Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

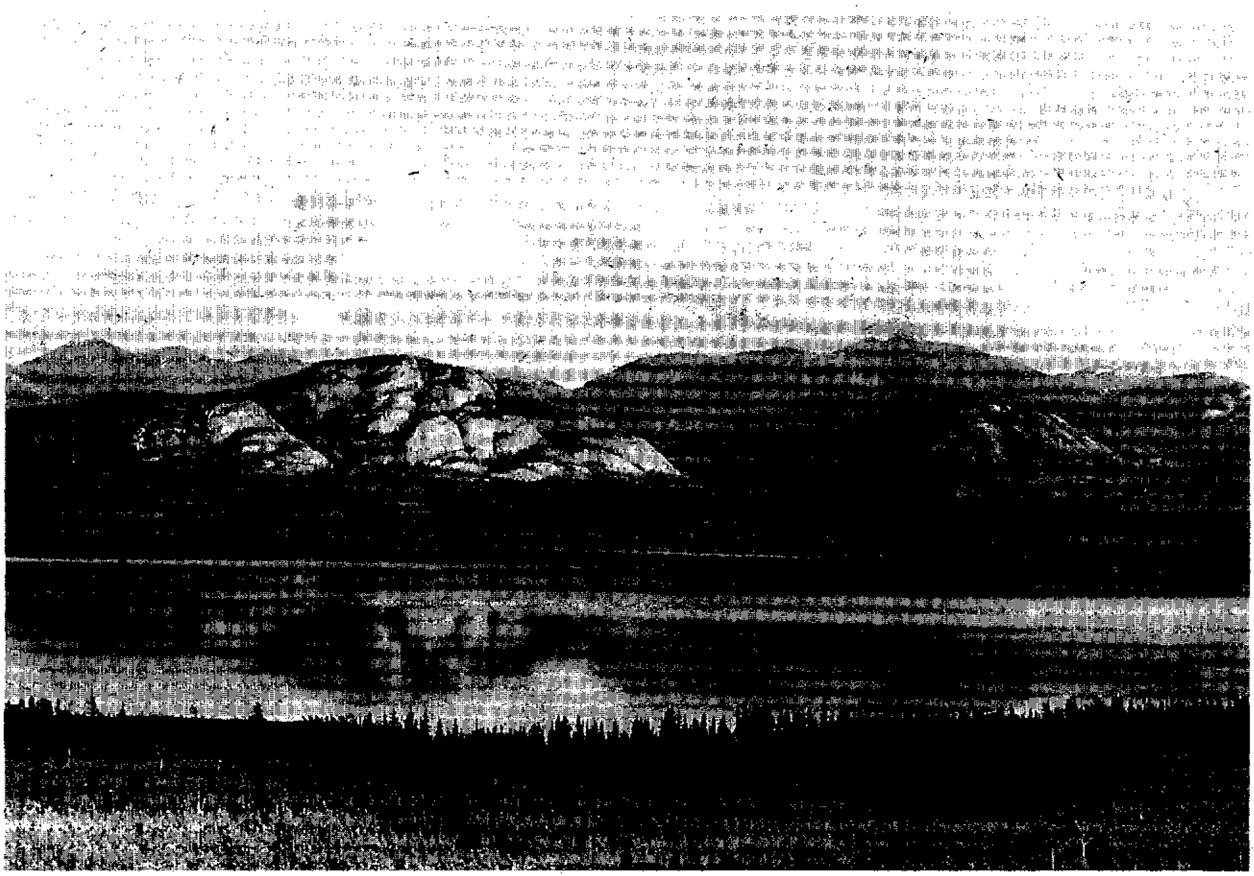
Exploration and Geological Services Division, Yukon Region

BULLETIN 8

A Transect Across Northern Stikinia: Geology of the Northern Whitehorse Map Area, Southern Yukon Territory (105D/13-16)

Craig J. R. Hart

with contributions from J. K. Mortensen, M. J. Orchard, J. Pálfy, H. W. Tipper and E. T. Tozer



Canada

Canada/Yukon Economic Development Agreement
To strengthen and diversify the Yukon economy

Yukon Economic Development

Exploration and Geological Services Division, Yukon Region

BULLETIN 8

A Transect Across Northern Stikinia: Geology of the Northern Whitehorse Map Area, Southern Yukon Territory (105D/13-16)

Craig J. R. Hart

with contributions from J. K. Mortensen, M. J. Orchard, J. Pálfy, H. W. Tipper and E. T. Tozer

1997

Catalogue no. R72-253/1997E

ISBN 0-662-25739-1

Published under the authority of the Minister of Indian and Northern Affairs Canada, Ottawa, 1997.

QS-Y110-000-EF-A1

Recommended citation:
Hart, Craig J. R., 1997. A Transect Across Stikinia: Geology of the Northern Whitehorse Map Area, Southern Yukon Territory (105D/13-16).
Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Bulletin 8, 112 p.

Cover: Looking east across the southern end of Lake Laberge to the Upper Triassic carbonate of the Limestone Range. The limestone contains fossils that are similar to species that existed in tropical portions of the western paleo-Pacific (Tethyan) Ocean. In addition, these limestones contain phylloidal algae which was thought to have become extinct at the end of the Paleozoic era. Near Whitehorse, this limestone unit hosts the numerous copper skarns that make up the Whitehorse Copper Belt. The peaks in the distance at left comprise the Joe Mountain Formation, which is Middle Triassic in age and has no obvious correlatives in the Cordillera.

Preface

This report covers the northern Whitehorse map area which, with four maps, provides a geological transect of the northern Intermontane Belt. This belt is mainly underlain by Stikinia, an island arc terrane whose origin is obscured by a complex Upper Paleozoic and Mesozoic history. The ages of the 25 units described in this report are refined with the assistance of approximately 50 new paleontological control points, and 20 isotopic dates. Many of the units are facies-dominated members of the Whitehorse Trough, which are, for the first time, defined with age control. Newly recognised Upper Paleozoic and middle Triassic volcanic packages add significantly to the tectonic history of the region. Refinements to the stratigraphy and magmatic history of this region are applicable to much of the Intermontane Belt.

The Whitehorse area has a high density of mineral occurrences, and in combination with an earlier phase of 1:50,000 geological mapping central Whitehorse map area, this study provides a geological framework for most of the occurrences within the region. In addition to their use in mineral exploration, the proximity of the study area to the City of Whitehorse ensures that these maps and report will play an increasing role in land use planning.

The area was mapped during the 1992 to 1995 field seasons. Funding was provided by the Canada/Yukon Geoscience Office through the Canada/Yukon Co-operation Agreement on Mineral Resources Development. The project was jointly managed with the Department of Indian Affairs and Northern Development as scientific authority and the Yukon Department of Economic Development as the administering agency.

Trevor Bremner
Chief Geologist and Regional Manager
Exploration and Geological Services Division
Northern Affairs Program, DIAND

Roderic P. Hill
Manager, Mineral Resources Program
Yukon Department of Economic Development

Préface

Le présent document couvre la région qui s'étend au nord de Whitehorse et dont les quatre cartes qui la figurent donne un transect géologique du Domaine intermontagneux septentrional. Ce domaine est principalement formé de la Stikinie, terrane d'arc insulaire dont l'origine est obscurcie par une histoire complexe au Paléozoïque supérieur et au Mésozoïque. L'âge des 25 unités décrites est précisé par une cinquantaine de nouveaux points de contrôle paléontologiques et 20 datations isotopiques. Nombre de ces unités sont des membres faciologiques de la cuvette de Whitehorse qui, pour la première fois, sont datés avec précision. Les cortèges volcaniques du Paléozoïque supérieur et du Trias moyen qui viennent d'être délimités permettent d'approfondir significativement le tectonisme qu'a subi cette région. Les nouvelles données sur la stratigraphie et l'histoire magmatique de cette région s'appliquent à la grande partie du Domaine intermontagneux.

La région de Whitehorse est le siège de grand nombre d'occurrences minérales, et si l'on combine la présente étude à des travaux de cartographie antérieurs à l'échelle de 1/50 000 dans le centre de la région de Whitehorse, elle propose un cadre géologique pour la plupart des occurrences de la région. En plus de servir à l'exploration minérale, ces cartes et le présent document joueront un rôle croissant dans la planification de l'aménagement des terres, la région à l'étude se trouvant à proximité de la ville de Whitehorse.

La cartographie de la région s'est déroulée durant les campagnes de 1992 à 1995. Elle a été financée par le Bureau géoscientifique Canada-Yukon par le biais de l'Accord de coopération Canada-Yukon sur l'exploitation minérale et a été gérée conjointement par le ministère des Affaires indiennes et du Nord canadien, pour l'aspect scientifique, et par le ministère du Développement économique du Yukon, pour l'aspect administratif.

Trevor Bremner
Géologue en chef et gestionnaire régional
Division des services géologiques et d'exploration
Programme des affaires du Nord, MAINC

Roderic P. Hill
Gestionnaire, Programme des ressources minérales
Ministère du Développement économique du Yukon

Contents

Figures

Tables

Appendices

In pocket

Abstract

Results from the geological mapping of four 1:50 000 map areas (NTS 105D/13-16) north of Whitehorse are presented. The maps form a transect across the northern portion of Stikinia — an accreted terrane of uncertain origin. This bulletin establishes a stratigraphic nomenclature, and provides descriptions for 16 units of layered rocks that constitute Stikinia. Portions of the adjacent Cache Creek Terrane, Yukon-Tanana Terrane and the Coast Plutonic Complex are also represented and described. In addition, biostratigraphic and isotopic age constraints are provided for almost all of the units.

Stikinia is composed of several tectonic elements that indicate an episodic depositional history characteristic of an island arc environment. A newly discovered Late Paleozoic package — here called the Takhini assemblage — is defined, and represents the most northerly strata correlated with the Stikine assemblage. Several packages of volcanic rocks of uncertain age and affiliation are here grouped and defined as the Joe Mountain Formation. This enigmatic suite is Middle Triassic in age, tholeiitic in composition, likely represents the initiation of the Whitehorse Trough basin and forms a unique Cordillera assemblage. Upper Triassic calc-alkaline volcanic rocks constitute the Lewes River Arc, and Upper Triassic to Middle Jurassic sedimentary rocks are the fill of a marginal basin known as the Whitehorse Trough.

Strata of the Whitehorse Trough Supergroup include: clasts of deformed Takhini assemblage; deep-water sediments as old as Ladinian; igneous clasts with Permian and Late Triassic isotopic dates; extensive Norian carbonates containing Tethyan faunas and phylloidal algae; Jurassic ammonites that represent almost every ammonite zone as young as Bajocian; and a mixed Tethyan-Boreal Early Jurassic faunal assemblage.

Plutonic rocks of the region are voluminous and, with the benefit of isotopic dates, can be divided into five plutonic suites (Long Lake, Teslin, Whitehorse, Mount McIntyre, Nisling Range), which record Early Jurassic, mid-Cretaceous and Early Tertiary magmatic epochs. Post-Triassic volcanic rocks are well dated and include the Early Jurassic Nordenskiöld dacite, mid-Cretaceous Mount Nansen Group (Byng Creek volcanics), Late Cretaceous Carmacks Group and the Windy-Table suite (Open Creek volcanics).

Mineral occurrences include a number of small copper-gold skarns and gold-quartz veins. Mapping identifies several regions of favourable geology for these and other types of deposits, including carbonate (granodiorite intrusive contacts, faulted caldera margins, altered fault breccias and quartz-rich rhyolite dykes.

Résumé

La cartographie géologique de quatre régions cartographiées à l'échelle de 1/50 000 (105D/13-16) au nord de Whitehorse forme un transect dans la portion septentrionale de la Stikinie — terrane accrété d'origine incertaine. Le présent bulletin contient une nomenclature stratigraphique et la description de seize unités de roches stratifiées comprenant la Stikinie. De petites portions du terrane de Cache Creek, du terrane de Yukon-Tanana et du complexe plutonique côtier qui leur sont adjacentes sont également représentées. De plus, des datations biostratigraphiques ou isotopiques sont également indiquées pour presque toutes les unités.

La Stikinie se compose de plusieurs éléments tectoniques qui révèlent une sédimentation épisodique caractéristique d'un milieu d'arc insulaire. Un cortège du Paléozoïque supérieur récemment découvert, appelé Assemblage de Takhini, est défini et représente les couches les plus septentrionales en corrélation avec l'Assemblage de Stikine. Plusieurs cortèges de roches volcaniques d'âge et d'affiliation incertains sont ici groupés et appelés Formation de Joe Mountain. Cette suite énigmatique date du Trias moyen, est de composition tholéiitique, est probablement à l'origine du bassin de la cuvette de Whitehorse et représente un assemblage exceptionnel de la Cordillère. Les roches volcaniques calco-alcalines du Trias supérieur incluent l'arc de Lewes River, et des roches sédimentaires du Trias supérieur au Jurassique moyen remplissent un bassin marginal appelé cuvette de Whitehorse.

Les couches du Supergroupe de la cuvette de Whitehorse incluent : des clastes de l'Assemblage de Takhini déformé; des sédiments déposés en mer profonde remontant aussi loin qu'au Ladinien; des clastes ignés datés par la méthode isotopique au Permien et au Trias tardif; de vastes roches carbonatées du Norien renfermant des faunes et des algues phylloïdales téthisiennes; des ammonites jurassiques qui limitent presque toutes les zones à ammonites au Bajocien; et une association faunistique du Jurassique précoce à la fois téthysien et boréal.

Les roches plutoniques de la région sont volumineuses et, sur la base de datations isotopiques, elles se divisent en cinq suites plutoniques (Long Lake, Teslin, Whitehorse, Mount McIntyre, Nisling Range) qui témoignent d'époques magmatiques du Jurassique précoce, du Crétacé moyen et du Tertiaire précoce. Les roches volcaniques postérieures au Trias sont bien datées et incluent la dacite de Nordenskiöld du Jurassique précoce, le Groupe de Mount Nansen du Crétacé moyen (roches volcaniques de Byng Creek) et le Groupe de Carmacks du Crétacé tardif et la suite de Windy-Table (roches volcaniques d'Open Creek).

Parmi les occurrences minérales figurent de petits skarns de cuivre-or et des filons de quartz aurifère. La cartographie et la prospection de la région confirment les levés géochimiques régionaux qui révèlent un potentiel accru pour ces types de gisements. La cartographie met également en évidence plusieurs régions dont la géologie est favorable à la présence de ces types de gisements ainsi que d'autres types comme des contacts intrusifs de roches carbonatées-granodiorite, des marges de caldeira fracturées, des brèches de faille altérées et des dykes de rhyolite quartzifère.

Introduction

The northern portion of the Whitehorse map area (105D) is underlain by a diverse assemblage of volcanic, sedimentary, plutonic and metamorphic rocks that record a tectonically active Late Paleozoic to Early Tertiary history of the northern Intermontane Belt (Figure 1). In the southern Yukon, rocks underlying this belt are divided into three terranes, which are juxtaposed along major faults — Stikinia, Cache Creek and Yukon-Tanana. Each terrane reflects a different stratigraphic and deformational history. A transect across Stikinia just north of Whitehorse (61°N latitude) is provided by four 1:50 000 maps (105D/13-16), and includes portions of the Coast Plutonic Complex and adjacent terranes.

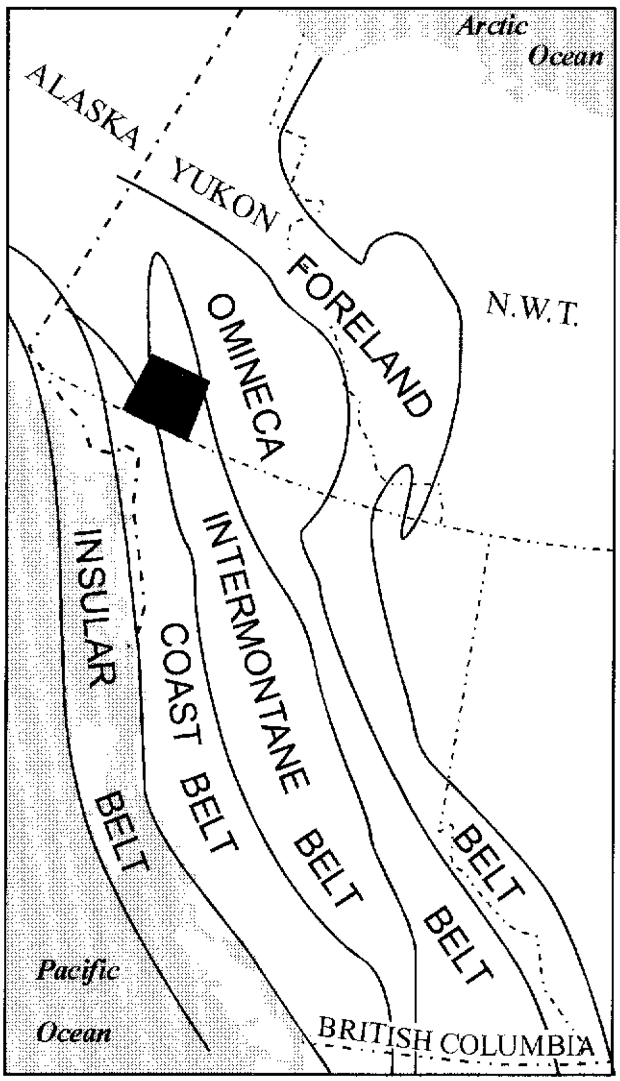


Figure 1. The Canadian Cordillera is divisible into five morpho-physiographic belts. The study area is largely within the northern portion of the Intermontane Belt. The Whitehorse 1:250 000 map sheet (105D) is shown in black. The study area is the northern portion of the black polygon and is shown in Figure 2.

The stratigraphy and ages of many of the units in the map areas were previously poorly understood or poorly defined. This bulletin establishes a stratigraphic nomenclature for the layered rocks and provides biostratigraphic and isotopic dates for most of the approximately 25 units.

Accurate geological maps for these areas have many applications. Copper, gold and silver deposits have been mined from several localities near Whitehorse, but deposits have not been found in the northern Whitehorse map area. Bedrock geology maps identify geological settings that might be favourable hosts to such mineralization. Furthermore, many mineral deposits in the Yukon are related to specific volcanic or plutonic units and being able to identify the locations of these rocks is essential for successful exploration. In addition, these maps provide a geological cross-section of the northern Intermontane Belt, which benefits our understanding of the rocks along the regional strike. The map areas also include the northern City of Whitehorse, several rural subdivisions and associated infrastructure, and proposed protected regions and lands set aside for jurisdiction by First Nations people. These maps will play a necessary role in land-use planning.

The map areas were studied during the 1992-1995 field seasons. This work is the second phase of the Whitehorse Geological Mapping Project, and adds four new maps to those areas completed during the first phase (1987-1990; Hart and Radloff, 1990; Figure 2). Both projects were funded by Canada/Yukon Economic Development Agreements.

As the regions covered by this project contain relatively few place names, many location references in the text relate to spot elevations of topographic highs on the 1:50 000 scale National Topographic System maps. Localities mentioned in the text are shown in Figure 3. Sample location co-ordinates for maps 105D/13 (Edition 2), 105D/14 and 105D/15 (both Edition 3) are based on North American Datum 1927; map 105D/16 (Edition 1) is based on North American Datum 1976 and has metric topography.

Access

Although the valleys north and west of Whitehorse, Yukon's largest city, are extensively developed, the surrounding mountains are infrequently traversed. Much of the geological exposures in the western map areas (105D/13, 14) are within walking distance of roads, whereas the eastern areas (105D/15, 16) require helicopter access (Figure 3). Map area 105D/13 is bisected by the paved Alaska Highway. Secondary roads follow the valleys of the Ibex River, Thirty-seven Mile Creek and the north side of the Takhini River (Old Dawson Trail). Across these valleys are a

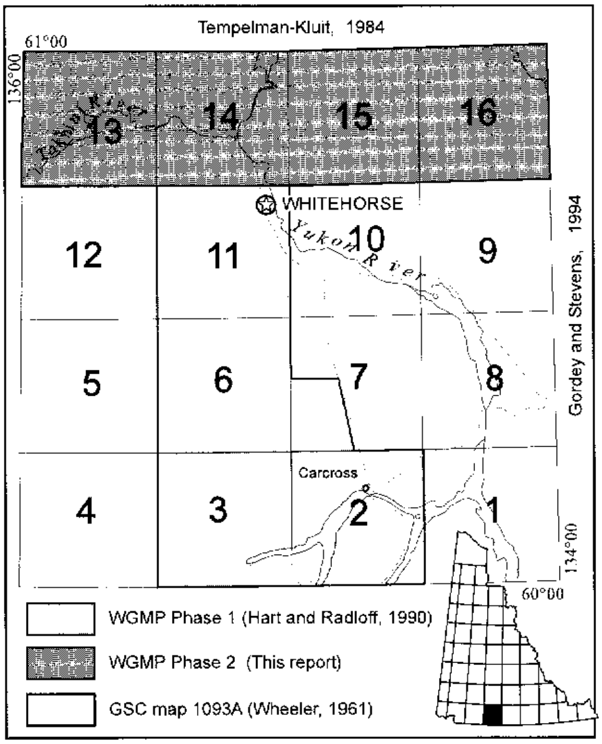


Figure 2. Index map showing locations of geological studies in the Whitehorse map sheet (105D). The map sheet is divisible into 16 1:50 000 map areas. The shaded areas denote the region covered by this report and by previous mapping of the Whitehorse Geological Mapping Project. Maps of Hart and Radloff (1990) were preceeded by maps of Doherty and Hart (1988) and Hart and Pelletier (1989a, b). This report also benefits from studies in the adjacent Laberge (Tempelman-Kluit, 1984) and Teslin (Gordey and Stevens, 1994a, b) map areas.

dense array of spur roads that are used to access timber for firewood. Map area 105D/14 is trisected by the paved Alaska and Klondike highways and accessed by good-quality secondary roads in the Takhini Hotsprings area and southwest of Lake Laberge. Similarly, there is excellent access along woodcutting roads in the western part of this sheet. The secondary and woodcutting roads throughout the western part of the map area are generally in good condition and require four-wheel drive only during wet periods.

The Joe Mountain sheet (105D/15) lacks roads or major trails. Access to the mountainous regions is by helicopter, although float planes can easily access most of the M'Clintock Lakes. The M'Clintock (or Michie Lake) winter road extends into the central part of the Mount M'Clintock sheet (105D/16) and a branch passes through the valley north of Augusta Mountain. The main branch follows Byng Creek northward to the top of its drainage and continues to the upper Sheldon Creek placer workings. Although sections of this road are badly rutted, muddy, washed out and overgrown, the road is passable during the summer months by all-terrain or tracked vehicles. A trail, shown on older maps leading from the Teslin River to Sheldon Creek, is completely overgrown and could not be found.

Previous work

The first recorded geological observations in the study area were by G. M. Dawson, while descending the Yukon River (Dawson, 1889). Reconnaissance coverage (1:250 000 scale) of the Whitehorse map area (105D) by Cockfield and Bell (1926, 1944) and subsequently by Wheeler (1961) provide the regional geological framework for this study. More recent mapping (1:250 000 scale) of the Laberge (105E, Tempelman-Kluit, 1984) and Teslin (105C, Gordey and Stevens, 1994a, b) map areas, as well as 1:50 000 mapping in the central Whitehorse map area (Hart and Radloff, 1990) has advanced the understanding of the regional geology and provided the foundation for many of the rock units used in this report. This report, and contained maps, supersedes reports and maps previously released as preliminary products (Hart and Brent, 1993; Hart, 1993a; Hart and Hunt, 1994a, b; 1995a, b).

Detailed and topical investigations within the map area provided a greater understanding of the Laberge Group conglomerate (Dickie, 1989; Dickie and Hein, 1995); Laberge Group biostratigraphy (Pálfy and Hart, 1995; Jakobs, 1994); granitic rocks in the western map area (Fyles, 1950); granitic rocks in the Cap Creek area (Morrison et al., 1979); structure of the Rabbitsfoot Canyon area (Stretch, 1993); structure of the Horse Creek ultramafite (Brown, 1994); geology of the Mount M'Clintock area (Schönicke and Weihe, 1992); and mineralization in the Mount Byng area (Bremner, 1991). Studies from just outside the study area that have a bearing on the regional geology include: an examination of the geology of the Whitehorse Copper Belt (Morrison, 1981); an evaluation of the carbonate reefs in the Lewes River Group (Reid, 1985); and new geochronology and an evaluation of the magmatic evolution of much of the Whitehorse area (Hart, 1995). In addition, several assessment reports accompanying mineral exploration activity provided useful geological information for specific areas. The report by Doherty (1988) was particularly valuable.

The Whitehorse Copper Belt consists of more than 25 skarn deposits that form a 30-km-long belt, from which over 123 000 tonnes of copper, 90 tonnes of silver and 7 tonnes of gold have been extracted (INAC, 1983). The northern extension of this belt is present in the map area (105D/14) and has attracted significant exploration efforts. However, despite its proximity to Whitehorse, the rest of the study area has been considerably less explored. Regional-scale exploration was undertaken by United Keno Hill

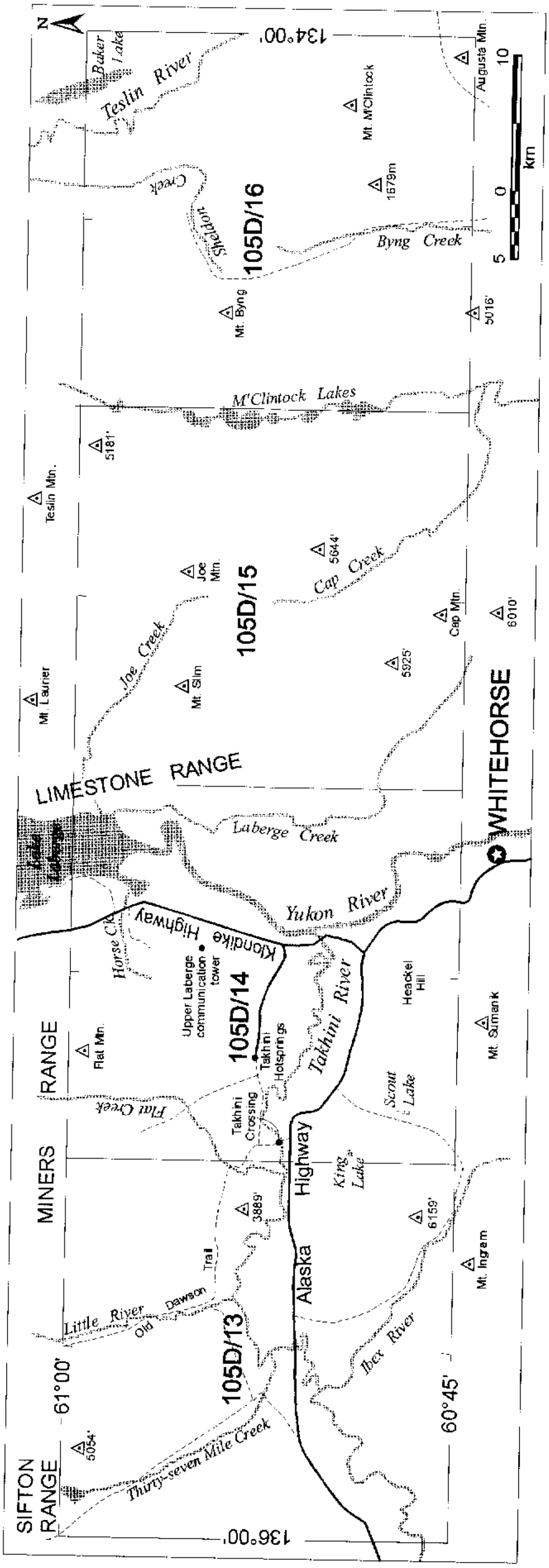


Figure 3 (left). Map showing the region covered by the four 1:50 000 map areas in this study, as well as the topographic and cultural features referred to. Note the numerous spot elevations of peaks whose locations are denoted by triangles, and used as reference features in the text. Dashed lines denote dirt roads of variable quality.

Mines in 1975, Hudson Bay Mining and Smelting in 1979, and Dupont Exploration in 1981, each effort directed primarily toward the discovery of copper skarns. Regional-scale geochemical silt sampling of the 105D map area by the Geological Survey of Canada (1985) identified several gold anomalies. That program spurred claim staking in the Joe Mountain map sheet by United Keno Hill Mines, but no further exploration effort has been documented.

Physiography

The study area is largely within the Teslin Plateau physiographic region (Mathews, 1986) of the Intermontane Belt but is divisible into two physiographic entities. The region west of the Yukon River is characterized by relatively low relief, low plateaus, rolling mountains and upland plateaus dissected by broad glacial valleys. The region east of the Yukon River is topographically higher and dominated by jagged mountains, cirques, arrÎtes and broad, north-trending plateaus between 5500 ft. (1670 m) and 6000 ft. (1830 m), which are dissected by steep-sided valleys. In this part of the study area, there is a strong correlation between rock type and physiography. Volcanic rocks typically support high, craggy mountains, plutonic rocks form reasonably high-standing (5000 ft./1520 m) plateaus and sedimentary rock units underlie plateaus and ridges with muted topographic expression.

The Yukon, Teslin, M'Clintock and Takhini rivers lie within wide, mature valleys. Secondary drainage features, such as the M'Clintock, Ibex and Little rivers, as well as Thirty-seven Mile Creek, severely underfit similarly broad valleys. The valleys are generally between 2100 to 2500 ft. (640-760 m) in elevation and covered by thick deposits of glacial debris and alluvium. Downcutting by the Yukon and Takhini rivers exposes evidence of a complex glacial history.

Glaciation and postglacial deposits

The study area was extensively glaciated during the McConnell (Wisconsin) advance (Jackson et al., 1991), and glacial features of the Whitehorse map area were well documented by Wheeler (1961). Significant glacial features in the map area are shown in Figure 4.

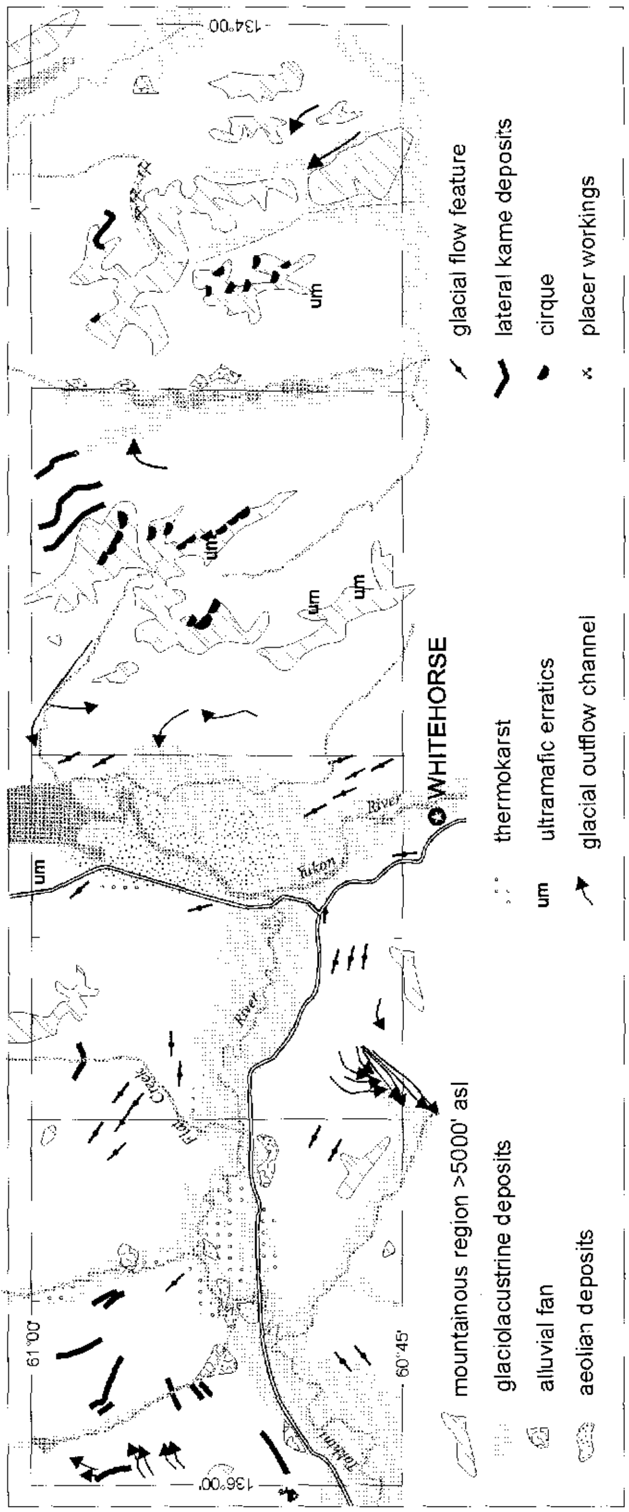


Figure 4 (left). Compilation map of surficial geology and locations of significant glacial and postglacial features in the study area. The physiography of this region of the Teslin Plateau is divisible into a western region of low relief and subdued topography and an eastern region of mountainous topography sculpted by alpine glaciation. Continental glaciers originating from the Cassiar Lobe moved northwestward across the area although the extreme western area was influenced by the northeastward movement of the Coastal Lobe. Glaciolacustrine deposits are particularly thick in the Takhini and Yukon River valleys. Data compiled from Wheeler (1961), Morison and Klassen (1991) and author's observations.

Glacial striae and erratics were regionally observed at 5500 ft. (1670 m), and as high as 5900 ft. (1800 m) near Joe Mountain. Glacial striae and drumlinoid features indicate that continental ice sheets moved northwest across the eastern region, following the Teslin, M'Clintock and Yukon River valleys (Figure 4). Numerous boulder erratics of tectonized ultramafite deposited on several southeast-facing slopes east of the Yukon River constitute a northwest-trending array originating from large ultramafite bodies of the Cache Creek Terrane. In the western part of the map area, ice moved eastward down the Takhini River valley, as indicated by glacial features and the presence of metasedimentary erratics as far east as lower Flat Creek. Northeastward ice flow was also reported from the adjacent Dezadeash sheet (Kindle, 1953). The zone of interaction between these two flow directions represents the culmination of the Coastal and Cassiar ice sheets.

Cirques are abundant only in the eastern map areas above 5000 ft. (1520 m). Glacial deposits are extensive below 4500 ft. (1370 m), which is the approximate elevation of the treeline. Kame terraces form numerous, continuous benches throughout the map area, as high as 5100 ft. (1555 m). Remnants of stacked strand lines are common throughout much of the map area between 4500 ft. and 5000 ft. (1370 and 1520 m). Glacial outwash deposits, particularly, kame and deltaic deposits, provide abundant aggregate deposits, which are exploited in more than 50 gravel pits in the western map area. Near Scout Lake, at least eight 'stacked' glacial outwash channels indicate that glaciolacustrine waters drained southwestward into the Ibex valley. Terrain dominated by eskers occurs in the M'Clintock and Teslin River valleys as well as east of Laberge Creek.

Postglacial deposits of varved glaciolacustrine silt and clay are widespread throughout the Takhini and Yukon River valleys. They are 30–70 m thick and typically capped by 1–5 m of fluvial sands and gravels, which in turn, are mantled by loess and eolian deposits. Eolian sand deposits dominate the region south of Lake Laberge to south of the Takhini River, where they form large parabolic dunes, largely covered by soil and trees.

The timing of deglaciation in the Whitehorse area is not precisely known but analysis of organic material from the bottom of a core containing lake sediments deposited on top of glaciolacustrine silt in the Takhini River valley gave a date of circa 11 ka (Cwynar, 1988). This suggests that not only had the glaciers retreated by this time, but that the waters of the glacial lakes had drained by then. Archeological evidence indicates that human occupation on glaciolacustrine sediments south of Whitehorse occurred approximately 9000 years ago (Hare, 1995). Examination of fossil pollen from a core containing sediments from a nearby shallow pond indicates that the region was dominated by white spruce, and juniper until 6.1 ka, when it was replaced by black spruce, which dominated until 4.1 ka (Cwynar, 1988). This wetter climate appears to have continued until approximately 2000 years ago, when the forests were again dominated by white pine.

Several localities of actively enlarging thermokarst lakes occur in the Takhini River area. The lakes are two to three metres deep, typically have collapsing banks and are formed within glaciolacustrine clays and silts (Klassen, 1979; Burn, 1987). Cores in the region locally intersected ice to depths of at least 9.5 metres. Alkaline basins on flat depressions upon glaciolacustrine silt in the Takhini River area and west of the Klondike Highway, are easily recognized by the accumulation of white sodium-rich saline crusts. The peculiar conditions at these sites favour the presence of rare and unusual herbs, insects and halophytes (Schweger et al., 1987).

Numerous continuous, parallel, north-northeast-trending air photo lineaments traverse the Annie Ned Batholith and Flat Creek pluton. These features are gullies, crevices and narrow canyons that are particularly well developed within the typically well-jointed granitic bodies. The features appear to be postglacial zones of expansion that resulted from postglacial rebound.

Acknowledgements

This bulletin benefits from the foundation laid down by John Wheeler and his subsequent inspiration. Julie Hunt provided exceptional field assistance (1993, 1994) and contributed to much of the geological interpretation and many of the concepts presented herein. Additional field assistance was provided by Jay Timmerman (1995) and Diane Brent (1992).

Conversations with, and detailed stratigraphic sections provided by, John Dickie gave the section on the Laberge Group an added dimension. Discussions with Mitch Mihalynuk, Grant Abbott, Stephen Johnston, Derek Thorkelson, Gary Johannson, Steve Gordey, and Derek Brown about Cordilleran geology continually refreshed the concepts presented in this bulletin. Mitch Mihalynuk also contributed to the definition of the magmatic epochs. Thanks also goes out to the prospectors and exploration company personnel who kept me in touch with developments throughout the region. Contributions of data and interpretations from Jim Mortensen, Mike Orchard, Jozsef Pálfy, Howard Tipper and Tim Tozer are appreciated and have added considerable depth to this report.

Tectonic Setting

Yukon Territory southwest of the Tintina Fault consists primarily of dissimilar fault-bounded crustal fragments, or terranes, that accreted to the ancient North American margin during the Mesozoic (Figure 5). Rocks underlying the study area belong to Stikinia, with flanking portions of the Cache Creek and Yukon-Tanana terranes (Figure 6). Each of these terranes has a unique pre-Cretaceous stratigraphic and deformational history that defines it-Cretaceous and younger rocks are not terrane specific.

Stikinia, the largest of the accreted Cordilleran terranes, is more than 1500 km long and 300 km wide at its widest point. In southern Yukon, Stikinia is 80 km across and composed of four tectonic elements: the Paleozoic Stikine assemblage, the Middle Triassic Joe Mountain volcanics; the Late Triassic Lewes River Arc and the Upper Triassic-Middle Jurassic Whitehorse Trough (Figure 7). Stikine assemblage rocks were deposited as part of a long-lived oceanic-arc complex. Joe Mountain volcanics are a local unit that may have originated as oceanic floor basalts, but were more likely a tholeiitic precursor to the more extensive Lewes River Arc. The Lewes River Arc was a calc-alkaline island arc that developed, at least in the west, on a basement of Stikine assemblage rocks.

The Whitehorse Trough was a marginal basin in which seven kilometres of detritus accumulated east of the developing and eroding Lewes River Arc (Figure 5). Whitehorse Trough strata were deposited on the Lewes River Arc in the west, and apparently on the Joe Mountain volcanics in the east (Figure 7). However, occurrences of serpentinized peridotite suggest that oceanic crust may exist beneath the central and eastern parts of the trough. Whitehorse Trough strata are lithologically diverse, stratigraphically complex and characterized by abrupt facies changes. This complexity reflects and records the nature of tectonic activity during deposition. The western, central and eastern facies belts reflect proximal, medial and distal facies, respectively, although some proximal facies clastics in the eastern belt indicate a possible eastern source.

The Whitehorse Trough was originally defined by Wheeler (1961) as a geosyncline that developed adjacent to a flanking arc. A back-arc origin was suggested by Tempelman-Kluit (1978) and Bultman (1979). Tempelman-Kluit (1979) proposed a fore-arc origin for the Whitehorse Trough, after mapping in the Laberge map area (Tempelman-Kluit 1978, 1980). Eisbacher (1981) stressed that, as subduction polarity may have changed during the basin's history, the term "arc-marginal basin" should be retained (Eisbacher,

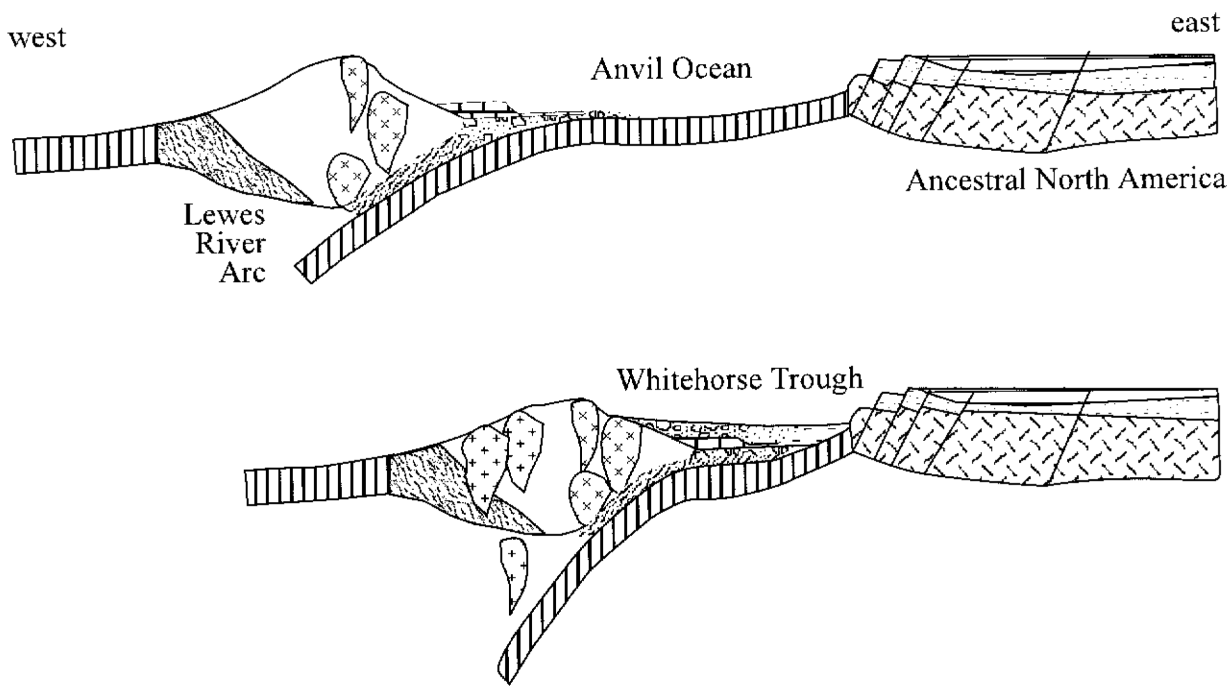


Figure 5. Schematic tectonic cross-section showing the development of the Whitehorse Trough in a fore-arc basin above a west-dipping subduction zone. This model, modified from Tempelman-Kluit (1979), shows the Lewes River arc constructed upon a Stikine assemblage basement (shaded), and not continental crust of the Yukon-Tanana Terrane. Whitehorse Trough is also shown to be partly underlain by oceanic rocks that floored the Cache Creek ocean. Whitehorse Trough deposition ceased when the trough was cut off from marine waters during the Intermontane Superterrane's accretion with North America in the Middle Jurassic.

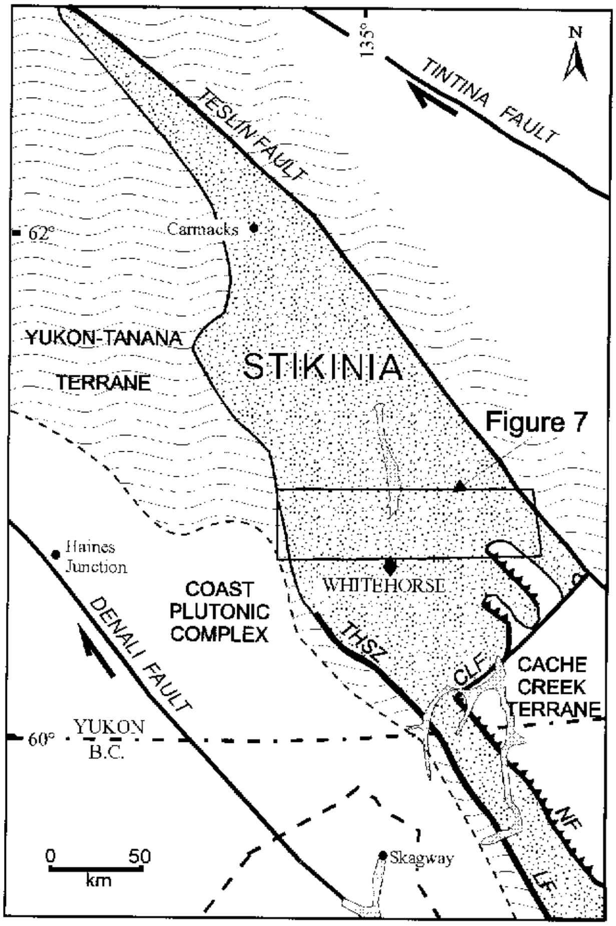


Figure 6. Tectonic setting of Stikinia, Yukon-Tanana and Cache Creek terranes in southern Yukon Territory modified from Wheeler and McFeely (1991). These terranes are the main component of the Northern Intermontane Superterrane. The study area (see Figure 2) is a transect across the various tectonic elements that constitute Stikinia, and includes portions of the adjacent terranes and the Coast Plutonic Complex. THSZ=Tally Ho shear zone; LF=Llewellyn Fault; CLF=Crag Lake Fault; NF=Nahlin Fault.

1974). The Whitehorse Trough as an east-facing, fore-arc basin is the keystone of Tempelman-Kluit's (1979) terrane assemblage model. This tenet has been supported by other workers, who confirm west-dipping subduction (Morrison, 1981; Hansen, 1987, 1988). Variations in facies and unit thicknesses documented in this report emphasize an eastward-deepening basin, but cannot substantiate basin-type, as the eastern margin of the basin is not known. This alone may be enough to preclude a back-arc origin and confirm a fore-arc origin.

The Cache Creek Terrane in the northern Cordillera comprises a Carboniferous to Permian oceanic assemblage dominated by carbonate, chert and mafic volcanic rocks. Minor but important occurrences of tectonized, alpine ultramafic bodies locally define the perimeter of this terrane. The Yukon-Tanana Terrane is composed of Paleozoic and older, pericratonic metasedimentary and metaigneous rocks that include an older, quartz-rich member known as the Nisling assemblage.

Terrane amalgamation

The amalgamated Stikinia, Cache Creek and Yukon-Tanana terranes collectively constitute the Northern Intermontane Superterrane (Johnston et al., 1993, 1994). Stikinia is juxtaposed with the Cache Creek Terrane along the Nahlin, Crag Lake and associated faults (Figure 6). These faults are partly delimited by occurrences of tectonized ultramafite. North of the Crag Lake Fault, Cache Creek Terrane rocks occur as thrust sheets above Stikinia, which have been cut by later normal faults to form horsts of Stikinia rocks and grabens of Cache Creek rocks (Gordey and Stevens, 1994a, b). The timing of amalgamation of the northern Stikinia and Cache Creek Terranes is restricted to the period after deposition of the youngest Cache Creek strata (late Early Jurassic; Cordey et al., 1991) but before the intrusion of the Fourth of July batholith into deformed Cache Creek strata at 172 Ma (Mihalynuk et al., 1992). Coarse clastic sediments dominated by chert attest to an emmergent Cache Creek Terrane by at least Bajocian time. Crustal thickening, resulting from Cache Creek obduction, may have initiated Middle Jurassic magmatism.

Yukon-Tanana Terrane rocks are faulted against Stikinia along its western and eastern contacts. The Tally Ho shear zone, a ductile deformed belt of metabasite with sinistral kinematic indicators forms Stikinia's western limit and is overprinted by brittle, dextral faulting of the Llewellyn Fault (Hansen et al., 1990; Radloff et al., 1990; Hart and Radloff, 1990). Eastern Stikinia is separated from the Yukon-Tanana Terrane by an unnamed fault along which Gordey and Stevens (1994a) indicated pre-mid-Cretaceous dextral movement. This fault is probably not the structure along which these two terranes were originally juxtaposed. The nature of the original juxtaposition is controversial. Currie and Parrish (1993) interpreted Yukon-Tanana Terrane rocks as overriding Stikinia, whereas Johnston and Erdmer (1995) interpreted the Yukon-Tanana Terrane as being driven beneath Stikinia. Interaction between Stikinia and the Yukon-Tanana Terrane may be as old as Late Triassic (Jackson, Gehrels et al., 1991), but most workers agree that these terranes were amalgamated by about 185 Ma.

The final amalgamation of the Intermontane terranes coincided with their accretion to the ancient margin of North America in the Middle Jurassic.

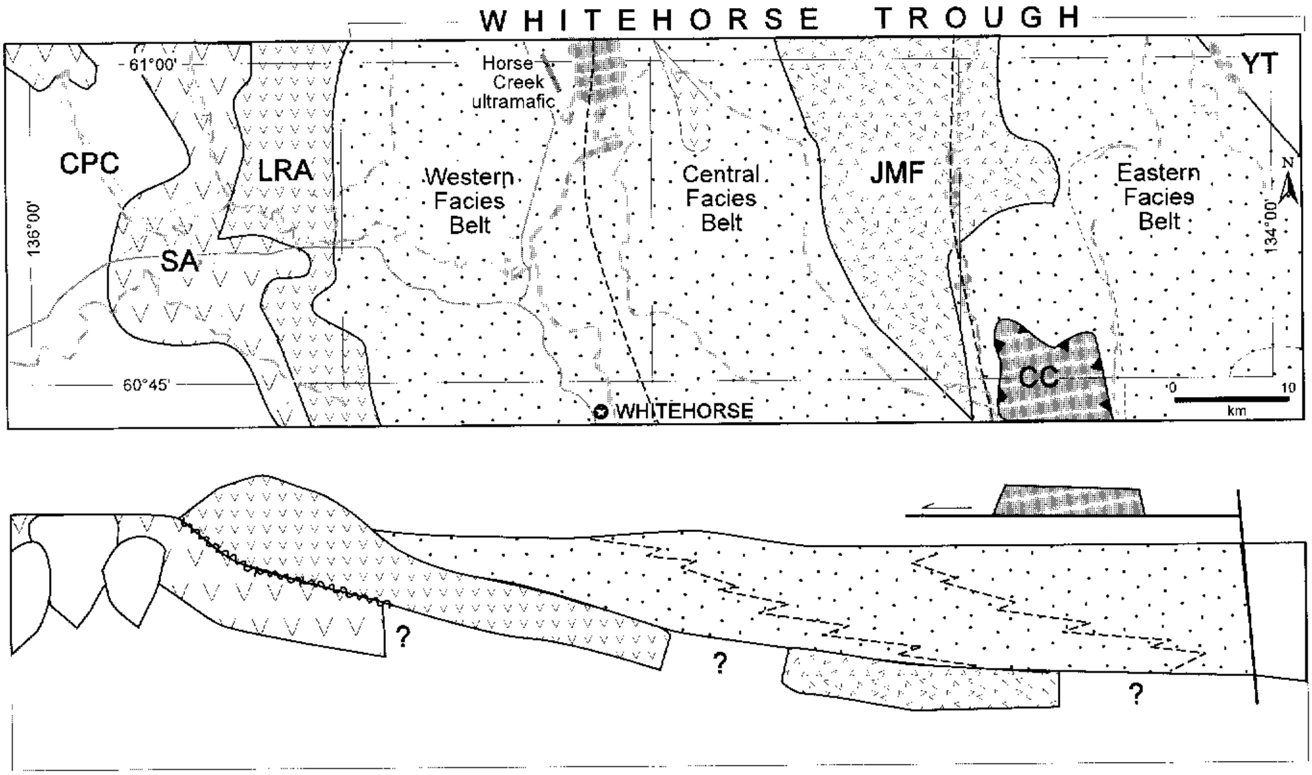


Figure 7. Major tectonic elements as displayed before deformation and Cretaceous magmatism. Cretaceous and younger rocks are not shown. The Coast Plutonic Complex is represented by Early Jurassic plutons of the Long Lake suite. The cross-section is schematic with no implied vertical scale, but shows the known and uncertain relations between the elements and terranes. Stipple pattern represents Whitehorse Trough Supergroup. Cache Creek Terrane (CC) is shown as a klippe although there is no information from the study area to confirm this. CPC=Coast Plutonic Complex, SA=Stikine Assemblage, LRA=Lewes River arc, JMF=Joe Mountain Formation, YT=Yukon-Tanana Terrane.

These events resulted in the shallowing and eventual closure of the Whitehorse Trough basin. The later phases of amalgamation likely resulted in the widespread deformation throughout the terranes.

Early Jurassic, mid- and Late Cretaceous magmatism attest to episodic emplacement of numerous plutons and coeval volcanic successions within and above the deformed crustal fragments. Regional stresses during the Late Cretaceous to Eocene reactivated existing faults and created a new series of north- and northwest-trending strike-slip faults.

Geology

The study area is underlain by portions of three terranes, each with a different pre-Cretaceous stratigraphy but similar Cretaceous and younger volcanic and plutonic rocks (Figure 7). The Yukon-Tanana Terrane is represented by rocks of the Nisling assemblage and the Cache Creek Terrane by rocks of the Cache Creek Group. Stikinia contains the Takhini assemblage, Joe Mountain Formation, Lewes River and Laberge groups. Rocks of the Joe Mountain Formation are lithologically similar to strata assigned to the Cache Creek Group but have a depositional association with Stikinia. Plutonic rocks are of Early Jurassic, Cretaceous and Early Tertiary age and belong to the Long Lake, Teslin, Whitehorse, Mount McIntyre and Nisling Range plutonic suites. Volcanic rocks include Jurassic Nordenskiöld dacite, the mid-Cretaceous Byng Creek volcanic complex and the Late Cretaceous Carmacks Group basalt.

Unreferenced isotopic age dates mentioned in the text are documented under Geochronology and in Appendices 5 and 6. Whole rock geochemical analyses from samples obtained throughout the study area are presented in Appendix 8.

Yukon-Tanana Terrane

Nisling Assemblage

Steep southwest-dipping, light brown and pink quartzite, and quartz-mica schist underlie the extreme northeastern part of the study area. The metasedimentary rocks are separated from the Laberge Group strata of Stikinia by a northwest-trending fault, and are overlain by flows of the Late Cretaceous Open Creek volcanics. The metasedimentary rocks are characteristic of the Nisling assemblage, which constitute the basal part of the Yukon-Tanana Terrane (Mortensen, 1992). Age constraints from strata in the Teslin map area that are equivalent to the Nisling assemblage suggest that it is pre-Devonian in age (Gordey and Stevens, 1994b), and may be as old as Proterozoic.

Cache Creek Terrane

Cache Creek Group

Rocks of this group occur in the southernmost part of map area 105D/16, and as a linear body west of the south end of Lake Laberge. They are massive, dark-green, variably altered, aphyric basalt with associated massive, dark-green, fine-grained, non-magnetic diabase and gabbro, with minor dun orange-brown weathering, strongly magnetic, serpentinized peridotite. These rocks are strongly chloritized and share characteristics such as reticulate networks of numerous white veinlets, with the Joe Mountain Formation.

The original contacts with adjacent units are not exposed, as they have been invaded by Cretaceous intrusive rocks. Despite similarities with the Joe Mountain Formation, the presence of serpentinized ultramafite suggests a strong correlation with the Cache Creek Terrane, which is abundant south of the map area. The lack of additional constraining data precludes a definitive correlation. These rocks yield no independant data with respect to their age or timing of emplacement.

Horse Creek ultramafite

A linear body of tectonized ultramafite is exposed west of the south end of Lake Laberge, north of Horse Creek. The occurrence strikes north-northwest for four kilometres and dips steeply to moderately to the east. In most localities this unit is 10-20 m wide, but is considerably wider (70 m) at its most southerly exposure. Although the ultramafite is thoroughly tectonized and altered to talc-serpentinite schist, immediately adjacent, steeply-dipping and tightly folded Laberge Group greywacke shows no evidence of shearing or faulting.

