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GEOLOGY AND MINERALIZATION OF THE ATLIN AREA, NORTHWESTERN BRITISH COLUMBIA (104N/11W and 12E)

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KEYWORDS: Regional geology, Atlin, Cache Creek Group, Cretaceous intrusions, stratigraphy, structure, lode gold, placer gold.

INTRODUCTION

A regional mapping project was begun in the Atlin area during the 1988 field season, following a compilation project started by D.V. Lefebure and M.H. Gunning in 1987. An area of 780 square kilometres was mapped at a scale of 1:50 000 during this first year of a proposed 4-year program. The map area is underlain by a thick succession of Paleozoic sedimentary and volcanic rocks of the Cache Creek Group which are intruded by Cretaceous granodiorite to granite. Placer mining has been ongoing in the Atlin area since 1898 and continues to be a major component of the local economy. Current exploration is focused on lode gold sources of the placer deposits.

PREVIOUS WORK

Gold in the Atlin camp was first discovered in 1898, by Miller and McLaren, on Pine Creek. Geological work in the early part of the century was conducted by both the Geological Survey of Canada and the Bureau of Mines, and is summarized by Gwillim (1901) and Cairnes (1913). During the 1950s and 1960s the Geological Survey of Canada conducted mapping in northwestern British Columbia and completed a 1:250 000-scale map of NTS sheet 104N and an accompanying memoir (Aitken, 1959). Several other publications also resulted from this work (Aitken, 1953; Gabrielse and Wheeler, 1961; Monger, 1966, 1967, 1968).

Several studies have addressed the stratigraphic problems within the Cache Creek Group (Link, 1965; Monger, 1975). Monger examined the Cache Creek Group in specific locations within the Atlin terrane, to better understand its stratigraphic relationships and tectonic framework. Lithogeochemical studies have focused on the Surprise Lake batholith, with which a significant uranium anomaly is associated (Ballantyne and Littlejohn, 1982). Recent geological investigations have focused on the lode gold mineralization of the area (Andrew, 1985; Lueck, 1985; Newton, 1985). Morphological and chemical characteristics of the placer gold have been examined (MacKinnon, 1986) and characteristics of placer and lode gold within the Atlin terrane have been compared (Ballantyne and MacKinnon, 1986).

REGIONAL SETTING

The map area is largely underlain by Mississippian to Upper Triassic rocks of the Cache Creek Group intruded by Cretaceous batholiths. The Cache Creek terrane (Monger *et al.*, 1982) is an important element in the Intermontane Belt, and outcrops almost continuously throughout the length of British Columbia (Figure 1-33-1). In northern British

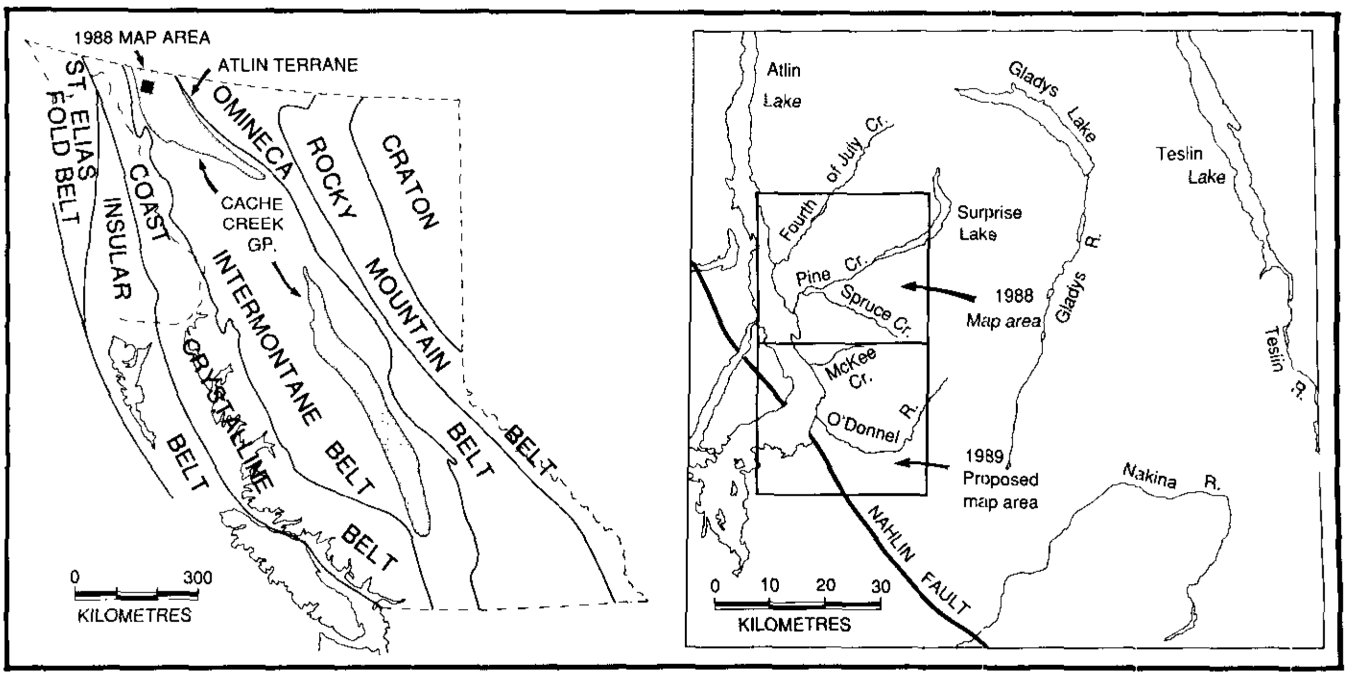

Figure 1-33-1. Location of the Atlin project and the distribution of the Cache Creek Group rocks throughout British Columbia (modified after Wheeler and McFeely, 1987).

