GEOLOGY AND MINERAL OCCURRENCES OF QUESNEL TERRANE, KLIYUL CREEK TO JOHANSON LAKE (94D/8, 9)

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KEYWORDS: Quesnel Terrane, Takla Group, Triassic-Jurassic plutons, pyroxenite, diorite, tonalite, granodiorite, magnetite, gold, copper, molybdenum.

INTRODUCTION

The Johanson Lake project is a two-year bedrock mapping program initiated by the Geological Survey Branch in 2003 as part of the Toodoggone Targeted Geoscience Initiative (TGI). The project focuses on a belt of Mesozoic arc volcanic and plutonic rocks in the eastern part of the McConnell Creek (94D) map sheet. This area contains a number of gold, copper and molybdenum mineral occurrences and Regional Geochemical Survey sample sites that returned anomalously high values of gold and copper. The aim of the project is to improve the quality and detail of bedrock maps for the area and determine the setting and controls of mineral occurrences. This will help guide exploration strategies on known mineral occurrences and focus exploration for new occurrences.

This report summarizes the results from the first year's fieldwork on the Johanson Lake Project. It covers an area of about 150 square kilometres that was mapped from July 19 to August 22, 2003 (Figure 1). Operating funds were provided by the Toodoggone TGI and a private-public partnership agreement with Northgate Exploration Ltd. The project area is 350 kilometres northwest of Prince George and encompasses rugged terrain within the Omineca Mountains. Road access to Johanson Lake is provided by the Omineca Resource Access Road. Most of the 2003 fieldwork was conducted from fly camps serviced by a Canadian Helicopters base at the Kemess Mine, 60 kilometres to the north-northwest.

PREVIOUS WORK

The Johanson Lake project area is located along the eastern edge of the McConnell Creek (NTS 94D) map sheet. Systematic geologic mapping of eastern McConnell Creek sheet was undertaken by the Geological Survey of Canada (GSC) in the early to mid 1940s and published as Memoir 251 with accompanying 1:253 440-scale geological map (Lord, 1948). There was little published geological information on the area prior to that time, although Lay's (1940) descriptions of geology and mineral occurrences in selected areas in the Aiken Lake sheet (NTS 94C/E) to the east included a very small part of the present map area along the lower reaches of Croyden Creek. The mineral occurrences along Croyden Creek, together with new discoveries within the McConnell Creek sheet to the west, some of which were made during the GSC's mapping program, were described by White (1948). Systematic mapping of the Aiken Lake sheet was completed by the GSC in the late 1940s, and published as Memoir 274 with 1:253 440-scale geological map (Roots, 1954).

Church (1974, 1975) mapped portions of the McConnell Creek sheet directly west of the current project area in response to interest generated by discovery of the Sustut copper occurrence in 1971. This work overlapped with the studies of Monger (1974, 1976, 1977; Monger and Paterson, 1974), which focused on Upper Triassic volcano-sedimentary rocks in the McConnell Creek map area (Monger and Church, 1977). These studies, together with several other detailed studies of specific map units, including those of Irvine (1974, 1976) on Alaskan-type intrusions and Woodsworth (1976) on granitoid intrusions, were incorporated in an updated geologic map of the eastern McConnell Lake map area at 1:250 000-scale (Richards, 1976a, b).

In 1987 the B.C. Geological Survey Branch initiated a multi-year program designed to investigate the mineral potential of Alaskan-type ultramafic-mafic intrusions within the province (Nixon and Rublee, 1988). This project included mapping and lithogeochemical studies of the Johanson Lake, Wrede Creek and Polaris ultramafic-mafic bodies located within and adjacent to the Johanson Lake project area (Nixon *et al.*, 1990a, b; Hammack *et al*., 1990; Nixon *et al*., 1997)

In the late 1980s, K. Minehan (1989a, b) studied the volcanic stratigraphy and petrochemistry of the Upper Triassic Takla Group a short distance north of Johanson Lake as part of her Masters project at McGill University. A subsequent Ph.D. study by G. Zhang, also at McGill University, focused on the structural geology of a region straddling the Finlay-Ingenika fault system and encompassing the present project area (Zhang, 1994; Zhang and Hynes, 1991, 1992, 1994, 1995; Zhang *et al*., 1996).

Areas both east and west of the Johanson Lake project area have been covered by recent 1:50 000-scale geological mapping programs by the B.C. Geological Survey Branch. The area to the east and southeast was mapped by Ferri *et al.* (1993; 2001b) as part of the Aiken Lake project, and the area around Lay and Wrede creeks,

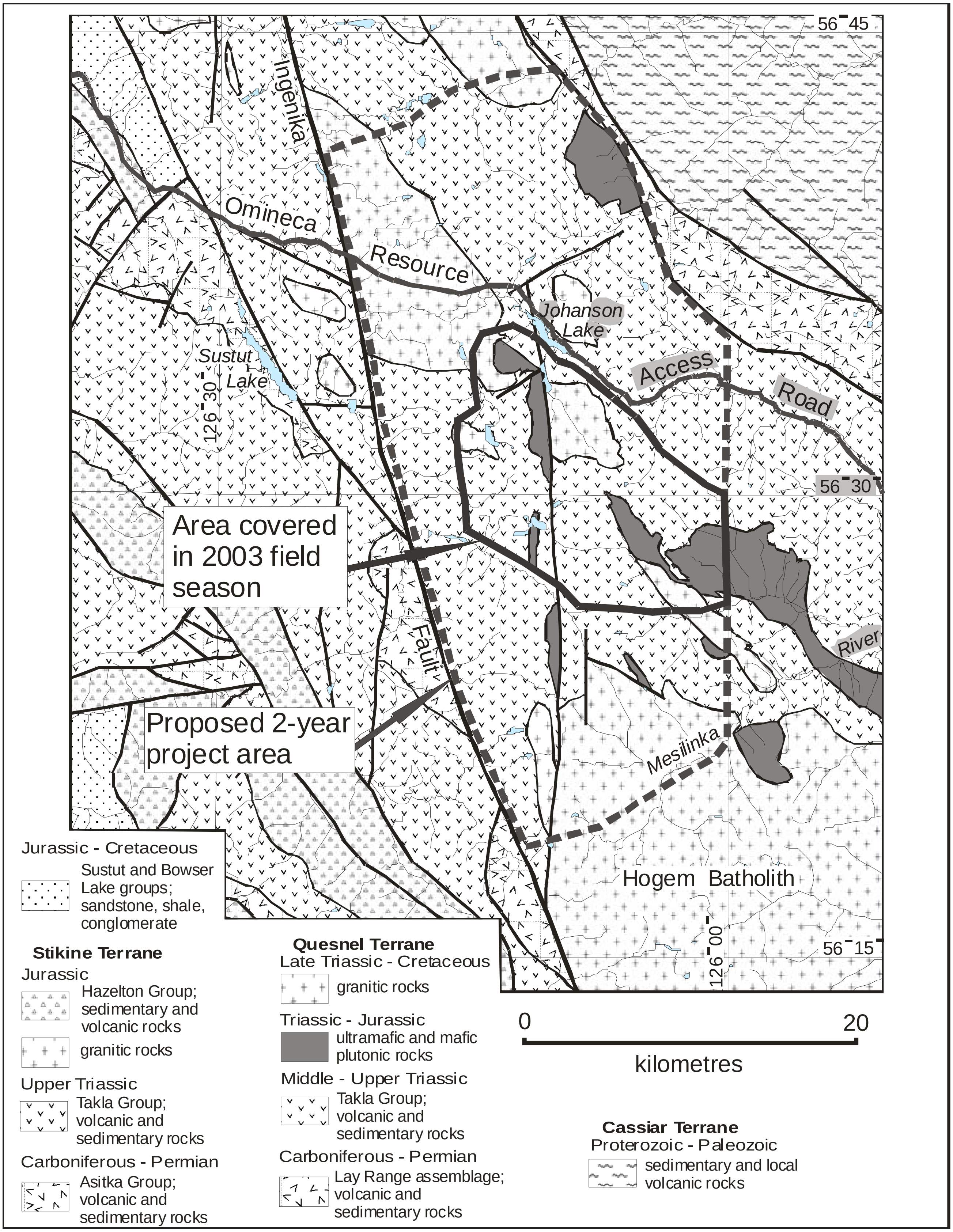

Figure 1. Location of the Johanson Lake mapping project and the area covered during the 2003 field season.

northeast of the project area, is covered by Ferri (2000a, b). The area west of Johanson Lake, underlain by the Stikine Terrane, was studied by Legun (1998, 2001a, b).