Within the tectonized serpentinite are numerous knockers and augen of undeformed ultramafic protoliths, which range up to a metre in diameter (Figure 8). The lenticular blocks are black to dark-green, fine-grained, highly-magnetic and variably serpentinized spinel lherzolite, spinel harzburgite and spinel peridotite (Brown, 1994). The knockers locally contain asbestos-filled extensional fractures at an acute angle to the main foliation direction. The matrix is a highly-sheared array of flattened and fissile scales of talc, serpentinite, chlorite, magnetite and hypersthene. Other minerals contained within the ultramafite include magnetite, ilmenite, forsterite,

Figure 8. A fist-sized augen of lherzolite in steeply-dipping, tectonized serpentinite of the Horse Creek ultramafite represents the protolith of the sheared serpentinite found in the matrix.

iddingsite and brucite. Wheeler (1961) also reported chromite and garnet.

Several metres of the western (hanging-wall) margin of the ultramafite are finer grained than the main body, have a lower percentage of fragments, and may represent a higher degree of cataclasis. The fragments are as described above. The matrix is black, fine grained and graphitic and hosts small (<2 cm), angular, unoriented fragments. This margin forms obvious, orange-weathering, resistant outcrops that result from intensive carbonate alteration, which overprints the cataclasite but only weakly affects the adjacent Laberge Group wacke. The alteration also results in the formation of green chromium micas and late-stage magnesite and ankerite veins.

The eastern portion of the ultramafite, best exposed in more southerly outcrops, is composed of massive outcrops of 10–50% angular ultramafite fragments in a fine-grained, blue-grey groundmass. Although this rock has the appearance of a cataclasite, the unsheared and unaltered appearance, and lack of fabric, suggest that it may be sedimentary melange.

Ductile deformation associated with shallow-plunging lineations indicate dominantly dextral, strike-slip displacement, but a rigorous kinematic evaluation has not been performed. Ductile deformation was followed by brittle deformation and the emplacement of late-stage carbonate veins in extensional fractures.

Interpretation and age

Questions about the emplacement of the Horse Creek ultramafite remain unanswered. The parallelism of the ultramafite, its foliation and the trend of the axial planes of the surrounding Laberge Group greywacke suggest a genetic link between deformation and folding. However, the greywacke has not endured the intensity of shearing and alteration that deformed the ultramafite. Furthermore, it does not appear that the greywacke has been faulted against the ultramafite; the greywacke on each side of the ultramafite is likely the same. It is possible that the greywacke was deposited upon the already sheared, altered and exposed ultramafite. However, because the entire thickness of the Lewes River Group is absent, the ultramafite must have occupied a high-standing position within the Whitehorse Trough, thus precluding the accumulation of Lewes River Group detritus. Upper Triassic sandstone east of Lake Laberge contains detrital chromium mica as a minor component (Reid, 1985) suggesting that altered ultramafite was exposed at this time.

The Horse Creek ultramafite yields a very high aeromagnetic response (>3000 gammas) that forms a narrow linear belt, which continues south-southeast, far beyond its surface exposure, across the Yukon River valley and east of Whitehorse (GSC, 1966, 1967). The magnetic linear belt aligns with, and is continuous with, ultramafic exposures that extend from Cantlie Lake to the south end of Marsh Lake. This large structure and the tectonized ultramafic rocks indicate the proximity of Cache Creek oceanic rocks either as basement to Triassic and Jurassic rocks of the Whitehorse Trough (Hart, 1993b) or as down-dropped portions of obducted Cache Creek klippe (Gordey, 1993).

The age of the ultramafic rocks is unknown, although Cache Creek ultramafic rocks are typically Permian and older. The age of the structure cannot be constrained, but ductile deformation was probably pre-Late Triassic and late brittle motion and associated carbonate alteration was probably Middle Jurassic in age.

Stikinia

Stikinia in the Yukon is composed of the Upper Paleozoic Takhini assemblage, Triassic volcanics and Upper Triassic-Middle Jurassic Whitehorse Trough Supergroup. The Takhini assemblage rocks are the westernmost occurrences of Stikinia in the Yukon. The Triassic volcanics include the Middle Triassic Joe Mountain Formation and the Late Triassic Lewes River Group. Whitehorse Trough strata consist of Upper Triassic Lewes River Group and the Lower-Middle Jurassic Laberge Group. No type sections have been designated and no unequivocal boundaries defined for any units, except those presented in this report. Formation and member names have been suggested for most of the Mesozoic rocks (Tempelman-Kluit, 1984) but they too lack type sections, boundaries and age constraints. Nomenclature and age ranges for units used in this report are given in Figure 9.

Takhini Assemblage

A package of variably deformed and metamorphosed mafic volcanic rocks in the western part of the map area forms a northwest-trending belt of discontinuous exposures from Mount Ingram to the Sifton Range. Originally considered to be deformed members of the Lewes River Group, they are considerably older than Triassic, as shown by recent age dating. Many of these outcrops, and much of this unit's western extent, are screens and pendants within the granitic rocks that constitute the eastern Coast Plutonic Complex. Takhini assemblage rocks are not found west of these intrusions, but pendants were also mapped by Wheeler (1961) south of the map area. The eastern contact of the Takhini assemblage, although not well defined, is recognized by a sharp decrease in the intensity of deformation, which likely coincides with an angular unconformity of overlying undeformed volcanic and sedimentary rocks.

Most of the Takhini assemblage comprises greenstone, greenschist or metabasite, but amphibolite, gneiss, schist and rare felsic metavolcanics and orthogneiss are also present (Figure 10). Less deformed equivalents include dark-weathering, massive to pillowed to fragmental, fine- to medium-grained basalt and basaltic andesite flows, breccia, tuff and a minor sedimentary component (Figure 10a, b). The deformed mafic rocks are composed of chlorite, actinolite, augite, albite and epidote with lesser biotite, muscovite and hornblende. Characteristically, the rocks contain augite phenocrysts, which locally form crowded porphyries and pyroxene gabbro. Amphibolitic rocks occur adjacent to the granitic rocks and as pendants within the plutons. Rare exposures of felsic rocks, such as rhyolite and its metamorphosed equivalents, quartz-sericite and quartz-biotite schist, are restricted to east of the mouth of the Ibex River (Figure 11).

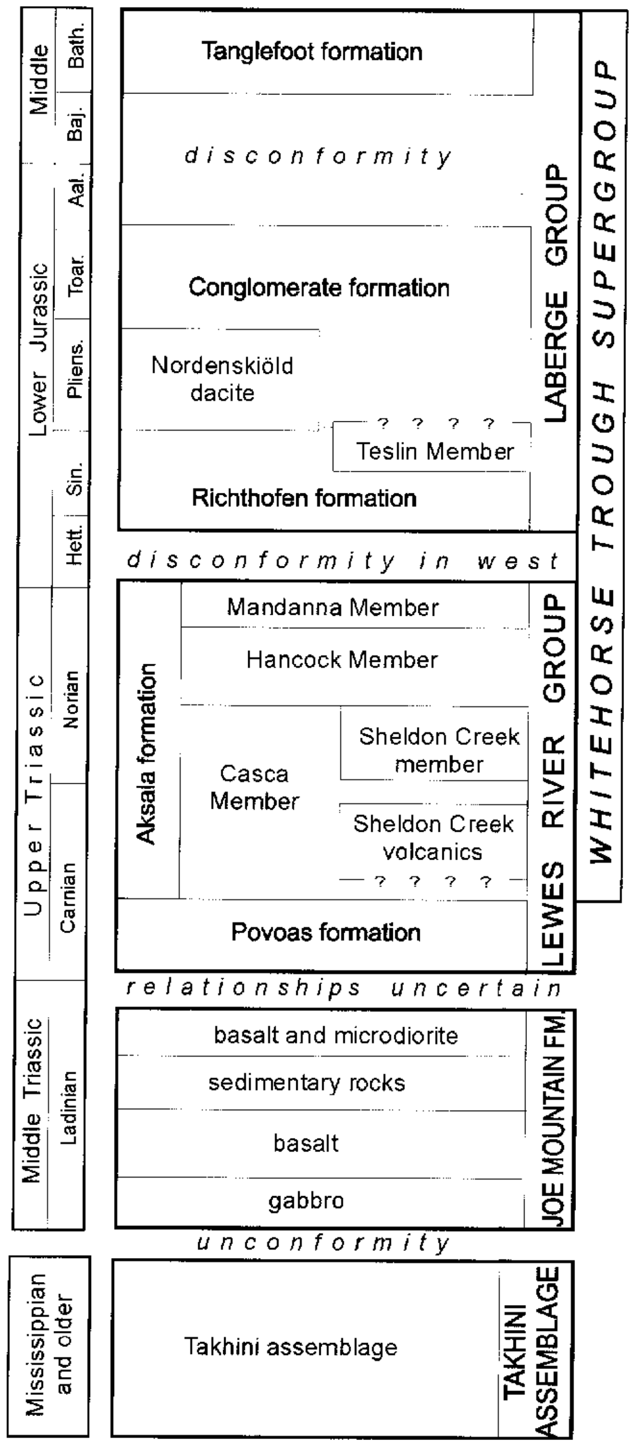


Figure 9. Temporal distribution and stratigraphic relationships of the units constituting Stikinia in the study area.

The sedimentary rocks are dominated by volcanogenic greywacke that is gradational to plagioclase and pyroxene crystal-lithic tuff. When deformed and

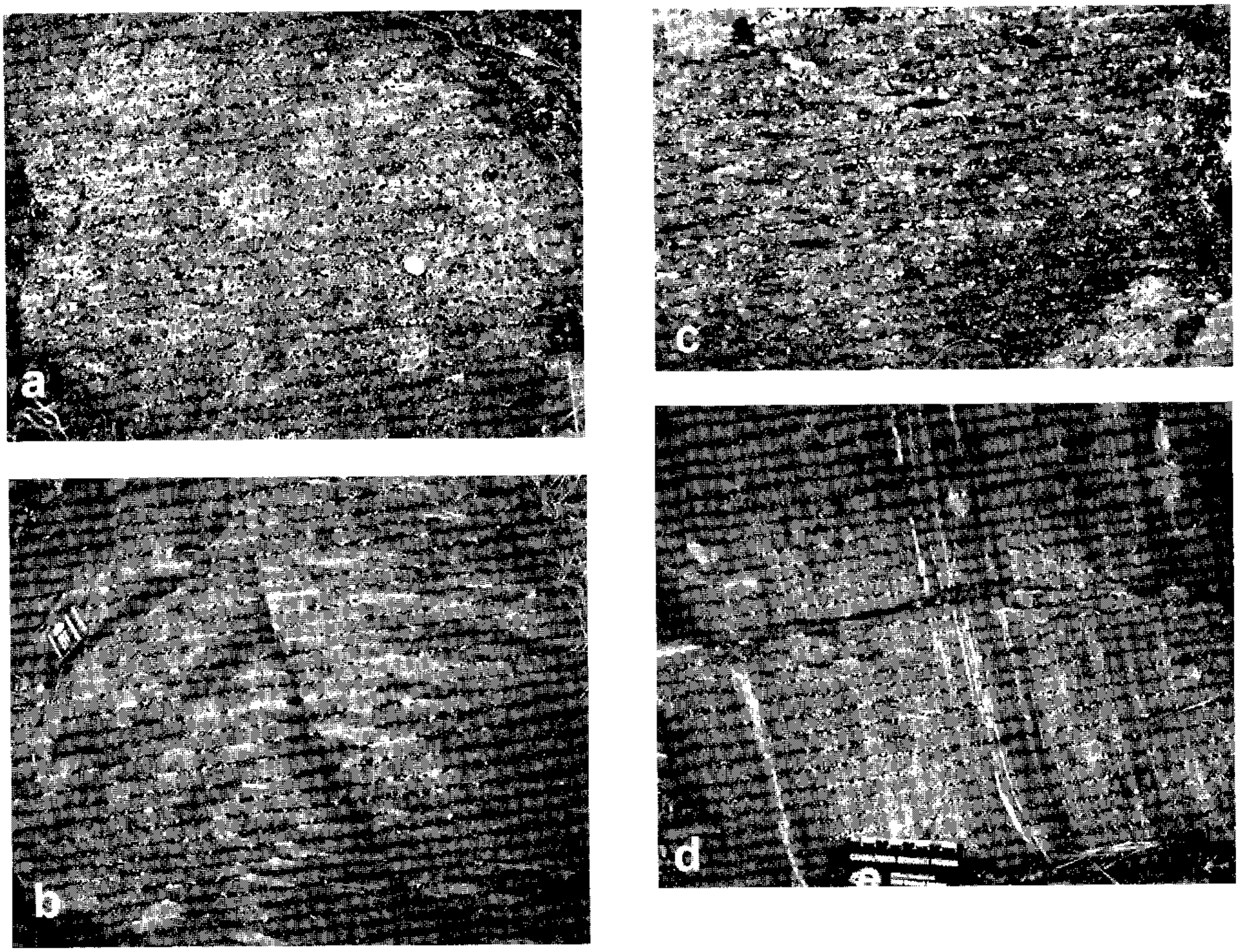


Figure 10. Rocks of the Takhini assemblage are variably deformed and metamorphosed. a) Massive, monolithic breccia of fist-sized fragments of augite porphyry (black spots) basalt entirely without fabric. These rocks are lithologically identical to much of the Povoas Formation of the Lewes River Group. b) Moderately foliated augite porphyry basalt breccia, looking down the axis of elongation (left) with no apparent fabric, but the kinematic surface (right) indicates near extreme elongation with length to width ratios approaching 10:1. c) Close up of moderately foliated augite-plagioclase porphyry crystal-rich lapilli tuff with strectched fragments and pyroxene phenocrysts. d) Steeply dipping gneissic foliation developed in fragmental augite-phyric basalt shows mineral segregation, but no devolopment of amphiboles or biotite.

altered, the sedimentary rocks are almost indistinguishable from the deformed volcanic rocks. A continuous and conspicuous white marble bed, and primary sedimentary structures preserved in less deformed rocks, confirm the sedimentary origin for at least some of this rock package. Several carbonate samples were determined to be barren of microfossils (Appendix 2b).

The Takhini assemblage is crosscut by at least three phases of felsic dykes, and a later phase of mafic dykes (Figure 12a). The felsic intrusions occur as both sills and dykes and are attributed to the Lower Jurassic Little River pluton and a younger, medium-grained dacite. Both of these intrusive phases are weakly folded (Figure 12b). Adjacent to the Annie Ned pluton, fine-grained rhyolite dykes crosscut the folded foliation. Mafic dykes are typically north-trending, fine-grained, and crosscut all phases of dykes.

Deformation and metamorphism

Takhini assemblage rocks are metamorphosed and deformed to mylonite, foliated metabasite, gneiss and amphibolite. The intensity and pervasiveness of the deformation decreases eastward. In westerly occurrences, the most intense metamorphism is adjacent to contacts with plutons and within pendants. Most rocks have undergone lower greenschist facies metamorphism but epidote-amphibolite facies metamorphism is evident locally.

Most of the rocks of this unit are mylonitic metabasite with a simple mafic mineralogy that is not amenable to the formation of foliations or lineations.

Figure 11. Felsic rocks are a minor but important component of the Takhini assemblage. They typically occur as mylonitic metarhyolite, quartz-muscovite schist and orthogneiss. This photograph of polydeformed volcanic strata shows the metarhyolite from which a U-Pb zircon age of 323 Ma was obtained. This date prohibits an association of the metavolcanic strata with the Lewes River Group and encourages a correlation of the Takhini assemblage with the Boundary Ranges metamorphic suite and Stikine assemblage in British Columbia.

These rocks have millimetre-scale flaser banding, whereas rocks containing feldspars, biotite or amphibole are foliated or have gneissic bands. Foliation surfaces are defined by the planar alignment of chlorite, biotite or amphiboles. Locally, the amphiboles are randomly oriented within the S1-plane. Gneissic banding results from centimetre-scale segregation of feldspars within the dominantly mafic rock (Figure 12b).

The attitudes of foliations vary considerably throughout the map area but are roughly northwest-trending with steep to moderate dips. At outcrop scale the foliation is folded. The folds are roughly northwest-trending with no preferred plunge directions. Lineations, most commonly defined by mineral elongations in gneissic polymineralic rocks and more highly strained rocks, plunge 25–45 degrees, but are folded to give variable azimuths (Figure 13). Perturbations in the folded attitudes result from disruption caused by the intrusion of the Little River and Annie Ned plutons and rotation of fault blocks.

A xenolith of conglomerate composed entirely of foliated metabasite clasts within the Little River batholith (186 Ma) (Figure 14) indicates that metamorphism and deformation of the Takhini assemblage occurred before the intrusion. In order to form the conglomerate, the Takhini assemblage was metamorphosed (probably at mid-crustal levels), uplifted and eroded, then the conglomerate was lithified before intrusion of the Little River batholith.

Age and correlation

This volcano-sedimentary package is remarkably similar to, and was originally assigned to, the Upper Triassic Lewes River Group (Wheeler, 1961; Hart, 1993a; Hart and Brent, 1993). The assignment was based on the presence of augite-phryic basalt and coarse-grained augite porphyries, which are considered to be the hallmark of Upper Triassic volcanic packages in the northern Cordillera. However, U-Pb zircon analysis of a felsic metavolcanic rock from within the mafic volcanic package yielded a latest Mississippian age of 323 Ma. This indicates that augite-phyric basalt and allied greenstones can no longer be confidently assigned to the Upper Triassic on the basis of lithology alone as they may be considerably older.

Similar correlation problems have been identified in northern British Columbia. Augite-phyric volcanic rocks in the Iskut area, mapped largely as Upper Triassic, have yielded Upper Paleozoic fossil ages (Brown et al., 1991; Bradford and Brown, 1993; Gunning, 1993; Mihalynuk et al., 1994a, b; Brown et al., 1996) and Mississippian U-Pb dates (355 to 325 Ma; Brown and McClelland, 1995). In the Tulsequah area, carbonate within augite-phyric volcanics considered to be Upper Triassic contained middle Pennsylvanian and older macrofossils (Rui, 1994). This led Mihalynuk et al. (1995) to address "The pyroxene porphyry problem" and, like Brown et al. (1991), they recognized that augite-porphyritic rocks could be either Upper Triassic or Upper Paleozoic and correlative with the Stikine assemblage.

Few lithological characteristics can be used to confidently differentiate the two rock packages (see Table 1), although many of the above workers recognized that Stikine assemblage rocks are generally more deformed than Upper Triassic rocks. Accordingly, and on the basis of similar lithology and a Late Paleozoic age date, the Takhini assemblage metavolcano-sedimentary package in the Yukon is correlated with the Stikine assemblage, and marks its most northerly documented occurrence. This assertion requires a reassessment of other occurrences of mafic volcanic and augite-phyric rocks in the Whitehorse map where Late Triassic age constraints are lacking or questionable. In particular, the deformed mafic rocks and sedimentary rocks of the Tally Ho shear zone (Hart and Radloff, 1990, p. 60-70), and many occurrences of Unit 3d (Wheeler, 1961) are possible components of the Takhini assemblage. Similarly, greenschist and amphibolitic metamorphic rocks in the eastern Coast Belt of northern British Columbia, which had previously been assigned to the Yukon-Tanana Terrane, were included in the Boundary Ranges metamorphic suite (Mihalynuk and Rouse, 1988). This suite has been correlated with the Stikine assemblage (Currie, 1994).

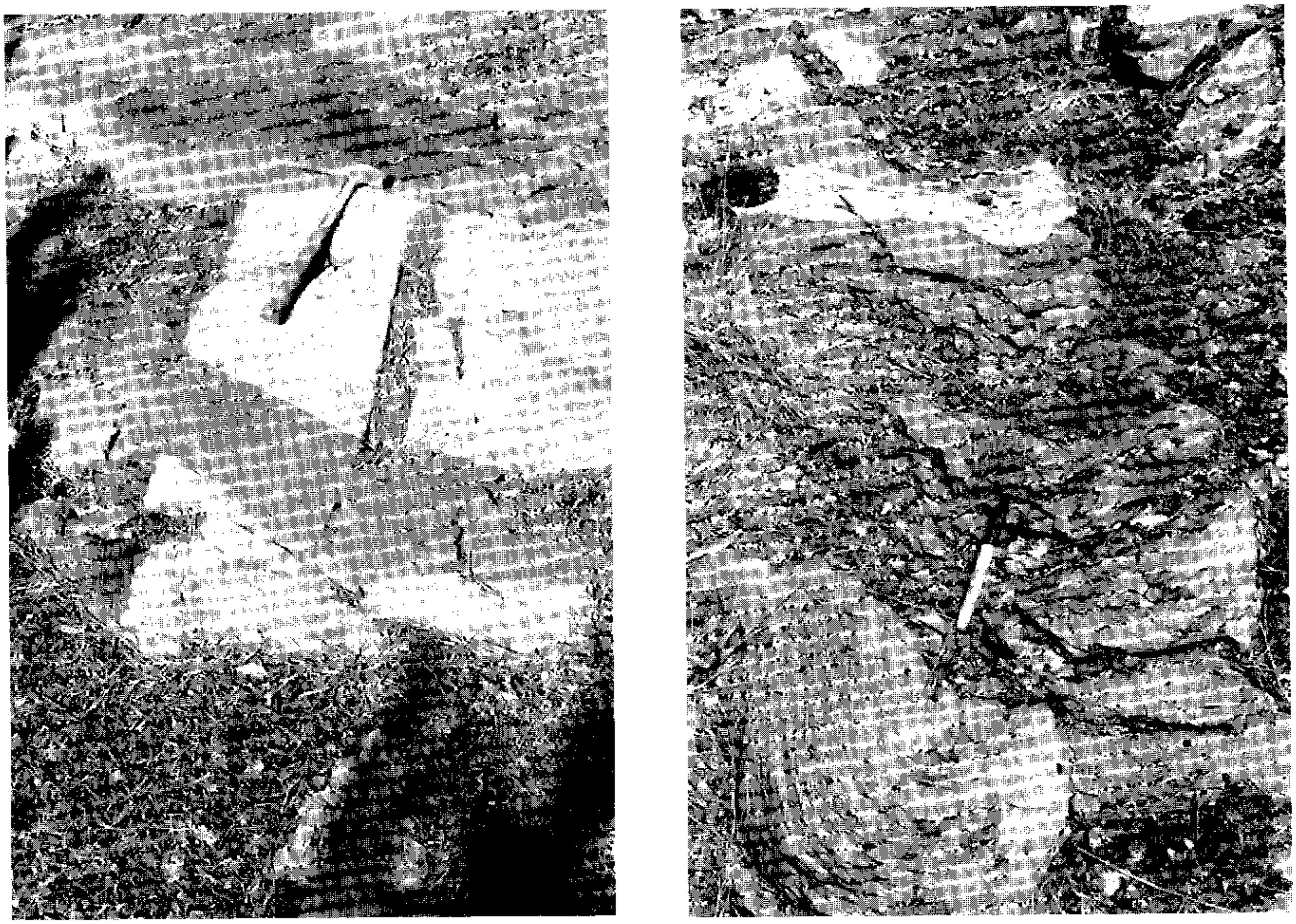


Figure 12. Deformed Takhini assemblage rocks are crosscut by several phases of dykes and sills. a) Undeformed dacite sills intruding greenschist and cut by later, north-trending andesite dykes (52 Ma). Felsic sills are of at least two generations including products from the 183 Ma Little River batholith and the 57 Ma Annie Ned batholith. b) Folded felsic sills indicate that folding of the foliation occurred after at least 186 Ma.

Triassic volcanic rocks

Mafic volcanic rocks in the map area are lithologically and compositionally similar. Although difficult to distinguish, three suites of Triassic volcanic rocks are defined: Joe Mountain Formation, Sheldon Creek volcanics and the Lewes River Group (Povoas formation). Each package is dominated by aphyric basalt, which typically lacks distinctive characteristics. In the eastern Whitehorse map area, this situation is further complicated by the presence of mafic volcanics of the Cache Creek Group and "volcanics of uncertain age" (Figure 15).

Joe Mountain Formation (new)

The high-standing massifs in the Joe Mountain and Mount Byng regions are largely underlain by a nearly contiguous succession of mafic volcanic rocks and their intrusive equivalents (Figure 16). Combined with similar rocks in the Teslin Mountain area to the north, the volcanics form a 40-by-20 km, northwest-trending region called the Joe Mountain

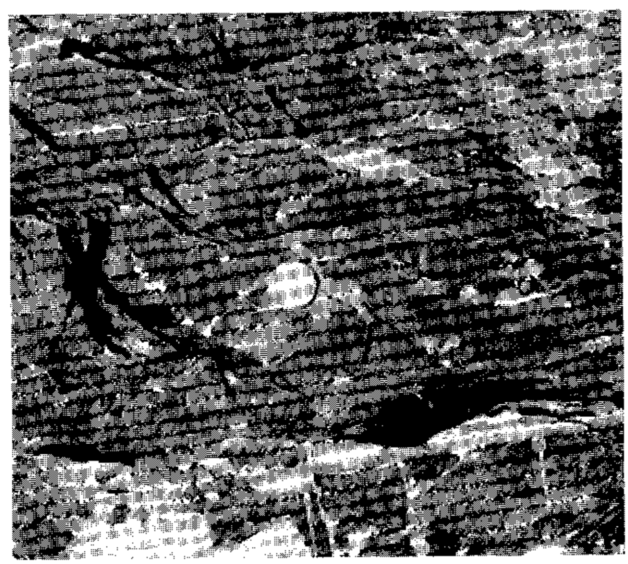


Figure 13. Schistose amphibolite of the Takhini assemblage with well-developed moderately plunging lineations. This locality, and most others dominated by amphibolite, are in pendants or adjacent to intrusions.

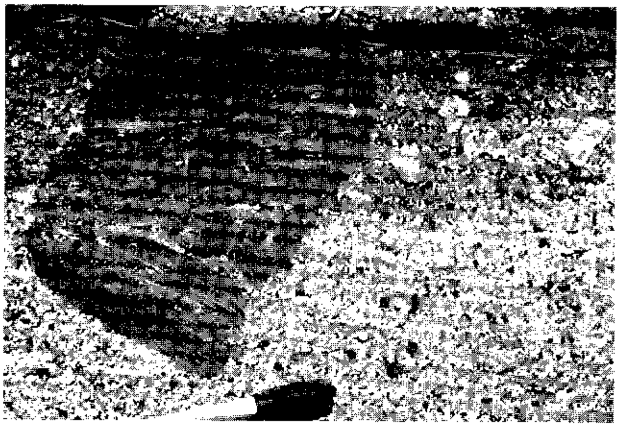


Figure 14. Clasts of Takhini assemblage gneiss compose a monolithic conglomerate that occurs as a xenolith in the 183 Ma Little River batholith. Note the megacrystic alkali fedlsaps at top right. This requires that deformation, uplift, erosion and deposition of Takhini assemblage occurred before the intrusion of the Early Jurassic batholith.

volcanic complex (Hart and Hunt 1994a, b, 1995a, b; Hart and Orchard, 1996). Rocks of the Joe Mountain volcanic complex are here described with a type section and given formation status.

Rocks of the Joe Mountain volcanic complex are generally faulted against adjacent units. Lower contacts are not exposed. Upper contacts are probably gradational with sedimentary rocks of the Lewes River Group, but sections potentially containing this contact have not been studied. The Joe Mountain volcanic complex is intruded by the mid-Cretaceous M'Clintock Lakes granite and the Mount Byng felsite. Several small epigenetic gold mineral occurrences are associated with the Joe Mountain Formation near Mount Byng (Bremner, 1991).

The Joe Mountain Formation comprises four units: 1) a lower unit of dark basaltic flows; 2) a clastic and calcareous sedimentary unit; 3) a thick upper unit of basalt flows and microdiorite; and 4) associated gabbro and diabase intrusions (Figure 17). The type section of the Joe Mountain Formation (Figure 18) includes the uppermost portion of the dark basalt unit, the sedimentary unit, and the lower portion of the thick basalt unit. The type section focuses on the sedimentary rocks responsible for providing the age control for the unit. The thickest, and most important, accumulations of volcanic rocks occur with subvolcanic microdiorite, diabase, and the gabbro plutons in the Joe Mountain and Mount Byng regions. Low temperature alteration to chlorite and epidote is pervasive.

1. The lower unit of pillowed **dark basalt** (informally called the "Old Pillows" by Hart and Hunt, 1994a) forms a thick sequence of stacked pillows and lesser massive flows and breccia over a large region south of Joe Mountain. The base of this unit is not exposed and its thickness is likely to be more than 500 m. Black- and brown-green-weathering, fine-grained, dense, generally aphyric, grey-green basalt typically occurs as stacks of small (average 60 cm in diameter) but locally large (1.2 m), well-developed pillows. The sequence contains rare, thin (less than 10 cm), discontinuous, interbedded sediments, which are typically cherty or limy (now recrystallized to sparry calcite). Calcite veinlets are common and reptile-like scaly chlorite is typical on the pillow surfaces. This unit is moderately to steeply dipping but locally vertical. Fault zones in this unit are characterized by ankeritic breccias and gossans with quartz veining and jasper.
2. A chaotic sequence of clastic and calcareous **sedimentary rocks** conformably overlie the "Old Pillows". At the headwaters of Cap Creek, the sedimentary sequence is approximately 2 km thick and contains approximately 30% volcanic flows (Figure 18). The sequence is dominated by recessive, well-bedded, tan-brown and grey-black argillite, with more resistant hyaloclastic conglomerate, pebbly sandstone and gritty limestone

Table 1. Criteria for distinguishing mafic volcanics of the Takhini assemblage from the Lewes River Group in the northern part of the Whitehorse map area.

Criteria	Takhini Assemblage	Lewes River Group (Povoas Formation)
Sedimentary rocks	Thin, no bedding, carbonate as marble	Thick, well-bedded, carbonate as limestone
Felsic rocks	Meta-rhyolite, mylonite and orthogneiss	Absent
Alteration	Chlorite, epidote	Hematite, chlorite, epidote
Metamorphism	Commonly greenschist but up to lower amphibolite facies	None
Deformation	Variable but pervasive foliation to polydeformed schistose and gneissic fabrics; fabrics are folded	Bedding is folded, locally sheared

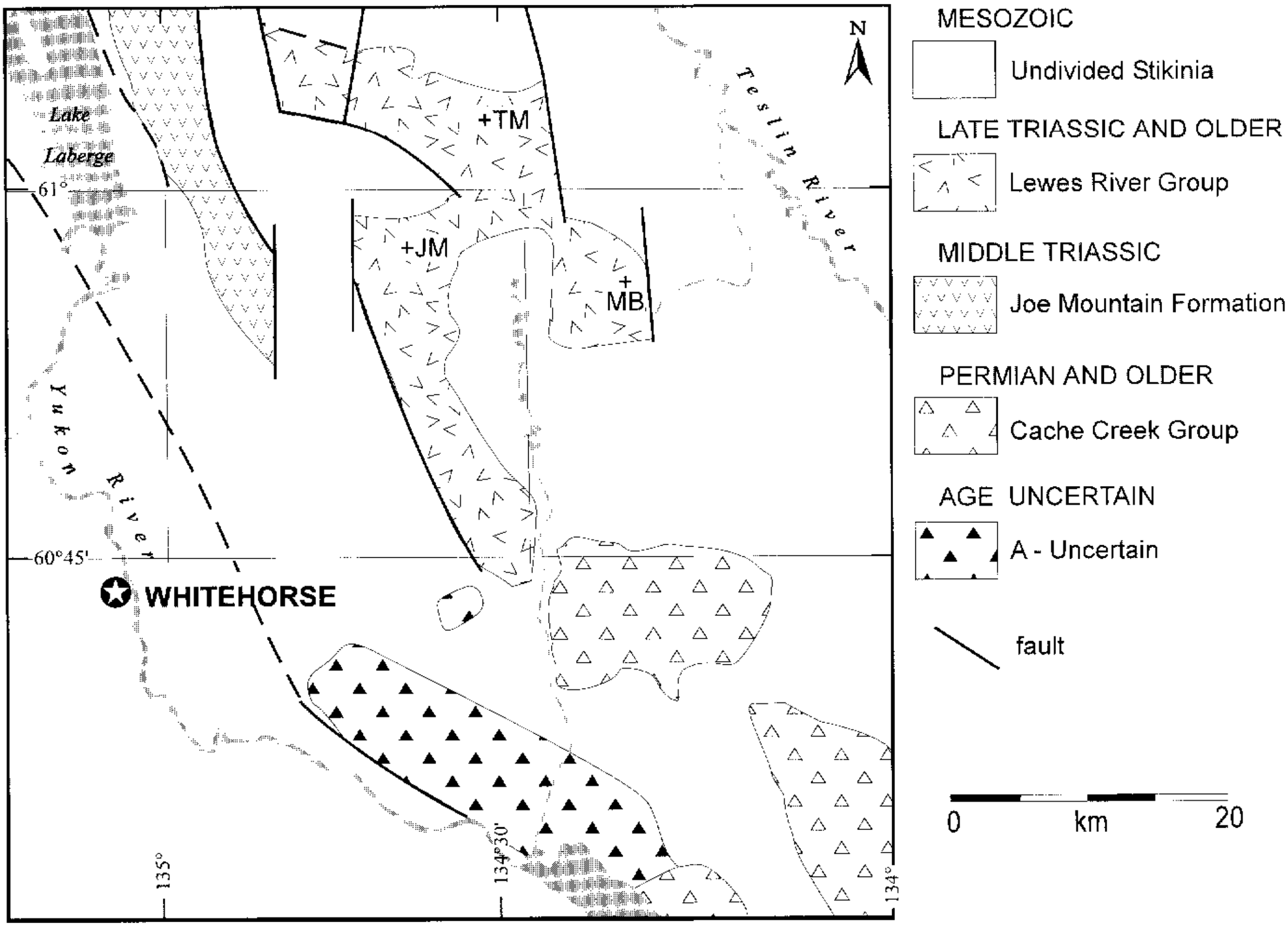


Figure 15. Occurrences of Triassic and older volcanic rocks in northeastern Whitehorse (105D), and south-eastern Laberge (105E) map areas. (Map areas of the study area are delineated by thin lines). The Joe Mountain Formation comprises rocks previously mapped as "volcanics of uncertain age", Hutshi Group and Mount Nansen Group. Geology compiled and modified from Wheeler (1961), Tempelman-Kluit (1984) and Hart and Hunt (1994a, 1995a). TM=Teslin Mtn., JM=Joe Mtn., MB= Mount Byng.

beds. Clastic rocks are poorly sorted, composed of angular fragments and typically monomictic. Limestone is generally dark grey, well-bedded, sandy and shaly, and contains rare, poorly preserved, thick-shelled pelecypods. Bivalves, probably *Daonella*? sp., were also observed in the lower part of this sequence.

3. The bulk of the Joe Mountain volcanic complex is composed of an upper unit of dark, blocky, resistant-weathering, massive, but locally pillowed, light green, relatively unaltered, **basalt and microdiorite** ("Young Pillows" of Hart and Hunt, 1994a). The microdiorite is fine to medium grained, generally nonmagnetic and, although dominantly aphyric, locally sparsely feldspar- and pyroxene-phyric, and at least 700 m thick. The pillows tend to be large (1(2 m), but are locally difficult to observe within the thick, massive, autobrecciated flows (Figure 19a). Much of this unit is characterized by reticulate networks of thin veinlets of a white mineral, probably albite (Figure 19b). In the Joe Mountain and Mount Byng areas, the diabasic successions are thick and massive and are interpreted as being subvolcanic in origin. Thin (20-200 m thick) sedimentary units are within the sequence of massive flows and more common in the south-eastern portions of the Joe Mountain map area.

4. The **gabbro**, exposed over much of the upland plateau north of Joe Mountain as well as north and west of Mount Byng, forms discreet plutons. This unit underlies and intrudes the microdiorite and basalt flows. It is characterized by leucocratic, coarse-grained and texturally variable, pyroxene gabbro (Figure 19c). The approximately equal percentages of plagioclase and pyroxene are intergrown, giving the pyroxene lath-like shapes. Locally, small marginal bodies of coarse-grained anorthositic and extremely coarse-grained (3-5 cm) pyroxenite (bronzite?) are associated with

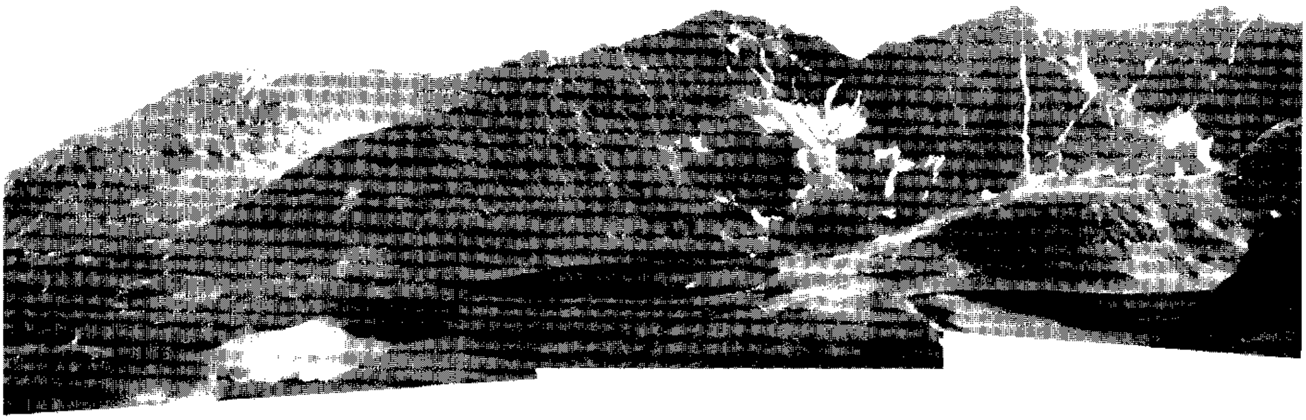


Figure 16. Looking southwest at resistant, dark-weathering mountains and cirques of the Joe Mountain Formation volcanics south of Joe Mountain (at extreme right). Similar topography and geology are exposed at Mount Byng and Teslin Mountain. Gabbroic plutons found in these regions are thought to reflect centres of volcanic activity.

the gabbro. As seen in thin sections, actinolite mantles pyroxene. The textural variation and intrusive relationship of the gabbro with the microdiorite indicates that the gabbro plutons represent hypabyssal magma chambers.

Geochemistry

Major-element whole-rock geochemical analysis indicates that the volcanic rocks of the Joe Mountain Formation are dominated by sub-alkalic basalt and basaltic andesite (Figure 20a). On a calc-alkaline/tholeiitic plot, the data are almost entirely within the iron-enriched tholeiite field (Figure 20b). The tectonic discriminant diagram suggests that the minor element composition of the Joe Mountain Formation is typical of island arc tholeiite and mid-ocean ridge (or marginal basin) basalts (Figure 20c). This geochemical character is distinct from the island arc calc-alkaline, high potassium basalts of the Lewes River Group. Analytical data are given in Appendix 8.

Age and correlation

Rocks here included as the Joe Mountain Formation were previously mapped as "volcanics of uncertain age" (Unit A), their metamorphosed equivalents (Unit Aa), the Cretaceous Hutshi Group (Wheeler, 1961) and the Cretaceous Mount Nansen Group (Tempelman-Kluit, 1984). The dominance of mafic,

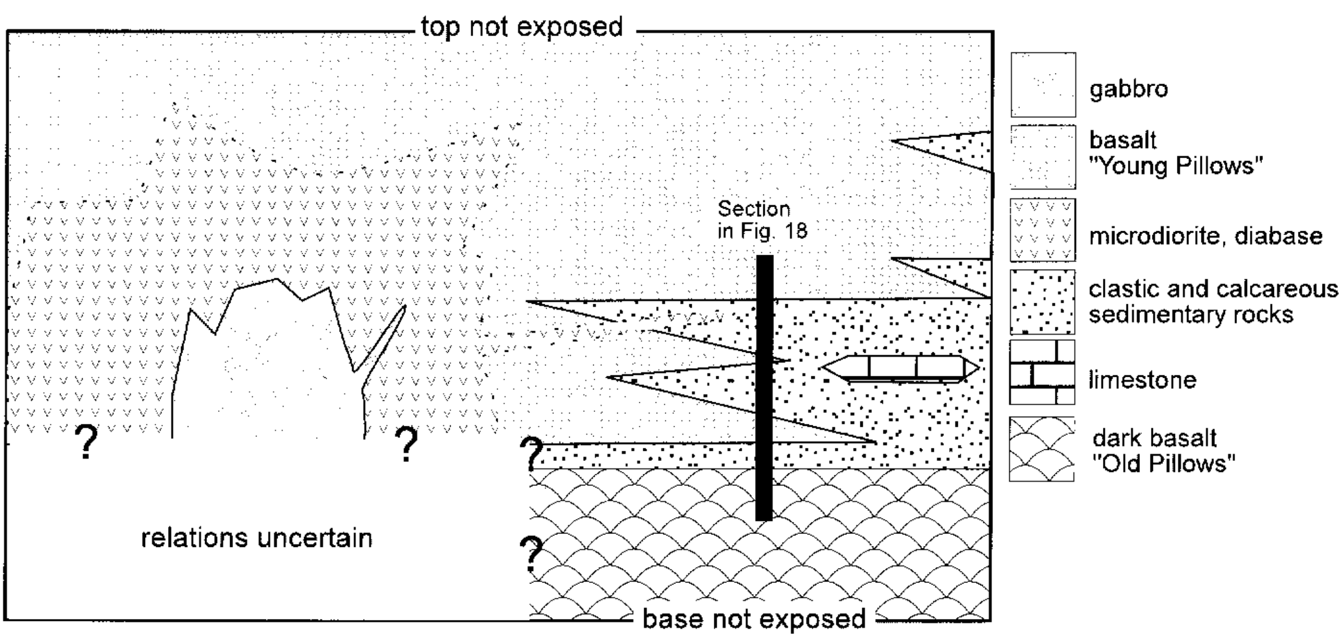


Figure 17. Schematic cross-section displaying the gross stratigraphic relationships between the various units of the Joe Mountain Formation. The "young pillows" and the microdiorite unit represent coeval extrusive and intrusive phases of the same unit.

submarine flows suggests a possible correlation with the Upper Triassic Lewes River Group. However, conodonts recovered from limestone beds at six localities within unit 2 are identified as Ladinian (Middle Triassic) in age (Hart and Orchard, 1996). Collections of pectinids are likely *Daonella* sp. (Appendix 1; E. T. Tozer, pers. comm., 1995) and further confirm a Middle Triassic age. The distinctive lithological associations, geochemistry and age of the Joe Mountain volcanic complex permits its classification as a formation.

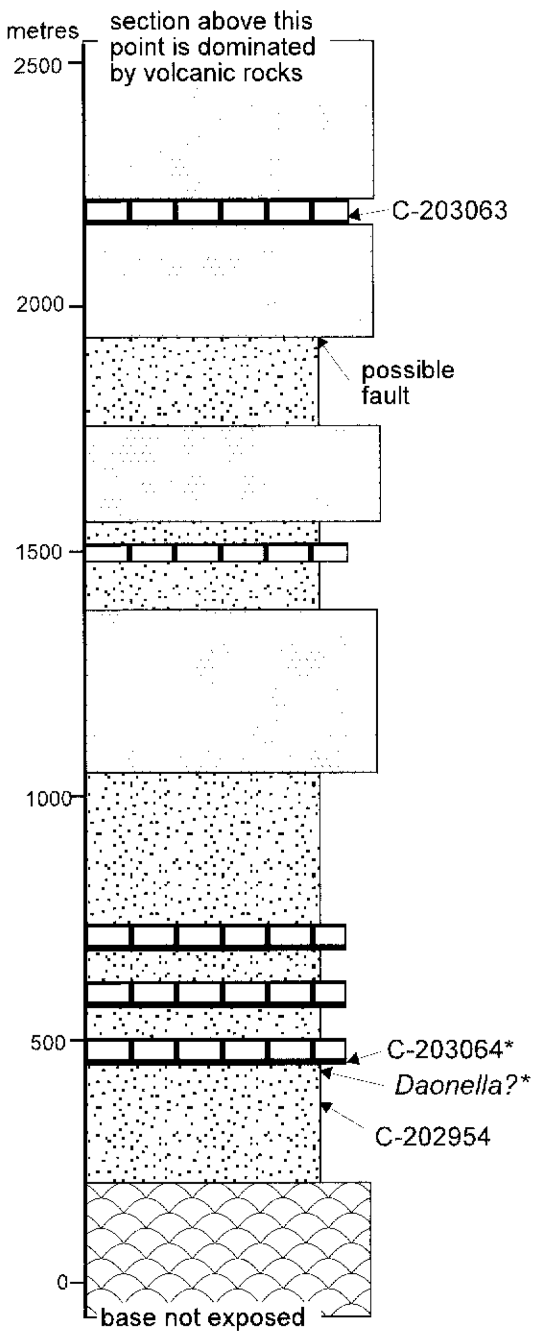


Figure 18. Section and sample localities from the dominantly sedimentary portion of the Joe Mountain volcanic complex (upsection from UTM Zone 8, 6752300N, 514300E). Conodont biostratigraphy (detailed in Hart and Orchard, 1996) suggests that unrecognized structural complexities exist in the section. *=projected onto section. See Figure 17 legend for lithology.

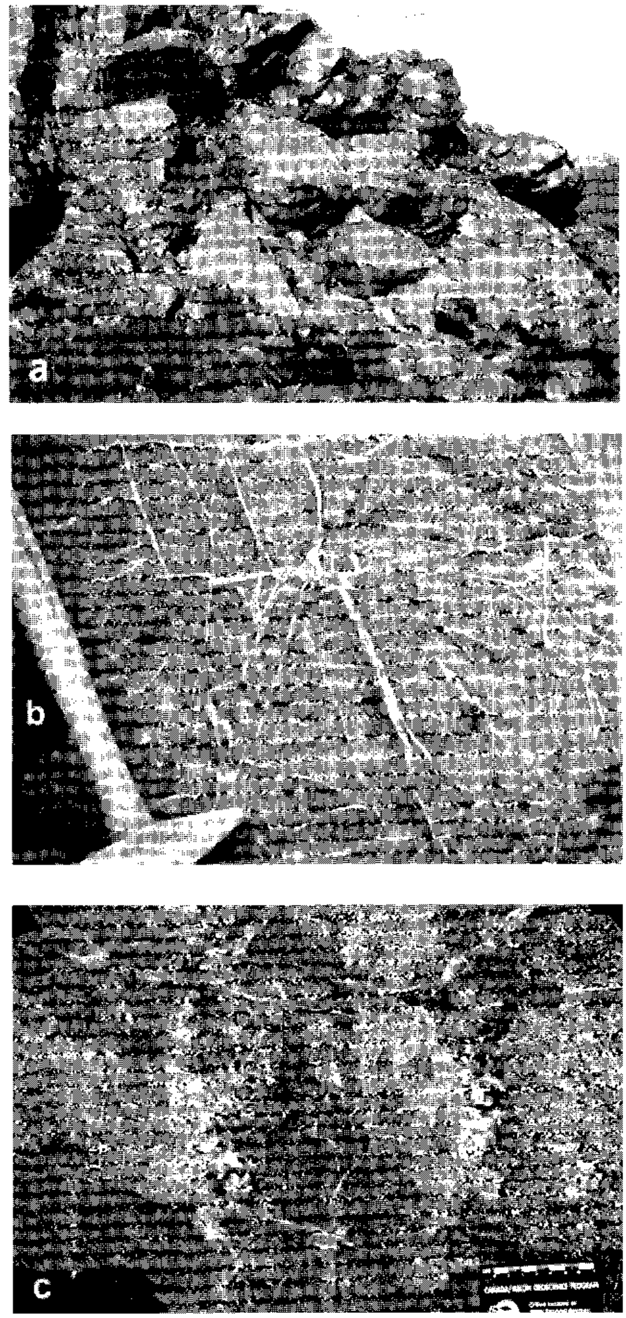


Figure 19. Typical rock types of the Joe Mountain Formation include: a) large bulbous pillows from the top of the section near Peak 5644'. Note pack at base of outcrop for scale; b) microdiorite, which is typically crosscut by reticulate networks of thin white veinlets (south of Mount Byng); and c) texturally variable, coarsely crystalline pyroxene gabbro (north of Joe Mountain).

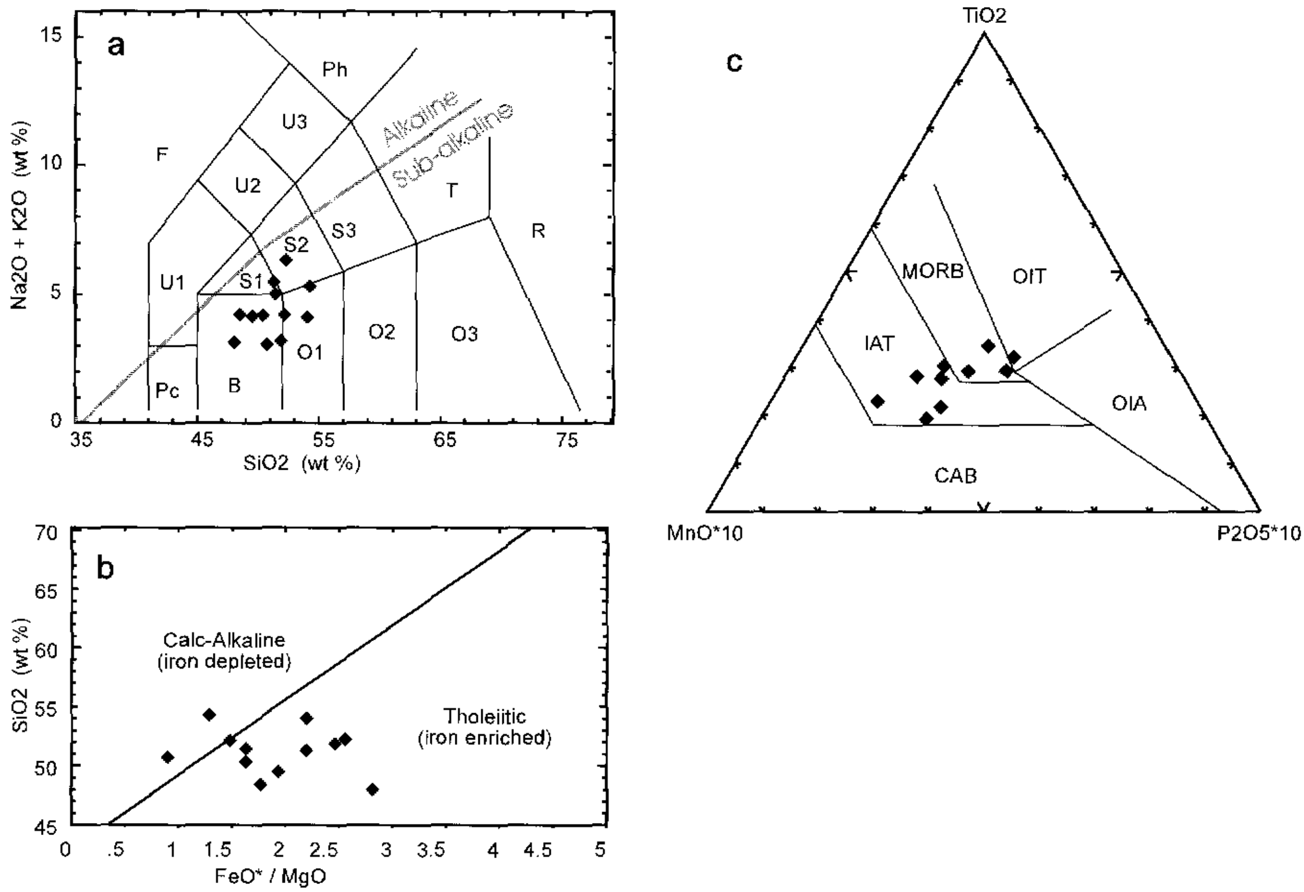


Figure 20. Geochemistry of the Joe Mountain Formation. All data are plotted as anhydrous. a) Total alkalis vs. silica classification diagram with subdivisions of Le Maitre (1989); B=basalt, O1=basaltic andesite, S1=trachybasalt, S2=basaltic trachyandesite. Alkaline/subalkaline curve from Irving and Barager (1971). As K2O values are typically less than 0.5%, Na2O is the significant alkali element. b) Calc-alkaline/ tholeiitic discrimination diagram (Miyashiro, 1974). c) Minor element discriminate plot for basaltic rocks (45-54% SiO2; Mullen, 1983). See Appendix 7 for analytical data.

The Joe Mountain Formation is difficult to date effectively by isotopic methods because the rocks do not contain the necessary minerals. Whole-rock K-Ar analyses of basalt and andesite flows yielded dates between 52 and 143 Ma indicating that the rocks have been variably reset by younger thermal events. A K-Ar whole-rock analysis of the gabbro gave an older date of 168±6 (Bremner, 1991) but this is still significantly younger than the stratigraphic ages. A whole-rock Rb-Sr analysis of andesite yielded a Late Permian date of 252±10 Ma (Bremner, 1991), but was a model age based on a single analysis.

Rocks of the Joe Mountain Formation are lithologically dissimilar to, older than, and not in depositional contact with, volcanic rocks of the Lewes River Group. However, Upper Triassic Lewes River Group conglomerate contains clasts of diabase and gabbro similar to that from the Joe Mountain volcanic complex. This suggests that Joe Mountain Formation rocks were emergent during the Late Triassic and were eroded and subsequently deposited in the Whitehorse Trough. Although the Joe Mountain Formation is along strike with the Cache Creek Terrane, and is lithologically similar to some Cache Creek rocks south of Carcross (Conrad series of Hart and Pelletier, 1989a), the detrital link between the Joe Mountain Formation and the Whitehorse Trough suggests that the Joe Mountain Formation is likely part of Stikinia.

To date, rocks of the Joe Mountain Formation have been recognized only in this geographically restricted region. They are the oldest rocks in the Whitehorse Trough and likely form the basement to the younger rocks of Stikinia, or at least to the oldest members of the Lewes River Arc. They may therefore be more extensive than mapped, and have not been recognized or are not exposed.

Middle Triassic rocks are rare in the accreted terranes of the Cordillera. Most other occurrences are chert-rich units in the Cache Creek Terrane with no associated volcanic rocks (see Hart and Orchard, 1996, for discussion). The Joe Mountain Formation is unique and has no obvious Cordilleran correlatives.

Sheldon Creek volcanics

Resistant exposures of basaltic volcanic flows and volcaniclastics underlie an area of approximately five sq. km, south of the Sheldon Creek. The base of the volcanics was not observed, but they appear to be conformably overlain by the Sheldon Member conglomerate of the Aksala formation. The volcanics are composed of slightly rusty-orange-weathering, massive and brecciated, locally pillowed, submarine flows of dark green basalt, hyaloclastic breccia and tuff (Figure 21). Although they are lithologically similar in some respects to Joe Mountain Formation basalt, their apparently higher stratigraphic position and distal postion from it, allows their separation as a minor unit.

Age and correlation

The age of these rocks is not directly known, but they apparently underlie a limestone bed that contains Carnian conodonts. While these volcanic rocks are unlike those of the Povoas formation, they do have some lithological similarities with Joe Mountain Formation rocks and rocks attributed to the Cache Creek Group in the southern part of map area 105D/16, but lack confident correlative characteristics. Geochemically, Sheldon Creek volcanics have characteristics similar to the Joe Mountain Formation.

Lewes River Group-Povoas Formation

Lewes River Group (Lees, 1934; Wheeler, 1961) is composed of a volcanic and sedimentary succession. The dominantly volcanic and volcanoclastic portions were termed the Povoas formation by Tempelman-Kluit (1984), although a type section, stratigraphic boundaries and lithological descriptions have yet to be defined. In the study area, Povoas formation rocks include augite-phyric and aphyric members. Both members contain massive and fragmental components, although coarsely fragmental volcanoclastic rocks dominate within the map area. Povoas formation rocks are well exposed at three localities in the study area-Takhini River, Scout Lake and Mount Slim.