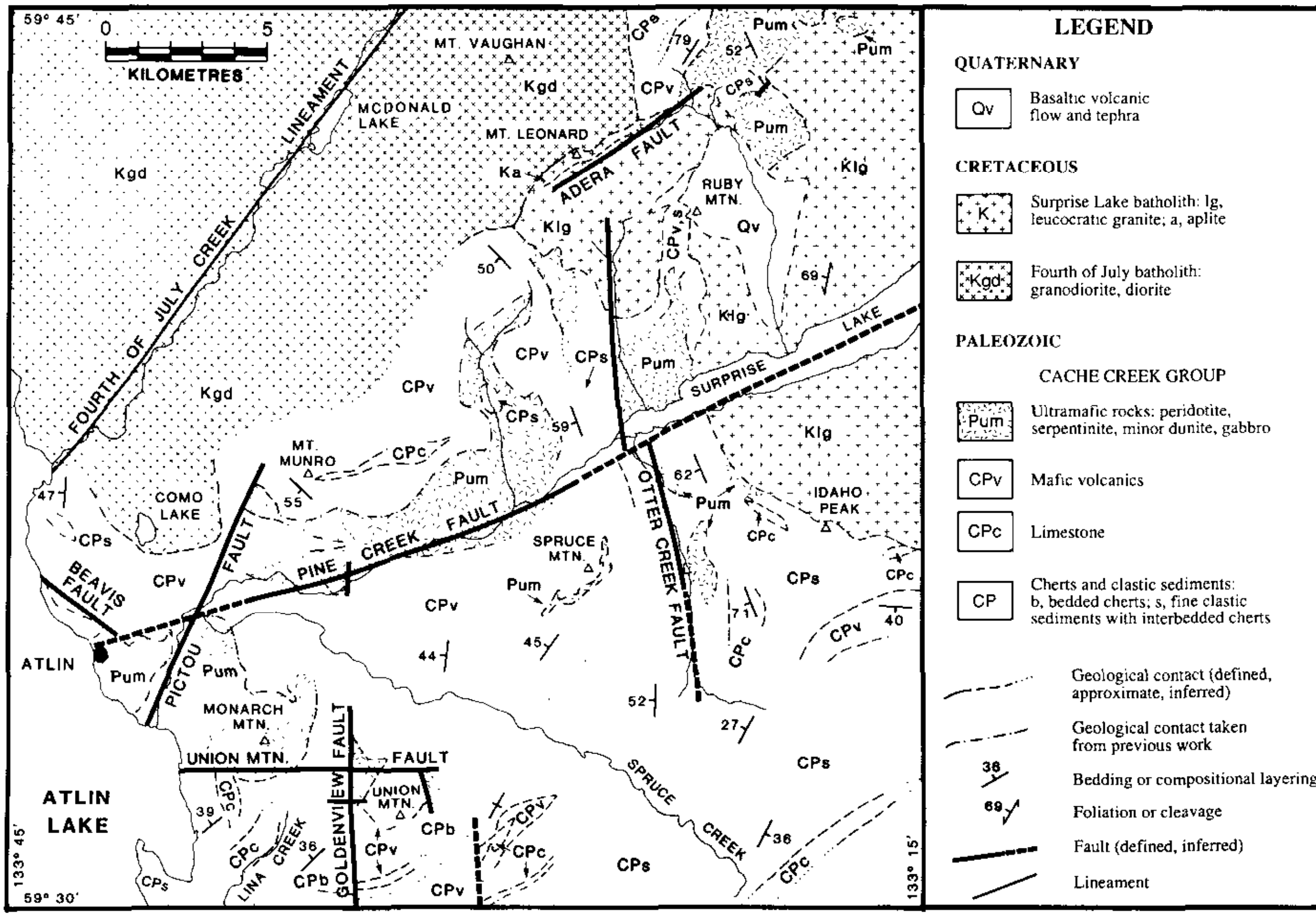

Figure 1-33-2. Geology map (104N/11W, 12E).

Columbia and the southern Yukon it is referred to as the Atlin terrane. The Atlin terrane is bounded to the west and southwest by the Stikine and Nisling terranes (Mihalynuk and Rouse, 1987), onto which it was thrust in the Middle or Late Jurassic (Monger, 1984), mostly along the Nahlin fault (Figure 1-33-1). The eastern boundary of the terrane is the subvertical Thibert Creek fault, which trends northwestwards into the Teslin lineament. It separates the Atlin terrane from deformed and metamorphosed Paleozoic and Mesozoic rocks to the northeast (Monger, 1975).

The main lithologies in the Atlin terrane are radiolarian chert, argillite, carbonate, submarine tholeiitic basalts and alpine-type ultramafic rocks. They are typically metamorphosed to subgreenschist grade (Monger, 1984). Cache Creek rocks are intercalated on all scales, although there is greater stratigraphic continuity in the Atlin terrane than in southern British Columbia.

In the Atlin terrane, Mississippian to Pennsylvanian basalt of the Nakina Formation represents the basal unit of the stratigraphic sequence (Monger, 1975). It is overlain by radiolarian chert and clastic sediments with lesser carbonate and volcanics of the Kedahda Formation. Interfingering of these two units is characteristic of the sequence. They are gradationally overlain by Upper Mississippian to Upper Permian Horsefeed Formation, a carbonate sequence 2000 metres thick, which in turn is unconformably overlain by clastic rocks of possible Mesozoic age (Monger, 1975).

Mafic and ultramafic rocks, mainly serpentinized peridotite and less common dunite and gabbro, range from linear bodies many tens of kilometres long, to pods and slivers a few metres in length. These rocks were called the "Atlin Intrusions" by Aitken (1953, 1959), and interpreted as coeval with the Nakina Formation basalts because of their close spatial association. Monger (1977) suggested that the large Nahlin ultramafic body may represent oceanic basement upon which the Nakina Formation was deposited.

LITHOLOGY

Rock exposure is best on the ridges above treeline (1370 metres), although felsenmeer is extensive and contacts are rarely exposed. Elsewhere outcrop is poor due to extensive glacial overburden except where creeks and placer mining have exposed bedrock.

CACHE CREEK GROUP

Clastic Sediments and Cherts (Unit CP):

Argillaceous sediments (CPs) underlie much of the southeastern part of the map area (Figure 1-33-2). The sediments are very siliceous, dark grey to black in colour, and very fine grained. They are almost always interbedded with some chert and contain thin, pale grey-weathering siltstone beds (Figure 1-33-3) which may comprise a significant component of the