REGIONAL GEOLOGIC SETTING

The Johanson Lake project area is underlain by rocks of the Quesnel Terrane, a volcanic arc terrane that is found along most of the length of the Canadian Cordillera. The Quesnel Terrane is in large part represented by Middle and Upper Triassic volcanic and sedimentary rocks, which are assigned to the Takla Group in northern and central British Columbia and to the Nicola Group in the south. These rocks are locally overlain by Lower Jurassic volcanic and sedimentary rocks, and are cut by a several suites of Late Triassic through Early Jurassic plutons. In north-central British Columbia, older components of the Quesnel Terrane comprise arc volcanic and sedimentary rocks of the Lay Range assemblage, which are restricted to the eastern margin of the Quesnel belt (Ferri, 1997).

Late Triassic-Early Jurassic intrusive rocks are a prominent and economically important component of the Quesnel Terrane. These include both calc-alkaline and alkaline plutonic suites, as well as Alaskan-type ultramafic-mafic intrusions. Many of these plutonic suites are found within and adjacent to the Hogem Batholith (Garnet; 1978; Woodsworth, 1976; Woodsworth *et al*., 1991) which extends from the Johanson Lake project area more than 150 kilometres south to the Nation Lakes area. In addition to Late Triassic-Early Jurassic rocks, the composite Hogem Batholith also includes younger granitic phases correlated with Early Cretaceous plutons that are common regionally and crosscut Quesnel and adjacent terranes.

At the latitude of Johanson Lake, Quesnel Terrane is contacted to the east by Proterozoic and Paleozoic carbonates and siliciclastics of the Cassiar Terrane, representing part of the ancestral North American miogeocline (Figure 2). Farther south, Quesnel and Cassiar terranes are separated by an intervening assemblage of Late Paleozoic oceanic rocks assigned to Slide Mountain Terrane. The boundary between the Quesnel and Cassiar terranes is a complex structural zone that includes late Early Jurassic east-directed thrust faults that juxtapose Quesnel Terrane above Cassiar Terrane (Ferri, 1997, 2000a; Nixon *et al*., 1997). These east-directed faults and related folds are locally overprinted by somewhat younger west-directed structures that reverse this stacking order (Bellefontaine, 1989), as well as by dextral strike-slip and normal faults that formed in Cretaceous and early Tertiary time (Ferri, 1997; 2000a).

The Quesnel Terrane in the Johanson Lake area is juxtaposed against the similar Stikine Terrane to the west, across the Finlay - Ingenika fault system. Regionally, however, these two arc terranes are separated by the intervening, oceanic Cache Creek Terrane which, in part, includes the remnants of a Mesozoic accretion-subduction complex related to the Triassic-Jurassic Quesnel magmatic arc (Travers, 1978; Struik, 1988). This subduction may have ultimately led to collision between Stikine and Quesnel terranes, as reflected in imbricate southwest-directed thrust faults within Cache Creek Terrane (Struik *et al*., 2001), the juxtaposition of Stikine Terrane beneath Cache Creek Terrane across northeast-dipping thrust faults (Monger *et al*., 1978), and the record of chert-rich detritus that was shed westward from Cache Creek Terrane into the Bowser Basin, which formed above Stikine Terrane beginning in Middle Jurassic time (Ricketts *et al*., 1992). The subsequent structural history of the area includes the development of prominent dextral strike-slip fault systems in Cretaceous and Early Tertiary time. These structures include the Finlay - Ingenika and Pinchi faults, which may have more than 100 kilometres of cumulative displacement, resulting in the omission of the Cache Creek Terrane at the latitude of the Johanson Lake area (Gabrielse, 1985).

LITHOLOGIC UNITS

The 2003 study area is underlain by Upper Triassic volcaniclastic and volcanic rocks of the Takla Group, together with abundant intrusions of ultramafic to granitic composition (Figure 3).

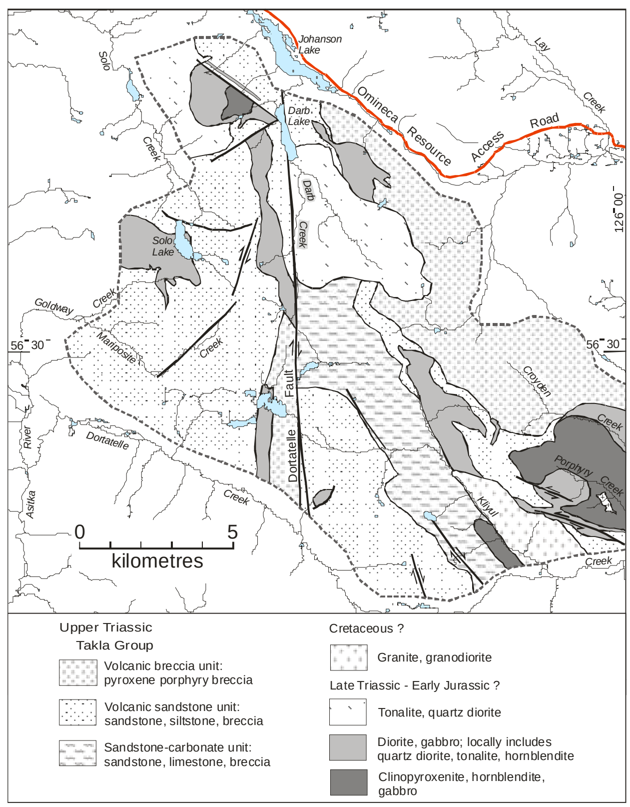

Figure 3. Generalized geology of the Kliyul Creek – Johanson Lake area, based on 2003 fieldwork and published reports referred to in text.

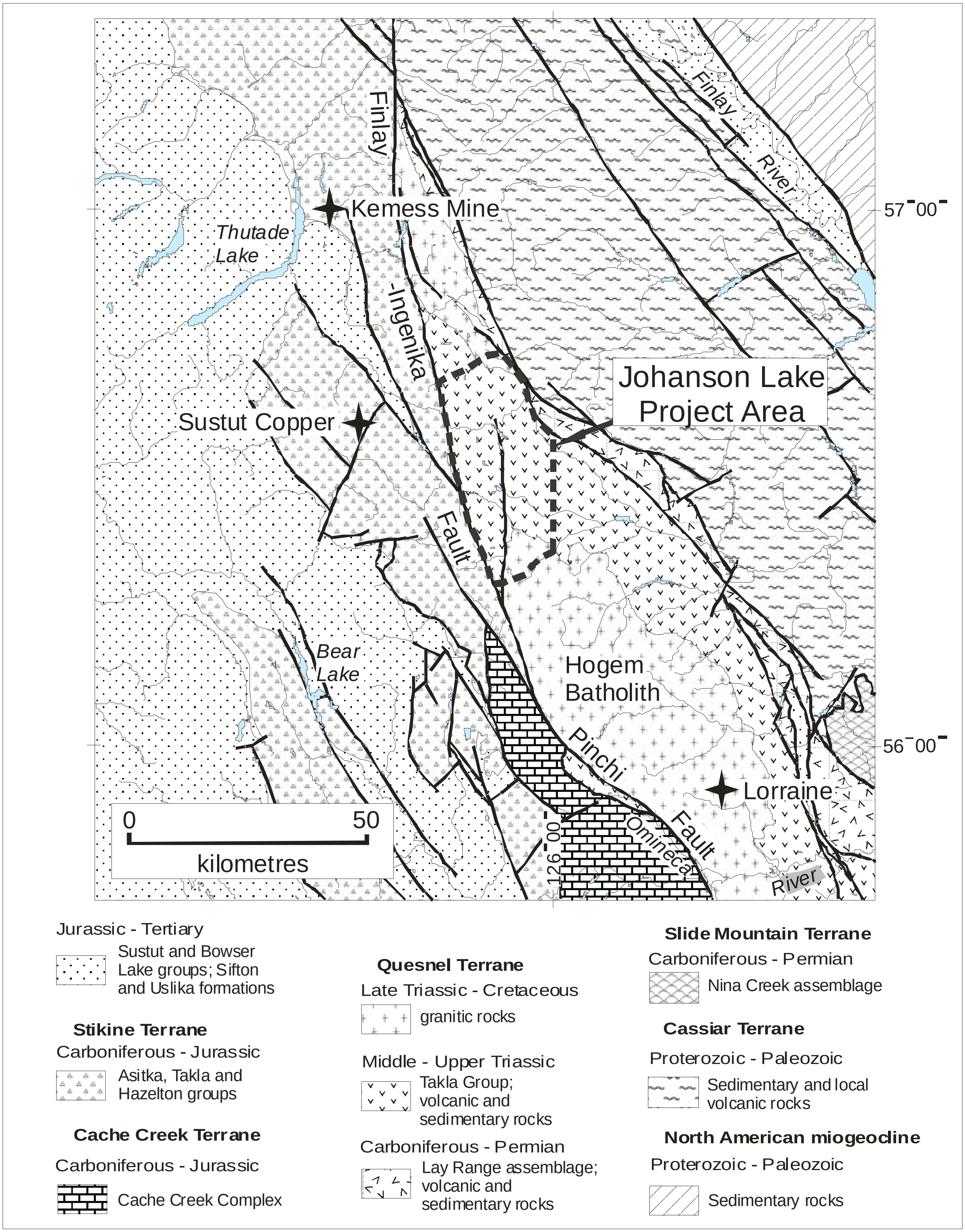

Figure 2. Regional geologic setting of the Johanson Lake project area.