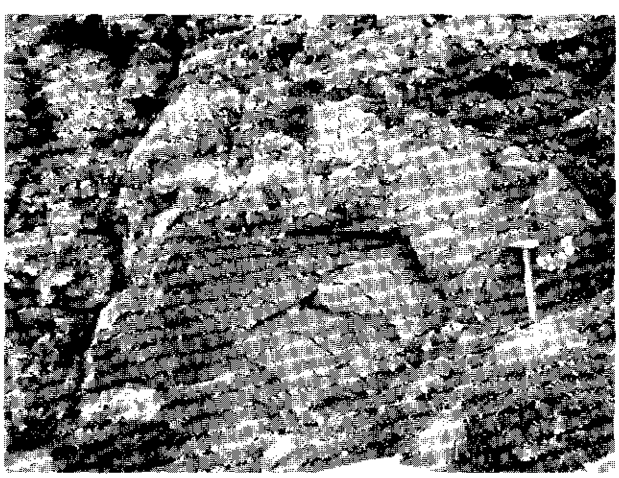


Figure 21. Highly altered, pillowed, brecciated and fragmental basalt flows of the Sheldon Creek volcanics.

Takhini River

Povoas formation forms a north-trending belt between Peak 6159', Peak 3889' and the Little River. The lower contact is not exposed, although it is likely unconformable above the deformed Takhini assemblage. The upper contact is locally gradational with sedimentary strata of the Lewes River Group (Aksala formation). The total thickness of the Povoas formation is over 1000 m at Peak 3889'. Lithologically the formation is dominated by resistant, dark green, massive basalt flows, monolithic tuff and agglomerate with ubiquitous chlorite and epidote alteration. This unit is characterized by augite-phyric basalt and coarse-grained, crowded augite porphyry and augite gabbro. Feldspar phenocrysts are small and rare, although large-bladed feldspar phenocrysts do occur locally.

Scout Lake

In the mountains around Scout Lake, and south toward the Ibex River and Jackson Creek, the Povoas formation is represented by a thick accumulation of coarsely fragmental, slightly hematitic, volcanoclastic breccia, conglomerate and tuff, with lesser greywacke and limestone lenses. True volcanic flows are thin and subordinate. Fragments are dominated by massive basalt and augite-phyric basalt. Chlorite and epidote alteration is ubiquitous. Measured sections south of the map area suggest that the clastic portion is over 1200 m thick. The volcanic succession is likely stratigraphically higher than the massive volcanic flows in the Takhini River area, although contact relationships were not seen. The succession appears to grade upward into the finer grained and more calcareous sedimentary rocks of the Aksala formation, but locally is unconformably overlain by clastic strata of the Jurassic Laberge Group.

Mount Slim

In the Mount Slim area (including exposures in the eastern Yukon River valley and near Peak 4089' south of Laberge Creek) mafic volcanic rocks occur in fault-bounded blocks that are juxtaposed with, but may also be beneath, Aksala formation sedimentary rocks. Lower contacts were not observed. The volcanics are dominated by massive flows, locally with well-developed pillows, autoclastic and hyaloclastic breccia. Much of this unit is also composed of volcanoclastic breccias, which likely originated as debris flows. The volcanics are dark-grey-green-weathering, resistant, strongly magnetic, dark grey, fine grained and aphyric-although locally, feldspar-phyric, basalt flows with vesiculated and calcite-, quartz- or jasper-filled amygdaloidal rims do occur. Locally, they also contain interpillow, or thin (1–2 cm), discontinuous beds of limestone, which is now sparry.

In addition to the absence of augite phenocrysts, the most diagnostic feature of this unit is local hematitic alteration, which imparts a distinctive maroon colour to most of the rocks on the plateau west of Mount Slim and within the eastern Yukon River valley occurrences. Epidote and chlorite alteration is common, as is patchy spilitic alteration. Volcanic rocks in the low hills northwest of Mount Slim typically contain maroon-coloured jasperoidal veins, stockworks, interpillow fill and breccia matrixes. The maroon colouration likely results from oxidation of iron in the volcanic rocks during periods of subaerial exposure and suggests that the pillowed flows were likely deposited in shallow water, or uplifted before burial by sediments.

Although the volcanic rocks around Mount Slim lack augite pheoncrysts, they are included in the Povoas formation by virtue of their hematitic alteration, continuity with rocks assigned to the Povoas formation in the Laberge map area, and a poorly constrained age assignment.

Age and correlation

The age of the Povoas formation in the map area is not directly known. However, the volcanoclastic section in the Scout Lake area is here correlated with strata in the Ibex River area that occur below Lower Norian, Juvavites-bearing limestone. Volcanic rocks at Mount Slim are probably stratigraphically below Mysidioptera-bearing limestone-a relationship that requires the volcanic rocks be Early Carnian or older. These limited constraints indicate that Povoas formation rocks are dominantly Carnian and older. This assertion is supported by a Late Carnian conodont age obtained from a thin limestone bed in the Lewes River Group volcanics in the Watson River area (M. J. Orchard in Hart and Radloff, 1990). Otherwise, there are few direct age constraints for Povoas formation rocks.

The Povoas formation is correlative with the Stuhini Formation in northern British Columbia and together they make up the Lewes River Arc. From west to east, the general character of the Povoas formation changes from massive augite-phyric basalt and porphyry, to fragmental volcanoclastic rocks and conglomerate, to hematitic, aphyric and pillowed flows. This transition is interpreted as representing a transect through a volcanic arc from the deep roots in the west, through proximal fragmental accumulations, to distal fragmental flows in the east. Although relationships were not observed, it is assumed that the arc was constructed unconformably upon a basement of Takhini assemblage strata.

Geochemically, Povoas formation rocks are distinct from the Joe Mountain Formation; they are calc-alkaline in nature with moderate to high potassium content. Although lithological criteria for distinguishing between the Upper Triassic and Paleozoic augite-phyric flows is presented (Table 1), the lack of age constraints from the augite-phyric rocks of the Takhini River and Scout Lake areas do not preclude their inclusion in the Takhini assemblage. The difficulty in distinguishing mafic rocks of various units emphasises the need for more study of rock units along the western margin of Stikinia.

Whitehorse Trough Supergroup

The study area forms a transect across the full width of a depositional basin known as the Whitehorse Trough. This basin, whose sediments extend from north of Carmacks to Dease Lake, British Columbia, for a strike length of 600 km, existed from the Middle Triassic to Middle Jurassic. The greater than seven kilometres of fill of the Whitehorse Trough is divided between the Aksala formation of the Lewes River Group, and all of the Laberge Group (Figure 22). Together these units constitute the herein defined Whitehorse Trough Supergroup. Extreme lithological variations within time-correlative strata across the trough make it difficult to determine confident correlations or compose a coherent stratigraphy.

Wheeler (1961) divided the stratigraphy of the Whitehorse Trough into three belts in order to highlight the across-strike lithological variations within the stratigraphy. Each belt crudely represents a particular facies association that reflects a particular depositional environment. Formations and members created by Tempelman-Kluit (1984) are largely facies-representative, and not time-stratigraphic, units. However, significant biostratigraphic contributions from paleontologists at the Geological Survey of Canada (Appendices 1, 2, 3) and the large number of stratigraphic sections from within the study area (Appendix 4), have allowed the development of some time-stratigraphic units, which are used in this report.

Whitehorse Trough strata rest on a variety of basements. In the extreme western part of the map area, they lie unconformably upon the deformed Takhini assemblage and conformably(?) upon Povoas formation volcanic rocks. Elsewhere, the basement is

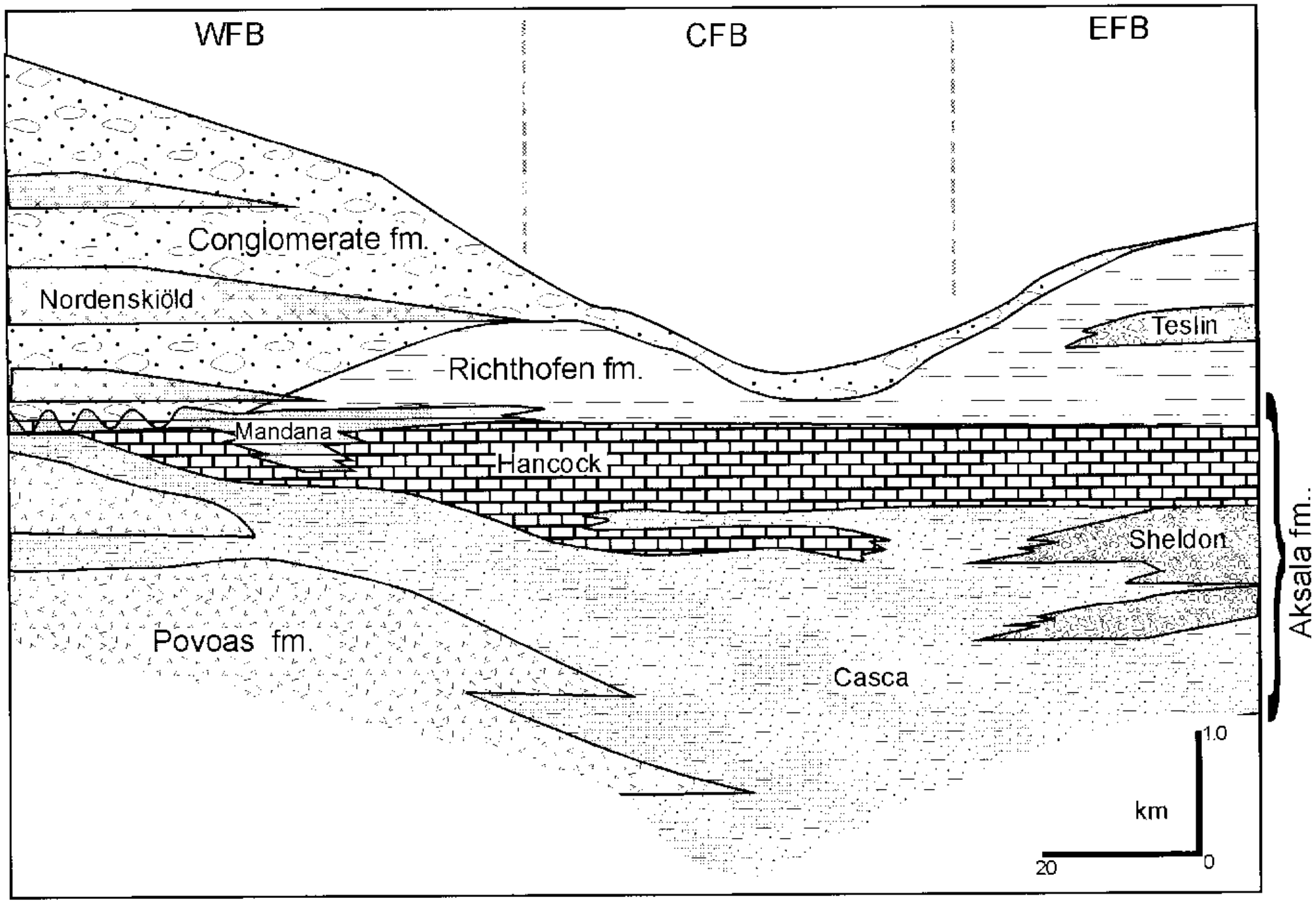


Figure 22. Cross-section of the Whitehorse Trough Supergroup showing the distribution and relationships of the various units. The section is composed from numerous stratigraphic sections compiled by various authors (see Appendix 4). WFB = Western Facies Belt, CFB = Central Facies Belt, EFB = Eastern Facies Belt.

uncertain, but the presence of the Joe Mountain Formation, and the Horse Creek ultramafic rocks in the central part of the trough, and the Cache Creek oceanic volcanic rocks in the eastern part of the trough, suggest that oceanic crust may be present.

Lewes River Group-Aksala formation

The sedimentary portion of the Lewes River Group (Lees, 1934) was termed the Aksala formation by Tempelman-Kluit (1984). These rocks outcrop across most of the study area east of Peaks 6159' and 3889'. The lower contact of the these rocks is not exposed, but in the western part of the map area they are likely conformable with volcanic rocks of the Povoas formation. In the central and eastern parts of the Whitehorse Trough, the basement is uncertain, although the lowermost Aksala formation may be conformable with strata of the Joe Mountain Formation. The upper contact of the Aksala formation is conformable with the Laberge Group except west of the Yukon River, where it is locally disconformable or has been substantially thinned or removed due to erosion. Aksala formation strata vary in thickness across the Whitehorse Trough from 1.2 km in the western facies belt to over 3 km in the central belt, to approximately 1.5 km in the eastern belt.

Aksala formation strata are lithologically variable, making stratigraphic correlations between sections and across the study area difficult. As a result, units within the Aksala formation are defined as members with similar characteristics, although they may in part be diachronous. In the Laberge area, Tempelman-Kluit (1984) divided the Aksala formation into three members: Casca, Hancock and Mandanna. Those members, and a fourth — the Sheldon — are defined in the following section. The nomenclature of Tempelman-Kluit (1984; and maintained by Hart and Radloff, 1990) is retained to allow correlation and comparison of strata throughout the Whitehorse Trough (Figures 9, 22).

Casca Member

The Casca Member is the lowest unit of the Aksala formation. It is lithologically diverse and lacks the diagnostic lithological associations that define the other members. Mainly within the central facies belt, it is up to two km thick, but is less than one km thick in the eastern facies belt, where it is partly diachronous with the Sheldon Member. Map patterns suggest that Casca strata may conformably overlie Povoas and Joe Mountain Formation volcanic rocks. Upper contacts are poorly defined and are most often gradational with Sheldon Member conglomerate or Hancock Member carbonate.

The Casca Member contains a wide range of fine- to medium-grained clastic strata (mainly sandstone, greywacke and argillite), which are locally pyritic or calcareous and usually not associated with hematitic mudstone, cobble conglomerate or limestone (Figure 23). In the upper reaches of Sheldon Creek, Casca Member rocks are dominated by a diagnostic black and white, bioturbated, siliceous mudstone with wispy siltstone laminae overlain by a succession of well-bedded, resistant gritty sands, and recessive, buff-brown-weathering, gritty and limy sandstones (Unit 1 of Hart and Hunt, 1995b). This succession includes sandy limestone and several, thin (less than 5 m), dark grey, fetid limestone beds and lenses with sparsely interbedded, light grey chert. The bioturbated mudstone contains the trace fossil *Zoophycus*.

Rocks attributed to the Casca Member in the Sheldon Creek area yielded conodonts that are mostly Carnian in age. Other localities are as young as Upper Norian as they host stratigraphically diagnostic *Monotis* sp. Casca Member rocks represent a finer-grained facies than the other members of this formation, which are locally dominated by conglomerate or carbonate. These rocks were deposited in a quiet, fairly restricted, deep, marine basin, which had local incursions by debris flows. The upper portion of the Casca Member is interbedded with conglomerate beds of the Sheldon Member, indicating episodic deposition of coarse clastic strata.

Figure 23. Looking westward at a >500m thick section of Casca Member hornfelsed argillite capped by sandstone near Mount Byng. Conodont data suggest that this section is Late Carnian in age. Mt. Byng, in the background, is composed of Middle Triassic Joe Mountain Formation.

Sheldon Member

The Sheldon Member is a coarse-clastic unit limited to the Sheldon Creek area of the eastern facies belt (Unit 2 of Hart and Hunt, 1995b). Its upper contact is with the carbonate of the Hancock Member and the lower contact is gradational with the Casca Member, although it is partly diachronous with both. Sheldon Member rocks are characterized by numerous, varied conglomerate units with lesser sandstone and limy siltstone (Figure 24). Conglomerate beds are nearly identical to the Laberge Group. They are composed of sub- to well-rounded, pebble-, cobble- and boulder-sized clasts of volcanic, intrusive and sedimentary origin.

Although generally polymictic, individual beds may be dominated by a single clast type. Most of the well-bedded conglomerate is dominated by well-rounded, fist-sized limestone clasts in contrast with the massive conglomerate, which contains angular, boulder-sized limestone clasts. Intrusive clasts in

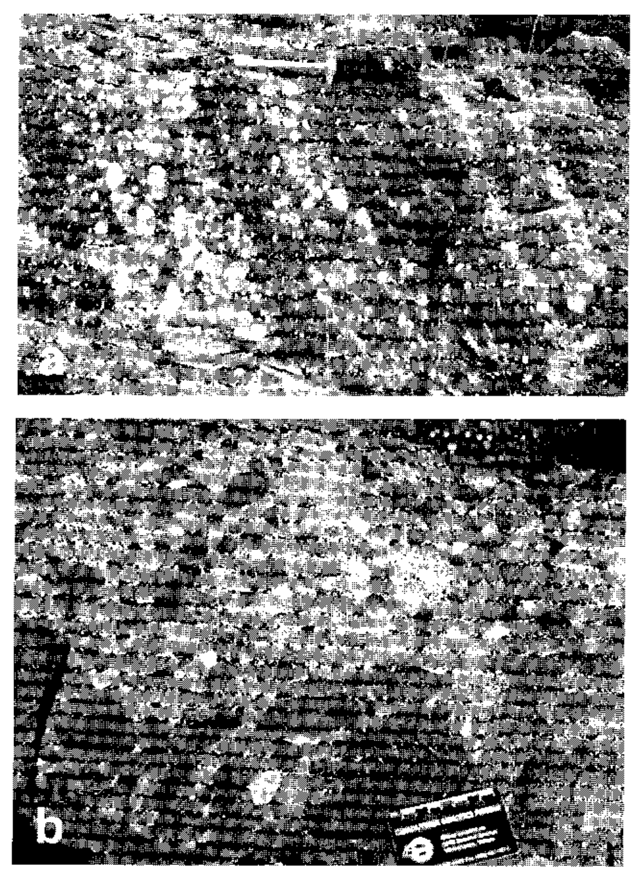


Figure 24. a) Well-stratified, limestone-cobble conglomerate of the Sheldon Member. b) Polymictic conglomerate of the Sheldon Member is dominated by a variety of volcanic and hypabyssal intrusive clasts as well as (typically angular and smaller) sedimentary clasts. Gabbro clasts are similar to, and probably derived from, the Joe Mountain Formation. Scale is in centimetres.

polymictic and intrusive-dominated conglomerate are predominantly well-rounded, light grey, feldspar-quartz-hornblende porphyry cobbles up to 40 cm in diameter. Alternatively, volcanic and microdiorite clasts with lithological similarity to Joe Mountain Formation rocks tend to be angular. There are also angular, pebble-sized clasts of light grey and green chert.

Sheldon Member strata are dominated by coarse clastics that are: stratigraphically below carbonate units that contain Upper Norian conodonts; stratigraphically above Casca Member strata with Upper Carnian conodonts; and contain fine-grained units that host Upper Norian macrofossils. Consequently, this member was deposited entirely within the Norian, but may be dominantly Middle to Upper Norian.

The dominance of conglomerate suggests that Sheldon Member rocks were deposited during an interval of uplift and erosion. The lower conglomerates are dominated by volcanic and intrusive clasts derived partly from the Joe Mountain Formation. Sedimentary clasts were eroded from uplift of a limestone platform that preceded the deposition of the thick carbonate package (Hancock Member) during the Late Norian. A Middle Permian U-Pb date was obtained from a hypabyssal igneous clast. Rocks of this age are unknown in northern Stikinia, thus suggesting a sedimentary link with a source terrain that includes Permian igneous rocks.

Hancock Member

The Hancock Member is here defined as the unit near the top of the Aksala formation that is dominated by limestone and limy siltstone. This member is continuous across the entire width of the Whitehorse Trough, although its thickness, distribution and lithological characteristics vary considerably, largely reflecting depositional variations (Figure 25). Limestone beds in the western facies belt are discontinuous, vary in thickness and are interbedded with Mandanna Member lithotypes, whereas limestones in the central belt are thick, continuous and reefal (Reid and Tempelman-Kluit, 1987). In the eastern facies belt, the limestone beds are thinner, lensoidal, but continuous as a unit.

Five main lithological units are recognized: 1) light grey limestone; 2) black limestone; 3) well-bedded limestone; 4) limestone conglomerate; and 5) limy siltstone. Dolostone, marble, karst limestone, non-limy argillite and pyritic siltstone are less common constituents of the Hancock Member.

1. Most of the limestone mountains in the region are composed of resistant, light-grey-weathering, **light grey limestone**. It occurs as thick, massive beds of sparsely bioclastic micrite that form beds up to 100 m thick, but are stacked to form a limestone section up to one kilometre thick. Occurrences are found in all facies belts, but the thickest accumulations are most common in the central belt, where they are associated with reefal limestone and limestone conglomerate.
2. The **black limestone** unit is characterized by a matrix of black carbonaceous lime mud with sparse white fossil fragments. The sparsely bioclastic micrite is well bedded in the Rabbitsfoot Canyon area but massive occurrences are dominated by highly fossiliferous packstone with abundant, large (30 cm), thick-shelled

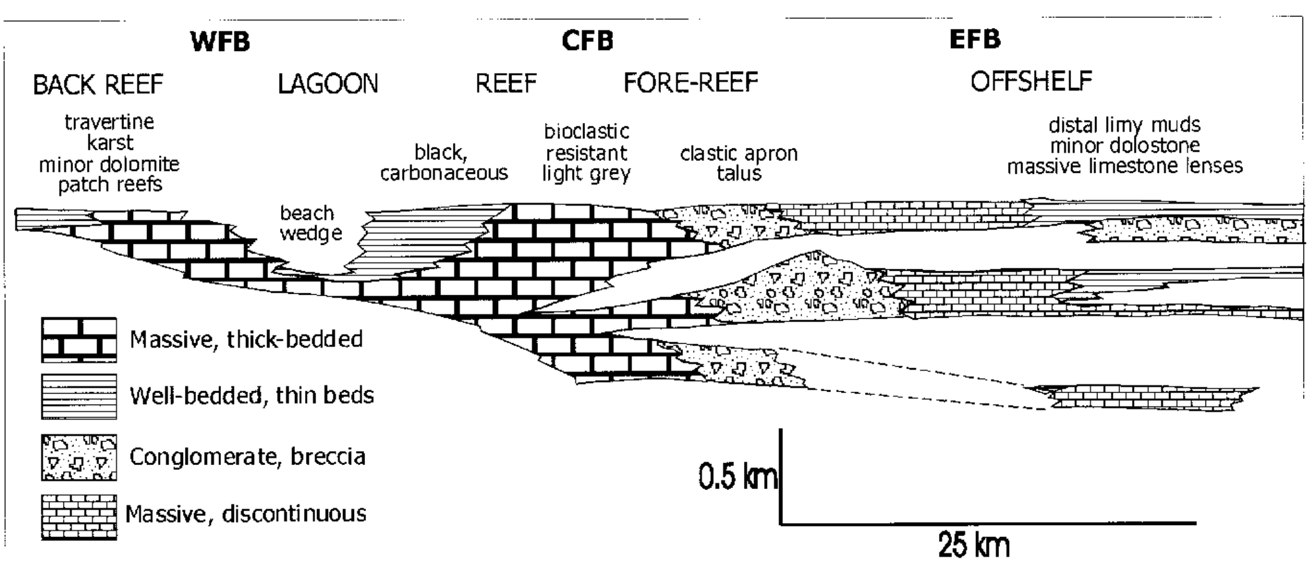


Figure 25. Schematic reconstruction of facies and distribution of Hancock Member carbonate dominated strata. WFB = Western Facies Belt, CFB = Central Facies Belt, EFB = Eastern Facies Belt.

pelecypods (*Megalodon* and *Dicercardium*) (Figure 26) and gastropods. Well-bedded occurrences contain discreet grains of detrital quartz and feldspar. Most of the occurrences are in the western facies belt.

3. **Well-bedded limestone** occurs as thin carbonate beds separated by thinner siltstone beds, or as interbedded limestone-argillite units. Excellent examples of this unit occur in the Rabbitsfoot Canyon and on Haeckel Hill. In both localities, some of the limestone is black, fetid, and interbedded siltstone units are present. In the Limestone Range, well-bedded limestone occurs beneath a thick succession of grey limestone and, west of Mount M'Clintock, it is interbedded with grey limestone lenses.
4. **Limestone conglomerate** occurs in thick massive beds in the Limestone Range, at Cap Mountain, and in the Byng Creek and Mount M'Clintock area. The nature of the conglomerate varies considerably from well-rounded, matrix-clast-supported cobbles to massive, angular boulders in an arkosic matrix, to matrix-supported, angular volcanic clasts in a micritic matrix. West of Mount M'Clintock, the conglomerate occurs interbedded with thin limestone beds (Wheeler, 1961; Jakobs, 1994).
5. **Limy siltstone** is ubiquitous among the Hancock Member limestones and varies from light grey and flaggy, to tawny and argillaceous. It comprises a greater portion of the Hancock succession in the eastern facies belt and, except for the dominance of limestone in the section, is similar to much of the Casca Member.

The Hancock Member carbonate locally contains abundant macrofossils or, less often, it forms discreet bioherms and reefs. The carbonate build-ups are mainly tabular with minor positive relief, except when stacked. The species forming reefs and carbonate cements are dominated by segmented calcareous sponges (*Sphinctozoa* and *Inozoa*), and supplemented by spongiomorphs, scleractinian corals, and algae (Reid, 1985; Senowbari-Daryan and Reid, 1987). Patch reefs of pelecypods and gastropods are not uncommon. Most reefal accumulations are in the central and eastern part of the western facies belts.

Figure 26. Large, thick-shelled pelecypods, probably megalodonts or *Dicerocadium* sp., typically occur with large gastropods in massive black limestone. These species are reliable indicators of shallow depths, probably no deeper than a few metres (Reid, 1985, p. 40).

Western Facies Belt

Excellent exposures of Hancock Member rocks are found north of the Takhini Hotsprings, where several beds of limestone are interbedded with Mandanna Member clastic strata. Other excellent exposures are found north of the Pilot Mountain subdivision, west of the Klondike Highway, at Rabbitsfoot Canyon and on the north and east flanks of Haeckel Hill. Hancock Member rocks of this facies belt are relatively thin and discontinuous as, locally, they were either not deposited or have been eroded away. West of the Takhini Hotsprings and north of the Pilot Mountain subdivision, light grey limestone is overlain by Laberge Group clastics. However, between these localities, Laberge Group strata lie directly on Mandanna Member sandstone, and the intervening limestone is missing.

The Rabbitsfoot Canyon exposure is a well-bedded section that is approximately 600 m thick. It includes thick- and thin-bedded limestone, interbedded limestone and argillite, well-bedded black limestone and well-bedded argillite. Most of the original rocks have been metamorphosed to marble and hornfels by the proximal intrusion of the mid-Cretaceous Whitehorse pluton. Although structurally disrupted (Stretch, 1993), and metamorphosed, the section maintains its stratigraphic integrity.

Central Facies Belt

Hancock Member rocks in the central facies belt form two narrow belts-one along the east wall of the Yukon River valley (Limestone Range) to Cap Mountain, and another extending from east of Cap Creek to upper Joe Creek. Both of these belts extend northward and form exposures along eastern Lake Laberge, and at Lime Peak (Reid and Tempelman-Kluit, 1987). Reefal accumulations are densest and thickest in this region. Limestone Range exposures are dominated by thick accumulations of massive grey limestone that overlie well-bedded and interbedded units. Southerly, along strike, the unit breaks up into thinner limestone units separated by clastic units until, at Cap Mountain, the thinner limestone beds are replaced by limestone conglomerate.

The upper Joe Creek and Cap Creek areas reveal a single, thick, massive, fossiliferous limestone bed, which is locally between thinner, upper and lower limestone beds separated by clastic strata. The uppermost limestone bed in this region is overlain by limy, black siltstone correlated with the lowermost Laberge Group.

Eastern Facies Belt

The Hancock Member in the eastern facies belt occurs in a single, 1- to 2-km-thick, east-dipping belt. The area west of Mount M'Clintock is characterized by numerous thin lenses of limestone, which occur within a continuous calcareous horizon (Figure 27). This unit also contains a significant thickness of limestone conglomerate, bioturbated mudstone, sandstone-siltstone couplets, massive greywacke, and thinly bedded, light green chert (see section in Wheeler, 1961, p. 44; and descriptions in Jakobs, 1994). The limestone is composed of light-grey-weathering, resistant, slightly recrystallized, sparsely bioclastic, massive micrite and well-bedded sandy limestone with rare internal laminations. Locally, solitary corals, sponges and brachiopods are contained in the limestone, but they are generally recrystallized and poorly preserved. This unit is up to 1500 m thick and contains between two and eight limestone beds or lenses that comprise up to one third of the section. These are among the most easterly occurrences of Hancock Member rocks.

Age and depositional environment

Hancock Member strata are broadly correlative with the Sinwa Formation in British Columbia. Conodonts and macrofossils from limestone units throughout the map area indicate that Hancock Member carbonate deposition spanned the entire Norian but was most extensive during the Late Norian. There is some evidence of extensive pre-Norian limestone deposition, although none of the samples collected from thick limestone units for conodont analyses yielded a pre-Norian age. However, the presence of carbonate clasts from two conglomerates suggest that Upper Carnian to Lower Norian limestone units were eroded. Carnian conodont collections were obtained from thin limestone beds in dominantly argillaceous successions, and a questionable Carnian macrofossil was obtained from the Limestone Range.

Bioclastic micrite, the dominant unit of the Hancock Member, represents deposition of a carbonate mud in a moderate energy, marine environment.

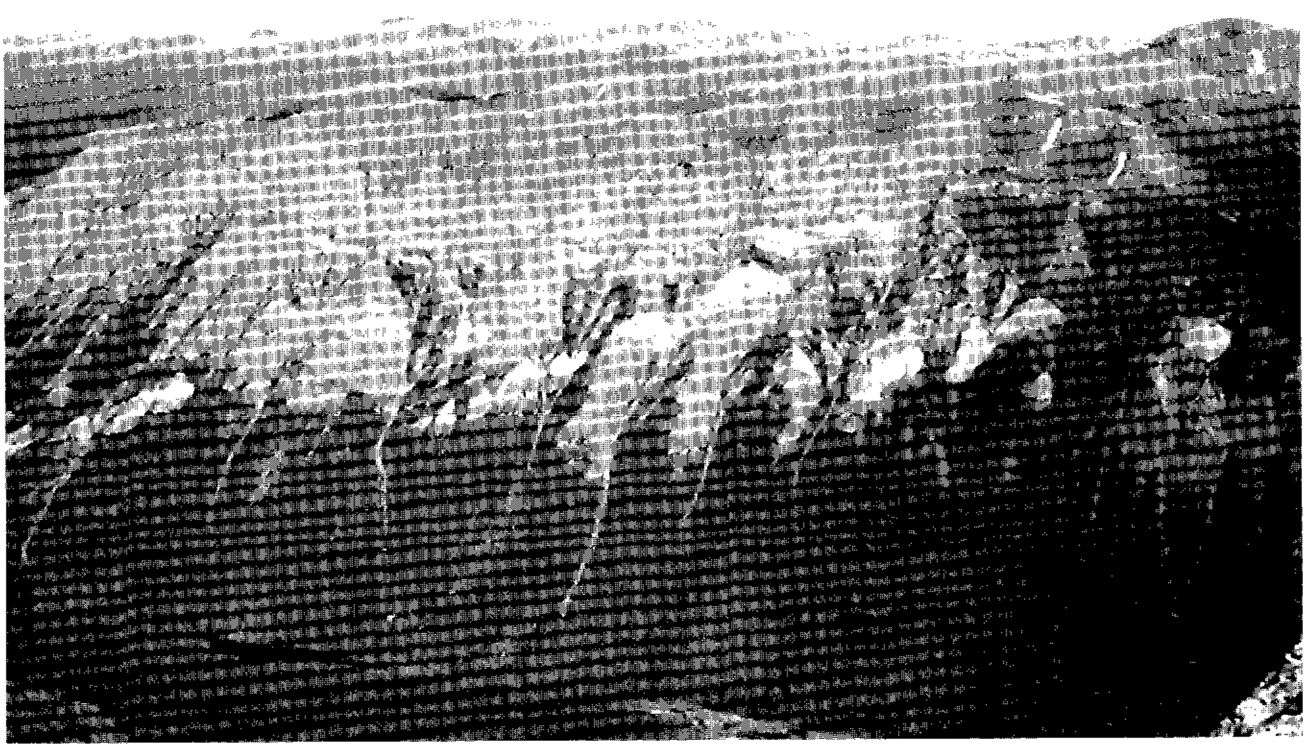


Figure 27. Thin, distal, lenticular carbonate beds of the Hancock Member northwest of Mount M'Clintock are well exposed on this cliff face. Some discontinuity of the beds is due to structural disruption. Much of this section is composed of limestone conglomerate (measured by Wheeler, 1961; and described in Jakobs, 1994). It is conformably overlain by Richthofen formation strata of the Laberge Group.

Fragmented and abraded shells and corals indicate reworking of biohermal material, which was transported into relatively quiescent depocentres. The black limestone represents accumulations in a locally anoxic and reducing (H_2S), restricted marine environment typical of subtidal to lagoonal zones. Limestone conglomerate represents the fore-reef erosion and deposition that occurred during drops in relative sea level. The varying character of the conglomerates indicates several modes of deposition, including accumulations of fore-reef talus aprons and sheet-like deposition in fans at the base of the carbonate apron.

Mandanna Member

The Mandanna Member is composed of well-bedded or massive, green and maroon to brick-red, bioturbated siltstone, greywacke, sandstone and tuff, with local occurrences of conglomerate. Mandanna Member rocks conformably overlie, and interfinger with, Hancock Member limestone and locally are conformably overlain by the Laberge Group. The Mandanna Member is restricted to the western facies belt, but is discontinuous and its thickness is variable. Where absent, it is likely eroded away. Within and south of the map area, it is restricted to west of the Yukon River valley, where it is represented at four main localities-Miners Range, Takhini Hotsprings, Alaska Highway and Haeckel Hill. Mandanna Member rocks were previously described by Dickie (1989).

Miners Range

In the southern Miners Range, 8 km north of the Takhini Hotsprings, a thick section of steeply dipping strata is dominated by Mandanna Member red siltstone and sandstone and interfingering Hancock Member limestone. The Mandanna mudstone beds are bioturbated and overlain by massive sandstone beds with rip-up clasts. Local conglomerate consists of subangular limestone clasts in a muddy maroon matrix. This section is overlain by a succession of maroon and white, planar-laminated, ungraded sandstone with heavy-mineral-concentrated laminae.

Takhini Hotsprings

Two sections are exposed near the Takhini Hotsprings. The first, immediately north of the Hotsprings, is a 400-m thick, moderate- to steep-dipping, section that lies conformably on limestone, and represents a transition into the Laberge Group. The section includes a basal succession of planar and cross-bedded, maroon and white sandstone, to interbedded, maroon, sandy mudstone and cobble conglomerate. The second section is north of the Hotsprings Road and is dominated by almost a kilometre of nearly flat-lying, thickly bedded, massive, maroon sandstone. The sandstone is composed of angular grains dominated by plagioclase with subordinate mafic minerals, lithic clasts, epidote and quartz in a maroon muddy matrix. Locally it contains pebbly conglomerate or is well laminated. Rip-up clasts of maroon siltstone are common.

Alaska Highway

Excellent exposures of the Mandanna Member along the Alaska Highway near km 1495 consist of a 100 m section composed of bioturbated red mudstone overlain by 2- to 20-m-thick, lensoidal beds of massive and cross-bedded, red sandstone. The beds are locally graded, contain arkosic interbeds and mudstone rip-up clasts, and are typically capped by thin (2-40 cm) beds of mudstone. The mudstone is generally bioturbated (dominantly *Skolithos* with *Chondrites*, *Cruziana* and *Scoyenia*), and locally contains ripples, caliche and mudcracks (Dickie and Hein, 1995). The sandstone is identical to that described for the Haeckel Hill and Takhini Hotspring Road localities.

Haeckel Hill

The region between Haeckel Hill and the Alaska Highway is underlain by a thick accumulation of massive, planar and low-angle cross-stratified, green, red and maroon arkosic sandstone and greywacke with lesser conglomerate. The beds are flat to shallow north-dipping and comprise a monotonous section approximately 1000 m thick. The sands are dominated by feldspar, hornblende/pyroxene(?) and lithic clasts of intermediate volcanics, but also contain small amounts of quartz. Although well sorted, the grains are angular and give the rock a tuffaceous appearance similar to the fine-grained Nordenskiöld dacite of the Laberge Group. Conglomerate is both matrix- and clast-supported and is dominated by 3-10 cm clasts of subangular, dark maroon basalt and feldspar-porphyry (andesite). The upper succession lithologically resembles the Alaska Highway locality. The lower portion of this section includes a few discontinuous, 10- to 30-m-thick limestone units and slightly thicker beds of tan brown, limy siltstone. Similar rocks north of the Hotsprings Road contain a higher percentage of quartz.

Age and depositional environment

Mandanna Member rocks do not host identifiable macrofossils but are assigned a Latest Norian and Hettangian age on the basis of the intimate association with the uppermost Hancock Member and its position beneath lowest Laberge Group strata. Rocks of this age in the western part of the Whitehorse

Trough are rare, and deposition across the Triassic-Jurassic boundary (in the western part of the Whitehorse Trough) is recorded only at these few localities. This unit is therefore considered transitional between the Lewes River and Laberge groups.

The Haeckel Hill and Hotsprings Road localities represent unusually large thicknesses of material of probable pyroclastic origin. The reworked tuffs are probably deeper water equivalents of the planar bedded sands found north of the Takhini Hotsprings and in the Miners Range. The planar- and cross-laminated sands reflect beach facies, and the overlying muds and conglomerate north of the Hotsprings reflect the incision and sheet flow of conglomerate across tidal mudflats.

The Mandanna Member is interpreted as having been deposited in a shallow, oxygenated, supratidal, beach/littoral setting with periodic subaerial exposure to an arid climate. The hematitic colouration is primary because of the presence of grey and green mudstone interbeds, and maroon clasts preserved in overlying strata. The *Skolithos*-dominated ichnofacies assemblage suggests a relatively high-energy sandy marine setting with shifting sediments, whereas the *Cruziana* ichnofacies indicates quieter conditions, such as in estuaries, lagoons and tidal flats (Frey and Pemberton, 1984). A tidal flat floodplain with periodic emergence and erosion by braided fluvial channels is the likely depositional environment. The Mandanna Member northwest of the Takhini Hotsprings reflects a transition from the low-energy, shallow-shelf sedimentation of the Lewes River Group to the high-energy sedimentation before the deep water, fan delta deposition of the Laberge Group (Dickie and Hein, 1995). The Alaska Highway locality reflects the progradation and stacking of sand beds across mud-dominated tidal flats.

Laberge Group

The Laberge Group (Cairnes, 1910; Cockfield and Bell, 1926; Bostock and Lees, 1938; Wheeler, 1961; Souther, 1971) is characterized by excellent exposures of polymictic cobble conglomerate, but also contains significant wacke, arkose, siltstone, argillite and tuff. In the study area, Laberge Group rocks are limited to the southern Miners Range (north of the Takhini Hotsprings Road and west of the South Klondike Highway), north of King Lake and a tract adjacent to the Teslin River, with a few smaller occurrences in the Cap Creek area. The lower contact generally is marked in the west by an unconformity overlying various components of the Aksala formation although sections conformable with the Mandanna Member do exist. In the central and eastern region there are conformable to gradational contacts of Laberge Group strata on the uppermost limestone of the Hancock Member. Upper stratigraphic contacts of the Laberge Group were not observed.

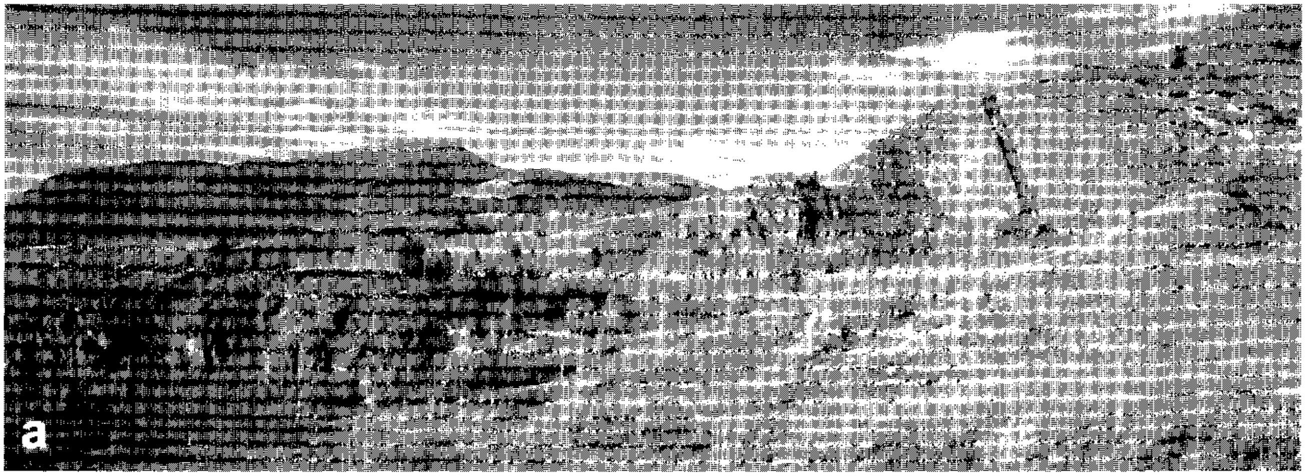
The thickness of the Laberge Group varies from more than three kilometres in the west to approximately one kilometre in the central and eastern belts, thus forming a westward-thickening clastic wedge. However, the thickness of the Laberge Group in the central belt is severely under-represented, as it is mostly missing because of uplift and erosion.

Like the Aksala formation, Laberge Group strata display extreme facies variations across the Whitehorse Trough. Consequently, confident stratigraphic correlations are difficult, making the application of nomenclature problematic. However, locally excellent biostratigraphic control aids in the recognition and definition of time-equivalent units. Laberge Group nomenclature in the study area follows that suggested by Templeman-Kluit (1984) and is applied where biostratigraphic control is good or the lithology is diagnostic; other strata remain undifferentiated. The Laberge Group in the study area consists of three formations: the Richthofen, Conglomerate, and Tanglefoot. Two additional units, the Nordenskiöld dacite and Teslin River conglomerate, occur as members. The Laberge Group, and the Conglomerate formation in particular, have been studied in detail by Dickie (1989) and Dickie and Hein (1995).

Richthofen Formation

Strata of the Richthofen Formation, the lowest unit of the Laberge Group, are thin to missing in the western belt, but thicken dramatically toward the central belt and remain thick in the eastern belt. These rocks are dominated by fine-grained lithotypes such as siltstone and interlaminated siltstone-sandstone couplets. Good exposures are found at three main localities: Takhini Game Farm, west of Lake Laberge (Horse Creek) and in a belt southwest of the Teslin River around Mount M'Clintock.

The Richthofen formation at the Game Farm locality is thin (less than 200 m) and poorly exposed. These strata are missing between the Game Farm and Peak 4023'. The Horse Creek section is well exposed but tightly folded, precluding confident estimates of thickness. The extent and structural pattern at this locality suggest a minimum thickness of 1500 m. The base of this section is not exposed at either locality, but the upper contact is sharply marked by massive polymictic cobble conglomerate (Figure 28). In the Teslin River-Mount M'Clintock area, Richthofen formation strata form a thick, monotonous succession, also tightly folded, but estimated to be about 1000 m thick. The lower contact is conformable or transitional with limestone and limy siltstone of the Hancock Member. Locally, however, Richthofen



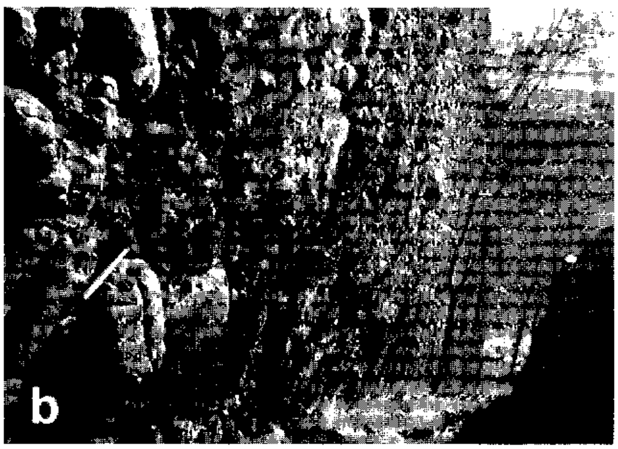


Figure 28. a) Looking northwestward at a section of upper Richthofen formation mudstone, argillite and greywacke (left) overlain sharply by lowermost Conglomerate Formation (right). The mudstone yielded an Upper Sinemurian ammonite collection. b) Base of conglomerate as exposed in hanging-wall of recessive weathering mudstone that once occupied the interval between the massive conglomerate beds.

strata unconformably overlie limestone-cobble conglomerate of the Hancock Member. West of the Klondike Highway, Richthofen strata are thin or absent and replaced by a disconformity between Hancock Member limestone and stratigraphically higher units of the Laberge Group. In the Mount M'Clintock area, Richthofen formation rocks are conformable with limestone and limestone conglomerate.

Richthofen formation strata are dominated by successions of brown-weathering, black siltstone and argillite with locally interlaminated light brown, fine sandstone couplets and incomplete Bouma sequences (Figure 29). The couplets (also described by Jakobs, 1994) are typically 2–6 cm in thickness, but form monotonously thick sections. The sandstone is ripple-cross laminated or planar laminated with a mildly scoured and loaded base. The sections of couplets are locally broken by massive beds of dark grey feldspathic greywacke. Much of the lower part of this unit, and exposures in the Mount M'Clintock area, are calcareous, and contain thin, discontinuous limestone beds. These rocks occur as extensive zones of hornfels around plutons. Intensive bioturbation is a characteristic of the black siltstone of this unit. Ammonites are rare.

In the upper Cap Creek area, recessive-weathering black, limy siltstone and resistant hornfels interpreted as belonging to the Richthofen formation, lie between Hancock Member limestone, and arkosic and lithic sandstone with pebble conglomerate, which likely marks the base of the Conglomerate formation. In the Mount M'Clintock area, the limy, black, bioturbated siltstone is locally metamorphosed to calc-silicate. In the lower Sheldon Creek area, the Richthofen greywacke includes granitic pebbles, and feldspar and quartz crystals as clasts, in an apparently tuffaceous matrix.

Age and depositional environment

The Richthofen formation, the lowermost member of the Laberge Group, generally lies upon Lewes River Group limestone, which locally yields uppermost Triassic fossils. In the western part of the map area, the contact is generally disconformable, but where conformable in the central and eastern part, Richthofen strata may be as old as earliest Jurassic. This is supported by a possible Hettangian to Sinemurian age determination from poorly preserved ammonites west of Mount M'Clintock (Jakobs, 1994). Ammonites higher in the formation from the Game Farm and Horse Creek areas, yielded fossils that confirm a Sinemurian age and locally are as young as lowermost Pliensbachian. Richthofen formation strata are roughly equivalent to the Inklin Formation strata of northern British Columbia (Souther, 1971).

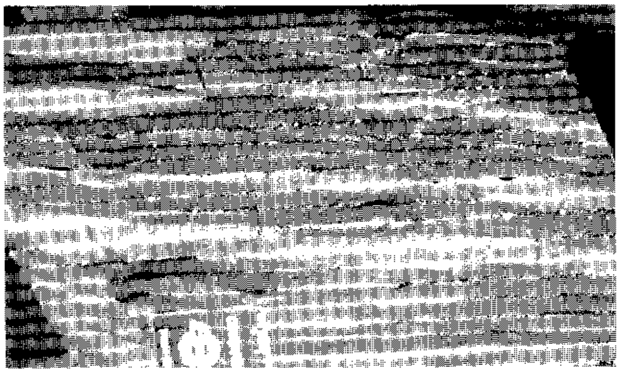


Figure 29. Interlaminated sandstone and mudstone couplets of the Richthofen formation typically combine to form thick sequences. The couplets reflect partial deposition of Bouma sequences typical of distal turbidites in mid- to distal fan locations.

The thick sections of couplets are interpreted as accumulations of CD(E) turbidites that were deposited in deep marine settings during a tectonically quiet interval. The thick succession in the Horse Creek area represents accumulations of mid- to distal-fan deltaic muds.

Conglomerate formation

Polymictic cobble and boulder conglomerate is a hallmark of the Laberge Group and the main component of the Conglomerate formation. The Conglomerate formation includes Nordenskiöld dacite as a member and contains appreciable amounts of wacke, tuff and tuffaceous sandstone in the upper portion. Most occurrences are restricted to the western facies belt with exceptional sections near the Takhini Hotsprings, Takhini Crossing and Horse Creek. Less extensive exposures occur north of the Hotsprings Road, near Cap Creek and south of Mount M'Clintock. The Conglomerate formation was introduced by Tempelman-Kluit (1984). Descriptions and evaluations of Laberge Group conglomerate occurrences are in Dickie (1989), Dickie and Hein (1988, 1992, 1995) and Hart et al., (1995).

The thickness of the Conglomerate formation varies considerably across the study area. Near Takhini Crossing, just the lower portion of the Conglomerate formation is over three kilometres thick and occurs as thick, massive and apparently continuous beds (Figure 30). The northeast limb of the Takhini Syncline includes a significant amount of the upper Conglomerate formation and is approximately two kilometres thick. Conglomerate beds here are thin (10-20 m), but form largely continuous sheets with local regions of thickening. Conglomerate formation strata in the central and eastern facies belts is poorly represented, considered to be less than one kilometre thick and dominated by sandstone and pebble- to grit-sized conglomerate. The Conglomerate formation forms a westward-thickening wedge. The thickest successions are in alluvial and proximal coastal fan conglomerates that also contain a substantial amount of Nordenskiöld tuff.

The lower contact of the Conglomerate formation is marked by the first appearance of cobble conglomerate. Typically it is a sharp, but irregular contact of massive conglomerate, down cutting or loading into Richthofen formation mudstone (Figure 28). The basal conglomerate typically contains mudstone rip-up clasts or locally mudstone rafts up to 3 m across. This contact is well exposed near Horse Creek and northeast of the Takhini Hotsprings. The upper contact of the Conglomerate formation is regionally undefined and is not apparent in the map area. Most of the upper portion of this unit lacks conglomerate.

Takhini Hotsprings

This section includes approximately 150 m of thin conglomerate and pebbly sandstone beds (2-5 m) in a stacked mudstone-sandstone succession (Dickie, 1989). The section sits on planar bedded beach sands of the Mandanna Member and is overlain by Nordenskiöld dacite. Clasts are small, well-rounded cobbles of volcanics and subordinate granitic. Some beds are dominated by angular sedimentary clasts. The section represents a transition from Mandanna Member to Conglomerate formation and lacks the intervening Richthofen formation.

Takhini Crossing

Conglomerate formation at this locality is dominated by thick, stacked, massive beds of matrix- and clast-supported, polymictic boulder and cobble conglomerate. The section is punctuated by interbeds of tuff and tuffaceous sandstone, and is more than 3 km thick. A portion of the section was published in Hart et al. (1995). Clasts are dominated by well-rounded and spheroidal granitic rocks, with a wide range of clast sizes from pebbles to boulders that are up to up to 1.5 m across (Figure 31). Conglomerate beds locally fine upward to sandstone, which contains laminae concentrated with magnetite. Interbedded tuff forms thick beds that separate conglomerate-dominated successions. Descriptions of the tuff are given in the section on Nordenskiöld dacite.

Horse Creek

The Horse Creek section (the Klondike Highway section of Dickie (1989)) includes over 300 m of conglomerate from only the lowermost portion of the Conglomerate formation (Figure 32). The basal

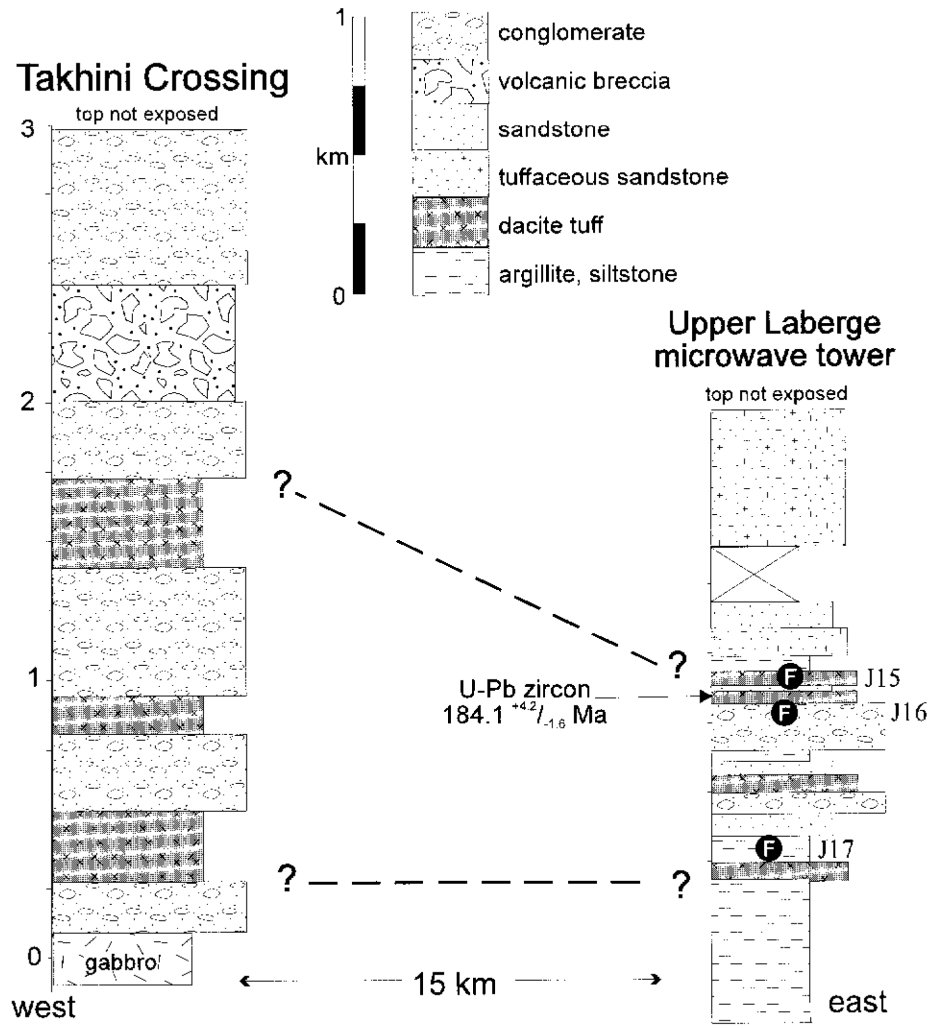


Figure 30. Stratigraphic sections from Takhini Crossing and the Upper Laberge communications tower indicate that the conglomerate and Nordenskiöld dacite thin considerably toward the east. Neither the base nor the top of the Takhini Crossing section is exposed suggesting that it may be much thicker than shown. The Upper Laberge section indicates that Nordenskiöld dacite first appears near the top of the argillite that constitute the Richthofen formation. This section is capped by a considerable thickness of reworked tuff (arkosic greywacke). The Nordenskiöld dacite is tightly constrained in this section. The J-numbers are fossil localities also used on the enclosed maps and in Appendix 3; units are all Pliensbachian in age.

conglomerate consists of both matrix-supported boulder conglomerate with mudstone rafts and clast-supported cobble conglomerate with heavily oxidized granitic clasts. Mudstone rafts, up to 3 m long, are a feature of some of the conglomerate beds in this section. Unidirectional paleocurrent indicators are abundant at this locality. Conglomerate beds fine upward to sandstone with a few preserved caps of black shale.

Clast provenance

Clast provenance studies by Dickie (1989) and in Hart et al. (1995) indicate that clast populations contain varying percentages of volcanic, plutonic and sedimentary components. Most volcanic clasts are typical of mafic rocks associated with the Lewes River Group Povoas formation. Plutonic clasts are of variable lithology although alkali feldspar megacrystic quartz monzonite is lithologically similar to the Little River batholith. Sedimentary clasts are all locally derived from the Mandanna and Hancock members of the Aksala formation. Metamorphic clasts are rare but are dominated by amphibolite and augite-chlorite schist-both constituents of the Takhini assemblage.

