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GEOLOGY OF THE GAGARYAH RIVER AREA LIME HILLS C-5 AND C-6 QUADRANGLES, SOUTHWEST ALASKA

by

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INTRODUCTION AND GEOGRAPHY

During June 21-22, 1992, and June 9-28, 1993, approximately 1,107 km^2 (432 mi^2) of the central Lime Hills Quadrangle in western Alaska were geologically mapped at 1:63,360 scale (sheet 1). The central and western part of the Lime Hills C-5 and C-6 Quadrangles consists of several northeast striking ridgelines composed of carbonate, clastic, and volcanic bedrock lithologies. Almost all of the eastern half of the study area is covered by glacial drift, and much of the lower elevations of the entire study area below the 1,300 foot (396 m) elevation is mantled by drift.

Relief ranges from 750 feet (229 m) on the low river floodplains to approximately 3,200 feet (975 m) at an unnamed hill at the northcentral limit of the map area. Two major trunk streams, the Gagaryah and Swift Rivers, flow southwest through the map area to the Kuskokwim River drainage from sources in the Revelation Mountains (See location map on sheet 1).

The study area is remote, and there are no roads or landing areas suitable for fixed wing aircraft. Most of the field work was supported by helicopter from a fly-in lodging facility owned by Bob Hannon at Big River about 25 km northeast of the study area.

The preliminary results presented in this report consist of: (1) the geologic map accompanied by a cross section and complete map unit descriptions; (2) four data tables that report major oxide and trace element analyses of igneous rocks, fossil identifications, paleocurrent data, and limited trace element analyses of mineral occurrences (tables 1-4 respectively); and (3) a brief introductory text.

GEOLOGICAL SUMMARY

Twenty bedrock and 12 unconsolidated deposits ranging in age from Upper(?) Cambrian to Holocene underlie the map area. Sheet 1 provides complete map unit descriptions of all lithologic units. A brief geologic summary is provided below. Bedrock units were studied by continuous ground traversing and augmented by thin section examination, and selected major oxide chemistry. Quaternary deposits and structural features were studied primarily by aerial photographic interpretation, and augmented by field checking.

BEDROCK GEOLOGY

Twenty bedrock units ranging in age from Late Cambrian to early Tertiary occur in a northeast trending belt stretching across the map area. Most layered units of the study area were originally described in the eastern McGrath Quadrangle and referred to by Brooks (1911) as the Tatina Group, after exposures on Tatina River, tributary to South Fork, Kuskokwim River. We have subdivided the layered rocks into four major categories: (1) the Upper Cambrian to Lower Devonian Dillinger Terrane; (2) the upper Lower Devonian to Upper Triassic Mystic Terrane; (3) the Upper Jurassic to Lower(?) Cretaceous Kahiltna Terrane; and (4) the Upper Cretaceous Kuskokwim Group overlap assemblage. Table 2 summarizes the fossil data available from layered rocks in the study area.

Paleozoic(?) plutonic rocks intrude intraformationally into lower Paleozoic rocks, and Late Cretaceous-early Tertiary intrusive and volcanic rocks intrude younger layered sequences.

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DILLINGER TERRANE

Churkin and others (1977) first presented graptolite and stratigraphic information for a Lower to mid-Paleozoic section in the Terra Cotta Mountains of the western Alaska Range. Armstrong and others (1977) referred to these Lower to mid-Paleozoic, deepwater rocks as "sedimentary rocks of the Dillinger River." Jones and others (1981, 1982) used the term "Dillinger Terrane" to describe a coherent, but complexly folded, assemblage of shale, sandstone, and deepwater limestones of Ordovician to Devonian age.

The Dillinger Terrane in the study area consists of (1) Upper Cambrian to Lowest Ordovician limestone turbidites (OCls; OCss) and intraformational gabbro and diorite sills and dikes (MzPzi); (2) Lower Ordovician to upper Lower Silurian graptolitic shale, chert and minor limestone (SOsh; lSl), (3) Middle to Upper Silurian sandstone turbidite, and minor laminated limestone (mSas; uSsl; mSl); and (4) Upper Silurian to Lower Devonian massive to laminated limestone, limestone breccia, and calcareous sandstone (DSl; DSls). Bundtzen and Gilbert (1983) suggested that the Dillinger Terrane reflects a generally shallowing upwards marine regime that includes basinal, turbidite fan, and foreslope depositional environments along a displaced, North American continental margin. Detailed geologic mapping carried out by Gilbert (1981), Bundtzen and others (1982, 1988), and Gilbert and others (1988, 1989, 1990) have demonstrated a coherent, litho-stratigraphic succession across 25,000 km^2 of the western Alaska Range and adjacent foothills. All of the Dillinger Terrane map units in the study area are also recognized in the McGrath A-2 and B-2 Quadrangles 70 km northeast of the study area, despite minor differences in thicknesses of sedimentary facies (Bundtzen and others, 1982, 1988). The Dillinger Terrane in the study area exhibits thicker carbonate units (DSl, DSls) and thinner sandstone turbidite components (mSas, uSsl) than an equivalent section to the northeast, which suggests some lateral variance in depositional environments along the flank of the Paleozoic continental margin.

We have adopted the formation nomenclature for litho-stratigraphic units recommended by Churkin and Carter (in press) for the Dillinger Terrane. The DSl and DSls units are equivalent to the Barren Ridge Limestone Formation, and the uSsl, mSas, mSl, and lSl units are equivalent to the Terra Cotta Sandstone Formation. However we subdivide the Post River Formation as defined by Churkin and Carter (in press) into two separate Formations. We retain the terminology of Post River Formation for graptolitic shale, chert and minor limestone of Lowest Ordovician to upper Lower Silurian in age, which is likely equivalent to the Road River Group of Yukon and Northwest Territories, Canada and eastcentral Alaska. The OCss and OCls units are herein named the Lyman Hills Formation after prominent exposures of the base of the Dillinger Terrane described by Gilbert (1981) in the Lyman Hills. We believe the OCls and OCss units are equivalent to the Rabbit Kettle Formation of Upper Cambrian to Lowest Ordovician age (Gordey and Anderson, 1993).

Diorite and gabbro dikes and sills (MzPzi) that intrude the silty limestone and shale of the Lyman Hills Formation have a distinct alkaline chemistry, and are similar to mafic igneous rocks described by Gabrielse (1963) that are hosted in equivalent stratigraphy in Yukon Territory, Canada.

We estimate that the Dillinger Group is at least 1,880 m thick in the study area. This compares to a thickness estimate of 2,750 m for equivalent stratigraphy in the southeast McGrath Quadrangle (Bundtzen and others, 1988). The chief difference is the significantly thicker turbidite fan section (Terra Cotta Sandstone Formation) in the McGrath Quadrangle.

MYSTIC TERRANE

The Dillinger Terrane in the study area is overlain by approximately 970 m of sublithic clastic sedimentary rocks, shallow water fossiliferous limestone, and pillow basalt and associated volcanics in two distinctive belts in the study area. One belt of mainly Early Devonian micritic limestone and limestone breccia (lDl), Upper Devonian massive limestone (uDl), and Upper Mississippian limestone, conglomerate, and minor chert (uMls) is exposed in a tectonic window under the Gagaryah Thrust Fault (sheet 1). The other belt overlies the top of the Dillinger Terrane in normal stratigraphic succession between Gagaryah and Swift Rivers and is composed of the same Early Devonian limestone (lDl), Devonian to Pennsylvanian sublithic sandstone and conglomerate (PDs), and a thick succession of

Upper Triassic pillow basalt, agglomerate, intraformational gabbro sills, and coarse volcaniclastic sedimentary rocks (Trab, Trvs). For the first time since mapping began in the western Alaska Range, we obtained conclusive evidence that the mafic volcanics of the Trab unit of the Mystic Terrane are Upper Triassic in age, based on identification of a well preserved, megafossil locality (sample no. 40, table 2). Previously microfossil evidence (radiolarians) suggested Devonian, Mississippian, or Triassic ages for these rocks.