The intrusions are not well dated, but are suspected to be Late Triassic-Early Jurassic and Cretaceous in age.

Takla Group

Armstrong (1946, 1949) used the name Takla Group for occurrences of Upper Triassic and Jurassic volcanic and sedimentary rocks exposed west and southwest of the main arm of Takla Lake in the Fort St. James map area. In addition to the exposures around Takla Lake, he also included in the group a more extensive belt to the east of the Pinchi fault, which extended from Pinchi Lake north-northwestward to beyond Germansen Lake. The name Takla Group was retained for both belts of Triassic-Jurassic rocks where they were traced northward into the McConnell Creek and Aiken Lake map areas by Lord (1948) and Roots (1954), respectively. Subsequent revisions to the nomenclature of the western belt, based largely on excellent exposures in the McConnell Creek map area directly west of the present study area, restricted the name Takla Group to Triassic rocks, and included the overlying Lower to Middle Jurassic volcanic-sedimentary succession in the Hazelton Group (Tipper and Richards, 1976; Monger, 1977; Monger and Church, 1977). In this revised scheme the Upper Triassic Takla Group within the Stikine Terrane is subdivided into 3 formal formations, the Dewar, Savage Mountain and Moosevale.

The eastern Takla belt, including the exposures in the Johanson Lake map area, is part of the Quesnel Terrane. The group has recently been mapped in some detail along a continuous belt extending for almost 250 kilometres from the Nation Lakes area northward to the eastern edge of the Johanson Lake project area (Ferri and Melville, 1994; Nelson and Bellefontaine, 1996; Ferri *et al*., 1992; 1993, 2001a, 2001b). The group has not been subdivided into formal formations within this belt, although several lithologically distinct, but partially coeval successions have been identified and named. In some of these studies the name Takla Group has been used for both Upper Triassic and Lower Jurassic rocks, as originally defined by Armstrong (1949). However, Nelson and Bellefontaine (1996) recognized that, in the Nation Lakes area, the Lower Jurassic rocks are readily distinguished from the Triassic rocks and are separated from them by an unconformity. They suggested that the term Takla Group be restricted to include only the Triassic rocks, and this recommendation is adopted here.

The Takla Group within the Johanson Lake project area is shown mainly as undivided volcanic and volcaniclastic rocks on the maps of Lord (1948), Richards (1976b) and Monger (1977). Zhang and Hynes (1991, 1992) subdivide the group into several informal units in their sketch maps of the area, some of which are reflected in the subdivisions applied here. For the purposes of this report, the Takla Group is subdivided into 2 major divisions and 3 units. The most widespread package comprises a heterogeneous assemblage of volcanic sandstones, siltstones and breccias, with local mafic volcanic flows, referred to as the volcanic sandstone unit. A subunit of this package comprises similar rocks intercalated with locally abundant limestone and limestone breccia; these rocks are assigned to the sandstone-carbonate unit. The third unit, referred to as the volcanic breccia unit, is dominated by massive breccias containing pyroxene porphyry volcanic fragments.

VOLCANIC SANDSTONE UNIT

Rocks assigned to the volcanic sandstone unit comprise most of the Takla Group west of the Dortatelle fault. The base of the unit is not seen, but it is overlain by the volcanic breccia unit in the southeastern part of this area, near the Dortatelle fault. East of the Dortatelle fault, the volcanic sandstone unit crops out as two belts that overlie, but also seem to interfinger with, an intervening belt comprised of the sandstone-carbonate unit. The western belt generally faces and dips to the southwest, and is truncated by the Dortatelle fault. The eastern belt faces and dips to the east, and is overlain by the volcanic breccia unit.

The dominant lithology within the volcanic sandstone unit is grey to green, fine to coarse-grained volcanogenic sandstone composed largely of feldspar crystals and feldspathic lithic fragments. Pyroxene grains, and lithic grains with pyroxene phenocrysts, are common in some sections but virtually absent in others. The sandstone occurs partly as well-defined, thin to thick beds (Photo 1) and partly as massive units, up to tens of metres thick, in which bedding is not apparent.

Photo 1. Well-bedded sandstone of the volcanic sandstone unit, south of west branch of Kliyul Creek.

Well-bedded intervals locally display graded bedding, scoured bases, flame structures and rip-up clasts. Locally, some sandstone units are calcareous.

Green siltstone, also probably of volcanogenic origin, is fairly common within the volcanic sandstone unit, either as thin beds intercalated with beds of coarser sandstone, or as thin-bedded to laminated intervals up to many metres thick comprised only of siltstone. Also present in places are intervals, locally more than 10 metres thick, of dark grey, rusty-weathered, thin-bedded siltstone and argillite. Thin to medium beds of dark grey limestone are also found within the unit, but are rare.

Coarse-grained intervals, ranging from pebbly volcanogenic sandstone or lapilli tuff to coarse breccias containing fragments approaching a metre in size, are not uncommon within the volcanic sandstone unit and typically form massive, resistant units many tens of metres thick. Fragments of feldspar porphyry and pyroxene-feldspar porphyry are commonly present, and clasts of hornblende-feldspar porphyry, diorite and tonalite were also observed. Also present are distinct units of very coarse breccia, one to several metres thick, that occur as single layers or a few closely spaced layers within much finer grained feldspathic sandstone intervals. These breccia units invariably contain mainly pyroxene porphyry fragments, which are supported by a matrix rich in pyroxene mineral grains. The clasts commonly range from a few centimeters to more than a metre in size, and some fragments have irregular amoeboid-like contacts and faintly chilled margins, suggesting that they were not completely cooled when they were incorporated into the breccia. These breccias probably represent mass flow deposits that tapped a different source than the much finer feldspathic sandstones with which they are intercalated.

Units of massive pyroxene porphyry and pyroxene-feldspar porphyry, probably derived from mafic flows and/or sills, are found scattered throughout the volcanic sandstone unit, but seem to be most common at higher stratigraphic levels.

SANDSTONE-CARBONATE UNIT

Rocks assigned to the sandstone-carbonate unit form a single belt that extends from the southern boundary of the map area northwestward about 10 kilometres to the Dortatelle fault and Darb Creek pluton. This belt is broadly anticlinal in nature, as the sandstone-carbonate unit is flanked by outward-facing rocks of the volcanic sandstone unit to both the northeast and southwest.

The dominant lithologies within the sandstone-carbonate unit are volcanogenic sandstones and breccias that are identical to those of the volcanic sandstone unit. Associated with these rocks however, are dark-grey limestones that are mixed with volcanogenic sandstone in lenses and layers that were probably derived from slump deposits (Photo 2). In many of these units there are subequal proportions of limestone and sandstone, and they form lenses and blocks that are intimately mixed in a chaotic fashion. In other units, one rock type predominates and appears to form a matrix containing clasts of the other. Still elsewhere, limestone occurs as discrete layers or patches, many tens of metres in size, that appear to form beds within the sandstone succession. However, some of these thick units contain laminations that are folded in a chaotic and irregular fashion suggesting soft-sediment deformation.

A very thick limestone unit exposed on the ridge south of the Darb Creek pluton, at the north end of the sandstone-carbonate belt, displays regular east dips that are concordant with bedding orientations in the overlying

Photo 2. Limestone mixed with volcanic sandstone, sandstone-limestone unit, head of Kliyul Creek.

volcanic sandstone unit. This might be a very large slump block within the sandstone-carbonate unit, or it might mark the transition into a part of the source terrain from which the slump blocks were derived. Monger (1977) collected Late Triassic macrofossils from this unit. Limestone samples from this area and others within the sandstone-carbonate unit were collected during the 2003 field season and are being processed for conodonts. The nature of this unit indicates, however, that any conodont ages will have to be interpreted with caution.

VOLCANIC BRECCIA UNIT

The volcanic breccia unit comprises a monotonous succession of mafic volcanic breccias dominated by clasts of pyroxene-phyric basalt (Photo 3). It locally includes narrow intervals of interbedded pyroxene-rich volcanic sandstone and siltstone, as well as massive pyroxene-phyric flows and/or sills.

Photo 3. Pyroxene porphyry breccia, volcanic breccia unit, upper Croyden Creek.

The unit is well exposed as a series of prominent ridges in the northwestern part of the map area. It also occurs in a narrow belt directly west of the Dortatlelle fault in the southern part of the map area. In both of these exposure belts it rests structurally, and apparently stratigraphically, above finer-grained and more distinctly bedded rocks of the volcanic sandstone unit.

