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KODIAK RESOURCES LIMITED

GEOLOGY OF ALBERT CANYON CLAIM AREA AS

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Part 2 - GEOLOGY

1. General Geology

The rocks of the area consist of a series of Lower Cambrian schists and gneisses which have been intruded by a variety of plutonic rocks. The age of these is unknown. The schists and gneisses have been folded into a large anticline which plunges moderately to the northeast. Albert Creek follows approximately the axial trace of this anticline so that equivalent rocks are found on both sides of Albert Canyon. The southwestern limb of the anticline is cut by intrusive rocks.

The metamorphic rocks have been divided into seven map-units based on lithology. These rocks belong to the Lardeau and Hamil Groups. The younger Lardeau Group is made up of a succession of phyllites and gneisses with minor limestone bands. The underlying Hamil Group rocks consist of quartzites, quartz-mica schists and several limestone bands which probably belong to the Badshot formation. The Hamil Group rocks represent more mature sediments than those of the Lardeau Group. Table 1 gives a generalized succession.

Underlying the Hamil Group is hornblende-biotite-quartz-plagioclase gneiss. It is lithologically distinctive and is an orthogneiss. It may be a wedge of basement rock which has been thrust up into the overlying metasediments during the earliest period of deformation.

Three separate intrusions have been mapped. These are, in order of emplacement, diorite, granodiorite and granite. The diorite has been further subdivided. They are high level intrusions, the roofs of which are now exposed. The may have formed during a single episode of magmatism and are probably connected at depth.

2. Description of the Metamorphic Rocks

(a) Hornblende-biotite-quartz-plagioclase gneiss (Map Unit 1)

In hand specimen the rock is medium-grained, greyish green in colour with a gneissic texture. Layers up to 3 mm thick of plagioclase and quartz are separated by thinner layers of biotite and hornblende. The well developed gneissosity is defined by parallel layers of aligned mafic minerals. Biotite is generally dominant over hornblende but some hornblende-rich bands are found. Many outcrops are cut by thin aplite and pegmatite dykes and veins, the rock is folspathised in places and grades from gneiss through a hybrid folspathic rock into granite. This is described in detail in conjunction with the description of the granite.

Thin section study shows that the rock consists of anhedral grains of strained quartz up to 1 mm in diameter. Long axes tend to parallel the foliation. Plagioclase is andesine (An_{36}) and forms anhedral grains 0.5 mm in diameter. Quartz and plagioclase (in a ratio of 1:1) make up 50% of the rock. Mafic minerals are biotite, hornblende and minor epidote. Tourmaline in quartz grains is an accessory mineral. Alteration is mild and consists of chlorite after biotite and traces of kaolinite in plagioclase.

This rock is lithologically dissimilar to the rocks of the overlying Hamil and Lardeau Groups and also to the Horsethief Creek Group which underlies the Hamil Group elsewhere in this region. It is an orthogneiss and may be a wedge of basement which has been thrust up during the earliest period of deformation to lie below the Hamil. Group. It has undergone the same deformation and metamorphism as the other metamorphic rocks in the area so is now apparently conformable with the overlying schists.

(b) Amphibolite and Limestone (Map Units 2 and 3)

Limestone crops on the northeast side of Albert Creek above Base Camp and on the high ground to the south and west of Camps 5 and 4. Two major bands. which are up to 200 feet thick, occur but they tend to thin and pinch out along strike. Several thin discontinous bands occur interbedded with quartzites and schists of Map Unit 2.

In hand specimen the rock is a grey weathering, white crystalline limestone consisting mainly of coarse-grained interlocking calcite crystals. Dolomite is a minor constituent. In places small amounts of serpentine are found. Thin section study shows this to have formed from olivine. Minor pyroxene was also observed. Rosettes of coarse tremolite crystals are common. The rock is poorly foliated or massive in character. The thinner bands tend to be moderately foliated, shown by alternating thin bands of grey and white limestone which grade into calcareous schists.

Skarn is developed in the limestone in places near the contact with granite. This is described in detail is the section on metamorphism.

Associated with the limestone are thin amphibolite beds. These occur 3000 feet southeast of Camp 4, immediately beneath one of the limestone units. Thin limestones are interbedded with the amphibolite which also crops out in thin discontinuous bands below the thinnest limestone bed above the Base Camp.

In hand specimen it is moderately or poorly foliated, medium-grained, dark green rock consisting of hornblende (75%), plagioclase (20%), and biotite (5%). Where biotite is absent or minor the rock tends to be more massive than usual. Garnet is a minor constituent in places.

(c) Quartzite and quartz-mica schist (Map Unit 4)

Rocks of this unit crop out on the northeast side of Albert Canyon and on the high ground around Camp 5. The unit is characterised by quartz-rich rocks and consists of a series of interbedded quartzites, quartz-mica schists and minor calcareous and politic schists. Some of the quartz-mica schists grade into quartz-felspar-mica gneiss.