We correlate both belts of rocks with the Mystic Terrane, which was originally defined by Jones and others (1981) as highly deformed and tectonically disrupted chert, argillite, conglomerate and volcanics of Devonian to late Paleozoic age. Included into the original definition of the Mystic Terrane are slivers of Ordovician graptolitic shale, pillow basalt, and Silurian platform rocks. Subsequent field work in the Talkeetna Quadrangle, where the Mystic Terrane was originally defined, show that all pre-Devonian rocks belong to the Dillinger Terrane (W.G. Gilbert and T.K. Bundtzen, oral commun., 1984). The Mystic Terrane ranges in age from late Early Devonian to Late Triassic in the study area, and ranges into the Lower Jurassic in the eastern McGrath Quadrangle. Gilbert and Bundtzen (1984) considered the Dillinger and Mystic Terranes as a single stratigraphic succession, and applied the term "sequence" to each. They (and we) have mapped the contact between the Dillinger and Mystic Terranes as a faulted, Lower Devonian unconformity.

The Dillinger-Mystic contact reflects significant changes in depositional environments in the study area, as well as through the western Alaska Range. In the study area, the Dillinger Terrane records a progressing marine regression between Latest Cambrian and Earliest Devonian time. The Mystic Terrane reflects rapid facies transitions that include deepwater marine turbidite, shallow marine, nonmarine, and rift(?) related, tholeiitic volcanic environments from Early Devonian to Late Triassic time. In the Dillinger Terrane, litho-stratigraphic units can be traced for many kilometers along strike. In the Mystic Terrane, units rapidly thicken, thin, or disappear along strike, possibly reflecting tectonic instability along the flanks of the North American continent from the mid-Paleozoic to lower Mesozoic.

Blodgett and Gilbert (1983, 1993), and Bundtzen and Gilbert (1983) have regarded deep water continental margin deposits of the Dillinger Terrane as laterally equivalent to the platform and shallow water facies units of the adjacent Nixon Fork Terrane (Jones and others, 1981). Decker and others (in press) have lumped the Dillinger, Nixon Fork, and Mystic Terranes into the single Farewell Terrane in recognition of their common sedimentary history. For this study we have retained the separate Terrane classification for descriptive and comparative value.

KAHILTNA TERRANE

Turbidite-dominated marine clastic rocks of presumed Mesozoic age crop out in low, glacially sculptured, bedrock hills in the eastcentral part of the study area. This sedimentary unit (KJss) is tentatively correlated with the Kahiltna Terrane, first defined by Jones and others (1981) for highly deformed Late Jurassic-Early Cretaceous flysch in the Kahiltna River region of the southern Alaska Range. The KJss unit contains distinctive OCls unit clasts from the Dillinger Group and granitic plutons, which are very similar to clasts identified in the Kahiltna Terrane in the McGrath A-2 Quadrangle (Bundtzen and others, 1988; Wallace and others, 1989).

KUSKOKWIM GROUP(?)

A 800 m-thick section of sandstone, conglomerate, and siltstone overlies the finer grained, turbidites of the KJss unit along the eastern flanks of the Lyman Hills. The coarse grained sedimentary beds of the KJs unit lack high energy flow regime sedimentary features indicative of turbidites, and probably includes fluvial channel deposits; or alternatively, coarse, marine foreslope deposits. A strong volcanic and sedigenic provenance is indicated by pebble analysis (sheet 1).

No definitive fossils have been found in either the KJs or KJss unit in the study area, and palynomorph studies (table 2) indicate either Mesozoic or Tertiary ages. Palynomorph contamination may have taken place in these samples.

The KJs unit may be younger than the underlying KJss unit and is tentatively correlated with the Late Cretaceous Kuskokwim Group overlap assemblage (Cady and others, 1955; Miller and Bundtzen, 1994).

MESOZOIC-CENOZOIC IGNEOUS ROCKS

Small bodies of biotite Alaskite (TKf) and columnar(?) jointed basalt (Tb) occur on isolated hills in the eastern portion of the study area. The TKf unit intrudes both the Upper Triassic basalt (Trab) and turbidite sandstone (KJss), but contact relationships between the Tb unit and host lithologies are obscured by Quaternary cover. Although we have not yet obtained radiometric ages, the TKf intrusions are similar petrographically and geochemically (table 1) to those described for early Tertiary plutons in the McGrath Quadrangle (Solie and others, 1991).

The Tb basalts are remarkably similar to Triassic tholeiitic dikes and sills in the Trab unit, based on comparisons of thin section petrography and major oxide chemistry (table 1). However, a K-Ar whole-rock age of 58.3 Ma was obtained from the Tb massive basalt unit in the study area (Bruce Gamble, oral commun., 1993).

QUATERNARY GEOLOGY

Glacial, fluvial and colluvial deposits cover about 65 percent of the study area. Three ages of glacial till and associated glacio-fluvial deposits dominate the Quaternary geology of the region. For this study, we have adopted the glacial stratigraphy proposed by Kline and Bundtzen (1986) for the western Alaska Range and Kuskokwim Mountains.

Glacial erratics are widely scattered throughout the study area, and some of the larger granitic erratics exhibit deep (1-3 cm) weathering rinds. Because these erratics have been located at elevations as high as 2,800 feet (892 m), pre-Wisconsin ice of the Selama or Lone Mountain Glaciations probably overrode the entire study area.

Modified till of the Early Wisconsin Farewell I Glaciation (Qgt_1) forms: (1) a prominent, 50-70 m thick, terminal moraine in lower Gagaryah River canyon; (2) thinner, 15-20 m thick, highly eroded, isolated, sheets in the major trunk valley of Swift River; and (3) lateral moraines along the east flank of Lyman Hills.

Late Wisconsin and Early(?) Holocene till (Qgt_2, Qgt_3) equivalent to the Farewell II Glaciation form prominent, unmodified terminal moraines that cover most of the eastern half of the study area. Outwash sequences (Qod) cut through glacial till subsequent to each cycle of deglaciation. These outwash deposits of differing ages have been lumped into a single unit designation (Qod) during this study.

Silt and peat, alluvial fan, reworked drift, and several colluvial deposits (Qsp, Qaf, Qrd, Qca, Qcf, Qc, Qat) cover older Pleistocene deposits, and reflect modification to the landscape during the Holocene.

STRUCTURAL GEOLOGY

A low-grade, dynamic metamorphic event deformed pre-Cenozoic rocks into a series of subisoclinal, upright to overturned folds ranging from outcrop to kilometer scales. Accompanying the large scale compressional deformation is a decollement referred to in this report as the Gagaryah Thrust Fault system, which was originally mapped by Gilbert and others (1990) in the Lime Hills D-4 Quadrangle northeast of the study area.

The Gagaryah Thrust Fault displaces Cambro-Ordovician silty limestone (OCls) of the Dillinger Terrane over upper Lower Devonian to Upper Mississippian carbonate-clastic units of the Mystic Terrane (uDl, lDl, uMls). The Mystic Terrane lithologies are exposed in a classic structural window for at least 25 km within a topographic trough oblique to the Gagaryah River valley (sheet 1). Conodont thermal maturation indices (CAI) in the overlying, older Dillinger Terrane range from 4.5 to 5.0 (sample nos. 3, 15, 23, table 2), whereas the CAI analyses of conodonts in underlying Mystic Terrane units range from 1.5 to 3.0 (sample nos. 19c, 26, 36, table 2). Such a sharp change in temperature-pressure conditions imply that a significant amount of overthrusting has taken place in the study area.

This postulated displacement is also consistent with the differences between the two Mystic Terrane sections in the Gagaryah River trough and Swift River areas, respectively.

