Geological, Geophysical and Petrographic Report on the Jaxd 8 Mineral Claim Kamloops Mining Division, British Columbia.

Statement of Work Number 305893

N.T.S. 92I/9W

50° 37' North Latitude,
120° 27' West Longitude

- for -

Teck Exploration Ltd.,

#350 - 272 Victoria Street,

Kamloops B.C.

V2C 1Z3

Jim L. Oliver M.Sc., P.Geol.,
Kamloops, British Columbia.

Nov. 30, 1994

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INTRODUCTION

During May and June of 1994, as series of technical surveys were initiated on the Jaxd 8, and surrounding mineral claims, as part of a broad based porphyry copper-gold exploration on the Iron Mask batholith. This assessment report documents some of the results of these programs as they relate to the Jaxd 8 mineral claim.

CLAIMS AND OWNERSHIP

The Jaxd 8 mineral claim is a single, one unit, two post mineral claim owned by Getchell Resources Inc., of Kamloops B.C.

Claim Name	Tenure Number	Record Date
Jaxd 8	320909	September 15, 1993.

The two posts which define the location of this claim and the connecting claim line were examined by the writer.

The statement of work number for this mineral claim is 3058983.

This mineral claim is currently under option to Teck Exploration Ltd., through an option agreement between Getchell Resources and Teck Exploration.

LOCATION AND ACCESSIBILITY AND PHYSIOGRAPHY

The Jaxd 8 mineral claim is located 14 kilometres southwest, by road, from the centre of the city of Kamloops. The claims straddle the Ajax haul road, approximately 6 km's east of the Afton Mine, Figure 1. Access to the claim area may be through this haul road or any of a number of smaller unimproved secondary roads accessed from the Lac La Jeune highway.

The geographic centre of the claim area is located close to 50° 37' North Latitude and 120° 27' West Longitude.

Much of the claim block is covered by second growth ponderosa pine and spruce. Scattered sagebrush and dry belt grasses occur on gentle south facing slopes in this area. Much of the claim block is cut by numerous small skid roads and trails, the result of earlier wood harvesting activity.

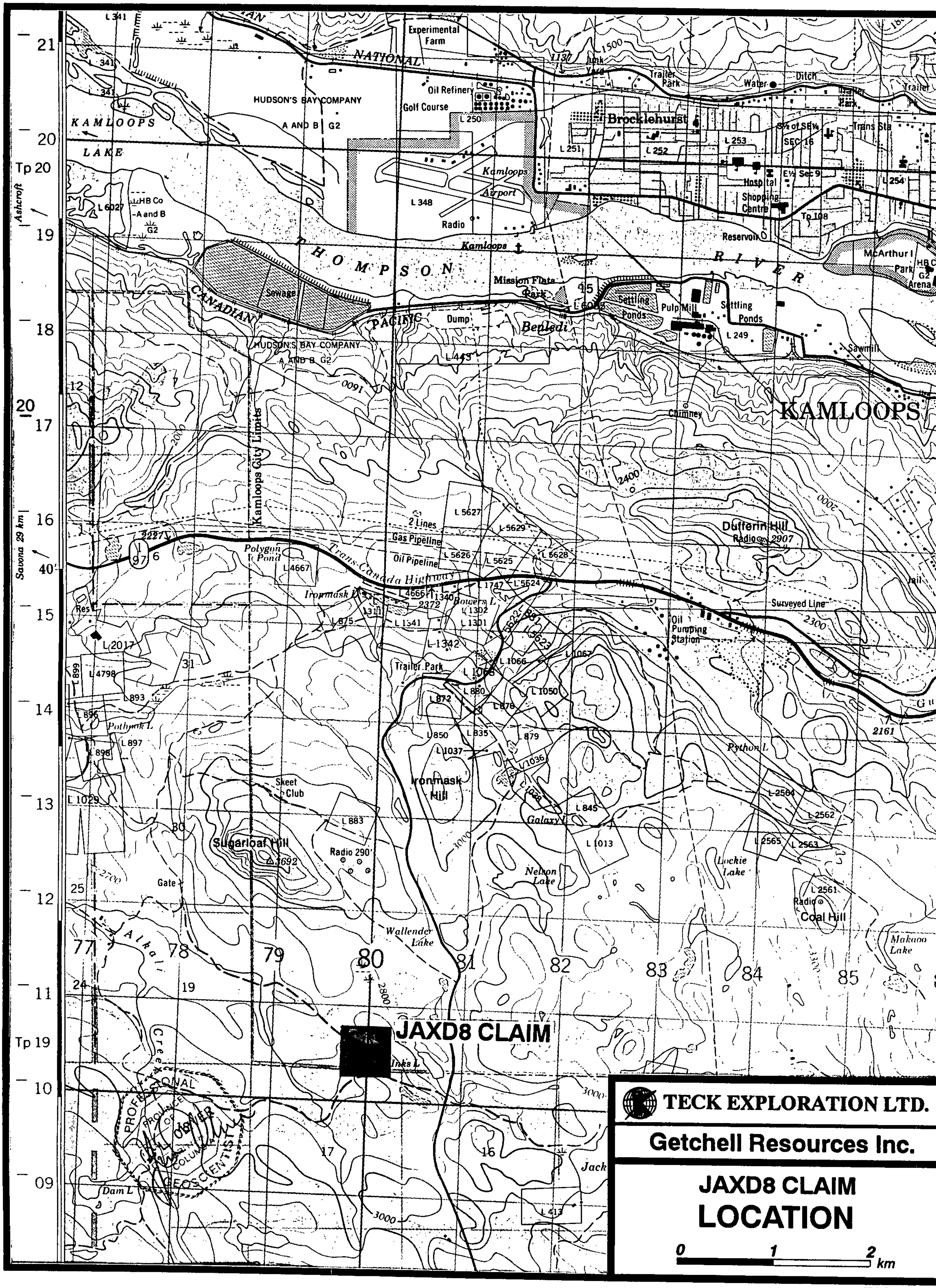

TECK EXPLORATION LTD.
Getchell Resources Inc.
JAXD8 CLAIM
LOCATION
0
1
2 km
JAXD8 CLAIM
Inks L.
KAMLOOPS
KAMLOOPS LAKE
THOMPSON RIVER
CANADIAN NATIONAL
CANADIAN PACIFIC
Trans-Canada Highway
Brocklehurst
Kamloops Airport
Experimental Farm
Oil Refinery
Golf Course
HUDSON'S BAY COMPANY
A AND B G2
Sewage
Dump
Mission Flats Park
Settling Ponds
Pulp Mill
Sawmill
McArthur I
Reservoir
Hospital
Shopping Centre
Chimney
Dufferin Hill
Radio 2907
Kamloops City Limits
2 Lines
Gas Pipeline
Oil Pipeline
Polygon Pond
Ironmask L.
Bowers L.
Trailer Park
Oil Pumping Station
Surveyed Line
Jail
Python L.
Ironmask Hill
Skeet Club
Sugarloaf Hill
Radio 290'
Galaxy L.
Nelson Lake
Lockie Lake
Coal Hill
Wallender Lake
Makaoo Lake
Alkali Creek
Dam L.
Gate
Pothook L.
Savona 29 km
Ashcroft
Tp 20
Tp 19
77
78
79
80
81
82
83
84
85

FIGURE 1

GENERAL GEOLOGICAL RELATIONS

The Jaxd 8 mineral claim lies a few hundreds of metres to the south of the south contact of the Sugarloaf phase of the Iron Mask batholith and the overlying Nicola volcanic rocks. The Iron Mask batholith forms a composite alkalic intrusion. Intrusive rocks are interpreted to be upper Triassic to Jurassic in age (Kwong, 1987) or earliest Jurassic (207 +/- 3 Ma, Gosh, 1993).

Within the northern Iron Mask area, Stanley et.al., (1993) have differentiated six submembers of the Carnian to Norian Nicola group volcanic rocks. Two of these, clinopyroxene and olivine porphyritic flows and plagioclase phyric basaltic flows, are predominant in the immediate surround to the Jaxd 8 mineral claims.

General geological relations near the Jaxd 8 claim, based on Kwong's 1987 map, are shown on Figure 2.

PREVIOUS EXPLORATION

Remnants of picketed grid lines, overgrown baselines and claim boundaries, and a few scattered trenches are the sole remaining traces of historical exploration near the Jaxd 8 claim.

