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GEOLOGY of WHITEHORSE, ALLIGATOR LAKE,
FENWICK CREEK, CARCROSS and part of
ROBINSON MAP AREAS (105D/11, 6, 3, 2, & 7)

by

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PREFACE

The geology of the area south of Whitehorse has played a key role in the historical and economic development of the Yukon.

Prospecting first took place in the region in the late 1800's as prospectors worked their way inland from the Pacific coast. Further explorations, the discovery of gold veins near Carcross and the Wheaton River and the Whitehorse Copper Belt, were stimulated by miners on their way to the Klondike (1896) and the building of the White Pass and Yukon Railway (1903). miles Canyon basalt formed treacherous cataracts on the Yukon River and created the need for a transportation terminus at what is now the City of Whitehorse. Damming of the Whitehorse rapids has provided southern Yukon with efficient hydro electricity.

The region has yielded over 12 tonnes of gold, 125 tonnes of silver and 123 000 tonnes of copper with minor amount of lead, zinc and cadmium. Exploration expenditures in the decade preceding this report exceed 30 million dollars.

This report describes the geology and mineral deposits of the Whitehorse, Wheaton and Carcross areas. The project was funded under the Mineral Sub-Agreement of the Canada-Yukon Economic Development Agreement (YEDA 01/87) and continued under the Canada-Yukon Economic Development Program.

This report accompanies the Geological Maps of Whitehorse, Alligator Lake, Fenwick Creek, Carcross and part of Robinson map areas (105D/11,6,3,2 & 7) by C.J.R. Hart et al.

ABSTRACT

Three allochthonous terranes, igneous rocks of the Cretaceous and Tertiary Coast Plutonic Complex and associated volcanic complexes compose the geology between Whitehorse and the Yukon-B.C. border. The Paleozoic and older(?) Nisling Terrane is composed of the quartz-rich Nisling assemblage, the carbonaceous Nasina assemblage and orthogneiss assumed to be Devonian-Mississippian in age. The Nakina sub-terrane of the northern Cache Creek Terrane is composed of Mississippian to Permian spilitized basalt, ultramafite, chert and limestone characterized by Tethyan faunal assemblages and dramatic facies variations. The northern Stikine Terrane is composed of the Upper Triassic Lewes River arc and its plutonic roots.

Upper Triassic to Middle Jurassic sedimentary rocks of the Lewes River and Laberge Groups collectively comprise the Whitehorse Trough overlap assemblage. Basal augite-phyric volcanic rocks of the Lewes River Group (Povoas Fm.) are unconformably overlain by sedimentary debris derived from the eroding arc (Aksala Fm.). These rocks are disconformably overlain by Laberge Group coarse clastics (Takwaehoni Fm.) deposited in laterally discontinuous submarine fans and conformably overlain by distal fine-grained equivalents (Inklin Fm.). Siliciclastic rocks of the Tantalus Formation were deposited in a variety of marine environments in a successor basin to the Whitehorse Trough during Upper Jurassic and Late Cretaceous(?) times.

Plutonic rocks cover approximately 40% of the project area and comprise over 30 individual bodies with a wide range of compositions. Plutonic rocks have been divided into six chrono-lithologically distinct suites: Late Triassic batholiths of the Klotassin plutonic suite; Early Jurassic syn-tectonic(?) foliated diorite; mid-Cretaceous granodiorite of the Whitehorse plutonic suite; mid-Cretaceous granophyric quartz monzonite of the Mount McIntyre plutonic suite; a poorly defined suite of Late Cretaceous intrusions with associated volcanism; and quartz-rich high-level Late Paleocene/Early Eocene intrusions of the Nisling Range Plutonic Suite which form the plutonic roots to Skukum Group volcanism. The Klotassin suite is assumed to form the plutonic roots to the Lewes River arc, but are isotopically dissimilar. The Bennett Granite provides a Late Triassic link between Nisling Terrane and the Lewes River arc. Cretaceous and Tertiary intrusions are peraluminous and comprise the Coast Plutonic Complex.

Isolated but widespread accumulations of intermediate mid- and Late Cretaceous volcanic rocks form the Mt. Nansen and Carmacks Groups. Four Late Paleocene/Early Eocene volcanic complexes of the Skukum Group are aligned in a northerly trend and represent deeper levels of erosion to the north. Skukum Group activity is also represented by numerous northeast-trending rhyolite dyke swarms representative of a transtensional regime.

Strata of the Whitehorse Trough were deformed into a set of open to tight, northwest-trending folds during Middle and(?) Latest Jurassic/Early Cretaceous compressional event(s). In northern Cache Creek Terrane, much of the deformation took place during Middle Jurassic terrane accretion, but Late Cretaceous southerly verging thrust faults are documented. Nisling Terrane metasedimentary rocks were metamorphosed prior to the intrusion of the Late Triassic Bennett Granite.

The Tally Ho shear zone is a narrow domain of penetrative, ductile deformation with evidence of Late Triassic, sinistral strike-slip displacement. It strikes northwest and dips steeply and marks the easternmost limit of Nisling Terrane exposures. It may represent a terrane boundary between the Lewes River arc and the Nisling terrane; alternatively it may be a transpressional structure within the arc itself. Vertical movement along this zone may be responsible for forming the western margin of the Whitehorse Trough and uplifting source terrains to the west. The Llewellyn Fault represents a brittle dextral reactivation along the eastern boundary of the shear zone and involves rocks as young as Paleocene.

The northern Cache Creek Terrane was thrust westward along the Nahlin Fault over strata of the Whitehorse Trough during Middle Jurassic time. Reactivation of the Nahlin Fault during Latest Cretaceous time included dominantly reverse with some strike-slip motion.

The Ibex Fault juxtaposed the Lewes River and Laberge Groups over the Tantalus Formation along a westerly verging thrust in Latest Jurassic/Early Cretaceous time. A series of northwest and west-northwest-striking faults, the Whitehorse Fault series, traverse most of the project area and cuts units as young as Eocene.

Mineral deposits in the project area are classified according to the nature of the ore forming fluids: magmatic, metamorphic(?), meteoric and evolved meteoric. Deposits formed from interaction with magmatic fluids are genetically associated with granodiorite of the Whitehorse plutonic suite. Epithermal gold veins formed from meteoric fluids and are divided into adularia-sericite and acid-sulphate types according to their characteristics. They are associated with structures which post-date the Eocene volcanic activity. Gold-bearing, base metal sulphide-rich, mesothermal quartz veins formed from fluids enriched in ^{18}O , and are classified as evolved meteoric in origin. Stibnite-, arsenopyrite- and galena-rich mesothermal veins can be further distinguished by fluid chemistry and isotopic composition. These occurrences were deposited in secondary structures at high angles to major, deep seated (terrane bounding) structures along which the fluids are assumed to have ascended.

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INTRODUCTION

PURPOSE AND SCOPE OF STUDY

The Whitehorse Geological Mapping Project was initiated through the joint Federal - Yukon Territorial Economic Development Agreement and contracted to Aurum Geological Consultants, Inc. in 1987. The project was initiated to provide 1:50 000 geological maps to aid mineral exploration and evaluation. Originally a two year project, the complexity and diversity of the geology, combined with a dramatic influx of important new, unpublished data necessitated a third year for re-evaluation and compilation of all data. This report summarizes data compiled from three years of mapping.

The project area (Figure 1) includes four entire 1:50 000 scale map sheets: Carcross (105D/2), Fenwick Creek (105D/3), Alligator Lake (105D/6) and Whitehorse (105D/11), and the southwestern portion of Robinson (105D/7) map area. Preliminary geological maps and reports on these map areas have been previously released by the Exploration and Geological Services Division of Indian and Northern Affairs-Yukon Branch in Whitehorse. Although all information contained in this report supercedes that previously published by this project (Doherty and Hart 1988; Hart and Pelletier 1989a and b), considerations of space and brevity have prevented the inclusion of all data in this volume and the original reports contain worthy detail on some subjects.

Concurrent isotopic age dating of rocks from the project area by R.L. Armstrong at the University of British Columbia has provided dramatic insight into the magmatic evolution of the area. Unreferenced isotopic ages throughout this report are from this data. The usefulness of this data cannot be overstated and interpretations are preliminary. The absolute ages are presented but without supporting analytical data. It is expected that all information will be made available as a separate paper to be published later.

Nomenclature and ages of igneous rock units have been in a state of evolution since the inception of this project. Terminology presented in this report is the result of an effort to rename units according to conventional standards and their igneous classification. Many of the igneous rock units were re-examined in the field. In addition, over 100 thin sections were examined and modal estimates from petrography were used to name the lithologies based on the IUGS classification of igneous rocks. Finally, similar lithologies were grouped and with additional considerations of their age, field and contact relations, and general character, new names were given to almost all rock units. Most of the unit names include place names which refer to either the locality from which an isotopic age date was obtained or a place where the unit is fresh and well-exposed. Geochemistry data was interpreted and used only to a limited extent to classify the units. All of the data is included in appendices in this volume, Doherty and Hart (1988), Hart and Pelletier (1989 a, b).

During the course of this study, most of the more than 100 known mineral occurrences were examined and sampled. Deposit types are related to the geology and a genetic model of the various vein types is presented. Mineral occurrence names are those used in the Yukon Exploration volumes of Indian and Northern Affairs Canada-Yukon Region.

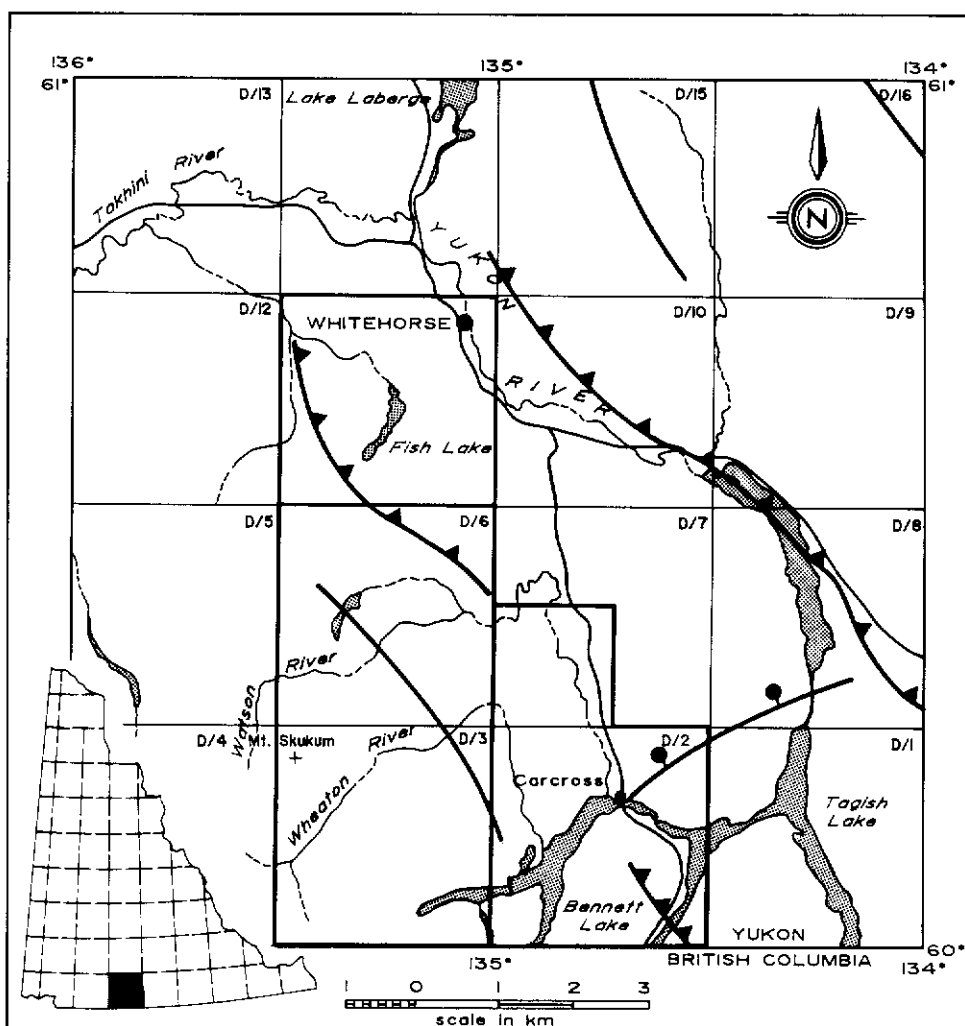


Figure 1: Location of project area on N.T.S. map sheet 105D: dark outlined map sheets this report; 105D/3 & 6 are Doherty and Hart 1988; 105D/2 & 7 are Hart and Pelletier 1989a; 105D/11 is Hart and Pelletier 1989b.

References throughout this report to the 'project area', 'study area', and 'map area' all refer to the entire area of study. When referring to a specific map area, the term 'map-sheet' has been used. If reference is made to the Whitehorse map-sheet, in all cases assume it is the 1:50 000 sheet, unless prefixed by (105D) in which case reference is being made to the 1:250 000 map-sheet.

Ages referred to throughout this report are those from the Decade of North American Geology Geological Time Scale (Palmer 1983).

LOCATION AND ACCESS

The study area forms an L-shaped region with the town of Whitehorse in the northeast corner and the Yukon-B.C. border forming the base (Figure 1). Road access to most of the study area is excellent. The Alaska and South Klondike Highways provide access from the city of Whitehorse in the north and town of Carcross in the south. The Annie Lake road traverses

into the heart of the Wheaton River valley and allows access to numerous secondary, 4x4 roads and "cat" trails. The Montana Mountain and Fish Lake roads provide good access in the Carcross and Whitehorse map-sheets respectively. Much of the southern part of the map area is accessible by boat. Remote areas in the western portions of the Whitehorse and southwestern portions of the Fenwick Creek map sheets must be reached by helicopter which can be chartered from Whitehorse or a seasonal base in the Wheaton Valley.

PHYSIOGRAPHY

The project area is entirely contained in the Teslin Plateau physiographic region. The topography is characterized by elevated tracts which together comprise a peneplain surface at approximately 5500' (1670 m). This plateau has been dissected by large rivers and severely modified by glaciation such that the slopes of the mountains are steep and generally free of alluvium. In the Whitehorse area, the topography is less pronounced and lower than the rest of the region. The low point of the study area is 2000' north of Whitehorse. In the western and southern portions of the project area, the ragged and serrated peaks have been modified by alpine glaciation reach heights greater than 7000' (2120 m).

Glaciation and Glacial Deposits

The effects of glaciation are responsible for the physical expression of the environment throughout the project area. Glaciofluvial deposits left by the retreating glaciers have provided surrounding communities with abundant supplies of sand and gravel.

Several glacial advances have covered the southern Yukon during the Pleistocene epoch. The most recent or McConnell advance took place approximately 30,000 years ago and advanced in a west-northwesterly direction across the central and northern project area (Wheeler 1961). The ice sheet may have originated from the Cassiar Lobe but the coastal accumulations of ice probably affected the more southerly portions of the project area. Glacial erratics have been located at elevations as high as 6500' (1980 m).

Glaciers carved out U-shaped valleys now filled by the waters of Bennett and Tagish Lakes or occupied by the Wheaton, Watson, Yukon and Ibex Rivers and Alligator and Fish Lakes.

The slow retreat of the continental ice sheet 8,000-10,000 years ago left large stagnant ice masses north and east of Whitehorse, near Louise Lake, in the upper Ibex River area, at the south end of Fish Lake, in the upper Two Horse Creek drainage and at Lewes and Annie Lakes. At each of these locations, pitted and hummocky gravelly terrane with numerous pot-hole lakes and variable amounts of kame and esker type deposits dominate.

Much of these remnant ice masses formed dams to the vast amounts of glacial melt water and created an extensive network of proglacial lakes. These lakes are easily recognized by their numerous, successive, horizontal strand lines and benches and accumulations of lacustrine silts. The strand lines can be observed on the sides of valleys between 3200' (975 m) and 3800' (1160 m) above sea level at Becker Creek, Mt. Kopje, Vesuvius Hill, Alligator Mountain and Hodnett Lakes. Similar features in the Ibex River valley have been observed as high as 4600' (1400 m) but are best developed at 4200' (1320 m). Raised beaches above Fish Lake are well developed below 4000' (1240 m).

Glacial Lake Carcross, which probably drained to the north through the Wheaton and Watson valleys, developed as a result of ice dams at Lewes and Annie Lakes. It covered all

portions of the Carcross map-sheet below 3200' (975 m) as indicated from wave cut terraces above Nares Lake. Water levels dropped periodically and formed numerous paleoshorelines between 2700' (825 m) and 2400' (730 m).

Varved glacial-lacustrine silt deposits have thicknesses up to 70 m near Whitehorse. These silts accumulated in response to a fairly long-lived lake which occupied the Yukon River valley south of its confluence with the Takhini River. Similar, though thinner deposits of silt were deposited in the Wheaton River valley between Vesuvius Hill and Skukum Creek, along the Watson River valley and northeast of Alligator Lake.

With the melting of the stagnant ice masses, sand and gravel were deposited in extensive esker and kame terranes in the upper Ibex River, Two Horse Creek and Lewes Lake areas. Outwash channels formed in response to lowering lake levels and deposited cross-bedded sands and gravels on top of the glacial-lacustrine silt deposits. At the present location of Carcross and the north end of Millhaven Bay, adiabatic winds coming off the alpine glaciers and across Bennett Lake, swept beach and outwash sands into parabolic sand dunes.

Alpine glaciers formed on the north and east facing slopes above 5500' (1670 m) and carved out or rejuvenated cirques and deposited morainal debris. Evidence of alpine glaciation is ubiquitous in topographically high areas in the southern and western portions of the project area. Permanent, though inactive, ice sheets are exposed in the headwalls of cirques on high peaks in the Montana Mountain and Mount Skukum areas.

PREVIOUS WORK

The first recorded geological work in the project area was undertaken by G.M. Dawson (1889) who spent several days in the Bennett and Tagish Lake area and commented on features near Whitehorse. Mineral exploration in the Wheaton and Windy Arm districts at the turn of the century stimulated geological investigations by McConnell (1906) and Cairnes (1908, 1910). The first topographic and geological map completed in the project area was of the Wheaton District by Cairnes (1912). The initial geological investigation of the copper deposits west of Whitehorse was initiated by McConnell (1909). Further reports on the mineral occurrences in the Wheaton and Windy Arm districts published by the Geological Survey of Canada include MacLean (1914), Cairnes (1916, 1917) and Bostock (1938, 1941).

In the early 1920's, reconnaissance geological mapping was undertaken in the Whitehorse area by Cockfield and Bell (1926, 1944). Systematic 1:250 000 geological mapping of the Whitehorse map sheet (105D) was initiated in 1946 by J.G. Fyles (1950), continued by J.R. Johnston in 1947 and completed by J.O. Wheeler during between 1948 and 1951 (Wheeler 1952, 1961).

Morrison (1979) produced a geological compilation map of the Whitehorse sheet using lithological and geochronological information obtained chiefly from Morrison et al. (1979). Morrison (1981) also studied the deposits of the Whitehorse Copper Belt. Detailed geological evaluations have been undertaken for the Bennett Lake (Lambert 1974), Montana Mountain (Roots 1982), and Mount Skukum (Pride 1985, 1986) volcanic complexes. Recent studies have concentrated on specific packages of rocks or mineral deposits and have been reference in the applicable chapter further in this report.

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We would like to acknowledge the following people for their contributions to the Whitehorse Geological Mapping Project during its three year development. R. Allan Doherty (Aurum Geological Consultants, Inc.) led the project in its first year, administered the contract, shared his expertise in the Wheaton Valley and contributed in many aspects to the final product. The project benefited from the keen observations and assistance of Karen Pelletier, Mark Fingland, Julie Hunt and Jane Weganast (all AGCI).

The evolution of ideas and interpretation of the geology greatly benefited from discussions with and information generously shared by Mitch Mihalynuk (BCMEMP-GRS), Jay Jackson (University of Arizona), Lisel Currie (Carleton University), John Dickie (Dalhousie University), Vicki Hansen (Southern Methodist University), Peter Von Gaza (University of Alberta) and Jim Mortensen (Geological Survey of Canada). Mihalynuk and the BCMEMP-GRS further provided access to their fluid inclusion stage. Howard Tipper, Mike Orchard and Walt Nassichuk (all GSC), and Glen Rouse (UBC) provided insightful communications about stratigraphy and fossil evaluations. John O. Wheeler (GSC) is thanked for sharing his keen memory on the geology of the Whitehorse area and for providing a much needed tectonic framework. Roger Hulstein, Harmen Keyser, Tom Garagan and Pat Garagan (all AGCI) made significant contributions to understanding the geology of the region by sharing their knowledge of the region. Lori Walton (AGCI) provided insightful information of the Montana Mountain area and assisted in our understanding of stable isotopes.

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Grant Abbott, Minerals Geologist of Exploration and Geological Services-INAC contributed time, advise, ideas and consultation on all aspects of the project, including the sizable job of editing this report.

TECTONIC SETTING

Much of the northern Cordilleran is characterized by assemblages of exotic rocks whose paleogeographic relationships with adjacent lithotectonic terranes are unknown. These terranes, now accreted, are bounded to each other and the North American miogeocline by faults. On the basis of their time of assembly and collision with North America, the accreted terranes form the Intermontane and Insular superterrane which are separated by the dominantly intrusive rocks of the Coast Belt. In the past decade, terrane nomenclature of the northern Cordilleran has been in a state of evolution as a result of new mapping and scientific data (Tempelman-Kluit 1979; Monger et al. 1982; Monger and Berg 1984; Wheeler et al. 1988).

The project area embraces portions of three allocthonous terranes along the western margin of the Intermontane superterrane as well as part of the Coast Plutonic Complex (Fig. 2). The three terranes represented include the Nisling, northern Cache Creek and Stikine Terranes. Sedimentary rocks of the Whitehorse Trough form an overlap assemblage which link the three terranes (Fig. 3).

The Paleozoic and older(?) Nisling Terrane (previously Yukon Crystalline Terrane; Tempelman-Kluit 1976, 1979) represents displaced continental passive margin assemblages of offshore sediments (Wheeler and McFeely 1987) which are exposed in the western margin of the northern Intermontane superterrane. Although Nisling Terrane rocks have stratigraphic similarities with coeval rocks of ancestral North America, they are separated from it by other terranes of the Intermontane superterrane. This led Tempelman-Kluit (1979) to suggest that it may represent a rifted continental fragment. It is composed of quartz-rich and carbonaceous metasedimentary rocks, carbonate and orthogneiss which were deformed at various times during the Late Paleozoic and earliest Mesozoic (see Wilson et al. 1985). Devonian-Mississippian orthogneiss in the Nisling Terrane (Pelly Gneiss, Simpson Range suite) is similar to that described in the Yukon-Tanana Terrane. Nisling Terrane metasediments were derived from Early and Late Proterozoic cratonic sources (Wasserburg et al. 1963; R.L. Armstrong unpublished data; Samson et al. 1989; Gerhels et al. 1990). In southernmost Yukon, much of the Nisling Terrane has been removed through uplift and erosion, and as a result is exposed as roof pendants and discontinuous blocks.

Upper Paleozoic rocks of the Cache Creek Group form three terranes in the Intermontane superterrane. The largest and best exposed of these occurs in north-central B.C. and southernmost Yukon and was formerly known as the Atlin Terrane (Monger 1975). Although this nomenclature has not been continued (Monger 1984; Monger and Berg 1984), in order to differentiate it from other exposures of Cache Creek Group rocks, the Atlin Terrane has been informally referred to as 'northern' Cache Creek Terrane (see Jackson and Gehrels 1990). This nomenclature is used in this report.

Northern Cache Creek Terrane is composed of a Late Mississippian to Middle Triassic ophiolitic assemblage of tectonized ultramafite, spilited basic volcanic rocks and gabbro, radiolarian chert and bioclastic limestone. Permian Cache Creek strata contain Tethyan faunal assemblages unlike those found in coeval miogeoclinal rocks of ancestral North America and suggest an exotic origin for the terrane.

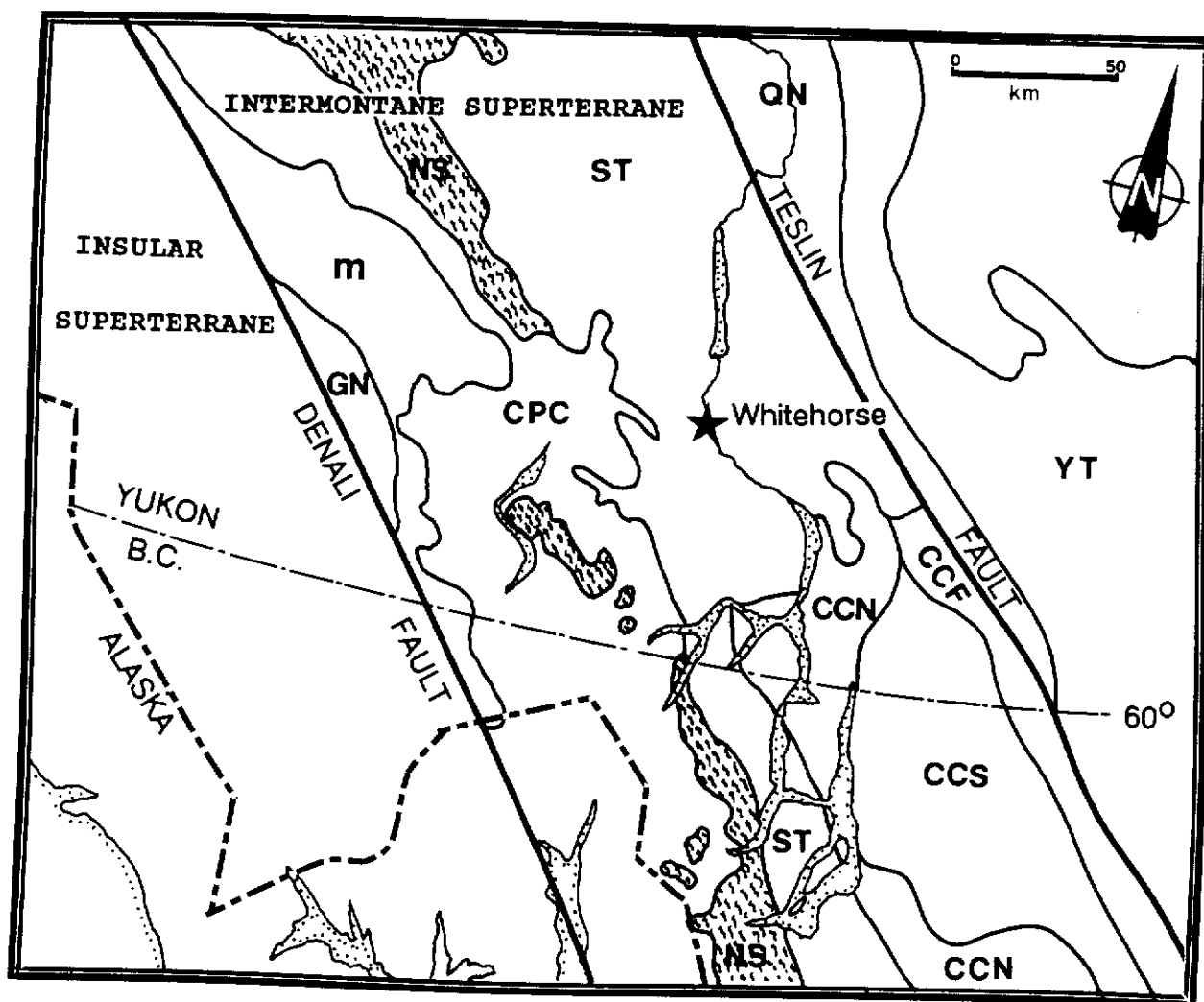


Figure 2: Tectonic elements of southwest Yukon Territory and adjacent portions of B.C. and Alaska (modified after Monger and Berg (1984) and Wheeler and McFeely (1988). Terrane and subterrane names: CCF = Cache Creek French Range; CCS = Cache Creek Sentinel; CCN = Cache Creek Nakina; CPC = Coast Plutonic Complex; NS = Nisling; QN = Quesnellia; ST = Stikinia.

Throughout most of the Stikine Terrane, Upper Triassic arc-style volcanic rocks were deposited unconformably on the Paleozoic oceanic sedimentary Stikine assemblage (Anderson 1989; Monger et al. in press). In Yukon, and northernmost B.C. however, this important basement does not exist. Instead, Stikine Terrane is defined entirely by the Upper Triassic Lewes River (and Stuhini) arcs and their plutonic equivalents (Wheeler et al. 1988). The basement to volcanic rocks of the northern Stikine Terrane is not apparent. This has lead some authors to use the informal 'northern' Stikine Terrane to differentiate it from the 'type' Stikine Terrane (Jackson and Gehrels 1990; Gehrels et al. 1990) of north-central B.C.

The Lewes River arc is composed of augite-phyric basalt, andesite feldspar porphyry flows and associated sedimentary rocks. Late Triassic batholiths assumed to represent the plutonic roots to the volcanics arc, are also considered to be part of northern Stikine Terrane (Wheeler et al. 1988) although they often occur far from any exposures of volcanic rocks.

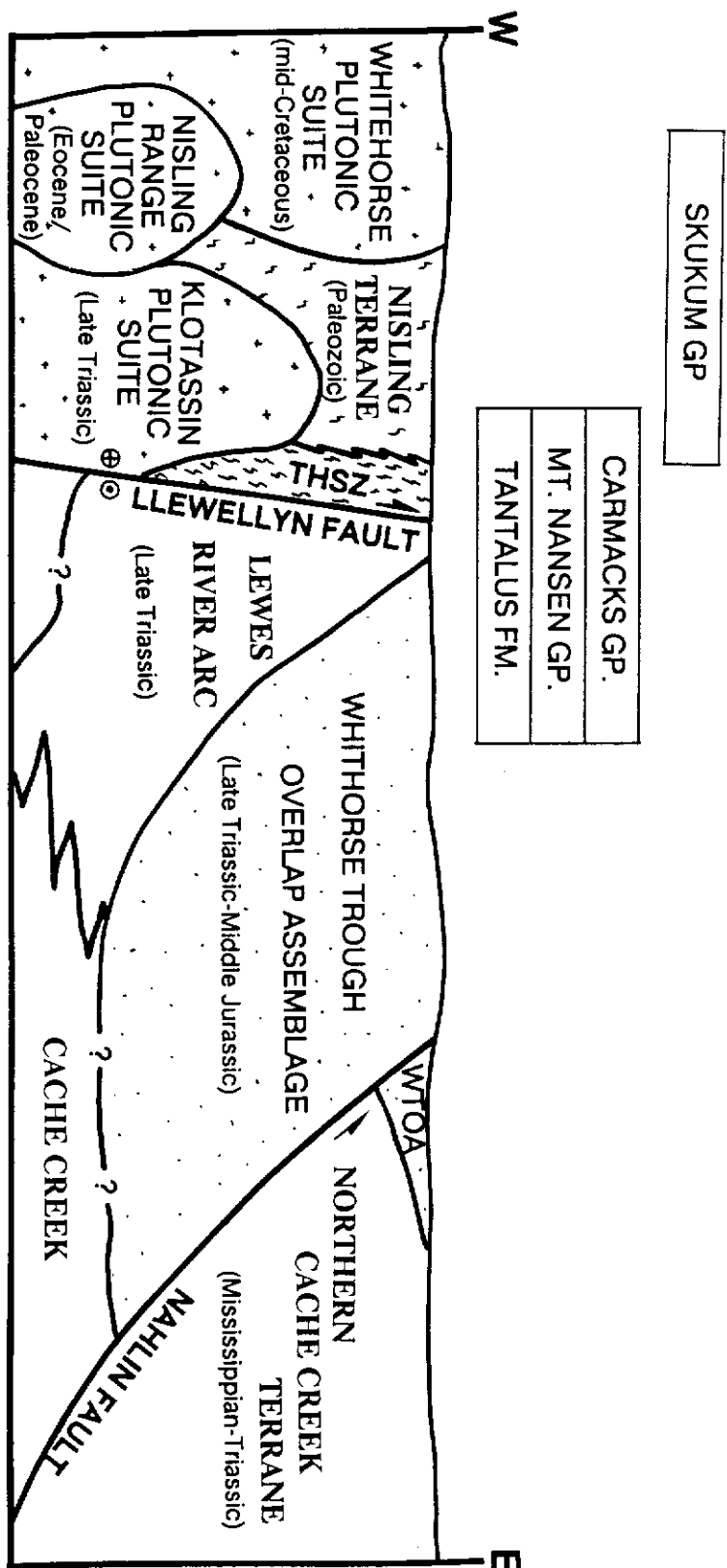


Figure 3: Generalized cross-section across the project showing relations of major tectonic building blocks. Whitehorse Trough overlap assemblage (WTOA) consists of Laberge Group and sedimentary portion (Aksala Fm.) of Lewes River Group. Whitehorse Trough sedimentary rocks unconformably overlie Nisling Terrane in northernmost B.C.. Tantalus Fm., Mt. Nansen Gp., Carmacks Gp. and Skukum Gp. occur as a Late Mesozoic/Early Cenozoic overlap assemblage. THSZ = Tally Ho shear zone.

The Whitehorse Trough is an elongate, arc-parallel depocentre in which sediments of the Lewes River and Laberge Groups (representative of a single, continuously operating deposystem (Tempelman-Kluit 1978)) accumulated during Upper Triassic to Middle Jurassic time. Whitehorse Trough sedimentary rocks are composed of material derived from, and deposited on the northern Stikine and Nisling Terranes. The eastern portion of the Trough may be underlain by rocks of northern Cache Creek Terrane, and received sediments from Quesnellia (Monger et al. in press). As such, the Whitehorse Trough forms an overlap assemblage.

The Coast Plutonic Complex is an elongate composite batholith of dominantly mid-Cretaceous age which links the Intermontane and Insular superterrane. It has been considered to be magmatic and metamorphic response to the accretion of the two superterrane (Monger et al. 1982).

GENERAL GEOLOGY

NISLING TERRANE

The Nisling Terrane is an enigmatic assemblage of quartz-rich metamorphic rocks that extends from eastern Alaska through Yukon to northern B.C. and southeast Alaska (Wheeler and McFeeley 1987; Wheeler et al. 1988). Cairnes (1914) originally used the term Yukon Group to define this package of older quartz-rich metamorphic rocks of probable Precambrian age. Tempelman-Kluit (1976, 1979) assigned them to the Yukon Crystalline Terrane. Other workers have suggested the term Nisling assemblage (Mihalynuk and Mountjoy 1990; D. Brew pers. comm. 1989). In this report, nomenclature similar to that defined by Wheeler and McFeeley (1987) is adopted.

Original attempts to divide this package into definable units were undertaken in west-central Yukon by Tempelman-Kluit (1974, 1976). In northern B.C., Mihalynuk et al. (1989) defined a chlorite-rich metamorphic assemblage that they called the Boundary Ranges metamorphic suite. Few chlorite-rich rocks have been found associated in the Nisling Terrane rocks in southern Yukon (this study; Erdmer 1989, 1990). Currie (1990) has divided Nisling rocks west of Atlin into four lithologically distinct informal units. The Nisling Terrane is the focus of numerous current studies (Erdmer 1989, 1990; Currie 1990; Gehrels et al. 1990; Jackson et al. 1990; Mortensen in prep.).

In the project area, rocks of the Nisling Terrane are found west of the Tally Ho shear zone and completely enclosed in plutonic rocks. They are divided into three mappable units: the metasedimentary Nisling and Nasina assemblages and undifferentiated orthogneiss.

Nisling assemblage (PNS)

This package is composed of rusty brown weathering, competent and non-fissile, biotite-muscovite-quartz-feldspar schist, quartzite, micaceous quartzite and marble. The rocks bear a strong, planar foliation which is parallel to the compositional layering, and at least one mineral lineation. Compositional layering is well defined in the schist and quartzite and ranges from 1 cm to 2 m in thickness. Compositional layering of marble bands is from 1-100 m thick. Although sillimanite has been identified in these rocks in northern B.C. (Currie 1990, Mihalynuk pers. comm. 1990) and near Aishihik Lake (Johnson 1988; Erdmer 1989) none has yet been identified in the project area. This unit is considered to be equivalent to the lower biotite schist unit of Tempelman-Kluit (1976) and the Florence Range metamorphic suite of Currie (1990).

Nasina assemblage (PN)

Although roughly similar in composition to the Nisling assemblage, the Nasina assemblage can be easily distinguished by the significant amounts of graphitic, commonly garnet-bearing, quartz-rich schists, lesser amounts of marble. The unit is well-exposed west of Mt. Skukum, just outside of the project area. These rocks are also well-foliated and lineated but the schists are strongly fissile along graphite partings, unlike Nisling assemblage rocks. Garnet-muscovite, garnet-graphite schists, and carbonaceous quartzite are common lithologies.

Undifferentiated Gneiss (Pgn)

On north Chieftain and Carbon Hills are feldspar-hornblende orthogneiss with minor biotite, epidote and chlorite. These rocks are not in contact with other Nisling lithologies but are included as part of the Nisling Terrane on the basis of relationships and descriptions from elsewhere (Tempelman-Kluit 1976; Currie 1990). These rocks are considered to be equivalent to the Pelly Gneiss of Tempelman-Kluit (1974, 1976, 1984), the Wann River gneiss as described by Currie (1990) and part of the Simpson Range gneiss of Wheeler and McFeely (1987).

Age and Interpretation

The age of the Nisling assemblage is poorly constrained. In western Yukon, near Dawson, the assemblage is overlain by Late Devonian volcanics and intruded by granitoids of the same age (Mortensen in prep.). A poorly preserved crinoid calyx was found in marbles near Mount Skukum. This, along with a similar finding near Dawson by Green (1972) indicates a Paleozoic age. Since fossil data is otherwise unknown in the Nisling assemblage, a portion of it may be Upper Proterozoic in age.

The Nasina assemblage is Middle-Late Devonian in age on the basis of macrofossils found in eastern Alaska by Gilbert and Redman (1977). Devonian Pb isotope model ages have been obtained from strataform galena (Mortensen pers. comm. 1989) and Late Devonian-Early Mississippian crystallization ages for interlayered metavolcanic rocks (Mortensen 1983).

In the project area, the age of the orthogneiss is constrained to pre-Late Triassic by the intrusion of the Bennett Granite (220 Ma). U-Pb zircon ages of similar rocks range from 364-340 Ma (Late Devonian-early Mississippian; S. Johnson pers. comm. 1990; Mortensen 1983 and in prep.). In western Alaska, zircons from augen gneiss returned a chord of 345-2300 Ma suggesting a Mississippian intrusive or metamorphic age with Proterozoic contamination (Aleinikoff et al. 1981).

A whole rock Rb-Sr isochron of metasedimentary Nisling assemblage rocks from the project area returned a model age of 1100 Ma. This corresponds well with an Rb-Sr model age of 1200 Ma from 15 km west of the project area (Watson et al. 1981). Similar Proterozoic Rb-Sr ages have been obtained in schists by L. Werner west of Atlin Lake (see Watson et al. 1981) and Wasserburg et al. (1963) in the Yukon-Tanana uplands of western Alaska. These ages support derivation from Early Proterozoic (Samson et al. 1989; Bennett and Hanson 1988; Gerhels et al. 1990) and Late Proterozoic (Wasserburg et al. 1963; Werner in Monger and Berg 1987; Armstrong unpublished data) cratonic sources. All ages indicate a Proterozoic protolith. This data is supported by Gehrels et al. (1990) who note that the metamorphic rocks contain detrital zircons of predominantly Proterozoic age.

NORTHERN CACHE CREEK (ATLIN) TERRANE

CACHE CREEK GROUP

The southeastern corner of the project area is underlain by Cache Creek Group rocks lithologically similar, and recognized as the equivalent to the type Cache Creek rocks in central B.C. (Dawson 1889). These rocks are part of the Nakina sub-terrane (previously Southwestern Facies belt of Monger 1975, 1977) of the Cache Creek Terrane (Monger and Berg 1984). Previously, the term Atlin Terrane was used to differentiate Cache Creek rocks in

the northern Cordilleran from those in southern B.C. (Monger 1975, 1977). The terrane will herein be referred to as the northern Cache Creek terrane after a convention recently set forth by Jackson and Gehrels (1990).

In the study area the Cache Creek Group is broken into three formations (Fig. 4). Rocks of the Nakina, Kedahda and Horsefeed Formations are exposed around Tagish Lake in large, imbricate thrust sheets. The western margin of the Cache Creek Group is in thrust contact with Whitehorse Trough strata along the northern extension of the Nahlin fault. The northern boundary of the northern Cache Creek Terrane is a vertical, northeast striking fault termed the Crag Lake Fault (Hart and Pelletier 1989a). The eastern contact of the northern Cache Creek Terrane, the Teslin lineament, is not exposed in the map area, but is a major fault contact as well.

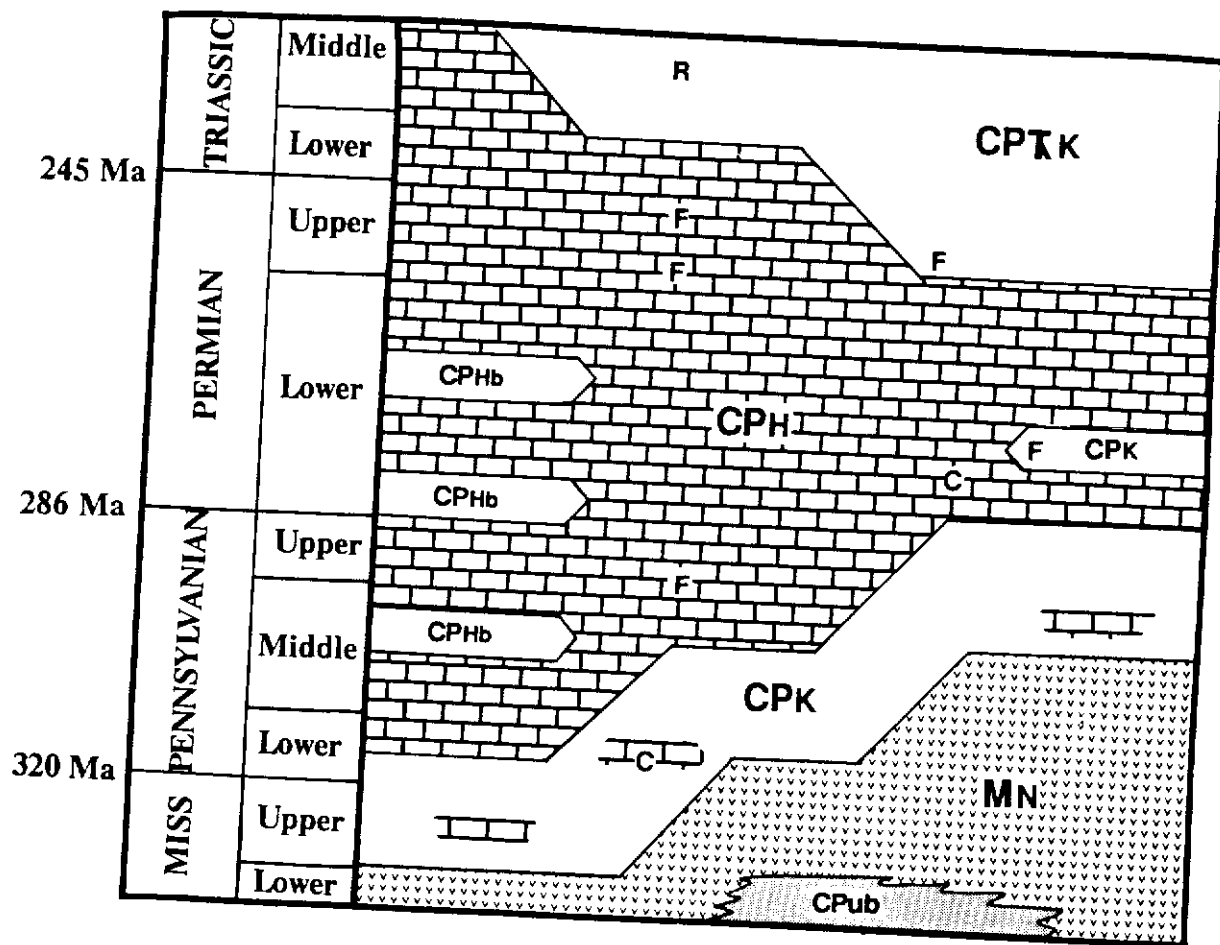


Figure 4: Schematic stratigraphic section of Cache Creek Group rocks of the Nakina subterrane (formerly Southwestern Facies Belt of Monger (1975)) as determined from (Monger 1975); C - conodonts (M. Orchard, pers. comm. 1989; and R - radiolaria maps.

