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PART B: STRATIGRAPHIC AND MAGMATIC SETTING OF MINERAL OCCURRENCES

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INTRODUCTION

Magmatic and stratigraphic settings exert a first order control on the formation of various mineral deposit types. Some settings are rich in mineral wealth while others are barren. Stratigraphic setting is of particular importance where stratiform or stratabound mineral deposits are concerned as orebodies are commonly restricted to specific stratigraphic intervals. For example, within the area bounded by the Alsek and Tatshenshini Rivers, Upper Triassic rocks include a stratigraphic interval that is spectacularly endowed with massive sulphide copper mineralization. On the other hand, no significant mineral occurrences have yet been recognized in either the thick and extensive Paleozoic limestones or the widespread Jura-Cretaceous granodioritic bodies. Thus, an understanding of the stratigraphic and magmatic setting of mineral occurrences is the first step toward accurate delineation of mineral potential tracts, a primary objective of the Tatshenshini project, as outlined in Part A. Structural and deformational events affecting the distribution of rocks formed within various stratigraphic and magmatic settings are discussed in Part C.

FUNDAMENTAL SUBDIVISIONS

The Tatshenshini project study area is largely underlain by rock of units of the accreted Alexander Terrane, bounded to the east and west respectively by small slivers of the Wrangellia Terrane, and possibly the Chugach Terrane. Four major lithologic packages are represented within the Alexander Terrane: Cambro-Ordovician clastic strata and associated mafic sills and pillow basalts; a thick Ordovician to Silurian carbonate succession; lithologically variable terrigenous, marine, and minor volcanic strata of Silurian to Permian age; and Upper Triassic, moderately deep water, marine carbonate and fine-grained clastic strata with associated rift-related(?) basalts. Two additional metavolcanic and metasedimentary assemblages of probable Alexander Terrane affinity underlie the southwestern part of the study area.

No mineral occurrences are known to have formed during deposition of lower Paleozoic strata. By contrast, Upper Triassic Alexander Terrane lithologies are host to the most significant mineral occurrences in the study area, including the huge Windy-Craggy copper-cobalt deposit. Upper Triassic strata of Wrangellia have many characteristics in common with contemporaneous rocks in the Alexander Terrane and also have demonstrated high mineral potential.

Two major intrusive suites are exposed within the map area. Dominantly granodioritic, but compositionally variable Jura-Cretaceous intrusions comprise the Saint Elias Plutonic Suite (Campbell and Dodds, 1983a) in the western part of the area. To the east, the Oligocene Tkope Plutonic Suite is also compositionally variable, but is dominated by granite to granodioritic phases. Tkope intrusions thermally metamorphose postaccretionary stratified units including deformed Early Tertiary clastic rocks.

Early Tertiary terrigenous sedimentary rocks occupy small, fault-controlled basins along Tats Creek and the western Tatshenshini River valley. The lower Tertiary strata host thin coal seams in both of these basins.

STRATIGRAPHY

CAMBRO-ORDOVICIAN SHEET SANDSTONE AND BASALT (COzsb)

Well-bedded clastic strata (COzsl; Figures 1-13-3 and 1-13-4) and intercalated basaltic sills (COzd and pillowed and unpillowed flows (COzb) attain a structural thickness of at least 2000 metres where they are well exposed on both sides of the Alsek River within 114P/13. Clastic units form distinct couplets composed of fine sandstone to siltsone, commonly with a calcareous matrix. They display exquisitely preserved, intricately interwoven crosslaminations and planar topsets (2-35 cm) interbedded with olive-grey mudstone (1-20 cm; Plate 1-13-1). Load casts and ball-and-pillow structures are common. Elsewhere the unit is dominated by very fine grained, parallel-laminated, siliceous (possibly tuffaceous) pyritic strata. Grading is uncommon.

Concordant, intermediate to basaltic sills and subaqueous, generally unpillowed flows 0.5 to more than 12 metres thick are commonly intercalated with the clastic succession. Locally they make up more than 80 per cent of the section over intervals of hundreds of metres. Sills and flows are difficult to distinguish from one another, as both have sharp contacts and either aphanitic or vesicular texture. Thicker sills are dioritic or diabasic in character. Other parts of the section are dominated by pillowed flows with associated flow-top breccias or coarse tuff.

Carbonate content of the clastic unit increases up section, and massive carbonate beds a metre or more thick are exposed at a few localities. The clastic strata are overlain (conformably?) by thick, platformal carbonates of Ordovician to Devonian age, providing a minimum age limit for the underlying unit. An inarticulate bivalve fossil recovered from a sandstone layer during the course of this study confirms a Cambrian or younger age (Norford, 1992; C-208163).

The base of the succession may be exposed where the Alsek River crosses the British Columbia - Yukon Territory border. At this locality it is structurally underlain by well-bedded, compositionally variable carbonate with tuffaceous and cherty interlayers. This unit extends into Yukon where it has been previously mapped as part of the overlying Cambrian to Ordovician package (Campbell and Dodds, 1983c).

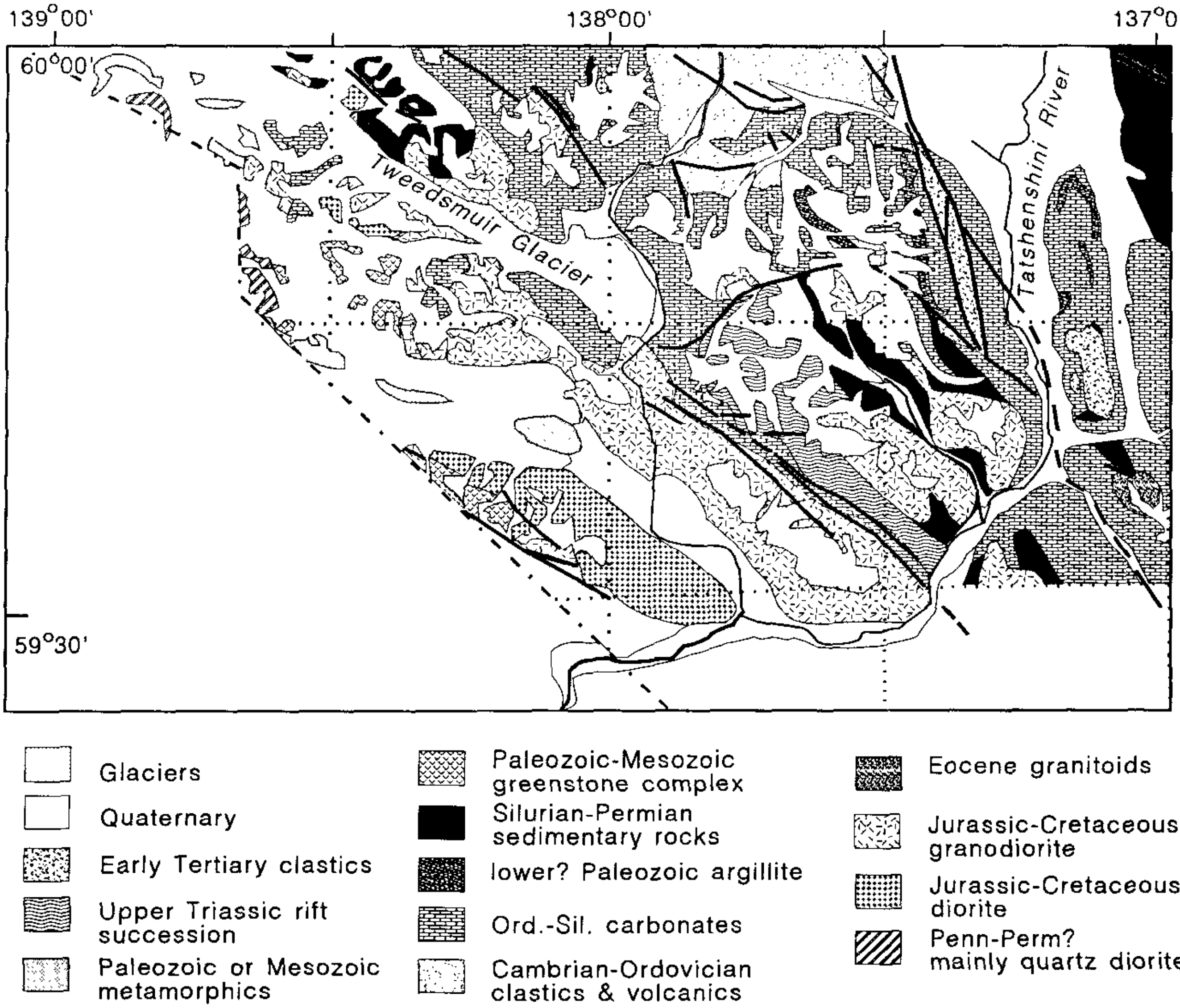


Figure 1-13-3. Much-simplified geological map showing only the most broadly defined units. Detailed 1:50 000-scale Open File maps are scheduled for release in early 1993.

Preserved bed-forms point to a sublittoral, wave or current-dominated environment (*e.g.*, Johnson, 1981). Sparce paleoflow determinations are largely unimodal to the north-northwest, indicating onshore wave-surge or long-shore current direction. The large number of concordant sills within the stratigraphic section supports a nearby magmatic source.

Ordovician to Silurian Carbonate (lPzc)

Volumetrically the most significant stratigraphic entity in the map area is a thick succession of limestones and silty limestones. It was formerly divided by Campbell and Dodds (1983a, b) into two broadly defined units; Ordovician to Devonian massive to laminated carbonate and siltstone (ODcs) and Silurian to Devonian massive limestone and marble (SDc). In this study, we further divide the succession on the basis of bedding thickness, per cent chert or siltstone, the presence of macrofossils, and relationships with overlying and underlying strata and diagenetic textures, in order to attempt a more complete understanding of the structural relationships and facies changes within the depositional basin. Most of the units are interpreted to have been deposited in a relatively shallow, subtidal marine environment, but there is little evidence of widespread bioturbation or skeletal debris, perhaps pointing to restricted or hypersaline waters.

Several of the following units may be coeval, but representative of different facies. Unfortunately, facies changes are difficult to document as the rocks are strongly deformed (Part C) and thermally metamorphosed near the contacts of plutons and thick dikes. Several lithologies are known to occur at more than one stratigraphic interval (Figure 1-13-4). Volcanic rocks, including lenses of dark green pillow basalt and tuffaceous rocks, are present in at least two localities within the carbonate-dominated succession and cherty layers may have a tuffaceous component.

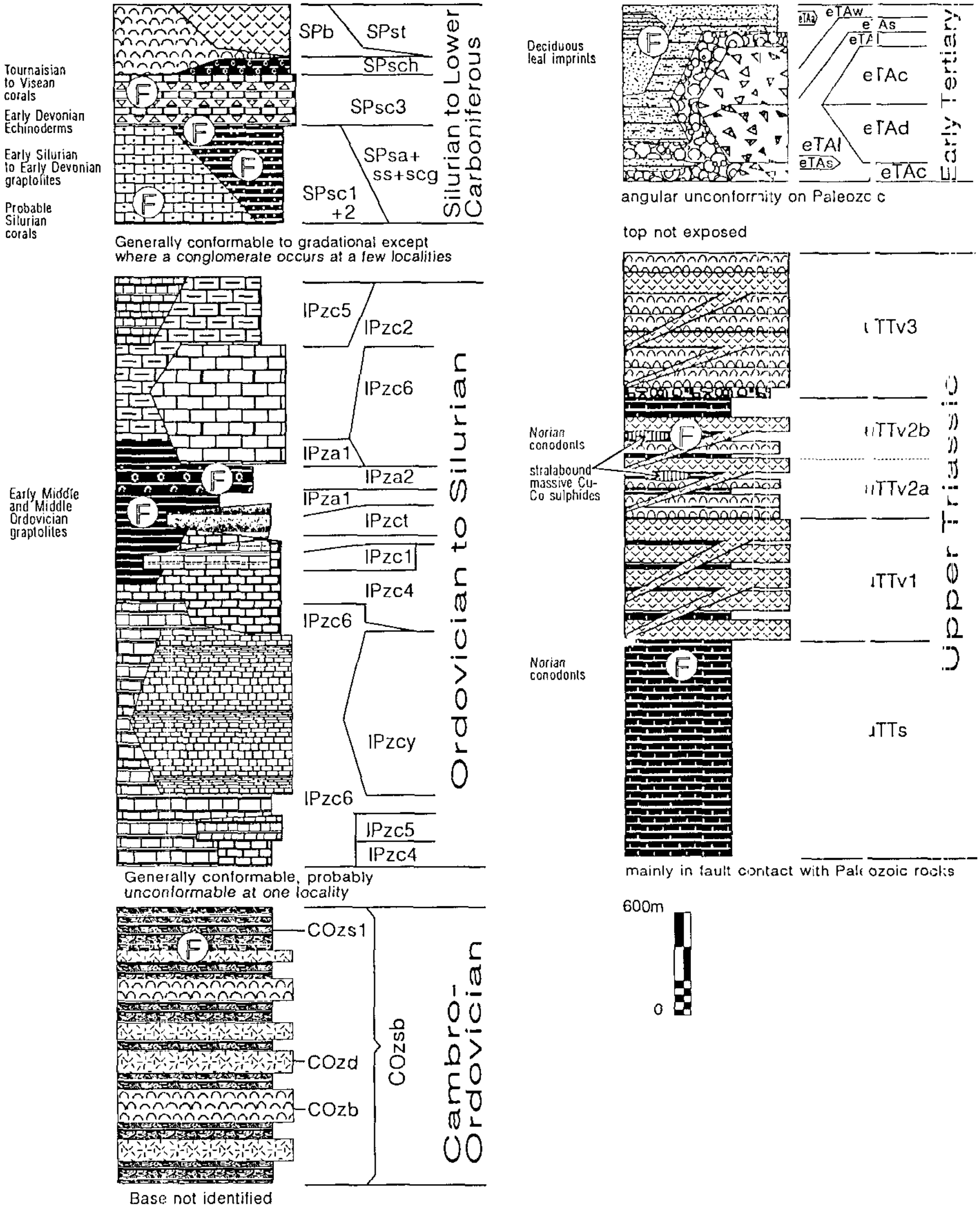


Figure 1-13-4. Stylized stratigraphic column showing relations and approximate average thickness of regionally mappable units within the Alsek-Tatshenshini area. Minor units of limited extent or those of unkown stratigraphic position are not shown. Some facies relationships are schematically shown as if the column represents a condensed west to east cross-section.

Plate 1-13-1. Cambro-Ordovician sheet sandstones (COzs1) showing low-angle trough cross-stratification, climbing ripple cross-stratification and hummocky(?) cross-stratification are interbedded with phyllitic argillite (dark). This combination of features probably formed in a sublittoral, current-dominated environment. View is to the west, and divisions on the scale card are 1 centimetre.

HETEROLITHIC LINSEN CARBONATE (lPzco)

Two end-member lithologies comprise this unit. Most abundant is very well bedded medium to dark grey, tan-weathering calcareous mudstone that forms 1 to 3-centimetre beds with tan, silty lenses 1 to 2 centimetres thick. Of lesser importance, but dominating the section in a few localities, is interlayered, cross-stratified calcarenite grading into micrite in 2 to 10-centimetre sets. At one locality the unit is capped by limestone-cobble conglomerate. These sediments are interpreted to have been deposited in a sublittoral environment.

DARK, THIN-BEDDED LIMESTONE (lPzc1)

Thin-bedded, dark grey to black, slatey, carbonaceous to fetid limestone grades into or is interlayered with argillaceous limestone and light grey, cross-stratified calcarenite. This unit includes minor but distinct "scoriaceous" carbonate. All lithologies comprising this unit are pyrite rich, with pyrite cubes several millimetres across. These rocks may represent a transgressional cycle and could be correlative with argillite containing Middle Ordovician graptolites.

TIGER-STRIPE CARBONATE (lPzc2)

A tiger-stripe pattern is created in these rocks where cryptocrystalline to finely recrystallized, irregular, medium grey, 1 to 5-centimetre beds are interlayered with 0.5 to 2-centimetre, relatively recessive, tan partings. Very fine laminae are preserved within the tan arenaceous layers (Plate 1-13-2a), although in places these layers are very irregular due to soft-sediment deformation resulting from regularly spaced, elongate, centimetre-scale diapirs (Plate 1-13-2b). Very fine grained, medium-bedded, buff siliceous interbeds are locally present. Near the faulted contact with Upper Triassic Tats group (informally named) stratigraphy, this unit is strongly recrystallized, light grey to white with a second foliation axial planar to centimetre-scale parasitic chevron folds outlined by millimetre-scale tan laminae.

Tiger-stripe carbonate probably occurs at several stratigraphic intervals. However, it consistently occurs beneath massive, fossiliferous, blue-grey limestone of probable Silurian age (*see* DPsc1).

MASSIVE CARBONATE (lPzc3)

This unit consists of massive, medium grey to tan limestone and marble with rubbly to hackly weathering characteristics, which breaks into irregular fist to pebble-sized pieces or platy fragments where strongly foliated. It is commonly white weathering where adjacent to intrusive contacts and locally contains abundant, dark green waxy dikes which are discordant to totally transposed (*e.g.*, Part C; Plate 1-13-10). We believe that, in places, this unit is in part equivalent to recrystallized megacyclic carbonate (*see* Unit lPzcy below).

THINLY INTERBEDDED CHERTY ARGILLITE AND CARBONATE (lPzc4)

Light to medium grey, thinly interbedded (<5 cm) carbonate and resistant cherty argillite layers form a distinctive unit which attains thicknesses of tens of metres. This unit is generally reddish weathering and commonly fissile. Small-scale structures are beautifully outlined by the contrasting lithologies with cherty layers behaving in a more brittle fashion than the intervening carbonate (Plate 1-13-3). These rocks were deposited in a quiet, moderately deep marine environment that experienced episodic influx of fine-grained clastic detritus. In some instances the resistant layers may be altered ash beds.

RIBBED CARBONATE (lPzc5)

Buff-weathering limestone with interbedded, resistant ribs (0.5-2 cm) of orange argillaceous to silty carbonate and well-laminated, buff silty argillite beds is a coarser variety of the preceding unit and in some localities is interlayered with it. Locally it overlies the Cambro-Ordovician section and may also be injected with mafic dikes. It may have been in part penecontemporaneous with the Cambro-Ordovician

unit, but deposited in a more carbonate-rich and lower energy environment. It is also overlain by Unit IPzc4 in part, and is known to occur at higher stratigraphic intervals.

LIMESTONE-PEBBLE CONGLOMERATE (IPzcc)

Light to medium grey carbonate chips, ranging from small pebble to cobble size, occur in a tan to medium grey carbonate matrix in a clast-supported conglomerate. These conglomerates form beds 0.5 to 2 metres or more thick (up to 30 m at the mouth of Alkie Creek). The beds may form sets within a dominantly argillite or carbonate host and do not appear to be restricted to specific stratigraphic intervals but rather record intrabasinal erosional events of various ages. In at least one locality a set of these conglomerate beds marks the break between carbonate and argillite deposition, probably through migration of the facies boundary rather than in response to a tectonic event.

MARBLE AND DIKE COMPLEX (IPzcd)

Light to medium grey weathering, compositionally layered marble or limestone with abundant dark green boudinaged basaltic dikes comprising as much as 50 per

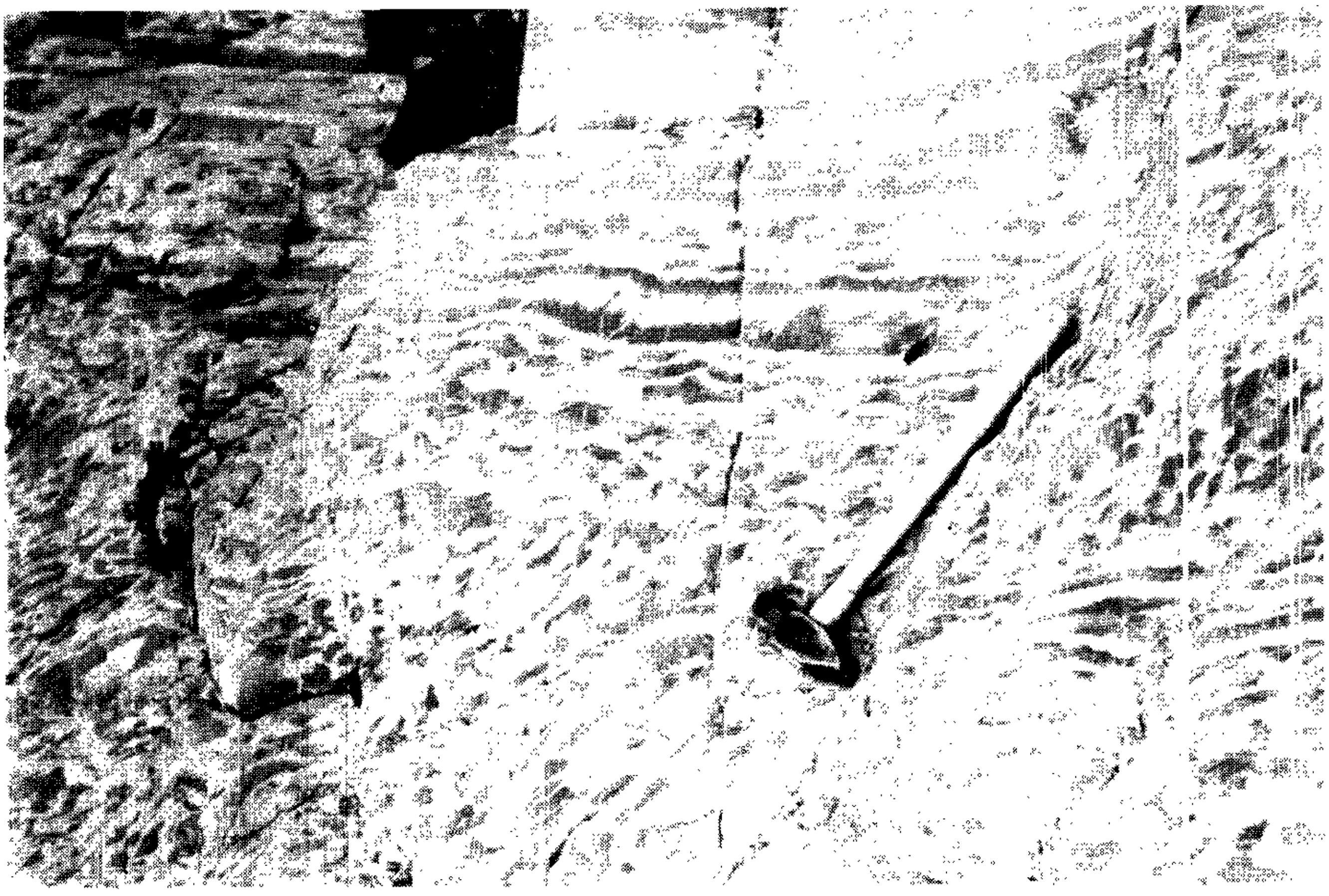


Plate 1-13-2. (a) A weathered outcrop of tiger-stripe carbonate (IPzc2) showing preservation of cross laminae within calcarenite beds and resistant nature of the more siliceous beds. (b) A glacially polished outcrop with distinctive disrupted beds. At east part of the disruption is thought to be due to soft-sediment deformation by slumping and decimetre-scale diapirism, perhaps resulting from deposition on a paleoslope.

Plate 1-13-3. Interbedded cherty argillite and carbonate (lPzc4) typically displays inhomogeneous deformation. Resistant cherty argillite layers deform brittly while thicker carbonate layers deform by plastic flow.

cent of the section, is a conspicuous and widespread lithologic association not restricted to a specific stratigraphic interval. White-weathering rinds of calcsilicate-altered marble commonly rim larger dikes, particularly in zones where dikes are abundant. Although the dikes clearly postdate deposition of host carbonate, they appear to be correlative to an overlying mafic complex that is in apparent depositional contact at one locality.

CALCAREOUS TURBIDITES (lPzct)

This unit consists of brown to rust and grey-weathering, calcareous, lithic turbidites, ranging from well bedded with crosslaminations and graded bedding well preserved, to thick pebbly massive beds. Complete Bouma sequences are locally preserved with divisions A B C±D and E, A B C or distal C D E and A E turbidites being the most common. Thicknesses range from 5 to 70 centimetres, with thicker beds generally corresponding to the more complete sequences. This unit grades into argillite containing Ordovician graptolites.

