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**DIAMOND DRILLING REPORT**  
**VULCAN PROPERTY, EAST KOOTENAY DISTRICT, B.C.**

Fort Steele Mining Division, British Columbia  
NTS 82F/16  
Latitude: 49° 47' North  
Longitude: 116° 20' West

Prepared for

**ASCOT RESOURCES LTD.**  
Vancouver, B.C.

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**GEOLOGICAL BRANCH  
ASSESSMENT REPORT**

**22,267**

October 30, 1991

Keewatin Engineering Inc.

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## 1.0 SUMMARY

The Vulcan property is located in the Purcell Mountains approximately 30 km northeast of the Sullivan Mine at Kimberly, B.C. The property consists of 12 claims (180 units) and is 100% owned by Cominco Ltd. Ascot Resources Ltd. has a right to earn a 60% interest in the property by spending \$1 million on exploration over three years.

The objectives of the program were to define the distribution of base metal sulfides, and of the sub-basin which forms the sulfide host in order that deeper drill tests can be planned. Deep drilling is required to explore the target areas on the property as surface geological work and electromagnetic surveys do not indicate the presence of near surface deposits.

The principle exploration target on the property is a Sullivan-type stratiform sediment-hosted massive sulfide deposit. The Sullivan Mine has produced 144 million tons of ore averaging 6.5% Pb, 5.6% Zn and 2.3 opt Ag to 1988. At Vulcan the styles of mineralization, host rocks and alteration all show strong similarities to the Sullivan Deposit. The best sulfide mineralization at Vulcan is exposed in a surface showing. Strata controlled pyrrhotite-galena-sphalerite occurs on the "Sullivan Horizon" in a 7.5 m thick zone which includes 1.5 m averaging 1.6% combined Pb-Zn. Grab samples of this zone assay up to 5.5% Pb-Zn and 22 opt Ag.

Five drill holes (1,003 m total) were completed in 1991 and these holes intersected the Lower Aldridge-Middle Aldridge Formation contact (LMC) or "Sullivan Horizon". These holes tested the "Sullivan Horizon" over a strike length of 2.6 km and to depths of up to 300 m below the surface. All drill holes encountered anomalous Pb-Zn-Ag (+ Cu-As) in the "Sullivan Horizon" immediately below the Lower Aldridge-Middle Aldridge contact. The best intersection was 2.5 m @ 0.8% Pb-Zn in Vu-91-2. A thickening of the sub-basin facies was also defined in DDH Vu-91-1 and 2.

The Vu-91-4 area also appears to be attractive with enhanced lithochemical anomalies, downhole UTEM anomalies and other geological indicators which suggest proximity to a

Sullivan-type mineralized zone. A follow-up program of deep drilling is recommended to test both the Vu-91-2 and Vu-91-4 areas with three holes totalling approximately 3,000 metres.

## 2.0 INTRODUCTION

### 2.1 Location and Access

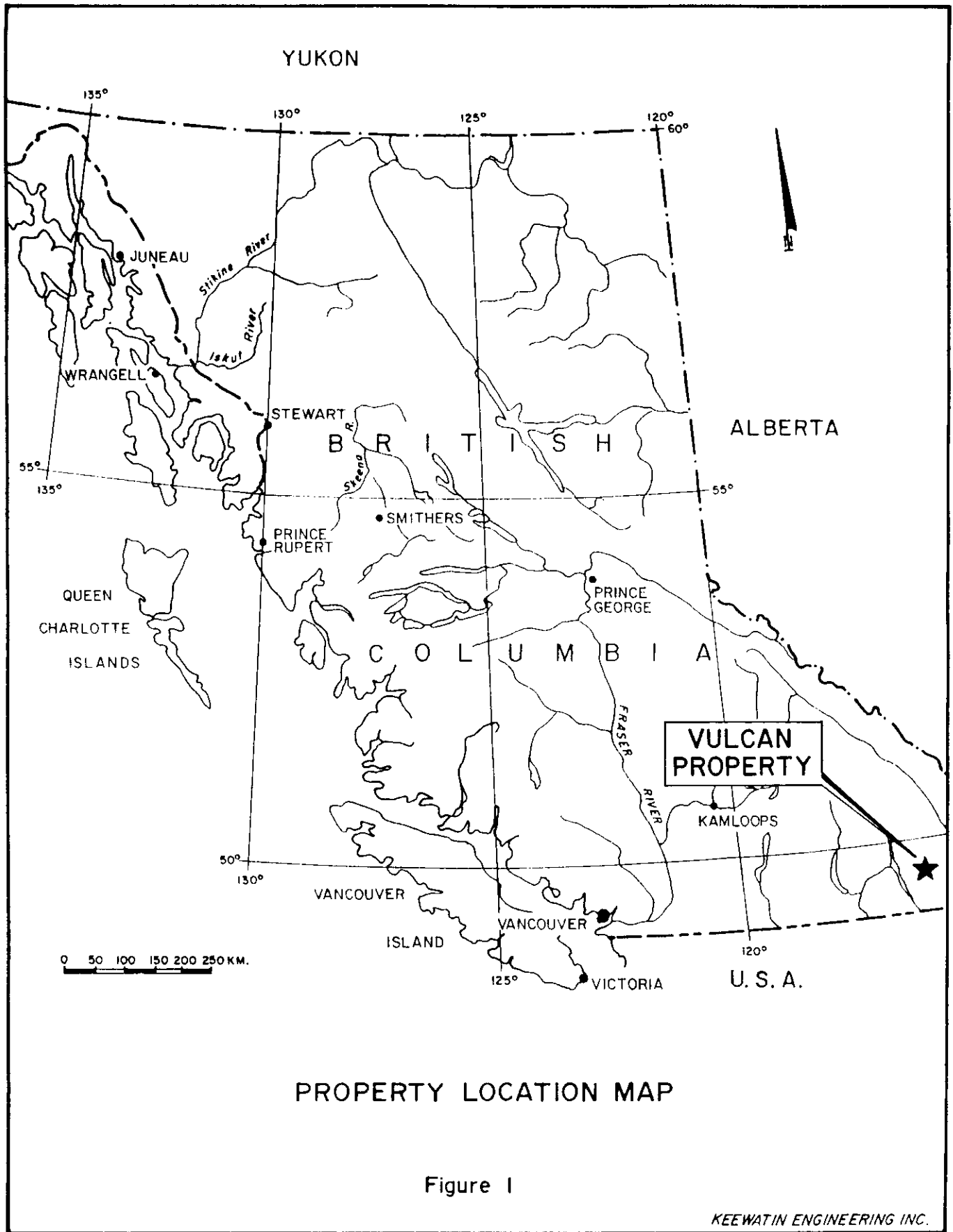
The Vulcan property is located in mountainous terrain approximately 30 km northeast of Kimberly, B.C. (Figure 1). Relevant locational information is as follows:

NTS Sheet	-	82F/16E
Latitude	-	49° 47' North
Longitude	-	116° 20' West
Mining Division	-	Fort Steele
Supply Centres	-	Cranbrook - 80 km by road
	-	Kimberly - 60 km by road

Commercial stands of timber occur on the lower mountain slopes and second growth forests occur in the valley bottom. The upper parts of the property are sparsely treed (thin tamarack), and are, in part, classified as areas of "high recreational value" by the B.C. government.

A power line supplying the Sullivan Mine passes approximately 15 km south of the property. Water is plentiful on the property, the White River, St. Marys River and Dewar Creek all flow across parts of the property.

The property is accessible by road, by proceeding 50 km west of Kimberly on the St. Marys Lake and River roads, then 8 km north on the Dewar Creek logging road. The Dewar Creek logging road crosses the southern part of the Vulcan property. A 4 x 4 access road was built by Cominco in 1979 and extends 2.5 km east of the Dewar Creek road 8 km post. The road has steep (+15%) grades and several tight switchbacks. This road extends to alpine meadow at 2,025 m elevation, and ends in West Basin, approx. 1.5 km northwest of the peak of Mt.



Patrick, on the Vulcan 1 claim. Access to Jurak Lake basin is by an old pack trail (2 hours on foot from the end of the road).

The 4 x 4 road was restored and water barred during the current program, and now provides a popular recreational access route to St. Marys Alpine Park. Alternate access to the alpine portions of the property is by helicopter charter from Cranbrook, B.C. (0.35 hrs one way).

During the 1991 program, all material and personnel were mobilized by helicopter from the landings on the access road to a camp established at 2,270 m elevation, situated on the south shore of a large pond on a small plateau 0.8 km south of Diorite (Jurak) Lake.