Detailed lithologic descriptions of the Cache Creek Group with regional correlations are given by Monger (1975, 1977). The dominantly volcanic Nakina Formation is overlain by the dominantly sedimentary Kedahda and Horsefeed Formations. The mostly carbonate

Horsefeed and predominantly chert Kedahda Formations are considered facies equivalents with the Horsefeed Formation unconformably overlying the Kedahda Formation locally.

The general stratigraphy and internal structure of the northern Cache Creek Terrane itself remain poorly understood. Monger (1975) suggested that the Nakina sub-terrane contains the most complete, and best exposed stratigraphic sequence and the largest age range of rock units. Attempts to define the stratigraphy has been undertaken by Monger (1975) and Hart and Pelletier (1989a). Coherent internal stratigraphy has also been suggested by Bloodgood et al. (1989) for the Sentinel sub-terrane in the Atlin area. Studies evaluating the tectonic history of the terrane have been initiated by Jackson et al. (1990), Cole (1989), Donelick (1986) and others.

Nakina Formation (MN)

Spilitized basalt flows, breccia, lithic tuff and diorite are the most abundant lithology of the Cache Creek Group and is correlated with the Mississippian Nakina Formation (Hart and Pelletier 1989a). The Formation is divided into two informal members based on the minor lithologies associated with massive greenstone. The Conrad member contains hornblende metadiorite with rare volcani-clastic and epiclastic interlayers within the massive greestone. The Nares member includes thin carbonate and chert bands in the greenstone which locally has relict pillow textures, and mappable tectonic lenses of alpine-type ultramafic rock (CPub) at or near its base. Although the two members show different areal distributions they are not considered mappable units. The upper contact of the Nakina Formation is not exposed in the map area but Monger (1975) suggests a gradational, stratigraphic upper contact is disrupted by bedding plane parallel thrust faults.

The Nakina Formation in the Tagish Lake area is correlated with the type Nakina on the basis of close lithologic and geochemical characteristics (Hart and Pelletier 1989a).

Kedahda Formation (CPK)

Ribbon chert and clastic sedimentary rocks containing reworked chert dominate the Kedahda Formation while black, fossiliferous limestone and pillow lava are minor constituents. Cherts are well-bedded, weather prominently, and are grey, black, red and brown. The formation is best exposed on Escarpment Mountain and at the junction of Tagish Lake and Windy Arm. Although argillite (and greywacke) is common in other sub-terrane (Monger 1975; Bloodgood et al. 1989; Bloodgood and Bellefontaine 1990), very little was observed in the map-area. A microfossil specimen collected from the south flank of Escarpment mountain yielded an Early Pennsylvanian age (M. Orchard written comm. 1989). East of Tagish Lake just outside the map area late Early Permian and Late Permian fusilinids were found in Kedahda limestone (Monger 1975). There are numerous unconformities in the Kedahda Formation.

Horsefeed Formation (CPH)

Massive, recrystallized bioclastic limestone and marble with lesser calcarenite and yellow dolostone comprise the Horsefeed Formation near the Windy Arm-Tagish Lake junction and on Bove Island. Chert, cherty calcarenite and beds of fossil debris define bedding at a few localities.

Sills and Flows in the Kedhada and Horsefeed Formations (CPHV)

Massive, dark green mafic igneous rocks form sills, laccoliths, and pillowed lava flows (Hart and Pelletier 1989a; F. Cole pers. comm. 1988). The rock appears to be aphanitic, spilitized basalt with chlorite amygdules. Exposures are generally concordant with bedding, tabular to lenticular, and range from less than 30 m up to several hundred metres thick. Minor or rare interlayers of mafic volcanic rock with clear extrusive features (see Figure 8, Hart and Pelletier 1989a) may be genetically associated with the hypabyssal intrusions. Dark brown pillowed basalt flows at the head of Ramshorn Creek unconformably overlie Kedahda chert.

Ultramafic Rocks (CPub)

Elongate bodies of foliated and serpentized peridotite and dunite are common at the base of the Nakina Formation. Only several are large enough to map. A strong cleavage in the surrounding greenstones of the Nakina formation is concordant with the long dimension of the bodies themselves and the fabric in the ultramafic rocks. Petrography shows relict outlines of pyroxene and olivine metamorphosed to serpentine, talc and amphibole.

Ultramafite occurs in rocks as young as Permian. Although ultramafic rocks may have originally been part of an intrusive complex, most occurrences are tectonized and therefore indicate structural, rather than intrusive emplacement. While the ultramafite may be as young as the Permian rocks they occur in, it is likely that they were coeval with, or formed the base of the Mississippian Nakina Formation.

Age and Interpretation

The age of northern Cache Creek Terrane rocks has largely been determined from fusulinid collections (Bain 1964; Reudisili 1965; Monger 1975, 1977) which range from Mississippian to Permian. More recently, conodont and radiolarian ages have extended the range from Mississippian to uppermost Triassic (Cordey 1990a, b; Mihalynuk and Mountjoy 1990; M. Orchard written comm. 1989; Jackson pers. comm. 1989).

In the project area, Permian and Early Pennsylvanian conodonts were collected from the uppermost Kedahda Formation in the Ramshorn Creek area (Orchard written comm. 1989). Foraminifers and algae of Pennsylvanian age have been collected from Bove Island (Nassichuk written comm. 1989). These dates fall with the ranges defined from fusulinids by Monger (1975).

The northern Cache Creek Terrane contains Permian Tethyan fauna and like the Cache Creek Terrane of southern B.C., is interpreted as a far travelled fragment of ocean floor.

STIKINE TERRANE

The Stikine Terrane in Yukon, consists of an Upper Triassic (and older?) volcanic island arc assemblage and its plutonic roots - the Lewes River Arc (Tempelman-Kluit 1979). The arc is overlain by Upper Triassic Lewes River Group and Lower to Middle Jurassic Laberge Group sedimentary rocks which collectively form the Whitehorse Trough. Lewes River Group consists of volcanic, volcanoclastic, clastic and carbonate rocks associated with the buildup and erosion of the arc. Marine coarse-clastic rocks of the Laberge Group conformably and disconformably overlie Lewes River Group rocks.

LEWES RIVER GROUP

The Upper Triassic Lewes River Group includes the dominantly volcanic Povoas Formation and the overlying, dominantly sedimentary Aksala Formation. The Aksala Formation has been divided into the volcanoclastic Annie member and the overlying, partially facies equivalent Hancock and Mandanna members (Figure 5; Tempelman-Kluit 1984; Hart and Pelletier 1989a, b). The base of the Lewes River Group is not exposed in the project area. Volcanic rocks which comprise the stratigraphically lowest portion of Lewes River Group are thickest in westerly exposures (Wheeler 1961), giving way to younger, dominantly sedimentary rocks to the east (centre of Whitehorse Trough). Metamorphosed and highly sheared Povoas Formation (Tally Ho shear zone) form the westernmost exposures of the Lewes River Group in the study area.

Povoas Formation (uTrP)

The Povoas Formation is exposed in a northwest-trending belt across the centre of the map area. Undifferentiated basalt with diagnostic augite phenocrysts, feldspar-phyric basaltic-andesite flows and auto-brecciated flows with aphanitic groundmass comprise the bulk of the Povoas Formation. Minor rock types include well-indurated, dark grey greywacke, agglomerate, green tuff, epiclastic rocks and thin carbonate beds. The unit is massive and bedding rare, as attitudes are commonly obscured by alteration. As a result, estimates of this unit's minimum thickness are difficult to make. On the west flank of the Montana Mountain massif at least several hundred metres are present but may be tectonically thickened. Near Mount Ingram (west of the project area) Morrison measured a 550 m thick volcanic section. Massive, altered greenstone mapped previously as Mv (Doherty and Hart 1988) and some mapped as Unit A or Aa by Wheeler (1961) do not contain diagnostic augite porphyry but is included as Povoas Formation on the basis of a Late Carnian conodont age from Twin Mountain.

Most of the Povoas Formation is only slightly altered or metamorphosed to chlorite grade. In the Tally Ho shear zone however, Povoas Formation rocks are more intensely metamorphosed and are distinguished as a mappable unit. Another unit in the Povoas Formation is a distinctive polymict conglomerate. The Povoas Formation includes three informal units described below.

Augite Porphyry (uTrP₁)

Massive augite porphyry basalt with medium-grained hornblende gabbro and associated volcanoclastics define a distinctive unit in the Povoas Formation. Rocks weather dark green and are green black. Much of the augite porphyry is fairly coarse-grained suggesting that it may represent subvolcanic feeder zones or an intrusive phase. Volcanoclastic rocks overlie augite porphyry unconformably and grade into the Annie Member. This relationship is well exposed at Needle Mountain, Lakeview Mountain and along the west wall of the Ibex River valley.

Metamorphosed (uTrPm)

This unit is composed of mafic to intermediate amphibolite and associated marble, all of which bear a pervasive and penetrative fabric. The dominant rock type is a forest green to pale green hornblende-plagioclase gneissic amphibolite with variable amounts of quartz, epidote, chlorite, actinolite and white mica. The gneiss has a prominent layer parallel foliation defined by the dimensional orientation of quartz and mica grains within the foliation plane.

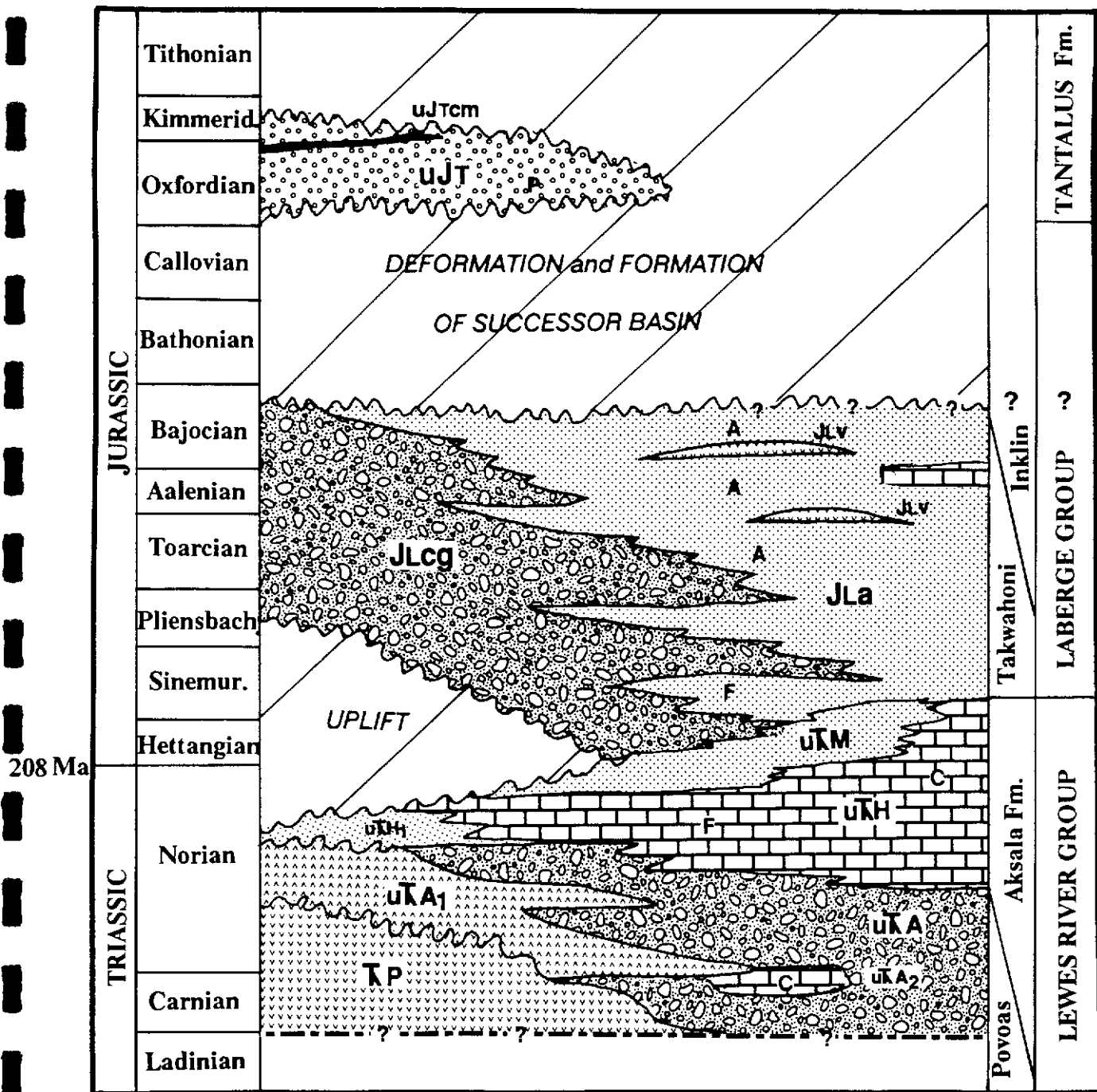


Figure 5: Schematic stratigraphic section of Whitehorse Trough as exposed in the project area and described in text. Diagonal slashes represent periods of erosion. Undulose lines represent unconformities and disconformities. Stratigraphic control determined from: P - palynology (G.E. Rouse written comm. 1989); A - ammonites (Wheeler 1961 and H. Tipper written comm. 1990); C - conodonts (M. Orchard, written comm. 1989); F - macrofossils (Wheeler 1961; except for Sinemurian fossil from Reid and Tempelman-Kluit 1988). Rock unit symbols are those used in text and maps.

Gneissic layers are thin, varying from 2 mm to 5 cm thick. A laminated, quartz-rich, pale green gneiss which is abundant on the east slope of Tally Ho Mountain is spatially associated with marble. Both appear to have sedimentary protoliths. Massive dark green to brownish black amphibolite with distinctive hornblende augen pseudomorphs of primary pyroxene phenocrysts is less abundant. The amphibolite is associated with a thin marble layer over most of the length of the shear zone. On the north facing slope of Tally Ho Mountain the marble is over 100 m thick. A very fine-grained quartzite in the Gold Hill area may have originally been a chert horizon.

Povoas Conglomerate (TrPcg)

Clast supported polymict conglomerate composed of well-rounded cobbles is exposed in outcrops on the plateau north of Friday Creek and two kilometres northwest of Ptarmigan Hill. Clast composition is dominated by mafic to intermediate, fine-grained volcanic with lesser plutonic, metamorphic and sedimentary clasts which average 20 cm in diameter but range up to 140 cm. Metamorphic clasts were most likely derived from the Nisling terrane. The unit looks very similar to the Laberge Group conglomerate.

The unit appears to unconformably overlie the Povoas Formation although contacts are not exposed. The dearth of other clastic rocks and the dominance of volcanic rocks suggest that the conglomerate is part of the Povoas Formation. Similar conglomerate is found west of Atlin unconformably overlying Late Triassic (Bennett Granite equivalent), but under the lowermost Annie equivalent limestone (Mihalynuk et al. unpublished field guide; Mihalynuk and Mountjoy 1990).

Aksala Formation

Volcano-sedimentary and volcanic rocks of the Aksala Formation comprise the greatest thickness of the Lewes River Group, a minimum of 1800 m. Coarse volcanoclastic rocks and andesite flows of the Annie member are overlain by finer-grained marine clastic and carbonate rocks of the facies equivalent Mandanna and Hancock Members.

Annie Member (uTrA)

The Annie member was proposed by Hart and Pelletier (1989a, b) to differentiate coarse volcanoclastic rocks from finer-grained marine sediments of the Mandanna member. It is composed dominantly of coarse-grained, immature volcanoclastic and epiclastic rocks with intercalated lava flows, tuff and minor limestone. The unit is massive to poorly bedded with uncommon beds or laminae of siltstone and greywacke defining distinct horizons in the sequence (c.f. Casca member, Tempelman-Kluit 1984). Both upper and lower contacts are rarely exposed. A minimum thickness of 1000 m is estimated for the Annie member on Needle Mountain though most exposures are thinner. The member is broken into 3 units: a dominantly volcanoclastic unit (uTrA), intermediate lava flows (uTrA₁) and limestone (uTrA₂).

The volcanoclastic unit (uTrA) is composed of coarse-grained volcanoclastic and lesser epiclastic deposits derived mainly from underlying Povoas Formation augite porphyry, Aksala Formation andesite and dacite porphyry and sedimentary beds. Angular to sub-rounded volcanic and sedimentary rock fragments in a crystal-rich, muddy matrix comprise lahars, clast supported agglomerate, angular pebble conglomerate and breccia. These grade laterally into or are interbedded with massive to thickly bedded crystal-lithic arenite. Minor beds of tuff and ash are recognized in this sequence with fine-grained epiclastic strata.

Light to dark green or maroon andesitic lava flows, associated agglomerate, breccia and red siltstone form a dominantly volcanic unit (**uTrA₁**) in the Annie member. Annie member andesites commonly contain an abundance of plagioclase phenocrysts in a trachytic, plagioclase-rich groundmass, but significantly fewer augite phenocrysts than the Povoas Formation basalts. Flows are interbedded and grade laterally into massive breccia and agglomerate composed of locally derived volcanic fragments.

Massive and bioclastic limestone and limestone breccia (**uTrA₂**) is found near the base of the Annie member on Needle, Lakeview, Goat and Grey Mountains, as well as near Dugdale Creek. The limestone is grey and white to pink and forms a thick, prominent bed which upon close inspection is often found to be internally deformed or tectonically dismembered. This limestone is correlated with similar beds in the Annie member in the east wall of the Ibex River valley (where its base is faulted) which contain *Halobia* fossils and are interpreted as early Norian or late Carnian (Wheeler 1961).

Hancock Member (**uTrH**)

The Hancock member is a maximum of about 600 m thick and is divided into white to light grey, massive to thickly bedded limestone (**uTrH**) and a rhythmically bedded limestone and siltstone (calc-rudite) unit (**uTrH₁**). The massive limestone unit is recrystallized in the Whitehorse Copper Belt and near McDonald Creek (Carcross sheet). Primary textures are preserved only in bioclastic horizons away from large intrusions. Sooty black limestone and tan dolostone are irregularly interbedded through the massive limestone west of Whitehorse (see Morrison 1981). Rhythmically interbedded white limestone and tan siltstone with undulatory bedding surfaces overlie massive limestone on Jackson Hill and at the Fish Lake Road turnoff. The Hancock member carbonates host skarn deposits of the Whitehorse Copper Belt and also provide important fossil control for the age of the Lewes River Group.

Mandanna Member (**uTrM**)

Red, purple, green and grey clastic rocks of the Mandanna member are found only on the Whitehorse sheet where they form sequences up to several hundred metres thick both above and below Hancock carbonate build-ups. The member is divided into three units, each representing facies equivalents with differing grain size and composition. Crystal-rich volcanogenic lithic greywacke and shale with minor red, bioturbated siltstone and pebble conglomerate (**uTrM**), coarse-grained lithic-rich arenite with minor shale and angular pebble conglomerate (**uTrM₁**), and a red siltstone unit with minor crystal-rich greywacke (**uTrM₂**) comprise the facies of the Mandanna member. Units are medium bedded to massive and common sedimentary structures include graded bedding, scour surfaces and channels, rip-up clasts, shallow cross-beds and ripple laminations.

Age and Interpretation

Macrofossil and conodont ages for the Lewes River Group range from Carnian to latest Norian (Tozer 1958; Wheeler 1961; Morrison 1981; Doherty and Hart 1988). Reid and Tempelman-Kluit (1987) suggested that the Group is as young as Sinemurian, although no Hettangian or Sinemurian fossils have been recovered from the project area. The depositional environment may have been too high energy for fossil preservation. Parts of the Povoas Formation may be older than Carnian (Doherty and Hart 1988; Tempelman-Kluit 1984). Deformed augite porphyry, identical to that found in the Tally Ho shear zone, forms clasts in conglomerate associated with limestone identified as Late Carnian (M. Orchard written comm.

1989). Thus deformation, uplift, and erosion of the Povoas Formation must have occurred before Late Carnian time, indicating that the parts of the Formation are older than Carnian. The prominent limestone bed which overlies Povoas Formation rocks at Needle Mountain is correlated with other limestone beds which contains (upper?) Carnian fauna (Wheeler 1961).

The Lewes River Group is considered to be an island arc assemblage. Volcanic rocks of the Povoas Formation represent the Lewes River Arc. Sedimentary accumulations of the Aksala Formation represent the basal Whitehorse Trough assemblage (Fig. 5). Wheeler (1961) noted that the Lewes River Group sedimentary rocks are thickest in a central, axial portion and thin to the east and west while volcanic rocks are restricted to the basal western portions of the Group. In addition, Late Triassic intrusive rocks which are thought to represent the core of the volcanic arc are found west of present exposures of volcanic rocks. Thus most of the Lewes River Group represents erosional remnants derived from a volcanic arc to the west and deposited in the Whitehorse Trough.

The depositional environment of the Lewes River Group was marine and near-shore marine. Basalts of the Povoas Formation were deposited as submarine basalt flows, feeder zones and possibly sub-volcanic magma chambers (Hart and Pelletier 1989 a, b; Doherty and Hart 1988). The local, well-rounded conglomerate at the top of the Povoas Formation probably represents a restricted marine fan or fluvial environment. From late Carnian to Norian time the arc evolved and eroded, resulting in Annie member marine sedimentation and andesitic volcanism. The volcanic pile was near wave base and locally built above sea level resulting in brightly coloured, oxidized horizons in the volcanic sequences. Abrupt facies changes and numerous erosional surfaces indicated by channels and fluviclastic deposition, indicate an actively eroding environment.

Throughout Norian time, carbonate deposition competed with clastic sedimentation and shallow marine sequences of the upper Aksala Formation formed. Widespread sedimentation of coarse clastic detritus displaced local areas of carbonate deposition in the lower Annie member. By late Norian time Hancock carbonate deposition dominated (Reid and Tempelman-Kluit 1987; Tempelman-Kluit in prep.) but was again regressed by shallow water and near shore clastics of the Mandanna member. Resulting facies equivalent carbonate (Hancock) and beach and tidal flat clastic (Mandanna) facies formed, with contemporaneous, though localized disconformities (Hart and Pelletier 1989b). Annie member andesitic volcanism continued at Needle Mountain and near Bennett Lake into upper Norian time.

What forms the basement of the Lewes River arc is uncertain. Lewes River Group correlative Stuhini Group is underlain by the Paleozoic Stikine assemblage in the type-locality Stikine River area of northern B.C., which is interpreted as oceanic basement to the arc (Monger and Berg 1984; Anderson 1988). Isotopic studies of Stikine arc rocks support a primitive source for arc magmas. Values of neodymium isotope values for the Lewes River (Jackson pers. comm. 1990) and Stuhini Groups (Samson et al. 1989) are primitive and considered typical of oceanic island arcs. Initial Sr ratios for Late Triassic plutons believed to be the roots of the Lewes River arc are transitional (between 0.7046-0.7058; LeCouteur and Tempelman-Kluit 1976; R.L. Armstrong unpublished data) and show little sign of contamination from a continental source during their formation and intrusion. However, geological relations suggest that part of the arc was built on continental Nisling Terrane rocks (Tempelman-Kluit 1979; Mihalynuk and Rouse 1988), but this is not reflected in the isotopic signatures obtained to date.

TALLY HO LEUCOGABBRO (Trb)

Coarse-grained, leucocratic hornblende orthogneiss form two linear belts between Tally Ho Mountain-Dickson Hill and Stony Mountain. The rock is composed of varying percentages of hornblende and plagioclase with rare quartz. Minerals have a strong grain shaped preferred orientation defining a planar to anastomosing foliation. The foliation is concordant with both the long dimension of the leucogabbro bodies and the foliation in the Povoas Formation elsewhere in the Tally Ho shear zone. The foliation may have originated either as an intrusive flow fabric or cumulate layering but has been tectonically enhanced. Gneissic banding and compositional segregation is developed in the most deformed specimens. The hornblende habit and presence of remnant orthopyroxene cores surrounded by hornblende observed in thin section indicate that hornblende pseudomorphs primary pyroxene.

ULTRAMAFIC ROCKS (Trub)

A small body of serpentized pyroxenite on Tally Ho Mountain may be associated with the leucogabbro. Red-brown weathering dunite, the most common rock type, contains serpentine-magnetite veinlets and some thin interlayers and irregular pods of green-black peridotite. A foliation is variably-developed with unknown geometry.

TRIASSIC-JURASSIC CONGLOMERATE (TrJcg)

Light green, well indurated heterolithic breccia and basal conglomerate is exposed in the slopes of the Bennett Range. Clast supported, angular and poorly sorted, this unit contains fragments of the Late Triassic Bennett granite and quartz, marble and metamorphic rocks assumed to be derived from Nisling Terrane. All range in size from grit to small cobbles.

The unit resembles the intrusion breccia found east of Alligator Lake (LTrbx). A cataclastic fabric is common and thermal alteration gives the rock a green hue.

This unit unconformably overlies the Triassic Bennett Granite and is unconformably overlain by Upper Jurassic to Early Cretaceous Tantalus Formation, thus constraining its age to Lower and Middle Jurassic. Its stratigraphic relationship with the Laberge Group is unknown, although it may be equivalent to Early Jurassic Laberge Group conglomerate and its unusual characteristics may reflect deposition from a local, restricted source. This unit is similar to Paleozoic to Triassic conglomerate (PTrc) described by Mihalynuk and Rouse (1988) in the Tutshi Lake area just south of the B.C.-Yukon border.

LABERGE GROUP

The Lower and Middle Jurassic Laberge Group is a stratigraphically complex sedimentary package which is exposed over much of the northern Intermontane Belt. In northern B.C. it has been divided into two formations: (1) the Takwahoni, composed of coarse-grained proximal facies which ranges from latest Pliensbachian to Early Bajocian, and (2) the Inklin, a fine-grained, distal clastic facies assemblage is Hettangian(?) to Pliensbachian and also may range as young as Early Bajocian (Monger et al. in press; Fig. 5). In southern Yukon, Tempelman-Kluit (1984) has divided the Laberge Group into four formations. The Laberge Group is characterised by interfingering, gradational contacts reflecting lateral and vertical facies variations. Dickie (1989) notes that the formation names provide a useful stratigraphic framework but do not correspond to laterally continuous, mappable units. Poor biochronological control, dramatic facies variations, and disruption by faulting and granite intrusion contribute to the problem of identifying and correlating stratigraphic marker units. A

more detailed description of the Laberge Group can be found in Dickie (1989), and Dickie and Hein (1990).

This study divides the Laberge Group into four lithologic units: polymictic cobble conglomerate; greywacke and arenite; argillite, siltstone and hornfels; and andesitic volcanics. Tuff and limestone are minor, local constituents.

The thickest exposures in the project area are in the Fish Lake Syncline where a minimum measured thickness of 2400 m (8000') was recorded by Wheeler (1961). Cairnes (1912) suggested a maximum aggregate thickness of 1525 m (5000') in the Wheaton District. Wheeler (1961) also measured a 1220 m (4000') section on Grey Ridge and 1600 m west of Brute Mountain.

Contacts of the Laberge Group with the underlying Lewes River Group in the project area are variable. Most contacts appear conformable, but are probably disconformable. True conformable relationships exist on Jackson Hill and in the Whitehorse Copper Belt, where Mandanna member lithic greywacke grades upwards into Laberge Group conglomerate. (The lowermost Laberge Group is generally composed of conglomerate or coarse sandstone.) On the southwest limb of the Fish Lake Syncline several hundred metres of section are missing and Laberge Group strata overlie the Hancock and Annie members of the Aksala Formation.

CONGLOMERATE UNIT (JLcg)

Polymictic cobble conglomerate interbedded with arenite, greywacke and argillite has a minimum thickness of 1700 m on the southwest limb of the Fish Lake Syncline. Other notable exposures occur on Brute and Caribou Mountains where finer grained horizons in the conglomerate sections range in thickness from a few metres to up to tens of metres.

Conglomerate typically forms well indurated steep sided, hummocky outcrops with distinctive rusty orange weathering surfaces. It is green-grey, thickly bedded to massive, poorly sorted, and both clast and matrix supported. The matrix is composed of immature, medium to coarse-grained feldspathic arenite and greywacke.

Clasts are sub- to well-rounded and range from 1 to 50 cm (average 8-15 cm) in size. Granitic and Lewes River volcanic rocks are the most common clast constituents, including aphanitic to feldspar porphyritic andesite, crystal-rich dacite, biotite and biotite-hornblende granite and granodiorite, leucogranite and quartz diorite. The percentage of intrusive clasts increase upsection, and comprise up to two-thirds of the clast population. Sedimentary rock fragments are less abundant, and include greywacke, siltstone and rare chert. Quartz, foliated quartzite and quartz-mica schist fragments are large and abundant (15%) in exposures near Fish Lake and west of Coal Lake, but are uncommon elsewhere. Limestone clasts are abundant (20%) near Caribou and Brute Mountains.

SANDSTONE UNIT (JLs)

Immature, feldspathic and lithic greywacke, arkose and arenite with minor interbedded argillite and conglomerate form sections up to 450 m thick east of Fish Lake.

Sandstone is dark grey and weathers pale to dark orange. It is medium to thickly bedded or massive, medium to coarse-grained, and poorly sorted. The framework is composed of angular to subrounded feldspar (35-60%), quartz (5-15%), lithic fragments (10-30%) and oxidized mafic minerals (5-10%). The matrix is composed of aphanitic to very fine-grained

chlorite and white mica. Pebbly sandstone or grit horizons are common, and contain between 10-35% subangular to rounded volcanic, chert and other sedimentary rock fragments. Conglomerate lenses and argillite intervals occur locally.

ARGILLITE UNIT (JLa)

The argillite unit is composed of interbedded argillaceous mudstone, siltstone and minor fine-grained sandstone. West of Fish Lake it occurs as thin intervals interbedded with conglomerate, while on Mount Golden Horn and east of Mt. Granger it is over 300 m thick. Other notable exposures occur on Idaho Hill, Folle and Caribou Mountains.

The argillite is dark red-brown weathering, light to dark grey and green, generally siliceous and contains abundant ammonites. Interbedded sandstone is composed primarily of fine-grained quartz and feldspar. Rhythmic mudstone and siltstone interbeds range in thickness from <1 cm to 4 cm, and sandstones from 1-2 cm. Primary features are commonly well exposed in hornfelsed sections and include ripple laminations, starved ripples, graded bedding, pinch and swell structures and soft sediment deformation features. Graded, alternating arenite-mudstone couplets compose sections several hundreds of metres thick east of Fish Lake.

Phyllite (JLm) on the southern slopes of Caribou Mountain contains flattened conglomerate and metasandstone.

LABERGE ANDESITE (JLv)

Porphyritic andesite flows, small plugs and dykes are uncommon in the Laberge Group. The largest exposure is on the east side of Goat Mountain where submarine, pillowed andesite porphyry flows, feeder dykes and small plugs intrude and are intercalated with sandy siltstone. Smaller exposures were seen on the east side of Folle Mountain and in the upper Ibex River area. The andesites are competent, massive, drab olive to dark green porphyries. Equant plagioclase phenocrysts are up to 6 mm across and compose 20-30% of the rock volume. Acicular hornblende phenocrysts are locally common.

Volcanic rocks on Grey Ridge, and small hypabyssal plugs in the Bennett Range and in northernmost B.C. (which intrude Laberge Group) resemble this unit, but probably represent a younger (Cretaceous) volcanic event.

Age and Interpretation

Ammonites collected by Wheeler (1961) from the Laberge Group in the study area range from earliest to early Middle Jurassic. The oldest rocks are upper Pliensbachian strata which rest unconformably above Norian and older Lewes River Group. Fossils previously thought to be as old as Sinemurian (Wheeler 1961; Frebold 1964) are Bajocian (H. Tipper pers. comm. 1989). Toarcian and Aalenian strata are most common in the Fish Lake syncline and Brute Mountain sections, including Aalenian tuffs near Bonneville Lakes. The youngest rocks are Aalenian to Lower Bajocian distal turbidites which are widespread in the study area. Equivalent rocks in northern B.C. contain Pliensbachian (Bultman 1979) and Toarcian (Mihalynuk and Rouse 1988) ammonites. Reid and Tempelman-Kluit (1987) report fossils ranging from Sinemurian to Aalenian in age in the Laberge Group north of the project area.

Three very small fractions of small, short zircons obtained from andesite porphyry flows returned a single, highly discordant U-Pb age younger than the stratigraphic age of the

intercalated distal turbidite sequence (Aalenian to Lower Bajocian(?)). The $^{207}\text{Pb}/^{206}\text{Pb}$ date (167 ± 48) suggests that an early to middle Jurassic age is possible, but it is not definitive. A better constrained stratigraphic age could be determined from fossilized ammonites found in the Goat Mountain section.

The relationship between the Laberge Group and underlying Lewes River Group is problematic as the contact is facies controlled and not always represented by the same lithological sequence. The contact has previously been determined as either the top of the highest carbonate (Hancock member) or the lowest granite clast-bearing conglomerate. Detailed mapping has shown that in many places shallow water sandstone of the Mandanna member is both above and below the carbonate. Mandanna member sediments above the carbonate are generally transitional with the Laberge Group making the contact difficult to define. In much of the map sheet the contact is conformable, although disconformities are locally recognized. In the Carcross area a disconformity is indicated by the presence of Lewes River Group clasts within the lower Laberge Group. Limestone clasts found in Laberge conglomerate contained Late Norian conodonts (M. Orchard written comm. 1990), indicating that they were probably derived from the underlying Lewes River Group. On the southwest limb of the Fish Lake Syncline hundreds of metres of section have been removed by erosion and Laberge Group disconformably or unconformably overlies the Annie Member or Povoas Formation.

The Laberge Group was deposited in a variety of environments characterized by lateral and vertical facies changes and includes proximal to distal facies. West of Fish Lake, conglomerate predominates representing the proximal Takwahoni facies. East of Fish Lake sandstone content increases progressively until argillaceous rocks dominate near Mount Golden Horn, comprising the more distal Inklin facies.

Conglomerate was deposited as coalescing marine fan conglomerate and debris flows with lesser deposits in alluvial bars and submarine channel complexes. Sedimentary structures such as tabular cross-bedding and extensively scoured bases of conglomerate beds are indicative of this environment. Dickie and Hein (1990) interpret interbedded conglomerate and argillite sections on Brute Mountain as advancing prodeltaic lobes deposited in deep marine slope facies. The Fish Lake Syncline is underlain by coarse clastics deposited in a huge, submarine fan complex. The thickness of the Laberge strata in the syncline is variable, with the thickest accumulations in the northwest. The southeast limb is approximately half as thick and composed of sandstone and argillite. Paleocurrent indicators measured in the Laberge Group show that sediment was transported from the northwest to the southeast. Similar paleocurrent directions are indicated in underlying Aksala Formation strata and suggests that the depositional system was set up at least by Norian time.

The progressive vertical increase in granitic clasts represents deeper erosion of the source arc. The high degree of rounding and sphericity of the clasts probably reflects high energy braided fluvial systems. Periodic flooding, typical of these systems, may have acted as the triggering mechanism for the deposition of conglomerate and greywacke as massive debris flows (Dickie 1989).

Massive feldspathic greywacke and arenite were deposited basinward and above the fan complexes. Low angle and planar stratified sandstone occasionally contain magnetite laminae indicative of beach facies. Graded sandstone-mudstone couplets are representative of Bouma BC(E) turbiditic sequences (Dickie 1988) deposited in distal environments.

JURASSIC VOLCANICS

Great thicknesses of Jurassic volcanic rocks are common throughout northwest British Columbia (Alldrick 1988; Armstrong 1988; Anderson 1989, 1990). Excepting for small accumulations in Laberge Group strata, Jurassic volcanics are generally unrecognized in southern Yukon despite the presence of early and middle Jurassic plutons (this study; Tempelman-Kluit 1984; Mortensen in prep.; Armstrong unpublished data). In the project area, two suites of volcanic rocks considered to be Jurassic in age have been defined; one has already been described as part of the Laberge Group. Both are of limited areal extent. Neither has characteristics similar to those described for the Nordenskiöld dacite (see Tempelman-Kluit 1984; in prep.).

UPPER JURASSIC VOLCANICS (uJv)

Dark grey to brown and brilliant orange weathering, dark blueish grey, feldspar-phyric massive intermediate volcanic, epiclastic and siliclastic rocks are exposed on the slopes of Chieftain and Carbon Hills overlooking the Wheaton River. Most exposures are severely altered or gossanous, difficult to classify, and as a result, have previously been given generic classifications (ie. Mv-Doherty and Hart 1988; Unit A-Wheeler 1961). Epiclastic sedimentary rocks associated with the volcanics are highly siliceous and grade upwards into sandstone, grit and conglomerate characteristic of the Tantalus Formation. The Tantalus rocks are composed almost entirely of quartzite clasts which probably result from the recrystallization of chert.

Age and Interpretation

The age of this unit is defined by its geological relationships with adjoining units. The close association with the Tantalus Formation on Carbon Hill and to a lesser extent on Chieftain Hill indicate that an Upper Jurassic age is probable (if we assume that all Tantalus Formation is Upper Jurassic). In addition, the volcanosedimentary package on Carbon Hill is unconformably overlain by volcanic rocks which returned a mid-Cretaceous K-Ar age of 107 Ma. The Carbon Hill package is also cut by andesite dykes presumed to be related to mid-Cretaceous volcanism and granitic dykes derived from the Carbon Hill Plug.

TANTALUS FORMATION (uJt)

The Tantalus Formation is a poorly understood assemblage of coal-bearing, siliciclastic strata which are discontinuously exposed over much of the south-central Yukon Territory. In the Whitehorse map-area, the Tantalus Formation is composed of greater than 600 m of chert-pebble conglomerate with interbedded sandstone, shale and coal.

West of Whitehorse the Tantalus Formation is preserved in a 30 km long crescent shaped, fault bounded wedge extending from along the east bank of the Ibex River to south of Double Mountain. Upper and lower contacts are no longer preserved.

In the Wheaton River area discontinuous erosional remnants overlie a variety of older rocks. On Mt. Bell, conglomerate unconformably overlies Paleozoic and older(?) metamorphic rocks of the Nisling Terrane. On Carbon and Chieftain Hills, conglomerate and sandstone are conformable and intercalated with volcanic rocks. On Finger Mountain minor conglomerate unconformably overlies a basal conglomerate (TrJcg) on the Late Triassic Bennett Granite.

The Tantalus Formation in the project area comprises approximately equal amounts of conglomerate and sandstone to shale and siltstone. Dark grey to brown weathering, massive to thick bedded, clast supported pebble conglomerate forms resistant, well indurated outcrops. Clasts are composed of well-rounded, 1-4 cm pebbles of grey, black, grey-blue, white and green chert and white quartz with minor quartzite. Clasts of intrusive or metamorphic rocks are rare, though typically larger. Clasts larger than 10 cm are rare. Conglomerate commonly grades upsection to poorly indurated gritty sandstone.

Sandstone generally is reddish-brown, contains a higher percentage of non-chert clasts, and clasts are less well rounded than those found in the conglomerate. Sandstone is often massive, gritty and poorly indurated. Shale, siltstone and sandy siltstone is well bedded, black or dark grey, and fissile. Some exposures also contain impure coal layers (uJtcm).

Above the Ibex River, three thick, fining upwards sequences are exposed. Channel-fill conglomerate forms lateral-accretion deposits which grade up to coarse-grained sandstones representing gradual channel abandonment. Conglomerate has sharp, often scoured lower contacts and contain rip-up clasts of finer grained rocks. Trough cross-beds are infrequently found in the conglomerate but more commonly in the overlying sandstone which also contain planar cross-stratified facies. Vertical-accretion deposits are represented by mud and siltstone which contain numerous plant fragments.

Fossilized plant fragments, mostly grasses but some ferns and ginkgo leaves, are common in dark grey mudstone layers. Tree limbs, sometimes coalified, are present in massive conglomerate.

Sandstone is composed of predominantly chert clasts, but contains a larger percentage of quartz, lithic and feldspar clasts (up to 50%) than do the conglomerates. Lithic clasts are typically schist or granitic. Clasts are sub-angular and there is often a larger percentage of matrix than seen in the conglomerate. Cement is generally cryptocrystalline quartz but calcite is a common interstitial constituent.

Plagioclase composes up to 25% of the clasts in some samples and in a few cases, white mica was observed as detritus. Long (pers. comm. 1990) has suggested that kaolinite, a common matrix constituent in clastics in the Ibex section, is not found in rocks in the Whitehorse Coal section and may be used to differentiate the two packages of strata.

Bush Mountain Facies

At Bush Mountain, in outcrops below the Whitehorse Coal deposit and in the lower reaches of Two Horse Creek, a characteristic chert/quartz-poor facies of the Tantalus Formation is exposed. These rocks typically have a maroon or grey-green hue, and are notable in the percentage of feldspar and lithic clasts. Epidote is a common secondary mineral. The arkosic wackes are well-bedded, and interbedded with epiclastic sandstone and "type" (cherty) Tantalus strata. Coal does not occur in this section, but limestone can be found locally.

Coal (uJtcm)

Coal seams outcrop in at least six localities over a 20 km strike length. At Whitehorse Coal, up to eight coal seams, ranging to 8.5 m, but generally less than 3 m in width have been determined. The coal overlies or is interbedded with black, carbonaceous mudstone, which generally overlies trough cross bedded sandstone. The upper contact of the coals is generally

scoured and overlain by coarse, massive conglomerate. The coals are laterally continuous and traceable for up to two kilometers (Bremner 1989).

Vitrinite reflectance values average 2.45%, but range between 1.68% and 3.68% (Hunt 1989). Coal rank varies between low volatile bituminous to anthracite and is locally influenced by dykes and buried intrusions.

Age

The Tantalus Formation has been assigned ages ranging from Late Jurassic to Eocene. Bell (1956) examined a faunal collection from near Mt. Bush and considered the flora to be Neocomian (early Lower Cretaceous) in age, but a Portlandian age (late Upper Jurassic) age was possible.

On the basis of palynomorph collections, Lowey (1984) suggested that Tantalus strata in the Indian River area was Early Cretaceous (Albian) in age.

Samples collected by the authors and evaluated for palynomorphs by G.E. Rouse (Palynorox Inc.) defined a Kimmeridgian-Oxfordian (upper Jurassic) age for strata of the Ibex River section (Appendix A). This age is in agreement with the Portlandian age suggested by Bell, and defines the oldest recognized strata of the Tantalus Formation. While it is much older than the Albian age defined by Lowey (1984), additional palynomorph collections from Tantalus strata in the project area indicate that some strata may be upper Cretaceous in age (G.E. Rouse written comm. 1990).

Provenance

Despite widespread proximal exposures of volcanic, plutonic, metamorphic and clastic sedimentary country rocks, chert is the dominant component of the Tantalus Formation. Provenance was therefore either strictly controlled or depositional conditions were such that other rock types were eliminated by chemical or physical weathering.