Structural style in the Dillinger and Mystic Terranes might be explained in terms of a thin-skinned detachment model, where the Dillinger Terrane continental-margin deposits have been detached from a rigid basement.

Younger, northwest trending, high angle faults show apparent right and left lateral offsets of up to 3 km. High angle, northeast trending longitudinal faults parallel to regional strike vertically offset the Paleozoic stratigraphy of the Dillinger Terrane from 100 to 300 m in the upper Gagaryah River valley. This youngest faulting event is probably correlative with more recent Cenozoic tectonics reported from other portions of the western Alaska Range (Gilbert and others, 1988).

MINERAL RESOURCES

No mineral production has taken place in the study area, and until recently, very little information about the region's mineral resource endowment was known. We have identified the following mineral occurrences: (1) barite-polymetallic or barite-only veins and stratiform deposits in DSl limestone; (2) gold-polymetallic anomalies in calc-silicate hornfels and skarn near diorite-gabbro sills (MzPzi); and (3) elevated copper content in Triassic pillow basalt. In addition, Eppinger (1994) has reported placer concentrations of cinnabar and gold from glacial drift and stream deposits.

BARITE (POLYMETALLIC) DEPOSITS

At least four barite (polymetallic) deposits are hosted in the DSl member of the Upper Silurian-Lower Devonian Barren Ridge Limestone. The KC Barite Prospect (sample no. 11; table 4) consists of a 3-m-wide, mineralized zone trending north 39° east across a low saddle for a minimum distance of 125 m; the mineralized zone then plunges down a steep slope into vegetation on both ends. The mineralization consists of light gray to white, nearly massive barite in tight, laminated limestone of the DSl unit. Mineralization is largely confined to rubble crop and few in-place exposures were found. Although only barite was recognized in hand specimen, the samples collected at the site contained up to 4.81 percent zinc, 678 ppm cadmium, and 684 ppm tungsten. An undetermined zinc silicate, not sphalerite, is the probable source of the zinc at the KC Barite Prospect. In addition anomalous strontium was also detected (795 ppm) suggesting celestite may also exist in a solid substitution series with the barite. Barite-polymetallic mineralization at the KC Barite Prospect both parallels and crosscuts sedimentary layers in host DSl limestone. Compositional banding in the barite mineralization itself is absent. Ferrigenous oxide coats individual sedimentary carbonate layers near the main barite-polymetallic mineralization.

Other barite occurrences were briefly investigated during the geological mapping studies (sample nos. 12, 18, 19; table 4). Unfortunately, accurate assays (>2.0 percent barium) were not obtained for this study. At all localities barite occurs in massive beds conformable to bedding, crosscutting veins, breccias, and in nodules within host DSl limestone. Unlike the KC Barite Prospect, only anomalous strontium (up to 1,599 ppm) was detected, which may indicate that celestite as well as barite occur in the mineralized zones. A sulfur isotopic analyses from barite at one occurrence (sample no. 19, SR-78499, Krueger Enterprises) yielded a del 34 value of + 35.5, which could be interpreted that seawater sulfate was involved in the mineralizing process.

Anomalous zinc values (350-950 ppm) were detected in ferrigenous gossan hosted within Upper Devonian limestone (uDl) of the Mystic terrane near the Gagaryah Thrust Fault (sample nos. 33, 35, sheet 1; table 4). The anomalous zinc values were picked up in grab samples, and no in-place exposures were identified.

Data thus far gathered is limited; however, overall field relationships, and trace element, and limited isotopic analyses suggest that the barite (polymetallic) occurrences and prospects (except sample nos. 33, 35) in the study area are sedimentary-exhalative deposit types (SEDEX) hosted in Upper Silurian-Lower Devonian Barren Ridge Limestone of the Dillinger Group. The barite (polymetallic) deposits of the study area contrast with the more extensively studied and much larger Gagaryah Barite deposit at the head of Gagaryah River about 35 km northeast of

Swift River, which is a SEDEX barite (zinc) deposit hosted in Upper Devonian, carbon-enriched shale of the Mystic Terrane (Bundtzen and Gilbert, 1991).

POLYMETALLIC SKARN OCCURRENCE

Hornfels aureoles and calc-silicate skarn are developed around small diorite and gabbro intrusions that cut OCls and OCss units of the Lyman Hills Formation. A diorite intrusion in the northwest corner of the study area (map no. 3, sheet 1; table 4) produced a significant gossan traceable in float for about 100 m, that yielded 1,018 ppm copper, 55 ppm gold (one of the region's' only lode gold anomalies), 141 ppm lead, and 217 ppm arsenic. This occurrence seems similar to several copper bearing gossans near diorite dikes that intrude OCls equivalent units in the Lyman Hills north of the study area (Gilbert, 1981).

COPPER ANOMALIES IN BASALT (TRAB)

Four grab samples of pillow basalt and related gabbro sills of the Trab unit contained from 142-452 ppm copper, probably reflecting the high copper background of Mystic Terrane basalt observed in other areas (T.K. Bundtzen, unpublished data; the late Bruce Reed, oral commun., 1982). The average 307 ppm copper content is significantly higher than copper values reported in the Nikolai Greenstone of southcentral Alaska, which is known for high background values of about 200 ppm copper (Bateman and McGlaughlin, 1920).

PLACER GOLD AND CINNABAR

Eppinger (1994) has described a number of placer gold and cinnabar occurrences scattered throughout the study area. Cinnabar seems to be distributed in streams draining the Dillinger Terrane, whereas a cluster of four gold anomalies were found in streams draining Mesozoic flyschoid rocks (KJs, KJss). This metal-lithology correlation is even more strongly expressed throughout the western Lime Hills Quadrangle (Gamble and others, 1988; Eppinger, 1994). Mineralized zones near MzPzi dikes and sills intruding the Dillinger Terrane are possible sources for cinnabar (and possibly some of the gold) placers in the study area. Cinnabar is associated with northeast trending, high angle faults cutting Early Paleozoic, "Dillinger" limestone at the past productive White Mountain mercury mine north of the study area (Sainsbury and MacKevett, 1965), and Gilbert (1981) found additional mercury occurrences southwest of the mine workings.

Although no lode gold occurrences were found in Mesozoic flysch, of the study area, significant lode gold deposits are associated with Late Cretaceous-early Tertiary plutons cutting Mesozoic flysch in mining districts such as Innoko, Iditarod, Aniak, and Cache Creek of western and southern Alaska (Miller and Bundtzen, 1994).

Some isolated gold anomalies are derived from streams draining glacial till, and hence are likely derived from distal lode sources in the Alaska Range or Revelation Mountains.

PETROLEUM POTENTIAL

No Rock-Eval pyrolysis geochemistry or porosity determinations were completed on layered rocks in the study area. Conodont color alteration index (CAI), thin section petrography, and palynomorph determinations from Paleozoic and Mesozoic sedimentary rocks indicate that most of the sedimentary lithologies are over mature and have been subjected to temperatures and pressures beyond those necessary for accumulation of oil and gas.

However, potentially important exceptions to this condition do occur in the study area. Specifically, carbonate units of the Mystic Terrane beneath the Gagaryah Thrust Fault (lDl, uDl, uMls, sheet 1) exhibit conodont CAI thermal values within the "oil window." A more detailed study of the Gagaryah Thrust Fault system and its regional implications seems warranted.

