GEOLOGY
OF THE
VALDEZ (A–5) QUADRANGLE, ALASKA

By
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INTRODUCTION

The Valdez (A-5) quadrangle occupies an area of approximately 200 square miles. It lies athwart the axis of the Chugach Mountains in the Valdez district of the Gulf of Alaska region. The highest point in the quadrangle is 7,067 feet above sea level on the ridge south of Heiden Canyon, and the lowest point is 500 feet on the flood plain of the Lowe River near the western boundary of the quadrangle. The relief between any particular valley and the adjacent ridgetop averages about 3,500 feet. Drainage of the northern half of the quadrangle flows east through the Tsina River into the Copper River, that of the southern half flows west through the Lowe River into Port Valdez. The major rivers are controlled by a prominent regional east-west structural trend. Tributary drainage is controlled by a strongly developed north-south joint system. The quadrangle is traversed from southwest to northeast by the Richardson Highway which crosses the Chugach Range at Thompson Pass near the center of the area. Only two families lived along this portion of the road in 1957. Approximately one-third of the map area is covered by glaciers or perennial snowfields. Deeply crevassed glaciers, swift glacial streams, precipitous slopes, and heavy brush greatly limit the accessibility of some portions of the quadrangle. Precipitous areas along the southern and northern boundaries of the map area and along the east and west central margins were inaccessible. In these areas photogeologic interpretation indicates continuity of the lithology and structural trends observed in adjacent localities. Structure symbols are shown only for those observations made on the ground. Bedrock is exposed over a considerable area on the ice free mountains and nunataks projecting above the glaciers, whereas the lower slopes are locally masked by frost-rived rubble and talus. Glacial and glaciofluvial deposits are widespread in the major valleys.

Spruce, aspen, and cottonwood grow in favored localities along the floodplains of the Tsina and Lowe Rivers up to elevations of 2,000 feet. Dense thickets of alder and willow cover many of the slopes between 500 and 3,000 feet. Between 3,000 and 4,000 feet mountain tundra consisting of dwarf shrubs, sedges, grasses, and mosses grows on the more gentle slopes and sheltered uplands. Only lichens grow above 4,000 feet.

The earliest geologic exploration in this area was a traverse of the Tasnuna and Lowe River valleys in 1898 by F. C. Schrader (1900), a member of a United States Army expedition seeking a route from Valdez to the interior. The following year geologic observations along the military trail, now the Richardson Highway, between Valdez and Tonsina were made by O. Rohn (1900) and by F. C. Schrader in 1900 (Schrader and Spencer, 1901). Later F. H. Moffit (1935, 1938, 1954) published three regional geologic maps at a scale of 1:250,000 which include all or portions of the Valdez (A-5) quadrangle.

BEDROCK

The Valdez (A-5) quadrangle lies within the outcrop belt of the Valdez group of Late Cretaceous(?) age (Moffit, 1954). These rocks, called the Valdez series by Schrader (1900) and the Valdez group by Grant and Higgins (1910), Capps and Johnson (1915), Johnson (1915, 1917), and Moffit (1954) have been variously described from the Prince William Sound region as slate and graywacke, quartzite, arkose, and argillite. The Valdez group crops out in a zone approximately 60 miles wide across the regional strike between Port Fidalgo on the south and Klutina Lake on the north.

In the Valdez (A-5) quadrangle rocks of the Valdez group consist of dark gray, fine-grained, foliated phyllitic graywacke which contains numerous thin quartz veinlets oriented parallel to the foliation. Because of the fine-grained texture of these rocks and the degree of metamorphism which they have undergone, primary bedding is not discernible megascopically. Thin sections of the rocks have been studied by Robert G. Schmidt, U. S. Geological Survey, and the descriptions are based upon his examination. Mineral composition is estimated by point-count (500 points). The rocks consist essentially of angular grains of quartz, plagioclase (oligoclase-andesine), and orthoclase in a very fine-grained matrix of the same minerals. Small flakes of muscovite and chlorite and shreds of graphite between the quartz-feldspar grains are aligned parallel to one another and give the rocks a pronounced schistosity. Accessory minerals are magnetite and sphere. Microfolds are developed at an angle to the main schistosity.

