Indian and Northern Affairs Canada
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Open File 1988-1

GEOLOGY OF GRAVEL CREEK (105B/10) AND IRVINE LAKE (105B/11) MAP-AREAS, SOUTHEASTERN YUKON

by

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This report is available from
Exploration and Geological Services Division,
200 Range Road, Whitehorse, Yukon Y1A 3V1

Price Canada: $5.00

PREFACE

This report describes the bedrock geology of Gravel Creek (NTS 105B/10) and Irvine Lake (NTS 105B/11) map-areas of southern Yukon. These two areas were mapped at 1:50,000 scale during the summer of 1987. Completion of these two sheets represents the final year of a three year regional mapping program in the Rancheria district. This work was funded through the Mineral Resources Subsidiary Agreement of the Canada-Yukon Economic Development Agreement, Contract YEDA 01/86.

ABSTRACT

The Irvine Lake and Gravel Creek map-areas lie within the northern Omineca Belt, west of the Tintina-Northern Rocky Mountain Trench (NRMT) fault. The eastern part of the area is underlain by Proterozoic to early Paleozoic meta-sedimentary rocks of Cassiar terrane (Monger 1984), a fragment of the North American miogeocline which has been displaced northward on the Tintina-NRMT fault. The western part of the area is underlain by basaltic meta-volcanics, serpentinized ultramafic rocks, meta-gabbro, and cherty and calcareous meta-sediments of the Slide Mountain terrane (Monger, 1984). Unfoliated to weakly foliated granitic intrusives (Marker Lake and Cassiar batholiths and Cabin Creek and Gravel Creek stocks) occur throughout the area intruding both the Cassiar and Slide Mountain terranes.

Slide Mountain and Cassiar terranes are juxtaposed by an east-verging thrust fault referred to in this area as the Zak fault. Southwest of Irvine Lake, the thrust places serpentine, basaltic meta-volcanics, and an undeformed dioritic intrusion onto a footwall consisting of the Proterozoic Tsaydiz Fm. and older units. Northwest of Irvine Lake, near Shootamook Creek, the thrust places cherty meta-sediments of the allochthon onto marble and quartzite inferred to be lower Cambrian Rosella and Boya Formations, respectively.

The northern end of the Cassiar batholith extends into the southwestern corner of Irvine Lake map-area. Its northeastern contact with rocks of Slide Mountain terrane is a sub-vertical, northwest-southeast trending mylonite zone several tens of metres wide. Mesoscopic structures including S-C fabrics and shear bands (Berthe' *et al*, 1979) prove dextral displacement parallel to a variably plunging, but commonly sub-horizontal stretching lineation. The mylonite zone lies along a pronounced topographic lineament which extends from the trace of the Cassiar fault south of the Alaska Highway northwestwardly into the Irvine Lake map-area. Although not conclusive, the topographic expression of this feature suggests that the Cassiar fault continues northwestwardly into Irvine Lake map-area rather than veering to the west as previously mapped (Poole, *et al*, 1960).

Mineral occurrences in this area are primarily near the contact of granitic intrusions and carbonate rocks. Carbonate rocks hosting the deposits belong to the upper Proterozoic Ingenika Group (Swannell, Tsaydiz, and Espee formations) rather than the Lower Cambrian Atan Group as has been inferred for nearby deposits in the

Rancheria district. Other, non-carbonate-hosted mineral occurrences include a porphyry Mo prospect and Ag, Pb, Zn veins.

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INTRODUCTION

Background, Purpose, and Scope of Study

Mapping of Gravel Creek and Irvine Lake map-areas represents the final phase of a three year investigation of the geological controls on mineralization in the Rancheria district. The Rancheria district comprises over 50 precious- and base-metal occurrences and is currently under active exploration. Investigations were initiated to provide the exploration community with detailed geological base maps and predictive models of ore deposition. To date, four 1:50,000-scale map-areas have been published: 105B/1 and B/2 (Lowey and Lowey, 1986) and 105B/7 and B/8 (Amukun and Lowey, 1987).

This report presents the results of three months of geological mapping during the summer of 1987. Mapping focused on four specific goals: (1) completion of 1:50,000- scale geological maps of the two areas, (2) documentation and correlation of the stratigraphy of the area, (3) determination of the structural geometry of the area, and (4) synthesis of the geological controls on mineral occurrences in the area.

Location, Physiography, and Access

Gravel Creek and Irvine Lake map-areas are at the northern end of the Cassiar Mountains, in Wolf Lake map-area (NTS 105B, 1:250,000) of southeastern Yukon. They lie approximately 55 km north-northwest of the Alaska Highway at Rancheria, 10 km east of Wolf Lake, and 100 km west-northwest of Watson Lake (Fig. 2).

The terrain is relatively rugged, especially in the south-central and southwestern parts of the area underlain by Marker Lake and Cassiar batholiths, respectively. In these areas, many geomorphic features indicative of alpine glaciation are present such as cirques (many with small tarns), horns, aretes, stoss and lee structures, and lateral and terminal moraines. The highest points of the region (up to 2036 m) and maximum relief are found in these parts of the map-areas. The remainder of the region is characterized by lower elevations and more moderate relief.

Due to the northern latitude, tree-line is relatively low (approximately 1400 m), leaving the highest elevations relatively free of significant vegetation. Rock exposure in the alpine areas in the southern parts of Irvine Lake and Gravel Creek map-areas is generally good; in the lower topography fringing these uplands, the

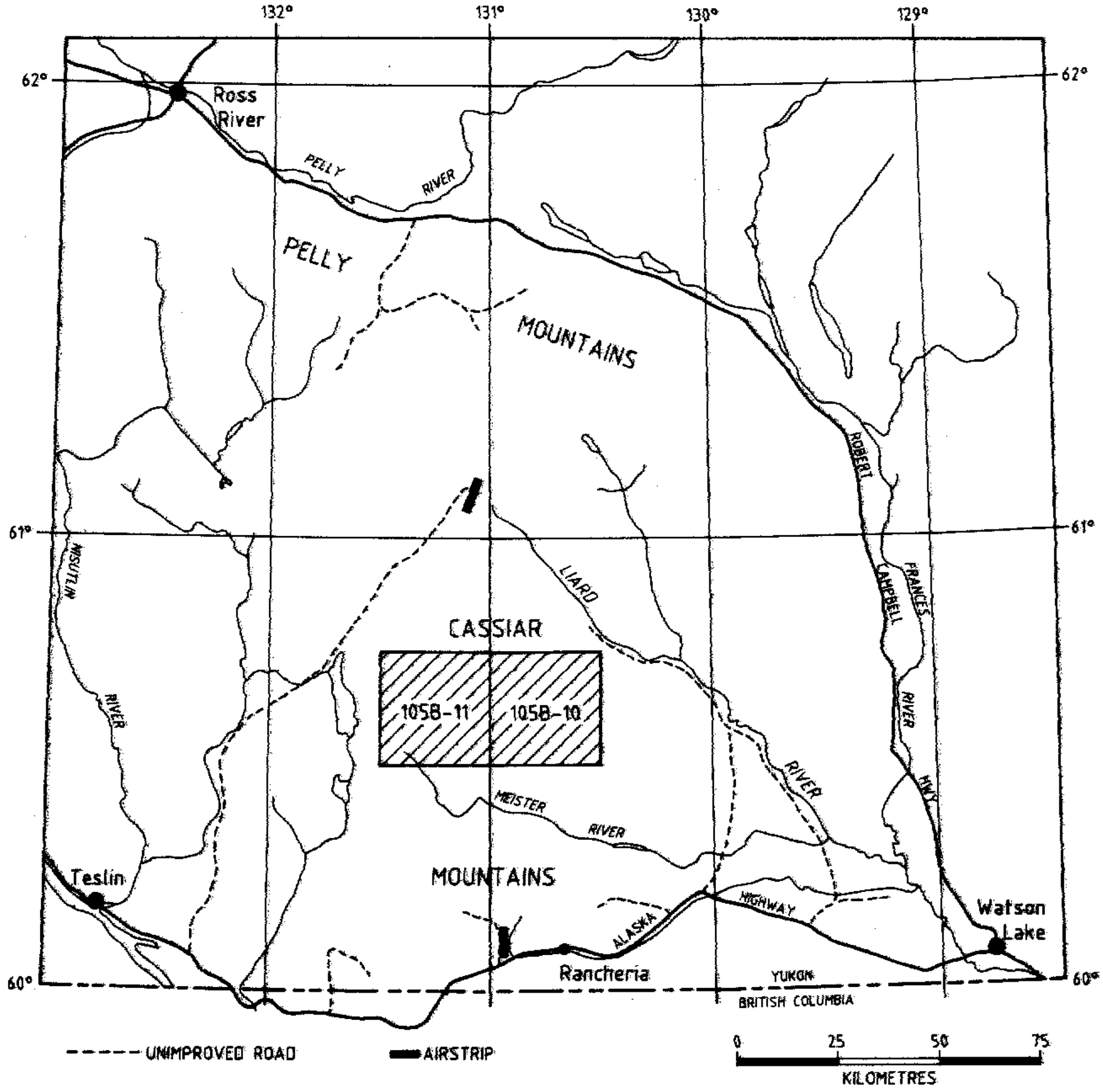


Figure 2: Map of southeastern Yukon showing the location of map areas with respect to geographic and physiographic features.

exposure ranges from poor in the bottoms and lower slopes of valleys to moderate along the intervening ridges.

The area is remote and roadless and a helicopter is necessary for access and camp moves. Our project utilized a Trans North Turbo Air helicopter based out of the Logan exploration camp (located near the southeast corner of Gravel Creek map-area) for the months of June and July and a Frontier Helicopters machine out of Watson Lake for the remainder of the summer. The project mobilized, was expedited, and demobilized out of Watson Lake.

Almost all mapping was done on foot, working out of tent camps placed by helicopter.

Previous Work

The bedrock geology of Gravel Creek and Irvine Lake map-areas was initially examined by Poole *et al* (1960) as part of 1:250,000-scale mapping of Wolf Lake Sheet (105B). This reconnaissance study outlined the general distribution of rock types in the area, established a regional stratigraphic and structural framework, and noted mineral occurrences. Since then, no systematic detailed bedrock mapping has been undertaken.

Geologic setting

Gravel Creek and Irvine Lake map-areas are located within the Omineca Crystalline Belt, near its northern termination (Fig. 3). In southern Yukon, the Omineca Crystalline Belt comprises primarily deformed and metamorphosed rocks belonging to three different and dissimilar geological terranes, Cassiar terrane, Slide Mountain terrane, and Dorsey terrane (Wheeler, 1987). Cassiar terrane consist of upper Proterozoic to Paleozoic miogeoclinal strata directly correlative with the North American continental margin sequence of the Rocky and Mackenzie Mountains. In contrast, Slide Mountain and Dorsey terranes consists primarily of highly deformed and imbricated middle and upper Paleozoic eugeoclinal rocks. Although representing dissimilar stratigraphic facies and tectonic settings, there is a growing body of evidence which suggests that Slide Mountain and Dorsey terranes may have formed in a basinal setting just outboard of the North American continental margin and was thrust onto the continental margin during Mesozoic convergence (Klepacki, 1983; Klepacki and Wheeler, 1985; Nelson, personal communication, 1987).

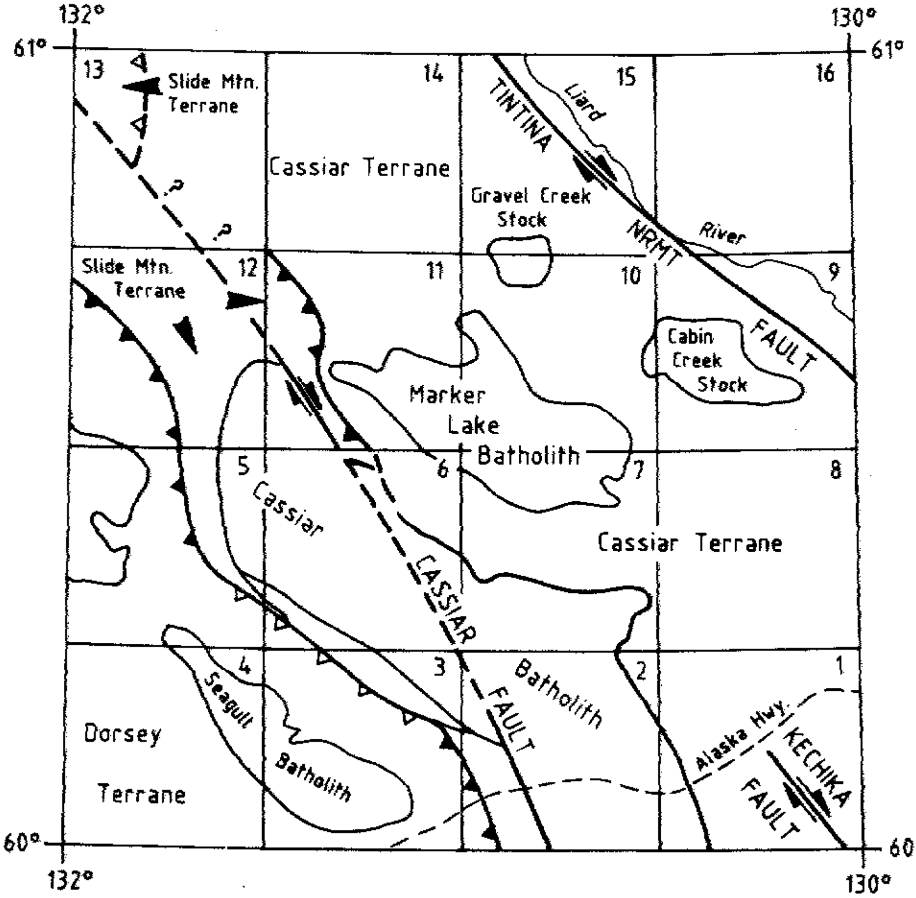


Figure 3: Geologic terranes of southeastern Yukon (Modified from Wheeler, 1987).

During the Cretaceous, voluminous granitic plutons intruded the continental margin of North America and the newly arrived oceanic terranes. The Omineca Crystalline Belt in southern Yukon and northern British Columbia is host to several of these large bodies, including Cassiar, Marker Lake, and Seagull batholiths (Fig. 3). Their ages are imprecise although reference is made to late Early Cretaceous conventional K/Ar determinations (Lowdon, 1961; Lowdon *et al.*, 1963; Wanless *et al.*, 1972, 1974). Their actual age of intrusion may be better constrained by U/Pb (zircon) geochronology in progress.

Following, or during the waning stages of plutonism, major dextral strike-slip faults with a cumulative displacement of possibly over 1000 km sliced the continental margin of North America (Gabrielse, 1985). The most prominent of these faults is the Tintina/Northern Rocky Mountain Trench fault, which bounds the Cassiar terrane on the northeast. Other significant faults pertinent to this study include the Cassiar fault which cuts the Cassiar batholith and the Kechika fault which trends toward the study area but has not been recognized (Fig. 3).

Meta-sedimentary rocks of Cassiar terrane and late Early Cretaceous granitic intrusions underlie most of Gravel Creek and Irvine Lake map-areas. Slide Mountain terrane underlies a small area in the southwestern part of Irvine Lake map-area.

Acknowledgements

This project would not have been completed except for significant logistical support from Grant Abbott of Exploration and Geological Services Division, Department of Indian Affairs and Northern Development, Whitehorse, for which I am extremely grateful. I would also like to acknowledge Grant's help in the field, his contribution to my understanding of Yukon geology, and his thorough editing of an early draft of this report.

I would especially like to thank Mike Stammers, chief geologist at the Logan property, for his generous hospitality which he offered us throughout the summer and for sharing with us his extensive knowledge of the area.

John and Joyce Steubenberg of TWI-LITE Expediting Services of Watson Lake provided excellent logistical support for our project.

I'd like to thank Earl the Pearl and, especially, Claude Marchand of Frontier Helicopters for their flying service and, in light of our tight flying budget, their efforts in arranging split ferries. Bryan Parsons of Trans North Turbo Air flew for us during the months of June and July.

This project was funded by a Canada-Yukon Economic Development Agreement contract to Tesso International Consulting Co. of Agincourt, Ontario. I would like to thank Sam Amukun of Tesso for his efforts in initiating and overseeing the project.

Finally, I would like to acknowledge the perserverance and able assistance of Francoise Goutier, Patty Carmichael, and Jim Oriotis, who suffered with me through the improperly advertised 'optimal mapping weather' of southern Yukon.

LITHOLOGICAL UNITS OF GRAVEL CREEK AND IRVINE LAKE MAP-AREAS

Gravel Creek and Irvine Lake map-areas contain most of the major tectonostratigraphic elements of the northern Omineca Crystalline Belt, including Cassiar and Slide Mountain terranes, and late Early Cretaceous granitoid plutons (Fig. 3).

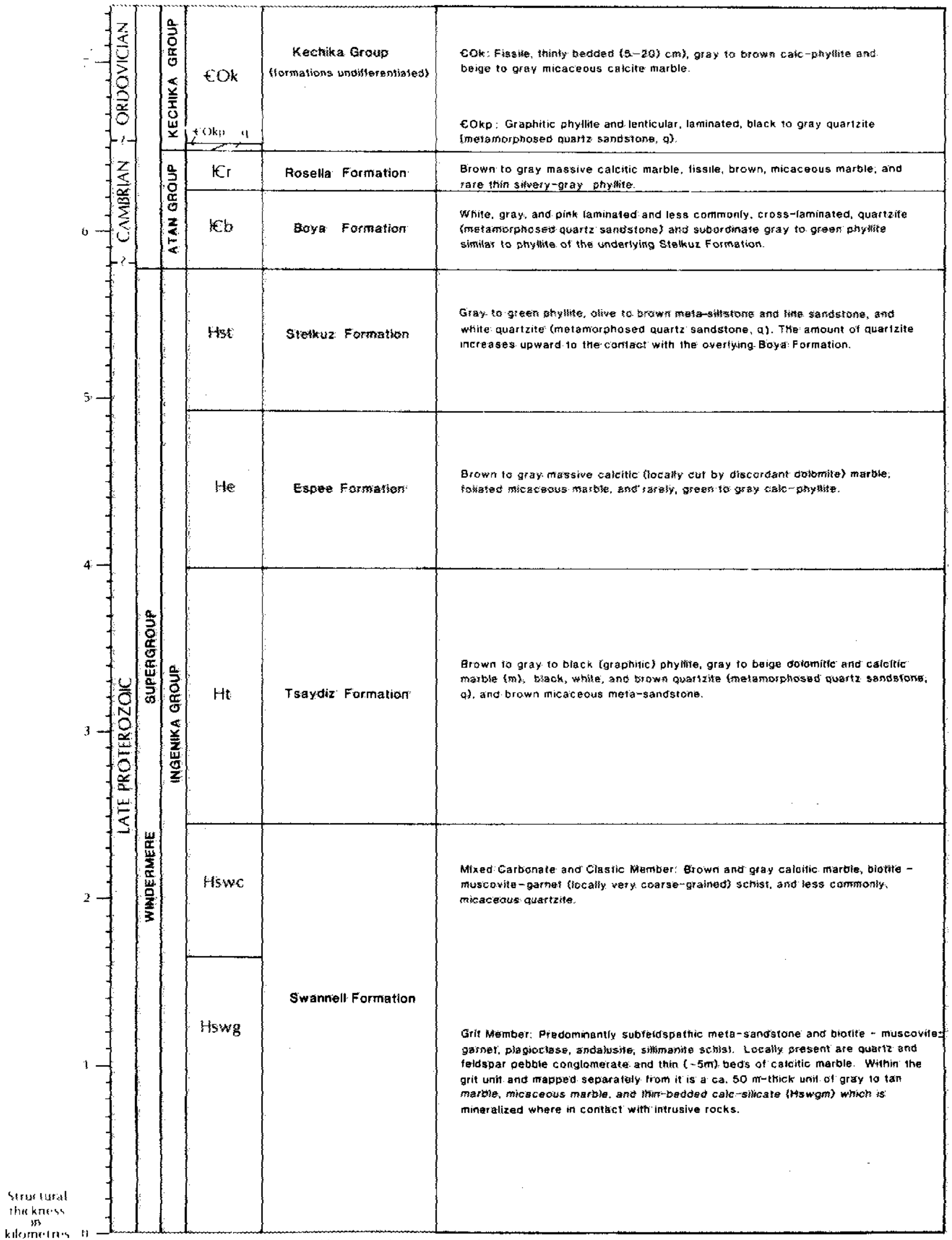
Cassiar terrane comprises deformed and metamorphosed fine- to coarse-grained siliciclastic rocks, carbonate rocks, and pre-kinematic intrusions. On the basis of lithostratigraphic similarity to other dated sequences, their age is inferred to range from Proterozoic to lower Ordovician. The absolute age of the pre-kinematic intrusive rocks is unknown.

Slide Mountain terrane comprises chert, graphitic phyllite or argillite, chert- and limestone-pebble conglomerate, basaltic meta-volcanics, deformed and metamorphosed gabbro, serpentinized ultramafic rocks, and foliated serpentinite. An unfoliated gabbroic pluton which ranges in composition from diorite to pyroxenite intrudes these rocks. Neither the age of this pluton nor its relationship to Cassiar terrane in known.

Four unfoliated to weakly foliated plutons are found in Gravel Creek and Irvine Lake map-areas: Cassiar and Marker Lake batholiths and Gravel Creek and Cabin Creek stocks. They range in composition from granodiorite to quartz monzonite.

Cassiar terrane

Cassiar terrane has been subdivided into eight mappable units (Fig. 4). The Proterozoic and lower Paleozoic stratigraphy of northern British Columbia strongly resembles the stratigraphy of this area and, as such, the stratigraphic terminology of Mansy and Gabrielse (1977) and Fritz (1980) are used for the Proterozoic and lower Paleozoic, respectively.



Period		Group	Symbol	Formation	Description
ORDOVICIAN		KECHIKA GROUP	€Ok	Kechika Group (formations undifferentiated)	€Ok: Fissile, thinly bedded (5–20) cm), gray to brown calc-phyllite and beige to gray micaceous calcite marble. €Okp: Graphitic phyllite and lenticular, laminated, black to gray quartzite (metamorphosed quartz sandstone, q).
CAMBRIAN		ATAN GROUP	l€r	Rosella Formation	Brown to gray massive calcitic marble, fissile, brown, micaceous marble; and rare thin silvery-gray phyllite.
			l€b	Boya Formation	White, gray, and pink laminated and less commonly, cross-laminated, quartzite (metamorphosed quartz sandstone) and subordinate gray to green phyllite similar to phyllite of the underlying Stelkuz Formation.
LATE PROTEROZOIC	WINDERMERE SUPERGROUP	INGENIKA GROUP	Hst	Stelkuz Formation	Gray to green phyllite, olive to brown meta-siltstone and fine sandstone, and white quartzite (metamorphosed quartz sandstone, q). The amount of quartzite increases upward to the contact with the overlying Boya Formation.
			He	Espee Formation	Brown to gray massive calcitic (locally cut by discordant dolomite) marble; foliated micaceous marble, and rarely, green to gray calc-phyllite.
			Ht	Tsaydiz Formation	Brown to gray to black (graphitic) phyllite, gray to beige dolomitic and calcitic marble (m), black, white, and brown quartzite (metamorphosed quartz sandstone, q), and brown micaceous meta-sandstone.
			Hswc	Swannell Formation	Mixed Carbonate and Clastic Member: Brown and gray calcitic marble, biotite – muscovite – garnet (locally very coarse-grained) schist, and less commonly, *micaceous quartzite.*
			Hswg		Grit Member: Predominantly subfeldspathic meta-sandstone and biotite – muscovite ± garnet, plagioclase, andalusite, sillimanite schist. Locally present are quartz and feldspar pebble conglomerate and thin (~5m) beds of calcitic marble. Within the grit unit and mapped separately from it is a ca. 50 m-thick unit of gray to tan *marble, micaceous marble, and thin-bedded calc-silicate (Hswgm) which is* mineralized where in contact with intrusive rocks.

Stratigraphic nomenclature: Atan Group Fritz, G.S.C. Paper 80-1B, 217-225, 1978

Windermere: Mansy and Gabrielse, G.S.C. Paper 77-19, 1980

Figure 4: Table of Cassiar terrane formations.

Windermere Supergroup (upper Proterozoic)

Ingenika Group

Swannell Formation, grit member: Hswgm

Swannell Formation is the local representative of the Windermere 'grit' unit. It is composed primarily of biotite - muscovite - quartz ± garnet, plagioclase, andalusite, sillimanite, staurolite schist; subfeldspathic meta-sandstone; and subordinate marble, calc-silicate rocks; and quartz- and feldspar-pebble conglomerate. Schist and finer grained meta-sandstone are the predominant lithologies found in Gravel Creek and Irvine Lake map-areas.

Swannell Formation schist is generally pelitic, but includes alumina-poor (quartz-rich) and calcareous compositions. Metamorphic minerals include plagioclase, chlorite, biotite, staurolite, garnet, muscovite, andalusite, and sillimanite. The parallel alignment of micaceous mineral imparts a prominent schistosity to these rocks. (See Chapters 3 and 4 for a more complete description of metamorphic and deformational fabrics).

Meta-sandstone is primarily thin- to medium-bedded and ranges from fine- to coarse-grained. Sedimentary structures are generally lacking although finer-grained and more thinly bedded meta-sandstone may show parallel lamination (Fig. 5) and graded bedding is locally apparent in coarser meta-sandstone.

Quartz- and feldspar-pebble conglomerate is locally important in the grit unit (Fig. 6). The thickest accumulation of conglomerate was found north of Cabin Creek where m-scale beds of conglomerate are associated with relatively thick and more obviously graded beds of coarse meta-sandstone and a higher overall meta-sandstone/schist ratio. Pebbles are subangular to rounded and up to 2 cm.

The grit contains beds (< 5 m-thick) of calcitic marble and garnet -diopside calc-silicate rocks. Although thin, some marble beds are persistent; south of Cabin Creek, individual marble units have been mapped for up to 7 kilometres. Laterally continuous gray to tan marble, micaceous marble, and thin-bedded calc-silicate (Hswgm, Fig. 7) about 50 m-thick in total have been traced discontinuously from the eastern edge of Gravel Creek map-area through the northern end of Marker Lake batholith and into the south central part of Irvine Lake map-area.