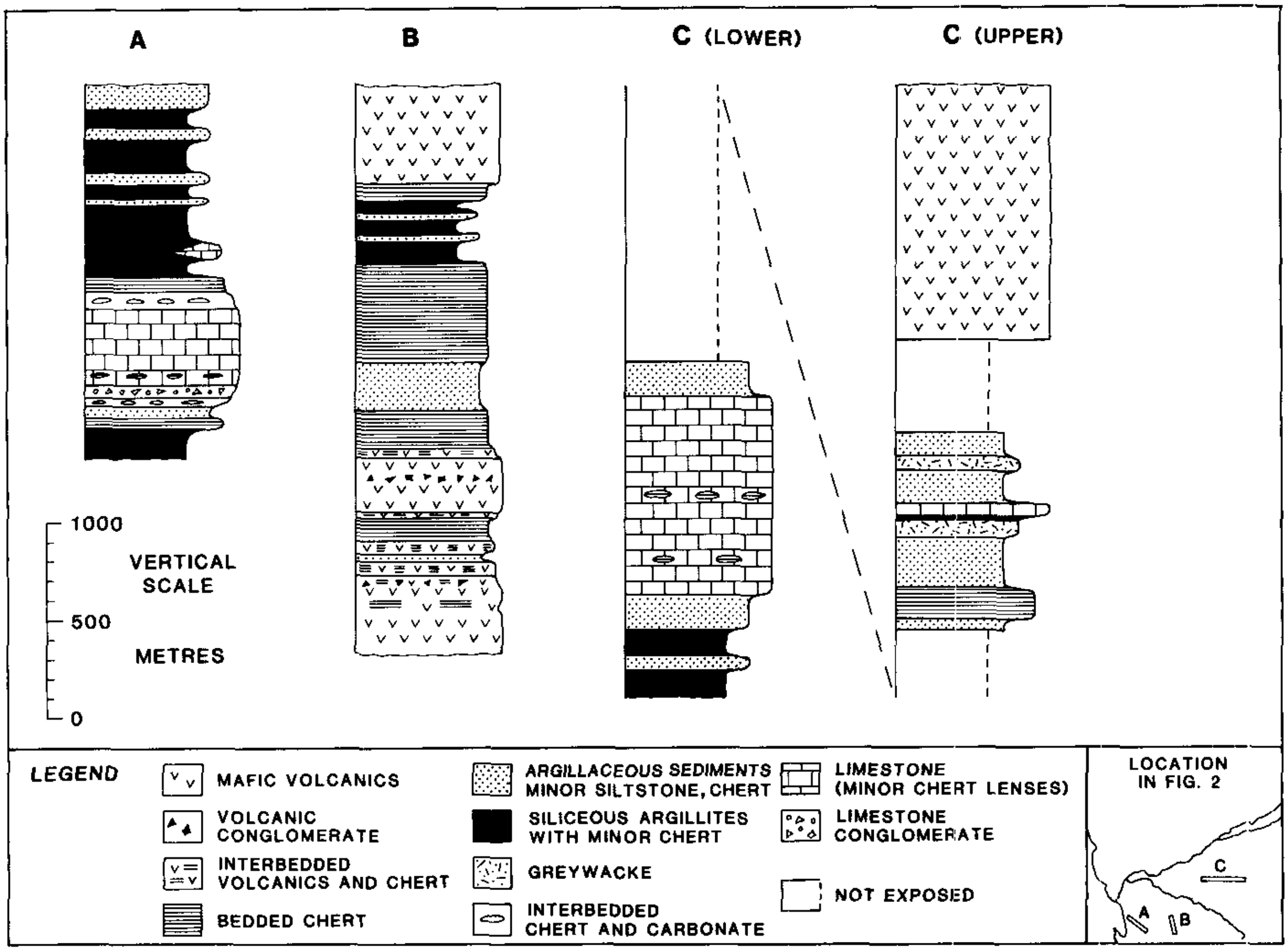

Figure 1-33-3. Stratigraphic columns emphasizing the relationships observed within the Cache Creek sediments.

section. The chert occurs as centimetre-scale discontinuous lenses and discrete beds, and may comprise up to 30 per cent of the unit. Locally, the fine-grained siliceous sediments have a flinty parting resembling cherts despite the significant clastic component.

Pure bedded cherts (CPb) are relatively rare except in the vicinity of Union Mountain and Lina Creek (Figure 1-33-3); they are microcrystalline, pale to dark charcoal-grey or rarely reddish brown in colour, and weather grey to off-white. The cherts are regularly bedded (ribbon bedded) with beds 2 to 10 centimetres thick, intercalated with thin beds of argillaceous sediments (Plate 1-33-1) and less commonly associated with the coarser, silty sediments. At Lina Creek, the chert is locally calcareous and is in gradational contact with limestone. The transition is marked by repetitive interbedding of discontinuous lenses and beds of both chert and limestone (Column A, Figure 1-33-3).

Greywacke is widespread though not abundant in Unit CP. It is a distinctive pale, buff-orange weathering, fine to medium-grained rock, usually interbedded with chert or silty argillite, and has a distinctive flaggy parting. On a ridge east of Spruce Mountain, the greywacke overlies finer clastics and contains clasts of the underlying sediments. It is gradationally overlain by limestone and becomes distinctly calcareous near the contact. These relationships are interpreted as facies transitions between the lithologies.

Limestone/Dolostone (Unit CPc):

Throughout the area, carbonate rocks are in contact with all other Cache Creek lithologies. Typical carbonates are mottled grey to white, fine to medium-grained limestones. Rare buff-weathering carbonate, which reacts poorly with 10 per cent hydrochloric acid, is interpreted as dolostone. Macrofossils are very rare but include shell and crinoid debris and a gastropod. The limestone is usually massive and bedding is obscure. Small limestone bodies are locally foliated at their contacts, larger bodies generally lack foliation. Gradational contacts are locally marked by limestone conglomerates and breccias (Figure 1-33-3). The limestone frequently occurs as large lensoid bodies, that stand out in the landscape due to their distinctive pale weathering colour (Plate 1-33-2).

Recrystallization and skarn alteration of limestone is common near the Surprise Lake batholith. Recrystallized limestone is medium to coarse grained, medium to dark grey in colour and weathers pale grey to white. It contains

Plate 1-33-1. Outcrop photograph of the typical association of cherts interbedded with fine argillaceous sediments.

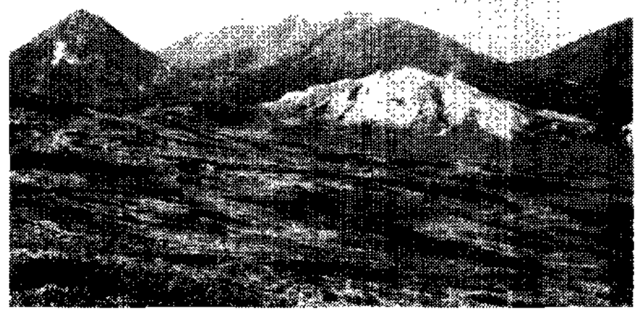

Plate 1-33-2. Larger bodies of limestone frequently have a lensoid geometry and are prominent features on the landscape due to pale weathering characteristics.

centimetre-scale beds or pods of green to brown-weathering, fine-grained calc-silicate. These are most common near contacts with clastic sediments and cherts or volcanics, and locally contain disseminated pyrite.

Volcanics (Unit CPV):

Massive mafic flows with lesser volcanic breccia and tuff comprise the volcanic assemblage. These lithologies underlie much of the central part of the map area; the best exposures are on Union Mountain and Spruce Mountain.

Textural rather than compositional variations seem to characterize the volcanic succession. The massive flows are pale to medium green on fresh and weathered surfaces, aphanitic to fine grained, and homogeneous. They are rarely porphyritic and, when present, phenocrysts of pyroxene and chalky weathering feldspar rarely exceed 1 millimetre in size. Pillow structures have been recognized on Sentinel Mountain (Monger, 1975) immediately south of the map-area, but no definite pillow structures have been observed within the flows of the Atlin area, except in talus at the southeastern boundary of the map area.