## 2.2 Physiography and Climate

The claims are located in the Purcell Mountain Range and the north part of the claims covers rugged mountainous areas up to 3,300 m elevation. The southern part of the claims covers moderate to gentle sloping mountainous terrain and includes parts of the flat St. Mary River valley at approximately 1,050 m elevation. The 1991 drill program was conducted in the rugged northern part of the claims.

The alpine areas are subject to heavy snowfall and north facing basins often remain snow-covered through much of the summer. Exploration at high elevations can often be conducted into early October, but the onset of winter conditions is unpredictable. Daytime temperatures of +20°C may persist at elevation during September and may be a constraining factor in helicopter supported drill moves. The lower elevations are generally snow covered from November to early May. Water for camp and drilling purposes is readily available from several small lakes and creeks on the property.

The tree line is gradual, with sparse tamarack persisting to approximately 2,400 m.

## 2.3 Property Status and Ownership

The property consists of 12 contiguous claims for a total of 180 units. The claim description is shown on Figure 2 and the relevant claim information is tabulated below:

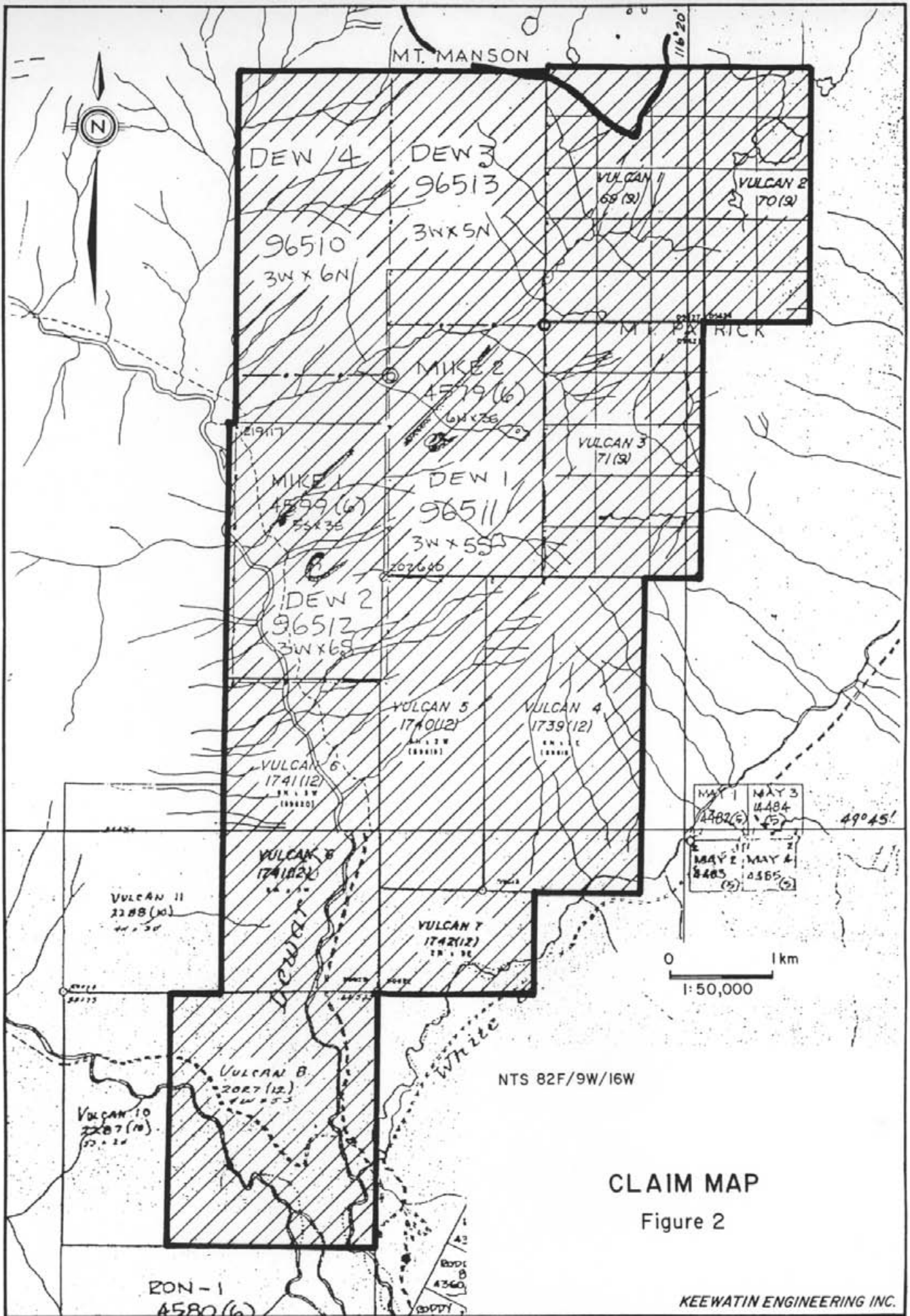
TABLE 1 - CLAIM STATUS SUMMARY				
Claim Name	No. of Units	Record No.	Record Date	Expiry Date
Vulcan 1	15	209668	September 27, 1976	September 27, 1996
Vulcan 2	10	209669	September 27, 1976	September 27, 1996
Vulcan 3	15	209670	September 27, 1976	September 27, 1996
Vulcan 4	18	209928	December 15, 1982	December 15, 1995
Vulcan 5	12	209929	December 15, 1982	December 15, 1995
Vulcan 6	18	209930	December 15, 1982	December 15, 1995
Vulcan 7	6	209931	December 15, 1982	December 15, 1995
Vulcan 8	20	210014	December 15, 1982	December 15, 1995
Dew 1	15	303770	August 25, 1991	August 25, 1992
Dew 2	18	303771	August 26, 1991	August 26, 1992
Dew 3	15	303772	August 25, 1991	August 25, 1992
Dew 4	18	303773	August 26, 1991	August 26, 1992
<b>Total 12 Claims</b>	180 units			

All of the claims are 100% owned by Cominco Ltd.. Ascot Resources Ltd. has the right to earn a 60% interest in the property by spending \$1 million on exploration over the next three years. The current program satisfies the first years' work commitment on the property. Ascot Resources Ltd. is the project operator and the exploration program was managed by Keewatin Engineering Inc. The Dew 1-4 claims were staked in 1991 to cover the deep down dip extensions of the target horizon along the west side of the property.

## 2.4 History of Exploration

The northern part of the Vulcan property was originally staked by Cominco in 1957. During 1957-58, Cominco conducted prospecting, detailed mapping, trail building and an experimental magnetometer-electromagnetic survey. Three short packsack drill holes were also completed on the Main Showing.





The Pb-Zn showings were discovered during this period and the mineralization was recognized as being strata-controlled. Widespread tourmaline mineralization was also noted and observed to be strata-controlled. A strong similarity between the Vulcan and the Sullivan Mine was documented by O.E. Owens of Cominco at this time. Lead-zinc-silver mineralization was noted to "occur in the same type of rocks, at the same point in the stratigraphic succession, and as the same type of mineralization" as at Sullivan (Owens, 1958). Recommendations for deep drilling were made, with such a program to be deferred until after regional geological studies were completed.

In 1971, Texas Gulf Sulfur re-sampled the showings and did some detailed geological mapping of the Main Showing area. The property was called Hilo at this time. No further work was done by Texas Gulf.

In the 1970's, regional stratigraphic correlation studies by Cominco established that the Vulcan mineralization occurs on the LMC. Regional studies also suggested that the Sullivan type setting defined by the 1958 work was unique, and appeared to be localized in the northern part of the current Vulcan claims.

The current Vulcan 1-3 claims were staked by Cominco Ltd. in 1976. A 4 x 4 access road was constructed to the Vulcan 1 claim, and a single drill test of the LMC was completed (Vu-79-1, 188 m) from the road. No mineralization or lithochemical anomalies were found at the LMC, which was marked by a distinctive pyrrhotite laminated wacke underlain by fragmental rocks. Minor weak Pb-Zn mineralization, was located in the Lower Aldridge Formation in this hole (1.1 m @ 0.35% Pb, 0.30% Zn).

The property was extended to the south (Vulcan 4-8 claims) in 1982.

In 1983, Cominco conducted rock geochemical sampling of the fragmental unit and LMC sequence throughout the Vulcan 1-3 claims. Several Pb-Zn-As anomalies were delineated by this work.

A surface UTEM and HLEM survey was conducted in 1984 covering the LMC and fragmental unit on the Vulcan 1-3 claims. Eight UTEM lines (1.2 - 1.8 km length) were surveyed from one transmitter loop. Weak UTEM anomalies were interpreted as indicating a "weak extensive (larger than loop dimension) conductor, with depth to top varying from 100 m to 200 m" (Visser, 1984). The conductor was located in the area of the completed Cominco drill hole.