The rocks of the breccia unit typically form resistant, blocky, green-brown to rusty-brown weathered exposures. Stratification, or contacts between different breccia units are generally not evident. Fresh surfaces are dark green to grey-green. Breccia fragments are dominantly or exclusively pyroxene and pyroxene-feldspar-phyric basalt, although there is commonly considerable textural variation among clasts based on size and abundance of phenocrysts, as well as proportions of feldspar versus pyroxene phenocrysts. Locally, in the panel west of the Dortatelle fault, the breccia also contains fragments of hornblende-feldspar porphyry and microdiorite.

Pyroxene±feldspar porphyry fragments within the breccias are typically angular to subangular and unsorted to poorly sorted. The fragments are commonly up to 10 centimetres in size and locally range up to several tens of centimetres. The matrix typically consists of pyroxene plus or minus feldspar crystals and small, commonly pyroxene-bearing, lithic grains. In many exposures it is virtually indistinguishable from the fragments, such that the breccia texture is not readily apparent. Locally the matrix is calcareous and recessive-weathering, causing the fragments to stand out in relief.

TAKLA GROUP CORRELATIONS

The Takla Group within the 2003 map area is contiguous with Takla exposures mapped as the Upper Triassic Plughat Mountain succession to the east and southeast (Ferri *et al*., 1993; 2001b). The Plughat Mountain succession in this area has been subdivided into two broad subdivisions; the first comprises units dominated by bedded tuffs and volcanic-derived sedimentary rocks, intercalated with local beds of argillite and limestone (units lTrP1 and lTrP2 of Ferri *et al*., 2001b), whereas the second comprises an overlying to laterally equivalent succession dominated by coarse breccias and agglomerates containing pyroxene-phyric basalt fragments (Unit lTrP3 of Ferri et al., 2001b). The first division of the Plughat Mountain succession correlates with the volcanic sandstone and sandstone-limestone units of the Johanson Lake area, whereas the coarse breccias and agglomerates that overlie and interfinger with the finer-grained facies are correlated with the volcanic breccia unit of this study. The Plughat Mountain succession has been traced more than 100 kilometres southward to the Germansen Lake area, where it is underlain by, and interfingers with, Middle to Upper Triassic sedimentary and local volcanic rocks assigned to the Slate Creek succession (Ferri and Melville, 1994). The Slate Creek succession comprises the base of the Takla Group in this area.

Farther south, in the Nation Lakes area, the Upper Triassic volcanic-dominant component of the Takla Group is subdivided into a lower, predominately epiclastic unit, the Inzana Lake succession, and an upper unit dominated by coarse augite-phyric breccias and agglomerates referred to as the Witch Lake succession (Nelson and Bellefontaine, 1996). This two-fold subdivision resembles the volcanic sandstone versus volcanic breccia subdivision applied to the present map area, as well as the broad lower and upper subdivisions that have been applied to much of the intervening Plughat Mountain succession. Nelson and Bellefontaine point out, however, that the simple correlations suggested by these subdivisions may be misleading, since the predominantly epiclastic units appear to interfinger and overlap in age with the pyroxene-rich volcanic breccia units. Furthermore, they suggest that facies and thickness relationships in the Nation Lakes - Germansen Lake area suggest that the Takla Group accumulated in and adjacent to at least two distinct volcanic centers that may or may not have been coeval.

Plutonic Rocks

MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS BETWEEN KLIYUL AND CROYDEN CREEKS

Clinopyroxenite, hornblendite, gabbro and diorite are the dominant lithologies within an intrusive complex that extends for about 4 kilometres westward from the eastern boundary of the map area, along Croyden and Porphyry creeks. These rocks form the northwestern end of a large, elongate, mafic-ultramafic complex, referred to as the Abraham Creek complex, that extends an additional 24 kilometres to the southeast (Ferri *et al*., 1993, 2001b). Within the present study area, the Abraham Creek complex has been subdivided into a central unit of mainly clinopyroxenite, hornblendite and mafic gabbro, and a unit dominated by diorite, gabbro and microdiorite which flanks the ultramafic unit to the north and south. Xenoliths of clinopyroxenite and hornblendite are common within the diorite unit, and an intrusion breccia containing fragments of clinopyroxenite and mafic gabbro within a leucodiorite host occurs locally along the contact between the two units. These relationships suggest that the ultramafic rocks are for the most part older than the dioritic rocks. Dikes of diorite, microdiorite, diabase, pyroxene porphyry, hornblende-feldspar porphyry and monzodiorite are common within both mappable units, and are though to be an integral part of the intrusive complex.

A separate body of mainly diorite, microdiorite, monzodiorite and gabbro crops out along the slopes east of the north branch of Kliyul Creek, to the west and northwest of the Abraham Creek complex. This body is similar to the diorite unit of the Abraham Creek complex, and the intervening Takla Group is cut by numerous diorite and microdiorite dikes of similar composition. The western diorite unit is therefore thought to be related to the Abraham Creek complex; this correlation is supported by the local presence of clinopyroxenite and hornblendite at the north end of the western pluton.

An ultramafic-mafic unit described as peridotite, gabbro and diorite crops out along the southwest slopes of Kliyul Creek in the southern part of the map area (Noel, 1971b). These rocks were not examined during the present study, but apparently intrude the sandstone-carbonate unit of the Takla Group, and are themselves cut by the Kliyul Creek granodiorite pluton.

JOHANSON LAKE MAFIC-ULTRAMAFIC COMPLEX

The Johanson Lake mafic-ultramafic complex is located in the northwestern part of the study area, about 1.5 kilometres southwest of Johanson Lake. These rocks were described briefly by Irvine (1976) and were subsequently studied in more detail by Nixon *et al.* (1990b, 1997). The latter authors subdivided the complex into two units; one dominated by clinopyroxenite and hornblendite, and another, more voluminous unit consisting mainly of gabbro to diorite. The Johanson Lake complex was not remapped during the 2003 field season, but is shown on Figure 3 after Nixon *et al.* (1997).

The Johanson Lake complex intrudes the volcanic sandstone unit of the Takla Group, presumably at a relatively high stratigraphic level since it is at the north end of a fairly extensive north-dipping structural panel. Unaltered hornblende from coarse-grained hornblendite of the Johanson Lake complex has yielded a K-Ar date of 232±13 Ma (Stevens *et al.*, 1982, sample GSC 80-46). This Middle Triassic date is suspect since it suggests that the intrusive rocks are older than their Upper Triassic host.

MAFIC INTRUSIVE COMPLEXES WEST OF THE DORTATELLE FAULT

Gabbro, diorite and microdiorite, with minor amounts of quartz diorite and tonalite, form a narrow, northerly-trending unit that has been traced for about six kilometres within the volcanic sandstone unit of the Takla Group just west of the Dortatelle fault where it follows Darb Creek. Similar rocks form a north-striking, sill-like body that marks the contact between the volcanic sandstone and volcanic breccia units a short distance to the south. These northerly-trending intrusive units are lithologically similar to the mafic portions of the Abraham Creek and Johanson Lake mafic-ultramafic complexes.

SOLO LAKE STOCK

The Solo Lake stock intrudes the volcanic sandstone unit of the Takla Group in the west-central part of the study area, along and southwest of Solo Lake. The intrusion consists mainly of light to medium grey, medium grained, equigranular hornblende quartz diorite to diorite. Melanocratic hornblende-rich diorite, locally grading to hornblendite, occurs locally, as do patches and dikes of mafic-poor tonalite. Dikes showing a similar range of composition are common within the Takla Group peripheral to the stock. The age of the stock is unknown, but a sample collected during the 2003 field season has been submitted to the UBC geochronology laboratory for U-Pb isotopic dating.

DARB CREEK PLUTON

Massive, light grey weathered, medium to coarse grained hornblende-biotite tonalite forms a pluton that is well exposed on the slopes surrounding the prominent eastern tributary of Darb Creek. Along its south margin the pluton truncates an east-dipping succession that includes all three map units of the Takla Group; where observed this contact is sharp, although the tonalite contains abundant xenoliths of country rock for a few tens of metres along its outer margin. The pluton is apparently truncated by the Dortatelle fault to the west, but this contact was not observed. Along its northeast margin the tonalite cuts an older northwest-trending stock consisting of diorite and quartz diorite. The age of the Darb Creek pluton is not known, but a sample of tonalite collected during the 2003 field season has been submitted to the UBC geochronology laboratory for U-Pb isotopic dating.

JOHANSON CREEK PLUTON

Massive, medium-grained, light-grey weathering hornblende-biotite tonalite to quartz diorite crops out in the northwestern corner of the 2003 map area, where it apparently intrudes both the Takla Group and the Johanson Lake mafic-ultramafic complex (Nixon *et al.*, 1997). These exposures represent the south end of a large, predominantly quartz diorite pluton that extends more than 10 kilometres farther north, and is referred to as the Johanson Creek stock by Richards (1976b). Biotite and hornblende separates from a sample of this pluton collected north of Johanson Creek have yielded K-Ar dates of 121±4 Ma and 142±12 Ma, respectively (Wanless *et al.*, 1979; samples GSC 78-12 and GSC 78-13).