Chert clasts were probably derived from the Kedahda Formation of the Cache Creek Group (northern Cache Creek Terrane) which contains grey, black, white, brown, brown-red and a distinctive malachite-green chert like the clasts in the Tantalus Formation. The presence of quartz (metamorphic), quartzite and mica suggest some detritus came from a quartz-rich metamorphic terrane (Nisling Terrane?).

Previous writers have speculated that the Anvil Range Group (upper Paleozoic) or Selwyn Basin (middle Paleozoic-Road River) of south-central and eastern Yukon may have acted as potential source areas. Oceanic, chert-bearing Upper Paleozoic and Lower Mesozoic strata of the Windy-McKinley Terrane of western Yukon should also be considered as a potential source area for chert clasts.

Interpretation

No detailed lithofacies or paleontological analyses have been undertaken on Tantalus Formation rocks in southern Yukon. Proposed depositional environments for rocks assigned to the Tantalus Formation have included beach (McConnell 1906), restricted continental basin (Bostock 1942), continental-fluvial (Tempelman-Kluit 1974 pers. comm. 1984; Hughes and Long 1980), fan-delta (Lowey and Hills 1988), braided river (Bremner 1989) and fluvial to marine shoreface transition (Hart and Pelletier 1989b). Palynomorphs collections from the

Indian River area indicate that the depositional environment for siliciclastic rocks assigned to the Tantalus Formation were dominantly limnic, but locally paralic.

Two palynological assemblages collected by the authors returned faunal populations composed entirely of marine dinocysts (Appendix A). This is in contrast to the dominantly limnic assemblage collected by Lowey (1984) near Carmacks and indicates that deposition was marine near Whitehorse. The extensive lateral occurrence of coal (over 20 km) in a relatively thin sequence of strata must be considered in depositional models.

The various lithofacies assemblages observed in the Whitehorse map-area display characteristics of both fluvial and shoreface environments.

Cyclical, fluvatile sandy siltstone, mudstone and coal were deposited with sandy beds during periods of overbank flooding until succeeded by higher energy deposition of massive conglomerate during channel migration, flooding or storm events. Most facies sequences are incomplete and have been terminated prematurely by massive conglomerate caps deposited during periods of high discharge.

The Ibex Valley section appears to represent a meandering, apparently fluvial system in which conglomerate was quickly deposited in a high energy setting. Sedimentary units of Tantalus strata near the Whitehorse Coal deposit are neither extensive or cyclical, and were deposited in a more complex environment than the Ibex section. The Whitehorse Coal section has characteristics similar to those found in distal gravelly braidplain environments as described by Rust and Koster (1984). Long (pers. comm 1990) has suggested that the Ibex and Whitehorse Coal sections are petrographically distinct and not representative of the same depositional environment.

Some aspects of the local sedimentology indicate the presence of beach facies and storm generated transgressive marine successions. A gravelly barrier island model (see Rahmani 1983; Reinson 1984) provides a back barrier (lagoonal) facies in which thin, laterally extensive coal could be deposited, but does not account for apparently fluvial, lateral accretion sequences. Alternatively, a well channeled, wave dominated delta with estuarine lagoons transgressed by gravelly shoals during storms could account for the deposition of all facies, the presence of marine dinocysts in an apparently fluvial environment and laterally extensive coal deposits. Further sedimentological and palynological study is required to definitively determine the depositional environment.

MILLHAVEN CONGLOMERATE (JKMcg)

Small exposures of clast-supported, immature, polymictic, generally red-weathering conglomerate with lesser sandstone, greywacke and shale, outcrop at the mouth of Millhaven Bay, in the lower Wheaton River valley, on Mount Stevens and Dickson Hill, and on Carbon and Chieftain Hills. Sub-angular quartz, quartzite, mica schist, granite, chert and intermediate volcanic clasts dominate. With the exception of the Millhaven Bay locality, the units are thin and show little lateral extent. The lower contact of the conglomerate appears to be unconformable everywhere. Upper contacts are not seen, but on Mount Stevens, Cretaceous? volcanics are presumed to overlie this unit and the volcanic rocks contain conglomerate clasts.

On Carbon and Chieftain Hills, the conglomerate is associated with chert-rich (Tantalus?) clastics although field relations are poor and the relative stratigraphic positions

remain indeterminate. Local compositional variations in the Millhaven conglomerate are large, in contrast to the consistent dominance of chert in the Tantalus Formation.

The unit represents a basal conglomerate deposited unconformably on several different units. Clasts were mostly derived from the metamorphic, quartz-rich Nisling Terrane. The hematitic oxidation indicates that the conglomerate was deposited sub-aerially, probably in a fluvial environment.

The Millhaven conglomerate contains clasts as young as the Late Triassic Bennett Granite. It is associated with (relations unknown) the Tantalus Formation and is overlain by volcanic rocks assumed to be Cretaceous. On Mt. Stevens, the Millhaven conglomerate is sheared and therefore older than that deformation. An age range of Upper Jurassic to Late Cretaceous is therefore possible.

CRETACEOUS VOLCANICS

Wheeler (1961) mapped numerous exposures of Hutshi Group and Unit A (volcanics of uncertain age) in the Whitehorse map area. Most of these occurrences are now recognized as being Cretaceous in age (Wheeler and McFeely 1987; Doherty and Hart 1988; Hart and Pelletier 1989a, b; Tempelman-Kluit 1984).

Volcanic rocks considered to be Cretaceous in age form thick accumulations in at least six localities in the project area: Montana Mountain, Finger Mountain, Carbon Hill, Mt. Stevens, Grey Ridge, Pugh/Bush/Perkins massif and Goat/Lakeview Mountains. Lithological characteristics of volcanic rocks in these areas are highly variable and not generally comparable or correlatable on this basis.

With the exception of the Montana Mountain complex, the volcanic piles are poorly dated and are presumed to represent mainly middle to Late Cretaceous volcanic activity. North of the study area, in the Laberge map-area, Tempelman-Kluit (1984) obtained a variety of whole rock, K-Ar ages for Cretaceous volcanics between 64 and 116 Ma. Cretaceous volcanic rocks in the project area returned dates between 58 and 106 Ma. Assigning nomenclature to the volcanics is difficult and depends largely upon their age, either mid-Cretaceous (Mt. Nansen Group) or Late Cretaceous (Carmacks Group).

MT. NANSEN GROUP

Carbon Hill Volcanics (mKMN)

Several small exposures of drab green brecciated and tuffaceous andesitic volcanics occur as nearly flat laying erosional remnants or pendants in the Carbon Hill area. They are differentiated from older upper Jurassic? volcanics which they unconformably overlie by their lighter colour, brecciation, and dark and resistant weathering characteristics. They also unconformably overlie the Bennett Granite and Tantalus Formation rocks and are intruded by the Late Cretaceous (96 Ma) Carbon Hill plug. These constraints support K-Ar ages of 105 and 106 Ma (unpublished data) taken from andesite and rhyolite respectively, 1 km northeast of Antimony Creek. The Carbon Hill volcanics are correlated with Montana Mountain volcanics on the basis of similar ages and characteristic breccias.

Montana Mountain Volcanic Complex

The middle Cretaceous Montana Mountain volcanic complex forms an isolated, elongate area of approximately 80 km² in the central part of the Carcross map area and extends southward into northern B.C. The volcanic complex was the focus of a study undertaken by Roots (1981, 1982). Three major compositional units are: intermediate lava flows and breccia; flow-banded and tuffaceous rhyolite; and andesite plugs and dykes. The volcanic rocks must have been deposited unconformably upon folded strata of the Laberge and Lewes River Groups, although the complex is fault-bounded. Normal and strike-slip faults juxtapose volcanic rocks against older Laberge Group sedimentary rocks on the west, south and northeast margins. The reactivated Nahlin Fault juxtaposes Carbo-Permian Cache Creek Group against the east side of the complex. The Carcross Pluton intrudes the complex on the north side.

The oldest and most extensive unit (**mKM₁**) consists of approximately equal amounts of massive to poorly bedded, dark green and maroon andesitic lava flows, breccia and tuff. Flows are generally aphanitic, dark to light green coloured and may contain 5-15% subhedral to euhedral feldspar phenocrysts (2-10 mm). Monolithic andesite breccia forms laterally extensive units which are interbedded with massive lava flows. Breccia clasts are commonly rimmed by aphanitic, darker coloured material which represents rapidly chilled primary volcanic ejecta. In the central part of the complex, crudely bedded to massive heterolithic, blocky pyroclastic tuff are interbedded with massive flows. Tuff horizons range in thickness from less than 1 m to up to 15 m, and are composed of 15-30% angular to irregular, whispy shaped andesite clasts (1-5 cm).

Rusty weathering, yellow and light orange rhyolite flows, pyroclastic rhyolite tuff and breccia are designated as a second unit (**mKM₂**). These rocks predominate in the southern portion of the complex, at Dail Peak, southeast of Windy Arm and in B.C. Rhyolite is commonly flow-banded and contains up to 25% combined anhedral quartz and white feldspar phenocrysts. Tuff and breccia is composed of angular, monolithic lapilli-sized fragments in a rhyolite matrix. The thickest accumulations of this unit occur at Dail Peak where it is approximately 1200 m thick (Roots 1982) and east of Windy Arm where 700 m of section have been estimated (Hart and Pelletier 1989a).

Aphanitic to feldspar- and hornblende-phyric, black-green andesite form small, resistant, massive plugs and large dykes (**mKM_{vd}**) along the western portion of the complex. They intrude all other units and contain xenoliths of country rock along their margins. Similar exposures are found in the eastern portion of the Bennett Range.

The volcanic rocks commonly show weakly to intensely propylitic alteration and are also locally weakly foliated. In thin section, plagioclase phenocrysts are variably replaced by sericite and the groundmass is a mottled mass of microcrystalline chlorite, epidote and calcite. Mafic minerals are replaced by chlorite and oxide minerals.

Faults associated with volcanic events in the Montana Mountain volcanic complex are difficult to recognize due to the lack of marker horizons and identifiable stratigraphy. Most faults in the complex are younger and may be related to subsidence or subsequent uplift during the intrusion of the Montana and Carcross Plutons. An easterly-striking fault between Mount Matheson and Montana Creek divides the dominantly mafic flows of the northern portion of

the complex from the stratigraphically higher intermediate and felsic rocks of the southern portion of the complex. A fracture cleavage is well developed in volcanic rocks adjacent to Wynton Creek.

Age and Interpretation

A concordant U-Pb zircon age of 94 ± 1.2 Ma was obtained from an intermediate, blocky, pyroclastic unit near the head of Pooley Creek. Flow banded rhyolite east of Windy Arm yielded a U-Pb zircon age of 83.7 ± 0.4 Ma which probably represents the youngest volcanic activity in the Montana Mountain Complex. A potassium-argon date of 65 Ma is probably reset by the intrusion of the Carcross Pluton. An older-intruding-younger relationship is apparent on the northern margin of the complex, where a border phase(?) aplite of the Montana Pluton (106.8 Ma; U-Pb) cuts the volcanic complex, for which the oldest date is 95 Ma. This discrepancy may be resolved by assuming that the intruded volcanics are an older portion of a long-lived volcanic pile or that the aplite is part of another (younger) intrusion. The concordance of the two ages for the volcanic rocks suggests that volcanic activity persisted for at least 10 million years. If some of the volcanic rocks are as old as the Montana Pluton then volcanism at the Montana Mountain complex spanned approximately 23 million years.

The Montana Mountain complex has been correlated with the mid-Cretaceous Mt. Nansen Group on the basis of its diagnostic breccias and field relationships (Roots 1982). This correlation is confirmed by the aforementioned age dates.

The Montana Mountain Complex forms an isolated, fault bounded volcanic remnant of predominantly intermediate lava flows and breccias, and less abundant but younger felsic volcanic rocks. The abundance of autoclastic breccias, debris flows, bombs and epiclastic breccia suggests explosive volcanism, proximity to vents and significant topographic relief. Abrupt thickening and brecciation of the felsic flows on Dail Peak may be due to ponding of lava in a depression or valley. The absence of interflow sediments suggests the volcanos formed in a subaerial environment.

Massive intermediate lava flows and breccia overlain by silicic pyroclastic tuffs and flow banded rhyolite represent contrasting styles and chemistry of volcanism. The transition from strato volcanos composed of intermediate lava flows to thick accumulations of pyroclastic tuff is common in evolving caldera type volcanic centres (Fisher and Schmincke 1984). While it is tempting to infer that the bimodal suite is representative of an evolving or zoned magma chamber, the time span between these two events precludes any decisive interpretation.

The northern part of the complex is thought to have been uplifted through normal faulting during emplacement of the Carcross Pluton (Roots 1982). This further resulted in the reactivation of older bounding faults.

CARMACKS(?) GROUP

Wheaton River Volcanics (Kv)

Resistant, blue-grey, green to black, thickly bedded to massive, porphyritic to aphanitic, vitreous andesite and dacite flows, breccia, tuff, and lesser epiclastic sediments are exposed in a northwest-trending belt extending from Mt. Stevens to the west end of Red Ridge. The thickest exposures are on Bush Mountain and Perkins Peak. They were included as part of the

Perkins Group of Cairnes (1912) along with some Lewes River Group volcanic rocks, but without the older volcanics, they are here termed the Wheaton River volcanics.

The basal section contains a significant thickness of epiclastic sediments and well-bedded tuff (**Kvs**) which distinguishes it from the overlying volcanics. The volcanics cannot be further subdivided without more detailed work.

The volcanic rocks are largely bounded on the west by younger intrusions and to the east by faults. Although considered to be in fault contact with Tantalus Formation clastics by previous authors, we feel that a steeply-dipping, continuous depositional sequence exists between the Tantalus Formation and the basal epiclastics of the Wheaton River volcanics on the ridge between Bush Mountain and Idaho Hill. A few poorly developed load casts suggest that Tantalus Formation rocks overlie the volcanics.

The volcanic pile has been intruded by granite of the Perkins Peak Plug between Perkins Peak and Bush Mtn., as well as on Mt. Wheaton and by numerous unmapped dykes. The close spacial relationship between the Perkins Peak Plug and the Wheaton River volcanics suggests that the Perkins Peak Plug was the plutonic roots to the Wheaton River volcanics.

Finger Mountain Volcanics (Kv₂)

The Finger Mountain volcanics underlie a small area (2.5 km²) south of Finger Mountain in the Bennett Range. These rocks are lithologically similar to the Wheaton River volcanics but their appearance is altered by hornfelsing. They do however contain more breccia, agglomerate, and felsic flows and breccias than the type Wheaton River volcanics. Volcanic rocks on Mt. Brown resemble the Finger Mountain volcanics, but contain granitic fragments, like tuff in the adjacent Bennett Lake complex.

A gossanous, altered rhyolite plug containing several percent of pyrite, outcrops on the west flank of the Bennett Range and may be coeval with the Finger Mountain volcanics (Hart and Pelletier 1989a). It is more silicic than Eocene rhyolite of the Skukum Group, but not dissimilar from rhyolite dykes associated with the Montana Mountain complex.

Grey Ridge Volcanics (Kv₁)

Volcanic rocks on Grey Ridge are thicker and more extensive than most other occurrences of Cretaceous volcanics. Although similar to the Wheaton River and Finger Mountain volcanics, these rocks contain more than 50% volcanoclastics as breccias, agglomerate and lahars, with minor tuff. Rhyolite is common as flow banded, anastomosing dykes with obsidian (commonly devitrified) margins.

Lakeview Mountain Volcanics (Kti)

Volcanic and plutonic rocks of unknown affinity form numerous small exposures of varying lithological characteristics in the Lakeview and Goat Mountains area. They intrude and overlie almost flat lying strata of the Laberge Group. The volcanic rocks form a crudely bimodal suite of feldspar and hornblende phyric pale green and light brown andesite flows and plugs, and white to grey, flow banded rhyolite. The andesites have characteristics similar to some Late Cretaceous(?) flows on Grey Ridge, but the rhyolite is like that of the Eocene Skukum Group. The associated intrusions are variable in their nature and unlike other suites of intrusions defined elsewhere in this report. Complete phase transitions exist between the intrusive andesite and medium-grained grey granodiorite.

This unit has characteristics of both Late Cretaceous and Eocene rocks found in the project area. A whole rock K-Ar date of 58.3 ± 2.0 Ma was obtained from andesite in the valley between Goat and Lakeview Mountains. This latest Paleocene date may indicate early Skukum Group volcanism or argon loss and a Late Cretaceous age.

Age and Interpretation

The age of the Wheaton River volcanics is equivocal. Field relations indicate that the volcanic rocks are the same age or slightly older than the early Late Cretaceous Perkins Peak Plug. However, the Perkins Peak Plug (70-97 Ma, whole rock Rb-Sr method) and the Folle Mountain granite (78 Ma; K-Ar) give younger ages than the andesite porphyry sampled from Mt. Wheaton and Folle Mountain (62 and 78 Ma respectively; K-Ar) and a rhyolite dyke on Idaho Hill (70 Ma; K-Ar). All dates *could be* Early Cretaceous or older (Armstrong written comm. 1989) and reset by the younger Folle Mountain and Wheaton Valley intrusions which have zircon ages of 78 Ma and and cooling (K-Ar) ages of 61 Ma.

The Wheaton River volcanics appear to underlie the Tantalus Formation. The best age constraints on the Tantalus Formation indicate an upper Jurassic age, which would make the Wheaton River volcanics at least that old. In addition, limestone beds in the volcanic sequence indicate a marine environment. Such environments were rare during upper Jurassic time and possibly did not exist into the Cretaceous (H. Tipper written comm. 1990). As a result, an upper Jurassic age for the volcanics is indicated.

However, the volume of nearby Late Cretaceous plutonic rocks in the Pugh/Bush/Perkins massif strongly suggests that the Wheaton Volcanics were part of a Late Cretaceous igneous event. Contemporaneous plutonism supports a significant Late Cretaceous igneous event. Evidence of Upper Jurassic igneous activity in southern Yukon is rare. In addition, there is evidence to support Late Cretaceous ages for part of the Tantalus Formation (see Lowey 1984; Lowey and Hills 1988; G.E. Rouse pers. comm. 1990).

The Finger Mountain volcanics unconformably overlie small erosional remnants of Tantalus Formation and the Late Triassic Bennett Batholith. They are intruded by the Paleogene Pennington quartz monzonite and are probably Late Cretaceous in age.

The Grey Ridge volcanics were unconformably deposited on the Laberge Group. Unlike the Finger Mountain and Wheaton River volcanics, Tantalus Formation rocks are not in contact or proximal with these rocks. A rhyolite dyke cutting the Grey Ridge volcanics returned a K-Ar date of 64 Ma. This date constrains the age of the volcanics to pre-Tertiary and may be coeval with the volcanics.

Cretaceous Rhyolite (Kr)

Sub-volcanic rhyolite plugs and dykes are scattered throughout the southern portion of the project area; most are spatially associated with Cretaceous volcanic rocks. An elongate plug intrudes the Laberge Group on the east side of Mt. Gilliam near the Grey Ridge volcanics. Rhyolite dykes also occur in the Montana Mountain, Mt. Stevens, Carbon Hill and Berney Creek areas.

This unit forms pale to rusty orange and pale green, brittle, well fractured, saccharoidal rhyolite and aplite dykes. Plugs commonly contain orange-pink (sanadine?) phenocrysts and quartz eyes, very similar to Eocene dykes. Unlike Eocene rhyolite, Cretaceous rhyolite dykes are more siliceous and lack flaggy partings.

Hart and Pelletier (1989a) suggested that two distinct generations of Cretaceous rhyolite was probable. This has been confirmed by isotopic dating. A rhyolite dyke on Carbon Hill has returned a K-Ar biotite date of 106 Ma. Rhyolite dykes on Idaho Hill and Grey Ridge have returned Late Cretaceous K-Ar ages of 70 and 64 Ma respectively. (All dates are from unpublished data).

Because there are so many exposures (dykes) of this unit, and they are similar to the Eocene suite, it is impossible to know with confidence which exposures are in fact Cretaceous. As a result, many dykes labeled as Eocene may in fact be Cretaceous. Undated rhyolite plugs on Mt. Anderson and Mt. McNeil are mapped as belonging to the Eocene suite but resemble the Cretaceous suite.

COAST PLUTONIC COMPLEX

The Coast Plutonic Complex has traditionally been considered to be a large linear batholith composed of mid-Cretaceous and Eocene plutons. Geological mapping and geochronometry has delineated numerous distinct plutons ranging in age from Late Triassic through Eocene.

Approximately 40% of the project area is underlain by rocks of the Coast Plutonic Complex. Petrography, geochemistry and isotopic age dating was performed on over 30 individual intrusive bodies. While most of the plutons were mapped and described during the first two years of this project, results of a concurrent geochronometric study undertaken with R.L. Armstrong, University of British Columbia has provided important insights into the igneous evolution of the area. In light of the new data, field relations have been reaffirmed, associations based on similar lithologies have been re-evaluated, and most of the plutonic units have been assigned names reflecting their age and lithology.

Five groups of plutonic rocks can be differentiated on the basis of age: Late Triassic, Early Jurassic, mid-Cretaceous, Late Cretaceous/Paleocene, and Early Eocene (Table 1 and Fig. 6). Each group is distinctive in its lithology and intrusive nature (Hart and Pelletier 1989 a & b). Late Triassic bodies form large, northwest-trending concordant batholiths of locally foliated, medium- to coarse-grained granite to granodiorite with pink alkali feldspar megacrysts. Early Jurassic bodies are composed of well-foliated, medium-grained hornblende diorite to granodiorite and occur as small satellite stocks to the Late Triassic batholiths. Together, the Late Triassic and Early Jurassic intrusions correlate with the Stikine (Anderson 1988) or Klotassin (Tempelman-Kluit 1976) plutonic suites. Mid-Cretaceous intrusions form northwest-trending plutons commonly greater than 10 km long. Lithologically they can be divided into two suites - the Whitehorse and Mount McIntyre plutonic suites. The Whitehorse plutonic suite is composed of medium-grained biotite-hornblende granodiorite to gabbro. The slightly younger Mount McIntyre suite is composed of hornblende-bearing, pink granophyric granite and ranges from quartz monzonite to syenite. The Late Cretaceous/Paleocene bodies are of various size and shape, but, with one exception can be distinguished by the predominance of biotite over hornblende as the primary mafic mineral. Generally they are medium- to coarse-grained granite, but range from quartz monzonite to quartz diorite. Eocene intrusions form small (<10 km), high level, discordant, circular stocks of alaskite or leucogranite with characteristic smokey quartz-eyes and very few mafic minerals. All of the groups occur in both the Coast and Intermontane Belts although Late Triassic/Early Jurassic plutons are poorly represented east of the Tally Ho shear zone.

NISLING RANGE PLUTONIC SUITE (54-60 Ma)

Late Paleocene to Early Eocene	Mt. McAuley Granite (54 Ma) Jackson Creek Granite (55 Ma) Ibex Alaskite (58 Ma) Pennington Granite (55 Ma) Crozier Creek Granite (60 Ma) Leucogranite (59 Ma)
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Paleocene	Carcross Pluton (64 Ma)
Mesozoic	quartz monzonite
Late Cretaceous	Folle Mountain Stock (78 Ma)
	Wheaton Valley Granodiorite (78 Ma)
	Perkins Peak Plug (97-77 Ma)

MT. MCINTYRE SUITE (107-119 Ma)

mid-Cretaceous	Mt. McIntyre Pluton (109 Ma) Granite phase Mount Ward Granite (119 Ma) Montana Mountain Pluton (107 Ma)
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WHITEHORSE PLUTONIC SUITE (109-119 Ma)

mid-Cretaceous	Whitehorse Pluton (116 Ma) leucocratic phase Mt. Anderson Pluton (119 Ma) Ibex River Gabbro (109 Ma) Mt. McNeil Pluton (119 Ma)
Jurassic? to Cretaceous	Fenwick Creek Diorite

Early Jurassic/ Late Triassic	Alligator Quartz Monzonite (190 Ma) Friday Creek Diorite (211 Ma) Bennett Granite (220 Ma)
	Ultramafite
	Tally Ho Leucogabbro

Table 1: Summary of plutonic suites and individual intrusions with their ages.

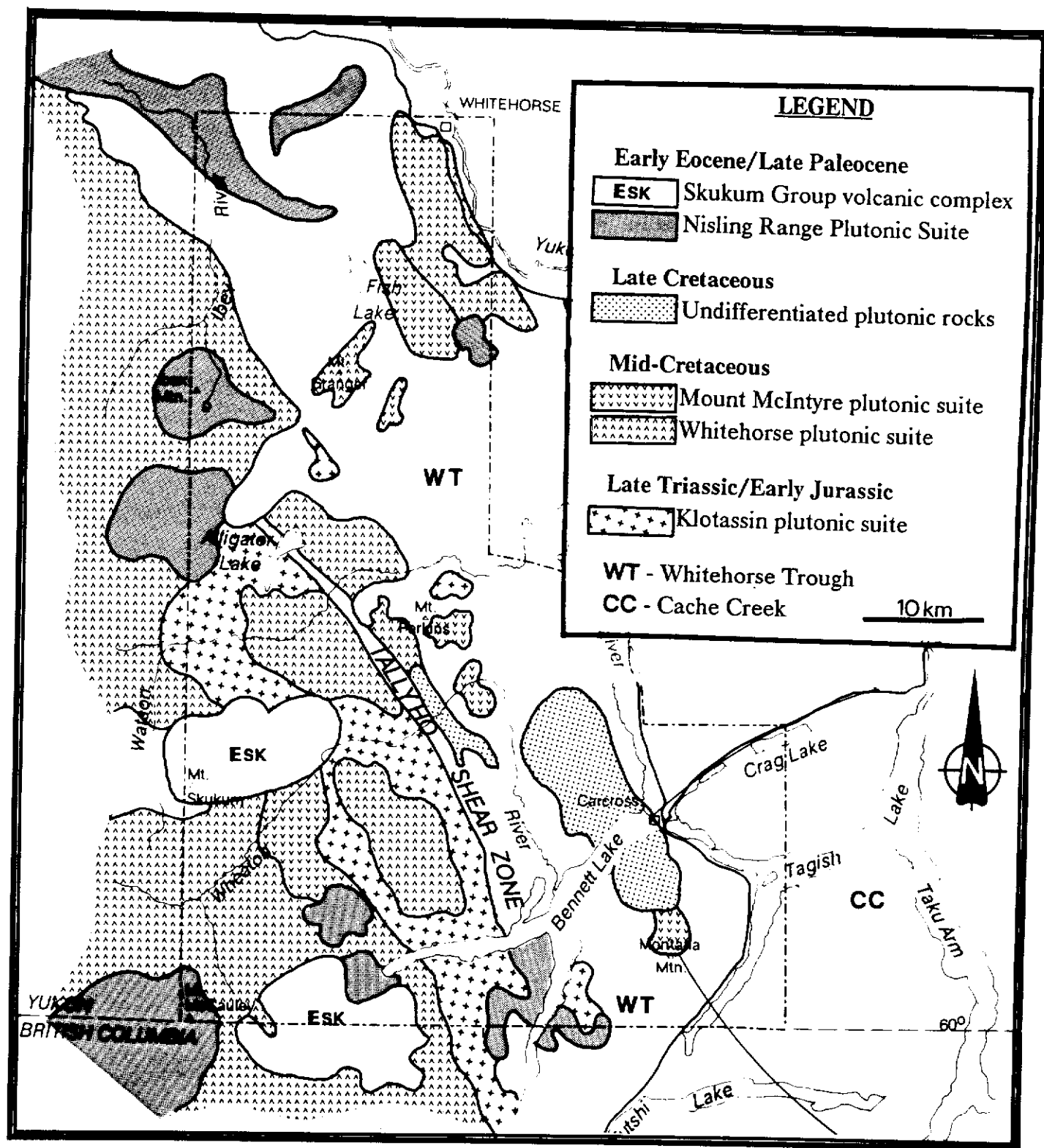


Figure 6: Distribution of the Late Triassic/Early Jurassic, mid-Cretaceous Whitehorse and Mount McIntyre, Late Cretaceous and Late Paleocene/Early Eocene Nisling Range plutonic suites in the project area. Eocene volcanic centres (ESK) are also shown.

The following descriptions summarize previous descriptions from Doherty and Hart (1988) and Hart and Pelletier (1989a, b) with further contributions from additional mapping, geochemistry and petrographic observation. Modal estimates in thin section were done by sight estimation, without point counts, and are rounded to the nearest 5%. The age constraints for the rocks are listed and interpreted. Name revisions from previous work are summarized in Appendix A.

LATE TRIASSIC BENNETT GRANITE (LTTrB)

The Bennett Granite forms the largest batholith in the area, up to 15 km wide and greater than 50 km long, extending from south of the B.C.-Y.T. border to west of Alligator Lake (Fig. 6). Its eastern contact is the Tally Ho shear zone. The Bennett Batholith intrudes metamorphic rocks of the Nisling Terrane and deformed rocks of the Tally Ho shear zone.

The Bennett Granite forms dark-grey to black, lichen covered, medium- to coarse-grained blocky outcrops. It is distinctive and easily recognized in the field by its large, tabular, alkali feldspar megacrysts up to 5 cm long (Fig. 7). They vary from creamy white to pink and fleshy brown in colour and contain plagioclase and hornblende poikilocrysts. The percentage of megacrysts (by volume) varies considerably from a few to almost 70%. Alignment of megacrysts was noted locally. Hornblende is the chief mafic mineral, although finer-grained biotite is not uncommon. Quartz is typically coarse-grained, opaque white to pale grey. Apatite, sphene, chlorite and magnetite(?) are common accessory minerals and sericite is locally common.

Composition of the Bennett Batholith is generally granite to granodiorite but ranges to quartz diorite and quartz monzonite. Hornblende diorite and monzodiorite form discontinuous phases along parts of its western margin and northwestern margins. A leucocratic phase with sparse pale pink alkali feldspar megacrysts (1-5%) occurs in the Bennett Lake area.

Though generally massive, numerous shear bands and a weak foliation are evident along its western margin. North of the Watson River and southwest of Alligator Lake a large area of this unit is cataclastically deformed.

Age and Interpretation

A U-Pb analysis on three zircon populations yielded a Late Triassic regressive intercept age of 220 ± 5 Ma (Doherty and Hart 1988). This date represents the oldest known intrusive age of rocks in the project area (excluding perhaps the Nisling Terrane orthogneiss) and is consistent with geological relations. The date is similar to that obtained for the Willison pluton west of Atlin (215 Ma Bultman 1979), and slightly older than other pre-Cretaceous batholiths west of the Whitehorse Trough such as the Aishihik Batholith (Johnson 1988). A $^{206}\text{Pb}/^{207}\text{Pb}$ date of 905 Ma was obtained from one zircon fraction from the Bennett Batholith (Doherty and Hart 1988).

The presence of significantly older Pb/Pb dates is indicative of contamination or derivation from Proterozoic continental crust. In the Aishihik Lake area, LeCouteur and Tempelman-Kluit (1976) obtained initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios greater than 0.7060 from similar Late Triassic batholiths. The most likely source of contamination in both cases is the para-autochthonous metamorphic Nisling Terrane which the batholiths intrude.

The Bennett Granite, which occurs entirely west of the Tally Ho shear zone, is part of the Late Triassic Klotassin suite which are in, or near the western margin of Stikinia. These batholiths have been suggested as coeval and probably co-magmatic equivalents to the volcanic Lewes River (Doherty and Hart 1988) and Stuhini (Anderson 1984) Groups. The Bennett Granite intrudes and links rocks of the Nisling Terrane and Lewes River Arc (northern Stikinia) indicating that these two tectonic elements were adjacent in Late Triassic time. This confirms the suggestion by Tempelman-Kluit (1979) that the Lewes River Arc was formed on or near the eastern margin of Nisling Terrane.

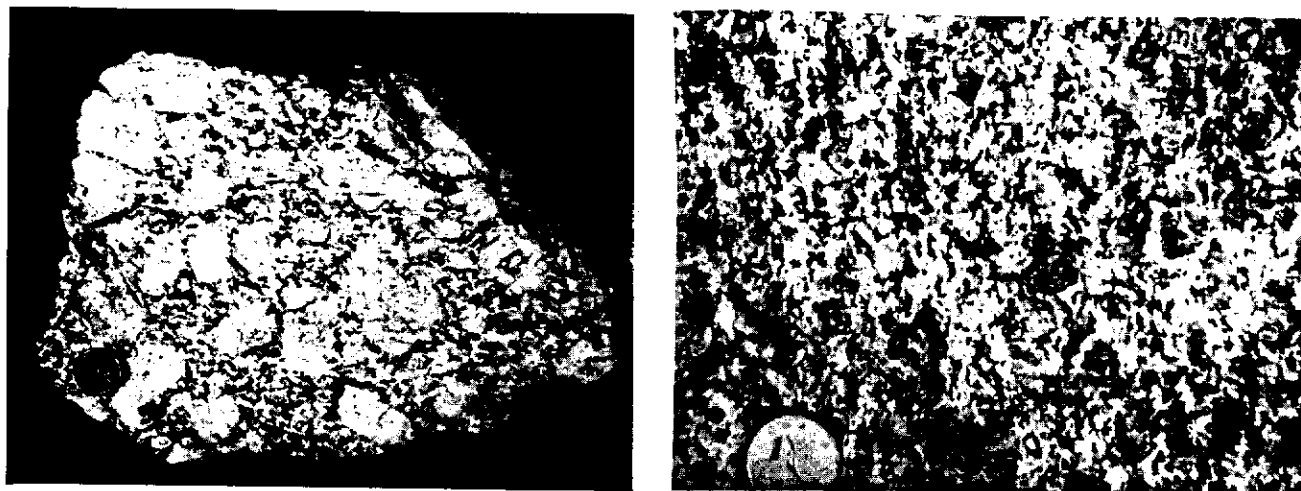


Figure 7: Examples of the textural variations in the Late Triassic Bennett granite; a) note the large, poikilocrystic alkali feldspar megacrysts; b) moderate foliation developed adjacent to the Tally Ho shear zone.

INTRUSION(?) BRECCIA (LTrbx)

Resistant, heterolithic breccia containing angular to sub-rounded fragments of Late Triassic Bennett Granite (60%) with lesser amounts of hornblende granodiorite, foliated augite porphyry, and rare metamorphic rock and quartz, underlies a 2 km² area on the slopes east of Alligator Lake. The breccia contains up to 60% matrix which is siliceous and light pale green to grey in colour.

The breccia intrudes deformed rocks of the THSZ and the Bennett Granite. Adjacent to the THSZ, the breccia is pervasively, though not intensively, sheared. The western portion of the brecciated area is cataclastically deformed and overprinted with discrete shear bands.

Two breccias outcrop west of Alligator Lake in the Bennett Granite. Cataclastic deformation is apparent but the development of a crackle breccia is more extensive. The origin of these breccias is enigmatic. The rounding of fragments and the high percentage of matrix suggests that a high degree of milling may have occurred. The heterolithic nature of the unit suggests that deep seated pressure release may have entrained other clast types during its vertical rise.

Timing of breccia formation is post 220 Ma (Bennett Granite age), but before the end of ductile deformation along the THSZ. These constraints suggest a latest Triassic age for breccia development.

LATE TRIASSIC FRIDAY CREEK DIORITE (LTrFC)

Hornblende and biotite-hornblende diorite and quartz diorite are exposed on the Friday Creek plateau (Doherty and Hart 1988). Two small exposures of argillically altered hornblende gneiss east of Ibex Mountain probably also belong to this unit. The diorite is crumbly, grey weathering, fine to medium-grained and well-foliated to gneissic. Petrographic inspection indicates a quartz dioritic composition, about 25% mafics consisting of interstitial hornblende and about 5% biotite altered to chlorite, 60% plagioclase as oligoclase (-An₂₃), and moderately deformed quartz comprising the remaining 15%. Sphene and opaques are accessory.

A U-Pb zircon age of 211.4 ± 1 Ma was determined from a sample collected above Friday Creek. Along trend to the east end of Red Ridge, similar hornblende granodiorite in an otherwise undifferentiated igneous complex (unit Mi) returned a concordant zircon U-Pb age of 201.8 ± 1.4 Ma and is thus correlated with the Friday Creek diorite.

EARLY JURASSIC ALLIGATOR ORTHOGNEISS (EJgA)

Pervasively foliated, medium-grained, equigranular biotite-hornblende quartz monzodiorite is exposed west of Alligator Lake, in the Summit Creek Pass area and west of Fenwick Creek. The alkali feldspar is white and the rock appears to be closer to granodiorite or quartz diorite in the field. The orthogneiss is spatially associated with the Bennett Granite and Nisling Terrane metamorphic rocks. In thin section the rock has about 20-35% mafics, up to 15% each quartz and k-feldspar with about 50% plagioclase. Plagioclase is extensively sausseritized while chlorite replaces biotite, indicating a degree of hydrous alteration. Rare alkali feldspar phenocrysts enclose small, anhedral quartz grains.

The foliation is non-penetrative but pervasive and generally strikes northerly. Localized dynamic recrystallization of feldspar seen in thin section is the only evidence of deformation observed.

This unit was originally considered to be Paleozoic in age (unit Pgdn of Doherty and Hart 1988) because it was thought to be the only intrusive unit with a pervasive foliation. However, $192.0 \pm 4/-24$ Ma (U-Pb) zircon ages indicate earliest Jurassic emplacement. The proximity of this unit to the Bennett Granite suggests that the several small exposures of the Alligator orthogneiss may be portions of a protracted Bennett Granite intrusive episode. Similar relationships between Late Triassic batholiths and smaller, Early Jurassic plutons have been documented elsewhere in the Stikine plutonic suite (Anderson 1983, 1984). The foliation in this unit may have formed during forceful intrusion.

MESOZOIC INTRUSION (Mi)

An intrusive complex at the east end of Red Ridge is mainly hornblende-rich granodiorite and diorite to the Early Jurassic Alligator diorite, the mid-Cretaceous Whitehorse pluton and the Late Cretaceous Wheaton Valley granodiorite and Perkins Peak plug. Early Jurassic and Late Cretaceous isotopic ages of 201.8 ± 1.4 (U-Pb zircon) and 80.6 ± 2.8 Ma (K-Ar hornblende) confirm some of these correlations.

WHITEHORSE PLUTONIC SUITE

Intrusive bodies with age, appearance, mineralogy and chemistry similar to that of the Whitehorse Pluton have been grouped to form the Whitehorse plutonic suite. They include

the plutons of the Mount Anderson granodiorite and bodies previously mapped as mKw, Kgd, mKgd, mKgr (Doherty and Hart 1988, Hart and Pelletier 1989a, b). The most extensive exposures underlie the areas around Mt. McNeil, Mt Ward, Mt. Anderson, upper Becker Creek, the Watson River and west of the city of Whitehorse.

The Whitehorse plutonic suite is composed of large, north-northwesterly-trending, intermediate, biotite-bearing, hornblende-rich plutons (Fig. 8) of mid-Cretaceous age. They are found in all tectonostratigraphic terranes of the project area. Compositions range from granodiorite, tonalite, quartz diorite to diorite and gabbro. Fresh, black euhedral hornblende and biotite rarely exceeding 30%, in an alkali feldspar poor, medium-grained, plagioclase-quartz matrix are characteristic of this suite. Plagioclase is commonly sausseritized, rendering its composition indeterminate. Accessory minerals include sphene, apatite, magnetite and muscovite. Mafic xenoliths are characteristic constituents of many of the bodies in the suite, particularly on the margins of the Whitehorse and Mt. Anderson plutons.

WHITEHORSE PLUTON (mKgw)

The Whitehorse Pluton has been well described by Morrison (1981) and Hart and Pelletier (1989b). General lithologies include biotite-hornblende granodiorite (Fig. 8), tonalite and diorite but the unit is distinguished by the large compositional variations between its margins and centre. The western margin is xenolithic and mafic in composition, including gabbro and diorite, and hornblende glomeroporphyroclasts enclose relict, augite cores. The centre of the batholith is leucocratic granodiorite.

This pluton is more altered than others in the suite. Chloritization is evident in most exposures, and epidote is common. Zones of hydrothermal alteration are apparent in the northern portion of the pluton. The leucocratic phase in the centre of the pluton may reflect the original chemistry of the Whitehorse pluton prior to contamination by assimilation of country rock (Morrison 1981). Mafic xenoliths in the Whitehorse plutonic suite probably result from the incorporation of pyroxene-rich country rocks of the Lewes River Group.

Leucocratic phase (mKqw)

Locally, granodiorite of the Whitehorse plutonic suite contains less than 10% mafic minerals and although similar in most respects to the Whitehorse and Mt. Anderson plutons, is conspicuous in its leucocratic nature. This phase is only rarely distinct enough to be mapped. This phase is similar to the central portions of the Whitehorse batholith and described by Morrison (1981).

IBEX GABBRO (mKdw; 105D/11)

Mafic intrusive rocks east of the Ibex River valley are named the Ibex Gabbro. While most exposures have phases of less mafic lithologies, gabbro (and diorite) are most apparent. On Jackson Hill, and north of Fish Creek, massive, coarse-grained pyroxene-hornblende gabbro intrudes Lewes River and Laberge Group rocks. North of the Fish Creek exposure, and along the east wall of the Ibex River valley, strongly magnetic, hypersthene-hornblende diorite forms a thin northwest-trending exposure which is well defined on airborne magnetic maps. This exposure is well described by Hart and Pelletier (1989b).

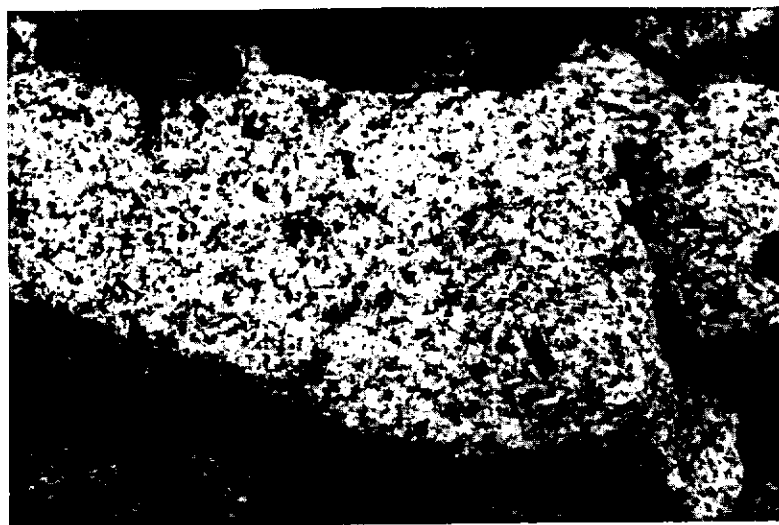


Figure 8: Granodiorite from the Mount Anderson pluton with euhedral hornblende and biotite phenocrysts in white, plagioclase-rich matrix typical of the Whitehorse plutonic suite.

MT. MCNEIL PLUTON (mKdw; 105D/3)

A large area in the vicinity of Mount McNeil and Berney Creek is underlain by granodiorite characterized by local accumulations of megacrystic, euhedral black hornblende phenocrysts (up to 75%) in a fine-grained, quartzofeldspathic groundmass. This melanocratic granodiorite is especially well exposed 2 km northeast of Mount Ward and in the Berney Creek valley.

MT. ANDERSON PLUTON (mKgMA)

The Mt. Anderson pluton and the pluton on both sides of the Watson River is granodiorite, distinguished from the Whitehorse pluton by the presence of euhedral phenocrysts of hornblende and biotite which commonly exceed 2 cm (Fig. 8), and a slightly higher percentage of alkali feldspar. This unit is generally very fresh with local zones of weakly developed, porphyry-style alteration and crumbly, argillic alteration. Numerous discrete shear bands are marked by zones of chloritic alteration.