Cominco's work program on the northern part of the property was discontinued following this survey. The objective of subsequent Cominco work was to locate and evaluate the LMC on the more accessible southern part of the property. Mapping, contour and grid soil geochemistry and UTEM/HLEM surveys were completed. Patchy soil Pb-Zn anomalies were outlined on the lower slopes of Mt. Patrick along the projection of the LMC. UTEM and HLEM anomalies were located on the inferred LMC extension and over the Lower Aldridge Formation. Five drill holes (Vu-84-1 to 4 and Vu-85-1) were completed by Cominco to test the best geophysical anomalies. All holes were entirely within the Lower Aldridge, and the anomalies were found to be caused by graphite and banded/laminated pyrrhotite (+ chalcopyrite) mineralization. These target areas are located within the current Vulcan property. The LMC remains untested in this part of the property, and additional weak geophysical anomalies occur on the possible projection of the LMC.

No further Cominco work programs were carried out in the 1986-90 period.

## 2.5 Objectives of the 1991 Work Program

The objectives of the Ascot program were to use drilling and down hole EM surveys to define the distribution of base metal sulfides and of the sub-basin which forms the sulfide host at shallow to intermediate depths in order that deeper drill tests can be planned. An important premise guiding this approach is that the target deposit will occur some distance below the surface. Shallow or subcropping deposits are not indicated by surface UTEM or detailed prospecting/mapping, already completed by Cominco. The geological modelling of the information derived from the 1991 holes, taken in conjunction with the geophysical interpretation defines the area(s) of highest potential for deep drill testing.

### 3.0 GEOLOGY

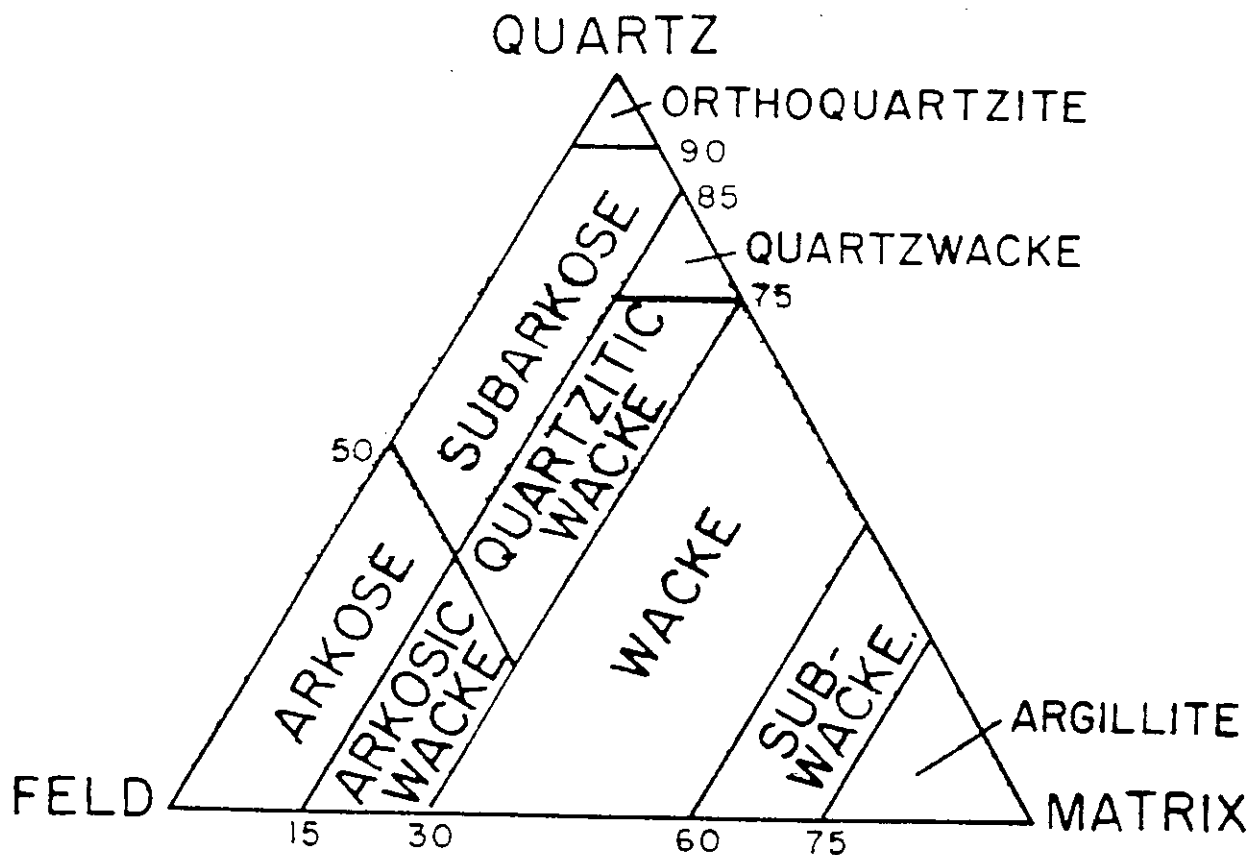
#### 3.1 Regional Geology

In the Purcell-West Kootenay area, middle Proterozoic stratiform sulfide mineralization is hosted by the Purcell Supergroup, which comprises a large intracontinental flysh basin. The base of the sequence is not exposed. The lowest unit is the Aldridge Formation, consisting of a +4,000 m thick sequence of siliciclastic sediments. The Aldridge Formation hosts the Sullivan Orebody, which occurs on the contact between the Lower and Middle Aldridge Formation (LMC). Proterozoic gabbro sills intrude the Aldridge Formation.

Sedimentological descriptions throughout this report will follow Cominco's field classification for siliciclastic rocks, as shown in Figure 3.

The **Lower Aldridge Formation** regionally consists of a rhythmic succession of laminated to thin bedded fine grained wacke (argillite) and quartzitic wacke (argillaceous quartzite). The sequence is characterized by minor amounts of fine grained disseminated pyrrhotite which imparts a characteristic rusty weathering nature to Lower Aldridge outcrops. Beds are typically graded, and local crossbedding occurs. Intervals of massive to thick bedded quartzitic wacke or quartz arenite also occur (e.g. "footwall quartzite" unit at the Sullivan Mine). Massive to poorly bedded lenses of intraformational conglomerate occur locally near the top of the Lower Aldridge Formation and are composed of Aldridge rock types in a wacke matrix.

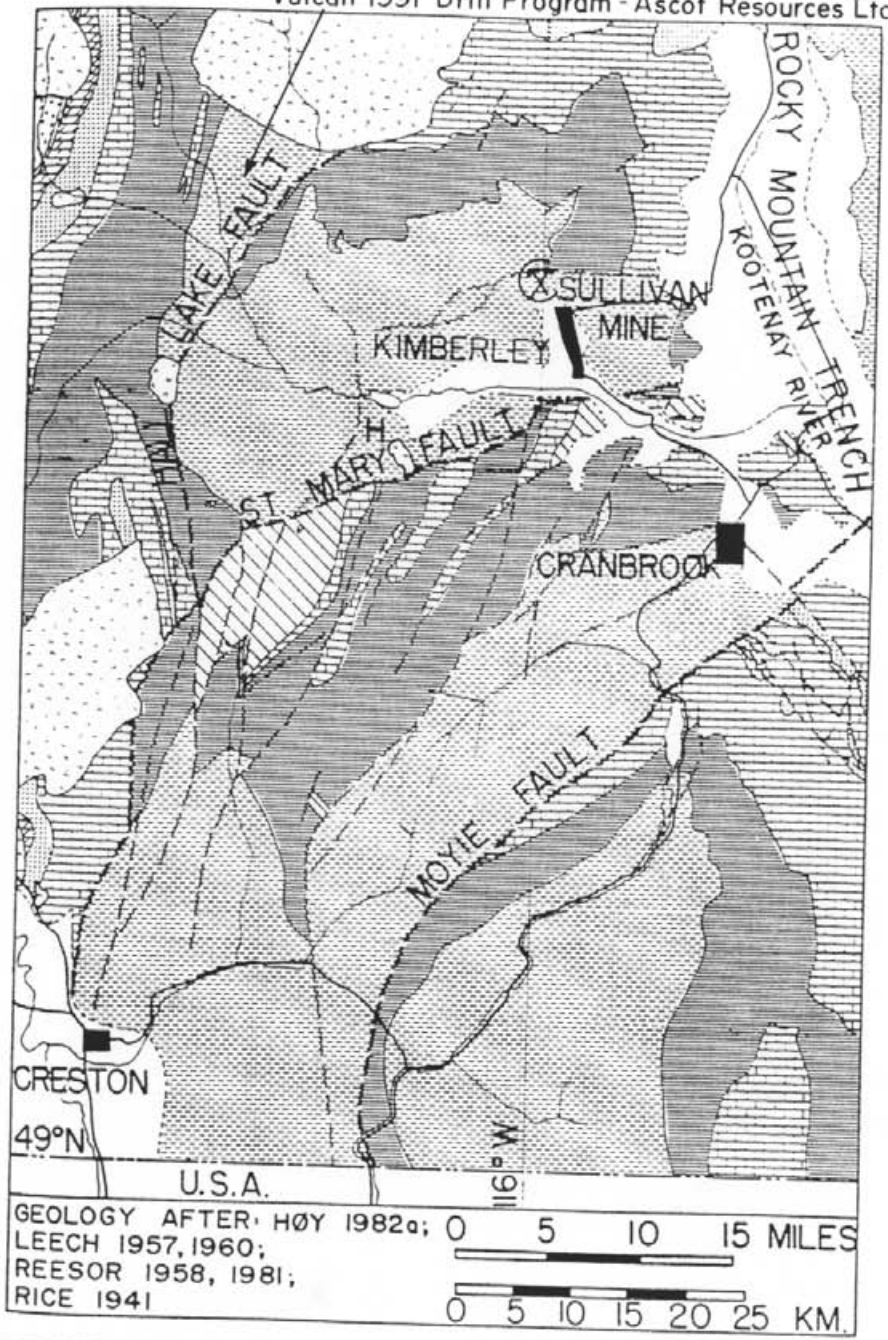
The **Middle Aldridge Formation** is predominantly medium to thick bedded light grey weathering quartzitic wacke turbidites consisting of medium grained massive quartz-rich bases overlain by thin wacke-subwacke (argillite) tops. Rip up clasts and flame structures commonly occur in the bases of the quartzite beds and are indicative of high energy, rapid deposition. Subordinate amounts of Lower Aldridge type lithologies are interbedded within the Middle Aldridge. Gabbro sills of the Moyie Intrusions intrude both Lower and Middle Aldridge, and are locally observed to crosscut stratigraphy.