KLIYUL CREEK PLUTON AND DAVIE CREEK STOCK

Light grey to pink weathered, medium to coarse grained biotite granodiorite crops out on the steep slopes northeast of Kliyul Creek near the southeastern corner of the 2003 map area. It intrudes the volcanic sandstone unit of the Takla Group as well as dioritic phases of the Abraham Creek mafic-ultramafic complex. A small stock of similar, but largely potassic-altered, biotite granodiorite (Davie Creek stock), measuring about 700 metres long by 300 metres wide, cuts across pyroxenite and related rocks of the Abraham Creek complex 1.5 kilometres to the northeast. This stock hosts the Davie Creek porphyry molybdenum occurrence.

The granodiorite along Kliyul Creek comprises the northwest end of a narrow pluton that extends for about 7 kilometres to the southeast. This pluton, together with several others of similar composition within and peripheral to the Hogem Batholith, are informally referred to as the Osilinka stocks by Woodsworth *et al.* (1991). They assigned the Osilinka stocks a Cretaceous age, based on their similarity to the Cassiar suite of plutons, and biotite K-Ar dates of 122±6 Ma (Wanless *et al*., 1972, sample GSC70-11) and 120 Ma (G. Woodsworth, unpublished data) from two separate stocks within the Hogem batholith. However, one of these dated stocks has recently yielded a U-Pb zircon date of 192.3 +2.1/-4.8 Ma (Nelson *et al*., 2003; J. Nelson, personal communication 2003), indicating that at least one of the Osilinka stocks is Early Jurassic in age. In order to determine the crystallization age of the granodiorite stocks in the present map area, a sample collected from the Davie Creek stock has been submitted to the UBC geochronology laboratory for U-Pb isotopic dating.

OTHER INTRUSIVE ROCKS

The only intrusion not previously mentioned, but sufficiently large to be portrayed on Figure 3, is a small body of chlorite-epidote-altered hornblende diorite that is exposed on the ridge north of Dortatelle Creek, a short distance east of the Dortatelle fault. This body intrudes the volcanic sandstone unit of the Takla Group along its northwest contact, but its southeastern contact is marked by a northwest-dipping chloritic shear zone that contains sigmoidal foliation domains suggesting components of reverse and sinistral movement.

Dikes are abundant in the vicinity of the mappable plutons within the study area, where they generally reflect the composition of the adjacent major intrusions. Dikes of pyroxene ±feldspar porphyry, diorite and microdiorite are common throughout the area. These dikes dip steeply and typically strike northwest, although northeast strikes were also observed. A number of northwest-striking pyroxene porphyry dikes on the ridge northeast of Croyden Creek contain common xenoliths of pyroxenite. Brown-weathering lamprophyre dikes were observed cutting the volcanic sandstone unit of the Takla Group south of upper Croyden Creek.

STRUCTURE

Mesoscopic Structure

The structure of most outcrops within the study area is characterized by brittle to brittle-ductile faults. A large proportion of these outcrop-scale faults strike northwest to north and dip steeply; some show evidence for dextral strike-slip displacement, consistent with the interpretation that these structures are related to Cretaceous-Tertiary dextral strike slip faults that are prominent regional structures (Zhang and Hynes, 1994). However, a significant number of northwest-striking, relatively ductile faults with sinistral displacement were also observed; these may relate to an earlier period of sinistral faulting that has not been well-documented in the region. Penetrative foliations are for the most part restricted to local high strain zones associated with faults. However, a weak slaty cleavage of more regional aspect is apparent locally, mainly in the southern part of the area. This cleavage is axial planar to local mesoscopic folds and, in the area west of the Dortatelle fault, is associated with larger folds with wavelengths of several hundred metres. The age of these structures is unknown; they may be related to the Cretaceous-Tertiary dextral strike slip faults that dominate the structure of much of the area (Zhang and Hynes, 1994), or might be vestiges of an older event, such as the late early Jurassic thrusting of the Quesnel Terrane over terranes to the east.

General Map-Scale Structure

The Kliyul Creek – Johanson Lake map area is separated into two domains by the north-striking Dortatelle Fault. The area east of the fault is broadly anticlinal in nature, with a poorly-defined hinge occurring within the western part of the sandstone-carbonate unit of the Takla Group. Along its northeast margin this unit dips and faces to northeast at moderate to gentle angles and is overlain by a relatively thin section of the volcanic sandstone unit, which is in turn overlain by a thick section belonging to the volcanic breccia unit. Along its southwestern margin, the sandstone-carbonate unit dips and faces southwestward at somewhat steeper angles, and is overlain by a thicker section of the volcanic sandstone unit. This western limb of the anticline is progressively truncated northward along the Dortatelle fault.

The volcanic sandstone unit in the southern part of the western domain is characterized by northerly-striking bedding that displays several dip-reversals across mainly north-plunging fold hinges. The easternmost fold limb comprises an east-dipping panel several kilometres wide that is overlain by the volcanic breccia unit adjacent to the Dortatelle fault. In the northern part of the western domain, a thick section of the volcanic sandstone unit is exposed in a more or less homoclinal panel that dips and faces to the north. This panel is separated from the folded rocks to the south by a complicated zone of faults in the vicinity of Solo Lake and upper Mariposite Creek.

Dextral Fault Systems

The structural geology of a region encompassing the current map area was studied by Zhang and Hynes (1991, 1992, 1994), who concluded that most of the deformation was related to dextral transcurrent movement on the Finlay-Ingenika fault system. They found that most faults were subvertical, and were either dextral strike-slip faults with northwest, north-northwest or north strikes, or sinistral strike-slip faults with east-northeast strikes. This suite of faults corresponds closely with the predicted orientations of structures that would form in a stress field resulting from dextral displacement along the Finlay-Ingenika fault (Tchalenko, 1970; Figure 18 of Zhang and Hynes, 1994). Zhang and Hynes also concluded, based on variations in the orientation of conjugate shear sets that formed early in the deformation history, that fault-bounded domains had rotated clockwise about subvertical axes in response to progressive displacement. Their analysis indicates rotations of up to 59 degrees adjacent to the Finlay-Ingenika fault, decreasing systematically to zero about 20 kilometres away from the main fault.

The suite of structures described by Zhang and Hynes (1994) was recognized during the 2003 mapping program, but almost exclusively at the outcrop scale. With a few exceptions, such as the Dortatelle fault, individual faults could not be traced confidently beyond a single ridge or cirque basin.

Dortatelle Fault

The Dortatelle fault was mapped by Richards (1976b), who shows it extending from the Ingenika fault northward about 40 kilometres to just beyond Johanson Lake (Figure 1). Parts of the fault were studied in detail by Zhang and Hynes (1994), who demonstrated that it was a dextral strike-slip fault on the basis of the geometric relationships between S and C surfaces and associated folds. The fault was not examined in detail during the present study, but is easily mapped on the basis of its prominent topographic expression and the apparent truncation of map units along it. Rocks adjacent to the fault, particularly on its west side, are commonly strongly foliated for several hundred metres beyond the fault trace. The foliation typically strikes north-northwest and dips steeply, consistent with the interpretation of dextral displacement along the fault.

Sinistral Faults

Faults with documented sinistral strike-slip displacement within the southeastern part of the study area are shown on Figure 4. Three of these strike east to northeast and are reasonably interpreted as conjugate riedel shears within a dextral fault system related to the Cretaceous-Tertiary Finlay-Ingenika fault (Zhang and Hynes, 1994). Most of the sinistral faults strike west-northwest to northwest, however, and probably represent a separate deformation event.

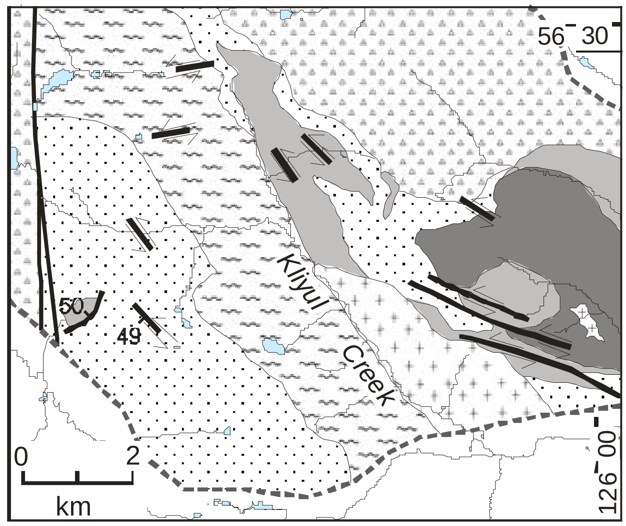

Figure 4. Sinistral faults in the southeastern part of the 2003 map area.