A ternary plot of clasts from throughout the Whitehorse Trough indicates a three-stage temporal transition from dominantly volcanic clasts to sedimentary clasts in the Upper Lewes River Group conglomerate to mixed sedimentary-volcanic clast population with minor granitic clasts in Lower Laberge Group to granitic clast dominated conglomerate in Upper Laberge Group (Figure 33). These trends represent erosion of the Lewes River Arc progressing to shelf uplift and erosion at the Triassic-Jurassic boundary, then arc uplift and erosion of the arc's plutonic roots. Dating of the granitic clasts indicates a population dominated by 208-215 Ma plutons (Hart et al., 1995). Some granitic clasts contain augite-phyric xenoliths, suggesting intrusion into either the Takhini assemblage or the Povoas formation.

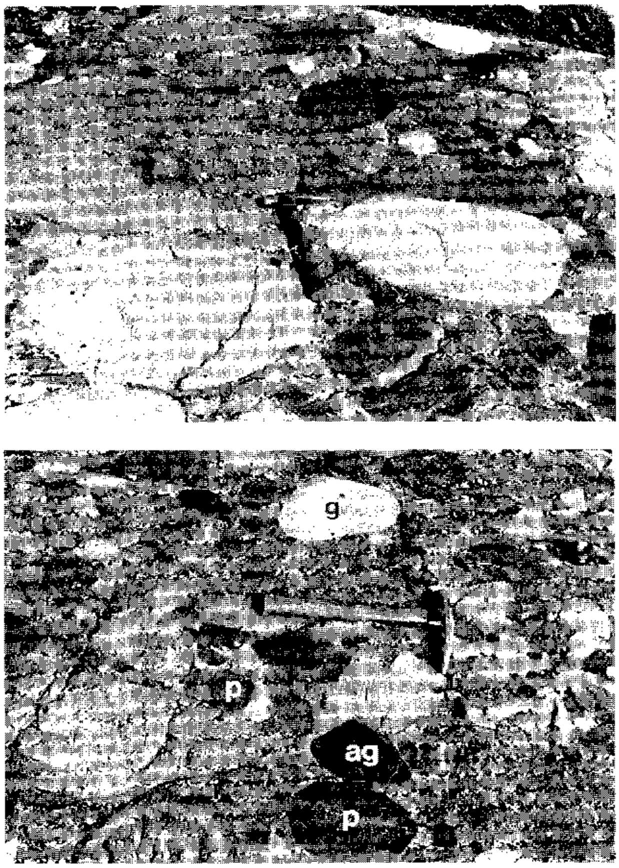


Figure 31. a) Laberge Conglomerate showing general large size and sphericity of granitic clasts at the Takhini Crossing site. b) Polymict conglomerate displaying array of clast types; g=granite, ag=agglomerate, p=augite porphyry, f=feldspar porphyry. Dark spot next to "g" in granitic clast is a xenolith of augite-phyric basalt suggesting that this granite originally intruded into a volcanic substrate.

Age and interpretation

Well-constrained Conglomerate formation strata between the Takhini Hotsprings road and the Miners Range, range from Early Pliensbachian to Early Toarcian in age. The Late Pliensbachian is particularly well represented by fossil collections. Toarcian exposures lack conglomerate. Conglomerate formation strata at other localities lack constraining data, although the presence of Nordenskiöld dacite at the Takhini Crossing locality strongly indicates a Pliensbachian age for these strata. Conglomerate formation strata in the Laberge map area (105E) were assigned a depositional interval of Sinemurian to Toarcian (Tempelman-Kluit, 1984). Conglomerate formation strata are roughly equivalent to the Takwahoni Formation as defined in northern British Columbia (Souther, 1971).

The suggested depositional environment for the Laberge Group conglomerates has ranged from alluvial fan (Wheeler, 1961) to deep marine (Eisbacher, 1974). Focused study by Dickie (1985) and Dickie and Hein (1995) indicated the conglomerates were deposited in several environments. Thin sheet flood and channelled conglomerates cutting mud flat and lagoonal sediments indicate an alluvial to fluvial setting for the Takhini Hotspring conglomerates. Conglomerate at the Takhini Crossing section reflects deposition in a restricted alluvial and proximal coastal fan setting. A very large average clast size, and exceptionally large individual clasts require an extreme topographic gradient typical of an uplifted source terrain. Large mudstone rafts, deep scours, unidirectional paleocurrent indicators, recumbant slump folds and boulder toesets interbedded with prodeltaic Richthofen formation muds reflect channelled conglomeratic progradation across deep-water, prodeltaic muds of the Horse Creek section.

Nordenskiöld dacite

Crystal tuff, informally called the Nordenskiöld dacite (Cairnes, 1910), is an important unit of the Laberge Group. Fresh rocks are resistant and dark blue-grey. Altered occurrences range from resistant, brick-red-weathering to less resistant pale-green-weathering, to recessive and crumbly buff-brown-weathering. This unit extends from Atlin, British Columbia to Carmacks in the central Yukon and within the map area, significant accumulations were mapped at King Lake, the Upper Laberge communication tower, and lower Sheldon Creek (Peak 1749 m). The tuff occurs at at least four horizons within a relatively narrow stratigraphic interval (Figure 30). The lowest occurrences are within the upper Richthofen formation argillite, although most tuff horizons are interbedded with coarse boulder beds of the Conglomerate formation. Higher horizons have a stronger sedimentary character and are considered to be reworked older tuff horizons.

Nordenskiöld dacite beds are dominantly massive, but locally consist of well-laminated, non-welded, sparsely fragmental, crystal-rich tuff (Figure 33a). The tuff is composed of dense granular accumulations of coarse-grained (2–4 mm) feldspar and quartz crystals, and fewer, finer grained (1–2 mm) hornblende and biotite crystals with sparse lithic fragments. The crystals are dominantly euhedral quartz and feldspar with broken corners, and subhedral biotite and hornblende. Sparse alkali feldspar occurs as euhedral megacrysts up to 2 cm across and much smaller broken crystal fragments. Dominantly angular, pebble-sized lithic clasts are fragments of granophyric dacite. Much smaller, argillite clasts and rare granodioritic clasts occur locally.

The thickness and character of the tuff layers vary from thick (350 m) and coarse-grained (4 mm),

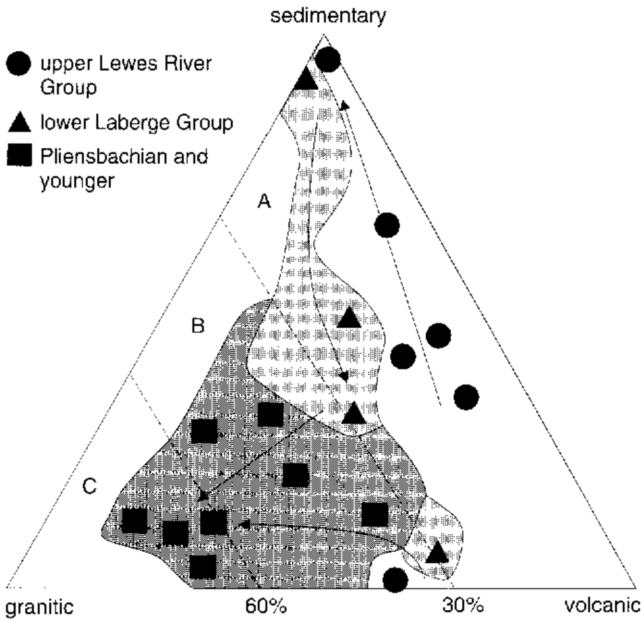


Figure 32. Ternary plot of granitic, sedimentary and volcanic clasts from conglomerates of the upper Lewes River and Laberge groups. Shaded regions cover modified point data of Dickie (1989), which were obtained from 50 or 100 clast counts from approximately 440 sites throughout southern Yukon, with an emphasis on sites in map area 105D/14. Changes in clast compositions over time are denoted generally by the shading and emphasized by the arrows: from Late Triassic to earliest Jurassic to Pliensbachian.

with large lithic clasts in the west, to thinner (50 m) and finer grained (2 mm) with fewer and smaller lithic clasts toward the east (Figure 30). A similar pattern is seen in the conglomerate beds, which thin basinward, and in clasts that fine basinward. At the Takhini Crossing locality, the unit has a cumulative thickness of approximately 700 m, whereas in the Upper Laberge section, located 15 km to the east, the combined bed thickness is less than 200 m.

Sedimentary rocks in the upper Sheldon Creek (Peak 1749 m) areas, in the eastern part of the study area, have a high density of euhedral feldspar, quartz and biotite crystals, and lithic fragments. The sandstones and the conglomerate matrix therefore have a significant tuffaceous component (Figure 34). The eastern occurrences are rich in coarse-grained biotite and sparse in hornblende, and have a high percentage of large (2-20 cm), angular, exotic (granitic, carbonate and argillite) lithic clasts. More detailed descriptions of these rocks are documented in Hart and Hunt (1995b). Although these rocks have similarities with Nordenskiöld dacite in the western part of the Whitehorse Trough, the large size of the lithic clasts suggests a probable local (eastern) source.

Petrographic examinations of typical Nordenskiöld tuff indicate that the dacite is composed of approximately 75% angular, and considerably fractured, crystals of euhedral feldspar and quartz, with lesser biotite and hornblende. Plagioclase constitutes 60–70% of the crystals and is dominated by andesine (An35). Quartz (15%, but up to 40%) occurs as: 1) large, round or bipyramidal, partly resorbed and embayed crystals; 2) sparsely as large (approximately 5 mm) polycrystalline aggregates; and 3) as lithic clasts of cryptocrystalline quartz. Mafic minerals are smaller and dominated by hornblende (up to 15%) with lesser biotite (1–5%). Alkali feldspar crystals (1–2%) are rare. Accessory minerals include titanite, apatite, augite, pyrite, magnetite, pyrrhotite, zircon and calcite. The crystals and lithic fragments are set in a matrix of fine crystal fragments, variably altered brown ash and particles of devitrified glass. Much of the matrix is an altered cloudy aggregate of submicroscopic chlorite, epidote, zoisite and leucoxene.

At most localities, tuffaceous components of the Nordenskiöld tuff are mixed with detrital components

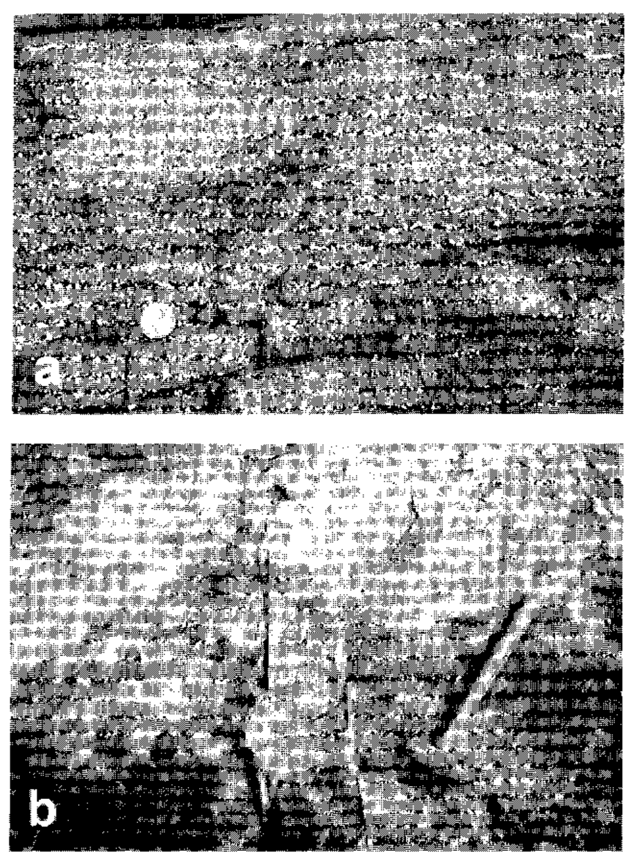


Figure 33. a) Coarse-grained, crystal-rich Nordenskiöld dacite showing large euhedral plagioclase (white) and hornblende (black). Euhedral quartz also occurs but cannot be differentiated in the photograph. b) Mottled alteration characteristic of the Nordenskiöld dacite. Altered rocks are lighter coloured. Note flattened tuff fragments parallel to hammer. Both of these photos are from the Takhini Crossing area and represent proximal facies crystal-lithic tuff.

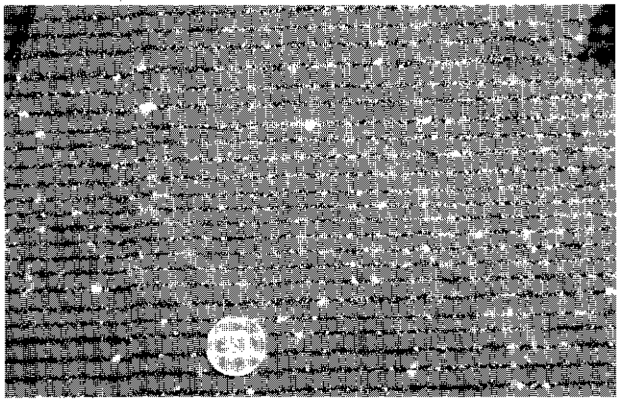


Figure 34. Coarse-grained, euhedral alkali-feldspar and biotite occur in this crystal-rich tuffaceous greywacke from lower Sheldon Creek. This unit may be equivalent to the Nordenskiöld dacite, but its presence in the eastern part of the Whitehorse Trough and slight lithological differences suggest a source different from Nordenskiöld dacite in the western Whitehorse Trough.

and form hybrid tuffaceous sandstone, arkosic sandstone and feldspathic wacke. These rocks are indistinguishable from "typical" Laberge Group sandstone. Cairnes (1912) stated that "the tuffs so resemble the (Laberge Group) arkoses that it is generally difficult or impossible to tell the two apart. These rocks also grade into one another such that they have almost equal claim to be called arkoses and tuffs". As a result of this similarity, the volcanogenic component is commonly difficult to recognize in the field and has, except where obvious or extensive, generally been overlooked and under-represented.

Alteration

Most occurrences of the Nordenskiöld dacite are altered. The most common alteration is characterized by a mottled appearance, where a spotty or textured appearance is a consequence of nonpervasive alteration (Figure 33b). The alteration is manifest in the matrix where altered portions are a lustrous, fine-grained, pale epidote green in place of unaltered, opaque, dark grey to blue. This alteration is characteristic of the more igneous-looking occurrences of this unit and not of the tuffaceous sandstone, suggesting that permeability is a condition of its formation. Johannson (1994) suggested that the alteration mineral associated with the mottling in the Atlin area is laumontite. This mineral retrogrades to quartz and epidote, which is the more common mineral assemblage found in the Whitehorse area.

Recessive, punky and crumbly weathering, buff-coloured outcrops of dacite are associated with regions of mottled alteration. At these localities, plagioclase crystals have been altered to soft, chalky white clay minerals (kaolin?). Similarly, the matrix has been altered to clays, calcite and chlorite, which have little ability to hold the crystals togther. Consequently, outcrops affected by this style of alteration erode into crumbly aggregate.

Many occurrences of this unit are maroon to brick-red as a result of hematitic alteration rather than weathering. The alteration is imparted by the oxidation of reduced iron-rich minerals and the resultant distribution of fine-grained hematite throughout the matrix. This alteration is primary and occurred shortly after the rock was deposited.

Age and correlation

The age of the Nordenskiöld dacite in the map area is well constrained by both isotopic and biostratigraphic methods. Analysis of a sample from the Upper Laberge communication tower yielded a U-Pb zircon age of 184.1+4.2/-1.6 Ma. Ammonites examined from beds above and below this site are representative of the Kunae Zone of the Upper Pliensbachian (Pálfy and Hart, 1995). Stratigraphically beneath this locality, the occurrence of ammonites of the Whiteavsei Zone indicates that Nordenskiöld dacite also occurs in the Early Pliensbachian. These age constraints are similar to those determined for dacite tuff near Atlin Lake, B.C. (Johannson et al., 1997).

Nordenskiöld dacite occurs at several stratigraphic levels within a stratigrapic interval that includes most of the Conglomerate formation and the upper Richthofen formation. Although this stratigraphic interval is well defined, tuffaceous rocks are found at other horizons, thus diminishing Nordenskiöld's value as a marker unit. The predominance of this unit along the western margin of the Whitehorse Trough, and the coeval intrusion of the Long Lake plutonic suite immediately west of the Whitehorse Trough suggest that the Nordenskiöld dacite was the extrusive equivalent of this suite.

Teslin River member

The Laberge Group east of the Teslin River is dominated by massive beds of clast- and matrix-supported, limestone boulder and cobble conglomerate. Angular limestone clasts, up to 30 cm in size, constitute 30–50% of the clast population. Other clasts are dominated by fine-grained and porphyritic volcanic rocks, and mudstone.

West of the Teslin River, limestone conglomerate forms beds 1 to 15 m thick in the lower part of the finer grained Richthofen formation (see Jakobs, 1994). Conglomerate east of the Teslin River may represent a more proximal facies, in which case it is probably earliest Jurassic in age, and derived from the east. Clasts from this locality contain Lower Norian conodonts, suggesting a derivation from the Hancock Member.

Tanglefoot Formation

A succession of folded, generally steep-dipping, coarse-siliciclastic rocks underlies a small region 8 km west of Flat Mountain. The rocks appear to have been deposited unconformably on top of Lewes River Group strata and are unconformably overlain by nearly flat-lying Carmacks Group volcanics. They are intruded and thermally metamorphosed by the Flat Creek pluton.

The section east of Flat Mountain is divisible into two parts. The upper section includes more than 500 m of tan- and buff-brown-weathering, interbedded, quartz and chert-rich, gritty sandstone, siltstone and conglomerate with coaly plant fragments. This is overlain by 250 m of dark grey siltstone and angular cherty sandstone. The lower siltstone package, now mostly hornfels, is well laminated and bedded, whereas the conglomerate forms thick massive beds (up to 15 m). The conglomerate is composed almost entirely of white, grey and black, subrounded chert clasts set in a black, sandy matrix (Figure 35). Clasts are graded to poorly sorted and range from sand-size to 5 cm. Sandstone throughout the section is poorly sorted but consists of 6- to 10-cm-thick, graded beds. The coaly fragments, dominated by grasses, are shiny and brittle and likely have a rank approximating anthracite.

Age and correlation

On the basis of a single ammonite from the lower siltstone package, the succession west of Flat Mountain was originally assigned to the early part of the Middle Jurassic of the Laberge Group (Wheeler, 1961). Lithological similarities and an abundance of coaly plant fragments, enabled these strata to be correlated with the Tantalus formation (Hart, 1993a). Re-evaluation of the original ammonite sample, however, confirms an early Middle Jurassic (Early Bajocian) age for these rocks, which are among the youngest Jurassic strata in the Whitehorse Trough. Samples evaluated for palynomorphs were barren.

Tempelman-Kluit (1984) placed all Bajocian rocks of the Laberge Group in the undefined Tanglefoot formation. The lower siltstone assemblage west of Flat Mountain has lithological similarities with the Tanglefoot formation described by Tempelman-Kluit. However, the overlying conglomerate, which is continuous with the siltstone, has lithological characteristics more closely allied with the Tantalus formation, whose age is poorly constrained but considered to be as young as Cretaceous. Therefore on the basis of the Bajocian ammonite, these rocks are considered to be part of the Tanglefoot formation.

The Tanglefoot formation contains a transition from dominantly fine-grained marine sediments to dominantly coarse-clastic, perhaps terrigenous, strata. This reflects a dramatic change in the depositional environment from near-shore marine to deltaic or gravelly shoreface. The exclusivity of chert clasts in the Tanglefoot formation is unique for the Laberge Group and requires a new and sole source for detritus. The only proximal source is the Cache Creek Terrane, which has thick Permian to Jurassic chert horizons (Cordey et al., 1991; F. Cordey, pers. comm., 1996). This source was therefore emergent by Bajocian time. The similarity of these strata with the poorly constrained Tantalus formation requires a re-evaluation of the existing stratigraphic nomenclature.

Whitehorse Trough petrography

The petrographic evaluation of Whitehorse Trough sandstones from the Whitehorse map sheet (105D) by Wheeler (1961) provides an excellent database that can be interpreted with the benefit of

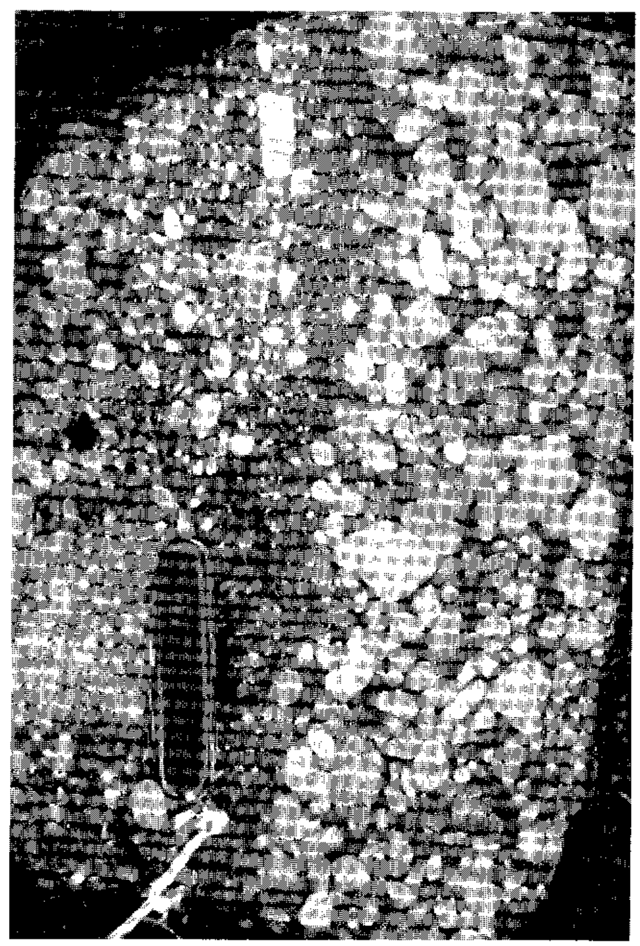


Figure 35. Chert pebble conglomerate containing coaly plant fragments from the Miners Range was interepreted (by the author) as Tantalus Formation, but an ammonite from the section reveals that it is Middle Jurassic in age and therefore part of the Laberge Group.

Table 2. Means of normalized detrital modes for Whitehorse Trough sandstones from the Whitehorse (105D) map area (calculated from data of Wheeler, 1961)

	Quartz	Plagioclase	K-feldspar	Lithics	Mafics	Matrix
Laberge Group (n=54)	8 ± 5	37 ± 9	6 ± 5	13 ± 9	1 ± 4	32 ± 10
Lewes River Group (n=27)	1 ± 3	37 ± 14	0 ± 6	5 ± 8	5 ± 6	39 ± 18

Note: data as percent, errors are one standard deviation.

modern classification schemes. This section interprets analyses from 27 samples of the Lewes River Group and 54 from the Laberge Group. More detailed stratigraphic assignment of the samples is not possible.

All the samples are texturally and compositionally immature. The clasts are generally coarse grained, poorly sorted and angular to subrounded. Mafic minerals and iron oxide clasts are common and most rocks contain 30 or 40% matrix. The dominance of plagioclase over quartz, and the high but variable percentage of lithic clasts are further indications of compositional immaturity. In general, Whitehorse Trough sandstones can be characterized as feldspathic wackes.

Whitehorse Trough sandstone detrital modes are shown in Table 2 and Figure 36. Lewes River Group samples are quartz-poor, lack alkali feldspar but have a higher percentage of mafic minerals and matrix compared to the Laberge Group. Higher proportions of quartz and alkali feldspar characterize the Laberge Group samples, although plagioclase remains essentially constant. Also apparent in the Laberge Group samples is an increase in clast size and percentage of lithic fragments.

Although compositional changes suggest a progression to more mature sediments with time, the Laberge Group is texturally immature. Two explanations are proposed. First, the source type or area may have changed. Lithic clasts indicate that the Laberge Group was derived from a granitic hinterland, whereas the Lewes River Group contains only mafic to intermediate volcanic clasts. Tectonic discriminant diagrams indicate a time progression from basement uplift to the transional arc, and toward the dissected arc field. The QmPK diagram (Figure 36b), could imply a transition from the intraoceanic arc to

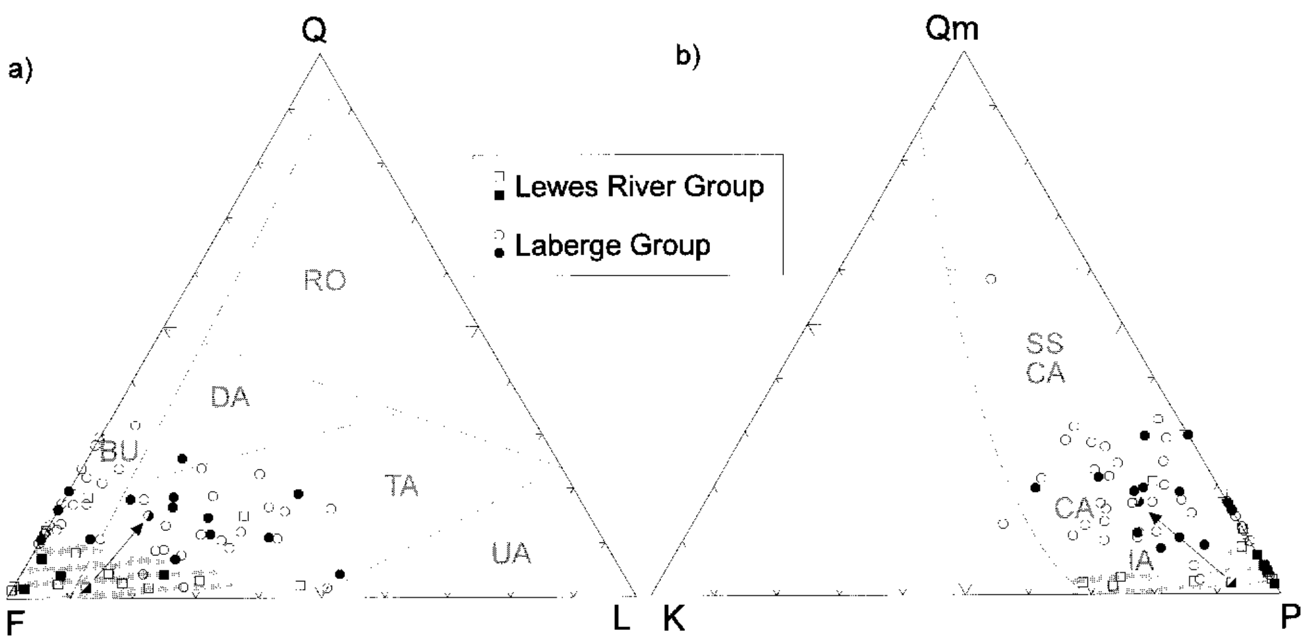


Figure 36. Tectonic discriminant ternary plots of sandstone composition of Whitehorse Trough sediments using data modified from Wheeler (1961). Regions dominated by Lewes River Group are shaded. Arrows indicate trends over time. Black circles are rocks from the study area, all others are from elsewhere in the Whitehorse map area (105D). Half-filled circles are means. a) QFL (quartz-feldspar-lithics) plot of detrital modes using discriminants of Dickinson et al. (1983). BU=basement uplift, RO=recycled orogen, DA= dissected arc, TA= transitional arc, UA=undissected arc. b) QmPK (monocrystalline quartz-plagioclase-alkali feldspar) plot of detrital modes using discriminants of Marsagli and Ingersoll (1992). Qm calculated as 95% of Q, as indicated by Laberge Group detrital modes in the Atlin area as evaluated by Johannson (1994) and Johannson et al. (1997). SSCA=strike-slip continental arc, CA=continental arc, IA=intraoceanic arc.

continental arc and strike-slip continental arc fields. Similarly, the QFL plot (Figure 36a) also indicates a temporal change in the tectonic setting and source areas.

Secondly, the changes in composition could have resulted from the addition of new material, specifically from the influx the Nordenskiöld dacite. This would have increased the amount of quartz and lithic fragments by deposition from airfall tuff. This suggestion is supported by the abundance of partially embayed, monocrystalline, euhedral crystals and tuffaceous lithic fragments in the Laberge Group sandstone. Trends shown on the the discriminant diagrams reflect a new source rather than progressive arc erosion and sandstone maturity.

Whitehorse Trough paleocurrents

Uni- and bidirectional paleocurrent indicators from the Laberge Group were obtained and analyzed by Dickie (1989) and presented in Dickie and Hein (1995) and Hart et al. (1995). The indicators suggest that sediment transport was dominantly toward the east. Furthermore, gravity-controlled features such as imbricated detritus, slide scars and slump folds, which give more accurate readings of flow direction, confirm the depositional features. Some sites yielded a wide range of directions while others were consistent in one direction. Radial paleoflow in distal fan settings and basin-parallel currents account for much of the variability.

The Lewes River Group strata contain fewer directional flow features. Imbricated clasts from limestone conglomerate in the Cap Mountain area demonstrate sediment transport to the east. Reliable unidirectional paleoflow indicators in the Sheldon Member include imbricated pebbles in well-bedded conglomerate, and slump folds in muddy horizons in bedded sandstone. When corrected to horizontal, these structures indicate that the general flow direction was from north to south, essentially parallel to the axis of the Whitehorse Trough. Measured and observed paleoflow currents are shown in Figure 37.

West-directed paleoflow has not been measured in Whitehorse Trough strata in the Yukon. However, study of proximal conglomerates in the eastern portion of the Trough suggests it existed. West-directed paleoflow has been recorded in the Laberge Group south of Atlin, British Columbia but was attributed to deflected turbidity currents (Johannson, 1994).

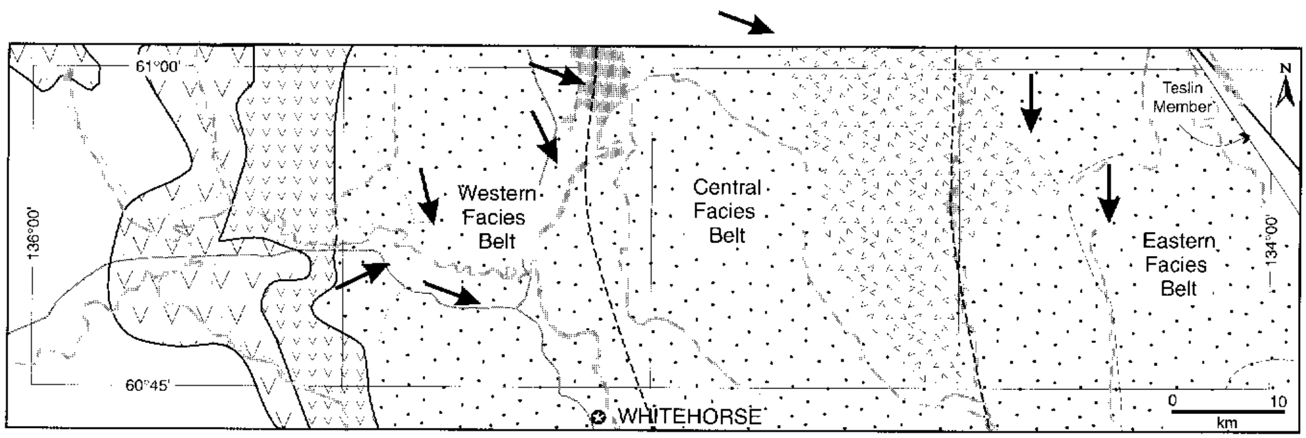


Figure 37. Direction of mean paleocurrent measurements from Laberge Group sediments in the study area and adjacent areas. Most data are from the Conglomerate formation and the upper Richthofen formation as measured by Dickie (1989). Determinations in the Eastern Facies Belt are from the Sheldon Member. See Figure 7 legend for lithology.

Biostratigraphy

Triassic

The Aksala formation is composed of four facies-dominated members, which cross time-stratigraphic horizons and make the use of rock-stratigraphic units impractical. However, sparse but diagnostic macrofossils within the facies-dominated, carbonate-rich Lewes River Group allow for the limited use of time-stratigraphic units. Four faunal successions were recognized by E. T. Tozer (1958; used by Wheeler, 1961) from collections made in the Laberge area (Lees, 1934; Tozer, 1958). These successions remain applicable and have been confirmed, modified and extended through advances in Triassic biochronology by Tozer (1967, 1979, 1994), and with the aid of conodont biostratigraphy (Orchard, 1991a, b). A compilation of Triassic macrofossils and microfossils collected from within the study area (Appendices 1, 2) define five faunal zones (Figure 38).

Most Lewes River Group macrofossils from the study area are bivalves, sponges and corals that have little biostratigraphic significance. However, sparse but key ammonites and other index fauna provide data that confirms a faunal zone as old as middle Early Carnian. The most widely representative sedimentary rocks of the Lewes River Group span the Amoenum and Cordilleranus zones of the Late Norian. Collections also indicate that the Late Carnian is represented, as is the uppermost part of the Early Norian, and sparse indications of Middle Norian are indicated by conodonts (Orchard, 1991a).

There are only a few definitive constraints on the age ranges of the various Aksala formation members (Figure 39). However, *Mysidioptera* sp. from within the carbonate-rich Limestone Range (Wheeler, 1961; p. 33) delimits a possible Late Carnian age (Tozer, 1962) and emphasises that thick units of Hancock Member carbonate may not be restricted to just the Late Norian. A Carnian age for Casca Member strata is indicated by a poorly constrained conodont collection from near Sheldon Creek. Conodont collections from the limestone-dominated Hancock Member give a Late Norian age for this succession. An Upper Norian conodont collection was also obtained from the limestone immediately north of the Takhini Hotsprings. Limestone clasts in a boulder conglomerate east of the Teslin River gave a Norian collection. Macrofossil collections of *Halobia*? sp. and *Monotis subcircularis* within the map area give further evidence of an age range that includes the Norian.

Fetid black limestone typically hosts abundant populations of large clam species. Megalodontid bivalves, first recognized by Lees (1934), and bivalves identified as dicerocarditids (Reid, 1985), commonly co-exist and are typically between 15-30 cm, although they can be as large as 50 cm across (Figure 26). The megalodontid bivalves are characteristic of Tethyan faunas. The dicerocaditid bivalves were also considered to be Tethyan, but re-evaluation suggests that they may be another species, similar to occurrences in the Wallowa Terrane, Sonora and Antimonio Terrane (Mexico) (G. Stanley, pers. comm., 1995).

The presence of scleractinian corals, megalodontids and *Monotis*, as well as *Gnomohalorites* and *Rhabdoceras*, is indicative of deposition in low paleolatitudes with probable Tethyan affinity (Tozer, 1982). Hancock Member carbonate contains the first Tethyan-type Upper Triassic sponge reefs in North America (Senowbari-Daryan and Reid, 1987). Some of the sponges are known only from the Tethyan realm, whereas others indicate a mixed Tethyan-North American affinity.

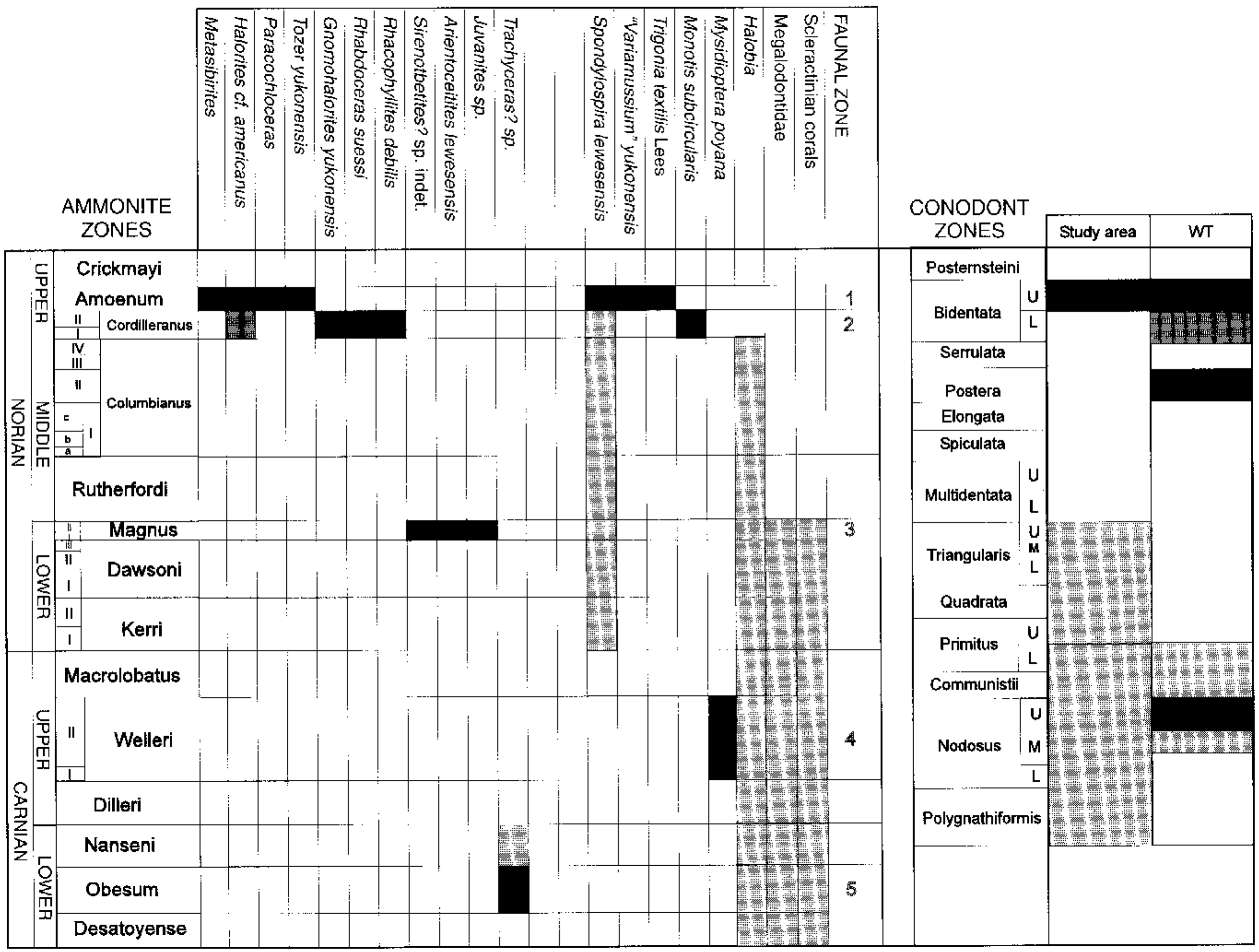
The Lewes River Group limestones also contain phylloidal algae. These algae occur as accumulations of leaf-like masses. In the Lime Peak area they are common at the top of the reef section (Reid, 1985), but in the Limestone Range they occur in the well-bedded strata at the base of thick, massive limestone units. The occurrence of phylloidal algae in Triassic rocks is unusual as they were thought to have become extinct at the end of the Permian.

Jurassic

Jurassic deposition is recorded by the Laberge Group and is divisible into four main lithological units, which have extreme across-strike facies variability. The units, and their facies equivalents are well constrained by assemblages of ammonites (Figure 40). Initial collections by Fyles (1950) and Wheeler (1961), evaluated by H. Frebold, have been supplemented by collections and identifications of Pálfy and Hart (1995), Pálfy (1995) and Pálfy and Tipper (1995). Collections from the study area are presented in Appendix 3.

The Laberge Group yields representative macrofossil collections of almost every ammonite zone and assemblage from the Sinemurian through to the Early Bajocian (Figure 40). Samples collected from within the study area indicate that the Sinemurian and Pliensbachian are best represented, particularly the Late Pliensbachian. The oldest Laberge Group strata west of the Yukon River are Early Sinemurian in age. Locally, however, there are continuous sections from the Lewes River Group through to the Laberge Group suggesting that the Hettangian may be represented but has not yet yielded fossils. East of the Yukon River, deep-water

Figure 38. Upper Triassic ammonite and conodont zonation (from Orchard, 1991a) with faunal representations of the Lewes River Group in the Yukon. Five macrofossil faunal zones are recognized. Macrofossils are compiled from: Tozer 1958, 1967, 1979, 1982, 1994, 1996; Wheeler 1961; and Appendix 1 and modified according to E. T. Tozer (pers. comm., 1995, 1996). Conodonts compiled from Orchard 1991a, b; c; 1993a, b, c; 1994; 1995a, b; 1997. Study area conodont collections are presented in Appendix 2. Light shading indicates less precise evaluations.



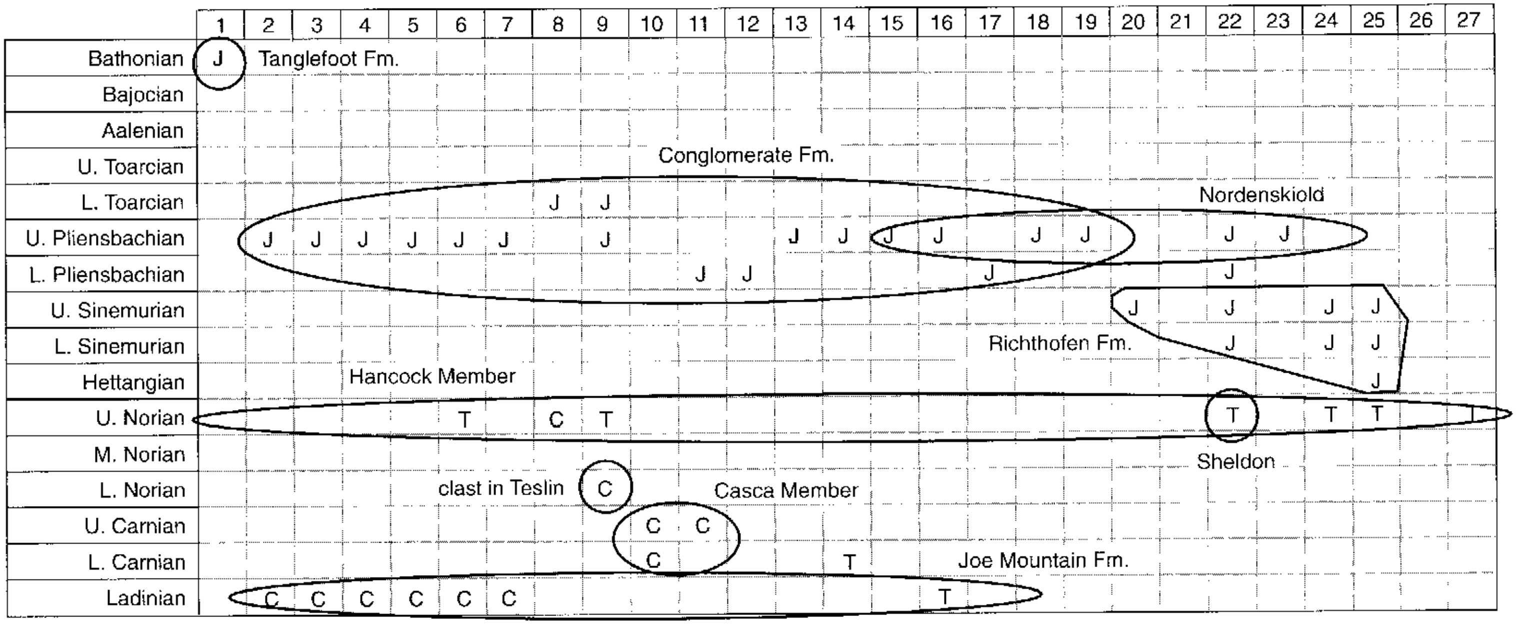


Figure 39. Compilation of fossil ages from members and formations of the Whitehorse Trough Supergroup within the study area. Sample numbers match those listed in Appendices 1, 2 and 3, and on the maps. Grey denotes collections with increased stratigraphic confidence. J=ammonite, T=Triassic macrofossil, C=conodont.

Figure 40. Zonal distribution of fossiliferous parts of Laberge Group in southern Yukon indicate that deposition occurred throughout the Lower Jurassic until the Middle Bajocian. Lighter shades indicate a lower degree of confidence. Numbers refer to the following references, bracketed numbers indicate revised collection. 1- Pálfy and Hart, 1995 and Tipper, 1994; 2-Pálfy and Tipper, 1995; 3-Jakobs, 1994; 4-Jakobs et al., 1994; 5-Dickie and Hein, 1992; 6-Poulton and Tipper, 1991; 7-Poulton, 1979; 8-Frebold, 1964; 9-Lees, 1934, 10-Frebold and Poulton, 1977. See Pálfy and Hart, 1995 for additional comments on 8 and 9.

Stage		North American Ammonite Zones or Assemblages	Map Area	Elsewhere 105D	Elsewhere Whitehorse Trough (Yukon)
BAJOCIAN	U				
	L	Oblatum Zone	2		7
		Kirschneri Zone			
		Crassicostatus Zone		1	
		Widebayense Zone			
		Amplectens Zone		6,7	
AALENIAN		Howelli Zone			
		Scissum Zone			
		Westermanni Zone		4	4
TOARCIAN	U	Yakounensis Zone			
		Hillebrandti Zone			
	M	Crassicosta Zone		1	
		Planulata Zone			
	L	Kanense Zone			2
PLIENS-BACHIAN	U	Carlottense Zone			
		Kunae Zone			
	L	Freboldi Zone			
		Whiteavesi Zone			1(9)
		Imlayi Zone			
		Tetraspidoceras Assem.			
SINEMURIAN	U	*Harbledownense* Assem.			3
		Varians Assem.	1		9
	L	*Arnouldi* Assem.			
		Coroniceras Assem.	?		
HETTANGIAN		Canadensis Zone			
		Doetzkirchneri Assem.	3		
		Franziceras Assem.	?		
		Euphyllites Assem.			
		Psiloceras Assem.			9,10

high mid low

sections near the Teslin River are also continuous with Triassic strata and contain poorly preserved ammonites and indeterminate bivalves that indicate possible deposition through the Hettangian-Sinemurian (Jakobs, 1994).

The Middle Toarcian to Aalenian is not represented in the study area, nor are there rocks lacking determinations that could represent this time span. The youngest rocks are represented by a single specimen, which has been assigned an Early Bajocian age and is among the youngest known occurrences of the Laberge Group.

Provinciality of ammonite collections can give insights into the paleobiogeography of the Whitehorse Trough. Sinemurian collections from the study area (and the Atlin area, see Johannson, 1994) include pandemic forms, such as *Epophioceras* and *Arnioceras*, which provide no useful paleobiogeographic information. Lower Pliensbachian *Metaderoceras* and *Reynescoeloceras* are indicative of a Tethyan association, but forms from the Atlin area also suggest alliances with eastern Pacific (North American) forms.

The Upper Pliensbachian faunas are dominated by species that have a strong Tethyan affinity such as *Arieticeras*, *Fontanelliceras* and *Protogrammoceras*. However, the local dominance of *Amaltheus* in some beds suggests a periodic but strong Boreal connection. A mixed Tethyan-Boreal fauna is to be expected in this region (Smith and Tipper, 1986; Smith et al., 1988) and has been well documented in the Atlin area (Johannson, 1993, 1994).

Flat, thin-shelled bivalves are variably distributed throughout the Laberge Group. They include *Bositra* and *Posidonotis*. The most common species in the study area, *Posidonotis semiplicata*, was recognized throughout western North America as occurring only in the latest Sinemurian, and therefore was considered a guide fossil (Pálfy et al., 1994). However, *P. semiplicata* forms shell pavements in horizons in measured sections in the northern part of map area 105D/14, which yielded ammonites from the Upper Pliensbachian Kunae and Carlottense zones (Pálfy and Hart, 1995). Therefore the age range of *P. semiplicata* is extended from Late Sinemurian to Toarcian. *Posidonotis semiplicata* is an example of an epibenthic bivalve that favoured low-energy, dysaerobic environments (Aberhan and Pálfy, 1996).

Post-accretionary Rocks

Rocks that were deposited or intruded after the terranes were assembled, and accreted to ancient North America, are considered to be post-accretionary. These are mainly igneous in origin and, except for a Jurassic unit, are Cretaceous and younger. They include several suites of plutonic rocks as well as the Carmacks Group, Open Creek and Byng Creek volcanics. Geochemical data for many of these units are given in Appendix 8.

Plutonic rocks

Granitic rocks are common throughout the map area (Figure 41). They can be assigned to Early Jurassic, mid-Cretaceous and Early Tertiary magmatic epochs from which five plutonic suites are defined: the Long Lake, Teslin, Whitehorse, Mount McIntyre and Nisling plutonic suites. Each plutonic suite has distinctive lithological characteristics and unique age ranges.

Long Lake Plutonic Suite

Coarse-grained, biotite-hornblende, alklali feldspar megacrystic quartz monzonite and granodiorite of the Little River batholith are exposed over a belt from near the Takhini River Bridge to the upper reaches of the Little River and Thirty-seven Mile Creek and beyond. The Little River batholith is easily recognized in the field by large (1–3 cm, up to 15 cm) pink alkali feldspar phenocrysts (Figure 14). Along its eastern margin, the batholith hosts numerous screens and pendants of Takhini assemblage metabasite. The western contact is intruded by granite of the Annie Ned batholith.

The Little River batholith comprises porphyritic, pink to white alkali feldspar (20%) set in approximately equal amounts of large, euhedral grey quartz and medium- to coarse-grained, euhedral to subhedral plagioclase, with 10% hornblende and biotite, and late interstitial alkali feldspar. Although the alkali feldspar megacrysts occur in most phases of the batholith, locally they are sparse, absent or accumulate in masses. The megacrysts typically contain zones of plagioclase, hornblende and sphene poikilocrysts. Plagioclase (andesine) is strongly zoned with more sodic rims. Accessory constituents include epidote, sphene and zircon. Hornblende quartz diorite forms an eastern marginal phase of this batholith, which was previously described by Fyles (1950).

Rocks of the Little River batholith are generally fresh but locally have a greenish grey hue because of a high percentage of partly digested metabasite inclusions. Elsewhere the batholith is characterized by a propylitic alteration assemblage that includes chlorite, epidote and sericite.

The Little River batholith hosts deformed metabasite screens and pendants placing its age younger than that of Takhini assembage metamorphism. Granitic clasts in Laberge Group conglomerate are lithologically similar to the Little River batholith and suggest a Lower Jurassic or older age. These observations support an Early Jurassic U-Pb zircon date of 183±2 Ma. This unit is lithologically similar to, and included within the pink quartz monzonite unit (of Tempelman-Kluit, 1976), which is now part of the Long Lake plutonic suite (Woodsworth et al., 1991; Johnston, 1993).

Teslin Plutonic Suite

Rocks of this suite consist of white- to pale-grey-weathering, coarse-grained, biotite-hornblende granodiorite to quartz monzonite and include the M'Clintock Lakes, M'Clintock River, and Mount M'Clintock plutons, and the finer grained Mount Byng felsite. Rocks of this unit intrude the volcanic rocks of the Joe Mountain Formation and the sedi-

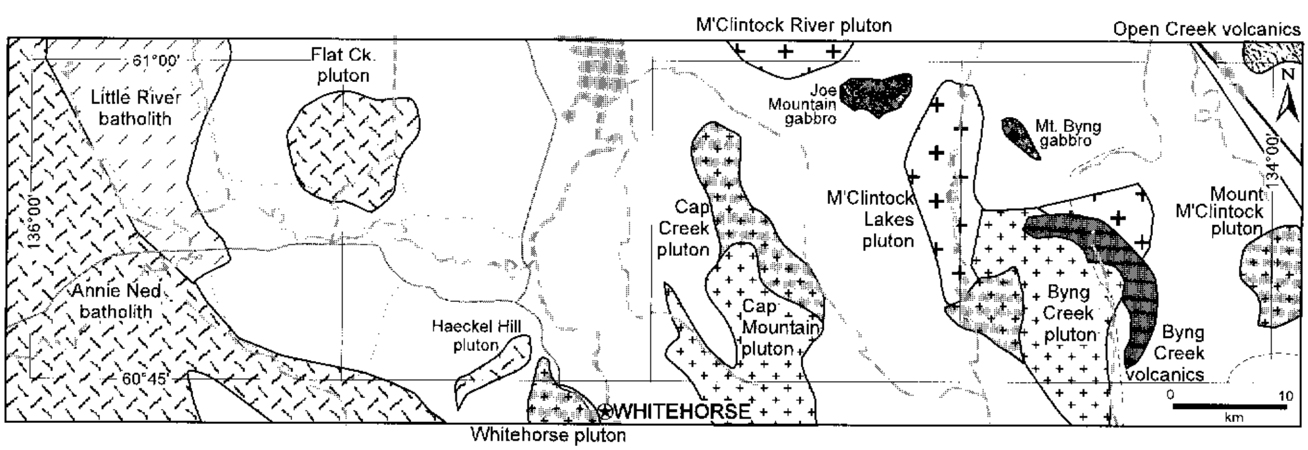


Figure 41. Distribution and names of the post-accretionary plutonic and volcanic rocks identified and described in this report.

mentary rocks of the Whitehorse Trough. They are in turn cut by dykes and various phases of the Byng Creek pluton.

This suite is typically composed of 25% quartz, 55% plagioclase and 10% alkali feldspar, and 10% biotite and hornblende. Plagioclase and alkali feldspar are both white and the same size and are difficult to distinguish, although locally, grey or pale pink alkali feldspar phenocrysts were observed. Light grey quartz crystals and aggregates are intergrown with plagioclase. Biotite and hornblende occur in equal amounts. Hornblende phenocrysts occur as laths up to 6 m long, and biotite is locally brown, slightly finer grained than hornblende, and euhedral. The M'Clintock Lakes pluton is well jointed, white weathering, coarse grained and homogeneous, whereas the Mount M'Clintock pluton is darker grey, medium grained and comprises several phases of granodiorite and quartz diorite.

The Mount Byng felsite is a recessive, light-weathering, vitreous, hornblende-feldspar-porphyritic felsite. Phenocrysts include one or more of large white plagioclase, acicular green-black hornblende and euhedral quartz. The felsite occurs as sills, north-trending dykes and small plugs in the northwest of Mount Byng.

The M'Clintock Lakes pluton is cut by dykes of the Byng Creek pluton indicating a mid-Cretaceous or older age. Isotopic age dates confirm this. A sample from the Mount M'Clintock pluton yielded a U-Pb zircon date of 119±1 Ma. The northern extension of the M'Clintock River pluton returned a biotite K-Ar date of 118±3 Ma (Tempelman-Kluit, 1984). The Mount Byng felsite yielded a K-Ar hornblende age of 121±5 Ma (Bremner, 1991) and therefore represent a finer grained phase of this suite. These dates are similar to circa 120 Ma dates reported for plutons in the western Teslin map area (Gordey and Stevens, 1994b; Hunt and Roddick, 1995) and assigned to the Teslin plutonic suite.

Whitehorse Plutonic Suite

This suite includes the Cap Creek, and smaller unnamed plutons near Byng Creek in the eastern map areas and small pendants in the western map areas. This unit is represented by several phases dominated by dark-weathering, blocky, medium- to coarse-grained, biotite-hornblende granodiorite and quartz diorite. The Cap Creek pluton intrudes Whitehorse Trough sedimentary rocks, and is cut by dykes of the Cap Mountain pluton. Four dominant lithologies are recognized in the Whitehorse plutonic suite.

1) Medium-grained, biotite-hornblende granodiorite is the most voluminous phase of this unit. It is composed of 15-20% quartz, 60% plagioclase, 5-10% potassium feldspar and 5-15% biotite and hornblende, locally with minor disseminated pyrite. Quartz is equigranular and intergrown with plagioclase. Potassium feldspar is fine grained and not apparent unless stained or seen in thin section. This phase is distinguished from others by its predominantly medium grain size, equigranular nature and higher percentage of quartz. Locally, some exposures are white weathering, leucocratic, and visibly altered. Compositionally they are similar to other rocks of this phase, except for the pervasive propylitic alteration.
2) Dark, fine-grained hornblende granodiorite outcrops in the vicinity of Peak 5852', and is composed of 50% grey plagioclase, 35% hornblende and 5-35% quartz. Fine-grained, biotite-rich and hornblende-rich phases are locally common. This phase is cut by phase 1 granodiorite and by coarse-grained, pink granite dykes.
3) Dark, blocky weathering, coarse-grained, hornblende quartz diorite and diorite are common in the Cap Creek and Mount M'Clintock plutons. This phase is composed mainly of plagioclase (60%) and hornblende (40%) with rare quartz, and is the most mafic, coarsest grained and oldest phase of this unit.