In the Valdez (A-5) quadrangle, no stratigraphic units in the Valdez group are sufficiently distinctive or continuous to map separately; therefore adequate appraisal of the thickness of the group cannot be made. The uniformly high dips and the intricacies of minor folding discernible in individual outcrops suggest considerable repetition of beds by isoclinal folding and possibly by shearing.

Throughout the area the rocks are characteristically seamed with thin white quartz veins of two types. The more prevalent type follows the foliation and reflects minor folding and contortions in the schistosity; the less prevalent type transects the foliation and follows prominent joints. The latter veins are commonly as much as one-eighth of an inch across, and on many outcrops show as a rectilinear grid. In many places intense silicification has resulted in prominent large-scale color banding parallel to the foliation.

Two small bodies of intrusive quartz monzonite are exposed in the Valdez (A-5) quadrangle. One is a sill which crops out along the south side of Worthington Glacier at an elevation of 3,700 feet; the other is a dike, which is exposed on the ridge at the head of 27 Mile Glacier. The sill is exposed along a linear distance of over 500 feet and varies in thickness between 2 and 4 feet. The dike approximately 4 feet wide and 800 feet long, trends N. 15° E., and dips steeply, sharply transecting the regional schistosity. Fragments of quartz monzonite, similar to the rock of these intrusive bodies, occur in moraines of several of the larger glaciers and indicate the presence of additional covered intrusive bodies in the area.

The sill is composed of grayish-white, medium-grained, muscovite-quartz monzonite. Microscopically it shows a hypautomorphic-granular texture in which the plagioclase is generally euhedral and quartz and orthoclase are subhedral to anhedral. The estimated mineral composition is as follows:

Essential minerals	Percent
Quartz	25
Plagioclase (oligoclase-andesine)	30
Orthoclase	25
Chlorite	10
Muscovite	5
Accessory minerals	
Sphene	Trace
Apatite	1
Zircon?	Trace
Alteration minerals	
Calcite altering from plagioclase; chlorite altering from hornblende or pyroxene.	Trace

The dike is composed of light greenish-gray medium-grained, schistose muscovite-quartz monzonite. Anhedral grains of quartz, plagioclase, orthoclase, and augite in the rock appear to have been rotated and broken, giving the rock a cataclastic texture. Muscovite and chlorite flakes are alined in streaks and bands and impart a schistose structure to the rock. The estimated mineral composition is as follows:

Essential Minerals	Percent
Quartz	35
Plagioclase	20
Orthoclase	15
Muscovite	15
Augite	2
Chlorite	10
Accessory minerals	
Sphene	1
Magnetite	1
Alteration minerals	
Calcite	1
Unknown minerals	
Brownish-black alteration of sphene, perhaps largely ilmenite. Translucent mineral with high refractive index but low birefringence associated with quartz and feldspar. Rare.	

The similarity in composition of the dike and the sill suggests that they were intruded during the same period. The dike rock, being discordant to the regional schistosity, seems to have been subjected to more post-intrusive alteration than the sill rock. The intrusive rocks are Late Cretaceous or Tertiary in age because they cut the Valdez group.

STRUCTURE

The most prominent structural feature of the bedrock is the pronounced east-west foliation. Departures of more than 5° in the prevailing strike of the foliation are uncommon, and no departures of more than 15° were observed. Dips are commonly steep and predominantly to the north.

In many bedrock outcrops a lineation expressed as wrinkles or warps along the planes of foliation results from the development of drag folds. On outcrops where the introduction of quartz parallel to the foliation renders the details of the drag folds visible, the axial planes of the drag folds parallel the regional foliation and their axes are either horizontal or plunge gently to the east or west.

A prominent joint set is oriented approximately perpendicular to the strike of foliation in rocks of the Valdez group. Lesser joint sets very nearly normal to the foliation and several joint sets with random orientations were observed (fig. 1). Dips of all joints are steep to vertical. Quartz has been introduced along many of the joint planes as thin sheets that show as a network of intersecting veins on the outcrops.

Several remarkably straight trenches, which are expressed topographically but are unrelated to foliation or joints, transect the regional structure of the Valdez group. These trenches have a common northwest trend and can be followed for distances of several miles. No structural offset could be observed across these features and the absence of distinctive stratigraphic units precludes the recognition of stratigraphic dislocations. There is no indication of an unusual degree of shearing or mineralization along these lineaments, and because evidence for origin of these features is lacking they are shown on the map simply as structural lineaments. Condon and Cass (1958) have recognized lineaments with trends parallel to those of the Valdez (A-5) quadrangle between Unakwik Inlet and Columbia Bay on Prince William Sound.