The sinistral faults are best represented by three structures, each traced for 2 to 3 kilometres, that form prominent topographic lineaments on the ridges and cirques between Kliyul and Porphyry creeks (Figure 4). From south to north, these are informally referred to as the South Bear Creek, North Bear Creek and Karen Creek faults (Grexton and Roberts, 1991). Sinistral offset of the mineralized layer on the Soup South occurrence by about 400 metres along the North Bear Creek fault was documented by McTaggart (1965), and sinistral displacement on all three faults was suggested by Grexton and Roberts (1991) on the basis of more equivocal evidence, consisting mainly of the apparent offsets of dikes. Sinistral movement along the South Bear Creek fault was confirmed during the present study. The fault is commonly defined by several tens of metres of sheared and foliated rock that at one place was observed to include well-developed S-C fabrics demonstrating a sinistral sense of shear.

None of the other northwest-striking sinistral faults shown on Figure 4 were traced for any substantial distance. Most comprise shear zones ranging from tens of centimetres to a few metres in width, with sinistral sense of displacement inferred from the angular relationship between the shear zone boundaries and the associated flattening foliation. Of note is the fact that these shear zones are in general more ductile than many outcrop-scale faults observed in the area, and that in two areas the shear zones were localized along pyroxene porphyry dikes. It is suspected that that sinistral faulting may have been broadly contemporaneous with the latter stages of mafic magmatism in the area.

MINERAL OCCURRENCES

Mineral occurrences within the Kliyul Creek – Johanson Lake map area are shown on Figure 5. Most contain copper and gold, and are associated with mafic-

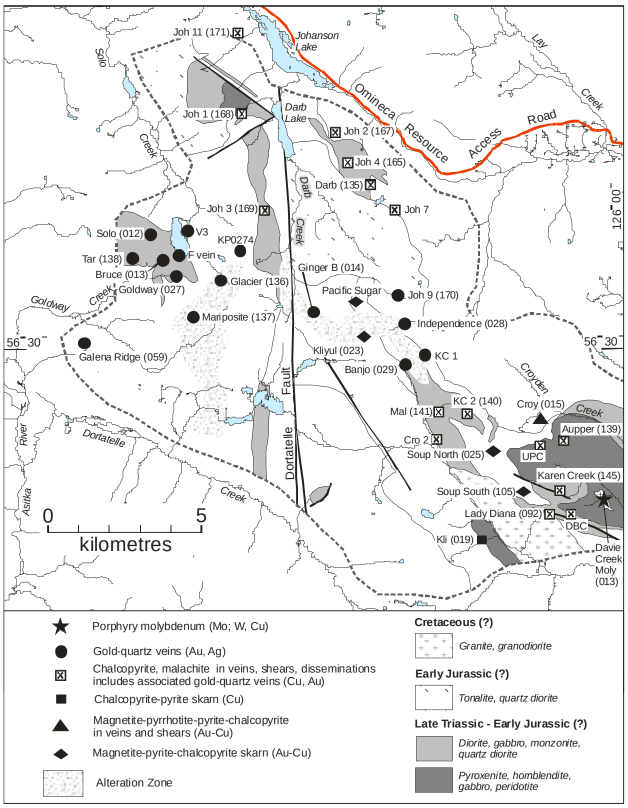

Figure 5. Locations of mineral occurrences in the Kliyul Creek – Johanson Lake map area. Occurrences found in the MINFILE database shown with 094D MINFILE number appended in brackets.

ultramafic plutons and related diorite dikes. These include pyrite-chalcopyrite in shear zones and veins within and peripheral to the ultramafic-mafic plutonic rocks; magnetite-pyrite-chalcopyrite lodes in shear zones peripheral to the plutonic rocks, and magnetite-pyrite-chalcopyrite skarn and replacement bodies where calcareous units of the Takla Group are intruded by diorite dikes. Gold-bearing quartz veins occur within shear zones in the Solo Lake stock. Veins containing gold and copper occur within a major quartz-pyrite alteration zone at the headwaters of Darb and Kliyul creeks, and within a quartz-carbonate alteration zone along Mariposite Creek. These major alteration zones underscore the area’s potential for large porphyry-style copper-gold mineralizing systems. Porphyry molybdenum mineralization associated with the Davie Creek stock is suspected to be Cretaceous in age, and considerably younger than most of the copper-gold mineralization.

Magnetite-Pyrrhotite-Pyrite-Chalcopyrite Shear Veins at the Croy Showing (MINFILE 094D 015)

The Croy occurrence, located on a bench southwest of Croyden Creek, was discovered in the mid 1940s and corresponds to mineralization described by White (1948) on the Shell claims. Early development work, including trenching and sampling, led to drill programs in the early 1970s and mid 1980s (Grexton and Roberts, 1991), although the results of the drilling were not filed for assessment credits. The mineralization is hosted in volcanic and volcaniclastic rocks of the Takla Group on the northwest margin of the Abraham Creek intrusive complex.

Mineralization at the Croy occurrence comprises massive to disseminated magnetite-pyrrhotite-pyrite-chalcopyrite associated with quartz-calcite-chlorite gangue. It occurs as lenses, locally arranged in en echelon fashion, within steeply dipping west-northwest to northwest trending shear zones. Mineralized areas are typically marked by abundant malachite and azurite staining. Although numerous mineralized zones have been recognized only two, traced for about 75 and 170 metres, respectively (Noel, 1971a) are known to have substantial lengths. The largest and most continuously mineralized section occurs within the longest of theses zones; it is about 20 metres long and averages less than 60 centimetres wide (White, 1948). White reports assay results from two channel samples collected about 15 metres apart within this mineralized segment. One, across 46 centimetres, yielded 0.28 ounces per ton gold, 1.1 ounces per ton silver and 6.5 per cent copper. The other, across 23 centimetres, contained 0.47 ounces per ton gold, 0.6 ounces per ton silver and 12.5 per cent copper.

Mineralization Along the South Margin of the Abraham Creek Intrusive Complex

Widespread mineralization within and adjacent to the southern part of the Abraham Creek mafic-ultramafic complex is represented by the Lady Diana (MINFILE 094D 092), DBC and Karen Creek (MINFILE 094D 145) occurrences. These occurrences correspond to the mineralization described by Grexton and Roberts (1991) from South Porphyry Ridge, Davie – Bear creeks and Karen Cirque, respectively.

Mineralization at the Lady Diana showing occurs over an area of about 200 metres by 200 metres, directly south of the South Bear Creek fault. It comprises pyrite-chalcopyrite disseminations, fracture fillings and stringers within microdiorite of the Abraham Creek complex and adjacent hornfelsed volcaniclastic rocks of the Takla Group. Chalcopyrite-bearing grab samples reported by

Grexton and Roberts (1991) are all enriched in gold, with a high of 3900 ppb Au from a sample that also contained 18.5 ppm Ag and 13670 ppm Cu. They also describe a narrow quartz vein containing galena, which yielded 15500 ppb Au, 214.7 ppm Ag and 18439 ppm Pb.

The DBC showing consists of narrow quartz veins and shear zones, sparsely mineralized with pyrite and chalcopyrite, spread over a relatively small area that straddles the North Bear Creek fault zone. The highest gold value from an *in situ* sample within this cluster reported by Grexton and Roberts (1991) came from a chlorite-quartz-carbonate-altered shear zone that contains trace chalcopyrite and pyrite, along with malachite, azurite and magnetite. This sample contained 4700 ppb Au, 24.4 ppm Ag and 30648 ppm Cu. A nearby sample mineralized with pyrite, malachite and magnetite, collected during the 2003 mapping program (sample 03PSC-54), yielded 1260 ppb Au, 14.4 ppm Ag and 10871 ppm Cu, as well as 66 ppb Pt and 75 ppb Pd.

The Karen Creek showing encompasses numerous occurrences scattered over a large area that straddles the Karen Creek fault. Mineralization includes gold-bearing quartz veins sparsely mineralized with pyrite and chalcopyrite, as well as pyrite-chalcopyrite-malachite as disseminations and within shear zones. One unusual occurrence, in the central part of the cluster, a short distance north of the Karen Creek fault, comprises a pod of massive sulphides and quartz located along the intersection of two faults. The sulphides include pyrite, chalcopyrite, galena and sphalerite. A sample from this pod yielded high base metal values, as well as 25000 ppb Au, 282.2 ppm Ag, 4730 ppb Hg and 881 ppm Sb (Grexton and Roberts, 1991, sample M136).