In the middle 1960's, Western Beaverlodge Mines conducted a large set of magnetometer, IP and soil geochemical surveys in this area. Portions of these surveys are likely to have cut the northern half of the Jaxd 8 mineral claim (Nicholls, 1965a and 1965b). Additional soil surveys, largely conducted by New Denver Exploration Ltd., in 1976, were concluded over ground to the east of the Jaxd 8 mineral claims (Sookachoff, 1976). Rock sampling and mapping programs were also carried near the present claims by Eureka Resources Inc., during 1989 (Leishman, 1990). Magnetometer surveys were completed on the adjacent Jaxd 1 to 6 mineral claims (Belick, 1992).

Other technical surveys may have been run in the Jaxd 8 area but the results of these surveys are unknown to the writer.

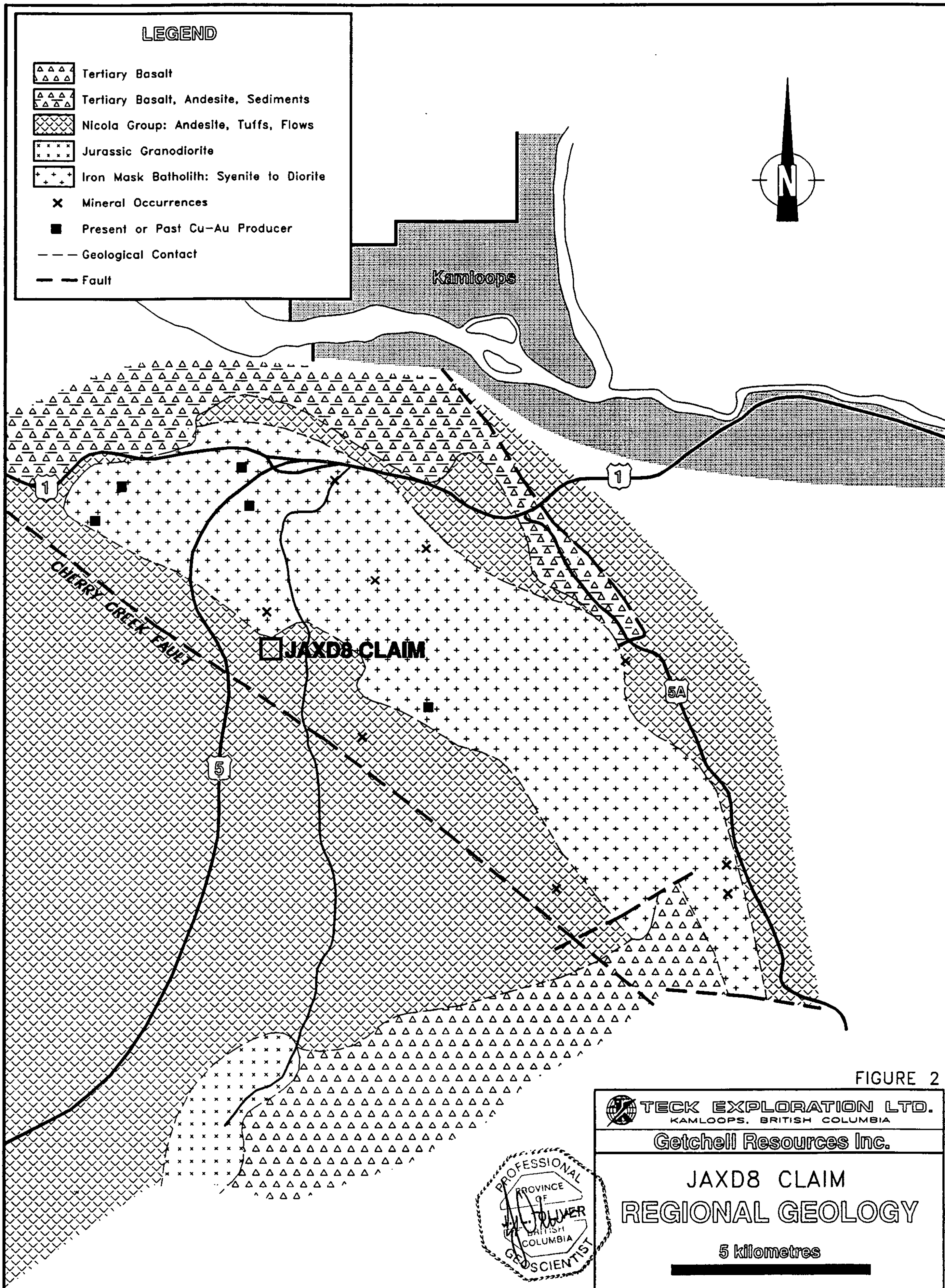


FIGURE 2

TECK EXPLORATION LTD.
KAMLOOPS, BRITISH COLUMBIA

Getchell Resources Inc.

JAXD8 CLAIM
REGIONAL GEOLOGY

5 kilometres

RESULTS OF GEOLOGICAL MAPPING

A 1:5,000 scale geological map which covers all of the Jaxd 8 mineral claim is shown on Figure 3. All geological mapping used a high quality orthophotographic base map with additional ground control provided by a compass and chain grid.

The very limited outcrop exposures in this area seriously restrict the geological interpretations which may be derived from this map. Regardless, the following points are relevant to the interpretation of these data:

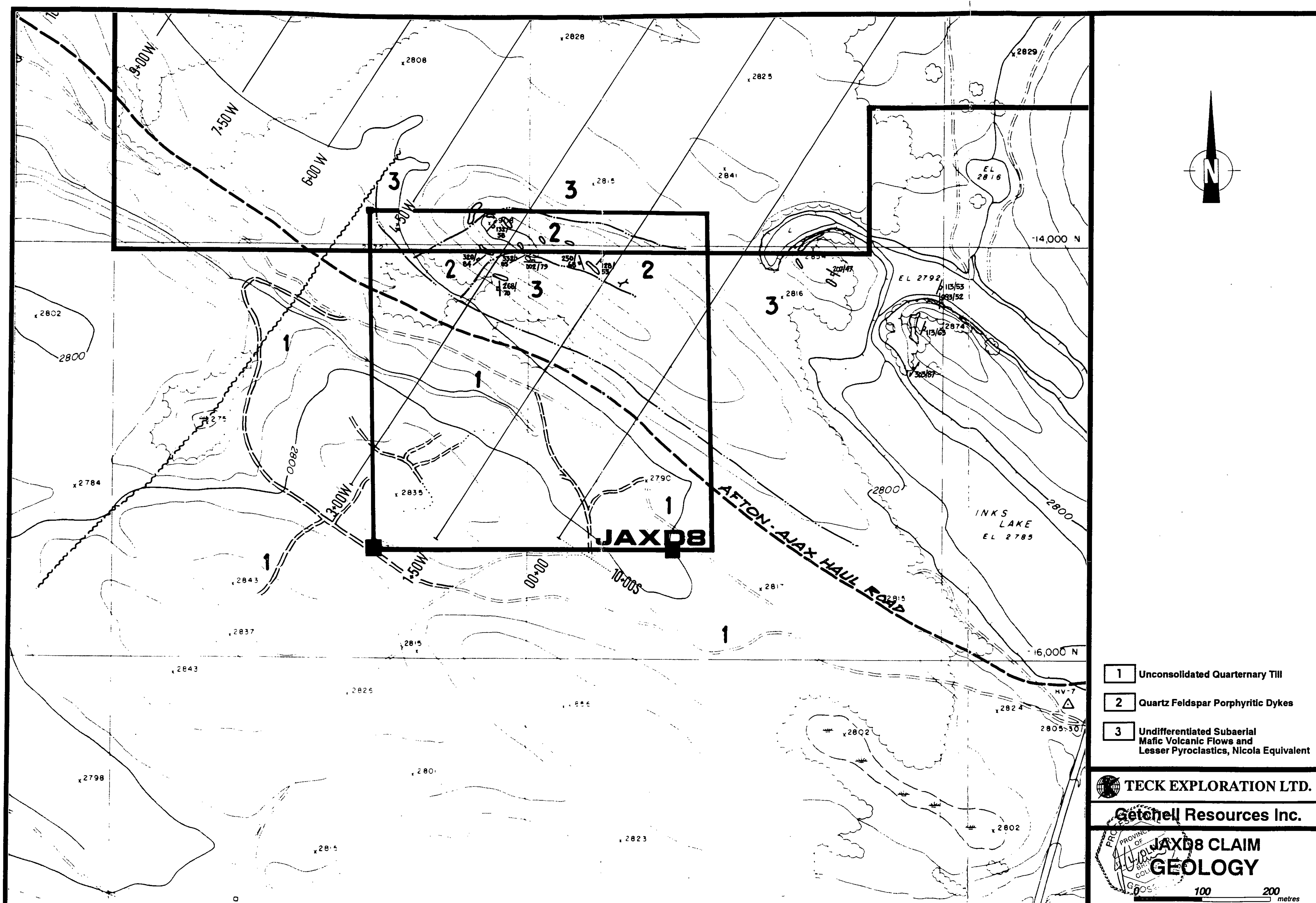
1. The north half of the Jaxd 8 map area is underlain by a buff to brick-red weathering subaerial basaltic flow sequence. Lesser fine grained ash falls and lapilli pyroclastics may be intercalated with this sequence. No definitive bedding orientations could be obtained from these outcrops.