Quartzites are medium-grained rocks. Mostly they are grey in colour but purer varieties are white or pink. Pure white or pink quartzite beds may be up to 150 feet thick but tend to pinch out along strike and grade into impure varieties. Grey quartzite contains biotite and grades into quartz-mica schist. Biotite and muscovite impart a poor or moderate foliation to the rock, depending on the amount of mica. Muscovite is subordinate to biotite. Alternating quartz and mica rich laminae are generally about 2 mm thick.

Interbedded with the quartzites are quartz-mica schists. These are grey or brown in colour, medium-grained and have a well-developed foliation defined by this laminae of micas separating quartz, with layers up to 3 mm thick. Where felspar is a major constituent of the light coloured payers, the rock becomes coarse-grained and gneissic. Muscovite and biotite occur in approximately equal amounts, but muscovite is dominant in the pelitic horizons. There are two generations of biotite, seen best in the pelitic bands. Find grained biotite, along with muscovite, defines the schistosity; medium grained biotite porphyroblasts are distributed randomly throughout the rock. Garnet and staurolite are found in some of the more pelitic horizons. Tourmaline and epidote are common accessories. Chlorite is forming after biotite in places, giving a greenish appearance to the rock. The schists associated with the limestones tend to be calcareous, epidote and calcite (or dolomite) form essential components of the rock. Individual beds range from a foot to several tens of feet in thickness.

These rocks are a metamorphosed series of arenenaceous sediments with minor limey and argillaceous bands.

(d) Phyllite (Map Unit 5)

This unit crops out extensively in the northeast part of the area and around Inaccessable Mountain. It forms the high ridge on the northeast side of Albert Canyon.

The rocks consist of a series of interbedded black and grey phyllites, calcareous phyllite and black carbonaceous limestone. They are fine grained and have a well-developed schistosity. Thin lenses and stringers of quartz and calcite parallel to the foliation give the rocks a streaky appearance. These vary from a few millimeters to a foot in thickness. The rocks consist mainly of quartz and micas, the latter imparting a marked schistosity and making the rocks very fissile. Calcite is a lesser constituent, although some bands are very limey and may grade into an impure limestone. Calcite occurs in thin laminae which are often leached out on the weathered surface. Graphite, which is ubiquitous, imparts a dark colour to some bands. In some areas pyrite (probably of sedimentary origin) is an essential mineral; usually it is minor.

Thin section study shows that quartz makes up about 50% of the rock. It is concentrated in thin layers and lenses, separated by micaceous lamines. The predominant mica is muscovite; chlorite is minor. Biotite occurs as randomly orientated porphyroblasts up to 0.5 mm in diameter. These are found on a regional scale. Calcite and graphite are of lesser importance and occur in thin laminae throughout the rock. This unit is a metamorphoses series of shale, limey shale and impure limestone and represent quieter sedimentary conditions than the underlying quartzites.

(e) Quartz-felspar-biotite gneiss and limestone (Map Unit 6 and 7)

These are the youngest metamorphic rocks of the area. They crop out at the head of the Alberta Creek and at the eastern edge of the map area. Map Unit 6 consists of well-foliated quartz-felspar-biotite gneiss. The rock is uniform in fabric and mineralogy. Bands up to 2 mm thick of felspar (mainly plagioclase) and quartz are separated by slightly thinner biotite-rich bands which define the foliation. Quartz generally predominates over felspar. Muscovite is minor. The rock is usually dark grey in colour, but where chlorite has replaced biotite, the rock has a greenish appearance.

Some bands, up to a few feet thick, are biotite rich which give the rock a schistose appearance. In these places there is a second generation of porphyroblastic biotites up to 2 mm in diameter in the rock. They are randomly orientated and are of regional signigicance. Minor garnet and kyanite was observed in such bands about 4000 feet east in Inaccessable Mountain.

Several bands of limestone (Unit 7) crop out within the gneisses. These range from a few feet to several tens of feet in thickness. Only the thicker units are shown on the map. Thinner beds are common at the base of Map Unit 6 near Inaccessable Mountain. The limestones are generally impure, although pure bands consisting almost entirely of coarse grained greyish calcite do occur. Usually the rock consists of alternating grey and white bands of variable thickness. The greyer bands contain quartz, micas and sometimes talc. The bands are often contorted. Small rosettes of tremolite are common in the white bands.

These rocks are metamorphosed greywackes and felspathic grits with minor interbedded limestone and represent a continuation of relatively quiet sedimentation which occurred during the formation of the underlying shales.