Cominco's field classification of siliciclastic rocks of the Purcell Supergroup.

VULCAN PROPERTY

Vulcan 1991 Drill Program - Ascot Resources Ltd.



GEOLOGY AFTER: HØY 1982a; 0 5 10 15 MILES  
 LEECH 1957, 1960;  
 REESOR 1958, 1981;  
 RICE 1941  
 0 5 10 15 20 25 KM.

LEGEND

- MESOZOIC GRANITIC INTRUSIONS
- PRECAMBRIAN HELLROARING CREEK STOCK
- CAMBRIAN EAGER FM.  
 CRANBROOK FM.
- PROTEROZOIC
  - WINDERMERE SUPERGROUP
    - HORSETHIEF CREEK GP.
    - TOBY FM.
  - PURCELL SUPERGROUP
    - MOUNT NELSON FM.
    - DUTCH CREEK FM.
    - NICOL CREEK FM.
    - VAN CREEK FM.
    - KITCHENER FM.
  - CRESTON FM.
  - ALDRIDGE FM.
  - FORT STEELE FM.

VULCAN PROPERTY  
 REGIONAL GEOLOGICAL MAP

The regional geological setting is shown in Figure 4. The Sullivan Deposit occurs on the east side of the Purcell Anticlinorium, a broad zone of dominantly easterly verging thrust and fold structures. The St. Mary Fault and the Hall Lake Fault are large thrust faults. The Vulcan property occurs in an upthrust block immediately west of the Hall Lake Fault between the Mesozoic White Creek Batholith (to the north) and the smaller Hall Lake Stock. The Hall Lake Fault thrusts Lower Aldridge Formation over the younger Creston Formation and passes several kilometres east of the Vulcan property.

The structural setting of the area north of the St. Marys Fault is characterized by small scale block and thrust faulting and by broad folding. Broad zones of strong cleavage development occur near major faults. Rocks are at a greenschist facies metamorphic grade, but well developed contact metamorphic rocks develop around Mesozoic intrusions (cordierite-staurolite schists).

### 3.2 Geology of the Sullivan Orebody

The following description of the Sullivan orebody is partly taken from Cominco's work (Hamilton et al., 1983). The reader is referred to this volume for a complete description of the mine. A simplified east-west geological section through the Mine is shown on Figure 5.










The Sullivan orebody occurs near the top of the Lower Aldridge Formation. It has the shape of an inverted and tilted saucer approximately 2,000 m along its north-south dimension and 1,600 m along its east-west dimension. It has flat to gentle easterly dips in the west, moderate easterly to northeasterly dips in the centre, and gentle easterly to northeasterly dips in the east. Footwall rocks are intraformational conglomerate and massive wacke overlain by wacke and pyrrhotite-laminated subwacke. The upper part of ore zone stratigraphy is composed of several fining-upward sequences of quartzitic wacke and subwacke.

Beneath the eastern part of the orebody are two gabbro sills separated by about 150 m of quartz-feldspar-biotite rock (locally called granophyre) which in places has the texture of an igneous differentiate and elsewhere has the texture of a highly altered sedimentary rock. The upper sill, 10 to 15 m thick, is located about 500 m below the orebody. The lower sill