Fine-grained, irregular colour laminations within the flows are interpreted as primary flow banding. Individual laminations vary in colour from pale to medium green and range in thickness from 2 to 50 millimetres. They are generally discontinuous and have diffuse to wispy terminations along strike. A very mottled fragmental texture on the weathered surface is characteristic.

Volcanic breccias within the flows typically contain rounded to subrounded clasts ranging in size from 3 to 30 centimetres. The clasts appear to be compositionally equivalent to the surrounding matrix, but are coarser grained and more porphyritic. Boundaries vary from sharp to diffuse, and may represent autobrecciation of the flow.

At Union Mountain lenses of chert (up to 1 metre in length) interfinger with the volcanics at the base of the sequence, suggesting a gradational contact between the sediments and volcanics. Also at Union Mountain, the base of the volcanic assemblage is locally marked by a thin tuff unit containing small vitric and lithic fragments.

Ultramafic Rocks (Unit PUM):

Peridotites, dunites and serpentinites comprise the ultramafic assemblage. Ultramafites occur as lensoid bodies, concordant with the stratigraphy (Figure 1-33-2). Contact relationships are obscured by shearing. On Monarch Mountain there is near continuous exposure of relatively unserpentinized ultramafic rocks in excess of 1 kilometre thick.

Peridotites dominate the unit and are typically khaki-brown to orange-weathering and green to black in colour. Texturally the peridotites vary from fine grained to moderately coarsely crystalline. Large pyroxene grains, ranging from 1 to 2 centimetres in length, are more resistant to weathering than the olivine-rich groundmass and form prominent knobs on weathered surfaces. Locally, glomeroporphyritic masses of pyroxene form large resistant clusters up to 15 centimetres in diameter. The best exposures of this texture occur on the ridge west of Boulder Creek.

Along the summit ridge, and to the west and north of Monarch Mountain, the pyroxenes occur in planar concentrations, defining a distinctive banding which may be interpreted as cumulate layering or a tectonite fabric (Plate 1-33-3). Individual layers vary in thickness from 1 to 50 centimetres, averaging 5 centimetres. Magnetite is locally abundant, occuring as fine segregations and individual grains up to 3 millimetres across.

Dunite has been mapped at the summit of Monarch Mountain where it occurs in sharp and conformable contact with the banded peridotites (Plate 1-33-4). The dunite is distinctively pale-weathering, very equigranular and dark green on the fresh surface. Small chromite grains, 1 to 3 millimetres in size, are evident on the weathered surface. The dunite occurs as a lens 10 metres wide and several tens of metres in length.

Discrete planar segregations of magnetite, commonly rimmed by fibrous serpentine, are an interesting textural variation. They are observed on Monarch Mountain, Mount Munro and Mount Barham, but are not continuous along strike. The segregations are generally less than 5 millimetres in thickness, usually with a preferred planar orientation, but are often crosscut by subparallel segregations of the same composition.

Plate 1-33-3. Large pyroxene crystals define a prominent banding within the peridotites, and may represent either cumulate layering or a tectonite fabric.

Serpentinization of the ultramafics is pervasive within fault zones and along lithologic contacts. It has resulted in a penetrative anastomosing fabric and complete retrogression of the primary mineralogy to serpentine minerals.

CRETACEOUS INTRUSIONS

Fourth of July Batholith (Unit KGD):

The Fourth of July batholith is a multiphase Cretaceous intrusion (Aitken, 1959). It underlies the northwestern quadrant of the map area where it varies from biotite hornblende diorite to granodiorite; its eastern limit is north and east of Mount Leonard. Aitken correlated the Fourth of July batholith with the Coast intrusions; Christopher and Pinsent (1979) obtained potassium-argon ages of 73.3 ± 2.6 Ma and 110 ± 4 Ma from biotite and hornblende, respectively.

The eastern phase is most typical of the Fourth of July batholith within the map area. It is well exposed north of Mount Leonard and in the Mount Vaughan area. North of Mount Leonard the batholith comprises coarse-grained hornblende diorite; elsewhere it is characterized by coarse-grained, equigranular hornblende biotite granodiorite.

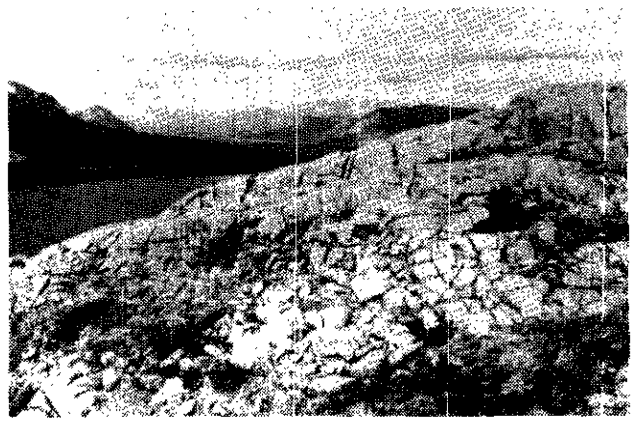

Plate 1-33-4. A sharp contact between dunites and peridotites on Monarch Mountain. The dunites, in the foreground, weather a pale blonde colour in contrast to the overlying peridotites.

Hornblende is ubiquitous. Xenoliths occur locally and consist of fine to medium-grained diorite up to 10 centimetres in size.

North of Como Lake the batholith consists of dull pink to grey-weathering megacrystic granite. Euhedral potassium feldspar megacrysts, up to 5 centimetres in size, comprise approximately 20 per cent of the rock volume, surrounded by the coarse-grained quartz and plagioclase-rich groundmass. Fine-grained biotite-rich mafic dykes are prevalent in this phase of the batholith and range from 5 centimetres to 150 centimetres in width.

Finer grained equivalents of the megacrystic granite have been recognized along the eastern shore of Atlin Lake. This variation is typically pale grey to pink-weathering, with small, acicular, black hornblende crystals. It occurs both as a minor phase within the batholith, and as dykes crosscutting the Cache Creek rocks along its southwestern margin.

Surprise Lake Batholith (Units Klg, Ka):

The Surprise Lake batholith underlies the northeast quadrant of the map area. Leucocratic granite (Klg) characterizes the batholith and is well exposed on Idaho Peak. Christopher and Pinsent (1979) report an average biotite potassium-argon age of 70.6 Ma. The granite is generally coarsely crystalline and equigranular, composed of smokey quartz, chalky plagioclase, potassium feldspar and accessory biotite. The presence of very smokey quartz is unique to the Surprise Lake batholith.

