**GEOLOGICAL AND GEOPHYSICAL REMOTE SENSING ASSESSMENT REPORT**

on the

**BUBAR #1 CLAIM**

located in the
GREENWOOD MINING DIVISION, B.C.
Bubar #1 CLAIM: 49° 04'N, 118° 54'W, N.T.S. 82E/2W

owned by:

**APPLIED MINE TECHNOLOGIES INC.**
4599 Tillicum Street
Burnaby, B.C. V5J 3J9

by:

K.V. CAMPBELL, Ph.D., P.Geo., F.G.A.C.

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# 1. Introduction

This report describes the initial results of a remote sensing study and GIS compilation of a claim area currently under investigation by **Applied Mine Technologies Inc.** in the Greenwood Mining Division of southern British Columbia. The objectives of the study were to commence the *preparation of a GIS and geological database to assist in planning of future exploration programs* on the mineral property and to identify geological structures through the analysis and interpretation of Landsat TM multispectral data. In conjunction with the study of satellite imagery a compilation and review of available geophysical data was made, to determine if the understanding of the structural geology of property could be improved upon.

A major part of the current work involved color imaging of satellite and elevation data. Assessment report requirements precluded incorporation of color reproductions and therefore grayscale renditions only are included in copies of the report submitted to the government.

## 1.1. Location, Topography and Access

The current study focused on the mineral claim area, Bubar #1 claim, located in Figure 1. The claim area lies within the Greenwood Mining Division. The physiographic region in this part of British Columbia is known as the Okanagan Highland, which is characterized by rounded mountains, ridges and gentle open slopes.

The Bubar #1 claim is located near the Kettle River and is centered about 7km east of the village of Rock Creek on the southern Transprovincial Highway (No.3), within NTS map sheet 82E/2W at approximately 49° 04'N, 118° 54'W. The claim straddles Bubar Creek on the north side of the Kettle River. The elevation of the claim ranges from 610m along the Kettle River to about 1,220m on the ridge crests either side of Bubar Creek.

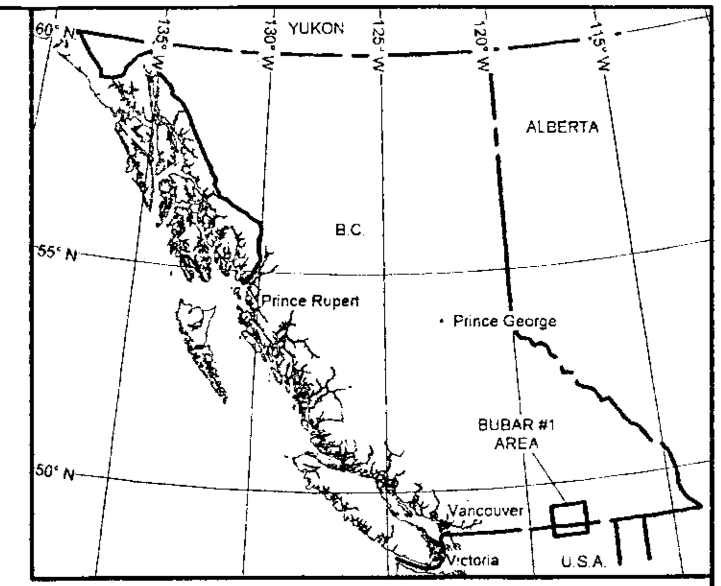
The vegetation cover is fairly open second growth fir and pine. Access to the property is along Bubar Creek.

## 1.2. Claim Ownership and Status

The Bubar #1 claim is wholly owned by **Applied Mine Technologies Inc.** Particulars of the claim are summarized in Table 1. Figure 2 is a claim plan of Bubar #1 claim. There are 20 units in the Bubar #1 claim.

**Table 1. Summary of claim particulars for the Bubar #1 Claim.**

| Claim | Claim Number | Claim Units | Current Expiry Date |
|---|---|---|---|
| Bubar #1 | 354705 | 20 | April 6, 1998 |


approximate topographic contours 400m interval

0 5 10
Kilometers

NTS 82 E

APPLIED MINE TECHNOLOGIES INC.

BUBAR #1 CLAIM

GREENWOOD MINING DIVISION, B.C.

LOCATION MAP

| Project: 98-293 | Date: Mar, 1998 | Scale 1:300,000 | Figure: 1 |
|---|---|---|---|

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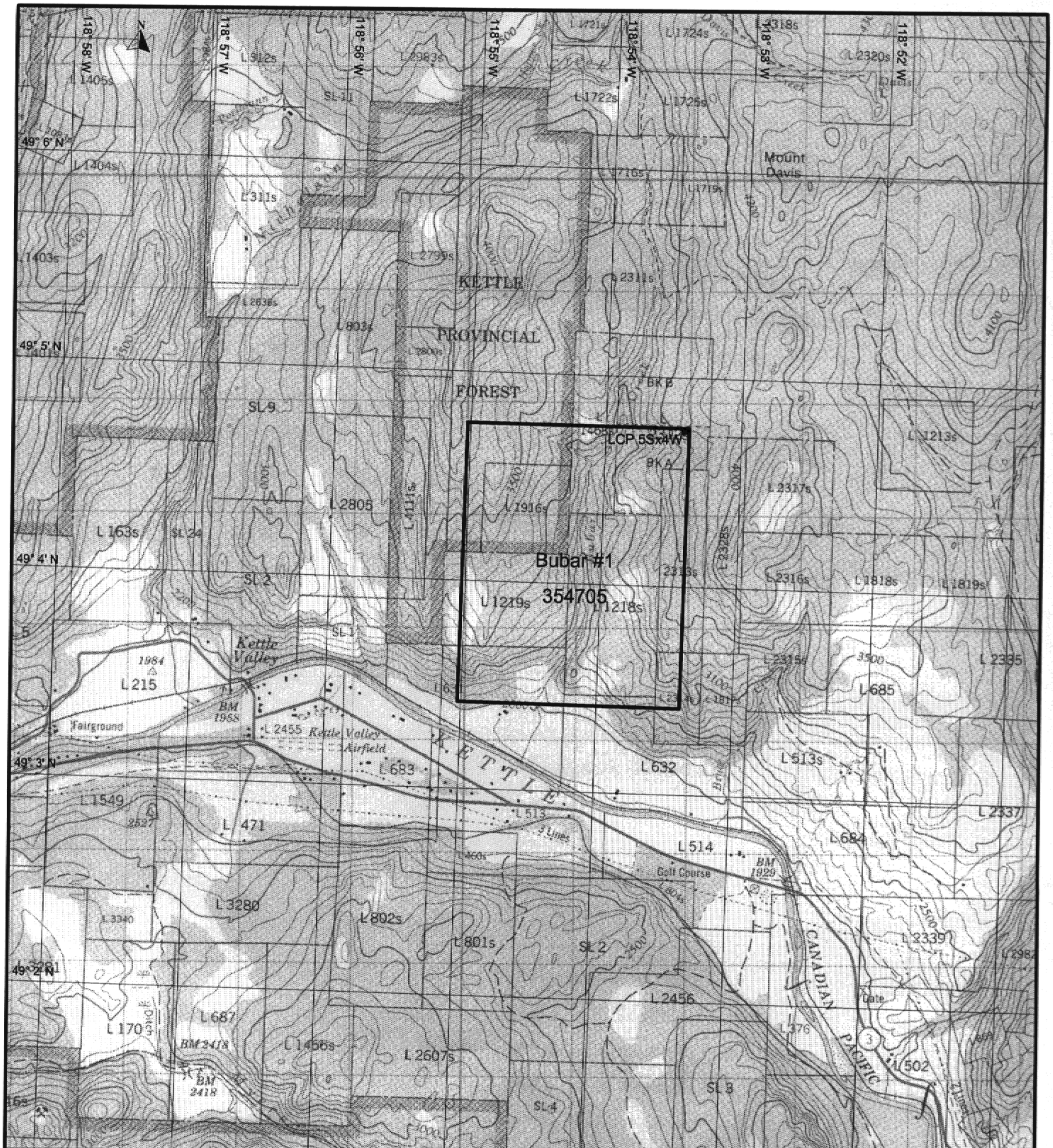
UTM 11 NAD 27




NTS 82 E/2

0 1 2
Kilometers

| |
|---|
| APPLIED MINE TECHNOLOGIES INC. |
| BUBAR #1 CLAIM |
| GREENWOOD MINING DIVISION, B.C. |
| CLAIM MAP |

| | | | |
|---|---|---|---|
| Project: 98-293 | Date: Mar, 1998 | Scale 1:50,000 | Figure: 2 |

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### 1.3. Previous Work

**Applied Mine Technologies Inc.** has undertaken no previous work on the Bubar #1 claim.

The present claim area covers the Bubar mineral occurrence (Minfile No. 082ESE201), also known as the Rubarb, on which two assessment reports have been filed.