CARBONATE MEGACYCLE SUCCESSION (lPzcy)

Depositional cycles with brown, argillaceous carbonate bases that grade upwards into light to medium grey, massive to well-bedded hackly weathering carbonate over thicknesses of 10 to 60 metres are very well developed near the confluence of Alsek River and Easy Creek. Distinct argillaceous bases weather with resistant, dark brown cherty argillite layers spaced 1 to 15 centimetres apart and stand out 1 to 3 centimetres from recessive yellow-brown carbonate (Plate 1-13-4a). Each cycle is composed of dozens of argillite partings rhythmically interlayered with carbonate, with a decrease in the argillaceous component structurally up section. Where best exposed north of Turnback Canyon there are at least ten of these units stacked in succession (Plate 1-13-4b).

In carbonate shelf environments worldwide, laterally persistent, evenly bedded shallowing-upward cycles containing algal mats are among the most commonly encountered carbonate lithologies. They are interpreted to be products of subtidal to supratidal carbonate deposition which exceeds subsidence rates (James, 1984). Cyclic deposition combined with preservation of possible algal mats within some of the cycles of Unit lPzcy point to a similar depositional environment, but several key features are lacking. Subaerial features such as desiccation cracks or evidence of cross-stratification or intercyclic conglomerate identified in other cyclic successions (James, 1984) have yet to be identified. Perhaps Unit lPzcy was deposited in a very quiet, lower intertidal to subtidal environment seaward of a periodically exposed part of the platform.

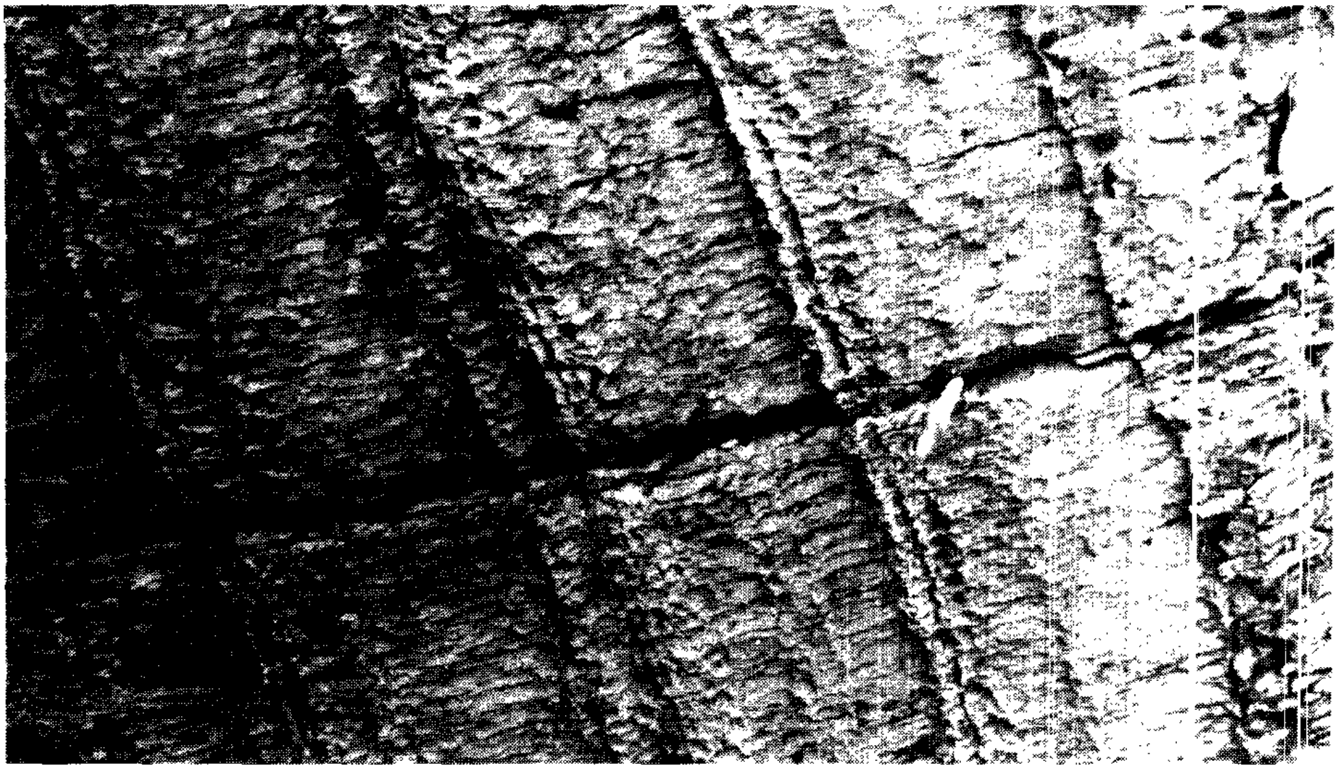
LOWER PALEOZOIC ARGILLACEOUS STRATA (MAINLY ORDOVICIAN, lPza)

Rocks of Unit lPza, which lies within the carbonate sequence, were previously mapped as part of the "Icefield Ranges pelitic assemblage" by Campbell and Dodds (1983a, b) which included rocks ranging in age from Late Triassic to Devonian and older. Once an extensive map unit, this pelitic assemblage has been greatly reduced, with inclusion of much of this unit with the lower Paleozoic carbonate and middle Paleozoic mixed sequences. Rocks still included within this unit are here referred to as lower Paleozoic argillaceous strata (lPza). They consist primarily of silty, black, grey or rusty argillite, which is commonly well laminated (lPza1). Rust coloration is primarily due to the oxidation of iron sulphides such as pyrite occurring as cubes up to 0.5 centimetre in diameter or as pyrrhotite blebs and wisps. A slatey to phyllitic cleavage with a well-developed microcrenulation occurs locally. Thickness of this unit is difficult to estimate as much strain has been accommodated by these rocks and they may be tectonically thickened by more than 100 percent.

Two other end-member lithologies are also common. A chert and siliceous argillite subunit is locally mappable, for example, northeast of Carmine Mountain where it is associated with early Middle Ordovician (Norford, 1992; sample C-168133) graptolite fauna (lPza2). Also, a light to dark grey calcareous argillite exposed at the headwaters of Tough Creek is a mappable subunit (lPzca3). Various proportions of the three compositional end members may occur over intervals of less than 100 metres.

LOWER PALEOZOIC VOLCANIC ROCKS (Pzb)

Volcanic flows and tuffs comprise a minor portion of the lower Paleozoic succession at several localities. Cherty intervals within Middle Ordovician shale north of Carmine



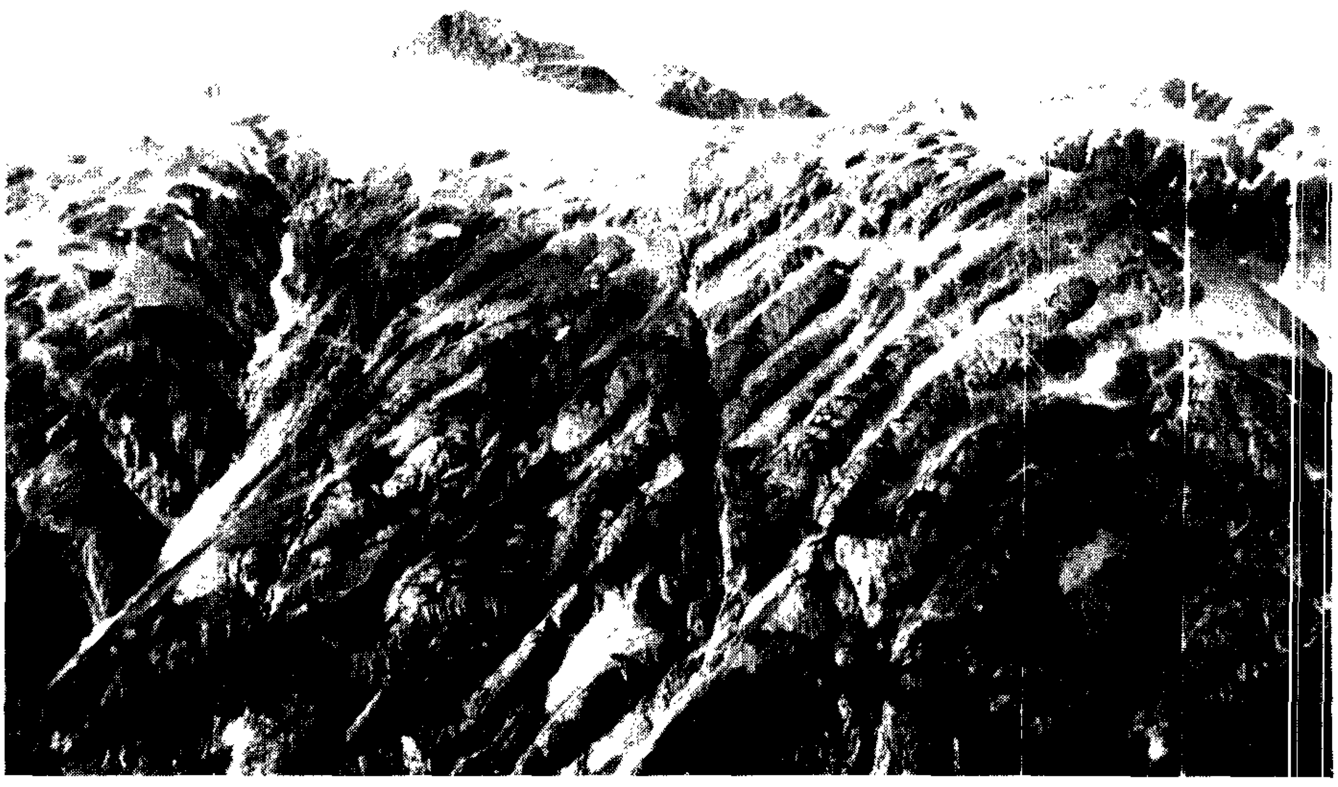


Plate 1-13-4. (a) Widely spaced, resistant argillaceous partings within the fine-grained portion of a megacycle succession (lPzcy). Normally carbonate beds between rhythmically interlayered argillite partings are 4 to 10 centimetres thick, whereas these are up to 20 centimetres thick. Felt-tipped marker is approximately 1 centimetre thick. (b) Stacked megacycles near the confluence of Easy Creek and the Alsek River. Approximately 1000 metres of relief is exposed in the foreground beneath the glacier.

Mountain (114P/14) locally contain ash-tuff layers. In the upper Tats Creek valley (114P/12) scoriaceous basaltic lapilli tuff and light green, siliceous, metamorphosed ash tuff (Plate 1-13-5a) are apparently interbedded with foliated Paleozoic carbonate. North of the headwaters of Sediments Creek (114P/13) a tabular body of pillow basalt (Plate 1-13-5b) 50 to 100 metres thick is enclosed in Paleozoic limestone. Stratigraphic tops may be indicated where a red-weathering, tuffaceous basal(?) section is in contact with recrystallized carbonate to the east while carbonate in contact to the west is not contact metamorphosed.

Middle to Upper Paleozoic Sedimentary Rocks

A sequence of limestone, argillite, sandstone, conglomerate and volcanic rocks of known and presumed middle to upper Paleozoic age overlies the carbonate succession in the Henshi Creek (114P/12), O'Connor River (114P/11), Easy Creek and upper Tweedsmuir Glacier (114O/16) and western Squaw Range (114P/14) areas. Siliciclastic rocks in other areas such as Sediments Creek, lower Henshi Creek and south of Tkope River may be the same age. Mappable units within this package are described following, in approximate order of abundance.

ARGILLITE AND SANDSTONE (SPsa, SPss, SPscg)

This unit consists of noncalcareous to calcareous black argillite (SPsa) or black limestone which is laminated to thin bedded, with or without medium to thick, orange weathering interbeds of fine to coarse-grained lithic sandstone (SPss) and granule to pebble conglomerate (SPscg). The proportion of coarser clastic rocks in a given section ranges from almost none to over 60 per cent, depending on location, with the thicker and coarser beds corresponding to the more sandstone-rich sections. Other horizons are dominated by coarse sandstone and conglomerate, and in the O'Connor River area, contain abundant plant fossils (swamp grass and fern fronds). Sandstone and conglomerate preserve sedimentary structures ranging from massive, pebbly to graded beds to planar to ripple cross-stratification. Black chert, graphitic argillite and light grey and rust-coloured pyritiferous volcanic(?) clasts are common. Pebble imbrication at one locality indicates westerly paleoflow.

Details of the argillite unit (SPsa) are less well known elsewhere, but in most localities the jet-black, highly fissile carbonaceous nature is apparent and serves to distinguish it from the more indurated, rusty weathering argillite of lower Paleozoic age. On the other hand it strongly resembles parts of the Upper Triassic sedimentary unit (uTTs).

LIMESTONE (SPsc1, SPsc2, SPsc3)

Limestone ranges from light to medium blue-grey and thin to medium bedded (SPsc1) to dark grey to black, fine grained, massive to medium-thin bedded (SPsc2), to medium-bedded, buff-weathering, black, fresh limestone with thinner recessive argillaceous interbeds (SPsc3).

Unit SPsc1 is typically blue-grey weathering, fossiliferous, and occurs as lenses up to 100 metres thick and a few kilometres long surrounded by sooty argillite. Fossils are prolific, locally forming crinoid columnal and stem packstone and rugosan coral packstone. Brachiopods and bryozoans are also abundant locally. Although recrystallization has masked many of the primary features, preliminary identification of these fossils suggests that the rocks are mainly Early Devonian (*e.g.*, Norris, 1992) to Early Carboniferous (W. Bamber, personal communication, 1992), although they could be as wide ranging as Silurian to Late

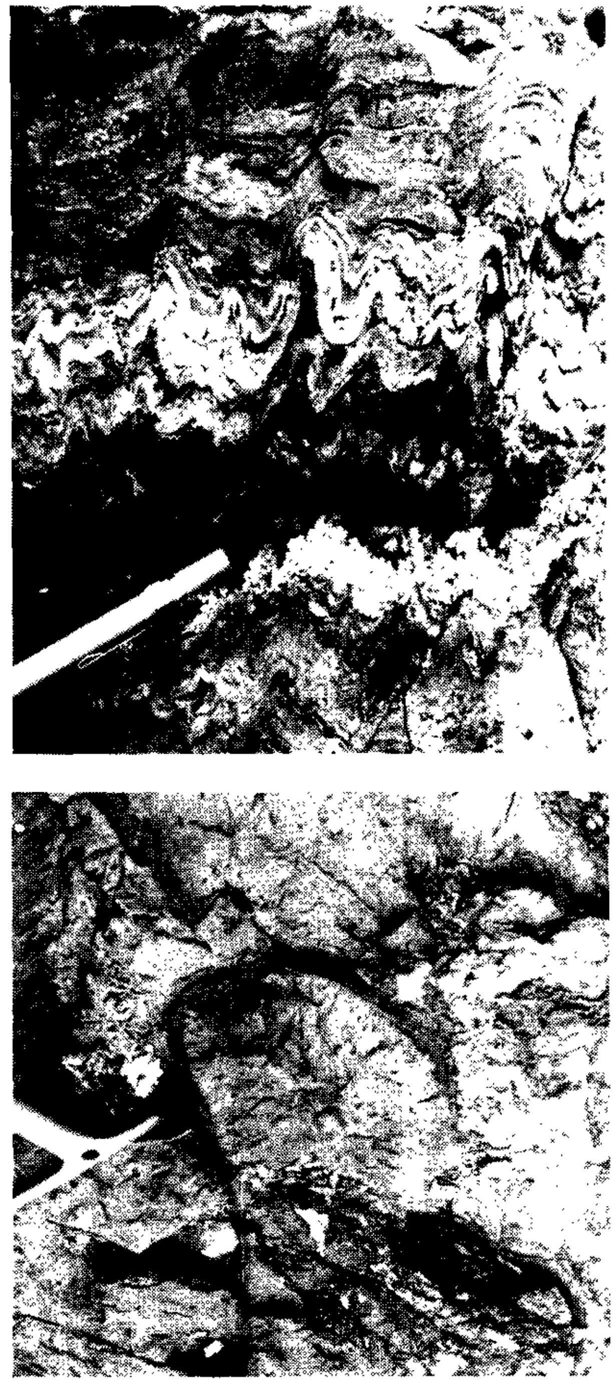


Plate 1-13-5. (a) Folded siliceous tuff layer within Paleozoic carbonate in the upper Tats Creek valley. (b) Pillows within a flow unit 50 to 100 metres thick, north of the headwaters of Sediments Creek.

Carboniferous and Permian. Limestone lenses of Unit SPsc1 are one of the most characteristic features of the middle to upper Paleozoic sequence, and are easily distinguished from the lower Paleozoic carbonates which are massive, unfossiliferous, and generally buff weathering.

ANDESITIC TUFF (SPst)

Green-weathering lapilli tuff with some ash and block tuff is exposed in the upper Tweedsmuir Glacier area, where it lies (depositionally?) between the basalt and chert units. Analogous lithologies occupy a similar structural(?) position in the Squaw Range where they are also associated with a greywacke unit (*see* SPsw below) and near the mouth of the O'Connor River where they structurally overly graptolite-bearing carbonaceous and gypsiferous shales of Silurian to Devonian age that contain white, clay-altered ash layers. Clast composition ranges from dark green (basaltic?) to light green and siliceous (dacitic?).

CHERT AND SILICEOUS ARGILLITE (SPsch)

A sequence of black to grey, thin-bedded chert and siliceous argillite 10 metres thick and with slatey partings is exposed in the upper Tweedsmuir Glacier area. It appears to structurally overlie the andesitic tuff unit and underlies a thick sequence of limestone (SPsc1) and argillite (SPsa). Tan to white, recrystallized chert and siliceous argillite, with associated phyllitic quartzite, are also present within a sequence of argillite and limestone in the Squaw Range.

BASALT (SPb)

A unit consisting of lensoidal, dark green, aphanitic, vesicular basalt flows crops out in the upper Tweedsmuir Glacier area. Facing is indicated by a presumed upward increase in the number and size of vesicles within individual flows 2 to 3 metres thick. The basalt flow unit appears to depositionally overlie a carbonate unit of unknown age, and is separated from the rest of the units described above by ice cover. Hence it may be one of the oldest units in the package or be unrelated to the remainder of the section. Basaltic flows are also exposed in the Squaw Range south of the Duke fault, where they are presumed to be late Paleozoic in age. They range from massive to rarely pillowed, and are associated with tuff and greywacke.

METAGREYWACKE (SPsw)

In the Squaw Range, brown to greenish metagreywacke varies from massive to thinly interbedded with slate. It is associated with tuff, argillite and basalt flows. Foliation is generally outlined by the development of chlorite and muscovite (phengite?), but locally garnet-biotite grade is attained. Higher metamorphic grade may be related to intrusion of thick gabbroic sills.

ARGILLITE AND CARBONATE COUPLET (SPsac)

A distinctive sedimentary couplet of carbonate-rich argillite overlain by orange-weathering carbonate is well exposed near the mouth of the O'Connor River and in a gorge south of Sediments Creek. Black carbonate interlayered with graphitic argillite may be microlaminated. Argillite is jet black, highly friable, gypsiferous, and contains white clay-altered ash layers with rare vesicular basaltic(?) bombs. Argillite contains graptolites of probable Early Silurian to Early Devonian age (Norford, 1992; sample C-168134), which are present in abundance above white to tan ash horizons. The upper carbonate is generally strongly disrupted, veined and, at one locality, talcose. The sedimentary couplet is found in association with the the argillite unit (SPsa) and sandstone unit (SPss) which contains rare ash-tuff horizons.

CONTACT RELATIONS AND FACIES INTERPRETATION

The relationship of this sequence of rocks to the underlying lower Paleozoic carbonate sequence appears to be complex. In the upper Tweedsmuir Glacier area (114O/16W), fossiliferous limestone overlies a section of the sandstone and argillite sequence, which in turn appears to overlie and in part be interbedded with the lower Paleozoic tiger stripe carbonate (lPzc2a). In the Easy Creek area argillite and fossiliferous limestone of the middle to upper Paleozoic package overly tiger stripe limestone or buff-weathering fine-grained facies of the carbonate megacycle unit (lPzcy). In the O'Connor River and Alkie Creek areas the contact is adjacent to medium to dark grey limestone of unknown age, with distinct, very fine, buff laminations (algal mats?). This facies seems to be present both in the upper part of the lower Paleozoic sequence and in the lower part of the middle to upper Paleozoic sequence.

Middle to upper Paleozoic sedimentary sequences represent a distinct departure from the carbonate-dominated platform environment of the lower Paleozoic sequence. Silurian rocks in the O'Connor River area include interbedded carbonates and graptolite-bearing argillite of presumed marine origin, as well as sandstones with abundant plant fossils of probable nonmarine origin. This suggests a swampy near-shore or deltaic environment, with marine incursions due to subsidence or channel abandonment. In the Alkie Creek area, the section includes thick to thin graded sandstone, laminated argillite, and thin to thick beds of limestone, including graded calcarenite. Beds are typically planar, and these rocks are perhaps marine turbidites such as those deposited at delta fronts.

Fossiliferous carbonate lenses within a section dominated by sooty calcareous and noncalcareous argillite, typical of the upper Henshi Creek and upper Tweedsmuir Glacier areas, suggest a reef to back-reef environment. Organic-rich argillite probably accumulated in anoxic lagoonal areas surrounded by biohermal patch reefs. Volumetrically minor tuffaceous units are common throughout the area and point to a magmatic episode(s), perhaps related to a tectonic event(s).

Overall, the middle to upper Paleozoic sequence appears to represent marine regression and clastic influx, with shallow-water platform carbonate sedimentation giving way to deltaic, possibly nonmarine environments and reef to back-reef (lagoonal) deposition. The laminated carbonate sequence that marks the transition in the Alkie Creek and O'Connor River areas is suggestive of a dry, periodically subaerial (tidal flat) environment.

Upper Triassic Tats Group (informal, uTT)

The nomenclature of Upper Triassic strata within northern Alexander Terrane, which comprise a submarine rift assemblage of fine-grained sediments and mafic volcanics, has undergone several revisions in recent years. Originally mapped by Campbell and Dodds (1983a), this stratigraphy was later refined by MacIntyre (1984) who included it in the informally named Tats group (MacIntyre, 1986). Rapid facies changes, abundant syndepositional and later faulting and folding and sedimentary-volcanic interfingering have prompted other workers to refer to these rocks as the Tats volcanic complex (Gammon and Chandler, 1986). However, a coherent stratigraphy does seem to exist, and is believed (Monger *et al.* 1991) to be correlative with the Hyd Group (Gehrels *et al.*, 1987) in southeast Alaska. Our preference is to maintain use of "Tats group".

Tats group stratigraphy is of critical economic significance in the region because it hosts the Windy Craggy volcanogenic massive sulphide deposit, which contains nearly 300 million tonnes of copper-cobalt ore reserves (Geddes Resources, 1992; Part D). Tats group strata are mainly restricted to a fault-bounded basin between Tats Creek on the west and Henshi Creek on the east. Mapping in 1992 established the presence of Tats group stratigraphic elements south along Tats Creek to the Tatshenshini River. In this report the Tats group is divided into regionally mappable units including a lower sedimentary unit and three major volcanic units following the subdivisions of MacIntyre (1984).

The Tats group lower sedimentary division (uTTs) has a structural thickness of 1000 to 1500 metres and is dominantly composed of black to dark grey or brown, thinly bedded, fissile and platy weathering calcareous siltstone and argillaceous limestone with calcalkaline basaltic sills. Also present are minor but conspicuous debris flows and quartz-lithic calcarenite beds. Accurate stratigraphic details and thicknesses are difficult to determine as this unit is everywhere strongly contorted.

The lower volcanic division (uTTv1) is generally not more than 1000 metres thick, and consists mainly of massive sills and perhaps structureless basalt flows with minor interbeds of sedimentary rocks like those of lower sedimentary division. Dark green to black flows and sills are locally porphyritic with a microdioritic, felted texture. Adjacent sedimentary strata are commonly hornfelsed. This unit is transitional between the sedimentary division and the middle volcanic division, and is absent in some localities.