Two samples collected during the present study confirm the general nature of mineralization at the Karen Creek showings. One (sample 03PSC-82) was from a silicified lens, heavily stained with limonite and malachite, within the Karen Creek fault zone. This sample yielded 1573 ppb Au, 16 ppb Pt, 67 ppb Pd, 11.78 ppm Ag and 4051 ppm Cu. The other sample came from a gently-dipping, white quartz vein that is exposed for more than 50 metres in a cliff face several hundred metres north of the Karen Creek fault. Where sampled, the vein is 30 centimetres wide and contains numerous rusted out pits containing traces of pyrite, as well as patches of chlorite and fragments of the dioritic wall rock. The sample (03PSC-84) yielded 20884 ppb Au, 25.620 ppm Ag and 113.5 ppm Cu. This vein was also sampled by Grexton and Roberts (1991) at three different locations, and yielded gold values ranging from 14000 ppb to 41500 ppb (samples S173, S174, S175).

Mineralization on the North Side of the Abraham Creek Intrusive Complex

Mineralization within the northern part of the Abraham Creek mafic-ultramafic complex is represented by the Aupper (MINFILE 094D 139) and UPC occurrences. These occurrences correspond to the mineralization described by Grexton and Roberts (1991) from Croyden Ridge and Upper Porphyry Creek, respectively. The mineralization in both areas comprises gold-bearing quartz veins, in part localized along shear zones, scattered throughout east-west zones about 1 kilometre long. The quartz veins commonly contain pyrite, chalcopyrite and malachite; one vein within the Aupper showing contains pyrite and galena. A sample selected from a quartz vein containing 2 to 5 per cent chalcopyrite on the Aupper occurrence yielded 2700 ppb Au, 43.5 ppm Ag and 38064 ppm Cu (Grexton and Roberts, 1991, sample A96). A grab sample from a shear vein with only a trace of pyrite on the UPC occurrence contained 25000 ppb Au and 46.1 ppm Ag (Grexton and Roberts, 1991, sample S146).

Mineralization Within the North Kliyul Creek Dioritic Stock

The dioritic stock that crops out on the slopes east of the north fork of Kliyul Creek hosts mineralization represented by the KC 2 (094D 140) and Mal (094D 141) MINFILE occurrences. The Cro 2 occurrence is along the southwest margin of the stock about 1 kilometre south of the Mal.

Mineralization at the KC 2 occurrence covers a broad area along the northeast margin of the stock and extends into the Takla country rocks. It includes quartz veins and silicified or quartz-carbonate-altered shear zones mineralized with magnetite, pyrite, chalcopyrite, malachite and azurite, and locally galena and sphalerite (Wilson, 1984; Cross, 1985). Shear zones trend northwest, north and northeast. Samples of mineralized material have yielded assay values of up to 5484 ppb Au and 14.5 ppm Ag (Cross, 1985).

The Mal occurrence comprises variably oriented quartz-carbonate veins associated with fractures and shear zones that occur over several hundred metres along a major tributary to the north fork of Kliyul Creek. Some of the veins and shears are mineralized with pyrite, galena and malachite. A sample of one rusty quartz-carbonate vein containing disseminated pyrite yielded 16200 ppb Au and 3.10 ppm Ag (Wilson, 1984).

At the Cro 2 occurrence, rocks of the Takla Group are cut by silicified, chloritized and pyritized shear zones for at least several tens of metres along the southwest margin of the diorite stock. The zone contains small quartz-pyrite veins, and a sample of one of these veins contained 294 ppb Au and 5.40 ppm Ag (Fox, 1991).

Magnetite-Pyrite-Chalcopyrite Skarn Occurrences

Mineralization on the Soup North (MINFILE 094D 025) and Soup South (MINFILE 094D 105) occurrences consists of one and locally two stratabound layers of magnetite that are exposed intermittently over a strike length of more than 2.5 kilometres (McTaggart, 1965; Williams, 1997). These layers occur within volcaniclastic rocks of the volcanic sandstone unit, which dip at low to moderate angles into the steep southwest-facing slope on which the showings occur. The Takla Group in this area is intruded by abundant dioritic to microdioritic dikes. The mineralized layers exposed on surface are 1 to 5 metres thick and comprise 60 to 100 per cent magnetite with disseminated pyrite and chalcopyrite, and gangue minerals that include epidote, tremolite, garnet and calcite. Williams (1997) reports that an oblique drill intersection of 22.71 metres across one of the magnetite layers on Soup North contains 1.09 ppm Au and greater than 3915 ppm Cu. The best gold values, up to 68 ppm, occur in the Saddle Gully zone on Soup North, where segments of stratabound magnetite mineralization and cross-cutting mineralized shears are localized along a north-northeast-striking fault zone (Smit and Meyers, 1984; Williams, 1997).

The Kliyul magnetite-pyrite-chalcopyrite occurrence (MINFILE 094D 023) is located in an area of poor bedrock exposure within the broad valley, bounded by gossanous bluffs and talus slopes, at the head of Kliyul Creek. Geology projected from the south and north suggests that the volcaniclastic rocks that host the mineralization are within the sandstone-carbonate unit of the Takla Group. The area was staked in 1970 and explored with silt, soil and geophysical surveys. Copper-gold mineralization associated with magnetite was discovered in 1974 by a drill program that tested a magnetic anomaly. Exploration by various companies subsequent to the initial discovery included diamond drilling in 1981 and reverse circulation drilling in 1993. The latter program extended the known skarn mineralization and suggested that the resource estimate of 2.5 million tons grading 0.3 per cent Cu an 0.03 ounces/ton Au from the initial drilling could be increased (Gill, 1993).

The Pacific Sugar skarn showing, located about 1 kilometre north of the Kliyul occurrence, was discovered in the mid 1990s. It is hosted by the volcanic sandstone unit of the Takla Group, which at this location includes an interval of calcareous siltstones and limestones. Exploration work to date has outlined a magnetite-pyrite-epidote-garnet skarn unit measuring 40 metres by 100 metres and 3 to 6 metres thick (Gill, 1995). Mineralization consists of massive magnetite and pyrite containing disseminations, impregnations and clots of pyrrhotite and chalcopyrite. Endoskarned diorite in the footwall of the unit is inferred to be the source of the skarn mineralization. The skarn was tested with 5 diamond drill holes, with a cumulative length of 154.8 metres, in 1996. Significant drill results include 2048 ppm Cu and 625 ppb Au over 3.97 metres (Leriche and Harrington, 1996).

Mineralization Associated with Diorite on the Northeast Margin of the Darb Creek Pluton

Numerous small occurrences of pyrite and chalcopyrite, are found within and adjacent to the dioritic stock located along the northeast margin of the Darb Creek pluton. This mineralization is described by Leriche and Luckman (1991a, b) and is represented by the Joh 2 (094D 167), Joh 4 (094D 165) and Darb (094D 135) MINFILE occurrences. Similar mineralization occurs at the Joh 7 occurrence, about 1 kilometre to the south-southeast, where Takla volcanic rocks are cut by numerous diorite dikes that may be related to the mineralized stock to the northwest (Gill, 1994).

The mineralization in this area occurs within the diorite stock, associated dikes and the Takla country rocks. Pyrite and chalcopyrite occur as disseminations, as blebs and disseminations in quartz veins, and in silicified shear zones. Malachite is commonly associated with the chalcopyrite, and also occurs as fracture and joint coatings in adjacent rocks. A 25 centimetre chip sample across a zone of disseminated chalcopyrite-pyrite, within the diorite stock at the Joh 4 occurrence, returned 2000 ppb Au, 13.8 ppm Ag and 21 517 ppm Cu (Leriche and Luckman, 1991b, sample KR 14).

Gold Quartz Veins Associated with the Darb Creek – Kliyul Creek Quartz-Pyrite Alteration Zone

A series of bright red and yellow outcrop bluffs and talus slopes define an irregular zone of quartz-pyrite±sericite alteration that extends from the head of Darb Creek for about 5 kilometres southeast, to the head of the north fork of Kliyul Creek (Figure 5). This conspicuous alteration attracted early prospectors in the area, who discovered the Ginger B (MINFILE 094D 014), Independence (094D 028) and Banjo (094D 029) gold-bearing quartz vein systems within and peripheral to the zone (White, 1948). The KC 1 occurrence, northeast of the Banjo, was discovered within the alteration zone at a later date (Fox, 1982).

The quartz veins at these showings are commonly found within shear zones that strike northwest, north or east, and are mineralized with various combinations of pyrite, chalcopyrite and galena. Significant gold and silver values have been reported from all of the occurrences (White, 1948; Fox, 1982; Christopher, 1986). A sample collected from a pyrite-chalcopyrite-bearing quartz vein on the Banjo showing during the 2003 mapping program contains 2251 ppb Au and more than 100 ppm Ag (sample 03PSC-93).

Gold Quartz Veins Associated with the Solo Lake Stock

Gold-bearing quartz veins within, and along the margins of, the Solo Lake stock are among the oldest documented mineral exploration targets within the study area. The Solo (MINFILE 094 D 012), Bruce (MINFILE 094D 013) and Goldway (MINFILE 094D 027) occurrences were explored in the mid 1940s and are described by White (1948). Exploration has continued intermittently to the present time, and new vein systems have been discovered, including the F vein (Pawliuk, 1985), the V3 occurrence (V1, V2 and V3 samples of von Rosen, 1986) and the Tar occurrence (MINFILE 094D 138; L veins of Richards, 1991).

