminiferas from the limestone suggest middle Eocene and Upper Cretaceous (Coniacian to early Santonian) ages (Table 2; W. Sliter, written commun., 1994). The only known source for rocks of this age are found at Cape Current on Afognak Island 250 miles to the southwest (Connelly, 1978). Regardless of the age assignment this unit was tectonically incorporated into the turbidite section

Tf — **Felsite Dikes (Tertiary)**—Includes two types: (1) leucocratic porphyry dikes with 20%-30% euhedral phenocrysts of potassium feldspar and quartz in a fine grained allotriomorphic groundmass. Intrudes only the Orca Group; (2) allotriomorphic granular, white weathering, fine grained dikes with approximately 30% quartz, 60% feldspar, and 20% altered mafic minerals. Thickness ranges from 0.3 m - 2 m. Intrudes the Orca and Valdez Group

Tg — **Leucocratic Granite (Oligocene)**—Light colored, leucocratic biotite granite. Color index ≤ 5. Common textures are allotriomorphic granular and hypidiomorphic granular. Comprises several igneous bodies - plutons of Cedar Bay, Terentiev Lake, Granite Cove, and Columbia Glacier stock and an unnamed elongate body northeast of Miners Lake. Also associated with pluton of Miners Bay. Correlated with other 34-Ma plutons in Prince William Sound, however, is more leucocratic and contains greater amounts of silica and alkalis

Tgd — **Gabbro and Diorite of Miners Bay (Oligocene)**—Fine to coarse grained, hypidiomorphic granular, quartz bearing biotite, hornblende, pyroxene gabbro and diorite with similar minerals. Geologic relations suggest that diorite is younger. Intruded by leucocratic granite (Tg) and correlated with similar rocks on Culross and Esther Islands, and in Eshamy Bay located to the west outside of the study area

Table 2. $^{40}Ar/^{39}Ar$ radiometric ages

Map No.	Age	Mineral	Comment	Sample No.	Pluton/Unit
1	38.6 ± 0.6	bio	plateau age	92SN07A	Miners Bay/felsic dike
1	41 ± 1	bio	disturbed, wt. avg	92SN07B	Miners Bay/gabbro
3	59.1±0.1	bio	isochron age	92SN08	Miners Bay/diorite
4	40 ± 1	bio	disturbed, wt. avg	92SN09	Miners Bay/diorite
5	25.4 ± 0.1	kspar	plateau age	92ANS75A	Miners Bay/granite
7	29.2 ± 0.3	microcline	isochron age	92SN01	Terentiev/granite
11	31.1 ± 0.2	kspar	isochron age	92SN04	Unakwik felsic porphyry
13	31.7 ± 0.1	kspar	isochron age	92SN012	Cedar Bay/granite
14	29.2 ± 0.1	kspar	isochron age	92SN14	Granite Cove/granite
15	37.6 ± 0.6	plag	plateau age	92SN05A	Glacier Island ophiolite sheeted dike

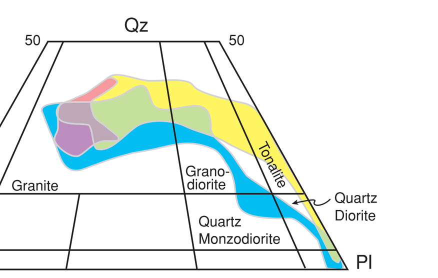


Figure 2. Modal plot of quartz (Qz), potassium feldspar (Ks), and plagioclase feldspar (Pl) for the 50 Ma (yellow) and 34 Ma (blue) and plutons in Prince William Sound. Plutons in the Special Study Area are shown in red.

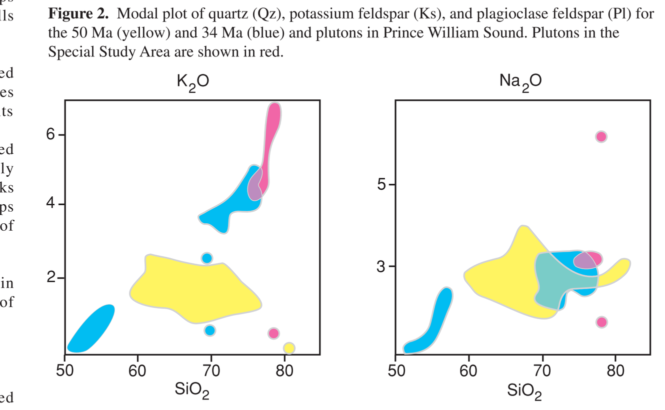


Figure 3. Silica vs alkalis variation diagrams for ~54 Ma (yellow) and ~34 Ma (blue) plutons in Prince William Sound. Plutons in the Special Study area are shown in red.

Tertiary Plutonic Rocks

Plutonic rocks in the study area were probably intruded around 39 Ma. The plutons are compositionally, lithologically, and petrographically similar to other dated 32-38 Ma plutons in Prince William Sound (Tysdal and Case, 1979; Nelson and others, 1985), and the Miners Bay pluton has been dated by K/Ar on biotite at 32.2±1.6 Ma and 38.4±1.9 Ma (Nelson and others, 1985). We obtained new $^{40}Ar/^{39}Ar$ analyses on samples of biotite, plagioclase, K-feldspar, and microcline from the major plutons, which lie between 59.1 and 25.4 Ma (see Table 2). We do not have $^{40}Ar/^{39}Ar$ release spectra to assess individual analyses. We note that three of the biotite ages from the Miners Bay pluton lie between 38.6±0.6 Ma and ~ 41 Ma, which is consistent with the K-Ar ages, but this suggests the 32.2 Ma K-Ar date suffered some argon loss. However, one $^{40}Ar/^{39}Ar$ isochron age on the main diorite phase of the Miners Bay pluton was 59.1±0.1 Ma (Table 2). This unusually old age may indicate the diorite is part of the older Sanak-Baranof suite of intrusives in Prince William Sound or that the isochron age includes gas with excess argon or recoil effects. The fact that an isochron age, or even a plateau age, was calculated indicates the argon systematics were not straightforward. Other new dates on intrusives are on K-feldspar or microcline, which are known to have low argon closure temperatures (<200 °C; McDougall and Harrison, 1988). All these dates are younger than K-Ar ages or the 32-38 Ma granitoids and thus we conclude these ages reflect uplift and final cooling of these intrusions. This is exemplified by the 25.4±0.1 Ma plateau age on K-feldspar from granite in the Miners Bay pluton—this is significantly younger than the 38-41 Ma $^{40}Ar/^{39}Ar$ dates on biotite from the intrusion.