FENWICK CREEK DIORITE (JKdFc)

Quartz diorite, diorite, and tonalite form extensive exposures north of the Bennett Lake complex near Fenwick Creek. The rocks are dark-grey, blocky, resistant weathering, fine- to medium-grained, fresh and unfoliated with acicular hornblende phenocrysts. The Fenwick Creek diorite (previously JKdi-Doherty and Hart 1988; Unit 2A-Lambert 1974) is distinguished by the presence of large volumes of blocky xenoliths and several phases of cross-cutting granodioritic dykes. Mafic minerals constitute between 30-65% of the rock. In one very fresh sample, small euhedral olivine comprises 25% of the rock in a hornblende-oligoclase matrix. A more felsic specimen is composed of 65% normally zoned labradorite/bytownite with only 5-10% quartz and the remainder of hornblende and large, interstitial biotite.

An absolute age for the diorite was not obtained, but geologic relations suggest the Fenwick Creek diorite is older than Late Paleocene leucogranite (59 Ma) which intrudes it. The Fenwick Creek diorite is petrographically similar to the Whitehorse plutonic suite and is presumed to be the same age.

Age and Interpretation

U-Pb zircon and K-Ar hornblende and biotite mineral, and mineral pair ages from both this study and Morrison et al. (1979) all confirm a mid-Cretaceous age for this suite. The zircon age, determined on samples from the Mt. Anderson and Watson River plutons is 119 ± 5 Ma (Doherty and Hart 1988). A minimum concordant date of $109 \pm 4/-3$ Ma (U-Pb zircon) was obtained on a sample collected south of Mount Ward. If the discordia is forced through the origin, the age could be as high as 121 ± 10 Ma. These ages confirm a 113 ± 4 Ma hornblende K-Ar date from the same locality (Morrison et al. 1979). A sample from the Mt. McNeil pluton on the Berney Creek Road returned an excellent concordant U-Pb zircon age of 111 ± 0.6 Ma. Slightly altered, hornblende-biotite quartz monzonite at the head of Boudette Creek (see Lambert 1974) is considered to be part of the Whitehorse plutonic suite. Although it yielded a K-Ar biotite age of 58.8 ± 3 (recalculated from M. Shafiqullah, Lambert 1974), this date is considered during Eocene magmatic activity. The Ibex gabbro was suggested to be Late Triassic in age by Hart and Pelletier (1989b). However, the gabbro is lithologically similar to clasts within Laberge Group conglomerate which have a U-Pb zircon maximum interpreted age of 109 ± 1.0 . Altered biotite-hornblende quartz monzonite east of Mt. McAuley is lithologically similar to other rocks of the Whitehorse plutonic suite. A biotite K-Ar age of 57 Ma (Lambert 1974) from it is considered to be reset by adjacent Eocene igneous rocks. Pyroxene-rich hornblende diorite from Mt. Hodnett returned a K-Ar age of 106 Ma which confirms the association with the Whitehorse plutonic suite.

MOUNT MCINTYRE PLUTONIC SUITE

Several mid-Cretaceous plutons lithologically and chemically similar to the Mt. McIntyre granite have been grouped in the Mount McIntyre plutonic suite. This suite is composed of the Montana Mountain, Carbon Hill and Mount Ward plutons as well as the Mount McIntyre pluton and several satellite stocks in the Mount Granger and Coal Lake areas. The suite includes the granophyric quartz monzonite unit of Wheeler (1961; Unit 9), Morrison et al 1979 and resembles unit Msqm west of Atlin (Currie 1990). Similar pink quartz monzonite has been described by Tempelman-Kluit (1974, 1976) and Doherty and Hart (1988) but have been determined to be Early Jurassic and Paleocene in age and Late Cretaceous are not related to the Mt. McIntyre suite.

The Mount McIntyre plutonic suite is characterized by pink, alkaline, peraluminous granite and quartz syenite with lesser quartz monzonite. While this suite is texturally variable, granophyric, alkali feldspar, hornblende granite is most common and diagnostic. Compositional variations are most evident in border phases. Acicular hornblende dominates over biotite as the primary mafic mineral except in border phases, but the total percentage rarely exceeds 20%.

MOUNT MCINTYRE PLUTON (mKqMM)

The Mt. McIntyre pluton shows the widest variation in mineralogy and composition of the suite and includes orange-weathering granite, quartz monzonite and quartz syenite. The northwestern portion of this pluton is underlain by atypical grey hornblende granodiorite

which may be an unusual border phase or part of the Whitehorse pluton. In thin section, the McIntyre pluton granites are somewhat quartz-poor and commonly exhibit graphic textural intergrowths of quartz and alkali feldspar. Primary mafic minerals are hornblende and biotite although xenocrysts and xenolithic crystal agglomerations of olivine and pyroxenes are relatively common. Some of these xenoliths appear to be ultramafic nodules composed of olivine, enstatite, diopside, and spinel.

Granite Phase (mKgMM)

Mappable border phases generally composed of granite, are found at the margins or roofs of some intrusions belonging to the Mount McIntyre suite (ie. the eastern portion of the Mount Granger pluton is a biotite-rich grey granite). Small exposures of grey-blue, medium-grained, biotite quartz anorthosite crop out on Coal Ridge. Hornblende-biotite granodiorite forms the eastern border of the Mount McIntyre pluton and may represent a border phase, but despite the age similarity of the two units (105-109 Ma), the border phase is unlike other border phases of this unit and probably part of the Whitehorse plutonic suite.

MOUNT WARD PLUTON (mKgMW)

Medium-grained biotite and hornblende granite and quartz monzonite in the Mount Ward, Fenwick Creek and West Arm areas is easily recognised in the field by its distinctive aggregates of pink alkali feldspar. The unit is light rusty-orange, recessive weathering, and massive. This unit has been previously described as the Mt. McNeil granite (KTgr; Doherty and Hart 1988).

CARBON HILL PLUTON (mKqCH)

The Carbon Hill plug underlies the west facing slopes of Carbon Hill as well as portions of Butte Creek. It forms recessive orange, granular weathering, medium-grained, red to pink and grey, biotite quartz monzonite and granite. The quartz content of this unit is highly variable. Biotite forms fine-grained masses among the coarser grained alkali feldspar and quartz. This unit is pervasively altered. Plagioclase are sausseritized and biotite is partially altered to chlorite. Local exposures are green weathering as a result of chlorite and epidote(?) alteration, or in areas adjacent to mineral occurrences as a result of sericite. Much of the alteration in the Butte Creek area is the result of surface weathering preserved under the sub-aerial Skukum Group volcanics.

MONTANA MOUNTAIN PLUTON (mKqM)

The Montana Mountain pluton (previously the Montana phase of the Carcross Pluton, unit Pc) underlies part of Montana Mountain. It has been described previously by Roots (1982) and Hart and Pelletier (1989b). Like the Mount Ward pluton, it is an orange-weathering, pink to mauve biotite and hornblende granite. The mauve appearance may be a result of chloritization of the mafic minerals. The main phase of the intrusion is medium-grained, but a border phase at its southern margin, intrusive into the Montana Mountain volcanics, is a fine- to medium-grained, cream-coloured aplite.

Age and Interpretation

A U-Pb zircon date of 109.0 ± 0.6 Ma was obtained from the Mt. McIntyre pluton. This date is older than a K-Ar date of 97 ± 3.3 Ma obtained from this pluton by Morrison et al. (1979). Granite from the Montana Mountain pluton returned a U-Pb zircon date of 106.8 ± 1.0

Ma A sample collected from Mount Ward yielded a discordia which forced through the origin gives an upper intercept or maximum age of 119.2 ± 12 Ma. Three $^{206}\text{U}/^{238}\text{Pb}$ ages from two fractions range between 106.8 and 109.8 Ma which is the expected age for this unit, the same as the Montana Mountain and Mount McIntyre plutons. A biotite/chlorite separate yielded a K-Ar age of 96 ± 15 Ma for the Carbon Hill pluton.

Although the Montana Mountain, Carbon Hill and Mount Ward plutons are lithologically, chemically and temporally associated with the Mount McIntyre plutonic suite, they do not possess the distinctive granophyric texture associated with this suite. Instead, their coarse crystalline nature may result from intrusion at deeper crustal levels or in an environment with a higher geothermal gradient (ie. Coast Plutonic Complex).

MESOZOIC QUARTZ MONZONITE (Mmz)

A small isolated body of quartz monzonite and monzodiorite underlies part of Pyramid Mountain on Grey Ridge. The intrusion encloses a pendant of Lewes River Group volcanic rock and is intruded by the Carcross pluton. The unit is resistant, dark grey, contains slightly more alkali feldspar than plagioclase, approximately 15% quartz and numerous xenocrysts of augite, presumably derived from the Lewes River basalts. Locally, well-zoned pink alkali feldspar crystals in a grey, fine-grained matrix, are up to 4 cm long.

The age and affiliation of this plug is unknown. Hart and Pelletier (1989a) suggested that it may be related to Late Triassic volcanism. The presence of pyroxene xenocrysts is however characteristic of the Mount McIntyre pluton and there may be some relationship between the two.

PERKINS PEAK PLUG (LKqPP)

The Perkins Peak Plug (previously KTal; Doherty and Hart 1988) is a light grey coloured, pink weathering, massive alaskite and K-feldspar granite restricted to the Perkins Peak massif and small bodies on Mount Wheaton and south of Carcross. It commonly appears as a coarse-grained crowded phenocrystic, white feldspar and quartz porphyry in a felted biotite-hornblende matrix. In thin section, coarse-grained plagioclase phenocrysts are in a very fine-grained mass of graphically intergrown alkali feldspar and quartz. Mafic minerals constitute less than 10% of the rock, consisting of very fine-grained agglomerations of unidentifiable mafics which are probably biotite.

The alaskite intrudes Laberge Group conglomerate and the Wheaton River volcanics. A single whole-rock Rb-Sr analysis indicates an age range between 70 and 97 Ma. The isochron is dependent upon initial Sr ratio, but indicates a definite Late Cretaceous age. Its close spatial relationship with these volcanics suggest that it may be coeval with them. Problems associated with confirming a date for the volcanic rocks and thereby providing an absolute oldest age for this unit are discussed earlier. This unit is spatially associated with rocks of the Carcross pluton (relations unknown) and may represent a phase or satellite pluton.

WHEATON VALLEY GRANODIORITE (LKgWV)

The Wheaton Valley granodiorite (previously JKgd; Doherty and Hart 1988) underlies the east central part of the study area from Alligator Mountain to Mount Hodnett and into the lower Wheaton River valley. It is only found east of the Tally Ho shear zone and commonly

crops out amongst exposures of the leucocratic phase of the Whitehorse plutonic suite and the Carcross Pluton.

It is composed of dark, variably foliated hornblende diorite, quartz diorite and lesser granodiorite. Hornblende is the dominant mafic mineral, although biotite and pyroxene have been observed. Mafic minerals are generally altered to chlorite giving the rock a dark hue similar to altered portions of the Whitehorse plutonic suite. In thin section, plagioclase is commonly sausseritized and tends to form glomerophyric clusters. Graphic intergrowths of quartz and alkali feldspar comprise up to 40% of the rock in the more granitic compositions. Many specimens are relatively quartz poor and classify as quartz diorite rather than granodiorite.

Near the Llewellyn fault zone local fracture cleavage, shear zones up to 3 m wide, and numerous faults are developed. Extensive chlorite alteration of mafic minerals is associated with this deformation.

A concordant U-Pb zircon age of crystallization of 77.7 ± 1.0 Ma was obtained from a sample of this unit from Mount Wheaton.

FOLLE MOUNTAIN GRANITE (LKqF)

The Folle Mountain granite forms a small plug on the south slope of Folle Mountain (previously Kgr; Doherty and Hart 1988). The granite is quartz rich, weathers pale pink, is medium- to coarse-grained, and contains large euhedral biotite crystals. In thin section, cores of large plagioclase laths are sausseritized. Finer grained specimens have plagioclase and quartz phenocrysts in a holocrystalline, alkali feldspar-rich matrix with accessory sphene. A similar-looking alkaline granite on the small hill north of Stevens Creek is correlated with the Folle Mountain granite. The granite is medium- to coarse-grained salmon-orange coloured, quartz-poor, and contains biotite.

The Folle Mountain granite yielded a concordant age of 78.2 ± 0.6 Ma (U-Pb zircon). This age agrees with the relative age deduced from field relations (Doherty and Hart 1988) and is similar to the Wheaton Valley granodiorite and possibly the Perkins Peak Plug.

CARCROSS PLUTON (Pgc)

The northwest-trending Carcross pluton is exposed on the northfacing slopes of the Montana Mountain massif and the southern portion of Grey Ridge. Small exposures of granite on the shores of Windy Arm are also assumed to belong to this unit. Near Conrad, the altered granite contains molybdenum as does 'type' Carcross Pluton south of Carcross. This unit intrudes rocks of the Cache Creek and Laberge Groups. The pluton is composed of massive, light grey weathering, biotite and hornblende-biotite granite to leucocratic granodiorite. Sparse accumulations of white, alkali feldspar megacrysts are diagnostic of this unit, but often difficult to distinguish amongst the white, sugary textured groundmass. Aplite and alaskite intrusive into volcanic rocks of the Montana Mountain complex may be part of the Carcross pluton. Alaskite similar to the Perkins Peak plug is associated with this unit 2 km south of Carcross. Phenocrystic biotite granite on Caribou Mountain is probably cogenetic with the Carcross Pluton.

A sample of the Carcross pluton taken from south of Carcross yielded a K-Ar biotite date of 64.3 ± 2.2 although this date may be too young as a result of Eocene argon loss (Morrison et al. 1979). To the south of the Carcross pluton, the lithologically distinct,

Montana phase (Hart and Pelletier 1989a) returned a U-Pb age of 106 Ma which confirms that the Montana Mountain pluton is a distinct and separate body from the Carcross pluton. Lithologically the Carcross pluton is not unlike others of Late Cretaceous age described elsewhere in the northern Cordillera (Tempelman-Kluit 1974; 1976; Anderson 1988). Late Cretaceous plutons in the northern Cordillera are typically molybdenum-bearing (Christopher et al. 1972).

LATE PALEOCENE LEUCOGRANITE (LPq)

Quartz-rich granite forms two circular exposures in the southern portion of the project area, east of Mount Ward and the in the upper reaches of Fenwick Creek; numerous smaller bodies are found within the Fenwick Creek quartz diorite. The unit is massive, resistant and blocky, white to buff weathering, and saccharoidal textured. Quartz is transparent to pale blue and forms interstitial intergrowths. In thin section much of the quartz is seen intergrown with alkali feldspar in a graphitic texture. Anhedral grains of quartz greater than 3mm in diameter show signs of deformation, including grain boundary migration and bubble trains indicative of healed microfractures. Plagioclase comprises about 15%, forming glomerophyric masses with overgrowths of sericite. Amber coloured biotite plus an opaque mineral do not exceed 10%. A finer-grained textural phase contains sparse phenocrysts of quartz and feldspar in a quartz-alkali feldspar graphic matrix.

An isochron determined from a single point, whole rock Rb-Sr analysis (assumed initial ratio of 0.705) returned a Paleocene age of 58.5 ± 12 Ma. The large error results from the low Sr content of this sample, but is diagnostic of Early Cenozoic granites (R.L. Armstrong written comm.). In addition, the leucocratic quartz-rich composition, sugary and miarolitic textures, circular plan and biotite > hornblende are characteristic of Early Paleogene age rocks in the study area.

NISLING RANGE PLUTONIC SUITE

Along the eastern margin of the Coast Plutonic Complex are numerous centres of Paleocene to Early Eocene volcanic and plutonic activity. The plutons have common lithological and chemical characteristics and form the Nisling Range plutonic suite (Anderson 1988). This suite is characterized by circular, discordant, high-level, medium to fine-grained, leucocratic granite and alaskite which commonly contain smokey quartz-eyes and fluorite miarolitic cavities. In the project area, they dominate the region around the Bennett Lake complex and the upper Ibex River drainage.

EOCENE IBEX ALASKITE (EEq)

The Ibex alaskite (previous symbols Eal and Tal) comprises several high level, generally circular plugs at the headwaters of the Ibex River. Distinctive of this unit is its pale buff or pink colour, light colour index, and the presence of dipyrmidal smokey quartz phenocrysts and miarolitic cavities. In thin section, the mafic minerals are dark brown biotite and sphene and constitute generally less than 5% of the rock; hornblende is rare. Up to 90% of the rock is composed of graphic intergrowths of quartz and alkali feldspar with plagioclase being a minor, finer-grained constituent. On Ibex Mountain and 5 km west of Alligator Lake, the Ibex alaskite intrudes felsic and intermediate accumulations of flow banded and fragmental volcanics (see Unit EEI).

EOCENE MT. MCAULEY GRANITE (EEqMM)

The Mt. McAuley granite (leucocratic granite of Lambert 1974) is exposed in the steep cliffs west of upper Boudette Creek and in a structure mimicking the ring dyke at the west end of the West Arm of Bennett Lake. It is distinguished in the field by its orange-brown, crumbly weathering character. Despite its friable nature it still forms large steep mountains (Fig. 9). The pluton is further characterized by the dominance of smokey subhedral quartz crystals (up to 60%), miarolitic cavities, coarse-grain size, ubiquitous interstitial fluorite and well-spaced joints. Lambert (1974) describes miarolitic cavities locally within the granite that are lined with crystals of quartz and fluorite. The Mt. McAuley granite is extensively intruded by porphyry dikes associated with the ring dyke complex of the of the Bennett Lake Complex.

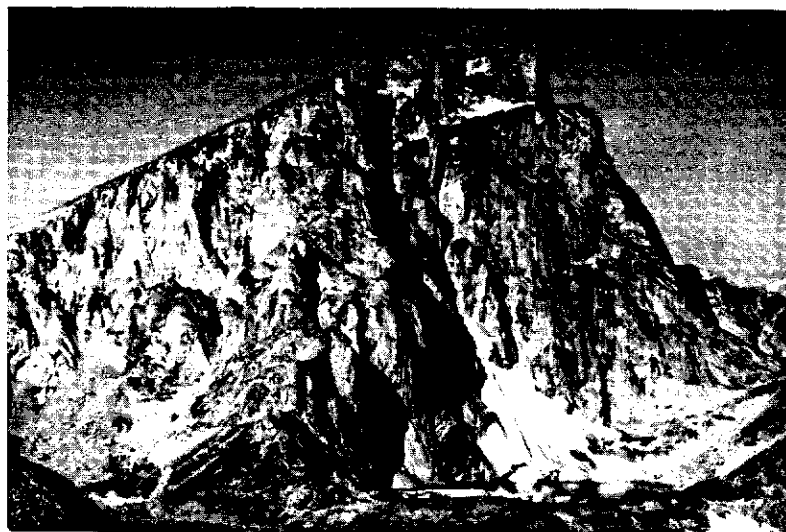


Figure 9: Exposure of Early Eocene alaskite near Mount McAuley belonging to the Nisling Range plutonic suite. Note the blocky widely spaced jointing and steep faces.

LATE PALEOCENE CROZIER CREEK GRANITE (LPqc)

The Crozier Creek granite (pink quartz monzonite of Lambert 1974; KTqm and Tgr of Doherty and Hart 1988) consists of several bodies of grey to orange weathering, well-jointed pink to orange coloured quartz monzonite and granite. They are located at the head of Fenwick Creek and west of the West Arm of Bennett Lake at Crozier Creek. The northernmost exposure in the map area underlies the northern portion of Ibex Mountain.

In thin section, alkali feldspar dominates over plagioclase (oligoclase) which is partially sausseritized. Biotite is the only mafic mineral and, including opaques, rarely exceeds 10%. A lithologically similar, orange weathering red granite pluton on Finger Mountain may be part of this family of granites, but contains more plagioclase than alkali feldspar.

PENNINGTON GRANITE (EEqp)

The Pennington pluton underlies the Bennett Lake region of the map area. The best exposures occur in the railcuts on the east shores of Bennett Lake near the Pennington train station and in the steep slopes of the Bennett Range. It intrudes the Late Triassic Bennett

granite, the mid-Cretaceous(?) Finger Mountain volcanics and a Late Cretaceous andesite plug. It consists of dark grey weathering, coarse-grained to porphyritic, biotite quartz monzonite and quartz-poor granite which contains phases with 2-3 cm phenocrysts of pink, perthitic alkali feldspar. Although similar to the adjacent Bennett granite which also contains pink alkali feldspar megacrysts, the Pennington granite can be differentiated by the recognition of the perthitic, and non-poikilocrystic nature of the phenocrysts. In addition, the Bennett granite contains white quartz while quartz in the Pennington granite is transparent or grey. A non-porphyritic phase of this granite in the Bennett Range and south of Dundalk Mountain may be void of the pink phenocrysts, but can be recognized by the euhedral nature of crystals, including biotite. Argillic alteration renders the plagioclase chalky. In the Bennett Range, numerous north-northwest-trending, discrete zones of shearing and cataclasis traverse the intrusion.

Red to pink quartz monzonite similar to, and assumed to be coeval with the Pennington granite forms a small pluton at Finger Mountain. Both are similar in many respects to the Crozier Creek granite.

The Pennington granite intrudes the continuation of the Llewellyn Fault on the B.C. border (Hart and Pelletier 1989a; Mihalynuk and Rouse 1988) and therefore brackets the age of significant movement along the fault. However, numerous shears in the granite suggest that some motion associated with the Llewellyn Fault may have taken place since its emplacement during Early Eocene time.

EARLY EOCENE JACKSON CREEK GRANITE (EEqJC)

Plutons near Jackson Creek, north of Jackson Hill and on the eastern flank of Mount Golden Horn are composed of coarse-grained, smokey quartz-eye granite which together, are termed the Jackson Creek granite. It is coarser-grained, darker and slightly more mafic than other lithologies in the Nisling Range Plutonic Suite and weathers light grey with distinct white feldspars and large grey quartz eyes (40%). In thin section, the minerals are glomerophyric making modal estimates difficult. Large (>3mm) white, alkali feldspar and anhedral, poikilitic quartz both show evidence of solid-state deformation while zoned plagioclase is relatively fresh. Both biotite and hornblende are mafic constituents and together comprise 10-12% of the rock. Biotite crystals are larger than hornblende and occur in clumps.

Age and Interpretation

The age of the Ibex Alaskite is well constrained by a zircon U-Pb, upper intercept (maximum) age of 58 ± 1 Ma (Doherty and Hart 1988;). A U-Pb zircon age obtained from the Mt. McAuley pluton, indicates that the body is 54.2 ± 0.2 Ma and also belongs to the Nisling Range Plutonic Suite. The age of the Crozier Creek granite is constrained by a U-Pb zircon date of 60 ± 0.6 Ma from Crozier Creek with supporting Rb-Sr single point isochron ages of 56.8 ± 1.4 Ma and 55.2 ± 2.6 from the Crozier and Fenwick Creek plugs, respectively (both assumed initial ratio of 0.705). K-Ar whole rock dates from these samples were slightly younger, probably reflecting surface weathering. Similarly, a hornblende K-Ar date of 54.9 ± 1.9 from the Pennington pluton has probably experienced some argon loss and may be as old as the lithologically similar Log Cabin granite (72 Ma zircon U-Pb; Barker et al. 1986). A biotite K-Ar age of 55 ± 1.9 Ma was determined for the Jackson Creek pluton (Morrison et al. 1979).

Ibex alaskite west of Alligator Lake and the Mt. McAuley granite are identical to and considered cogenetic with quartz-feldspar granite porphyry in the ring dykes of the Bennett Lake volcanic complex.

The Nisling Range Plutonic Suite is correlated with the Nisling Range Alaskite (Muller 1967; Tempelman-Kluit 1974, 1976; Tempelman-Kluit and Wanless 1975), the Ibex Alaskite (Doherty and Hart 1988; Hart and Pelletier 1989a, b;) and the Atlin and Birch Mountain plutons of Bloodgood and Bellefontaine 1990). Reliable ages obtained from these rocks, and those outside of the study area, indicate a narrow range from between 54 and 60 Ma. This age range corresponds with ages determined from numerous Skukum Group rhyolite dykes from the map area (R.L. Armstrong pers. comm. 1989). This suite is spatially and temporally associated with Skukum Group volcanic activity and is assumed to represent their plutonic equivalents.

Despite the lithological variations in the Nisling Range Plutonic Suite, geochronology confirms a similarity in temporal distribution. In addition, interpretive geological relations can explain relationships between the various rock units. Coarse-grained plutons in this suite (ie. Jackson Creek granite) intruded Whitehorse Trough rocks. The thickness of Trough strata allowed slow cooling of the plutons resulting in a coarse crystal size. Holocrystalline rocks similar to the Crozier Creek granite at Ibex Mountain are faulted against fine-grained, miarolitic Ibex alaskite and may represent a deeper level of the plug.

SKUKUM GROUP

Early Paleogene Skukum Group volcanic rocks are part of the Sloko Group volcanic province of northern B.C. and southern Yukon (Souther 1977; Armstrong 1988). In the project area, the Skukum Group consists of the Mount Skukum Volcanic Complex and Bennett Lake Cauldron Complex, the roots of two eroded complexes, numerous rhyolite dykes and several very small ($> 1\text{km}^2$) eruptive centres.

Skukum Group rocks gained prominence in the 1980's with the discovery of an economic, epithermal gold deposit in the Mount Skukum Volcanic Complex (McDonald et al. 1987). The geology of the Bennett Lake complex has been evaluated by Lambert (1974) and the Mount Skukum complex has been documented by Smith (1982, 1983), Pride (nee Smith 1985, 1986); McDonald (1987), Doherty and Hart (1988) and Love (1989, 1990a). A comparison of these two complexes is given by Smith (1983) and Doherty and Hart (1988). This report will briefly describe the salient features of this package of rocks, introduce new nomenclature for rocks of the Mount Skukum Volcanic Complex and will include new data and interpretations. Readers are encouraged to seek out the aforementioned references for additional information or more detailed descriptions.

MOUNT SKUKUM VOLCANIC COMPLEX

The Mount Skukum Volcanic Complex (MSVC) is an Early Eocene, bimodal sequence of sub-aerial volcanic and volcanoclastic rocks covering 140 km^2 which were deposited unconformably upon metamorphic and plutonic rocks of the Nisling Terrane and Coast Plutonic Complex. The complex forms a northeast-trending $20 \times 11\text{ km}$ ellipsoid which is bounded by faults along its southern and eastern contacts. The maximum accumulated thickness of the volcanic strata is estimated at 850 m, but nowhere are all units found in succession. The complex is divided into two parts. The southeastern portion of the complex is underlain by dominantly andesitic flows and breccias. Thick accumulations of younger felsic

pyroclastic rocks (Vesuvius Formation) form a fault bounded graben nested into the northeastern part of the complex.

The stratigraphy of the MSVC has been in a state of evolution since it was first divided into five informal formations by Pride (1985, 1986; see Smith 1985). McDonald (1987), and subsequently Doherty and Hart (1988) and Love (1989) have all made contributions to the understanding of the stratigraphy. Most notably, they indicated that felsic flows, lapilli tuff and ignimbrite of Formation 4 (of Pride 1986), actually overlie her Formation 5.

Informal formation names suggested by Pride (in Love 1990a) have been assigned to rocks previously known by formation or cycle numbers. The stratigraphy (and nomenclature) in this report and enclosed maps is the sum of all work completed to date. It corresponds closely to that developed by Love, but breaks the formations into mappable units as first presented by Doherty and Hart (1988). The evolution of the nomenclature is outlined in Table II. Most formations are adequately described in previous reports.

This Report		Doherty & Hart		Pride 1986	Love 1990
	EEr	Cycle 7	Er		
VESUVIUS FM.	EEV ₆	Cycle 6	Es ₃	Formation 4	VESUVIUS FM.
	EEV ₅		Er _f		
	EEV ₄		Er _t		
	EEV ₃		Embx		
	EEV ₂		Ewt		Upper
	EEV ₁		Elt		Lower
	EESK	Cycle 5	ESK		
WATSON RIVER FM.	EEWR ₃	Cycle 4	Eab	Formation 5	WATSON RIVER FM. Upper
	EEWR ₂	Cycle 3	Ean	Formation 3	Lower
	EEWR ₁		Edt		
BUTTE FM.	EEBC ₂	Cycle 2	Es ₂	Formation 2	Upper
	EEBC ₁		Es ₁		Middle
	EEBC		Es		Lower
MOUNT REID FM.	EEMR		Ec _g	Formation 1	
IBEX FM.	LPI	Cycle 1	Eva		

Table II. Rock unit correlation for nomenclature of the Mount Skukum Volcanic Complex.

Rocks of the poorly understood Ibex formation (LPI) however have not been previously described (Unit Eva, Doherty and Hart 1988). They are composed of fine-grained to sparsely porphyritic, dark blue-grey, dense, siliceous rhyolite and dacite flows and lithic tuffs which commonly contain granitic fragments. In the northern portion of the MSVC they appear to be deposited unconformably upon granitic basement and overlain by Butte formation clastic and epiclastic rocks. Similar rocks are found north of the MSVC on peaks west of the uppermost drainage of Ibex River and on Ibex Mountain. There they are intruded by the Ibex Alaskite (58 Ma U-Pb; Doherty and Hart 1988) which indicates that they are older than other volcanic strata (51-53 Ma) at the MSVC. Alternatively, previous dates for Skukum Group volcanic rocks using less accurate isotopic methods (ie. K-Ar, Rb-Sr) may have provided dates younger than the volcanic succession.

Structurally, the MSVC shows evidence of forming two northeast-trending elliptical, concentric fault bounded cauldrons. The faults are best defined in the eastern portion of the complex where several hundred metres of felsic pyroclastics (Vesuvius Formation) are downropped by two arcuate faults against granitic basement rocks. North of Mount Kopje, the fault system is composed of two, sub-parallel northeast-striking faults which curve and splay southward across Butte Creek into the Main Zone and Wedding Ring Creek. Stepped normal faults form between the two larger faults. The western and southern margins of the complex are faulted against country rocks but are not part of the cauldron bounding faults.

BENNETT LAKE CAULDRON SUBSIDENCE COMPLEX

The Bennett Lake volcanic complex (BLVC) is a 19 x 30 km volcanic centre composed of two fault bounded, nested cauldrons. Each cauldron represents a resurgent cycle of cataclysmic pyroclastic eruptions. Each cycle contributed approximately 2000 m of rhyo-dacitic ash-flow tuffs and breccias with lesser rhyolite and andesite flows to the cauldron fill. The BLVC differs from the MSVC in that a greater thickness of strata remain preserved and lithologically it contains a higher percentage of acidic and pyroclastic volcanics (c.f. andesite flows). A change from acid to intermediate volcanism during each eruptive cycle represents the tapping of a vertically zoned magma chamber (Lambert 1974).

Structurally, the complex is dominated by a series of arcuate, slightly concentric step faults cut by a few larger radiating faults. A central rhyolite plug and ring dyke system representing late stage doming are well developed.

The Bennett Lake complex is at least as old as the cross-cutting ring dyke which is coeval with the Mt. McAuley granite (54 Ma). This date is the oldest so far suggested for this complex (cf. Lambert 1974; Morisson et al. 1979).

EARLY EOCENE RHYOLITE (EEr)

Rhyolite dykes, swarms and plugs related to Skukum Group volcanism form numerous exposures throughout the southern portion of the project area (see Lambert 1974; Smith 1982; McDonald 1986; Doherty and Hart 1988). They vary between aphanitic rhyolite and granite porphyries and include the Bennett Lake complex ring dyke and border phases of the Nisling Range Plutonic Suite. They are typically pale to buff or rusty orange, mauve or tan in colour with flaggy partings, Liesgang banding and occasional flow banding.

Extensive northeast-striking dyke swarms can be traced for several kilometres near Carbon, Johnson, Gold and Mineral Hills. Dykes are up to 200 m wide but are typically less

than 10 m. Approximately ten irregularly shaped rhyolite plugs between one and six square kilometres have been mapped. Quartz (and calcite) stockworks with fluorite are found in the plugs at Folle Mountain, Carbon Hill and Mount Kopje.

The pyritiferous rhyolite plug on the east slope of the Bennett Range cuts the Paleogene Pennington Pluton and is therefore probably Eocene in age.

Potassium-argon dating has returned ages on these rocks between 51 and 60 Ma (Morisson et al. 1979; McDonald and Godwin 1986; R.L. Armstrong unpublished data). An Rb-Sr isochron determined from samples obtained from several different rhyolite plugs yielded an age of 53 Ma (Pride and Clark 1985). The Mt. McAuley granite is gradational with quartz-feldspar granite porphyry and the ring dyke. The possible cogenetic relationship between these two units suggests that the ring dyke is probably as old as the Mt. McAuley granite (54 Ma).

MILES CANYON BASALT (MPMC)

Miles Canyon basalt is well exposed in the Alligator Lake volcanic complex between Alligator Lake and Ibex River, at Miles Canyon, and at Pass Lake. Steep sided, butte-like erosional remnants of flows are distributed throughout the Whitehorse and northern Alligator Lake map-sheets. These rocks are the youngest in the area and unconformably overlie all others. They have been previously examined by Fyles (1950), Wheeler (1961), Eiche (1985), Doherty and Hart (1988) and Hart and Pelletier (1989b).

Weathered outcrops are brown and commonly covered in a conspicuous orange lichen, while fresher outcrops are a hematitic black-red colour. The basalt forms columnar-jointed, amygduloidal and vesicular, sub-aerial and sub-marine, autobrecciated and pillowed flows. Though typically aphanitic, locally visible trachytic feldspar microlites or olivine xenocrysts may be abundant. Amygdules are mainly calcite although chlorite(?) and a white zeolite were also observed. Scoria is common, and particularly abundant at Pass Lake (Copper Cliff) and at the Alligator Lake volcanic complex (ALVC).

Individual flows are typically thin (2-3 m), but accumulated to moderate thicknesses in depressions (ie. Miles Canyon 30 m) or near the source vents (ie. Pass Lake 55 m; ALVC >100 m). Flows were deposited unconformably on unconsolidated materials (INAC 1988, p. 129) or intercalated with sand, gravel or peat (Wheeler 1961). Dykes are massive, dark weathering, 1-3 m wide and occur in swarms near source vents.

The ALVC (Eiche 1985) is the most extensive exposure of Miles Canyon basalt and covers approximately 50 km² and consists of a basaltic shield capped by two spatter cones. The total extrusive volume is less than 0.5 km³. Spinel-lherzolite xenoliths up to 30 cm in diameter have been observed.

Age and Interpretation

Miles Canyon basalt near Ibex Mountain and McCrea returned K-Ar dates of 2.4 and 8.8 Ma respectively (R.L. Armstrong unpublished data). The ALVC has not been dated but may be younger as indicated by the well preserved nature of the spatter cones.

Several exposures of this unit are found at elevations above 5000', but no accumulations have been observed in the adjacent valley (ie. Ibex). While each exposure may represent an individual vent, the flows may be contemporaneous with glaciation and crossed valleys over

glaciers and prevented from occupying valley floors. As a result, a single flow may have deposited many erosional remnants exposed at topographically high levels. Flows found at topographically low levels (ie. Miles Canyon) may have been deposited during interglacial periods.

Excepting for the obvious source vents at the ALVC, an additional vent is assumed to exist on the north flank of Mount Golden Horn where dyke swarms and notable accumulations of scoria were observed. This is the interpreted source of the Miles Canyon flows.

STRUCTURE

The structural style of the project area is typical of regions composed of accreted terranes. Terranes are fault-bounded and have unique internal structural histories which contrast structural histories in adjacent terranes. The geological architecture of the project area involves the juxtaposition of three lithotectonic terranes: (1) Nisling, (2) northern Cache Creek, and (3) northern Stikine. The Nisling Terrane metasedimentary rocks provide clues to pre-accretionary deformation. Strata of the Whitehorse Trough forms an overlap assemblage and contains evidence of Mesozoic deformation.

Terrane-bounding faults in the project area show evidence of the structural history of terrane amalgamation. Commonly, deformation associated with these major structures extend for some distance into the terrane interior. In addition, older faults were commonly reactivated during subsequent deformation and now comprise polydeformed zones with complex timing relationships. The early Late Triassic Tally Ho shear zone, which forms the boundary between the Nisling Terrane and volcanic rocks of northern Stikine Terrane (Lewes River arc), was reactivated in Late Cretaceous and Eocene(?) time along brittle structures of the Llewellyn fault zone. The northern Cache Creek Terrane was thrust on top of Whitehorse Trough strata along the Nahlin Thrust Fault in Middle Jurassic time and was reactivated during Late Cretaceous and Eocene(?) time. The Crag Lake fault is interpreted as a tear fault directly related to Nahlin thrusting.

Younger structures independent of terrane bounding faults include strike-slip faults, structures associated with Eocene volcanic activity and uplift, and a widespread system of northeasterly-trending faults and fractures. Major structures of the project area are illustrated in Figure 10.

NISLING TERRANE

Schist and gneiss of the Nisling Terrane bear a shallowly dipping penetrative fabric. A well developed foliation and locally lineation are defined by aligned metamorphic minerals such as micas, quartz and plagioclase. Commonly this foliation is folded by tight minor folds with unknown geometry. Thus Nisling Terrane rocks in the project area have been deformed at least twice. In northern B.C., up to four phases of deformation have been suggested for this package of rocks (Mihalynuk et al. 1989). Wilson et al. (1985) have defined the ages of deformation and thermal events in Nisling Terrane rocks.

Geologic relations determined from mapping in the project area indicate that most of the deformation was pre-Late Triassic. This is indicated by dykes of Late Triassic Bennett Granite which cross cut deformed Nisling Terrane rocks. Since the Bennett Granite is locally deformed by Tally Ho shear zone deformation (see below), younger structures in the Nisling Terrane may be attributed to this event. At least one phase of deformation is probably younger than Mississippian, the inferred age of deformed orthogneiss included within the Nisling Terrane. Early Jurassic thrust faulting suggested for the Yukon-Tanana Terrane (Mortensen in prep.), probably also took place in Nisling Terrane rocks and may have been responsible for the juxtaposition of the various assemblages.

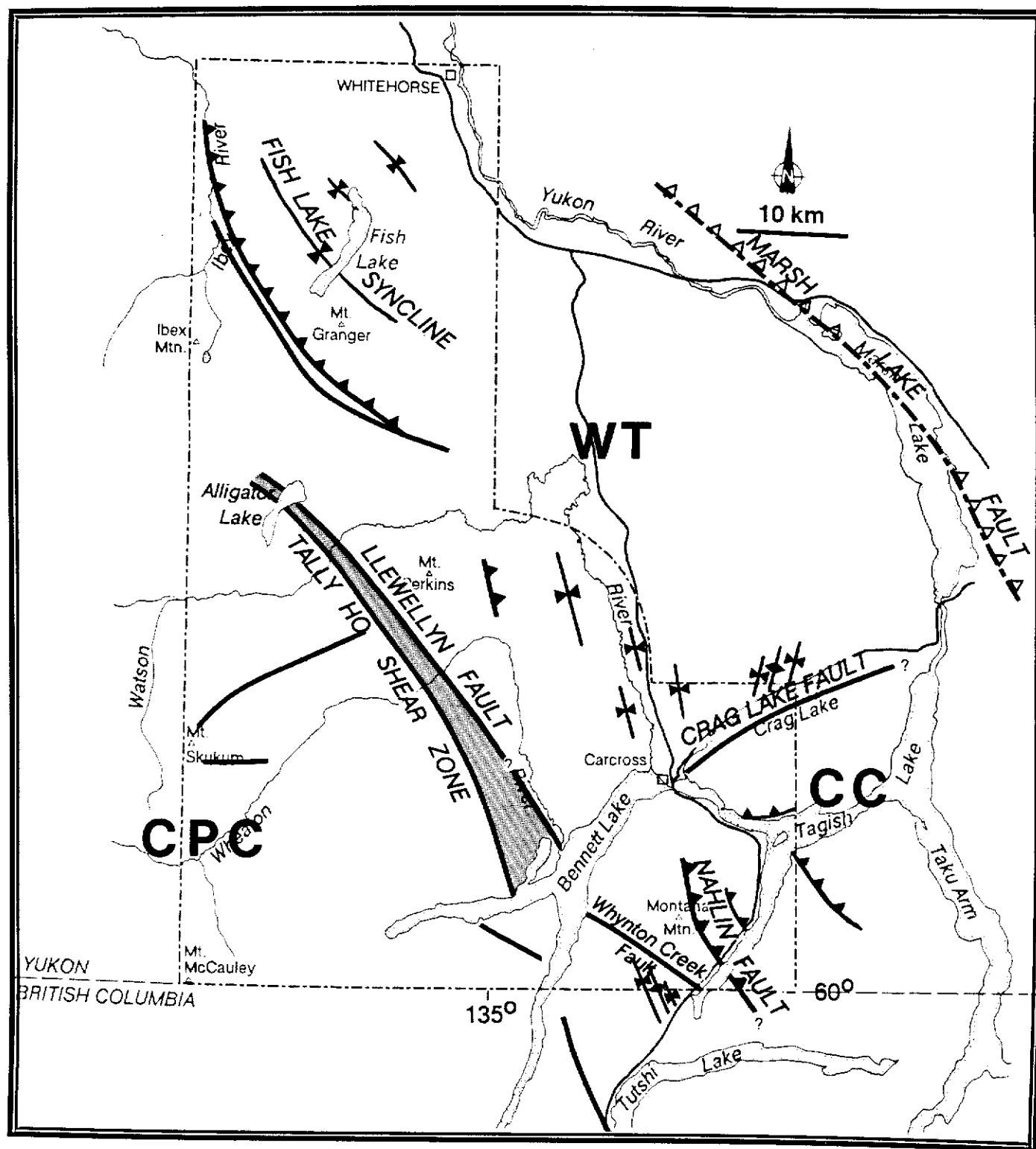


Figure 10: Map showing prominent structures of the project area as they relate to major tectonic elements. Tally Ho Shear Zone is shaded area. CC - Cache Creek Terrane; CPC - Coast Plutonic Complex (and Nisling Terrane); WT - Whitehorse Trough (includes Lewes River arc).

NORTHERN CACHE CREEK TERRANE

The internal structure of the northern Cache Creek Terrane is complex and difficult to characterize due in part to the extreme variations and poor documentation of Cache Creek stratigraphy, but reflect the terrane-bounding Nahlin and Crag Lake faults. Steeply-dipping, west and southwest verging thrust faults are the most prominent structural features of the northern Cache Creek Terrane in the map area. These are associated with tight to isoclinal, overturned and recumbent folds and faulted folds. The thrust faults are offset by northeast-striking, steeply dipping tear faults of varying magnitude.

The thrust faults are best documented where stratigraphy is well-defined, southeast of Bove Island and just east of the map boundary where Carboniferous and Permian volcanic and carbonate rocks are juxtaposed against rocks of the same age (Monger 1975). A similar structural style is interpreted for rocks southeast and west of Windy Arm and on Nares Mountain but is difficult to document due to poor stratigraphic control.

A southwesterly-verging thrust, the Conrad thrust fault, is well exposed in a road cut (kilometre 92 of South Klondike Highway) north of Conrad (Figure 11). Mylonitic Nakina volcanics in the hanging wall are juxtaposed against a granitic plug which is cut by the thrust. The fault is distinguished from other thrust faults in the northern Cache Creek Terrane by its shallow dip.



Figure 11: Exposure of the southwesterly-verging, shallow dipping Conrad thrust fault in road cut. Sheared Nakina Formation (Late Mississippian?) is in the hanging wall and Late Cretaceous(?) molybdenum-bearing granite in the footwall.

A fault is inferred to exist between exposures of the Nakina Formation and the Horsefeed and Kedahda Formations at Nares Lake. Greater than 1000 m of vertical displacement along the fault is documented by the juxtaposition of units at lake level. This fault appears to be more southerly verging than the steeper thrusts, and together with the Conrad thrust fault, form part of a shallowly dipping series of thrust faults similar to those described in Cache Creek rocks near Atlin by Bloodgood and Bellefontaine (1990).