The vein systems associated with the Solo Lake stock are well described by Richards (1991). Each occurrence shown on Figure 4 comprises a number of veins, with individual veins ranging from several metres to several hundred metres in length, and from a few centimeters to several metres in width. Gold and silver ratios are commonly near one to one, and the precious metals are associated with pyrite, and locally galena and sphalerite. Visible gold has been reported from the A and C veins of the Bruce occurrence. The A vein has returned assay values up to 74.19 grams/tonne Au over 29 centimetres (Phendler, 1984).

The geometry of the vein systems is most apparent at the Solo and Bruce occurrences, where individual veins are arranged en echelon within northwest-striking zones that approach one kilometre in length. Individual veins strike more northerly than the overall system, and are inferred to occupy extensional fractures within dextral shear systems (Richards, 1991). Alteration related to the veins is minimal, and Richards (1991) suggests that the veins may be related to fault movements during the late stages of emplacement and cooling of the Solo Lake stock.

Gold Quartz Veins and Stockwork within the Mariposite Creek Alteration Zone

A zone of quartz-ankerite-pyrite alteration, marked in part by conspicuous orange-brown-weathered outcrops, extends north and south of upper Mariposite Creek for a total length of about 5 kilometres (Figure 5). Quartz veins are an integral part of this alteration, and exploration at the Glacier (MINFILE 094D 136) and Mariposite (MINFILE 094D 137) occurrences, where veins are particularly dense, has been directed towards evaluating the area's potential to host a bulk tonnage gold deposit. Gill (1996) reports that 743 rock samples collected in the area of the Mariposite and Glacier occurrences included 70 samples (9 per cent) that contained greater than or equal to 500 ppb Au. Two diamond drill holes on the Mariposite occurrence intersected high density quartz-carbonate vein and stockwork intervals, but these contained only weak gold mineralization (Gill, 1996).

Davie Creek Moly (MINFILE 094D 113)

Porphyry molybdenum mineralization is associated with the Davie Creek stock, which intrudes hornblendite and associated rocks of the Abraham Creek complex on the south side of lower Porphyry Creek. The stock and associated mineralization was discovered by Rio Tinto in 1963, and was explored by diamond drilling in 1964. Subsequent drill programs by various companies in 1979, 1981 and 1982 have demonstrated that much of the stock is mineralized (Folk, 1979a; Bowen, 1982; Norman, 1982). Molybdenite occurs in quartz veinlets with pyrite and local traces of chalcopyrite, and along dry fractures. The mineralization is commonly associated with strong K-feldspar alteration. Soil and rock sampling indicate that the molybdenum mineralization is flanked by peripheral zones of tungsten and copper enrichment (Folk, 1979b).

Other Occurrences

KLI (MINFILE 094D 019)

The Kli occurrence, on the slopes southwest of Kliyul Creek near the southern boundary of the map area, consists of small skarn zones along the sheared contact between an ultramafic-mafic plug and the sandstone-carbonate unit of the Takla Group (Noel, 1971b). Mineralization consists of irregular disseminations of chalcopyrite and pyrite within epidote-calcite-garnet-quartz-diopside(?) skarn.

GALENA RIDGE (MINFILE 094D 059)

The Galena Ridge showing comprises a northeast-striking quartz vein, up to 30 centimetres wide, within Takla volcaniclastic rocks about 1 kilometre south-southeast of the confluence of Mariposite and Goldway creeks. The vein was discovered in 1984 during an exploration program by BP Resources Canada Limited in the area between Goldway and Dortatelle creeks. The vein contains 10% pyrite, 5% galena and minor chalcopyrite. A high-grade grab sample from the vein contained 4000 ppb Au and 170.6 ppm Ag (Meyers and Smit, 1985).

JOH 1 (MINFILE 094D 168)

The Joh 1 occurrence is within diorite of the Johanson Lake mafic-ultramafic complex, about 1 kilometre west of Darb Lake. It comprises a limonite and malachite stained quartz vein, about 60 centimetres wide, containing minor blebs of chalcopyrite. A chip sample across this vein returned 3479 ppm Cu and 4200 ppb Au (Leriche and Luckman, 1991a).

JOH 3 (MINFILE 094D 169)

The Joh 3 occurrence, hosted by fractured diorite and microdiorite about 1 kilometre west of Darb Creek, consists of shear zones and quartz veins sparsely mineralized with pyrite and chalcopyrite. The showing is centred on a north-northwest striking vertical shear zone, about 3 metres wide, that contains disseminated pyrite. A one metre chip sample across this zone yielded 5900 ppb Au, 1338 ppm Cu and 1.9 ppm Ag (Leriche and Luckman, 1991b). About 200 metres south of this shear zone is a gently-dipping quartz vein, one to three metres wide, that locally contains minor amounts of pyrite, chalcopyrite and malachite. A 40 centimetre chip sample within a relatively sulphide-rich part of this vein yielded 2508 ppm Cu, 5.4 ppm Ag and 356 ppb Au.

JOH 9 (MINFILE 094D 170)

The Joh 9 occurrence consists of a rusty quartz vein containing disseminated pyrite, collected from a northwest-dipping shear zone along the southern contact of the Darb Creek pluton. A 64 centimetre chip sample across the vein contained 1100 ppb Au (Leriche and Luckman, 1991b, sample KR08).

JOH 11 (MINFILE 094D 171)

The Joh 11 occurrence refers to a grab sample of hornfelsed volcanic rock collected by a claim staker on the Joh 11 claim, a short distance west of Johanson Lake. The sample was submitted for assay and returned 2288 ppm Cu, 8.3 ppm Ag and 1200 ppb Au (Leriche and Luckman, 1991a, sample 14940).

KP0274

Grab sample KP0274 was collected from a northeast trending zone of quartz veins, about 20 centimetres wide, that cuts the Takla volcanic sandstone unit 1.5 kilometres east of Solo Lake. The sample yielded 5500 ppb Au (Gill, 1996).

SUMMARY

The Takla Group within the Kliyul Creek – Johanson Lake area has been subdivided into 2 major divisions. The lower division, represented mainly by the volcanic sandstone unit, comprises massive to well-bedded, commonly feldspar-rich, volcanic sandstones, intercalated with volcanic breccias and local mafic flows. The sandstone-carbonate unit, also included in the lower division, is made up of similar rocks, but with significant amounts of limestone that in large part occurs within slump breccias and as clasts in conglomerate. The upper division, comprising the volcanic breccia unit, consists of massive pyroxene-rich volcanic breccias and pyroxene porphyry flows. This two part subdivision of the Takla Group is similar to the lower and upper divisions that have been applied to the Plughat Mountain succession of the Takla Group to the east and southeast of the map area (Ferri *et al*., 1992, 1993, 2001a, b).

The Takla Group is cut by numerous plutons that are tentatively subdivided into three suites. The oldest comprises clinopyroxenite, hornblendite, gabbro and diorite of the Abraham Creek and Johanson Lake mafic-ultramafic complexes, as well as several diorite stocks that are similar to the dioritic phases within those complexes. These rocks are suspected to be Late Triassic –Early Jurassic in age They are cut by tonalite and quartz diorite of the Darb Creek and Johanson Creek plutons, which must be younger and are suspected to be Early(?) Jurassic. The Kliyul Creek and Davie Creek granodiorite plutons are the youngest plutonic rocks in the area, and are suspected to be Cretaceous following Woodsworth *et al*. (1991). U-Pb dating in progress will provide some constraints with which to test these assignments.

Northwest-striking sinistral faults are recognized in the southeastern part of the map area and are thought to predated the dextral faults that dominate much of the region's structure. The sinistral faulting may have been coincident with some of the mafic magmatism, and sinistral faults appear to control some of the copper-gold mineralization in the Abraham Creek complex.

Copper and gold mineralization, occurring as veins and disseminations, magnetite-pyrite-chalcopyrite lodes in shear zones, and magnetite-pyrite-chalcopyrite skarns, is widespread within the area. It is in large part spatially associated with the mafic-ultramafic intrusive rocks, and with substantial alteration zones at Mariposite Creek and the head of Kliyul Creek. A number of the occurrences have significant gold values that warrant more investigation. Porphyry molybdenum mineralization associated with the Davie Creek stock is thought to be much younger and probably Cretaceous in age.

ACKNOWLEDGMENTS

I thank Sen Huy-Tan for his capable and enthusiastic assistance during fieldwork. I am also grateful to Carl Edmunds and Chris Rockingham of Northgate Exploration Ltd. for their interest in the area, and for entering into the partnership agreement that provided the funding necessary for fieldwork.

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