Exposures of the southeast portion of the Cap Creek pluton are foliated. The east-trending, steeply dipping foliation is defined by parallelism of plagioclase and hornblende. Quartz and potassium feldspar are not broken, flattened or smeared out. The foliation is interpreted as magmatic and is related to emplacement of the crystallizing magma.

The Cap Creek granodiorite gave a U-Pb age of 111±1 Ma and the pluton at the head of Byng Creek gave a U-Pb age of 115.5±1 Ma. These dates are close to, although on the high side of, the 108–112 Ma range that Hart (1995) suggested for the Whitehorse plutonic suite. K-Ar hornblende (92.1±3.8 Ma) and Rb-Sr whole rock isochron (n=3) (92±48 Ma) dates (Morrison et al., 1979) from the Cap Creek pluton are younger than the U-Pb dates and indicate a disturbance in these less robust isotopic systems.

Mount McIntyre Plutonic Suite

The main representatives of this suite are the Cap Mountain and Byng Creek plutons and associated outliers, which are composed of numerous phases of pink granite, quartz monzonite and quartz syenite. The plutons intrude sedimentary rocks of the Whitehorse Trough, and the Cap Creek granodiorite. Dykes and sills of the Byng Creek pluton intrude, and have an intimate spatial relationship with, volcanic rocks of the Byng Creek volcanic complex. Field characteristics include pale-orange- to white-weathering, fresh pink surfaces and locally miarolitic cavities. The suite is also characterized by extreme textural variability. Five main phases have been identified. All of the phases are characterized by their pink colour, and pale-orange to white weathering. Most phases exhibit moderately chloritized mafic minerals and weakly sausseritized plagioclase.

1) Coarse-grained, quartz-rich granite constitutes most of the plutons and has a general composition of: 30% quartz, 30% plagioclase, 30% alkali feldspar, 5% biotite and a small percentage of hornblende. Quartz is grey and forms clusters and aggregates. Alkali feldspar occurs as coarse-grained aggregates and locally as single, large (8 mm), zoned phenocrysts, whereas plagioclase crystals are 3–5 mm across. Biotite is generally the dominant mafic phase with euhedral crystals (2 mm); lesser hornblende is lath-like (6 mm long). Accessory minerals locally include sparse molybdenum and chalcopyrite. Fine-grained mafic clots, 1–5 cm across, of hornblende and plagioclase are common features in this phase as are xenoliths of fine-grained granodiorite or coarse-grained hornblende granite.
2) Medium-grained, quartz-poor, quartz monzodiorite contains 5% quartz, 50% plagioclase, 30% potassium feldspar and 15% mafic minerals. Quartz and plagioclase are coarser grained (3–5 mm) and are set in a finer grained anhedral matrix of potassium feldspar. The mafic mineral assemblage is dominated by hornblende, but includes biotite and fine-grained mafic clots.
3) Granophyric quartz monzonite is characterized by plagioclase, hornblende and quartz phenocrysts set in a fine-grained, sucrosic, pink potassium feldspar and quartz matrix. The phenocrysts constitute up to 50% of the rock. Euhedral plagioclase phenocrysts vary widely in size (up to 8 mm) and form most of the phenocryst population. Acicular hornblende and black biotite up to 5 mm long make up about 15% of the phenocrysts and also occur in the fine-grained groundmass. Quartz phenocrysts are grey and glassy, locally up to 5 mm across and constitute up to 15% of the phenocryst population.
4) Aplite and rhyolite are white, yellow and pink, fine grained, locally quartz-phyric (up to 5%) and locally flow banded. It forms dykes that cut all other phases of this unit. A small percentage of fine-grained biotite or hornblende (rarely both) are typical components. White potassium feldspar locally forms phenocrysts or late-stage pegmatitic veins with quartz and hornblende. Quartz-feldspar porphyry plugs and dykes are common in the Byng Creek area.
5) The Laberge Creek monzonite is distinguished from the other phases by its dark pink groundmass and heavily chloritized hornblende phenocrysts and was recognized only near upper Laberge Creek. This medium-grained phase is composed of plagioclase (40%) and hornblende (15%) phenocrysts in a finer grained, dark pink, potassium feldspar matrix with approximately 10% quartz. Epidote and chlorite are common on fracture surfaces. Dykes similar in composition to this phase were found in the Joe Mountain area.

Mid-Cretaceous U-Pb zircon dates were determined for the Cap Mountain (107.6±1 Ma) and Byng Creek (111±15 Ma) plutons. A rhyolite dyke from near Mount Byng, which was dated as 104±4 Ma by K-Ar whole rock analysis (Bremner, 1991), is correlated with this suite. The Cap Mountain and Byng Creek plutons are lithologically similar to, and correlated with, the 106-109 Ma age range of the Mount McIntyre plutonic suite, as defined by Hart (1995).

Analysis of biotite from Cap Mountain quartz monzonite yielded a K-Ar date of 98.6±3.4 Ma and three samples of quartz monzonite yielded a Rb-Sr isochron of 92±5 Ma (Morrison et al., 1979). These dates are younger than the U-Pb ages determined from this suite (circa 108 Ma; Hart, 1995). Oxygen isotopic analysis on the Cap Mountain (and Cap Creek) plutons (Dagenais, 1984) give $\partial^{18}O$ quartz-feldspar values of +3.5‰ and +5.2‰. These values reflect significant depletion in $\partial^{18}O$ and indicate hydrothermal alteration by meteoric fluids. Alteration has apparently resulted in the isotopic rehomogenization of the rock and reset both the K-Ar and Rb-Sr systems — probably at the times given by their respective dates. Consequently these dates do not reflect the timing of crystallization, which likely occurred at approximately 109 Ma.

The intermingled distribution of the numerous intrusive phases are indicative of upper level intrusion with phases of chilling and injection. This interpretation is supported by the presence of miarolitic cavities, and the numerous dykes and crosscutting relationships with coeval subaerial volcanic rocks of the Byng Creek volcanic complex.

Ta'an plugs

Several small exposures of intrusive rocks form a linear belt from north of the Takhini Hotsprings Road into the eastern Miners Range and farther north into the Laberge map area. The name refers to the proximal Ta'an Kwach'an village on the shore of Lake Laberge. The intrusive bodies are all small (less than 1 sq. km), except for one body in the Miners Range. They are lithologically variable from gabbro to granite, but are dominated by resistant, fine-grained, biotite-hornblende granodiorite. The smaller bodies are more mafic. The plugs cut folded Laberge Group strata and have obvious, rusty weathering hornfels zones. Hornfels zones are pyritic and locally contain accumulations of arsenopyrite. As the plugs are proximal to subaerial volcanic rocks of the Late Cretaceous Carmacks Group, they are assumed to be genetically related to unit uKCp of Tempelman-Kluit (1974). However, a biotite K-Ar date of 50.6±1.4 Ma from the large plug in the eastern Miners Range suggests that this suite is likely Early Tertiary in age.

Nisling Range Plutonic Suite

This suite includes the Annie Ned batholith, Haeckel Hill and Flat Creek plutons. These plutons are discordant, leucocratic and characterized by smoky grey quartz crystals and miarolitic cavities. The Annie Ned batholith underlies much of the extreme western part of the study area and intrudes the Takhini assemblage and Little River batholith. The Flat Creek pluton forms a circular body northeast of the Takhini Hotsprings. The Haeckel Hill pluton is a northeast-trending elliptical body which, like the Flat Creek pluton, intrudes Lewes River Group strata.

This suite is dominated by recessive-weathering, white, grey, pale-orange to cream-coloured granite, alaskite and leucocratic quartz monzonite. The rocks are medium to coarse grained and have the appearance of a crowded porphyry, but locally contain phases of fine-grained granite porphyry, alaskite and aplite. This unit averages about 30% smoky quartz, 60% alkali feldspar (orthoclase and minor microcline) and small percentages of plagioclase (oligoclase), biotite, and hornblende, with accessory magnetite, fluorite, apatite and zircon. Miarolitic cavities are nearly ubiquitous in most phases. They average 2-3 mm, but the larger cavities, up to one centimetre across, are lined by smoky quartz, orange alkali feldspar and fluorite. The Annie Ned batholith and Flat Creek plutons were described in detail by Fyles (1950).

The Annie Ned batholith's roof and margins are dominated by quartz-feldspar porphyry. The Haeckel Hill pluton has a marginal fine-grained phase that includes flow-banded and brecciated rhyolite. It also has an unusually high magnetic response (more than 3400 milligammas; GSC, 1967). It was described previously by Hart and Radloff (1990), who suggested that it was equivalent to the Jackson Creek pluton.

Age and correlation

U-Pb zircon analysis of the Annie Ned batholith gives an age of 57.1±0.2 Ma (Hart, 1995), which is older than the biotite K-Ar age of 51.2±2.0 Ma determined by Morrison et al., (1979). A similar date of 53.6±0.2 Ma (U-Pb zircon) was obtained from the Flat Creek pluton. This is in stark contrast to a previously determined K-Ar date, which incorrectly indicated that this pluton was 223 Ma (Lowdon, 1960). The Haeckel Hill pluton is undated but is lithologically equivalent to other members of this suite and the adjacent Jackson Creek pluton, which yielded an Early Tertiary biotite K-Ar age of 55±1.9 (Morisson et al., 1979). Analysis of rocks of this suite typically yield ages of between 58 and 54 Ma (Tempelman-Kluit, 1976; Hart, 1995)

The Annie Ned and Flat Creek plutons have an erosional geochemical signature anomalous in F, U and W (GSC, 1985). In addition, the Annie Ned pluton has very high Rb/Sr ratios (Hart, 1995). These data, combined with the presence of fluorite, indicate that this suite is highly fractionated. The miarolitic cavities indicate emplacement at high crustal levels (1-3 km). The character and age of these rocks are typical of the Nisling Range plutonic suite as previously described by Tempelman-Kluit (1976), Anderson (1988) and Hart (1995).

Volcanic rocks

Three packages of Cretaceous volcanic rocks occur in the study area: the Byng Creek volcanic complex, Open Creek volcanics and the Carmacks Group.

Byng Creek volcanics

Numerous exposures of lithologically diverse, subaerial, intermediate and felsic flow and pyroclastic rocks exposed near the headwaters of Byng Creek collectively form the Byng Creek volcanic complex. This complex nonconformably overlies M'Clintock Lakes granite and the folded sedimentary rocks of the Whitehorse Trough. Sheeted sills and dykes of dacite porphyry and rhyolite crosscut strongly brecciated and moderately altered granodiorite northeast of Peak 1821 m (Figure 42a). Four lithological units have been identified: 1) an andesite-dominated unit; 2) felsic pyroclastics, 3) dacite porphyry, and 4) rhyolite and associated hypabyssal intrusive rocks.

1) The andesite-dominated unit consists of dark-weathering, massive, non-magnetic, aphyric and feldspar-phyric andesite flows, andesite flow breccias and heterolithic breccia and tuff (Figure 42b). The heterolithic breccia is composed of lapilli- to bomb-sized angular fragments of dominantly andesitic rocks and granodioritic country rock. A basal conglomerate, composed of well-rounded, pebble- to cobble-sized granitic and volcanic clasts, is locally present.
2) The felsic pyroclastic unit is composed of light-orange-weathering, massive and blocky, light grey, vitreous, felsic lapilli tuff, locally with

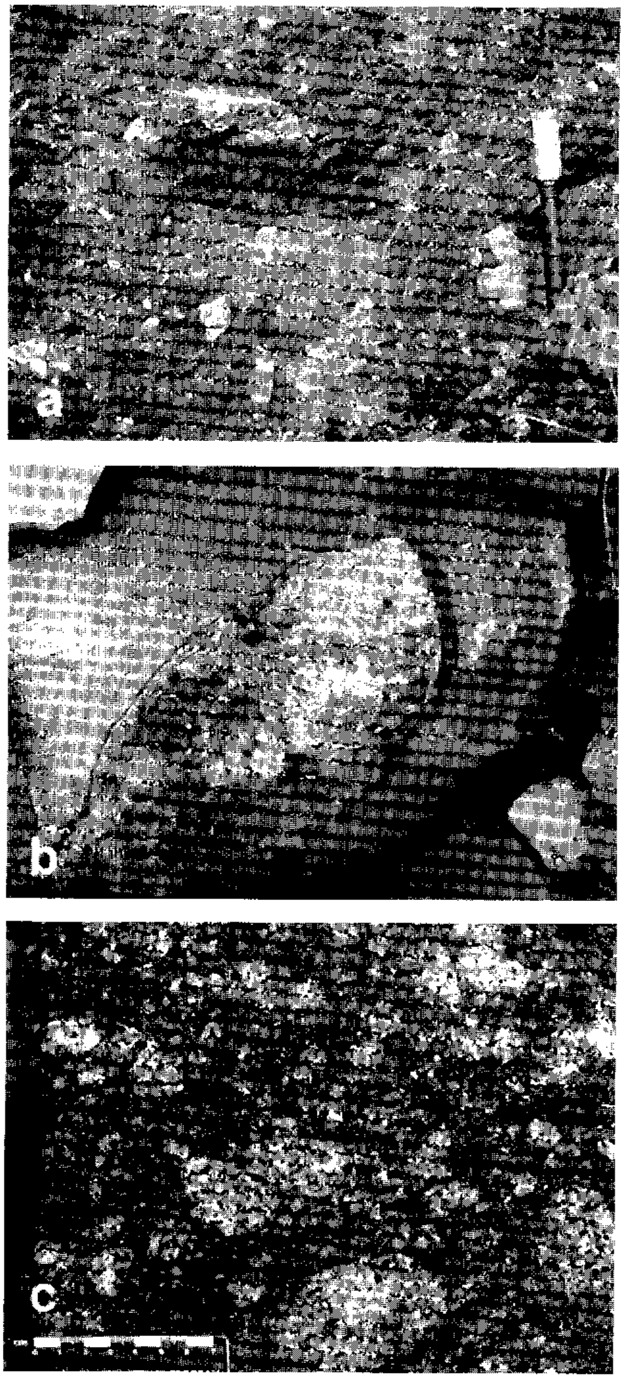


Figure 42. a) Unit of heterolithic andesite tuff with angular volcanic and country-rock fragments, which is an important unit in the mid-Cretaceous Byng Creek volcanic complex (BCVC). Scale is 15 cm long. b) Feldspar-phyric dacite porphyry of the BCVC with a dark chilled margin enveloping the rafted wallrock xenolith. This "chilled" dacite is a common dyke-forming lithology. c) Granodiorite country rock shattered and milled by explosions associated with the emplacement of the BCVC. Sheeted dykes and sills of the BCVC dacite cut the breccia. A sill complex northeast of Peak 1821 m is interpreted to be a feeder to the volcanic complex, and displays mutually crosscutting relationships with the quartz monzonite Byng Creek pluton.

bomb-sized clasts. The lapilli are dominated by angular fragments of flow-banded rhyolite and quartz-feldspar porphyry.

3) The dacite porphyry is composed of pale- to dark-grey-weathering, black, grey, maroon and pink, fine-grained and vitreous dacite with 15-40%, 0.4-1.0 mm, euhedral white feldspar phenocrysts (Figure 42c). Sparse quartz and mafic (hornblende?) phenocrysts are also recognized. These rocks are dominantly intrusive, occur as sills and dykes with obvious chilled margins and are spatially associated with flow-banded rhyolite. Locally, they may be extrusive.
4) Rhyolite flows and hypabyssal intrusions of flow-banded rhyolite and quartz-feldspar porphyry plugs, dykes and sills are distributed throughout the Byng Creek volcanic complex and adjacent environs. These rocks typically weather light orange, yellow, white and pink.

Small exposures of quartz-phyric rhyolite and dacite flows, tuffs, breccia and assorted fragmental volcanics on a ridge west of the M'Clintock Lakes are also included within this suite. Some of the breccias are in a black matrix that may be tourmaline.

The eastern margin of the Byng Creek volcanic complex is faulted and downdropped against the M'Clintock Lakes granite and Lewes River Group sedimentary strata. The Byng Creek volcanic complex is interpreted as the erosional remnant of a nested caldera complex that was uplifted and tilted toward the northeast with the volcanic rocks preserved in the downtilted, northeast portion of the caldera. The distribution of volcanic and subvolca-nic rocks suggests that the original caldera complex was more than 15 km across. A sill complex that crosscuts brecciated country rock is interpreted as a feeder zone for the volcanic rocks.

Although the Byng Creek volcanic complex has lithological similarities to Skukum Group volcanic rocks southwest of Whitehorse, the spatial, lithological and crosscutting relationships between the Byng Creek volcanic complex and the mid-Cretaceous Byng Creek pluton suggest that the two are coeval and that the Byng Creek volcanic complex is mid-Cretaceous in age. A concordant U-Pb zircon date of 113.5+2.3/-0.7 Ma from felsic tuff confirms this.

Open Creek volcanics

Cliff-forming exposures of nearly flat-lying, vertically and columnar jointed flows with thin ash and lapilli tuff layers occur in the extreme northeastern part of the map area and adjacent map areas (Figure 43). These rocks are light-orange-weathering, dark grey to blue-grey aphanitic dacite with sparse, clear subhedral quartz phenocrysts. Locally, a maroon-

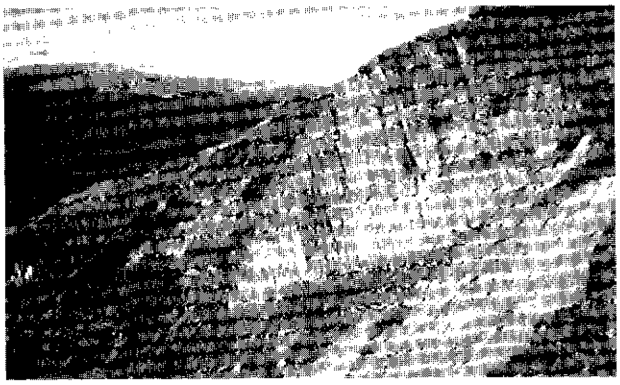


Figure 43. North-looking view of shallow-dipping dacite flows and tuff horizons of the Late Cretaceous Open Creek volcanics. These rocks locally overlie the Yukon-Tanana Terrane and have a basal conglomerate unit.

weathering, basal clastic sedimentary package is present. The volcanic rocks unconformably overlie metamorphic rocks of the Yukon-Tanana Terrane and are continuous with the Open Creek volcanics in the Laberge map area (Tempelman-Kluit, 1984). Analysis of rhyolite yielded a U-Pb zircon date of 78.3±0.2 Ma. This age is similar to the two K-Ar whole rock dates of 80±2.3 Ma and 83.4±2.1 Ma from the Laberge area (Stevens et al., 1982) and confirm a Late Cretaceous age for these rocks. These dates and rocks are similar to those determined for rhyolite flows and fragmentals of the Windy-Table suite (Hart, 1995), which include occurrences at Windy Arm and Table Mountain in British Columbia.

Carmacks Group

Resistant, dark-weathering, thickly bedded, nearly flat-lying subaerial flows of mafic and intermediate volcanic rocks form much of the Miners Range in the northernmost part of the west-central study area. These flows unconformably overlie folded Whitehorse Trough strata and are intruded by the Flat Creek pluton. The flows are dominated by dark blue, green and purple basalt and basaltic andesite. They are dominatly massive but include flow breccia, agglomerate, tuff and minor clastic sediments. They are aphanitic to fine grained but are locally pyroxene-phyric or contain accumulations of aligned plagioclase phenocrysts (Figure 44). Aphanitic flows are commonly amygdaloidal with fillings of chlorite and calcite.

Microscopically, the basalts consist of fine-grained aggregates of labradorite (An_{65}), clinopyroxene with finer grained biotite, amphiboles, opaque oxides, and secondary chlorite, epidote and calcite. Plagioclase phenocrysts (andesine?) are tabular and lath-shaped, 5–15 mm in length, and moderately saussuritized. A more detailed evaluation of the Miners Range Carmacks Group is given in Grond (1980).

Preliminary geochemical evaluation of the Carmacks Group showed it consisted of highly potassic, calc-alkaline volcanics (Grond et al., 1984). More detailed work by Francis et al. (1995) indicated that much of the Carmacks Group is shoshonitic, although most Miners Range samples are in the high-K field. From a contiguous package of Carmacks Group flows north of the map area, K-Ar analysis on whole rock and feldspar samples yielded ages of 72.4±2.5 and 69.1±2.6 Ma (Grond et al., 1984).

Dykes

Except for the region between the Takhini Hotsprings and the Yukon River, dykes are ubiquitous throughout the study area. Fine-grained felsic dykes in the region west of the Hotsprings are most Casca Member strata likely attributable to the Annie Ned plutonic suite, although sills with large alkali-feldspar megacrysts are probably related to the Little River batholith. Andesite dykes in this region are typically the final magmatic phase as they crosscut all units and yield K-Ar dates of 52 Ma. Between the Yukon and Teslin rivers there are three phases of dykes. The oldest phase consists of diabase dykes that cut only rocks of the Joe Mountain Formation. The other two phases are felsic and cut most other units. A felsite suite is fine grained and siliceous, but has plagioclase and acicular hornblende as its most common phenocryst. These dykes are related to the Teslin plutonic suite. Slightly younger, slightly coarser grained, typically quartz-phyric dykes, and small plugs, are genetically related to late phases of the Mount McIntyre suite and the Byng Creek volcanic complex.

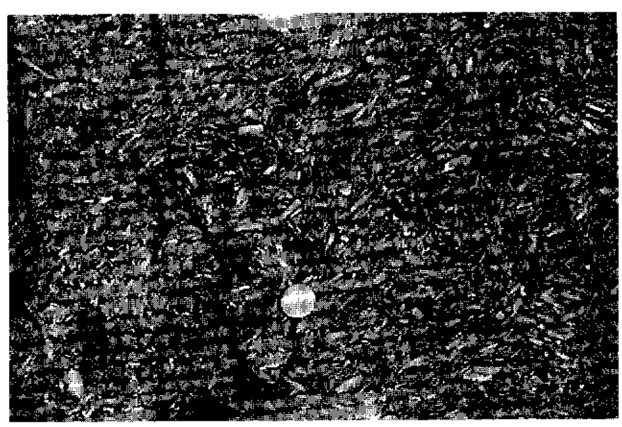


Figure 44. Bladed plagioclase porphyritic andesites are typical of the lower Carmacks Group in the Miners Range.

Geochronology

This bulletin presents 12 new U-Pb zircon dates and nine new K-Ar dates, along with a summary of new and existing geochronological data. Data tables are given in Appendices 5 and 6 with concordia plots for the U-Pb dates presented in the Figures here. Compiled geochronological data from the study area are presented in Appendix 7 and include location data for all of the new samples. All age dates presented here were generated by Jim Mortensen and coworkers at the University of British Columbia.

Magmatism was episodic during the Late Paleozoic, Mesozoic and Early Cenozoic, but occurred in pulses that define magmatic epochs. The oldest date so far obtained from the study area is a late Mississippian U-Pb age of 322.9±1.2 Ma from a metarhyolite bed in the Takhini assemblage (Figure 45). This date is critical in differentiating these rocks from the lithologically similar Upper Triassic Povoas formation, and suggests a new correlation with the Boundary Ranges and Stikine assemblage in northern British Columbia. A poorly constrained date of 270±6 Ma obtained from an igneous clast in Upper Triassic strata indicate a newly documented Permian source area for some Whitehorse Trough detritus (Figure 45).

Four magmatic epochs are apparent among Mesozoic and Cenozoic igneous rocks in the Intermontane and Coast belts of southern Yukon (Hart, 1995). Plutonic rocks with similar lithological characteristics, and which yield similar isotopic ages, are defined as a plutonic suite. In some cases, two or more plutonic suites occur within a narrow time span and constitute a magmatic epoch. The isotopic database reveals an Early Jurassic Aishihik epoch, mid-Cretaceous Whitehorse epoch, Late Cretaceous Carmacks epoch and Early Tertiary Skukum epoch. The new age dates from the northern Whitehorse map area can be interpreted within this framework (Table 3).

Late Triassic Stikine Epoch

Although plutons of this age are not represented in the study area, U-Pb analysis of four igneous clasts from the Jurassic Laberge Group yielded Late Triassic dates of between 208 and 215 Ma. These dates are likely coeval with Upper Triassic volcanism of the Povoas formation.

Early Jurassic Aishihik Epoch

A determination of 183±2 Ma for the Little River batholith and a similar age of 184.1+4.2/-1.6 Ma for the Nordenskiöld dacite (both U-Pb) represent the Early Jurassic Magmatic Epoch (Figure 46). These dates indicate that the two units are co-eval, and lithological similarities indicate that they may also be cogenetic. The dates and lithology of the Little River batholith also support an association with the Long Lake plutonic suite (Woodsworth et al., 1991).

Mid-Cretaceous Whitehorse Epoch

The mid-Cretaceous is the most voluminous magmatic phase in the study area and is represented by three suites: the Teslin, Whitehorse and Mount McIntyre plutonic suites. The Teslin suite is represented by the M'Clintock River, M'Clintock Lakes and Mount M'Clintock plutons, which yielded dates approximating 120±2 Ma (Figure 47). The Whitehorse plutonic suite is represented by the Whitehorse and Cap Creek plutons and small unnamed plutonic remnants at the head of Byng Creek. These plutons yielded dates of 112±3 Ma. The Mount M'Clintock

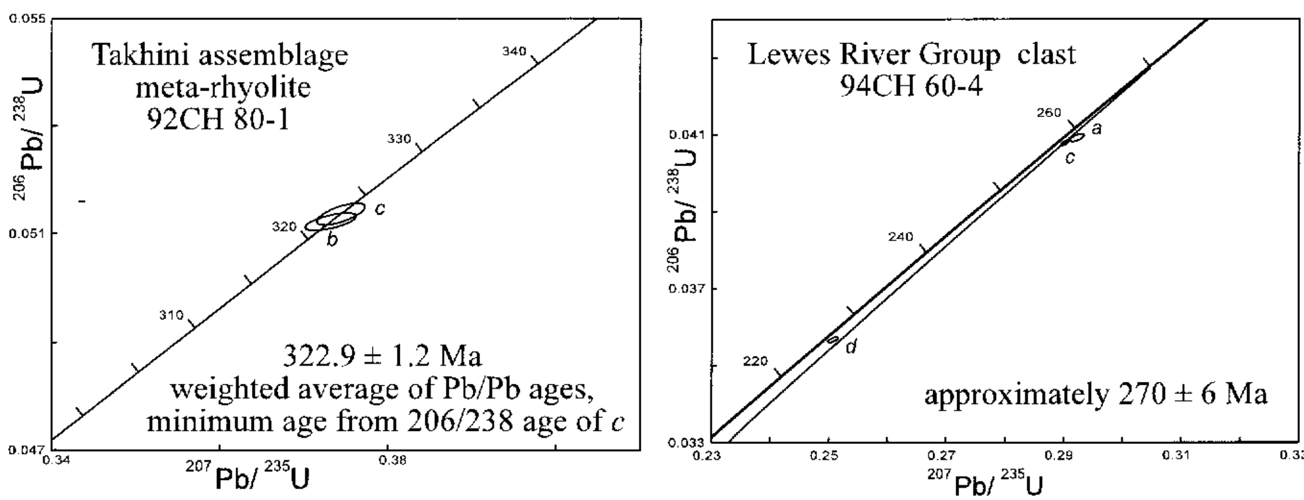


Figure 45. Concordia diagrams for U-Pb analysis of zircons from Late Paleozoic rocks.

Table 3. Magmatic epochs and plutonic suites for rocks within and adjacent to the study area

Unit (volcanic rocks in italics)	**Main Lithology**	**Best Date**
	Late Triassic (Stikine) Magmatic Epoch	
Laberge Group Clasts	granodiorite	215-208 Ma
	Early Jurassic (Aishihik) Magmatic Epoch	
Long Lake plutonic suite (186-183 Ma)		
Little River batholith	quartz monzonite	183±2 Ma
Nordenskiöld Member	dacite	184.1 + 4.2/-1.6 Ma
	Mid-Cretaceous (Whitehorse) Magmatic Epoch	
Teslin plutonic suite (122-116 Ma)		
M'Clintock Lakes pluton	granite	115±1.5 Ma
M'Clintock River pluton	granite	118±3 Ma
Mount M'Clintock pluton	granodiorite	119.5±1 Ma
Whitehorse plutonic suite (113-108 Ma)		
Cap Creek pluton	granodiorite	111±1 Ma
Whitehorse pluton	granodiorite	112±2 Ma
Mount Nansen Group-Byng Creek	andesite	113.5 + 2.3/-0.7 Ma
Mount Mcintyre plutonic suite (109-106 Ma)		
Cap Mountain pluton	quartz monzonite	107.6±1 Ma
Byng Creek pluton	quartz monzonite	111±15 Ma
	Late Cretaceous (Carmacks) Magmatic Epoch	
Carmacks Group-Miners Range	basalt	71±2 Ma
Open Creek volcanics	rhyolite	78.3±0.2 Ma
	Early Tertiary (Skukum) Magmatic Epoch	
Nisling Range plutonic suite (58-53 Ma)		
Ta'an Plugs	diorite	50.6±1.4 Ma
Flat Creek pluton	granite	53.6±0.2 Ma
Annie Ned Batholith	granite	57.1±0.2 Ma
Skukum Group	basalt-rhyolite	54±2 Ma

Note: Age ranges of the plutonic suites include age dates from outside the map area, particularly those reported in Morrison et al. (1979) and Hart (1995).

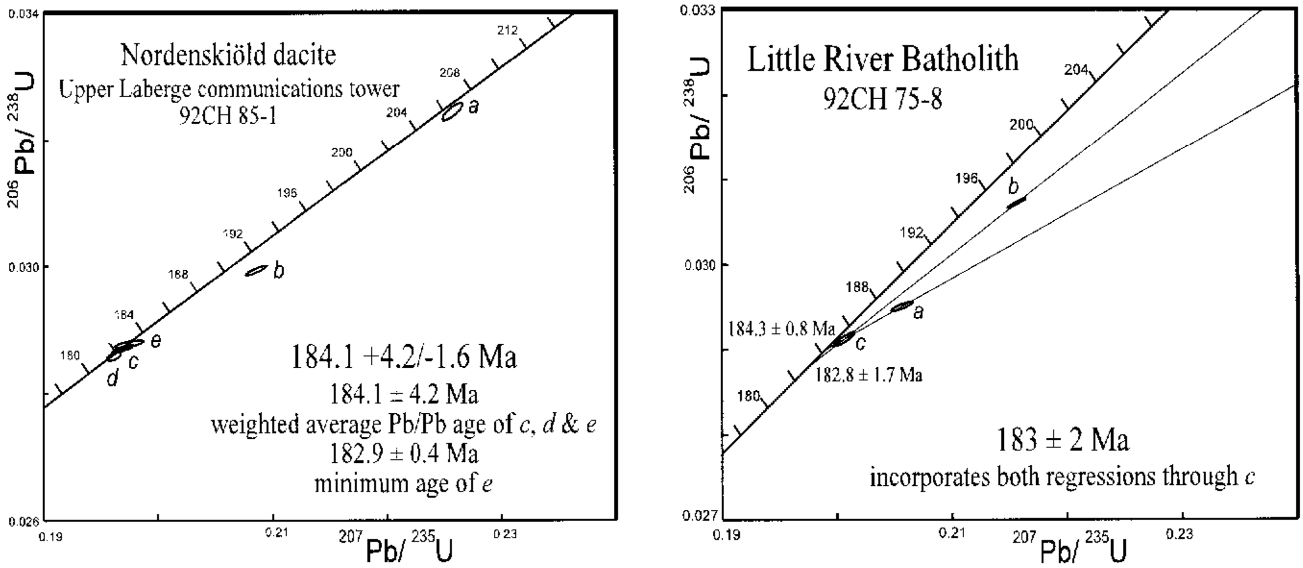


Figure 46. Concordia diagrams for U-Pb analysis of zircons from Early Jurassic rocks.

plutonic suite is represented by the Cap Mountain and Byng Creek pluton, which yielded dates of 108±2 Ma. Also representative of the mid-Cretaceous are the Byng Creek volcanics, which form a caldera in the Byng Creek pluton, and yield an essentially coeval U-Pb date of 113.5 +2.3/-0.7 Ma.

Late Cretaceous Carmacks Epoch

The Late Cretaceous is only represented by volcanic rocks in the study area. The Open Creek volcanics yielded a U-Pb date of 78.3±0.2 Ma (Figure 48), which supports similar K-Ar dates for these rocks in the Laberge map area (Tempelman-Kluit, 1984). They are coeval with lithologically similar rocks near Windy Arm and Table Mountain, British Columbia (Windy-Table suite of Hart, 1995). Carmacks Group rocks from just north of the map area in the Miners Range yielded circa 70 Ma K-Ar dates (Grond et al., 1984), although recent Ar-Ar dates indicate younger ages of circa 62 Ma (D. Francis, pers. comm., 1996).

Early Tertiary Skukum Epoch

The Annie Ned batholith and the Flat Creek plutons yielded U-Pb dates of 57.1±0.2 Ma and 53.6±0.2 Ma (Figure 49). These dates support similar K-Ar and Rb-Sr dates, but indicate a 3.5 Ma span between the two units. A single representative of the Ta'an plugs from the Miners Range was expected to yield a Late Cretaceous date similar to the proximal Carmacks Group, but analysis showed an Early Tertiary K-Ar age of 50.6±1.4 Ma. The Flat Creek pluton was previously dated at 223 Ma (Lowden, 1960). The analysis of this rock is questionable and the date is considered to be incorrect. Dykes of felsic and mafic composition similarly yield Early Tertiary K-Ar ages between 55 and 52 Ma.

The locations of significant age dates that reflect crystallization ages are presented in Figure 50. Other age dates, in Appendix 7, reflect cooling ages and can assist in determining a thermal history of the region.

Thermally reset age dates

The various closure temperatures and abilities of datable minerals to retain daughter products of radioactive decay make it possible to determine the thermochronological history of the study area. For example, the Coast Plutonic Complex has had significant thermal influence over the western part of the study area. Most K-Ar systems in older rocks have been variably reset toward Early Tertiary dates. Farther east, K-Ar analysis of hornblende from a Triassic granite clast in Lower Jurassic Laberge Group strata near Takhini Crossing yielded a 144 Ma date (Morisson et al., 1979). As there was no magmatic event at this time, the clast is thought to represent partial resetting (Ar loss) during a mid-Cretaceous or Early Tertiary thermal event. In contrast, a hornblende date from Nordenskiöld dacite approximately 15 km east of the Takhini Crossing site gave a K-Ar date of 180±5 Ma. This date is concordant with the U-Pb date suggesting that no thermal event over 550°C has affected this region.

In the eastern study area, Joe Mountain Formation volcanics, determined paleontologically to be Middle Triassic, yield Late Cretaceous to Early Tertiary K-Ar whole rock ages, whereas others retain semblances of antiquity with dates of 143 and 165 Ma. This suggests a complex scenario whereby some rocks were variably reset during the Early Tertiary, while others were only marginally affected. Resetting to Early Tertiary time is surprising considering that

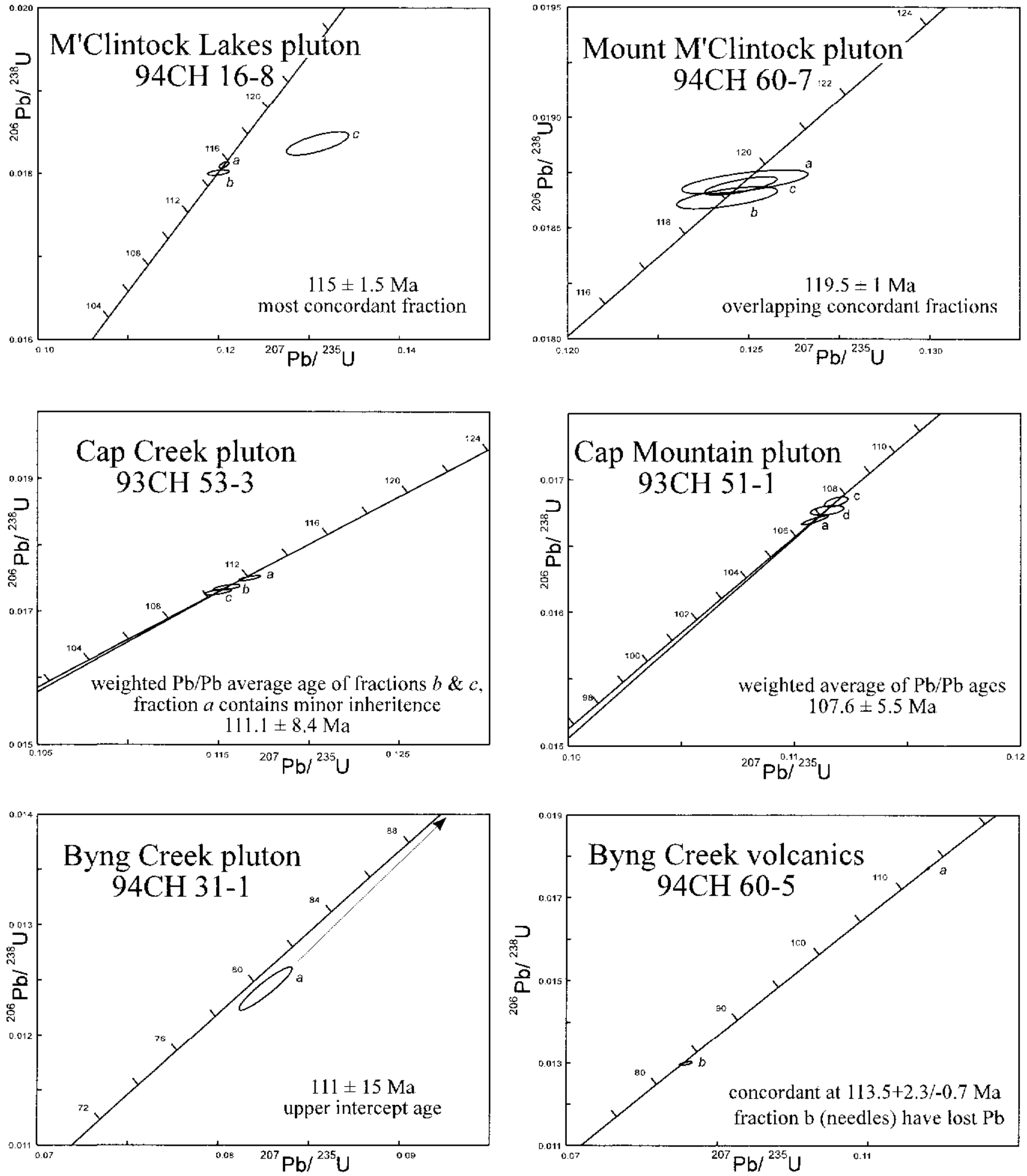


Figure 47. Concordia diagrams for U-Pb analysis of zircons from mid-Cretaceous rocks.

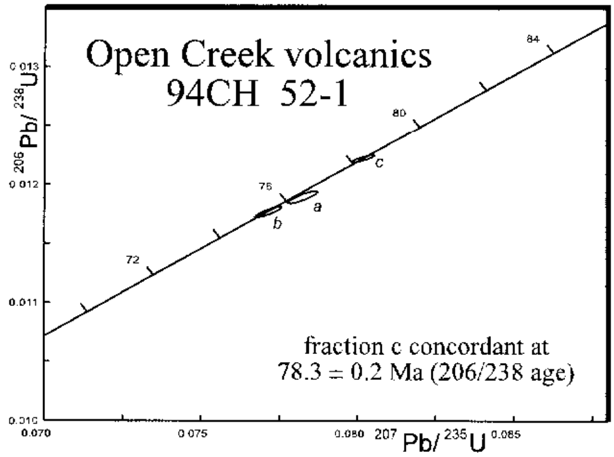


Figure 48. Concordia diagrams for U-Pb analysis of zircons from Late Cretaceous rocks.

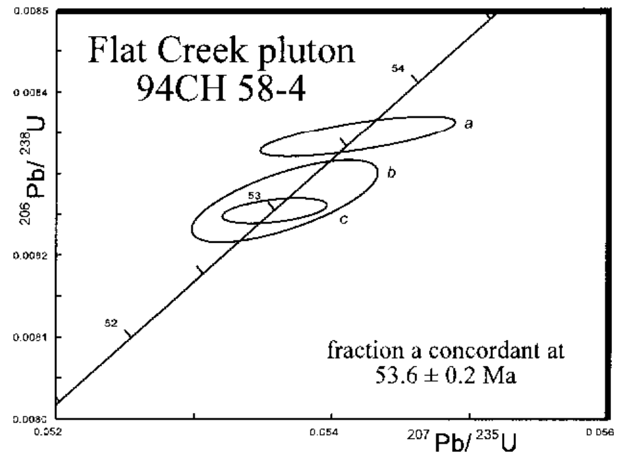
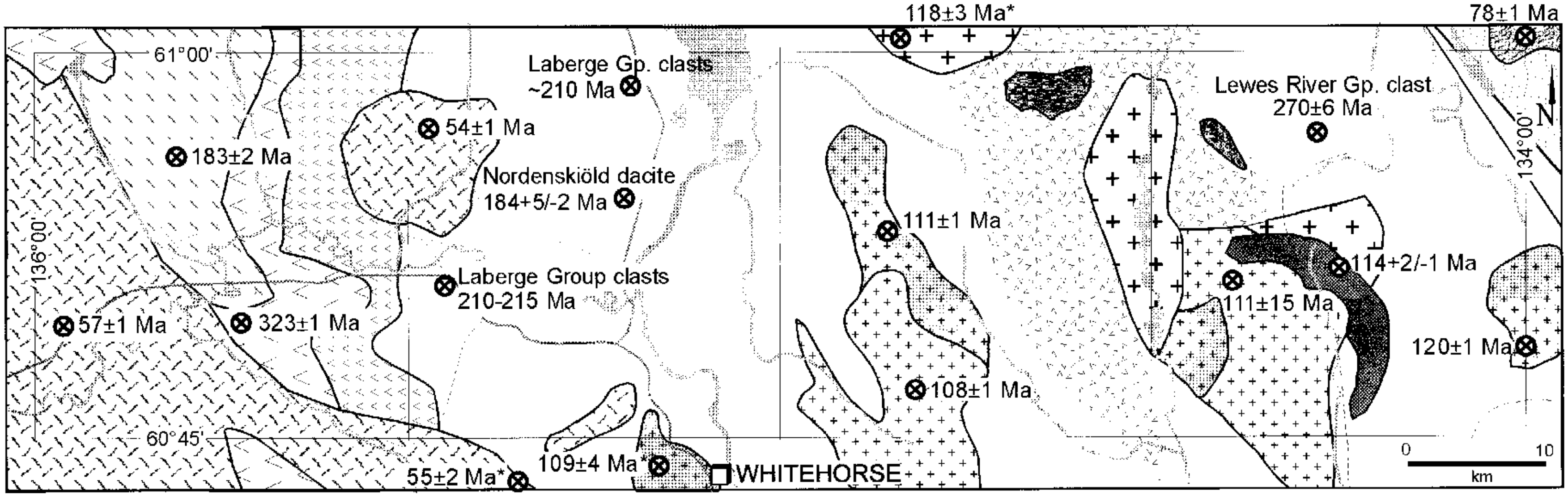


Figure 49. Concordia diagrams for U-Pb analysis of zircons from Early Tertiary rocks.

there are no plutonic rocks of this age in this region. These dates are mainly from whole rocks where the potassium (and Ar) is mainly resident in small feldspars, which are particularly susceptible to resetting by low-temperature hydrothermal processes. However, biotite K-Ar ages from the region yield mid-Cretaceous dates that are essentially concordant with the U-Pb dates suggesting that temperatures of about 250°C have not been reached since the mid-Cretaceous.

Fission tract ages from apatite from the west-central part of the map area (105D/14) suggest that this region passed through the 100°C isotherm at approximately 100 Ma (Dickie et al., 1992) but dates of circa 60 Ma indicate local thermal effects by the intrusion of the Flat Creek pluton during the Early Tertiary.

Figure 50. Locations of significant age dates from the study area. Dates are rounded to the nearest integer and errors (2 sigma) are rounded up to the nearest integer. All dates were obtained using the U-Pb method on zircons at The University of British Columbia, except *=K-Ar biotite. See Appendix 7 for additional age dates.



Tectonic Elements

- Whitehorse Trough Supergroup
- Lewes River Arc
- Joe Mountain Formation
- Stikine Assemblage
- Yukon-Tanana Terrane

Plutonic Suites

Early Tertiary
- **Nisling Range Plutonic Suite**

Mid-Cretaceous
- Mount McIntyre Plutonic Suite
- **Whitehorse Plutonic Suite**
- Teslin Plutonic Suite

Early Jurassic
- **Long Lake Plutonic Suite**

Middle Triassic
- **Joe Mountain Formation gabbro**

Volcanic Rocks

Late Cretaceous
- Open Creek volcanics

Mid-Cretaceous
- Byng Creek volcanic complex

Whitehorse Plutonic Suite

Mount McIntyre Plutonic Suite

Structure

As in most of the Yukon Territory, pre-mid Cretaceous rocks of the study area have been deformed such that a northwest-trending structural fabric predominates. Deformation and subsequent erosion has produced geological and deformational belts that represent different structural layers and structural styles across the study area. West of the Yukon River valley, the rocks form belts that are progressively younger toward the east and represent an oblique section through the stratigraphic packages that make up Stikinia. From west to east, these belts contain vestiges of high-grade metamorphic rocks, which occur as pendants in the Coast Plutonic Complex, grading eastward to medium-grade metabasite of the Takhini assemblage, to unmetamorphosed, folded rocks of the Triassic Lewes River arc and Jurassic portions of the Whitehorse Trough. East of the Yukon River is an anticlinorium with a core of Middle Triassic Joe Mountain Formation flanked by folded limbs of Whitehorse Trough strata (Figure 51). This feature is here defined as the M'Clintock Anticlinorium.

Two explanations for the presence of Cache Creek Terrane in the study area are either as a downdropped klippe or the exposed core of the M'Clintock Anticlinorium. The original contacts of Cache Creek Terrane rocks with adjacent Stikinia were obliterated by the intrusion of Cretaceous plutons. The first possibility requires that Cache Creek Terrane was emplaced during a period of thrust faulting and considerable displacement. The second suggests that the Cache Creek Terrane underlies Stikinia and that the M'Clintock Anticlinorium, and probably the regional geology, plunges to the north.

Evidence of only one Mesozoic deformation event is apparent. Deformation affecting pre-Mesozoic rocks is discussed in the section on the Takhini assemblage.

Folds

The nature of folds throughout the study area is variable and is typically correlated with rock type. Massive and competent rock units, such as conglomerate and basalt, display open folds, whereas argillaceous rocks are tightly folded, sheared and locally cleaved, and limestone is tightly folded, sheared and

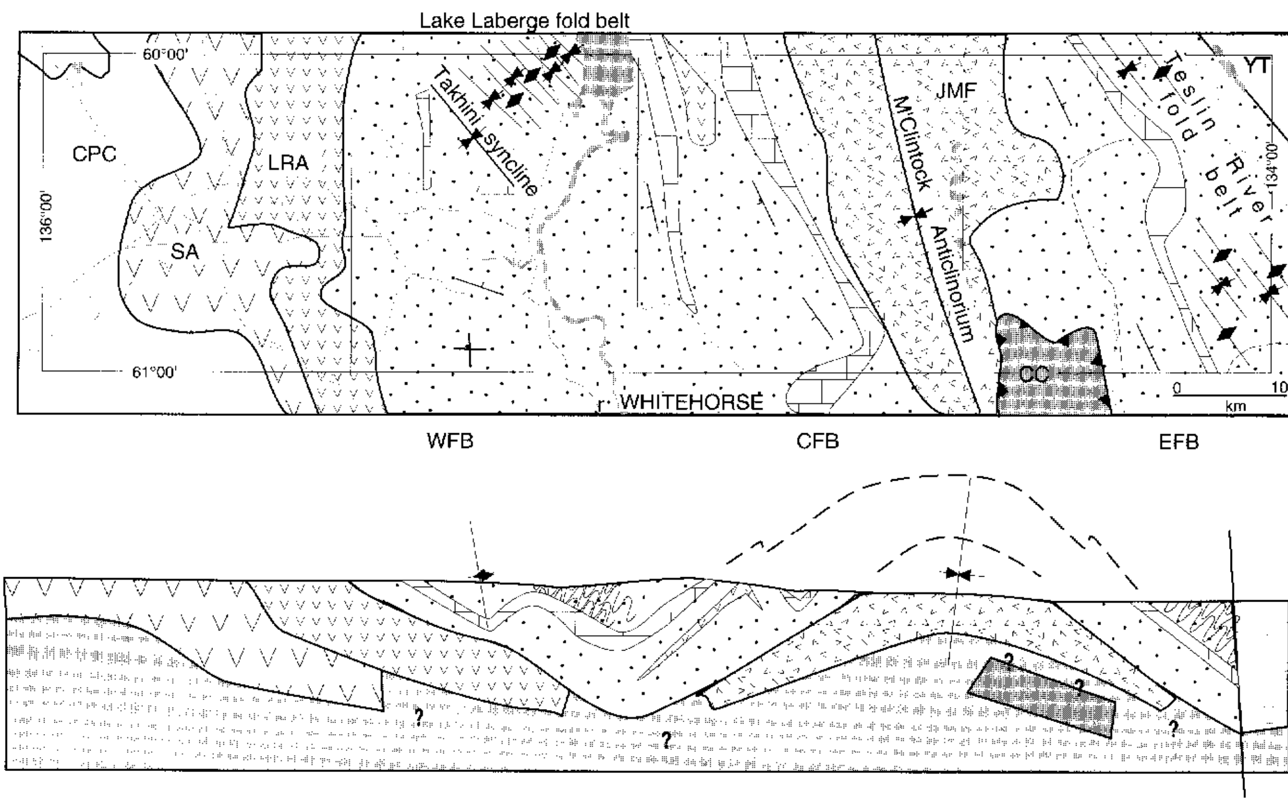


Figure 51. Structural belts and locations of major folds and fold belts before faulting of intrusion of Cretaceous intrusions. Fold symbols in the belts are representative. No vertical scale is implied on the cross-section. Area with horizontal rules represents region of east-trending, fault-related folds. See Figure 7 legend for lithology, except for limestone, which is here denoted by a brick pattern. Stipple pattern denotes Whitehorse Trough Supergroup. CPC=Coast Plutonic Complex, SA=Stikine Assemblage, LRA=Lewes River Arc, CC=Cache Creek Terrane.

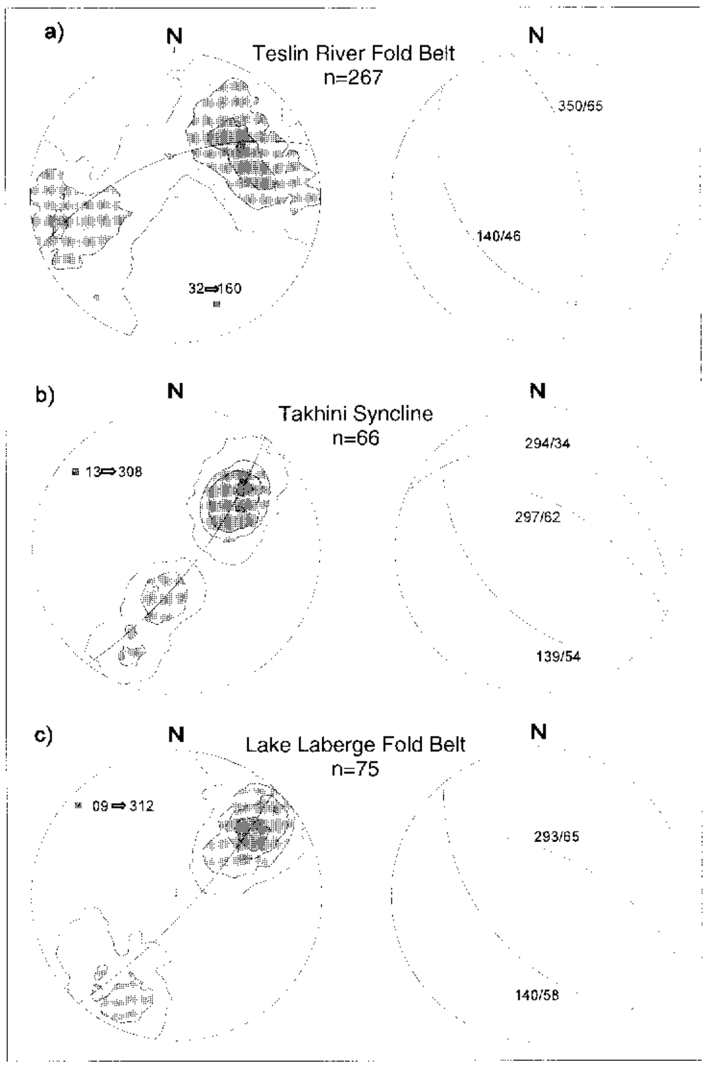
mullioned. Folds are ubiquitous in Whitehorse Trough and Takhini assemblage rocks, but less easy to observe in the massive volcanic rocks of the Povoas Formation and Joe Mountain Formation. The axes of large folds, as well as fold belts, are shown in Figure 51.

The Takhini Syncline represents a large open fold that formed in strata dominated by conglomerate, dacite and arkose. The syncline plunges shallowly to the north and has a half-wavelength of about six kilometres. Structural data confirm a shallow, northward plunge and well-rounded northeastern limb (Figure 52). Although a large syncline had been mapped with an axis along Cap Creek (Wheeler, 1961), this feature is reinterpreted as a fault. Numerous smaller folds exist, however, at the headwaters of Cap and Joe creeks.

Argillaceous rocks of the Richthofen formation form two fold belts. Both are dominated by tight, upright, slightly asymmetrical folds with nearly horizontal fold axes and wavelengths on the order of one to two kilometres. Axial regions are locally represented by a fracture cleavage or shearing. The Lake Laberge fold belt extends from the Horse Creek area into the Miners Range, encompassing most of the region between Lake Laberge and Fox Lake. Steep, upright limbs with small axial regions and shallow, northwest plunge predominate (Figure 52). These rocks lie beneath the more competent rocks of the Conglomerate formation (including the Nordenskiöld dacite) and above the uppermost Lewes River Group limestone, resulting in significant differences in deforma-tional style and amount of shortening between these two units.

The Teslin River fold belt is also dominated by argillaceous rocks of the Richthofen formation, but contains massive conglomerate beds. The geometry of the folds is not as well understood as those in the Lake Laberge Fold Belt, as there is greater variation in configuration. In general, the folds are slightly asymmetric to overturned with weak northeastward vergence and moderate, south-southeastward plunge. Some folds plunge steeply to vertically and axial planes are cut by shear. Units adjacent to or within limestone beds are isoclinally folded and overturned with a well-developed axial planar, slaty fracture cleavage. Deviations of northwest-trending, vertical fold axes result from forceful intrusion of plutons, proximity to large strike-slip faults, and competency contrasts within the stratigraphy. The regional northwestward plunge is further supported by detailed fold analysis from Rabbitsfoot Canyon (Stretch, 1993).

Figure 52. Left: mesoscopic structural data shown as lower hemisphere stereonet plots of poles to bedding with best-fit girdles and statistically determined fold axes for Laberge Group strata. Contour interval is 3.75%. Right: mean bedding planes determined from poles to bedding maxima. Two northeast-dipping limbs are plotted for b) representing two extremes in maxima.



East-trending anticlines and synclines form several tight, upright folds with short (1 km) half-wavelengths in Upper Triassic Lewes River Group strata east of Mount Slim. These folds are characterized by closely spaced, chaotic attitude changes associated with competency contrasts in greywacke units adjacent to limestone beds. The anomalous attitudes of the axial trends may result from strike-slip motion on several parallel, north-trending, strike-slip faults that traverse this region.

An evaluation of tectonic shortening cannot be made with confidence as the map area is intruded by younger plutons, contains a significant percentage of massive volcanic rocks, and lacks marker horizons. Total shortening of the Whitehorse Trough at this latitude is estimated to be no greater than 25%.