Satellitic to the main body is the Mount Leonard stock, within which several different phases have been mapped. The main granitic phase has similar weathering characteristics to the granite in the Idaho Peak area, but is not as coarsely crystalline. A granitic aplite phase (Ka) marks the contact between the Surprise Lake and Fourth of July batholiths. This marginal phase is traceable over a strike length of approximately 2.5 kilometres, from the summit of Mount Leonard to west of Boulder Creek (Figure 1-33-2). The aplite is grey to white on fresh and weathered surfaces, and is characterized by a very sugary equigranular texture. Smokey grey quartz-eyes up to 5 millimetres in size are locally developed. Plagioclase is present as small lath-shaped crystals up to 1 centimetre in length. Minor amphibole occurs as green, bladed crystals, immediately east of the Mount Leonard summit. This occurrence of hornblende is anomalous within the Surprise Lake batholith.

Quartz-eye porphyry dykes are also present in the Mount Leonard area and range from 1 to 5 metres in width. The dykes are typically grey to rusty weathering and grey on the fresh surface, with an aphanitic to phaneritic groundmass supporting smokey quartz-eyes up to 1 centimetre in diameter.

STRUCTURE

FAULTING

The dominant structures in the Atlin area are characteristic of brittle deformation. Faults and fractures are recognized throughout the area, and occur in all lithologies. The truncation of lithologic units, localization of intense brittle deformation, imbrication of diverse lithologies and linear physiographic features comprise the field evidence supporting fault traces. Fault movement along lithologic contacts is indicated by the pervasive shearing along many contacts. Shearing and serpentinization are characteristic of all ultramafic contacts. Reactivation of the fault zones is indicated by crack-seal textures within associated vein systems, crosscutting relationships of veins of differing composition, and zones of repeated brecciation.

Two major fault systems have been mapped (Figure 1-33-2). A series of east-northeast-trending faults occurs throughout the area, represented by the Pine Creek, Union Mountain and Adera faults, as well as many minor structures not shown on the map. A north-trending fault system is represented by the Golden View and the Otter Creek faults. A complimentary system of shears is developed parallel to the east-northeast structural trend on the Atlin Ruffner property. The Beavis and Pictou faults are oblique to the major trends. The Fourth of July Creek lineament also trends oblique to the major trends and is a prominent topographic feature.

FOLDING

The structural trends indicate that the stratigraphic sequence has been deformed into a broad northwesterly plunging synform. Mesoscopic fold structures are weakly developed and are generally absent. They are manifest as broad, open warps of bedding. Where a sense of asymmetry is observed, it is compatible with a regional synformal geometry. An axial-planar cleavage is locally developed within the argillaceous sediments, striking northwest and dipping moderately to the west. An intersection lineation, defined by the intersection of cleavage on the bedding surface, plunges shallowly northwest.

ALTERATION AND MINERALIZATION

Mineralization and alteration are often concentrated along the fault zones which may have acted as a pathway for hydrothermal fluids. Alteration envelopes are associated with virtually all known lode gold deposits in the Cache Creek rocks and provide larger and more obvious exploration targets than the veins themselves. Within the alteration envelopes, primary textures of the protolith are commonly destroyed. At least three stages of alteration have been recognized; serpentinization and carbonitization preceded listwanitic alteration, intense silicification and the development of quartz veins and stockworks which host the gold mineralization. Ballantyne and MacKinnon (1986) have suggested that the gold is introduced during a post-listwanitic stage, which is compatible with relationships observed elsewhere.

Serpentinization of the ultramafic rocks is manifest as veinlets, arcuate fractures and massive replacements. Hydration of olivine has resulted in the development of magnetite and serpentine; the serpentine minerals include chrysotile, antigorite and lizardite. The magnetite produces a strong magnetic response which can be used to trace the serpentinites in areas of thick overburden.

Carbonate alteration is widespread in the ultramafics and associated Cache Creek rocks. The ultramafics have been altered to ferroan magnesite or breunerite (Newton, 1985). Talc and mariposite occur within elongate orange to buff-weathering zones of carbonate alteration related to faulting or shearing. This is interpreted as listwanitic alteration, although pyrite is less abundant than in the classic Russian localities (Ballantyne, personal communication, 1987).

The mineral deposits in the Atlin area can be divided into four groups:

(1) lode gold deposits hosted by the Cache Creek Group and associated ultramafic rocks;
(2) vein-hosted silver-lead systems with associated copper, lead and gold;
(3) skarns, veins and porphyry systems related to the Surprise Lake batholith; and,
(4) placer deposits.

Auriferous quartz veins containing the elemental association of gold, silver, lead, zinc, bismuth, antimony, tellurium, arsenic, nickel, cobalt and carbon dioxide (Ballantyne and MacKinnon, 1986) are found only within the Cache Creek Group. Silver-lead systems such as Atlin-Ruffner are relatively rare, but may have a gold association. Skarns, veins and porphyry deposits containing diverse suites of elements (W, Sn, U, F, Zn, Pb, Co, Cu, Mo and Ag) occur within or adjacent to the Surprise Lake batholith. Placer deposits are derived from both groups of deposits.

LODE GOLD DEPOSITS

The Imperial, Yellowjacket, Lakeview, Surprise, Golden View, Pictou, and Beavis are some of the numerous auriferous quartz vein and stockwork prospects in the Cache Creek rocks (Figure 1-33-4). Many of the veins are located near contacts between the ultramafic and volcanic rocks. Veins vary from a few centimetres up to 2 metres wide and pinch and swell along strike. Individual veins can sometimes be traced for hundreds of metres; they contain quartz, carbonate and coarse gold with disseminations of pyrite, sphalerite, galena and chalcopyrite. Ore microscopy studies have identified the following metallic minerals: electrum to argentiferous gold, galena, sphalerite, gersdorffite, bismuthinite, tetrahedrite, hessite and tetradymite (Ballan-