In 1970 DeKalb Mining Corp. performed a regional soil survey with analyses for Pb, Zn, Ni, Mo, Cu, Ag and Co. Two nickel and cobalt geochemical soil anomalies were identified by this work on either side of Bubar Creek proximal to outcrops of greenstone, partly serpentinized ultrabasic rocks and quartzites. Up to 1,100 ppm Ni and 48 ppm Co were reported (Assessment Report 2950).

In 1984 Prominent Resources Corp. completed a program of soil sampling, VLF and ground magnetics. Soils were analysed for Cu, Pb, Zn, As, Au and Mo. Gold values of up 310 ppb were reported. Geochemical and geophysical anomalies were described as having a generally north trend (Assessment Report 12095).

# 2. Geology

## 2.1. Regional Geology

Figure 3 shows the regional geology of the southern portion of the Penticton map sheet, NTS 82E, from the GSC digital Open File, 2948 (1995) which for this area is based on work by Templeman-Kluit (1989).

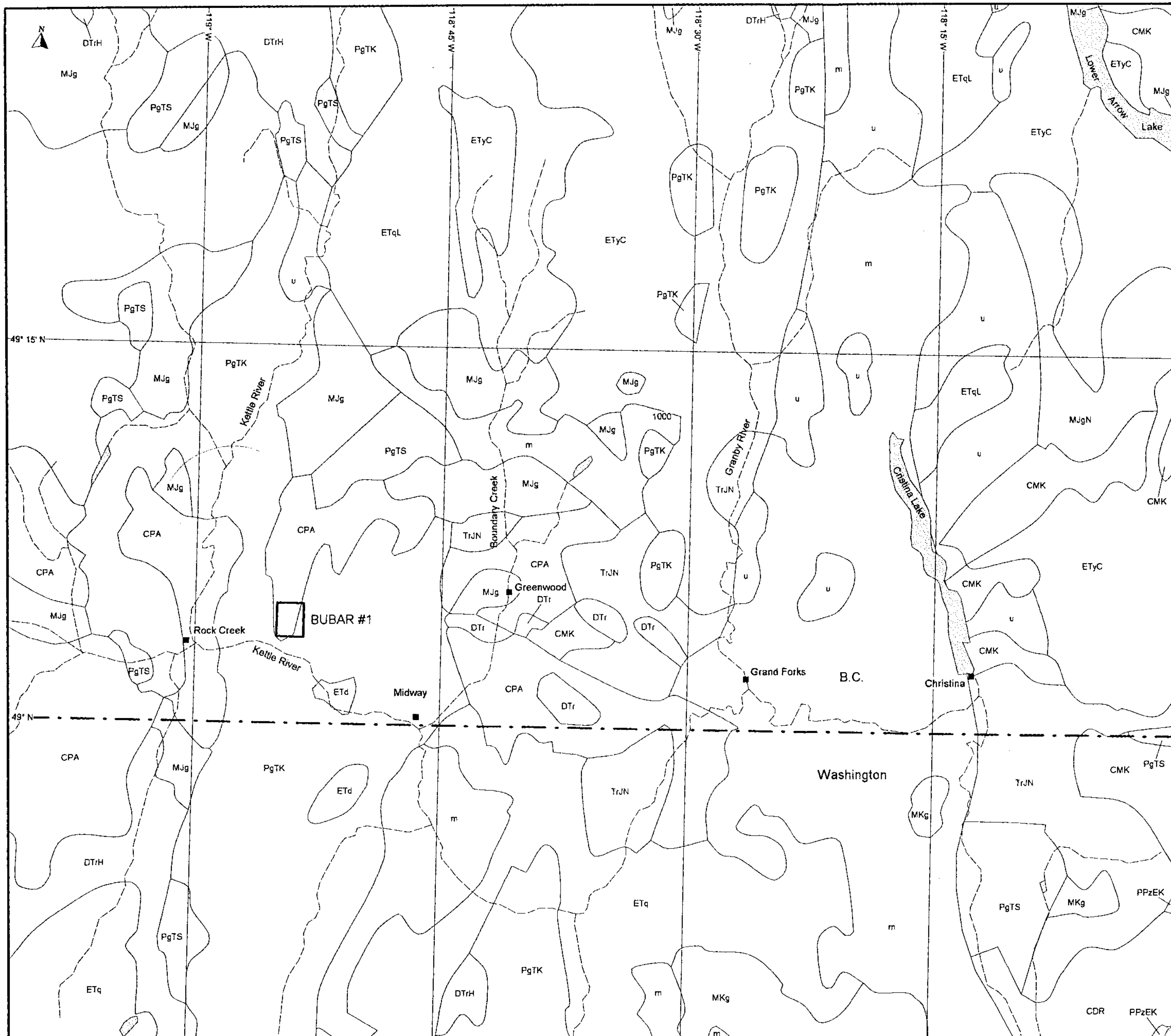
The claim area lies within the Omineca morphogeological belt. It is an uplifted region, extensively underlain by metamorphic and granitic rocks, which straddles the boundary between the accreted terranes to the west and ancestral North America to the east (Gabrielse and Yorath, 1992). In southernmost B.C. the Omineca belt includes parts of both the Quesnellia and Kootenay accreted terranes. Quesnellia was an oceanic and volcanic island arc terrane whereas the Kootenay terrane was a pericratonic assemblage. The claim area is situated in what is mapped (Templeman-Kluit, 1989) as Quesnellia terrane proximal to post-accretionary granitic rocks.

In southern B.C. the Upper Paleozoic strata of Quesnellia are relatively poorly known and are referred to by many local names. There does appear to be two distinct rock assemblages that characterize two of the subterranes of Quesnellia; the Harper Ranch and Okanagan subterranes (Gabrielse and Yorath, 1992). The Harper Ranch subterrane includes arc-related clastic, volcaniclastic and carbonate rocks and occurs from north of Kamloops to south and east of Vernon. The Okanagan subterrane includes chert, argillite, basalt, greenstone and ultramafic rocks and occurs largely in the Boundary District. It includes a number of assemblages, some of which may be in part chronostratigraphic equivalents: limestone and argillite of the Carboniferous to Permian Mt. Attwood Fm.; chert and greenstone of the Knob Hill Group; and quartzite, metachert, phyllite, schist, greenstone and marble of the Kobau Group. Rocks of the latter group, particularly chert, argillite, basalt and associated ultramafic rocks, are correlated (Okulitch, 1973) with the Anarchist assemblage in Canada and are identified mostly west of 119° longitude. However, in Washington State the Anarchist Group includes rocks similar to the Harper Ranch Formation, both of which are assumed to be late Paleozoic. In Washington State the Anarchist Group is described (Hickey, 1992) as unconformably overlain by the Kobau Formation. (Note that usage of the terms 'group', 'formation' and 'assemblage' are after those given by the source reference.)