Timing of folding

The timing of folding of Stikinian rocks is poorly constrained. The youngest rocks that were clearly involved in the folding are the chert-rich, coal-bearing Tantalus formation. The age of these rocks is poorly constrained, although locally they lie gradationally above the Tanglefoot formation. In the study area, Tanglefoot formation rocks are Lower Bajocian. The next youngest rocks are the mid-Cretaceous Byng Creek volcanics. These rocks dip moderately, but likely as a result of faulting and not folding. Similarly, mid-Cretaceous plutons typically have steep contacts with adjacent units and their map relationships do not suggest that they have been folded or that they incurred a regional tilt. A paleomagnetic and barometric study of the Whitehorse pluton confirms that it has not been tilted since its emplacement (Harris et al., 1997). In conclusion, folding is constrained to after the Early Bajocian and before the mid-Cretaceous. However, the chert-rich nature of the Tantalus and Tanglefoot formations suggests the emergence of a new source terrane, which could indicate that the uplifted Cache Creek Terrane was both the source of detritus and the probable cause of folding during the Middle Jurassic.

Faults

Faults are ubiquitous in the region. Several series of largely parallel faults are recognized and described according to the geographic location in which they are best exposed.

Teslin River area

Northwest-trending faults dominate the extreme northeastern part of the study area and control the physiography of the Teslin River valley. The faults, which include strands of the Teslin Fault, are spatially associated with, and cut, the Teslin River fold belt. The northeasternmost fault juxtaposes Yukon-Tanana Terrane rocks with the Laberge Group of Stikinia and, although it is unlikely that this is the original structural boundary between these two terranes, it probably has the greatest offset of this series. This fault continues southeast into the Teslin map area where, according to Gordey and Stevens (1994a), dextral motion occurred before intrusion by a Cretaceous pluton.

In the northeastern part of the map area, these faults apparently cut a north-trending series, but both series are assumed to result from the same structural regime. The amount of displacement across these faults is uncertain, as marker units do not exist and similar rocks are juxtaposed.

Lake Laberge Fault Zone

Numerous, dominantly north-northwest-trending, anastomosing and through-going faults are displayed in the eastern wall of the Yukon River and Lake Laberge valley. The major structures probably responsible for these faults are likely buried beneath the valley sediments, and quite likely created a weak zone along which the valley formed. Although only a few of the faults are exposed, numerous strong lineations are apparent on aerial photographs and satellite images, and an array of faults mapped in the Laberge area to the north (Tempelman-Kluit, 1984) attest to the significance of this fault zone.

Geologically, the Lake Laberge fault zone separates dominantly Triassic rocks on the east from a thick succession of Jurassic strata west of the valley, indicating at least some west-side-up motion. The array of several parallel faults with intervening ladder faults, characterizes slip transfer across a strike-slip structure.

Takhini region

Several north-trending normal faults occur south of the Takhini Crossing and north of the Takhini Hotsprings. The two largest faults are the Scout Lake and Takhini faults. Both of these faults mark regions of dramatic eastward thickening of the Whitehorse Trough sediments. Accordingly, and in agreement with Dickie et al., (1992), these faults likely represent Late Triassic to Early Jurassic structures that originally controlled the western margin of the Whitehorse Trough, but show evidence of reactivation immediately after folding.

The north-trending faults are all steep and have east-side down normal displacements with up to 2 km of offset. The faults cut folded strata but not the adjacent Paleogene Flat Creek pluton. Minor offset is recognized where the Takhini Fault cuts the Upper Cretaceous Carmacks Group. Thus, the major offset along the Takhini Fault and allied structures is confined to pre-Late Cretaceous time. In support are fission-track analyses of apatite, which indicate cooling through 100°C at 64±9 Ma west of the fault and 104±12 Ma east of the fault (Dickie et al., 1992). These data are also consistent with west-side up displacement of the fault. The age discordance may reflect motion between 100 Ma and 60 Ma. Alternatively, the apatite samples from west of the fault may have been partly annealed by the heat given off by the nearby Flat Creek pluton during its intrusion at about 54 Ma.

Marsh Lake Fault

Tectonized ultramafic rocks in the Horse Creek area indicate the presence of a significant structural feature. This feature yields a notable north-northeast-trending aeromagnetic anomaly, which extends southward across the Yukon River valley toward Marsh Lake. The anomaly represents the magnetic expression of tectonized serpentinite bodies aligned along a through-going structure. This feature is the Marsh Lake Fault, and the Horse Creek exposure is its northernmost exposure. Although a kinematic evaluation has not been undertaken on the Horse Creek ultramafite, preliminary observations indicate primarily dextral displacement in both ductile and brittle deformation of the ultramafite.

Other faults

Thrust faults are rare and poorly understood in the study area. They were observed only in the Hancock Member limestone units at Rabbitsfoot Canyon where the upsection magnitude of the faults is minimal (20 m). Flat-lying faults cut the Joe Mountain Formation in a few localities. They appear as one-metre-wide zones of quasi-ductile deformation containing a weak north-trending lineation. Similar rocks on both sides of the fault indicate minimal upsection displacement. Folded argillaceous strata in the Teslin River area are locally cut by outcrop-scale thrust faults, again with a minor upsection component. The Cache Creek Terrane rocks may be underlain by a large thrust fault.

Arcuate faults define the eastern margin of the Byng Creek volcanic complex, which was down-dropped into the surrounding country rock. These faults cut the mid-Cretaceous Byng Creek volcanic complex rocks but are in turn, cut by a younger, northwest-trending series of faults.

In the central and eastern parts of the map area, north-trending faults cut all the units and strongly control the local drainage and topography. The faults merge into, and appear to originate from, the more oblique strike-slip faults of the Lake Laberge and Teslin fault zones. Movement on these structures is limited to a few kilometres of dextral, strike-slip offset, although locally, up to two kilometres of vertical offset is apparent.

Mesozoic History of the Whitehorse Trough

The Whitehorse Trough is a major component of Stikinia. The trough extends more than 600 km from north of Carmacks south to the Tulsequah and Dease Lake areas of northern British Columbia. Its present width varies from 75 km near Whitehorse to nearly 200 km in British Columbia. The trough accumulated a thickness of more than seven kilometres of sedimentary and igneous detritus from the Middle Triassic to Middle Jurassic. Subsequent intrusions, overlapping volcanic units and faulting have obscured the original western margin of the trough. The present eastern boundary is along the Teslin Fault array. These features separate Stikinia from the metamorphic rocks of the Yukon-Tanana Terrane.

Upper Paleozoic

The tectonic setting of the region before the formation of the Whitehorse Trough is not well known. Upper Paleozoic volcanic and sedimentary strata of the Takhini assemblage are thought to represent an island-arc package. The now metamorphosed rocks formed at least part of the western basement as they are unconformably overlain by clastic strata of the Whitehorse Trough. In addition, this relation constrains the Takhini assemblage metamorphism to pre-Late Triassic.

Middle Triassic

Middle Triassic (Ladinian) tholeiitic pillowed volcanics and associated sediments of the Joe Mountain Formation are exposed in the central part of the trough. Their tholeiitic nature is consistent with either rift-related, sea-floor volcanism or arc intiation. These volcanics and sediments are the oldest rocks in the Whitehorse Trough and appear to record the initiation of the basin. Ladinian sediments include proximal coarse clastics, although locally, strata characteristic of deep water deposition grade upward to lithotypes similar to the Carnian Aksala formation.

Upper Triassic

Carnian sedimentation was coeval with arc volcanism that occurred along the western margin of the trough. Although age data for the volcanic rocks are sparse, basaltic flows and coarse clastics are associated with sediments containing Carnian conodonts. The rising arc shed volcano-clastic debris toward the east in mass flows that were subsequently reworked into a shallow-water shelf, which eventually developed along the trough's western margin. Carnian sediments in the central part of the Whitehorse Trough are distal in character with thin beds, fine-grained laminae, thin carbonate horizons and rare primary pyroclastic material. Carbonate deposition at this time may have been extensive but is so far recorded only by poorly constrained macrofossils, and limestone clasts in Jurassic conglomerate that yield Late Carnian conodonts.

The Norian was a period of extensive carbonate deposition across the width of the trough. Dramatic facies changes are reflected in varying styles, positions and thickness of reefal, lagoonal, and platform carbonate units (Figure 53). The leading edge of the volcanoclastic shelf was the favoured site for reef development. Coarse carbonate-rich clastic and volcanoclastic deposits prograded and transgressed across the carbonate shelf. These apparently competing depositional styles reflect a dominantly quiescent environment of carbonate formation punctuated by short-lived periods of erosion and clastic deposition in sheets, fans and reefal aprons. This regime reflects periodic drops in relative sea-level, which exposed topographically high carbonate features, and possibly the entire carbonate shelf, to erosion. In the eastern part of the Whitehorse Trough, polymictic, volcanic-rich conglomerate appears to be of proximal origin, suggesting an eastern source. The conglomerate there also contains numerous large and well-rounded hypabyssal intrusive clasts of Permian age. They, too, likely reflect a proximal source, but the source remains unknown.

By the Late Norian, carbonate deposition dominated across the entire width of the Whitehorse Trough. This suggests that the Whitehorse Trough was essentially filled (shallow throughout) and that subsidence did not keep up with deposition. The occurrence of large molluscs (e.g., *Megalodon* sp.) within 30 km of the present eastern side of the trough indicates a water depth not exceeding a few metres at that point.

Uppermost Triassic strata along the western margin of the trough are dominated by the oxidized, supratidal and lagoonal muds and feldspathic sandstone of the Mandanna Member. These rocks are interbedded and coeval with carbonate units deposited in the central and eastern parts of the Whitehorse Trough. Crystal-rich sandstone of pyroclastic origin, locally constitutes a significant thickness of the Mandanna Member.

Triassic-Jurassic boundary

The Triassic-Jurassic boundary is represented by a disconformity throughout much of the western Whitehorse Trough. The contact is typically of Pliensbachian Laberge Group conglomerate disconformably overlying units of the Triassic Lewes

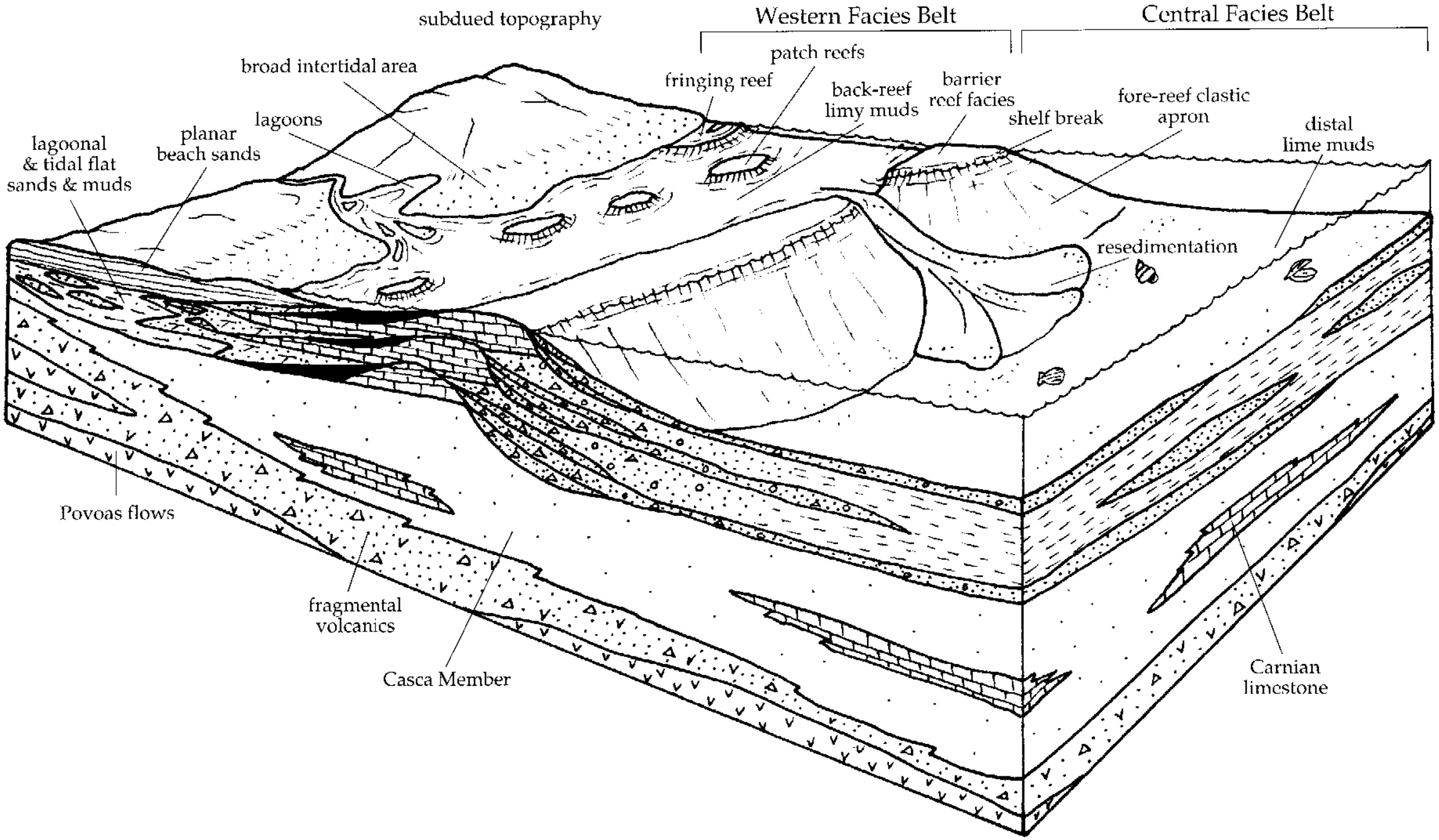


Figure 53. Late Triassic (Norian) deposition of Whitehorse Trough (Aksala Formation) strata.

River Group. At some localities, the entire Triassic arc has been removed, thus exposing the Upper Paleozoic Stikine assemblage basement. A drop in relative sea-level during the earliest Jurassic exposed parts of the western margin of the Whitehorse Trough, resulting in several hundred metres of erosion and reworking of the Mandanna and Hancock members. Farther east in the axial portions of the trough, the section is continuous, and characterized by a shaling-up of the carbonate and deposition of deeper water, distal muds of the Richthofen formation. Consequently the lithological similarity across this interval and the poor age control confound efforts to establish a suitable contact.

Lower Jurassic

Earliest Jurassic deposition is characterized locally by limy Richthofen formation siltstone and sandstone-mudstone couplets. The accumulation of these fine-grained clastic sediments, mainly as mid- to distal fan turbidites, was accommodated by a relative deepening of the Whitehorse Trough ocean throughout the Hettangian to Sinemurian.

Latest Sinemurian time was marked by a dramatic influx of coarse conglomerate across a disconformity in westernmost parts of the trough, but conformably across Richthofen formation sediments deeper in the basin. Clasts in the lowermost conglomerates are heavily oxidized, suggesting a warm and arid climate before erosion.

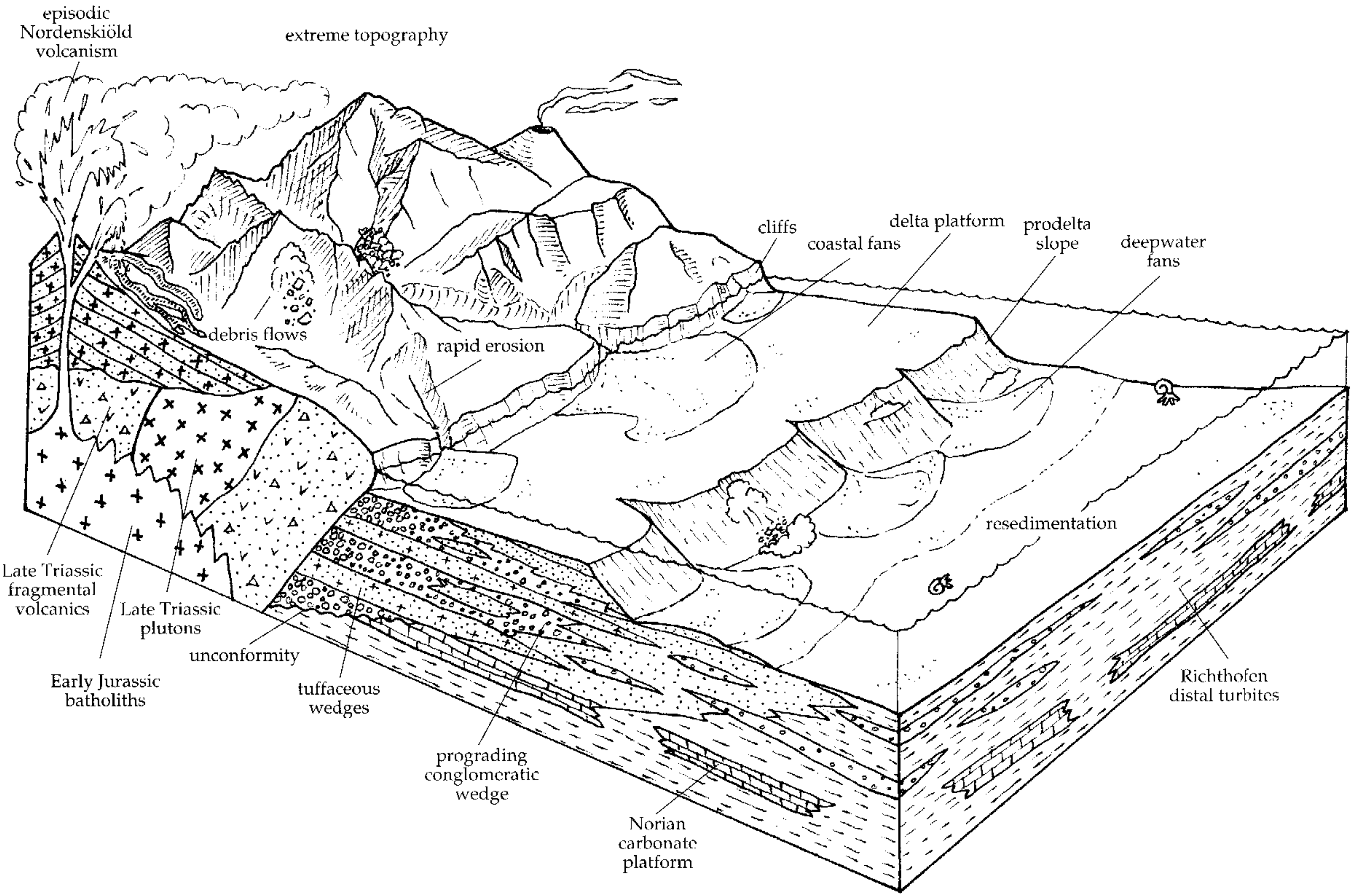
The Pliensbachian is notable for thick wedges of Conglomerate formation coarse clastics and primary Nordenskiöld Member volcanic material (Figure 54). In places, the Pliensbachian represents more than half the entire thickness of the Laberge Group. Conglomerate clasts are generally very large and require an extreme topographic gradient to transport the detritus. This uplift was contemporaneous with the intrusion of the Long Lake plutonic suite and Nordenskiöld volcanism and, taken together, represent a significant Pliensbachian tectonic event. Basin subsidence appears to have kept pace with deposition such that coarse clastics prograded toward the central trough.

Deposition continued until the Lower Toarcian with recycling and reworking of the Pliensbachian pyroclastic material. Coarse clastic deposition ceased locally but continued elsewhere in the trough. Directly south of the map area, in the Fish Lake syncline as well as other localities along the western part of the Whitehorse Trough, Toarcian, Aalenian and Bajocian strata are known. Rocks as young as Bajocian are unconformable upon Upper Triassic Lewes River Group strata, thus requiring removal of any pre-existing Jurassic strata.

Middle Jurassic

In the Early Bajocian, Laberge Group deposition changed dramatically as arc-derived detritus was superceded by the siliciclastic material constituting the Tanglefoot formation. These strata were deposited in a series of small successor basins along the western margin of the Whitehorse Trough. The strata record a transition from dominantly fine-grained marine sediments to dominantly coarse-clastic, paralic and terrigenous sediments. This shift reflects a dramatic change in the depositional environment from nearshore marine to deltaic or gravel-rich shoreface. The predominance of chert clasts in the Tanglefoot formation implies a new, distinct, sole source for detritus. The Cache Creek Terrane is the most likely source and must have been emergent at that time. These data confirm that the initiation and eventual obduction of the Cache Creek Terrane was coeval with the closure of the Whitehorse Trough, led to the development of siliciclastic successor basins during the late Aalenian, and was probably the cause of structural deformation in Stikinia.

Figure 54. Early Jurassic (Pliensbachian) deposition of Whitehorse Trough (Laberge Group) strata.



Mineral Deposits

Mineral exploration and claim staking has occurred at 45 localities in the study area (Yukon MINFILE, 1995). Of these, 18 host mineralization; the remainder are geochemical or geophysical anomalies. Most of the mineral occurrences are copper skarns and quartz-sulphide veins with gold (Table 4). The geology of the region suggests that these deposit-types have the greatest potential to occur in economic proportions. The locations of the mineral occurrences are shown in Figure 55. Yukon MINFILE summarizes known information on Yukon mineral occurrences, and this report focuses on new observations. Sample numbers and geochemical data referred to here are contained in Appendix 9.

Skarns

The Whitehorse Copper Belt (WCB; see Watson, 1984) includes numerous copper-, gold- and silver-bearing skarns that formed in pendants of Lewes River Group limestone on the top and western shoulder of the Whitehorse granodiorite pluton. The northernmost occurences of the Whitehorse Copper Belt occur in the southern part of map area 105D/14, immediately west of the Alaska Highway, where the Whitehorse pluton plunges shallowly to the north. No economic deposits occur in this region but the **War Eagle** deposit, just south of the map boundary, yielded approximately 900,000 tonnes of 1.25% Cu, 0.22 g/t Au, 8.6 g/t Ag, 0.005% Mo ore. As very little previous exploration targeted gold as a primary commodity, the skarns of the copper belt continue to receive interest from explorationists.

Copper skarns in the map area include the **Anaconda** (MINFILE occurrence # 200) and **Rabbitsfoot** (#125), which occur in two nearly continuous, north-dipping horizons of skarnified limestone and limy argillite in a pendant above the granodiorite. In addition to values of up to 7% copper, the **Anaconda** silicate skarn also contains anomalous gold (1.4 g/t), silver (70 g/t) and bismuth (0.08%) (Kindle, 1964). North and west of these occurrences, several small, high-grade occurrences of wollastonite skarn containing bornite, chalcocite and malachite have been uncovered. A grab sample of this material yielded 5.6% Cu, 51 g/t Ag and 700 ppm Bi. Float boulders of this material have been found as far north as the Kulan industrial subdivision. Another sample of this material, discovered in recent trenching north of the War Eagle pit, graded 15% Cu, 270 g/t Ag and 1.45 g/t Au (R. Hamil, pers. comm. 1995).

Copper mineralization also occurs within the Whitehorse pluton. Trenching of the region north of the current garbage dump (for geotechnical purposes related to expansion of the dump) uncovered several localities with abundant chalcocite and malachite on fracture surfaces in the granodiorite. This mineralization resembles supergene zones of porphyry copper deposits and increases the potential for such a deposit to occur in the drift-covered region north of the garbage dump. Locally, molybdenite occurs along fractures and sparse disseminations of chalcopyrite occur within the weakly altered granodiorite.

Skarn occurrences of this area are unlike most skarn deposits of the Whitehorse Copper Belt as they are dominated by silicate minerals and contain little magnetite. This suggests a limestone, as opposed to dolostone protolith. The granodiorite-hosted occurrences are supergene in origin and result from erosion and enrichment of metals from higher level deposits. The shallow northward plunge of the Whitehorse pluton into limy sediments provides a large surface area along which potential skarns and granite-hosted deposits may have formed. However, the poor exposure and glacial cover in the region make basic prospecting difficult.

Outside the copper belt, a new copper-diopside-magnetite skarn was discovered in the Takhini assemblage marble south of the Takhini River Bridge (**Farm**, #82). Just north of the map sheet, the **Ruth** occurrences (105E#8) are also magnetite-rich skarns in the Takhini assemblage marble. A grab sample gave 2.8% Cu, 9.5 g/t Ag and elevated Zn values.

In the eastern map areas, barren garnet-diopside-epidote skarns are common near Whitehorse plutonic suite granodiorite (mainly the Cap Creek pluton) in limy sediments. Only the **Pow** showing (#50), is known to contain notable sulphide minerals. Molybdoscheelite, magnetite float with 0.83% Cu, and Cu-in-soil anomalies are also reported from this showing (Yukon MINFILE, 1995; Downing, 1980). A brief examination of the property by the writer indicates that it is geologically complex. Two granitic phases and two dyke phases cut folded limy Upper Triassic Lewes River Group sediments. Vein stockworks and porphyry-style disseminated sulphide minerals in granite were discovered during the visit. A grab sample of silicified and sulphidized granite gave values of 3% for Cu, 20 ppm for Ag and 310 ppb for Au (Figure 56; Sample 93CH 11-2).

Gold veins

The region hosts a few quartz veins, some contain base metal sulphide minerals and anomalous gold values. The **Mount Byng** occurrence (#184, 189, see also Bremner, 1991) consists of several, north-trending quartz veins and associated rusty-weathering carbonate alteration zones. The veins are generally not more than 20 cm wide and the alteration envelopes are about twice the width of the veins. The

Table 4. List of mineral occurrences in the study area (105D/13-16)

No.	Name	NTS	Commodity	Type/Notes
45	Ingram	105D/12	Zn, Pb, Ag	vein
46	Ibex	105D/14		
47	Cutoff	105D/14	Ag, Au	vein
48	Effie	105D/14	asbestos	
49	Labe	105D/15		
50	Pow	105D/15	Cu	skarn
51	Ace	105D/15	Au, Ag	vein
52	Haeckel	105D/14		
54	Tremar	105D/14	Cu	skarn, aeromagnetic anomaly
77	Larson	105D/13		
78	Expo	105D/14		aeromagnetic anomaly
80	Imp	105D/14	Cu	
81	Stony	105D/13	Mo	geochemical anomaly
82	Farm	105D/13	Cu, Zn	skarn
83	Wagon	105D/13		
86	Wheeler	105D/10,13		no evidence of an adit
87	Calvin	105D/13		
91	Allison	105D/14	Cu	
104	Suits (King Lake)	105D/14	Cu, Mo	porphyry
113	Midgett	105D/14	Cu	vein
114	Texel (Abi)	105D/16	Pb, Zn, Ag	vein
117	Trot	105D/13		
118	Charlie	105D/14		
119	Kali	105D/14	Cu	
121	Tenney	105D/14	Cu	skarn
124	Garbage Dump	105D/14		geophysical anomaly
125	Rabbitsfoot	105D/11,14	Cu, Mo	skarn
126	Thirty Seven	105D/13		geophysical anomaly
129	Sewage	105D/14		
130	Suburbia	105D/14	Pb	geochemical anomaly?
133	Hyde	105D/13		
139	Dry Bone	105D/14		
141	Gammon	105D/16	Au	geochemical anomaly
142	Byng	105D/16	Au	
147	Dupont	105D/14	Au	geochemical anomaly
148	Slewe	105D/15	Au	geochemical anomaly
149	Erge	105D/15	Au	geochemical anomaly
150	Utshig	105D/16	Au	geochemical anomaly, gossan
151	Dust	105D/14		
155	Takhini	105D/14		
174	Cap Creek	105D/15		
175	Seybold	105D/16		
184	Movement (R17)	105D/16		vein, breccia
187	Balt	105D/16		
189	Mt. Byng	105D/16	Au, Cu, Ag	vein
194	Cameo	105D/14		
197	Joe Creek	105D/15	Au	vein
199	OJ	105D/14		geophysical anomaly
200	Anaconda (Zircon)	105D/14	Cu, Mo	skarn
201	Rip-rap	105D/14	Rip-rap	quarry
202	Bee	105D/14	Pb, Zn, Ag	vein
203	Grumpy	105D/15	Au	vein
8	Ruth	105E/2	Cu, Ag	skarn

Note: Numbers are those used in Yukon Minfile.

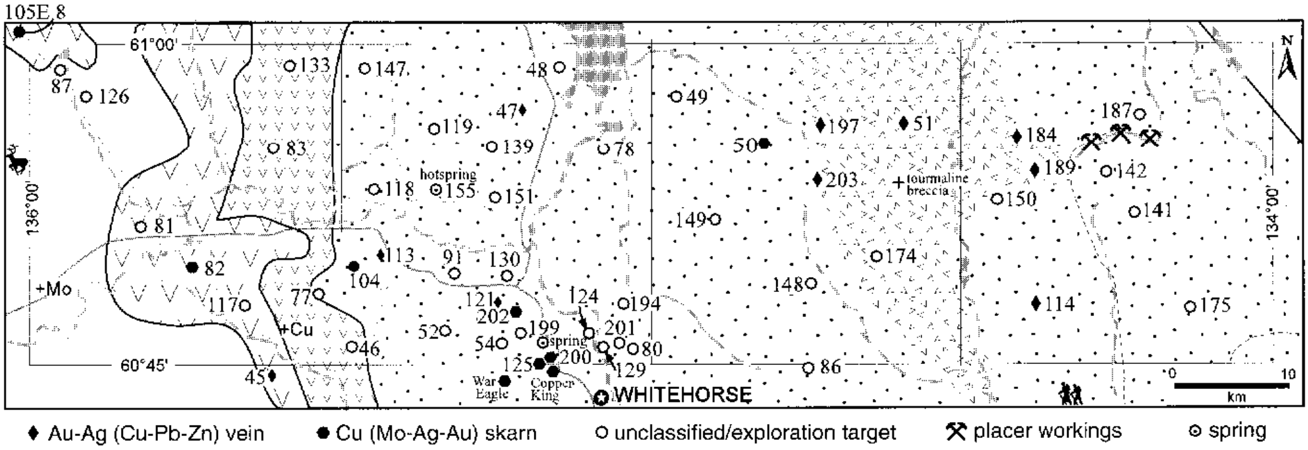


Figure 55. Locations of mineral occurrences within the study area. The numbers refer to those in the Yukon MINFILE. The base map is from Figure 7 and lacks Cretaceous and younger rocks (mainly plutons).

veins are composed almost entirely of white, locally vuggy, cockscomb quartz with sparse sulphides, including pyrite, chalcopyrite and tetrahedrite. A grab sample taken from a trench at the main zone (94CH 12-4) gave values of 44 g/t for Au and 85 g/t for Ag, which is within the range of 18 to 127 g/t reported by Bremner (1991). Elevated Cu, Pb, Bi, As and Sb values associated with this sample suggest that these elements are potential pathfinder elements for gold mineralization in this region in addition to Hg and W, which were suggested by Bremner (1991).

Several occurrences of quartz veins and quartz float were discovered in map sheet 105D/15 during mapping (Figure 57a). Analysis of two new quartz veins yielded anomalous gold values. At the head of Joe Creek (#197), the **Joe** showing consists of banded and massive white quartz with sparsely disseminated pyrite and arsenopyrite. A grab sample (93CH 26-5A) yielded 1150 ppb Au. At the headwaters of Cap Creek, quartz stringers in a north-trending, siliceous felsic dyke were discovered. A grab sample (95CH 14-1) yielded 10.6 g/t Au. Both showings are 0.5–1 m wide, of unknown length and in faults that cut the Joe Mountain volcanics. Thin quartz veins are associated with rusty pyritic hornfels zones around small plutons that intrude Laberge Group sediments west of Lake Laberge.

Vivid orange-weathering, carbonate-altered rock occurs as 0.5–2 metre wide alteration zones along faults and adjacent to veins in Triassic volcanic rocks. The best developed zone is near Mount Byng, and consists of a breccia with fragments cemented by pale green chalcedonic quartz (R17 zone in Bremner, 1991). Open space fillings also consist of banded and crystalline ankerite and dolomite. Analysis of a grab sample (94CH 16-5) gave a slightly anomalous Au value (106 ppb).

The **Bee** (#202) showing consists of one large, and several smaller, shear-hosted arsenopyrite-galena-sphalerite veins that cut hornfels-rich Lewes River Group sediments. The veins yielded Ag values of up to 171 g/t and weak gold values. The property also includes a large region underlain by variably altered and pyritiferous, brecciated rhyolite. Lead isotopes from the veins suggest an Early Tertiary age. The rhyolite is a satellite body of the Haeckel Hill pluton, which is also Early Tertiary.

Regional geochemistry

Regional stream silt geochemical data from the Geological Survey of Canada (1985), indicate that several areas are anomalous in one or more elements. Although weak, Au and Cu anomalies are concentrated in the regions underlain by volcanics of the Joe Mountain Formation (Figure 58). Sparse but extremely high Au values (1810, 1540 and 787 ppb) remain unexplained. A few scattered Ag and Hg anomalies have no obvious geological association. Anomalies of Sn and W come from streams draining granitic rocks-particularly the Cap Mountain pluton, although the highest W anomaly relates to the Flat Creek pluton. Anomalies of U and F in water, and Mo in silt are coincident with the distribution of the Annie Ned and Flat Creek plutons (Figure 59). Arsenic anomalies west of the south end of Lake Laberge are thought to be derived from pyritic hornfels zones in Laberge Group sediments that developed around small intrusive bodies of the Ta'an suite. Nickel anomalies coincide with the Cache Creek ultramafic rocks exposed in the southernmost portion of 105D/15.

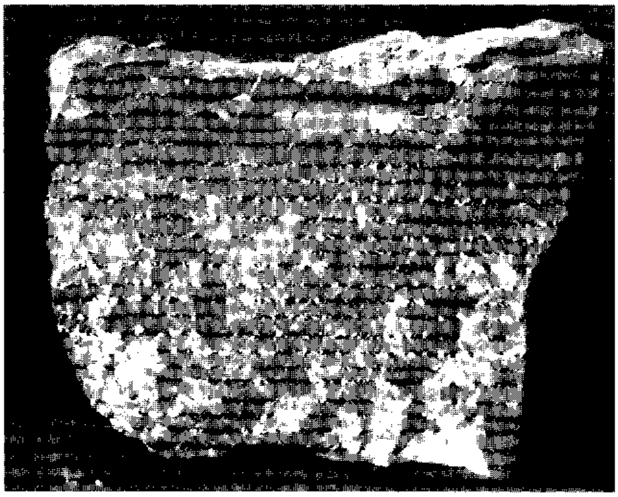


Figure 56. Cut surface of rock sample 93CH 11-2. This rock is a silicified and sulphidized granite from the northern Cap Creek pluton near the POW showing. The grey patches in this otherwise leucocratic rock, are fine-grained pyrite and chalcopyrite.

Exploration targets

The geology of the region suggests that the following areas warrant consideration: 1) the faulted caldera margins of the Byng Creek volcanic complex are possible hosts for epithermal gold-bearing quartz veins; 2) molybdenite on fracture surfaces of the Annie Ned batholith support geochemical anomalies in the region (**Stony** #81; GSC, 1985) and suggest porphyry potential; 3) the source(s) of numerous, slightly elevated gold-in-silt values draining volcanic rocks of the Joe Mountain Formation is uncertain and has not been linked to known showings. It is likely that the metal values are associated with quartz veins hosted in the north-trending fractures and associated felsic dykes that cut this package; 4) chalcopyrite and malachite locally occur on fracture surfaces in Mandanna Member red sedimentary rocks and are likely the type of mineralization reported for several showings (#91, 113, 130). This style of mineralization is particularly common adjacent to dykes and small plutons; and 5) the Cache Creek Terrane, southeast of the map area, contains listwaenite-hosted gold prospects (Hart, 1996; Ash and Arksey, 1990), which may also occur in Cache Creek volcanic and ultramafic rocks in the southern part of map area 105D/16.

The eastern map areas are considered to have good exploration potential for: 1) copper-molybdenum (tungsten) skarns; and 2) gold-bearing quartz veins.

Skarns are hosted in limestone and limy siltstone of the Upper Triassic Lewes River Group at, or near, contacts with granitic rocks. Rusty-weathering, silicified, bleached or pyritic siltstone in hornfels regions around the plutons should also be considered, as they locally contain arsenopyrite and may have associated gold. The Cap Creek granodiorite and associated phases are considered to be the most likely granitic rock to form skarns due to their higher iron content and lithological similarity with the Whitehorse pluton.

Quartz veins and boulders of quartz vein-float are common throughout the eastern map area. Float boulders are commonly angular, occur in dense concentrations, and are locally greater than one metre in diameter, indicating proximal sources (Figure 57b). Most of the quartz is milky white and either coarsely coxcomb or occurs as anastomosing sets of veins. Anomalous gold values are associated with veins that contain trace amounts of disseminated fine-grained arsenopyrite, small blebs of late-stage galena, or bladed calcite. Quartz veins are commonly associated with large, through-going, north-trending faults. However, as these faults are physiographic lows, adjacent, parallel faults, and associated felsic dykes are also good prospecting targets. Fault-hosted quartz

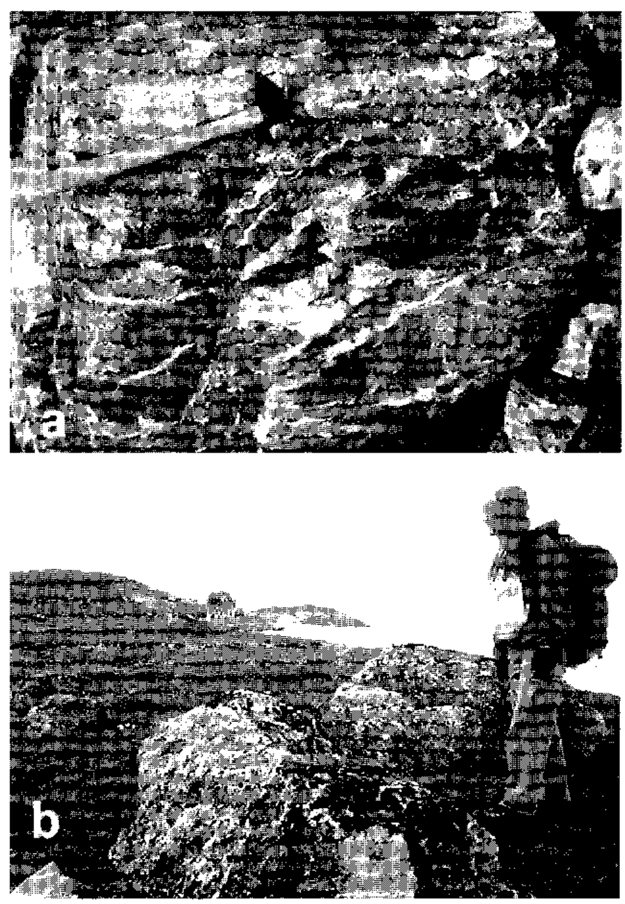


Figure 57. Large float boulders of massive white vein quartz are not uncommon features of central map area 105D/**15.** a) Quartz vein and vein stockwork with sparse arsenopyrite. A grab sample of this material yielded anomalous gold values of 1150 ppb. b) Quartz boulders up to 1.5 m across south of the Dow showing.

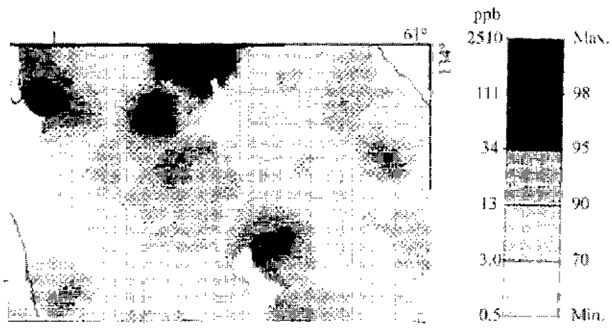


Figure 58. The contoured distribution of Au-in-silt anomalies from the northeastern part of the Whitehorse map sheet (105D) A spatial distribution of anomalous gold values is indicated and suggests a possible genetic relationship. These rocks have received little exploration attention and the source of the gold anomalies has not yet been identified. Detail from Geological Survey of Canada (1985).

veins in the Povoas and Joe Mountain Formation volcanics have rusty-weathering, Fe-carbonate alteration, and jasper veins that yield anomalous Au values (612 ppb, sample 93CH 32-7).

Tourmaline breccias were discovered west of the M'Clintock Lakes (Figure 60). Although metallic minerals were not observed, elsewhere in the Yukon they are associated with porphyry-style mineralization or they host low-grade gold values (i.e., Dawson Range). The significance of the breccias is not yet fully understood.

Placer deposits

Placer gold was first reported in Sheldon Creek by Lees (1936, p. 25), where numerous workings were active on the west fork before 1934. In one location above the canyon, seven men obtained $40 worth of gold from an area the size of a tent. Work between 1934 and 1984 is not documented. In 1984, Orion Construction explored three sites on the west fork of Sheldon Creek with heavy equipment (Debicki and Gilbert, 1986). Two of these sites were stripped and 3000 cubic yards (765 cubic m) of material were sluiced from one of them. Bedrock was not encountered in the valley bottom and gold production was not documented. A seismic reflection survey defined the basic stratigraphy and thickness of the gravels (LeBarge and Morison, 1990).

The source of the placer gold in Sheldon Creek is unknown and there are no known lode mineral occurrences in the drainage. Speculation on a potential source is based on the following evidence:

- gold occurs in gravels in the west fork, suggesting a source region in that drainage;
- no granitic plutons or Cretaceous volcanic rocks (both potential sources) are exposed within the drainage basin. Middle Triassic volcanic rocks underlie the headwaters;

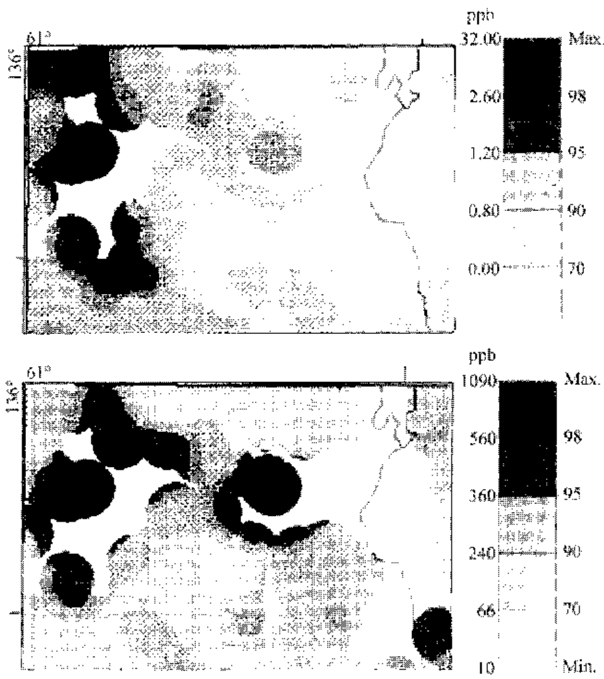


Figure 59. Contoured distribution of F (top) and U in-water anomalies of the northwestern part of the Whitehorse map sheet (105D) indicate a spatial relationship between anomalies and the Annie Ned granite. U is also anomalous in waters draining the the Flat Creek pluton. These granitic rocks are highly fractionated and contain fluorite as an accessory mineral. Detail from Geological Survey of Canada (1985).

- many of the cobbles in the gravels are composed of vivid orange-weathering, carbonate-altered sedimentary rock; and
- sedimentary rock cobbles in the gravels contain thin (1–5 cm wide), barren white quartz veins. Alteration is not intense and the local quartz veins are thin and barren of mineralization.

Thus veins in the sedimentary rocks may be the source of the placer gold and are a potential exploration target. Alternatively, detrital gold from the wide plateau to the south of the creek may have been scoured by glaciers, transported and deposited in the Sheldon Creek valley, where it has since been reworked by contemporary fluvial action. The east-trending character of the creek may have prevented the scouring and dispersion of placer gold by the northward advancement of the glaciers and allowed any preglacial, or glacially transported placer gold to remain concentrated in the creek.

Hydrocarbon potential

Little effort has been directed toward the exploration for hydrocarbons, despite numerous coal localities throughout the Whitehorse Trough (Hunt, 1994). The Tantalus formation, which hosts most coal deposits in the Whitehorse Trough, does not

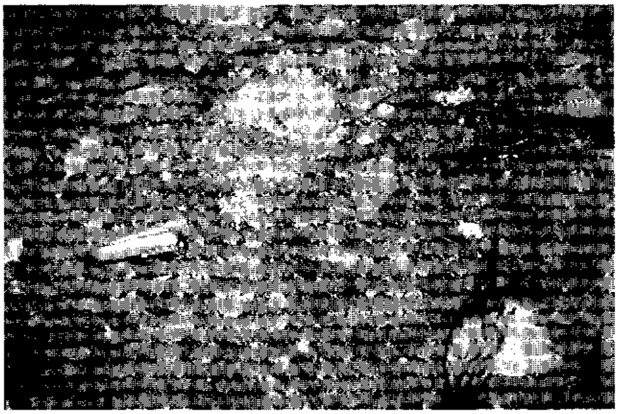


Figure 60. Tourmaline breccia found associated with volcanic rocks west of the M'Clintock Lakes.

occur in the study area. Conodont alteration indices from Upper Triassic limestone in the study area are mostly five or higher, indicating that regional thermal effects were too great for the preservation of oil or gas. Furthermore, structural complications in the region limit the possibilities for the concentration and containment of hydrocarbons.

Hotsprings

There are two known warm springs in the map area: the Takhini Hotsprings and the Versluce warm spring. The Takhini Hotsprings have a constant temperature of 46°C, a pH of 7.4 and flow at about 250 L/min from a pit dug into glacial till. A few streams of gaseous bubbles are apparent within the vent pool, as is a weak sulphurous odour. Sheeted, banded chalcedonic quartz veins, 1–3 cm thick, occur in the sedimentary rocks that form the hills north of the hotspring, suggesting that hydrothermal activity occurred over a considerable time (Figure 61). The hotsprings are likely channelled upward along one of the north-trending normal faults located north of the hotsprings.

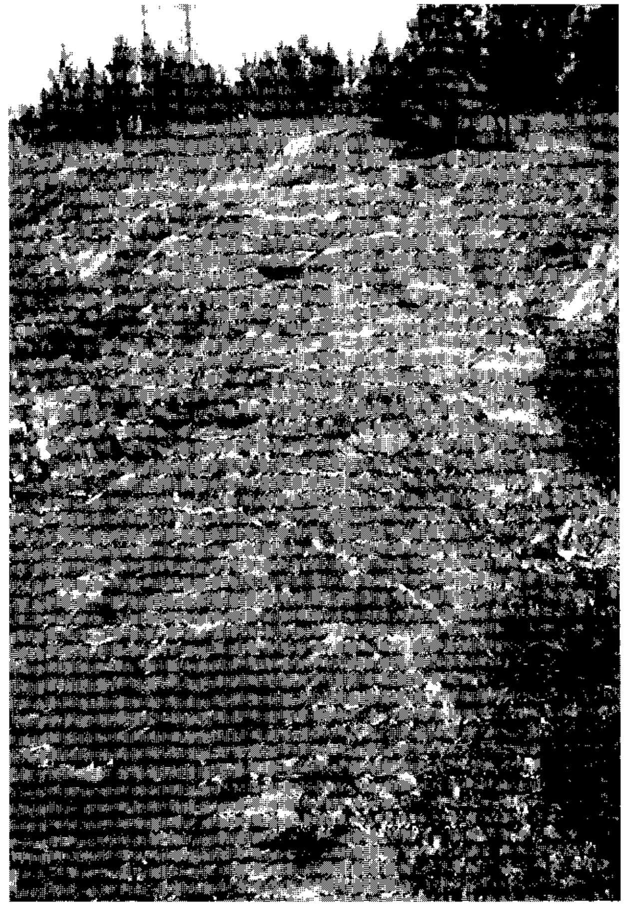


Figure 61. Sheeted quartz veins (white) cutting Laberge Group sandstone north of the Takhini Hotsprings. These veins suggest that hydrothermal activity continued in the region for a considerable time.

The Versluce spring (100 m west of the north end of Rabbitsfoot Canyon) has a summer temperature of 12°C, a pH of 7.8 and a flow rate of less than 50 L/min. There is no known structure near this spring, although there is a small fault in the Rabbitsfoot Canyon.

References

Aberhan, M. and Pálfy, J., 1996. A low oxygen tolerant East Pacific flat clam (*Posidonotis semiplicata*) from the Lower Jurassic of the Canadian Cordillera. Canadian Journal of Earth Sciences, v. 33, p. 993-1006.

Anderson, R. G., 1988. An overview of some Mesozoic and Tertiary plutonic suites and their associated mineralization in the northern Canadian Cordillera. In R. P. Taylor and D. F. Strong (eds.), Recent Advances in the Geology of Granite-related Mineral Deposits, Canadian Institute of Mining and Metallurgy, Special Volume 39, p. 96-113.

Ash, C. H. and Arksey, R. L., 1990. Tectonic setting of listwanite-related gold deposits in northwestern British Columbia (104N/12). B. C. Ministry of Energy, Mines and Petroleum Resources, Open File 1990-22.

Bostock, H. G. and Lees, E. J., 1938. Laberge map-area, Yukon. Geological Survey of Canada, Memoir 217, 32 p.

Bradford, J. A. and Brown, D. A., 1993. Geology of the Bearskin Lake and Tatsamenie Lake map areas, northwestern British Columbia (104K/1 and 8). In Geological Fieldwork 1992. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1993-1, p. 159-176.

Bremner, T., 1991. Mount Byng mineral occurrence. In Yukon Exploration 1990, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 52-56.

Brown, D. A. and McClelland, W. C., 1995. U-Pb dates for northern Stikinia: Tulsequah/Chutine areas (104F, K). Geological Association of Canada, Program and Abstracts, v. 20, p. A10.

Brown, D. A., Logan, J. M., Gunning, M. H., Orchard, M. J., and Bamber, W. E., 1991. Stratigraphic evolution of the Paleozoic Stikine Assemblage in the Stikine and Iskut River area, northwestern British Columbia. Canadian Journal of Earth Sciences, v. 28, p. 958-972.

Brown, D. A., Gunning, M. H., and Greig, C. J., 1996. The Stikine Project: Geology of western Telegraph Creek map area, northwestern British Columbia (NTS 104G/5, 6, 11W, 12 and 13). British Columbia Ministry of Employment and Investment, Bulletin 95, 175 p.

Brown, R. D., 1994. The Petrology and Structure of a Sheared Serpentinite Body and Folded Greywacke Sequence, Lake Laberge, Yukon Territory. Unpublished B.Sc. thesis, University of Alberta, 48 p.

Bultman, T. R., 1979. Geology and Tectonic History of the Whitehorse Trough west of Atlin, British Columbia. Unpublished Ph.D. thesis, Yale University, 284 p.

Burn, C. R., 1987. Thermokarst ponds and ground temperatures in the Takhini Valley. In S. R. Morison and C. A. S. Smith (eds.), Guidebook to Quaternary Research in the Yukon, XII INQUA Congress, Ottawa, Canada. National Research Council of Canada, p. 34.

Cairnes, D. D., 1910. Lewes and Nordenskiöld Rivers Coal District, Yukon Territory. Geological Survey of Canada, Memoir 5, 70 p.

Cairnes, D. D., 1912. Wheaton District, Yukon Territory. Geological Survey of Canada, Memoir 31, 196 p.

Cockfield, W. E. and Bell, A. H., 1926. Whitehorse District, Yukon. Geological Survey of Canada, Memoir 150, 63 p.

Cockfield, W. E. and Bell, A. H., 1944. Whitehorse District, Yukon. Geological Survey of Canada, Paper 44-14, 24 p.

Cordey, F., Gordey, S. P. and Orchard, M. J., 1991. New biostratigraphic data for the northern Cache Creek Terrane, Teslin map area, southern Yukon. In Current Research, Part E, Geological Survey of Canada, Paper 91-1E, p. 67-76.

Currie, L. D., 1994. Geology and Mid-Jurassic amalgamation of Tracy Arm Terrane and Stikinia of northwestern British Columbia. Unpublished Ph. D thesis, Carleton University.

Currie, L. D. and Parrish, R. R., 1993. Jurassic accretion of Nisling Terrane along the western margin of Stikinia, Coast Mountains, northwestern British Columbia. Geology, v. 21, p. 235-238.

Cwynar, L. C., 1988. Late Quaternary vegetation history of Kettlehole Pond, south-western Yukon. Canadian Journal of Forest Research, v. 18, p. 1270-1279.

Dagenais, G. R., 1984. The Oxygen Isotope Geochemistry of Granitoid Rocks from the Southern and Central Yukon. Unpublished M.Sc. thesis, University of Alberta, 168 p.

Dawson, G. M., 1889. Report on an exploration in the Yukon District, N. W. T. and adjacent northern portion of British Columbia, 1887. Geological Survey of Canada, Annual Report 1887-1888 (new series) part 1, report 13.

Debicki, R. and Gilbert, G. W., 1986. Yukon Placer Mining Industry 1983-1984. Placer Mining Section, Yukon, Indian and Northern Affairs Canada, 157 p.

Dickie, J. R., 1989. Sedimentary Response to Arc-Continent Transpressive Tectonics, Laberge Conglomerates (Jurassic), Whitehorse Trough, Yukon Territory. Unpublished M.Sc. thesis, Dalhousie University, 361 p.

Dickie, J. R. and Hein F., 1988. Facies and depositional setting of Laberge conglomerates (Jurassic), Whitehorse Trough. In Yukon Geology, Vol. 2, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 26-32.

Dickie, J. R. and Hein F., 1992. A Pliensbachian submarine slope and conglomeratic gully-fill succession: Richthofen to Conglomerate Formation transition (Laberge Group), Brute Mountain, Yukon. In Yukon Geology, Vol. 3, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 71-85.

Dickie, J. R. and Hein F., 1995. Conglomeratic fan deltas and submarine fans of the Jurassic Laberge Group, Whitehorse Trough, Yukon Territory, Canada: fore-arc sedimentation and unroofing of a volcanic island arc complex. Sedimentary Geology, v. 98, p. 263-292.

Dickie, J. R., Grist, A. M., and Donelick, R. A., 1992. Differential uplift across the Coast Plutonic Complex-Northern Stikine Terrane contact, Yukon; preliminary evidence from apatite fission-track thermochronometry. In Yukon Geology, Vol. 3, Exploration and Geological Services Division, Indian and Northern Affairs, Yukon, p. 160-166.

Dickinson, W. R., Beard, L. S., Brakenridge, G. R., Erjavec, J. L., Ferguson, R. C., Inman, K. F., Knepp, R. A., Lindberg, F. A., and Ryberg, P. T., 1983. Provenance of North American sandstones in relation to tectonic setting. Geological Society of America Bulletin, v. 94, p. 222-235.

Doherty, R. A., 1988. Report on the Byng claims (105D/16), Yukon Territory. Beavon Consultants Ltd. and M. J. Moreau Enterprises Ltd. Assessment Report 091873.

Doherty, R. A. and Hart, C. J. R., 1988. Preliminary geology of Fenwick Creek (105D/3) and Alligator Lake (105D/6) map areas. Exploration and Geological Services Division, Indian and Northern Affairs: Yukon Region, Open File 1988-2, 88 p.

Downing, D. A., 1980. GAR claims geochemical survey. Hudson Bay Exploration and Development Company Limited, Assessment Report 090622, 8 p.

Eisbacher, G. H., 1974. Evolution of successor basins in the Canadian Cordillera. In R. H. Dott and R. H. Shaver (eds.), Modern and Ancient Geosynclinal Sedimentation, Society of Economic Paleontologists and Mineralogists, Special Publication 19, p. 274-291.

Eisbacher, G. H., 1981. Late Mesozoic-Paleogene Bowser Basin molasse and cordilleran tectonics. In A. D. Maill (ed.), Sedimentation and Tectonics in Alluvial Basins. Geological Association of Canada, Special Paper 23, p. 125-151.

Francis, D., Jackson, M., and Johnston, S., 1995. Primary ankaramitic magmas for potassic calc-alkaline volcanics of the Cretaceous Carmacks Group. Geological Association of Canada, Program with Abstracts, p. A.34.

Frebold, H., 1964. Lower Jurassic and Bajocian ammonoid faunas of northwestern British Columbia and southern Yukon. Geological Survey of Canada, Bulletin 243, 24 p.

Frebold, H. and Poulton, T. P., 1977. Hettangian (Lower Jurassic) rocks and faunas, northern Yukon Territory. Canadian Journal of Earth Sciences, v. 14, p. 89-101.