SURFICIAL DEPOSITS

Surficial deposits in the Valdez (A-5) quadrangle include drift, moraine, and associated alluvium of two episodes of post-Pleistocene glaciation, Recent alluvial fan deposits, and extensive rubble fields derived from rocks of the Valdez group.

PLEISTOCENE DEPOSITS

One of the most remarkable features of the area is the dearth of Pleistocene glacial deposits in spite of the widespread evidence of one or more periods of extensive ice cover. Erosional evidence comprising U-shaped valleys, hanging tributary valleys, truncated spurs, glacial benches, and segments of marginal drainage channels indicate that ice has filled these valleys to altitudes above 3,500 feet. Presumably this area in common with other mountainous regions of Alaska has been subjected to at least one major episode of Pleistocene glaciation, but in spite of this no mappable glacial deposits older than those of the areally restricted, post-Pleistocene, Marshall Pass glaciation remain.

The following reasons are advanced for the absence of older drift:

(1) Region of glacial scour and nondeposition.

During times of widespread glaciation this region served as one of many source areas which contributed ice and glacial debris to major glaciers terminating many miles away. Hence it was primarily a locus of glacial erosion rather than deposition.

(2) Scarcity of supraglacial debris.

A major portion of debris carried by mountain glaciers is contributed by the ice-free peaks, and ridges standing above the ice. In this area ice-covered terrain far surpassed ice-free terrain during the Pleistocene glaciation. The debris, therefore, was largely limited to material plucked and scoured from the resistant country rock.

(3) Position relative to regional snowline.

Depression of the regional snowline during the widespread Pleistocene glaciations would place most, if not all, of the area above the regional snowline. This would limit meltwater activity to a relatively short period of time during deglaciation with the consequent limitation both areally and volumetrically of water-laid drift which can be distinguished from colluvium in an area of uniform lithology.

(4) High precipitation and steep slopes.

A combination of high precipitation and steep slopes characterizes the area. Ice marginal deposits on the steep valley walls would have a very high moisture content. Consequently, as supporting ice melted, during deglaciation, the deposits would slump successively down the steep walls into the adjacent valleys until they reached the high-gradient meltwater streams that would transport them beyond the area. The deeply incised gully systems on the steep valley walls attest to the continued vigor of this flushing action. Only in small swales behind resistant rock benches is it possible to find patches, too small to be mapped, of coarse colluvium with admixed medium- and fine-grained subrounded materials which appear to be the sole remnants of former ice-marginal deposits.

RECENT DEPOSITS

DEPOSITS OF THE MARSHALL PASS GLACIATION

Distribution and Extent.—The earliest episode of glaciation represented by mappable deposits is here named the Marshall Pass glaciation after deposits north of Deserted Glacier in the Marshall Pass area at the head of Heiden Canyon. During Marshall Pass time, glaciers from the high mountains south of the quadrangle advanced beyond the confines of the narrow canyons where the ice now terminates, and coalesced on the broad, gently sloping bench flanking Heiden Canyon. North of Thompson Pass the Marshall Pass glaciation was less extensive than to the south, as a result of smaller areas above regional snowline and decreasing precipitation inland from the coast. Several valleys south of Thompson Pass, which are ice-free at present, contain well-developed Marshall Pass moraines. This is not typical of valleys north of Thompson Pass. Thus the distribution of Marshall Pass ice appears to have been similar to (progressively less extensive inland) the present distribution of glaciers.

In the valleys of Ptarmigan Creek and Tsina River deposits of the Marshall Pass glaciation have been largely removed by vigorous stream action. Along these valleys only remnants of lateral moraines high above the present stream channels and isolated outwash terraces have been preserved.