Granitic intrusives in the Rock Creek area include Middle Jurassic Nelson plutonic rocks and Eocene porphyritic granite (Shingle Creek Porphyry).

The Rock Creek area is characterized by windows of Paleozoic and Mesozoic volcanic and sedimentary rocks between large down-faulted blocks of Tertiary cover. Despite being one of the older mining districts in the province the level of geological mapping is best described as scarce, the most recent sources of information for the west half of NTS sheet 82E being Fyles (1988) and Templeman-Kluit (1989). There are points of disagreement between these authors, particularly in the assignation of the Paleozoic rock units.

Most of the pre-Tertiary rocks in the Rock Creek area are mapped by Fyles as belonging to the Knob Hill Group, a thick assemblage of mainly greenstone and chert. These rocks are ascribed by Templeman-Kluit to the Carboniferous or Permian. Templeman-Kluit maps some of these as belonging to the Carboniferous or older Anarchist Group, Unit CPA on Figure 3; greenstone, amphibolite and serpentinized equivalents, which are similar for the most part to the Knob Hill Group of Fyles. North of the Kettle River these rocks are relatively undeformed pillow lavas, greenstones and fine-grained diorite. Small irregular masses of altered serpentinite or listwanite are a common occurrence in these rocks. Sedimentary rocks within the Knob Hill Group or Anarchist Group include chert, argillite and limestone. A white dolomite south of the Kettle River is ascribed to this group.




UTM 11 NAD 27

| TECTONIC ASSEMBLAGES | | INTRUSIVE SUITES | |
|---|---|---|---|
| TERTIARY | | | |
| PALEOGENE | | | |
| PgTK | Kamloops | ETyC | Coryell |
| PgTS | Sifton | ETqL | Ladybird |
| | | ETq | undivided |
| | | ETd | undivided |
| MESOZOIC | | CRETACEOUS | |
| TrJN | Nicola | MKg | undivided |
| | | JURASSIC | |
| | | MJgN | Nelson |
| | | MJg | undivided |
| DEVONIAN - TRIASSIC | | DEVONIAN - TRIASSIC | |
| DTrH | Harper Ranch | DTr | undivided |
| CARBONIFEROUS - PERMIAN | | | |
| CPA | Anarchist | | |
| CARBONIFEROUS | | | |
| CMK | Milford | | |
| CAMBRIAN - DEVONIAN | | | |
| CDR | Rocky Mountains | | |
| PROTEROZOIC | | | |
| PPzEK | Eagle Bay | | |
| m | uncertain age, undivided metamorphic | u | uncertain age, undivided plutonic |

0 5 10
Kilometers

NTS 82 E

APPLIED MINE TECHNOLOGIES INC.

BUBAR #1

GREENWOOD MINING DIVISION, B.C.

TECTONIC ASSEMBLAGE MAP
(from Journeay and Williams, 1995)

| Project: 98-293 | Date: Mar, 1998 | Scale 1:300,000 | Figure: 3 |
|---|---|---|---|

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The structure of the Rock Creek region is dominated by Tertiary faults that mark the boundaries of the Tertiary rock units. Many faults are intruded and obscured by Tertiary dykes. Fyles (1988) considers the faulting to be the result of east-west extension. The predominant structural fabric is the north to northeastern trending faults associated with Tertiary block faulting. The Paleozoic rock units in the local area of Rock Creek have a foliation trending northwesterly.

The current level of available geological mapping on the property is not considered adequate for any mineral exploration program.

### 2.2. Property Geology

Figure 4 is a 1:50,000 scale map of a portion of the regional geological database by the GSC.

The area of the claim is mapped as being underlain by the Carboniferous to Permian Anarchist Fm. and the Tertiary Kamloops Group. According to Templeman-Kluit (1989) the latter is comprised of several formations and units, including the Kitley Lake Fm. (pale trachyandesite), Yellow Lake Fm. (phonolite) and the Springbok Fm. (conglomerate) in the Bubar Creek area. It is certain that the geology is more complex than is represented in Figure 4.

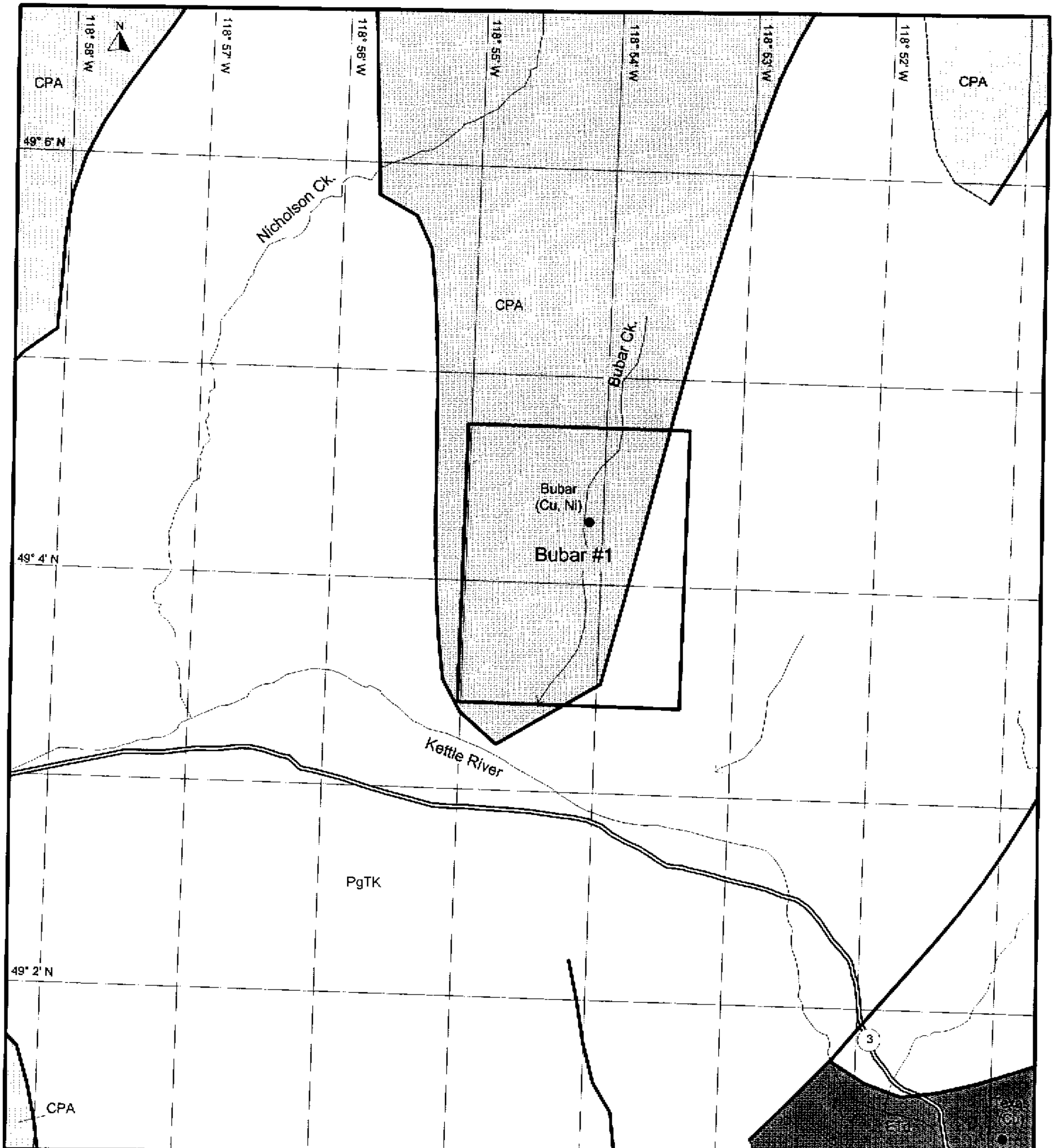
Faults are mapped by the GSC at the contacts of the Anarchist greenstones and related rocks with the younger Tertiary sedimentary and volcanic rock units. These trend north-northwest to north-northeast. The tectonic setting of the area is such that these relatively young faults can be expected to exhibit primarily normal displacements.