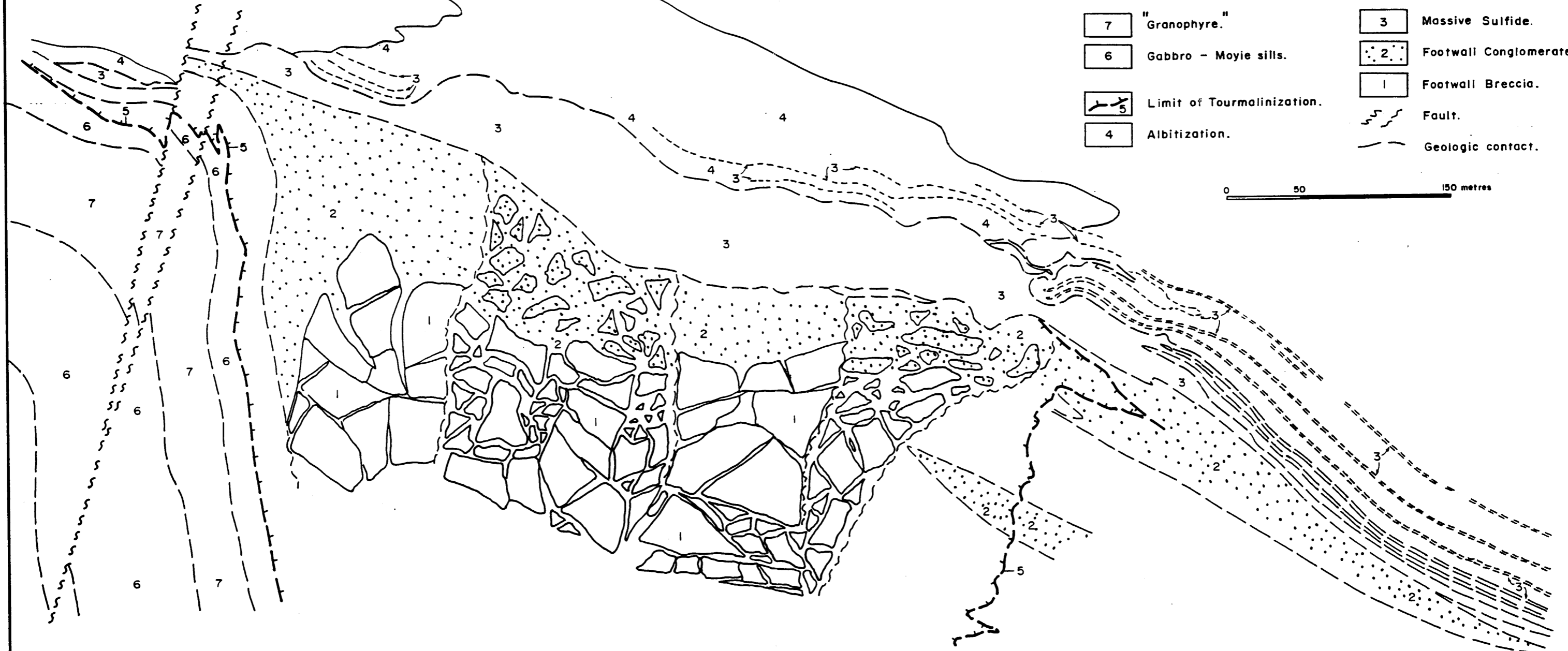
West

East

**LEGEND**

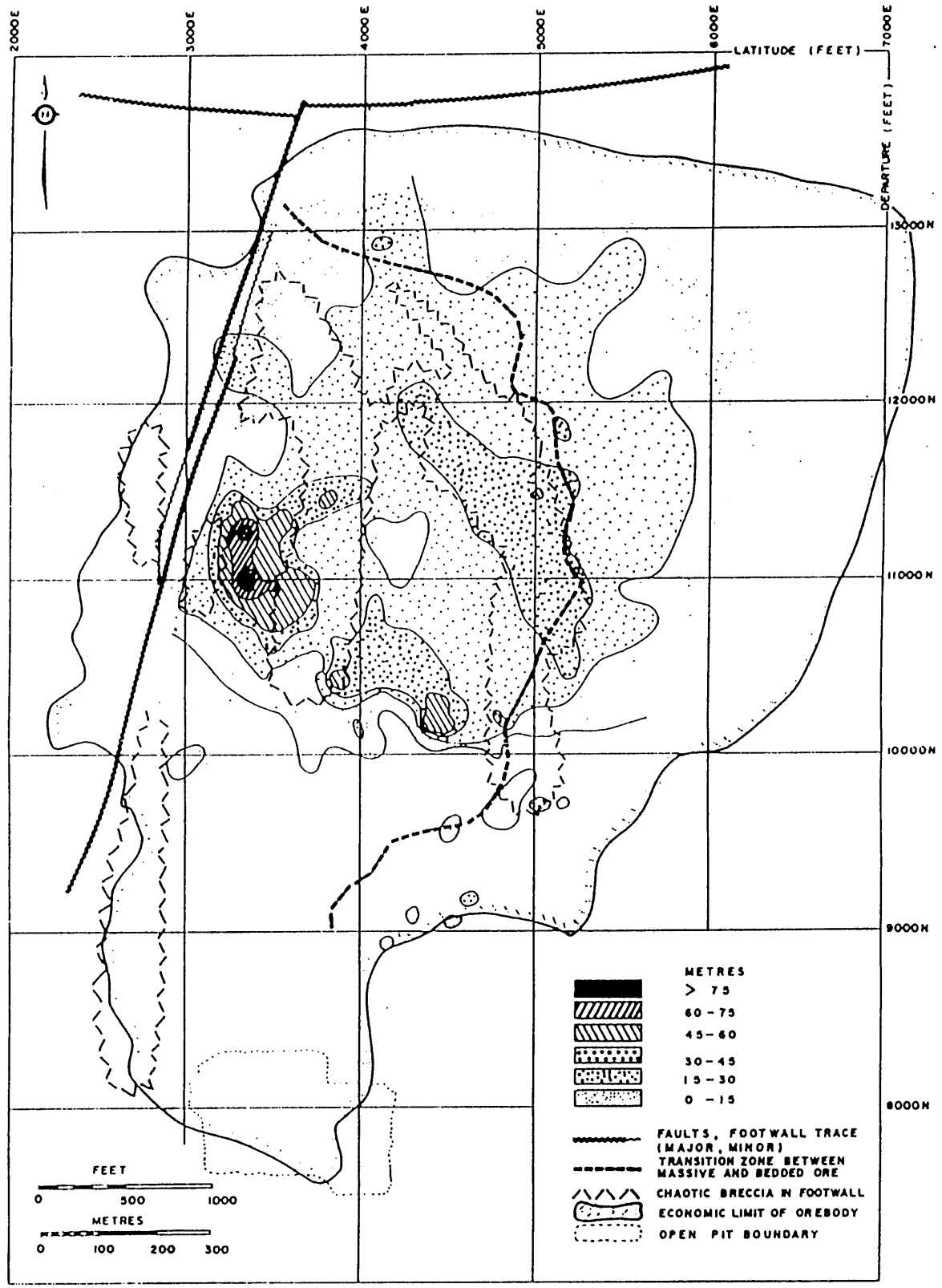
- |  |  |
|--|--|
|  "Granophyre."              |  Massive Sulfide.       |
|  Gabbro - Moyie sills.      |  Footwall Conglomerate. |
|  Limit of Tourmalinization. |  Footwall Breccia.      |
|  Albitization.              |  Fault.                 |
|  |  Geologic contact.      |

0 50 150 metres

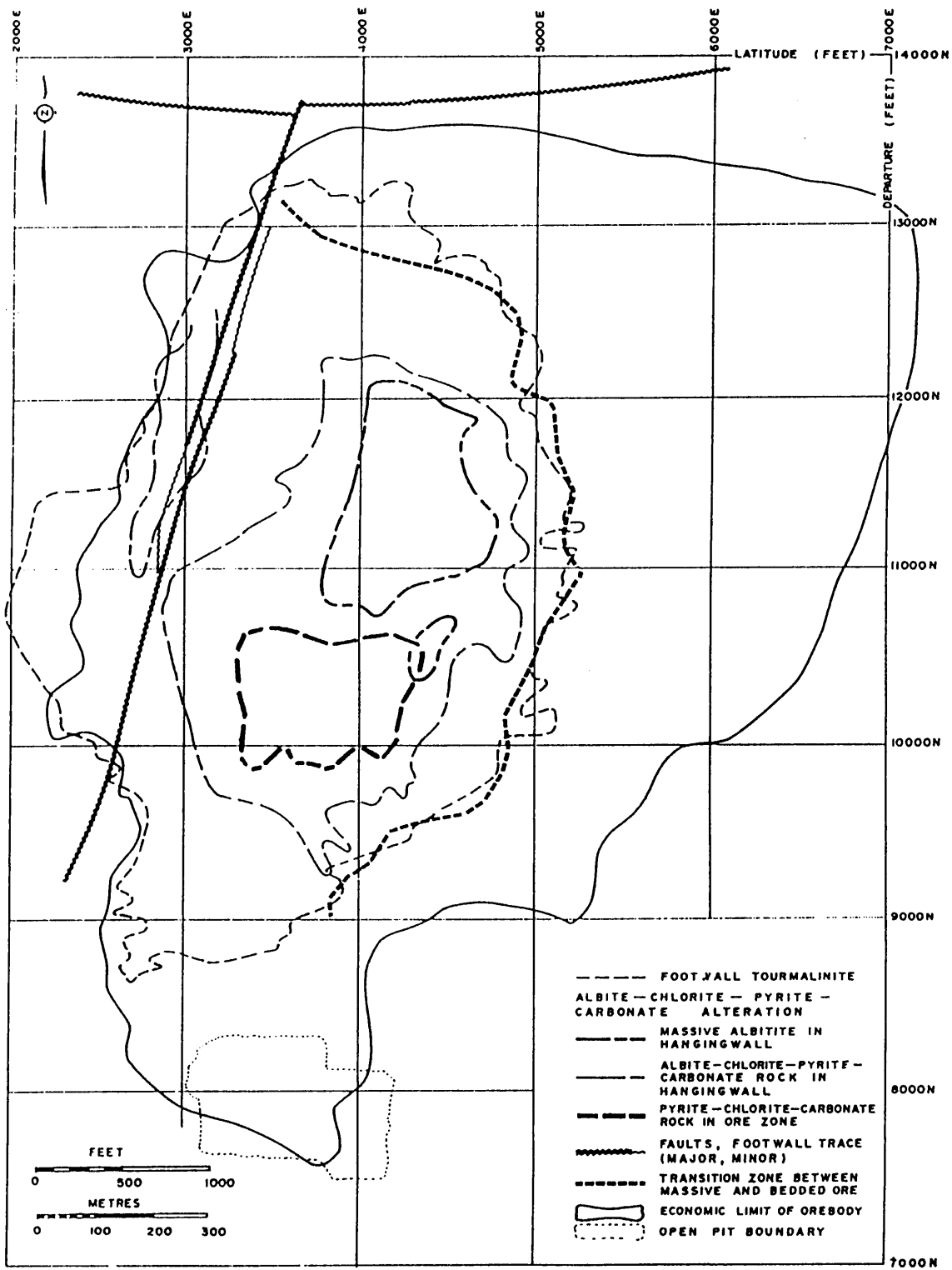


**SULLIVAN MINE  
GEOLOGICAL SECTION**





ISOPACH MAP OF THE FOOTWALL CONGLOMERATE  
 UNDER THE SULLIVAN OREBODY  
 (After Hamilton et al, 1982)



Distribution of altered rocks in and adjacent to the Sullivan orebody  
 (After Hamilton et al, 1982)

is 50 m thick. Below the orebody there is an abrupt change in the attitude of the gabbro-granophyre complex and it rises steeply to approach the footwall of the orebody near its western margin. West of here the gabbro-granophyre complex dips downward to again resume a sill-like form at approximately its original stratigraphic position. The resultant configuration is a north-northwest trending arch.