3. Description of the Igneous Rocks

(a) Hornblende-biotite diorite (Map Unit 8)

This rock crops out on the highest parts of the area around Mount Littleburn and at the head of South Albert Creek. Contact with the country rock is sharp and steep and the intrusion appears to have the form of a plug.

In hand specimen the rock is dark greyish green, coarse grained, equigranular and holocrystalline consisting of plagioclase (55%), hornblende and biotite (40%) and pyrite and magnetite (5%). The rock is rather heterogeneous in both mineral proportions and texture throughout the area of outcrop. Both coarse and medium grained varieties are found, often there is a gradation from one to the other within a small area. The ratio of hornblende to biotite is variable, usually hornblende exceeds boitite. Pyrite and magnetite are ubiquitous and form a significant part of the rock.

A small satellite plug of diorite 2500 feet northwest of Mount Littleburn has a distinctive porphyritic texture (Map Unit 8b). The rock here has the same mineralogy as the main body, but hornblende forms clots of phenocrysts which may be up to an inch in diameter. Biotite is a minor constituent.

Crude mineralogical banding, consisting of alternating light and dark coloured bands up to 2 feet thick was observed on a cliff 4000 feet east of Mount Littleburn. Banding was continuous over a distance of 2000 feet and appeared to be sub-horizontal.

A thin section study shows that all the felspar in the diorite is plagioclase (An_{42}). Grains are subhedral with an average size of 3 mm, although some larger phenocrysts are developed in places. The plagioclase grains tend to be aligned, probably a result of rhythmic accumulation which is macroscopically expressed in the mineralogical banding noted above. Anhedral biotite and hornblende grains occur as clusters, biotite is generally smaller than hornblende which may be up to 3 mm in length. Pyrite and magnetite are associated with the mafic silicates, magnetite being predominant over pyrite. Accessory minerals are rutile, apatite, zircon and haematite. Alteration is moderate; some biotites are almost completely altered to chlorite and epidote. Chlorite also forms from hornblende. Kaolinite and sericite form from felspar. Deformation has resulted in the fracturing of plagioclase and banding of biotite. This has probably aided alteration.

There appears to be a zonal pattern to the mineralogical variations in the diorite. Due to the extremely rugged nature of the terrain this could not be confirmed by more detailed sampling. The central part of the plug appears to be more basic than the margins where there is less hornblende, pyrite and magnetite. This is particularly true of pyrite. Around Mount Littleburn and near the granite contact there is a higher proportion of light minerals and biotite is the major mafic phase, in some places minor quartz was observed. Textural and mineral variations are more noticeable in these areas.

A separate phase of the diorite has been mapped as foliated granodiorite (Map Unit 8a). This crops out 1500 feet southwest of Camp 5. It is in sharp contact with surrounding quartzites and grades into the diorite. It is a medium or coarse grained, generally equigranular, holocrystalline rock consisting of felspars (50%), quartz (20%) and varying proportions of biotite and hornblende (30%). Generally biotite and hornblende form in equal proportions but where the foliation is well defined biotite predominates. The foliation is marked by parallel alignment of biotite and hornblende and is parallel to the foliation in the surrounding quartzites. It appears to be due to shearing, both the plagioclase and the mafic minerals have been smeared out along shear planes. Recrystallisation occurred during deformation with the formation of smaller biotites in the shear planes and the development of plagioclase porphyroblasts. In places the rock becomes an augen gneiss.

Thin section study of a moderately foliated specimen confirms that the rock has been deformed. The felspare (plagioclase 40%, alkali felspar 10%) are fractured, all quartz grains have undulose extinction and biotite appears to have been squeezed between the felsic minerals. The plagioclase is oligoclase (An_{26}), some crystals of which show a small degree of normal zoning with an albitic rim. Alkali felspar consists of coarsely perthitic orthoclase and microcline which includes smaller orthoclase, quartz and biotite.

Patches of a similar, but undeformed, rock are found near Mount Littleburn and in the contact zone of the diorite and granite although a separate phase was not mapped in these places as gradations to hornblende-biotite diorite are observed in single outcrops.

This rock is similar mineralogically to the granodiorite near Inaccessible Mountain.

(b) <u>Biotite-hornblende granodiorite (Map Unit 9)</u>

This rock crops out between Avon Creek and South Albert Creek, and to the west of Albert Creek. Contacts with the surrounding rocks are sharp where seen and, near Inaccessable Mountain, are steep and dip slightly inwards towards the centre of the intrusion.

In hand specimen the rock is greenish grey in colour, hypdiomorphic equigranular and consists of quartz (20%), felspar (60%), biotite and hornblende (20%). Biotite generally exceeds hornblende. It is usually uniform in character, although a porphyritic variety is found in places. This variety which has plagioclase phenocrysts up to 5 mm long contains more hornblende. Biotite and to a less extent hornblende and plagioclase, define a crude foliation in the rock.