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Table 1. *Major oxide and trace element analyses and CIPW normative minerals from selected igneous rocks, Lime Hills C-5 and C-6 Quadrangles, southwest Alaska*[a]

Major oxide analyses

Map no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Sample no.	93BT31C	93BT34B	93BT51	93BT52	93BT53	93BT98	93BT103	93BT122	93GL12	93GL55	93HA17	93KC45	93KC59
SiO_2	56.05	46.95	45.94	45.77	72.44	47.61	48.16	46.97	48.28	48.33	47.39	48.55	47.75
TiO_2	1.05	1.73	2.76	1.63	0.06	1.68	2.12	2.59	2.31	2.07	3.26	2.27	3.01
Al_2O_3	15.65	16.30	13.28	10.86	14.08	14.18	15.72	14.33	13.78	15.79	14.51	13.89	13.43
Fe_2O_3	4.10	2.15	3.39	2.96	0.70	4.13	2.57	5.10	4.53	3.20	5.58	2.23	3.01
FeO	5.41	7.66	8.88	8.75	0.39	7.72	8.11	8.11	9.98	7.59	9.01	9.46	10.82
MnO	0.20	0.16	0.18	0.19	0.01	0.23	0.17	0.18	0.22	0.18	0.22	0.17	0.23
MgO	1.09	5.50	5.50	12.47	0.19	6.12	6.82	4.85	5.99	6.66	4.27	4.94	5.20
CaO	3.30	10.94	9.18	11.23	1.36	12.40	8.88	8.81	10.33	8.94	8.33	10.44	9.11
Na_2O	4.97	2.60	2.72	1.43	3.39	2.10	3.16	3.36	2.41	3.36	3.41	2.77	2.62
K_2O	5.11	1.45	1.92	0.41	4.61	0.06	0.97	0.74	0.61	0.91	1.36	0.89	1.22
P_2O_5	0.18	0.19	0.43	0.13	0.06	-0.03	0.32	0.15	0.08	0.38	0.27	0.25	0.21
LOI	0.85	2.06	3.03	1.92	1.10	1.01	0.39	2.52	0.92	1.17	2.24	1.58	1.73
Cr_2O_3	- -	0.04	0.01	0.13	-0.01	0.01	0.01	-0.01	-0.01	0.01	-0.01	0.03	-0.01
BaO	0.114	0.105	0.069	0.018	0.102	0.007	0.048	0.016	0.030	0.048	0.109	0.085	0.046
TOTAL	98.07	97.84	97.29	97.90	98.48	97.23	97.45	97.72	99.46	98.64	99.95	97.56	98.38

CIPW normative minerals

Map no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Sample no.	93BT31C	93BT34B	93BT51	93BT52	93BT53	93BT98	93BT103	93BT122	93GL12	93GL55	93HA17	93KC45	93KC59
Quartz	0.000	0.000	0.000	0.000	32.920	2.793	0.000	0.376	1.586	0.000	0.000	0.415	0.193
Corundum	0.000	0.000	0.000	0.000	1.217	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Orthoclase	31.094	8.960	12.047	2.528	28.000	0.368	5.909	4.594	3.659	5.520	8.233	5.486	7.462
Albite	43.303	22.335	24.436	12.626	29.482	18.459	27.564	29.866	20.698	29.185	29.559	24.450	22.946
Anorthite	5.460	29.826	19.490	22.960	6.532	30.217	26.643	22.936	25.355	25.987	20.765	23.824	22.028
Nepheline	0.000	0.363	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diopside	8.615	20.968	21.147	27.532	0.000	27.186	13.501	17.826	21.415	13.756	16.130	23.568	19.299
Hyperstene	0.415	0.000	2.889	14.431	0.545	11.372	9.126	11.104	15.983	8.109	9.763	13.785	17.137
Olivine	2.512	10.395	8.151	11.903	0.000	0.000	8.502	0.000	0.000	7.742	0.281	0.000	0.000
Magnetite	6.122	3.260	5.219	4.479	1.043	6.221	3.842	7.768	6.667	4.763	8.289	3.373	4.517
Ilmenite	2.054	3.436	5.566	3.230	0.117	3.315	4.151	5.168	4.453	4.036	6.343	4.497	5.917
Apatite	0.429	0.460	1.057	0.314	0.143	0.072	0.764	0.365	0.188	0.903	0.641	0.604	0.503

Table 1. (Continued)

Trace element analyses

Map no.	Sample no.	Nb (ppm)	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Sample description
1	93BT31C	157	159	253	51	568	Pyroxene diorite (MzPzi)
2	93BT34B	29	75	527	25	147	Intermediate sill with large hornfels aureole (MzPzi)
3	93BT51	51	62	577	41	284	Triassic metabasalt (TRab)
4	93BT52	18	17	318	20	120	Triassic pillow basalt (TRab)
5	93BT53	13	161	188	5	50	Biotite latite intrusion (TKf)
6	93BT98	11	4	202	23	95	Triassic pillow basalt (TRab)
7	93BT103	13	29	409	34	191	Columnar jointed basalt (Tb)
8	93BT122	19	28	460	29	150	Gabbro sill in Triassic volcanics (TRab)
9	93GL12	12	24	333	37	135	Diorite dike (MzPzi)
10	93GL55	13	25	410	34	167	Columnar jointed basalt (Tb)
11	93HA17	20	34	620	51	227	Gabbro sill (MzPzi)
12	93KC45	27	33	516	37	217	Gabbro/diorite sill or dike (MzPzi)
13	93KC59	19	45	386	47	212	Diorite dike (MzPzi)

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[a] Major oxide analyses by Bondar-Clegg, Ltd., 130 Pemberton Ave., North Vancouver, B.C., Canada V7P2R5.
Trace element X-ray fluorescence analyses by Rainer J. Newberry, University of Alaska, Fairbanks, Alaska 99709.
CIPW normative data calculated with UAF/PETCAL program, University of Alaska, Fairbanks, Alaska 99709.

Table 2. *Fossil identifications from the Lime Hills C-5 andC-6 Quadrangles, southwest Alaska*[a]

Map. no.	Field no.	Lithologic unit[b]	Description	Age
1	93BT34c[a]	mSl	Fragments of *Monograptus* sp. (graptolite).	Probably Silurian
2	93BT35[a]	SOsh	*Monograptus* sp.; *Climacograptus* sp.; *Dicranograptus*, sp. (graptolites).	Llandoverian stage, late Early Silurian
3	93WCANS153[b]	mSl	*Ozarkodina excavata excavata* (B&M) (Conodont), CAI = 5.0.	Middle Silurian to Early Devonian
4	93BT32[a]	SOsh	*Climacograptus* sp. (graptolite).	Late(?) Ordovician-Early Silurian
5	93GL21[a]	SOsh	Biserial graptolites, too poorly preserved to be identified.	Ordovician
6	93GL22[a]	SOsh	*Orthograptus* cf. *O. calcaratus priscus*, *Leptograptus* sp. (graptolites).	Caradocian stage, Middle Ordovician
7	93KC55[a]	SOsh	Poorly preserved diplograptid graptolites.	Probably Middle or Late Ordovician
8	93GL71[a]	SOsh	Fragment of either *Dicellograptus* sp. or *Dicranograptus* sp. (graptolites).	Approximately Middle to Late Ordovician
9	93GL69[a]	SOsh	*Pseudoclimacograptus* cf., *P. hughesi*; *Climacograptus.*	Llandoverian stage, Early Silurian
10	93KC53[a]	SOsh	Fragment of *Glyptograptus* sp.	Middle Ordovician to Early Silurian
11	93ABd33[a, c]	mSl	Orthoconic nautiloid cephalopods, and a cardiolid bivalve; monograptid graptolite not identifiable.	Middle(?) Silurian
12	93ABd34[c]	mSl	Orthoconic nautiloid cephalopod.	Middle(?) Silulrian
13	93ABd30[c]	lDl	Undetermined solitary rugose corals, syringoporoid tabulate corals, small bulbous stromatoporoids.	Probably same age as map no. 14, or Emsian to Eifelian stages, (late Early to early Middle Devonian)
14	93ABd18[c] (93GL49)	lDl	Smooth gypidulinid brachiopods (2 species) *Atrypa* sp.; *Vagrania* sp. *Fimbrispirifer* aff *F. pseudoscheii* (Brice) crinoid ossicles; undetermined smooth ostracods.	Emsian to Eifelian stages (late Early to early Middle Devonian

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[a] Graptolite identifications by Claire Carter, U.S. Geological Survey, Menlo Park, California.
[b] Conodont identifications by Norm Savage, University of Oregon, Eugene, Oregon.
[c] Invertebrate fossil identifications by R.B. Blodgett, U.S. Geological Survey, Reston, Virginia.
[d] Palynomorph identifications by Hideyo Haga, Micro Paleo Consultants, San Diego, California.
[e] Conodont identifications by R. Stamm, U.S. Geological Survey, Reston, Virginia.
[f] Pelecypod identifications by Norm Silberling, U.S. Geological Survey, Menlo Park, California.