The other plutons in the study area, which have similar chemistry (Table 3) and petrography, include the Terentiev Lake, Granite Cove and Cedar Bay plutons. Petrographically these plutons have modal compositions that overlap the modal compositions of the two dated suites (Fig. 2); however, their chemistry is distinctly more enriched in alkalis and silica than any of the dated plutons (Fig. 3) from other locations in western Prince William Sound (Nelson and others, 1985).

Strontium and neodymium isotopic data (Table 4) indicate the ~38-41 Ma granites in Prince William Sound and in the study area were derived from melting of relatively evolved rocks. This hypothesis is consistent with their origin being anatectic melts of the graywackes. The Knight Island ophiolite was derived from a relatively primitive source region. The Miners Bay gabbro has a modeled initial Sr and Nd ratios intermediate between the ophiolite and the granitoids.

Structure

After incorporation of the sediments into the accretionary complex the sediments were folded into kilometer-scale tight folds. The Special Study Area is at the hinge of the orocline of southern Alaska (Grantz, 1966) where the regional strike of bedding changes by about 90°. Adjacent structural domains in the study area defined by the trend of bedding may be up to a 90° difference in strike of bedding in adjacent domains. This change reflects a structural pattern developed during oroclinal bending similar to the style of bending a bar (Haeussler and Nelson, 1993). Because the plutons are locally but not pervasively involved in faulting related to oroclinal bending, Haeussler and Nelson (1993) suggested that the bending occurred during and soon after intrusion of the plutons.

The major structural break in the area is the Contact fault. This fault separates the Valdez Group sedimentary rocks from the Orca Group rocks to the south. A crude minimum displacement along the fault can be estimated by the apparent offset of the conglomerate unit to the south of Miners Lake. The closest conglomerate on the north side of the Miners Bay-Kadin Lake splay is located to the east of the of the Miners Bay pluton 250 miles to the northeast. The apparent left-lateral offset of the Miners Bay pluton may not be real since the eastern sliver is coarse grained granite and no granite is found along the south side of the Miners Bay pluton.

Numerous faults and lineaments cross the study area (Haeussler and Nelson, 1993). Most faults are parallel with a north-south or NNW-SSE orientation. Displacements are minor since no significant offset of geologic contacts were observed. One exception is the fault that cuts the north end of the Cedar Bay pluton. Although this fault does not offset the pluton-sedimentary rock contact it does structurally enclose the undivided Late Cretaceous volcanic and sedimentary rock unit within the Orca Group. This structural relation may indicate a significant, pre-Cedar Bay pluton, extensional(?) fault. Strike-slip displacements of several kilometers are permissible on some faults that juxtapose different sedimentary facies if they are older than the plutons.

Table 1. Fossil ages

Map No.	Age	Sample No.	Fossil	Unit	Identified by
A	Coniacian-early Santonian	92ANS49	foraminifera	TKvv	W. Sliter, 1995
	Turonian Coniacian	92ANS49	calcisphere nannofossil	TKvv	B. Rosen, 1993
B	mid- Eocene	92ANS55	foraminifera	TKvv	W. Sliter, 1995
	Coniacian or early Cenozoic	92ANS55	foraminifera	TKvv	B. Rosen, 1993
	probably Mesozoic	92ANS55	radiolaria	TKvv	C. Blome, 1994

Table 4. Sr and Nd isotopic data on igneous rocks of the Prince William Sound area of southern Alaska

Sample number	Rb (ppm)	Sr (ppm)	Rb/Sr measured	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$	Assumed Age (Ma)	SIR	Sm (ppm)	Nd (ppm)	Sm/Nd	$^{143}Nd/^{144}Nd$ measured	$^{147}Sm/^{144}Nd$ calculated	NIR
Tertiary plutons outside the Special Study area in Prince William Sound													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Special Study area plutons													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Knight Island Ophiolite													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 3. Major-element geochemistry of igneous rocks

Oligocene plutons within the Special Study Area

Oxide	Cedar Bay	Cedar Bay	Cedar Bay	Cedar Bay	Cedar Bay	Terentiev	Terentiev	Granite Cove	Columbia Gl.	Miners Bay	Miners Bay	Miners Bay	Miners Bay	Knight I. Ophiolite
SiO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Al2O3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe2O3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FeO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MgO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CaO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Na2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H2O +	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H2O -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TiO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P2O5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MnO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Oligocene plutons outside of the Special Study Area in Prince William Sound. See Figure 1 for locations of plutons

Oxide	Perry Island	Perry Island	Perry Island	Esther Island	Esther Island	Esther Island	Eshamy	Eshamy	Nellie Juan	Nellie Juan	Culross Island	Culross Island	Dike	Dike
SiO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Al2O3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe2O3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FeO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MgO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CaO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Na2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H2O +	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H2O -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TiO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P2O5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MnO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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