### 2.3. Mineral Occurrences

There are two mineral occurrences reported in the area of the Bubar #1 claim, as shown on Figure 4. These are the Bubar (Minfile 082ESE201) and Texas (Minfile 082ESE119).

The Bubar occurrence consists of lead, zinc, nickel and cobalt geochemical anomalies in soil overlying greenstone, serpentite and chert of the Knob Hill Group, which is equivalent to the Anarchist Fm. of Figure 3.

The Texas or Midway occurrence is a chalcopyrite, bornite and pyrite bearing skarn reportedly developed in Triassic limestone and chert pebble conglomerate intruded by Cretaceous monzonitic porphyry. Neither of these rock units are differentiated on the regional GSC digital map shown in Figure 3.




NTS 82 E/2

TECTONIC ASSEMBLAGES

TERTIARY

PALEOGENE

PgTK Kamloops

MESOZOIC

CARBONIFEROUS - PERMIAN

CPA Anarchist

INTRUSIVE SUITES

ETd undivided

geological fault

geological contact

mineral occurrence

0 1 2

Kilometers

APPLIED MINE TECHNOLOGIES INC.

BUBAR #1 CLAIM

GREENWOOD MINING DIVISION, B.C.

PROPERTY GEOLOGY
(from Journeay and Williams, 1995)

| Project: 98-293 | Date: Mar, 1998 | Scale 1:50,000 | Figure: 4 |
|---|---|---|---|

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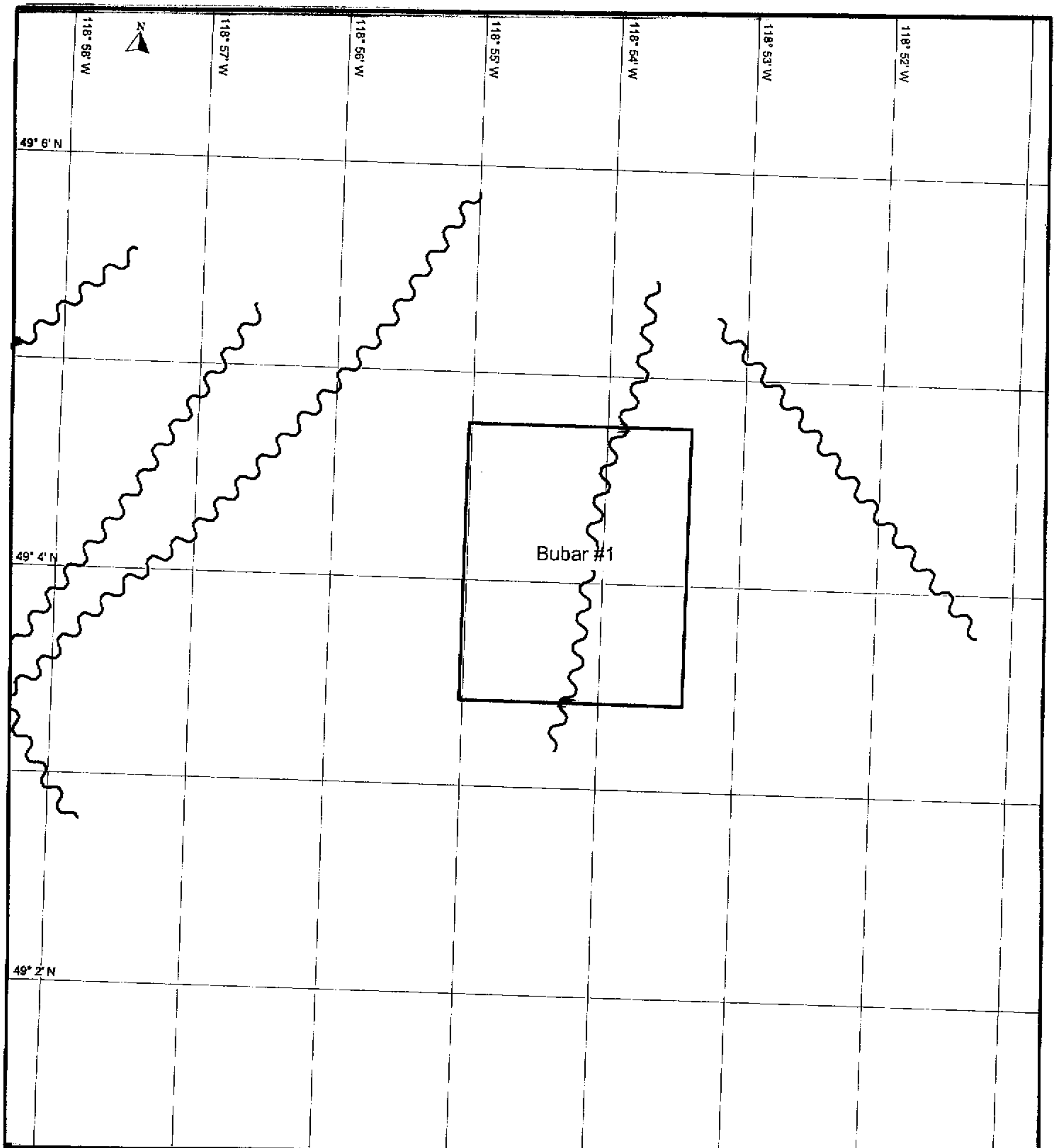
UTM 11 NAD 27

## 3. Geophysics

Regional aeromagnetic surveys published by the Geological Survey of Canada in 1973 cover the Bubar #1 claim area. Figure 4 shows a portion of the GSC map 8497G for the Rock Creek area, originally published at a scale of 1:50,000.

The area of the claim is dominated by the aeromagnetic highs along the north-south trending ridge west of Bubar Creek and the high on the east side of the creek. The magnetic high on the west side of the creek approximates the mapped distribution of the Anarchist greenstones and is considered a result of these rocks having a higher magnetic susceptibility relative to the Tertiary sedimentary rocks that overlie them. The north-northeast trending magnetic discontinuity interpreted along Bubar Creek approximates the fault mapped there by the GSC. At this time it would appear that this structure is the most significant large scale fault crossing the Bubar #1 claim.




BUBAR #1 CLAIM

Fault

AEROMAGNETIC INTERPRETATION

(Overlay to Figure 5)