The orebody attains maximum thickness of 100 m approximately 100 m northwest of its geographic centre, and thins outward in all directions. To the east, the orebody thins gradually. Eastward from the economic limit, the ore zone stratigraphy grades gradually to a sequence of pyrrhotite-laminated wacke/subwacke (argillite) three to five metres thick that persists laterally for at least five kilometres. To the north, the orebody thins more rapidly, but the ore zone stratigraphy is truncated by the Kimberly fault before the economic cut-off is reached. To the west the orebody thins abruptly and is cut by dyke-like apophyses of the footwall gabbro. To the south, within the orebody, ore zone thickness changes are generally irregular and abrupt.

Two satellite deposits, the Stemwinder and the North Star, are located 2 km and 3.5 km respectively south of the Sullivan deposit.

The key features of the stratigraphic setting and mineralization are summarized as follows:

Fragmental or Conglomerate: The main sulfide lens at Sullivan is underlain by a large intraformational conglomerate unit. The conglomerate is thickest over the vent area, and thins to the east (see Figure 6). The conglomerate unconformably overlies the Lower Aldridge Formation. Bedded massive sulfides rest either directly on conglomerate or are separated from it by a few 10's of metres of laminated pyrrhotitic mudstones.

Chaotic Breccia: This zone is developed in the vent area and disrupts both conglomerate and bedded footwall sediments (see Figure 6). The breccia consists of fragments of Aldridge sediments from sand size to pieces 10's of feet across. Bedded blocks and fragments are often twisted and rotated. Blocks of conglomerate are

mixed in with bedded and massive blocks, giving the unit a heterogeneous, chaotic nature. Sulfide minerals form up to 30% of the chaotic breccia unit, often forming the breccia matrix. The breccia is interpreted as the feeder system for the overlying sulfide deposit.

Tourmaline: Tourmaline alteration forms a broad footwall replacement zone. Massive aphanitic tourmalinite also forms thin stratiform layers in the immediate footwall sediments. Tourmaline alteration overprints much of the chaotic breccia zone (see Figure 7).

Albitic Alteration: Albite replacement occurs as a broad alteration halo in the deposit hangingwall. Massive sulfides are altered to pyrite-chlorite-albite rock beneath the albite halo (see Figure 7).

Sulfides: (see Figures 5 and 7). Massive to delicately laminated sulfides form the Main Band and several less important ore bands. They are conformably overlain by normal Middle Aldridge turbidite sediments. Massive sulfide zones up to 100 m thick occur. The principle sulfide minerals are pyrrhotite-galena-sphalerite. The sulfides are believed to be hydrothermal exhalative sediments formed above sea floor vents.

Stratigraphic Position: The orebody is located on the Lower Aldridge-Middle Aldridge Formation contact (LMC).

The G.S.C. and B.C. Geological Survey Branch have recently commenced a major study of the Sullivan Deposit. Some of the early observations of this study appear to highlight previously undocumented aspects of the deposit, and these will be reviewed in some detail, as they are relevant to the results from the Vulcan drilling.

The vent zone alteration is described as quartz (silica) rich. Quartz forms rare veins or a breccia matrix cement with calcite-pyrrhotite-chlorite (+ tremolite-tourmaline-biotite-muscovite-sphene-ilmenite). This alteration assemblage contains traces of sphalerite-galena-chalcopryrite-arsenopyrite and is found crosscutting the footwall fragmental rocks.

Sulfide matrix breccias in the vent complex are cemented by pyrrhotite with muscovite-quartz-chlorite-tourmaline-calcite and garnet. Chalcopyrite is common as inclusions in the pyrrhotite along with fine arsenopyrite and traces of sphalerite-galena.

In general, the hydrothermal vent or feeder zone is marked by minor sulfide-quartz veining below the western orebody, and "appears to be manifested upwards by a fragmental with cement or matrix of quartz, calcite, pyrrhotite, tremolite, tourmaline, mica, sphere, garnet and sulfides" (Leitch, 1991). The matrix varies from silica rich to sulfide rich. Similar footwall mineralization and calcsilicate alteration assemblages have been observed in the Vulcan drilling.

The mineralogy of the thinly bedded sulfide zone on the southeast fringe of the Sullivan deposit is also noteworthy. This sequence is called the "Concentrator Hill Horizon". Pyrite and pyrrhotite laminations predominate but thin dark laminations/layers of quartz-carbonate-garnet-hydrobiotite-muscovite and chlorite occur interlayered with the sulfides. Minor tourmaline, sphalerite and galena is associated with these calc-silicate layers. This assemblage represents the fringe of the Sullivan orebody.

This research project may also suggest a possible sill or tuff horizon immediately below the orebody or widespread alteration of this horizon by magmatic fluids related to the gabbro intrusions (Leitch, 1991).

### 3.3 Property Geology (see Plan 1)

The Vulcan property contains a large body of Sullivan-type intraformational conglomerate just below the LMC, measuring approximately 3 km in strike and up to 250 m thick. Stratiform pyrrhotite-galena-sphalerite mineralization occurs at the top of the conglomerate and is overlain by normal Middle Aldridge turbidite sediments. The best values from outcrop sampling are 1.52 m @ 1.6% combined Pb-Zn, from the Main Showing and these values occur within a weakly mineralized section 7.5 m thick. This mineralization is hosted by altered laminated mudstone containing calc-silicate horizons and bands. Patchy albitic

alteration occurs in the hangingwall sediments. Tourmaline occurs as strata-controlled disseminations in the footwall of the conglomerate.

The host package is folded and steeply to moderately dipping, but is not strongly metamorphosed. Large gabbro sills intrude the Middle Aldridge Formation within 100 m of the conglomerate hangingwall.

### 3.3.1 Rock Types

Middle and Lower Aldridge Formation Siliciclastics. Rocks comprising these units are typical of the regional rock types and are described in Section 3.1. The Lower Aldridge is predominantly composed of laminated to thin bedded fine grained pyrrhotite bearing wacke. The Middle Aldridge is predominantly thick to medium bedded sequences of quartzitic wacke turbidites.

Fragmental (Conglomerate). This unit occurs near the top of the Lower Aldridge Formation. Many textural variations were noted. The most common type contains rounded medium to fine grained biotitic quartzitic wacke fragments and flat light grey subwacke fragments in a massive fine grained wacke matrix. Disseminated pyrrhotite commonly replaces the biotite-rich clasts, which locally become semi-massive pyrrhotite. Fragments comprise between 15 and 35% of the rock, average 2-3 cm and are matrix supported. The matrix usually contains finely disseminated pyrrhotite, and the unit always weathers to a very rusty brown. Wacke and mudstone fragments are generally smaller and more angular than the quartzitic fragments.

Bedding is rare within the fragmental rock type itself, although intervals of normal bedded Lower Aldridge sediment commonly occur within it. Prominent slump folds commonly occur at the base of fragmental intervals. Fragmental rocks locally contain quartz-feldspar-amphibole-biotite-pyrrhotite concretions(?) often with a pale bleached or a dark biotite-rich halo.

Two theories are considered plausible for the formation of the fragmentals. They may be large slump conglomerate units formed during graben-type faulting and tilting at the close of Lower Aldridge time. Alternatively they may be extruded onto the sea floor during dewatering of the Lower Aldridge sequence, perhaps utilizing zones of cross-strata permeability related to sub-basin development. There is evidence that both of these processes have a role in the formation of fragmentals of the Aldridge Formation.

Conglomeratic Rocks. These rocks are similar in all respects to the fragmental but contain <10% clasts, usually in a massive wacke matrix. Clast types are similar to those in the fragmental unit and are unsorted. Clasts are matrix supported. Fragments tend to be smaller than in the true fragmental. This rock type grades into massive wacke.

Massive Wacke. Massive wackes commonly occur near the top of the Lower Aldridge and are usually interbedded with conglomeratic wacke or fragmental. This rock type is believed to represent a settling out of fine material following fragmental formation and is of a similar composition to the fragmental matrix. Massive wackes are believed to represent more distal settings to the fragmentals, being further removed from the fractures or fault scarps which control fragmental development. They may also accumulate at the top of fragmental sections, as a setting out of suspended clay/silt after conglomerate deposition.

Pyrrhotite Laminated Wacke/Subwacke. This unit occurs immediately below the Lower Aldridge-Middle Aldridge contact (LMC) in holes Vu-91-1 to 5 and in Vu-79-1, and averages approximately 8 m thick. This lithology is interpreted as an argillaceous sub-basin facies and forms a cap to the fragmental rock units within the sub-basin. The unit is directly correlated with the mineralized sequence at the Sullivan Mine. Similar rock types are often interbedded within the upper 50 m of the fragmental and over the lowermost 20-30 m of the Middle Aldridge.