Nature of the Drift.—In the type locality at Deserted Glacier a prominent terminal moraine composed of till, containing a high percentage of coarse angular rock fragments, with minor quantities of stratified drift marks the maximum extent of ice during Marshall Pass glaciation. Knob and kettle topography characterized by many undrained depressions is well preserved on the inner slopes of the moraine. Relief of the morainal ridge varies considerably depending on the detailed topographic setting at any given place. However, the maximum relief is approximately 150 feet. The moraine is completely covered with vegatation. The maximum extent of the terminal moraine is two miles beyond the present ice front.

Damming in the interlobate area between Deserted Glacier valley and the next valley to the west resulted in the deposition of approximately 75 feet of stratified silt, sand, and gravel, during Marshall Pass glaciation. These deposits have been deeply channeled by streams. Outwash deposits of the Marshall Pass glaciation are preserved as terrace remnants along the Tsina River from above its junction with Ptarmigan Creek downstream to the quadrangle boundary and beyond. The terrace remnants are composed of coarse boulder and cobble gravel with interbedded lenses of pebble gravel and sandy beds. The gradient of the Marshall Pass outwash channel as represented by these terrace remnants is considerably lower than that of the present Tsina River, suggesting that during Marshall Pass time partial damming of the Tsina River or of the Copper River took place. Reconnaissance of the lower course of the Tsina River, beyond the quadrangle boundary, indicates that one of the hanging glaciers east of the confluence of the Tsina and Tiekel Rivers may have blocked the drainage.

Age and Correlation.—No organic deposits suitable for absolute age determination were found in any deposits of the Marshall Pass glaciation in this area. Consequently it is necessary to rely on the less diagnostic criteria afforded by degree of weathering, topographic modification, and sequential analogy in attempting to date the Marshall Pass glaciation.

Drift of the Marshall Pass glaciation is relatively fresh and unweathered. Slight oxidation and staining to a depth of a few inches was observed on till of the Marshall Pass glaciation near Ptarmigan Drop and on outwash of the Marshall Pass glaciation along the Tsina River. The moraines of the Marshall Pass glaciation are very little modified. There are many kettle lakes and the drainage is poorly integrated. The relative position and extent of moraines of the Marshall Pass glaciation appears to correlate most closely with the "1 mile" moraine of the Matanuska Glacier described by Williams and Ferrians (1958). The degree of weathering of Matanuska deposits also appears to be comparable to that of the drift of the Marshall Pass glaciation. The age of the "1 mile" moraine is "of the order of a few thousand years but less than 4,000 years" (Williams and Ferrians 1958).

DEPOSITS OF THE WORTHINGTON GLACIATION

Distribution and Extent.—A well-developed moraine borders the terminus of each of the active glaciers in the area. The glacial episode during which these moraines were deposited is here referred to as the Worthington glaciation after the deposits at Worthington Glacier immediately north of Thompson Pass. The southern tongue of Worthington Glacier debouches into an open relatively flat valley bottom. There the moraine is composite with four distinct lobate ridges and intervening swales. The northern tongue terminates in a narrow, constricted valley, and is fronted by a single, lobate morainal ridge. Both of these tongues feed from a relatively symetrical source area, therefore the deposition of simple or complex terminal lobes would appear to be dependent upon the detailed morphology of the locus of deposition rather than upon any significant climatically controlled cycles of advance and retreat. This same topographic control of the morphology of end moraines appears to be expressed throughout the quadrangle.

Nature of the Drift.—The youngest moraine at Worthington Glacier is composed of till containing a high percentage of angular boulders with lenses of stratified drift. The maximum relief of this moraine is approximately 80 feet. The moraine is partly breached by a melt-water channel and many undrained depressions still remain. Deposits adjacent to the glacier front are ice-cored. The outermost slopes of the moraine are covered with brush and scattered spruce and aspen; elsewhere the moraine is free of vegetation.

Outwash-apron and valley-train deposits from the Worthington glaciation and alluvial deposits from meltwater runoff channels merge to form the Recent alluvial fill in the trunk valleys. Comparable deposits in the high-gradient tributary drainageways form alluvial fan deposits flanking the major valleys.

Age and Correlation.—The largest spruce tree on the Worthington moraine has 65 annual rings. The earliest available photograph of Worthington Glacier was taken in 1898 (Abercrombie, 1900). The photograph shows that the glacier terminus was then approximately 1,000 feet in advance of and 100 feet higher than its present position. The 1898 position is apprroximately 500 feet short of and 100 feet lower than the position of maximum extension occupied during the Worthington glaciation. Thus the age of the Worthington maximum is greater than 65 years and is probably of the order of several hundred years.