Monger (1975, 1977) has recognized up to three periods of deformation in parts of the northern Cache Creek Terrane: (1) Permo-Triassic; (2) possible Triassic; and (3) early Late Jurassic. Tight folds, steep thrust faults, and (synchronous?) tear faults reflect the Jurassic compressional event which was responsible for the dominant motion on the Nahlin Fault.

Shallow dipping thrust faults such as the Conrad thrust fault cut molybdenum-bearing phases of the Paleocene (64 Ma) Carcross Pluton. Lithologically similar, molybdenum-bearing plutons of the Surprise Lake batholith has yielded Late Cretaceous K-Ar ages of 63-75 Ma (see Anderson 1988; Christopher et al. 1972). This age constraint corresponds with latest Cretaceous or early Tertiary reactivation of the Nahlin Fault (Hart and Pelletier 1989a), Bloodgood and Bellefontaine (1990).

NAHLIN FAULT

The Nahlin Fault forms the western boundary of the northern Cache Creek Terrane along which Cache Creek Group rocks are juxtaposed against Whitehorse Trough and northern Stikinia strata. The fault is best developed near Atlin and Dease Lakes in northern B.C. where lowermost Cache Creek Group strata and ultramafite are uplifted and deformed along a southwesterly verging thrust fault. The fault was first recognized in the Yukon by Hart and Pelletier (1989a) where it is exposed south of Carcross on the Montana Mountain massif and east of Windy Arm. It had not been previously identified as its northern trace was mapped as being overlain (and intruded?) by younger volcanics. The northernmost trace of this fault in B.C. has been described near Atlin (Bloodgood and Bellefontaine 1990) and north of Graham Inlet of Tagish Lake (Mihalynuk and Mountjoy 1990).

South of Carcross the Nahlin Fault abuts Nakina Formation volcanic rocks against Jurassic Laberge Group argillite (Fig. 12). The Laberge Group rocks are deformed into contorted folds with no apparent similarity in axial planes. Nakina Formation rocks near the fault are variably sheared, foliated and brecciated and contain tectonized ultramafic bodies. The mid-Cretaceous Montana Pluton anneals the deformed Cache Creek and Laberge Group rocks near the northern continuation of the Nahlin Fault.

This structure is interpreted as the northern extension of the Nahlin Fault. The total stratigraphic throw along this fault is in the order of 3-7 km which is the minimum to maximum combined thicknesses of the strata between lowest Cache Creek and uppermost Jurassic Laberge strata. Timing is constrained by the intrusion of the mid-Cretaceous Montana Pluton (106 Ma U-Pb). Near Dease Lake, movement along this fault has been well constrained by fossil and stratigraphic evidence to Bajocian-Bathonian (Middle Jurassic) time (H. Gabrielse pers. comm. 1988).

At Pooley Creek, a north-northwesterly striking, northeasterly dipping (65°) fault juxtapose mid-Cretaceous Montana Mountain volcanic rocks (88-95 Ma U-Pb) against the Nakina Formation (Fig. 12). In contrast to the deformation described above, this fault zone is composed of numerous intermixed lenses of iron-carbonate altered andesite and greenstone

with a well developed zone of cataclasite and argillaceous gouge. Across Windy Arm the contact is less deformed but is represented instead by several imbricate thrust sheets of Cache Creek and uppermost Montana Mountain volcanic rocks. The trace of this brittle fault is obscured by overburden north of Pooley Creek.

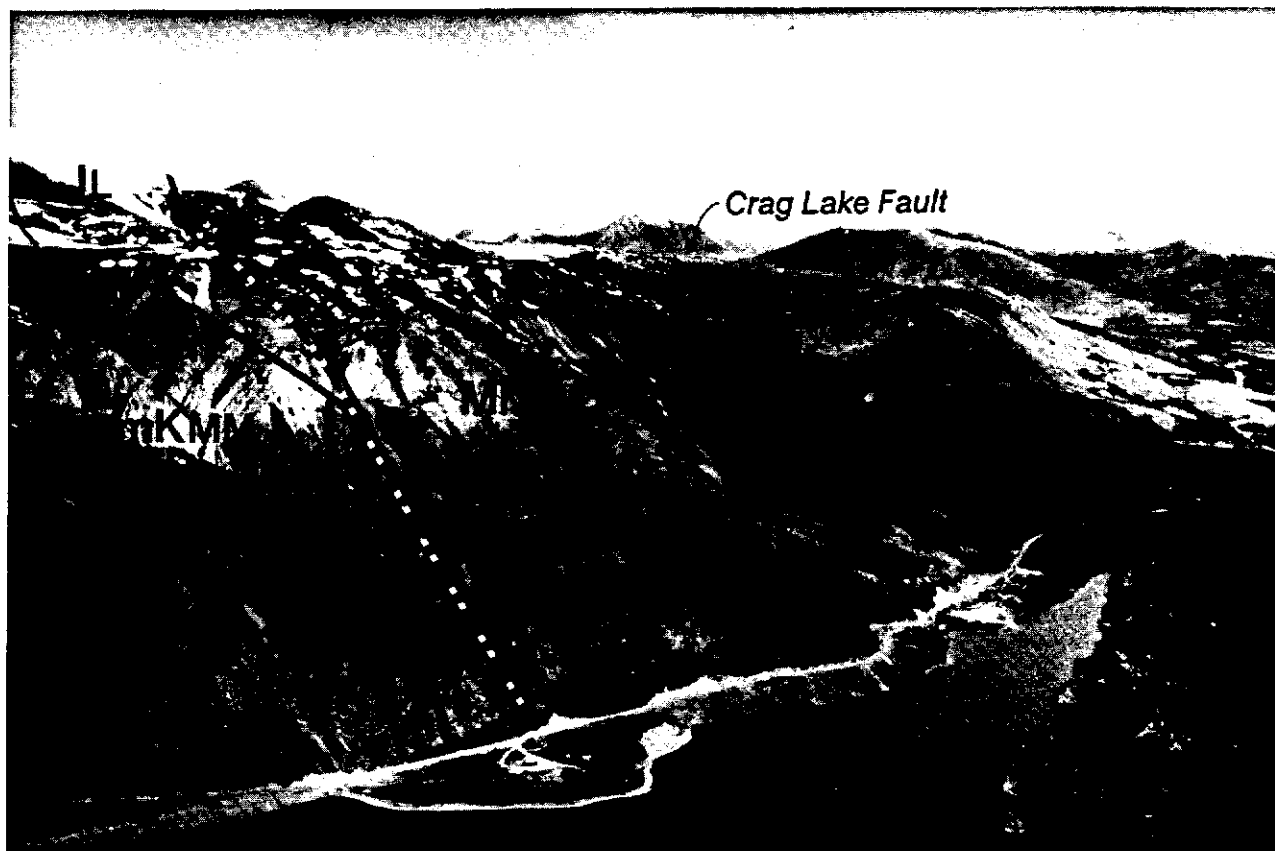


Figure 12: Trace of the Nahlin Fault on the east slope of the Montana Mountain massif; Windy Arm of Bennett Lake and South Klondike Highway in foreground.

This fault is brittle and involves rocks as young as 88 Ma and is interpreted as representing a reactivation of the Nahlin structure. Vertical motion along this northwesterly-directed reverse fault exceeds the 1200 m thickness of the Montana Mountain volcanics exposed above Windy Arm. There may be a component of dextral strike-slip motion along the Nahlin fault, determined from the character of the fault zone, cleavage development, and the proximity of other, concurrent(?) dextral strike-slip faults (e.g. Wynton Creek and Llewellyn faults). West of Atlin, Bloodgood and Bellefontaine (1990) document a similar, but southwesterly-dipping reverse fault they term the Atlin Mountain fault. The Atlin Mountain Fault is plugged by the Early Eocene Atlin Mountain pluton (57 Ma K-Ar, Bultman 1979). Reactivated motion on the Nahlin Fault postdates the youngest Montana Mountain volcanics (88 Ma U-Pb) and is therefore constrained between 88-59 Ma.

CRAG LAKE FAULT

The northeast-striking Crag Lake Fault follows the Crag Lake valley and juxtaposes Nakina Formation rocks of the northern Cache Creek Terrane against the Laberge Group (Wheeler 1961). Although not exposed, the fault represents vertical movement at least equivalent to the thickness of the Laberge Group (2200 m) and much of the sedimentary portion of the Cache Creek Group (total >7000 m).

The actual mechanism for movement along this structure is unknown. Most other bounding faults with the northern Cache Creek Terrane are west and southwest verging thrusts, making a north verging thrust fault unlikely. It may reflect a tear fault related to thrust motion on the Nahlin Fault. Nearby, northeast-striking phyllite and overturned folds in the Laberge Group are probably related to motion along the fault (Hart and Pelletier 1989a)

STIKINE TERRANE (AND WHITEHORSE TROUGH OVERLAP ASSEMBLAGE)

FOLDS

Layered sedimentary, volcanoclastic, and volcanic rocks of the northern Stikine terrane are deformed into northwest trending, upright folds along the western margin of the Whitehorse Trough (Tempelman-Kluit 1974). The geometry of folds in the map area is disrupted by intrusions and younger block faulting, resulting in the formation of poorly defined structural domains of the fold phase. The fold geometry is best characterized where large, map-scale structures such as the Fish Lake syncline can be delineated. Other map-scale folds include those between and on Gray Ridge, Watson Ridge, near Spirit Lake, and in the Whitehorse Copper Belt. Minor or parasitic folds are abundant in the finely layered lithologies of the Laberge Group.

The general fold style is determined from field observations of minor folds, map geometry, and a stereoplot of regional bedding attitudes for the Laberge and Lewes River Groups (Fig. 13). The folds are upright and open with moderate to steeply dipping limbs. Folds near Mount Dean and Caribou Mountain are tight and upright to slightly overturned. Stereoplot data are loosely clustered about two limb areas which are best defined by poles from the Fish Lake syncline (Fig. 13). Limbs dip moderately to the northeast and southwest,

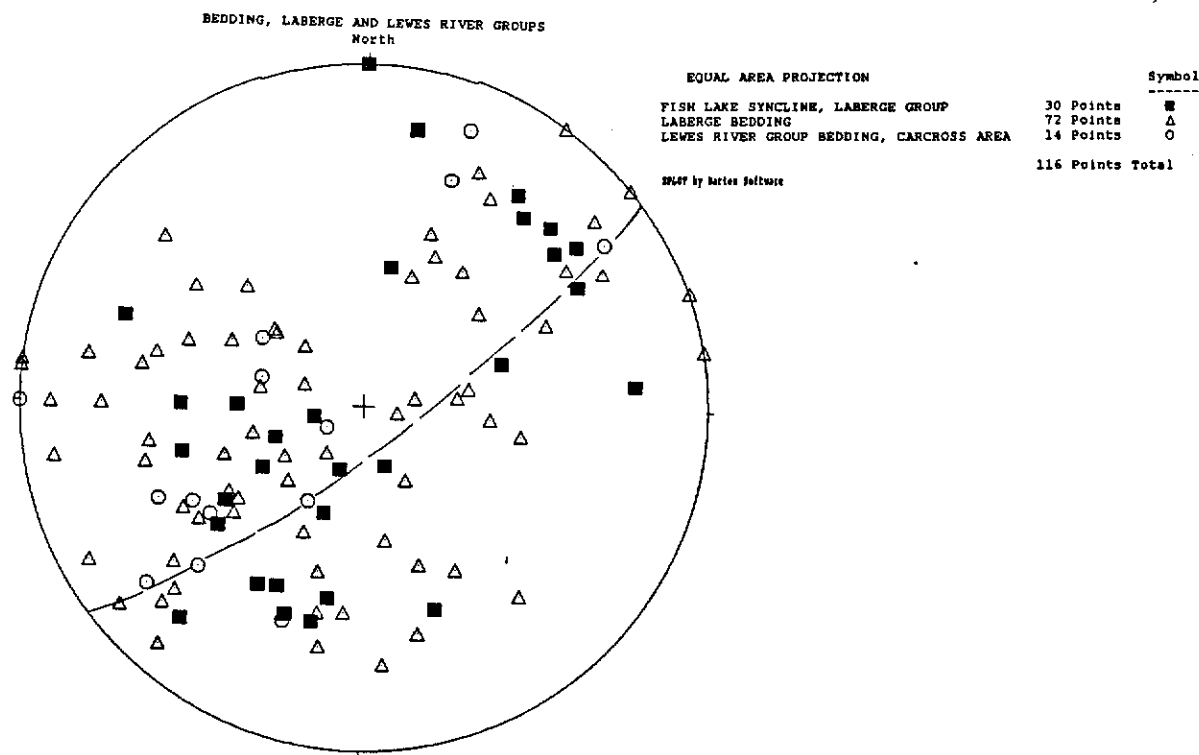


Figure 13: Stereonet of poles to bedding in the Laberge and Lewes River Groups. Poles fall on a loosely defined pi-girdle (dashed great circle) with a pi-axis, parallel to the regional fold axis, plunging shallowly to the northwest.

with northeast dips consistently steeper. The greater cluster of poles in the southwest quadrant may indicate that the southwest dipping limb is shorter than the northeast dipping limb, perhaps indicating some fold asymmetry and westerly fold vergence. Limbs and hinges are rounded, indicated partly by the spread of poles to bedding along a loosely defined pi-girdle. The fold axis plunges shallowly to the southwest based on the map pattern of the Fish Lake syncline. Cleavage is not developed and the orientation of the axial plane is unknown but most likely dips steeply to the east. Fold wavelengths in the project area average about 1-2 km, yet the Fish Lake syncline is about 12-15 km wide. There, the core of the syncline is underlain by massive conglomerate which probably affects the fold style. Alternatively, compression may be translated to the Ibex thrust fault which prevents fold development.

FAULTS

Ibex Thrust Fault

The Ibex thrust fault is well exposed along the eastern slope of the Ibex River valley where the Triassic Lewes River and Laberge Groups are emplaced on the Upper Jurassic Tantalus Formation (Fig. 14). The fault dips shallowly to the east and is marked by a several metre wide zone of protomylonite derived primarily from the Tantalus sandstone and lenses of breccia and carbonate ultramylonite formed from Lewes River limestone. Total movement along this fault is unknown.

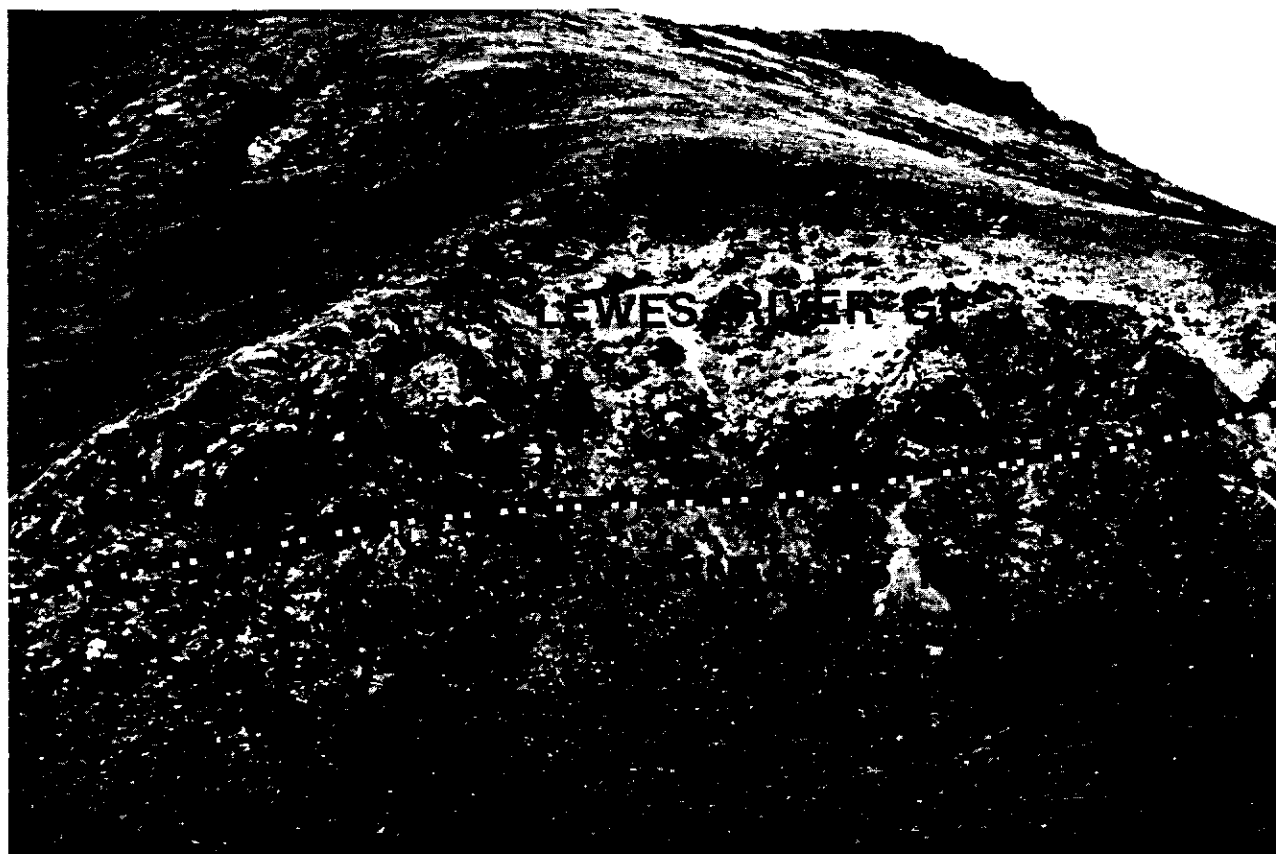


Figure 14: Ibex thrust fault exposed on slope to the east of the Ibex River. Annie Member of the Triassic Lewes River Group is in the upper plate with Upper Jurassic Tantalus Formation in the lower plate.

In the Folle Mountain/Bush Mountain area, a steeply dipping fault between the Tantalus and Laberge strata has similar characteristics to the Ibex thrust. Fault gouge containing Tantalus clasts in a clay-rich, protomylonite matrix was found between Bush Mountain and Idaho Hill, while tectonized, pale quartzite was mapped on the north slope of Folle Mountain. Both the fault and bedding dip steeply indicating subsequent rotation into subvertical positions by intrusion of Late Cretaceous and Eocene granites or faulting.

Other Ibex Faults

Sub-parallel structures complicate geologic relations west of the Ibex thrust fault. A narrow belt of sheared and metamorphosed Povoas Formation augite porphyry resembles rocks of the Tally Ho shear zone. Its east and west contacts with mid-Cretaceous granodiorite are considered to be faults. Granodiorite east of the meta-augite porphyry is itself wedge-shaped and tabular and appears to be juxtaposed against the Tantalus Formation which forms the footwall of the Ibex thrust. The Tantalus Formation is neither hornfelsed or cut by dykes. The western contact of the meta-augite porphyry is also interpreted as a fault due to a lack of intrusive features and parallel structures.

The faults are interpreted as steeply, west-dipping reverse faults. To the south, steeply dipping reverse fault cuts the southern extension of the Ibex thrust fault. Discreet shear bands in granodiorite adjacent to the contacts may indicate some strike-slip motion.

Timing

It is likely that the folding of Whitehorse Trough strata was related and synchronous with thrusting along the Ibex thrust fault. The Ibex thrust fault is cut by the 55 Ma Jackson Creek granite and no evidence yet suggests that mid-Cretaceous plutons were involved in the thrusting. Thrusting and folding involved the Upper Jurassic Tantalus Formation. Deformation responsible for folding, and movement on the Ibex thrust fault was part of a regional compressional event during post-Upper Jurassic, pre-middle Cretaceous time.

Motion on other faults in the Ibex area is younger than the Ibex thrust fault which some cut. The southernmost continuation of one of these faults cuts volcanic rocks on Lakeview and Goat Mountains which are either Late Cretaceous or early Tertiary in age. Consequently, the difference in age and deformation style distinguish the Ibex thrust fault from the 'other Ibex faults'.

TALLY HO SHEAR ZONE

The Tally Ho shear zone (THSZ) is a prominent northwest-trending structure defined by a 1-4 km wide, linear belt of rocks traceable for over 40 kilometres. It is composed of steeply dipping, highly strained volcanic and sedimentary rocks of the Lewes River Group bounded by younger, variably sheared granitic rocks (Fig. 15). The zone extends northwesterly across the Wheaton River valley from the north shore of West Arm to Alligator Lake. North of Alligator Lake the THSZ is covered by extensive flows of Plio-Miocene Miles Canyon Basalt. To the south on Stony Mountain the zone widens, the shear structures are less well-developed, and metamorphic grade is lower. South of West Arm the characteristic shear zone rocks have been displaced by Late Mesozoic/Early Cenozoic intrusive rocks. Information presented here, has developed through studies by Doherty and Hart (1988), Hart and Pelletier (1989a) and Radloff et al. (1990).



Figure 15: Looking north towards Mount Hodnett. Cretaceous granodiorite is in sheared contact with the west margin (left) of the Tally Ho shear zone and in fault contact with Llewellyn fault on east (right). Photo is approximately 1.8 km across.

Nisling Terrane metamorphic rocks are found exclusively west of the THSZ whereas volcanic rocks of the Lewes River Arc are found entirely to the east of the structure. However, Late Triassic plutonic rocks coeval with the Lewes River arc enclose pendants of the Nisling Terrane and occur entirely west of the Tally Ho shear zone.

Detailed mapping and structural analysis across ten transects of the zone, reveal complex displacement and strain histories. Asymmetric shear sense indicators in the shear zone are consistent with development in a region of high strain and would not be developed in a fold belt or during regional deformation. Schistosity in the Nisling Terrane typically displays shallow dips which are dissimilar from the strain associated with the steeply-dipping, linear Tally Ho shear zone.

The distribution of rock units in the Tally Ho shear zone no longer represents the original stratigraphic position of the rock units. The shear zone is composed of the metamorphic equivalents to the Povoas Formation of the Lewes River Group and are described in the preceding chapter. A prominent and pervasive foliation which is parallel to locally preserved compositional layering. Very small scale (1-2 cm across), rootless isoclinal fold hinges are found within foliation planes and discordant compositional layers merge with the foliation, suggesting that original stratigraphy is completely transposed. In addition, no stratigraphic continuity across or along the zone is recognized.

Geometry

The original geometry of the zone is uncertain because the boundaries of the shear zone have been modified by younger intrusions and faulting. The granites generally follow a planar contact and form long thin plutons parallel with the shear zone margins. This suggests that the intrusion of the granites was controlled by the shear zone. Many contacts are modified by brittle faults and shear bands associated with the Llewellyn Fault zone. Rare apophyses of granite are found within the shear zone but good intrusive contacts are only rarely seen.

The shear zone boundaries can be observed in natural transects cut by east trending river valleys, such as the south facing slope of Mount Hodnett (Fig. 15). They have a straight map trace and are steeply dipping. The western margin dips steeply to the west, parallel to the average foliation dip (Fig. 16a). Discrete fault surfaces presently define much of both the western and eastern boundaries of the shear zone which are in turn cut by east-northeast striking faults and fractures.

Structures

A well developed, planar foliation is defined by the alignment of platy and prismatic metamorphic minerals parallel to compositional layering. A parallel gneissosity is developed in certain rock types such as the leucogabbro and laminated, paragneissic amphibolite (Fig. 17). The foliation is present in all lithologies but is less well developed in the ultramafic and the massive hornblende amphibolite. The foliation strikes consistently northwest and dips steeply, both northeast and southwest (Fig. 16a). The consistency of foliation orientations indicates that there has been only one phase of ductile deformation and that the foliation has not been greatly affected by later deformation.

The foliation is locally deformed in two structural domains. Spaced C-surfaces and shear bands cut or deflect the fabric in the centre of the shear zone where strain was concentrated and most intense. A second domain is within small shear zones, commonly along the margins of the main shear zone where shear bands related to the Llewellyn fault zone modify the character of the foliation. In the coarse-grained leucogabbro for example, a planar foliation (Fig. 18a) or locally developed S-C composite fabric is modified to an anastomosing fabric with a rippled, non-symmetric appearance.

In the foliation plane, a consistently oriented mineral lineation is defined by dimensional orientations of platy and prismatic minerals, elongate aggregates and rods of quartz (Fig. 18b) and feldspar, minor fold axes, and elongate porphyroclast tails. The plunge is shallow, generally less than 20° , mostly toward the southeast and to a lesser extent to the northwest (see Fig. 16b). Erratic trends with generally steeper plunges were observed on the margins of the shear zone. Quartz C-axis fabrics measured in quartz-rich amphibolites confirm that the lineation is parallel to the mineral elongation direction (V. Hansen pers. comm. 1990). This classifies the lineation as a stretching lineation (Ramsey and Huber 1987) which is considered parallel to the bulk transport direction of rocks in which it is developed. Indicators of relative shear sense are observed in the plane which is parallel to this lineation and perpendicular to the rock foliation.

Folds are uncommon in the poorly layered rocks of the THSZ but are best developed in those lithologies with the best compositional layering. Minor folds, several mesoscopic, and one map-scale fold are present on Tally Ho Mountain. Minor folds are common in the marble

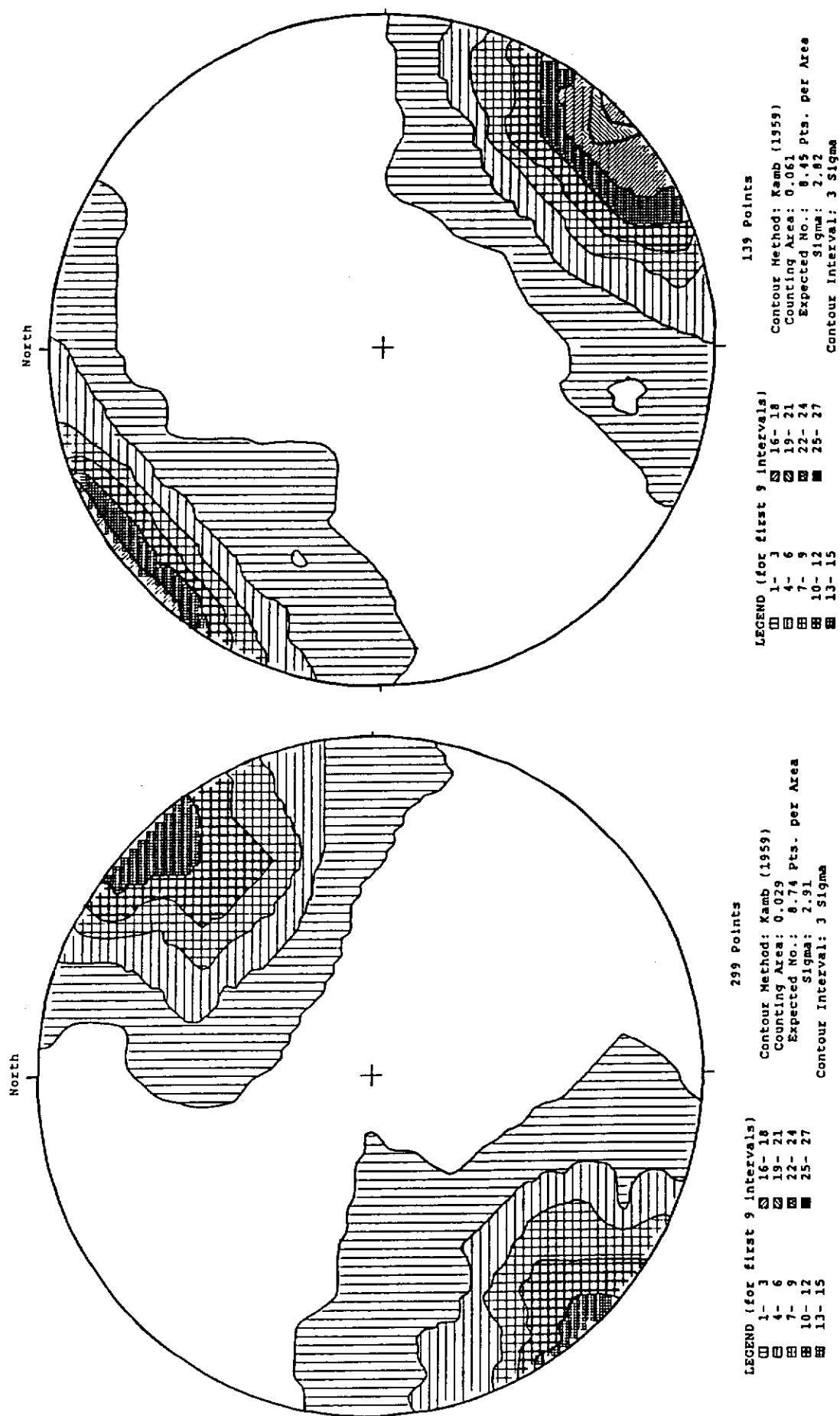


Figure 16: From the Tally Ho shear zone, contoured stereonets of (a) poles to bedding, showing consistent northwest strike and steep dip; and (b) lineations, showing shallow plunge to the southeast and less, to the northwest.



Figure 17: Metamorphosed Povoas Formation showing mylonitic flaser fabric and quartz veins offset by later brittle shears.

and much less common in the laminated (para)gneiss. In the marble, folds are moderate to tight, have an amplitude-wavelength ratio of at least 2:1, and have fold axes parallel to the regional stretching lineation. Axial planes parallel the general foliation orientation, but a foliation also appears to parallel the folded compositional layering. Thus the axial planar foliation probably constitutes a second foliation surface. The mesoscopic and map scale folds are also outlined by the marble. The mesoscopic folds are open, symmetrical "m" folds parasitic in the hinge of the larger order structure, a map-scale antiform exposed on the north face of Tally Ho Mountain. The antiform has planar, steeply dipping limbs and plunges shallowly to the southeast. The crest of the fold is exposed down plunge for several hundred metres on Tally Ho Mountain as a narrow band of marble. Minor folds within the laminated, pale-green paragneiss are intrafolial and have tight hinges with high amplitude-wavelength ratios to isoclinal hinges with distended limbs. Only a few folds were observed and the fold axes are chaotic to indeterminate. We interpret these to be early formed folds which have undergone axial plane shearing, resulting in an overall transposed foliation. Continuous deformation has re-folded the foliation in less competent lithologies such as the marble antiform.

Metamorphism

The composition of rocks in the Tally Ho shear zone precludes the development of diagnostic mineral assemblages but all of the rocks are metamorphosed to at least greenschist facies. The presence of chlorite in the rocks of mafic igneous composition indicates that the greenschist-amphibolite facies transition has not been reached. The presence of hornblende over actinolite indicates that higher rather than lower greenschist facies exists. On this basis, the shear zone rocks are mostly middle greenschist facies. However, there is some suggestion that metamorphic grade increases to lower amphibolite grade on the west side of the shear zone (V.Hansen pers. comm. 1989), perhaps as a result of thermal upgrading.

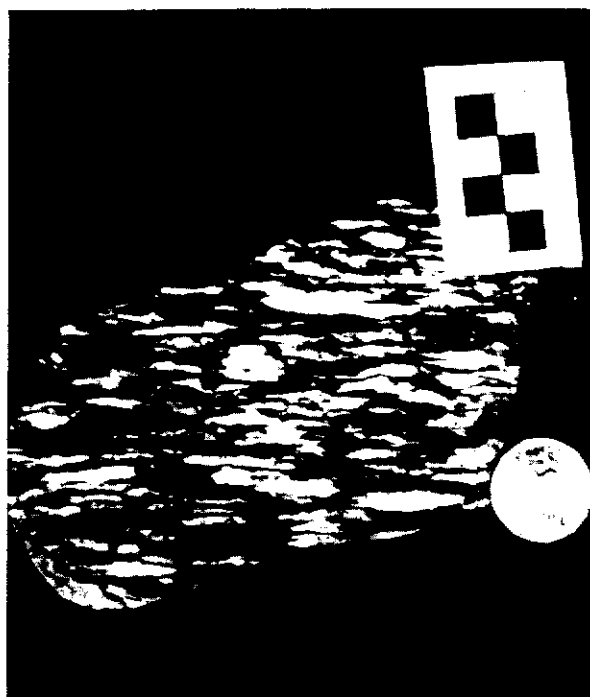


Figure 18: Structural style of the Tally Ho shear zone; a) well-developed planar foliation in the Tally Ho leucogabbro; scale bar is in centimetres; b) strong rodding meta-Povoas Formation which defines the regional stretching lineation.

Kinematics

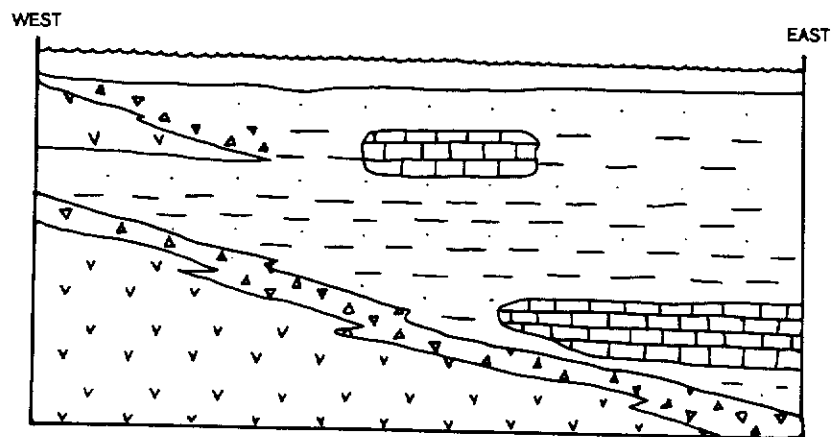
A preliminary study of kinematic indicators across the THSZ was undertaken in order to better understand the tectonic history of the shear zone. Kinematic indicators were observed in outcrop and a preliminary shear sense could be determined using certain structures in the field. These structures include shear bands, rotated porphyroclasts, and rare S-C fabrics. Microstructural study of oriented thin sections revealed additional kinematic indicators and allowed more careful analysis of relationships and relative ages between structures. Kinematic indicators observed in thin section are rotated porphyroclasts (Passchier and Simpson, 1986), mica fish (Lister and Snoke, 1982), displaced broken grains, composite planar fabrics including both shear bands and S-C fabrics (Simpson and Schmid 1983), and quartz C-axis fabrics (V. Hansen written comm. 1990).

Results

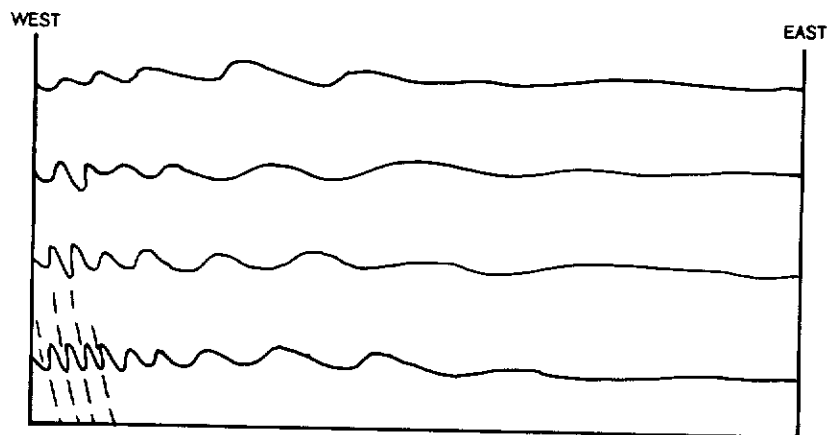
Evaluation of the kinematic indicators reveals that the THSZ had a complex movement history involving at least two, and possibly three, stages of movement. Most of the structures were produced by a single phase of deformation but others have undergone polyphase deformation. Polyphase structures yield equivocal or ambiguous results and must be discarded from the data set (see Simpson and Schmid 1983).

The earliest structures developed indicate sinistral motion. They include a pervasive foliation and lineations, folds, rotated porphyroclasts (sigma type; Passchier and Simpson 1986;

T_1 : Deposition of inhomogeneous island arc assemblage



T_2 : Folding initiated



T_3 : Folding intensifies; shearing initiated along axial planes; strain concentrated at depth and to the west

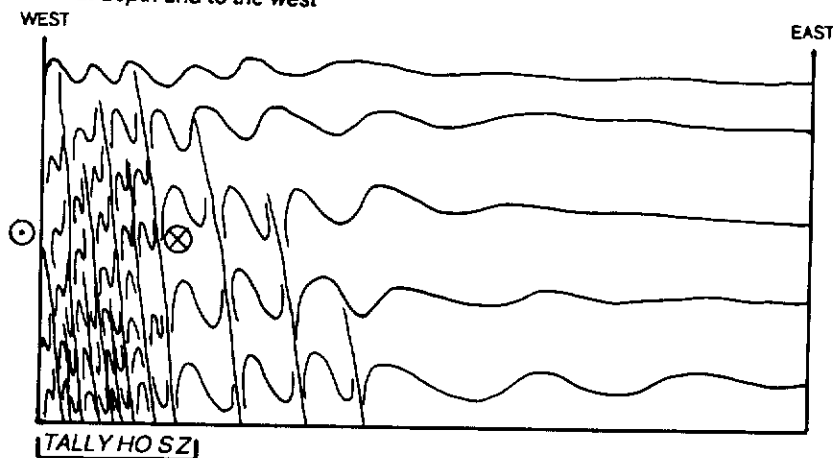


Figure 19: Schematic illustration of the development of the Tally Ho shear zone and the transition from deformed to undeformed Lewes River Group. Not to scale.

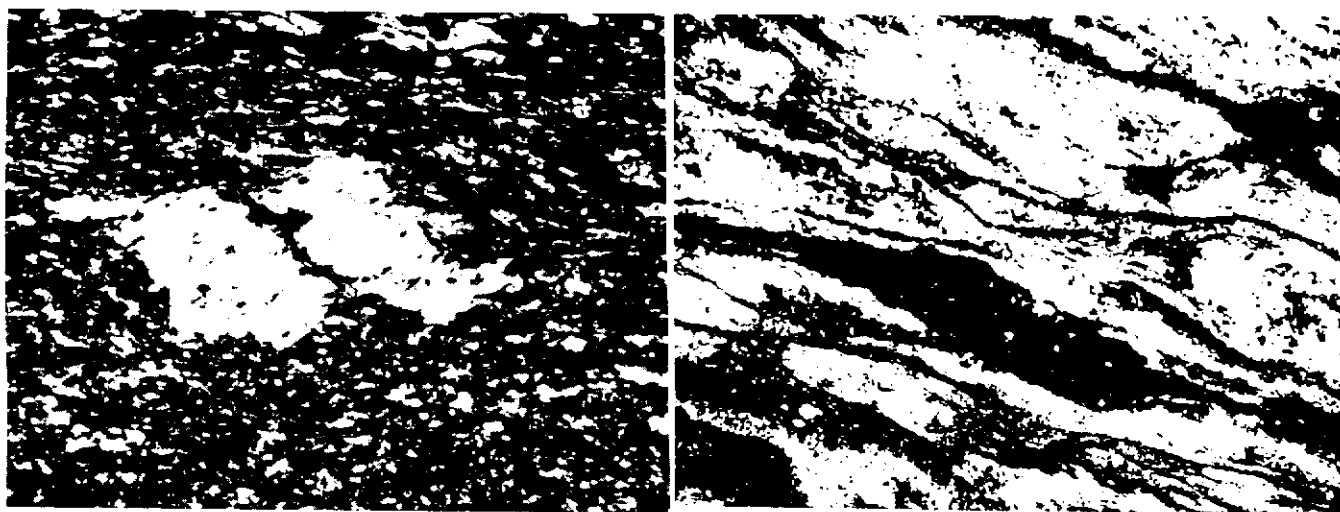


Figure 20: Photomicrograph of sinistral shear sense indicators; a) sigma type porphyroclasts in fine-grained amphibolite matrix, meta-Povoas Formation; long dimension of photo is appx. 2 mm, plane polarized light; b) S-C fabric in Tally Ho leucogabbro with sinistral shear sense; long dimension is 7.5 mm across; negative image of plane polarized light.

Fig. 20a), sinistral shear bands (Fig. 21) and C-surfaces (Fig. 20b), mica fish, and displaced broken grains. These structures are well developed in Carnian (and older?) Povoas Formation rocks, the Triassic Tally Ho leucogabbro, and to a lesser extent in the ultramafic rocks on Tally Ho Mountain. The Late Triassic Bennett granite (intrudes the deformed rocks of the THSZ constrains the upper age for this deformation at 220 ± 5 Ma (U-Pb, Doherty and Hart 1988). It contains inclusions of foliated and unfoliated Povoas Formation and itself is locally foliated. The foliation is cut by sinistral shear bands (Fig. 22), indicating that the deformation had not entirely ceased by the time of the granite's cooling. However, deformation likely stopped soon after since the granite is not pervasively deformed.

A second set of structures which indicate a phase of *dextral* shearing can be clearly separated from the sinistral phase. Overprinting relationships were established in rocks bearing indicators of both shear senses. Structures with a dextral sense of shear are developed in plutons of the mid-Cretaceous Whitehorse plutonic suite, Late Cretaceous Wheaton Valley granite and the Povoas Formation and the Tally Ho leucogabbro. Discreet 0.5-2.0 metre wide shear zones in the granites display penetrative foliation and lineation and dynamically reduced grain size. Outside of these shear bands, the granites locally exhibit a spaced cleavage (ie. Mt. Hodnett, Mt. Stevens). This foliation, along with the penetrative, earlier foliation in the Povoas Formation and the leucogabbro, is cut by spaced shear bands which deflect or offset the foliation in a dextral sense. In thin section, mica fish, displaced broken grains, and composite fabrics (Fig. 23a) were observed with the same shear sense. One instance of microfolding was observed in the motion plane which gave a dextral shear sense, consistent with the other kinematic indicators (Fig. 23b).

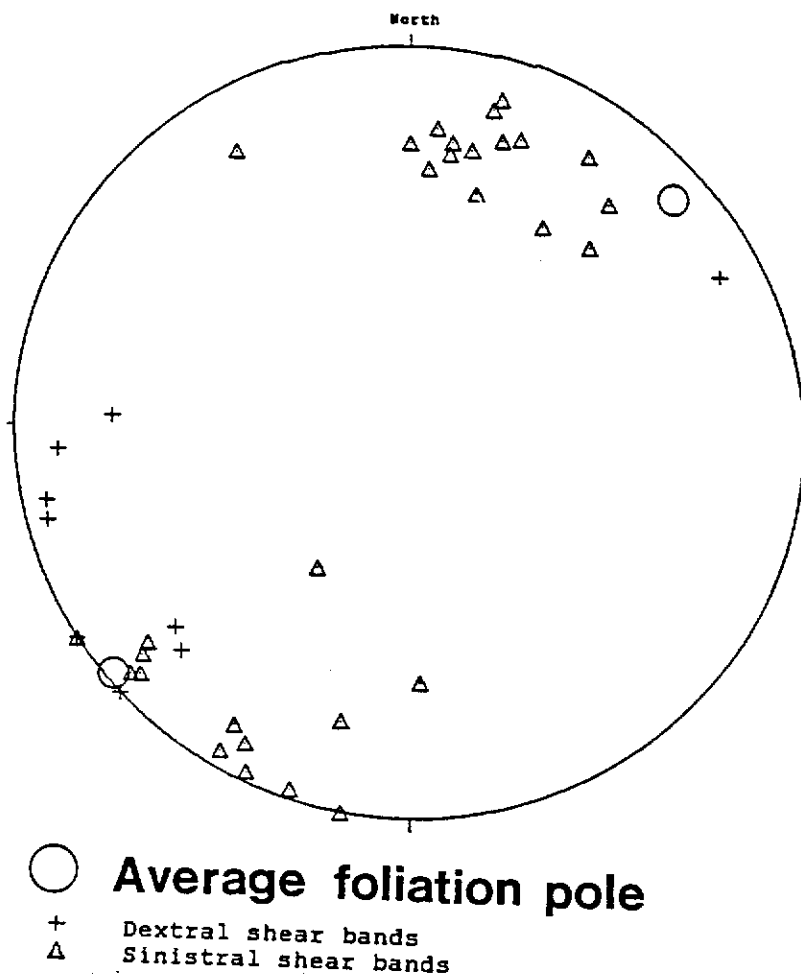


Figure 21: Stereonet of poles to sinistral and dextral shear bands developed in the Tally Ho shear zone. Sinistral shear bands strike more westerly than the average foliation while dextral shear bands strike more northerly than the foliation.