Distribution, thickness and contact relations

The grit member of the Swannell Formation is distributed concentrically around the Marker Lake batholith. It is best exposed between Cabin and Allan Creeks, where a homoclinally dipping section is at least 3.5 km-thick. In Irvine Lake

Figure 5: Thin, plane laminated beds in grit member of Swannell Formation (Hswg) north of Cabin Creek.

Figure 6: Quartz- and feldspar-pebble conglomerate in Swannell Formation grit member (Hswg) north of Cabin Creek.

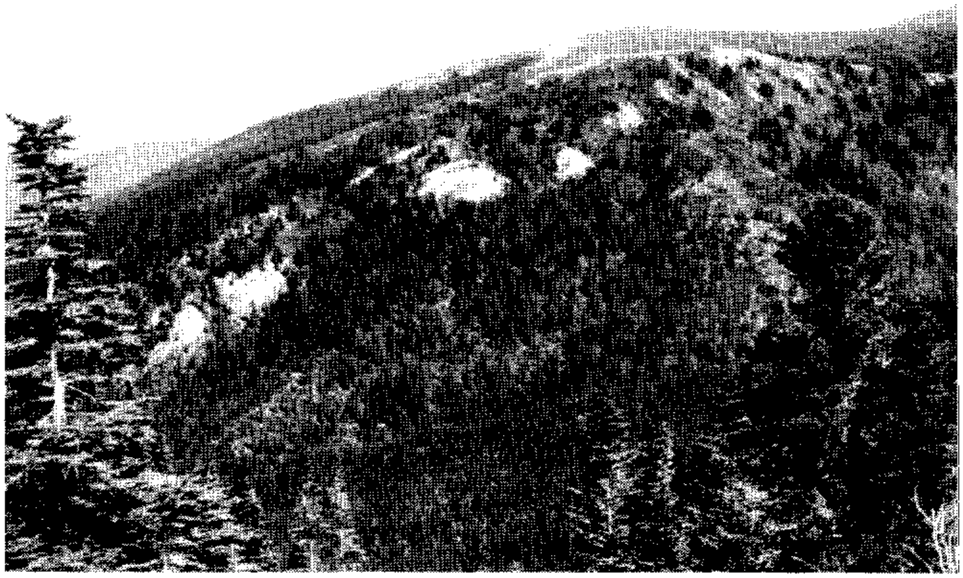


Figure 7: North dipping marble in Swannell Formation grit member (Hswgm) south of Cabin Creek. Marble is mineralized along ridge in middleground near contact with Cabin Creek stock (tungsten, Tung property) which underlies the ridge in background. View is to the east, south of Cabin Creek.

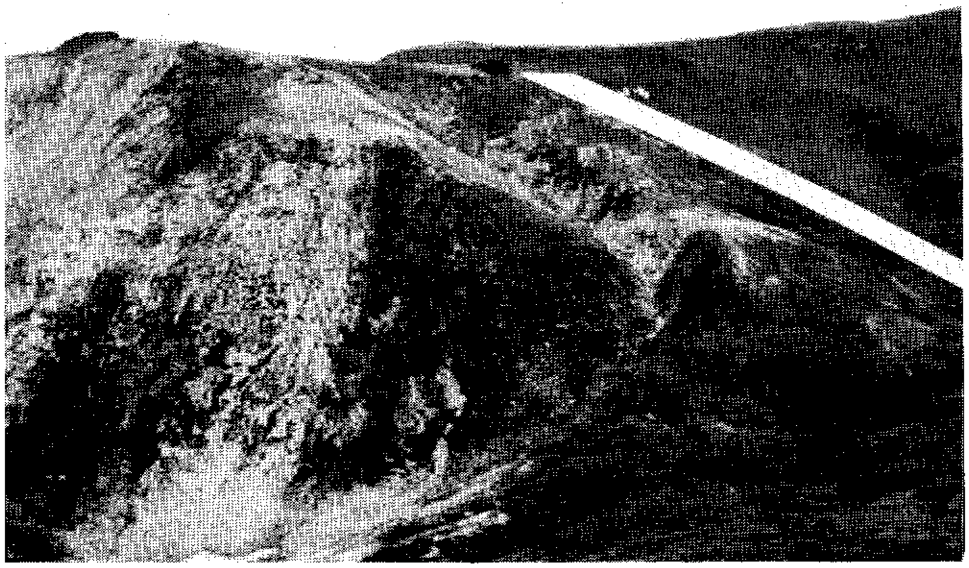


Figure 8: Thrust contact between dolomite, black quartzite, and graphitic phyllite of Tsaydiz Formation (Ht, footwall) and serpentine and greenstone at base of Slide Mountain terrane (Pz?s and Pz?mv, hanging wall). Isolated black rock in top center of photograph is block of graphitic phyllite and quartzite contained within serpentinite. View is to the southeast, west of Irvine Lake, Irvine Lake map-area.

map-area, it is well exposed southwest of Irvine Creek. Although the top of the unit may be traced throughout the map-area, the bottom is not exposed.

Swannell Formation, mixed clastic and carbonate member: Hswc

This unit, which is informally given 'member' status because of its thickness and lateral continuity, includes brown and gray calcitic marble; biotite - muscovite ± garnet (locally very coarse-grained) schist; finely laminated silvery gray phyllite and orange-brown marble; and less commonly, micaceous quartzite and calcite cemented quartz- and feldspar-pebble conglomerate. The member is primarily calcareous in contrast with the siliciclastic rocks of the underlying 'grit' unit and phyllite of the overlying Tsaydiz Formation.

Distribution, thickness and contact relations

The mixed clastic and carbonate member of the Swannell Formation outcrops concentrically around Marker Lake batholith (Figs. 1A and 1B) and is absent in the southeastern corner of Gravel Creek map-area where only the lower part of the Swannell Formation is exposed.

Its thickness ranges from approximately 1500m in the central part of Gravel Creek map-area to 600m in the southwestern part of Irvine Lake map-area.

Contacts with the overlying Tsaydiz Formation and the underlying member of Swannell Formation are sharp. The basal contact is placed at the base of the first carbonate in the series of marbles which compose this unit; its top is defined as the upper contact of the last carbonate below the phyllite (locally quartzite) of Tsaydiz Formation.

Tsaydiz Formation: Ht

The Tsaydiz Formation consists of brown to gray to black (graphitic) phyllite; gray to beige dolomitic and calcitic marble; black, white, and brown quartzite (metamorphosed quartz sandstone); and brown micaceous meta-sandstone. The unit is primarily phyllite; beds of carbonate and quartzite up to 5 m-thick constitute less than 15% of the unit. North of the Marker Lake batholith along the boundary between the two map-areas, the base of the Tsaydiz Formation is a 3 m-thick bed of white to salmon quartzite. Southwest of Irvine Lake, beds of dolomitic marble up to 5 m-thick interbedded with graphitic phyllite occur starting about 300m above the base of the unit. The uppermost observed (below the thrust contact with Slide Mountain terrane) beds of dolomitic marble are also intercalated with beds of white, black, and gray quartzite. The amount of quartzite increases to the southeast along strike.

Distribution, thickness and contact relations

The Tsaydiz Formation is the thickest in Gravel Creek and Irvine Lake map-areas and underlies a significant portion of the north-central part of Gravel Creek map-area and the northwestern part of Irvine Lake map-area. In southwestern Irvine Lake map-area, it forms part of the homoclinally dipping panel of Ingenika Group rocks lying directly beneath serpentinite of Slide Mountain terrane (Figs. 1A and 1B).

The unit is approximately 1.6 km-thick in the western part of Gravel Creek map-area and over 1.1 km-thick in the southwestern part of Irvine Lake map-area.

Throughout the map-area, the Tsaydiz Formation is in sharp and conformable stratigraphic contact with the underlying mixed clastic and carbonate member of Swannell Formation and with the carbonates of the overlying Espee Formation. In southwestern Irvine Lake map-area, Tsaydiz Formation is in thrust contact with serpentinite of Slide Mountain terrane (Fig. 8).

Espee Formation: He

The Espee Formation consists primarily of brown to gray massive calcitic (locally cut by discordant dolomite) marble, foliated micaceous marble, and rare green to gray calc-phyllite. In the northwest corner of Irvine Lake map-area, it appears as massive unbedded marble with rare intercalations of thinly bedded phyllitic marble.

Distribution, thickness and contact relations

The Espee Formation is best exposed in the northeast corner of Gravel Creek map-area where it passes from an upright (east- to northeast-dipping) to near-vertical to overturned orientation around the hinge of the Buttes Anticline (Fig. 9; see Ch. 3). It also crops out in the northeastern and north-central parts of Gravel Creek map-area, and in the north-central part of Irvine Lake map-area where gray to beige marble forms prominent ridge-capping outcrops east of Shootamook Creek.

The Espee Formation ranges in thickness from 900m in the northeastern corner of Gravel Creek map-area to approximately 350m in the north-central part of Irvine Lake map-area.

Figure 9: Hinge zone of regional scale D_2 Buttes Anticline, closing buff to gray marble of Espee Formation (He) and gray to green phyllite, sandstone, and quartzite of Stelkuz Formation. View is to the north, northeast corner of Gravel Creek map-area.

Figure 10: Steeply dipping beds of meta-sandstone and quartzite in basal Stelkuz Formation. Upper contact of Stelkuz Formation with Boya Formation is just out of view to the right. View is to the south, northeast Gravel Creek map-area.

Both the upper and lower contacts of the Espee Formation are sharp and conformable. This massive unit stands in distinct contrast to both underlying and overlying phyllites (Fig. 9).

Stelkuz Formation: Hst

The Stelkulz Formation consists primarily of gray to green phyllite with subordinate olive to brown micaceous meta-siltstone and meta-sandstone and white quartzite. The quartz content of meta-sandstone and -siltstone beds is high and these strata may be easily mistaken for quartzite but break more easily. In northeastern Gravel Creek map-area, the amount of quartzite apparently increases upwards to the contact with overlying massive quartzite of the Boya Formation (Fig. 10).

The Stelkuz and Tsaydiz formations are similar and difficult to differentiate. Both are phyllitic and contain quartzite. However, Tsaydiz Formation contains a significant percentage of carbonate rocks and lacks meta-siltstone and fine meta-sandstone; Stelkuz Formation, on the other hand, is rarely calcareous and contains abundant meta-siltstone and fine meta-sandstone. To distinguish them unambiguously requires knowledge of the underlying and overlying rocks: Tsaydiz Formation is overlain by the distinctive cliff-forming Espee Formation and underlain by Swannell Formation and Stelkuz Formation is underlain by Espee Formation and overlain by distinctive quartzite of the Boya Formation.

Distribution, thickness and contact relations

The Stelkuz Formation is best exposed in the northeast corner of Gravel Creek map-area where it is folded into a near-vertical orientation. It is also found in the north-central part of both Gravel Creek and Irvine Lake map-areas.

The unit ranges in thickness from 800m in the northeast corner of Gravel Creek map-area to 650m in north-central Irvine Lake map-area. In the latter location, two phases of map-scale folding are recognized and the measured thickness may reflect structural modification.

Everywhere in Gravel Creek and Irvine Lake map-areas, the Stelkuz Formation is in sharp, conformable contact with the underlying Espee Formation (Fig. 9). Its contact with the overlying Boya Formation is gradational and therefore arbitrarily placed at the base of the first massive thick-bedded quartzite greater than 2 m-thick above a sequence composed primarily of thick-bedded quartzite.

Atan Group (lower Cambrian)

Boya Formation: lCb

The Boya Formation comprises white, gray, and pink laminated and less commonly, cross-laminated, quartzite (metamorphosed quartz sandstone), and subordinate gray to green phyllite similar to phyllite of the underlying Stelkuz Formation (Fig. 11).

Distribution, thickness, and contact relations

The Boya Formation is best exposed in the northeastern corner of Gravel Creek map-area. It is also found in north-central Irvine Lake map-area where discontinuous exposures extend northward from the prominent bend in Irvine Creek into and east of the valley of Shootamook Creek.

The unit ranges in thickness from 250m in northeast Gravel Creek map-area to 350m in Irvine Lake map-area. In the latter locality, however, at least one of the contacts of this unit is faulted.

The Boya Formation is gradational with phyllite and quartzite of the underlying Stelkuz Formation and in sharp contact with limestone of the overlying Rosella Formation. Locally, in Irvine Lake map-area, the contact of the Boya Formation with other rocks is a fault.

Rosella Formation: lCr

The Rosella Formation is primarily brown to gray massive to intraclast-bearing calcitic marble and fissile, brown, micaceous marble. Rarely, thin beds of silvery-gray phyllite are present. Archaeocyathids, which are common in other occurrences of the Rosella Formation, occur in one locality in the Irvine Lake map-area, west of Shootamook Creek and establish the age of the Rosella Formation as late Early Cambrian.

The Rosella Formation may be distinguished from the lithologically similar Espee Formation only on the basis of its smaller thickness and its basal contact with Boya quartzite and upper contact with the phyllite of the Kechika Group.

Distribution, thickness, and contact relations

The best exposure of the Rosella Formation is in northeastern Gravel Creek map-area where a long, continous cliff of Rosella occurs on the western limb of the Sayyea Syncline (Fig. 12). It also occurs east of Shootamook Creek where it is in contact with Boya Formation.

Figure 11: Massive quartzite of Boya Formation. Bedding is indistinct although steeply dipping (subparallel to hammer handle) with tops to west (right). Pronounced planar fabric dipping to the right is S_2. The relationship of bedding to S_2 indicates steep to overturned limb of west-verging D_2 fold. Asymmetric fold of S_2 is D_3. View is to the north, north of Cabin Creek, Gravel Creek map-area.

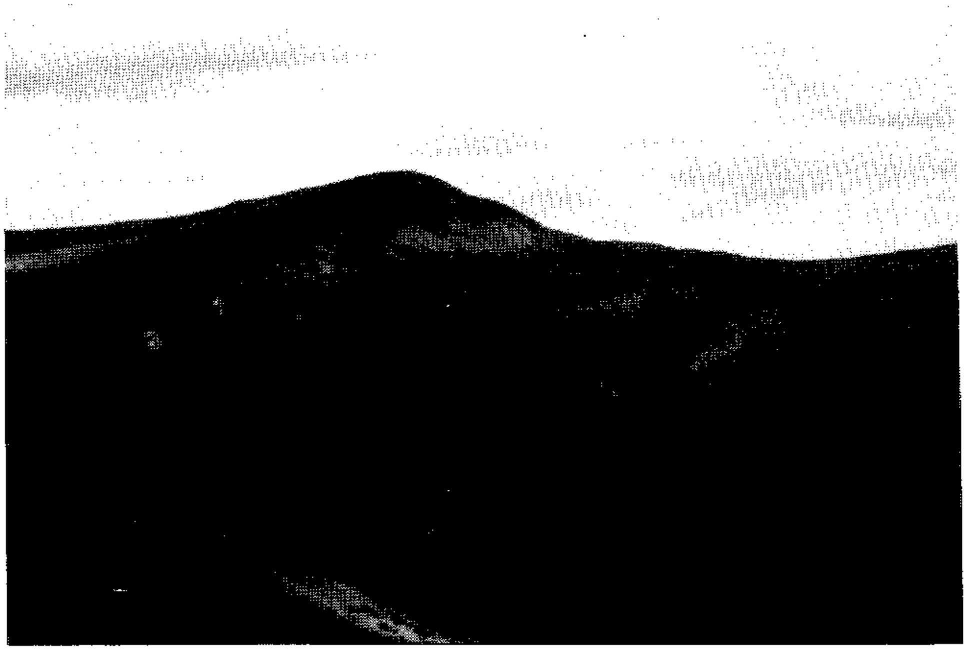


Figure 12: Southeast dipping slope underlain by basal graphitic phyllite and quartzite of Kechika Group (top), light coloured marble of Rosella Formation (middle), and not visible at base, quartzite of Boya Formation. View is to the northeast, north of Cabin Creek, Gravel Creek map-area.

In northeastern Gravel Creek map-area, the Rosella Formation is approximately 125m-thick. Due to poor exposure and structural complexity, no estimate of thickness is possible in Irvine Lake map-area.

Both the lower contact of the Rosella with Boya Formation quartzite and its upper contact with phyllite or quartzite of the Kechika Group are sharp (Fig. 12).

Kechika Group (upper Cambrian to middle Ordovician): COk, COkp, COkq

Two subunits of the Kechika Group are present in Gravel Creek map-area: a 40m-thick basal unit of graphitic phyllite (COkp) and laminated black quartzite (COkq) and an upper unit of fissile, thinly bedded (5 - 20 cm), gray to brown calc-phyllite and beige to gray micaceous calcite marble (COk, Fig. 13). The basal unit is primarily graphitic phyllite; quartzite occurs as lenses up to 2 km-wide in the longest exposed dimension and up to 30m-thick.

Distribution, thickness, and contact relations

The Kechika Group occurs only in northeastern Gravel Creek map-area (Fig. 1B). Approximately 150m of the unit are found; the top is not exposed.

The basal phyllite/quartzite unit is in sharp and conformable(?) stratigraphic contact with the underlying Rosella Formation.

Paleozoic? (pre-kinematic) intrusive rocks: Pz?og

An elongate body of foliated to gneissic hornblende diorite is found between Cabin and Gravel creeks (Fig. 1B). Parallel green amphibole defines a foliation in a matrix of plagioclase feldspar. This foliation is conformable with the main phase foliation in surrounding country rocks.

The diorite is in contact with the Tsaydiz, Espee, and Stelkuz formations. Spatially associated with the intrusion are foliated mafic dykes which cross-cut all units, implying a minimum age of lower Ordovician.

Slide Mountain terrane

The Slide Mountain terrane includes deformed mafic meta-volcanic and meta-plutonic rocks, serpentinized ultramafic rocks, foliated serpentinite and serpentinite-matrix breccia, chert, argillite, limestone, chert- and limestone-pebble conglomerate, siltstone, an undeformed mafic to ultramafic pluton, and undeformed

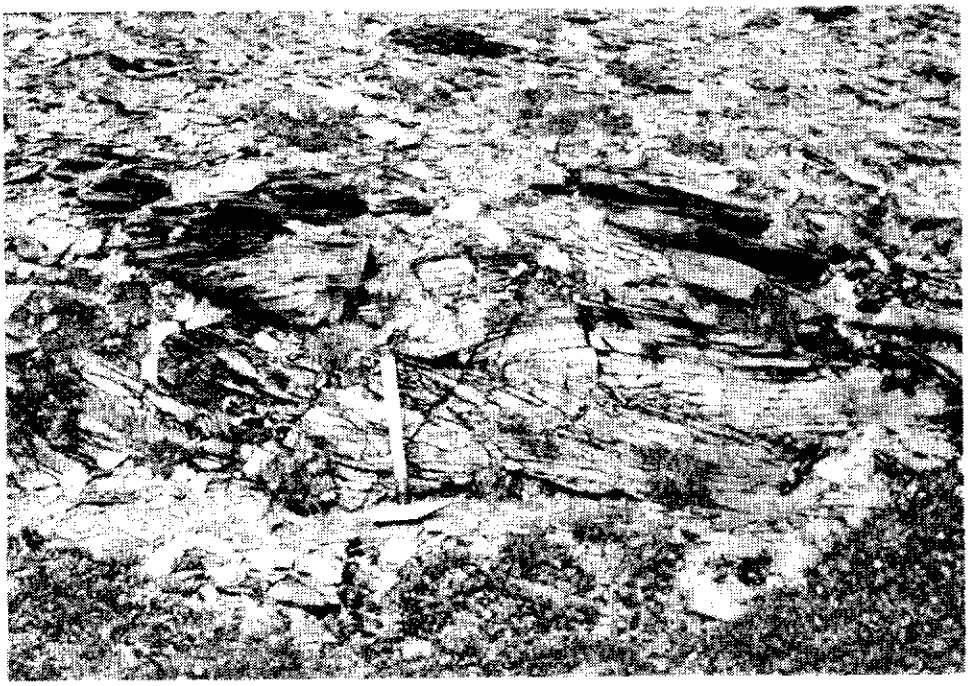


Figure 13: Fissile and finely laminated calc-phyllite and marble of Kechika Group (COk) cut by a west-verging D_2 thrust fault. View is to the north, northeast corner of Gravel Creek map-area.

plagioclase-porphyritic basaltic dykes. Except for good ridge-top exposures in southwestern Irvine Lake map-area, the Slide Mountain terrane is poorly exposed. Six map-units have been defined but detailed stratigraphy and contact relations remain unclear.

Foliated serpentinite unit: Pz?s

South of the east-west trending section of Irvine Creek, foliated and lineated scaly green to greenish-white serpentine and small resistant brown to orange bleached-looking lenses of an unknown silicate material cut by veins of fibrous serpentine form a discontinuous layer up to 50 m-thick in the contact zone of Slide Mountain terrane with the underlying Cassiar terrane. Locally, large blocks (up to 3 m) of graphitic quartzite and gray dolomite of the Tsaydiz Formation are incorporated into serpentinite forming a serpentinite-matrix breccia (Fig. 8).

Foliated mafic meta-volcanic unit: Pz?mv

Strongly foliated and locally lineated fine-grained, chlorite, actinolite, and plagioclase-bearing greenstone of unit Pz?mv crops out in the western part of Irvine Lake map-area from its southern boundary northward to the east-west trending portion of Irvine Creek. The greenstone structurally overlies the basal foliated serpentinite unit.

Cherty meta-sedimentary unit: Pz?ms

Unit Pz?ms consists of deformed and metamorphosed chert, argillite, minor mafic meta-volcanic, and tentatively includes poorly exposured chert- and limestone-pebble conglomerate and siltstone found at the eastern end of a low ridge west of the westernmost outcrops of Rosella(?) Formation. This unit overlies a mixed unit of mafic meta-volcanics, meta-gabbro, and serpentinized ultramafic rocks (Pz?gs). Unit Pz?ms has been observed only along one ridge in the poorly exposed northwestern part of Irvine Lake map-area, but may occur further to the northwest outside the boundaries of the map-area.

Calcareous meta-sedimentary unit: Pz?ca

Dark gray, thin- to medium-bedded marble, siltstone, and phyllite form a klippen above phyllite and quartzite of the Stelkuz Formation east of the valley of Shootamook Creek. Although similar rocks have not been observed in Slide Mountain terrane across Shootamook Creek to the west, they are totally unlike

Cassiar terrane rocks. The structural nature of its basal contact with Cassiar terrane and its lithostratigraphic dissimilarity with Cassiar terrane imply correlation with Slide Mountain terrane.

Mixed meta-gabbro, serpentinized ultramafic, and mafic meta-volcanic(?) unit: Pz?gs

Massive meta-gabbro, serpentinized peridotite, and minor mafic rocks (which may be dykes rather than flows) are found in the westernmost part of Irvine Lake map-area. This unit is poorly exposed, appearing only along the tops of three east-west trending ridges north of Irvine Creek. It is overlain by Pz?ms; the nature of the contact cannot be determined due to poor exposure.

Unfoliated mafic to ultramafic intrusive: Pz?gdp

Unfoliated coarse-grained quartz diorite, diorite, leucogabbro, and pods of pyroxenite of unit Pz?gdp are found in southwestern Irvine Lake map-area. The contact with unit Pz?mv is sharp and the intrusion contains foliated greenstone xenoliths identical to Pz?mv suggesting an intrusive relationship. The age of intrusion of Pz?gdp is not known; samples were taken for U/Pb dating. Similar unfoliated intrusions in southwest Wolf Lake map-area and Jennings River map-area (104O) are middle Jurassic (Wanless *et al.*, 1972, 1974; Abbott, 1981).

This unit is considered part of Slide Mountain terrane rather than a post-obduction intrusion because it is compositionally distinct from the suite of post-obduction granitic rocks and more akin to the mafic to ultramafic rocks of Slide Mountain terrane. This interpretation implies that some of the fabric of Slide Mountain terrane rocks formed before the obduction of the terrane.

Post-obduction intrusive rocks

Four unfoliated to weakly foliated granitic plutons are found in Gravel Creek and Irvine Lake map-areas: Cassiar and Marker Lake batholiths and Cabin and Gravel Creek stocks. Their compositions range from quartz diorite to potassium feldspar mega-crystic granite. Individual bodies are composite but were not mapped in sufficient detail to subdivide.

Gravel and Cabin Creek stocks and Marker Lake batholith intrude Cassiar terrane rocks exclusively. Cassiar batholith is inferred to intrude Cassiar terrane based on the presence of large xenoliths of marble, well-bedded quartzite, and schist; the actual intrusive contact was not observed. Cassiar batholith is known to intrude Slide Mountain terrane in northern British Columbia; this intrusive relationship was not observed in the map-area.

In southeastern Gravel Creek map-area, the contacts of Cabin Creek stock and Marker Lake batholith with the grit member of the Swannell Formation are transitional and obscured by the presence of large amounts of concordant and discordant granitic pegmatite. Wall rocks composed of varying amounts of granitic pegmatite pass through a narrow transition zone of mixed wall rock, massive granitic rocks, and pegmatite into a zone of mixed massive granitic rocks and pegmatite and then into the massive granitic rocks of the plutons proper. The spatial relationship of the pegmatite with the contact zones of the two plutons is consistent with a late-stage magmatic origin of the pegmatite.

The ages of these bodies are constrained only by K/Ar determinations which range from 98 to 128 Ma (Lowdon, 1961; Lowdon, *et al.*, 1963l; Wanless *et al.*, 1972, 1974) and by K/Ar determinations on associated pegmatites of 73 Ma (muscovite; Wanless *et al.*, 1974).

STRUCTURAL GEOLOGY

Two major faults divide the map-area into three domains each characterized by a different structural geometry, style, and possibly age. Cassiar? fault, a major dextral strike-slip fault extending across the southwestern corner of Irvine Lake map-area, separates the Cassiar batholith domain to the southwest, from the Slide Mountain terrane domain to the northeast. Zak fault, the basal thrust of the Slide Mountain terrane, separates Slide Mountain terrane domain to the west from the Cassiar terrane domain to the east.