This section study shows that the felspars consist of olitioclase (An_{24}) (50%) and orthoclase (10%). Plagioclase is euhedral or subhedral. some grains have resorbed margins where in contact with quartz and orthoclase. Orthoclase is anhedral with maximum grain size of 1 mm. It is coarsely and irregularly perthitic and shows patchy development of microcline twinning. Quartz is anhedral with maximum grain size of 1 mm and is interstitial to the felspar. All grains show undulatory extinction and have undergone cataclasis causing the recyrstallisation of many small grains with sutured margins. Biotite and hornblende form anhedral laths up to 1.5 mm in length and tend to occur together. Accessory minerals are apatite, sphene and iron ore. Alteration is mild and consists of the formation of chlorite from biotite; and epidote sericite and calcite from plagioclase.

The similarity of this rock to some parts of the diorite suggests that this is a later differentiated phase of the magma which formed the diorite.

(c) Biotite Granite (Map Unit 10)

The youngest rock type found in the area is biotite granite. It crops out around Avon Creek and between Base Camp and Camps 4 and 5. This body of granite has the form of a plug with gradational contacts. The roof of the plug is now exposed. A second body of granite has the form of a dyke. This crops out between Inaccessable Mountain and Camp 5. It is petrographically similar to the main body of granite and is probably connected to it at depth.

In hand specimen the rock is grey, medium-grained, hypidiomorphic and equigranular consisting of quartz (30%), felspar (50%) and micas (20%). The mica is generally biotite but in places muscovite is also present in lesser amounts. The texture and mode of this rock is fairly uniform throughout the area of outcrop except at the contacts, which are usually gradational. A thin section study of 4 specimens shows that the felspars consist of microperthitic orthoclase with small amounts of microcline (30%) and oligoclase (An_{20}) (20%). The oligoclase shows minor normal and oscillatory zoning. The felspar grains are subhedral or anhedral and are usually about 1 mm in diameter with plagioclase generally larger than orthoclase. Quartz (30%) consists of anhedral grains up to 2.5 mm in diameter. Much of the quartz appears strained, indicated by the presence of undulose extinction and smaller strain-free grains which have formed from a larger grain during cataclasis. Micas (20%) are generally about 1 mm in length and are interstitial to quartz and felspar. Where two micas are present, biotite greatly exceeds muscovite and the two are intergrown. They show less evidence of deformation than the quartz, although some grains are bent. Accessory minerals are rutile, apatite, zircon and magnetite. Alteration is mild. Biotite is altering to chlorite and occasionally epidote. Kaolinite and sericite are found as flecks in the felspar.

Foliated granite which grades into gneiss at the contacts is similar to the massive granite although the plagioclase is somewhat more calcic (An_{28}). In some outcrops there is a sharp contact, in others the contact is gradational and irregular. The foliation in the granite, which is defined by alignment of biotite appears to be a relict metamorphic foliation. Away from the contacts the granite is massive.

Gradational contacts are best seen in the offshoots of the main granite body in Avon Creek, around Camp 4, and on the west side of Steep Creek. Here the country rock appears to have been granitised. A gradation from biotite granite, through foliated biotite granite to hornblende-biotite-quartz-plagioclase gneiss can be observed over a distance of 800 feet. Most of the granite outcrops here contain xenoliths of gneiss which have been felspathised, the foliation in these is conformable with the foliation in the immediately surrounding gneiss. The gneiss into which the granite intrudes has been felspathised. This is apparent in outcrops up to 3000 feet from the contact. The first sign of this is the appearance of small plagioclase augen. As the granite is approached small patches of plagioclase develop from the augen and both conformable and cross-cutting lenses and streaks of felspar and quartz are found. These range in size from a few tenths of an inch to 3 feet in thickness and are discontinuous. Nearer the contact the gneiss takes on the appearance of a foliated granite with a similar mineralogy to the main granite.

Small dykes and veins of coarse-grained pegmatite and fine-grained aplite are found both conformable to and cutting the foliation in the orthogneiss in this and other areas. Many of these bodies are garnetiferous.

Where the granite dyke intrudes the diorite about 1500 feet southeast of Camp 5, there is an intermingling of the two rock types over a zone about 200 feet wide, although 2700 feet west of Camp 5 or a ridge the contact is seen to be vertical and sharp. Where the two rock types are mixed, sub-rounded xenoliths of diorite are contained in the granite. These vary in size from a few inches to several feet in diameter; most of the smaller ones appear to have been recrystallised to a fine-grained dark rock. Several small irregularly shaped dykes of fine-grained aplite are found near the contact. These cut both the diorite and the granite although contacts with the granite are gradational in places.