Figure 22: Foliated Late Triassic Bennett granite which intrudes the western margin of the Tally Ho shear zone and contains elongate inclusion of meta-Povoas Formation with a concordant foliation. Both foliations and the inclusion are cut by a sinistral shear band.



Figure 23: Photomicrographs of dextral shear sense indicators from 119 Ma Whitehorse pluton within Tally Ho shear zone on Mt. Hodnett; a) grain shape preferred orientation (gspe) of dynamically recrystallized quartz is at a moderate angle to the foliation, S_1 ; b) microfolds seen within the motion plane (parallel to foliation and perpendicular to stretching lineation). Long dimension of photos are 3 mm, crossed nicols.

Interpretation and Summary

The development of penetrative, ductile fabrics under conditions of upper greenschist to amphibolite facies metamorphism are associated with kinematic indicators giving a sinistral sense of shear parallel to a shallowly plunging, southeast trending stretching lineation. These features are believed to represent a single phase of continuous, locally intense deformation in the Tally Ho shear zone beginning during Carnian time (230 Ma?) and ending just after 220-215 Ma.

The tectonic significance of the Tally Ho shear zone remains ambiguous. The Tally Ho shear zone forms a boundary between the Lewes River arc and the Nisling Terrane in southernmost Yukon. If the Late Triassic Bennett batholith, which encloses pendants of the Nisling Terrane represents the plutonic roots of the Lewes River arc, then the Tally Ho shear zone must be an intra-arc shear zone. This implies that the Nisling Terrane would form the basement of the Lewes River arc and that significant vertical motion accompanies sinistral displacement on the THSZ, juxtaposing crystalline basement and the volcanic arc. Alternatively, if the Late Triassic Bennett Granite is not genetically related to the Lewes River arc the Tally Ho shear zone is the terrane bounding structure between the Nisling and northern Stikine terranes. The shear zone would represent a domain of sinistral and vertical convergence between the two terranes.

Vertical motion associated with Late Triassic sinistral translation would form a trough with a steep westerly margin and uplifted source terrain. Sedimentary rocks of the Lewes River and Laberge Group were deposited in such a depocenter, comprising the Whitehorse Trough overlap assemblage.

The dextral set of structures are neither pervasive nor penetrative and are associated with shallowly plunging lineations with the same orientation as the older sinistral set. Structures and motion related to this phase of deformation are associated with the Llewellyn fault zone.

LLEWELLYN FAULT ZONE

The Llewellyn Fault Zone (LFZ) is a steeply-dipping, continuous and anastomosing brittle structure which parallels and overprints the ductile Tally Ho shear zone (Fig. 15). South of the project area in B.C., the fault continues past the south end of Tutshi, Tagish and Atlin Lakes (Bultman 1979; Mihalynuk and Rouse 1988b and other mapping). The faults preferentially occur along the eastern margin of the shear zone (Fig. 15) where lenticular fault blocks of shear zone and granitic rocks are juxtaposed in strike-slip duplexes. Narrow belts of intrusive rock adjacent to the fault zone may be fault bounded or syn-kinematic. The Wheaton Valley granodiorite was assumed to be pre-Cretaceous (Doherty and Hart 1988) on the basis of its well-developed foliation. A U-Pb date of 78 Ma however suggests that the foliation may be a result of syn-kinematic intrusion controlled by the fault.

On Mount Stevens, the fault has up to three main traces and volcanic and granitic rocks between the faults are generally moderately to well foliated. South of this point the faults are not exposed but are assumed to exist in the lower Wheaton River Valley. At Bennett Lake the Early Eocene Pennington Pluton plugs the fault.

Structures associated with the LFZ are described with the THSZ as second phase or dextral structures. The juxtaposition of rock types across the fault indicates that the net displacement is potentially large. Timing of the motion is complex and may have been intermittent both in space and time as mid- and Late Cretaceous plutons (as young as 78 Ma) are variably affected. The Early Eocene Pennington Pluton, although not displaced by the fault, is cut by numerous discrete shear bands.

The THSZ-LFZ form boundary of dramatic contrasts in the thickness of Whitehorse Trough strata. Greater than five kilometres thickness is assumed east of the structure, but none exist (in Yukon) west of the structure. While it has been suggested that the Tally Ho shear zone may be the controlling feature (earlier this chapter), the variation may also be accounted by post-Middle Jurassic uplift and erosion of sediments deposited west of the THSZ-LFZ or juxtaposition by strike-slip displacement along the LFZ.

The motion history of the Tally Ho shear and Llewellyn Fault zones is summarized in Table III.

MOTION HISTORY OF THE TALLY HO SHEAR ZONE

PHASE	1	2
AGE	Late Triassic	post mid-Late Cretaceous
SHEAR SENSE	sinistral	dextral
STRUCTURAL STYLE	ductile penetrative planar well-developed L-S tectonites local S-C fabric shear bands common	semi-brittle non-penetrative anastomosing domains locally developed L-S tectonites rare S-C fabric shear bands common
METAMORPHISM	greenschist to amphibolite	lower greenschist
CRUSTAL LEVEL	middle	upper
STRUCTURE NAME	TALLY HO SHEAR ZONE	LLEWELLYN FAULT

Table III: Motion history of the Tally Ho shear zone. See text for explanation.

OVERPRINTING STRUCTURES

WYNTON CREEK FAULT

The Wynton Creek fault strikes west-southwest along the Wynton Creek and upper Dundalk Creek valleys. It downdrops the Montana Mountain volcanic complex against Jurassic Laberge Group rocks. The displacement of the unconformity between the Montana Mountain volcanic rocks and the Laberge sedimentary rocks must be greater than the 1500 m thickness of volcanic strata found north of the fault. The normal motion on this fault may reflect post-volcanic subsidence of the volcanic complex.

The fault offsets the contact between the Laberge and Lewes River Groups in a dextral sense, approximately 5 km. For several hundred metres north of the fault, felsic Montana Mountain volcanic rocks are fracture cleaved parallel to the fault. The Wynton Creek fault is a normal fault which accommodated strike-slip motion in post-mid-Cretaceous time. The two styles of motion may have been synchronous (during volcanic subsidence?) or strike-slip motion may post-date normal motion. A sub-parallel fault near Dundalk Mountain and another at an oblique angle to the Wynton Creek fault at the headwaters of Knob Creek also show evidence of dextral displacement.

BERNEY CREEK FAULT

The Berney Creek Fault strikes east along the southerly facing slope of Mount Reid above Berney Creek and includes one major and several smaller parallel, normal faults. The fault forms the southern contact of the Mount Skukum igneous complex. Primary flow structures and splash features in the volcanics suggest that the fault probably formed a steep scarp prior to Skukum volcanism (Morin pers. comm. 1987), and was reactivated during caldera collapse. This is consistent with vein textures and dyke ages at the Mount Reid deposit which indicate post-emplacement (post 60 Ma) brecciation of the vein. Mt. Skukum volcanic rocks were downdropped with respect to the Nisling assemblage and Mt. McNeil granodiorite on the south side of the fault. Other easterly-trending faults in the Wheaton River area (ie. Carbon Hill) may be related to the Berney Creek fault.

WHEATON LINEAMENT

The Wheaton Lineament (Doherty and Hart 1988; Vesuvius-Chieftain Lineament of Von Gaza and Eyton 1988) is a 30 km long, linear, slightly negative topographic feature which is best observed on air photographs and digitally enhanced Landsat TM imagery. The lineament strikes at 035° and is best developed between Vesuvius Hill and Berney Creek but continues as far south as southern Primrose Lake and north to Hodnett Lakes. Parallel faults and strike-slip shears on Mount Reid, Mount McNeil and Chieftain Hill and brecciation and alteration adjacent to the trace of the lineament suggest that it is a fault.

Several smaller parallel lineations and structures have been interpreted as representing deep-seated fractures (Von Gaza and Eyton 1988). A similar suggestion has been made for the Wheaton Lineament (Doherty and Hart 1988). This structure cuts rocks as young as Early Eocene.

STRUCTURES RELATED TO EOCENE RESURGENT VOLCANIC COMPLEXES

Resurgent domes and faults associated with Early Eocene volcanism is found at the Bennett Lake Cauldron and Skukum Caldera Complexes as well as in small remnant portions

yof a third and fourth centre along the map boundary west of Alligator Lake. Structures associated with the volcanic complexes consist of poorly developed radial fracture systems, apical graben structures, nested cauldernas and block faulting. Northeast striking fractures extend away from the Mount Skukum and Bennett Lake complexes into the country rock. A major structure recognized in the Bennett Lake Complex includes a concentric ring dyke and radial fracture system (Lambert 1974). Structures associated with Ibex Mountain igneous activity have not been recognized.

The lithologies currently exposed in each igneous centre reflect a northward trend of greater erosion and unroofing. The Bennett Lake Complex, composed of approximately 4000 m maximum thickness of volcanoclastic material, tuff and breccia is the least eroded of the four centres. The Skukum Complex comprises approximately 2000 m thick of volcanic material. The Ibex Mountain centre is the most deeply eroded with only a few hundred metres of remnant patches of volcanic material exposed amongst high-level alaskite.

The development of the Eocene complexes maybe related to regional transtension that accompanied right-lateral strike-slip motion on the northwest striking Shakwak-Denali and Tintina faults (Souther 1977).

WHITEHORSE FAULT SERIES

A series of widespread northeast to north-northeast-striking faults and fractures are grouped into the informal Whitehorse fault series. The structures are sub-parallel, spaced approximately 1-3 km apart and have steep dips. Displacement varies from 0-2.0 km. Near Alligator Lake several of these faults offset the Tally Ho shear zone in an apparent sinistral sense. Near the Whitehorse Coal property, the consistency of sense of displacement is lost and apparent offsets vary between fault blocks possibly reflecting differential, vertical displacements.

On the Whitehorse sheet these structures strike approximately 050° and show little or no offset. To the south, they strike 070° and show greater displacements. Northeast-striking faults on the Carcross sheet may be related. Doherty and Hart (1988) suggested that many parallel linear features, best observed on air photographs probably represent other unmapped faults.

Rhyolite dykes genetically related to Skukum volcanism locally into these structures suggesting that they predate resurgent doming of Skukum rhyolite (53 Ma Rb-Sr; Pride and Clark 1985). In several locations however, the rhyolite is brecciated and hydrothermally altered, indicating post-Early Eocene reactivation. Such a structure, which shows evidence of multiple brecciations, hosts the Said-The, high-level epithermal vein deposit. In addition, the southern contact of the rhyolite plug north of Butte Creek (Central Intrusion) is steep and probably faulted (Love 1990b) along an east-northeast-striking fault.

The origin of these structures is somewhat enigmatic. It was first suggested by Doherty and Hart (1988), and supported by data collected and analysed by Love (1989, 1990b), that the faults represent Riedel style fractures related to major, northwest-striking strike-slip faults (ie. Denali, Teslin, Tintina) active during Paleogene time.

ECONOMIC GEOLOGY

More than 100 mineral occurrences are known in the project area, and form three main camps; the Wheaton River District, the Montana Mountain area and the Whitehorse Copper Belt. Each region is characterized by certain deposit types which can be related to the geology or structures found there. This chapter will characterize each mineral camp by presenting a geological and metallogenic perspective, describing important deposits and discussing metallogenic models. Mineral occurrence names are those used in on the accompanying maps and in the Yukon Exploration series (YEX) published by Indian and Northern Affairs.

WHEATON RIVER DISTRICT

The Wheaton River District essentially covers the drainage of the Wheaton River. Active exploration in the area began before the turn of the century as miners infiltrated the area on their way to the Klondike (see McConnell 1906; Cairnes 1906, 1909, 1912). The dominant deposit style in this district is gold-bearing quartz-sulphide veins. The close spatial distribution of vein deposits in the Wheaton area was generally thought to indicate a common origin for most of the deposits. With the discovery of the Mt. Skukum epithermal gold deposit in 1983, the associated Eocene Skukum Group volcanic rocks were considered to be the genetic source of much of the gold in the Wheaton District, and have since become the focus of numerous exploration programs (McDonald et al. 1986).

CLASSIFICATION

Several attempts have been made to classify the deposits of the Wheaton District. During an evaluation of the area early this century, Cairnes (1912) recognized four types: a) gold-silver quartz veins; b) antimony-silver veins; c) silver-lead veins; and d) contact metamorphic ore-deposits. Both Cairnes and Morisson (1978, 1979) suggested that the mineral occurrences were formed from fluids derived from intrusive igneous rocks.

Fluid inclusion and oxygen isotope studies by Rucker (1988) concluded that the complexity of the vein systems make them impossible to categorize on the basis of fluid chemistry or mineralogy.

A vein classification suggested by Doherty and Hart (1988) included: a) epithermal gold veins associated with Eocene volcanics; as well as b) antimony-silver veins with or without zinc, gold or arsenic; and c) gold-silver-telluride quartz veins.

Classifications based upon vein mineralogy alone can be misleading because different mineral assemblages may reflect vertical zonation of the vein. As a result, the classifications presented here attempt to define deposit types based upon the chemistry of fluids responsible for vein formation, as determined from vein mineralogy, geological relations, metal ratios, stable isotopes and fluid temperature or composition as determined through fluid inclusion analyses.

Mineral deposits in the Wheaton District can be divided according to the composition of the fluids which formed them - magmatic, metamorphic?, meteoric and evolved meteoric (Table IV). Veins formed from meteoric and evolved meteoric fluids are roughly equivalent to epithermal and mesothermal veins, respectively.

EPITHERMAL (Meteoric Fluids)

Quartz-Adularia

Bonanza type

MAIN CIRQUE
BRANDY
LAKE
TANGO

High-Level

GOAT
SAID(PLUS)
TYCON
PUGH
LATER
SILVER QUEEN

Fluorite

BOUDETTE

Other

BEAR

Quartz-Sulphide

PARTRIDGE
SCAR
GLENLIVET
SHAW

MESOTHERMAL (Evolved Meteoric Fluids)

Stibnite-rich

PORTER
GODDELL
BECKER-COCHRAN
EVENING
OCEAN
EMPIRE
BOSTOCK
CRAIG
OPULENCE

Galena-rich

MT. STEVENS
MT. ANDERSON
GOLD HILL
MINERAL HILL*
LEGAL TENDER
DAIL
RED RIDGE*
OMNI
TALLY HO*

Arsenopyrite-rich

CHARLESTON
IDAHO HILL
VENUS (and others)
LULU

MAGMATIC

Skarn

MT. ANDERSON (ROB)
FLEMING
DAYIR

Contact

FINGER
WABONA
COLLEGE GREEN
EVIEW
MT. WHEATON

Porphyry

PARTRIDGE
ALLIGATOR
INCO
FOXMO
CONRAD
MARKMOLY
LATRIELLE
CARCROSS

METAMORPHIC

ODD
CROMWELL
MILLHAVEN
HOD

UNKNOWN

NAIAD
BEN

WAL
CLEFT

LUCKY BOY

Table IV: Classification of Mineral Occurrences in the Wheaton-Carcross Area.
Occurrence names are those used in Yukon Exploration volumes
(INAC 1989).

MAGMATIC DEPOSITS

Occurrences formed as a result of their association with magma and magmatic fluids in the Wheaton District include porphyry copper, molybdenum and skarn deposits. Porphyry copper occurrences (Alligator, Latreille, Inco) are generally poorly developed. They are dominated by assemblages of weak argillic and phyllic alteration, and in the case of the Alligator showing, a pyrite halo. Malachite staining and thin grey-quartz and chalcopryrite (or molybdenum at Latreille) veins are common in fractures and joints in the alteration zones. Weakly developed alteration assemblages with infrequent evidence of copper mineralization was recognized east of Vesuvius Hill and in the upper Becker Creek area.

Molybdenum occurs in a porphyry-style setting at Latreille, but at the Foxmo and Rob occurrences, forms large rosettes in thin grey-white quartz veins hosted in hornblende diorite and stringers in skarnified Nisling assemblage marble, respectively.

Metalliferous skarns formed in Nisling assemblage marble also include the Fleming occurrence where marble hosts two eight metre wide bands of specular hematite and magnetite with sparsely distributed chalcopryrite. Wollastonite-calcite-tremolite is the dominant skarn assemblage. This occurrence has gold grades up to 7.1 g/t Au with elevated Bi and W values (Hulstien pers. comm. 1989) and reported elevated zinc.

Porphyry copper occurrences in the Wheaton District are exclusively in mid-Cretaceous granodiorite of the Whitehorse plutonic suite which is also associated with copper skarns of the Whitehorse Copper Belt. Gold in these deposits is associated with elevated bismuth and tungsten values and not molybdenum. This relationship is also recognized in the Whitehorse Copper Belt (Hart and Pelletier 1989b). Although Whitehorse plutonic suite rocks are spatially associated with the molybdenum and skarn deposits of the Wheaton District, their genetic association is indefinite.

METAMORPHIC(?) VEINS

Several vein occurrences are hosted in the metamorphosed greenstone of the Tally Ho shear zone. These include the Millhaven, Cromwell, Odd, and Gold Reef deposits and are composed of fine-grained white to grey, waxy (metamorphic?) quartz and dominance of chalcopryrite over galena. Veins at Gold and Mineral Hills are similar to this suite but also have characteristics of galena-rich mesothermal veins discussed later.

Veins and metal values of this classification are generally discontinuous. The Odd vein on Dickson Hill however, is up to two metres wide, traceable on surface for 30 m and has returned a drill intersection of 1.37 m of 46.3 g/t Au and 20 g/t Ag (INAC 1987). Numerous small, discontinuous, concordant quartz (+/- chalcopryrite) veins occur in the shear zone (eg. Fig. 17) and have returned values up to 0.5% Cu and 320 ppb Au, >50 ppm Ag. Other mesothermal and epithermal veins in the shear zone, can be differentiated from the syn?-metamorphic veins by their gossanous carbonate alteration of the wallrock.

Petrographic examination of the Odd vein found that very small (4 microns) fluid inclusions are ubiquitous throughout the sample. Cursory fluid inclusion examination found that primary inclusions were extremely rare and failed to equilibrate at temperatures below 500°C. Later cross-cutting quartz veins equilibrated at 263°C (both values uncorrected for pressure). Because they are concordant, and the wallrock is not altered, fluids may have been derived through metamorphic dehydration during Late Triassic ductile deformation of the

Tally Ho shear zone. Volcanic rocks of the Lewes River Group contain high background copper values which may have contributed to the copper in these veins.

A metamorphic quartz vein sampled from Nisling Terrane metasedimentary rocks returned gold and silver values of 400 ppb and 32 g/t respectively.

EPITHERMAL VEINS

Several deposits in the Wheaton District have epithermal characteristics (see Berger and Bethke 1985) including high level, open space and crustiform deposition of white quartz, chalcedony, and calcite with or without sulphides. They can be differentiated from mesothermal deposits by the presence of Mn-minerals and high background mercury values. Their fluids typically have lower CO₂ and salt (0.7% at Mt. Skukum) contents, and lower homogenization temperatures than those of mesothermal deposits (see Nesbitt et al. 1986; Heald et al. 1987; Nesbitt 1988). In the Wheaton area, most epithermal veins occur in Eocene volcanic centres, are associated with Eocene Skukum Group rhyolite dykes or younger cross-cutting structures.

Two types of epithermal veins occur in the Wheaton District: quartz-rich and sulphide-rich. Quartz-rich epithermal veins include the Mt. Skukum ore deposits (Cirque, Brandy and Lake), the Tango, Goat, Said-The, Plus, Pika, Bear, Pugh, Tycon and Silver Queen. In addition to displaying several of the aforementioned characteristics, these veins contain fluorite and have hydrothermal alteration assemblage dominated by sericite and adularia. Disseminated pyrite is common in wallrock where alteration is intense. Ore minerals include native gold or electrum and less than 1% pyrite. These deposits have very high gold:silver ratios. They are in structures which appear to post-date the main volcanic events and are often brecciated and show evidence of reactivation or multiple stage fluids. In most cases the host lithology is intermediate volcanic flows. The higher level veins (ie. Goat, Said, Tycon) show evidence of high-dilation, hydrothermally cemented wallrock breccia with multiple episodes of brecciation and cementing. This episodic deposition typically occurs in the top 1-2 km of veins and may have been induced by the dynamic effects of rupturing in strike-slip fault zones (c.f. Martha Hill New Zealand).

The sulphide-rich epithermal veins include the Glenlivet, Aul, Part, Goat (Shaw) and Ridge occurrences. These veins are dominated by argentiferous galena, chalcopryrite, chalcocite or pyrite with quartz and anhydrite in the gangue. The veins have low to very low gold:silver ratios, but locally return good gold grades (ie. Part vein 58 g/t Au, 3442 g/t Ag; INAC 1988 p. 111). Advanced argillic alteration assemblages (alunite, kaolinite) typical of low pH systems are notable. Although these veins are not as well studied as the quartz-rich veins, these veins appear to be hosted in syn-volcanic structures (associated with caldera collapse?) cutting dominantly felsic rocks.

Mount Skukum

The Mt. Skukum gold deposit has been the focus of several studies (McDonald 1987; McDonald and Godwin 1986; McDonald et al. 1986; Love 1989, 1990a, b). The mine operated between February 1986 and July 1988 and produced approximately 80,000 ounces of gold from 220,000 tons of ore (Bassnet 1989). The deposit consists of three steeply dipping quartz-carbonate veins hosted in a sequence of sub-horizontal andesites in the Main Cirque area of the Early Eocene Mount Skukum volcanic complex. The Cirque deposit was the primary

source of ore, although the Lake and Brandy were developed with underground workings and test stopes.

The veins are composed of white, bladed calcite filled with white massive quartz and sericite. Precious metals occur in all veins as electrum and native silver grains averaging 15-20 microns (McDonald 1987). Ore grades in the Brandy and Lake veins are very erratic. Sulphide content is very low but minor rhodonite, rhodochrosite, galena, sphalerite and pyrite occur in the Lake vein. Several well-defined, steeply-dipping ore-shoots have been delineated in the Cirque vein (McDonald 1986).

Alteration

McDonald (1987) has shown that the alteration assemblage associated with the Mt. Skukum veins is dominated by silica, sericite, adularia and calcite. Throughout the complex, propylitic alteration assemblages are well developed.

Doherty and Hart (1988) suggested that geochemically distinct, low silica rhyolite may be associated with gold-bearing quartz veins. McDonald (pers. comm. 1989) has suggested that the unique chemistry may not be primary but possibly is a function of alteration. Intense argillic alteration south of the deposit (alunite cap zone) is representative of syn-volcanic acid-sulphate alteration and is not related to the ore forming processes in the Main Cirque (Love 1990a).

Structural Control of Deposits

The Cirque vein occurs where a steeply-dipping fault, striking at 55° cuts a rhyolite dyke. The ore zone is in a dilational zone which strikes at 035° . The change in strike has been attributed to refraction between the rhyolite and the host andesite (Love 1990b). Sinistral motion along the fault subsequently produced the opening into which the vein was deposited. The Brandy and Lake veins were created by strike-slip or normal motion along parallel fault planes but dilation did not occur to the same extent as at Cirque because rheological differences in the rock types were not available for fault refraction. As a result, Love (1990b) has suggested that the intersection of faults and dykes may provide good exploration targets.

The ore zone faults may be continuous with the northwest-striking faults of the Whitehorse fault series. These faults were active during post-early Eocene time as they contain brecciated and hydrothermally altered Skukum Group rhyolite. At the Said occurrence, they host brecciated, high-level chalcedony-fluorite veins with erratic gold values. If the Mt. Skukum ore bodies are associated with the Whitehorse fault series, then the structure and ore forming processes need not be genetically associated with the volcanic processes themselves, but may be related to regional conditions (Love 1990b).

Altered wallrock at the Skukum deposit is dated at 51 Ma (K-Ar method; McDonald 1987), several millions years younger than the age of the complex (this report) and supports suggestions that the Mt. Skukum ore deposits formed in post-volcanic, regionally controlled structures.

Discussion

Two distinct volcanic related epithermal environments in the Wheaton River District are classified primarily on the basis of vein and alteration mineralogies are the Adularia-Sericite type and the Acid-Sulphate type (see Hayba et al. 1986; Heald et al. 1987 for characteristics and references).

Deposits of the Adularia-Sericite type are typically low-sulphide, base metal poor with high gold: silver ratios. They are often formed from multiple fluids in reactivated structural zones and contain fluorite or elevated Hg at high levels. They are associated with structurally complex environments or deep seated structures and ore-formation post dates the host by greater than 1.0 Ma. Adularia and sericite alteration of the wall-rock is characteristic. Occurrences belonging to this archetype include the Cirque, Brandy, Lake, Tango, Goat, Said-The, Plus, Pika, Bear, Pugh and Tycon. The presence of Mn-bearing minerals at the Mt. Skukum deposit is diagnostic to the adularia-sericite deposit type.

Occurrences of the Acid-Sulphate type are sulphide-rich, and typically contain argentiferous galena, chalcopryite, chalcocite or pyrite. Advanced argillic alteration assemblages (alunite, kaolinite) are typical. Anhydrite and quartz are common gangue minerals. Typical hosts are intrusive felsic rocks near caldera margins. Mineral occurrences belonging to this archetype include the Glenlivet, Aul, Part, Goat (Shaw) and Ridge.

Isotopic oxygen compositions of fluids responsible for the formation of epithermal deposits in the Wheaton District plot immediately (+5 to +15 per mil) to the right of the local meteoric water line (Fig. 24). The Mount Skukum deposit yielded ^{18}O values between -9.8 and -13.7 per mil (McDonald 1987). Rucker (1988) obtained ^{18}O values between -14.0 and -19.1 from chalcedonic quartz and fluorite veins outside of Eocene volcanic complexes. Wheaton River District epithermal veins therefore formed from moderately shifted ^{18}O meteoric water. Epithermal veins in the Wheaton District may not be directly (or genetically) associated with Eocene volcanic centres and other features (ie. younger structures) may have controlled their formation.

MESOTHERMAL VEINS

Most gold-bearing veins in the Wheaton District mesothermal in character (see Nesbitt et al. 1986; Nesbitt 1988; Kerrich 1990). These veins are characterized by the presence of pyrite and arsenopyrite, galena or stibnite with a massive or coarsely crystalline, clear or white quartz gangue. Sphalerite, chalcopryite, bornite and native gold have also been recognized. Telluride minerals have been reported in veins in the eastern portion of the district. The alteration assemblages are dominated by carbonates or silica flooding with minor pyrite. The veins are in a variety of rock types (granite is most common), are of moderate width (up to 6 m) and generally dip steeply. Fluid inclusions have higher homogenization temperatures, CO_2 and salt contents (commonly > 5%) than those in the epithermal deposits.

Wheaton District mesothermal veins can be divided according to the dominant sulphide mineral - galena, arsenopyrite and stibnite. This division of deposits is used for convenience and is does not necessarily infer a metallogenic classification, as vertical mineralogic zonation is characteristic of mesothermal veins.

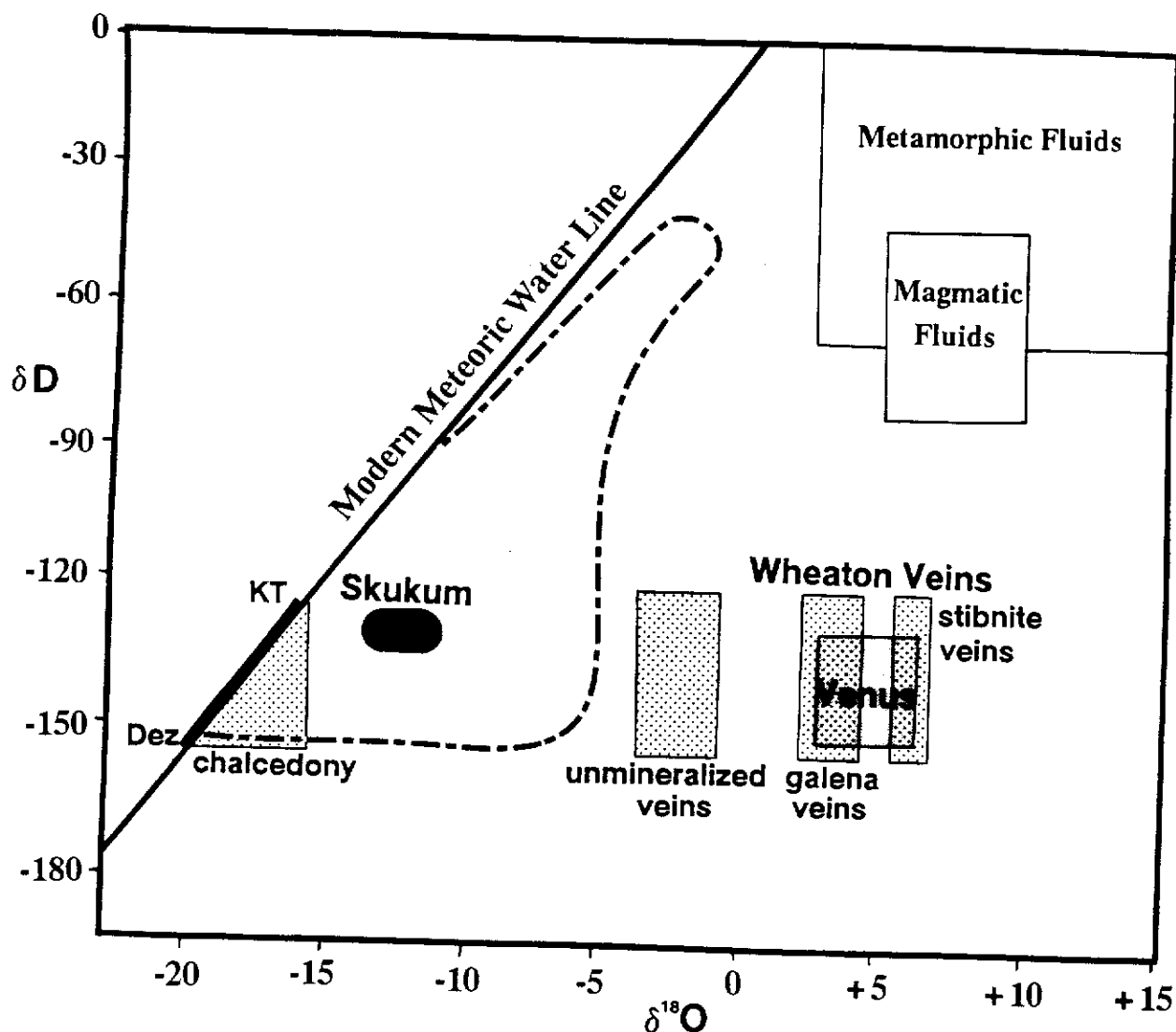


Figure 24 : $\delta^{18}\text{O}$ versus deuterium plot showing fields where mineralized, unmineralized and chalcedonic quartz veins of the project area plot. KT indicates meteoric fluid composition during Cretaceous-Tertiary time (Margaritz and Taylor 1976); Dez represents present day well water composition from Dezadeash area (Daganais 1986). Thick line represents range of modern meteoric water in Yukon Territory. Broken line encompasses zone of epithermal volcanic related epithermal deposits.

Galena-rich veins

Gold-bearing quartz veins rich in galena occur in the eastern portion of the Wheaton District. They include veins found at Tally Ho Gulch, Mount Stevens, Mount Anderson, Gold Hill and Mt. Reid/Skukum Creek. In most cases, coarse-grained quartz dominates the vein mineralogy with either thin, poorly developed bands, or discontinuous lenses and pods (up to 40 cm thick) of galena with pyrite, sphalerite or chalcopyrite. Tetrahedrite is common in Mt. Anderson veins. Although Au-Ag tellurides (sylvite, hessite) have been previously reported at Gold Hill and Mt. Stevens (Cairnes 1912; Wheeler 1961) they have not been confirmed by recent studies or sampling. Sericite is common in the wallrock of veins hosted in granite (eg. Legal Tender) but where the host rock is mafic (or contains a large amount of mafic minerals, eg. diorite), carbonate alteration is more apparent. All veins except the Legal Tender dip steeply and except the east-striking veins at Mt. Anderson, and northeasterly-striking veins at Mt. Reid, trend northwesterly.

Mount Stevens

Gold-bearing veins near Mount Stevens are dominated by quartz with either small zones of disseminated euhedral galena (chalcopyrite and pyrite) or large (5-50 cm) lenses of massive galena with pyrite and chalcopyrite. The disseminated type are generally associated with white, fine-grained quartz associated with quartz-rich aplite dykes. The lenses of massive sulphide occur in veins with coarse-grained quartz and evidence of open space filling. The galena is paragenetically late. Visible gold is associated with both types of veins.

All veins in the Mt. Stevens area strike north-northwesterly, sub-parallel to the regional structural trend. They are hosted in sheared granitic and volcanic rocks adjacent to the Tally Ho shear and Llewellyn fault zones. Veins at Mt. Stevens may be copper-rich due to the high background copper of the host Tally Ho Shear zone rocks.

Mount Reid (Skukum Creek)

The Mount Reid (Skukum Creek) deposit is a steep southerly-dipping, northeasterly-trending, gold and silver-bearing sulphide-quartz vein and vein breccia hosted in variably altered granodiorite and quartz monzonite. Two zones, the Rainbow and Kuhn, are reported to contain 867,890 tonnes (882,000 tons) grading 7.6 g/t (0.221 opt) Au and 275 g/t (8.02 opt) Ag including 111,930 tonnes (113,750 tons) of 13.0 g/t (0.379 opt) Au and 443 g/t (12.94 opt) Ag (Northern Miner, March 20, 1989). A fault displaces the main vein and separates the Kuhn zone from the Rainbow Zone at 5500' (1680 m).

The vein mineralogy is dominated by grey-blue quartz and crudely-banded zones of fine-grained, paragenetically early pyrite and arsenopyrite with galena and lesser sphalerite, stibnite, tetrahedrite, chalcopyrite, pyrrargyrite and bornite. The primary vein character is rarely preserved, as post-emplacement brecciation of the ore has remobilized most of the sulphides into the matrix of the breccia. Wallrock is brecciated (and sheared) for up to 5 m away from the vein and fragments are commonly incorporated in the vein.

Fluid inclusion studies on the Skukum Creek vein indicate that the system is rich in CO₂. Homogenization temperatures were difficult to obtain because of the poor quality of available inclusions. Decrepitation of CO₂-rich inclusions occurred at 293°C and 330°C and indicate that homogenization temperatures are probably greater.

The vein structure is a fault which is sub-parallel to the Wheaton Lineament (see Structure chap.; Doherty and Hart 1988; Von Gaza and Eyton 1989). The vein is continuous down the north face of Mount Reid and has been traced across Skukum Creek for a short distance. Its southerly trace appears to be continuous with a splay of the eastern Berney Creek fault. The structure appears to have been developed in pre-Eocene time. The age of this deposit is 59 Ma as determined from the dating of mineralized and unmineralized dykes. Brecciation of the vein is thought to have occurred during cauldron collapse of the Mt. Skukum volcanic complex.

Arsenopyrite-rich veins

Idaho Hill

More than 20 silver-rich, arsenopyrite-galena (quartz) veins traverse the east (Union Mines) and south (Nevada) facing slopes of Idaho Hill. Another vein is reported on the north face of Folle Mountain (Cairnes 1912). The veins are in hornfelsed argillite and greywacke of

the Laberge Group and are locally spatially association with Late Cretaceous rhyolite dykes. The veins are sub-parallel, strike north-northwesterly and dip moderately to the west, generally following the bedding planes of the host strata. They pinch and swell but can be traced for upwards of a hundred metres.

The veins at the Union Mine occurrence are typically narrow (2-60 cm), and composed of massive coarse-grained arsenopyrite (and galena) with very little quartz, some pyrrhotite, sphalerite and rare chalcopyrite. Those at the Nevada occurrence are typically thicker (>30 cm), contain more quartz and have banded or lenticular sulphide-quartz textures similar to those at Montana Mountain. This vein contains less arsenopyrite and more pyrite, pyrrhotite and black sphalerite than the Union veins. Late stage calcite is often weathered away giving the veins a vuggy appearance.

Two stages of mineralization at Idaho Hill were identified by Rucker (1987). The first deposited arsenopyrite, quartz and calcite with galena; the second deposited pyrite-pyrrhotite-chalcopyrite and sphalerite in stringers cross-cutting (or replacing) the first. The best reported gold value from the Idaho Hill area (9050 ppb) was obtained from a galena-rich arsenopyrite vein with no quartz (Doherty and Hart 1988). Like some of the Montana Mountain veins, gold may be limited to those veins with arsenopyrite and galena.

Rucker (1988) suggested that the Idaho Hill veins are petrologically similar to the Skukum Creek deposit. As noted above, they have characteristics similar to veins of the Montana Mountain area as well as having similar isotopic signatures (Fig. 24).

No evidence of faulting was observed in the structures hosting the veins as they tend to follow bedding planes. The veins may have replaced the host argillite (Cairnes 1912).

Stibnite-rich veins

Cairnes (1912) recognized three different types of stibnite veins: 1) antimony only; 2) antimony and gold; and 3) antimony and silver. He further recognized that types 1) and 3) grade into each other. These gradations are considered to be part of the vertical zonation typically associated with mesothermal veins.

Most stibnite veins of the Wheaton District occur in an east-trending belt from Chieftain Hill to Becker Creek. Single veins are exposed near Stony Mountain (Opulence) and west of the upper Watson River (Bostock). All veins but one, strike easterly (90° - 110°) and dip steeply. The veins have large vertical and horizontal extents and are spatially associated with large, vivid orange gossans.

The ores consist of quartz, calcite, barite, stibnite, sphalerite, jamesonite, galena and tetrahedrite. The veins vary from being almost entirely composed of sulphides (Evening) to entirely of quartz with very small disseminated sulphides. Silver-rich veins are generally dominated by quartz and contain galena and tetrahedrite at the expense of stibnite (Cairnes 1912). The quartz is generally grey-blue in colour due to the presence of disseminated fine-grained sulphide minerals. Coarse-grained sulphides are paragenetically late and locally fill open spaces in the veins. Stibnite occurs as long, well-developed, often radiating prismatic crystals. Sphalerite is honey to red coloured and most common in veins above Antimony Creek (ie. Porter). Barite was most common in the uppermost portions of the Goddell vein, in an unnamed vein 500 m south of Goddell Gulch and in some small veins at the head of Antimony Creek. Anomalous mercury values have been obtained in rock samples from most

of the stibnite-bearing veins and have been reported in soil samples taken from the plateau above the Goddell and Becker-Cochran veins (Doherty and Hart 1988; this report Appendix C).

Slickensides were observed underground at Becker-Cochran and Porter indicating that the veins are filling fault zones and are not simple fractures. Clay gouge, argillic alteration and moderate brecciation is observed in some of the veins (Ocean, Goddell, Becker-Cochran) indicating some post-emplacement brecciation).

The similarity in vein characteristics, alteration and attitude of the occurrences on Carbon and Chieftain Hills suggests that the systems may be continuous across the Wheaton Valley. The geology (and magnetic response) of the two areas is identical and suggests that a major cross-cutting fault is *not* concealed beneath the valley fill of the Wheaton River.

Carbon Hill

The Carbon Hill deposits include the Becker-Cochran (Yukon Antimony), Porter, Goddell and several unnamed veins. Up to 25 veins have been discovered on the western slope of Carbon Hill where exposure is excellent. Major veins trend easterly, but numerous, smaller veins strike northerly.

The Becker-Cochran deposit, at the head of Becker Creek, contains 160,000 tons of 4% antimony (NCMI 1983) and is the only deposit on Carbon Hill with defined tonnage. It is in a 300 m long, 2.1 m wide shear zone striking at 120° , dipping between 65° - 85° to the south (Hylands 1966). Shear zones reported by Wheeler (1961) also trend northwesterly and north-northwesterly, and at least one set is post-ore (Rucker 1988). The deposit is in granite, the Tantalus Formation, mid-Cretaceous volcanics, and adjacent to a rhyolite dyke along most of its length. The ore is coarsely brecciated and composed of grey-blue quartz, fine-grained unidentified disseminated sulphide minerals and coarse-grained stibnite, filling open spaces. Carbonate alteration of adjacent andesite or feldspars and mafic minerals in granite typifies the alteration associated with the Becker-Cochran deposit. Underground samples contain up to 0.38% arsenic (Wheeler 1961) and is indicative of localized arsenopyrite which is probably an important control of gold distribution.

The Porter occurrence includes numerous veins on the south facing slopes above Antimony Creek. Most are less than 1 m wide, and strike slightly more northeasterly (55°) than other veins on Carbon Hill, but numerous east-striking shears are present. The veins are entirely in the altered Carbon Hill granite. Nearby, late, post-ore andesite dykes trend northeasterly and easterly. At the head of Antimony Creek, several small quartz-stibnite-sphalerite-barite veins accompanied by intense sericite alteration of the host granite may represent an extension of the Porter system. Values up to 15% lead (Wheeler 1961), 6.9 g/t gold and 2994 g/t silver (INAC 1986, p. 71) have been documented from the Porter vein.

The Goddell occurrence outcrops in Goddell Gully and is traceable on surface for over 700 m and has a vertical exposed extent of over 450 m (from 5600' to 3500'). Two dominant, steeply dipping, east-striking veins up to 2.8 m wide, traverse the mountainside, cutting intense argillically altered granite. The quartz-stibnite veins are parallel to rhyolite dykes and at approximately 4150' (1265 m) contain minor arsenopyrite and jamesonite (Cairnes 1912). South of the main gully (and the veins) at 4400' (1340 m), quartz-carbonate altered, silica flooded andesite dykes are oblique (southeast-trending) to the veins. These dykes contain small, disseminated acicular needles of arsenopyrite and return gold grades up to 12 g/t Au.

Drilling has intersected this zone of mineralization at 150 m (500') below the Wheaton River valley bottom (2700' above sea level). Reported values include 3.94 g/t Au (0.115 opt) over 34.4 m (113'), including 6.4 m (21') of 13.37 g/t (0.39 opt) and 4.56 g/t (0.133 opt Au) over 63.7 m (209'), including 11.3 m (37') of 20.9 g/t (0.61 opt) (Northern Miner Nov. 14, 1988). Intersections are approximately 65 m apart. This intersection extends the vertical extent of this occurrence to almost 900 m.

Chieftain Hill

The Morning and Evening veins on Chieftain Hill have been traced for 60 m and are up to 1.4 m wide. The Ocean vein is characterized by intense argillic alteration of wallrock and brecciation of quartz-sulphide vein, identical to that found at Goddell. Gold values in the Ocean vein are up to several grams/tonne and silver to 200 g/t with elevated Sb, As, Pb, and Zn as well as Hg.

DISCUSSION

Vertical mineral zonation characterizes mesothermal veins at Carbon Hill (Fig. 25). The upper portion of Carbon Hill veins are characterized by barite and stibnite with elevated mercury values (>5000 ppb). Stibnite has been recognized elsewhere, forming at near surface conditions (Lingren 1905). Cairnes (1912) first recognized that stibnite veins in the Wheaton District were indicative of high level veins. Fluid inclusion work by Rucker (1988) indicates that homogenization temperatures of these veins is approximately 160°C. These characteristics are typical of epithermal vein systems. Deeper in the veins, stibnite remains but sphalerite, then galena are occur with late stage quartz at the expense of barite. Homogenization temperatures average 260°C. Still deeper, arsenopyrite and jamesonite precipitate in the vein at a level from which homogenization temperatures are up to 360°C. Carbon dioxide gas content and are assumed to increase with depth.