15	93WCANS112[b]	uSsl	*Ozarkodina* cf. O. *excavata excavata* (B&M); (Conodonts); collected from same strata as 93BT40 (16); CAI = 5.0.	Late Silurian
16	93BT40[a]	uSsl	*Lobograptus progenitor* (Urbanek), *Pristiograptus* cf. *P. tumescens* (Wood).	*Neodiversograptus nilssoni* zone, Ludlovian stage; Late Silurian
17	93BT128[a]	SOsh	Very well preserved *Goniograptus thureaui* (McCoy) *Didymograptus* sp. (extensiform) graptolites.	Early Ordovician (Arenigian stage); Zones of *Isograptus victoriae maximodivergens* and *Orograptus*
18	93KC79[a]	SOsh	Possibly *Tetragraptus* sp. (graptolite).	Early Ordovician
19a	83RB61[c]	uDl	*Gypidula* sp., *Hypothyridina* sp., *Variatrypa* (*Radiatrypa*) sp., *Theodossia* aff. T. *keenei* (Crickmay), *Tenticospirifer* sp., bellerophontid gastropod steinkern, indeterminate gastropod steinkern, solitary and colonial rugose corals.	Middle to Late Frasnian stage, Late Devonian
19b	83RB60[c]	uDl	*Gypidula* sp., *Hypothyridina* sp., *Variatrypa* (*Radiatrypa*) sp., smooth ambocoelid brachiopod, *Tenticospirifer* sp., bellerophontid gastropod steinkern, indeterminate gastropod steinkern, solitary and colonial rugose corals.	Middle to Late Frasnian stage, Late Devonian
19c	83RB62[b,c]	uDl	*Hypothryidina* sp., *Gypidula* sp., *Variatrypa* (*Radiatrypa*) sp., *Spinatrypina* (*Exatrypa*) sp., *Theodossia* aff. *T. keenei* (Crickmay), *Tenticospirifer* sp., pleurotomarid gastropod with fine revolving spiral lirae, loxonematid gastropod steinkerns, indeterminate gastropod steinkerns, solitary rugose corals, colonial rugose corals (several species present). Conodont *Polygnathus pacificus* (Savage and Funai); CAI = 2.0.	Middle to Late Frasnian stage, Late Devonian
19d	83RB63[c]		*Gypidula* sp., *Hypothyridina* sp., *Variatrypa* (*Radiatrypa*) sp., smooth ambocoelid brachiopod, *Tenticospirifer*, indeterminate gastropod steinkerns, solitary and colonial rugose corals.	Middle to Late Frasnian stage, Late Devonian
20	83RB59[c]	uDl	Productid brachiopod, rhynchonellid brachiopod, *Variatrypa* (*Radiatrypa*) sp., *Tenticospirifer* sp., smooth ambocoelid brachiopod, rugose corals.	Frasnian stage, Late Devonian
21	92BT190[c]	uDl	Rugose and tabulate corals.	Frasnian stage, Late Devonian
22	92BT191[c]	uDl	*Amphipora* sp. (stromatoporod).	Probably Devonian
23	93WCANS78[b]	DSl(?)	*Polygnathus pacificus(?)* (Savage and Funai) conodont with CAI = 4.5.	Frasnian(?), Late Devonian

24	93ABd17[a,c] (83RB58)	mSl	Orthoconic nautiloid cephalopods, cardiolid bivalve; *Monograptus* cf. *M. ludensis* (Murchison) graptolite found immediately below the interbedded interval platy limestone, siltstone, and shale containing the above molluscan fauna.	Wenlockian stage, Middle Silurian
25	92BT192[c]	uDl	Phillipastreid coral.	Probably Frasnian
26	93WCANS83[b]	uDl	Conodont *Polygnathus pacificus* (Savage and Funai) CAI = 3.0.	Frasnian stage, Late Devonian
27	93ABd12[c]	uDl	*Syringopora*, undetermined solitary corals, *Phillipsastraea* and an indeterminate bellerophontid gastropod.	Frasnian stage, Late Devonian
28	93ABd11[c]	uDl	*Amphipora*, undetermined solitary rugose coral, *Phillipsastrea*, and bellerophontid gastropods (in cross-section).	Late Devonian
29	83RB56 (93Abd8)	uDl	*Devonoproductus* sp., *Productella* sp., *Gypidula* sp., undetermined rhynchonellid, *Neatrypa* cf. *N. rubromitra* (Crickmay), *Theodossia* sp., *Tenticospirifer* sp., smooth ambocoelid brachiopod, *Aglaoglypta* sp., bellerophontid gastropod steinkerns, *Orecopia* n. sp., Loxonema sp., indeterminate gastropod steinkerns, dandroid tabulate corals, solitary and colonial rugose corals.	Frasnian stage, Late Devonian
30	83RB57[c]	uDl	*Neatrypa* cf, *N. rubromitra* (Crickmay)	Frasnian stage, Late Devonian
31	93KC68a[d]	KJs	Palynomorphs include: Undifferentiated gymnosperm pollen (R); *Alnipollenites* sp. (A); Betulaceae (F); *Laevigatosporites* sp. (C); *Lycopodiumsporites* sp. (V); Onagraceae (V). Mostly yellow-amber coaly organics. The coloration of the coaly organics and palynomorphs appear more compatible than 93BT124.	Tertiary(?) or Cretaceous(?)
32	93ABc13[d]	KJs	Indeterminate plant fragment.	Indeterminate
33	93BT113[d]	KJs	Palynomorph is *Alnipollenites* sp. (V). Sparse organics. Mainly brownish woody-fusinitic material. The single pollen grain is light-colored, and is probably a surface contaminant.	Indeterminate
34	93GL82[c]	lDl	*Alveolites* sp., undetermined digitate tabulate coral; favositid tabulate coral; solitary rugose coral; coarse ribbed atrypid brachiopod; high spired gastropod; abundant echinoderm ossicles; two-holed crinoid ossicles; smooth ostracods; abundant calcareous algal remains.	Emsian, late Early Devonian.