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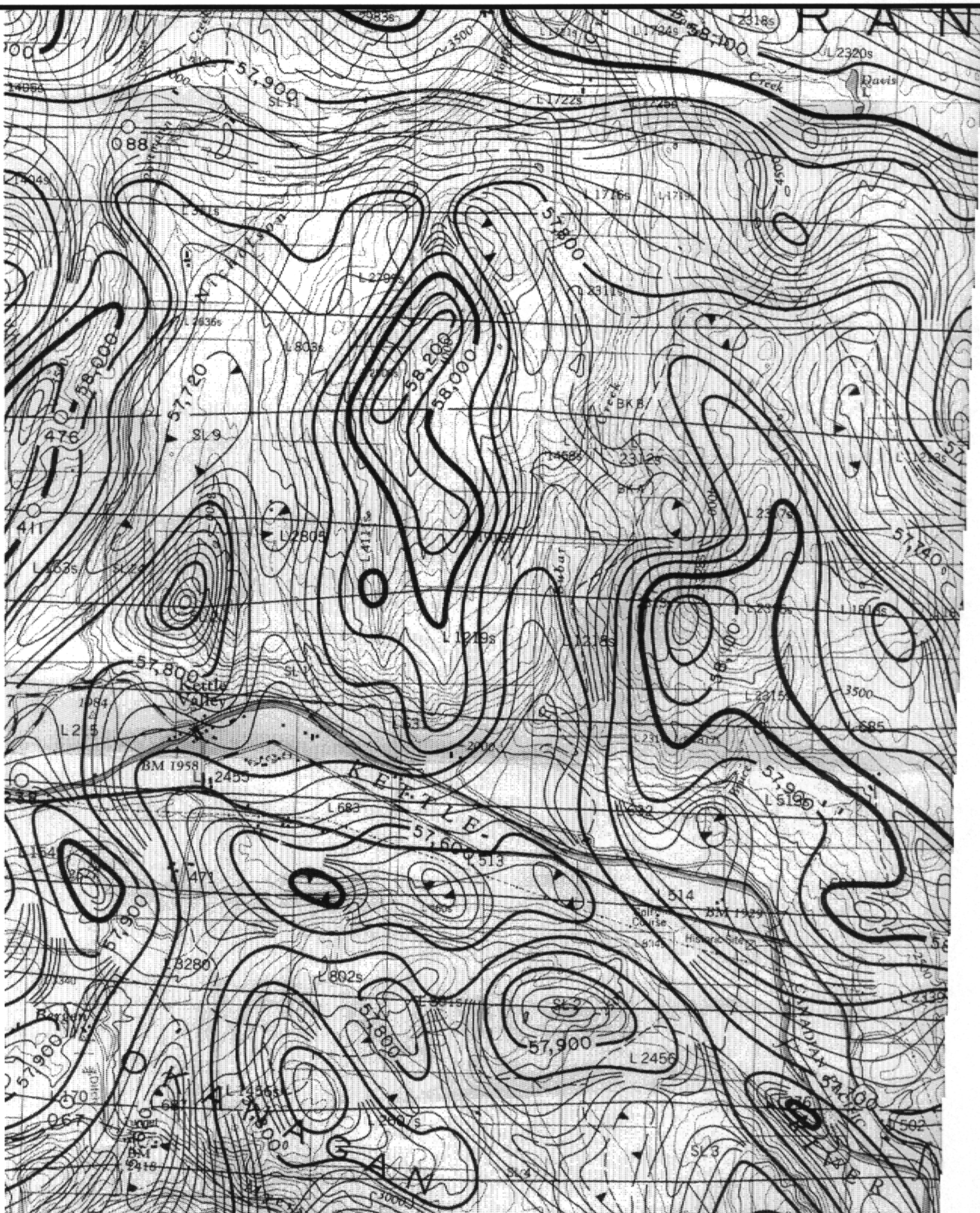
UTM 11 NAD 27




0 1 2
Kilometers

APPLIED MINE TECHNOLOGIES INC.

BUBAR #1 CLAIM

GREENWOOD MINING DIVISION, B.C.

REGIONAL AEROMAGNETICS
(from GSC 8497G, 1973)

| Project: 98-293 | Date: Mar, 1998 | Scale: 1:50,000 | Figure: 5 |
| --- | --- | --- | --- |

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# 4. Remote Sensing Investigation

## 4.1. Introduction

The scenes of Landsat Thematic Mapper (TM) digital data acquired for the study were those for Track 044, Frames 025 and 026, imaged on August 31, 1987. The full scene measures about 185 x 170km and the original pixel size of the raw data is 28.5m.

Basic principles and characteristics of Landsat TM imagery are provided in Appendix I.

## 4.2. Method

The full scene of Landsat data was geometrically corrected using 1:50,000 topographic maps in a NAD27 ellipsoid, UTM Zone 11. A subset of data, covering the study area, was extracted and used for the generation of image maps and study.

A number of band combinations, ratios and principal components were experimented with, TM bands 345 (BGR) showing the most differentiation of cover types. Figure 6 is a small scale image map of the border district. Figure 7 is an approximate 1:50,000 scale image map of the Bubar #1 Claim.

Primary coniferous forest cover in the TM345 composites is shown by the dark green hues. Leafy green vegetation along the drainage courses and in the alpine areas are shown by the lime to yellow green hues. Bare outcroppings are shown by magenta hues. Water is shown by black.

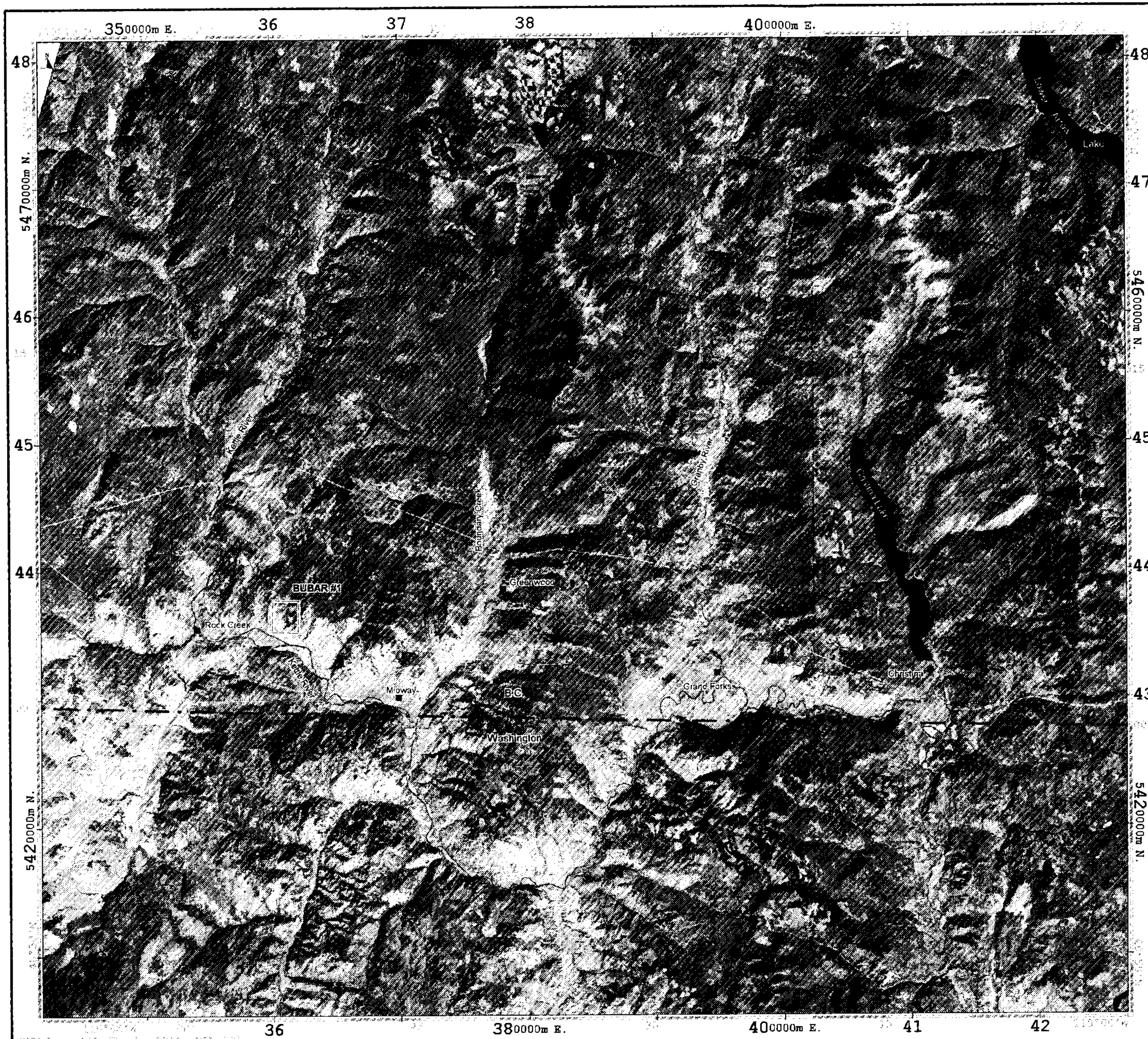
Conventional feature analysis and interpretation procedures are followed in working with Landsat imagery. Two factors are considered; the *spectral* aspects (relative brightness and color combinations) and the *spatial* aspects (distribution of data groups). Analysis of imagery is concerned only with the spectral aspects. In contrast, interpretation is the explanation of the meaning or significance of any part with respect to the whole and relates to both spectral and spatial aspects of the data as well as their relevance to the surficial conditions which they reflect or the subsurface relationships which they are imposed upon. Image interpretation (in the current study) is the identification of geologically correlated elements of landscape; namely landform, drainage and cover patterns, according to the spatial aspects.