Mesothermal veins of the Wheaton District show evidence of isotopic oxygen shift from the assumed values of meteoric fluids of Cretaceous-Tertiary time (see Margaritz and Taylor 1976). Carbon Hill veins are extremely ^{18}O enriched and range from between +17.4 to +21.6 per mil (Fig. 24). Samples of galena-bearing veins were moderately enriched in ^{18}O with values between +9.4 and +12.7 per mil (Fig. 24). Non-mineralized, low temperature veins with depleted ^{18}O values between -2.3 and +1.6 per mil may reflect near surface mixing of groundwater with evolved meteoric vein fluids at high-levels (all isotopic data is from Rucker 1987). Deuterium values have not been obtained for deposits in the Wheaton District, but are assumed to be similar to those obtained from the Venus deposit in the Montana Mountain area (ie.-132 to -159 per mil; see Walton 1987).

These formation fluids probably originated as meteoric fluids and have undergone enrichment of ^{18}O as a result of intense exchange and evolution with heavier oxygen in the adjacent wallrock. In the process of isotopic exchange, waters also become enriched in metals, salts and CO_2 . This isotopic shift of meteoric waters evolves during low grade metamorphism at depths of 9-15 km (Nesbitt 1988, 1989; Nesbitt and Mullenbachs 1988). In order to drive fluids from such depths to near surface conditions, where chemical disequilibrium can result in mineral precipitation, a vertically continuous, permeable zone must exist along which the fluids may ascend rapidly. Such zones are generally attributable to large, deep seated faults and fractures (Sibson et al. 1988). The major zone of permeability is rarely mineralized, instead, zones of secondary fracturing are often the only areas mineralized (Sibson 1987).

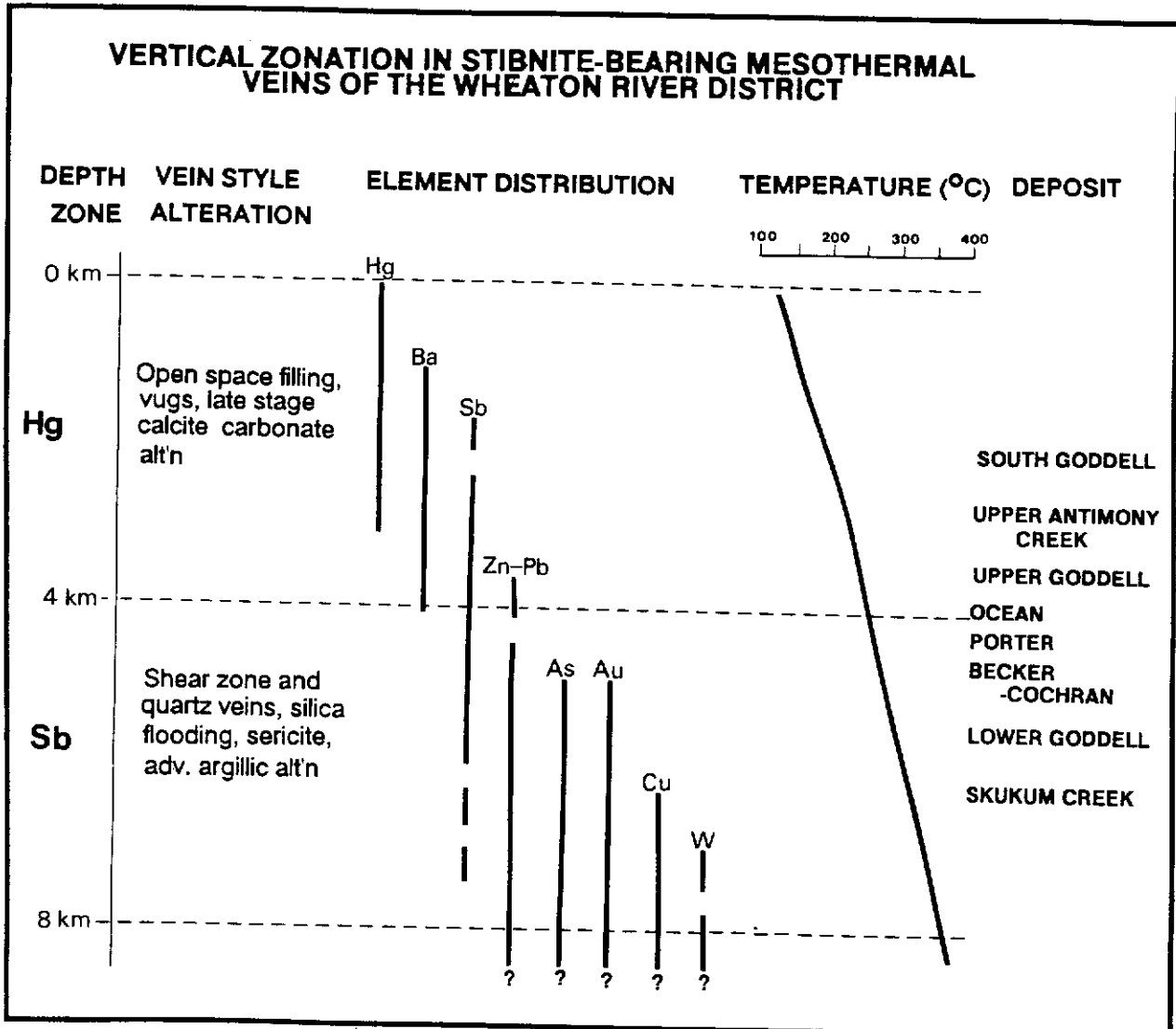


Figure 25: Summary diagram illustrating the vertical zonation associated with stibnite-bearing mesothermal veins in the Wheaton District. CO₂ content is assumed to increase with depth. Depth and zone information from Nesbitt et al. (in press).

The Llewellyn Fault may have acted as the conduit for fluids which formed the quartz-sulphide veins in the eastern portion of the Wheaton District. These veins are equivalent to those described previously as Galena-rich veins (excluding the Mt. Reid/Skukum Creek deposit). This suite of veins has a characteristic mineral assemblage dominated by galena and chalcopyrite. They can be distinguished by their isotopic signatures and are proximal to the Llewellyn Fault (Fig. 26). The isotopic signature of these veins is similar to that of the Montana Mountain area which have also been related to a deep seated fracture (Hart and Pelletier 1989a; this study). Telluride minerals which have been associated with these veins have been reported in other veins adjacent to the Llewellyn Fault (eg. Engineer; see Mihalynuk and Mountjoy 1990).

Stibnite-rich veins (and the Mt. Reid/Skukum Creek vein) in the western portion of the district may also be related to a major structure (Fig. 26). To date, no major fault has been recognized. However, either the Wheaton Lineament or the east-striking series of faults and shears which host the deposits may have provided the required zone of vertical permeability (c.f. Coast Ranges Megalineament, Leach et al. 1987; Light et al. 1989). The numerous, steeply dipping host structures may have formed as parallel dilational and normal faults between two strike slip zones (ie. Llewellyn and another as yet unrecognized fault to the west). The Wheaton Lineament, although not recognized as a major fault, is spatially associated with numerous gossans, zones of alteration and brecciation and is proximal to the Mt. Reid and stibnite-rich veins.

Veins in the western portion of the Wheaton District are distinguished by the presence of a greater percentage of sulphide minerals and the presence of stibnite. Gold is associated with arsenopyrite. The veins have the most enriched ^{18}O isotopic signature in the District.

Age of mineralization on Carbon Hill and Mount Reid is probably 59 Ma as determined from K-Ar dating of mineralized and unmineralized, and cross-cutting rhyolite dykes on the western face of Carbon Hill (R.L. Armstrong unpublished data).

OTHER DEPOSITS

The Mt. Wheaton is unlike other deposits in the Wheaton River District. The deposit consists of silicified intermediate Cretaceous volcanics and associated quartz stockworks adjacent to the intrusive contact with a Late Cretaceous intrusion. The stockwork is composed of white, fine-grained quartz with up to a few percent galena and chalcopyrite. Gold and silver values are approximately equal. Petrographically, the quartz is dominated by numerous vapour-filled primary inclusions which homogenize at temperatures $>350^{\circ}\text{C}$. All evidence suggests that this deposit results from the interaction between the granite and the host andesite. An adjacent rhyolite dyke is not silicified. Fifty tons of hand picked ore averaging 120 g/t Au was reportedly mined from this deposit in 1989.

The Charleston and Earl veins fit the classification of a mesothermal vein, but since they do not have a dominant metallic mineral, they have not been included in this classification scheme. The Charleston and Earl veins are dominated by quartz and contain only sparsely disseminated blebs of arsenopyrite and galena. Fluid inclusion work indicates that their homogenization temperatures range between 270° and 350°C , and that CO_2 was a common fluid constituent.

The Raca copper deposit on the south end of Chieftain Hill is poorly understood. Much of the deposit is hosted in Skukum Group volcanic rocks as fracture and vesicle-fillings

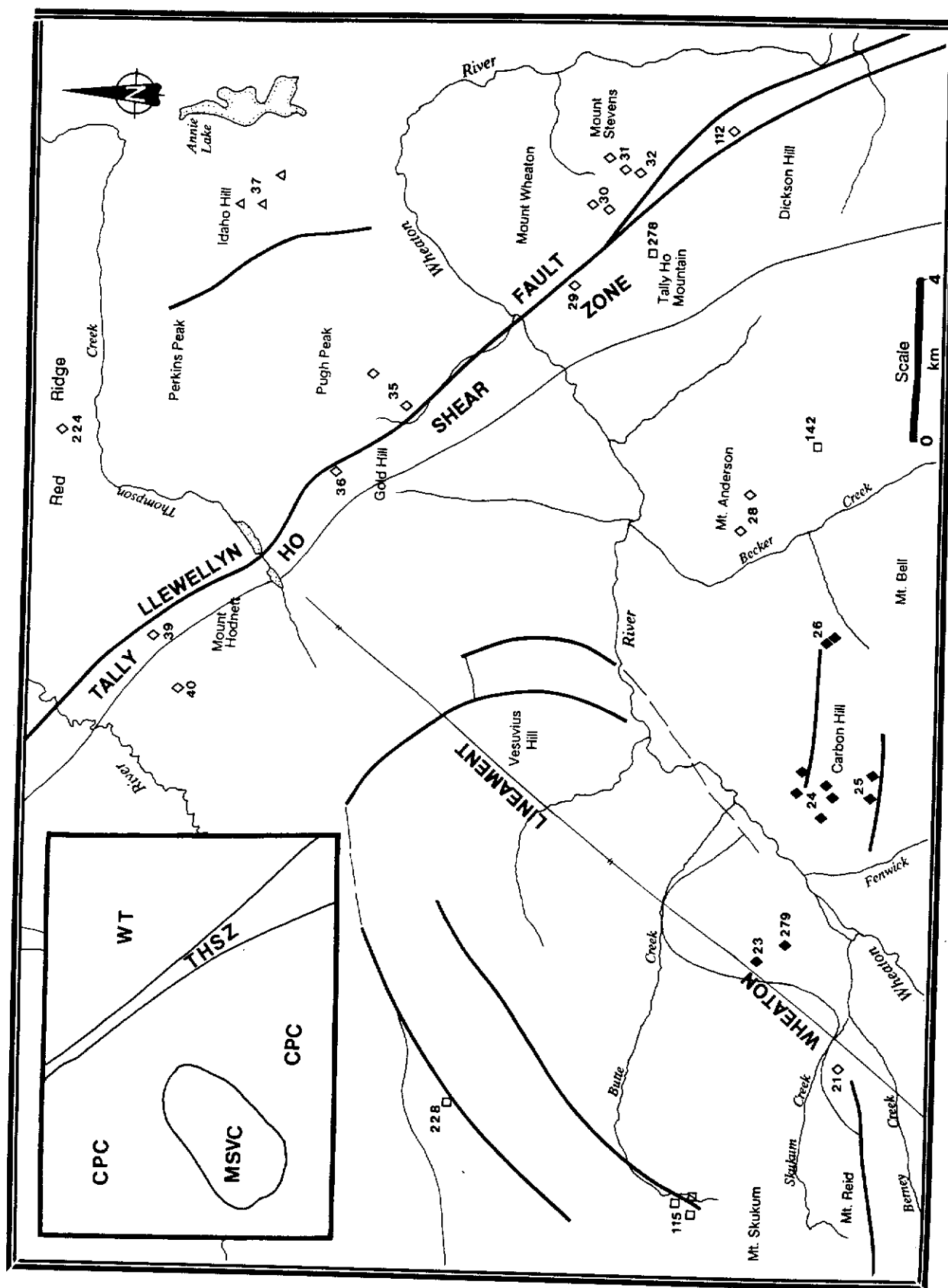


Figure 26: Distribution of vein occurrences in the Wheaton River District. Solid diamonds - Stibnite-rich veins; open diamonds - Galena-rich veins; open triangles - Arsenopyrite-rich veins; open squares - epithermal veins. Note proximity of stibnite veins with east-trending structures and Wheaton Lineament, and galen veins with Llewellyn Fault. Numbers are those used in Yukon Exploration volumes. CPC-Coast Plutonic Complex, WT-Whitehorse Trough, MSVC-Mount Skukum Volcanic Complex.

in andesite flow tops or the breccia matrix and native copper has been reported (Wheeler 1961). It is considered to be a porphyry style deposit (NCMI 1983) but may be a manto-type copper deposit. Such deposits are commonly associated with cauldron complexes (ie. Buena Esperanza, Chile; see Sillitoe 1977) and have not yet been recognized in the Skukum or Bennett Lake complexes.

Asbestos occurs in anastomosing stringers up to 1 cm thick, in serpentinized pyroxenite at Tally Ho Mountain. In a roadcut immediately east of Carcross, chrysotile fibers up to 30 cm long are found in fractures of Horsefeed Formation dolomitic limestone.

Placer gold has been reported in small quantities from Schnabel and Skukum Creeks, Midnight Gulch and the Wheaton River.

MONTANA MOUNTAIN DEPOSITS

Approximately 20 polymetallic, gold-bearing quartz veins are hosted in rocks of the mid-Cretaceous Montana Mountain volcanic complex and Montana pluton along an eight kilometre, northwest-trending belt between Windy Arm and Brute Mountain. Total production from the area exceeds 37,550 ounces of gold and 1,228,813, ounces of silver, from approximately 154,000 tonnes of ore from mainly the Venus and Arctic Caribou deposits. Total reserves in the district exceed 200,000 tonnes (Hart and Pelletier 1989a). The veins strike to the north-northeast and east-northeast, and dip shallowly (40° - 65°) to the northwest.

The veins are characterized by two mineralogically distinct stages which are best developed at the Venus deposit and have been described by Walton (1986, 1987). Stage I vein material comprises ribbon-banded early quartz with arsenopyrite and pyrite which is deposited along the vein margins. Stage II is composed of later, coarsely crystalline, vuggy quartz with sphalerite, galena and native gold. Calcite is most common as a late stage vein filling. Fluid inclusion studies by Walton (1987) indicate that homogenization temperatures for fluids from the Venus vein averaged 275°C . Stage II fluids were typically 30°C cooler.

Walton (1987) has shown that gold from Stage II fluids at Venus was precipitated electrochemically in microfractures in Stage I arsenopyrite, thus leaving Stage II fluids depleted in gold. Hart and Pelletier (1989a) suggested that at Uranus and other veins, gold values are significantly higher in Stage II vein material, and in those cases, the microfracturing of Stage I material may not have been accomplished. Venus and other veins (eg. Montana), show evidence of syn-depositional (Stage I) faulting that may have accounted for the microfracturing and site formation. Carbon dioxide effervescence may have been another mechanism for gold precipitation.

Stubens (1988) has suggested that the Venus vein is richer in gold (and has higher gold:silver ratios) towards the north, closer to the reactivated Nahlin Fault and above the 2700' level. Deposits further away from the Nahlin Fault (ie. Humper, Red Deer, Ruby Silver) are recognized for their silver values and not their gold grades. High gold values up to 46 g/t have been obtained from drill holes intersecting the silver-rich Joe Petty vein at depth (L. Walton pers. comm. 1988). Homogenization temperatures are 75°C lower than in the Venus vein. Gold-rich veins appear to be closer to the reactivated Nahlin Fault, and silver-rich veins are farther away and have lower homogenization temperatures.

Isotopic data evidence from the Montana Mountain area indicates that the mineralized veins are characterized by ^{18}O enriched fluids in the +10 to +14 per mil range. Deuterium values are related to latitude and range between -123 to -159 per mil (all data from Walton 1987; Fig. 24). Accordingly, fluids responsible for the formation of the mineralized veins in the Montana Mountain area are composed of meteoric waters which has chemically evolved as a result of interactions with rocks undergoing low grade, greenschist metamorphism (Nesbitt and Mulenbachs 1988; see also Goldfarb et al. 1988). A magmatic contribution is not apparent. Fluid inclusion studies indicates that such interactions occur at depths of 9-12 km (Nesbitt 1988, 1989) and possibly as deep as 15 km (Nesbitt and Mulenbachs 1988). Deep fluids such as these require vertically continuous, highly permeable zone or conduit for rapid fluid upflow. Such zones are often attributed to deep seated strike-slip (Nesbitt and Mulenbachs 1988) or reverse faults (Sibson et al. 1988).

The reactivated Nahlin Fault itself is unmineralized. However, mineralized veins occupy a zone within 3.5 km and have orientations oblique or perpendicular to the Nahlin Fault. Sibson (1987) has suggested that zones of secondary fracturing are often the only areas mineralized. Veins in the Montana Mountain area appear to have been preferentially mineralized due to their secondary and oblique nature to the reactivated Nahlin Fault (Hart and Pelletier 1989a). The richest veins in gold appear to be proximal to the fault, while silver rich veins are distal.

Veins were preferentially deposited in the brittle, siliceous rocks of the Montana Mountain volcanics and Montana pluton. Presumably, the altered, chlorite-rich greenstone of the Cache Creek Group does not have the rheological/mechanical properties necessary to develop or maintain brittle fractures. Alternatively, the structural regime responsible for the development of the ore-hosting structures did not exist east of the Nahlin Fault.

Mineral occurrences in the Montana Mountain area had been considered to be genetically related to the volcanic or plutonic host rocks. Isotopic data indicates that mineralizing fluids were not derived from the volcanic or plutonic host rocks. The age of the mineralizing event is younger than the mid-Cretaceous host rocks and is possibly related to reactivated motion of the Nahlin Fault during Late Cretaceous or Early Tertiary time.

WHITEHORSE COPPER BELT

The 24 skarns of the Whitehorse Copper Belt form a 30 km long, northwest-trending zone, 5 km west of Whitehorse. They have been studied previously by McConnell (1909), Kindle (1964), Tenney (1981), Morisson (1981), Watson (1984) and Meinert (1986). All skarns are hosted in carbonate-rich strata of the Hancock (and Mandanna) members of the upper Triassic Lewes River Group near their contacts with gabbro to granodiorite of the mid-Cretaceous Whitehorse pluton. The largest and richest deposits of the area are hosted in roof pendants or enclaves of carbonate rocks near the western margin of the pluton.

Contact metamorphic assemblages are poorly developed, suggesting that ore formation was mainly the result of metasomatic reactions (Morrison 1981). The nature of the skarn and ore mineral assemblages is a function of the skarn protolith (Morrison 1981; Meinert 1987). Non-dolomitic protoliths form skarns rich in hedenbergite and light brown garnet with idocrase and wollastonite. Chalcopyrite dominates a magnetite-poor, ore mineral assemblage. Dolomitic protoliths are richer in iron and form diopside and red-brown garnets with considerable amounts of magnesium-rich olivine. Olivine is easily retrograded during

hydrothermal alteration to serpentinite, talc, brucite, phlogopite and magnetite. These deposits are bornite-rich and form large masses of magnetite.

Precious metal values are best developed in bornite-rich magnetite skarns hosted in dolomitic assemblages which have undergone retrograde alteration as a result of later stage hydrothermal alteration (Meinert 1987; Hart and Pelletier 1989b). Gold is geochemically associated with elevated bismuth, tungsten and arsenic values.

The Whitehorse Copper Belt is responsible for the production of 123 000 tonnes of copper, 90 tonnes of silver and seven tonnes of gold from over 10 million tonnes of ore (INAC 1983). Current reserves are estimated at 3 million tonnes in six separate ore bodies (Watson 1984).

NEW OCCURRENCES

A few small, previously undiscovered, or undocumented mineral occurrences were encountered by the Whitehorse Geological Mapping Project. In the upper Becker Creek drainage, the Craig showing (YEX 258) consist of six thin (up to 20 cm) argentiferous galena, stibnite, sphalerite, molybdenite, barite veins cutting altered Mount Anderson granodiorite. Grab samples returned silver values up to 1310 g/t. In the same area, weakly developed porphyry copper alteration with weak copper mineralization, is developed in the granodiorite.

In the Bennett Lake complex, a grab sample from a 0.5 x 80 m zone of disseminated pyrite, galena, sphalerite and chalcopyrite in argillically altered rhyolite tuff yielded 135 g/t Ag, 2.6% Pb and 2.7% Zn. A zone of gossanous oxidized sulphides outcrops on the north facing slope of Lakeview Mountain. Malachite and azurite were the only recognizable minerals, but an assay returned 230 g/t Ag, 4.72% Cu and 4.36% Pb.

Two new occurrences of molybdenum were found. The Conrad (YEX 282) occurs in grey quartz veins with pyrite in a granite exposed in a roadcut at kilometre 93 of the South Klondyke Highway. The Markmoly showing (YEX 283) is hosted in granite near its contact with Cache Creek rocks south of Carcross. In both occurrences the host granite is the Carcross pluton.

Locally derived float of stibnite-quartz breccia above Millhaven Creek (YEX 74) appears to be hosted in carbonate altered mylonitic greenstones of the Tally Ho shear zone. An assay returned 460 ppb Au, 83 g/t Ag, >2% Sb with elevated Zn and mercury.

Gossanous quartz-carbonate altered greenstones 2 km northwest of Perkins Peak are cut by ankerite and siderite veins which contains anomalous precious metal values (510 ppb Au and >50 ppm Ag).

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APPENDIX A

PALYNOLOGICAL AGE DATES

SAMPLE: WC-1MF BB-92
LOCATION: NORTH FISH CREEK

PALYNOMORPHS

Pollen

Vitreisporites pallidus most common in Jurassic

Dinocysts

Gonyaulacysta jurassica Oxfordian-Kimmeridgian

Gonyaulacysta jurassica var. *longicornis* Oxfordian-Kimmeridgian

Nannaceratopsis cf. pellucida Oxfordian-Kimmeridgian

Pareodinia minuta Oxfordian-Kimmeridgian

AGE: Upper Jurassic: Oxfordian-Kimmeridgian

SAMPLE: CH88 23-1,2 MF BB-92

LOCATION: WEST SLOPE ABOVE IBEX RIVER

PALYNOLOGY

Dinocysts

Gonyaulacysta jurassica Oxfordian-Kimmeridgian

Nannoceratopsis pellucida Oxfordian-Kimmeridgian

Netrelytron stegastum Oxfordian-early Kimmeridgian

Gonyaulacysta jurassica var. *longicornia* Oxfordian-Kimmeridgian

Pareodinia ceratophora Bajocian-Albian

Tenua pilosa Oxfordian-Kimmeridgian

AGE: Upper Jurassic: Oxfordian-Kimmeridgian

Both samples evaluated by G.E. Rouse of Palynorox, Inc., Vancouver, B.C.

APPENDIX B

COMPARISON of OLD and NEW SYMBOLS, AGE DATES and UNIT NAMES FOR PLUTONIC UNITS

NEW SYMBOL	OLD SYMBOL(S)	BEST DATE	REFERENCE	NAME
Er	Er	52-58 Ma,K,R	1,4	Skukum Group rhyolite
EEqMM	Tgr	54 Ma,U	1	Mt. McAuley Granite
EEq	Egr	55 Ma,K	3	Jackson Creek Granite
EEql	Eal	58 Ma,U	1	Ibex Alaskite
EEqP	Kgr	55 Ma, K	1	Pennington Granite
LPqCC	KTqm,LKlg,Tgr	60 Ma,U	1	Crozier Creek Granite
LPq	LKlg	59 Ma,R	1	Leucogranite
PgC	Pc	64 Ma,K	3	Carcross Pluton
KTi	JKgd,Jdi?	none	--	undifferentiated intrusions
Mi	JKgd	none	--	undifferentiated intrusions
Mmz	Mmz	none	--	unnamed quartz monzonite
LKqF	Kgr	78 Ma,U	1	Folle Mountain Stock
LKgWV	JKgd	78 Ma,U	1	Wheaton Valley Granodiorite
LKqP	KTal	79-97 Ma,R	1	Perkins Peak Plug
mKqMM	mKrm	109 Ma,U	1	Mt. McIntyre Suite
mKgMM	mKrm	none		granite phase (MMS)
mKqMW	KTgr	119 Ma,U	1	Mount Ward Granite
mKqM	Pm	107 Ma,U	1	Montana Mountain pluton
mKgW	mKw	116 Ma,K	3	Whitehorse Plutonic Suite
mKqW	mKw	none		leucocratic phase (WPS)
mKgW ₁	mKgD	119 Ma,U	2	Mt. Anderson Pluton
mKdW ₁	Kgd	109 Ma,U	1	Ibex River Gabbro
mKgW ₂	JKdi?	119 Ma,U	1	Mt. McNeil Pluton
JKdFC	JKdi	none		Fenwick Creek Diorite
EJA	Pgdn	190 Ma,U	1	Alligator Quartz Monzonite
LTrFC	Jdi,Pgdn	211 Ma,U	1	Friday Creek Diorite
LTrgB	Trgd,Pgdn	220 Ma,U	2	Bennett Granite
Trub	Trub	pre-220 Ma	2	ultramafite
Trb	Trb	pre-220 Ma	2	Tally Ho leucogabbro

REFERENCES

- 1- Armstrong, R.L. 1990, written communications.
- 2- Doherty and Hart 1988.
- 3- Morrison et al. 1979.
- 4- Pride and Clark 1985.

Old symbols from Doherty and Hart (1988) and Hart and Pelletier (1989a & b)

APPENDIX C

METALS GEOCHEMICAL and ASSAY DATA, SAMPLE DESCRIPTIONS and LOCATIONS

SAMPLE NO.	Au(ppb)	Ag(opt)	Ag(ppm)	Ag(opt)	Cu	Mo	Pb	Zn	As	Ba	Sb	V	Hg
CH7-6	82	4.7			148	17	1328	1004	6	5500	6	3	410
CH11-2	<10	19.9			8412	8	159	3647	6	<100	3	200	30
CH12-6	41	>50	6.75	>20000		5	>10000	8700	180	460	11	3	110
CH13-6	<10	4		4.72%	673	3	483	303	78	1400	8	3	20
CH15-1	59	5.3			405	10	238	9304	130	470	8	<2	35
CH15-2	13	0.7			76	<1	81	129	11	110	8	<2	30
CH15-3	62	3.9			50	308	151	40	39	540	7	2	110
CH16-1	>30000	2.155	>50	2.96	2255	5	>10000	85	39	<100	43	<2	5
CH16-2	>30000	1.354	>50	2.74	2073	2	>10000	125	56	140	112	4	5
CH18-2	320	3.7			51	691	257	23	5	1200	5	6	10
CH20-3	25	0.6			12	<1	76	6	6	<100	<1	<2	35
CH23-2	6590	>50	56.94		13900	272	>10000	174	<69	<370	1270	31	1100
CH23-3	16100	>50	14.46		26	2	>10000	30	14	<100	50	<2	90
CH23-4	150	>50	2.02		15	2	9140	7	6	<100	9	<2	75
CH26-2	7120	>50	40.78		5941	2	>10000	>20000	<210	500	2290	<16	1550
CH26-3	5270	>50	5.35		1314	20	>10000	15440	827	<100	135	9	600
CH30-2	590	>50	2.73		734	<1	1520	1007	3430	<640	734	<2	720
CH30-3	1370	>50	5.94		376	1	5680	417	2250	<230	1900	<10	1250
CH31	370	32.3			18	<1	638	92	190	<250	273	3	500

SAMPLE NO.	LOCATION	DESCRIPTION	LAT	LONG
CH7-6	Carbon Hill	Black ochre with minor fg sulphides in bx with calcite in mix with minor qtz. Azurite + white oxides. Hosted in rusty alt'd greenstones.	60 11'00"W	135 13'45"W
CH11-2	Fleming Ridge West	Massive, cg specular hematite with blebs of 1-2% cpy and residual qtz, minor mal and white & yellow ochres.	60 13'15"W	135 13'30"W
CH12-6	Goat Mtn.	Rusty, spongy oxides of Fe, Mn, Cu & Malachite with minor cpy, v. porous azurite.	60 25'00"W	135 02'40"W
CH13-6	Lakeview Mtn.	Silicified, rusty weath. fg sediment or rhyolite with 3-5% diss. pyrite.	60 27'00"W	135 02'45"W
CH15-1	Lakeview Mtn.	Rusty - same as MP11-0, minor gn, 3% py, 2% sph, 0.25% gn. Minor late open space qtz.	60 27'00"W	135 02'45"W
CH15-2	Pugh Pk. 6000'	Massive, chalcedony, yellow to light grey slightly rusty.	60 17'20"W	135 05'40"W
CH15-3	Pugh Pk. 5200'	Banded white & dk grey qtz with chalcedony, minor diss py in grey qtz.	60 17'22"W	135 05'00"W
CH16-1	Wheaton Mtn.	Sugary, fresh, qtz flooded breccia with qtz vein (rextlrd?) with up to 3% diss. cpy in blebs and minor gn.	60 15'30"W	135 01'40"W
CH16-2	Wheaton Mtn.	Same as 16-1 with greater gn than cpy.	60 15'30"W	135 01'40"W
CH18-2	Conrad	Massive, white, grey qtz with < 1% diss. masses of molybdenum and rare blebs of py.	60 05'05"W	134 33'40"W
CH20-3	Dickson Hill	White, fg sugary qtz. No rust, minor xenos of chl and rare cpx. Near diamond drill hole.	60 13'00"W	135 00'45"W
CH23-2	Mt. Stevens	Med. cg massive galena (40%) in crse xline qtz with minor, 1-2 % cpy.	60 14'00"W	135 00'10"W
CH23-3	Acme, Mt. Stevens	Massive white sucrossic (bull) qtz with thin bands of med-gr. diss. gn. V. minor cpy & py; 1-2 % Gn, with rust (ilmenite) + some malachite.	60 14'05"W	135 00'15"W
CH23-4	Mt. Stevens, pit 3	Coarsely xline, white (sl. rusty) qtz with few cox vugs & weathered out py. V. late stage fg magnetite & galena.	60 13'55"W	135 00'20"W
CH26-2	Mt. Anderson	Coarse-grained galena (60%) with qtz + py/aspy to 5%.	60 12'30"W	135 09'00"W
CH26-3	Mt. Anderson	Disseminated, coarse-grained galena and pyrite in coarse grained white quartz vein	60 12'30"W	135 09'00"W
CH30-2	Chieftan Mill-Low	Clear veins with fg, dk gray sulphides (Sb, Ga), limonite, AsO assoc. with white quartz.	60 11'25"W	135 21'10"W
CH30-3	Chieftan Mill-Low	Wide zone of argillic alt'n., clear veins where white qtz hosts fg, dk gray sulphides (Sb, Ga), limonite, AsO(?); minor py sim to ONMI with less sulphides and Becker Cochrane but brown.	60 11'25"W	135 21'10"W

SAMPLE NO.	LOCATION	DESCRIPTION	LAT	LONG
CH31	Chieftan Hill-North	Massive sacrosic opaque white/grey bell qtz in Wisling, vein lense. No visible sulphides.	60 12'15"W	135 20'40"W
CH32-1	Porter Extension	Coarse, sacrosic + med. xline qtz (white + trans), much dk gray qtz w/ Sb (or Gm). No Ba, much sericite alts. and minor FeCO ₃ .	60 10'25"W	135 16'30"W
CH33-2	Carbon Hill	Crystalline, radiating Sb needles to 4 cm in gangue of, and replacing crystalline, orthorhombic Barite tabs to 5cm. Minor qtz, sphal. Sb 40%.	60 11'00"W	135 16'10"W
CH34-3	Upper Empire Mt. Rodnett	Chl. schist - mylonitic greenstone with fg galena on fracture sfrs. and diss. in preferred bands of flaser fabric. Minor epidote.	60 12'00"W	135 19'20"W
CH34-5	Mineral Hill	Slight rusty weath. sacrosic, white, ball qtz w/ diss. blebs of cpy (pref. @ edges nr. chl.). Other blebs of gn (+py?) in zones of fracture intersections. Minor grey qtz, MnO, + lim., total 1-2 % sulphides; Fe? Disseminated blebs of galena and pyrite with minor chalcocopyrite in coxcomb quartz vein	60 20'10"W	135 13'30"W
CH-F35	Legal Tender	Disseminated blebs of galena and pyrite with minor chalcocopyrite in coxcomb quartz vein	60 14'50"W	135 19'50"W
CH36-5	Thompson Creek	Orange weathering FeCO ₃ vein with chalcedonic qtz and ankerite.	60 20'30"W	135 00'00"W
CH39-1	Sugarloaf Hill	Slightly serpentinized, black, fq ultramafite.	60 05'35"W	134 40'00"W
CH40-4	Mt. McAuley, Tarn II	White radiating qtz vein + chalcedonic & drusy bx (c.f. SAID) with vugs infilled with bladed ct. Also purple fluorite.	60 01'45"W	135 29'45"W
CH41-1	Gold Hill	Slight rusty weath. coarse xline milky white qtz with 1-2% gn, tet, mal.	60 10'00"W	135 09'30"W
CH41-5	Golden Reef	Milky white, crystalline qtz.	60 10'00"W	135 08'50"W
CH44-5	Goddell 5700'	Rusty weath. with dk grey & white qtz breccia (ala Becker Cochran) fg Sb or gn.	60 00'10"W	135 16'10"W
CH44-6	Goddell 5600'	Yellow weath. dk grey qtz with fg sulphides (Sb?).	60 00'10"W	135 16'10"W
CH46-3	Upper Millhaven Ct	Slight rusty with vary, pale grey, coarsely crystalline quartz with vugs and minor limonite + MnO, hosted in Lfrqb near meta. rock felseneer.	60 06'15"W	135 04'30"W
CH47-3	Stripe-west	Very rusty with crystalline cox qtz with thick (1 cm) band of fine-grad galena and arsenopyrite, disseminated pyrite throughout.	60 00'10"W	134 31'25"W
CH47-4	Stripe-west	Banded qtz, arsenopyrite, pyrite, no galena, scorodite.	60 00'10"W	134 31'25"W
CH49-3	Gray Ridge	Drusy qtz breccia with lots of vugs, calcite casts with volcanic clasts.	60 10'20"W	134 55'10"W
CH50-4	Mt Wheaton Trench 1	Rusty weathering, cg cox qtz (no vugs) with minor blebs (lt) of gn.	60 15'00"W	135 02'55"W
CH50-5	Mt Wheaton Trench 2	Same as 50-4 but no rust, banded px @ margins, buggy with gn + cpy, py.	60 14'45"	135 01'45"W
CH54-1	Earl	White, milky qtz breccia with weathered out, argillic altered wallrock frags + graphite, minor scorodite, f.g. sulphides in fractures.	60 11'00"W	135 31'00"W

SAMPLE NO.	Au(ppb)	Au(opt)	Ag(ppm)	Ag(opt)	Cu	Mo	Pb	Zn	As	Ba	Sb	V	Hg
CH32-1	<23	4.6	312	<1	383	>20000	36	2000	634	<2	>5000		
CH33-2	<10	5.8	122	<1	430	10030	<2	<100	>30000	<2	>5000		
CH34-3	<25	0.8	25	<1	48	362	215	3100	1890	<9	4700		
CH34-5	368	>50	6.68	3786	1	4071	461	220	212	2	1000		
CH-T35	>30000	2.644	>50	4.25	375	17	>10000	212	3	<100	15	<2	2000
CH36-5	130	16.7	90	13	5049	107	8	270	13	<2	40		
CH39-1	37	1	13	<1	190	51	20	590	2	<2	40		
CH40-4	49	7.5	32	3	1933	132	4	<100	12	<2	30		
CH41-1	780	28.4	124	2	1749	93	5	<100	3	<2	10		
CH41-5	92	3	23	3	650	52	14	230	3	4	10		
CH44-5	2230	6.6	34	2	296	2082	1340	<390	1970	<10	>5000		
CH44-6	1300	3.4	38	7	330	1216	2590	<970	6200	<16	>5000		
CH46-3	<10	0.7	27	5	10	7	49	140	3	<2	<5		
CH47-3	2750	44	562	5	3059	>20000	16600	<100	98	<9	3800		
CH47-4	5620	10.2	66	2	583	1350	>30000	<350	127	<13	250		
CH49-3	220	3.3	69	4	285	49	13	2000	2	<2	50		
CH50-4	45	6.5	10	3	818	32	22	<100	47	<2	650		
CH50-5	510	16	262	6	1138	17	17	<100	33	<2	250		
CH54-1	1930	30.1	59	26	2451	67	1360	230	14	5	30		

SAMPLE NO.	Au(ppb)	Au(opt)	Ag(ppm)	Ag(opt)	Cu	Mo	Pb	Zn	As	Ba	Sb	V	Hg
CH55-2	67	1			77	28	91	469	170	1800	17	<2	25
CH55-6	1130	>50	6.46		1701	49	>10000	81	260	340	56	7	10
CH56-1	>30000	1.209	>50	27.92	866	40	>10000	223	120	<410	309	<7	330
CH56-2	<10	3.1			30	2	89	116	44	140	2	3	35
CH57-2	220	6.7			133	2	420	11	19	170	19	<2	>5000
CH57-3	190	4.4			127	3	309	138	150	1300	157	<2	2000
CH57-4	46	0.9			10	2	69	31	9	930	8	<2	130
CH57-7	64	5.1			6302	4	43	19	7	100	9	<2	160
CH61-1	3050	5.1			40	4	275	37	7520	<100	15	<2	10
JR22-1	>30000	>50	2.54		30	167	516	117	11	<100	17	<2	10
JR22-3	510	>50	10.50		109	8	>10000	121	24	<100	61	<2	460
JR32-9	440	1.1			106	57	83	29	140	450	12	7	50
JR33-2	26	1.1			3324	2	277	203	12	630	3	<2	150
JR34-5	350	6.6			575	28	58	17021	10	130	3	13	540
JR30-6	43	1			49	3	46	8	7	1400	1	<2	20
JR39-2	17	0.3			14	2	29	31	7	940	2	<2	15
JR39-3	13	0.5			13	6	36	10	4	870	1	<2	15
JR41-1	<10	0.3			24	2	27	90	8	550	3	<2	5
JR42-4	20	0.4			15	2	35	36	19	1700	1	<2	240

SAMPLE NO.	LOCATION	DESCRIPTION	LAT	LONG
CH55-2	Red Ridge	Rusty with black, hornfelsed argillite (JLa) with wispy bands of pyrite concordant with bedding; poss. sphalerite.	60 21'30"W	135 05'35"W
CH55-6	Red Ridge	Slight rusty weathering, medium white cor. qtz with diss. pyrite and blebs of fg galena and tetrahedrite.	60 21'30"W	135 07'30"W
CH56-1	Charleston	Medium-grd white cor qtz vein breccia filled with minor vugs and 2nd drusy qtz vugs, then f.g. arseno. + minor galena. Minor banding in qtz.	60 10'45"W	135 30'45"W
CH56-2	Charleston	Star vein.	60 10'45"	135 31'00"W
CH57-2	Creek 2 km NW of Stony Mtn.	Slightly waxy, milky white qtz and fractures filled with limonite.	60 09'00"W	135 02'00"W
CH57-3	"	Similar to 57-2 with slightly rusty weath. qtz breccia and f.g. gray sulphides (gn?) Pln fractures up to 3%, numerous fragments of wallrock (granite) altered to clay.	60 09'00"W	135 02'00"W
CH57-4	"	Milky white, slight rusty weath. qtz and qtz breccia with limonite and siderite, minor Ba + ankerite (all as alteration), minor vugs w/ cg cor.	60 09'00"W	135 02'00"W
CH57-7	"	Slight rust weath. saccharic white qtz with minor fractures and diss. blebs of cpy (near margins) and in fractures.	60 09'20"W	135 01'00"W
CH61-1	"	Rusty weathering, slightly banded, arsenopyrite-qtz vein with minor galena	60 09'20"W	135 01'00"W
JR22-1	Mt. Anderson	Qtz-molybdenite stark pieces of float, assoc. Ca-gt, epidote, calcite, galena. Contact stark between granite and Wsling.	60 12'30"W	135 00'00"W
JR22-3	Mt. Anderson	Five samples across 2 m width Whirlwind vein (107/86 SW) on west slope.	60 12'10"W	135 09'45"W
JR32-9	Mt. Perkins	Cg white qtz with galena seams, rusty alteration.	60 20'07"W	135 05'05"W
JR33-2	Tally Ho Mtn.	Dk. orange rusty weath. limonite & poss. scorodite stained volcanic with minor MnO.	60 13'25"W	135 03'00"W
JR34-5	Mt. Modnett	Malachite & azarite stained microrline white to gray metamorphic qtz with minor, vfg chalcocopyrite or tetrahedrite.	60 19'15"W	135 12'20"W
JR38-6	West Mt. McNeill	Densely diss. and blebby pyrite (fg+mg) in alt'd. mylonitic basalt. Py (20%), fg ga (3%), and rare (1%) sph, 5% sugary qtz.	60 08'45"W	135 28'40"W
JR39-2	Millhaven Ck area	Sugary qtz, rusty and green (sericite) weath. irregular vein/body.	60 06'40"W	135 06'45"W
JR39-3	Millhaven Ck area	Stony mtx rhyolite, diss. pyrite. Holozline, lger tsp, few mafics. Adjacent to qtz vein, specimen JR39-3.	60 06'40"W	135 06'45"W
JR41-1	Carcross-Skagway Rd., km 96.3	White, crse grd qtz filling open spaces; minor pyrite stain. About 2 m wide, strikes 135, dips moderately steeply NE.	60 07'30"W	134 34'15"W
JR42-4	Gray Ridge North	Pale green fsp ppy dike intruding and oxidizing limestone; diss. pyrite.	60 19'50"W	134 56'45"W
JR46-6	Stony Mtn. east flank	Massive gray andesite with diss. sulfides (py).	60 07'40"W	134 59'40"W

SAMPLE NO.	As(ppb)	Au(opt)	Ag(ppm)	Ag(opt)	Cu	Mo	Pb	Zn	As	Ba	Sb	V	Mg
JR46-6	22		0.3		75	4	26	19	7	1000	1	4	25
MP1-1	<10		0.3		156	37	7	25	6	100	0	3	20
MP11-8	13		28.8		417	9	1540	>20000 1.93%	72	1400	6	2	50
MP15-1	<10		0.3		23	7	19	116	4	2500	3	5	20
MP21-1	420		47.9		657	<1	7190	182	0	170	60	<2	200
MP21-2	980		>50	9.33	3180	13	>10000 9.04%	265	9	230	198	2	620
MP21-3	840		23.5		12	2	1101	38	4	540	3	9	30
MP34-1	16		3.4		10	1	583	13	7	130	54	<2	175
MP34-6	40		2.5		278	1071	200	214	0	1900	13	6	70
MP35-1	6670		>50	3.73	252	17	>10000 7.59%	107	15	<100	26	<2	1000
MP35-2	2070		15.7		107	32	5982	104	16	110	2	<2	120
MP40-1	29		1.2		16	4314	647	44	4	790	<1	3	40
MP41-4	53		0.3		4	31	113	4	4	<100	<1	<2	10
MP42-1	<64		>50	27.69	5070	56	561	436	310	1400	1090	<26	1200
MP42-2	<10		6		27	18	20	6	9	110	0	5	30
MP46-4	<10		3.0		29	3	22	3	6	<100	6	<2	15
MP53-3	<10		0.7		325	4	14	32	20	<100	3	<2	20
MP56-1	<10		0.8		22	2	13	3	0	<100	3	<2	10
MP60-1	88		1		7	2	7	5	140	<100	13	<2	25
MP60-B	<10		0.4		36	3	28	63	38	1300	29	<2	20