Of the three domains, the Cassiar batholith domain is simplest. It is underlain by weakly foliated granitic rocks and xenoliths of deformed siliciclastic and carbonate meta-sediments.

Slide Mountain and Cassiar terranes are more complexly deformed than the Cassiar batholith domain. Slide Mountain terrane meta-volcanic and meta-sedimentary rocks are strongly foliated and rocks of Cassiar terrane have macroscopic and microscopic structural geometries indicative of poly-phase deformation. Analysis of deformation in Cassiar terrane is straightforward, facilitated by good exposure and a clear stratigraphy. In contrast, poor exposure and the lack of important marker beds in the Slide Mountain terrane preclude more than a simple description of its structural geometry.

Structural geometry of the Cassiar terrane

Rocks of the Cassiar terrane are deformed by an early, eastwardly verging phase of regional ductile deformation and a subsequent phase of westwardly verging regional ductile deformation; a third phase of ductile deformation is locally important. Bedding and structures associated with the first two phases of deformation are domed upward around the unfoliated Marker Lake batholith; pegmatitic marginal phases of the Marker Lake batholith are deformed by third phase structures. All structures are cut by steep normal faults with trends ranging from northwest to northeast. The absolute ages of deformation are uncertain although the cross-cutting relations just described imply that the two phases of regional deformation pre-date the late Early Cretaceous intrusion of the Marker Lake batholith, the local third phase post-dates Marker Lake batholith, and brittle faulting post-dates all other structures.

Regional deformation

All Cassiar terrane meta-sediments in the area display a pronounced planar tectonic fabric. This fabric is congruent with the most commonly observed and locally most prominent folds in the area. Close examination of this fabric reveals that it is defined by the axial surfaces of tight folds of an earlier schistosity. This observation permits the inference that the prominent foliation and most of the folds belong to at least the second phase of deformation. As there are no data indicating deformation prior to the earlier schistosity, the early schistosity is referred to as S_1 and structures deforming S_1 (foliations and folds) are referred to as D_2 structures. In turn, the locally important third phase of ductile deformation is referred to as D_3.

First-phase structures (D_1)

First-phase structures comprise a ubiquitous but cryptic schistosity (S_1) and a map-scale east- to northeast-verging anticline-syncline fold pair. D_1 structures intermediate in scale between handspecimen and map scale are conspicuously lacking.

At all metamorphic grades, S_1 is defined by the parallel orientation of micaceous minerals. It is tightly folded by second-phase crenulations making it extremely difficult to see in the field except under ideal conditions. S_1 is almost everywhere aligned sub-parallel to bedding and the sense of vergence of S_1 with respect to bedding is unknown.

The Shootamook Anticline, located east of Shootamook Creek (Figs. 1A and 1C), is the only map-scale D_1 structure defined in the area. It is a tight to isoclinal fold with an axial surface which is observed to dip to the west at shallow structural levels and to the east at intermediate structural levels and is constrained to dip to the west at deeper structural levels (Fig. 1C). The change in orientation of its axial surface is due to D_2 back-folding and it is therefore considered to be a D_1 structure. However, due to poor exposure, it has not been possible to document a congruent change in the relationship between bedding and S_1 around the hinge of the Shootamook Anticline, thereby establishing unambiguously that it is a D_1 structure.

The closure of the companion syncline to the Shootamook Anticline is defined by the Espee Formation south of the east-west trending portion of Shootamook Creek (Fig. 1C). Here, in contrast to the tight to isoclinal profile of the Shootamook Anticline, the syncline is an open fold. The difference in geometry is attributed to the tendency of superposed backfolding to unfold suitably oriented early structures.

The age of D_1 deformation is not known. The location of the Shootamook Anticline in the immediate footwall of the thrust fault contact with Slide Mountain terrane is suggestive of a relationship between this structure and the emplacement of Slide Mountain terrane. If so, D_1 deformation would be early middle Jurassic in age (see summary in Monger, 1984).

Second-phase structures (D_2)

The most prominent structures in Cassiar terrane formed during the second phase of deformation. These include map-scale and smaller folds, a ubiquitous foliation (S_2), and a lineation defined by the intersection of S_2 with bedding (L_{0x2}). In contrast to the eastward to northeastward vergence of D_1 deformation, the overall vergence of second-phase deformation is to the west or southwest as reflected in the asymmetry of major and minor folds and the relationship of S_2 to bedding on long upright limbs of major folds.

S_2 is defined by the axial surfaces of tight to isoclinal folds of S_1 and dark seams of opaque (organic?) material inferred to be stylolitic solution cleavages (Fig. 14B). Metamorphic minerals define S_2 only when S_1 is completely transposed into S_2 by isoclinal folding (Fig. 18).

The relationship between S_2 and the most common folds is evident in their geometry. S_2 is axial planar to these folds, changing its relationship to bedding congruently around their hinges (Fig. 14). In addition, L_{0x2} is sub-parallel to their hinges. These data establish that S_2 formed synkinematically with these folds.

Two map-scale westwardly verging D_2 anticline-syncline pairs are known. The Buttes Anticline and Sayyea Syncline are in the northeastern corner of Gravel Creek map-area (Fig. 1B). In Irvine Lake map-area, the axial surface of the Shootamook Anticline is folded by the Gravel Creek anticline-syncline pair (Figs. 1A, 1C). The Gravel Creek syncline is well exposed at the northern end of the Marker Lake batholith, near the divide between the Gravel Creek drainage and a small valley flowing westwardly into Irvine Creek (Fig. 15).

The absolute age of D_2 deformation is not known. D_2 structures deform early middle Jurassic? D_1 structures and are cross-cut by the unfoliated late Early Cretaceous Marker Lake batholith and Cabin and Gravel creek stocks. As such, westwardly verging D_2 deformation in this area is post-early middle Jurassic and pre-late Early Cretaceous.

Figure 14a: West verging relationship between gently dipping upright bedding and S_2, Espee Formation north of Cabin Creek. View is to the north.

Figure 14b: Symmetrical to east verging relationship between steeply dipping to overturned bedding and S_2, Espee Formation northeast corner of Gravel Creek map-area. View is to the north.

Figure 15: Southwardly closing, near-recumbent D_2 fold of Swannell Formation grit (Hswg) and mixed clastic and carbonate members (Hswc) at the north end of Marker Lake batholith, Irvine Lake map-area.

Deformation associated with pluton intrusion

Intrusion of the large granitic plutons had a profound effect on the orientation of bedding and previously formed structures. Bedding and S_2 both dip radially away from Marker Lake batholith (see Appendix 1 for compilation of structural data). A local arch of bedding and S_2 between the Gravel Creek stock and the Marker Lake batholith implies a possible subsurface connection between them. In Irvine Lake map-area, D_1 and D_2 structures change from a north-south trend into an east-west orientation near the contact of the Marker Lake batholith. The prominent east-northeast-trending fault north of the Marker Lake batholith may have formed as a brittle response to the intrusion of the pluton.

Third phase structures (D_3)

Third phase structures range from map-scale open folds of D_2 and earlier structures to cm-scale crenulations of S_2. Map-scale structures are most prominent in Gravel Creek map-area (Fig. 1B). In its northeastern corner, the western limb of the D_2 Sayyea Syncline is re-oriented from a northeast-striking, northwest-dipping orientation into a north-striking, east-dipping orientation. As S_2 is also re-oriented similarly and the orientation of axial surfaces of D_3 crenulations remain the same (see Appendix 1 for a compilation of structural data), this deformation is ascribed to D_3 deformation.

Map-scale third phase folds are too open to accurately measure the orientation of their hinges. Outcrop- and cm-scale D_3 structures are generally oriented north-northwestwardly (Appendix 1). This orientation agrees well with the pole to the great circle girdle of poles to S_2.

Third phase folds fold unfoliated pegmatites which are inferred to be the latest stage of the intrusion of the Marker Lake batholith and Cabin Creek stock; as such third phase structures are post-late Early Cretaceous in age.

Faulting in the Cassiar terrane

The Cassiar terrane is traversed by a number of small displacement faults. Map-scale faults trend northwestwardly to eastwardly with a larger number of faults oriented east-northeastwardly (Fig. 16). No map-scale faults were observed in outcrop so it has not been possible to determine their actual displacement vectors; many show normal stratigraphic offsets, however.

The density of faults is much higher in the eastern side of Gravel Creek map-area. This eastward increase in fault density implies proximity to a larger scale

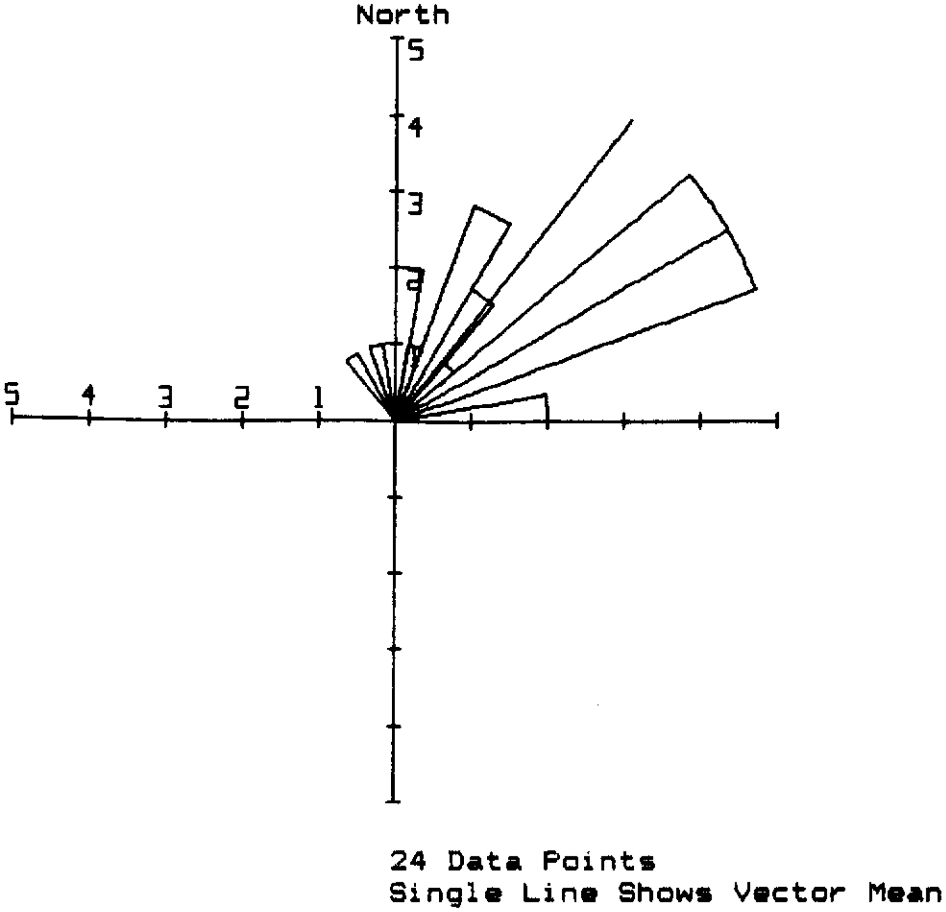


Figure 16: Rose diagram summarizing the strikes of map-scale high-angle faults in eastern Gravel Creek map-area

feature. The Tintina/Northern Rocky Mountain Trench fault lies in the valley of the Liard River immediately to the east of Gravel Creek map-area and the eastward increase in the density of faults in Gravel Creek map-area may reflect its presence. Such a relationship has been proposed by Abbott (1984) to explain the geometry of faults in the Rancheria district.

Structural geometry of Slide Mountain terrane

Structural analysis of Slide Mountain terrane is inhibited by poor exposure. Contacts between lithologic units are not exposed, so it is not known if they are faulted or conformable. Some structural data has been collected from fragmentary exposures of Slide Mountain meta-sediments but an amount insufficient for a rigorous analysis. Most structural data comes from the better exposed meta-volcanic and serpentinite units south of Irvine Creek.

Basaltic meta-volcanics and serpentinite south of Irvine Creek exhibit a pronounced foliation, S_p, and locally a lineation, L_p. In serpentinite, S_p is defined by parallel alignment of flattened and elongate serpentinite fibres and platelets. The long axes of serpentine fibres show a range of orientations, reflecting the complexity of strain in the serpentinite layer, and also possibly post-kinematic recrystallization. In meta-basalt, S_p is defined by flattened feldspar-rich layers and lenses; L_p is weakly defined by rodding within these layers.

The orientation of S_p varies systematically (Fig. 1A; Appendix 1). In the eastern exposures, S_p is approximately sub-parallel to the basal thrust contact of the Slide Mountain terrane with the Cassiar terrane. In the west, near the Cassiar? fault, S_p has a steep to near-vertical orientation, sub-parallel to the trace of Cassiar? fault.

The variations in orientation of S_p with proximity to structures of different ages imply contributions to the total strain at different times. The parallelism of S_p with the basal fault of Slide Mountain terrane implies that some of the strain implicit in S_p can be attributed to the early middle Jurassic emplacement of Slide Mountain terrane onto Cassiar terrane. However, because foliated xenoliths of basaltic meta-volcanic are contained within unfoliated plutonic rocks believed to be part of the allochthon (and therefore intruded before emplacement of the allochthon), some of the strain must have occurred before emplacement of the allochthon. The parallelism of S_p with the Cassiar? fault implies that S_p has been re-oriented again by strain associated with post-late Early Cretaceous displacement across the fault.

Zak fault

The Zak fault is the terrane boundary between the Slide Mountain and Cassiar terranes. It is a west-dipping fault zone characterized by an up-to-50 m-thick zone of foliated serpentinite and serpentinite-matrix breccia (composed mainly of footwall lithologies) in Slide Mountain terrane and a thin zone of mylonitic rocks of the Cassiar terrane footwall. It has been traced almost continuously from the southern boundary of Irvine Lake map-area to Irvine Creek and is inferred to continue northward to the northern boundary of the map-area (Fig. 1A).

Kinematic indicators were observed at one location in the zone of mylonitic footwall. In this location, mylonitic quartzite of Tsaydiz Formation displays a prominent E-W trending quartz rodding and S-C fabrics (Berthe' *et al.*, 1979) indicating thrust movement to the east.

Cassiar? fault

Cassiar? fault is a steep, northwest-trending zone of foliated granitic rocks and chlorite schist separating meta-volcanic and plutonic rocks of the Slide Mountain terrane from the weakly foliated to unfoliated granitic rocks of Cassiar batholith. The zone has been observed for approximately 5 km from just south of Irvine Creek to an unnamed linear valley draining northwardly into Irvine Creek. The continuation of the fault to the southeast is somewhat speculative but it appears to be continuous with a topographic lineament which intersects the Cassiar fault at Carlick Creek south of the Alaska Highway, hence its correlation.

Kinematic indicators are well displayed in outcrops of a mylonitic carbonate xenolith in the Cassiar batholith just south of Irvine Creek. These outcrops are dominated by a pronounced sub-vertical foliation and a gently to moderately plunging lineation. Careful examination of the fabric exposed in the horizontal plane (XZ kinematic plane) reveals a set of shear bands (Berthe' *et al.*, 1979) and S-C fabrics (Fig. 17). The sense of inclination of S and C surfaces and the direction of dip of shear bands indicate a dextral sense of displacement across the mylonite zone. The sense of inclination of S and C fabrics at outcrop scale is reflected at a larger scale by the systematic counterclockwise sense of inclination of foliations in Cassiar batholith to the trace of the Cassiar? fault (Fig. 1A).

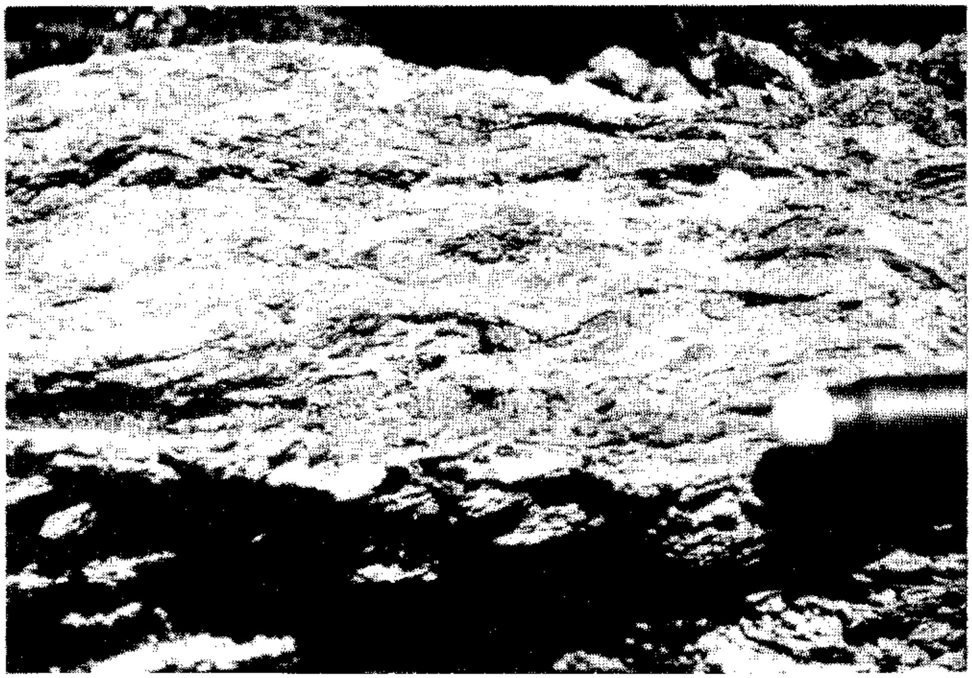


Figure 17: Calc-mylonite along Cassiar? fault. S-C fabrics and shear band geometry (Berthe' *et al*, 1979) prove dextral displacement on Cassiar? fault. View is vertically downward, onto plane which is perpendicular to mylonitic foliation and containing mylonitic lineation (XZ kinematic plane). South of Irvine Creek, Irvine Lake map-area.

METAMORPHISM

Rocks in Gravel Creek and Irvine Lake map-areas exhibit variations in metamorphic grade which reflect the variable influences of regional dynamothermal metamorphism and contact metamorphism. In general, rocks of all ages in Cassiar terrane are sub-greenschist facies except near the Marker Lake batholith where sillimanite grade is reached. In the Slide Mountain terrane, mafic meta-volcanic rocks are greenschist facies chlorite-actinolite schists and ultramafic rocks are pervasively serpentinized.

Cassiar terrane

Forty five thin sections of pelitic rocks from Cassiar terrane were analyzed petrographically by P. Carmichael. This study has confirmed the sequence of structural events deduced from outcrop observations (Chapter 3), determined that S_1 and S_2 are defined by low-grade minerals (muscovite and chlorite), and determined that higher-grade minerals are superimposed at random over S_2.

Figs. 18A and B are thin-section photomicrographs illustrating typical features of Cassiar terrane pelites. The earliest structural fabric, S_1, is defined by muscovite; S_2 is defined by the axial surfaces of tight crenulations of S_1. Higher-grade minerals such as biotite, garnet, andalusite, and sillimanite are randomly superimposed over S_2 and are locally deformed by D_3 strain.

Fig. 19 is a map of the distribution of metamorphic minerals in pelitic rocks of the Cassiar terrane. Metamorphic mineral are concentrically zoned around the Marker Lake batholith with the highest-grade minerals (sillimanite and andalusite) closest to the batholith and a progressive decrease in grade radially away from the batholith. This pattern implies that the intrusion of the Marker Lake batholith introduced the heat responsible for growth of the younger higher-grade minerals.

Slide Mountain terrane

The distribution of metamorphic minerals in the Slide Mountain terrane is not well known. Pelitic meta-sediments are rare; where observed, muscovite and chlorite are the highest-grade minerals. Hand-specimen examination of mafic meta-volcanic rocks reveals the ubiquitous assemblage chlorite-epidote-actinolite, again indicating greenschist facies conditions.

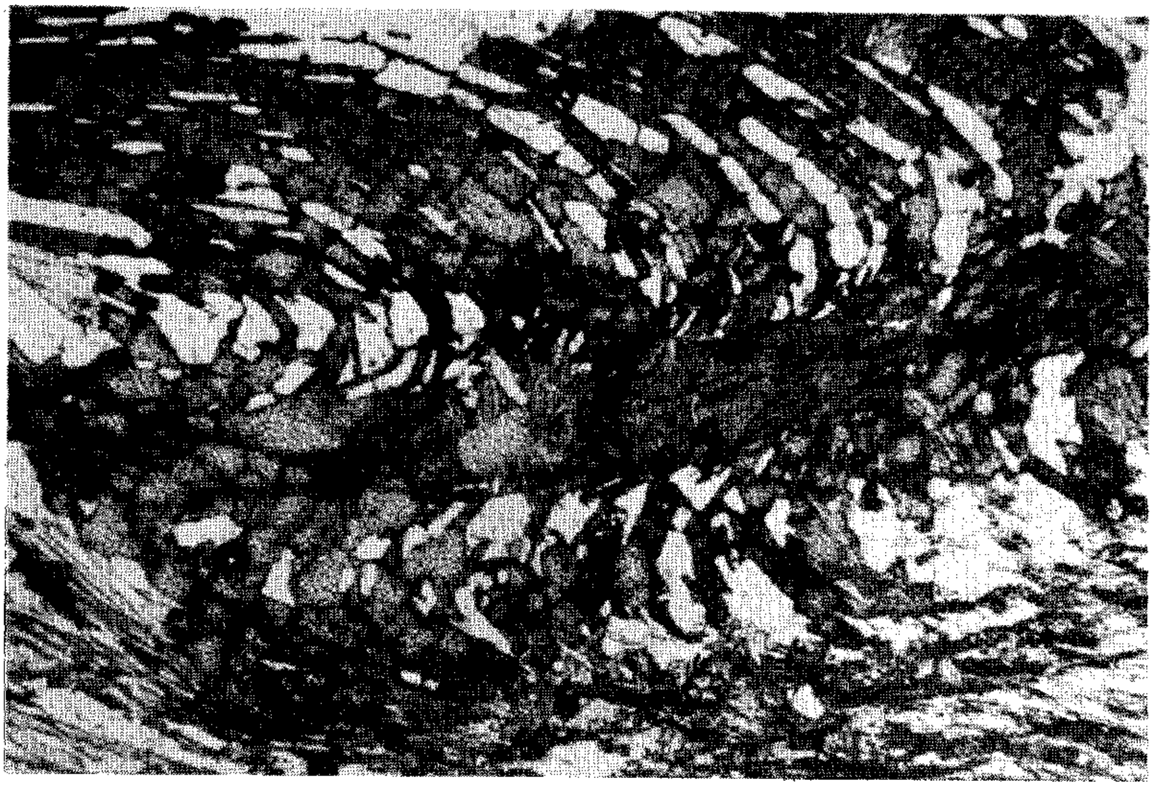


Figure 18a: Garnet porphyroblast superimposed over D_2 fold of S_1 outlined by elongate quartz grains. Growth of garnet therefore post-dates D_2 folding.

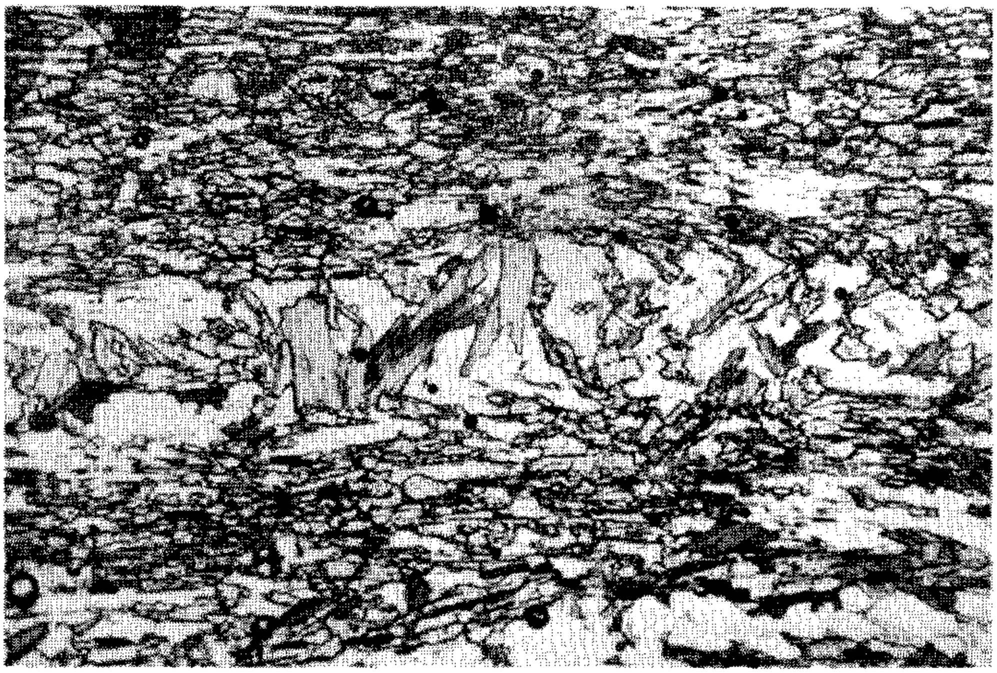


Figure 18b: Undeformed andalusite and biotite grains superimposed on tight D_2 fold of S_1, demonstrating post-D_2 growth of andalusite.