Contacts with the quartzites and schists are sharp and steep. It would appear that these rocks are chemically unsuitable, except locally, for reaction with the granite.

4. Metamorphism

(a) Regional and thermal metamorphism

The schists and gneisses of the area belong to the almandine amphibiolite facies of regional metamorphism (Barrovian type). The metamorphic grade is uniform throughout the area. Garnet and staurolite are indicator minerals found in the quartz-mica schists and pelitic schists. Kyanite is found in the quartz-felspar-biotite gneiss.

A second period of metamorphism occurred after the last episode of deformation. This resulted in the formation of minerals characteristic of the upper greenschist facies. Randomly orientated biotite porphyroblasts in the schists and phyllites formed at this time. Some garnets and kyanite broke down to muscovite and chlorite and first formed biotite retrogressed to chlorite in places. Tremolite in the limestones formed at this time.

Imprinted on the regional metamorphism is a period of thermal metamorphism caused by the intrusions in the southwest half of the area. This is of local extent. Between Mount Littleburn and Camp 4, the quartzitic nature of the rocks precludes the formation of new minerals. The only moticeable affect is a slight loss of schistosity in some of the more micaceous bands close to the contacts.

Near Inaccessable Mountain the effects of thermal metamorphism are more noticeable. Here the phyllites and schists lose their schistosity and become massive hornfelses near the contact with the granodiorite. Laths of andalusite have developed in places in the phyllites. These have now been replaced with muscovite.

(b) Metasomatism

The metasomatic effect of the granite on the orthogneiss has been described in the section on the granite. The other metasomatic effect is in the formation of skarn in limestone.

Within the limestones east of Camp 5 at 8000 feet, small lenses and patches of coarse-grained inequigranular skarn are developed. These range in size from a few inches to 3 feet in length. Distribution of skarn patches is irregular and they do not make up a significant portion of the rock. A similar skarn occurrence is found where a small granitic dyke cuts through a thin limestone band 1500 feet northwest of Mount Littleburn. Here replacement has occurred along the foliation as well as in patches. Minerals in the skarn are garnet and diopside with lesser amounts of quartz, calcite and epidote. The proportion of garnet and diopside is variable. Some of the lenses are zoned with garnet at the centre surrounded by diopside. Small patches of skarn are developed in the limestone near the contact with granodiorite between Inaccessable Mountain and Glacier Creek. These are very minor occurrences.

Extensive development of skarn is found in the limestone which crops out 2500 feet southeast of Camp 4. A continuous band of skarn, averaging 3 feet in thickness, occurs over a distance of 2500 feet near the base of the limestone. The skarn band follows the foliation in the limestone and is itself vaguely banded. Skarn minerals are garnet and diopside with lesser amount of epidote, quartz, calcite, actinolite and vesuvianite. Red garnet and green diopside are concentrated along certain planes, giving the rock its banded appearance. Associated with the main bank of skarn are smaller lenses and discontinuous bands.

Associated with the main skarn minerals are minor sulphides and schealite. These are discussed in the section on mineralisation.

5. Structure

(a) Folding

On a regional scale, the rocks in this area lie on the southeast limb of the Illecilliwatt Syncline, a major complex fold trending northwest-southeast which here has been folded over into a recumbent anticline. This has been refolded to give the major structure of the area which is a complex anticline whose axial trace plunges moderately towards the northeast and whose axial plane dips towards to south.

The rocks on the northeast side of Albert Canyon are generally striking northwest-southeast with a moderate dip. At the head of Albert Canyon their attitude swings roung at the hinge of the major anticline and rocks on the southwest side of the Canyon strike northeast-southwest. This limb of the anticline has a steeper dip. Except locally, the intrusions in the southwestern part of the area have not displaced the surrounding rocks.

Three periods of folding have affected the rocks of this area. Each period has produced distinctive minor folds, with attendant lineations and foliations. A detained analysis of the minor structural elements was not attempted, although the general structure may be worked out from the outcrop pattern and the relationship between minor structures. Figure 1 is a generalised cross-section of the area showing major structural features and styles of minor folding.

The earliest phase (F_1) was the formation of isoclinal recumbent folds. Evidence of this is seen in the phyllites and schists where tight isoclinal folds with sharp hinge line on a scale of 3 inches to several feet was observed. Lineations in the phyllites trending north and northwest represent the axial trace of these folds. This period of deformation produced the foliation in the metamorphic rocks, which is nearly parallel to the compositional layering or bedding. In many places the compositional layering has been transposed to lie parallel to the foliation. Commonly in the micaceous quartzites, one limb of an F_1 fold has been destroyed and structures resembling cross-stratification have been developed.