2. The west-northwest trending ridge which outcrops over the northern third of the claim area overlies a pale buff-orange, coarse grained quartz-feldspar porphyritic (QFP) dyke. These rocks are likely discordant to the underlying volcanic rocks.

3. Strong hornfels development occurs near the contacts of the QFP dykes and basaltic flows. Contact effects are defined largely by the development of sucrosic clinozoisite. Sulphide mineral phases are not associated with hornfelsed dyke contacts.

4. The development of numerous brittle failures and fractures and weak calcite vein injection, suggests that the northwestern portions of the QFP dyke may be truncated and offset by a northeast trending normal fault.

5. The southern half of the claim area is likely to be underlain by a till sheet of indeterminent thickness. These tills are characterized by (i) a non-oxidized, clay rich gray buff matrix, and by (ii) an abundance of cobble sized transported rock fragments of mixed origin.



JAXD8
AFTON - AJAX HAUL ROAD
INKS LAKE
EL 2785
EL 2816
EL 2792
-14,000 N
-16,000 N
9+00W
7+50W
6+00W
4+50W
3+00W
1+50W
00+00
10+00S
1 Unconsolidated Quarternary Till
2 Quartz Feldspar Porphyritic Dykes
3 Undifferentiated Subaerial Mafic Volcanic Flows and Lesser Pyroclastics, Nicola Equivalent
TECK EXPLORATION LTD.
Getchell Resources Inc.
JAXD8 CLAIM
GEOLOGY
100
200
metres

FIGURE 3

PROTON MAGNETOMETER SURVEY

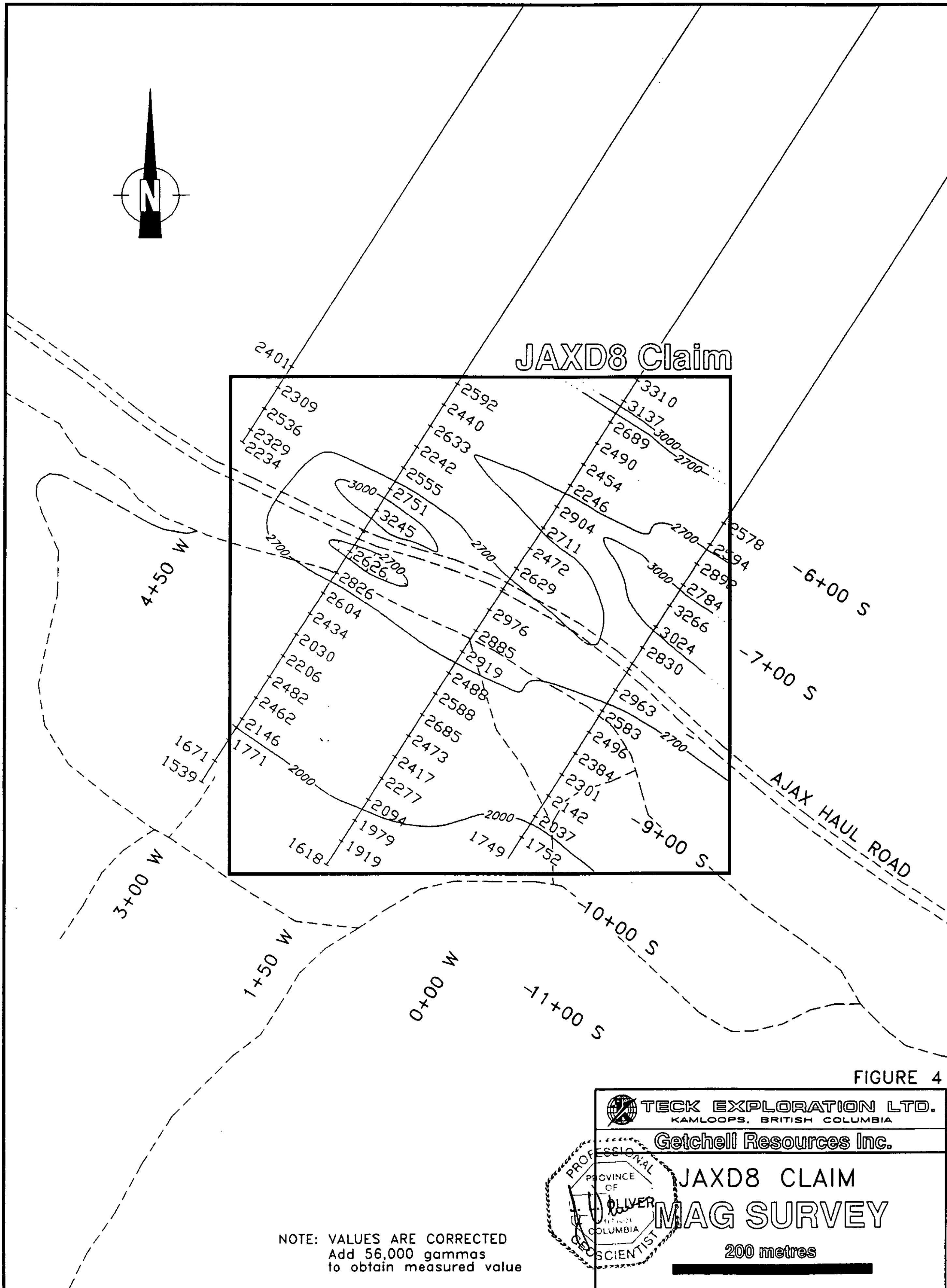
The magnetic survey used a Geometric's Model 826A portable, proton magnetometer. This magnetometer measures the total intensity of the earth's magnetic field from a range of 20,000 to 100,000 gammas with an accuracy of +/- 10 gammas.

The survey was completed across four grid lines orientated at 032.5 degrees. Stations were read every 25 metres. No readings were taken across the Ajax haul road or on berm piles flanking the haul road. Repeat readings were taken at the north end of each survey line to permit time dependent diurnal variation corrections.

At the onset of the survey, the coarse setting of the magnetometer was set to the regional magnetic field at 56,000 gammas.

The results of this survey are shown on Figure 4. Isomagnetic contours have been interpreted based on intervals of 2000, 2700 and 3000 gammas.

Operating procedures for the Geometrix magnetometer are outlined in Appendix I.



N
JAXD8 Claim
2401
2309
2536
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2234
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2242
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2604
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2685
2473
2417
2277
2094
1979
1919
1618
3310
3137
2689
2490
2454
2246
2904
2711
2472
2629
2963
2583
2496
2384
2301
2142
2037
1752
1749
2578
2594
2898
2784
3266
3024
2830
3000
2700
2000
4+50 W
3+00 W
1+50 W
0+00 W
6+00 S
7+00 S
9+00 S
10+00 S
11+00 S
AJAX HAUL ROAD
NOTE: VALUES ARE CORRECTED
Add 56,000 gammas
to obtain measured value
FIGURE 4
TECK EXPLORATION LTD.
KAMLOOPS, BRITISH COLUMBIA
Getchell Resources Inc.
JAXD8 CLAIM
MAG SURVEY
200 metres
PROFESSIONAL
PROVINCE OF BRITISH COLUMBIA
OLIVER
GEOSCIENTIST

PETROGRAPHY

Several thin sections were cut from rocks taken from the exposures near the north-central portions of the map area. Plates and descriptive summaries from some of these samples are included in this report.

Sample Number J4a

This rock is representative of a non-hornfelsed plagioclase phyric flow sequence. As is shown in Plate 1, the rock matrix is composed of angular plagioclase phenocrysts supported by a microlith feldspar rich matrix. The An content of these feldspars, based on twin plane relations, is approximately An 60. Mafic minerals are poorly preserved in this matrix. Most have been replaced by iron rich carbonates and lesser chlorite.
Net sulphide or oxide content in this sample is extremely light. Hematite is the sole oxide phase and averages less 8% by volume.