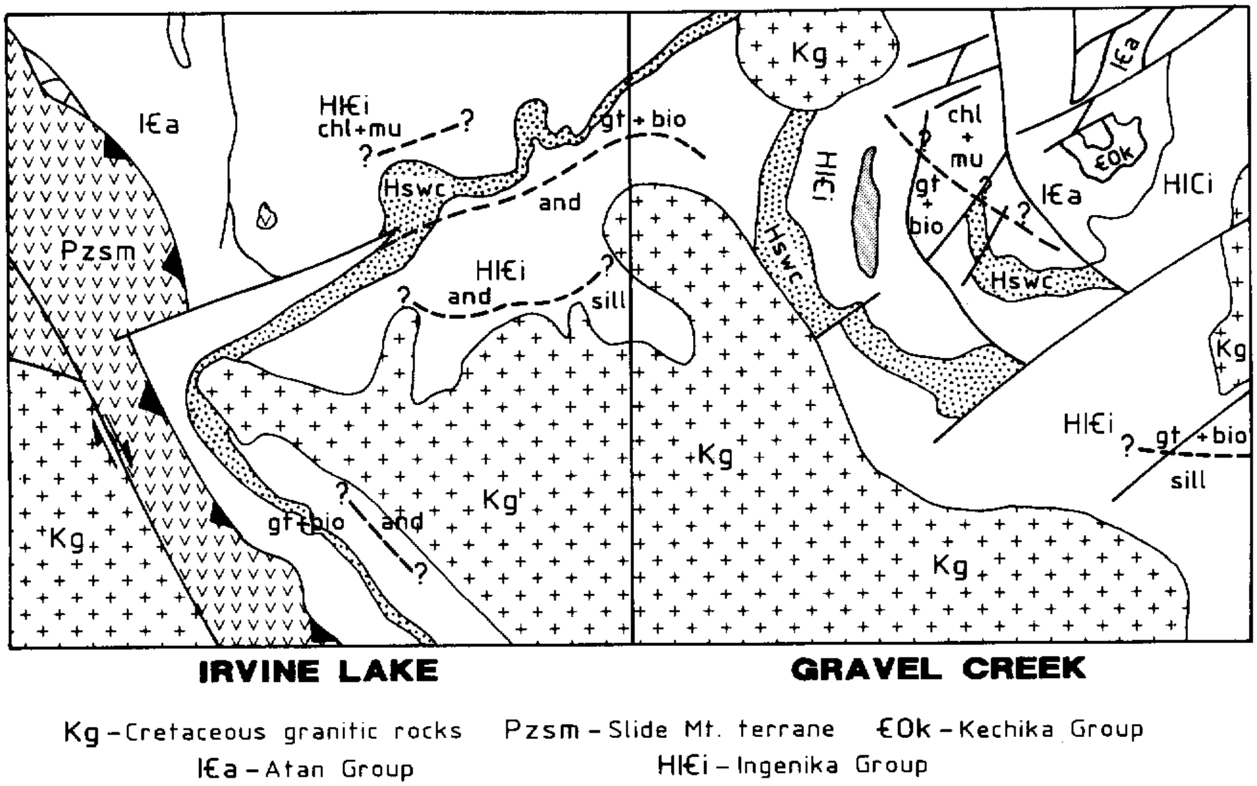


Figure 19: Distribution of metamorphic minerals from petitic rocks, Gravel Creek and Irvine Lake map-areas.

Cassiar batholith somewhere in 105B/6. (2) Many of the carbonate bodies that host mineralization in Gravel Creek and Irvine Lake map-areas are not Lower Cambrian Atan Group as previously thought but belong instead to upper Proterozoic Ingenika Group. The prominent Swannell Formation grit member marble, Hswgm, which hosts TUNG, SOURCE, IRVINE, and SILVER CREEK, is observed to trend out of Irvine Lake map-area to the southeast and will likely intersect the Cassiar batholith somewhere in 105B/6. (3) A major shear zone (Cassiar? fault) cuts across Cassiar batholith from the western boundary of Irvine Lake map-area southeastward into 105B/6 and likely continues into Cassiar fault near Carlick Creek south of the Alaska Highway. As numerous mineral occurrences are associated with shear zones, prospecting along this trend may be rewarding.

ECONOMIC GEOLOGY

Fourteen mineral occurrences are located in Gravel Creek and Irvine Lake map-areas (Figs. 1A and 1B). These include: 1) W ± Zn, Pb skarns (TUNG, TEAM, STONEAXE, SOURCE), (2) Ag ± Pb, Zn vein (BINGY (MN/AG), COM (?), SILVER CREEK), (3) Pb, Zn, Ag skarn (SILVER CREEK, CABIN), (4) porphyry Mo (THRALL), and (5) Cu in silicified and brecciated dolomite (ZAK). (Appendix 2 contains summaries of assessment reports from these occurrences.) This chapter places these occurrences in a geological context and suggests areas of mineral potential.

Figs. 1A and 1B clearly illustrate the controls on mineralization in many of the occurrences. TUNG, SOURCE, IRVINE, and SILVER CREEK are located in the immediate vicinity of the contact between Cabin Creek stock or Marker Lake batholith and the prominent marble unit (Hswgm) in the grit member of the Swannell Formation. TEAM (western occurrences) and CABIN are located near the contact between carbonates of Tsaydiz Formation and the Gravel Creek and Cabin Creek stocks, respectively. STONEAXE is located near the contact of a thin Swannell Formation grit member marble with the Gravel Creek stock. TEAM (eastern occurrences) is located in a fault-controlled breccia zone cutting Espee Formation marble. ZAK is located in dolomitic marble and quartzite of the Tsaydiz Formation near small (not mappable at 1:50,000) granitoid stocks. The relationship between carbonate rocks and granitic intrusions is evident.

The remaining mineral occurrences are in granitic rocks. THRALL is a qz-mo porphyry stockwork in granodiorite which intrudes diorite and greenstone of Slide Mountain terrane. MR and BINGY (MN/AG) are veins cutting granitic rocks and COM (54-59) covers boulders of massive galena and sphalerite in muscovite granite.

Suggestions for future prospecting

Three results of this study are important to prospectors. (1) Large areas of serpentinite and serpentinized ultramafic rocks which by analogy with other areas (Coveney, 1981) are potential candidates for gold mineralization. Serpentinite at the base of Slide Mountain terrane is locally altered, possibly providing the necessary conditions for mineralization. The Zak fault trends to the southeast out of Irvine Lake map-area; it and its associated serpentinite zone are likely to intersect the

Cassiar batholith somewhere in 105B/6. (2) Many of the carbonate bodies that host mineralization in Gravel Creek and Irvine Lake map-areas are not Lower Cambrian Atan Group as previously thought but belong instead to upper Proterozoic Ingenika Group. The prominent Swannell Formation grit member marble, Hswgm, which hosts TUNG, SOURCE, IRVINE, and SILVER CREEK, is observed to trend out of Irvine Lake map-area to the southeast and will likely intersect the Cassiar batholith somewhere in 105B/6. (3) A major shear zone (Cassiar? fault) cuts across Cassiar batholith from the western boundary of Irvine Lake map-area southeastward into 105B/6 and likely continues into Cassiar fault near Carlick Creek south of the Alaska Highway. As numerous mineral occurrences are associated with shear zones, prospecting along this trend may be rewarding.

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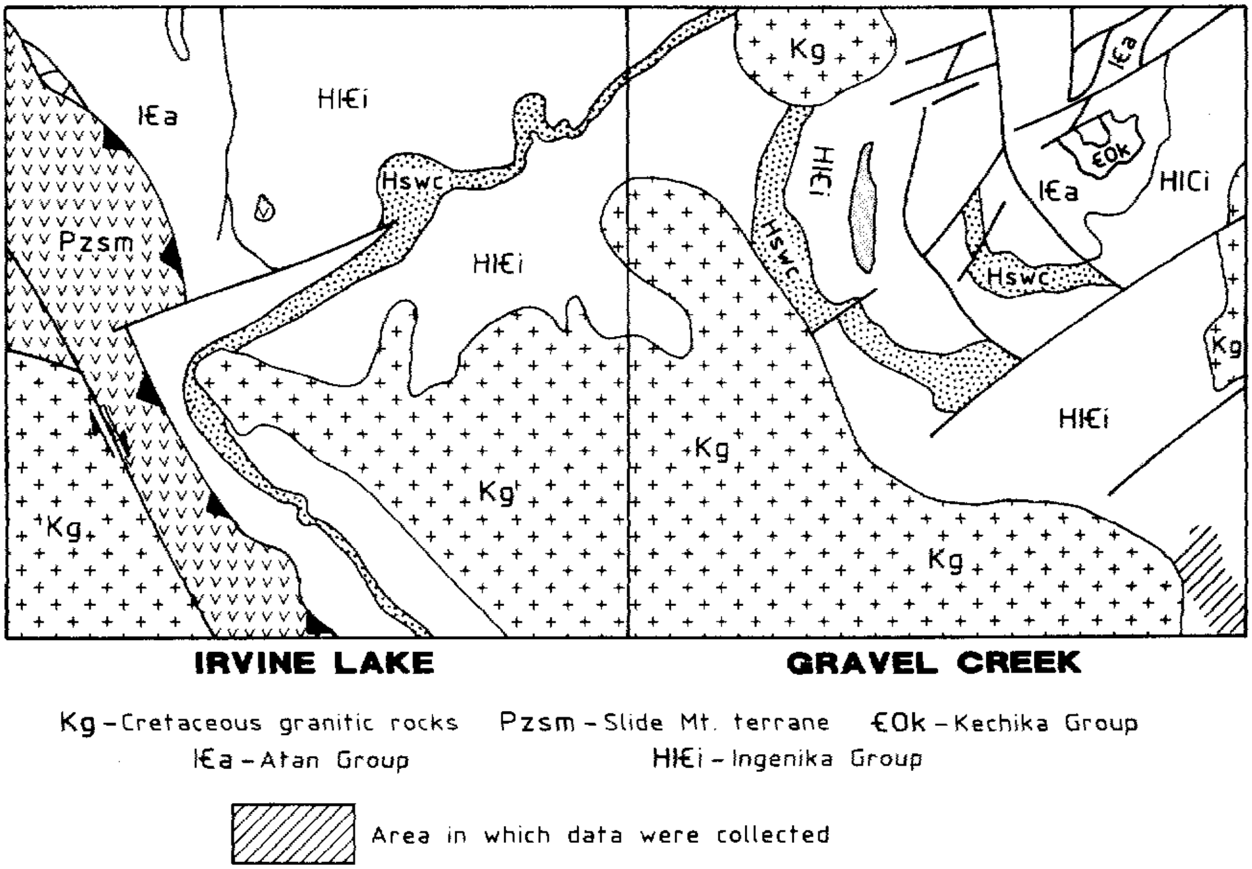
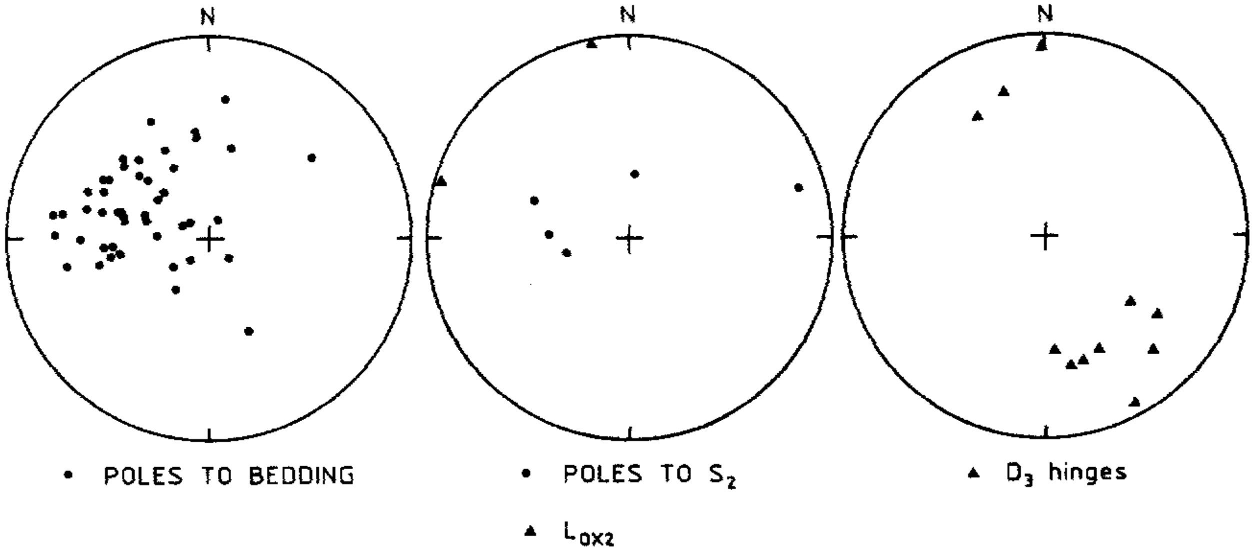
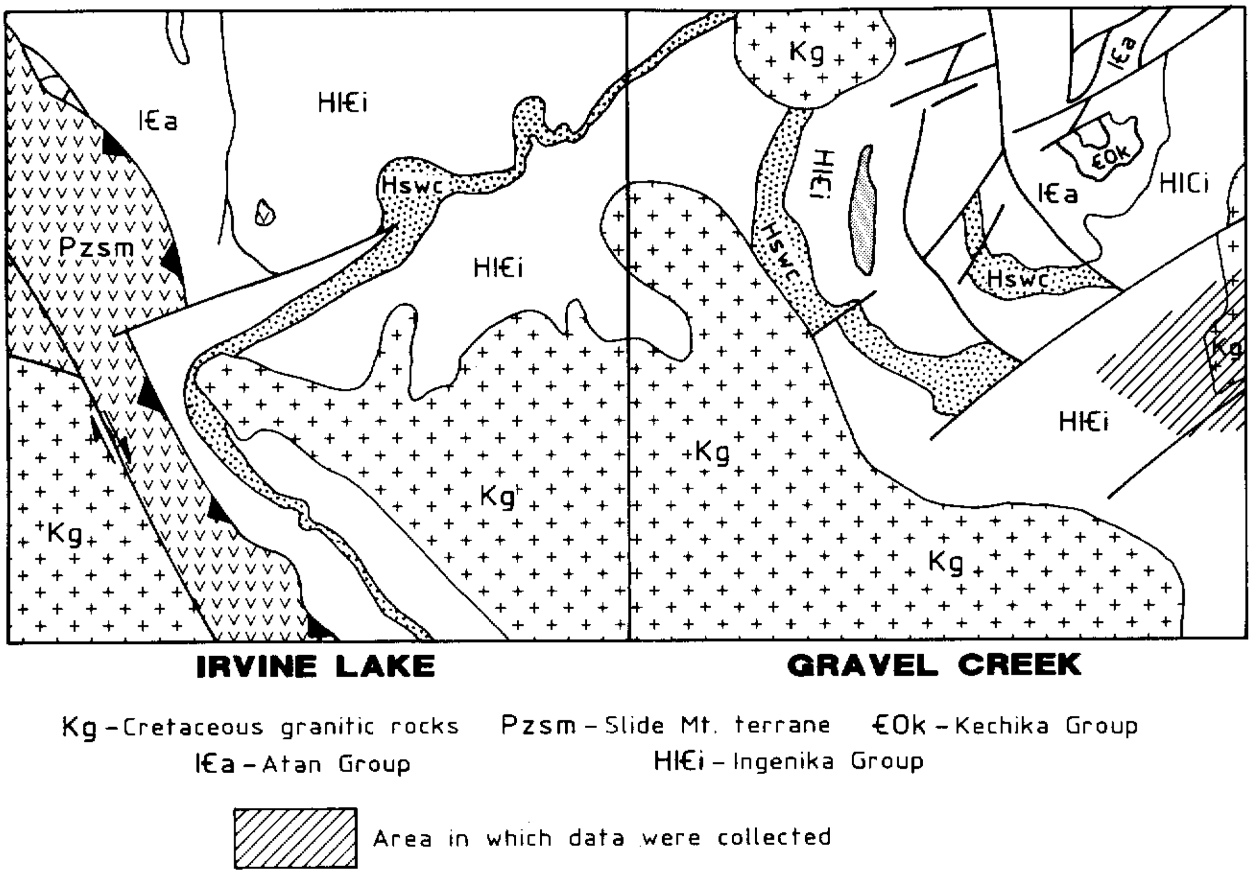
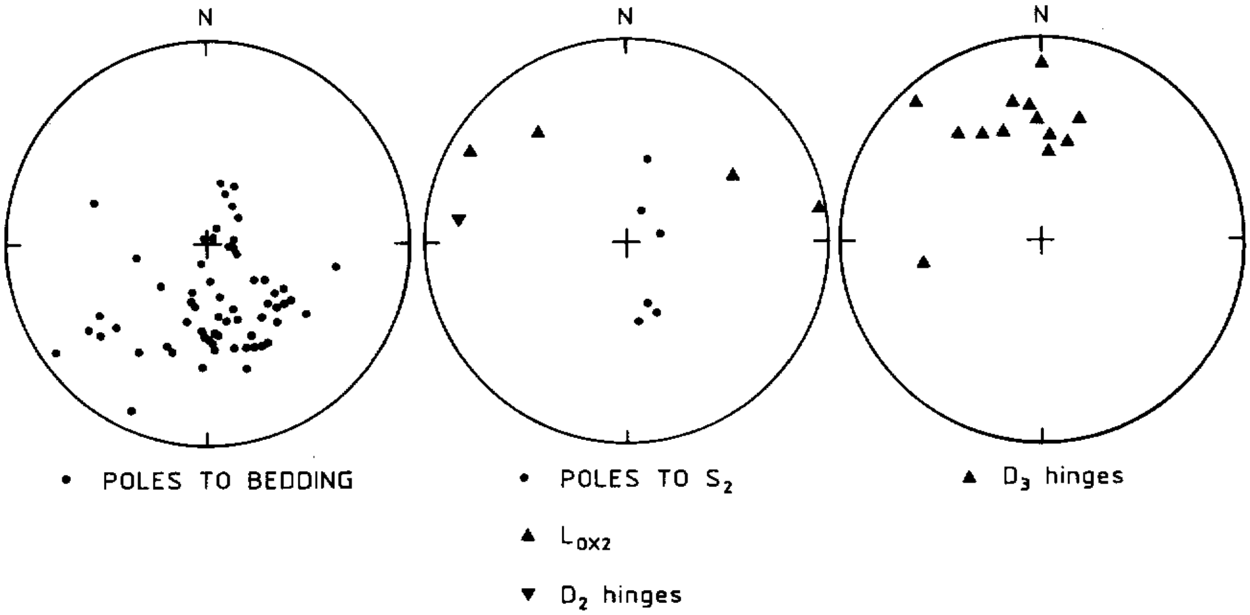
Appendix 1

COMPILATION OF STRUCTURAL DATA


lЄa
HlЄi
Hswc
Pzsm
Kg
ЄOk
HlCi
IRVINE LAKE
GRAVEL CREEK
Kg - Cretaceous granitic rocks
Pzsm - Slide Mt. terrane
ЄOk - Kechika Group
lЄa - Atan Group
HlЄi - Ingenika Group
Area in which data were collected


N
N
N
• POLES TO BEDDING
• POLES TO S₂
▲ L_ox2
▲ D₃ hinges


IЄa
HIЄi
Hswc
Pzsm
Kg
ЄOk
HICi
IRVINE LAKE
GRAVEL CREEK
Kg - Cretaceous granitic rocks
Pzsm - Slide Mt. terrane
ЄOk - Kechika Group
IЄa - Atan Group
HIЄi - Ingenika Group
▨ Area in which data were collected


N
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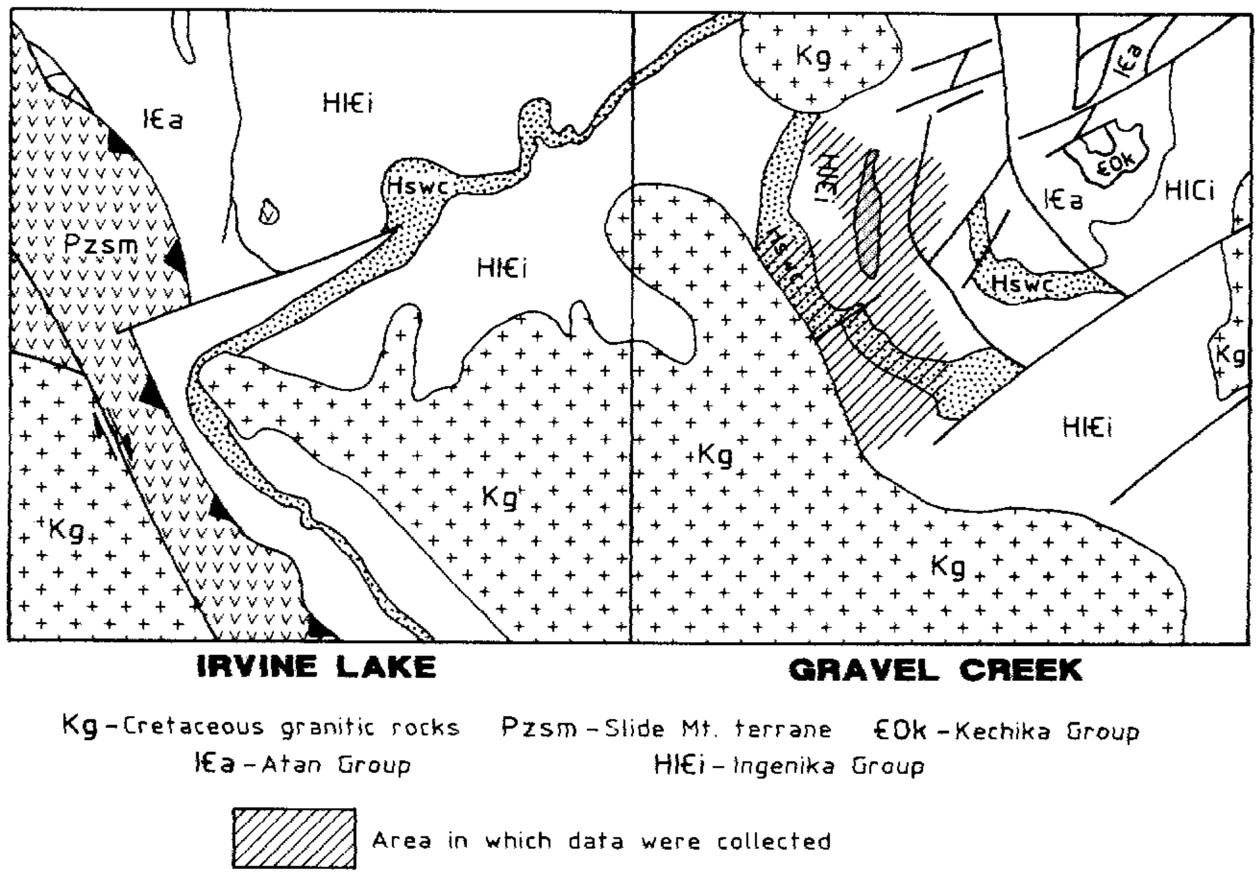
N
● POLES TO BEDDING
● POLES TO S2
▲ Lox2
▼ D2 hinges
▲ D3 hinges


IЄa
HIЄi
Hswc
Pzsm
Kg
ЄOk
HIЄi
IRVINE LAKE
GRAVEL CREEK
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Pzsm - Slide Mt. terrane
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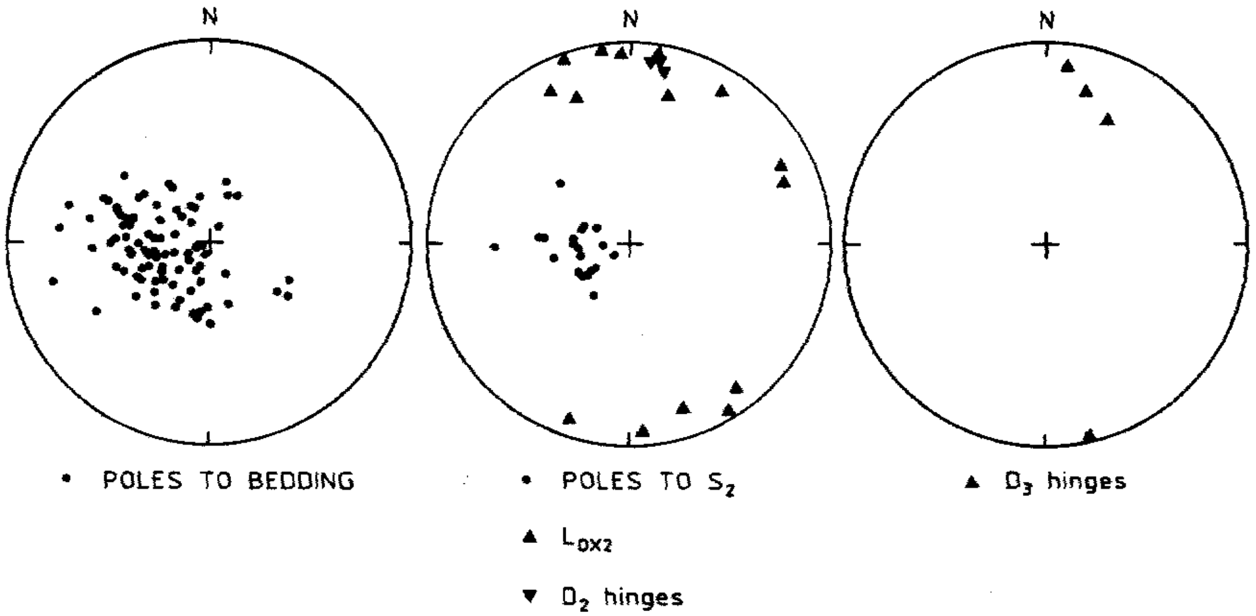
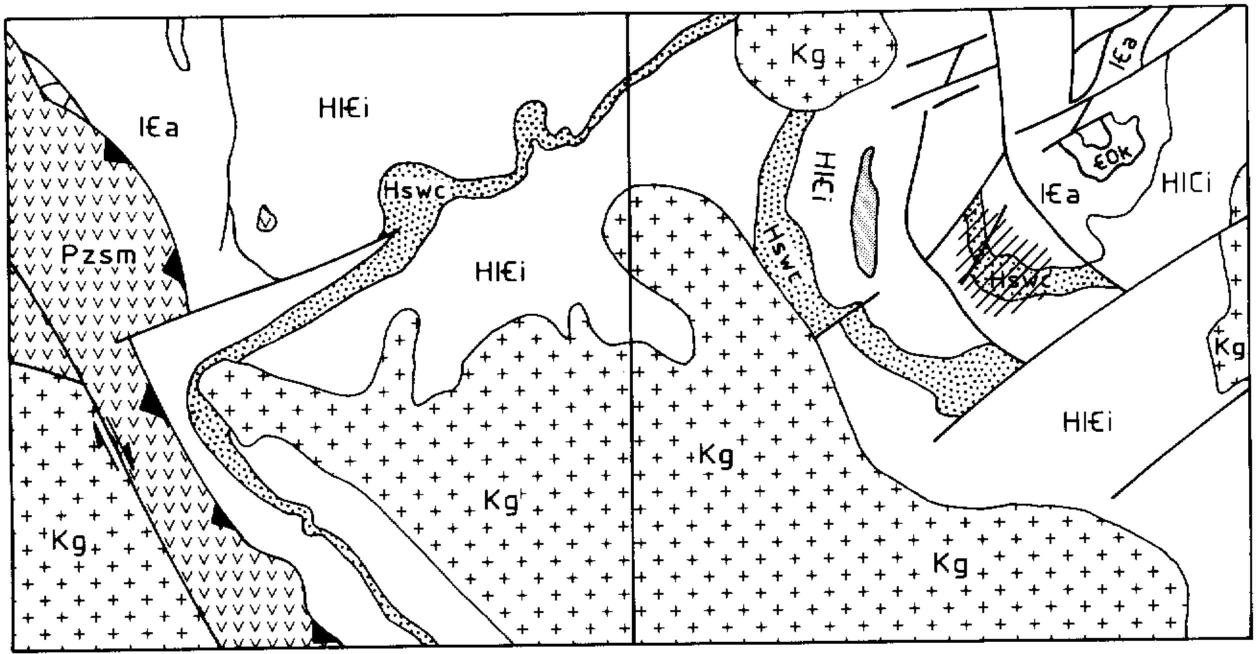