Cover patterns are determined by spatially related spectroradiometric groups of data that relate to the reflective properties of surficial materials (vegetation, soil, rock, etc.). The topographic position of these patterns is not a necessary parameter in establishing their presence or boundaries. Geologic materials and/or conditions can be inferred by direct or indirect evidence.

Landform patterns are determined by spatially related spectroradiometric groups of data that relate to topographic conditions of the landscape without respect to the materials present. In the manual interpretive technique, familiar to any air photo interpreter, these boundaries are usually determined by a change in slope or alignment. The objective is to classify an area into terrain units, based on landform shape, size, drainage density, etc., the premise being that an area of similar landform infers similar resistance to surficial agents of erosion and/or to the competence of geologic materials.

Drainage is a special condition of landform; that being the line(s) of lowest landform per unit area. There are three important factors in assessing drainage; pattern, density and gully shape. Landsat imagery can evaluate and compare the first two of these up to scales of 1:25,000 but gully shape can only be assessed in a general way.

Lineaments are mappable simple or composite linear features which may be geomorphic (caused by relief) or tonal (caused by reflectance contrasts). Their inference is dependent upon various




0 5 10
Kilometers

NTS 82 E

| APPLIED MINE TECHNOLOGIES INC. | | | |
|---|---|---|---|
| BUBAR #1 CLAIM | | | |
| GREENWOOD MINING DIVISION, B.C. | | | |
| REGIONAL IMAGE MAP<br>LANDSAT TM BAND 5 | | | |
| Project: 98-293 | Date: Mar, 1998 | Scale: As Shown | Figure: 6 |

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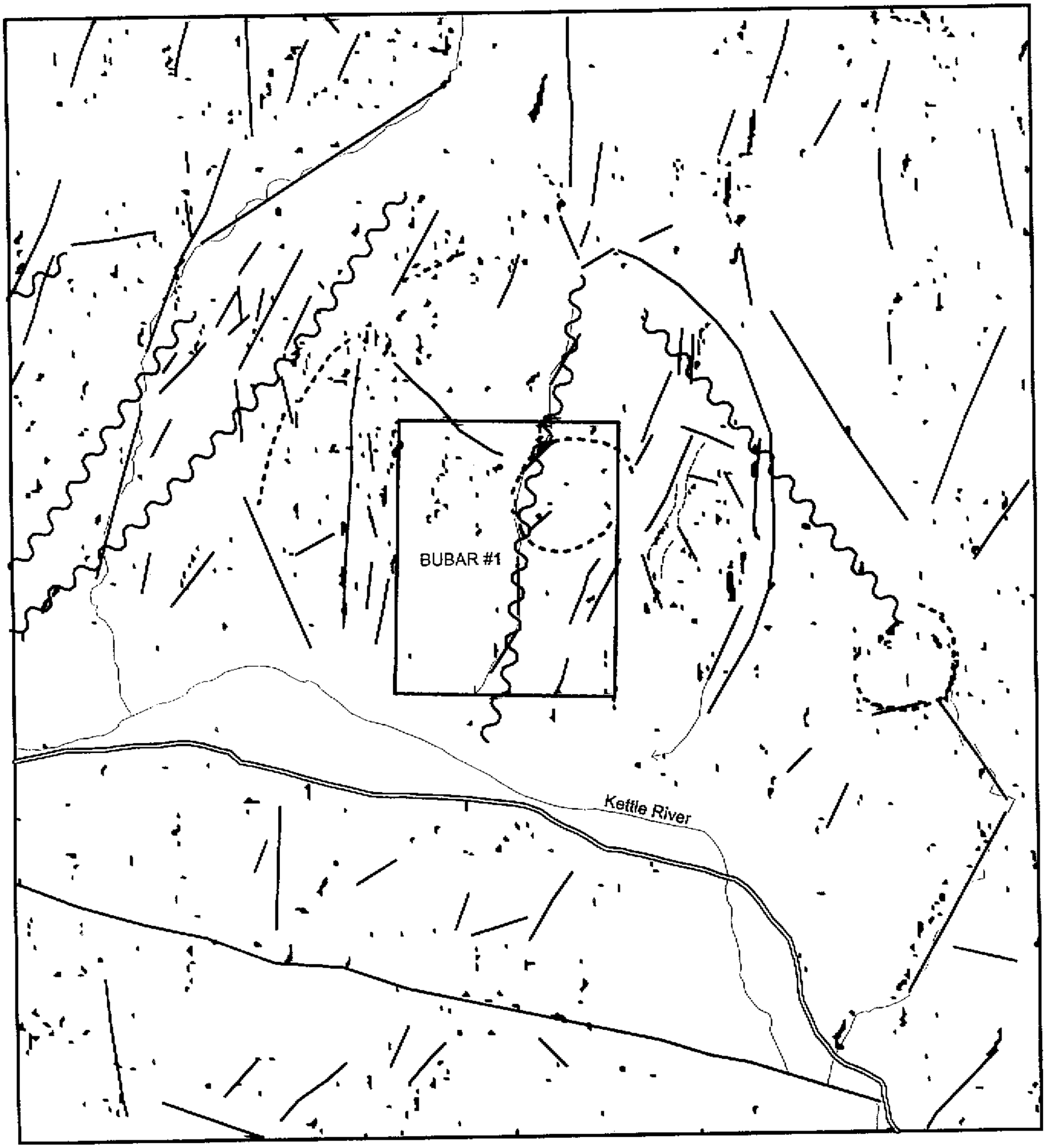


Discontinuities interpreted from aeromagnetics

Bedrock fractures interpreted from imagery

Marker bed or layer

Curvilineament or circular feature

Areas of possible iron-oxide enrichment; discount low-lying areas of alluvium and clearings due to farms, powerlines

BUBAR #1 CLAIM

FEATURE COMPILATION

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(Overlay to Figure 7)

UTM 11 NAD 27


NTS 82 E/2

0 1 2
Kilometers

APPLIED MINE TECHNOLOGIES INC.

BUBAR #1 CLAIM

GREENWOOD MINING DIVISION, B.C.

## PROPERTY IMAGE MAP

LANDSAT TM BANDS 5,4,3 (R,G,B)

| Project: 98-293 | Date: Mar, 1998 | Scale: 1:50,000 | Figure: 7 |
|---|---|---|---|

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UTM 11 NAD 27

assumptions. Geomorphic lineaments may be landforms, linear boundaries between different types of terrain or breaks within uniform terrain. Tonal lineaments may be a straight boundary between areas of contrasting tone or a stripe against a background of contrasting tone. Differences in vegetation, moisture content, soil or rock type or land-use practices account for most tonal contrasts.

In this project almost all the lineament delineation was done at an approximate scale of 1:50,000 directly on the computer digital file. Because the minimum mapping length is about 0.5cm this means the shortest lineament mapped is about 250m in length.

The types of lineaments delineated on the Landsat imagery are linear segments of large valleys, linear depressions (mostly linear drainage segments), linear ridges, linear bases of steep slopes, linear concave breaks in the slope and tonal lineaments. Linear geomorphic lineaments were compiled for the Bubar #1 property.