A middle volcanic division (uTTv2) can be divided into a lower volcanic and sill-dominated section (uTTv2a) and an upper sediment-dominated sequence (uTTv2b) in order to facilitate mapping in some areas. Volcanogenic massive sulphide horizons in the Icebridge Glacier area are thought to occur in the upper sequence, at a stratigraphic position similar to the Windy Craggy massive sulphide horizon.

The middle volcanic division ranges from 600 to approximately 2200 metres thick, and consists of interbedded pillow basalt and calcareous siltstone with minor tuff, chert and limestone-clast debris flows. Basaltic sills are present in some locations and are particularly conspicuous in the upper sediment-dominated division. Some "sills" may actually be massive flows. Careful along-strike observations have shown that some units that in one place appear to be sills, can be traced into demonstrably pillowed lavas. Both sills and thick flows may hornfels sediments at their margins.

Volcanic flows and sills of the middle division are cogenetic (Peter, 1992) and calcalkaline (MacIntyre, 1986). Peter determined that the basalts are tholeiitic, but this conclusion was based upon major element geochemistry of altered samples. Less altered sills consistently plot within the calcalkaline field and analysis of the relatively immobile elements (Hf, Th, Ta) shows that most samples are calcalkaline.

The upper volcanic division (uTTv3) ranges from 500 to 1000 metres thick, and consists almost entirely of massive to pillowed basalt flows. This unit also includes basaltic sills, but sedimentary rocks are very minor to absent. An agglomerate unit, 50 or more metres thick, is locally present near the base of the unit, but identical rocks probably occur throughout the upper volcanic division.

Equivalent Upper Triassic strata also outcrop south and east of the map area. In addition, a Paleozoic to Mesozoic greenstone complex in the Vern Ritchie Glacier area has protoliths similar to the Tats group and hosts a newly discovered copper occurrence (Part D). Until an age of the metamorphic rocks is firmly established, correlation with Tats group stratigraphy should be regarded as tenuous at best.

Paleozoic or Mesozoic Greenstone-Carbonate Complex

A Paleozoic or Mesozoic Greenstone-Carbonate Complex is exposed within 114O/9, 15 and 16. It consists primarily of dark green to black, aphanitic to bladed feldspar porphyritic flows. Textures vary from massive to amygdaloidal, with rare remnant pillows which are commonly masked by a moderate to strong foliation or patches of epidote-chlorite alteration. Interbedded(?) marine sedimentary rocks include carbonates, including brown to white-weathering marble layers up to several hundred metres thick, sharpstone volcanic conglomerate with calcareous matrix, dark grey chert(?) and wacke, and at one locality, a pyritic sericite schist. Greenstone-dominated rocks give way westward to structurally underlying thin to medium-bedded calcareous to siliceous(?) wacke with interbedded argillite, a unit which is characteristically red-brown to greenish weathering. All components of the complex are intruded by Jurassic-Cretaceous granitoid rocks, and are thus no younger than Middle Jurassic, but may be as old as early Paleozoic. A predominance of metabasalt suggests a protolith such as the Upper Triassic Tats group, but thick carbonate horizons are more typical of the Paleozoic succession. More work is needed to resolve these possibilities.

A newly discovered copper showing, the Vern occurrence, contains up to 15 per cent chalcopyrite, but its extent could not be determined due to precipitous terrain. Two kilometres northwest of the Vern showing is a gossanous cliff face approximately 50 metres high. This zone was not examined because it is located below a potentially hazardous icefall (*see* also Part D).

Paleozoic or Mesozoic Schist and Gneiss

Rocks mapped as Paleozoic or Mesozoic schist and gneiss are primarily exposed in the western part of the map area (114O/9 and 15) and locally around the margins of batholiths, where protolith textures are no longer evident. The latter grade into less recrystallized rocks, which include the upper and lower Paleozoic carbonate and clastic sequences.

A northwest-trending linear belt of relatively coarse, amphibolite-grade rocks crops out along the International Boundary. Retrograde greenschist facies recrystallization has affected some of these rocks. Except where they can be traced into identifiable lithologies, protolith ages are unknown, although they may be largely late Paleozoic in age and derived from the Devonian to Permian sequence. Mapping during 1992 permitted definition of the following units:

- Metapelite, metasiltstone, calcareous metapelite and quartzite(?), which is generally buff or light grey to dark grey, schistose, and often brown weathering. Schistose varieties include biotite-actinolite (or hornblende)-plagioclase-quartz-muscovite schist;
- Medium-grained, strongly foliated metabasite, primarily hornblende-plagioclase or actinolite-plagioclase schist, with minor secondary epidote and quartz. In 114O this unit includes low-grade equivalent chlorite-epidote-actinolite schist;
- Coarse white to orange marble, with associated calcareous skarn and calcsilicate gneiss. Calcsilicate layers commonly include epidote, diopside, wollastonite and grossular in bands;
- Medium grey pyritiferous phyllite and semischist with calc-phyllite and thin to thick phyllitic limestone interbeds;
- Quartz-rich metasediments, including quartzite and siliceous meta-argillite. As mapped, this unit includes subordinate phyllite and carbonate;
- Green-grey weathering, dark green, gneissic banded amphibolite, which may be cut by epidote-feldspar±quartz veins, and is interlayered with the metapelite and carbonate units;
- Strongly foliated, fine to coarse-grained dioritic orthogneiss.

Early Tertiary Clastic Succession

A folded and faulted but unmetamorphosed sequence of presumed Early Tertiary age is preserved in a north-trending basin, 2 to 3 kilometres wide, along the west side of the Tatshenshini River valley and in small (1 km^2) grabens in the Tats Creek valley. The Early Tertiary succession is relatively easily distinguished by lack of a pervasive cleavage and by locally abundant plant fossils including deciduous leaf imprints and coal. It is primarily of nonmarine alluvial, fluvial and possibly lacustrine(?) origin.

The Early Tertiary clastic succession consists of the following interfingering units: dark brown weathering argillite; light brown weathering platy wacke, which locally contains black, well-rounded pebbles of vesicular basalt; laminated to medium-bedded shale, siltstone, and sandstone with coal-bearing interbeds and minor conglomerate; pebble conglomerate, made up of subangular to subrounded clasts of black argillite, chert, shale, limestone and intermediate to felsic volcanics in a muddy matrix; and angular to well-rounded coarse cobble to boulder conglomerate.

Three coarse conglomerate end-members are recognized on the basis of the type of substrate eroded: limestone clasts in a carbonate matrix, diorite-clast conglomerate and breccia, and green volcanic clasts in a red, oxidized matrix. Limestone conglomerate may contain up to 50 per cent well-rounded, unfoliated basalt clasts. Lack of a fabric in volcanic clasts suggests that they may be derived from relatively young volcanic rocks like those that cap Carmine Mountain.

Very coarse rocks comprise the bulk of the section in the northeastern part of the depositional basin, and are essentially absent at the southwestern end, where a relatively thin basal unit consists of mixed lithic-pebble and rare argillite-cobble conglomerate. Overall, rocks in this basin fine from east to west and north to south. Stratification in the conglomerates ranges from absent to crude and subhorizontal, locally with pebble imbrication. Within the coal-bearing section of sandstone, shale and conglomerate, sandstone beds are medium to thick, lensoidal, and vary from trough cross-stratified to ripple cross-stratified to planar bedded, with laminated shale to fine sandstone interbeds. Locally abundant plant fossils, including fragments of leaves and stems of broadleaf and less commonly needle-leafed plants are most common in this part of the section. Coal seams, generally less than 50 centimetres thick, occur within the shaly parts of the section. The wacke unit makes up perhaps 70 per cent of the section in the southern end of the basin. It consists of a monotonous sequence of poorly bedded, fissile sandstone with rare plant fossils. Argillite is only a minor constituent, most closely associated with the wacke unit.

The type and distribution of facies (Plate [illegible]-13-6) suggests that the lower Tertiary section was deposited in a fault-bounded basin, with alluvial fans derived from a large fault scarp bounding the eastern side of the basin, grading westward into fluvial deposits. During part of the basin history the northern part of the fault scarp evidently had greater relief than the southern part. Wacke and argillite units in the southwestern part of the basin represent lower energy, possibly lacustrine, environments.

Coarse arkose (probably locally derived from adjacent Jura-Cretaceous plutonic rocks) and conglomerate, locally with interbedded coal, are found in association with massive, light grey to light yellow, clay-rich units, several metres thick, in small basins along the Tats Creek valley. Clay beds of this type generally have a volcanic source, suggesting a possible tie with Eocene and Oligocene (?) volcanic strata east of the immediate study area (Campbell

Plate 1-13-6. Coarse angular limestone conglomerate of probable Early Tertiary age was probably deposited not far from a basin-bounding fault scarp.

and Dodds, 1983a). Basin formation is probably contemporaneous with major Late Cretaceous to Early Tertiary north to northwest-trending strike-slip faulting in the region.

Tertiary(?) Carmine Mountain Volcanics

On Carmine Mountain (114P/11) a relatively flat-lying volcanic and sedimentary sequence unconformably overlies lower Paleozoic marble, and apparently includes stratigraphic elements of both middle and late Paleozoic and Early Tertiary age. Units that directly overlie the Paleozoic marble are slightly foliated and include: medium to dark green lapilli tuff and agglomerate; carbonate-matrix limestone cobble to boulder conglomerate; subangular argillite-chip pebble conglomerate; and well-rounded polymictic pebble conglomerate. Limestone float with corals of possible Devonian age was found in a covered area between the first two units. Carmine Mountain is capped by massive andesite and lesser basalt flows, massive to columnar jointed dacite and rhyolite flows, and light to medium grey or grey-green dacitic to rhyolitic ash and lapilli tuff. Together with the conglomeratic rocks these felsic volcanic strata are essentially undeformed, and may be Early Tertiary in age, possibly correlative with the "Oligocene and older" volcanics of Campbell and Dodds (1983a).

INTRUSIVE ROCKS

Intrusive rocks underlie about 25 per cent of the map area, increasing in abundance to the west. Basic intrusive rocks range from Cambro-Ordovician to Tertiary age. Intermediate to felsic intrusives are dominantly Mesozoic or younger.

Jurassic(?) and Older

Intrusive units of presumed pre-Jurassic age range in composition from diorite to gabbro and are commonly foliated. They underlie parts of the westernmost and easternmost map area. Age is constrained by their crosscutting relationship with carbonate strata at least as young as Ordovician, while some evidence supports transitional relationships with basaltic rocks interbedded with upper Paleozoic(?) strata. At two localities in the upper Tats Valley (114P/12), map patterns suggest that these rocks are crosscut by part of the Jura-Cretaceous plutonic suite. Such an interpretation is supported by observations at one locality where a mafic border phase apparently intrudes older basaltic rocks. The rocks include an amphibolite unit, an agmatite unit, and a greenstone, gabbro and diorite complex.

VARIABLY FOLIATED, POLYPHASE BASALT-GABBRO COMPLEX

Previously unmapped rocks of a basalt-gabbro complex form elongate bodies less than a kilometre across (114P/12) but several kilometres long, which display intrusive relationships with each other and enclosing Paleozoic carbonates west of Tats Glacier. Intrusive phases included in this complex are a brecciated, medium-grained hornblende-feldspar-porphyritic gabbro or diorite, and a crowded feldspar-porphyritic hypabyssal body with a black groundmass which is intruded by and intrudes a dark green, aphanitic basaltic phase. A weak to strong foliation is locally developed and all units are chloritized and epidotized.

These rocks may be correlative with nearby basalt agglomerate which apparently forms part of the Paleozoic stratigraphy. They may also be related to the Paleozoic to Mesozoic greenstone-carbonate complex or the Squaw-Datlasaka Ranges gabbro-diabase sills of Campbell and Dodds (1983a). However, both the aphanitic and porphyritic phases are lithologically similar to flows within the Tats group volcanic stratigraphy. Current age controls do not provide a basis for favouring one or the other of these alternative correlations.

SQUAW-DATLASAKA GABBRO-DIABASE

Several lithologies are included in this unit which is widely exposed in the Squaw Range (114P/14). It is composed of variably foliated, medium-grained, aphanitic to feldspar-porphyritic basalt, diorite and gabbro. South of Talbot Creek the unit is mainly dark green to black weathering and grades both south and west into a dike complex within Ordovician carbonate with a steady increase in the number of screens of marble (and felsic tuff?). They are locally cut by coarse quartz-carbonate veins up to 20 centimetres wide. These rocks are interpreted as Paleozoic to Mesozoic intrusive rocks by Campbell and Dodds (1983a).

Rocks north of Talbot Creek that were included with this unit by Campbell and Dodds (1983a) are mainly bright green due to ubiquitous chlorite-epidote alteration. They intrude intercalated wacke and other marine sediments, flows and tuffs. Mylonitic fabrics are locally well developed on the margins of these bodies, particularly the structurally lower contacts. As a consequence, we attribute at least some repetition of these sills to west-dipping thrust faults.

JURASSIC-CRETACEOUS PLUTONS

Intrusive rocks of Jurassic to Cretaceous age comprise the volumetrically most significant intrusions in the central and western parts of the map area. These include the Noisy Range batholith, Battle Glacier batholith, Easy pluton and the Not Yet pluton, which form north-northwest-trending, elongate bodies conforming to the regional structural fabric. In most intrusions of this age it is possible to demonstrate an early, foliated, dominantly dioritic border phase and a later granodioritic to quartz monzonitic phase. Foliated zones are also present in the relatively younger, more felsic phases.

Potassium-Argon cooling ages from these bodies fall within the 130 to 160 Ma range (Dodds and Campbell, 1988), and place them in the Saint Elias Plutonic Suite of Campbell and Dodds (1983a).

DOMINANTLY DIORITIC (BORDER) PHASE

Dominantly dioritic rocks occur as homogeneous bodies in the westernmost part of the map area (Battle Glacier batholith) or as heterogeneous border phases around relatively homogeneous granodioritic to quartz monzonitic bodies, and as small plutons in 114P/13 and 14 and 114O/16. They are dominated by orange to green-weathering, medium to coarse-grained, epidote and chlorite-altered diorite. Adjacent the Border Ranges fault they are particularly strongly deformed and are intruded by variably deformed fine-grained porphyritic dikes with black to white, tabular plagioclase phenocrysts.

Where these dioritic phases are restricted mainly to the borders of more felsic bodies or to small plutons, several distinct phases are typically present. These range from hornblendite to hornblende-rich quartz diorite or hornblende leucogabbro containing rare coarse, euhedral plagioclase crystals. Each phase or mixture of phases may vary from fine to very coarse grained and unfoliated to strongly foliated. Foliation generally follows a northwest to northeast trend, concordant with the foliation in the intruded Paleozoic to Mesozoic metasedimentary country rocks, suggesting forceful emplacement. The intrusions commonly contain up to 25 per cent irregularly shaped, foliated, melanocratic xenoliths composed mainly of hornblende, biotite and plagioclase. Unfoliated aplitic to pegmatitic dikes and epidote-calcite-quartz veins commonly cut the border phase (Plate 1-13-7).

Skarn associated with dioritic phases is best developed north of the Windy Craggy area (114P/13) where mineralized garnet-epidote-diopside-wollastonite skarn hosts irregularly distributed pods and lenses of massive and disseminated pyrrhotite, chalcopyrite, sphalerite and magnetite at the contact between carbonate and clastic sediments (*see* Part D).

GRANODIORITE TO QUARTZ MONZONITE PHASE

Leucocratic phases dominate the relatively homogenous interiors of many of the large Jura-Cretaceous plutons. Medium to coarse-grained, weakly to strongly foliated biotite hornblende granodiorite or tonalite to hornblende-biotite quartz monzonite are most common. Both end-member compositions are light to medium grey and blocky weathering. Average outcrops are composed of 60 to 70 per cent fresh, equigranular feldspar, 10 to 30 per cent interstitial quartz, and 20 to 30 per cent hornblende and biotite. Hornblende crystals are usually shiny black, prismatic and subidiomorphic. Biotite forms hypidiomorphic booklets up to 1 centimetre in diameter. These rocks occasionally con-

Plate 1-13-7. (a) Polyphase intrusive border phase typical of the Saint Elias Plutonic Suite. Several foliated and unfoliated mafic phases are cut by late aplitic phases. (b) Zones rich in platy xenoliths, such as the one shown here, are common within Jura-Cretaceous plutons, particularly near margins or screens.

tain potassium feldspar megacrysts up to 2 centimetres in size, which may be zoned. The potassium feldspar content of the matrix is not known.

Paleozoic carbonate-rich sediments in contact with leucocratic intrusions are only weakly altered, in contrast with the well-developed skarn alteration associated with the dioritic intrusive phases. Contacts are usually concordant with compositional layering in the country rocks and the contact zones may contain up to 80 per cent decimetre to metre-sized, rounded, elongate or equidimensional, mafic-rich xenoliths. The xenoliths are mainly composed of hornblende, biotite and lesser plagioclase and tend to decrease in quantity away from the contact. Narrow aplite and felsic pegmatite dikes are common. Where a foliation is developed it is generally concordant with layering in the country rocks, indicating forceful emplacement. Weak chlorite-epidote-altered zones occur locally.

Oligocene (?) Tkope Plutonic Suite

The southeastern part of the map area (114P/11E, south of the O'Connor River) is partially underlain by the Tkope River batholith (Jakobsen *et al.*, 1980), which occupies the western margin of a series of much larger, epizonal, polyphase but dominantly granitic intrusions of the Oligocene Tkope Plutonic Suite (Campbell and Dodds, 1983a).

Within the map area, the batholith is homogeneous, unfoliated and dominated by pinkish, fine to medium-grained, equigranular, hornblende biotite granite. Biotite occurs as glomerocrysts. Weathered surfaces are greenish grey and blocky. Volumetrically less significant biotite-hornblende granodiorite and alaskite are also present. Batholith borders are unfoliated, medium-grained gabbro and diorite. An intrusion in the extreme northeast corner of 114P/11, consisting of orange to pink-weathering medium-grained granite, may also be part of the Tkope suite.

PART C: DEFORMATION AND STRUCTURAL STYLES

By M.T. Smith, M.G. Mihalynuk, and D.G. MacIntyre

INTRODUCTION

The Tatshenshini project is a mapping and mineral potential study of portions of NTS map sheets 114O and 114P lying west of the Haines Highway, and centred on the Windy Craggy copper-cobalt volcanogenic massive sulphide deposit. Goals of the project, field methodology, and field season statistics are outlined in Part A of this paper, and lithologic descriptions are provided in Part B; Part D describes the major areas of mineral potential. We have emphasized collection of structural data in our field program, as a clear understanding of the structural geology of the region is critical to predicting its mineral potential, both in terms of defining structures that host mineral deposits and more generally, defining areas of favorable geology. In order to avoid redundancy, the reader is referred to summary diagrams in Parts A and B of this paper for names of geographical features, detailed geology, locations of major terranes, *etc.* (Figures 1-13-1, 1-13-2).

The deformational history and structural styles evident within the Tatshenshini map area are complex and highly variable. An early (pre-Triassic?) phase of ductile deformation is manifest primarily by isoclinal folds of variable orientation. The main phase of ductile deformation, evidenced by tight to isoclinal folds and low-grade greenschist facies metamorphism, postdates deposition of the informally named Upper Triassic Tats group. It both predates and is coeval with Late Jurassic to Early Cretaceous plutonism, as some plutons contain a foliation parallel to the regional trend of deformation, while others crosscut some fabric elements. Emplacement of Jurassic-Cretaceous plutons resulted in additional folding, elevated synkinematic metamorphic grade and/or postkinematic contact metamorphism near the margins. The last (composite) phase of deformation is ductile to brittle in nature and resulted in the local development of penetrative shear fabrics and crenulation cleavage, and discrete faults and shear zones, including large northwest-trending faults. Some faults record early sinistral and later dextral strike-slip movement. The latter are associated with east-trending (antithetic?) cross faults. This phase of deformation is suspected to be in part Early Tertiary, based on the presence of fault-related sedimentary rocks of this age in small graben-like structures, and by association with other large dextral strike-slip faults in the region such as the Denali and Border Ranges faults (*e.g.*, Lanphere, 1977; Roeske *et al.*, 1990). A separate domain of northwest-striking amphibolite grade gneiss and schist is exposed along the western border of the study area in 114O/15 and 114O/9. Its relationship to the rest of the map area is unclear.

A CAUTIONARY WORD

Foliation types and orientations, and fold sets, are difficult to classify because of dramatic contrasts in the relative competency of different units, a condition which is present on all scales. Bedding in the Paleozoic carbonate sequence is often transposed, and these rocks readily deform into a confusing array of seemingly randomly oriented ptygmatic folds, particularly adjacent to intrusive contacts (Plate 1-13-8). By contrast, sedimentary structures are well preserved in the relatively resistant Cambrian-Ordovician volcanic sequence, where most of the deformation is taken up by brittle faults in the hinge zones of large kink folds. Another extreme example of competency contrasts is in the Upper Triassic sequence, where the Tats group lower sedimentary sequence is tightly folded and sheared, but pillows in the overlying basalt sequence are almost undeformed. On an outcrop scale, competency contrasts are well displayed in large carbonate and (to a lesser extent) argillite domains that are intruded by 10 to 50 per cent mafic dikes (Plates 1-13-9 and 1-13-10). The latter are broken and boudinaged, while the carbonate has flowed around the competent layers, resulting in complex fold patterns. On an even smaller scale, thin bedded argillite and limestone units show spectacular examples of brittle-ductile behavior in rocks that are folded or display shear fabrics (*see* Part B, Plate 1-13-3).

Large strain gradients are in evidence even in relatively homogeneous rocks. Plate 1-13-11 illustrates the effects of simple shear(?) on a marker bed consisting of rugosan packstone. Over an interval of approximately 20 centimetres, the corals range from nearly undeformed to almost unrecognizable, with a minimum of several hundred per cent elongation of the corals at the bottom of the bed. As this phenomenon would probably pass unrecognized in a monotonous sequence of argillite or limestone, it underscores the need for caution when interpreting the thickness, nature and distribution of sedimentary sequences (and stratiform mineral deposits) in this area.

BEDDING, CLEAVAGE AND FOLIATION

All strata with the exception of the Tertiary are cleaved or foliated. Rocks south of the Vern Ritchie Glacier and along the western border of 114O/15 are completely recrystallized and lack protolith textures; the dominant planar element is a gneissic to coarse schistose layering. In all other areas protolith textures are at least locally preserved, with bedding commonly parallel or subparallel to foliation. As already mentioned, bedding may be transposed into the foliation direction, particularly in thin-bedded carbonates. This phenomenon is primarily restricted to areas adjacent to the high-grade metamorphic rocks, the margins of plutons and to the Squaw Range. Elsewhere, metamorphic layering usually takes the form of a weakly to strongly developed axial planar cleavage, ranging from slaty to phyllitic in nature.