Rubble.—Coarse rubble derived primarily by frost riving and colluvial action from rocks of the Valdez group is ubiquitous throughout the quadrangle. It is mapped as a separate unit only where thick scree and talus accumulations on the steeper slopes or extensive block fields on gentle slopes obscure the underlying deposits.

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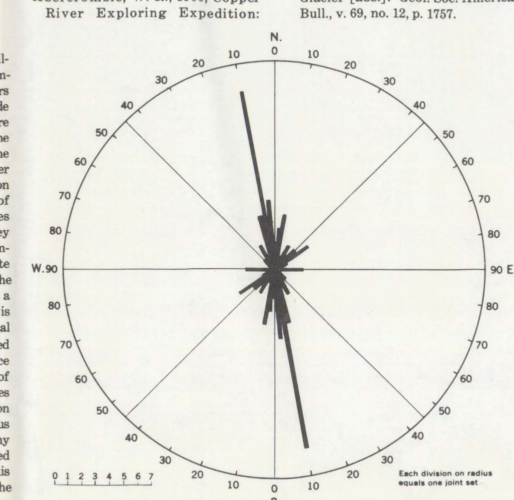

ORIENTATION OF MAJOR JOINT SETS IN ROCKS OF THE VALDEZ GROUP
All joints steep to vertical

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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VALDEZ (A-5) QUADRANGLE
ALASKA
GQ-142

EXPLANATION

Qwd — Drift
Drift and moraines of the Worthington glaciation; chiefly till with pockets and lenses of sand and gravel

Qal — Alluvium
Alluvial deposits of trunk valley streams, chiefly outwash-apron and valley-train deposits of existing glaciers; includes deposits related to the Worthington glaciation; chiefly sand and gravel; well stratified

Qaf — Alluvial fan deposits
Alluvial deposits of tributary streams, chiefly outwash and valley-train deposits of existing hanging glaciers; includes deposits related to the Worthington glaciation, in some places incorporates deposits related to the Marshall Pass glaciation; chiefly coarse gravel and cobbles; poorly stratified

Qmd — Drift
Drift and moraines of the Marshall Pass glaciation; chiefly till with pockets and lenses of sand and gravel

Qmo — Outwash
Outwash deposits of Marshall Pass glaciation now preserved as terrace remnants along present streams; also includes channel gravel remnants of abandoned marginal drainageway deposits; chiefly sand and gravel; well stratified

Qr — Rubble
Angular fragments derived from rocks of the Valdez group forming talus and block fields; locally, may include drift of pre-Marshall Pass age

Worthington glaciation; Marshall Pass glaciation; Recent; Pleistocene — QUATERNARY

Quartz monzonite intrusive rocks — Upper Cretaceous(?) or Tertiary(?) — CRETACEOUS(?) OR TERTIARY

Kv — Valdez group
Phyllitic graywacke — Cretaceous(?) — CRETACEOUS(?)

Contact
Dashed where indefinite

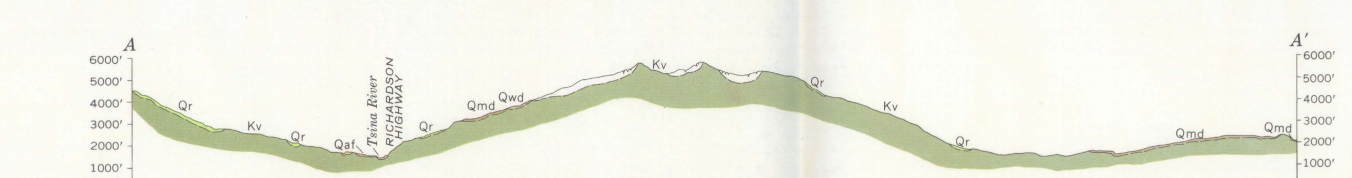
Strike and dip of foliation

Strike of vertical foliation

Strike and dip of joint

Strike of vertical joint

Structural lineaments



SECTION ALONG LINE A–A'

GEOLOGIC MAP
OF THE
VALDEZ (A–5) QUADRANGLE, ALASKA

By
H. W. Coulter and E. B. Coulter
1961