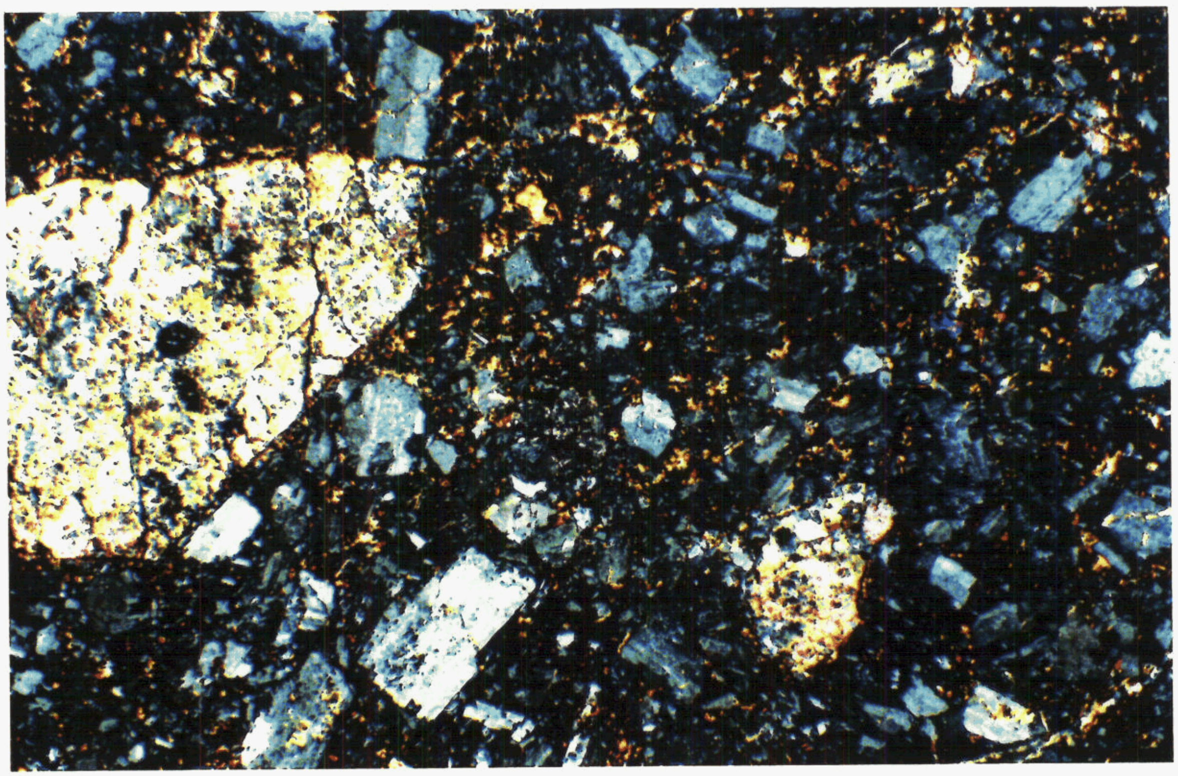

Plate 1. Plagioclase Phyric Flows. Non-aligned plagioclase phenocrysts occur throughout the rock matrix. Net feldspar content may exceed 75% of this rock. The large phenocryst in the left field of view is a clinopyroxene preferentially replaced by carbonate and lesser uralite. Crossed polars, 25X, field of view 5.25 mm.

Sample J3

This rock sample is identical in its protolith to sample J4 but the rock has been strongly hornfelsed by the adjacent QFP dyke rock. Two outstanding features define this contact aureole. These include (i) the development of abundant, 15% by volume, hematite disseminated throughout the rock matrix (Plate 2) and (ii) the presence of stubby euhedral crystals of clinozoisite which now occupies up to 45% of the rock. Most significantly, pyrite or other sulphide phases are not noted in these hornfelsed rock samples.

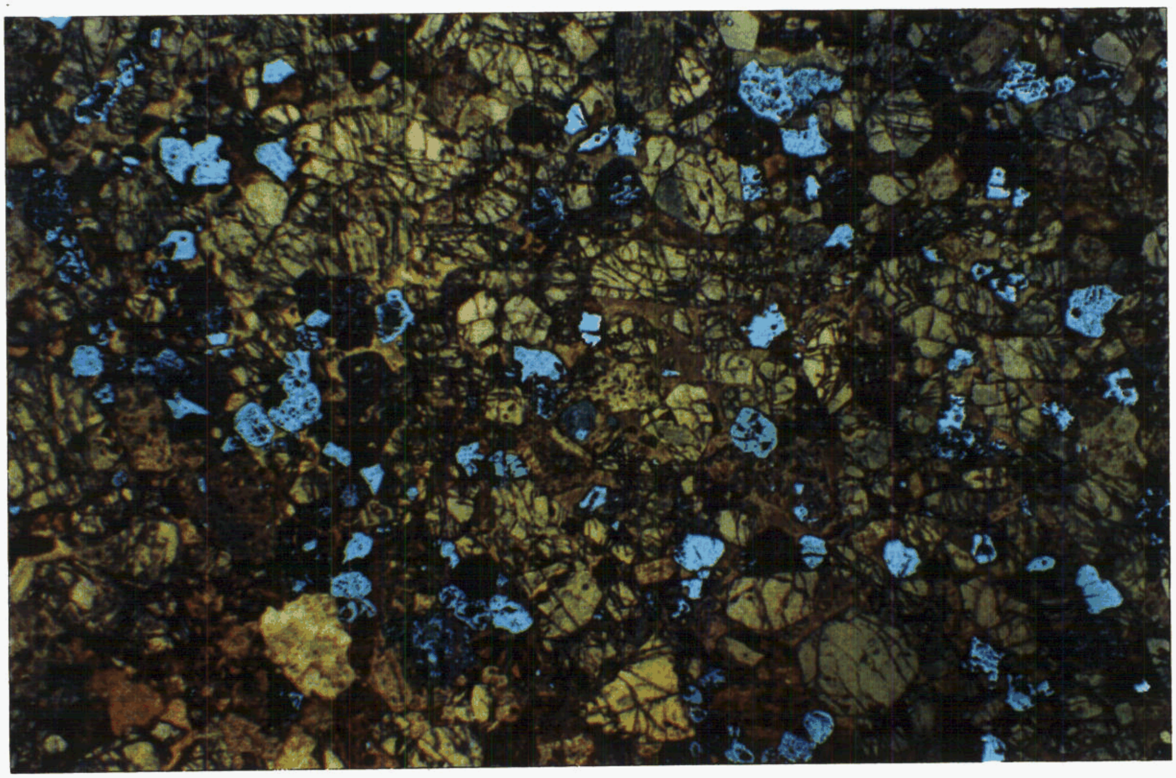

Plate 2. Disseminated Hematite, Sample J2. Abundant fine grained hematite is disseminated throughout the rock matrix. Most of the high relief, non-opaque phenocrysts in the matrix of this rock is clinozoisite. Reflected and weak transmitted light, 25X; field of view 5.25mm.

Sample J3.

This rock sample has been taken from a QFP outcrop located due north of the Ajax haul road. In this sample, two predominant phenocryst phases may be noted (i) sub-rounded to tear-dropped shaped quartz eyes and (ii) elongate, dull brown partially carbonitized hornblende phenocrysts. A third phenocryst phase, coarse feldspar phenocrysts, are weakly to poorly represented in this photomicrograph.