Representative orientations of planar elements (including bedding and foliation) are illustrated in Figure 1-13-5, together with orientations of folds. In much of the area, foliation and bedding strike north to northwest, roughly parallel to the regional trend of major faults. Notable exceptions are the southwest part of 114O/16, where an east-

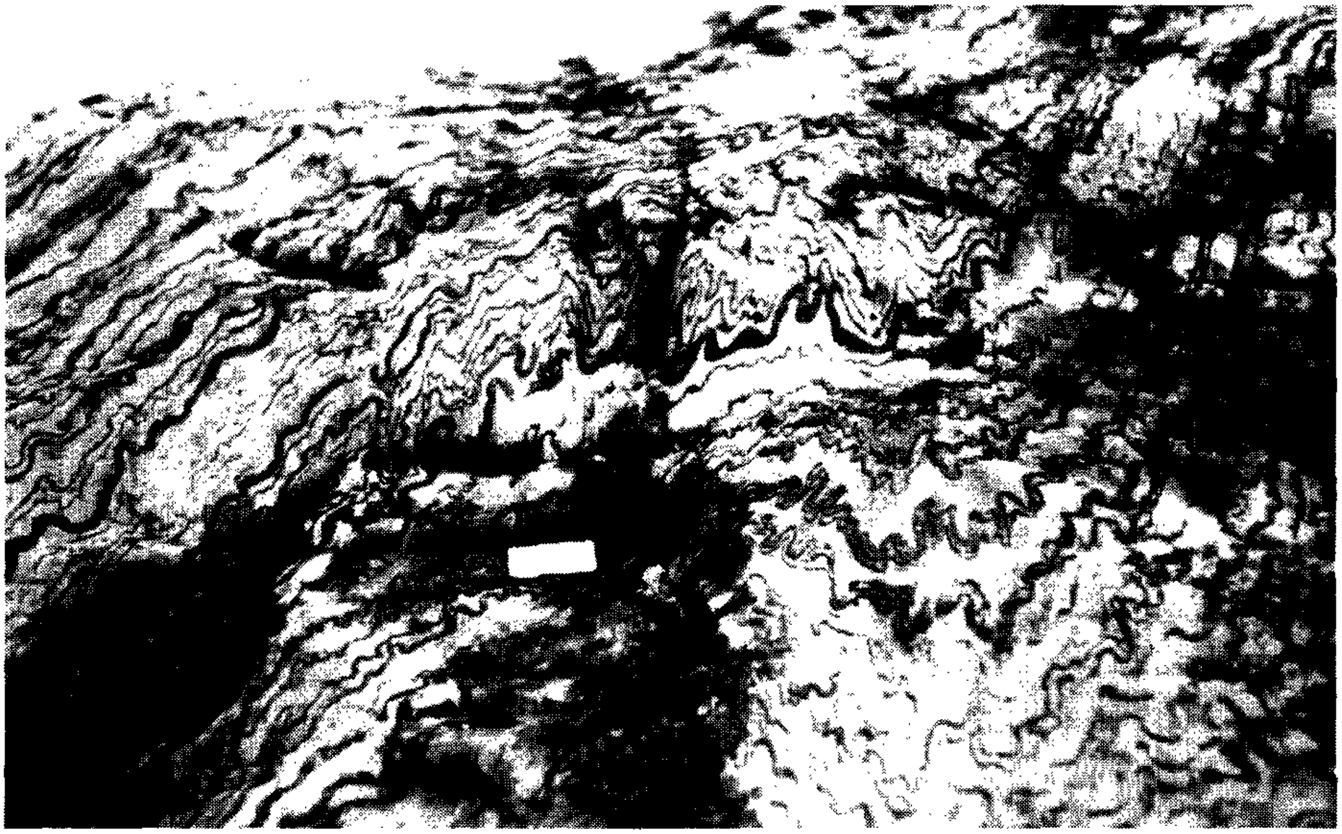


Plate 1-13-8. Ptygmatic folds in marble adjacent to a pluton. The rectangular card is 10 cm long.

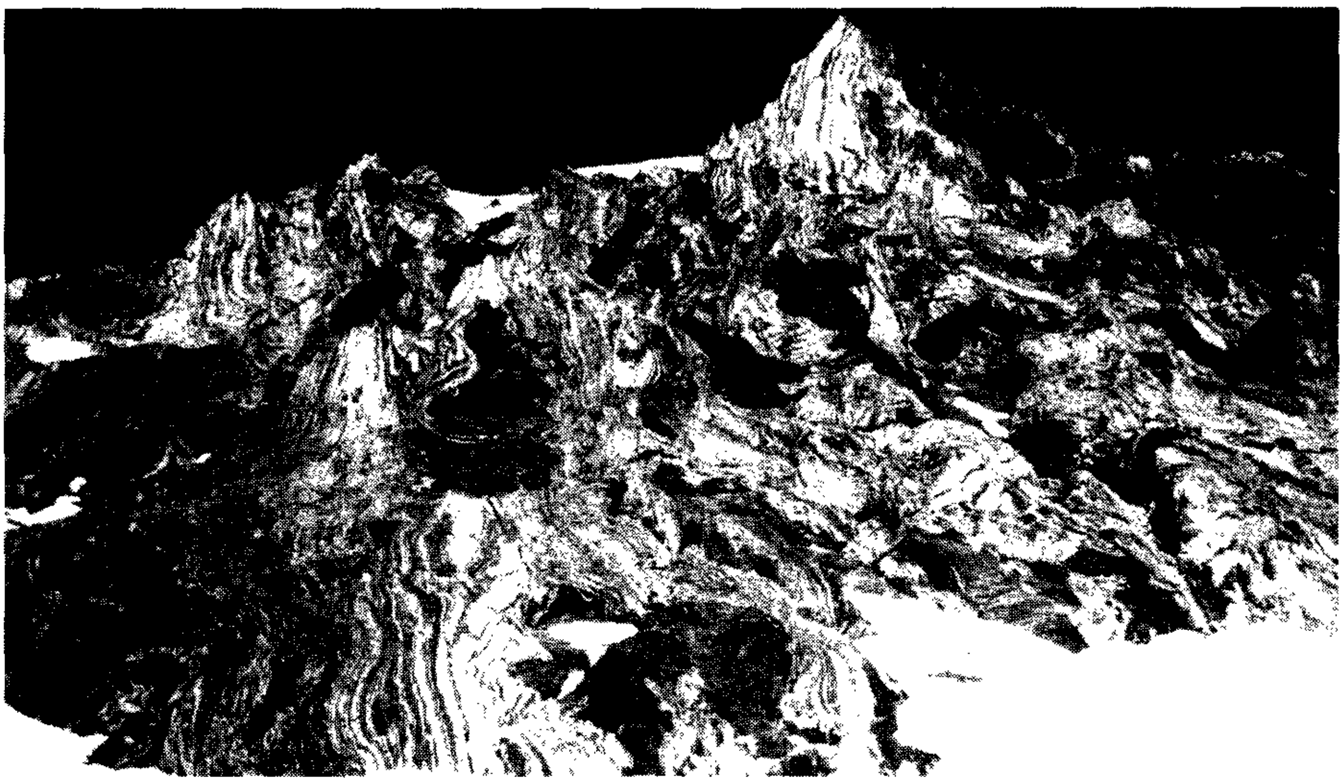


Plate 1-13-9. Boudinage of mafic dikes in marble. View is up and to the north, with the total elevation gain from the bottom to the top of the photo approximately 800 metres. Dark coloured boudins are 3 to 10 metres thick. Note the complex fold patterns produced in response to necking and boudinage of relatively brittle dikes. Photo was taken near the head of Henshi Glacier.

Plate 1-13-10. Boudinaged mafic sill in ductily deformed argillite. Rectangular card is 10 centimetres long.

Plate 1-13-11. Evidence of strain partitioning in limestone. Rugosan corals in the middle part of the photograph are essentially undeformed, and become extremely elongated over an interval of only a few centimetres.

northeast strike prevails, and in the southeast part of 114P/11, where the complex interaction of plutons, folds and faults produces a diverse pattern of foliation orientations.

FOLDS

The earliest generally recognized phase of folding is manifest as a set of centimetre to metre-scale intrafolial isoclines of variable (though often gently plunging) orientation, reflecting variability in foliation orientation (Plate 1-13-12). This set is primarily restricted to the lower Paleozoic carbonate section, and is not clearly present in the Upper Triassic section, and thus may predate it.

The second protracted "phase" of folding resulted in mostly upright to steeply inclined, tight to isoclinal folds, often with tight (chevron) fold hinges. These folds range from map scale to tens of metres in amplitude, to centimetre scale. Representative fold axes from the map area are plotted on Figure 1-13-5. In many areas, notably in the southern part of 114P/14, the southeastern half of 114P/13, and the northern part of 114P/11, the axes of kilometre to decametre-scale folds are near vertical to steeply or moderately inclined to the north or south (Figure 1-13-5 and Plate 1-13-13). In much of 114P/12, the folds trend approximately northwest and dip moderately. In 114O/16 north,

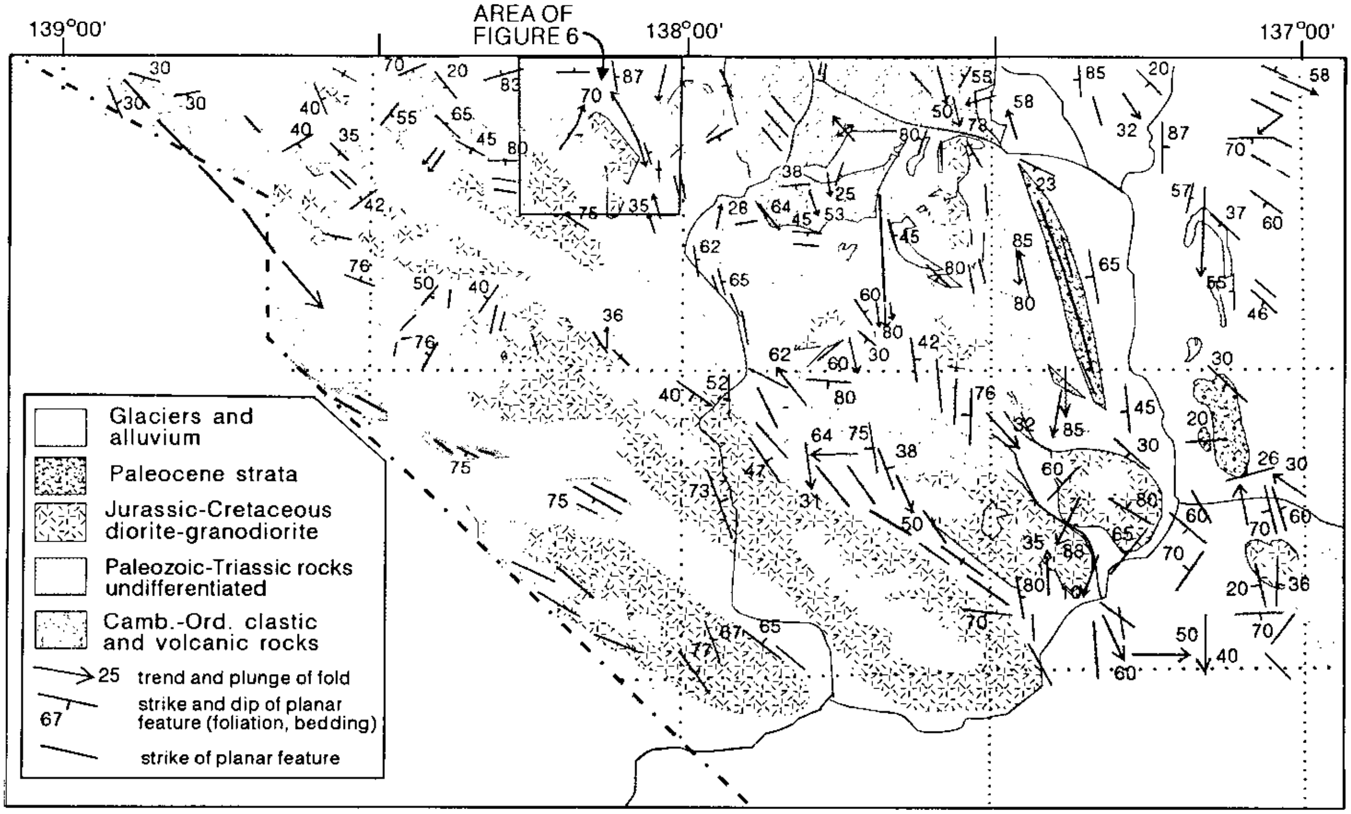


Figure 1-13-5. Simplified geological map showing major fold axes and foliation trends within the map area. *See* Part B, Figure 1-13-4 for a more detailed geological map.

Plate 1-13-12. First phase intrafolial isoclines in the Paleozoic carbonate unit. View is to the northwest. Photo is taken a few kilometres north of Tats Lake.

Plate 1-13-13. Second phase folds with steeply inclined axes, exposed on a cliff face. Helicopter for scale. Photo taken along the O'Connor River, south of Carmine Mountain

several large folds in the vicinity of Easy and Tough creeks range from open to tight and have gently to steeply plunging axes (Plate 1-13-14). The hinge lines and/or axes of these folds parallel the margins of several plutons (Figure 1-13-6). This suggests that the folds formed prior to Late Jurassic time and were shouldered aside during pluton emplacement, or were formed in response to intrusion during Late Jurassic to Early Cretaceous time. This interpretation of the timing of folding is substantiated by observations from other areas, where folds crosscut and are contact metamorphosed by intrusions (*e.g.*, Tatshenshini River valley north of the mouth of Henshi Creek), and by areas where the axial planar cleavage is manifest as a foliation in adjacent intrusive bodies.

In the gneissic package of rocks in 114O/9 and 10, folds trend northwest but have horizontal to gently plunging hinge lines. Their relationship to the steeply plunging folds to the east and northeast is unclear.

A number of "cross" folds with moderately east to north-northeast or west to north-northwest plunging hingelines postdate the earlier folds by an unknown time interval. Folds of this type are common in the northwestern half of 114O/16, where they are relatively open and have wavelengths of up to several hundred metres.

A late phase crenulation cleavage or kink banding is developed in some areas, largely restricted to the immediate vicinity of thrust faults at the contact of Triassic and Paleozoic rocks in 114P/12. In these areas, depositional laminae in argillite and limestone are deformed by centimetre-scale chevron folds (Plate 1-13-15 and may be transposed and thickened by densely spaced folds with wavelengths of up to 1 centimetre and amplitudes of up to 10 centimetres. Crenulation cleavage is also locally present in phyllitic argillite units in the Range Creek and Tatshenshini Valley areas.

Lastly, open, north to north-northwest-trending chevron folds with subhorizontal axes deform lower Tertiary strata west of the Tatshenshini River, and thus indicate deformation of Early Tertiary or younger age.

FAULTS

NORTHWEST-TRENDING FAULTS

The dominant fault set in the map area dips steeply and strikes north to northwest, parallel to the trend of crustal-scale, terrane-bounding, dextral strike-slip faults, including the Denali-Duke fault system (in the extreme northeastern corner of 114P/14) and Border Ranges fault (in the southwest corner of 114P/12 and 114O/9). Regionally, motion along these faults is interpreted to be mainly dextral strike-slip, mid-Cretaceous to Tertiary, and both ductile and brittle in nature (*e.g.*, Lanphere, 1977; Roeske *et al.* 1990). Other

Plate 1-13-14. Folded argillite (dark) and limestone (light) near the confluence of Tough Creek and Supercub Creek. View is to the east-northeast. Note thrust fault within the limestone sequence at left.

large northwest-trending faults in the study area are designated the Tats Creek, Sediments Creek and Debris fault zones (Figure 1-13-7).

BORDER RANGES FAULT

The Border Ranges fault is a major structure separating the Alexander Terrane from the outboard Chugach Terrane. To the south, Roeske *et al.* (1990) and Brew and Morrell (1979) describe the fault zone as a complex feature at least 10 kilometres wide. Brew and Morrell called this feature the Tarr Inlet suture zone, consisting of sheared phyllite, slate, conglomerate, chert and greenstone, interpreted to be Permian in age and part of the Wrangellia Terrane. They interpreted the northeastern boundary of this zone to be the Art Lewis fault of Campbell and Dodds (1983a), which trends down the Art Lewis and Battle glaciers but does not extend south of the terminus of the Battle Glacier, and the southern boundary to be the Border Ranges fault mapped by Campbell and Dodds (1983a) to south of the Reynolds Glacier.

A fault zone and related rocks that we interpret as part of the Tarr Inlet suture zone crops out long the northern margin of the Reynolds Glacier (114O/9) as a series of anastomozing brittle shear zones which cut the Jurassic-Cretaceous (148 and 172 Ma K-Ar hornblende ages; Dodds and Campbell, 1988) Battle Glacier batholith and the sedimentary rocks (chert, greenstone, greywacke and argillite of uncertain age and affinity) that it intrudes. At one location on 114P/12, discrete strands of the fault zone are up to 10 metres wide, outlined by strongly sheared quartz-graphite mylonite. In other areas the strain is more widely distributed to include other lithologies and silicic, argillic and chloritic alteration with disseminated sulphides are variably developed. A more intact sequence of rocks, similar to those involved in the fault zone is present in the northern Battle Range, intruded by plutonic rocks. We are unsure at this time whether they represent an intact "boudin" in the Tarr Inlet suture zone and are part of Wrangellia (as might be consistent with the interpretation of Brew and Morrell, 1979), or lie north of the zone and are part of the Alexander Terrane.

DUKE FAULT

The Duke fault, a strand of the Denali fault system as mapped by Campbell and Dodds (1983b), trends down Squaw Creek in the extreme northeast corner of 114P/14 and juxtaposes the Alexander Terrane and a small sliver of the Wrangellia Terrane. Our mapping indicates a northwest-trending, imbricate zone of high-angle and southwest-dipping thrust faults in this area. Some rock types exposed to the south of the original mapped trace of the fault are similar to some to the north. However, as our mapping covers less than 10 kilometres of the interpreted fault trace, we are reluctant to question its status as a terrane-bounding structure. Nevertheless, most deformation within the fault

zone appears to be younger (*e.g.*, Lamphere, 1977) than the Pennsylvanian stitching (Gardner *et al.*, 1988) of Wrangella and Alexander terranes.

TATS CREEK FAULT ZONE

The Tats Creek fault zone consists of a series of parallel, steep, northwest-trending faults that cut the Noisy Range pluton and Paleozoic and Mesozoic strata to the northeast (Figure 1-13-8), dissecting the latter into a series of narrow fault panels. Some of the fault strands, including one contact between the Noisy Range pluton and Paleozoic carbonates, have a ductile mylonitic fabric with sinistral shear sense, overprinted by more brittle dextral shears. Other fault strands contain only brittle fabrics. One such fault is continuous over a length of more than 12 kilometres within the Noisy Range batholith, and is manifest by a red and green zone of brecciation and cataclasis up to 30 metres wide, accompanied by chloritic and hematitic alteration of the country rocks. It may merge with or be related to a series of closely spaced parallel faults exposed at the north end of the Tats Creek valley, and may also be temporally related to a wide, mineralized gouge zone in plutonic rocks exposed near the mouth of Tomanous Creek, south of the Tatshenshini River (Figure 1-13-10).

At least three small (1 km^2) graben structures are present along these faults, containing poorly consolidated sedimentary rocks including sandstone, conglomerate and light grey to buff claystone. These rocks contain coal and other plant remains, and are interpreted to be Early Tertiary and of nonmarine origin on the basis of correlation with other similar coal-bearing units in the region. They are assumed to be contemporaneous with faulting and representative of local transtensional conditions (*i.e.*, small pull-apart basins).

Although post Early Tertiary movement on these faults cannot be interpreted with certainty, the possibility of Miocene to Recent movement is suggested by numerous topographic lineaments parallel to the faults and offset stream channels in the Tats Creek valley. Microseismicity studies of the Windy Craggy region over a recent 2-year period showed no significant seismic activity in this valley (Horner, 1989).

The full extent and distribution of faults in the Tats Creek valley is difficult to elucidate due to heavy brush and drift cover. However, at the mouth of Tats Creek, numerous closely spaced shear zones disrupt a section of rocks 3 kilometres wide exposed along the northwest bank of the Tatshenshini River.

DEBRIS FAULT SYSTEM

The Debris fault system consists principally of two north-northwest-trending faults which in part enclose a down-dropped, trough-like depositional basin filled with lower

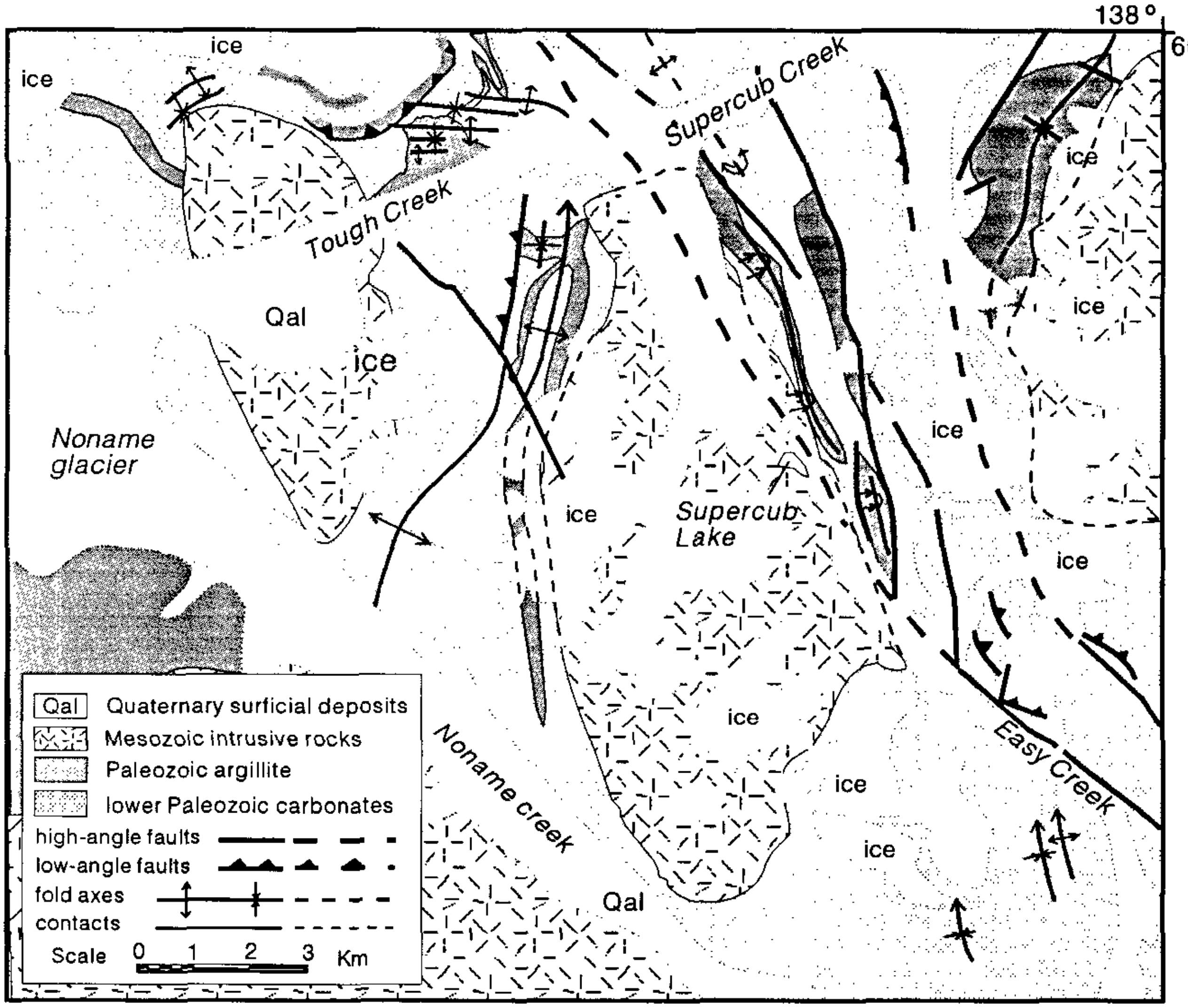


Figure 1-13-6. Detail of Supercub Lake area (114O/16) showing inter-relationship of folds and intrusions. *See* Figure 1-13-5 for location.

Figure 1-13-5. Simplified geological map showing major fold axes and foliation trends within the map area. *See* Part B, Figure 1-13-3 for a more detailed geological map.

Tertiary sedimentary rocks (Figure 1-13-10). The two bounding faults enclose numerous smaller faults, which may merge to the south into a single, moderately southwest-dipping fault. The westernmost fault is, in part, a west-dipping, high-angle reverse fault that places the Paleozoic carbonate sequence over the lower Tertiary sedimentary rocks. Facies distribution (*i.e.*, lack of coarse detritus adjacent to the fault) of sedimentary rocks in the Early Tertiary basin suggests that most of the dip-slip motion on this fault postdates sedimentation. Maximum synsedimentary displacement is on the easternmost fault, as evidenced by a boulder conglomerate and breccia unit within the sedimentary sequence adjacent to the fault, suggesting derivation from a fault scarp and down-to-the-west displacement. A brittle shear zone at least 50 metres wide is in part contained within bluish, chlorite-altered volcaniclastic rocks and marks the main fault trace. Cumulative down-to-the-west dip-slip motion across the fault is estimated to be at least a kilometre; the magnitude of strike-slip motion is unknown. Quaternary cover within the Tatshenshini and Tkope River valleys obscures the southern continuation of the fault.