The attitude of F_1 minor folds has been changed by subsequent deformation (F_2 folding). Prior to F_2 folding, these structures would parallel the regional structural trend delineated by the Illecillewaet Syncline. The F_1 folds on the northeast side of Albert Canyon tend to be flat lying or dipping moderately towards the northeast. These structures are steeper dipping towards to southwest on to southwestern side of Albert Canyon. The rocks here lie on the underlimb of the refolded F_1 recumbent anticline.

F_2 folds are similar open folds with rounded hinge line seen in the small-scale crumpling of the F_1 foliation plane and the formation of open folds on the limbs of the tight F_1 folds. The axis of these small folds defines a lineation which trends towards the northeast. The axial trace of the major F_1 structure has been deformed about such an axis, giving rise to the present outcrop pattern. The main period of metamorphism occurred during this time.

F_3 folding produced minor kink folds on the limbs of both F_1 and F_2 folds. Folding was about an axis parallel to F_2 so that the effect of F_3 was to tighten already existing folds. This was a minor episode of folding as was probably part of the same deformational period of F_2.

(b) <u>Faulting</u>

Two types of faults occur in the area. These are shear faults associated with the intrusions and an earlier set of thrust faults.

Shear faults can be traced over a strike length of up to 6000 feet. Usually they die out in shorter distances. Brecciation occurs along some fault planes, but this is not extensive. Displacement along strike is not large.

Shearing is associated, at least spacially, with the intrusions. Foliation within the granite may be due to shearing or metasomatism. In the latter case, a gradation from orthogneiss to granite can be observed in the field. Thin section study shows that such rocks are also deformed. The quartz grains show undulose extinction and have sutured margins. In places there is a marked development of schistosity, defined by the alignment of biotite and plagioclase. Augen of felspar (both alkali and plagioclase) may develop and there is a reddening of the felspar. This is due to post-intrusive shearing.

The formation of aligned biotite in the granodiorite near Inaccessible Mountain without the development of obvious shear planes suggests that some shears may be syn-intrusive. Recrystallisation in the foliated granodiorite near Camp 5 suggests that the rocks were still hot while being deformed.

An earlier set of thrust faults in the northeastern part of the area has been recognised. These are parallel to the strike and dip of the foliation in the phyllites which they cut and are recognised only by the presence of calcareous fault gouge which weathers out easily. Two major thrusts have been mapped, but there are several minor ones which are distinguished from foliation planes only by the presence of a narrow band of fault gouge. The magnitude of the major thrusts is not known. Thrusting was from the northeast and probably occurred during the formation of F_1 foliation for which it was partly responsible since the two are parallel.

The thrusts have been effected by F_2 deformation. 1500 feet south of Camp 3 a set of parallel tension gashes cuts the foliation and thrust planes at a high angle. These strike southeast-northwest and are perpendicular to F_2 fold axes. They are now filled with quartz, calcite and minor pyrite. Size ranges from lenses a few inches to several tens of feet in length. Maximum width is two feet. Only the larger ones contain calcite, usually the small gashes are filled entirely with quartz.

6. Mineralisation

Mineralisation in the area is of two types, although both appear to be related to the intrusions in the southwest. The most widespread is associated with faulting; of more significance is disseminated mineralisation.

Associated with the shears there is a localised zone of gossan. This is due to the presence of pyrite in these zones which has oxidized, causing rust to develop on the rock surfaces around the shears. Mineralisation is not extensive.

Extensive mineralisation is found near the thrust faults, 2000 feet south of Camp 3 where there is a large area of gossan. This occurs in the phyllites which are cut here by major thrust faults. Pyrite is disseminated through the phyllites throughout this area. This appears to be an original feature of the rock. During thrusting, folding and metamorphism the pyrite may have been mobilised and concentrated near the thrusts. It is now disseminated throughout the rock and is especially concentrated along the foliation planes and thrusts. This has resulted in extensive rusting in the area.

Subsequent to this, a second period of mineralisation occurred here. Quartz-filled tension gashes associated with the second period of deformation cut the thrust faults in this area. The Larger vein-like ones also contain calcite and are often zoned with calcite and tourmaline at the margin. Pyrite, pyrrhotite and minor chalcopyrite occur with quartz in thses veins. Other quartz-calcite and aplitic veins and pods are found along minor thrust planes. These also contain pyrrhotite, minor pyrite and chalcopyrite and very rarely scheelite. Locally the phyllite around these veins has been silicified. Gradations from phyllite through massive chert to quartz can be observed over a distance of a few feet. Pyrrhotite, sphalerite and tourmaline are disseminated through the chert and also occur in small patches and stringers adjacent to the veins.

This period of mineralisation occurred subsequent to the folding and faulting and is probably related to the intrusions in the southwest of the map area. Mineralising solutions associated with these intrusions have been concentrated along previously formed tension gashes and faults. Nowhere in this area, do sulphides constitute more than a minor part of the rock.