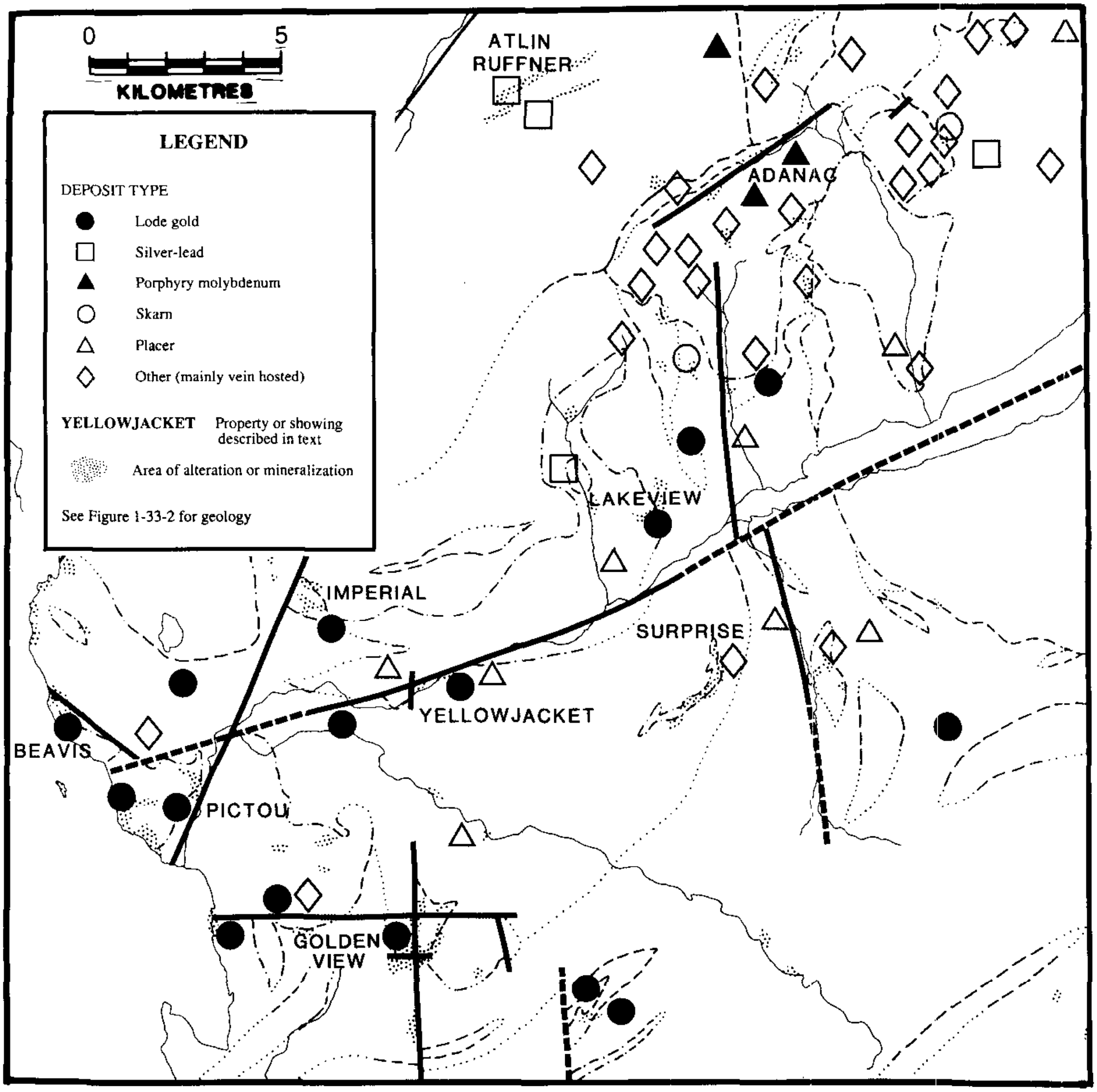

Figure 1-33-4. Mineralization and alteration within 104N/11W, 12E.

tyne and MacKinnon, 1986; Ballantyne, personal communication, 1987).

The age of mineralization for the lode deposits is younger than the host Cache Creek Group rocks, and is presumed to be older than the Fourth of July and Surprise Lake batholiths. Typically the batholiths contain a suite of elements significantly different from the Cache Creek hosted mineralization. Preliminary lead isotope data (Andrew, 1985) has been interpreted to give a Triassic age for mineralization at Surprise, Lakeview, Discovery and Golden View.

Imperial Property (MINFILE 104N 008)

The Imperial mine is on the southwestern flank of Mount Munro, approximately 8 kilometres northeast of Atlin. The ground was first claimed in 1899 and two adits were driven, with a total of 144 metres of underground development. Average grades of 13.7 and 5.1 grams per tonne gold respectively, were recovered from 245 tonnes of ore mined on the upper level, and 23 tonnes from the lower level. This is the only recorded lode gold production from the Atlin camp.

Mineralization is vein hosted, fault controlled, strikes northwest and dips moderately south. The wallrocks are serpentinized peridotites. Carbonatization of the host rock and local development of talc-carbonate schist are typical of the alteration along the fault zone. Gossanous patches are developed in areas a few centimetres across where pyrite is concentrated. Mariposite occurs within the carbonate alteration and is usually associated with millimetre to centimetre-scale quartz veinlets and stockworks. There is little visible sulphide mineralization but galena, chalcopyrite and pyrite have been recorded.

Yellowjacket Property (MINFILE 104N 014)

The Yellowjacket prospect is on Pine Creek, 9 kilometres east-northeast of Atlin. The lode gold was originally discovered by placer miners in 1899; a 30-metre shaft sunk at the turn of the century intersected an alteration zone containing quartz veins carrying visible gold. The shaft has since been covered by placer tailings and its location is unknown. No further work was done on the property until 1983 when Canova Resources Ltd. optioned the claims from local prospectors. Homestake Mineral Development Company acquired the property in 1986, and has completed a comprehensive exploration program including more than 10 000 metres of drilling which has delineated a zone 5 to 10 metres wide, extending 200 metres along strike and up to 90 metres down dip.

The Yellowjacket zone is located along the southern contact of a major ultramafic body with mafic volcanic rocks, and is coincident with the Pine Creek fault. Within the fault zone, numerous lenses of volcanic and serpentinized ultramafic rock are cut by dykes of diorite, gabbro and diabase. Rocks within the fault zone are intensely altered to carbonate, talc, chlorite, sericite and mariposite. Coarse electrum occurs in quartz veins 1 to 2 centimetres wide which form stockworks with grades of 3 grams per tonne gold or better over significant widths (Ronning, 1986; Lefebure and Gunning, 1988). Sparse arsenopyrite, pyrite and gersdorffite are also present in the veins.

Lakeview Property (MINFILE 104N 009)

The Lakeview property is approximately 16 kilometres northeast of Atlin, between Birch and Boulder creeks. Development in 1902 involved driving a 25-metre adit in the Lakeview quartz vein. Exploration did not resume until 1981 when Yukon Revenue Mines Ltd. acquired the property and obtained low-grade gold values in altered volcanics and quartz veins. Between 1982 and 1987 Cream Silver Mines Ltd. completed diamond drilling, detailed geological mapping, geochemical and geophysical surveys, trenching, blasting and bulk sampling.

The mineralization is hosted by quartz veins cutting carbonate-altered Cache Creek mafic volcanics, close to the contact with ultramafic rocks. The Lakeview vein occurs within a 30-metre-wide shear zone; it is at least 1.5 metres wide at the adit and has been traced for 800 metres along strike. The veins contain pyrite, galena, green chromium mica, gold, argentite and sphalerite.