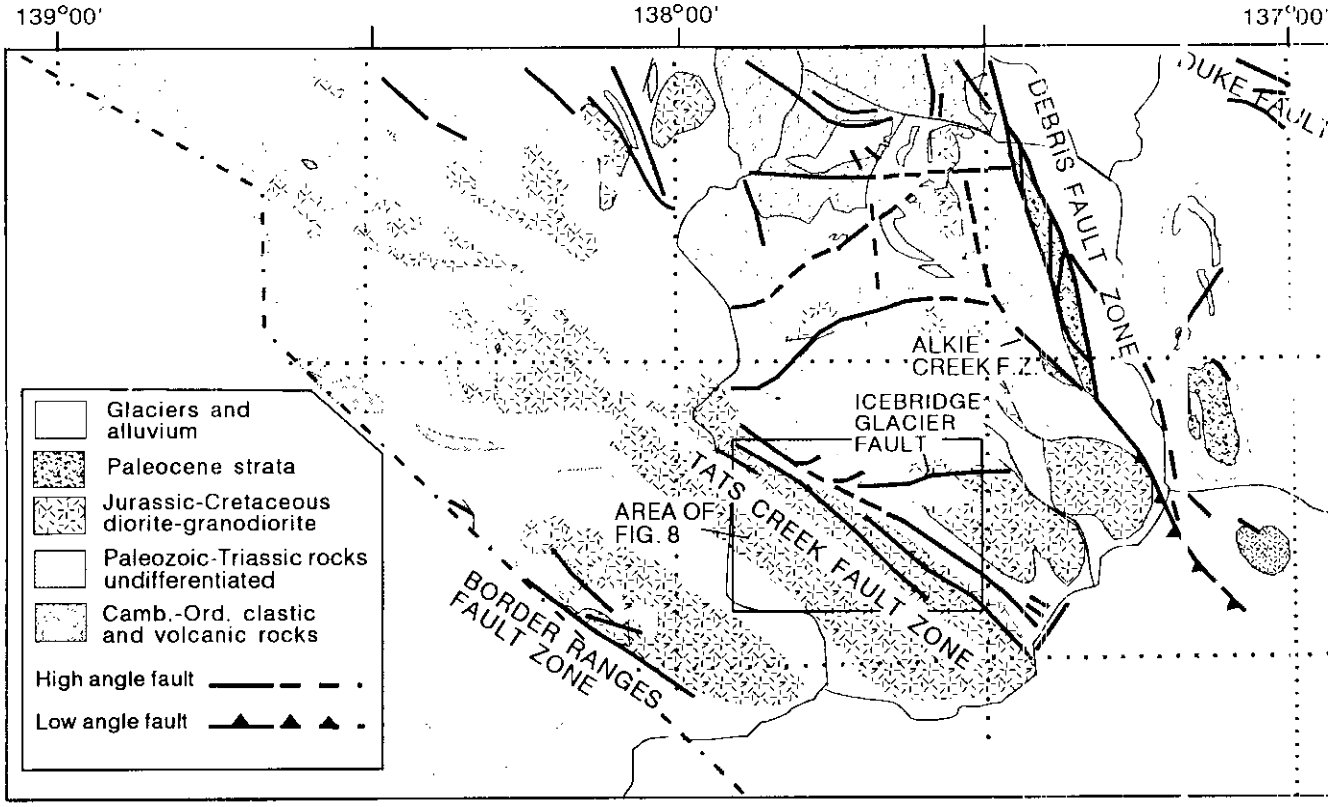


Figure 1-13-7. Simplified geological map showing the distribution of major faults in the map area.

However, excellent exposures in one locality in the Tkope River valley reveal a moderately south-southwest-dipping shear zone at least 30 metres wide, developed in a sequence of graphitic argillites juxtaposed against a relatively intact sequence of sandstones and calcsilicate rocks, which may be the continuation of the fault zone.

OTHER NORTH AND NORTHWEST-TRENDING FAULTS

The northwest-trending, anastomosing Alkie Creek fault zone is apparently a splay off the main Debris fault zone, which crosses, then parallels the northern margin of Alkie glacier (local name). It bounds another wedge of lower Tertiary sedimentary rocks. Several parallel high-angle faults also transect the South Range Creek area (114P/13N), the area of Easy Creek and Supercub Creek (114O/16) and the Silurian-Permian section north of the upper Tweedsmuir Glacier (informal: No Name glacier) on the same map sheet.

North-trending faults are mapped in the eastern part of 114O/16, north of the Alsek River, and in 114P/13, where they offset the Cambrian-Ordovician volcanic and lower Paleozoic carbonate contact. Similar faults also occupy the prominent north-trending glacial valleys on this map sheet. These faults lie within and are parallel to the tightened hinges of large north-trending folds. This phenomenon is well displayed in south-facing slopes north of the Alsek River and east of Easy Creek, where the hinge areas of several upright, kilometre-scale chevron folds in the mega-cycle sequence are faulted.

EAST-TRENDING (ANTITHETIC?) CROSS FAULTS

A series of east-trending cross faults dissects the map area, particularly on the 114P/12 and 114/P 3 map sheets. They do not appear to offset the northwest-trending faults, and thus may be coeval and antithetic.

Southernmost and largest of the mapped east-west trending faults is the Icebridge Glacier fault (Figure 1-13-8). Near Icebridge Glacier, this fault is manifest as a discrete fault zone with approximately 1.5 kilometres of post Early Cretaceous sinistral strike-slip motion, probably antithetic to dextral motion on the Tats Creek fault zone. The timing and sense of motion are constrained by offset of a pluton contact and accompanying brittle deformation of its thermal aureole. This fault zone widens to the east where a zone of fault breccia and gouge within Jurassic-Cretaceous plutonic rocks is at least 1 kilometre wide (Plate 1-1?-16). A series of four subparallel faults, spaced approximately a kilometre apart, are mapped to the northwest (Figure 1-13-8). Offset on each of these faults is unknown, but is expected to be less than on the Icebridge Glacier fault.

The recognition of the Icebridge Glacier fault and other east-trending faults in this area has important implications for mineral potential studies. The Tats showing (MacIntyre, 1984) is terminated to the south along the Icebridge Glacier fault. The newly discovered Rainy Monday showing (*see* Part D) is terminated to the north along the fault. Further investigation may reveal that the two represent the same.

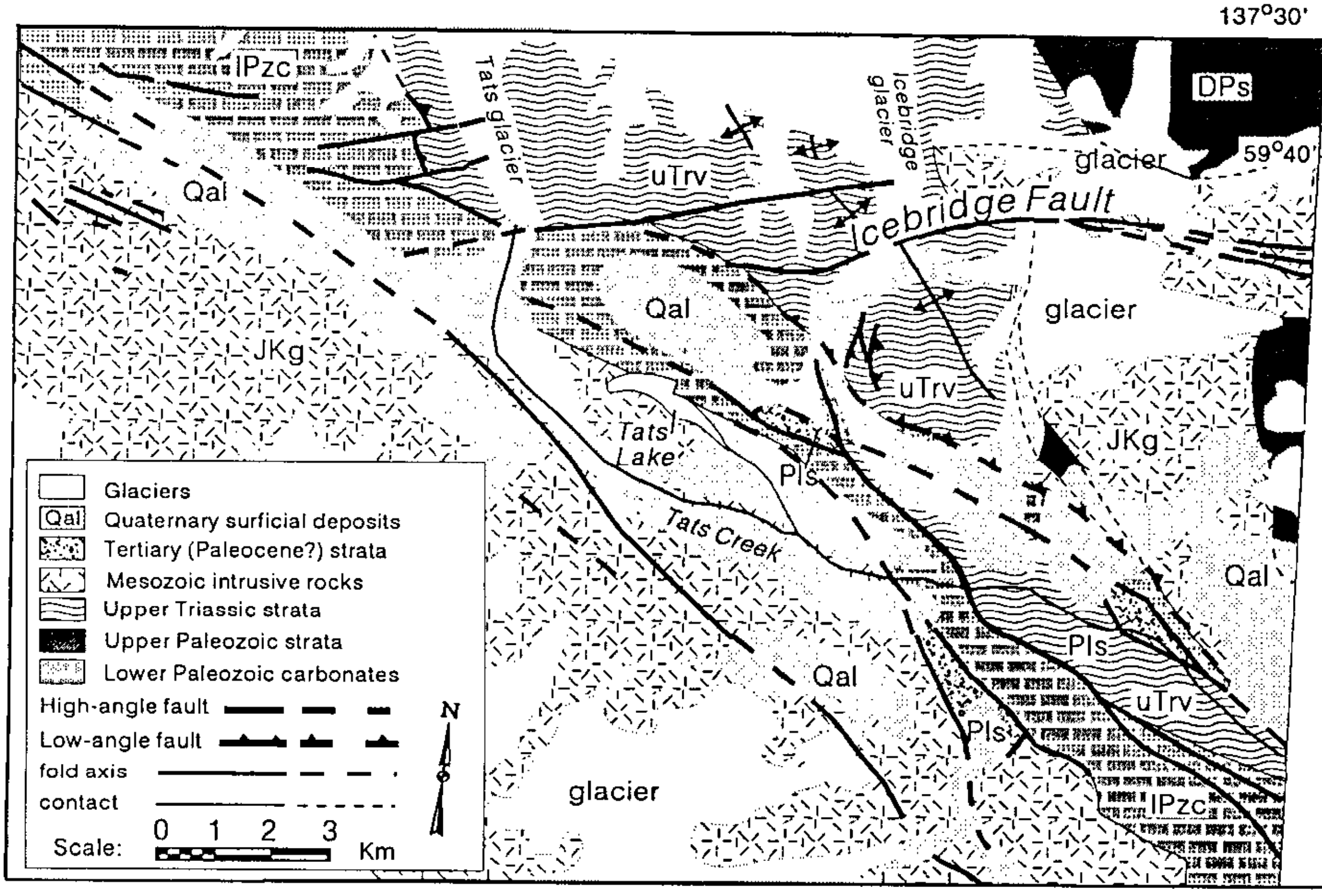


Figure 1-13-8. Detail of Tats Creek valley showing distribution of major northwest-trending strike-slip faults, and east-trending cross faults. *See* Figure 1-13-7 for location.

Plate 1-13-16. Icebridge Glacier fault zone near Henshi Creek. The lighter coloured rocks at left are brittly deformed granite. View is to the east, approximately parallel to the fault zone.

offset massive sulphide horizon. Other massive sulphide bodies, including the Windy Craggy orebody, may also be offset along these faults.

Approximately 20 kilometres to the north of the Icebridge Glacier fault, a large, arching, east-northeast-trending fault on the southern edge of 114P/13 may have relatively large displacement. It places Upper Triassic and Devonian-Permian rocks to the south against Paleozoic carbonate rocks to the north. Another fault with smaller displacement parallels it 10 kilometres to the north.

Lastly, a series of small, northeast to east-trending faults dissect the Cambrian-Ordovician volcanic units in 114P/13. These are most evident where they offset the contact between the volcanic unit and overlying Paleozoic carbonates. Overall, the sense of offset across many of these faults is north-side-up, with each block exposing deeper stratigraphic levels. Each individual block appears to be rotated slightly, with down-to-the-south sense of motion. Additional work will confirm this interpretation. Numerous smaller scale faults may show sense of motion similar to that described above.

Thrust Faults

Large numbers of thrust faults are not readily apparent in the map area, although cryptic thrust faults, particularly in the monotonous carbonate unit may be identified as we receive more biostratigraphic information. The northwestern contact of the Tats group is an east-dipping thrust, and a series of stacked northeast-dipping thrust faults can be seen in the lower Paleozoic carbonate sequence at the mouth of Easy Creek. A thrust fault within the carbonate sequence at the mouth of Tough Creek is illustrated by Plate 1-13-14. As previously described, the Debris fault zone may merge to the south with a gently south to southwest-dipping zone with top-to-the-north (dextral reverse) displacement. Several southwest-dipping thrust faults have also been mapped in the Squaw Range.

PENETRATIVE SHEAR FABRICS

Evidence of penetrative ductile shear has been noted in several locations. In some cases, it is clearly related to a mapped fault, such as the zone of mylonitic rocks along Tats Creek. In other areas, diffuse zones of sheared rocks are not clearly related to any discrete fault. They consist of a series of closely spaced shears which disrupt the foliation or bedding, and form a penetrative fabric on outcrop and larger scales (Plates 1-13-17a and b). These zones are widely distributed throughout the map area, particularly on 114P/12 and 114P/13, are typically steeply dipping, oriented east-west to northwest-southeast, and show both dextral and sinistral shear sense.

DISTINCT STRUCTURAL DOMAIN IN 114O/9 and 114O/15

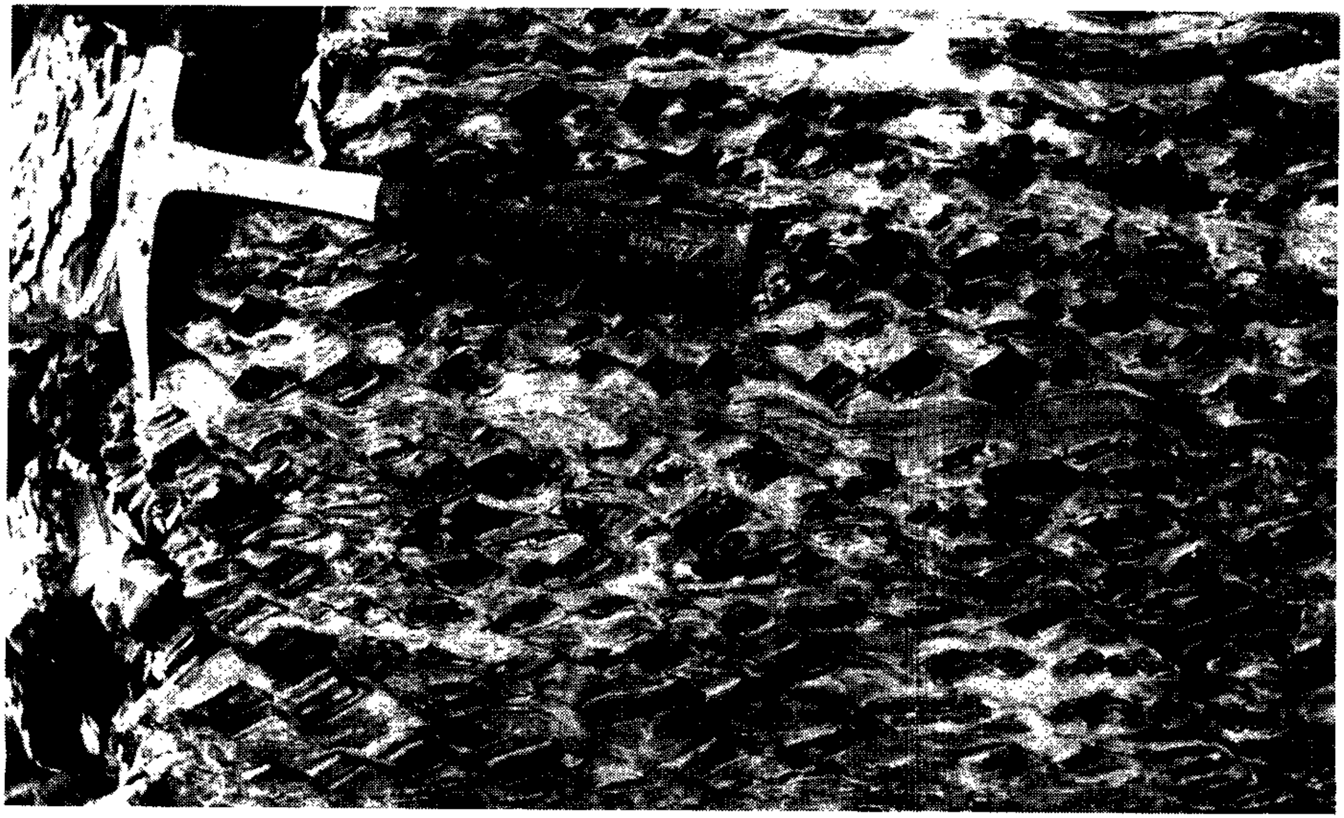
A distinct structural domain consisting of strongly deformed amphibolite-grade rocks underlies the nunatak and ridge system that divides the Vern Ritchie and Battle glaciers in 114O/9, and areas along the western margin of 114O/15. These rocks consist of medium-grained plagioclase-hornblende gneiss, calcsilicate gneiss and biotite-quartz-feldspar schist. In 114O/9, they form a series of northwest-striking, steeply southwesterly dipping compositional bands, with foliation parallel to compositional layering. Tight to isoclinal folds and mineral lineations also follow this northwesterly trend and dip gently to moderately to the southeast. Competent layers within this package are isoclinally folded and refolded, then boudinaged, testifying to a complicated strain history (Plate 1-13-18). Sinistral shear-sense indicators predominate in the area of the nunatak, however, there is evidence for both dextral and sinistral shear in other locations.

It is uncertain how this domain relates to the rest of the study area. The contact between these and lower grade rocks to the northeast is intruded by a linear diorite body in one locality; elsewhere it is ice covered. The zone of high-grade rocks is parallel to a ductile shear zone in the Tats Creek valley with sinistral shear sense; thus the former may represent the deeper levels of a northwest-trending sinistral shear zone of late Mesozoic age. This hypothesis may be important from a mineral potential standpoint as it implies significant offset of the presumed western continuation of Tats group stratigraphy. Alternatively, these rocks may be analogous to the pre-Ordovician Wales Metamorphic Suite of Gehrels (1990), which forms the basement to the rest of the Alexander Terrane in southeast Alaska, and with which the rocks in the present study area share many lithologic and structural characteristics. However, we have not as yet identified any appropriate candidates for radiometric determination of protolith age in order to test this hypothesis.

METAMORPHISM

As with structural styles, the metamorphic history of rocks in the map area is difficult to summarize due to the large area, the presence of numerous plutons, which underlie over 30 per cent of the area, and the predominance of lithologic types such as limestone and argillite that do not facilitate recognition of isograds at subamphibolite metamorphic grades. The presence of authigenic albite, chlorite and epidote in mafic rocks interbedded with the above indicates that most rocks in the study area are subgreenschist to low greenschist facies. Adjacent to the margins of large plutons, foliated pelitic rocks contain fine-grained biotite and rare garnet, and mafic rocks contain fine-grained actinolite, suggestive of low to middle greenschist facies conditions. Contact metamorphic aureoles are also present around the margins of some plutons, suggesting that, in at least some cases, intrusion of the Jurassic-Cretaceous suite outlasted metamorphism.

Gneissic and coarse schistose rocks in the southwestern part of the study area record metamorphic conditions distinctly different from those elsewhere. Rocks with mafic protoliths are amphibolite-grade hornblende+plagioclase+biotite±garnet gneiss or schist and pelitic assemblages contain the assemblage biotite+muscovite+garnet+plagioclase+quartz. Rocks in some areas contain a weak greenschist facies (actinolite+chlor-



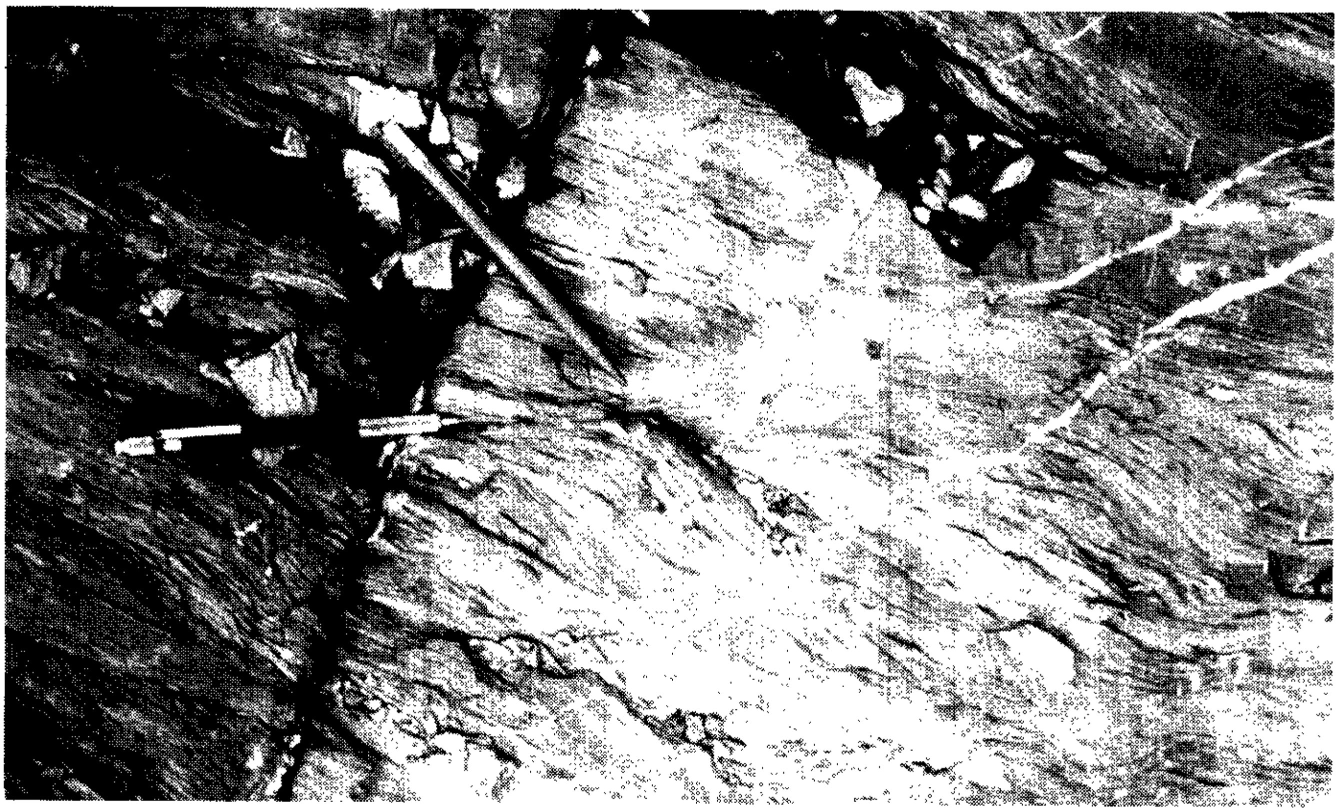


Plate 1-13-17. (A) Shear fabric developed in a sequence of thin-bedded argillite and limestone. The limestone has flowed, whereas the argillite has deformed brittly. The photo was taken between the Alsek River and south Range Creek. The shears are oriented roughly north-south, and the sense of shear is sinistral and east side up. (B) Shear fabric developed in argillaceous limestone of the megacycle sequence, east bank of the Alsek River west of Mount Blackadar. Shears are oriented roughly west-northwest, and the sense of shear is sinistral.

Plate 1-13-18. Fabric developed in calcsilicate gneiss in the amphibolite-grade package south of the Vern Ritchie Glacier. Note coarsely recrystallized texture, rootless folds, conflicting senses of shear, and rotation and extreme boudinage of the competent boudin in the upper half of the photograph.

ite+epidote) overprint, apparently related to or postdating emplacement of granitic dikes, which contain only this assemblage.