Very rarely, grains of scheelite are associated with pyrrhotite in the minor thrusts described above. Elsewhere on the property scheelite is found in shears and veins in other rocks. At the head of Avon Creek scheelite is found in a narrow shear in quartz-felspar-biotite gneiss. Grains of scheelite up to 3 mm in diameter are concentrated in a narrow zone of fault gouge about 1 foot wide. Mineralisation is discontinuous along strike and very localised on the shear plane. Occasionally scheelite is found on fracture surfaces in the hornblende-biotite-quartz-plagioclase gneiss. This is of very local significance.

Scheelite-bearing quartz veins are found throughout the area. On the northeast side of Albert Canyon several such veins were found. One of these which cuts through quartz-mica schists and calcareous schists near Base Camp contains sphalerite, minor pyrrhotite, pyrite and tourmaline besides scheelite. The scheelite occurs as discrete grains or aggregrates up to 2 cm in diameter at the edge of the vein. Scheelite is found with pyrite in thin quartz veins at the head of Avon Creek. These scheelite bearing veins are discontinuous and narrow. Scheelite is found locally within the veins associated with pyrite.

500 feet northeast of Camp 5 a discontinuous, 10 feet thick quartz vein is located along a shear. Emplacement of the vein was prior to, or perhaps synchronous with shearing as it has been broken up and shattered in places. Scheelite occurs as large grains within the fractures and as large pods up to 4 inches in diameter throughout the vein. Similar veins are found 2000 feet to the northeast of Camp 5 and in the boulders in the talus slope 2500 feet southeast of Camp 4. Scheelite is the only mineral (apart from quartz) in these veins. Mineralisation is confined to the veins and is not found in the schists and limestones or granite which are cut by the veins.

On the northeast side of Albert Canyon 5000 feet east of Base Camp a large boulder of scheelite-bearing quartzite was found. Thin and polished section study shows that this rock is petrographically similar to unmineralised quartzite but contains, in addition to quartz and biotite, pyrrhotite, pyrite, sphalerite and minor chalcopyrite and scheelite. The sulphides are disseminated throughout the rock but tend to be concentrated along the foliation plane. Sphalerite also occurs as small lenses. Scheelite grains up to 0.5 mm in diameter are scattered throughout the rock but are particularly associated with sphalerite. The source of this boulder was not found, but may be a thin band within the sequence of schists and quartzites.

The association of scheelite and sphalerite in this rock and in the veins on this side of Albert Canyon suggest that the scheelite and sphalerite have been introduced at the same time by the agency of quartz-rich solutions. The localised silicification and mineralisation of phyllite next to quartz-veins near Camp 3 has been described above. Pyrrhotite and sphalerite are also associated with this. This suggests that the mineralised quartzite boulder described above is of local significance and may have formed close to some quartz vein.

Disseminated scheelite occurs in rocks near the contact of the granite in the southwestern part of the map area. Around Camp 4 where the contact of the granite and hornblende-biotite-quartz-plagioclase gneiss are gradational, small patches of scheelite are occasionally found in the felspathised gneiss. Scheelite is alos found on fracture surfaces of such rocks. It is found in all gradations from gneiss to pegmatitic granite, but nowhere is mineralisation of more than extremely local extent. Scheelite appears to be disseminated throughout the area, rather than being concentrated in any particular locality in this type of rock.

An exception to this was found in a boulder at the junction of Avon Creek and Albert Creek which contains about 2% disseminated scheelite. This rock appears to be a silicified and felspathised gneiss so that it now has the appearance of a coarse-grained pegmatitic rock. Similar rock was observed locally at the contacts of the granite and gneiss. Pyrite is associated with the scheelite in the boulder. The source of this rock was not found, but the gradational and discontinuous nature of the granite/gneiss contact suggests that the scheelite is probably of local significance.

The most significant type of scheelite mineralisation is in skarn. Scheelite in skarn is mostly confined to the area between Camps 4 and 5. Elsewhere in the area very minor scheelite is found in skarn about 3000 feet southeast of Inaccessable Mountain. Several boulders of skarn are found at the head of Avon Creek but these are barren apart from an occasional speck.

1500 feet northwest of Mount Littleburn patches of skarn with about 0.5% scheelite were found. The scheelite is disseminated throughout the rock and has a grain size of up to 1 mm. Generally it is very fine-grained. Associated with the scheelite are minor amounts of cuproscheelite? It is very fine-grained and fluoresces a bright greenish-yellow in short-wave ultraviolet light. Mineralisation is dincontinuous within the skarn.

The source of the scheelite here is the granite. A granite dyke cuts the beds of limestone and quartzite near Mount Littleburn. The skarn is concentrated near the contact.