Frey, R. W. and Pemberton, S. G., 1984. Trace fossil facies models. In R. G. Walker (ed.), Facies Models, Geoscience Canada Reprint Series 1, Second Edition, p. 189-208.

Fyles, J. G., 1950. Geology of northwest quarter of Whitehorse map-area, Yukon and studies of weathered granitic rocks near Whitehorse. Unpublished M. A.Sc. thesis, University of British Columbia, 156 p.

Geological Survey of Canada, 1966. Aeromagnetic map of 105D/14. 1:63,630 scale. Geological Survey of Canada, Map 3377G.

Geological Survey of Canada, 1967. Aeromagnetic map of 105D/14. 1:253,440 scale. Geological Survey of Canada, Map 7003G.

Geological Survey of Canada, 1985. Regional stream sediment and water geochemical data, Whitehorse map sheet (NTS 105D) Yukon, Open File 1218.

Gordey, S. P., 1993. Stikine, Cache Creek and Quesnel terrane interactions in southern Yukon. Program and Abstracts, Geological Association of Canada, p. A-36.

Gordey, S. P. and Stevens, R. A., 1994a. Preliminary interpretation of bedrock geology of the Teslin area (105C), 1:250 000 scale. Geological Survey of Canada, Open File 2886.

Gordey, S. P. and Stevens, R. A., 1994b. Tectonic framework of the Teslin region, southern Yukon Territory, southern Yukon Territory. In Current Research, Part A, Geological Survey of Canada, Paper 1994-A, p. 11-18.

Grond, H. C., 1980. New K-Ar dates and geochemistry for Mount Nansen volcanics, Yukon. B.Sc. thesis, University of British Columbia.

Grond, H. C., Churchill, S. J., Armstrong, R. L., Harakal, J. E., and Nixon, G. T., 1984. Late Cretaceous age of the Hutshi, Mount Nansen and Carmacks groups, southwestern Yukon Territory and northwestern British Columbia. Canadian Journal of Earth Sciences, v. 21, p. 554-558.

Gunning, M. H., 1993. Character and Evolution of an Upper Carboniferous to Upper Permian Succession in an Extensional Oceanic Tectonic Setting; Stikine Assemblage, Northwest Stikinia, Scud River Area (NTS 104G), British Columbia. Unpublished M.Sc. thesis, University of Western Ontario, 305 p.

Hansen, V. L., 1987. Structural, metamorphic and geochronologic evolution of the Teslin suture zone, Yukon: evidence for Mesozoic oblique convergence outboard of the northern Canadian Cordillera. Unpublished Ph.D. thesis, University of California, 261 p.

Hansen, V. L., 1988. A model for terrane accretion: Yukon Tanana and Slide Mountain Terranes, northwest North America. Tectonics, v. 7, p. 1167-1177.

Hansen, V. L., Radloff, J. K., and Hart, C. J. R., 1990. Tally Ho Shear Zone, southern Yukon: Kinematic evolution and tectonic implications: Geological Association of Canada, Abstracts with Program, v. 15, p. A53.

Hare, P. G., 1995. Holocene occupations in the southern Yukon: new perspectives from the Annie Lake site. Occasional Papers in Archeology No. 5. Heritage Branch, Government of Yukon, 147 p.

Harris, M. J., Symons, D. T. A., Blackburn, W. H., and Hart, C. J. R., in review (1997). Paleomagnetic and geobarometric study of the mid-Cretaceous Whitehorse pluton, Yukon Territory. Canadian Journal of Earth Science.

Hart, C. J. R., 1993a. Preliminary geological map (1:50 000) of the Thirty-Seven Mile map area (105D/13), southern Yukon Territory. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1993-4 (G).

Hart, C. J. R., 1993b. Northern Stikinia — constructed on a Cache Creek basement. Program and Abstracts, Geological Association of Canada, p. A-41.

Hart, C. J. R., 1995. Magmatic and tectonic evolution of the Intermontane Superterrane and Coast Plutonic Complex in southern Yukon Territory. Unpublished M.Sc. thesis, University of British Columbia, 196 p.

Hart, C. J. R., 1996. Geology and mineralization of the TOG, listwaenite-hosted gold occurrence in southern Yukon Territory. In Yukon Exploration and Geology, 1995, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 87-104.

Hart, C. J. R. and Brent, D., 1993. Preliminary geology of the Thirty-seven Mile Creek map sheet (105D/13). In Yukon Exploration and Geology 1992, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 39-48.

Hart, C. J. R. and Hunt, J. A., 1994a. Geology of the Joe Mountain map area (105D/15), southern Yukon Territory. 1:50 000 geological map, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1994-4 (G).

Hart, C. J. R. and Hunt, J. A., 1994b. Geology of the Joe Mountain map area (105D/15), southern Yukon Territory. In Yukon Exploration and Geology, 1993, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 47-66.

Hart, C. J. R. and Hunt, J. A., 1995a. Geology of the Mount M'Clintock map area (105D/16), southern Yukon Territory. 1:50 000 geological map, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1995-4 (G).

Hart, C. J. R. and Hunt, J. A., 1995b. Geology of the Mount M'Clintock map area (105D/16), southern Yukon Territory. In Yukon Exploration and Geology, 1994. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 87-104.

Hart, C. J. R. and Orchard, M. J., 1996. Middle Triassic (Ladinian) volcanic strata in southern Yukon and their Cordilleran correlatives. In Current Research Part A, Geological Survey of Canada, Paper 96-1A, p. 11-18.

Hart, C. J. R. and Pelletier, K. S., 1989a. Geology of Carcross (105D/2) and part of Robinson (105D/7) map areas. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs, Open File 1989-1, 84 p.

Hart, C. J. R. and Pelletier, K. S., 1989b. Geology of Whitehorse (105D/11) map area. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs, Open File 1989-2, 51 p.

Hart, C. J. R. and Radloff, J. K., 1990. Geology of Whitehorse, Alligator Lake, Fenwick Creek, Carcross and part of Robinson map areas (105D/11, 6, 3, 2 & 7). Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1990-4, 113 p.

Hart, C. J. R., Dickie, J. R., Ghosh, D. K. and Armstrong, R. L., 1995. Provenance constraints for Whitehorse Trough conglomerate: U-Pb zircon dates and initial Sr ratios of granitic clasts in Laberge Group, Yukon Territory. In D. M. Miller and C. Busby (eds.), Jurassic Magmatism and Tectonics of the North American Cordillera, Geological Society of America Special Paper 299, p. 47-64.

Hunt, A. and Roddick, J. C., 1995. A compilation of K-Ar and ^{40}Ar-^{39}Ar ages. Report 24. In Radiogenic Age and Isotopic Studies, Report 8. Geological Survey of Canada, Paper 95-2.

Hunt, J. A., 1994. Yukon Coal Inventory 1994. Energy and Mines Branch, Department of Economic Development, Yukon Territorial Government, 169 p.

INAC, 1983. Yukon Geology 1982. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.

Irving, T. N. and Barager, W. R. A., 1971. A guide to the chemical classification of the common volcanic rocks. Canadian Journal of Earth Sciences, v. 8, p. 523-548.

Jackson, J. L., Gehrels, G. E., Patchett, P. J., and Mihalynuk, M. G., 1991. Stratigraphic and isotopic link between the northern Stikinia and an ancient continental margin assemblage, Canadian Cordillera. Geology, v. 19, p. 1177-1180.

Jackson, L. E., Ward, B., Duk-Rodkin, A., and Hughes, O. L., 1991. The last Cordilleran ice sheet in southern Yukon Territory. Geographic Physique et Quaternaire, v. 45, p. 341-354.

Jakobs, G. K., 1994. Jurassic stratigraphy in the northwestern Teslin and northeastern Whitehorse map areas, Yukon Territory. In Current Research, Part E, Geological Survey of Canada, Paper 1994-1E, p. 1-6.

Jakobs, G. K., Smith, P. L., and Tipper, H. W., 1994. An ammonite zonation for the Toarcian (Lower Jurassic) of the North American Cordillera. Canadian Journal of Earth Sciences, v. 31, p.919-942.

Johannson, G. G., 1993. Preliminary report on the stratigraphy, sedimentology and biochronology of the Inklin Formation in the Atlin Lake area, northern British Columbia. In Current Research, Part A, Geological Survey of Canada, Paper 93-1A, p. 37-42.

Johannson, G. G., 1994. Provenance constraints on Early Jurassic evolution of the northern Stikinian arc, Whitehorse Trough, Atlin Lake, northwestern British Columbia. Unpublished M.Sc. thesis, University of British Columbia, 299 p.

Johannson, G. G., Smith, P. L., and Gordey, S. P., 1997. Provenance constraints on Early Jurassic evolution of the northern Stikinian arc: Evidence from the Laberge Group, Whitehorse Trough, northwestern British Columbia. Canadian Journal of Earth Sciences, v. 34, p. 1030-1057.

Johnston, S. T., 1993. The Geological Evolution of Nisling Assemblage and Stikine Terrane in the Aishihik Lake area, southwest Yukon. Unpublished Ph.D. thesis, University of Alberta, 270 p.

Johnston, S. T. and Erdmer, P. E., 1995. Hot-side up aureole in southwest Yukon and limits of terrane assembly of the northern Canadian Cordillera. Geology, v. 23, p. 419-422.

Johnston, S. T., Hart, C. J. R., Mihalynuk, M. G., Brew, D. A., and Ford, A. B., 1993. Field Guide to accompany 1993 NUNA Conference: "The Northern Intermontane Superterrane", Marsh Lake, Yukon, 67 p.

Johnston, S. T., Hart, C. J. R., and Mihalynuk, M. G., 1994. Report on NUNA Field Conference - The Northern Intermontane Superterrane. Geoscience Canada, v. 21, p. 27-29.

Kindle, E. D., 1953. Dezadeash map-area, Yukon Territory. Geological Survey of Canada, Memoir 268, 68 p.

Kindle, E. D., 1964. Copper and iron resources, Whitehorse Copper Belt, Yukon Territory. Geological Survey of Canada, Paper 63-41, 46 p.

Klassen, R. W., 1979. Thermokarst terrane near Whitehorse, Yukon Territory. In Current Research, Part A, Geological Survey of Canada, Paper 79-1A, p. 385-388.

Le Maitre, R. W., 1989. A Classification of Igneous Rocks and Glossary of Terms; Blackwell, Oxford, 193 p.

Lebarge, W. P. and Morison, W. R., 1990. Yukon Placer Mining and Exploration 1985-1988, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, 151 p.

Lees, E. J., 1934. Geology of the Laberge area, Yukon. Transactions of the Royal Canadian Institute, v. 20, part 1, p. 1-48.

Lees, E. J., 1936. Geology of Teslin-Quiet Lake area, Yukon. Geological Survey of Canada, Memoir 203, 30 p.

Lowden, J. A., 1960. Age determinations by the Geological Survey of Canada , Report 1 — Isotopic Ages. Geological Survey of Canada, Paper 60-17, p. 7-8.

Marsagli, K. M. and Ingersoll, R. V., 1992. Compositional trends in arc-related, deep marine sand and sandstone: a reassessment of magmatic arc provenance. Geological Society of America Bulletin, v. 104, p. 1637-1649.

Matthews, W. H., 1986. Physiographic map (1:5 000 000) of the Canadian Cordillera. Geological Survey of Canada, Map 1701A.

Mihalynuk, M. G., Meldrum, D., Sears, S., and Johannson, G., 1995. Geology and mineralization of the Stuhini Creek area (104K/ 11). In Geological Fieldwork 1994, British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1995-1, p. 321-342.

Mihalynuk, M. G., Smith, M. T., Gabites, J. E., Runkle, D., and Lefebure, D., 1992. Age of emplacement and basement character of the Cache Creek Terrane as constrained by new isotopic and geochemical data. Canadian Journal of Earth Sciences, v. 29, p. 2463-2477.

Mihalynuk, M. G., Smith, M. T., Hancock, K. D., and Dudka, S., 1994a. Regional and economic geology of the Tulsequah River and Glacier areas (104K/12 & 13). In Geological Fieldwork 1993, British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1994-1, p. 171-197

Mihalynuk, M. G., Smith, M. T., Hancock, K. D., Dudka, S., and Payne, J., 1994b. Tulsequah River and Glacier areas (104K/12 & 13). British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File map 1994-3.

Mihalynuk, M. G. and Rouse, J. N., 1988. Preliminary geology of the Tutshi Lake area, northwestern British Columbia (104M/15). In Geological Fieldwork, Paper 1988-1, British Columbia Ministry of Energy, Mines and Petroleum Resources, p. 217-231.

Miyashiro, A., 1974. Volcanic rock series in island arcs and active continental margins. American Journal of Science, v. 274, p. 321-355.

Morison, S. R. and Klassen, R. W., 1991. Surficial geology, Whitehorse, Yukon Territory; scale 1:250 000. Geological Survey of Canada, Map 12-1990,

Morrison, G. W., 1981. Setting and origin of skarn deposits in the Whitehorse copper belt, Yukon. Unpublished Ph.D. thesis, University of Western Ontario, 306 p.

Morrison, G. W., Godwin, C. I., and Armstrong, R. L., 1979, Interpretation of isotopic ages and 87Sr/86Sr initial ratios for plutonic rocks in the Whitehorse map area, Yukon. Canadian Journal of Earth Sciences, v. 16, p. 1988-1997.

Mortensen, J. K., 1992. Pre-mid-Mesozoic tectonic evolution of the Yukon-Tanana terrane, Yukon and Alaska: Tectonics, v. 11, no. 4, p. 836-853.

Mullen, E. D., 1983. MnO/TiO2/P2O5: a minor element discriminate for basaltic rocks of oceanic environments and its implications for petrogenesis. Earth and Planetary Science Letters, v. 62, p. 53-62.

Orchard, M. J., 1991a. Conodonts, time and terranes: an overview of the biostratigraphic record in the western Canadian Cordillera. In M. J. Orchard and A. D. McCracken (eds.), Ordovician to Triassic Conodont Paleontology of the Canadian Cordillera, Geological Survey of Canada, Bulletin 417, p. 1-26.

Orchard, M. J., 1991b. Upper Triassic conodont biochronology and new index species from the Canadian Cordillera. In M. J. Orchard and A. D. McCracken (eds.), Ordovician to Triassic Conodont Paleontology of the Canadian Cordillera, Geological Survey of Canada, Bulletin 417, p. 299-335.

Orchard, M. J., 1991c. Report on conodonts and other microfossils from the Atlin, Laberge, Teslin and Whitehorse map areas. Geological Survey of Canada. Unpublished report OF-1991-2.

Orchard, M. J., 1993a. Report on condonts and other microfossils from the Teslin (105C) and Whitehorse (105D) map areas. Geological Survey of Canada. Unpublished report OF-1993-31.

Orchard, M. J., 1993b. Report on condonts and other microfossils from the Whitehorse (105D) map area. Geological Survey of Canada. Unpublished report OF-1993-56.

Orchard, M. J., 1993c. Report on condonts and other microfossils from the Whitehorse (105D) and Laberge (105E) map areas. Geological Survey of Canada. Unpublished report OF-1993-44.

Orchard, M. J., 1994. Report on conodonts and other microfossils from the Whitehorse (105D) map area. Geological Survey of Canada. Unpublished report MJO-1994-26 (revised).

Orchard, M. J., 1995a. Report on condonts and other microfossils from the Teslin, Whitehorse and Finlayson Lake map areas. Geological Survey of Canada. Unpublished report MJO-1995-19.

Orchard, M. J., 1995b. Report on condonts and other microfossils from the Whitehorse (105D) and Lake Laberge (105E) map areas. Geological Survey of Canada. Unpublished report MJO-1995-32.

Orchard, M. J., 1997. Report on condonts and other microfossils from the Whitehorse (105D) map area. Geological Survey of Canada. Unpublished report MJO-1997-10.

Pálfy, J., 1995. Fossil report on Jurassic macrofossils from the Whitehorse map area. Unpublished report prepared for the Canada/ Yukon Geoscience Office.

Pálfy, J. and Hart, C. J. R., 1995. Biostratigraphy of the Lower to Middle Jurassic Laberge Group, Whitehorse map area (105D), southern Yukon. In Yukon Exploration and Geology 1994. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 73-86.

Pálfy, J. and Tipper, H. W., 1995. Report on Jurassic ammonites from the Laberge Group in southern Yukon. Geological Survey of Canada. Unpublished report J2-1995-HWT.

Pálfy, J., Smith, P. L., and Tipper, H. W., 1994. Sinemurian (Lower Jurassic) ammonoid biostratigraphy of the Queen Charlotte Islands, western Canada. Géobios, Mémoire Spécial, v. 17, p. 385-393.

Poulton, T. P., 1979. Jurassic trigoniid bivalves from Canada and western United States of America. Geological Survey of Canada, Bulletin 282, 56 p.

Poulton, T. P. and Tipper, H. W., 1991. Aalenian ammonites and strata of Western Canada. Geological Survey of Canada, Bulletin 441, 71 p.

Radloff, J. K., Hart, C. J. R., and Hansen, V. L., 1990. Late Triassic sinistral translation on the Tally Ho shear zone, Yukon. Geological Society of America, Abstracts with Program, no. 01803, p. 76.

Reid, R. P., 1985. The facies and evolution of an Upper Triassic reef complex in northern Canada. Unpublished Ph.D. thesis, University of Miami, Fisher Island Branch, 437 p.

Reid, R. P and Tempelman-Kluit, D. J., 1987. Upper Triassic Tethyan-type reefs in the Yukon. Bulletin of Canadian Petroleum Geology, v. 35, p. 316-332.

Rui, L., 1994. Report on 15 collections of fossils from the northwestern Tulsequah map area, northwestern British Columbia (NTS 104K/12, 13). Geological Survey of Canada. Unpublished report C1-EWB-1994 Rui-1-1994.

Schönicke, O. and Weihe, T., 1992. Geological-sedimentological mapping of the Teslin River area, Whitehorse, Yukon Territory, Canada. Diploma Map Report, Geological Institute of the Technical University of Clausthal, Germany, 73 p.

Schweger, C. E., Matthews Jr., J. V., and Cwynar, L. C., 1987. Alkaline basins and Two Horsemen pond. In S. R. Morison and C. A. S. Smith (eds.), Guideboook to Quaternary Research in the Yukon, XII INQUA Congress, Ottawa, Canada. National Research Council of Canada, p. 34-35.

Senowbari-Daryan, B. and Reid, R. P., 1987. Upper Triassic sponges (*Sphinctozoa*) from southern Yukon, Stikine terrane. Canadian Journal of Earth Sciences, v. 24, p. 882-902.

Smith, P. L. and Tipper, H. W., 1986. Plate tectonics and paleobiogeography: Early Jurassic (Pliensbachian) endemism and diversity. Palaios, v. 1, p. 399-412.

Smith, P. L., Tipper, H. W., Taylor, D. G., and Guex, J., 1988. An ammonite zonation for the Lower Jurassic of Canada and the United States: the Pliensbachian: Canadian Journal of Earth Sciences, v. 25, p. 1503-1523.

Souther, J. G., 1971. Geology and mineral deposits of the Tulsequah map-area, British Columbia: Geological Survey of Canada, Memoir 362, p.

Steiger, R. H. and Jäger, E., 1977. Subcommission on geochronology: convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Stevens, R. D., Delabio, R. N., and Lachance, G. R., 1982. Age determinations and geological studies. Geological Survey of Canada, Paper 82-2, 56 p.

Stretch, G., 1993. Structural analysis of deformed carbonates of the Lewes River Group: Alaska Highway road cut between Whitehorse and Porter Creek, southern Yukon Territory. Unpublished B.Sc. thesis, University of Alberta, 28 p.

Symons, D. T. A., Harris, M. J., Blackburn, W. H., and Hart, C. J. R., 1996. Paleomagnetic determinations of the geotectonic displacement of the northern Intermontane, Yukon: progress report and preliminary results from the Whitehorse pluton. Lithoprobe Transect Meeting, Abstracts, p. 118-131.

Tempelman-Kluit, D. J., 1976. The Yukon Crystalline Terrane, enigma in the Canadian Cordillera. Geological Society of American Bulletin, v. 87, p. 1343-1357.

Tempelman-Kluit, D. J., 1978. Reconnaissance geology, Laberge map-area, Yukon. In Current Research, Part A, Geological Survey of Canada, Paper 78-1A, p. 61-66.

Tempelman-Kluit, D. J., 1979. Transported cataclasite, ophiolite and granodiorite in the Yukon: evidence of arc-continent collision. Geological Survey of Canada, Paper 79-14, 27 p.

Tempelman-Kluit, D. J., 1980. Highlights of field work in Laberge and Carmacks map areas, Yukon Territory. In Current Research, Part A, Geological Survey of Canada, Paper 80-1A, p. 357-362.

Tempelman-Kluit, D. J., 1984. Laberge (105E) and Carmacks (115I) map-areas. Two maps (1:250 000) and legends, Geological Survey of Canada, Open File 1101.

Tipper, H. W., 1994. Report on collections from the Whitehorse map area (105D), Yukon Territory. Geological Survey of Canada. Unpublished report J8-1994-HWT.

Tozer, E. T., 1958. Stratigraphy of the Lewes River Group (Triassic), Central Laberge area, Yukon Territory. Geological Survey of Canada, Bulletin 43, 28 p.

Tozer, E. T., 1967. A standard for Triassic time. Geological Survey of Canada, Bulletin 156, 103 p.

Tozer, E. T., 1979. Latest Triassic ammonoid faunas and biochronology, western Canada. In Current Research, Part B, Geological Survey of Canada, Paper 79-1B, p. 127-135.

Tozer, E. T., 1982. Marine Triassic faunas of North America: their significance for assessing plate and terrane movements. Geologische Rundschau, v. 71, p. 1077-1104.

Tozer, E. T., 1994. Canadian Triassic Ammonite Faunas. Geological Survey of Canada, Bulletin 467, 663 p.

Tozer, E. T., 1996. Report on macrofossils form the Whitehorse (105D) map area. Geological Survey of Canada. Unpublished report ETT-1996-1.

Watson, P., 1984. The Whitehorse Copper Belt: a compilation. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs, Canada, Open File.

Wheeler, J. O., 1961. Whitehorse map-area, Yukon Territory. Geological Survey of Canada, Memoir 312, 156 p.

Wheeler, J. O. and McFeely, P., 1991. Tectonic Assemblage Map of the Canadian Cordillera. Geological Survey of Canada, Map 1712A.

White, W. M. H., Erickson, G. P., Northcote, K. E., Dirom, G. E., and Harakal, J. E. 1967. Isotopic dating of the Guichon batholith, British Columbia. Canadian Journal of Earth Sciences, v. 4, p. 677-690.

Woodsworth, G. J., Anderson, R. G., and Armstrong, R. L., 1991. Plutonic regimes, Chapter 15. In H. Gabrielse and C. J. Yorath (eds.), Geology of the Cordilleran Orogen in Canada. Geological Survey of Canada, Geology of Canada, no. 4, p. 281-327 (also Geological Society of America, The Geology of America, v. G-2).

Yukon MINFILE, 1995. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs, Canada.

APPENDIX 1. Compilation of Triassic macrofossils and localities from the study area. Identifications are by Dr. E.T. Tozer (GSC, Vancouver).

Map No.	Sample No.	NTS	UTM Zone 8	Locality	Material	Stage/Zone	Reference/Note
T1		105D/14	484500 6756800	7.7 km N of Hotsprings	thick-shelled bivalves	Upper Norian	
T2		105D/14	479950 6754750	5.7 km N of Hotsprings	JOW and Fyles locality	Upper Norian	Wheeler, 1961
T3		105D/14	480000 6750200	1.1 km N of Hotsprings	corals	Upper Norian	Age confirmed by conodonts
T4	F12	105D/14	487300 6748500	N of Pilot Mountain subdivision, near Peak 2844'	JOW locality	Upper Norian	Wheeler, 1961
T5	F4	105D/14	481400 6739500	2 km S of Old Alaska Highway subdivision	JOW locality		Wheeler, 1961
T6	GSC 14862 F1, JOW11	105D/14	486100 6784500	1.5 km NE of Haeckel Hill	*Spondylospira lewesensis*, *Pecten* (*Variamusium*) cf. *Klushaensis* Lees, *Neomegalous* n. sp.	Upper Norian	Wheeler, 1961
T7	F8	105D/14	486500 6736250	E of Mount Sumanik	thick shelled bivalves incl. *Dicerocardium* and *Megalodon*		
T8		105D/14	470400 6740200	1 km N of Crestview	JOW locality		Wheeler, 1961
T9	GSC 17577 JOW16	105D/15	506500 6761100	6 km N of Mount Slim @ 3500'	*Spondylospira lewensis*, *Pecten yukonensis*	Upper Norian	Wheeler, 1961
T10		105D/15	507750 6761000	6 km N of Mount Slim @ 4200'			
T11	C-202989 JT 10-1	105D/15	508500 6761000	6 km NNE of Mount Slim, 1 km NW of Peak 5109'	thick-ribbed inflated indet. bivalve in limestone		Tozer, 1996
T12	C-202988 93CH 49-3	105D/15	504250 6758300	4.7 km NW of Mount Slim @ 3450'	*Daonella* or *Halobia* sp. ammonite indet.	prob. Upper Triassic	Tozer, 1996
T13	C-202991 93J 43-8	105D/15	505300 6758000	3.6 km NW of Mount Slim @ 4300'	ammonoid indet., poss. arpaditid	Upper Triassic	Tozer, 1996
T14	GSC 17565 JOW1	105D/15	501750 6757150	6 km WNW of Mount Slim @ 3200'	*Mysidioptera* sp., small smooth ammonites, indet. echinoid radiole	Lower? Carnian	Wheeler, 1961
T15		105D/15	508250 6755000	1 km E of Mount Slim	JOW locality		Wheeler, 1961
T16	C-202987 93CH 34-3	105D/15	515200 6752100	3.5 km S of Joe Mountain	probably *Daonella* sp.	Ladinian	Tozer. 1996. Age confirmed by conodonts

APPENDIX 1 (Cont'd)

Map No.	Sample No.	NTS	UTM Zone 8	Locality	Material	Stage/Zone	Reference/Note
T17		105D/15		5 km S of Joe Mountain	poorly preserved thick-shelled bivalves	Ladinian	Age confirmed by conodonts
T18	C-203055 93CH 14-5	105D/15	514950 6749350	1.9 km NW of Peak 6214', E of upper Cap Creek	thin-shelled brachiopods indet.		Tozer, 1996
T19	GSC 17551 JOW19	105D/15	515800 6748400	0.9 km WSW of Peak 6241', E of upper Cap Creek @ 5400'	*Pecten yukonensis*		Wheeler, 1961
T20		105D/15	516400 6746400	2 km W of Peak 5644'	corals, bivalves, sponges		
T21		105D/16	538850 6758300	2.4 km E of Peak 1851 m, N of upper Sheldon Creek	JOW locality		Wheeler, 1961
T22	C-202990 95CH 31-6	105D/16	539000 6756400	4 km E of Peak 1980 m @ 1640m, N of Sheldon Creek	*Monotis subcircularis* Gabb	Cordilleranus Zone Upper Norian	Tozer, 1996
T23	C-203074 J94-11-5	105D/16	540060 6753025	4.5 km east of Mount Byng @ 1700 m, S of Sheldon Creek	coral, thecosemmillia?		
T24	GSC 17567 JOW13	105D/16	544800 6747850	1 km W of Peak 1679 m @ 4000'	*Pecten yukonensis*	Upper Norian	Wheeler, 1961
T25	GSC 17568 JOW14	105D/16	545000 6747300	0.8 km SW of Peak 1679 m @ 4200'	*Pecten yukonensis*	Upper Norian	Wheeler, 1961
T26		105D/16	542400 6746400	S side of Peak 1821 m, E of Byng Creek	JOW locality		Wheeler, 1961
T27	C-202992 94CH 25-1	105D/16	547800 6739750	5.5 km SSW of Mount M'Clintock 6.9 km NW of August Mountain	*Monotis subcircularis* Gabb ammonites indet.	Cordilleranus Zone Upper Norian	Tozer, 1996

Appendix 2a. Compilation of microfossil identifications and localities from the study area. Identifications are by M.J. Orchard, (GSC, Vancouver). CAI=conodont alteration index.

Map No.	Sample Numbers	NTS	UTM Zone 8	Unit Location	Fossils	Epoch, Stage CAI	Reference/Note
C1	C-203081 94 CH 57-3	105D/14	480000 6750300	Hancock Member 1.6 km NNW of Takhini Hotsprings	conodonts	Late Norian 5.5	Orchard, 1995b
C2	C-156604	105D/14	485678 6739090	Hancock Member 1 km N of Haeckel Hill	conodonts, ichthyoliths	latest Middle-Late Norian 6	Orchard, 1991b collected by J. Jackson
C3	C-203051 93JH 14-7	105D/15	518800 6747350	Joe Mountain Formation 1.5 km NE of 5644'	conodonts	Middle Triassic 5	Orchard, 1994 Hart and Orchard, 1996
C4	C-203056 93CH 15-3	105D/15	517925 6745925	Joe Mountain Formation 0.6 km SW of Peak 5644'	conodonts , ichthyoliths sponge spicules	Middle Triassic, Ladinian 5-6	Orchard, 1994 Hart and Orchard, 1996
C5	C-203062 93CH 47-4	105D/15	523300 6739000	Joe Mountain Formation 1.8 km SSE of Peak 4835' @ 4850'	conodonts, ichthyoliths	Middle Triassic, Ladinian 5	Orchard, 1994 Hart and Orchard, 1996
C6	C-203063 93CH 48-2	105D/15	516400 6750200	Joe Mountain Formation 1.4 km N of Peak 6241' @ 6125'	conodonts, ichthyoliths shell fragments	Middle Triassic, Ladinian 5-6	Orchard, 1994 Hart and Orchard, 1996
C7	C-203064 93CH 34-4	105D/15	515973 6752099	Joe Mountain Formation 3.5 km S of Joe Mountain @ 5750'	conodonts, ichthyoliths sponge spicules	Middle Triassic, Ladinian 5	Orchard, 1994 Hart and Orchard, 1996
C8	C-202972 95CH 14-1	105D/15	515000 6752300	Joe Mountain Formation 3.4 km SSW of Joe Mountain @ 5900'	conodonts, foraminifers, ichthyoliths	Late Norian-Rhaetian 5	Orchard, 1997
C9	C-202973 95CH 14-7	105D/15	516000 6750900	Joe Mountain Formation 4.6 km S of Joe Mountain @ 5700'	conodonts, ichthyoliths, sponge spicules, echinoderms	Middle -Late Triassic 5	Orchard, 1997
C10	C-202954 93CH 28-1	105D/15	515350 6752200	Joe Mountain Formation 3 km S of Joe Mountain @ 5900'	conodonts, ichthyoliths	Middle Triassic, Ladinian 5	Orchard, 1994 Hart and Orchard, 1996
C11	C-176064 91-43-09	105D/16	542300 6746750	Hancock Member 9 km SE of Mount Byng just N of Peak 1821 m	conodonts, ichthyoliths, tubes foraminifers	Late Norian 5.5-6	Orchard, 1993a collected by S. Gordey
C12	C-203080 94CH 52-3	105D/16	553800 6755450	Laberge Group limestone clast 1 km east of Teslin River, 5.5 km SSE of Baker Lake	conodonts, foraminifers ichthyoliths, arm hooks	Early? Norian 5-6	Orchard, 1995b
C13	C-176063 91-43-08	105D/16	539650 6752850	Casca Member 3.7 km ESE of Mount Byng	conodonts, ichthyoliths sphaeromorphs	Carnian 5.5-6	Orchard, 1993a collected by S. Gordey
C14	C-203078 CH 35-6	105D/16	536650 6752500	Casca Member 1 km SE of Mount Byng saddle	conodonts, ichthyoliths	Late Carnian 5	Orchard, 1995b
C15	C-203069 J94 4-3B	105D/16	540065 6757090	Lewes River Group? N of M'Clintock Lakes @ 4430'	conodonts, ichthyoliths, shell fragments	Permian-Triassic 2-3	Orchard, 1995b

Appendix 2a (Cont'd)

Map No.	Sample Numbers	NTS	UTM Zone 8	Unit Location	Fossils	Epoch, Stage CAI	Reference/Note
C16	C-210107	105D/16	546475 6744525	Hancock Member 3.7 km W of Mount M'Clintock	conodonts, ichthyoliths shell fragments	Middle-Late Norian 4.5-5.5	Orchard, 1995a collected by G. Jakobs
C17	C-210114	105D/16	546525 6744475	Laberge Group limestone clast 4.5 W of Mount M'Clintock	conodonts, ichthyoliths	Late Carnian 5-5.5	Orchard, 1995a collected by G. Jakobs
C18	C-202980 95JTI-52	105D/15	510950 6760250	5.8 km NE of Mount Slim @ 4670'	conodonts	Late Norian-Rhaetian 5	Orchard, 1997
C19	C-202981 95JTI-58	105D/15	517050 6747000	10.75 km NNE of Cap Mountain @ 5080'	conodonts, icthyoliths	Late Carnian 5	Orchard, 1997
C20	C-202982 95JTI-60	105D/15	516500 6746375	10.15 km NNE of Cap Mountain @ 5240'	conodonts, ichthyoliths	Late Norian-Rhaetian 5.5	Orchard, 1997
	C-203082 94CH 60-1	105E/02	505550 6769750	Hancock Member West peak of Lime Peak	conodonts, ichthyoliths, echinoderms, holothurians	Late Norian 4	Orchard, 1995b

APPENDIX 2b. Compilation of barren or indeterminant microfossil localities

Map No.	Sample Numbers	NTS	UTM Zone 8	Unit Location	Fossils	Epoch, Stage CAI	Reference/Note
	C-203083 94JH MountLaurier	105E/02	507750 6764950	Hancock Member East shoulder of Mount Laurier	echinoderms holothurian (*Theelia* sp.)	Triassic	Orchard, 1995b
	C-202969 94CH 61-3	105D/10	525890 671380	Unknown unit Old gravel pit N of Marsh Lake E of Alaska Highway sheared marble	barren		Orchard, 1995b
	C-108234 92CH 27-3	105D/13		Takhini Assemblage, marble	barren		Orchard, 1993c
	C-108235 92CH 18-2	105D/13		Takhini Assemblage, marble	barren		Orchard, 1993c
	C-108236 92CH 19-2	105D/13		Takhini Assemblage, marble	barren		Orchard, 1993c
	C-108237 92CH 51-2	105D/13		Takhini Assemblage, marble	barren		Orchard, 1993c
	C-108239 92CH 29-3	105D/13		Takhini Assemblage, marble	barren		Orchard, 1993c
	C-108241 92CH 51-4	105D/13		Takhini Assemblage, marble	barren		Orchard, 1993c
	C-108233 92CH 19-1	105D/13		Takhini Assemblage, marble	barren		Orchard, 1993c
	95CH 10-1	105D/14	488700 6735600	Lewes River Group 1.15 km NE of Fire Tower at Heackel Hill	barren		
	C-203093 94CH 59-1	105D/14	488350 6748500	0.5 km N of Pilot Mountain subdivision	ichthyoliths	indeterminate	Orchard, 1995b
	C-203076 93CH 1-1	105D/14	489950 6752900	Lewes River Group W of Klondyke Highway near Rodeo Grounds	barren		Orchard, 1995b
	C-202974 95CH 13-4	105D/15	502250 6755000	Lewes River Group 5.2 km W of Mount Slim @ 3585'	ichthyoliths	indeterminate	Orchard, 1997
	C-202975 95CH 13-5	105D/15	503650 6755500	Lewes River Group 3.8 km W of Mount Slim @ 4700'	foraminifers	indeterminate	Orchard, 1997
	C-202977 95CH 14-5	105D/15	515355 6752200	Joe Mountain Formation chert clasts, 3.6 km S of Joe Mountain @ 5900'	barren		Orchard, 1997

APPENDIX 2b (Cont'd)

Map No.	Sample Numbers	NTS	UTM Zone 8	Unit Location	Fossils	Epoch,Stage CAI	Reference
	C-203065 93CH 33-5	105D/15	516700 6753350	Joe Mountain Formation 2.4 km SSE of Joe Mountain	barren		Orchard, 1994
	C-203066 93CH 56-C	105D/15	506900 6749175	Lewes River Group 2.4 km SSE of Joe Mountain 5.9 km SSW of Mount Slim @ 4500'	barren		Orchard, 1994
	C-203067 J93 26-9	105D/15	518100 6752050	Joe Mountain Formation 4 km SE of Joe Mountain	barren		Orchard, 1994
	C-203054 93CH 14-1	105D/15	517250 6747900	Joe Mountain Formation 1.2 km NW of Peak 6241'	barren		Orchard, 1994
	C-303002 95CH 31-1	105D/16	535500 6755300	Casca Member 2.3 km N of Mount Byng @ 1800 m	barren		
	C-202986 95 JTi 95	105D/16	537450 6753650	Casca Member 1.5 km NE of Mount Byng @ 1420 m	barren		Orchard, 1997
	94CH 5-1 C-203072	105D/16	540055 6760080	Lewes River Group 2.5 km W of Sheldon Creek	barren		Orchard 1995
	94 CH 5-10 C-203073	105D/16	539030 6760800	Lewes River Group 3.75 km W of Sheldon Creek	ichthyoliths	indeterminate	Orchard, 1995
	C-203077 94 CH 23-12	105D/16	539030 6745850	2 km NW of Mount M'Clintock @ 1650 m	barren		Orchard, 1995
	C-202966 94 CH 14-2	105D/16	539925 6752900	4 km E of Mount Byng	barren		Orchard, 1995
	C-20307994 CH 36-3	105D/16	537250 6751900	2 km SE of Mount Byng @ 1700'	barren		Orchard, 1995
	C-203094 94CH 14-5	105D/16	541250 6752875	200 m E of Peak 1851 m. Sheldon Creek elev. 1840 m., chert clasts	barren		
	C-202978 95JTI-45	105D/15	506450 6761000	6 km N of Mount Slim @ 3650'	foraminifers, echinoderms	indeterminate	Orchard, 1997
	C203070 93JH 4-5	105D/16	541010 6758065	north M'Clintock Lakes @ 4420'	barren		Orchard, 1995
	C-202979 95JTI-48	105D/15	508000 6761200	6.2 km N of Mount Slim @ 4550'	barren		Orchard, 1997
	C-202976 95CH 10-1	105D/14	488700 6735600	1.15 km NE of Haeckel Hill fire tower @ 3900'	barren		Orchard, 1997
	C-202977 95CH 14-5	105D/15	515355 6752200	3.6 km S of Joe Mountain @ 5900'	barren		Orchard, 1997

APPENDIX 3. Compilation of Jurassic macrofossil identification and localities from the study area. Identifications are by H.W. Tipper (GSC, Vancouver) and J. Pálfy (UBC).

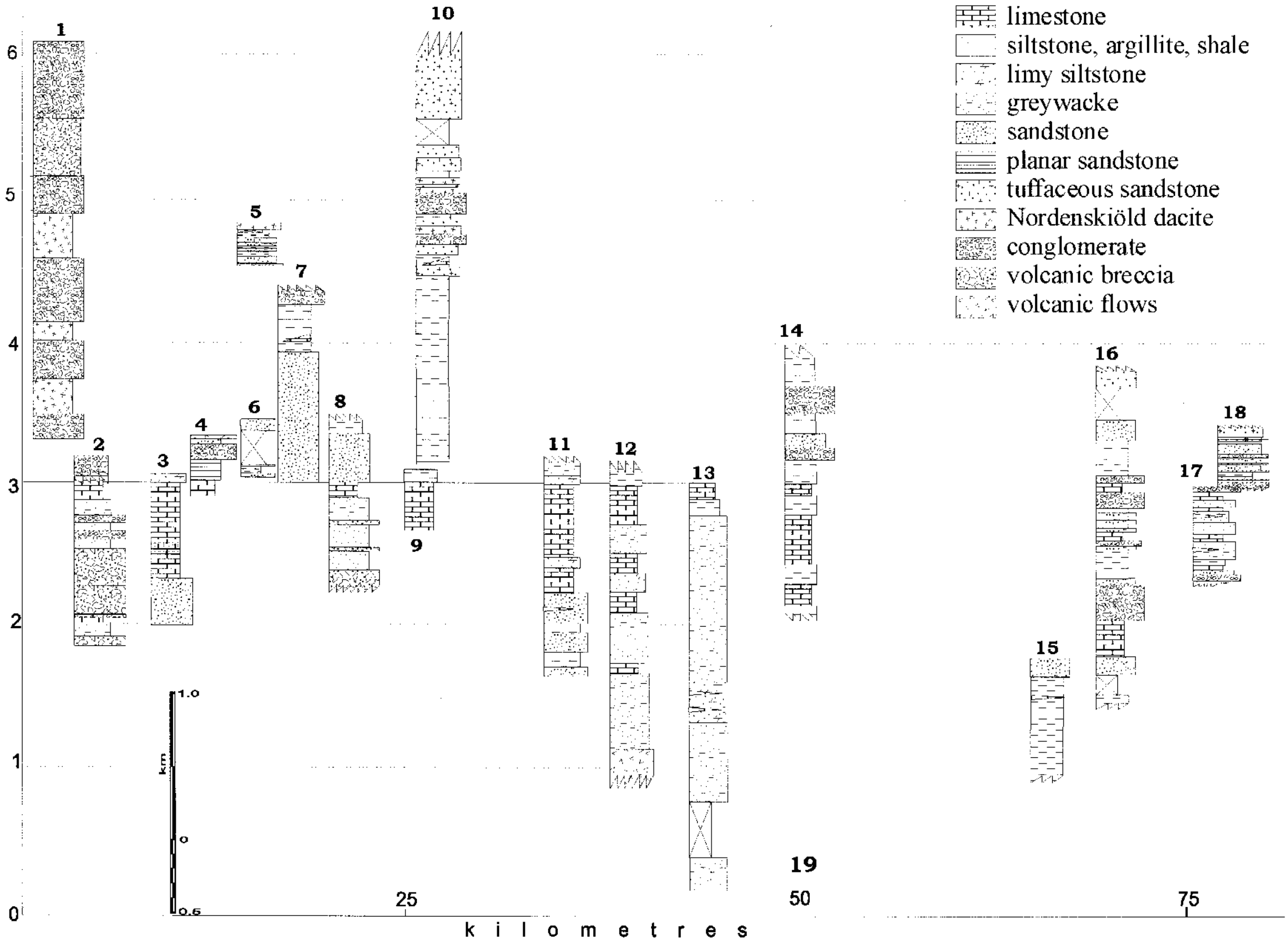
Map No.	Sample Numbers	NTS	UTM Zone 8	Locality	Fossils	Zone/Assemblage Stage	Reference/Note
J1	13084 F5, JOW50	105D/13	471700 6761000	Miners Range, 5.5 km NE of Peak 4838'	*Stephanoceras* sp. *Chondroceras* sp.	Kirschneri or Oblatum Lower Bajocian	Pálfy and Tipper, 1995
J2	C-210914	105D/14	483380 6757520	Miners Range, 5.4 km SE of Flat Mountain, M2	*Leptaleoceras* aff. *accuratum* (FUCINI) *Lioceratoides* (*Lioceratoides*) sp. *Protogrammoceras* ex gr. *kurrianum* (OPPEL)	Kunae or Carlottense Upper Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995
J2	C-210912	105D/14	483300 6757400	Miners Range, 5.5 km SE of Flat Mountain, M3	Arieticeratinae gen. et sp. indet. *Amaltheus* sp. *Lioceratoides* (*Lioceratoides*) cf. *grecoi* (FUCINI) *Lioceratoides* (*Lioceratoides*) sp. *Protogrammoceras* sp.	Carlottense Upper Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995
J2	C-108248 93CH 8-2	105D/14	483250 6757500	Miners Range, 5.6 km SE of Flat Mountain	*Lioceratoides (Paciferas) propinquum* (WHITEAVES) *Lioceratoides (Lioceratoides)* sp. *Arieticeras* sp. *Protogrammoceras paltum* (BUCKMAN) *Posidonotis semiplicata* (HYATT)	Carlottense Upper Pliensbachian	Tipper, 1994
J2	C-210911	105D/14	483270 6757310	Miners Range, 5.5 km SE of Flat Mountain, M4	*Canavaria*? sp. indet. *Lioceratoides* (*Lioceratoides*) cf. *allifordense* (MCLEARN) *Lioceratoides* (*Paciferas*) *propinquum* (WHITEAVES) *Protogrammoceras* ex gr. *paltum* (BUCKMAN) *Protogrammoceras* ex gr. *kurrianum* (OPPEL) *Posidonotis semiplicata* (HYATT)	Carlottense Upper Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995
J3	C-210910 C-108249 93CH 8-3	105D/14	483390 6757000	Miners Range, 6.1 km SE of Flat Mountain, M5	*Juraphyllites*? sp. *Fontanelliceras* cf. *fontanellense* (GEMMELLARO) *Canavaria*? sp. indet. *Lioceratoides* (*Lioceratoides*) cf. *allifordense* (MCLEARN) *Lioceratoides* (*Lioceratoides*) sp. *Lioceratoides* (*Paciferas*) *propinquum* (WHITEAVES) *Protogrammoceras* ex gr. *paltum* (BUCKMAN)	Carlottense Upper Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995 Tipper, 1994
J4	C-108250 93CH 8-4*	105D/14	488050 6753500	Miners Range, 6.6 km SE of Flat Mountain	*Lioceratoides (Paciferas) propinquum* (WHITEAVES), *Protgrammoceras* sp.? *Arieticeras algovianum*? (OPPEL)	Carlottense uppermost Pliensbachian	Tipper, 1994
J5	13093 F15, JOW41	105D/14	483800 6756100	Miners Range, 7.1 km SE of Flat Mountain	*Lioceratoides* spp. *Arieticeras* aff. *algovianum* (OPPEL) *Arieticeras* and/or *Leptaleoceras* spp. aptychi	Carlottense Upper Pliensbachian	Pálfy and Tipper, 1995
J6	13083 F6, JOW39	105D/14	484300 6758300	Miners Range, 5.5 km SE of Flat Mountain	*Amaltheus* cf. *stokesi* (SOWERBY) hildoceratid indet. ammonite indet.	Kunae Upper Pliensbachian	Pálfy and Tipper, 1995
J7	13085 F7, JOW40	105D/14	482200 6757550	Miners Range, 5.0 km SE of Flat Mountain	*Fanninoceras* sp. *Arieticeras* and/or *Leptaleoceras* spp. hildoceratid indet.	Upper Pliensbachian	Pálfy and Tipper, 1995

APPENDIX 3. (Cont'd)

Map No.	Sample Numbers	NTS	UTM Zone 8	Locality	Fossils	Zone/Assemblage Stage	Reference/Note
J8	C-210909	105D/14	483890 6756890	Miners Range, 6.5 km SE of Flat Mountain, M8	*Lioceratoides* (*Lioceratoides*) sp. Harpoceratinae gen. et sp. indet	Kanense Zone Lower Toarcian	Pálfy, 1995 Pálfy and Hart, 1995
J8	C-210908	105D/14	483885 6756890	Miners Range 6.5 km SE of Flat Mountain, M7	*Lioceratoides* (*Lioceratoides*) cf. *allifordense* (MCLEARN) *Lioceratoides* (*Lioceratoides*) sp. *Lioceratoides* (*Paciferas*) *propinquum* (WHITEAVES) *Dactylioceras* ex gr. *simplex* (FUCINI)	lower Kanense lowermost Toarcian	Pálfy 1995 Pálfy and Hart, 1995
J9	C-210906	105D/14	483850 6756800	Miners Range 6.5 km SE of Flat Mountain, M9	*Lioceratoides* sp. *Protogrammoceras* ex gr. *paltum* (BUCKMAN) *Dactyloceras* ex gr. *simplex* (FUCINI)	upper Carlottense to lower Kanense uppermost Pliensbachian to lowermost Toarcian	Pálfy, 1995 Pálfy and Hart, 1995
J9	C-210907	105D/14	483880 6756890	Miners Range 6.5 km SE of Flat Mountain, M6	*Lioceratoides* spp.	upper Carlottense uppermost Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995
J10	93CH 10-2	105D/14	485400 6758100	6.7 km SE of Flat Mtn	ammonites indet.		
J11	C-210913 C-108244 92CH T-36	105D/14	482540 6758180	Miners Range 4.6 km SE of Flat Mountain, 5200', M1	*Metaderoceras* aff. *mouterdei* (FREBOLD) *Gemmellaroceras* sp. *Weyla* sp. other bivalves	upper Whiteavesi to lower Freboldi Lower Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995 Tipper, 1994
J12	C-202983 95JT 105 13095 F16, JOW42	105D/14	4872500 676060	7.2 km N of communication tower	*Metaderoceras* cf. *talkeetnaense* (THOMSON AND SMITH) *Tropidoceras*? sp. *Reynesocoeloceras* sp.	Whiteavesi or Freboldi Lower Pliensbachian	Pálfy and Tipper, 1995
J13	13100 F13, JOW32	105D/14	486650 6750500	4.6 km SSW of communication tower	*Protogrammoceras* ex gr. *kurrianum* (OPPEL) *Lioceratoides* spp.	Carlottense or Kanense? Upper Pliensbachian or Lower Toarcian?	Pálfy and Tipper, 1995
J14	13101 F14, JOW 47	105D/14	487000 6750600	4.0 km SSW of communcation tower	*Aveyroniceras* sp. *Reynesoceras*? sp. hildoceratid indet.	Kunae Upper Pliensbachian	Pálfy and Tipper, 1995
J15	C-210902 C-203053 J93 16-1	105D/14	487700 6753595	250 m W of communication tower, on road, T2	*Arieticeras* sp. *Posidonotis semiplicata* (HYATT)	Kunae Upper Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995 Tipper, 1994
J16	C-210904 C-203068 93CH 20-1	105D/14	488020 6753520	about 50 m N of communication tower, T1	*Arieticeras* sp. *Phylloceras* sp. *Fieldingiceras*? sp. bivalve and gastropod coquina	Kunae? Upper Pliensbachian?	Pálfy, 1995 Pálfy and Hart, 1995 Tipper, 1994
J17	C-108242 92CH 52-2	105D/14	488350 6753800	0.5 km NE of communication tower @ 3400'	*Gemmellaroceras aenigmaticum* (GEMMELLARO), *Dubariceras silviesi*? (HERTLEIN), *Acanthopleuroceras* sp.?	Whiteavesi mid-Lower Pliensbachian?	Tipper, 1994

APPENDIX 3. (Cont'd)

Map No.	Sample Numbers	NTS	UTM Zone 8	Locality	Fossils	Zone/Assemblage Stage	Reference/Note
J18	no collection	105D/14	487400 6753800	600 m W of communication tower	*Amaltheus* cf. *stokesi* (SOWERBY)	Kunae Upper Pliensbachian	
J19	C-210903	105D/14	487620 6753595	300 m W of communication tower, on N side of road, T3	*Amaltheus* cf. *stokesi* (SOWERBY) *Reynesoceras*? sp. indet	Kunae Upper Pliensbachian	Pálfy, 1995 Pálfy and Hart, 1995
J20	C-210901 C-108238 92CH 51-1	105D/14	490670 6760410	N side of Horse Creek road, H1	*Epophioceras*? sp.	Varians? Upper Sinemurian	Pálfy, 1995 Pálfy and Har, 1995 Tipper, 1994
J21	13090 F11	105D/14	483150 6752600	4.2 km NE of Takhini Hotsprings	ammonites indet. bivalve indet.	indeterminate	Pálfy and Tipper, 1995 some similarities with collection J16
J22	13094 F9, JOW23	105D/14	482800 6751750	3.4 km NE of Takhini Hotsprings	ammonite indet., some resemblance to *Arnioceras* or *Arieticeras* coleoid indet. bivalve indet.	Sinemurian? or Pliensbachian?	Pálfy and Tipper, 1995
J23	13091 F8	105D/14	483200 6751700	3.6 km NE of Takhini Hotsprings	*Fanninoceras* sp. hildoceratid indet.	Upper Pliensbachian	Pálfy and Tipper, 1995
J24	C-202984 95JT 110	105D/14	482700 6749175	Laberge Group, 2.0 km E of Hotsprings	*Arnioceras miserabile* (QUENSTEDT) *Arnioceras* ex gr. *ceratitoides* (QUENSTEDT) *Arnioceras* sp.	Arnouldi or Varians? Lower or Upper Sinemurian?	Pálfy and Tipper, 1995
J25	C-210111 C-210113	105D/16	547675 6746900	3.5 km W of Mount M'Clintock	ammonites, poorly preserved schlotheimid?	Hettangian- Sinemurian	Jakobs, 1994
J26	C-210112	105D/16	547050 6747325	3.5 km W of Mount M'Clintock	bivalves indet.		Jakobs, 1994
J27		105D/16	550900 6749650	5 km N of Mount M'Clintock	JOW locality		Wheeler, 1961



Appendix 4. Stratigraphic sections, and their locations, used to construct Figure 22.

Section	Locality	Reference
1	King Lake to Alaska Hwy. km 1505	Hart unpublished, from map; see also Morrison, 1981, p. 56; Dickie, 1989; Dickie and Hein, 1995; Hart et al., 1995
2	Ibex River, east wall near juction with Jackson Creek	Hart unpublished; see also Morrison, 1981, p. 57; Wheeler, 1961, p. 37
3	Jackson Creek, north wall	Morrison, 1981, p. 57
4	Northwest of Takhini Hotsprings	Dickie, 1989, p. 318-323
5	Northeast of Takhini Hotsprings	Dickie, 1989, p. 318-323
6	Alaska Highway	Dickie, 1989, p. 324, Dickie and Hein, 1995
7	Hotsprings road	Morrison, 1981, p. 58; Dickie 1989, p. 324
8	Haeckel Hill	Hart unpublished, from map
9	Rabbitsfoot Canyon,	Hart unpublished
10	Comunication tower	Hart unpublished, from map
11	Hill 3878', south of map area	Morrison 1981, p. 58
12	Manoir Butte, north of map area	composite section compiled from Tozer, 1958
13	Hill 6010', north of map area	Wheeler, 1961, p. 42
14	East of Cap Creek	Hart unpublished, from map
15	Upper Sheldon Creek	Hart unpublished
16	Lower Sheldon Creek	Hart unpublished, from map
17	Peak 1679 m	Wheeler, 1961, p. 44
18	Northeast of Mt. Augusta	Hart unpublished
a	Miners Range	Pálfy and Hart, 1995
b	South of Horse Creek	Dickie, 1989, p. 344-346, Hart et al., 1995
c	South limb of Takhini Syncline	Wheeler, 1961, p. 54
d	East of upper Cap Creek, Joe Mountain Formation	Hart, this report
e	3.8 km WSW of Mount M'Clintock	Jakobs, 1994 and unpublished

Note: letters represent sections not used in the construction of Figure 22.

Appendix 5. U-Pb zircon analytical data.