DEFORMATIONAL AND TECTONIC HISTORY

A structure versus time diagram (Figure 1-13-9) illustrates our preliminary interpretation of the structural and metamorphic history of the map area, based on the relationship of deformational phases to each other and to rocks of known ages. Other evidence used to construct this diagram (discussed in Part B) includes fossil age data and the extrapolation of relationships interpreted from adjacent areas. Locally developed conglomeratic horizons and a change in depositional environment from carbonate platform to siliciclastic-dominated reef and backreef during Late Silurian or Early Devonian time suggests the possibility of nearby tectonic activity. This time period corresponds to the Klakas Orogeny of Gehrels *et al.* (1987) in southeastern Alaska. The earliest documented phase of deformation, manifest by intrafolial isoclinal folds may be related to a Pennsylvanian-Permian plutonic event documented to the north and south of the study area (Dodds and Campbell, 1988; Hudson, 1983).A depositional hiatus or period of erosion of unknown duration lasted from late Paleozoic through Middle Triassic time. Basalt and fine-grained sedimentary rocks of the Upper Triassic Tats group were deposited in graben-type basins, suggesting an overall extensional regime and rifting. Peter (1992) equated the depositional

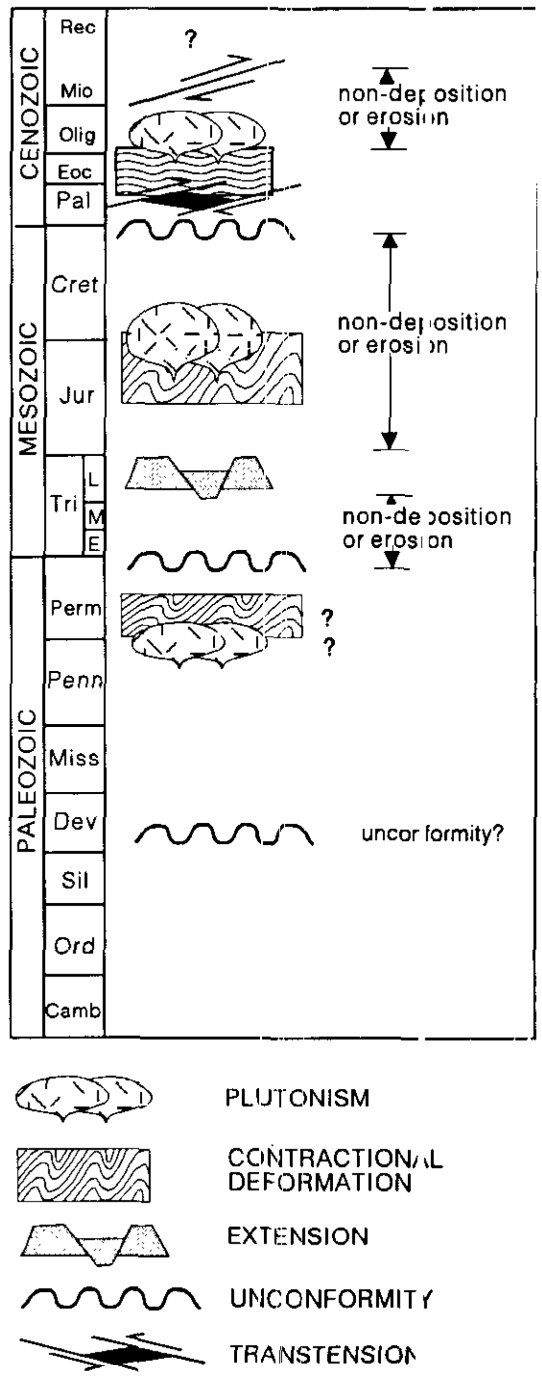


Figure 1-13-9. Structure versus time diagram showing postulated timing of plutonism, unconformities, contractional, strike-slip, and extensional episodes in the study area. See text for explanation.

setting of the Tats group to the modern day Guaymas Basin. A major episode of contractional deformation and metamorphism began post Late Triassic (Norian) deposition but prior to Late Jurassic plutonism. In places significant deformation accompanied an extensive episode of Late Jurassic to Early Cretaceous plutonism (Dodds and Campbell, 1988). These plutons are calcalkalic and are interpreted to be related to northeast-directed subduction along the present-day Boundary Ranges fault zone (Plafker *et al.*, 1989; Hudson, 1983). During middle to Late Cretaceous time, northwest-trending zones of ductile shear, with mainly sinistral offset, cut both the plutons and older rocks. Brittle to ductile shears with dextral offsets are imposed on these early ductile shear fabrics . This episode of faulting continued from Late Cretaceous to Early Tertiary time, based on the presence of synorogenic clastic rocks in pull-apart(?) basins and the postulated relationship of these faults to other crustal-scale dextral strike-slip faults in the region (Lanphere, 1977; Pavlis *et al.*, 1989). The synorogenic clastic rocks are themselves folded and faulted, suggesting that orogenesis outlasted sedimentation. The Oligocene Tkope intrusions followed this episode of strike-slip faulting. The Tkope intrusions are also brittly deformed, testifying to continued tectonic instability in the region. Miocene to Recent motion on these faults cannot be documented with certainty, however, some geomorphic features suggest the possibility of relatively recent movement.

PART D: MINERAL INVENTORY UPDATE (114P AND 114O)

By D.G. MacIntyre, M.G. Mihalynuk and M.T. Smith

INTRODUCTION

A key objective of the Tatshenshini project is the creation of an up to date inventory of the mineral resources of the project area. Unlike some parts of British Columbia, the Tatshenshini area is not as well explored and the documented mineral occurrences in the MINFILE database do not represent an accurate inventory of the mineral endowment of the region. In order to obtain a more complete assessment of known mineral occurrences, James J. McDougall was engaged to assist ministry crews in locating and sampling occurrences that for the most part are undocumented. Mr. McDougall is credited with the discovery of the Windy Craggy copper-cobalt massive sulphide deposit in 1958 and has spent many years exploring the Tatshenshini area. His contribution to the Tatshenshini mineral assessment project was invaluable and helped ministry crews develop a more complete mineral inventory of the area. Much of the information that follows is derived from unpublished reports and verbal communications provided by Mr. McDougall, particularly for the Buck, Jo and Pup properties (McDougall *et al.*, 1989: McDougall, 1990a, b).

The following descriptions are of properties and showings visited and sampled during the 1992 field season. The descriptions include location, mineralization and alteration, hostrocks, previous work and potential for additional discoveries. The descriptions are arranged according to deposit type. An updated list of mineral occurrences is given in Table 1-13-1; mineral occurrence locations discussed in this report are shown in Figure 1-13-10. Note that several of the occurrences described below are new discoveries made during the 1992 mineral assessment project.

STRATIFORM DEPOSITS

VOLCANOGENIC MASSIVE SULPHIDE (Cu±Zn, Ag, Au, Co)

The most economically significant exploration targets in the Tatshenshini project area are volcanogenic massive sulphide deposits of the Windy Craggy type. These deposits are hosted by Late Triassic submarine volcanic and sedimentary rocks of the Tats group (informal, *see* Part B). The world-class Windy Craggy deposit, which is owned by Geddes Resources Ltd., is estimated to contain reserves of nearly 300 million tonnes grading 1.38 per cent copper (Geddes Resources, 1992). Approximately $47 million has been spent on exploration of this deposit to date.

WINDY CRAGGY AREA

Five new copper occurrences were discovered while mapping the Alsek-Tatshenshini area during the 1992 field season. Four of these are located in a 20 square kilometre area centred approximately 15 kilometres southeast of Windy Craggy and 5 kilometres northeast of Tats Lake (Figure 1-13-11). Here, as at Windy Craggy, the host stratigraphy includes interbedded pillowed flows, calcareous siltstones and sills of the middle Tats member of the Tats group. Assays of up to 20 per cent copper have been obtained from the most extensively mineralized of these

TABLE 1-13-1
MINERAL OCCURRENCES, TATSHENSHINI PROJECT AREA, 114O AND 114P (NORTH)

MINFILE	Name	Map	Easting	Northing	Status	Class	Commodities
1	DUCK'S FACE	114P13E	349024	6629208	showing	Gypsum	Gypsum
2	WINDY CRAGGY	114P12E	345882	6624001	dev prospect	VMS	Cu,Co,Au,Ag,Zn
3	TATS	114P12E	346300	6618157	prospect	VMS	Cu,Ag,Co,Zn,Au
4	SQUAW CREEK PLACER	114P14E	383639	6651175	past prod	Placer	Au,Cu,Ag
5	O'CONNOR RIVER	114P10E	402302	6611501	dev prospect	Gypsum	Gypsum,Anhydrite
6	KIM	114P10E	404133	6611397	showing	Vein	Zn
7	MAID OF ERIN (L 722)	114P10E	410487	6604177	past prod	Skarn	Ag,Cu,Au,Zn,Bi
8	STATE OF MONTANA (L 283)	114P10E	412496	6601985	past prod	Skarn	Ag,Cu,Au,Bi
9	VICTORIA (L 903)	114P10E	412082	6603046	prospect	Skarn	Ag,Zn,Pb,Au,Cu
10	ADAMS (L 727)	114P10E	414051	6603310	prospect	Skarn	Pb,Zn,Ag
11	LAWRENCE (L 955)	114P09W	415598	6605751	prospect	Skarn	Ag,Pb,Zn,Au,Cu
12	SIMCOE (L 382)	114P09W	421281	6607329	showing	Skarn	Au,Cu,Fe*,Mo
13	MILDRED (L 213)	114P09W	420566	6606980	showing	Skarn	Ag,Cu,Fe*
14	CANADIAN VERDEE	114P09W	420628	6603105	showing	Skarn	Ag,Cu,Zn,Au,B,Fe
15	GOLD CORD	114P07E	414635	6590919	showing	Vein	Au,Ag,Cu
16	*GOLD RUN CREEK PLACER*	*114P15W*	*398394*	*6642389*	past prod.	*Placer*	Au
17	WINDSOR (L 804)	114P10E	412257	6603916	showing	Skarn	Cu,Zn
18	HUMBIRD - DISCOVERY	114P10W	398969	6620537	showing	Vein	Ag,Pb,Zn,Cu
19	BORNITE	114P10E	409658	6605265	prospect	Skarn	Cu,Mo,Pb,Zn
20	WAR EAGLE (L 901)	114P10E	412332	6603660	showing	Skarn	Fe
21	SHEEP	114P14E	383310	6652121	showing	Dissem	Cu
22	KELSAL 24	114P16W	416273	6628790	showing	Vein	Cu
23	KELSAL 32	114P16W	416866	6628312	showing	Vein	Cu
24	HUMBIRD - CREEK	114P10W	398684	6621775	showing	Vein	Ag,Zn,Pb,Cu
25	HUMBIRD - SOUTH	114P10W	399093	6619750	showing	Vein	Ag,Cu,Zn,Pb
26	HUMBIRD - CAMP	114P10W	398831	6621461	showing	Vein	Ag,Cu,Zn,Pb
27	LUNAR	114P10E	408838	6618130	showing	Vein	Ag,Pb,Zn
28	NADAHINI MOUNTAIN	114P10E	403536	6615790	showing	Asbestos	Asbestos
29	HIBERNIAN	114P10E	411378	6607083	showing	Skarn	Cu,Ag,Pb,Zn
30	MOUNT MANSFIELD	114P15E	407030	6641544	showing	Vein	Cu
31	C AND E NORTH	114P15W	400921	6647868	showing	Shear	Cu,Ni
32	C AND E SOUTH	114P15W	401979	6642757	showing	Shear	Zn,Sb,Pb,Sr
33	WC 17	114P12E	348854	6610421	showing	Shear	Au,Ag
34	TATS CREEK	114P12E	358082	6609730	showing	Vein?	Cu,Au,Ag
35	BARBICAN MOUNT	114P12E	353283	6610367	showing	Vein	Ag,Cu,Au
36	KLEHINI RIVER SW	114P10E	403614	6604261	showing	Vein	Zn,Ag,Cd
37	ALSEK TRIBUTARY	114P12W	338573	6616510	showing	Contact	Cu,Au,Ag
38	FAULT CREEK	114P10W	387210	6611759	showing	Vein	Ag,Pb,Zn,Au
39	CAMP CREEK	114P10E	405085	6606109	showing	Skarn	Ag,Cu,Au
40	KLEHINI RIVER NE	114P10E	406378	6607362	showing	Vein	Ag,Pb,Zn,Cu
41	ALSEK	114P12E	345439	6618051	showing	VMS	Cu,Au,Ag
42	INSPECTOR CREEK	114P10E	412472	6600287	showing	Contact	Cu,Ag
43	BASEMENT - JUNE 24	114P06W	368299	6580037	showing	VMS	Ba,Ag,Cu,Pb,Zn,Au,Co
44	BASEMENT - JUNE 21	114P06W	367508	6579742	showing	Vein	Au,Cu,Ag
45	BASEMENT WEST	114P06W	365480	6582755	showing	VMS	Cu,Ag,Au,Co,Zn
46	HUMBIRD - DOME	114P10W	389087	6620862	showing	Repl	Ag,Cu,Zn,Pb,Au
47	SAM - NORTH GLACIER	114P10W	394190	6620222	showing	Vein	Cu,Zn,Pb
48	SAM - MAIN GLACIER	114P10W	394007	6619298	showing	Skarn	Cu,Pb,Zn,Ag,Au
49	KEL	114P09W	421987	6622322	showing	Vein	Cu,Au,Ag,Zn
50	VALIA	114P07W	405811	6594631	showing	Ind [illegible]	Cu,Pb,Zn,Ag,Fe*
51	MOUNT BIGGER	114P07W	406385	6596498	showing	Vein	Pb,Ag,Cu,Zn
52	PENDANT GLACIER	114P12E	358309	6618779	showing	Vein	Zn,Cu,Ag,Au,Pb
53	PAMPERO RIDGE	114P13E	350159	6636375	showing	Vein	Zn,Cu,Ag
54	GRAMPS CRAG	114P13E	350271	6629158	showing	VMS	Cu,Zn,Ag
55	AEOLIAN STEEPLE	114P12E	350625	6624344	showing	VMS	Zn,Ag,Cu
56	VEGA (L 145)	114P10E	412589	6604582	showing	Skarn	Ag,Cu,Zn,Au
57	ALU	114P03E	384583	6574124	showing	Skarn	Cu,Mo,Wo
58	SAC	114P06E	378422	6577364	showing	Porphyry	Cu
59	HAINES ROAD	114P15E	408349	6630000	showing	VMS	Ba
60	SQUAW VALLEY	114P14E	387157	6643598	showing	Asbestos	Asbestos
61	RIME	114P12E	352959	6622083	prospect	VMS	Au,Ag,Cu,Pb,Zn,Co
62	HERBERT WEST	114P07E	412437	6577664	showing	VMS	Au,Ag,Cu,Co,Pb
63	HERBERT EAST	114P07E	413880	6577631	prospect	VMS	Ag,Cu,Zn,Au,Co,Pb
64	LOW HERBERT	114P07E	414892	6573489	prospect	VMS	Cu,Ag,Au,Zn,Pb,[illegible],Ba
65	MOUNT HENRY CLAY	114P08W	415804	6573753	prospect	VMS	Au,Cu,Ag,Zn
66	JARVIS SOUTH	114P08W	415010	6588579	showing	Dissem	Cu
67	HIGH JARVIS	114P07E	413228	6598012	showing	VMS	Zn,Ag,Au
68	GRIZZLY HEIGHTS	114P07E	410872	6578319	prospect	Vein	Au,Ag
69	KUD	114P14E	387069	6638074	showing	Vein	Cu,Ag,Au
70	FAIR	114P11E	378554	6620388	prospect	Skarn	Cu,Zn,Pb,Au,Ag
71	LOW JARVIS	114P07E	415935	6595630	showing	VMS	Cu,Zn,Ba
72	EMPIRE (L 288)	114P10E	413074	6605190	showing	Skarn	Ag,Cu
73	ARIZONA (L 285)	114P10E	413868	6605481	showing	Skarn	Ag,Cu,Pb
74	GILROY (L 730)	114P10E	414490	6605312	showing	Skarn	Ag,Cu,Zn
75	MOCKING BIRD (L 284)	114P10E	414005	6604704	showing	Skarn	Ag,Cu,Zn
76	NEW YORK (L 287)	114P10E	413837	6604244	showing	Skarn	Ag,Cu
77	EVENING (L 800)	114P10E	414469	6604384	showing	Skarn	Ag,Cu,Zn
78	FRISCO (L 154)	114P10E	414938	6604219	showing	Skarn	Ag,Cu,Zn,Pb,Au
79	FAIRFIELD (L 821)	114P10E	413210	6604258	showing	Skarn	Ag,Cu
80	SADDLE 3/4	114P10E	411202	6599044	showing	Vein	Au,Ag
81	SADDLE 2	114P10E	411610	6599654	showing	Skarn	Ag,Cu,Au
82	KR 1	114P10E	407159	6600844	showing	Vein	Au,Ag,Cu
83	KR 4	114P10E	407109	6598834	showing	Vein	Au,Ag,Cu
84	KR 7	114P10E	413288	6597446	showing	Vein	Au,Ag,Cu
85	LAWRENCE LIMESTONE	114P10E	415298	6606345	showing	Limestone	Marble, limestone
none	Buck	114P/7	403200	6577500	showing	Hydroth	Cu,Au
none	Pup	114P/6	389200	6569500	showing	Hydroth	Cu,Au
none	Goldrun	114P/15	394750	6640850	showing	VMS	(Zn,Pb)
none	Jo	114P/11	377500	6620400	showing	Skarn	Cu
new	Carmine	114P/11	378150	6624300	showing	Vein	Pb,Cu,Zn,Ag,Au
new	Rainy Monday	114P/12	350500	6615300	showing	VMS	Cu,Au,Ag
new	Tequila Sunset	114P/12	352850	6614625	showing	VMS	(Cu)
new	Ice Bridge	114P/12	351400	6618000	showing	VMS	Cu,Zn
new	Skid	114P/12	351275	6614050	showing	VMS	Cu
new	Norm	114O/16	641650	6640250	showing	Vein	Ag,Pb,Au
new	Vern	114O/16	645000	6632000	showing	VMS	(Cu)
new	Wounded Hedgehog	114O/9	664900	6623800	showing	Skarn	(Cu)
new	Lonely	114P/13	364750	6648000	showing	Skarn	(Cu)
new	Mojey	114P/13	341950	6629850	showing	Skarn	(Cu)

Abbreviations: VMS = volcanogenic massive sulphide, Dissem = disseminated, Hydroth = hydrothermal.

Notes:
- MINFILE data from 1988 release
- elements enclosed in parentheses are expected based on observed mineralogy, however, analyses are not yet available.
- occurrences with MINFILE = 'none' are from J. McDougall, unpublished data
- occurrences with MINFILE = 'new' were discovered by BCGS mapping crews in 1992.

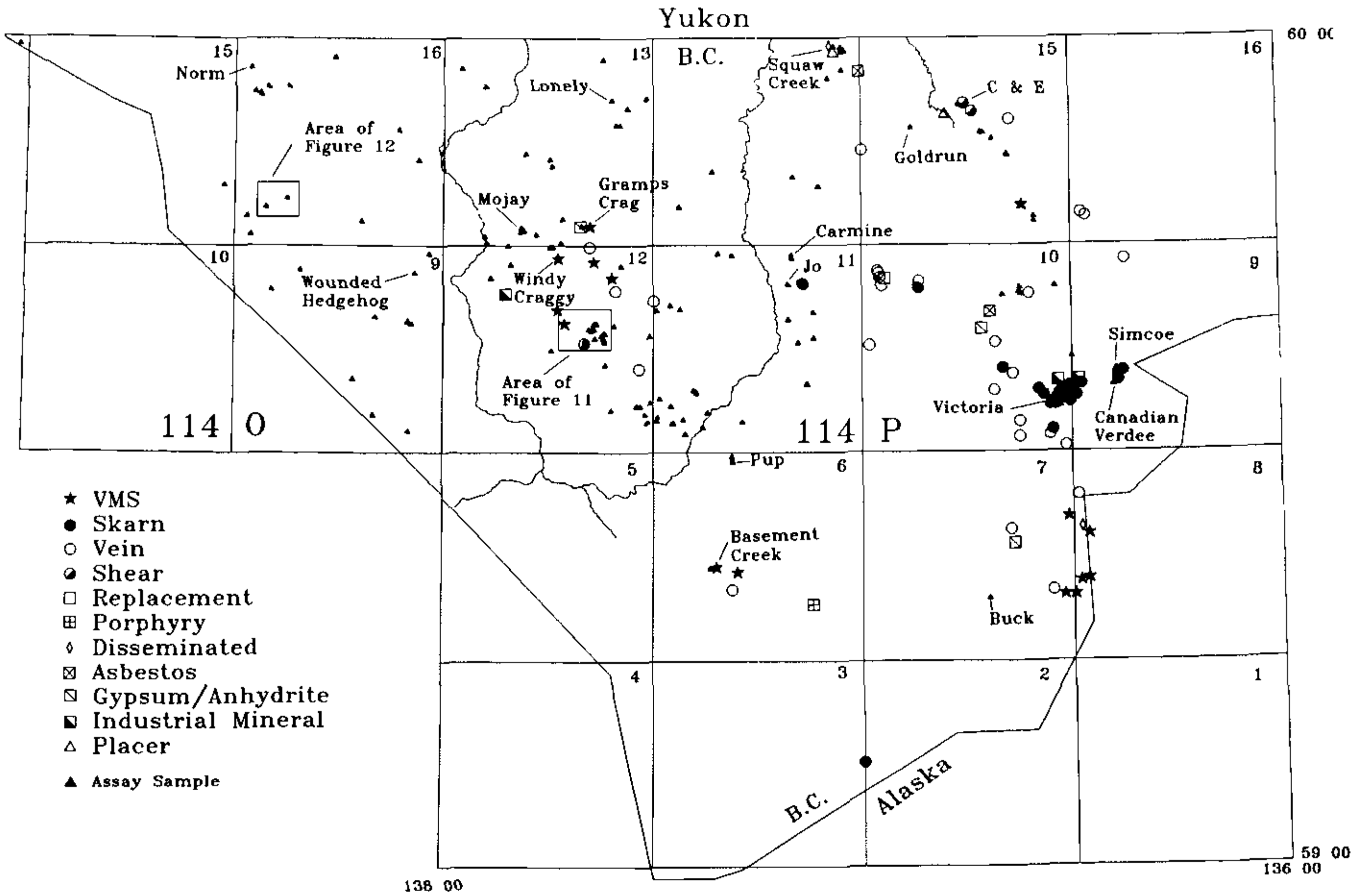


Figure 1-13-10. Location of assay samples and occurrences discussed in text. *See* Figures 1-13-11 and 1-13-12 for locations of the Rainy Monday, Ice Bridge, Skid, Tequila Sunset and Vern showings.

new occurrences, the Rainy Monday deposit. Such new discoveries demonstrate the very high mineral endowment of the Upper Triassic Tats group and the high potential for the discovery of new reserves.

The new discoveries can be subdivided into two different types of stratiform deposits. The first, which includes the Rainy Monday, Tequila Sunset and Skid occurrences is characterized by chalcopyrite and pyrite stringers and lenses, and stratiform, banded chalcopyrite and pyrrhotite-rich layers within foliated, chloritized basalt and lesser cherty argillite. The second type, which includes the Ice Bridge showing, is characterized by pyrite and pyrrhotite laminae with minor chalcopyrite in calcareous to cherty argillites and siltstone. The latter is probably at a stratigraphically higher level than the main massive sulphide bearing sequence and may represent a waning phase of sulphide deposition.

Rainy Monday

The Rainy Monday showing was discovered while the authors (MacIntyre and Mihalynuk) were mapping the area west of the Ice Bridge glacier (local name). The discovery showing is located on the west side of a north-trending ridge just above the valley floor (Figure 1-13-11). Here, a resistant, rusty weathering outcrop of massive to semimassive sulphide protrudes from a scree and grass-covered slope. Pillowed flows crop out to the north and south of the sulphide zone and calcareous siltstone talus occurs upslope to the northeast. The hostrocks are typical of the middle Tats member of the Late Triassic Tats group. The host stratigraphy is contained within a northwest-trending belt that is offset by an east-striking fault north of Tats Lake. The most likely fault restoration solution places the Rainy Monday deposit on strike with the mineralogically similar Tats showing (Figure 1-13-11), thus increasing the overall length of the prospective horizon.

The Rainy Monday discovery showing dips steeply to the northeast and is about 8 metres wide. Within the zone are lenses of porous iron oxide and hydroxide 5 metres wide that locally contain remnants of coarse-grained pyrite and partly oxidized chalcopyrite stringers up to 20 centimetres thick. Mineralization persists over a slope distance of 30 metres but the strike continuation of the zone is lost beneath alpine vegetation and scree to the west and east. Although the surface showing is extensively weathered and oxidized, samples of coarse-grained pyrite and chalcopyrite were obtained for assay (Table 1-13-2, Nos. 12-15, 112). These contained copper concentrations up to 13.5 per cent and gold up to 0.72 gram per tonne.