N
N
N
• POLES TO BEDDING
• POLES TO S_2
▲ L_{ox2}
▼ D_2 hinges
▲ D_3 hinges



IRVINE LAKE **GRAVEL CREEK**

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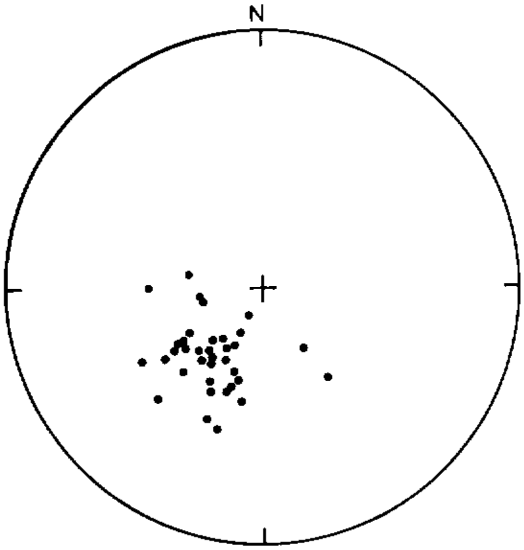
l€a - Atan Group Hl€i - Ingenika Group

▨ Area in which data were collected



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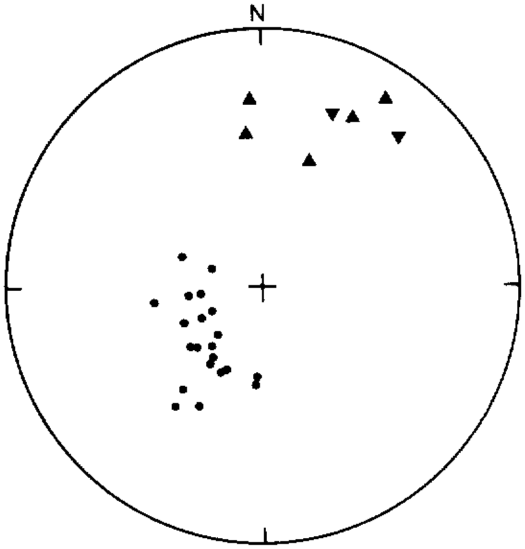

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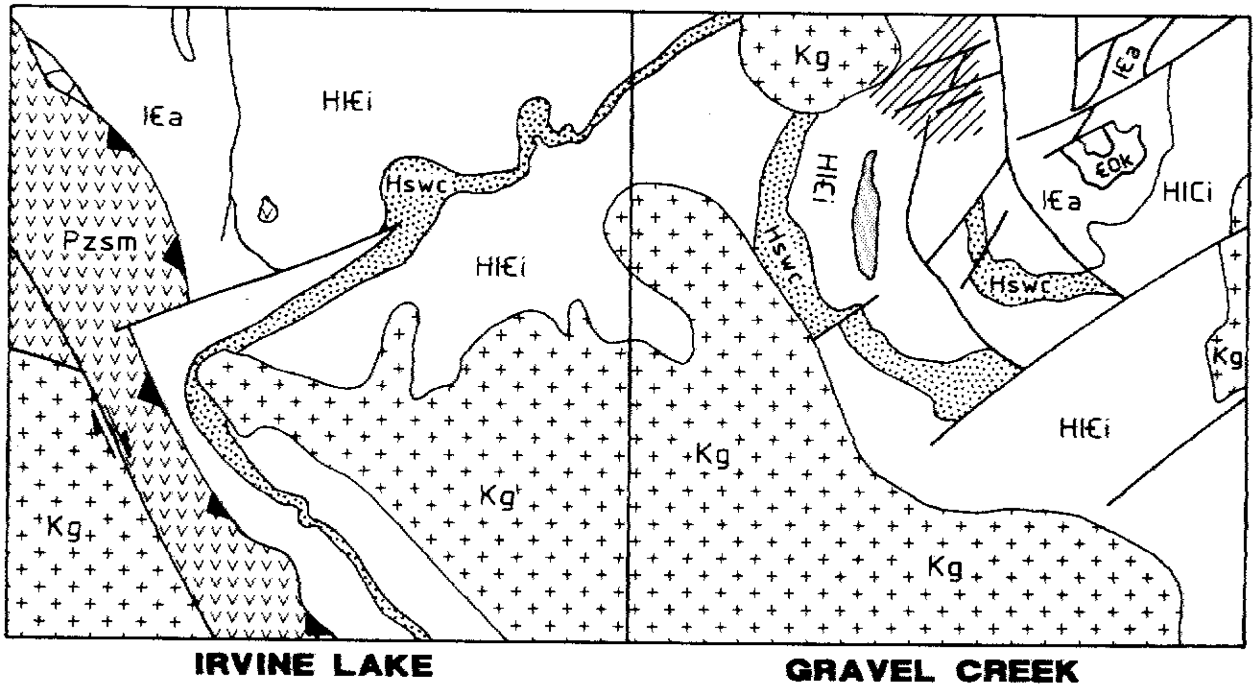
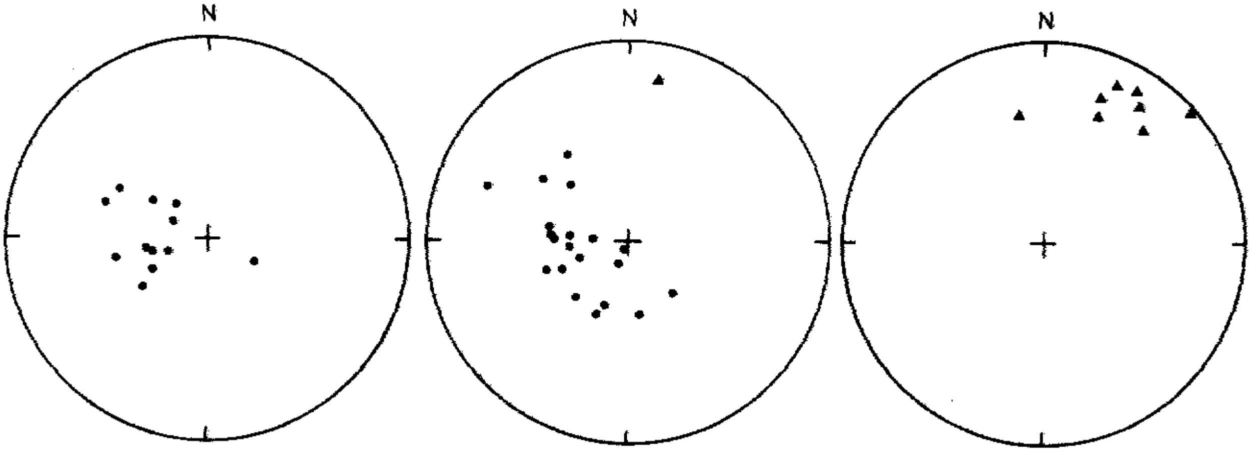
▲ L_{ox2}

▼ D_2 hinges



Kg - Cretaceous granitic rocks Pzsm - Slide Mt. terrane ЄOk - Kechika Group
IЄa - Atan Group HIЄi - Ingenika Group

▨ Area in which data were collected



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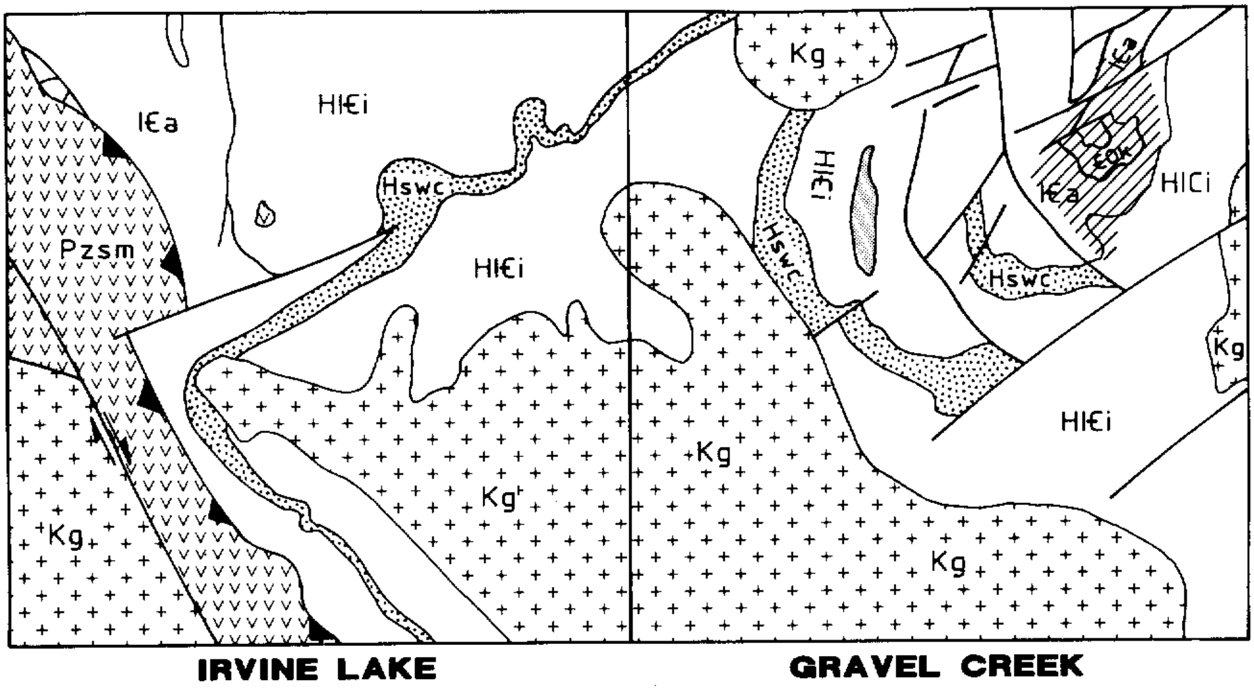
● POLES TO S_2
▲ L_{ox2}
▲ D_3 hinges



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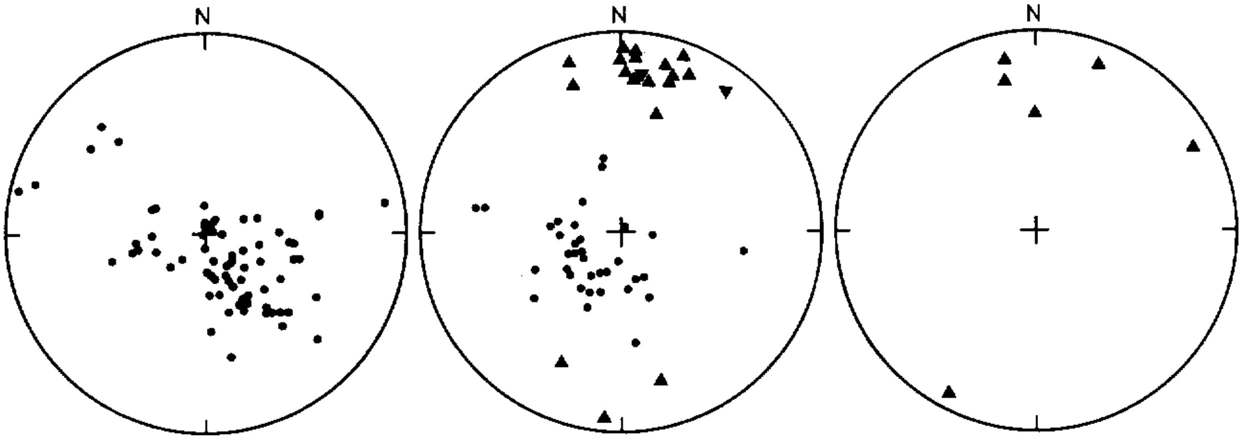
lЄa - Atan Group HlЄi - Ingenika Group

▨ Area in which data were collected



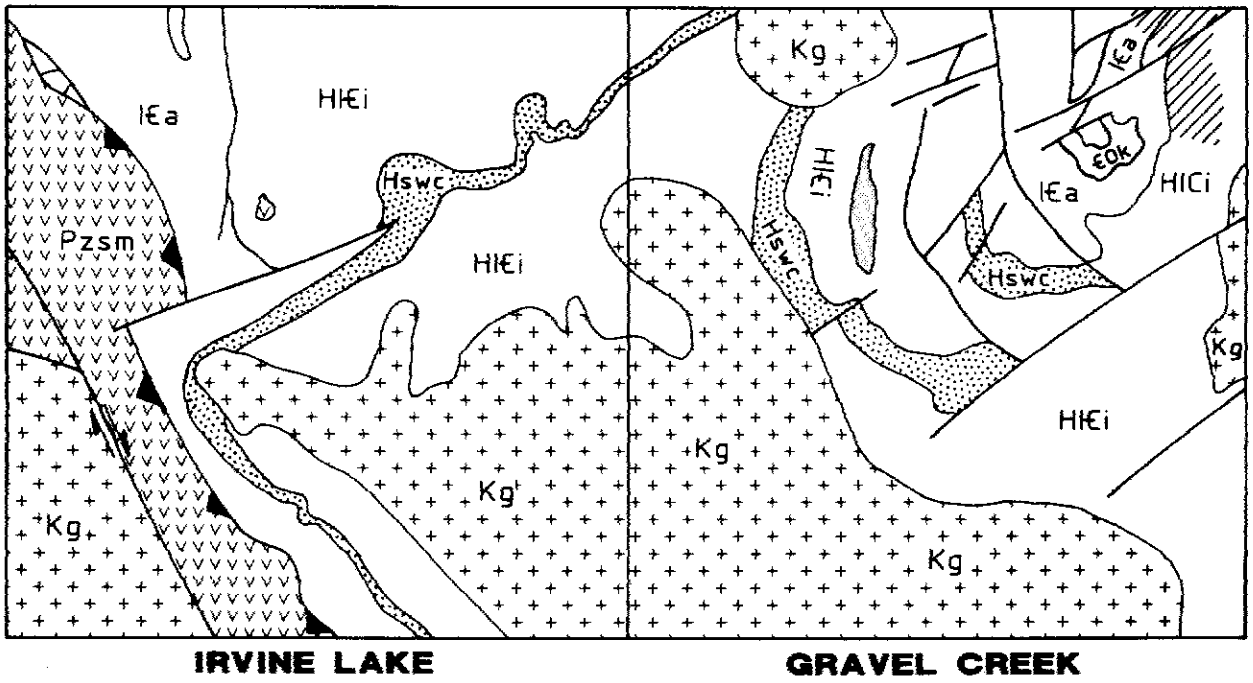
• POLES TO BEDDING

, • POLES TO S_2

▲ L_{ox2}

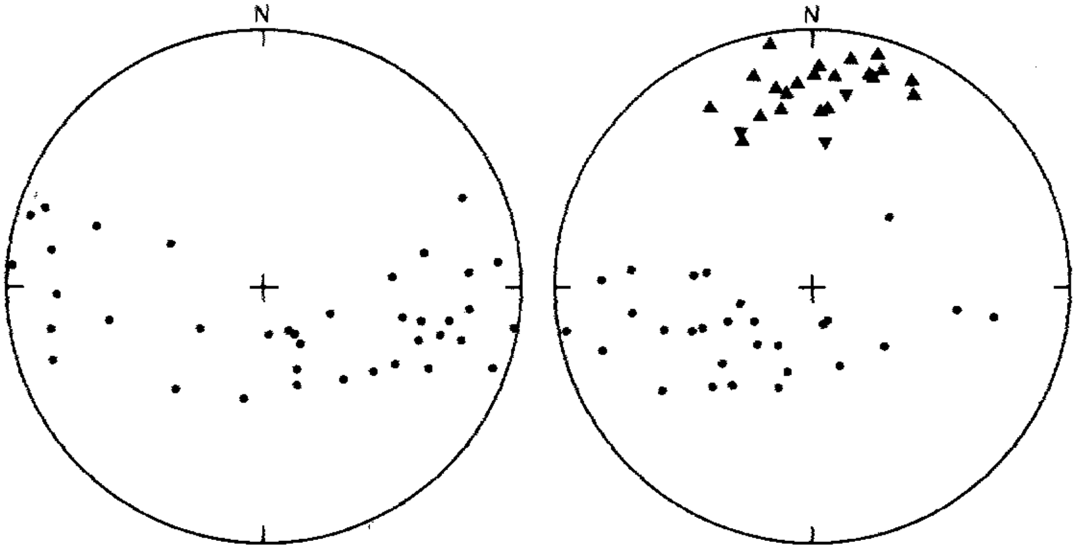
▼ D_2 hinges

▲ D_3 hinges



Kg - Cretaceous granitic rocks   Pzsm - Slide Mt. terrane   ЄOk - Kechika Group
IЄa - Atan Group   HIЄi - Ingenika Group

▨ Area in which data were collected



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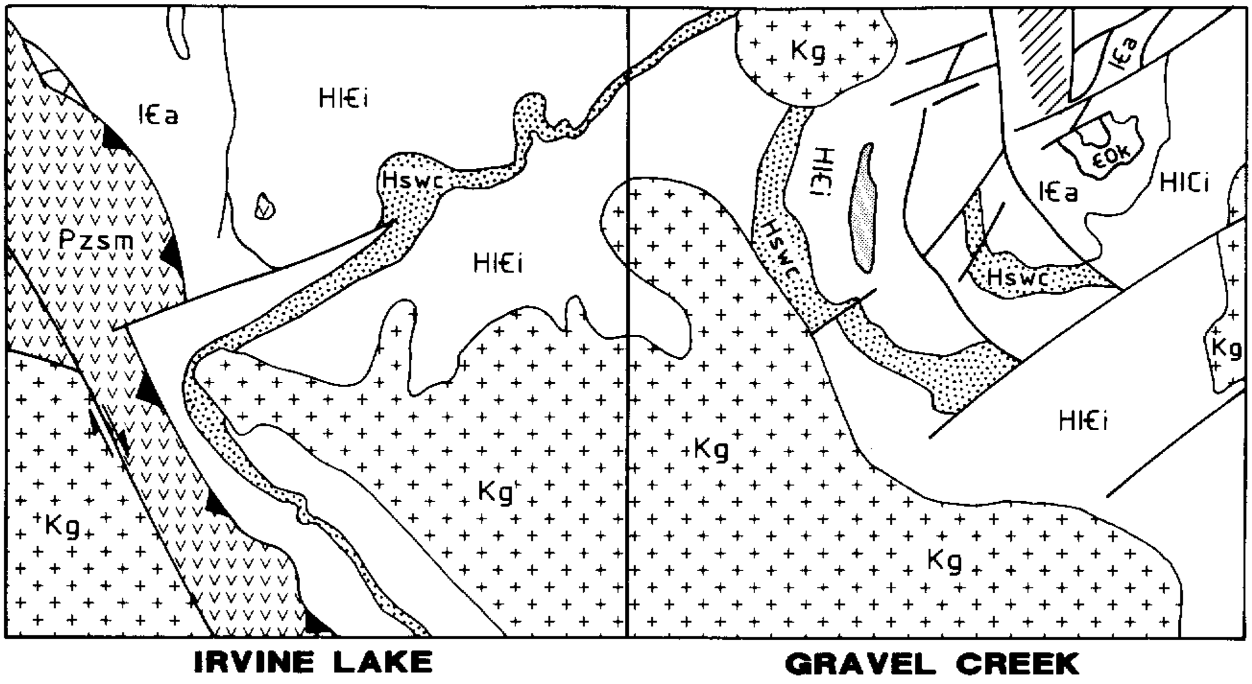
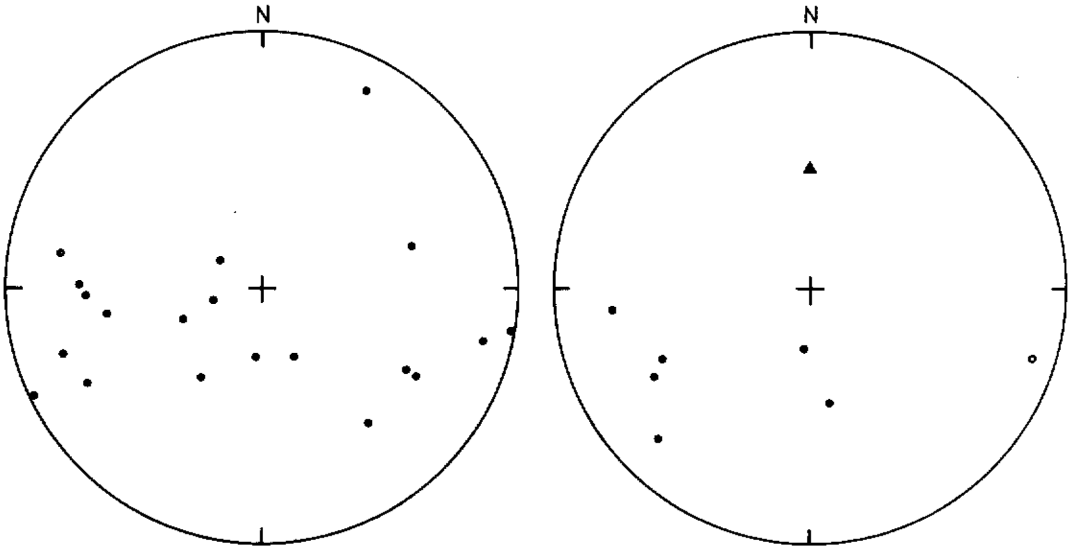
▼ D_2 hinges



Kg – Cretaceous granitic rocks Pzsm – Slide Mt. terrane ЄOk – Kechika Group

lЄa – Atan Group HlЄi – Ingenika Group

▨ Area in which data were collected



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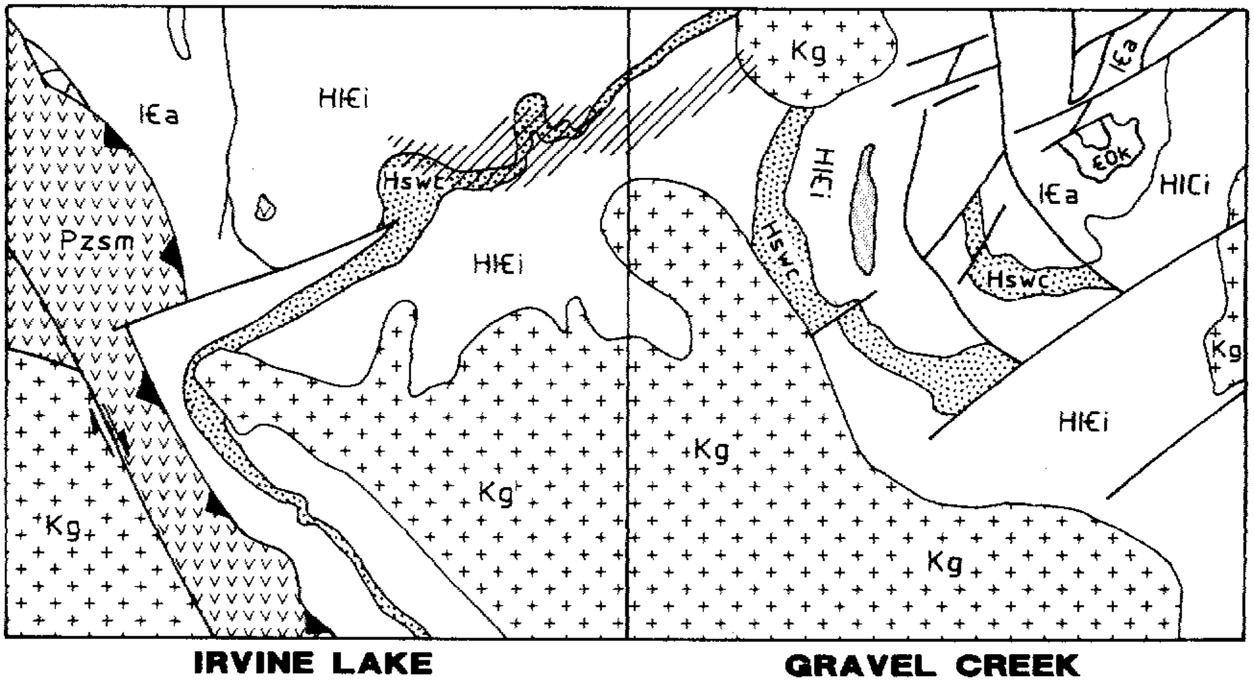
▲ L_{ox2}



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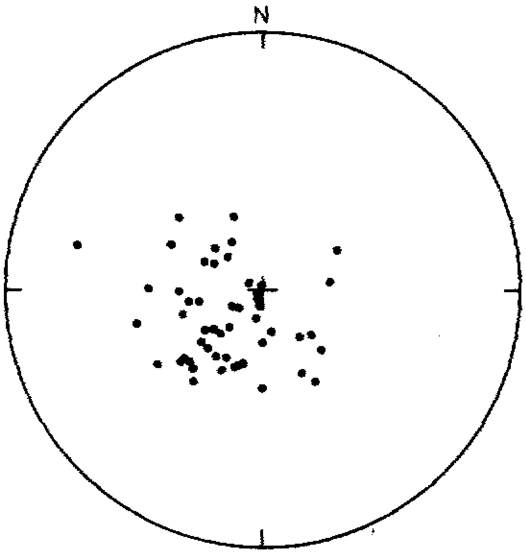
▨ Area in which data were collected