35	93ABd38[c] (93GL75)	uDl	*Phillipsastraea* sp.; *Tenticospirifer* sp.	Frasnian stage, Late Devonian
36	93ABd39[c,e]	uMl	Several types of productoid brachiopods, smooth spiriferoid brachiopod, trilobite cranidium, conularid, crinoid ossicles, conodonts include: *Gnathodus texanus* Roundy: 29 Pa elements; *Gnathodus girtyi simplex* Dunn: 18 Pa elements; *Gnathodus bilineatus* (Roundy): 32 Pa elements; *Lochrela commutatus* Branson & Mehl: 25 Pa, 4 Pb, 9 M elements; *Vogelgnathus campbelli* (Rexroad): 6 Pa elements; *Vogelgnathus postcampbelli* (Austin & Hursi): 2 Pa elements; *Hindeodus* aff. *H. cristulus*: 3 Pa, 1 Pb, 1 M, 1 Sa, 3 Sb, 4 Sc elements; *Cavusgnathus unlcomis* Youngquist & Miller: 1 Pa element; *Cavusgnathus* sp. indet.: 3 broken Pa elements; *Kladognathus sp.*: *1 Sa, 1 Sb, 4 Sc, 1 Sd* elements; *Idioprioniodus* sp.: 1 Pa/Pb?, 1 Sb element; *Gnathodus n.* sp., illustrated as *G. bil. bollandensis*, plate 4, figure 13, of Zhizhong and Qiang (1988): 15 Pa elements; Unassigned ramiform elements: 5 Pb, 4 M, 1 Sa, 5 Sb-Sc elements; Fragments: ~211. CAI = 1.5.	Early to middle Chesterian stage, Late Mississippian
37	93ABd40[c]	uMl	Undetermined productoid brachiopods.	Probably Late Mississippian based on similarities to map no. 36
38	93BT124[d]	Trab	Undifferentiated gymnosperm pollen (C); *Alnipollenitres* sp. (F); Betulaceae (R); *Lycopodiumsporites* sp. (R); *Sphagnumsporites* sp. (R). Sparse organics. Mainly black woody-fusinitic organics. The palynomorphs are well preserved and light-colored relative to the other plan material recovered. This assemblage consists of long ranging taxa.	Indeterminate
39	93BT101[d]	Trvs	Undifferentiated gymnosperm pollen, from same unit as map no. 40.	Probably Late Triassic
40	93BT102[f] (93ABd45)	Trvs	*Halobia*, cf., *H. fallax* or *H. cordillerana* (Smith) pelecypod; late type of juvavitid *Indojuvavites* and clionitid ammonites; *or* distichitid and thedititid ammonites.	late Early to mid-Middle Norian stage Late Triassic

Samples collected by T.K. Bundtzen (BT), Karen Clautice (KC), Greg Laird (GL), Bob Blodgett (ABd or RB), and Norm Savage (NS).

Table 3. *Paleocurrent data from Kahiltna and Dillinger terranes, Lime Hills C-5 and C-6 Quadrangle, Alaska*

Map no.	Field no.	Unit	Azimuth (corrected for tilt)	Azimuth mean	Flow regime and structure measured
1	93BT129	OCss	35° 40° 32° 43°	37.5	Lower; crossbeds
2	93BT131	OCss	65°	65.0	Upper; flutes
3	93BT133	OCls	35° 38° 50°	41.0	Upper; flutes
4	93BT114	KJss	155° 130°	147.5	Upper; flutes
5	93BT112	KJss	140° 152° 129° 125° 180° 170°	149.0	Lower; imbricate pebbles

Table 4. *Geochemical determinations of selected bedrock types and mineral occurrences in Lime Hills C-5 and C-6 Quadrangles, Alaska*[1]

Sample no.	Map no.	Au ppb	Ba ppm	Cr ppm	Cs ppm	La ppm	Ce ppm	Sm ppm	Eu ppm	Sc ppm	Hf ppm	Ta ppm	Th ppm	U ppm	Na pct	Rb ppm	Ag ppm	Cu ppm	Pb ppm	Zn ppm	Mo ppm	Ni ppm	Co ppm	Cd ppm
93AG008A	5a	<5	3200	<50	<1	<5	<10	0.9	<2	1.9	<2	<1	1.2	5.0	0.23	17	0.2	9	<2	5	4	7	<1	1.0
93AG008B	5b	<5	760	<50	<1	<5	<10	1.1	<2	1.9	<2	<1	1.8	4.2	1.00	<10	<0.2	11	6	3	8	5	<1	<1.0
93AG008C	5c	<5	540	<50	<1	<5	<10	0.7	<2	<0.5	<2	<1	<0.5	2.4	0.12	<10	0.6	88	2	9	2	3	<1	<1.0
93AG011A	40a	<5	1500	<50	6	12	26	3.6	<2	1.5	<2	2	5.0	3.2	2.70	160	<0.2	9	3	57	<1	4	1	<1.0
93AG011D	40b	<5	460	<50	3	11	24	3.2	<2	2.9	<2	<1	3.5	3.1	0.10	48	0.6	59	114	329	<1	3	1	1.5
93AG014	28a	<5	430	250	<1	25	44	5.7	2	24.0	3	2	3.4	1.0	2.80	19	<0.2	314	4	84	<1	80	33	<1.0
93AG014X	28b	8	390	240	<1	28	37	6.4	3	27.0	5	2	3.7	1.4	2.90	29	<0.2	318	3	83	4	79	32	<1.0
93BT31B	4	6	1800	110	<1	130	220	15.0	<2	8.3	12	12	22.0	6.8	4.30	97	<0.2	136	4	114	2	28	13	<1.0
93BT34A	3	55	200	<50	<1	7	<10	1.5	<2	3.0	<2	<1	2.3	7.5	0.07	<10	<0.2	1018	141	55	17	20	311	1.7
93BT35	2	<5	2700	<50	<1	9	22	2.7	<2	6.6	3	<1	4.3	10.0	0.86	29	<0.2	53	5	29	12	48	3	<1.0
93BT42	26	36	380	<50	<1	10	14	2.3	<2	3.5	<2	<1	0.7	1.4	<.05	<10	0.2	119	4	13	<1	6	4	<1.0