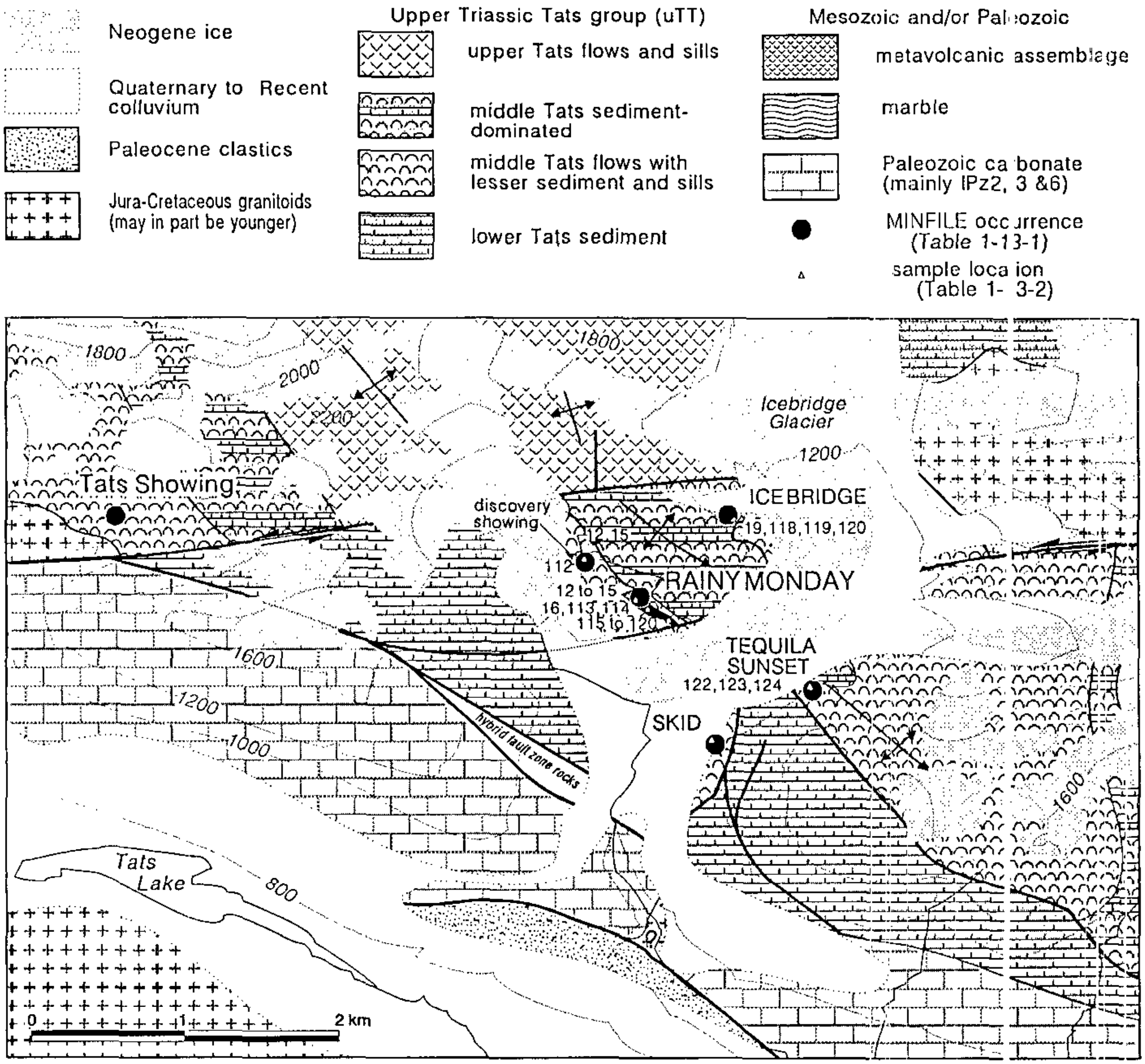


Figure 1-13-11. Generalized geologic setting of newly discovered copper occurrences in the vicinity of Tats Lake (central 114P/12). Thick lines indicate fault contacts.

The southeast strike of the discovery showing suggests that the host stratigraphy may crop out on the east side of the ridge where a steep but accessible scree slope extends from the ridge crest to just above lateral morraines covering the base of the slope. Several rusty weathering, resistant knobs protrude from the scree slope and each of these exposures were found to be oxidized massive to semimassive sulphide similar to the discovery showing. The lenses are interbedded with intensely chloritized flows and calcareous, carbonaceous siltstone and argillite. The host stratigraphy strikes north-northwest and dips steeply to the northeast.

Overall mineral content within the eastern zone is difficult to determine due to the high degree of oxidation and, in places, scree cover. The oxidized sulphide lens occurs within a northwest-trending zone that is over 100 metres wide. The mineralized zone comprises stringers and lenses of massive chalcopyrite and pyrite up to 30 centimetres thick and, where adequately exposed, such lenses can be seen to comprise up to 15 per cent of gossanous zones. Some of the lenses are cut by postmineral mafic dikes or sills which may have recrystallized an original fine-grained protolith. Grab samples collected from several different localities on the slope (Table 1-13-2, Nos. 16-18, 113-117) contained up to 20.2 per cent copper, 2.4 grams per tonne gold and 39 grams per tonne silver.

Mineralization within the southeastern zone has a visible vertical extent of 150 metres and appears to continue

TABLE 1-13-2
PRELIMINARY ASSAY RESULTS, TATSHENSHINI PROJECT AREA, 114O AND 114P (NORTH)

Text ref. #	Sample No.		NTS#	Easting	Northing	rock type	minerals	sulph %	Au (g/t)	Ag g/t	Cu ppm	Pb ppm	Zn ppm	Co ppm	As ppm	Ni ppm	comments
5	DMA92	3 12	114P/6	365600	6582700	mass. sulph.	po,cpy	50		1.1	0.59%	9	300				McDougall showing, Basement Ck.
9	DMA92	5 22 1	114P/11	378200	6623900	float/semi-mass	py,gn	20		196	272	13.13%	0.53%				float in saddle, west Carmine Mtn.
10	DMA92	6 33	114P/7	403200	6577500	volc breccia	py	2		0.4	22	187	51				Buck property
12	DMA92	12 64 1	114P/12	350500	6615300	mass. sulph	py,<cpy	25-30	0.02	<.5	0.01%	<5	38	349	<50	41	Rainy Monday
13	DMA92	12 64 2	114P/12	350500	6615300	mass. sulph.	cpy,<py	35-40	0.43	18	5.44%	8	74	650	117	38	Rainy Monday
14	DMA92	12 64 3	114P/12	350500	6615300	mass. sulph.	py,cpy	25-30	0.27	11	5.32%	9	74	488	50	30	Rainy Monday
15	DMA92	12 64 4	114P/12	350500	6615300	dissem. sulph.	py,cpy	10-15	1.71	11	0.10%	7	699	238	98	41	Rainy Monday
16	DMA92	12 65	114P/12	350850	6615150	oxidized sulph.	cpy,mt	60	2.00	31	6.66%	<5	919	80	<50	34	Rainy Monday
17	DMA92	13 66 1	114P/12	350500	6615300	mass. sulph.	py,cpy	60	1.70	11	2.37%	<5	312	280	<50	63	Rainy Monday
18	DMA92	13 66 2	114P/12	350500	6615300	banded sulph.	cpy,py	20	0.14	5	0.79%	5	214	80	<50	55	Rainy Monday
19	DMA92	13 69	114P/12	351400	6616000	lam. sulph.	po,cpy	15	0.62	4	0.46%	63	935	138	196	65	Ice Bridge Glacier showing
20	DMA92	14 72	114P/6	369200	6596950	breccia	py	5		<0.2	132	14	75				Pup breccia
21	DMA92	14 73	114P/6	369200	6596750	breccia	py	5		<0.2	86	10	85				Pup breccia
24	DMA92	15 78 2	114P/15	394750	6640850	barite-carb.	py,sp,mt	<1		72	23	513	450				Goldrun property
25	DMA92	15 78	114P/15	394750	6640850	barite-carb.	py,sp,mt	<1		19	71	508	0.12%				Goldrun property
27	JO SHO		114P/11	377500	6620400	limestone	bo	5		8	1.20%	12	190				Jo showing
28	JTI92	3 2	114P/10	415050	6604000	skarn	py,sp,gn	40		13	490	476	17.70%				Night showing, Copper Butte
29	JTI92	4 3	114P/9	420900	6605650	skarn	mg,sp,bo	50									Canadian Verdee
30	JTI92	4 5	114P/9	421325	6607700	skarn	mg,sp,bo	50		42	0.40%	10	0.11%				Simcoe
35	JTI92	8 7	114P/9	415400	6609450	alaskite	mt,az	?		7	0.27%	15	32				Stonehouse Ck.
38	JTI92	16 4	114P/14	367800	6635850	mylonitic carb.	bo,hem,mt	2	3.08	2	619	19	125	94	2900	<50	fault zone
52	MDE92	3 1 B	114P/10	413750	6602850	skarn	gn,sph,mt	80		175	11	1.12%	3.00%				near Adams prospect
53	MDE92	3 5	114P/10	412150	6604075	greenstone	po	3		3	0.16%	23	200				State of Montana
54	MDE92	3 6	114P/10	412800	6604350	skarn	bnt, mt	10		710	13.10%	50	136				State of Montana
56	MDE92	3 8	114P/10	413450	6603600	skarn	sph	10		61	233	0.91%	0.24%				near Adams prospect
57	MDE92	4 4	114P/9	415500	6606350	skarn	cpy,gn	45		14	301	0.35%	6.70%				Lawrence prospect
58	MDE92	4 5	114P/9	415550	6606550	skarn	gn, sph	30									Lawrence prospect
64	MDE92	15 6	114O/16	641650	6650250	vein	gl,py	15	2.07	540	196	10.50%	83	34	63000	<100	Norm showing
79	MDE92	30 6 B	114O/9	664900	6623600	amphibolite	po,cpy,bo	70									Wounded Hedgehog showing
80	MDE92	32 1 2	114P/13	354750	6646000	skarn	po,cpy	50									Lonely showing
97	MMI92	1 4	114P/10	408750	6618100	argillite	po,sp	up to 80		1.5	61	71	65				Lunar showing
99	MMI92	3 4	114P/10	414400	6604250	basalt?	py,sp,gn	40		19	365	0.11%	3.00%				Evening showing
101	MMI92	3 10	114P/10	413800	6603900	skarn	py,trace cpy,po	95		2	920	12	0.40%				NewYork/Cariboo
102	MMI92	3 11	114P/10	413800	6603350	skarn	gn,sp,py	?		32	365	6.18%	8.80%				Adams
112	MMI92	20 4 2	114P/12	350500	6615300	basalt	py > cpy	15	0.72	15	13.50%	5	192	0.27%	0.19%	197	Rainy Monday
113	MMI92	20 5	114P/12	350850	6615200	basalt	cpy	?	0.12	18	8.60%	<5	589	38	<50	20	Rainy Monday
114	MMI92	20 6	114P/12	350800	6615100	basalt	cpy	?	0.96	25	13.60%	<5	359	56	<50	7	Rainy Monday
115	MMI92	21 2	114P/12E	351200	6616000	basalt	py	25	0.19	5	0.36%	<5	99	264	76	43	Rainy Monday
116	MMI92	21 3 1	114P/12E	351250	6615250	basalt	cpy	85	2.37	36	10.20%	<5	136	273	50	5	Rainy Monday
117	MMI92	21 3 2	114P/12E	351250	6615250	basalt	cpy	90	1.29	39	20.20%	<5	321	175	50	5	Rainy Monday
118	MMI92	21 5 1	114P/12E	351550	6616050	argillite	po > cpy	10	0.33	3	0.43%	49	0.29%	127	50	74	Ice Bridge Gl. showing
119	MMI92	21 5 2	114P/12E	351550	6616050	argillite	po > cpy	10	0.70	3	0.36%	59	0.41%	122	65	73	Ice Bridge Gl. showing
120	MMI92	21 6	114P/12E	351550	6616000	argillite	cpy,po	10	0.24	1	0.13%	52	815	52	289	52	Ice Bridge Gl. showing
122	MMI92	22 7	114P/12	352650	6614625	hornfels lim.	cpy	10	0.037	0.8	870	7	80	450	41	320	Tequila Sunset
123	MMI92	22 9 1	114P/12	352125	6614400	basalt	cpy >> py	10	0.41	6	0.86%	20	0.22%	710	380	120	Tequila Sunset
124	MMI92	22 9 2	114P/12	352125	6614400	basalt	cpy >> py	15	0.56	12	1.56%	9	173	78	11	<50	Tequila Sunset
144	MSM92	1 3 B	114P/10	408500	6618350	skarn	mt, py, po	80		1.2	78	9	400				
146	MSM92	3 6	114P/10	412800	6604100	skarn	gn + ?	5-10		55	1.06%	1.02%	1.43%				State of Montana
147	MSM92	3 8	114P/10	412150	6603450	skarn	gn,sp,py,mt	80		235	0.54%	17.90%	30.00%				Victoria
148	MSM92	4 3	114P/9	420950	660550*	skarn	bo,mt,az	20		375	17.95%	230	1.60%				Canadian Verdee
151	MSM92	10 1	114P/13	341950	6628850	skarn	po,py,bo,cpy	80	0.007	4	523	5	41	550	4.2	240	Mojay showing
167	MSM92	13 13	114P/11	378150	6624300	qtz vein	galena qvm	15	5.81	150	0.37%	4.37%	0.13%	34	63000	<100	Carmine

beneath lateral moraine near the valley floor. Assuming that the discovery showing and lenses exposed on the east-facing scree slope are at the same stratigraphic level, the Rainy Monday mineralized zone has a strike length of at least 600 metres, is up to 100 metres thick and extends down dip at least 150 metres. These dimensions suggest the deposit has significant tonnage potential. This combined with the high copper, gold and silver values obtained from assay samples suggest that the Rainy Monday is a significant new volcanogenic massive sulphide deposit.

Ice Bridge

The Ice Bridge showing is located approximately 1000 metres north of the Rainy Monday deposit (Figure 1-13-11). Here, rusty, calcareous, cherty argillite and siltstone are interbedded with massive to pillowed flows. The clastic rocks contain fine-grained pyrrhotite laminae 0.5 to 2 centimetres thick that contain variable amounts of chalcopyrite. Over intervals of a few centimetres the sulphide content is as much as 10 per cent. Analyses of samples from this occurrence return values of up to 0.46 per cent copper and 0.41 per cent zinc. The laminated nature of the mineralization, the argillaceous hostrocks and the higher zinc values distinguish these showings from the Rainy Monday. The Ice Bridge showing is at a higher stratigrapic level, assuming no major fault or fold complications within the intervening succession.

Tequila Sunset

The Tequila Sunset showing is located southeast of the Ice Bridge glacier (Figure 1-13-11). The showing includes discrete, yellow and orange gossanous zones, 0.5 to 3 metres wide of tectonically admixed fine-grained sediment and foliated basalt (now chlorite schist) that occur within the hinge zone of a faulted, south-plunging anticline. A sequence of en echelon mineralized zones is exposed across about 20 metres and may extend over 100 metres of a cliff face south of the Ice Bridge glacier terminus. Malachite-stained chalcopyrite and pyrite occur as stratabound stringers within the pods. Chalcopyrite may comprise up to 15 per cent of the rock over intervals of less than 0.2 metre.

Controls on the distribution of the sulphides appear to be predominantly structural. This showing is similar in style to the Rainy Monday and the anticline is on trend with the Rainy Monday showing. Extents of the mineralization both above and below the immediate discovery zone are untested; such testing will require technical climbing and drilling.

SKID

A thin veneer of foliated basalt forms the steep cliff faces at the base of the ridge southeast of the Ice Bridge glacier. Chalcopyrite occurs as stringers and blebs up to fist-size within the foliated basalt. Lateral moraine is plastered on the slopes both above and below the showing. Bedrock is exposed in a series of waterfalls that erode through the moraine. Assays from grab samples yield up to 1.56 per cent copper and 0.22 per cent zinc (Table 1-13-2). Further exploration may require trenching and technical climbing.

GRAMPS CRAG (MINFILE 114P 054)

The Gramps Crag showing is located in rugged terrain in the extreme southwestern corner of 114P/14. It lies northwest of a belt of rocks correlated with the Upper Triassic Tats group. A field check indicates that the showing is marginal to a dioritic intrusive unit, in a sequence of metasedimentary rocks intruded by abundant mafic sills or flows. In this sense, the sequence resembles the lower or middle Tats volcanic sequence, to which it has been correlated (Warwick *et al.*, 1984). However, the metasedimentary rocks, which make up less than 10 per cent of the sequence, include marble and chert-pebble conglomerate, lithologies more typical of the Silurian-Permian sequence, which crops out to the north and east. The showing is hosted in vesicular basalt, and consists of a massive sulphide layer or lens approximately 20 centimetres thick, consisting of massive pyrrhotite and pyrite, chalcopyrite, malachite and azurite. Assay results are pending.

OCCURRENCE WEST OF THE ALSEK RIVER

Another showing was discovered on a small, remote nunatak 35 kilometres west-northwest of the Windy Craggy deposit, near the head of the Vern Ritchie Glacier.

VERN

The Vern showing occurs in Paleozoic to Mesozoic greenstones on the south side of a small nunatak. (Figure 1-13-12). Chalcopyrite occurs as malachite-stained blebs within wacke (?) near the gradational contact between dominantly plagioclase-porphyritic basalt flows and buff to brown-weathering banded marble. The copper grades are visually estimated to be up to 5 per cent in places. The extent of the mineralization is not known. Other rocks within the contact zone are lapilli and block tuff and volcanic breccia, all cemented by carbonate. Very fine-grained basalt dikes up to 40 centimetres thick crosscut the succession.

On the north side of the nunatak the succession is mainly chert or siliceous volcanic rocks (tuff?) and pyritic sericite schist. A bright orange gossanous zone is exposed over

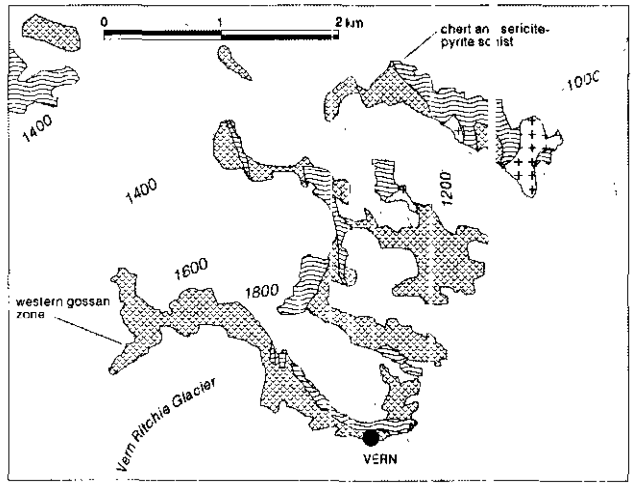


Figure 1-13-12. Geologic setting of the Vern occurrence (*see* Figure 1-13-11 for legend).

several tens of metres below an ice fall on the western end of the nunatak.

MELBERN LAKE – BASEMENT CREEK AREA

Several copper showings are known in the watershed of Basement Creek, a northwest-flowing tributary of the Tatshenshini River. The upper part of the creek is incised into a broad U-shaped valley exposing a nearly continuous section of northwest-trending, steeply dipping, interbedded marine sedimentary and volcanic rocks of possible Triassic age. Numerous bright orange and red gossans occur along the trend of the creek, several of which are known sulphide occurrences. These rocks are part of a narrow belt of gossans and copper showings that extends from Melbern Lake, northwest across the Tikki Glacier, down Basement Creek and northward toward Tomahnous Creek. A section through the belt is exposed on the cliffs north of the Tikki Glacier. Here the beds dip steeply and malachite staining occurs locally on cliff faces. A white-weathering gypsum bed is exposed near the top of the cliff section. This belt of marine sedimentary and volcanic rocks is bounded by granitic plutons and may be a roof pendant.

BASEMENT CREEK (MINFILE 114P 043, 044, 045)

Three showings have been located on the Basement Creek property – the Basement West or McDougall (MINFILE 114P 045), June 21st (MINFILE 114P 044) and June 24th (MINFILE 114P 043). Only the McDougall showing, which is exposed on both banks of an east-flowing creek, approximately 100 metres from its confluence with Basement Creek, was examined during the 1992 program. This showing is a vertical, resistant, north-trending coarse-grained, massive to semimassive sulphide lens up to 5 metres thick. The massive sulphide is predominantly pyrrhotite with lesser chalcopyrite and pyrite. The lens is interbedded with steeply dipping chlorite schist, mafic sills and limestone. A grab sample from the southern exposure of the lens contained 0.59 per cent copper and slightly anomalous zinc and silver (Table 1-13-2, No. 5).

The June 21 showing is mainly pyrrhotite veins and stringers with some anomalous copper and gold values in a garnet-tremolite-bearing marble; the June 24 showing is a bedded barite-carbonate exhalite that contains weakly disseminated sphalerite, pyrite, chalcopyrite and galena (Perkins, 1985). The hostrocks are interbedded chlorite schist, mafic volcanics and limestone with numerous mafic sills and dikes.

The belt of possible Triassic rocks that hosts the Basement Creek baritic exhalite and massive sulphide showings extends over 50 kilometres along strike and has high potential for the discovery of additional stratiform massive sulphide deposits.

SQUAW CREEK AREA

Squaw Creek has historically been an important placer mining camp with a reputation for producing large nuggets of both gold and copper. It occupies a linear valley which follows the trace of a major terrane-bounding fault, the Duke fault (Figure 1-13-1). This fault separates part of Wrangellia from the Alexander Terrane (Campbell and Dodds, 1983a). Bedrock mineralization is believed to occur within rocks of Wrangellia Terrane affiliation.

SHEEP (MINFILE 114P 021)

A zone of copper-iron sulphide pods hosted in foliated and unfoliated aphanitic basalt flows and calcareous marine sediments is exposed on the north end of Barrier Ridge, east of upper Squaw Creek. Showings are mainly within a contorted basalt-dominated section near the steeply dipping contact with a less deformed package of calcareous to shaly argillite and wacke. Lithologies associated with predominantly dense, locally pillowed, nonmagnetic, aphanitic basalt flows are: interpillow, laminated micrite; massive white to black and green banded chert (exhalite? or tuff); rusty, well laminated cherty argillite; calcareous siltstone and brown to black, fetid limestone.

Pods of pyrrhotite are up to 1 by 5 metres in size, but commonly 10 to 30 centimetres. Chalcopyrite typically occurs as blebs or veinlets within pyrrhotite, and locally within basalt and chert where it may comprise up to 2 per cent of the rock over a width of 9 metres. Chalcopyrite veinlets also contain pyrite, calcite and subordinate quartz. The mineralized zone is exposed in a series of trenches within east-flowing creek gullies over a strike length of approximately 200 metres. Continuity across strike is about 50 metres, but due to Quaternary cover, its eastern limit is not known to within a kilometre. Smaller zones of massive sulphide mineralization crop out to the northwest within the stream-bed of the eastern fork of Squaw Creek.

Past exploration on the zone includes six diamond-drill holes totalling less than 200 metres (Bapty, 1968) together with airborne and electromagnetic surveys, but the results of the program are not available. In later years, additional geophysical and geochemical work was done on areas peripheral to or overlapping the Sheep property. These programs were aimed at locating the lode source of the Squaw Creek placers.

Mineralized rocks on the Sheep property are probably Late Triassic in age; similar in age and lithology to the Tats group (*see* Part B) which hosts the Windy Craggy deposit. However, these rocks are believed to be part of Wrangellia Terrane (Campbell and Dodds, 1983a) and as such probably belong to a slightly older stage (Carnian) than the Norian Tats group of the Alexander Terrane (*e.g.*, MacIntyre, 1983). Since such a correlation has mineral potential significance, samples for rare-earth element and microfossil analyses were collected as part of this study to test the correlation. The results of these analyses are pending as this paper goes to press.

POLYMETALLIC BARITE-SULPHIDE DEPOSITS (Cu-Zn-Pb-Ag-Au)

GOLDRUN

The Goldrun property (Dat and Bar claims) extends from Goldrun Creek southwestward to Datlasaka Creek. Access to the property is by a dirt road which connects to the Haines Highway approximately 3 kilometres to the east. The property was located in 1988 after prospector Ted Hayes discovered an isolated outcrop of bedded barite with weak sulphide mineralization protruding from the grassy, east-facing slope of a rounded, northwest-trending ridge. The property was briefly visited and sampled as part of the Tatshenshini mineral assessment project.

The Goldrun property covers part of a narrow, fault-bounded, northwest-trending, southwest-dipping belt of poorly exposed, possibly Late Triassic volcanic and sedimentary rocks that extends from Squaw Creek to southeast of Datlasaka Creek. A crinoidal limestone of possible Devonian age crops out along the southwest edge of the property and may be the basal member of a southwest-dipping thrust panel.