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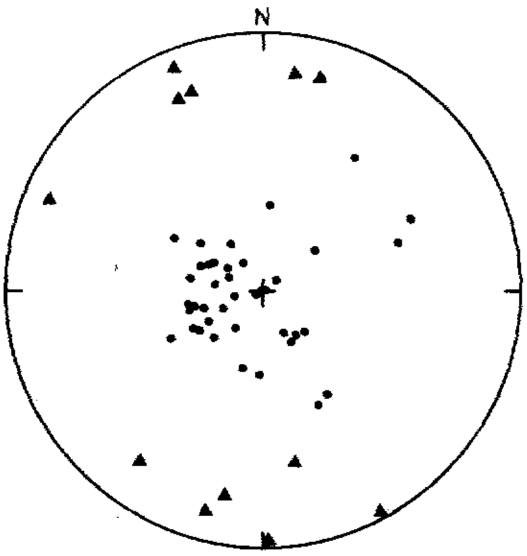

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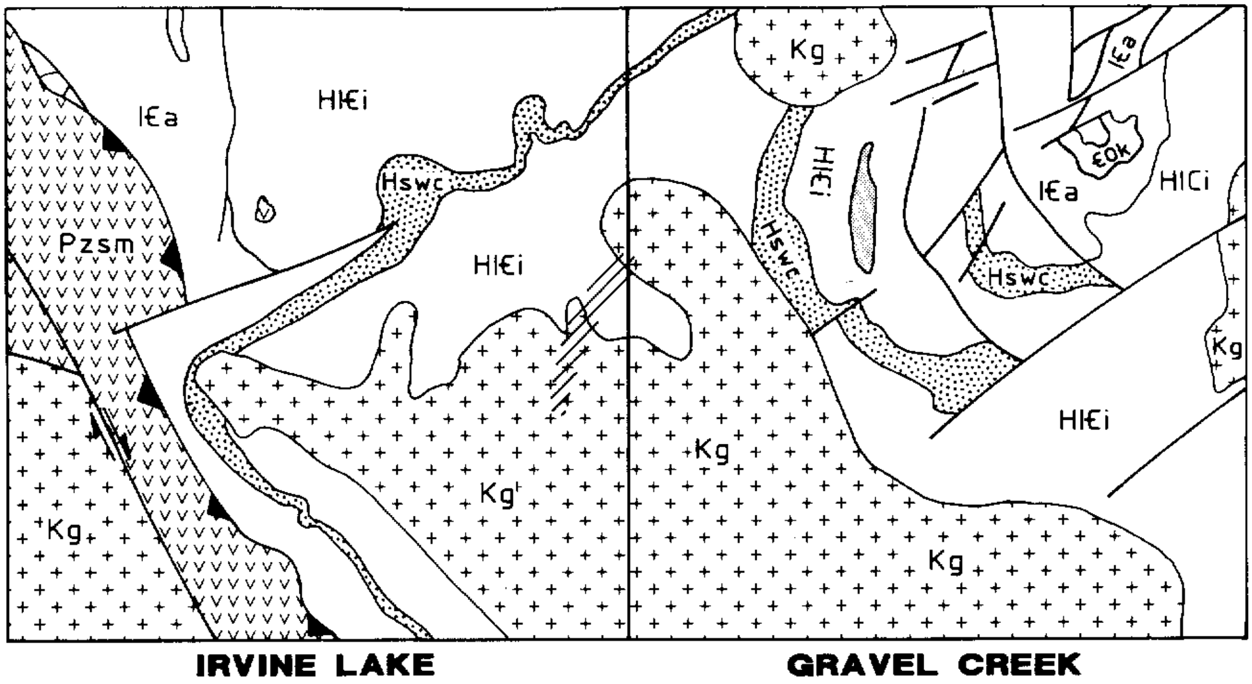
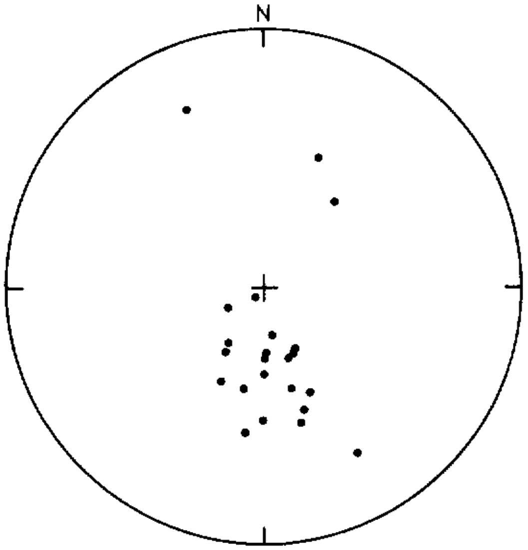
▲ L_{ox2}



Kg - Cretaceous granitic rocks   Pzsm - Slide Mt. terrane   ЄOk - Kechika Group
lЄa - Atan Group   HlЄi - Ingenika Group

▨ Area in which data were collected



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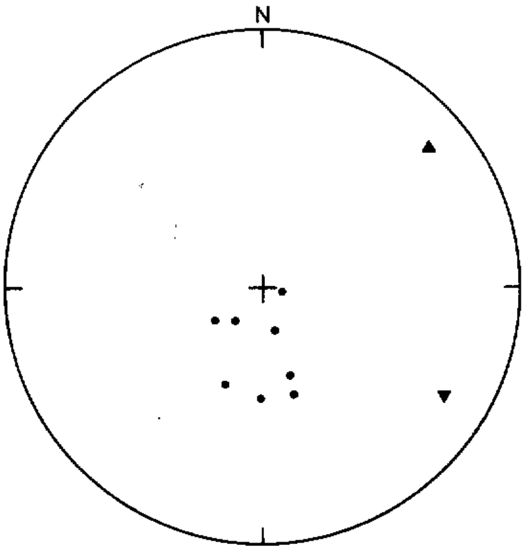

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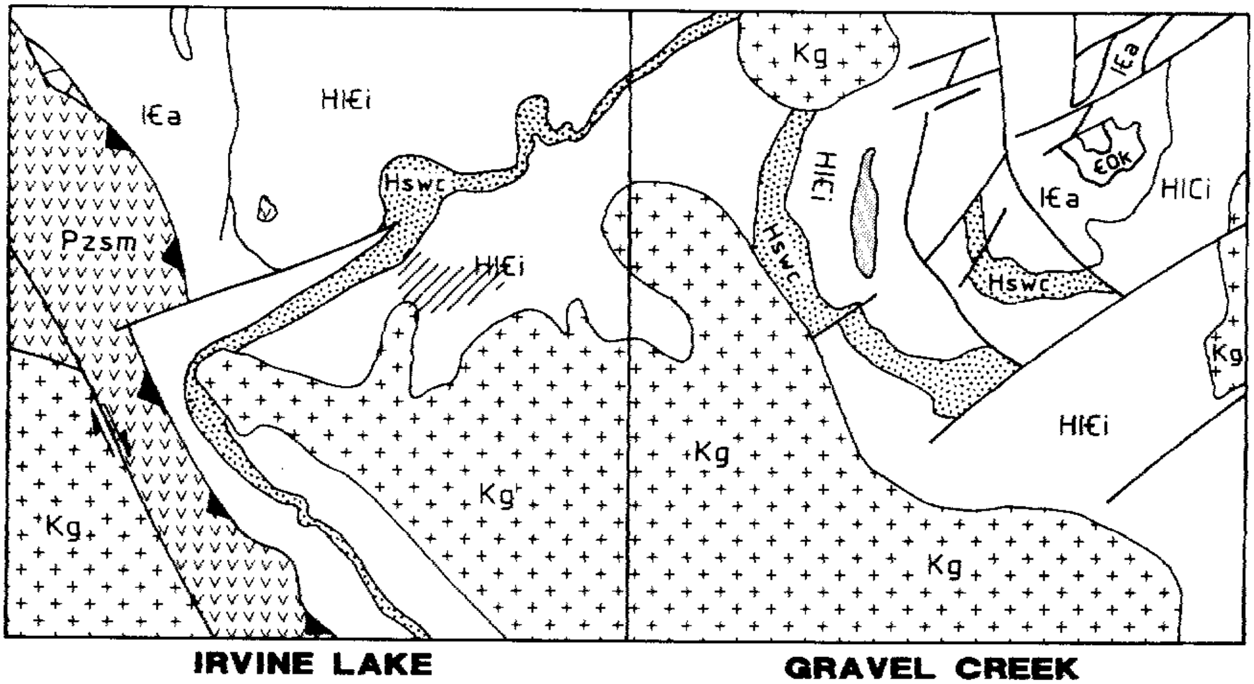
▲ L_{ox2}

▼ D_2 hinges



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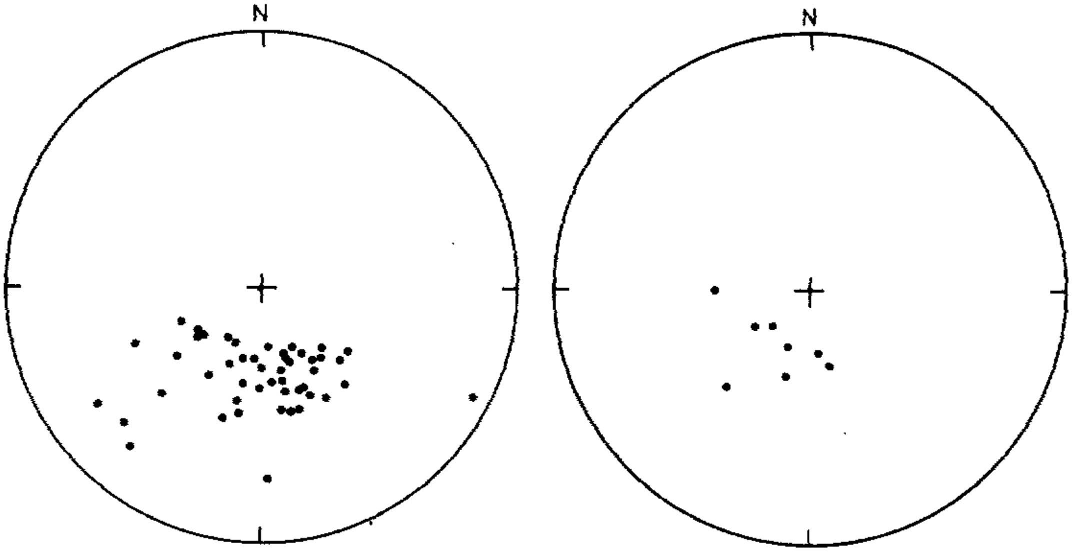
l€a - Atan Group Hl€i - Ingenika Group

▨ Area in which data were collected



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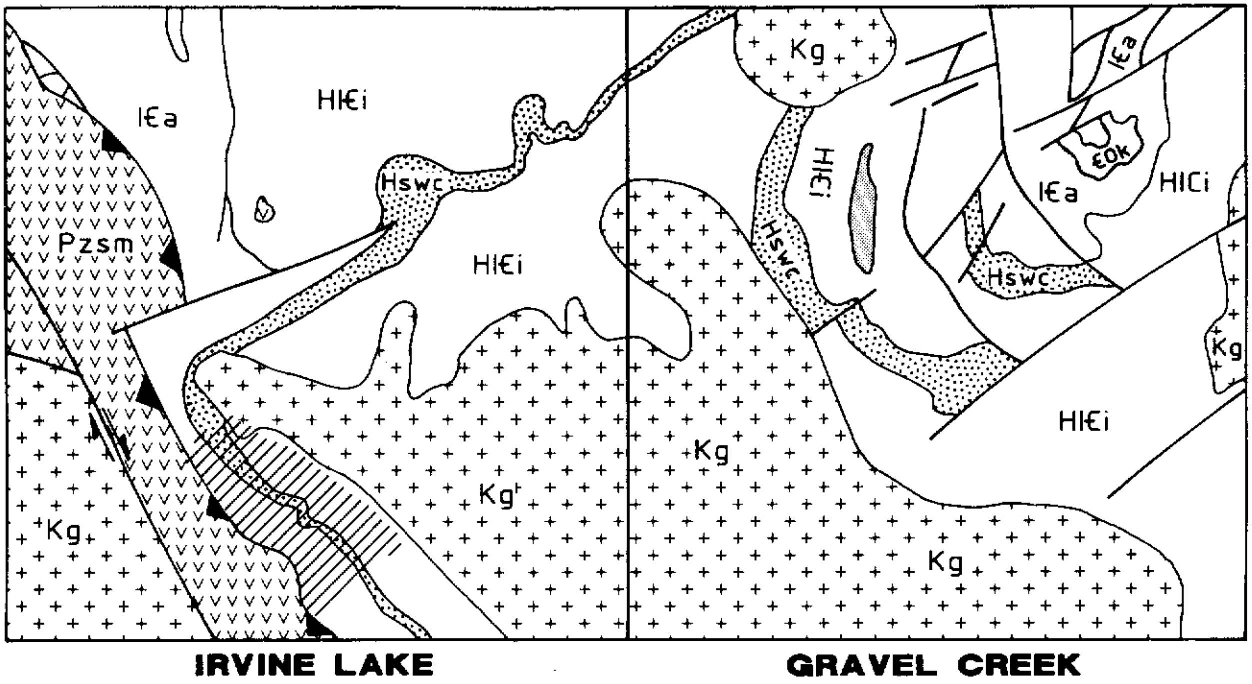
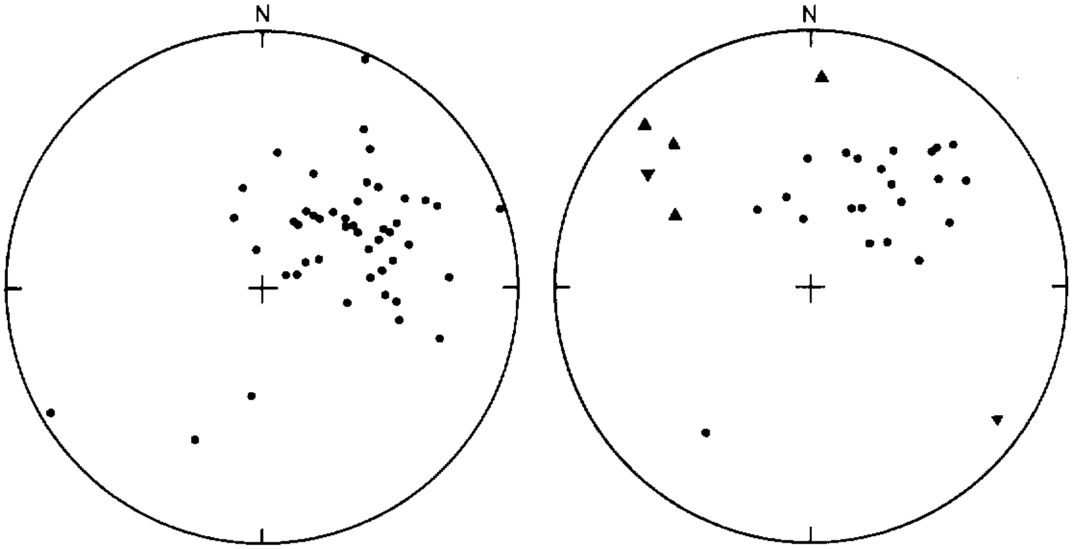
• POLES TO S_2



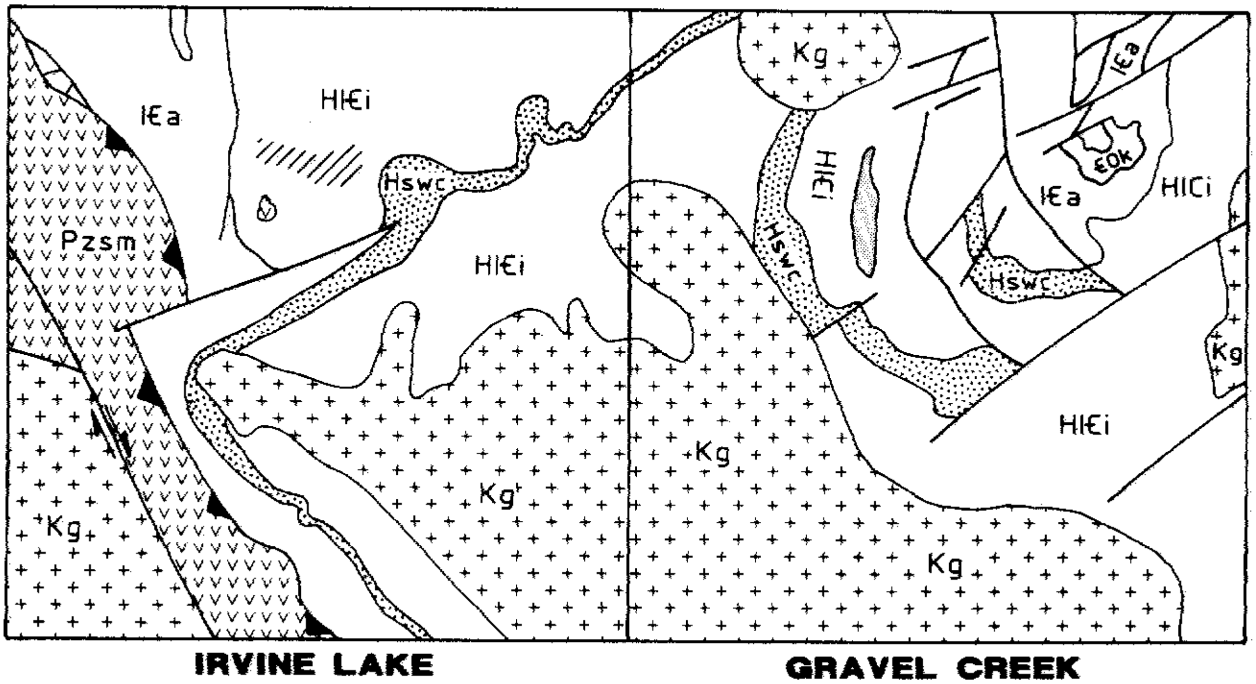
Kg - Cretaceous granitic rocks   Pzsm - Slide Mt. terrane   ЄOk - Kechika Group
lЄa - Atan Group   HlЄi - Ingenika Group

▨ Area in which data were collected



- • POLES TO BEDDING

- • POLES TO S_2
- ▲ L_{ox2}
- ▼ D_2 hinges



Kg - Cretaceous granitic rocks Pzsm - Slide Mt. terrane €Ok - Kechika Group
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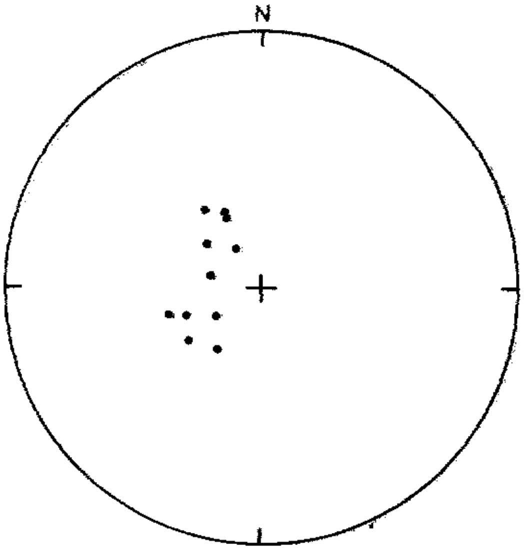
▨ Area in which data were collected



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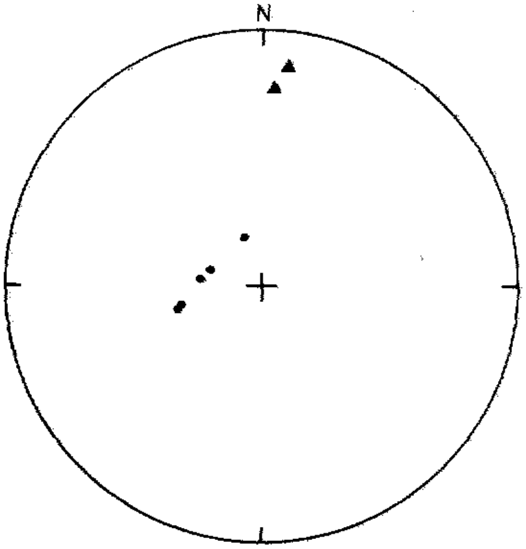
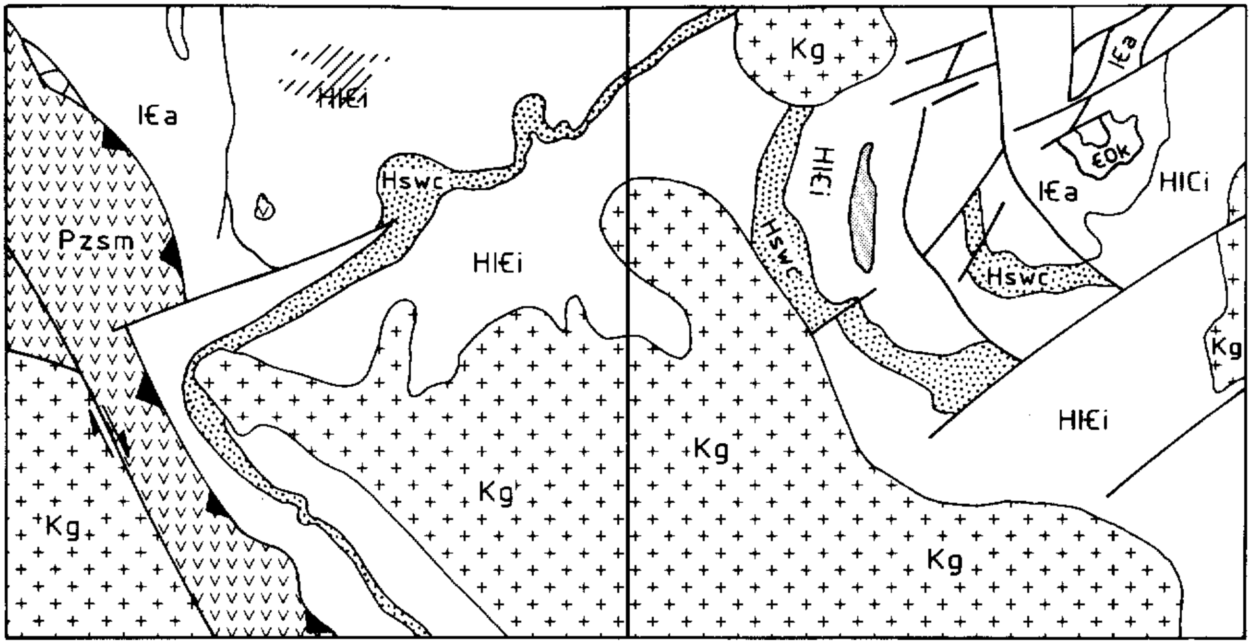


• POLES TO S_2

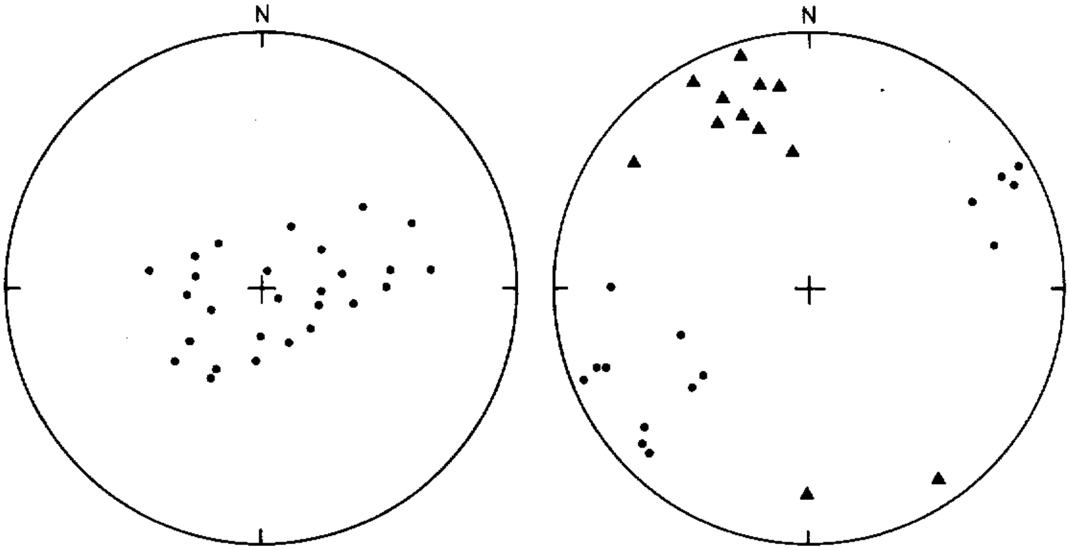
▲ L_{ox2}



IRVINE LAKE **GRAVEL CREEK**

Kg – Cretaceous granitic rocks   Pzsm – Slide Mt. terrane   ЄOk – Kechika Group
IЄa – Atan Group   HIЄi – Ingenika Group