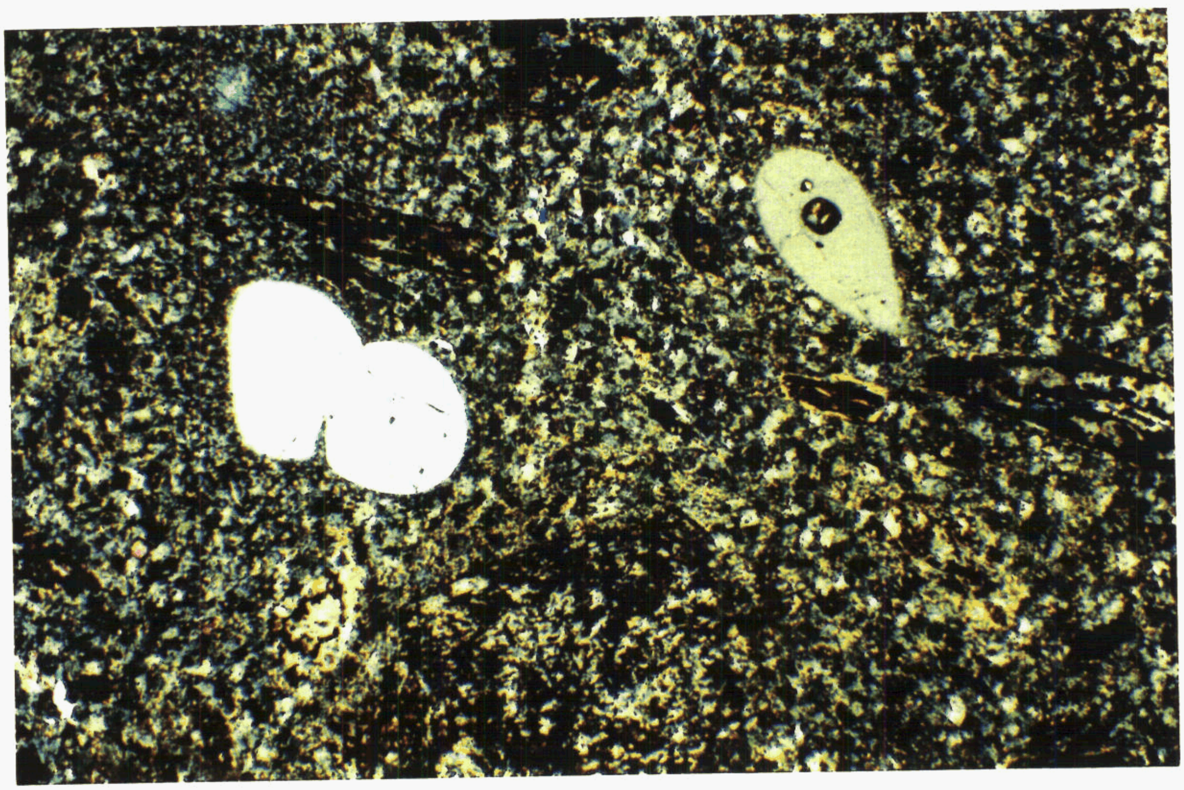

Plate 3. Quartz and Feldspar Porphyritic Dyke Rock. Coarse quartz and hornblende phenocrysts are clearly visible in this thin section. The rock matrix is composed of sericitized and carbonitized plagioclase and mafic phenocrysts. No oxide or sulphide phases are noted in this thin section. Crossed polars, transmitted light, 25X; field of view 5.25 mm.

DISCUSSION OF RESULTS AND RECOMMENDATIONS:

i. Discussion of Results

The principle findings of technical surveys across the Jaxd 8 mineral claim are the following:

1. The claims are underlain by subaerial plagioclase phyric basaltic flows, of the Nicola Group.

2. Subaerial flows are cut by coarse grained quartz porphyritic dykes. The abundance of free quartz in these intrusions suggests that they are unlikely to be related to the Iron Mask batholith. These intrusions are more likely related to Tertiary igneous events.

3. Strong clinozoisite hornfels development occurs within the volcanic rocks near quartz feldspar porphyry dyke contacts. Hornfelsing of volcanic rocks occurs without significant sulphide development. An oxide phase, hematite, is strongly associated with the hornfelsed contact aureoles.

4. One interpreted fault which trends north-northeast is mapped across the western portion of the Jaxd 8 mineral claims. The existence of this fault is inferred from the increased density of brittle failures, weak calcite vein injection, and the presence of a topographic low.

5. A moderate magnetic high strikes west-northwesterly across the top one third of the Jaxd 8 property. This magnetic high roughly tracks the position of a linear ridge. Outcrops of quartz feldspar porphyritic intrusions and basaltic flows are mapped in this area. However, these rocks do not have a significant ferro-magnesium content. The anomaly may in part be generated by rapid changes in overburden thickness, which likely increases, both north and south of this ridge. Increasing overburden depths will generally produce subdued anomalies and decrease the intensity of the bedrock magnetic signature.

The magnetic intensity typically decreases south of the Ajax haul road. The southern half of the Jaxd8 claim is characterized by a very flat and weak ground magnetic signature.

ii. Recommendations:

Subsequent work on this property should focus on developing a soil and rock geochemical data base. To date, these data have not been developed or acquired for this property. Emphasis must be placed on defining the potential for blind mineralized zones beneath areas of extensive drift or till cover.

REFERENCES

Belik, G. (1992): Geophysical Report on the Jaxd Group (Jaxd1 to 6, Jaxd 7 Fr) Kamloops Mining Division, British Columbia. Private Corporate Report to Getchell Resources Inc., 9 pages.

Gosh, D. (1993): Uranium-Lead Geochronology; in Porphyry Cu-Au Systems of British Columbia, Mineral Deposit Research Unit, The University of British Columbia, Annual Technical Report, pages 11.1 - 11.26.

Kwong, Y.T.J. (1987) Evolution of the Iron Mask Batholith and Associated Copper Mineralization; B.C. Ministry of Energy, Mines and Petroleum Resources, Bulletin 77.

Leishman, D.A. (1990): Geological and Geochemical Report on the Jaxd Claims; Private Corporate Report to Eureka Resources Inc.

Nicholls, E.B. (1965a): Geophysical Report on Rainbow Group of Claims for Western Beaver Lodge Mines Limited. Private Corporate Report to Western Beaver Lodge Mines Limited; 6 pages.

Nicholls, E.B. (1965b): Geophysical Report on Rainbow Group of Claims for Western Beaver Lodge Mines Limited. Private Corporate Report to Western Beaver Lodge Mines Limited; 10 pages.

Sookachoff, L. (1976): Geochemical Report on the Feb Claim for New Denver Exploration Limited; Assessment Report #11,690.

Stanley, C.R., Lang, J.R. and Snyder,L.D. (1994): Geology and Mineralization in the Northern Part of the Iron Mask Batholith, Kamloops, British Columbia; in Geological Fieldwork 1993, Grant, B. and Newell J.M., Editors, B.C. Ministry of Energy, Mines and Petroleum Resources, Paper 1994-1, pages 269-274.

STATEMENT OF QUALIFICATIONS

I, **JIM L. OLIVER,** of the City of Kamloops, Province of British Columbia, **DO HEREBY CERTIFY THAT:**

1. I am a senior geologist with Teck Exploration Ltd., with a business office at #350 - 272 Victoria St., Kamloops British Columbia, V2C 1Z3.

2. I hold a combined degree, Bachelor of Science, Honours Geology and Geophysics, granted by the University of British Columbia (1982), a Master of Science in Geology, granted by Queen's University (1985) and I am currently enrolled in a Doctoral program at the latter university.

3. I am a Fellow of the Geological Association of Canada.

4. I have actively practised my profession as a geologist for the past twelve years.

Pre-graduate work experience includes base and precious metal exploration in British Columbia and the Yukon (1979 - 1981).

Post-graduate work experience includes exploration for gold and base metals in Ontario, the Northwest Territories, British Columbia, the southwestern United States, Alaska, Iceland, Jamaica and Indonesia (1982 - 1994).

5. During the third week of May, 1994 mapping and geophysical programs were completed on the Jaxd8 mineral claim. All mapping was done by Oliver and the magnetometer survey was run by Douglas Nikart under my direction. To improve the survey coverage of the subject claims, magnetometer lines south of the Ajax haul road were surveyed in fourth week of September. The cost of the additional survey, completed after the filing date, has not been accrued against the Jaxd8 claim.

6. I have no direct, indirect or contingent interest in the subject claims, or in Getchell Resources Inc., nor do I intend to receive such interest.

PROFESSIONAL PROVINCE OF J. L. OLIVER BRITISH COLUMBIA GEOSCIENTIST

Jim L. Oliver, M.Sc P.Geol.

Dated at Kamloops, British Columbia, this 30 th day of November, 1994.

Appendix I

Operating Procedures for the Geometrics Magnetometer

IV.
FIELD PROCEDURES AND DATA REDUCTION

Magnetic Cleanliness and Sensor Positions

Most of the applications for portable magnetometers require that *the operator be relatively free of magnetic materials on his person.* The importance of checking oneself cannot be over-estimated if measurements on the order of 1 gamma are desired. In field surveys, the usual magnetic material one may have may include, of course, the obvious such as a rock pick, Brunton comppass, pocket knife, or instrument console and the not-so-obvious effects of the pivot in eyeglasses, the pants clip at the top of men's trousers, the light meter in a camera, the magnet in the speaker of a tape recorder, metal in a clipboard, some mechanical pencils, some keychains, and the steel shank in one's shoes or boots. Of course, some of these items cannot be altered or left behind and some are not significant in any event. The sensor itself should be kept clean to avoid possible contamination by magnetite-bearing dirt on the sensor surface. In order to check the 'heading effect', i.e., the effect of orientation on the observed field intensity during a field survey, the operator can take readings at each of the four cardinal directions while pivoting about the position of the sensor and note the changes. If the maximum change is typically less than 10 gammas, the average readings on a line will probably not be affected by more than 5 gammas and individual readings by less than this inasmuch as readings along the profile are more-or-less along a given heading ± perhaps 30° about one orientation. If a sensitivity of 1 gamma is desired, the heading error should be less than several, preferably 2 gammas or less and depending upon the desired sensitivity, the operator should make some effort to face in the same direction, if possible, for all readings on a given traverse.