Texturally the rock type is a fine grained wacke to subwacke, similar to the massive wacke units, but it contains distinctive dark biotite-pyrrhotite rich laminations. The laminations are usually 1-2 mm thick and separated by several cm of massive wacke. The pyrrhotite usually occurs as fine grained disseminations within the dark laminations, but is clearly strata-

controlled. Some continuous pyrrhotite-pyrite-arsenopyrite laminations also occur (as opposed to disseminations) but these are only well developed in the subwacke interval within the fragmental in Vu-91-5. A few thin stratiform pyrite laminations also occur in Vu-91-3. Traces of chalcopyrite were observed with the pyrrhotite in Vu-91-3, galena in Vu-91-2, sphalerite in Vu-91-5 and arsenopyrite-pyrite-sphalerite in Vu-91-4.

The unit is phyllitic in holes 3 and 5 and sulfides are remobilized into cleavage in these holes. Fine grained disseminated needle tourmaline was observed in the unit in Vu-91-1.

Quartz veinlets and stringers are often developed within this rock type and usually have accessory pyrrhotite-pyrite. Minor Pb-Zn-Cu sulfide mineralization also occurs as fracture fills and stringers. In hole Vu-91-2 such mineralization occurs in hairline fractures and has associated calcite and fluorite.

Anomalous geochemical values are associated with the pyrrhotite laminated wacke in holes Vu-91-1, 2, 3 and 4 only. A base metal bearing calc-silicate band of possible sedimentary origin occurs at the top of the unit in hole Vu-91-4.

Gabbro. The gabbro intrusions are generally sill-like and consist of medium to coarse grained amphibole-plagioclase with minor biotite and chlorite. Minor disseminated pyrrhotite is common. In places, the gabbros have sharp chilled margins, locally with albite-chlorite or biotitic alteration selvages in adjacent sediments. Gabbro contacts can also be gradual and replacive, with coarse calc-silicate assemblages replacing adjacent sediments. Such replacive zones have only been identified on the bases of the gabbro sills (e.g. Vu-91-2, 173 m). In Vu-91-3 parts of the gabbro have a high albite content and this is believed to be the primary feldspar in this zone. The albitic section contains 5 to 8% pyrrhotite.

The gabbroic rocks are strongly altered. Chlorite-biotite (+ calcite) alteration is common. Garnet is well developed in places. In Vu-91-3 a +100 m interval contains 5-15% garnet porphyroblasts in the 1-5 mm size range, with accompanying calcite-chlorite-pyrrhotite alteration. Minor epidote alteration was observed in Vu-91-2.



Coarse pyrrhotite clots with minor chalcopyrite occur in the gabbro in Vu-91-4 (3-50 m).

Calc-Silicate Units. Calc-silicate bands and units from <0.5 to 9 m thick occur in holes Vu-91-1, 2, 4 and 5. In Vu-91-1, five separate calc-silicate bands occur in a zone up to 30 m beneath the LMC. In Vu-91-2, two units occur within 20 m of the LMC. A 1.5 m thick unit also occurs in the Middle Aldridge (approximately 49 m in Vu-91-2). Two units occur within Vu-91-4 and are both within 15 m of the LMC. Two units occur in hole Vu-91-5, but are well below the LMC in wacke-subwacke units interbedded within the fragmental. Calc-silicate units occur as conformable lenses adjacent to the mineralized zone in the Main Showing exposure, where they exhibit strong continuous parallel banding features. A continuous stratabound unit of coarse to medium grained calc-silicate rock also occurs in laminated wacke just below the LMC to the west of Mount Patrick (up-dip of Vu-91-4). Here it is 1-3 m thick. Similar coarse calc-silicate was observed crosscutting the fragmental unit southeast of Vu-91-1 but this zone is poorly exposed.

The calc-silicate is a mottled to banded, coarse to medium grained rock with a quartz-pink feldspar-tremolite-chlorite-calcite mineralogy. Garnet, epidote, albite and biotite are common accessories. Mineralization (Pb, Zn, Cu, As) is commonly associated with this rock type. Sphalerite occurs as discontinuous laminae (e.g. Vu-91-1, 26.45-27.05), blebs and coarse clots, fracture fills and as very fine grained disseminations with arsenopyrite. Weak secondary sphalerite mineralization is locally observed. Galena is usually associated with pyrrhotite in quartz veinlets and stringers, but also occurs as fine disseminations with sphalerite. Pyrrhotite commonly comprises 5-10% as disseminations, clots and stringers, locally with chalcopyrite inclusions. Pyrite mainly occurs as disseminations and fracture fills.

The calc-silicate assemblages locally occur in the margins of gabbro intrusions and, in places, show textural variations resembling gabbro (e.g. 173.5-176.1 in Vu-91-2). These calc-silicate types are typically coarse grained, and clearly form as a replacement of original sedimentary (siliciclastic) rock types. They are believed to have formed by magmatic-hydrothermal processes related to the gabbroic intrusive event. These rocks may be included in the "granophyre" classification of Cominco. The mineralogy of this rock type is similar to the

mineralogy of alteration observed in the footwall vent system of the Sullivan Mine by workers on the GSC/BCDM Sullivan Project.

A second textural type of calc-silicate rock occurs in the Vulcan drill holes, and is best developed on the LMC in Vu-91-4 (191.42-192.85). This is a fine grained amphibole, biotite, feldspar, calcite rock with 5-10% disseminated pyrrhotite and minor pyrite-arsenopyrite. The unit appears to be sedimentary in nature and is strongly anomalous in Pb-Zn-Ag-Cu. This unit is interpreted to be a primary sedimentary layer with an abnormal original chemistry, which produced a distinctive metamorphic assemblage during re-crystallization. The stratabound calc-silicate west of Mt. Patrick, although coarser grained than the Vu-91-4 unit, is continuous and extensive. It may correlate with the Vu-91-4 calc-silicate, and field relations in outcrop suggest that it also has a primary sedimentary origin. The calc-silicate units below the LMC in Vu-91-5 are also conformable, have sharp planar contacts with siliciclastic sediments and are Pb-Zn enriched. Mineralization in the bottom of Vu-79-1 (1.1 m @ 0.35% Pb, 0.30% Zn) is hosted by similar fine grained calc-silicate rocks, which can be correlated with those in Vu-91-5. The mineralogy and style of these zones may be analogous to the dark Pb-Zn bearing calc-silicate bands and laminations interlayered with sulfides in the Concentrator Hill Horizon on the east fringe of the Sullivan Mine.

### 3.3.2 Alteration

Silicification. This is the most widespread alteration type noted in the core from the Vulcan drilling program. A pervasive aphanitic silica flooding of the host siliciclastics is the most common mode of occurrence.

In Vu-91-1, wacke intervals occurring below the LMC and interbedded with the top of the fragmental are locally silicified. Silicification appears to form as selvages to the coarse, replacive calc-silicate units, and appears to be part of the replacive process involved in the formation of these units.

In Vu-91-2, wacke and fragmental rocks are extensively silicified over 14 m below the LMC. Additional silicification occurs as selvages to a gabbro/calc-silicate unit approximately 18 m below the LMC.

In Vu-91-3, strong, extensive silicification occurs in the Middle Aldridge and is also apparent throughout Middle Aldridge outcrops in this area. The main gabbro unit here is believed to contain a high proportion of assimilated siliciclastic sediments. Minor silicification also occurs directly on the LMC in this hole.

In Vu-91-4, the more permeable quartzite units of the Middle Aldridge are silicified. Silicification also occurs in a massive wacke unit below the LMC with associated tremolite-calcite and Cu-As lithogeochemical anomalies. Only minor silicification occurs in Vu-91-5, in a wacke interval within the fragmental.

In general, silicification is more strongly developed in the Vulcan area than it is regionally. There is a spatial association between silica alteration and calc-silicate or altered gabbro (garnet-chlorite-albite rich gabbro). It is suggested that silica is driven out of replaced or assimilated siliciclastics during gabbro intrusion or calc-silicate replacement, and is redistributed into permeable quartzitic horizons or into sediments in the margins of the gabbro/calc-silicate replacement units.

Albitization. Albitization has not been identified with confidence at Vulcan. Positive identification requires Na analysis, and this work has not been undertaken. Albite alteration normally consists of a fine grained massive white to cream aggregate. Albitic replacement zones usually occur in the margins of gabbro sills and generally have the same distribution as silicification. Chlorite mainly occurs as a minor constituent in albite zones. Albite (+ chlorite) alteration is believed to be related to gabbro intrusion.

Tourmalinization. Tourmaline at Vulcan is widely distributed through the upper part of the Lower Aldridge Formation and locally occurs within wacke and subwacke bands in the lower part of the Middle Aldridge. Tourmaline occurs as fine acicular disseminations (to 20% of the rock) and is usually strongly strata-controlled within laminations or bands.