The Discovery showing is bedded, calcareous baritic exhalite with minor concentrations of fine-grained pyrite, galena, sphalerite, chalcopyrite, pyrrhotite and argentite. Christopher (1990) reports assays up to 6.7 grams per tonne gold, 227.0 grams per tonne silver and 51 per cent barium. Other showings on the property include the "Massive Sulphide Creek" and "Zinc Mountain" neither of which were visited during the 1992 program. Christopher reports analyses from the Zinc Mountain showing up to 94 447 ppm zinc, 60 289 ppm lead and 150.7 ppm silver. The Massive Sulphide Creek occurrence is a gossanous zone of greater than 15 per cent sulphide in mafic volcanics. No anomalous base or precious metal values are reported for this occurrence (Christopher, 1990). Assay results for two samples collected from the discovery outcrop are given in Table 1-13-2 (Nos. 24 & 25). These barite-rich samples contained 19 and 72 ppm silver with anomalous concentrations of zinc and lead. Sulphides are less than 5 per cent and are very fine grained. The hostrocks are sericite-quartz-talc-carbonate schists that may have formed by alteration of a felsic volcanic protolith. The occurrence of talc and an enrichment in nickel suggests some of the protolith rocks may have been mafic volcanics (Naciuk, 1991). Chloritic schists crop out to the northeast and presumably down section from the baritic exhalite horizon.

The Goldbank Ventures Ltd. - Sutton Resources Ltd. joint venture completed 12 diamond-drill holes totalling 1134 metres, an induced polarization survey, trenching, mapping and rock geochemistry on the Goldrun property in late 1990. The drilling intersected a 10-centimetre bed of massive pyrite with trace to minor argentite, sphalerite and chalcopyrite within the calcareous baritic exhalite zone. The stratiform mineralization assayed 0.27 gram per tonne gold, 1087 grams per tonne silver, 1.14 per cent copper, 0.22 per cent lead and 2.14 per cent zinc (Naciuk, 1991). Regional exploration led to the discovery of another baritic zone up to 130 metres thick, 14 kilometres to the southeast of the Discovery showing. Naciuk (1991) reports analyses from this zone up to 3000 ppb gold, 57.0 ppm silver, 24 350 ppm copper, 31 512 ppm lead and 41 610 ppm zinc. This zone was not visited during the 1992 program.

The mineralization and hostrocks at the Discovery showing on the Goldrun property are very similar to those at the Late Triassic Haines barite-lead-zinc deposit in the Mount Henry Clay area, just south of the International Boundary and the Greens Creek polymetallic massive sulphide deposit in southeast Alaska. The Goldrun showings are also on strike with other sulphide occurrences in the Squaw Creek area to the northwest. The hostrocks for these occurrences, which crop out in a narrow northwest-trending belt, have obvious high potential for undiscovered stratiform barite-sulphide and polymetallic massive sulphide deposits.

HYDROTHERMAL ALTERATION ZONES (Cu-Au-Ag)

Buck

The Buck property, located 69 kilometres southeast of Windy Craggy, consists of 54 claim units that were staked in 1989 to cover a large brown to orange-weathering gossanous zone at the confluence of the Tkope River and Tsirku Glacier (McDougall *et al.*, 1989). The property was visited briefly with Mr. McDougall during a reconnaissance of the area.

A mineralized and altered zone approximately 4 kilometres long and up to 3 kilometres wide is exposed along a northwest-trending ridge that is bounded to the east by the Buckwell Glacier, to the south by the Tsirku Glacier and to the west by the Tkope River. McDougall *et al.* (1989) suggest the zone continues up to 8 kilometres to the south under the Tsirku Glacier but do not clearly state the basis for this conclusion. Where exposed, the zone includes brecciated quartz-carbonate-altered volcanic and sedimentary rocks of possible Triassic age. Bedding, as defined by pyritiferous sediments, trends northwest and dips steeply east. Intensely deformed black argillaceous sediments and limestones that may be correlative with the lower part of the Tats group outcrop to the west of the Tkope River, presumably at a lower stratigraphic level. Rugged ridges and peaks north of the zone appear to be mainly volcanic and could be the upper part of the Tats group.

Sulphide mineral assemblages within the zone include varying proportions and concentrations of fine-grained disseminated to coarse-grained, interstitial pyrite, pyrrhotite and rare chalcopyrite. Manganese oxide coats fracture surfaces. Within the zone, intense silica flooding and development of mariposite are reported. Secondary silica is apparently present as grey chert to opaline masses rather than as veins and veinlets. The style of alteration has been described as listwanitic but there is no evidence for an ultramafic protolith and elsewhere within the zone the alteration assemblages suggest a high-level hydrothermal system of possible epithermal origin. Many of the rocks within the altered zone are light coloured and are mapped as felsic volcanics but this coloration probably reflects intense silica-sericite-clay alteration rather than original rock composition.

Samples from various locations within the zone are reported to contain anomalous gold, copper and silver values (McDougall *et al.*, 1989). A sample from a pyritic shear zone near the crest of the ridge apparently assayed 18.41 grams per tonne gold, 0.58 per cent copper and 25.5 grams per tonne silver. Other samples from the area contained up to 0.9 per cent copper, 0.22 per cent zinc 4.1 grams per tonne silver, 0.23 per cent manganese and 176 ppm arsenic with generally low but anomalous gold values. A single grab sample collected during a short visit to the property contained slightly anomalous lead (Table 1-13-2, No. 10)

Additional sampling in 1990 failed to delineate any continuous zones of gold, silver or copper concentration although isolated samples returned copper values between 0.15 and 0.85 per cent and zinc values to 2.44 per cent (McDougall, 1990a). Small zones of massive to semimassive pyrite occur along northwest and northeast-trending shear zones. Northwest-trending basaltic dikes and sills up to 35 metres wide also appear to be intruded along these zones. Brecciation is apparently associated with these basaltic intrusions and narrow copper-bearing shears parallel their northeastern contacts.

The Buck hydrothermal system represents a large and relatively unexplored exploration target in the Tatshenshini mineral assessment area. It appears to be a high-level, possibly epithermal hydrothermal system, with indications of potentially economic concentrations of gold, silver and copper. Because of the areal extent of the zone of mineralization and alteration, much more work will be required to fully assess the mineral potential of this property.

Pup

The Pup property, which includes 40 claim units, was staked in 1989 to cover a zone of intensely brecciated and pervasively mineralized volcanic rock that crops out at the confluence of Pup (local name) and Tomahnous creeks (McDougall *et al.*, 1989; McDougall, 1990a). The breccia zone was sampled as part of the Tatshenshini mineral assessment.

Clasts within the breccia are 1 to 5 centimetres in diameter, subangular to subrounded and are crudely stratified. They are predominantly dark grey, fine-grained chlorite and sericite-clay-altered volcanic rocks with minor oxidized quartz and calcareous sediments. In places, oxidation and leaching has produced a porous, poorly consolidated mass of breccia fragments with coarse-grained, oxidized sulphide clusters occupying solution cavities. Minerals identified include cuprite, copper carbonates, fine-grained pyrite and chalcopyrite. Late quartz veins cut the breccia. Iron oxide cemented boulders occur in the lower part of Pup Creek and clay-rich fault gouge was observed in the bed of Tomahnous Creek. Quartz-carbonate veining is reported north of the creek but was not examined.

Samples from the mineralized breccia are reported to contain up to 1.03 grams per tonne gold, 12.4 grams per tonne silver, 1.67 per cent copper and 0.07 per cent molybdenum (McDougall *et al.*, 1989). Assays results for two samples collected from the breccia zone during the 1992 program are summarized in Table 1-13-2 (Nos. 20 & 21). Neither of these samples returned significant metal values. However, the mineralized zone is large and much additional sampling and possibly drilling is required to fully evaluate the significance of the Pup breccia zone.

The Pup breccia is located along a major fault zone that trends parallel to Tomahnous Creek and may connect with a strand of the Tats Creek fault zone northwest of the Tatshenshini River. Intensely fractured granitic rocks crop out downstream from the breccia zone. The breccia is believed to have formed by explosion of a high-level cupola above a subvolcanic intrusion that may have been emplaced into the fault zone (McDougall, 1990b).

The poorly consolidated nature of the Pup Creek breccia and its location along a fault zone that offsets Early Tertiary sediments in Tats Creek suggests brecciation and mineralization are post-Paleocene to Recent in age. This type of fault-controlled hydrothermal activity may occur along other major Tertiary to Recent faults in the Tatshenshini area. For example, a similar, but untested fault breccia is exposed 6 kilometres north of Sediments Creek.

In addition to the breccia zone, a bedded gypsum-andydrite deposit occurs in calcareous sediments exposed immediately north of the breccia and adjacent to a quartz diorite stock. There is probably no relationship between the evaporite deposit, which is most likely Triassic in age, and the mineralized breccia.

C and E North (MINFILE 114P 031) and C and E South (MINFILE 114P 032)

The C and E North and South showings are located east of the Haines Highway near Stanley Creek. Hostrocks are a sequence of strongly altered, mafic volcanic rocks of Wrangellian affinity and Paleozoic or Mesozoic age (Dodds and Campbell, 1983a). The showings are located immediately west of the main strand of the Denali fault, and are apparently genetically related to it. Rocks are light orange weathering and strongly carbonate altered, with numerous quartz-carbonate veinlets. Protolith types are difficult to impossible to distinguish over an area at least 1 kilometre wide and several kilometres long. Neither "showing" was located with certainty. They may correspond to the northern and southern baselines of an extensive grid of cut lines. Quartz-carbonate alteration is common along the Denali fault zone to the south of these showings. Three samples of orange-weathering, intensely quartz-carbonate altered rocks did not return anomalous values of silver, lead, copper or zinc (not listed in table).

MINERAL DEPOSITS RELATED TO PLUTONS

Quartz-Carbonate Veins (Pb, Ag±Zn)

Norm

The Norm showing is a new discovery located on the steep northwest-facing slope of a nunatak in the northeastern part of the Tweedsmuir Glacier, 4 kilometres south of the Yukon border (NTS 114O/16, northwest corner). The nunatak is underlain by a pluton 2.5 kilometres wide consisting of layered and massive hornblende gabbro and diorite. Its age is not known, but it may be related to abundant Jurassic-Cretaceous plutonic rocks in the area. The contact of the pluton is covered by ice but it presumably intrudes fossiliferous limestone, argillite, sandstone and volcanic rocks of probable Devonian age.

The gabbroic host contains reddish weathering gossanous zones composed of quartz-carbonate veins and altered selvages. A west-trending vein, 1 metre wide, that was examined in the course of this study contains up to 30 per cent coarse galena as small veinlets and lenses, as well as disseminated pyrite. A single grab sample from this vein assayed 10.5 per cent lead, 2.07 grams per tonne gold and 540 grams per tonne silver, and is also anomalous with respect to arsenic, antimony and tin (Table 1-13-2, No. 64). Other gossanous zones within this body were not investigated.

Carmine

Small (2 - 10 cm thick) quartz veins with coarse galena were found in a north-trending gully on the north side of a small divide on the northwest side of the Carmine Mountain plateau (114P/11N), approximately 5 kilometres north of the Jo showing (*see* below). Hostrocks are rhyolite and dacite flows and tuff intruded by biotite-quartz-feldspar porphyry with accessory hornblende. The flows unconformably overlie lower Paleozoic marble and may be Tertiary in age. A single sample returned 150 grams per tonne silver, 5.8 grams per tonne gold, 0.37 per cent copper, 4.37 per cent lead and 0.13 per cent zinc, and is also anomalous with respect to arsenic and antimony (Table 1-13-2, No. 167).

Skarn Deposits

SHOWINGS NORTH AND WEST OF WINDY CRAGGY

The potential for skarn-hosted mineral deposits north and west of Windy Craggy has not been previously investigated in any detail, although up to 30 per cent of the area is underlain by plutonic rocks, mostly of Jurassic-Cretaceous age, that cut Paleozoic limestone. The plutonic rocks can be divided into two broadly defined map units: relatively homogeneous quartz monzonite or granodiorite, with rare potassium feldspar megacrystic granite, and a relatively heterogeneous complex of tonalitic to dioritic or gabbroic rocks (*see* Plate 1-13-7 for an example of the latter). The more felsic plutons generally do not have skarn mineralization associated with them. Their contacts are usually sharp, but from a distance the intrusions can be difficult to differentiate from the country rock where they intrude massive limestone or marble. The heterogeneous, dioritic plutons, in contrast, have abundant alteration and skarn mineralization associated with them, and contacts, particularly where they intrude argillite units, can be mapped from a distance by the presence of wide, red-orange-weathering zones of alteration. Most of the alteration within both the argillite sequences and the plutons up to several tens of metres from the contacts consists of disseminated pyrrhotite (up to 30% but more commonly 2-5%), with associated garnet-epidote-pyroxene skarn in calcareous rocks. In some areas, however, massive sulphide layers or pods are present. Three of the most significant prospects investigated to date are briefly described below. In addition to the new discoveries several other skarn localities have yielded copper values in the 500 ppm range.

WOUNDED HEDGEHOG

The newly discovered Wounded Hedgehog mineral occurrence is located near the toe of the Vern Ritchie Glacier approximately 4 kilometres northwest of Vern Ritchie Lake, on 114O/9NW. The area is underlain by a sequence of massive, recrystallized carbonate rocks intruded by Jurassic-Cretaceous plutonic rocks. At the showing, coarse white marble is intruded by a north-northwest-trending body of hornblende amphibolite, which is moderately to strongly foliated. Red-weathering altered zones occur along this contact, the colour primarily the result of weathering of disseminated pyrrhotite. A brief examination of one of these zones revealed a 1 by 2 metre pod containing approximately 70 per cent very fine grained massive pyrrhotite, chalcopyrite, and lesser bornite. Assay results are pending.

MOJAY

The Mojay showing is located on the southern border of 114P/13, 4 kilometres east of the Alsek River on the west side of a narrow glacial canyon. At this locality, coarse, white marble is intruded by Jurassic-Cretaceous(?), variably foliated hornblende diorite and gabbro. At least four intrusive phases were noted in this area. The contact with host marble is extremely irregular, and numerous dikes with skarn-mineralized (mainly garnet+epidote+hornblende±pyroxene) selvages are present. Northwest-trending rusty weathering, resistant lenses of sulphide-bearing skarn are exposed in the canyon, mainly developed within the dioritic pluton contact zone and numerous marble screens. The sulphides are primarily disseminated pyrrhotite and pyrite. One such zone measures approximately 10 metres by 200(?) metres. Lenses of massive sulphide within these zones consist primarily of pyrite, pyrrhotite, chalcopyrite and bornite(?). The extent and distribution of massive sulphide mineralization is largely unknown, as most outcrops are inaccessible in cliff faces or were mapped only by aerial reconnaissance. One sample returned an analysis of 4 ppm silver, 550 ppm cobalt and 523 ppm copper (Table 1-13-2, No. 151). Although the mineralization seems to be of a skarn type, the consistent northwest trend to these bodies suggests a degree of structural control as well.

There are similar showings in the next valley to the east, where at least three large west-northwest-trending rusty weathering skarn lenses are exposed. One such lens developed within the marble at the contact between the marble and the diorite body, consists of very fine grained disseminated and massive pyrite and pyrrhotite, with slightly coarser, disseminated pyrite and pyrrhotite within the diorite body. Only minor development of calcsilicate skarn was observed here, in contrast to the first locality. Two samples collected from this locality did not yield anomalous assays for silver, copper, lead or zinc.

LONELY

The Lonely showing is located approximately 4 kilometres south of the confluence of Range and South Range creeks, where the lower Paleozoic carbonate and Paleozoic argillite units are intruded by a Jurassic-Cretaceous heterogeneous dioritic pluton. Argillaceous rocks host up to 50 per cent pyrrhotite and chalcopyrite as pods and lenses. Calc-silicate skarn alteration is pervasive along this contact. The sulphide zone has a northwest trend and may be in part structurally controlled. Assay results are pending.

Several other localities along the margin of this pluton were also examined and sampled. Most of the sulphide mineralization consists of disseminated pyrrhotite.

CARMINE MOUNTAIN AREA

JO

The Jo showing was briefly visited and sampled during the 1992 program. It is located on the crest of a small north-trending ridge approximately 2 kilometres west of Red Mountain and 1.5 kilometres south of Frederickson Creek.

Red Mountain is underlain by rusty red weathering, pyritic andesite to basalt flows and related sills of probable Late Cretaceous to Tertiary age. These rocks sit with angular discordance on intensely folded Paleozoic carbonates. Outcrops of carbonate form rounded crests of several north-trending hills on the west slope of the mountain. A north-west and north-trending swarm of dikes, sills and plugs of basalt, diorite and quartz monzonite porphyry cuts the carbonates.

The Jo showing is a disseminated bornite skarn developed near the contact of a dioritic plug. Several small pits probably record exploration work at the showings many years ago. Three samples collected by Geddes Resources Limited in 1990 contained 0.7 to 1.18 per cent copper and 5.9 to 7.0 grams per tonne silver and up to 0.18 per cent zinc. A grab sample collected during a brief stop at the showing assayed 1.20 per cent copper and 3 grams per tonne silver (Table 1-13-2, No. 27).

McDougall (1990) describes the location of a showing in Frederickson Creek, approximately 1.5 kilometres north of the Jo showing and 3.5 kilometres southwest of Carmine Mountain. It occurs in a deep gorge and is not easily accessible and was not visited during the current project. According to McDougall (1990), interest in Frederickson Creek was generated by the discovery of bornite-rich float near its confluence with the Tatshenshini River. Subsequent work located a copper-stained outcrop in a steep gorge that apparently yielded assays of up to 6.8 grams per tonne gold. Follow-up work by Geddes Resources in 1990 failed to relocate the showing due to high water levels in Frederickson Creek.

Outcrop in Frederickson Creek is reported to be mainly limestone with lesser intercalations of shale and cherty argillite of probable Paleozoic age. Sedimentary strata strike northerly and dip steeply; they are cut by basalt dikes and sills and small diorite plugs. The showing is assumed to be a skarn related to emplacement of these intrusions.

RAINY HOLLOW AND THREE GUARDSMEN AREA (114P/10W AND 9E)

The Rainy Hollow and Three Guardsmen areas (114P/10W and 9E) contain abundant skarn prospects, generally believed to be associated with intrusion of the Oligocene Tkope intrusions, and have been the target of mineral exploration efforts since the late 1800s (Watson, 1948). Field checks were made of approximately half of the MINFILE localities in these areas. Several localities were visited by Webster *et al.* (1992) and are not included here, but many more have never had the benefit of a field check. Three of the latter are briefly described below. Most of these prospects are now located to within approximately 100 metres, in contrast to previous investigations which placed them only within 0.5 to 1 kilometre of their correct position.

VICTORIA (MINFILE 114P 009)

The Victoria prospect is located on a west-facing hill slope a few hundred metres south of the War Eagle showing. An adit has been driven into the hillside, and approximately 50 metres above it, a small pit has been excavated in skarn-mineralized marble. The skarn consists of coarse garnet and wollastonite, with lenses of massive sulphide consisting primarily of coarse galena and sphalerite. Watson (1948) reported 188 grams per tonne silver from a sample from this locality. A single grab sample consisting of approximately 80 per cent coarse galena, sphalerite, pyrite and malachite returned 235 grams per tonne silver, 17.90 per cent lead, and 30.0 per cent zinc (Table 1-13-2, No. 147). Lead isotope analysis of this sample will help to determine the timing of mineralization.

SIMCOE (MINFILE 114P 012)

The Simcoe showing is located approximately 150 metres above Clayton Creek on the east side. A trail leads to an adit driven into the steep mountainside an unknown distance, with a small waste dump at the portal. Copper staining is obvious around the portal, however massive and disseminated sulphides were observed mainly in the dump. Rusty weathering zones project up the hillside above the adit, and in part delineate an east-trending, high-angle contact between foliated quartz diorite and greenish metasedimentary rock. Greenish, unfoliated, porphyritic dikes crop out throughout the area. A grab sample of semimassive sulphide containing sphalerite and bornite returned 42 grams per tonne silver, 0.40 per cent copper, and 0.11 per cent lead (Table 1-13-2, No. 30).

We were unable to locate the Mildred showing (MINFILE 114P 013) in this area. Its approximate recorded location corresponds to the contact between the Three Guardsmen batholith and metasedimentary country rocks where it changes orientation from north-south to roughly east-west. The contact is rusty weathering and contains disseminated sulphides, apparently a continuation of the skarn mineralization at the Canadian Verdee showing (*see* below).

CANADIAN VERDEE (MINFILE 114P 014)

The Canadian Verdee showing is located along a ridge crest south of Three Guardsmen peak, in a sequence of metamorphosed argillite, quartzite and marble, intruded by quartz diorite. Metasediments and intrusive rocks are strongly foliated along a north to north-northeast trend, and dip steeply to the west. The intrusive body is locally mylonitized along the contact, with amount of strain decreasing to the west, away from the contact. Most of the skarn alteration is a garnet-epidote-diopside-actinolite assemblage developed within the marble unit. Pods and lenses of massive magnetite and malachite, azurite and bornite are developed within the foliation. Massive pyrite-pyrrhotite-chalcopyrite skarn was observed in float. Iron and copper-stained rocks are visible in cliff faces to the south of the showing, and continue along strike for at least a kilometre north of the showing. Evidence of drilling was noted in several locations along the strike of the mineralized zone. A single grab sample containing bornite, malachite and azurite returned 375 grams per tonne silver, 17.95 per cent copper and 1.6 per cent zinc (Table 1-13-2, No. 148).

The foliated plutonic rocks are part of the Three Guardsmen batholith, for which the unfoliated parts are demonstrably Oligocene in age (Dodds and Campbell, 1988) and related to the Tkope intrusions, with which most of the skarn showings in the Rainy Hollow camp are associated. However, Dodds (1988) has suggested that some of the rocks in the Three Guardsmen batholith (presumably the more foliated ones) may be Cretaceous.

Several other skarn localities were noted in the course of our survey of the Rainy hollow area that are not presently part of the MINFILE inventory. One is located approximately 500 metres southwest of the Adams prospect (MINFILE 114P 010), and consists of a weathered roadcut and nearby exposures of galena-sphalerite-magnetite and massive magnetite skarn in a mixed sedimentary sequence intruded by granitic dikes. A grab sample returned 175 grams per tonne silver, 1 per cent lead and 3 per cent zinc. Several reddish weathering, resistant skarn lenses are located along the east side of Wilson Creek, of the Adams prospect.

PRELIMINARY MINERAL POTENTIAL ASSESSMENT

The following constitutes our preliminary assessment of the Alsek-Tatshenshini area. As only a small number of assays have been completed, this assessment is based almost entirely on geological observations recorded during a 2-month field season in the areas outlined in Figure

1-13-1. With the exception of visits to showings and prospects described, our observations (and hence interpretations) do not extend to the southern part of the Tatshenshini map area. Additional data will be provided by completion of regional geochemical surveys.

- Rocks with high mineral potential are Late Triassic in age and occur in a relatively restricted, northwest-trending belt approximately 7 kilometres wide (Figure 1-13-4). They may have formed in an ancient rift system not unlike the present-day Red Sea or Gulf of California (*e.g.*, Peter, 1992). Parts of this belt of Upper Triassic rocks contain significant copper deposits, such as Windy Craggy. To emphasize this, our mapping alone resulted in the discovery of four new copper occurrences within 15 kilometres of the Windy Craggy deposit. Most significant of these is the Rainy Monday showing. It is over 600 metres long, over 150 metres deep, and is up to 100 metres thick. Assay samples from this zone have yielded up to 20 per cent copper, up to 2 grams per tonne gold, up to 28 grams per tonne silver and up to 0.27 per cent cobalt.
- Metamorphic rocks exposed near the southwestern border of the map area may also have significant mineral potential. A mineral occurrence that we discovered in this area is visually estimated to contain up to 5 per cent copper in rocks that were originally much like those at Windy Craggy. However, the area is remote, rugged and icebound.
- Paleozoic limestone underlies a significant portion of the map area but contains only a few scattered mineral occurrences that appear to be of limited extent. Therefore, areas dominantly underlain by these rocks are tentatively assigned a low mineral potential. Assay and regional geochemical survey results to test these observations are pending.
- The third major rock type in the map area, Jura-Cretaceous granitic rock, is associated in some instances with iron-copper skarn or lead-silver vein mineralization at intrusive contacts. These occurrences tend to be small and irregular, and therefore offer relatively low mineral potential. However, high-grade veins such as the newly discovered Norm occurrence could have economic significance.

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