The sensor for a proton magnetometer may be carried on a 8-foot (2.2 meter) staff, on a backpack, on an extended staff to 12 feet (4 meters) or more as necessary, or by a second person as represented in *Figure 8.* The sensor on an 8-foot staff is by far the most common means for field measurements removing the sensor sufficiently far from the console and from the operator so as not to be much affected by normal items of clothing, etc. The purpose of mounting a sensor on an extended 12 foot or longer staff is to remove the sensor from the locally disturbing effects of highly magnetic surface materials, such as surface laterite, glacial till, or highly magnetic outcropping rocks. The sensor may also be raised in the case of very high magnetic gradients which would otherwise ruin the magnetometer signal and prevent any reading whatsoever (see following sections). An additional reason for an extended staff will be described in Chapter VIII in reference to vertical gradient measurements. There are also occasional reasons for a second person carrying the sensor while the first person carries the console together, perhaps, with magnetic or other materials that must necessarily be on his person such as pick, tape recorder, another instrument or rock samples.

The sensor may be carried in a backpack pouch for more convenient field operation where 5 or 10 gamma sensitivity is all that is desired, but care should be taken to check the effects of the batteries and console (particularly the very magnetic alkaline batteries). The backpack pouch frees the hands for taking notes, pushing aside the underbrush and, in general, balances the load of the console and decreases fatigue.

Operational Considerations

Valid Readings Vs. Noise

It is important to establish that, in fact, the magnetometer is providing valid readings. The simplest means of confirming that what is being observed is a magnetic field reading and not random, meaningless instrument readings (i.e., noise) is to take several readings in succession in one location without moving anything, and note the repeatability. Successive readings should be within ± 1 gamma, ± 0.25 gamma or ± 1 count for whatever the sensitivity setting. Valid readings should not, under any naturally-occurring circumstances including magnetic storms, vary by as much as ± 10 or ± 100 gammas in a few seconds; if such is observed, the readings represent either noise or a degradation of the signal-to-noise ratio with the observed corresponding loss in terms of sensitivity. Under certain circumstances even successive readings repeating to within several gammas may still represent noise. To confirm that these readings are indeed magnetic field, simply 'kill' the signal by placing,

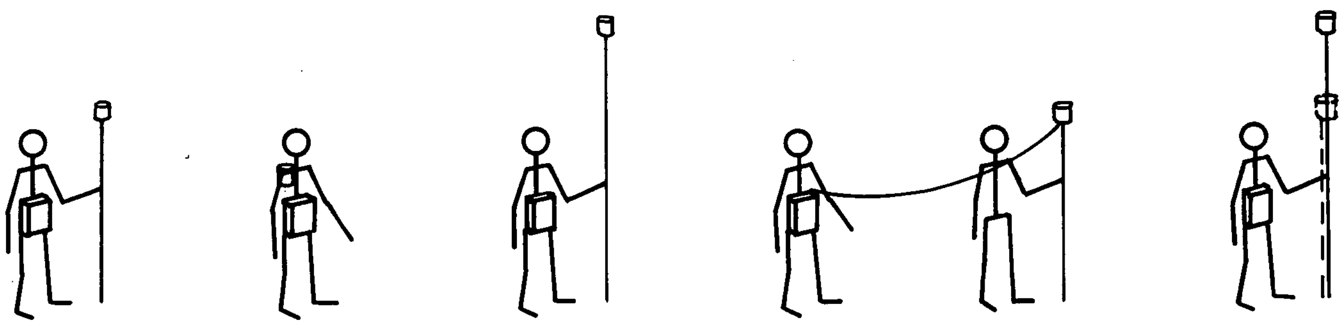

Figure 8. Sensor Carrying Positions

momentarily during the reading, something magnetic adjacent to the sensor such as one's shoe, watch, certain rocks, etc. Random readings varying by 10 or 100 gammas or more would then be observed in addition to their deviating considerably from the readings without the object present. Another but less certain method is to take readings at intervals of increasing distance from an object or location known to produce a magnetic anomaly.

Typical reasons for a proton magnetometer not producing valid readings may be: electrical noise from AC power lines, transformers or other radiating sources; high magnetic gradients from underlying rocks, nearby visible or hidden iron objects, fence lines or improvised iron hardware improperly used near the sensor; improper orientation of the sensor (even when 'omni-directional'); expired batteries, incorrect range setting or instrument failures, broken or nearly broken sensor cable, and other malfunctions usually described in the instrument operating manual.

Valid but distorted readings may result from several other conditions including the above effects of high magnetic gradients, magnetic dirt or other magnetic contamination on the sensor and any magnetic bias on the operator. Time variations (Chapter III and following) and the effects of direct current in distant power lines and trains (Chapter IX) can also distort magnetic observations.

Sensor Orientation

According to the theory of operation of the proton magnetometer, the total intensity, measured as the *frequency* of precession, is independent of the orientation of the sensor. The *amplitude* of the signal, however, does vary (as $\sin^2\theta$) with the angle between the direction of the applied field within the sensor and the earth's field direction. Variation of signal amplitude does not normally affect the readings unless there is simply insufficient signal to be measured accurately, i.e., a minimum signal amplitude is required above which a variation in amplitude does not affect the readings.

Ideally, the applied field in the sensor should be at right angles to the earth's field direction. The direction of the applied field is governed by the configuration of the polarizing coils in the sensor which are commonly either solenoids (cylindrical) or toroids (ring or doughnut-shaped). The solenoid produces an applied field parallel to its axis, whereas the toroid produces a field which is ring-shaped about the axis of the toroid (consult the instrument operations manual to determine the direction of these axes with respect to the sensor housing). Solenoids are used because they produce somewhat higher signal than a toroid and are less perturbed by electrical noise, whereas a toroid is inherently omnidirectional. In the ideal case, a solenoid should be held horizontal and in any direction in a vertical field, and should be held vertical in a horizontal (equatorial) field for maximum signal amplitude. A toroidal sensor should be held with its axis vertical in a vertical field, and pointing north in an equatorial field to obtain maximum signal. A field which dips greater or less than 45°, should be treated as though it were a vertical or horizontal field respectively.

Instrument Readings

Measurements are normally made at regular intervals along a grid or otherwise selected path whose locations are noted for subsequent plotting. Simple pacing is usually adequate with readings every 6, 10, 50, 100, 500, or even 1,000 feet (2 to 300 meters), as anomalies, field, and either geological or search requirements dictate. Traverses may be selected along pathways or other accessible routes and occasional locations noted on an aerial photograph or map using paced distances in between. The density of readings along the traverse should be related to the wavelength of anomalies of interest such that several readings are obtained for any such anomaly. A single trial line with relatively dense stations is usually attempted first to determine the required station density. It is important never to hold the magnetometer sensor within one or two feet of the ground, if possible, in order to avoid effects of minor placer magnetite which usually collects on the surface of the ground, and also to avoid the effects of microtopography or outcropping rock surfaces.

Readings may be noted in a field notebook or, if desired, on a miniature tape recorder, but care must be taken to magnetically compensate the speaker magnet and motor following the theory given in Chapter VI if one is to use a recorder. The convenience of the recorder is that only one hand is needed and the data may be played back for fast, convenient plotting.

Correction for Time Variations

Some ground magnetic surveys require correction for diurnal and micropulsation time variations. Correction is required if the anomalies of interest are broad (thousands of feet) and typically less than 20 to 50 gammas, or if the profile lines are very long, or if the objective of the survey is a good magnetic contour map expressive of deep-seated anomaly sources. Also, if the survey is performed in the high magnetic latitudes in the auroral zone where typical micropulsations are 10 to 100 gammas, correction for such variations would be necessary. On the other hand, if one is merely interested in profile information of anomalies of several hundred gammas or if the anomalies are only 20 gammas but can be traversed completely in less than 5 minutes, no time variation correction is needed. Perhaps *most surveys* fit the latter criteria and *do not actually require any such correction for time variations.*

The simplest method of correcting for time variations involves repeated readings in the same orientation at the same station at different times during the survey. If a smooth curve is drawn through the readings plotted as a function of time (every hour or so), these values can be subtracted from all other readings provided that each reading also includes the time at which it was observed. To avoid an extremely long and repeated walk to a single reference station, it is also possible to 'double-back' to take a second or third reading on each given traverse to determine at least the time variations for that traverse. Still another technique is to emulate what is done on aeromagnetic surveys, namely, obtain rapidly acquired measurements on tie lines or lines which cross the principal traverse lines at each end and perhaps in the center. The stations common to each traverse and tie lines should be known and occupied while facing the same direction to avoid heading errors. The simplest method for using these tie lines is to make each intersection agree by linearly distributing the error on each traverse line and holding the tie line values fixed—provided the tie line data were acquired rapidly.