3000 feet east of Mount Littleburn boulders of scheelite-bearing skarn were found in moraine at an elevation of 7000 feet. These also contain traces of cuproscheelite? and minor pyrrhotite and may have originated in a band of limestone in the schists around Mount Littleburn.

The most extensive development of skarn is in the limestone 2500 feet wouthwest of Camp 5 which outlines the overturned limb if a major fold. This had already been described. Associated with the skarn minerals (garnet and diopside with minor epidote, quartz, calcite, actinolite and vesuvianite) are pyrite, pyrrhotite, chalcopyrite, molybdenite and scheelite (plus cuproscheelite?). These minerals occur disseminated throughout the rock but not in high concentrations. Thin section study shows that the scheelite formed before the silicates in the skarn.

The steep and unstable nature of the ground prevented a complete examination of the outcrop here but several boulders of skarn below the cliffs here contain fairly significant amount of scheelite (up to 1%) and essential (but minor) pyrrhotite. The extent of scheelite mineralisation is not known. Several boulders of banded skarn containing about 1% scheelite and minor disseminated pyrrhotite and chalcopyrite were found near Camp 5. Presumably these originated from the limestone which crops out in the immediate area.

Not only is scheelite found in skarn but also in limestone itself. Boulders of hard, recrystallised limestone are found in the talus slopes 2500 feet southeast of Camp 4. Very finely disseminated and large anhedral crystals of scheelite are contained in these.

Pyrrhotite is consistently associated with scheelite. In places massive pyrrhotite is found, although not in the limestone. The quartzites and schists above the limestone on the ridge southeast of Camp 4 are extremely rusty. These lie in the core of an overturned anticline. Faulting and shearing is common and several lenses and discontinuous bands of limestone are seen to be interbedded with the schists. Most of the schist boulders on the talus slopes beneath this ridge (and also on the outcrop on top of the ridge) contain some disseminated pyrrhotite. A complete gradation from schist through mineralised schist to massive pyrrhotite can be seen in the scree. Rare specks of scheelite and chalcopyrite are found with the pyrrhotite.

Sulphide mineralisation may be related to at least two shears which strike approximately north-south. Replacement of the schists by pyrrhotite is not continuous but is patchy and is concentrated near the shears on both sides of the ridge. On the southwest side of this ridge, near the top band of limestone, the schists are but by many small discontinuous quartz veins and aplite dykes whihc have also been affected by shearing. Pyrrhotite and secondary biotite with minor scheelite is associated with the aplite stringers.

In this area mineralising solutions appear to be related to the underlying granite. Pyrrhotite-bearing solutions from the granite were channeled along shears and replaced patches of the schists. Shearing was active during and after intrusion. Molybdenite, pyrite and chalcopyrite were also deposited from these solutions. Molybdenite is a common accessory in many aplite dykes in this area and is also found in some pegmatitic rocks near Inaccessable Mountain. It is very minor, as is chalcopyrite. Scheelite was not deposited except in minor instances until these solutions intersected a calcareous horizon where scheelite and then garnet and diopside formed.

7. Geological History

The following is a summary of geological events during the formation of the rocks in the map area.

1. Deposition of sandstones, grits and limestones (Hamil Group) on granitic basement, followed by deposition of calcareous silts, grey-wackes and minor limestone (Lardeau Group) during the Lower Cambrian.

2. Phase 1 folding which deformed these rocks into a large recumbent anticline with north-westerly trend and southwesterly closure. During this period thrusting from the northeast occurred and the basement was caught up in the overlying sediments. This period of deformation produced the main schistosity in the rocks, and was common to basement and cover.

3. Phase 2 folding which produced open folds trending to the northeast and plunging easterly. Earlier tight folds on all scales were refolded. The rocks were raised to the amphibolite facies of regional metamorphism at this time.

4. Phase 3 folding which tightened already existing folds and is of local affect. Metamorphism waned to the upper greenschist facies.

5. Differentiation of a basic magma to give rise to high level intrusions of diorite and granodiorite. This was followed by intrusion of granite with attendent minor aplite dykes.

6. Granitisation of the basement rocks near the margins and roof of the granite and production of hornfelses locally around the intrusives.

7. Faulting and shearing in and around the intrusive soon after and during the intrusive episode.

8. Pyrite and pyrrhotite mineralisation along faults and shears and emplacement of quartz and quartz-calcite veins. Pyrite, pyrrhotite and sphalerite accompanied the formation of some quartz veins. Locally massive pyrrhotite formed. Locally scheelite was deposited in veins, in the granitised basement rocks and along shears and fractures.

9. Production of skarn in the limestones with accompanying minor sulphide and scheelite mineralisation.

10. Uplift and erosion, mainly by ice, of the metasedimentary cover to expose the roofs of the intrusions.