Surprise Showing (MINFILE 104N 076)

The Surprise showing is on the northeastern flank of Spruce Mountain, 3 kilometres southwest of Surprise Lake. There is little recorded work history for the property, although it is briefly described in a 1925 Geological Survey of Canada Summary Report and several theses (Andrew, 1985; Newton, 1985).

Carbonatized ultramafic and volcanic rocks host the main quartz vein which is 3.5 metres wide. Talc-carbonate and silica-carbonate alteration are concentrated close to the contact between the two lithologies. Veins and stockworks contain disseminations of mariposite, galena and minor pyrite. Several mafic dykes occur parallel to the vein, trending south and dipping moderately to the west.

Golden View (MINFILE 104N 042)

The Golden View property is on the western flank of Union Mountain approximately 6 kilometres southeast of Atlin. Work on the property has been sporadic since it was first staked in 1899, and has involved some underground development and trenching (Newton, 1985). Descriptions of the property are included in Minister of Mines Annual Reports for the periods 1902-1938 and 1950-1971.

The property is underlain by Cache Creek mafic volcanic and ultramafic rocks. Quartz veins and stockworks host the mineralization which occurs within discrete lensoidal zones of quartz-carbonate (listwanite) alteration, along the trace of the Golden View fault. Mariposite, associated with listwanitic alteration, is frequently concentrated within thin bands while minor chalcopyrite, pyrite and malachite occur primarily as disseminations in veins and host rock.

Pictou Property (MINFILE 104N 044)

The Pictou prospect is west of Pine Creek, at the southern end of the new airstrip, 3 kilometres northeast of Atlin. A 20-metre adit and 7-metre shaft were excavated in 1900. In 1987 and 1988, Homestake Mineral Development Company conducted geophysical and geochemical surveys, surface trenching and diamond drilling. Gold assays as high as 13.5 grams per tonne gold have been obtained from quartz veins.

The mineralization is hosted by ultramafic rocks which have been extensively brecciated during carbonatization and silicification (Plate 1-33-5). Talc is a minor constituent of the carbonate alteration and quartz veins occur as stockworks, breccia veins and veinlets 2 to 10 millimetres wide. Coarse euhedral crystals frequently occur along vein margins, indicating open space filling. Gold mineralization is related to intense silicification associated with abundant green chromium mica, fine-grained chalcopyrite, pyrite and tetrahedrite.

Beavis Property (MINFILE 104N 011)

The Beavis property is 2 kilometres north of Atlin and 1 kilometre east of Atlin Lake. The property geology has been described in Minister of Mines Annual Reports between 1902 and 1933. Recent trenching has increased exposure dramatically.

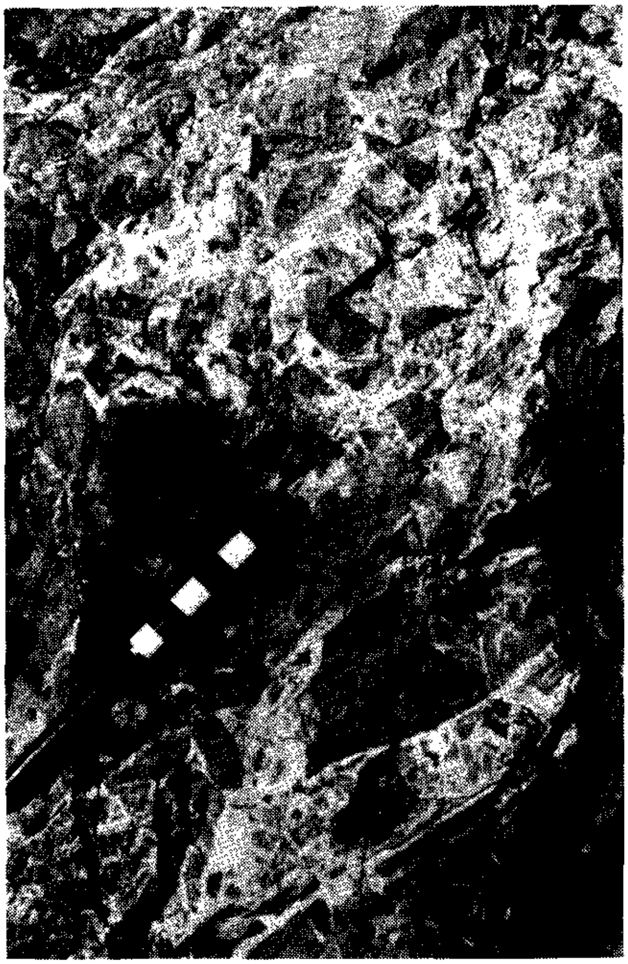

Plate 1-33-5. Intense brecciation of the host rock resulting from silica flooding following carbonate alteration on the Pictou prospect.

The mineralization is hosted within Cache Creek sediments and minor volcanics, close to the contact between volcanics and ultramafics. The contact is faulted and characterized by brecciation and intercalation of diverse Cache Creek lithologies. Gold is concentrated along this contact and is associated with carbonate-silica alteration, quartz stockworks and open space vein filling. Green mica and pyrite are disseminated within strongly silicified zones. Numerous crosscutting mafic and felsic dykes, believed to be related to the Fourth of July batholith, have been affected by the alteration and mineralization.

SILVER-LEAD SYSTEMS

Atlin Ruffner Mine (MINFILE 104N 011)

The Atlin Ruffner mine is south of Mount Vaughan, approximately 23 kilometres northeast of Atlin. The property was initially explored as a silver-lead-zinc prospect, with minor gold and copper. It has been described in numerous Minister of Mines Annual Reports from 1900 to 1968, and has had an extensive work history. Between 1974 and 1976, Atlin Silver Corporation milled approximately 1610 tonnes of ore and an additional 1082 tonnes were mined by Trident Resources Inc. (now Trident Industries Limited) during 1981. In 1988, Homestake Minerals commenced detailed geologic mapping and sampling of the property.

The mineralization is vein-hosted and confined to dioritic to diabasic dykes which crosscut granodiorite to quartz monzodiorite of the Fourth of July batholith. There are six mineralized dykes striking consistently east-northeast and dipping steeply northwest. They range in width from 1 to 8 metres, and one has been traced over a strike length of at least 2500 metres. The contacts of the dykes with the surrounding rock are sharp, but strongly sheared. They are characterized by intense brecciation and the development of quartz and quartz-carbonate stockworks within which massive galena, sphalerite and aresenopyrite are the principal sulphide minerals. Minor chalcopyrite, pyrite, tetrahedrite, bornite and molybdenite are also present in the stockworks. Crack-seal textures and open-space fillings are common in the veins.