Processing was also done to enhance surface iron oxidation enrichment. Two techniques were employed, both based on the fact that iron oxides have their maximum reflectance in the visible red (TM Band 3) and minimum reflectance in the visible blue (TM Band 1). The first technique is a simple ratio of TM3/TM1. The second technique uses the arithmetic sum of ([TM3-TM1] + TM3). The common result is a range of values normally distributed between DN of 0 and 255, the brightest values being indicative of strong visible red reflectance. An arbitrary judgement is then made as to the DN value above which any pixel can be considered spectrally anomalous. As a starting point, the top 1 to 2½% of the population is encoded as being anomalous and worthy of follow-up. The reader is cautioned that this technique, which is widely used in remote sensing investigations, is not foolproof. In an area completely devoid of iron alteration an arithmetic technique will still result in a normal distribution of results and the top few percent may be only due to the occurrence of dark colored rocks. Field checking is mandatory.

### 4.3. Results

Fieldwork is absolutely necessary to test any conclusions. No structural remote sensing study can replace the geological field examination. At best it can provide some overview and compilation benefits and hopefully lead to some hypothesis for subsequent fieldwork focus.

The overlay accompanying Figure 7 shows the compilation of features for the Bubar #1 property.

The predominant lineament set trends north-northeast, similar to main fault trend mapped by the GSC. At this scale the topographic lineament along Bubar Creek consists of a number of short, somewhat divergent, segments. These approximate the magnetic discontinuity interpreted from the aeromagnetics.

On the east side of Bubar Creek there is a number of north-northeast trending geomorphic breaks, gullies and vegetation stripes about midway between the creek and the ridge to the east. These possibly mark the fault mapped by the GSC separating the Anarchist greenstones, etc. from the Tertiary volcanics and sediments. This raises the possibility of a structural zone with a width of up to 500m running along the east side of the creek.

There are some subtle circular features in the area. Most notable is the feature near the center of the claim, about 1km in diameter, and the much larger suspect feature, about 5km in diameter, that is cleft by Bubar Creek. The feature on the west side of Bubar Creek could be nothing more than an old landslip whereas that on the east side of the creek may only mark the contact between different Tertiary volcanic and/or sedimentary rock units. Nevertheless, their spatial situation along the Bubar Creek interpreted structural zone is suspicious enough to warrant field checking to determine if there is any possibility that they are some expression of intrusives (?), associated with the Anarchist Fm.

There is another circular feature southeast of the claim that is defined both by geomorphology and areas deemed anomalous in respect to their iron oxidation index. It should be prospected to determine if the area has any potential for mineralization.

Possible traces of marker beds or layers occur on the ridge and knoll east of Bubar Creek. These should be visited to see if bedding attitudes of the Tertiary strata mapped there can be determined and if the contact with the older rocks to the west can be found.

Areas of possible iron alteration are shown on the overlay to Figure 7. Those on the Bubar #1 claim should be field checked to see if they are any more or less oxidized than surrounding areas or if they mark bedding traces. Many are elongated in a north-south direction and this may be an expression of the elongate knolls and rock ribs in the area. The spectrally anomalous areas do appear to be more prevalent over the two magnetic highs recognized on the aeromagnetic map but this might be due to there being more rock exposed in these areas than in the forested regions or along the Kettle Valley.

## 5. Recommendations

1. The limited work done is the first step in building up a GIS and satellite image database for the project. The products of the work include orthorectified Landsat TM imagery, a digital elevation model of the region, geocoded aeromagnetic data and a preliminary overview of the gross bedrock structures on the Bubar #1 property.
2. Prior to the first pass of the field mapping it is recommended that an air photo interpretation be done using 1:15,000 or 1:20,000 air photos. Detailed topographic mapping, including the creation of a 3 dimensional elevation data set, should be done before the commencement of fieldwork.
3. An understanding of the lithologies and structures on the property is paramount. To this end it is recommended that the claim area be field mapped to a scale of at least 1:10,000.

Respectfully submitted,

*ERSi Earth Resource Surveys Inc.*
K.V. Campbell. Ph.D., P.Geo., F.G.A.C.

## 6. Itemized Cost Statement

**Data acquisition and preprocessing**

| | | |
|---|---|---|
| Remote Sensing Analysis: | | |
| K.V. Campbell; 10 hours @ $100/hour | | $ 1,000.00 |
| Air photos | | $ 140.90 |
| GIS, CADD work, map preparation (color and B&W sets) | | |
| M. Goyer; 30 hours @ $35/hour | | $ 1,050.00 |
| G. Rigby; 5 hours @ $50/hour | | $ 250.00 |
| Report materials and reproduction; 5 copies | | $ 500.00 |
| Secretarial | | $ 100.00 |
| | **Total:** | **$ 3,040.90** |

PROFESSIONAL
PROVINCE OF
K. V. CAMPBELL
BRITISH COLUMBIA
GEOSCIENTIST

*ERSi Earth Resource Surveys Inc.*
K.V. Campbell. Ph.D., P.Geo., F.G.A.C.

March 6, 1998

## 7. Certificate

I, KENNETH VINCENT CAMPBELL, resident of North Vancouver, Province of British Columbia, hereby certify as follows:

1. I am a geologist employed by ERSI Earth Resource Surveys Inc., Suite 311A, 255 West First St., North Vancouver, British Columbia.

2. I graduated with a degree of Bachelor of Science, Honors Geology, from the University of British Columbia in 1966, a degree of Master of Science, Geology, from the University of Washington in 1969, and a degree of Doctor of Philosophy, Geology, from the University of Washington in 1971.

3. I have practiced my profession for 31 years. I am a Fellow of the Geological Association of Canada (F0078) and have been a member of the Association of Professional Engineers and Geoscientists of British Columbia since August 11th, 1992.

4. This report, dated March 6th, 1998 is based on my understanding of the geological setting of the Bubar #1 claim and an examination of satellite imagery over the area.

5. I have no direct, indirect or contingent interest in shares or business of Applied Mine Technologies Inc. nor do I intend to have any such interest.

6. This report is made available both in printed and digital formats. Permission is given by the author to Applied Mine Technologies Inc. to use this report, in all or in part, in any format in their Prospectus or Statement of Material Facts.

Dated at North Vancouver, Province of British Columbia
This 6th day of March, 1998

K.V. Campbell, Ph.D., P.Geo., F.G.A.C.
Geologist

March 6th, 1998

## 8. Bibliography

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## APPENDIX 1

### Basic Principles of Multispectral Imagery and Characteristics of Landsat Thematic Mapper

The first of the five Landsat satellites that have provided digital imagery for earth observation was launched by the United States in 1972. Landsat 5 is currently operational and, like others before it, carries electro-optical sensors. The satellite orbit is near-polar, passing north to south over the daytime side of the planet several times daily. The orbit shifts progressively westward so that the entire surface of the earth can be imaged in 16 days.

The scanner aboard Landsat 5 is known as the Thematic Mapper (TM). This measures the brightness values over different portions of the electromagnetic spectrum, known as wavebands, with digital numbers (DN) between 0 and 255 (the range of 8-bit data). The Thematic Mapper records data from 7 wavebands. The brightness values, or gray levels, are recorded over individual spectral sampling areas known as pixels (from picture elements). The pixel size is nominally 30x30m for the visible and reflected infrared bands and 120x120m for the thermal infrared band. The wavebands are compared in Figure 1 together with wavebands recorded in other satellite systems. The current study utilized TM data because of its superior qualities of ground cell resolution and spectral range.

The seven TM wavebands are the three visible bands (TM 1, 2 and 3 in the order of blue, green and red), one near-infrared band (TM 4), two short-wave infrared bands (TM 5 and 7) and one band in the thermal infrared region (TM 6). Waveband TM 6, 10.4 to 12.5 micrometers, plots off-scale in Figure 1. The energy measured by bands 1 to 5 and 7 is that reflected from the sun; only TM 6 measures energy emitted at the surface. Radiation reflected from the earth's surface back to the satellite (i.e. TM 1 to 5 and 7) has not penetrated more than a few micrometers into the surface material.