93BT52	25	19	810	210	<1	38	57	8.7	<2	25.0	6	3	4.9	1.5	3.00	88	<0.2	452	12	94	<1	32	22	<1.0
93BT53	27	<5	1100	<50	7	10	25	3.9	<2	1.0	2	2	5.0	2.9	2.80	200	<0.2	12	3	93	<1	2	<1	<1.0
93BT58	13	<5	250	130	2	26	51	7.5	2	10.0	5	<1	6.0	2.7	2.20	57	<0.2	26	8	92	<1	41	12	<1.0
93BT64	16	<5	350	66	<1	13	28	3.2	<2	11.0	<2	<1	4.4	3.3	2.20	20	<0.2	128	10	45	<1	30	12	<1.0
93BT65A	14a	<5	680	<50	<1	<5	<10	0.7	<2	0.8	<2	<1	<0.5	<0.5	<.05	<10	0.5	97	6	47	3	2	2	1.0
93BT65B	14b	<5	<100	<50	<1	<5	<10	1.1	<2	1.0	<2	<1	<0.5	<0.5	<.05	<10	0.4	83	5	2	<1	<1	1	<1.0
93BT69	18	<16	>20000	<250	<2	<5	<25	<0.2	<2	<0.5	<9	<1	<0.5	<1.3	<.05	<10	0.3	46	3	7	1	<1	<1	<1.0
93BT82	24	<5	2100	90	3	25	46	5.2	<2	12.0	4	<1	7.3	3.6	1.20	84	<0.2	62	11	74	3	38	12	1.0
93BT94	30	<5	3400	<50	1	130	220	14.0	2	17.0	8	11	17.0	4.6	0.07	<10	<0.2	366	10	103	2	35	26	<1.0
93BT95	29a	19	160	61	<1	20	27	8.2	6	32.0	5	1	2.9	0.8	1.00	<10	<0.2	351	36	391	<1	18	20	<1.0
93BT95B	29b	<5	730	80	<1	18	32	4.1	<2	8.2	3	<1	4.6	1.9	1.70	39	<0.2	122	15	40	1	17	7	<1.0
93BT128A	20a	8	1800	89	4	14	23	3.1	<2	8.1	<2	<1	4.6	6.6	0.23	80	0.3	76	14	225	11	50	8	2.0
93BT128B	20b	<5	1800	63	4	11	21	2.0	<2	8.0	<2	<1	3.8	4.5	0.25	65	<0.2	64	13	226	6	37	6	2.5
92BT192	35	<5	660	120	3	18	46	3.6	<2	10.0	3	<1	5.5	4.7	0.73	18	<0.05	31	15	950	5	114	13	7.
92BT193b	38b	<5	790	190	2	32	82	5.4	3	16.0	10	<1	6.9	2.9	1.70	6	<0.5	61	22	350	7	76	38	<2.0
92BT186	36	<5	470	<50	<1	<5	110	0.4	<2	0.6	<2	<1	<0.5	0.6	0.08	<10	0.6	7	15	25	<1	2	2	<2.0
92BT188	34	<5	540	110	4	46	110	7.8	2	14.0	9	2	13.0	3.6	1.60	200	<0.2	27	23	82	5	37	12	<2.0
92BT189	33	<5	490	78	4	33	72	6.0	3	10.0	8	<1	10.0	2.6	1.30	130	2.9	20	61	69	16	36	11	6.1
92BT173	38a	<5	250	70	<1	18	36	3.4	<2	11.0	4	<1	4.9	2.0	0.62	39	<0.2	43	18	79	3	43	16	<2.0
92BT185	37	<5	<100	<50	<1	<5	<10	0.7	<2	1.5	<2	<1	<0.5	<0.5	<0.05	40	<0.2	11	13	14	4	3	<1	<2.0
93BT128C	20c	<5	2400	72	4	11	24	2.1	<2	8.4	<2	<1	4.8	5.0	0.36	64	<0.2	50	9	125	8	41	7	1.7
93BT128D	20d	<5	2400	96	6	16	29	3.5	<2	10.0	3	<1	5.1	7.0	0.26	81	<0.2	66	14	157	14	38	6	1.7
93BT128E	20e	11	1700	68	4	9	15	1.6	<2	7.1	<2	<1	3.5	3.9	0.19	63	<0.2	46	13	102	8	24	5	1.3
93BT128F	20f	5	1400	<50	4	13	24	1.9	<2	8.8	<2	<1	4.5	4.8	0.28	67	<0.2	29	15	75	14	33	6	<1.0
93BT1338	23	<5	<100	<50	<1	<5	<10	0.8	<2	1.3	<2	<1	<0.5	<0.5	0.05	<10	0.5	86	6	5	4	2	2	<1.0
93GL11	22	10	300	280	1	12	23	7.0	4	55.2	5	1	1.2	<0.5	2.70	39	<0.2	333	6	82	3	40	30	<1.0
93GL14	21	13	1000	<50	9	36	56	7.8	4	34.0	5	3	5.0	1.5	2.80	52	<0.2	338	15	111	4	28	30	<1.0
93GL32	10	8	1400	220	1	45	86	8.1	2	29.0	7	1	13.0	4.0	4.50	100	<0.2	289	7	144	3	37	22	<1.0
93GL84	1	<5	3000	<50	2	160	280	15.0	4	14.0	7	12	18.0	5.5	0.84	110	<0.2	135	5	136	<1	42	33	<1.0
93HA17	8	8	1600	190	<1	22	50	11.0	5	53.8	7	2	2.8	1.0	3.30	45	<0.2	403	<2	92	<1	33	27	<1.0
93HA18	9	11	640	51	2	24	52	10.0	4	44.0	8	2	3.5	1.0	3.20	52	<0.2	381	3	93	<1	15	21	<1.0
93KC07	32	10	800	470	4	40	60	10.0	3	46.0	7	3	5.4	1.3	2.30	21	<0.2	346	2	84	<1	82	32	<1.0
93KC30	11a		>20000	<260	<3	<5	<48	<0.2	<2	<0.5	<13	<1	<2.5	<2.5	<.10	<10	<0.2	16	<2	479	<1	2	<1	3.8
93KC30C	11b	<16	>20000	<230	<3	<5	<24	<0.2	<2	<1.1	<5	<1	<1.4	<1.3	<.11	12	<0.2	41	6	48100	7	7	2	678.7
93KC30F	11c	<24	>20000	290	<3	<5	<35	<0.2	<2	<0.5	<12	<1	<1.3	<1.9	<.11	<10	<0.2	20	<2	10863	<1	2	<1	226.1
93KC33	12	<5	10100	<50	<1	<5	<10	0.3	<2	<0.5	<2	<1	<0.5	<0.5	0.12	<10	0.7	93	<2	141	4	1	1	1.8
93KC35	17	<5	5600	<50	<1	8	12	1.7	<2	2.9	<2	<1	1.3	1.5	0.70	<10	0.4	94	4	181	3	8	3	2.8
93KC37	15	<5	7100	<50	<1	6	11	1.3	<2	2.1	<2	<1	1.4	1.1	0.40	16	0.4	81	4	71	<1	4	2	1.5
93KC39	19	<26	>20000	210	3	<5	<45	<0.3	<2	<1.6	<9	<1	<1.4	<2.1	<.38	<10	0.3	58	<2	20	<1	4	1	<1.0
93KC44	6	<5	1100	<50	<1	<5	<10	1.3	<2	1.8	<2	<1	0.8	0.6	0.32	<10	0.5	88	2	17	<1	6	2	<1.0
93KC46	7	<5	>20000	230	1	21	38	3.9	<2	15.0	5	<1	6.2	4.3	0.71	19	<0.2	119	3	45	<1	29	9	<1.0
93KC59	31	10	560	100	2	23	49	10.0	3	45.0	6	1	3.2	1.0	3.00	31	<0.2	393	<2	54	<1	29	28	<1.0
93KC78C	39	23	1000	190	26	24	53	5.2	<2	20.0	<2	<1	6.8	3.5	2.00	200	<0.2	142	4	91	<1	42	22	1.6