Fraction	Wt. mg	U ppm	Pb[1] ppm	206Pb/204Pb	Pb[2] pg	208Pb %	206Pb/238U	207Pb/235U	Corr. Coeff	207Pb/206Pb	207/206 Age Ma
94CH 60-4 Cobble from Lewes River Group (105D/16)											
A	0.142	241	10	3668	23	15.2	0.04078 ±.08%	0.2901 ±.12%	.7518	0.05161 ±.08%	268.0 +3.5/-3.5
C	0.073	124	5	1333	17	15.4	0.04091 ±.12%	0.2922 ±.21%	.6608	0.05180 ±.16%	276.5 +7.3/-7.3
D	0.096	259	10	1589	35	12.8	0.03568 ±.10%	0.2507 ±.16%	.7086	0.05096 ±.12%	239.2 +5.4/-5.4
92CH-80-1 Felsic Metavolcanic in Stikine Assemblage (105D/13)											
B	0.051	412	21	980	64	10.1	0.05122 ±.16%	0.3732 ±.41%	.6449	0.05284 ±.33%	321.8 +14.9/-15.1
C	0.052	374	19	566	114	10.7	0.05136 ±.20%	0.3744 ±.38%	.6802	0.05286 ±.29%	322.6 +13.0/-13.1
92CH-75-8 Little River Batholith (105D/13)											
A	0.153	328	9	2383	39	7.3	0.02950 ±.10%	0.2056 ±.24%	.8704	0.05055 ±.16%	220.3 +7.3/-7.3
B	0.241	379	12	6565	27	8.5	0.03072 ±.09%	0.2156 ±.19%	.9605	0.05090 ±.10%	236.5 +4.7/-4.7
C	0.148	447	13	5090	24	7.6	0.02912 ±.14%	0.2006 ±.22%	.8919	0.04996 ±.12%	193.2 +5.5/-5.5
92CH-85-1 Nordenskiöld Tuff (105D/14)											
A	0.152	367	12	3296	34	12.8	0.03245 ±.21%	0.2257 ±.20%	.8403	0.05045 ±.12%	215.8 +5.4/-5.4
C	0.205	385	12	2676	53	13.3	0.02870 ±.10%	0.1970 ±.24%	.8539	0.04976 ±.16%	184.0 +7.5/-7.5
B	0.214	326	10	3937	33	12.6	0.02993 ±.13%	0.2085 ±.22%	.8999	0.05053 ±.12%	219.3 +5.4/-5.4
E	0.089	376	11	1415	43	13.8	0.02877 ±.10%	0.1975 ±.32%	.7316	0.04978 ±.26%	184.6 +12.0/-12.0
D	0.106	410	12	2158	36	13.2	0.02858 ±.12%	0.1961 ±.15%	.5911	0.04977 ±.13%	184.1 +5.9/-5.9
94CH-60-7 Mount M'Clintock hornblende biotite granodiorite (105D/16)											
A	0.234	327	7	368	256	15.7	0.01871 ±.14%	0.1249 ±.70%	.6563	0.04842 ±.61%	119.6 +28.7/-29.2
B	0.167	493	10	553	179	17.4	0.01864 ±.13%	0.1244 ±.56%	.6334	0.04841 ±.49%	119.5 +22.9/-23.2
C	0.142	371	7	788	80	16.4	0.01869 ±.11%	0.1248 ±.40%	.7342	0.04842 ±.33%	119.9 +15.4/-15.5
94CH-16-8 M'Clintock Lakes biotite granite (105D/15)											
A	0.068	922	17	1134	64	12.8	0.01810 ±.11%	0.1206 ±.22%	.6191	0.04833 ±.18%	115.4 +8.5/-8.5
B	0.084	1963	36	468	418	11.0	0.01801 ±.09%	0.1200 ±.51%	.4887	0.04833 ±.48%	115.7 +22.4/-22.7
C	0.045	1553	30	112	851	13.3	0.01836 ±.39%	0.1310 ±1.3%	.7003	0.05172 ±1.1%	273.2 +49.2/-50.7
93CH-53-3 Cap Mountain Pluton (105D/15)											
A	0.201	301	6	2228	30	15.6	0.01750 ±.11%	0.1167 ±.27%	.7875	0.04838 ±.19%	118.1 +8.9/-8.9
B	0.113	309	6	1589	24	17.7	0.01736 ±.13%	0.1155 ±.32%	.6632	0.04825 ±.26%	111.4 +12.2/-12.2
C	0.255	444	8	1549	80	17.7	0.01729 ±.14%	0.1150 ±.33%	.6779	0.04823 ±.26%	110.8 +12.1/-12.2
93CH-51-1 Cap Creek Pluton (105D/15)											
A	0.227	505	9	1437	85	16.9	0.01670 ±.10%	0.1109 ±.26%	.8932	0.04816 ±.18%	107.1 +8.4/-8.5
C	0.071	717	13	1137	48	13.8	0.01684 ±.11%	0.1118 ±.23%	.5780	0.04818 ±.19%	107.9 +9.0/-9.1
D	0.192	741	14	1093	140	17.6	0.01677 ±.11%	0.1114 ±.33%	.4408	0.04818 ±.30%	108.2 +14.1/-14.2

Appendix 5 (Cont'd)

Fraction	Wt. mg	U ppm	Pb[1] ppm	206Pb/204Pb	Pb[2] pg	208Pb %	206Pb/238U	207Pb/235U	Corr. Coeff.	207Pb/206Pb	207/206 Age Ma
94CH-31-1 Byng Creek Volcanic Complex (105D/16)											
A	0.064	492	7	596	43	17.7	0.01242 ±.79%	0.0826 ±.88%	.9300	0.04823 ±.33%	110.6 +15.4/-15.5
94CH-60-5 Byng Creek Volcanic Complex (105D/16)											
A	0.195	831	15	4528	40	13.4	0.01770 ±.08%	0.1179 ±.09%	.8376	0.04829 ±.05%	113.5 +2.3/-2.3
B	0.196	353	5	346	174	15.7	0.01300 ±.17%	0.0858 ±.50%	.6864	0.04789 ±.41%	93.7 +19.2/-19.4
94CH-52-1 Open Creek Volcanics (105C/13)											
A	0.139	3192	47	3541	90	27.2	0.01189 ±.22%	0.0782 ±.30%	.8762	0.04772 ±.15%	85.5 +7.2/-7.3
B	0.077	3397	54	3634	52	33.4	0.01177 ±.19%	0.0771 ±.27%	.8853	0.04755 ±.14%	77.1 +6.5/-6.5
C	0.131	2744	43	4658	57	29.6	0.01222 ±.13%	0.0802 ±.23%	.8732	0.04758 ±.13%	78.6 +6.1/-6.1
94CH-58-4 Flat Creek Pluton (105D/14)											
A	0.130	396	3	364	78	9.1	0.00835 ±.15%	0.0542 ±.65%	.7210	0.04709 ±.56%	53.6 +26.3/-26.7
B	0.130	546	4	297	134	9.3	0.00827 ±.31%	0.0537 ±.63%	.6928	0.04708 ±.47%	53.1 +22.3/-22.7
C	0.135	635	5	593	77	9.6	0.00825 ±.09%	0.0536 ±.35%	.4476	0.04708 ±.32%	53.2 +15.3/-15.5

Notes. All analyses are by Jim Mortensen at the Geochronology Lab of The University of British Columbia.
Errors are ±1 std. error of mean in % except 207/206 age errors, which are ±2 std. errors in million years (Ma).

1 Radiogenic Pb.

2 Total Common Pb in analysis.

Appendix 6. K-Ar data and dates.

Sample	Unit	Material Analyzed	K (%)[a]	^{40}Ar [b] cc/gm	^{40}Ar (%)	Date $\pm 2\sigma$[c] (Ma)	Comment
93CH 52-2	Joe Mountain Fm.	wr	2.28	4.659	77.8	51.8 ± 1.6	reset
93CH 55J	Joe Mountain Fm.	hb	0.108	0.3285	40.8	76.6 ± 2.6	reset
93CH T-22	Joe Mountain Fm.	wr	0.233	0.6944	59.2	75.1 ± 2.5	reset
92CH 85-1	Nordenskiöld dacite	hb	0.726	5.341	87.3	180 ± 5	185 Ma by U-Pb
93CH 53-3	Cap Creek pluton	bi	5.23	21.940	90.7	105 ± 3	111 Ma by U-Pb
94CH 60-6	Byng Creek volcanics	wr	2.535	10.136	57.6	100 ± 2	113 Ma by U-Pb
92CH 80-2	rhyolite dyke	wr	3.77	8.330	92.1	56.0 ± 1.4	same as Annie Ned pluton
92CH 80-3	andesite dyke	wr	2.43	4.996	91.4	52.1 ± 1.3	cuts Annie Ned pluton
93CH T-11	Ta'an plug	bi	4.23	8.436	78.2	50.6 ± 1.4	younger than expected

NOTES: K analyses are by J. Gabites and D. Runkle, and Ar analyses are by J. Harakal, Geochronometry Laboratory, The University of British Columbia. Sample locations are given in Appendix 7.

[a] Potassium was determined in duplicate by atomic absorption using a Techtron AA4 spectrophotometer on dilute sulphate solutions buffered by Na and Li nitrates. K (%) is average of at least two determinations.

[b] Argon was determined by isotope dilution using an AEI MS-10 mass spectrometer with Carey Model 10 vibrating reed electrometer, high purity ^{38}Ar spike, and conventional gas extraction and purification procedures as described by White et al. (1967).

[c] The errors reported, based on multiple analyses for K, are estimated at two standard deviations as related to the calculated date. IUGS conventional decay constants (Steiger and Jäger, 1977) are $^{40}K/b = 4.962 \times 10^{-10} a^{-1}$, $^{40}K/e = 0.581 \times 10^{-10} a^{-1}$, and $^{40}K/K = 0.0001167$ atom ratio.

Appendix 7. Compilation of isotopic age dates from the study area. Data are in Appendices 5 and 6. Only significant dates are plotted on the 1:50 000 maps.

SAMPLE	UNIT	NTS sheet	LATITUDE	LONGITUDE	LOCALITY	ROCK TYPE	METHOD/ MATERIAL	DATE Ma±2σ	REFERENCE/NOTE
Takhini assemblage									
92CH 80-1	Takhini assemblage	105D/13	60°49.2'	135°43.6'	3.9 km S of Takhini R. bridge	felsic metavolcanic	U-Pb zr	322.9±1.2	
Joe Mountain volcanic complex									
93CH 52-2	JMVC	105D/15	60°51.8'	134°40.2'	2.0 km S of Peak 6241', E of Cap Creek	fs porphyritic andesite flow	K-Ar wr	51.8±1.6	reset
93CH 55J	JMVC	105D/15	60°59.7'	134°32.9'	Peak 5181', W of N M'Clintock Lake	basaltic andesite flow	K-Ar hb	76.6±2.6	reset
Y89-18-4	JMVC	105D/16	60°55.6'	134°20.7'	Mount Byng area	andesite flow	K-Ar wr	143±5	Bremner, 1991
Y89-18-4	JMVC	105D/16	60°55.6'	134°20.7'	Mount Byng area	andesite flow	Rb-Sr wr	252±10	Bremner, 1991; model age
Y89-18-2	JMVC	105D/16	60°56.5'	134°22.9'	Mount Byng area	cg px gabbro pluton	K-Ar wr	168±6	Bremner, 1991
93CH T22	JMVC	105E/3	61°02.6'	134°35.0'	Teslin Mountain	andesite flow	K-Ar wr	75.1±2.5	reset
Lewes River Group									
94CH 60-4 95CH 31-7	Sheldon Member	105D/16	60°57.4'	134°17.5'	2.2 km E of Peak 1851 m, Sheldon Creek area	dacite ppy clast	U-Pb zr	270±6	poorly constrained
					STIKINE EPOCH				
Laberge Group									
Y88-1A	Conglomerate fm.	105D/14	60°51.2'	135°25.9'	Alaska Highway, km 1505	granitic clast	U-Pb zr	208+10/-3	Hart et al., 1995
Y88-1E	Conglomerate fm.	105D/14	60°51.2'	135°25.9'	Alaska Highway, km 1505	granitic clast	U-Pb zr	215.3±3.3	Hart et al., 1995
Y88-2A	Conglomerate fm.	105D/14	60°518.5'	135°11.0'	Klondyke Highway @ Horse Creek	granitic clast	U-Pb zr	209.5±8	Hart et al., 1995
Y88-2B	Conglomerate fm.	105D/14	60°518.5'	135°11.0'	Klondyke Highway @ Horse Creek	granitic clast	U-Pb zr	210+6/-3	Hart et al., 1995
WHA 11	Conglomerate fm.	105D/14	60°51.2'	135°25.9'	Alaska Highway, km 1505	granitic clast	K-Ar hb	144±5	Hart et al., 1995

Appendix 7 (Cont'd)

SAMPLE	UNIT	NTS sheet	LATITUDE	LONGITUDE	LOCALITY	ROCK TYPE	METHOD/ MATERIAL	DATE Ma±2σ	REFERENCE/NOTE
Laberge Group (Cont'd)									
YT-2	Conglomerate fm.	105D/14	60°51'	135°28'	3 km S of Takhini Crossing	aphyric andesite clast	FT ap	62.7±8.5	Dickie et al., 1992
YT-3	Conglomerate fm.	105D/14	60°53.5'	135°23'	NW of Takhini Hotsprings	granite clast	FT ap	61.8±12.1	Dickie et al., 1992
YT-4	Conglomerate fm.	105D/14	60°53.5'	135°22'	NW of Takhini Hotsprings	volcanogenic sandstone	FT ap	67.7±6.9	Dickie et al., 1992
YT-5	Conglomerate fm.	105D/14	60°52.5'	135°15'	N of Pilot Mountain subdivision	hb granodiorite clast	FT ap	95.8±13.9	Dickie et al., 1992
YT-6	Conglomerate fm.	105D/14	60°53'	135°13'	N of Pilot Mountain subdivision	augite ppy clast	FT ap	113±10	Dickie et al., 1992
					AISHIHIK EPOCH				
92CH 85-1	Nordenskiöld	105D/14	60°55.0'	135°13.2'	Upper Laberge communication tower	crystal dacite tuff	U-Pb zr	184.1+4.2/ -1.6	
92CH 85-1	Nordenskiöld	105D/14	60°55.0'	135°13.2'	Upper Laberge communication tower	crystal dacite tuff	K-Ar hb	180±5	
YT-1	Nordenskiöld	105D/14	60°49'	135°28'	King Lake, 5 km S of Takhini Crossing	andesite tuff	FT ap	63.6±6.6	Dickie et al., 1992
Long Lake Plutonic Suite									
92CH 75-8	Little River batholith	105D/13	60°56.2'	135°48.5'	9 km N of Takhini River Bridge	ksp megacrystic qz monzonite	U-Pb zr	183±2	
					WHITEHORSE EPOCH				
Teslin Plutonic Suite									
94CH 16-8	M'Clintock Lakes pluton	105D/16	60°53.3'	135°17.8'	3.5 km SE of Mount Byng	cg bi granite	U-Pb zr	115.5±1	
94CH 60-7	Mount M'Clintock pluton	105D/16	60°55.0'	135°13.2'	4.8 km SE of Mount M'Clintock	hb-bi granodiorite	U-Pb zr	119.5±1	
Y89-18-1	felsite	105D/16	60°56.0'	134°22.5'	3.1 km NW of Mount Byng	felsite plug	K-Ar hb	121±5	Bremner, 1991
GSC 81-44	M'Clintock River pluton	105E/2	61°01.5'	134°41.4'	6 km SE of Mount Laurier	cg bi granite	K-Ar bi	118±3	Stevens et al., 1982

Appendix 7 (Cont'd)

SAMPLE	UNIT	NTS sheet	LATITUDE	LONGITUDE	LOCALITY	ROCK TYPE	METHOD/ MATERIAL	DATE Ma±2σ	REFERENCE/NOTE
Whitehorse Plutonic Suite									
93CH 53-3	Cap Creek pluton	105D/15	60°53.0	134°49.0'	2.5 km N of Peak 5852', W of Cap Creek	cg hb-bi gd	U-Pb zr	111±1	
WHA 2	Cap Creek pluton	105D/15	60°48.7'	134°47.5'	2.2 km NE of Peak 5925', W of Cap Creek	granodiorite	K-Ar hb	92.1±3.8	Morrison et al., 1979
WHA 2	Cap Creek pluton	105D/15	60°48.7'	134°47.5'	2.2 km NE of Peak 5925', W of Cap Creek	granodiorite	Rb-Sr wr n=3	92±48	Morrison et al., 1979
McIntyre Plutonic Suite									
93CH 51-1	Cap Mountain pluton	105D/15	60°48.0'	135°49.0'	Peak 5925', E of Laberge Creek	cg bi>hb qz monzonite	U-Pb zr	107.6±1	
94CH 31-1	Byng Creek pluton	105D/16	60°57.4'	135°21.5'	4.4 km SSW of Mount Byng	pink qz monzonite	U-Pb zr	111±15	one zircon fraction
WHA 3A	Cap Mountain pluton	105D/15	60°48.0'	134°47.5'	5.5 km NW of Cap. Mountain	pink qz monzonite	K-Ar bi	98.6±3.4	Morrison et al., 1979
WHA 3A	Cap Mountain pluton	105D/15	60°48.0'	134°47.5'	5.5 km NW of Cap. Mountain	pink qz monzonite	Rb-Sr wr n=3	92±5	Morrison et al., 1979
Byng Creek volcanic complex									
94CH 60-5	BCVC	105D/16	60°52.2'	134°16.5'	5.9 km SE of Mount Byng	dacite lapilli tuff	U-Pb zr	113.5+2.3/ -0.7	
Y89-18-3	BCVC	105D/16	60°56.0'	134°22.5'	3.5 km NW of Mount Byng	quartz ppy rhyolite dyke	K-Ar wr	104±4	
94CH 60-6	BCVC	105D/16	60°49.2'	134°11.8'	7.6 km WSW of Mount M'Clintock	rhyolite lapilli tuff	K-Ar wr	100±2	
C A R M A C K S E P O C H									
Open Creek volcanics									
94CH52-1	Open Creek volcanics	105E/1	60°00.5'	134°00.2'	3 km E of Baker Lake	qz-phyric dacite flow	U-Pb zr	78.3±0.2	

Appendix 7 (Cont'd)

SAMPLE	UNIT	NTS sheet	LATITUDE	LONGITUDE	LOCALITY	ROCK TYPE	METHOD/ MATERIAL	DATE Ma±2σ	REFERENCE/NOTE
					SKUKUM EPOCH				
Nisling Range Plutonic Suite									
Y88-32A	Annie Ned pluton	105D/13	60°48.4'	135°59.3'	Alaska Highway, km 1538	cg bi qz monzonite	U-Pb zr	57.1±0.2	Hart, 1995
Y88-32A, D	Annie Ned pluton	105D/13	60°48.4'	135°59.3'	Alaska Highway, km 1538	bi qz monzonite and aplite dyke	Rb-Sr wr, n=2	56.4±1.5	R.L. Armstrong unpublished
WHA 1	Annie Ned pluton	105D/13	60°50'	135°53'	Alaska Highway, km 1532	biotite granite	K-Ar bi	51.2±2.0	Morrison et al., 1979
94CH 58-4	Flat Creek pluton	105D/14	60°57.7'	135°28.2'	11.2 km NW of Takhini Hotsprings	biotite granite	U-Pb zr	53.6±0.2	
	Flat Creek pluton	105D/14	60°53'	135°33'	Flat Creek road crossing	granodiorite	K-Ar bio	227±15	Lowden, 1961 too old
Associated dykes and plugs									
92CH 80-2		105D/13	60°49.2'	135°43.6'	3.9 km SE of Takhini River bridge	rhyolite dyke	K-Ar wr	56.0±1.4	
92CH 80-3		105D/13	60°49.9'	135°42.7'	2.8 km SE of Takhini River Bridge	N-trending andesite dyke	K-Ar wr	52.1±2.6	
93CH T11	Ta'an plug	105D/14	60°58.2'	135°18.3'	4.5 km SE of Flat Mountain	fg bi-hb qz monzonite	K-Ar bi	50.6±1.4	

Abbreviations: ap = apatite; bi = biotite; fs = feldspar; hb = hornblende; ksp = potassium feldspar; qz = quartz; zr = zircon; px = pyroxene; gd = granodiorite; cg = coarse grained; ppy = porphyry; fg = fine grained; wr = whole rock; FT = fission track ; U-Pb = uranium-lead; K-Ar = potassium-argon; Rb-Sr = rubidium-strontium; **n** number refers to number of analyses used to create isochron.

Appendix 8. Whole-rock major element oxide and trace element data.

SAMPLE #	NTS	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	Cr_2O_3 %	LOI %	TOTAL %	Lab	Ba ppm	Rb ppm	Sr ppm	Y ppm	Sc ppm	Zr ppm	Nb ppm	Ta ppm	Pb ppm	Th ppm	U ppm	Ga ppm	Cu ppm	Lab
Nisling Range Plutonic Suite																													
Y88-32A	105D/13	68.60	0.34	15.10	3.57	0.12	0.80	2.49	4.18	3.72	0.13	<0.01	0.30	99.30	X	18	125	315	21		147	11		14		16	9		A
Y88-32D	105D/13	75.70	0.05	12.30	2.73	0.05	0.12	0.65	4.24	4.19	0.03	<0.01	0.00	100.10	X	xx	157	59	24		83	11		16		19	8		A
92CH 16-A	105D/13	67.70	0.40	15.60	3.55	0.08	0.97	2.76	4.53	3.53	0.15	0.04	0.15	99.46	X	1150	111	343	23		179	12	26	3	14	<2		<2	X
92CH 20-2	105D/13	72.20	0.21	14.10	2.11	0.06	0.31	1.01	4.58	4.72	0.05	0.04	0.30	99.69	X	807	142	98	36		236	19	25	19	18	3		<2	X
92CH 75-4	105D/13	74.20	0.10	12.90	1.43	0.05	0.25	0.44	4.49	4.53	0.02	0.04	0.70	99.15	X	131	169	16	42		139	22	38	19	16	<2		<2	X
92CH 28-1	105D/13	74.00	0.10	13.70	1.30	0.05	0.14	0.50	4.72	4.84	0.03	0.03	0.05	99.46	X	202	158	27	44		146	23	31	12	17	<2		<2	X
JTI95-63	105D/13	72.18	0.10	14.18	1.63	0.06	0.10	0.68	4.33	4.93	0.02	<0.01	0.61	98.82	A	335	207	44	45		128	29		26			18	< 5	A
JTI95-64A	105D/13	72.90	0.22	13.52	2.36	0.05	0.58	1.09	3.72	5.19	0.06	<0.01	0.61	100.31	A	726	187	115	31		143	20		17			15	< 5	A
JTI95-67	105D/13	72.39	0.18	12.88	2.18	0.05	0.22	0.65	3.71	5.12	0.04	<0.01	0.59	98.02	A	1068	179	102	35		236	18		19			18	< 5	A
Ta'an Plugs																													
93CH T-11	105D/14	66.80	0.43	15.60	3.65	0.10	0.86	2.20	4.54	4.17	0.14	-0.01	1.05	99.50	X														
93CH 10-1	105D/14	66.80	0.43	15.40	3.58	0.11	0.93	2.19	4.53	4.06	0.15	-0.01	1.25	99.40	X														
Carmacks Group																													
DB 12-6	105D/13	60.40	0.57	16.40	5.90	0.11	3.88	5.79	2.65	1.31	0.29	0.04	2.55	99.89	X	1163	37.3	728	16.5	16	115	4.7	0.4	92.2	4.3	2.4		14	S
92CH 33-1	105D/13	58.90	0.89	19.50	5.37	0.05	2.27	3.91	3.34	3.00	0.32	0.07	1.35	98.97	X	907	92.6	457	15.2	18	146	10.1	0.6	12.9	4.6	4.1		173	S
92 CH T-33	105D/13	58.00	0.91	16.80	7.80	0.11	2.15	6.54	2.49	2.12	0.32	0.07	0.80	98.11	X	706	68.7	464	13.6	18		7.7	0.6	10.4	3.7	1.1		25	S
Open Creek Volcanics																													
94CH 52-1	105D/16	62.69	0.71	15.72	5.43	0.10	2.89	5.28	4.21	1.96	0.29	<0.01	1.49	100.78	A	1465	62	639	18	13	194	11		17			17	19	A
Byng Creek Volcanic Complex																													
94CH60-6	105D/16	73.48	0.20	13.78	1.57	0.03	0.52	0.41	4.72	4.13	0.08	<0.01	0.10	99.00	A	1800	125	140	18	3	156	17		20			14	<5	A
94CH60-5	105D/16	72.87	0.28	13.06	2.09	0.10	0.75	2.45	3.70	3.49	0.08	<0.01	2.10	100.96	A	1824	112	200	21	4	148	17		22			15	10	A
J9433-2	105D/16	76.37	0.09	13.39	0.82	0.01	0.42	0.19	1.92	6.90	0.01	<0.01	0.79	100.91	A	3691	179	105	23	3	70	17		21			12	<5	A
94CH29-2A	105D/16	75.50	0.16	12.80	1.34	0.06	0.16	0.61	4.15	4.18	0.04	<0.01	0.10	99.10	A	1181	141	51	29	3	171	20		26			16	8	A
94CH30-3	105D/16	66.64	0.48	15.39	3.97	0.09	1.85	3.34	4.22	2.75	0.17	<0.01	0.79	99.70	A	1563	81	456	20	9	145	13		24			18	<5	A
94CH31-2A	105D/16	74.78	0.22	13.25	1.62	0.07	0.75	1.16	3.13	4.05	0.06	<0.01	1.60	100.69	A	1699	138	148	20	3	150	18		40			14	<5	A
89-18-3	105D/16	71.83	0.20	12.50	6.49	0.08	0.59	1.47	3.61	3.22	0.08	0.02	0.23	100.31	A	1651	94	209	11	2	108	11		17			13	35	A
Mount McIntrye Plutonic Suite																													
93CH51-1	105D/15	70.44	0.31	14.21	2.32	0.05	0.78	1.72	4.32	3.47	0.09	<0.01	0.73	98.43	A	1189	120	195	17	4	166	17		17			16	<5	A
93CH12-3	105D/15	73.06	0.24	12.72	1.72	0.04	0.66	0.91	3.86	4.05	0.07	<0.01	0.45	97.78	A	982	163	81	20	3	129	21		25			14	6	A
93CH4-2	105D/15	71.13	0.28	13.69	1.98	0.04	0.77	1.23	3.98	3.79	0.08	<0.01	0.74	97.72	A	1282	123	181	15	3	137	14		23			16	<5	A
J93-33-3	105D/15	71.80	0.31	14.20	2.05	0.07	0.85	1.88	4.31	3.50	0.10	<0.01	0.80	99.90	X	1494	123	215	16		157	15		22			17	<5	A
93CH 42-3	105D/15	74.10	0.19	12.60	1.29	0.05	0.39	0.81	3.99	4.53	0.05	<0.01	0.45	98.40	X	911	168	74	16		111	18		25			15	<5	A
Whitehorse Plutonic Suite																													
93CH35-2	105D/15	68.82	0.33	15.28	2.58	0.06	1.42	3.21	4.45	2.50	0.13	<0.01	0.54	99.32	A	1236	85	462	12	6	109	11		29			19	6	A
93CH42-2	105D/15	62.13	0.46	17.63	3.99	0.09	2.95	5.60	4.77	1.74	0.14	<0.01	1.09	100.58	A	918	54	419	16	10	186	10		10			18	47	A
93CH 13-3	105D/15	51.50	1.91	16.70	8.87	0.14	4.44	7.11	3.88	1.05	0.41	<0.01	2.25	98.30	X	511	37	658	14		96	10		8			18	29	A
93CH 53-3	105D/15	65.90	0.51	16.50	3.45	0.08	1.99	4.29	4.66	1.73	0.20	<0.01	0.75	100.10	X	1344	50	585	15		147	9		20			16	6	A
JTI95-74	105D/14	49.10	0.75	16.93	9.45	0.13	4.82	7.88	3.20	1.75	0.72	0.01	6.16	100.90	A	588	48	405	34		165	6		5			18	27	A
Teslin Plutonic Suite																													
93CH 55H	105D/16	68.00	0.35	15.30	2.61	0.07	1.42	3.32	4.64	2.59	0.14	<0.01	0.65	99.10	X														
J93 45-6B	105D/16	71.50	0.31	14.50	1.78	0.05	0.64	1.42	4.19	3.26	0.11	<0.01	1.35	99.10	X	1009	95	306	16		110	15		35			16	<5	A
89-18-1	105D/16	69.64	0.33	15.74	2.59	0.04	1.72	4.12	4.88	0.45	0.16	0.01	1.15	100.82	A	657	10	685	6	6	96	5		<5			18	12	A

SAMPLE #	NTS	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	Cr_2O_3 %	LOI %	TOTAL %	Lab	Ba ppm	Rb ppm	Sr ppm	Y ppm	Sc ppm	Zr ppm	Nb ppm	Ta ppm	Pb ppm	Th ppm	U ppm	Ga ppm	Cu ppm	Lab
Nordenskiöld Formation																													
92CH 39-1	105D/14	63.60	0.48	16.30	4.72	0.09	1.77	4.07	4.06	2.88	0.18	0.04	0.90	99.09	X	1210	75	735	14		143	11	19	22	14	4		<2	X
92CH 85-1	105D/14	64.50	0.44	16.10	4.23	0.09	1.86	3.39	5.02	3.12	0.17	0.05	0.90	99.87	X	1200	63	557	16		136	11	20	14	4	<2		<2	X
94CH2-8	105D/14	67.56	0.41	15.59	3.87	0.08	1.76	2.27	4.79	2.99	0.18	0.01	1.39	100.89	A	1648	57	1077	14	8	122	11		11			17	7	A
94CH34-5A	105D/14	62.41	0.60	15.22	6.80	0.09	2.40	3.07	4.37	2.51	0.22	<0.01	2.98	100.67	A	1158	63	460	14	14	148	8		17			20	19	A
94CH34-5B	105D/14	59.47	0.64	15.84	6.69	0.10	3.64	5.05	4.34	1.72	0.22	0.01	2.88	100.62	A	1155	45	587	16	17	131	7		8			19	15	A
95CH-12-5	105D/14	61.71	0.56	16.63	6.32	0.14	2.35	4.30	4.22	2.93	0.26	<0.01	1.40	100.81		1509	86	793	17		142	12		11			21	11	A
95CH-6-2	105E	60.02	0.74	15.80	7.59	0.14	4.30	4.25	2.27	3.20	0.29	<0.01	0.99	99.61		1195	131	964	24		142	14		12			19	26	A
95CH-6-2(2)	105E	59.79	0.75	15.58	7.55	0.14	4.47	4.29	2.10	3.29	0.29	<0.01	0.95	99.21		1166	133	947	23		149	13		13			20	10	A
ATLIN	104M	58.56	0.63	18.37	5.66	0.12	1.80	6.09	5.10	0.87	0.22	<0.01	2.90	100.31	A	204	27	742	19	10	128	11		10			21	<5	A
JTI95-82	105D/14	62.89	0.63	16.17	5.44	0.10	2.47	4.94	3.62	2.92	0.29	<0.01	1.30	100.78		1293	72	701	19		129	13		14			22	10	A
Little River Batholith																													
92CH 8-2	105D/13	68.20	0.25	16.10	1.89	0.04	0.80	1.96	6.53	3.20	0.09	0.04	1.00	100.10	X	2270	51	1340	6		135	8	25	14	4	<2		<2	X
92CH 44-A	105D/13	66.90	0.32	16.30	2.55	0.06	1.03	2.13	5.19	2.91	0.11	0.03	1.15	98.68	X	1280	79	952	11		117	9	30	17	<2	<2		<2	X
92CH 41-3	105D/13	66.80	0.35	14.90	3.70	0.10	2.46	3.60	3.87	2.88	0.14	0.05	1.00	99.85	X	615	71	642	12		106	9	9	18	<2	<2		<2	X
92CH 75-8	105D/13	67.40	0.32	15.10	3.09	0.10	0.85	4.87	3.82	3.43	0.15	0.03	0.80	99.96	X	889	105	718	17		115	9	13	32	12	<2		<2	X
Clasts																													
93CH 45/C	105D/15	42.60	0.36	13.60	9.18	0.18	7.03	9.95	1.97	1.91	0.05	0.07	11.50	98.40	A	1881	18	350	12		28	<2		<5			11	<2	A
95CH-31-7	105D/16	61.26	0.48	16.47	6.52	0.14	2.53	2.24	6.31	1.82	0.20	<0.01	2.86	100.83	A	616	45	721	14		143	8		7			18	< 5	
Povoas																													
94CH 34-3		49.48	0.70	13.46	11.22	0.20	7.26	10.56	2.96	1.14	0.34	0.03	2.18	99.52	A	385	25	391	15	38	50	2		<5			15	165	A
94CH 56-1	105D/14	48.55	0.81	13.80	9.09	0.16	10.73	9.64	2.03	1.80	0.37	0.13	2.69	99.80	A	623	30	411	15	35	54	3		<5			14	67	A
94CH 61-1	105D/09	49.65	0.83	16.81	9.96	0.18	4.11	10.48	3.12	1.97	0.43	<0.01	2.35	99.87	A	3922	30	1173	19	30	115	7		17			17	103	A
93CH 49-1A	105D/15	74.40	0.67	11.10	5.11	0.06	1.11	0.63	5.29	0.08	0.15	<0.01	1.40	100.00	X	93	5	93	35		93	3		9			10	17	A
93CH 49-1B	105D/15	72.80	0.69	11.30	4.27	0.06	0.97	1.92	4.53	0.63	0.15	<0.01	2.55	99.90	X	216	12	122	34		91	2		7			7	37	A
92CH 45-1	105D/13	55.50	0.82	14.00	7.14	0.12	5.21	7.69	1.95	2.93	0.49	0.06	2.50	98.41	X	1289	80	863	22		190	15		17			16	71	A
92CH 3-1	105D/13	48.10	0.57	9.52	12.20	0.21	11.40	13.10	0.99	0.25	0.18	0.08	3.10	99.70	X	34	3	345	12		37	3		5			12	27	A
13A	105D/15	50.06	0.44	15.76	10.30	0.14	7.97	6.40	5.31	0.08	0.04	0.09	4.41	100.99	A	25	< 2	287	16		56	< 2		< 5			12	75	A
95CH 13-16	105D/15	49.32	0.62	14.97	9.95	0.17	7.51	7.77	4.86	0.16	0.08	0.02	5.48	100.90	A	89	4	108	14		52	< 2		< 5			14	126	A
95CH 13-1GC	105D/15	57.76	0.43	14.28	9.89	0.09	5.26	4.39	5.62	0.36	0.04	0.13	1.86	100.10	A	85	8	124	11		47	< 2		< 5			10	7	A
Sheldon Creek Volcanics																													
94CH 14-7	105D/16	49.06	1.17	13.35	11.14	0.20	6.78	8.35	3.88	0.08	0.10	0.02	6.15	100.28	A	47	3	78	26	44	69	<2		<5			14	31	A
94CH 17-5	105D/16	47.12	1.64	12.71	11.59	0.23	6.40	9.76	3.76	0.17	0.15	<0.01	6.07	99.59	A	134	6	88	34	45	98	4		<5			11	62	A
95CH 31-3	105D/16	47.18	0.87	15.66	13.10	0.19	8.20	6.79	4.06	0.13	0.11	0.01	4.68	100.98	A	15	4	47	28		84	< 2		6			18	98	A
95CH 31-4	105D/16	46.45	1.37	14.89	14.10	0.21	6.42	6.60	4.73	0.10	0.17	<0.01	5.85	100.89	A	< 2	5	77	36		116	2		< 5			22	48	A
Joe Mountain Formation																													
95CH-14-3	105D/15	49.12	1.08	12.99	12.76	0.11	6.09	8.09	2.63	0.88	0.21	0.04	7.03	101.03	A	55	15	139	31		93	3		< 5			14	12	A
94CHT-9	105D/16	49.53	2.36	12.89	12.64	0.21	5.18	8.16	5.17	0.12	0.29	<0.01	3.01	99.57	A	13	5	92	47	39	172	5		<5			18	31	A
89-18-4	105D/16	48.87	1.07	15.79	14.17	0.17	7.19	9.25	3.96	0.29	0.11	0.05	<0.01	100.73	A	39	6	84	23	41	72	3		<5			14	99	A
93CH 46-6	105D/15	51.00	0.94	16.60	9.46	0.16	3.88	8.32	3.47	0.41	0.15	<0.01	4.70	99.10	X	185	10	344	27		95	3		<5			15	128	A
93CH 52-2	105D/15	50.80	0.84	16.50	12.60	0.22	4.43	5.50	3.73	2.41	0.13	<0.01	2.35	99.50	X	794	34	384	19		60	3		<5			16	149	A
93CH 55J	105D/15	47.20	2.06	12.80	16.50	0.19	5.27	11.00	2.97	0.12	0.20	0.01	0.20	98.50	X	101	4	260	48		147	6		17			21	161	A
93CH 55K	105D/15	49.70	0.60	16.10	7.51	0.15	7.50	13.40	2.65	0.34	0.05	0.05	0.65	98.70	X	33	5	117	16		40	2		<5			13	92	A
93CH T22	105D/15	48.10	1.61	13.60	13.70	0.21	6.37	9.41	3.75	0.29	0.18	0.02	1.25	98.50	X														
J93 26-1	105D/15	50.50	0.97	16.20	11.80	0.21	4.31	10.10	2.78	0.33	0.14	<0.01	0.95	98.30	X	138	9	265	21		68	2		<5			19	52	A
93CH 32-2	105D/15	50.00	2.15	15.50	11.50	0.23	6.35	6.28	4.76	0.11	0.29	0.02	1.75	98.90	X	70	3	102	45		160	6		<5			21	9	A

SAMPLE #	NTS	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	Cr_2O_3 %	LOI %	TOTAL %	Lab	Ba ppm	Rb ppm	Sr ppm	Y ppm	Sc ppm	Zr ppm	Nb ppm	Ta ppm	Pb ppm	Th ppm	U ppm	Ga ppm	Cu ppm	Lab
Joe Mountain Formation (cont.)																													
93CH 33-2b	105D/15	52.20	0.94	14.20	9.73	0.16	6.83	6.84	5.02	0.09	0.12	0.03	3.70	99.90	X	30	4	37	22		60	2		<5			11	65	A
95CH-14-4	105D/15	45.05	1.27	14.22	11.06	0.19	7.97	10.12	2.86	0.70	0.16	0.05	7.12	100.77	A	51	15	175	23		108	< 2		< 5			14	51	A
95CH-14-6	105D/15	46.16	1.00	16.61	14.39	0.24	5.31	6.86	4.47	0.20	0.20	<0.01	5.41	100.85	A	87	4	273	28		100	3		< 5			18	26	A
95CH-14-8	105D/15	46.52	0.72	18.11	11.99	0.20	5.44	8.30	4.20	0.41	0.17	<0.01	4.41	100.48	A	112	11	591	20		87	< 2		< 5			16	141	A
95CH-14-9	105D/15	46.32	0.59	17.57	14.43	0.24	7.27	6.80	3.43	0.17	0.18	<0.01	3.87	100.89	A	93	5	251	19		78	< 2		< 5			11	22	A
95CH-25-A	105D/16	48.14	0.16	20.47	5.14	0.10	9.29	12.90	2.16	0.15	0.01	0.06	2.21	100.78	A	20	5	160	6		32	< 2		< 5			10	105	A
95CH-25-A2	105D/16	48.97	1.07	15.12	9.37	0.10	9.35	11.85	2.12	0.20	0.14	0.06	1.70	100.04	A	31	5	203	26		92	2		< 5			13	7	A
95CH-TM	105E/02	46.73	0.71	15.76	13.33	0.21	7.92	4.89	4.02	0.21	0.05	0.02	7 03	100.87	A	50	5	196	17		54	< 2		< 5			15	121	A
94 CH-52-2B	105D/15	50.28	0.68	17.83	12.92	0.22	4.99	4.96	3.64	2.22	0.17	<0.01	2.90	100.80	A	717	33	315	20		77	< 2		< 5			15	90	A
Cache Creek Group?																													
13B	105D/16	50.38	1.85	17.31	14.05	0.09	5.54	3.30	5.71	1.56	0 22	0.02	0.87	100.89	A	45	29	243	45		142	3		< 5			22	46	A
13C	105D/16	51.56	1.20	15.18	12.37	0.22	6.14	6.26	5.42	0.34	0.27	0.02	1.61	100.57	A	78	11	209	42		150	3		9			17	40	A
95CH-31-5	105D/16	49.53	1.00	15.78	11.06	0.18	8.61	8.71	3.64	0.08	0.14	0.03	1.72	100.46	A	4	3	113	32		88	< 2		< 5			17	73	A
JTI95-100	105D/16	50.09	1.43	14 87	10.34	0.11	7.14	9.00	3.93	0.14	0.18	0.03	0.85	98.11	A	25	< 2	121	32		119	6		< 5			15	< 5	A

LABS- X=XRAL Assay Labs. of Don Mills, Ontario; A= Activation Laboratories of Ancaster, Ontario; S = University of Saskatchewan in Saskatoon. All analyses by XRF except those at S by ICP-MS.

Appendix 9. Geochemical assay data from rock and silt samples.

SAMPLE	UTM Zone 8V	DESCRIPTION	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Ba ppm	Note
	105D/13	Au by fire assay, all other elements by ICP. All analyses by International Plasma Laboratories (IPL), Vancouver										
621714	471250E 6762600N	silt sample	27	0.2	53	62	278	<5	<5	2	149	
92CH 8-4	460450E 6740000N	garnet-diopside-magnetite skarn	11	1.4	157	161	7994	7	<5	4	15	23% Fe
92CH 18-4	472150E 6740850N	milky white coxcomb quartz vein, no visible sulphides	16	<0.1	213	17	54	<5	<5	3	5	
92CH 29-2	446850E 6764450N	coarse-grained magnetite skarn with chalcopyrite and bornite	11	9.5	2.8%	24	4385	13	<5	4	<2	28% Fe
92CH 30-2	467750E 6752600N	altered andesite flow with 10% disseminated pyrite	45	0.6	57	123	337	<5	<5	2	54	
	105D/15	Au by fire assay at NAL, Whitehorse, all other analyses at IPL, Vancouver using ICP ;*repeat analysis by Bondar-Clegg, 30g FA-AA										
93CH-6-3	516625E 6736700N	sparry calcite vein, with druzy and chalcedonic quartz and limonite		0.2	59	5	67	<5	<5	3	26	
93CH-11-1	510325E 6753060N	rusty-weathering, silicified and bleached, hornfelsed mudstone, 3% fine-grained disseminated sulphides	<5	0.2	177	11	15	6	<5	3	18	
93CH-11-2	510325E 6753060N	silicified and sulphidized leucocratic granitoid with stringers and blebs of pyrite cut by late veinlets of chalcopyrite (5%)	310 *318	20.4	3.0%	17	348	6	<5	4	55	
93CH-11-3	510325E 6753060N	phyllically altered, silicified granite with sericite, chlorite and epidote, cut by quartz veinlets	9	0.5	151	10	13	5	<5	10	283	
93CH-11-4	510325E 6753060N	float boulders of pale to medium-green, mottled, silica flooded rock with quartz-calcite alteration, minor pyrite	5	0.4	31	24	53	<5	<5	3	159	
93CH-11-5	510325E 6753060N	silicified garnet-epidote-diopside skarn with cross-cutting coxscomb quartz - calcite veins with sparse chalcopyrite and arsenopyrite?	5	0.4	117	7	19	264	<5	84	8	0.2% W
93CH-11-6	510150E 6752450N	quartz vein float, massive white to rusty, altered to argillite, yellow breccia fragments of intrusive host rock	6	0.1	5	6	5	9	<5	10	5	
93CH-11-7	509850E 6751525N	rusty weathering granitoid with trace of finely disseminated pyrrhotite (<1%)	5	0.2	15	10	12	<5	<5	3	61	
93CH-13-1	510375E 6747550N	silicified granodiorite cut by grey-green vuggy quartz stringers with minor bladed calcite boiling texture	3	0.2	2	11	20	<5	<5	3	8	
93CH-13-2	510250E 6747550N	intrusive altered to argillite cut by white coxcomb quartz veins with sparse galena blebs	95	4.6	5	2128	22	<5	<5	2	72	
93CH-15-6	518100E 6746225N	rusty massive to banded quartz stockwork vein float with vugs of limonite, in felsite dyke	6	0.3	29	17	35	6	<5	3	19	

Appendix 9 (Cont'd)

SAMPLE	UTM Zone 8V	DESCRIPTION	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Ba ppm	Note
93CH-25-3	511200E 6751850N	chip sample across 1.1 m wide boulder of bright orange -weathering ankeritic fault breccia with white and grey silicified vuggy networks, quartz veins and coarsely crystalline calcite stringers	8	<0.1	3	5	82	<5	<5	13	1715	
93CH-25-5	511900E 6753050N	rusty, recessive-weathering, light grey pyrrhotiferous, silicified hornfels	8	0.2	108	8	86	<5	<5	2	48	
93CH-26-1	514450E 6752500N	medium-grained, dark grey diabase dyke with disseminated blebs of pyrite	7	0.1	35	18	49	<5	<5	3	354	
93CH-26-5A	514750E 6753600N	quartz stockwork, locally coxscomb, with trace pyrite and fine-grained arsenopyrite, altered brecciated rhyolite fragments	1150 *1308	1.2	17	124	76	405	<5	6	15	
93CH-26-5B	514750E 6753600N	white, massive quartz, some stockwork, locally coxscomb quartz	90	0.2	3	7	12	20	<5	4	20	
93CH-28-2	515800E 6751650N	white, massive quartz vein in a rusty felsic dyke, minor disseminated pyrite	74	0.4	11	13	93	42	<5	5	14	
93CH-32-7	517300E 6752400N @ 5400'	massive jasper vein in fault zone cutting pillow basalt	612	<0.1	17	18	13	16	<5	4	7	
93CH-32-8	517300E 6752400N	rusty weathering white quartz vein with fine-grained, bladed calcite texture	21	<0.1	94	45	16	12	<5	4	6	
93CH-32-9	517300E 6752400N	gossanous, brecciated ankeritic quartz vein	12	<0.1	36	11	39	<5	<5	4	11	
93CH-32-10	517000E 6752400N	rusty weathering, banded and massive, white, locally vuggy quartz vein float	520 *497	2.0	23	312	71	122	<5	6	12	426 ppm W
93CH-33-1	517850E 6753300N	large, rusty weathering boulders of volcanic rock with veinlets and disseminations of pyrite	7	0.2	71	20	174	<5	<5	3	3	
93CH-33-3	517950E 6753100N @ 5330'	rusty, coxscomb, 10 cm wide, vuggy quartz vein with tourmaline; ACE property	19	<0.1	40	17	18	<5	<5	6	22	62 ppm Bi
93CH-33-4	517950E 6753100N @ 5040'	gossanous volcanics with disseminated and blebby pyrite, minor arsenopyrite; ACE property	12	<0.1	132	18	90	<5	<5	3	2	
93CH-34-2	516200E 6752300N @ 5600'	pillow volcanics cut by a feldspar-hornblende porphyry andesite dyke, cross-cut by a 2 m wide pyritic shear zone with quartz	32	1.3	102	28	348	84	<5	9	9	
93CH-40-1	509300E 6744850N	coarse-grained pink granite with trace chalcopyrite and molybdenum?	<5	<0.1	31	10	22	<5	<5	4	226	
93CH-42-1	507350E 6738400N	rusty weathering, medium grained, hornblende diorite with malachite staining and disseminated chalcopyrite	<5	2.2	529	25	42	<5	<5	3	74	

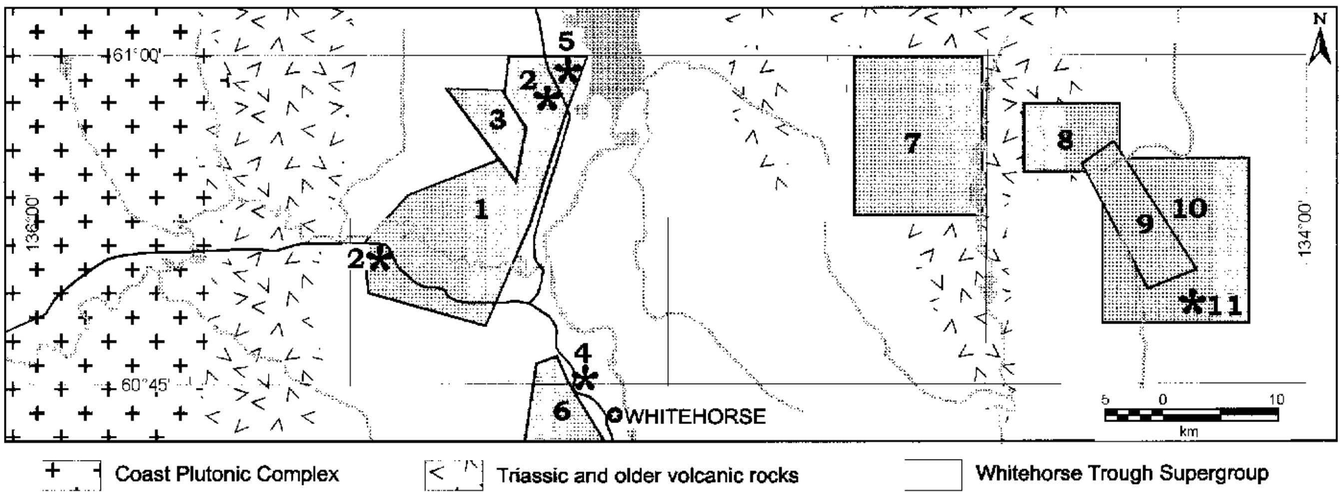
Appendix 9 (Cont'd)

SAMPLE	UTM Zone 8V	DESCRIPTION	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Ba ppm	Note
J93-6-2	483150E 6761550N	rusty weathering granitic talus with 0.5% disseminated arsenopyrite	11	0.9	51	163	31	6	<5	9	128	
J93-13-1	516600E 6748350N	0.3 m wide banded quartz-calcite vein with minor bladed calcite textures	618 *762	0.2	23	2	10	6	<5	5	9	
J93-24-6	512550E 6750900N	rusty weathering andesitic dyke with blebs and disseminations of pyrite and arsenopyrite	6	0.2	230	21	22	8	<5	2	15	
J93-27-2A	518005E 6753015N	strongly magnetic, hornfelsed pillow volcanics with disseminated pyrite on fractures	5	6.8	97	1983	222	<5	18	3	12	
J93-27-2B	518005E 6753015N	massive to cockscomb, vuggy and druzzy vein quartz with brecciated volcanic wall-rock fragments	18	<0.1	70	84	46	<5	<5	5	14	
J93-29-4	514080E 6756095N	rusty weathering, ankeritic dyke in fault zone	10	<0.1	7	78	54	<5	<5	3	38	
J93-32-11B	510020E 6753055N	hornfelsed siltstone with minor disseminated pyrite	51	<0.1	96	58	37	14	<5	50	124	
J93-32-11C	510020E 6753055N	skarnified limestone - garnet, epidote, minor disseminated pyrite	23	<0.1	86	22	32	44	<5	94	18	357 ppm W
J93-34-3	507065E 6745035N	limy, fine grained sandstone cut by numerous vuggy quartz veinlets	19	0.4	38	11	48	<5	5	5	31	
J93-36-6	509020E 6741060N	quartz float, very rusty and vuggy, ankeritic with malachite staining	5	<0.1	4	8	18	166	18	6	58	343 ppm Co 504 ppm Cr
J93-37-2	511015E 6740055N	coarse-grained pink, quartz monzonite with trace disseminated molybdenum	<5	<0.1	5	9	27	<5	<5	2	93	
J93-37-3	511007E 6740075N	rusty-weathering silicified felsic, quartz-phyric dyke, minor disseminated pyrite and arsenopyrite	5	<0.1	14	30	26	6	<5	6	46	
J93-37-8	512050E 6741050N	rusty weathering, ankeritic fine-grained, grey-green dyke	<5	<0.1	<1	95	35	<5	<5	3	109	
J93-32-15	509080E 6754065N	silt sample	18 *5	<0.1	35	13	62	<5	<5	3	140	
CH-112626	511200E 6762600N	silt sample	18 *<5	<0.1	28	23	95	<5	<5	5	348	
CH-163528	516300E 6752800N	silt sample	24 *13	<0.1	53	19	74	7	<5	3	135	
CH-178538	517800E 6753800N	silt sample	12	<0.1	48	29	129	12	<5	2	120	
CH-080555	508000E 6755500N	silt sample	38	<0.1	98	27	189	5	<5	2	126	

Appendix 9 (Cont'd)

SAMPLE	UTM Zone 8V	DESCRIPTION	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Ba ppm	Note
CH-161526	516100E 6752600N	silt sample	18 *12	1.2	153	73	174	26	<5	6	155	
CH-075385	507500E 6738500N	silt sample	13 *24	<0.1	55	26	102	<5	<5	3	223	
	115D/16	Au by 30 gram fire assay, all other elements by ICP. Analyses by Chemex Laboratories										
94CH-11-2	529920E 6755850N	rusty weathering, carbonate altered breccia with banded druzy and fine-grained spongy carbonate, 0.40 m wide.	<5	<0.2	1	12	36	<5	<5	<1	7	
94CH-12-4	534500E 6755450N	rusty-weathering, vuggy, cockade quartz vein with limonite, scorodite and MnO staining and minor, fine-grained chalcopyrite 0.20 m wide, Mount Byng property	44.9 g/t	85.3 g/t	472	438	9	741	405	38	67	Bi 226 ppm Mo 38 ppm
94CH 4-1	541700E 6756900N @ 1460 m	orange weathering, crystalline carbonate (ankerite) with brecciated wallrock fragments	<5	<0.2	12	6	21	<5	<5	<1	12	
94CH 15-6	542350E 6747400N @ 1790 m	white quartz stockwork float with coxcomb vugs	7	0.2	7	3	6	12	<5	4	28	
94CH 16-5	538300E 6752500N @ 1720 m	massive grey quartz stockwork cutting and parallel to northwest-trending, rusty weathering alaskite dyke	106	0.4	13	<2	2	<5	<5	13	13	
J94-5-7b	541010E 6762015N	sheared quartz vein (5 cm wide) with minor pink carbonate (5%) alteration and graphitic margins, no visible sulphides	<5	<0.2	20	12	49	<5	<5	11	210	
J94-8-2	530300E 6758375N	andesite cut by 3- to 5-cm-wide calcite veins in three, 20-cm-wide shear zones, no visible sulphides	<5	<0.2	1	3	7	<5	<5	<1	10	
J94-8-5	530550E 6758225N	brecciated diorite cut by felsic quartz-phyric intrusive cut by white, vuggy and rusty-weathering quartz veins, no visible sulphides	<5	<0.2	126	3	14	<5	<5	1	28	
J94-33-1a	535450E 6734850N	ultramafite cut by 15 cm wide felsic dyke with minor quartz-calcite veins, no visible sulphides.	<5	0.3	12	<2	<1	<5	<5	3	18	
J94-34-11	534300E 6740850N	rusty weathering, bleached, fine-grained intrusive	7	<0.2	3	7	49	<5	<5	22	55	
J94 4-1	540050E 6757040N	silt sample	<5									
CH-94-5-11	540200E 6760000N	silt sample	<5									
CH94-18-1	550150E 6748900N	silt sample	42									
CH94-5-12	540600E 6760150N	silt sample	15									
CH94-Camp5	541100E 6750450N	silt sample	20									

Appendix 10. Locations of previous bedrock geological studies.



1. Dickie, 1989; Dickie and Hein, 1995
2. Hart et al., 1995
3. Pálfy and Hart, 1995
4. Stretch, 1993
5. Brown, 1994
6. Morrison 1981
7. Hart and Orchard, 1996
8. Bremner, 1991
9. Doherty, 1988
10. Schönicke and Weihe, 1992
11. Jakobs, 1994

Exploration and Geological Services Division

Bulletin 1	The Whitehorse Copper Belt: Mining Exploration and Geology 1967 - 1980 (105D)	D.Tenney
Bulletin 2	Geology and Genesis of the Mount Skukum Epithermal Gold-Silver Deposits, Southwestern Yukon Territory (105D)	B.W.D. McDonald
Bulletin 3	Shape and Composition of Lode and Placer Gold from the Klondike District, Yukon, Canada (115O, parts of 116B)	J.B.Knight, J.K. Mortensen and S.R.Morison
Bulletin 4	Sedimentology of Placer Gravels near Mt. Nansen, Central Yukon Territory (115I)	W.P. LeBarge
Bulletin 5	Natural Land Reclamation for Mineral Exploration Properties and Placer Mines in Yukon	C. Mougeot
Bulletin 6	Geology of the McQuesten River region, Northern McQuesten and Mayo Map Areas, Yukon Territory (115P/14-16, 105M/13-14)	Donald C. Murphy
Bulletin 7	Geology of the Mayo Map Area, Yukon Territory (105M)	Charlie Roots
Bulletin 8	A Transect Across Northern Stikinia: Geology of the Northern Whitehorse Map Area, Southern Yukon Territory (105D/13-16)	Craig J.R. Hart
Bulletin 9	Geology of the Upper Hart River Area, Eastern Ogilvie Mountains, Yukon Territory (116A/10,11)	Grant Abbott

Copies available from: Geoscience Information and Sales, Exploration and Geological Services Division, Indian and Northern Affairs Canada, 102-300 Main St., Whitehorse, Yukon, Y1A-2B5.
Phone 867 667-3264, Fax 867 667-3267.
Visit our Web Site: http://www.yukonweb.com/government/geoscience/