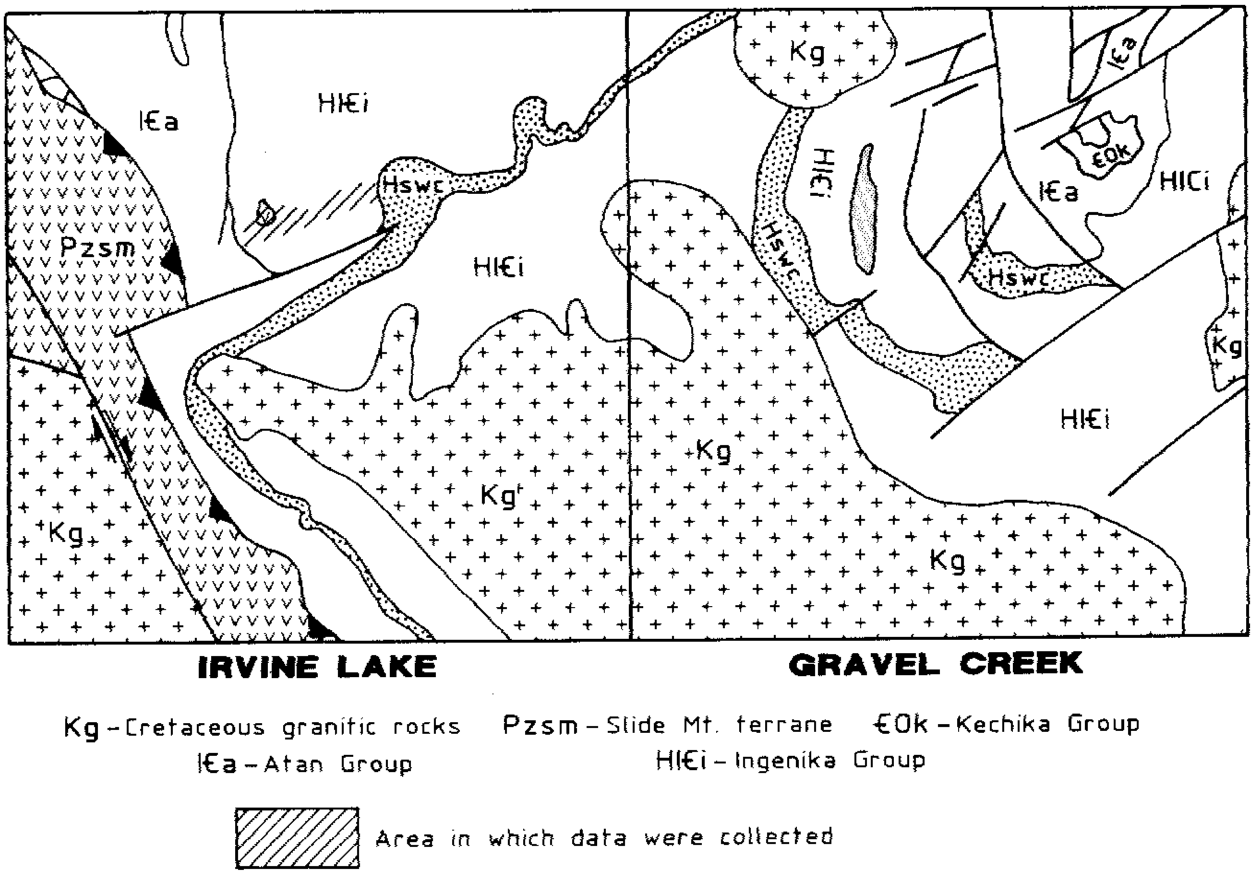
▨ Area in which data were collected

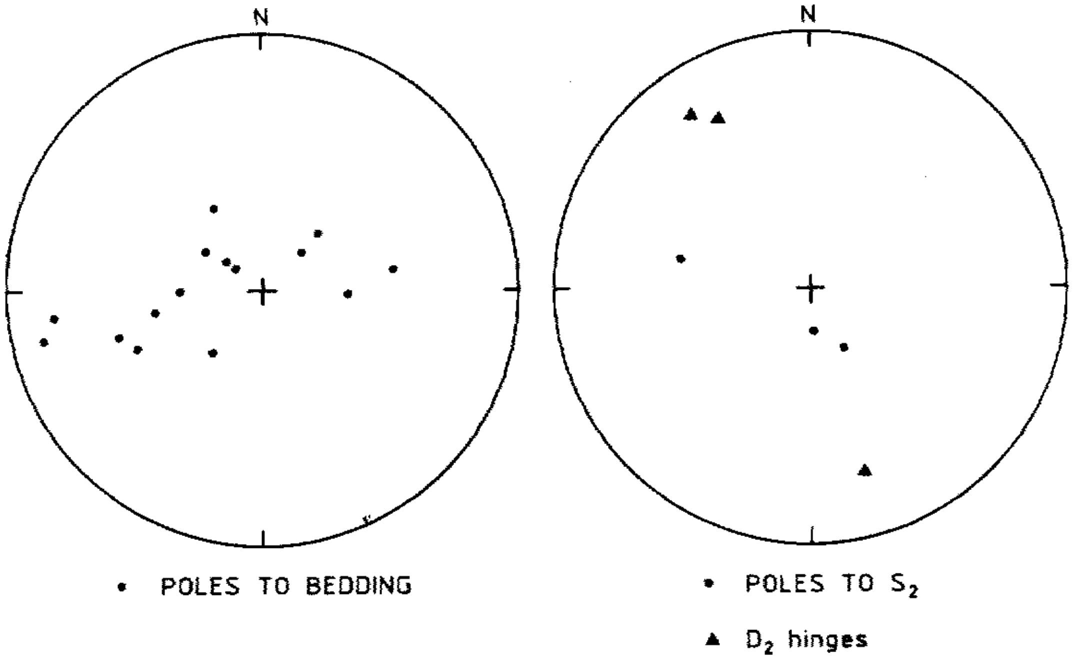


• POLES TO BEDDING

• POLES TO S_2

▲ L_{ox2}


IℓЄa
HIЄi
Hswc
Pzsm
Kg
ЄOk
HIЄi
IRVINE LAKE
GRAVEL CREEK
Kg - Cretaceous granitic rocks
Pzsm - Slide Mt. terrane
ЄOk - Kechika Group
lЄa - Atan Group
HlЄi - Ingenika Group
Area in which data were collected


N
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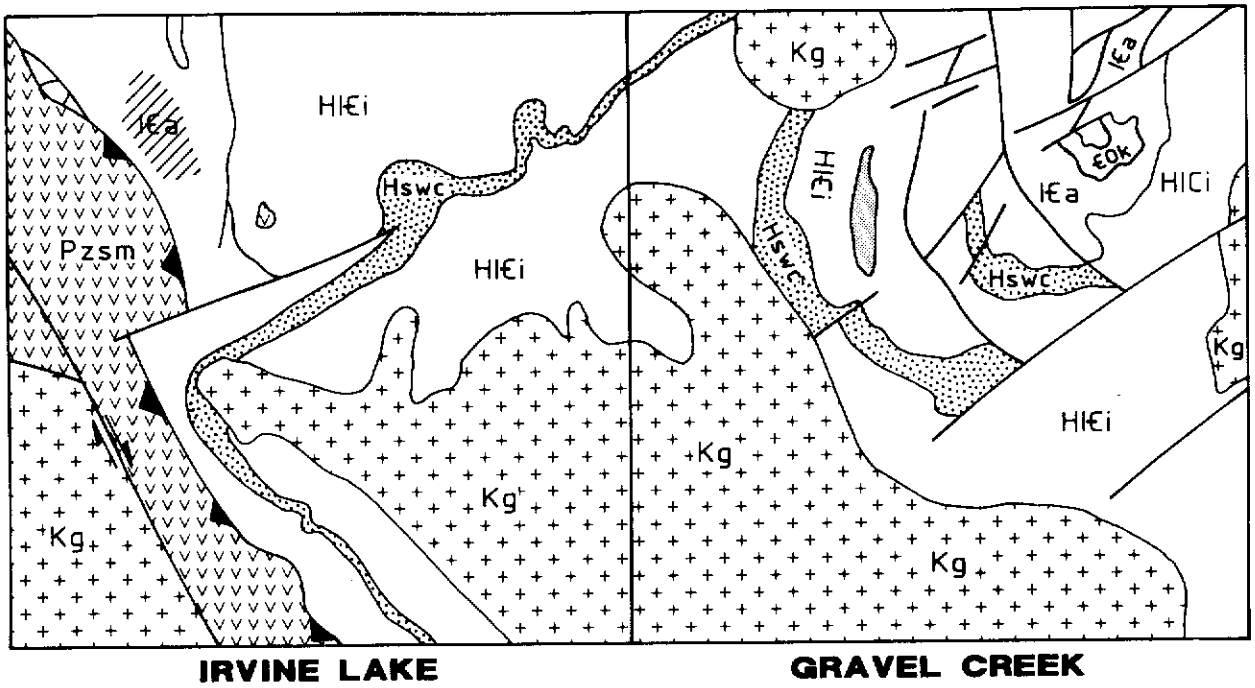
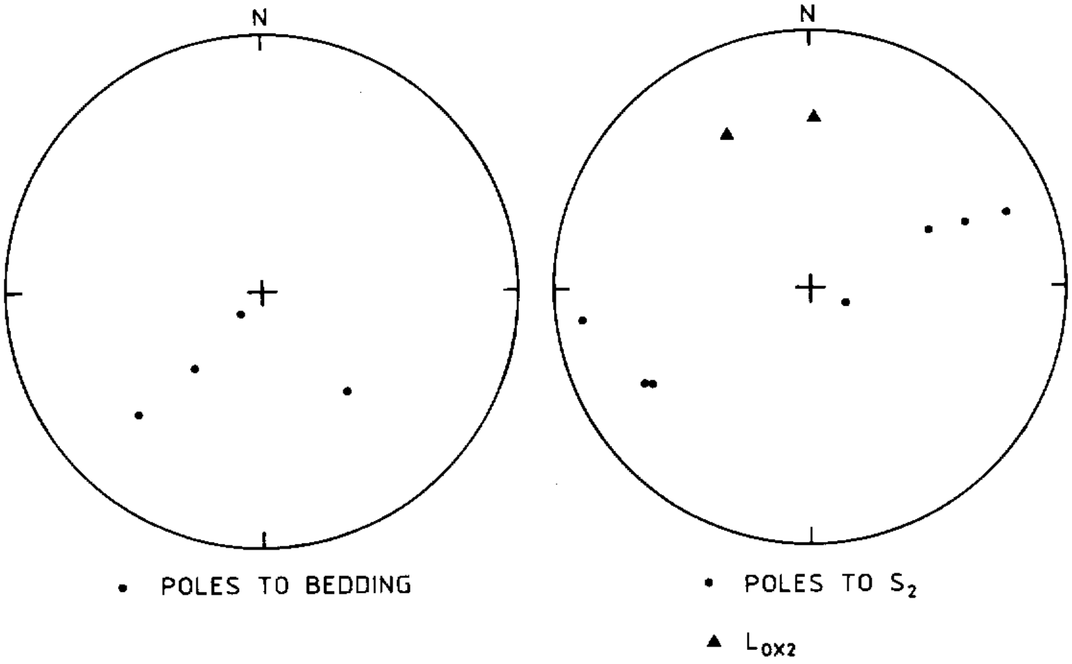
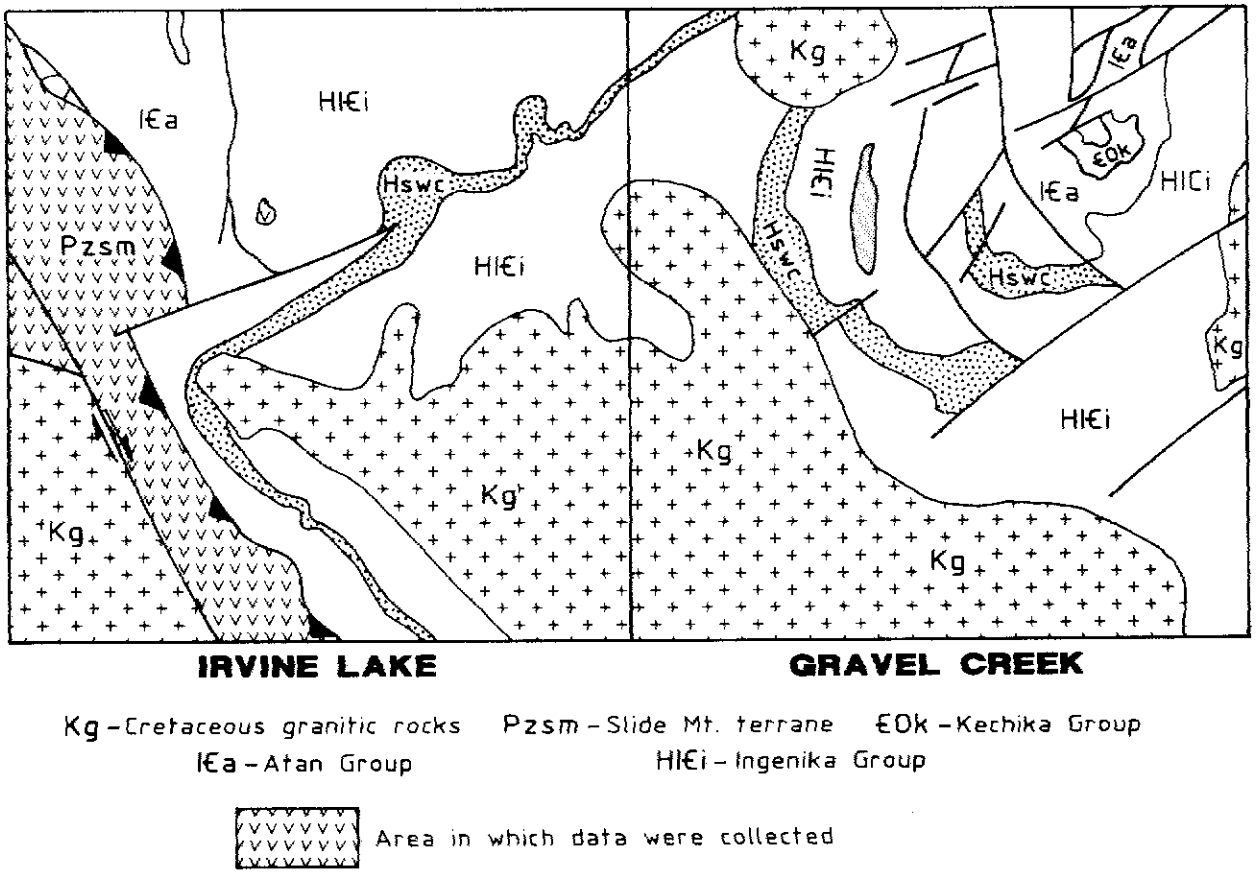
• POLES TO BEDDING
• POLES TO S2
▲ D2 hinges



Kg – Cretaceous granitic rocks Pzsm – Slide Mt. terrane ЄOk – Kechika Group
lЄa – Atan Group HlЄi – Ingenika Group

▨ Area in which data were collected




lЄa
HlЄi
Hswc
Pzsm
Kg
ЄOk
HlCi
IRVINE LAKE
GRAVEL CREEK
Kg - Cretaceous granitic rocks
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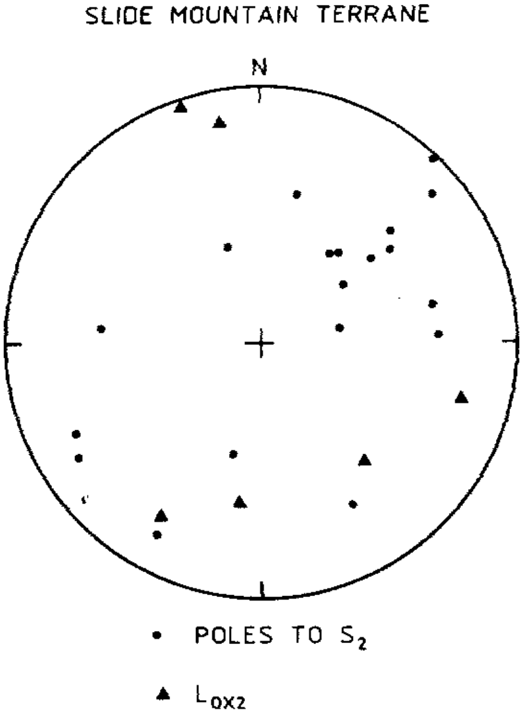

SLIDE MOUNTAIN TERRANE
N
• POLES TO S2
▲ Lox2

Appendix 2
SUMMARY OF MINERAL OCCURRENCES

35. IRVINE (105B/10: 60° 38'N, 131 12'W)Unmineralized

These claims are underlain by schist, meta-sandstone, and marble (Hswgm) of the upper Proterozoic Swannell Formation. A trench was dug in carbonaceous siliceous schist with highly limonitic and manganiferous portions during early prospecting.

Updated from summary by R. Debicki (YEG, 1981)

36. TUNG (105B/10: 60° 35'N, 130 30'W) Tungsten skarn

The property is underlain by schist and marble (Hswgm) of Upper Proterozoic Swannell Formation and quartz monzonite and marginal granitic pegmatites of Cabin Creek stock. Scheelite and powellite-bearing garnet-pyroxene skarn is developed along the margins of a northwardly dipping marble (Hswgm). The skarn is exposed in float for about 300 m along strike over widths of between 1 and 6 m. Rare molybdenite, galena, and sphalerite are also reported. Garnet-diopside skarn with minor scheelite, pyrrhotite, and rare chalcopyrite is also reported in lime-cemented meta-grits. Scheelite occurs locally as coarse-grained disseminations in pegmatite, along fractures, and in quartz veins.

Updated from summary by J.G. Abbott (YEG, 1981)

43. ZAK (105B/11: 60° 32'N, 131 15'W) Cu, in silicified dolomite and breccia

The Zak property is underlain by quartzite, phyllite, and dolomite of the Proterozoic Tsaydiz Formation, and the basal serpentinite unit of Slide Mountain terrane (Pz?s). Two mineralized zones are described, one where weakly disseminated pyrite and chalcocite are found in silicified dolomite and the other where malachite and chalcocite are found in weakly gossaned mylonite and breccia.

Updated from summary by R. Debicki (YEG, 1981)

58. COM (105B/10: 60° 30'N, 130 33'W) Vein(?)

This property is underlain by muscovite granite of Marker Lake batholith. No *in situ* mineralization is reported; several angular to subrounded boulders of massive galena and sphalerite in fragmented muscovite granite occur in Hydra Creek.

Summarized from summary by R. Debicki (YEG, 1981)

59. BINGY (105B/10: 60° 31'N, 130 39'W) Pb, Ag vein

This property is underlain by granodiorite of the Marker Lake batholith. According to J.G. Abbott, who visited the property in 1983, "Fragments of massive galena up to 10 cm across, black and rusty oxide fragments and black manganese coated intrusive fragments comprise the dumps of two small hand pits dug into felsenmeer and overburden. Weak airphoto lineaments suggest the possibility that the galena and alteration are related to north-trending faults." Silver-bearing galena is reported from manganese oxides in veins cutting granitic rocks (YEG, 1987).

Updated from summary by J.G. Abbott (YEG, 1985) and note in YEG (1987).

60. CABIN (105B/9, 10: 60° 41', 130° 32'W) Unmineralized target

This property is underlain by phyllite, quartzite, marble, and garnet-diopside-tremolite skarn of the upper Proterozoic Tsaydiz Formation and granodiorite to quartz monzonite of Cabin Creek stock. Although a favourable setting for tin or tungsten mineralization, none is reported.

Updated from summaries by R. Debicki and J.G. Abbott (YEG, 1981).

72. TEAM (105B/10: 60° 43'N, 130° 46'W) Zn, W skarn

This property is underlain by phyllite, meta-sandstone, marble, and skarn of upper Proterozoic Tsaydiz and Espee Formation and granodiorite to quartz monzonite of Gravel Creek stock. Mineralization consists of scheelite-sphalerite bearing skarns (western showings) and

88. STONEAXE (105B/10, 15: 60° 44'N, 130° 57'W) W skarn

This property is underlain by schist, meta-sandstone, marble, and garnet-quartz-diopside-scheelite skarn of the upper Proterozoic Swannell Formation grit member and altered and bleached quartz monzonite to granodiorite of Gravel Creek stock. Mineralization consists of medium grained disseminations and coarse-grained aggregates along fractures and bedding planes and is attributed to contact with dykes and apophyses of main Gravel Creek stock.

Updated and summarized from assessment report 091009 by Michael Stammers.

89. THRALL (105B/11: 60° 33N, 131° 20W) Mo porphyry

This property was staked to cover a small granodiorite stock containing stockwork quartz-molybdenite mineralization. The granodiorite stock and associated porphyritic quartz and feldspar granodiorite bodies intrude diorite (Pz?gdp) and greenstone (Pz?mv) of Slide Mountain terrane. Porphyritic felsite bodies host the major part of the best stockwork mineralization which occurs over a length of 200m. K-feldspar and slteration envelopes are common and are strongly developed adjacent to some veins. Weak, pervasive clay, chlorite, and sericite alteration is also common.

Updated and summarized from a summary by P. Watson (YEG, 1983)

90. SOURCE (105B/11: 60° 37'N, 131° 10'W) W skarn

This property is underlain by meta-sandstone, schist, marble, and mineralized garnet-diopside skarn of the upper Proterozoic Swannell Formation (Hswg and Hswgm) and quartz monzonite to granodiorite of the Marker Lake batholith. Scheelite, galena, sphalerite, magnetite, and chalcopyrite are found as skarn minerals and fluorite is found in quartz carbonate veins.

Updated and summarized from assessment report 091074 by Michael Stammers.

Uncatalogued

SILVER CREEK (105B/11, near SOURCE and IRVINE described above) Ag, vein

This claim covers the contact between meta-sandstone, schist, and marble of the Upper Proterozoic Swannell Formation (Hswg, Hswgm) and granodiorite and quartz monzonite of the Marker Lake batholith. Silver-rich galena is reported from veins.

Updated from note in YEG (1987).

MR (105B10, located south and east of SOURCE, IRVINE, and SILVER CREEK described above) Ag in quartz veins

This property covers the contact between meta-sandstone and schist of the upper Proterozoic Swannell Formation (Hswg) and granodiorite and quartz monzonite of the Marker Lake batholith. Silver-rich galena is reported from quartz veins.

Personal communication with representative of United Keno Hill Mines.

Indian and Northern Affairs, Canada
Exploration and Geological Services Division
Yukon Region

Figure 1A

GEOLOGICAL MAP OF IRVINE LAKE MAP AREA (105B/11)

To accompany
OPEN FILE REPORT 1988-1:
Geology of Gravel Creek (105B/10) and
Irvine Lake (105B/11) Map Areas
by
Donald C. Murphy

Funded by
Canada-Yukon Economic Development Agreement
Contract # 01/86

LEGEND

UNFOLIATED GRANITIC ROCKS

MESOZOIC

CRETACEOUS

Kg	Granite, quartz monzonite, granodiorite, quartz diorite

SLIDE MOUNTAIN TERRANE

PALEOZOIC (?)