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[1] Analytical data from Bondar-Clegg Laboratories, North Vancouver, British Columbia, Canada. Elements determined by Induced Nuclear Activation and Induced Coupled plazma techniques, except where otherwise noted Sn, Br, Ir, Tb, Yb, Lu, Bi, and Te were looked for but not detected Anomalies by inspection (underlined).

Sample no.	As ppm	Sb ppm	Fe ppm	Mn ppm	V ppm	W ppm	Al %	Mg %	Ga ppm	Na %	K %	Li ppm	Nb ppm	Sr ppm	Y ppm	Ti %	Zr ppm	Sn ppm	Sample description
93AG008A	<5	<5	0.16	5	21	<20	0.13	0.03	<2	<.01	0.05	<2	<1	10	1	<.01	4	5	Iron concretions in limestone (mSl)
93AG008B	6	<5	0.46	5	13	<20	0.18	0.02	<2	0.03	0.03	<2	<1	9	2	<.01	5	<5	Iron concretion in limestone (mSl)
93AG008C	<5	<5	0.11	38	<1	<20	0.03	0.53	<2	0.01	0.01	<2	29	1337	4	<.01	2	<5	Iron concretions in limestone (mSl)
93AG011A	17	<5	0.71	115	<1	<20	0.69	0.09	4	0.07	0.23	49	1	13	1	0.02	14	5	Ferricrete in felsic intrusion (Tkf)
93AG011D	14	<5	1.37	530	1	<20	0.38	1.14	<2	0.01	0.08	4	15	437	5	<.01	4	6	Ferricrete in felsic intrusion (Tkf)
93AG014	<5	<5	4.68	757	56	<20	2.87	1.70	8	0.05	0.04	8	7	47	10	0.45	39	<5	Ferricrete in pillow basalt (Trab)
93AG014X	11	<5	4.39	720	49	<20	2.79	1.57	8	0.04	0.03	7	8	47	10	0.44	44	<5	Ferricrete in pillow basalt (Trab)
93BT31B	<5	<5	4.90	880	21	<20	1.84	0.80	11	0.07	0.09	19	10	21	26	0.38	38	11	Veined diorite, MzPzi
93BT34A	217	14	>10.00	114	70	<20	0.67	0.10	31	<.01	<.01	<2	4	25	4	0.05	6	5	Ferricrete gossan in skarn zone, near MzPzi
93BT35	<5	<5	2.07	80	43	<20	1.21	0.97	4	0.01	0.07	11	<1	6	5	<.01	10	<5	Grab sample Sosh shale
93BT42	<5	<5	1.05	417	16	<20	0.33	0.35	<2	<.01	0.03	2	22	670	6	<.01	1	10	Ferricrete gossan in DSl
93BT52	<5	<5	3.59	295	54	<20	3.22	0.57	11	0.36	0.14	10	8	153	16	0.53	19	<5	Grab sample, pillow basalt, Trab
93BT53	<5	<5	0.72	78	<1	<20	0.75	0.05	4	0.06	0.24	47	2	17	<1	0.02	20	9	Gray sulfide(?) in felsic intrusion, TKf
93BT58	6	<5	2.76	413	35	<20	1.71	1.02	4	0.03	0.26	24	<1	8	20	<.01	3	6	Grab sample, Mystic sandstone (PDs)
93BT64	12	<5	2.66	160	70	<20	2.11	2.26	10	0.02	0.09	120	16	351	7	0.14	14	<5	Ferricrete stain in DSl limestone
93BT65A	<5	<5	0.28	186	<1	<20	0.07	0.50	<2	<.01	<.01	<2	30	743	2	<.01	<1	7	Hydrothermal breccia in DSl limestone
93BT65B	<5	<5	0.36	208	<1	<20	0.02	1.19	<2	<.01	<.01	<2	28	498	2	<.01	<1	<5	Hydrothermal breccia in DSl limestone
93BT69	7	<5	0.11	102	<1	<20	0.07	0.04	<2	0.07	0.01	<2	13	795	2	<.01	2	<5	Abundant white barite in DSls carbonate limestone
93BT82	14	<5	2.82	893	41	<20	1.65	0.87	<2	0.03	0.24	27	5	133	9	0.04	4	20	Grab sample Frasnian limestone (uDl)
93BT94	<5	<5	5.18	574	101	<20	1.10	0.11	4	<.01	0.09	9	10	432	9	<.01	3	9	Hornfels in OCls silty limestone
93BT95	<5	<5	2.97	385	87	<20	2.36	0.52	11	0.02	0.03	6	6	257	16	0.36	11	5	Veined intermediate dike MzPzi
93BT95B	<5	<5	1.13	247	22	<20	0.96	0.79	3	0.03	0.02	19	19	330	10	0.14	17	5	Hornfels in OCls with calc-silicates
93BT128A	8	7	1.92	130	92	<20	1.20	0.88	3	0.01	0.34	13	2	86	9	<.01	7	5	3 m chip-channel, SOsh
93BT128B	15	<5	1.73	210	58	<20	0.93	1.13	<2	<.01	0.24	11	2	122	6	<.01	5	10	3 m chip-channel, SOsh
92BT192	12	12	2.7	289	174	<20	3.31	0.75	- -	0.79	0.95	- -	9	142	13	- -	46	- -	Ferricrete gossan in uDl
92BT193b	13	<5	5.46	1016	130	<20	6.95	2.52	- -	1.65	1.25	- -	13	192	18	- -	66	- -	Ferricrete gossan in OCls
92BT186	<5	<5	0.23	81	34	<20	0.20	0.27	- -	0.08	0.02	- -	<5	481	<5	- -	<5	- -	Grab sample DSl
92BT188	20	7	3.85	315	93	<20	6.88	1.16	- -	1.57	2.20	- -	15	66	17	- -	102	- -	Ferricrete stain in mSas
92BT189	191	74	2.85	416	69	21	5.31	1.32	- -	1.28	1.68	- -	21	166	15	- -	80	- -	Grab sample mSas clastic
92BT173	58	<5	3.34	890	97	<20	5.00	2.66	- -	0.70	0.99	- -	10	425	9	-	63	- -	Ferricrete gossan in OCls
92BT185	19	<5	0.39	103	34	<20	0.4	0.17	- -	0.05	0.06	- -	<5	396	<5	- -	<5	- -	Ferricrete stain DSls
93BT128C	9	<5	1.94	161	52	<20	0.99	0.84	2	0.01	0.24	13	1	60	5	<.01	7	<5	3 m chip channel, SOsh
93BT128D	19	6	1.87	96	83	<20	1.15	0.70	3	0.01	0.32	13	<1	42	7	<.01	8	5	2 m chip channel, SOsh
93BT128E	13	<5	1.42	80	42	<20	0.73	0.48	2	<.01	0.20	8	<1	40	3	<.01	4	7	4 m chip channel, SOsh
93BT128F	19	6	1.99	60	42	<20	0.94	0.47	4	0.01	0.27	10	<1	18	4	<.01	7	5	6 m chip channel, SOsh
93BT1338	10	<5	0.44	327	<1	<20	0.12	1.03	<2	<.01	0.02	3	28	1101	3	<.01	<1	<5	Hornfels in OCls
93GL11	<5	<5	4.93	418	145	<20	2.65	1.20	11	0.15	0.08	16	4	40	15	0.34	4	5	Ferricrete alteration in mafic dike, MzPzi
93GL14	<5	<5	5.21	600	95	<20	2.22	1.00	10	0.13	0.32	23	3	99	14	0.27	15	<5	Mafic dike geochem, MzPzi
93GL32	10	<5	4.68	723	153	<20	1.53	1.98	11	0.06	0.12	27	4	230	14	0.03	3	<5	Mafic dike geochem, MzPzi, intrudes DSl
93GL84	<5	<5	5.45	859	69	<20	3.78	1.55	10	0.03	0.26	57	8	233	12	0.25	8	6	Large altered MzPzi dike with hornfels
93HA17	<5	<5	5.03	382	172	<20	2.00	0.98	11	0.09	0.18	26	4	38	19	0.31	8	<5	Mafic dike with gossan (MzPzi)
93HA18	<5	<5	5.18	402	228	<20	1.70	0.43	13	0.11	0.26	14	4	31	20	0.24	7	<5	Gossan in platey limestone (mSl)
93KC07	<5	<5	5.73	537	291	<20	1.83	1.19	11	0.10	0.19	16	3	98	15	0.30	15	<5	Mafic dike (MzPzi) with skarn(?)
93KC30	7	<5	0.11	15	<1	<20	0.06	0.03	<2	0.02	0.01	<2	2	751	<1	<.01	2	<5	Barite mineralization in DSl
93KC30C	<5	17	0.81	101	<1	684	0.11	0.14	9	.01	0.04	<2	<1	411	<1	<.01	<1	<5	Massive barite in DSl
93KC30F	<5	7	0.21	31	<1	177	0.04	0.05	6	<.01	<.01	<2	<1	376	<1	<.01	<1	<5	Massive barite in DSl
93KC33	<5	<5	0.23	104	<1	<20	0.01	0.63	<2	<.01	<.01	<2	29	926	1	<.01	2	<5	Disseminated barite, DSl
93KC35	<5	<5	0.74	162	4	<20	0.12	0.52	<2	0.01	0.05	4	28	1182	5	<.01	2	<5	Ferricrete stain in DSl unit
93KC37	<5	<5	0.57	170	<1	<20	0.23	2.06	<2	0.02	0.10	3	23	1599	3	<.01	2	<5	Possible barite vein in DSl
93KC39	<5	<5	0.32	85	2	<20	0.50	0.20	<2	0.32	0.06	<2	15	599	3	<.01	2	<5	Massive barite vein in DSl
93KC44	<5	<5	0.47	183	<1	<20	0.16	0.21	<2	0.01	0.03	2	24	1024	5	<.01	1	<5	Quartz calcite vein
93KC46	11	<5	0.61	76	29	<20	2.62	0.43	5	0.02	0.03	6	11	335	6	0.18	14	<5	Mineralized(?) MsPzi dike
93KC59	8	<5	5.32	463	185	<20	2.22	0.87	13	0.12	0.15	15	4	61	19	0.38	8	5	Massive barite? vein
93KC78C	34	<5	3.68	162	130	<20	2.36	1.73	12	0.14	1.41	38	4	66	7	0.29	<1	6	Pillow basalt (Tab)