Figure 2 presents some typical reflectance curves for common materials. These curves represent the percent of incident light reflected by a material as a function of wavelength. They are routinely used in image processing and analysis to recognize spectral regions in which various materials can be differentiated and to provide a comparative standard for identifying spectra of unknown materials. Image processing techniques are developed by examining spectral curves and noting where the reflectance of a particular material behaves differently than other materials. Mathematical procedures are then applied to the digital data so as to distinguish between various cover types such as vegetation, clay alteration or some particular lithology.

Digital imagery is commonly viewed either as a single band grayscale image or as a multiband composite. Table 1 and the spectral curve for healthy vegetation (Figure 2) illustrates how such curves can be used to predict the resultant color in a three-band composite. For example, vegetation has the highest reflectance values in the green portion of the spectrum (TM 2) over the range of the three visible bands. This is why our eyes perceive a green color in our natural color composite (Case 1, Table 1). However, vegetation has even higher reflectance in the near-infrared (TM 4) and this is why IR (infrared) film or imagery, which ignores the visible blue component and projects visible green, red and near-infrared wavebands with blue, green and red components, represents broadleaf vegetation with bright red colors (Case 2, Table 1). Similarly, a composite of TM 3, 4 and 5 (also written as TM 345) represented in the order of blue, green and red (written as BGR) shows the same vegetation with green hues (Case 3, Table 1).]

**Table 1. Color composite generation.**

| | Color Representation or Projection | | | |
|---|---|---|---|---|
| **Case** | **BLUE** | **GREEN** | **RED** | **Resultant Color Representation on Composite Image** |
| 1 | TM 1 (blue) | TM 2 (green) X | TM 3 (red) | green |
| 2 | TM 2 (green) | TM 3 (red) | TM 4 (NIR) X | red |
| 3 | TM 3 (red) | TM 4 (NIR) X | TM 5 (SWIR) | green |

Dominant (bright) band of each 3 band composite shown by 'X'

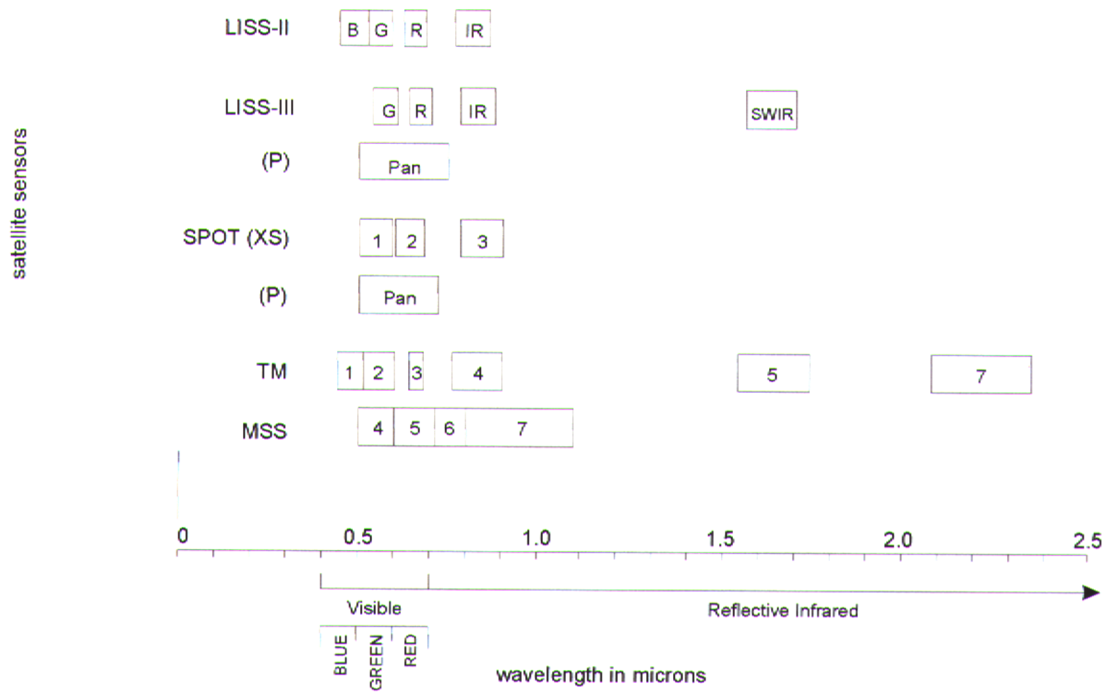


Figure 1. Satellite scanner wavebands or bandpasses.

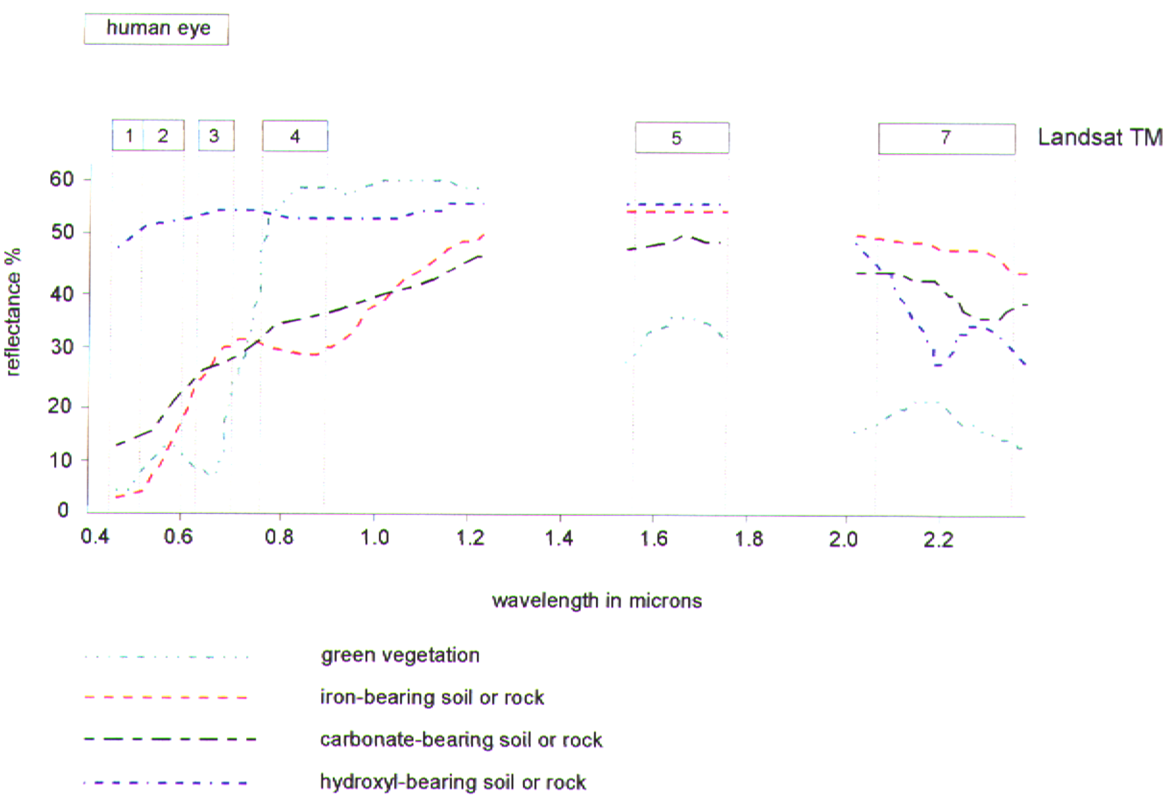


Figure 2. Diagrammatic spectra, illustrating positions of diagnostic iron, clay, carbonate and chlorophyll absorption bands and the bandpasses of TM sensors.