Pz?gdp	Diorite, quartz diorite, gabbro, pryoxenite
Pz?ca	Marble, phyllite, meta-siltstone
Pz?ms	Chert, argillite, chert-pebble meta-conglomerate, meta-siltstone
Pz?mv	Basaltic meta-volcanics
Pz?gs	Gabbro, serpentinized ultramafic, minor meta-basalt
Pz?s	Serpentinite

CASSIAR TERRANE

PALEOZOIC

CAMBRIAN
Lower Cambrian
ATAN GROUP

l€r	Rosella Formation: marble, minor calc-phyllite
l€b	Boya Formation: quartzite, minor phyllite

PROTEROZOIC

Windermere Supergroup
INGENIKA GROUP

Hst	Stelkuz Formation: phyllite, quartzite, minor micaceous meta-sandstone
He	Espee Formation: marble, minor dolomite, calc-phyllite
Ht	Tsaydiz Formation: phyllite, quartzite, dolomitic marble

Swannell Formation:

Hswc	Mixed clastic and carbonate member: marble, schist, and meta-sandstone
Hswg	Grit member: schist, quartzofeldspathic meta-sandstone, thin marble
Hswgm	Grit member marble: marble and calc-silicate rocks

SYMBOLS

Geological boundary (defined, approximate, covered)

Strike-slip fault (defined, approximate, covered)

Thrust fault, teeth on upper plate (defined, approximate, covered)

Normal fault, ball on downthrown side (defined, approximate, covered)

High-angle fault (defined, approximate, covered)

Axial surface trace, upright anticline (defined, approximate, covered)

Axial surface trace, upright syncline (defined, approximate, covered)

Axial surface trace, overturned anticline, arrows point in direction of dip of axial surface (defined, approximate, covered)

Axial surface trace, overturned syncline, arrows point in direction of dip of axial surface (defined, approximate, covered)

81 14 11 g m s Bedding; tops known, unknown; overturned. g, gently; m, medium; s, steep (estimated from airphoto or binoculars)

12 52 Foliation, phase of deformation indicated by number or tic marks

4 Joint

82 Shear fracture

21 Foliation measured in granitic rocks

13 9 Mylonitic foliation, lineation

57 Vein (q, quartz)

40 Dyke

x Outcrop, area of outcrop in generally covered areas

● 39 Mineral occurrence (numbers correspond to those in DIAND publication, Yukon Exploration and Geology, 1984)

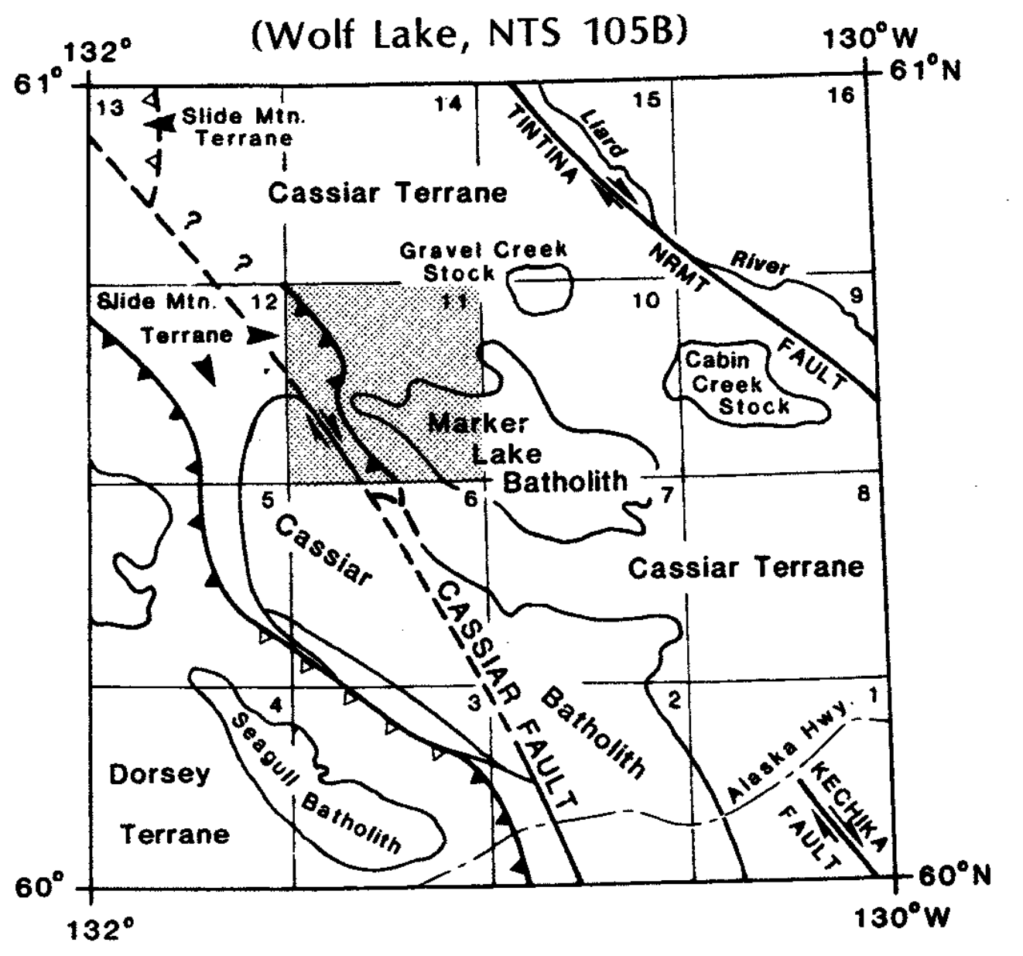
MINERAL OCCURRENCES

IRVINE	(35)	Pb (?), Zn (?); replacement (?)
ZAK	(43)	Cu, silicified and brecciated dolomite; vein Ag, Pb, Zn, Cu
THRALL	(89)	Mo, porphyry
SOURCE	(90)	W, skarn
SILVER CREEK		Ag, Zn; vein

(Not catalogued, includes ground formerly covered by 35 and 90)

REFERENCE MAP

(Wolf Lake, NTS 105B)



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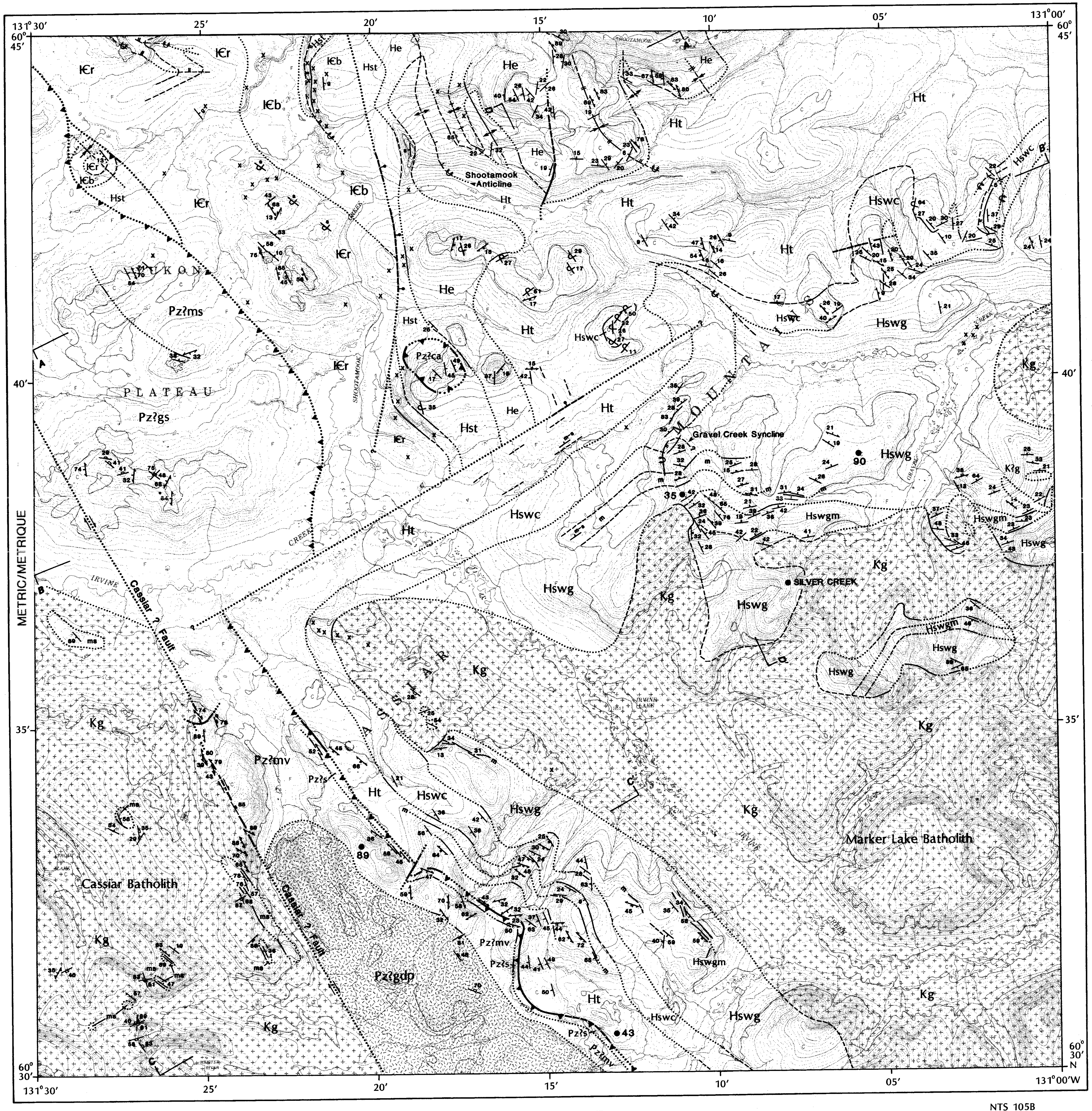
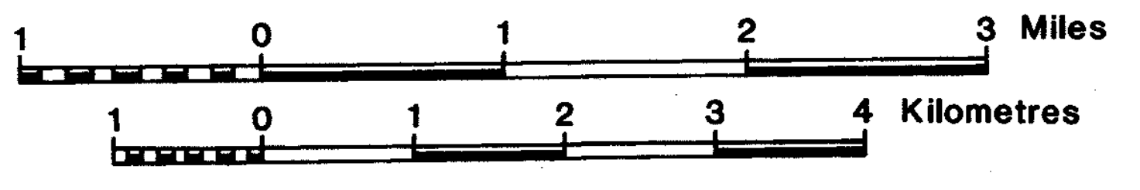


IRVINE LAKE

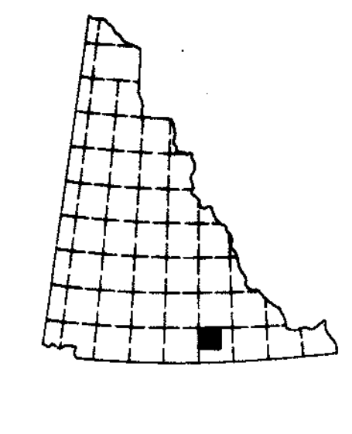
YUKON TERRITORY

Scale 1:50,000



Magnetic declination (1984) 30°18′ East
Decreasing annually 7.7′

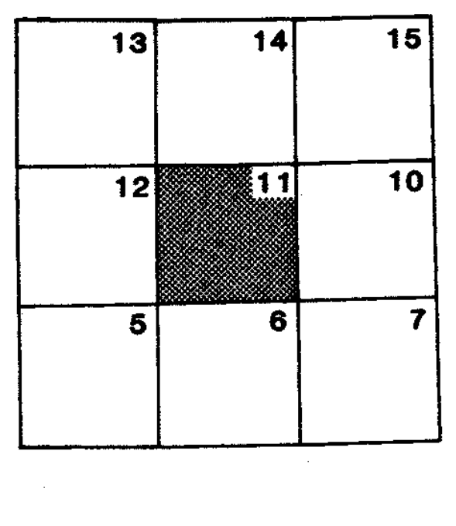
Elevations in metres above Mean Sea Level
Contour interval 20 metres



Geology by D.C. Murphy
with the assistance of
F. Goutier, P. Carmichael,
and J. Oriotis,
1987

Drawn by G.D. Hodge

NTS 105B



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Indian and Northern Affairs, Canada
Exploration and Geological Services Division
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Figure 1B

GEOLOGICAL MAP
OF
GRAVEL CREEK MAP AREA
(105B/10)

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LEGEND

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MESOZOIC

CRETACEOUS

Kg	Granite, quartz monzonite, granodiorite, quartz diorite
▨	Pegmatite-rich marginal zone

CASSIAR TERRANE

PALEOZOIC

Pz?og	Hornblende diorite orthogneiss

CAMBRIAN AND (?) LOWER ORDOVICIAN
KECHIKA GROUP

€Ok	Calc-phyllite, marble
€Okp	Graphitic phyllite
€Okq	Quartzite

CAMBRIAN
Lower Cambrian
ATAN GROUP

l€r	Rosella Formation: marble, minor calc-phyllite
l€b	Boya Formation: quartzite, minor phyllite

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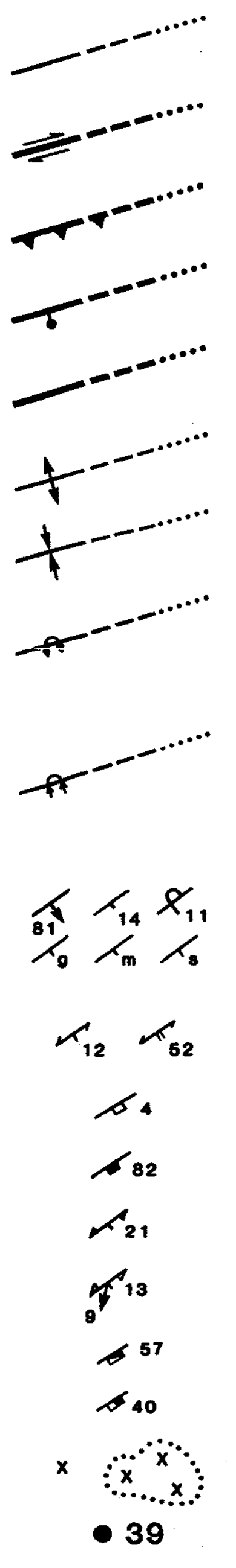
SYMBOLS



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- Strike-slip fault (defined, approximate, covered)
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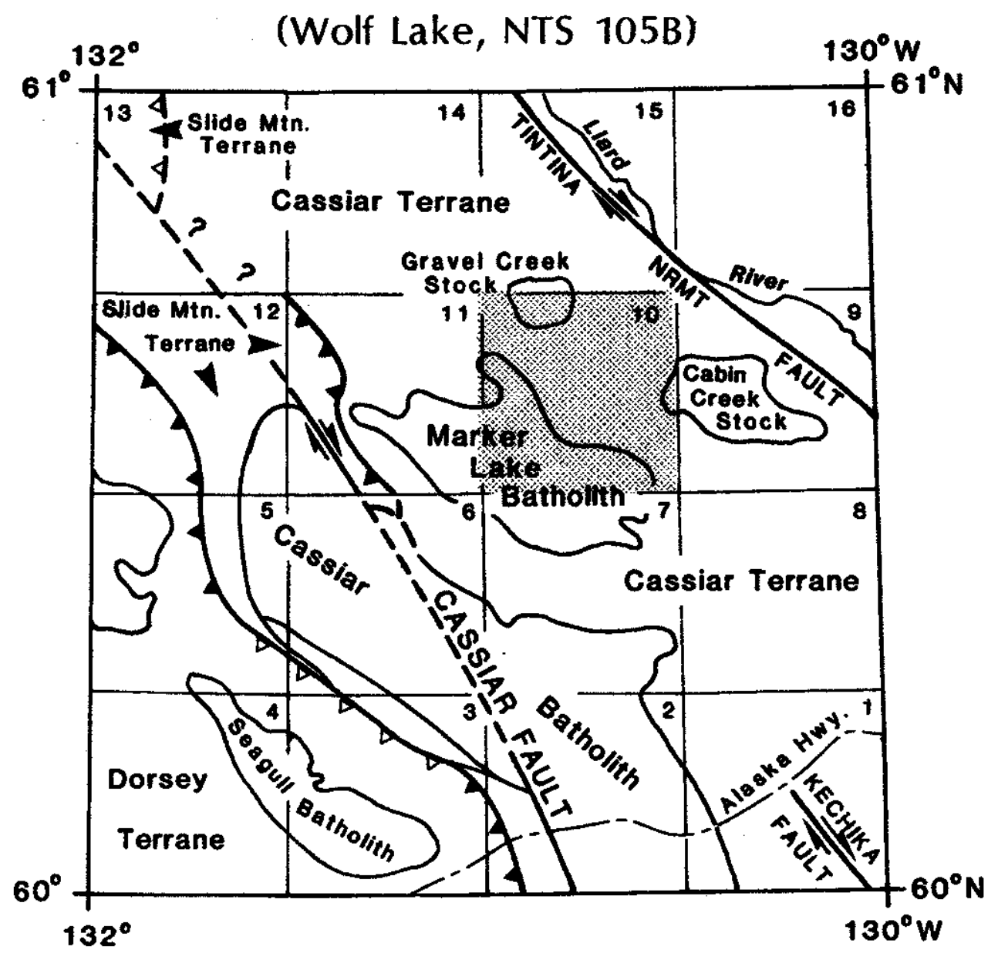
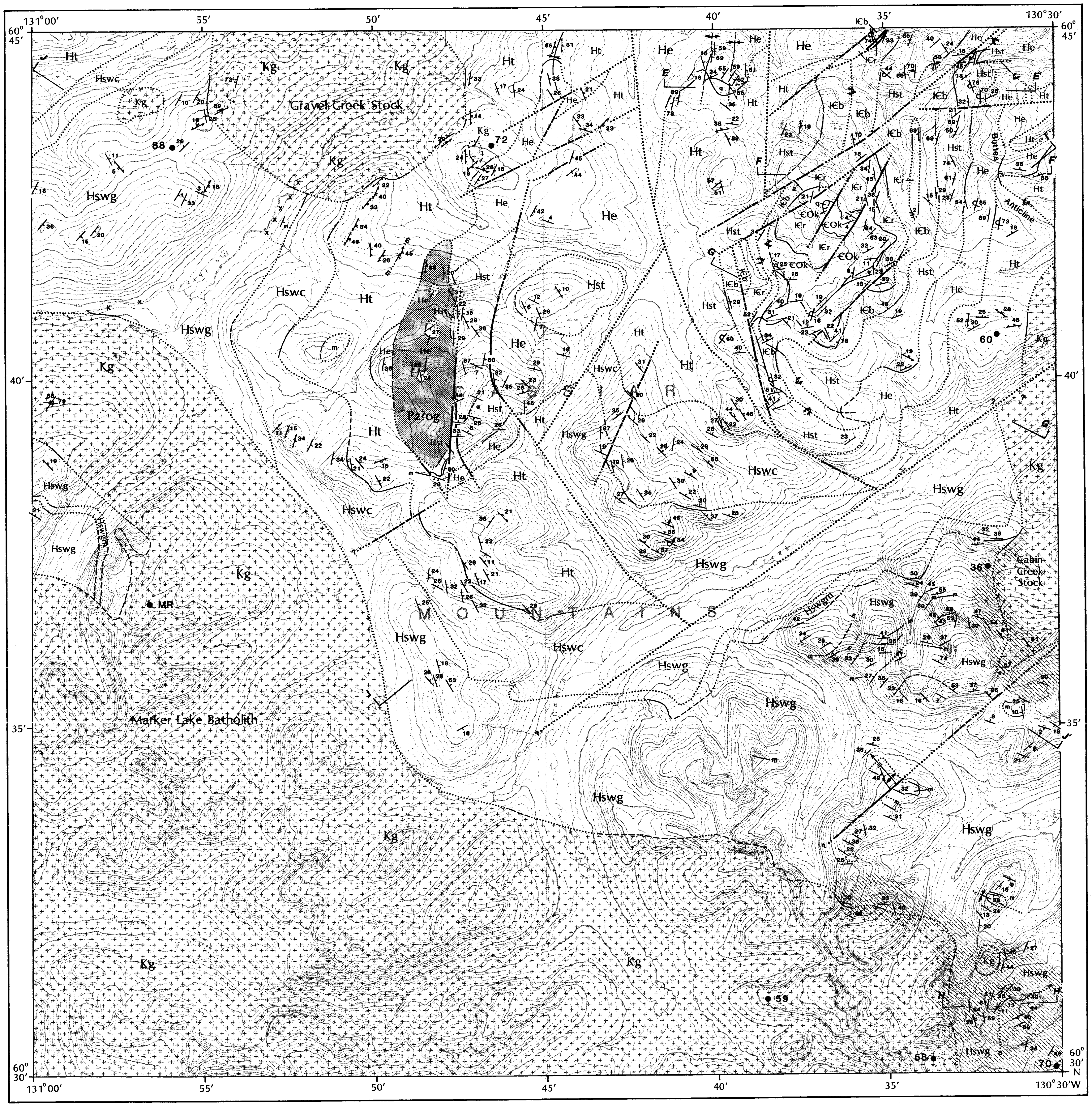
- Shear fracture
- Foliation measured in granitic rocks
- Mylonitic foliation, lineation
- Vein (q, quartz)
- Dyke
- Outcrop, area of outcrop in generally covered areas
- Mineral occurrence (numbers correspond to those in DIAND publication, Yukon Exploration and Geology, 1984)

MINERAL OCCURRENCES

TUNG	(36)	W, skarn
COM	(58)	Pb, Zn; vein
BINGY	(59)	Ag, Pb, Zn; vein
CABIN	(60)	Pb, Zn, Ag; skarn
LOGAN	(70)	Zn, Ag; shear zone hosted
TEAM	(72)	Zn, W; skarn, fault-controlled breccia
STONEAXE	(88)	W, skarn
MR (not catalogued)		Ag, vein

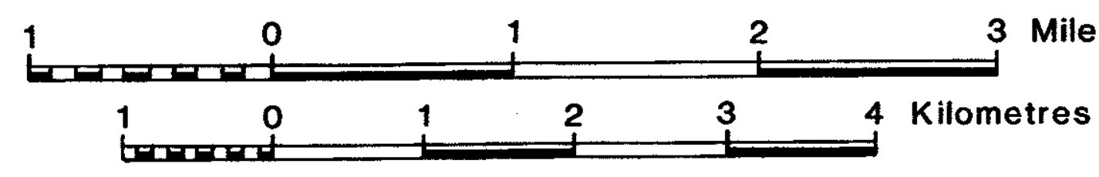
REFERENCE MAP
(Wolf Lake, NTS 105B)

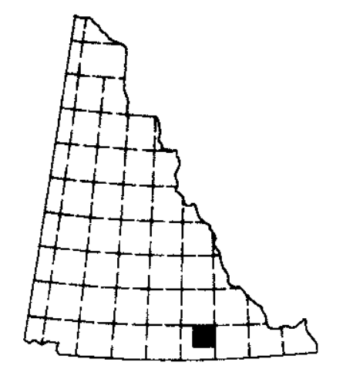




GRAVEL CREEK
YUKON TERRITORY

Scale 1:50,000





Magnetic declination (1965) 32°14′ East
Decreasing annually 4.8′

Elevations in feet above Mean Sea Level
Contour interval 100 feet

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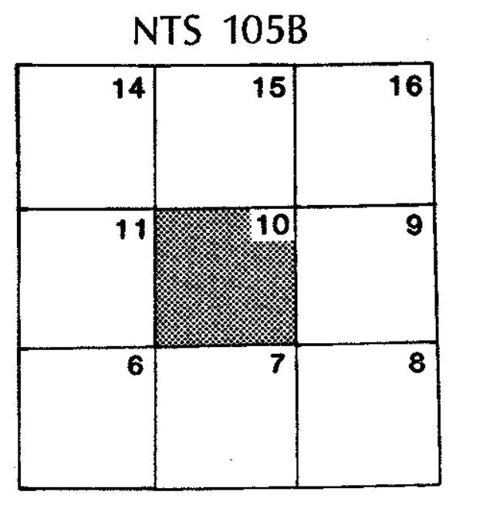

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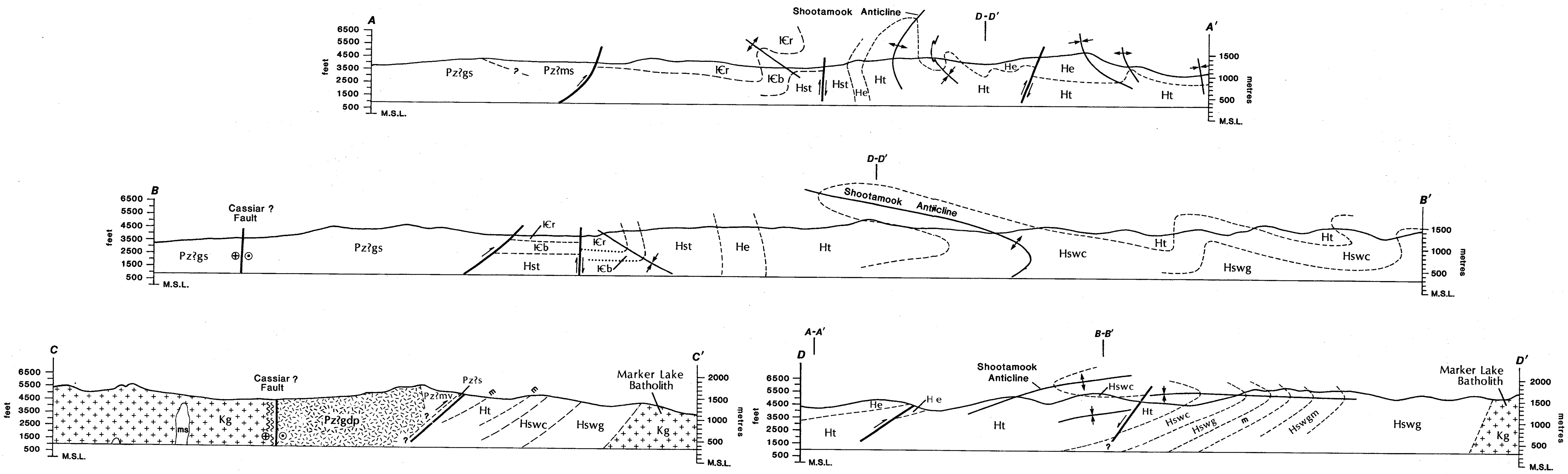
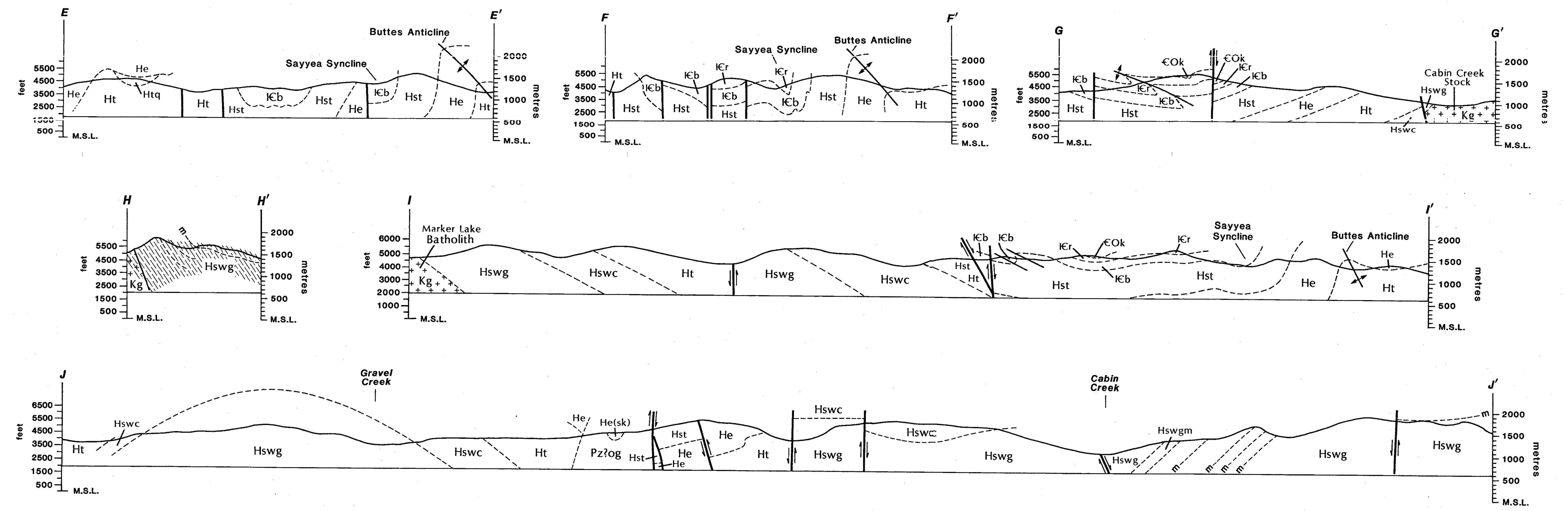
IRVINE LAKE (105B 11)



GRAVEL CREEK (105B 10)



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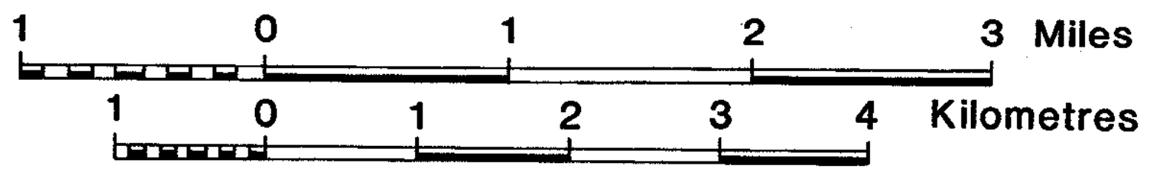

Figure 1C

DIAGRAMMATIC CROSS-SECTIONS
IRVINE LAKE AND GRAVEL CREEK MAP AREAS
YUKON TERRITORY

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