SAMPLE NO.	LOCATION	DESCRIPTION	LAT	LONG
MP1-1	Ibex area	White to lt. grey moderately banded to massive slightly rusty weathering quartz.	60 35'20"N	135 24'15"W
MP11-6	Lakeview Mtn	Rusty, fg, green with py + sph; adjacent to rhyolite dike.	60 27'10"N	135 03'00"W
MP15-1	Conrad	Silica flooded granite with qtz stringers & diss. py (4%).	60 05'05"N	134 33'40"W
MP21-1	Mt. Stevens	Massive white sacrossic (bull) qtz with thin bands of med-gr. diss. gn. V. minor cpy & py; 1-2 % Gn.	60 14'00"N	135 00'15"W
MP21-2	Mt. Stevens	As above, with rust (ilmenite) and some malachite	60 14'00"N	135 00'15"W
MP21-3	Mt. Stevens	Numerous white, fg qtz (meta) in mylonite zone in JRGd; 3 m wide. Relic py & minor blebs of gn.	60 14'00"N	135 00'15"W
MP34-1	Mt. Anderson	Half metre wide orange stained vein within a dyke; chalcedony fairly abundant; no visible mineralization.	60 11'30"N	135 07'45"W
MP34-6	Mt. Anderson	Small qtz veins through a mildly foliated granite; Molybdenite rosettes scattered throughout, some cpy in granite.	60 12'25"N	135 05'20"W
MP35-1	Mineral Hill	Quartz vein with a lot of galena, minor cpy and possibly some tetrahedrite; coxcomb quartz.	60 20'10"N	135 13'35"W
MP35-2	Mineral Hill	Chip sample across approx. 1 m wide quartz vein.	60 19'45"N	135 14'45"W
MP40-1	Sugarloaf Hill	Finely crystalline white to grey quartz with disseminated patches of molybdenum; hosted in Carcross Pluton near contact w/ Cache Ck Gp	60 00'40"N	134 41'20"W
MP41-4	Boudette Creek	Quartz vein in foliated Wisling (quartz not foliated but looks metamorphic); no mineralization apparent.	60 04'15"N	135 29'00"W
MP42-1	Gold Hill	Quartz vein in an altered granite exposed in trenches, malachite, azurite staining & massive tetrahedrite & galena.	60 17'50"N	135 09'30"W
MP42-2	Gold Reef	Quartz taken from waste pile of shovels; visible py, cpy and a fg, dark silvery mineral	60 18'00"N	135 08'45"W
MP46-4	Mt. McNeil	Quartz float, rusty orange weathering taken near a small gossan; no visible mineralization, sugary texture (granular).	60 00'20"N	135 29'35"W
MP53-3	Stony Mtn.	Small qtz veins cutting volcanics; vein and host rock mineralization of chalcocopyrite, bornite, hematite, poss. sphalerite.	60 09'40"N	134 59'10"W
MP56-1	Stony Mtn.	Abundant cavity filling qtz in float, radiating bundles with pyrite cubes within bundles.	60 09'45"N	134 59'30"W
MP60-1	Montana Mtn.	Cavity filling vein qtz in a siltstone breccia. No apparent malachite.	60 03'30"N	134 39'20"W
MP60-8	Montana Mtn.	Rhyolite dyke with blotches of pyrite surrounded by a f.g. silvery metallic mineral.	60 03'30"N	134 39'15"W

APPENDIX D

WHOLE ROCK GEOCHEMISTRY and SAMPLE DESCRIPTIONS

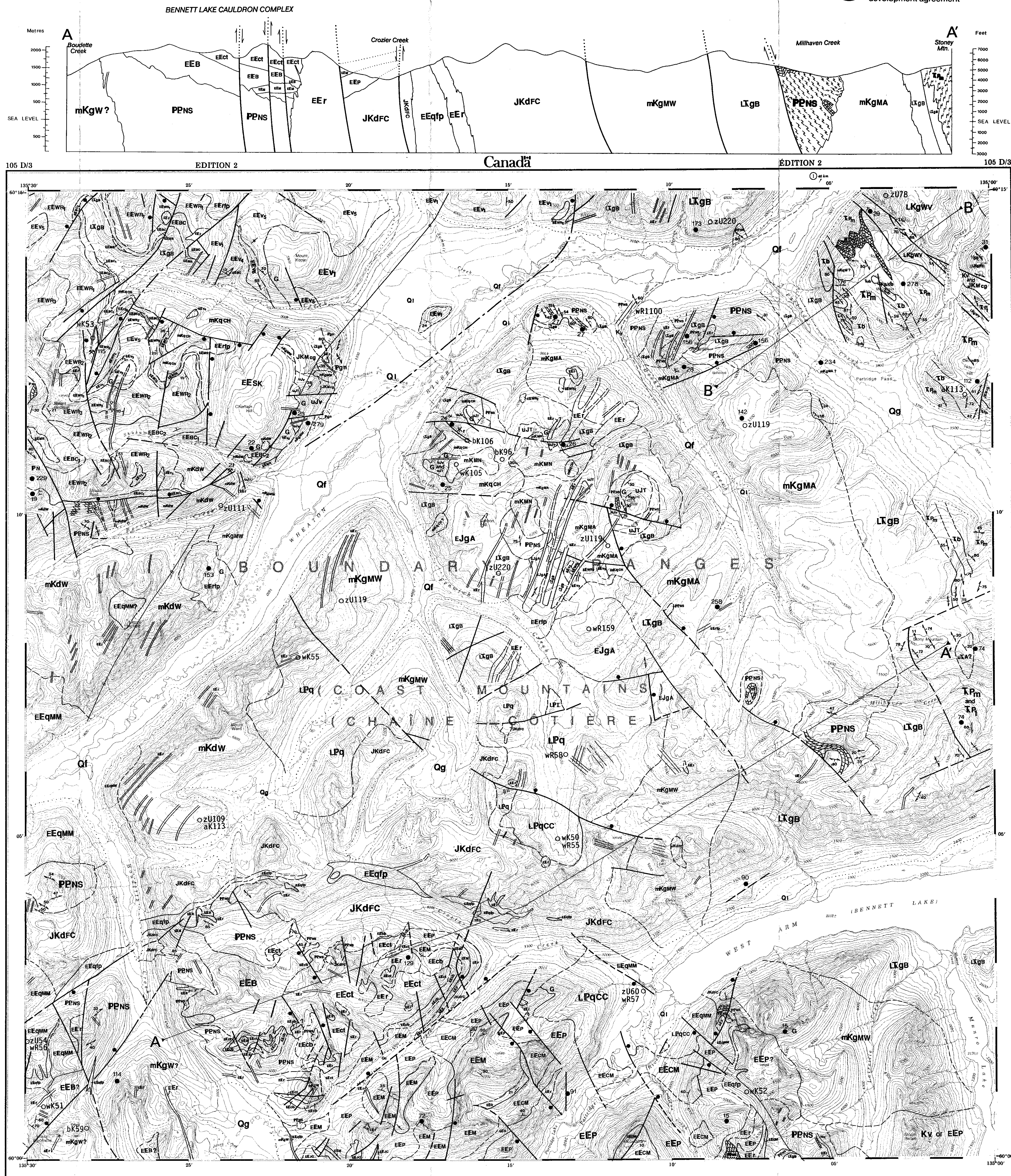
	89CH10-1	89CH7-1	89CH6-1	NP2-1	CH12-1	89CH 7-5	89CH5-2	89CH48-3	89CH52-1	89CH58-1	89CH60-5	89CH70
SiO2	54.54	65.10	52.27	46.79	56.57	45.50	48.92	64.50	67.17	65.83	68.07	63.44
Al2O3	18.96	15.38	13.22	10.58	16.55	19.00	14.15	15.97	15.40	16.42	15.42	15.61
Fe2O3	8.04	3.33	0.02	11.20	6.47	9.30	10.46	2.73	3.57	3.88	3.50	4.25
MgO	2.93	1.29	5.49	5.38	3.18	4.03	7.96	1.39	0.85	1.39	1.20	1.84
CaO	7.73	2.93	8.55	10.02	6.35	9.50	9.68	3.90	2.33	3.94	2.97	3.35
Na2O	3.71	4.13	4.14	2.80	2.88	3.42	1.71	4.98	3.63	4.11	3.50	2.92
K2O	1.00	3.55	0.48	0.43	3.12	0.93	2.78	1.32	3.95	2.81	3.36	3.37
TiO2	1.11	0.52	0.69	1.39	0.76	1.25	0.8	0.37	0.49	0.44	0.54	0.45
P2O5	0.27	0.15	0.29	0.08	0.18	0.08	0.33	0.18	0.13	0.14	0.17	0.17
MnO	0.16	0.10	0.13	0.16	0.10	0.12	0.2	0.07	0.10	0.10	0.07	0.05
Cr2O3	0.01	0.00	0.06	0.01	0.01	0.01	0.08	0.012	0.010	0.008	0.004	0.013
Ba ppm	964	1326	51	286	1516	450	455	1726	1644	1269	1555	1543
La ppm	25	34	25	25	27	25	25	41	52	29	34	33
Zr ppm	95	186	37	36	183	20	49	124	188	96	112	83
Y ppm	23	18	11	11	24	7	16	8	29	10	11	16
Nb ppm	52	60	21	37	29	40	20	28	48	50	45	37
LOI %	0.4	3.1	6.0	3.0	3.4	6.5	2.8	4.2	2.0	0.1	0.8	4.0
S %								0.16	0.01	0.01	0.01	0.21
TOTAL	99.85	99.85	99.36	99.90	99.86	99.73	99.96	99.94	99.95	100.01	99.89	99.75

	NP49-2	NP49-3	NP49-4	NP49-5	NP49-6	NP49-7	NP49-8	NP49-9	89CH75-8	ZR 4-1	ZR 4-2	ZR 4-3
SiO2	59.96	64.95	51.89	47.29	52.8	45.64	56.63	51.42	51.47	52.20	52.65	51.38
Al2O3	18.00	15.06	14.37	15.36	13.66	15.50	16.12	16.57	1.73	17.80	18.61	16.24
Fe2O3	4.53	4.41	7.33	7.40	7.71	9.42	6.74	7.90	5.41	8.79	8.52	10.98
MgO	2.37	1.86	4.76	6.35	4.13	9.83	6.12	8.79	18.86	3.65	3.27	4.20
CaO	4.38	3.05	11.21	12.76	11.52	6.75	5.36	4.88	20.49	7.44	6.10	7.45
Na2O	3.99	4.01	3.12	2.24	2.34	2.11	4.16	2.39	0.13	3.39	3.63	2.86
K2O	3.62	4.05	2.16	2.35	3.71	3.46	2.44	4.72	0.07	3.59	3.76	3.68
TiO2	0.57	0.59	0.67	1.09	0.61	1.19	0.62	0.69	0.19	0.67	0.67	0.98
P2O5	0.26	0.27	0.34	0.37	0.27	0.48	0.29	0.34	0.04	0.42	0.43	0.78
MnO	0.09	0.09	0.21	0.17	0.21	0.10	0.13	0.15	0.13	0.18	0.17	0.23
Cr2O3	0.013	0.008	0.035	0.039	0.072	0.047	0.045	0.038	0.328	0.013	0.012	0.010
Ba ppm	1965	2456	1032	1215	1470	1195	995	1574	10	894	945	1142
La ppm	42	34	25	38	25	50	25	25	25	27	25	25
Zr ppm	118	100	42	103	43	135	62	46	10	63	104	35
Y ppm	15	12	13	19	14	24	16	13	5	17	18	19
Nb ppm	35	53	20	67	20	49	23	46	20	41	62	20
LOI %	1.4	1.0	3.4	4.0	2.1	4.9	0.9	1.7	1.0	1.3	1.8	0.7
S %	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL	99.54	99.79	99.68	99.65	99.69	99.74	99.74	99.87	99.86	99.61	99.81	99.70

Cu ppm	52	50	482	135	11	13	70	152	8	158	141	363
Zn	67	55	66	70	82	109	75	72	39	76	72	93
Ni	50	38	98	125	200	194	155	116	144	29	34	27
Co	25	17	44	52	30	39	36	38	51	30	23	51
Sr	2931	1047	827	1397	972	626	821	680	43	863	755	757
Ce	118	90	39	111	43	105	40	21	20	66	20	21
Ta	20	20	20	20	20	20	20	20	20	20	20	20

SAMPLE DESCRIPTIONS

SAMPLE NO	UNIT	LOCATION	DESCRIPTION
89CH10-1	mKdw	Jackson Hill	magnetic px-hb gabbro
89CH7-1	mKqCH	Carbon Hill SE	red quartz monzonite
89CH6-1	uTrA ₁	Ibex River	andesite fsp-ppy flow
MF2-1	mKdw	Ibex River	magnetic px-hb gabbro
CH12-1	JLan	Lakeview Mtn.	fsp-hb andesite ppy
89CH T-5	mKdw	Ibex River	magnetic px-hb gabbro
89CH5-2	uTrP	Ibex River	augite porphyry
89CH48-3	PgC	Conrad	fine-grained bio-hb granite
89CH52-1	LPqP	Finger Mtn.	bio-hb granite w/ megaxtic kspar
89CH58-1	mKgW	Ibex River west	hb-granodiorite
89CH60-5	PgC	Grey Ridge	fine-grained bio-hb granite
89CH70	uTrH	Watson Ridge	felsic tuff (in limestone)
MP49-2	uTrA ₁	Needle Mtn 5570'	Feldspathic sandstone with andesite
MP49-3	uTrA ₁	" " 5440'	volcanic breccia, fg matrix
MP49-4	uTrA ₁	" " 5150'	px-phyric basalt
MP49-5	uTrA ₁	" " 4530'	biotite phyric flow
MP49-6	uTrA ₁	" " 4200'	conglomerate
MP49-7	uTrA ₁	" " 4100'	dyke in limestone
MP49-8	uTrA ₁	" " 3900'	px-phyric basalt
MP49-9	uTrA ₁	" " 3800'	intercalated basalt and siltstone
89CH75-8	Trub	Tally Ho Mtn.	ultramafite
ZR 4-1	Trb	Tally Ho Mtn.	hornblende leucogabbro
ZR 4-2	Trb	Dickson Hill	hornblende leucogabbro
ZR 4-3	Trb	Dickson Hill	hornblende leucogabbro



LEGEND

QUATERNARY

- Qf Unconsolidated gravel, sand and silt of fluvial or glaciofluvial origin
- Ql Unconsolidated gravel, sand, silt and varved clay of lacustrine or glaciolacustrine origin
- Qc Unconsolidated glacial moraine, kame, esker and drift material
- Qg Unconsolidated, locally derived colluvium and felsenmeer

TERTIARY

EARLY EOCENE

SKUKUM GROUP

- EEqtp Pale to rusty orange weathering, coarse grained quartz feldspar rhyolite porphyry with accessory fluorite, occurs as small plugs and ring dikes (Bennett Lake Complex); may be equivalent to Nisling Range Alaska (51 Ma K-Ar)

BENNETT LAKE CAULDERA COMPLEX

- EEBc Boudeite Creek Formation: Basalt, rhyolite, and tuff

- EEc1 Crozier Tuff and Lava: tuff, ignimbrite, and rhyolite lava

- EEc2 Lemieux Creek Formation: Granitic boulder conglomerate and breccia

- EEc3 Crozier Breccia: Volcanic breccia and conglomerate

- EEc4 MacCauley Creek Formation: Ignimbrite

- EEc5 Gault Formation: Granite boulder conglomerate

- EEc6 Cleft Mountain Formation: Ignimbrite, dacite, and andesite lava

- EEc7 Partridge Lake Formation: Ignimbrite

- EEc8 Mount Skukum Volcanic Complex: Buff weathering domes, plugs and laccolites of coarse grained rhyolite feldspar porphyry; may be equivalent to Nisling Range Alaska (53 Ma Rb-Sr)

- EEc9 Flaggy, orange, rusty orange, to white orange, mauve or tan, fine-grained rhyolite dikes, dyke swarms, and flow domes; composite dikes are common

- EEc10 Undifferentiated Skukum Group volcanic rocks

- EEc11 Upper Vesuvius Formation: Light tan brown, well-bedded airfall tuff, epiclastic sandstone and siltstone

- EEc12 Flaggy, dark red, purple to grey, white to pale green flow banded, auto-brecciated and spherulitic rhyolite flows

- EEc13 Well-bedded, purple and grey rhyolite tuff and lithic tuff; probably equivalent to EEc2 or EEc9

- EEc14 Intra-cauldron collapse breccia: composed of very large blocks of flow banded rhyolite (EEc9)

- EEc15 Lower Vesuvius Formation: Dark reddish brown, columnar jointed densely welded tuff; includes unwelded tuff on Vesuvius Hill

- EEc16 Massive to well-bedded, pastel coloured, slightly altered rhyolite to intermediate tuff, lithic tuff and welded tuff

- EEc17 Watson River Formation: Massive to poorly-bedded, dark brown and purple to pale green, commonly columnar-jointed andesite and andesite porphyry flows and associated tuff; exposures on Carbon Hill are lithologically similar and assumed to be equivalent

- EEc18 Pale green dacite to andesitic lithic tuff, commonly densely welded

- EEc19 Butte Creek Formation: Unwelded tuff and epiclastic rocks

- EEc20 Interbedded epiclastic sediments, bedded tuff, and lithic tuff

- EEc21 Moderately well-bedded, pastel coloured felsic and altered felsic pyroclastic rocks, commonly interbedded with associated grey, green, and purple epiclastic rocks

- EEc22 Mount Reid Formation: Massive, hematitic, clast-supported, cobble and boulder conglomerate, contains locally derived basement fragments

- EEc23 Nisling Range Plutonic Suite: Mt. McAuley Granite: orange brown, crumbly weathering, medium- to coarse-grained smoky quartz rhyolite, quartz-rich granite (54 Ma U-Pb)

- EEc24 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc25 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc26 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc27 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc28 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc29 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc30 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc31 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc32 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc33 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc34 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc35 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc36 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc37 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc38 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc39 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc40 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc41 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc42 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc43 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc44 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc45 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc46 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc47 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc48 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc49 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc50 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc51 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc52 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc53 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc54 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc55 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc56 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc57 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc58 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc59 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc60 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc61 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc62 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc63 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc64 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc65 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc66 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc67 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc68 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc69 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

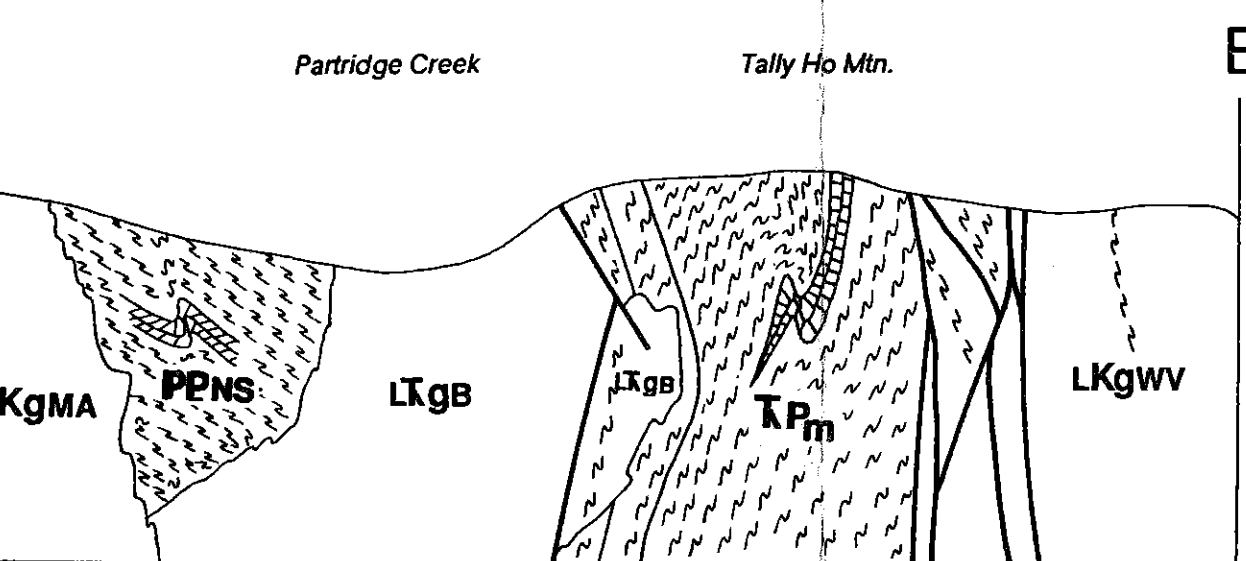
- EEc70 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc71 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group

- EEc72 Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (50 Ma U-Pb)

- EEc73 Leucogranite: white weathering, medium-grained, saccharoidal textured, mafic-poor biotite granite (59 Ma Rb-Sr)

- EEc74 ISEX FORMATION: Dark, vitreous, flow-banded rhyolite dikes with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than ISEX Alaska and unconformably (?) below Butte Creek Formation, may be part of Skukum Group



SYMBOLS

- Limit of outcrop.....
- Geological boundary (defined, approximate, assumed).....
- Bedding (top known, tops unknown).....
- Primary igneous flow banding.....
- Dyke (inclined, vertical).....
- Schistosity (metamorphic foliation and gneissosity).....
- Mineral lineation.....
- Shear band.....
- Fault (defined, approximate, covered; ball on down).....
- Dropped side.....
- Fault (transcurrent).....
- Mafic dike swarm.....
- Adit, caved.....
- Locality of isotopic age determination.....
- Igneous, metamorphic, sedimentary rock.....
- Material: amphibole, biotite, zircon, whole rock.....
- Method: U-Pb, K-Ar, Rb-Sr.....
- Cross section line.....
- Mine or past producer (Numbers refer to INAC Yukon Exploration volume).....
- Mineral occurrences (Numbers refer to INAC Yukon Exploration volume).....
- Lineament.....
- Gossan.....
- Breccia.....

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MINERAL OCCURRENCES

YEX Number	NAME	Commodity
15	LATREILLE	Cu, Mo
19	CHARLESTON	Au, Ag, Pb, Zn, As
21	MT. REID	Au, Ag, As, Pb, Zn, Sb, Cu
22	RACA	Cu, Ag, Au, Sb
23	MORNING	Sb, Zn, As
24	GODDELL	Cu, Fe
25	PORTER	Sb, Ag, Pb, Zn, Au
26	BECKER COCHRAN	Sb, Ag, Pb, Zn, Au
27	FLEMING	Cu, Fe
28	MT. ANDERSON	Pb, Ag, Au, Pb
29	TALLY-HO	Au, Ag
31	BUFFALO	Au, Ag
32	SHAW	Cu, Pb, Zn, Au
74	OPULENCE	Sb, Ba
90	WEST	Au, Ag, Pb
91	PARTY	Au, Ag
112	ODD	Cu, Ag
114	NAIAD	Pb, Ag
115	MT. SKUKUM MINE	Au, Ag
129	GLENLIVET	Au, Ag, Pb
142	TYCON	Au, Ag, Pb, Zn
153	SCAR	Au, Ag, Pb, Zn
155	ROB	Au, Ag
173	WAL(MR)	Au, Ag, Pb, Zn, Au
229	EARL	Au, Ag, Pb, Zn, Cu
234	FOXMO	Mo
258	CHRAIG	Ag, Sb, Pb, Zn, Cu
278	SILVER QUEEN	Au
279	OCEAN	Ag, Au, Sb, Zn

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

GEOLOGICAL MAP OF FENWICK CREEK (105D/3)
MAP AREA

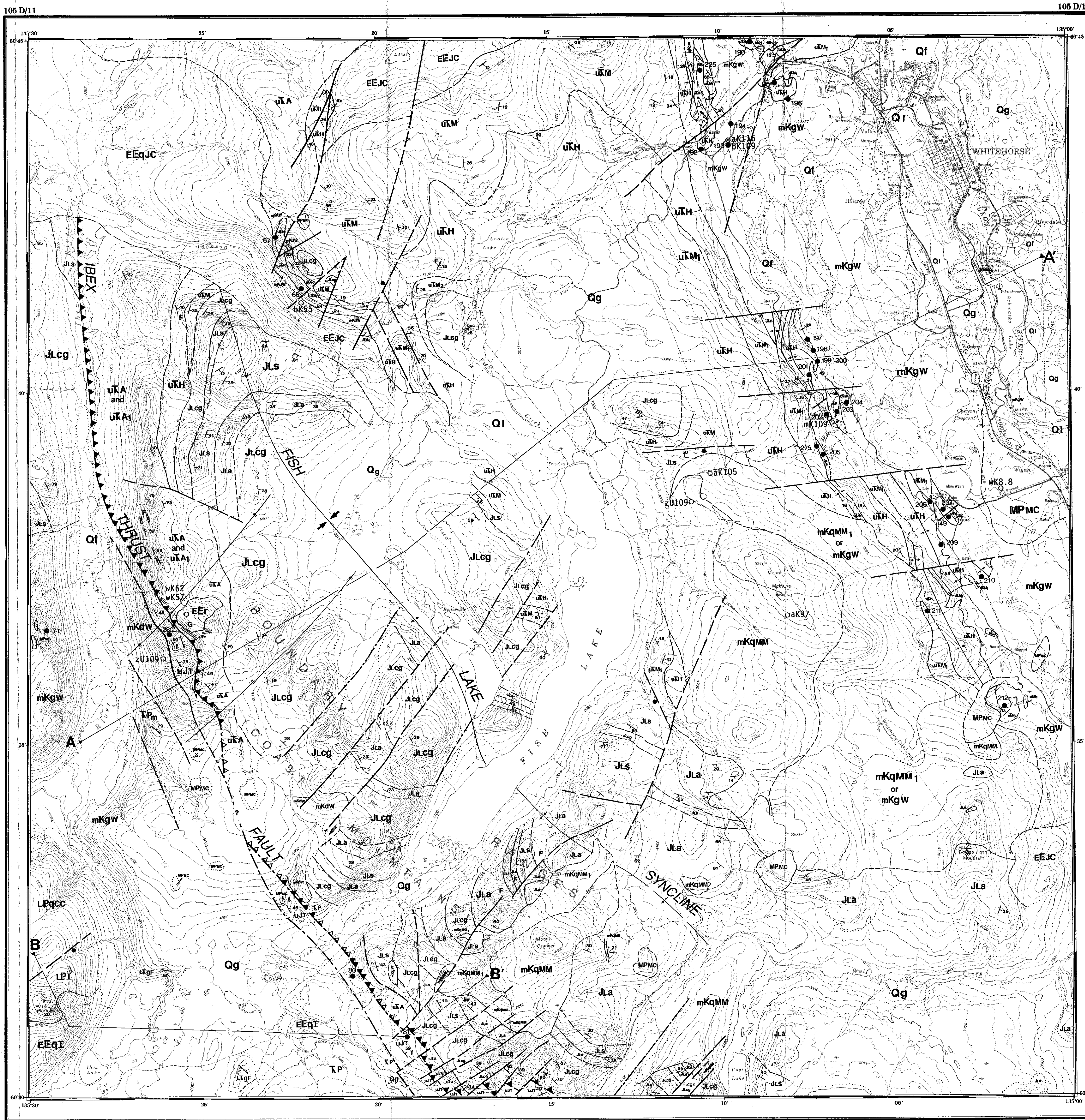
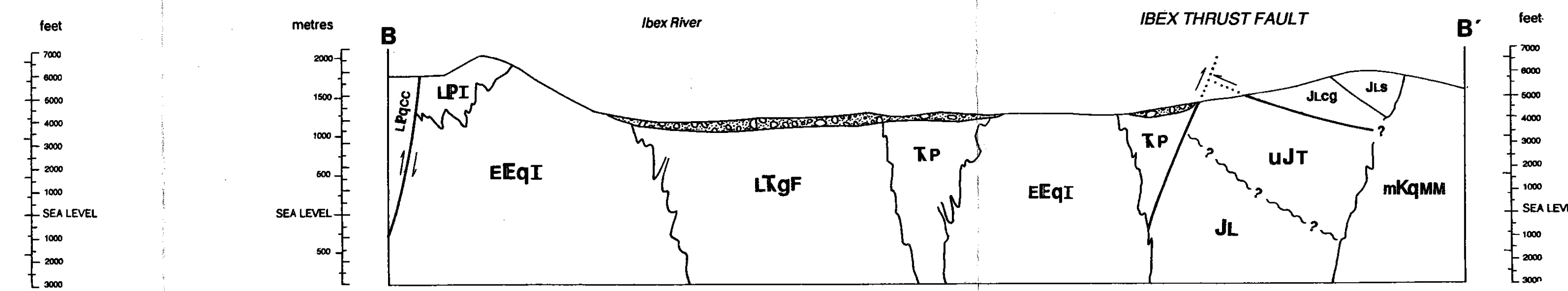
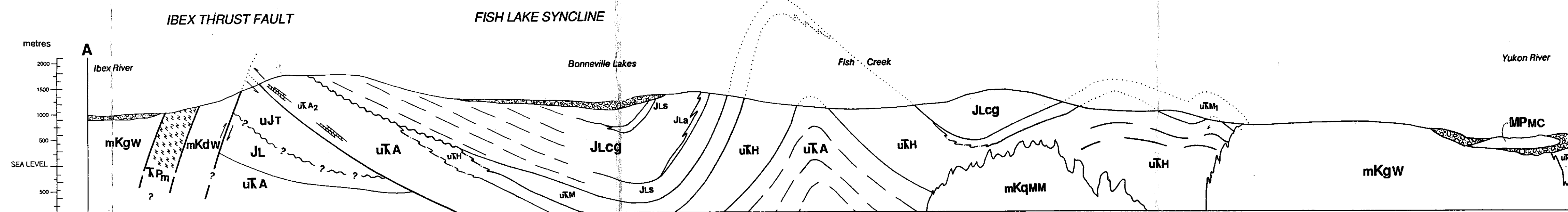
Geology by C.J.R. Hart, R.A. Doherty, J.K. Radloff,
J.A. Hunt, M.P. Fingland, and J. Weggenast

to accompany

OPEN FILE REPORT 1990-4

Geology of Whitehorse, Alligator Lake, Fenwick Creek, Carcross and part of Robinson map areas (105D/116,3,2,7); C.J.R. Hart and J.K. Radloff, Aurum Geological Consultants, Inc.

Funded by Canada-Yukon Economic Development Agreement
(Contract YEDA 01/87)



LEGEND

QUATERNARY

- Qf** Unconsolidated gravel, sand and silt of fluvial or glaciofluvial origin
- Ql** Unconsolidated gravel, sand, silt and varved clay of lacustrine or glaciolacustrine origin
- Qg** Unconsolidated glacial moraine, kame, esker and drift material

TERTIARY

MIOCENE-PLIOCENE

- MPMc** Miles Canyon Basalt: Dark red to brown weathering, columnar jointed olivine basalt flows commonly amygdaloidal and vesicular with ultramafic xenoliths (8.8 Ma; 2.4 Ma, both K-Ar)

EARLY EOCENE

- EEf** Flaggy, orange, rusty orange, to white orange, mauve or tan, fine-grained rhyolite dykes, dyke swarms, and flow domes; composite dykes are common

EARLY EOCENE TO LATE PALEOCENE

- EEqC** NISLING RANGE PLUTONIC SUITE
Jackson Creek Granite: light grey weathering, coarse-grained, smoky-quartz, eye biotite granite, leucocratic with white potassium feldspar (55 Ma K-Ar)

- EEqI** Ibx Alaskite: light pink to buff weathering, micritic, fine- to medium-grained alaskite (58 Ma U-Pb)

- LPqcc** Crozier Creek Granite: pale pink to orange brown weathering, medium- to coarse-grained leucocratic, biotite granite (60 Ma U-Pb)

- LKp** IBEX FORMATION
Dark, viscous flow-banded rhyolite flows with sparse feldspar phenocrysts and welded tuff, commonly contains granitic fragments; older than Ibx Alaskite and unconformably (?) below Bette Creek Fm.; may be part of Skukum Group.

CRETACEOUS

MID-CRETACEOUS

- mKqMM** MT. MCINTYRE PLUTONIC SUITE
Mt. McIntyre Pluton: pale orange weathering, fine- to medium-grained, pink granophyric with phases of quartz monzonite, granite and monzonite; xenoliths common along margins (116 Ma U-Pb)
Granite Phase: medium-grained, euhedral biotite granite to granodiorite border phase

- mKgW** WHITEHORSE PLUTONIC SUITE
Whitehorse Pluton: dark grey weathering, medium-grained biotite-hornblende granodiorite, tonalite, and diorite with common mafic xenoliths and local weak foliation (116 Ma K-Ar)
Ibx River Gabbro: dark grey, coarse-grained, mesocratic, often strongly magnesian, hypersthene-hornblende diorite, quartz diorite, and gabbro (109 Ma U-Pb)

JURASSIC

UPPER JURASSIC

- uJT** TANTALUS FORMATION (OXFORDIAN-KIMMERIDGIAN)
Massive to thickly bedded chert pebble conglomerate with recessive, poorly indurated, gritty sandstone and quartz sandstone with interbedded dark grey shale

- uJtm** Recessive weathering, highly fractured, high ash anthracite to low volatile bituminous coal

- uJv** Rusty weathering, blue-grey andesite porphyry flows and breccia

LOWER AND MIDDLE JURASSIC

- JLa** LABERGE GROUP (HETTANGIAN? TO BAJOCIAN)
Dark red-brown weathering, rhythmically and thinly bedded, tawny to dark green and grey, silty argillite, shale and siltstone; local horrefels; contains ammonoid fossils and rare coaly plant fragments; minor interbedded massive sandstone and conglomerate

- JLs** Pale to dark orange weathering, dark grey, massive and thickly to medium bedded, medium to coarse-grained feldspathic and lithic greywacke with lesser arkose, arenite, and grit; uncommon argillite and conglomerate lenses

- JLcg** Rust-orange weathering, resistant, thickly bedded to massive, clast- and matrix-supported polymict cobble conglomerate; clasts of granitic rock and Lewis River Group volcanics with lesser schist, metamorphic quartz, limestone, and other sedimentary clasts; granitic clasts dominant higher in section; interbedded greywacke, arenite and argillite

LATE TRIASSIC

- LKGF** Friday Creek Diorite: foliated, fine- to medium-grained hornblende quartz diorite to diorite with minor biotite (211 Ma U-Pb)

UPPER TRIASSIC

LEWES RIVER GROUP (CARNIAN TO SINEMURIAN)

- uKM** AKSALA FORMATION
Mandan Member (Late Norian to Early Sinemurian): Red, purple, green and grey, medium bedded to massive, crystal-rich greywacke and shale; minor interbedded pebble conglomerate and red, bioturbated siltstone. Equivalent facies include:
Coarse-grained, tan to brown, massive, lithic arenite; minor angular clast conglomerate, argillite and shale.
Well-bedded, red to maroon, poorly indurated, bioturbated siltstone with crystal-rich greywacke.
Hancock Member (Norian): resistant, white to light grey weathering massive and thickly bedded limestone, bioclastic horizons and marls; minor sooty black limestone and tan dolomite.
uKM₂
uKM₃
uKM₄
uKM₅
Annis Member (Karnian to Norian): Resistant, massive to moderately well-bedded, red, purple, and green matrix (and clast) supported agglomerate pebble conglomerate, and basaltic debris flows; clasts of augite porphyry and subvolcanic diorite porphyry with crystal-rich wacke matrix; interbedded arenite and minor tuff.
uKA₁
uKA₂
Andesite Ledsar (and augite) porphyry flows, agglomerate and breccia; minor red siltstone.
Massive, grey, white to pink (commonly sheared or recrystallized) limestone and bioclastic limestone breccia; located near the base of this member

- TP** POVOAS FORMATION (CARNIAN AND OLDER?)
Resistant, massive light to dark green weathering, dark green to black, argillite phyllite basalt and basaltic andesite flows and breccia; minor well-indurated dark grey greywacke, agglomerate, tuff, and associated epiclastic rocks with thin carbonate beds.
Metamorphosed equivalent: Foliated to massive pale to dark green plagioclase-hornblende amphibolite; laminated pale green quartzofeldspathic gneiss and massive amphibolite with relict augite phenocrysts, marble and rare quartzite

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COMPILATION SOURCES

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SYMBOLS

- Limit of outcrop.....
- Geological boundary (defined, approximate, assumed).....
- Bedding (top known, tops unknown).....
- Primary igneous flow banding.....
- Facies change.....
- Dyke (inclined, vertical).....
- Schistosity (foliation or gneissosity).....
- Anticline, syncline.....
- Fault (defined, approximate, covered; ball on down dropped side).....
- Thrust fault (defined, approximate, covered; teeth on upper plate).....
- Adit.....
- Locality of isotopic age determination.....
- Igneous, metamorphic, sedimentary rock.....
- Material: amphibole, biotite, zircon, whole rock.....
- Method: U-Pb, K-Ar, Rb-Sr.....
- Cross section line.....
- Fossil, microfossil locality.....
- Mine or past producer (Numbers refer to INAC Yukon Exploration volume).....
- Mineral occurrence (Numbers refer to INAC Yukon Exploration volume).....
- Volcano.....
- Lineament.....
- Gossan.....
- Breccia.....

MINERAL OCCURRENCES

YEX Number	NAME	Commodity
49	LITTLE CHIEF	Cu, Fe, Au, Ag
67	GROUSE	Cu, Fe, Au, Ag, Bi
70	HARNIAK	Cu, Au, Ag
81	FISH LAKE	COAL
81	LUSCAR	COAL
190	RABBIT FOOT	Cu
192	PUEBLO	Cu, Fe, Au, Ag
193	RESERVOIR LAKE	Mo, W
194	SHEELITE	W
195	COPPER KING	Cu, Fe, Au, Ag
196	CARLISLE	Cu
197	SPRING CREEK	Cu
198	EMPRESS OF INDIA	Cu
199	RETRIBUTION	Cu
200	BEST CHANCE	Cu, Fe
201	GRATIER	Cu, Fe
202	ARCTIC CHIEF	Cu, Fe, Au, Ag
203	SUBURBAN	Cu, Fe
204	VERONA	Cu, Fe
205	POLAR	Cu
206	BIG CHIEF	Cu, Fe, Au, Ag
207	MIDDLE CHIEF	Cu, Fe, Au, Ag
209	VALERIE	Cu, Fe, Au, Ag
210	NORTH STAR	Cu, Fe, Au, Ag
211	PASS LAKE	Cu
212	COPPER CLIFF	Cu
225	WAR EAGLE	Cu, Mo, Ag
226	ANACONDA	Cu
274	GULCH	Cu, Fe
275	QUINALTA	Cu
280	IBEX	COAL

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

GEOLOGICAL MAP OF WHITEHORSE (105D/11)
MAP AREA

Geology by C.J.R. Hart, K.S. Pelletier, J.K. Radloff,
M.P. Fingland, and J.A. Hunt

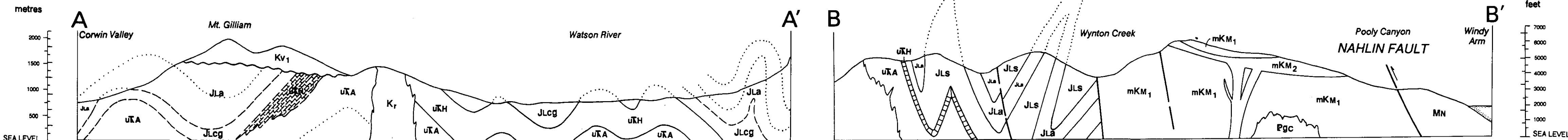
to accompany

OPEN FILE REPORT 1990-4

Geology of Whitehorse, Alligator Lake, Farwick Creek, Carcross and part of Robinson map areas (105D/11, 6, 3, 2, 7); C.J.R. Hart and J.K. Radloff of Aurum Geological Consultants, Inc.

Funded by Canada-Yukon Economic Development Agreement

(Contract YEDA 01/87)



SYMBOLS

- [illegible]

MINERAL OCCURRENCES

YES	Number	NAME	Commodity
2	3	LULU	Ag,Au,Cu
3	5	MILLET	Pb,Zn
5a	58	VENUS	Au,Ag,Pb,Cu
5b	59	VAPTER	Au,Ag,Pb,Zn
5c	60	EXTENSION(MOUNTAIN HERO)	Au,Ag,Pb,Zn
5d	61	MOON(MOUNTAIN HERO)	Au,Ag,Pb,Zn
7	7	THISTLE(AURORA)	Au,Ag,Pb,Zn
8	8	JEAN	Au,Ag,Pb,Zn
9	9	ART CARIBOU(BIG THING)	Au,Ag,Pb
10	10	CARCROSS	Cu,Mo
11	11	KNOB HILL	Cu,Zn
12	12	WAGON	Cu,Zn
13	13	COLLEGE GREEN	Cu,Zn
14	14	FINGER	Cu
31	31	BUFFALO HUMP	Au,Ag,Pb
32a	32	MT. STEVENS - ACME	Au,Ag
32b	32	MT. STEVENS - MIDNIGHT	Au,Ag,Pb
33	33	CROMWELL	Ag,Cu,Pb,Zn
34	34	MILLHAWNE	Ag,Pb,Zn
96	96	RAILROAD	Ag
97	97	ART(ROOTS)	Au,Ag,Pb
104	104	BEER	Au,Ag,Pb
136	136	JOE PETTY	Ag,Au
137	137	URANUS	Au,Ag,Pb
138	138	M.A.	Au,Ag,Pb
189	189	PEPPER	Au,Ag,Pb
198	198	PRIDE OF YUKON	Ag,Pb
273	273	RUEP SILVER(RED DEER)	Ag,Pb
275	275	HUMPER	Ag,Pb
282	282	CONRAD	Ag,Mo
283	283	MARKMOLY	Ag

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LOWER AND MIDDLE JURASSIC

- | | |
|----|--|
| Jm | Dark brown weathering, rhythmic and thinly bedded, tawny to dark green and grey, silty <u>phyllite</u> , shale and althornite, local hornfels. |
| Jm | Coarse grained fossiliferous, silty <u>conglomerate</u> fragments, minor interbedded massive sandstones and conglomerate. |
| Jm | Resistant, grey to brown, finely laminated <u>phyllite</u> . |
| Jm | Pale to dark orange, weathering, dark grey, massive and thinly bedded medium to medium to coarse-grained feldspathic and lithic <u>conglomerate</u> with lesser argillite, argillite, grey, uncommon argillite and conglomerate lenses. |
| Jm | Rust-orange weathering, resistant, thinly bedded to massive, clastic and matrix-supported polymict coarse <u>conglomerate</u> , clasts of granitic rock and Lewis River River gneiss volcanics with lesser schist, metamorphic rocks, and argillite. Matrix is composed of fine-grained calcic dominant hornfels in section; interbedded greyish, argillite and argillite. |
| Jm | Pale green, heterolithic, angular, poorly sorted basal <u>conglomerate</u> and calcic flows containing fragments of Barnett Gneiss. Nailing metamorphic rock and unfractured sedimentary rock. |

**GEOLOGICAL MAP OF CARCROSS (105D/2)
AND PART OF ROBINSON (105D/7) MAP AREAS**

Geology by C.J.R. Hart, K.S. Pelletier, J. M.P. Finland, and J.A. Hunt

to accompany

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