A local recording base station, i.e., diurnal station monitor, is the most ideal method and certainly the most accurate for removing time variations. The time variations can readily be removed from each reading, again assuming that the time is noted for each reading on the traverse to within a minute or so of the base station. The base station should not be further away than 100 miles from the area of the survey for agreement within a few gammas and should be positioned more than 200 feet away from local traffic and other disturbances (see Chapter VII). The diurnal base station, if left to continue recording during each evening, can indicate magnetic storms in progress and may be examined at the start of a survey day to determine if any useful measurements can actually be obtained during such conditions. During a magnetic storm, it is best not to obtain field data with the objective of removing the storm variations as the survey magnetometer and base station may not agree better than 5 or 10 gammas.

High Magnetic Gradients

In the case where an extremely high magnetic gradient destroys the signal as evidenced by successive non-repeating measurements, it may be necessary to raise the sensor up to 10 or 12, sometimes 15 feet in order to move the sensor to a region of lower gradient. This will only happen over outcropping or nearly outcropping large masses of perhaps altered ultrabasic rocks, magnetic iron ore deposits or ore bodies containing a large percent of pyrrhotite and in the near vicinity of buried iron objects in the applications for search. Such an event would only occur if the gradient exceeds several hundred gammas per foot. If the span of high gradient is not too wide, it may not actually be necessary to obtain measurements precisely at the highest gradient. Measurements on either side of the anomaly can be extrapolated or be used to at least indicate the contacts of such a highly magnetized formation. Furthermore, as the signal disappears and the readings diverge considerably from ± 1 or 2 counts, it may be worthwhile to note approximate indications of magnetic field gradient which on some instruments is displayed on the front panel as signal amplitude (which is a function of gradient). In areas of highly magnetic surface conditions, as noted in a previous section but where a signal is still obtained, another alternative in acquiring meaningful data other than that of using an extended staff would be to make 2 to 5 measurements per station, for example, at the points of a cross centered at the actual primary station location. The average of these readings would later be used to draw a profile. In this way, some of the surface noise is averaged out.

In the absence of anomalous surface conditions and for reasons more fully described in Chapter VIII, it may be useful for both geological and search applications to measure the vertical gradient of the total field. The vertical gradient is obtained by making 2 total field measurements, one over another, taking the difference in the readings and dividing by the distance between them.

Data Reduction

The profiles when plotted should be smoothly varying and expressive of the anomalies of interest. (NOTE: The nature of the disturbances or anomalies of interest, their width, character, signature, and amplitude are discussed in Chapter V, following.) Should there be an excessive amount of such geologic/magnetic noise, at a wavelength much shorter or much longer than is of interest, it is possible to apply simple filtering or smoothing techniques to facilitate interpretation of the profile. As a rule of thumb, *never remove or filter out anomalies whose wavelength is on the order of the depth to sources of interest.* A number of advanced techniques for data enhancement or filtering as employed in airborne surveys or well-gridded ground surveys will not be discussed within the scope of the Manual but are listed to acknowledge their existence: Vertical derivatives, upward and downward continuation, reduction-to-the-pole, bandpass filtering, trend surface filtering, spectral analysis, trend enhancement, magnetization filtering, and others most of which are applied to two-dimensional data.

Profile Smoothing

Anomalies of very short wavelength (much shorter than the probable depths to sources of interest) may be present and caused by the magnetic effects of the magnetometer operator, or simply by surface magnetization contrasts in the surface or near-surface materials as mentioned earlier. In removing such effects, the eye itself tends to enhance what one is seeking. Another simple and obvious method is of course to pencil or trace through the noise. A more objective technique is to apply a running average or weighted running average to the data (see Figures 9 and 10). For a 3-point weighted

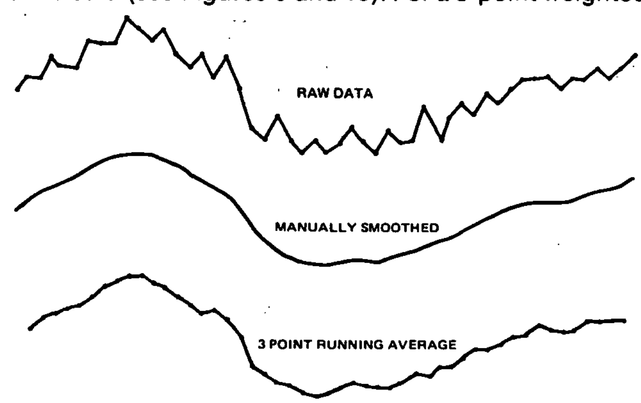

Figure 9. Profile Smoothing

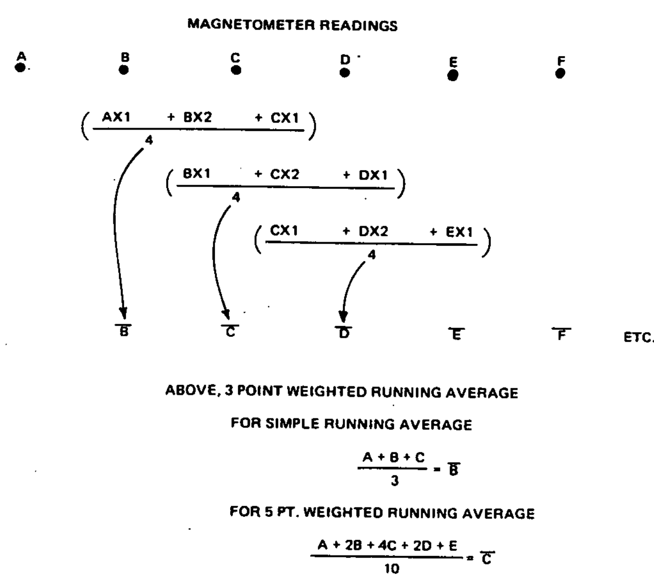

Figure 10. Running Averages

running average, for example, one would multiply the value at a given station by 2, add the values of the two adjacent stations, divide the sum by 4. This value is then set aside for that station for later recompilation of a new profile while advancing to the next station to perform the same procedure *(see Figure 10)*. A 5-point running average might utilize a weighting factor of 4 for the central point, 2 for each adjacent point, and 1 for the outside points while dividing by 10 to obtain the averaged value. More sophisticated techniques are also possible such as polynomial curve fitting, least squares, digital bandpass filtering, etc. The number of points or interval over which the averaging or filtering is to be performed for removal of such 'noise' should be much shorter (perhaps $1/5$ to $1/10$) than the anomalies of interest.

Removal of Regional Gradients

In most cases, the anomalies of interest usually appear superimposed on a much broader anomaly which is not of interest. This broader anomaly, or regional gradient, due to the main earth's field or very deep or distant sources, may appear simply as a component of slope in the curve and although it is subjectively determined, is often removed from the data in order to better examine the anomaly. This gradient is removed from a single profile as shown by *Figure 11* by drawing a straight line or broadly-curved line through the non-anomalous portions of the curve. The values are then subtracted at each station and replotted to present the 'residual' values, hopefully expressing only the anomalies of interest which in this case would be the anomalies occurring at the shallower depths. The vertical gradient, measured according to the methods prescribed in Chapter VIII, also serves to remove or largely reduce the regional gradient.

Contour Maps

Most survey traverses are not sufficiently close nor well-arranged in plan to allow the compilation of a contour map. Such is usually the case when only mineral exploration data are desired, in broad reconnaissance surveys, or when surveying in extremely rugged terrain where large areas are otherwise inaccessible. Profiles are, in fact, usually adequate particularly for anomaly sources with very long, horizontal dimensions. Contour maps are nevertheless useful in cases where little is known of the geology or magnetic sources, where the anomaly sources are either small or extremely large, or for ascertaining, on a more objective basis, the distribution of the anomalous masses or very subtle longer wavelength features. Many surveys for search also require broad coverage and perhaps contour map presentation. An alternative to the construction of contour maps for broad two-dimensional coverage is the presentation of 'offset profiles' or profiles plotted on abscissae which also serve to show the location of the traverse lines drawn on a map.

Constructing a contour map requires that large effects from diurnal variations or the heading effects, if any, be removed; that is, that there be a single datum level for all traverses or readings. The process of removing the regional gradients, as described above, frequently serves to remove these other sources of errors as well and is satisfactory as long as one is not interested in the longer wavelength anomalies removed as part of the gradient.