MINERALIZATION RELATED TO THE SURPRISE LAKE BATHOLITH

The Surprise Lake batholith is a texturally varied leucocratic granite with biotite granite and granite porphyry phases, and is similar to other granites with associated tin-tungsten-uranium-molybdenum mineralization. The presence of roof pendants of Cache Creek volcanics near Ruby Creek and a down-faulted block of Cache Creek volcanics along the Trout Lake valley (Aitken, 1959) suggest the western part of the batholith is not deeply eroded. Typically the roof zone and apophyses of volatile-rich intrusions are favorable locations for mineralization. In the Surprise Lake batholith, wolframite, scheelite and cassiterite veins and minor greisen, often with associated fluorite, occur in the roof zone. The veins are best developed in the Mount Leonard stock, and on Mount Weir, outside of the current map area.

Skarn deposits are developed in the Cache Creek limestones immediately adjacent to the Surprise Lake batholith. Pyrite, pyrrhotite, chalcopyrite, galena, sphalerite and fluorite replace the recrystallized limestone in relatively small pods or lenses.

Uranium (14.6 ppm) and thorium (45.6 ppm) contents in the Surprise Lake batholith are high compared to most low-calcium granite bodies. The primary uranium minerals are believed to be syngenetic in origin, crystallizing at the same time as the major rock-forming minerals, but circulating magmatic and meteoric waters have remobilized and concentrated uranium in new locations within the batholith and adjacent country rocks (Ballantyne and Littlejohn, 1982). In the Mount Weir area the mineralization is derived from late magmatic fluids and is related to metasomatic alteration and enrichment of uranium. Kasolite, metazeunerite and wulfenite occur along fractures and fluorite, sphalerite and magnetite with minor cassiterite and niobium-bearing ilmenite are vein-hosted. Springs with an unusually high radon content are associated with faults in the batholith and may reflect hydrothermal fluids generated by convection cells driven by radiogenic heat. Buried, postmagmatic hydrothermal uranium concentrations may be developed along these faults. Ballantyne and Littlejohn (1982) have identified near-surface deposition of kasolite and metazeunerite on fractures in the batholith and anomalous concentrations of uranium in stream waters and sediments on and around the batholith, suggesting that leaching and redeposition of the uranium has occurred.

ADANAC MINE

The Adanac molybdenum deposit is in a porphyry setting in the multi-phased Mount Leonard stock, satellitic to the Surprise Lake batholith. First discovered in 1967, the deposit was being prepared for production in the early 1980s when a drop in molybdenum prices brought the project to a halt. Open-pit reserves are 152 million tonnes grading 0.063 per cent molybdenum (Christopher and Pinsent, 1979).

The Adanac mineralized zone consists of molybdenite as coatings on fractures and in quartz veins. Pyrite and rare chalcopyrite are restricted to the veins and fractures (Christopher and Pinsent, 1979). Wolframite, arsenopyrite, scheelite and fluorite occur in some veins within and peripheral to the mineralized zone which is hosted by quartz monzonite intruded by a weakly mineralized quartz monzonite porphyry. The Adera fault truncates the ore zone to the north. Propylitic to argillic alteration is indicated by chloritization of biotite, and plagioclase altered to sericite, clay and carbonate (White *et al.*, 1976). Locally potassic alteration extends up to 5 centimetres from fractures.

PLACER DEPOSITS

Placer deposits occur in river gravels deposited in channels up to 12 metres thick and 400 metres wide (MacKinnon, 1986). Gold, cassiterite, chromite, scheelite, and wolframite are concentrated in the channels. Formed during the Pleistocene, these placer gravels are a distinctive rusty or reddish colour, decomposed and cemented by clay, iron oxides or wad. During the Wisconsin glaciation the placer gravels were first buried by lacustrine sediments, then morainal debris and finally glaciofluvial and till deposits up to 100 metres thick (Milner, 1983). In some localities creeks have cut down through the former channels and have concentrated gold in the present creek bed. Comparison of placer nuggets and gold grains from lode deposits in the same area has proved the placer gold is derived from the lodes (MacKinnon, 1986; Ballantyne and MacKinnon, 1987).

The Atlin camp is among the largest producers of placer gold in British Columbia, with production of more than 19 000 kilograms since its initial discovery in 1898 (Debicki, 1983). Virtually all placer production has focused on the recovery of gold except for an attempt to recover wolframite on Boulder Creek during the early 1950s. Chromite, scheelite and wolframite were identified in significant concentrations; minor osmium, iridium and ruthenium alloys with minor platinum and palladium were also found in the placer concentrates (MacKinnon, 1986).

CONCLUSIONS

Field mapping has identified the following characteristics of the Cache Creek Group.

- A generalized stratigraphy can be defined for the entire map area.
- All sedimentary units occur interbedded with each other at scales from centimetres to hundreds of metres.
- Gradational contacts are observed between limestones and clastic sediments, cherts and clastic sediments, and cherts and volcanics.
- Hybrid lithologies such as limy chert, limy greywacke and intraformational breccias are typical of gradational contacts.

These observations suggest the Cache Creek Group rocks were deposited under similar conditions, near a source of clastic material and probably in a shallow oceanic basin or a back-arc setting. Previously the Cache Creek terrane has been interpreted as a tectonic mélange (Monger, 1984; Price *et al.*, 1985) although significant, faulting has not obliterated stratigraphic continuity in the Atlin area. As there is less structural disruption the Atlin terrane may provide a unique study area for the Cache Creek Group.

Field examination of the ultramafic rocks has shown that:

- Ultramafic bodies vary greatly in size.
- There is a close spatial relationship between the ultramafic and volcanic rocks, although smaller ultramafic bodies also occur in sedimentary sequences.
- Ultramafic contacts are sheared or faulted, with no chilled margins or contact metamorphism of adjacent rocks.
- Relatively pristine textures, such as pyroxene-rich bands and dunite layers, suggest that the ultramafics represent primary cumulate or tectonite features.

The ultramafic rocks were probably formed in the lower oceanic crust and subsequently tectonically emplaced into an oceanic-basin assemblage of volcanics and sediments. The larger masses of peridotite were structurally emplaced within the volcanics, and were obducted as a coherent wedge. Imbrication of the package created slivers of ultramafics which occur in contact with all Cache Creek lithologies.

Auriferous quartz veins have been shown to be the source of the placer gold deposits in the Atlin area (MacKinnon, 1986; Ballantyne and MacKinnon, 1986). Lode gold is almost exclusively restricted to quartz veining and stockworks associated with fault zones, anomalous geochemistry and intense listwanite alteration. Faults are common at ultramafic-volcanic rock contacts. Listwanites may grade inwardly to a talc-carbonate-mariposite-rich core, and these intense alteration envelopes are a common signature of major faults. The gold mineralization appears to be later than the listwanite alteration.

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