The following guide should be useful to one not familiar with the techniques of constructing a magnetic contour map, or plan view of the anomalous total intensity. A contour or iso-intensity map is analogous to a topographic map and is a map on which are drawn lines (contours) of equal intensity, at convenient and regular intensity intervals, as would be observed were a magnetometer used to occupy every point on the surface of the ground. The contoured values are at best extrapolations and interpolations across areas where measurements are not actually taken. Such a map is drawn with the knowledge that the magnetic field is smoothly

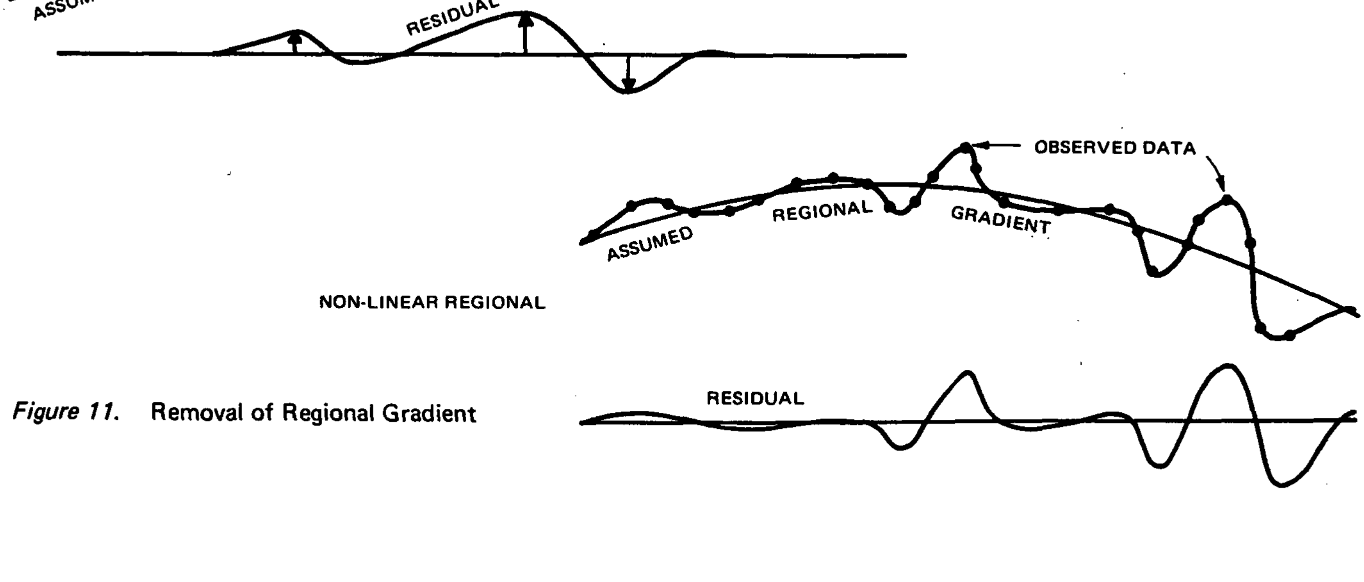

Figure 11. Removal of Regional Gradient

varying and on the assumption that one is interested only in broad features expressed by such a map. Features much smaller than the spacing between adjacent traverses should be examined on a profile basis only and should not be sought nor included on a map presentation.

Construction of a Contour Map

Given a set of readings obtained on a traverse, the time variations, if significant, should be removed, perhaps the regional gradient removed and the profiles smoothed. Values are then selected from these smoothed profiles at widely-spaced intervals not less than, say, ½ or ¼ the spacing between adjacent traverses or at similarly spaced but significant points on the profile, namely, maxima, minima, inflection points, etc. In other words, the values to be contoured should be more-or-less equally distributed in plan view. Anomalous features which 'obviously' extend across several traverses might be included also. The total intensity values thus selected and representative of the principal features are posted at their proper locations on a base map made of material which will support numerous erasing of penciled lines and including references to location.

Examine the dynamic range of the values and select 5 or 10 intensity levels through this range at convenient values such as every 20, 100, or 1000 gammas. Draw these contours according to the instructions below and then fill in the intermediate contour lines, i.e., every 10, 50, or 500 gamma contours, depending upon which coarse valuse above were originally selected, until contours appear in all segments of the map. Magnetic intensity values and contours should, in theory, be smoothly varying and should thus be smoothed at the later stages of contouring by removing sharp bends or corners. After such smoothing, other contour lines as needed to cover the map adequately are carefully drawn between the fair-drawn contours and appropriate labels applied. In areas of steep gradients, only a few coarse contour lines are drawn to avoid numerous and insignificant fine details. Since closed contours (closures) appear the same for maxima and minima, they are differentiated by applying hashure marks or other indications on the inside of the minima.

The position of the various contours is selected by manually (eye and mental calculation or by using proportional dividers, although not really necessary) interpolating linearly between all the neighboring values as shown in *Figure 12.* In this case, it was decided to draw contours at 10 gamma intervals. The contour line near data point value 91 would subsequently be smoothed to pass through this data point following the guidelines given above.

Contour lines should never cross nor pass between pairs of data points which are both higher or both lower than the value of the contour. Also in some regions of zero or near zero gradient such as at a saddle point (region between two adjacent maxima or minima), there exists an ambiguity in the direction of the lines. However, it does not matter under such conditions which of the two possible sets of contours are drawn.

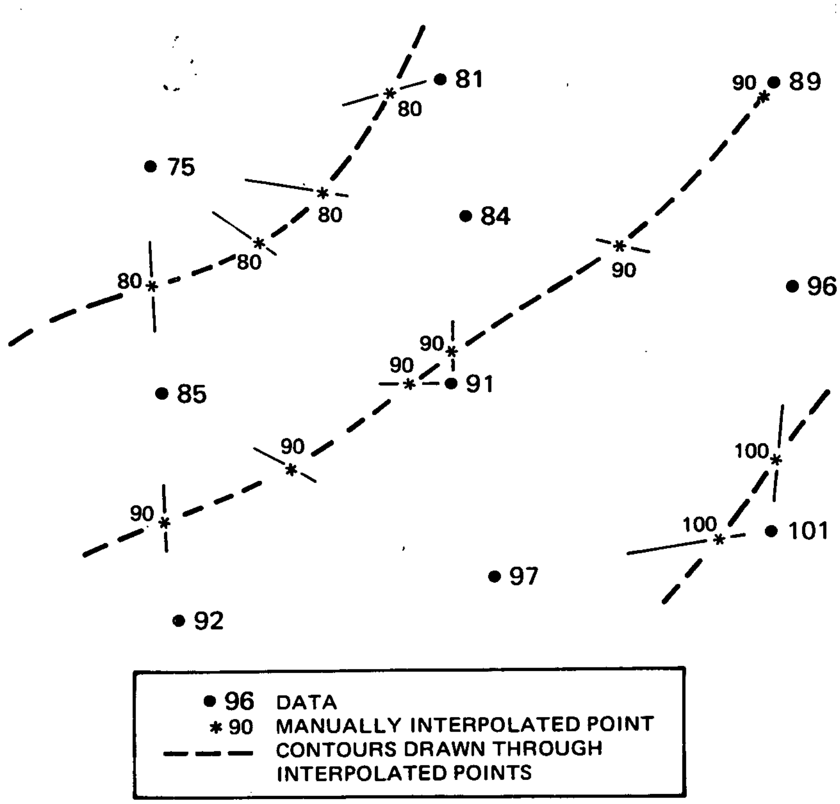

Figure 12. Interpolation and Contouring

APPENDIX II.

Statement of Expenditures

STATEMENT OF EXPENDITURES

JAXD 8 PROJECT 1994

I. Activities of J. Oliver (M.Sc., P.Geol.)

Geological Mapping	1.0 day
Petrography	0.5 day
Report Writing	1.0 day
Total J. Oliver: 2.5 days @ $355/day:	$ 887.50

II. Activities of Doug Nikirk

Magnetometer Survey	0.25 day
Total D. Nikart: 0.25 day @$155.00/day	$ 38.75

III. Drafting and Map Preparation Charges

Stephen Archibald	1.0 day
Total S. Archibald 1.0 day @ 155.00/day	$ 155.00

V. Materials

Thin Sections 4@$25/section	$ 100.00
Truck Rental 1.0 day	$ 50.00
Reproduction	$ 75.00
Photomicrographs	$ 100.00

TOTAL: $ 1,406.25

PROFESSIONAL PROVINCE OF J.L. OLIVER BRITISH COLUMBIA GEOSCIENTIST

Jim Oliver,
Dec. 5, 1994
Kamloops, B.C.