### 3.3.3 Structure

The main structural feature of the drill area is a broad open anticlinal fold plunging steeply to the northeast. Structural mapping was not conducted during the current program.

O.E. Owens of Cominco conducted the most recent mapping of the drill area (at 1:10,000 scale) and describes the structure as follows (Owens, 1958):

"The Lower Aldridge rocks have been folded into large north-south trending anticlines and synclines, and they have been refolded into a west plunging anticline by the intrusion of the White Creek batholith. Within these major folds are numerous smaller closed folds. Some of these, as along the eastern part of the map area, strike north-south; others as in West Basin strike east-west. The smaller folds appear to pinch out within short distances and their plunge is variable.

The Middle Aldridge rocks are relatively slightly folded except near the granite. They are part of a thick homoclinal series dipping westward.

North-south trending, steeply dipping faults are common in the eastern part of the map area. These are usually related in space to tight folds and are probably genetically related to them.

Sulfide mineralization was not observed to have any spatial relationship to folds or faults".

Cleavage is weakly to strongly developed in the Vulcan drill cores and is believed to represent an axial plane cleavage related to the major fold. Cleavage is strongest in Vu-91-5, believed to be near the axial plane area of the fold. Argillaceous rocks are phyllitic in this hole. Tight minor folds are also apparent in the pyrrhotite laminated wacke lithology in Vu-91-5 and sulfides are strongly remobilized into cleavage features.

### 3.4 Mineralization

Pyrrhotite Laminated Wacke. The main mineralization type at Vulcan consists of strata-controlled Fe-Pb-Zn-Ag sulfides and is hosted by a biotite-pyrrhotite laminated wacke to subwacke lithology immediately below the Lower Aldridge-Middle Aldridge contact. The

mineral host is directly correlated with the sequence hosting stratiform mineralization at the Sullivan Mine.

Pyrrhotite occurs in dark biotite-rich laminations which are usually 1-2 mm thick and are separated by several cm of massive wacke. The pyrrhotite usually occurs as fine grained disseminations within the dark laminations, but is clearly strata-controlled. Some continuous pyrrhotite-pyrite-arsenopyrite laminations also occur (as opposed to disseminations) but these are only well developed in the subwacke interval within the fragmental in Vu-91-5. A few thin stratiform pyrite laminations also occur in Vu-91-3. Traces of chalcopyrite were observed with the pyrrhotite in Vu-91-3, galena in Vu-91-2, sphalerite in Vu-91-5 and arsenopyrite-pyrite-sphalerite in Vu-91-4.

Quartz veinlets and stringers are often developed within this rock type and usually have accessory pyrrhotite-pyrite. Minor Pb-Zn-Cu sulfide mineralization also occurs as fracture fills and stringers. In hole Vu-91-2 such mineralization occurs in hairline fractures and has associated calcite and fluorite.

A variation of this mineralization type is exposed at the Main Showing where pyrrhotite-sphalerite-galena mineralization occurs over a 7.5 m thickness. This mineralization appears to be recrystallized and slightly remobilized, but is otherwise similar to the mineralization described above. The best interval within this section is:

Main Showing: 1.52 m @ 0.35% Pb, 1.25% Zn (previous Cominco sampling)

The author collected several grab samples of this material, the best of which assay up to 5.5% Pb-Zn combined and 22 opt Ag. Anomalous base metals occur in the same host sequence in holes Vu-91-1, 2, 3 and 4, but not in Vu-91-5 or Vu-79-1. The distribution of Pb-Zn-Ag in the same stratigraphic position over a 2.6 km strike strongly suggests that the metals are a primary sedimentary component contemporaneously deposited with the hosting sediments.

Calc-Silicate Hosted Mineralization. A second style of mineralization is associated with calc-silicate units which occur in the Lower Aldridge within several 10's of metres of the LMC.

Sphalerite occurs as discontinuous laminae (e.g., Vu-91-1, 26.45-27.05), blebs and coarse clots, fracture fills and as very fine grained disseminations with arsenopyrite. Weak secondary sphalerite mineralization is locally observed. Galena is usually associated with pyrrhotite in quartz veinlets and stringers, but also occurs as fine disseminations with sphalerite. Pyrrhotite commonly comprises 5-10% as disseminations, clots and stringers, locally with chalcopyrite inclusions. Pyrite mainly occurs as disseminations and fracture fills.

In most cases, it appears that primary sulfide minerals have been coarsely recrystallized, and remobilized during the replacive process of calc-silicate formation. However, in Vu-91-4 there is evidence of Pb-Zn-Ag-Cu-As enrichment in a calc-silicate horizon of possible sedimentary origin, which is located directly on the LMC.

Footwall Stringer Mineralization. In Vu-91-4 an extensive section of massive wacke and fragmental contains pyrrhotite stringers with minor chalcopyrite and arsenopyrite. The sulfides are hosted by quartz-chlorite-biotite (+ tremolite-calcite) stringers with random orientations. Geochemically anomalous Cu-As (+ Zn, Au) occurs in this unit. This is an assemblage similar to the calc-silicate unit, and underlies a base metal enriched calc-silicate on the LMC which is interpreted to be a sedimentary unit. The stringer mineralization can be interpreted as a sulfide matrix to a large scale breccia zone.

This mineralization is developed over approximately 70 m in Vu-91-4, but is strongest in an 18 m section and is accompanied by silicification.

Stratiform Massive Iron Sulphides. Bands of massive (100%) to semi-massive (60-100%) pyrrhotite (+ pyrite, chalcopyrite) occur in the Lower Aldridge. Sulfides occur as medium to coarse grained aggregates within the bands. Contacts are often planar and conformable. Two bands (3 and 7 cm thick) occur in a massive wacke in Vu-91-4, are about 22 m below the LMC and appear to be the source of a strong in hole UTEM anomaly. The strong anomaly would suggest that these zones are laterally extensive. Minor coarse grained chalcopyrite is associated with these sulfide bands.

Similar bands of massive pyrrhotite (+ chalcopyrite) were intersected in Cominco drill holes in the southern part of the property in 1984-85. All these zones are hosted by Lower Aldridge sediments.

Thin pyrrhotite-pyrite laminations occur in a subwacke interbedded within the fragmental in Vu-91-5. No anomalous base metal values were detected and no down hole geophysical anomalies occur in a down hole survey through this zone.

### 3.5 Economic Potential

The principle exploration target on the property is a Sullivan type stratiform, sediment-hosted massive sulfide deposit. The Sullivan produced 144 million tons averaging 6.5% Pb, 5.6% Zn and 2.3 opt Ag to 1988 and remains in production. The Sullivan is one of the largest deposits of this type in the world and has had a major impact on the economy of B.C. for a period exceeding 75 years.

At Vulcan there are strong indications of a Sullivan style mineralizing process within a pyrrhotite laminated wacke sequence immediately below the Lower Aldridge-Middle Aldridge contact. The Sullivan Mine also occurs immediately below this contact. The potential for a near surface deposit at Vulcan is limited, as the area is well exposed and surface UTEM surveys do not indicate a shallow deposit.

The potential target is deep and large. For example, a 54 million ton deposit (1/3 Sullivan size) might be contained in a 600 m x 600 m x 50 m thick zone at a depth of +500 m below surface. Although the horizon dips steeply, there is still an extensive strike length over which the target is within drill range (approximately 9 km on the property). The completed drill program was a shallow to intermediate depth investigation of the area considered to be most favourable based on surface geology. Two areas were located where deeper drilling can be recommended. These are down dip of Vu-91-2 and down dip of Vu-91-4.

#### 4.0 EXPLORATION AND DEVELOPMENT

##### 4.1 Geological Examinations

No new geological mapping was done, however the previous detailed mapping conducted by Cominco (1:10,000) was checked in the field and was found to be adequate for the purposes of the Ascot program. It was intended to conduct some detailed mapping in the area of the Main Showing, but this could not be accomplished due to the quick pace of the drill program and later due to snow cover. The measurement of detailed stratigraphic sections along ridges was also commenced, but snowfall precluded completion of this work. Detailed geological examinations were conducted of all exposures of the Lower Aldridge-Middle Aldridge contact zone.

##### 4.2 Geochemistry

Rock geochemical sampling was conducted on the pyrrhotite laminated wacke, calc-silicate and other sulfide bearing rock types in the vicinity of the LMC. The purpose of this work was to document geochemical level Pb-Zn-Ag-Cu-As enrichment of the target horizon. Narrow sample intervals were selected in order to evaluate individual thin horizons suspected of being metal rich, and to avoid excessive dilution from surrounding sulfide poor material. This type of sampling is desirable where significant mineral bearing units of exploration importance can be confined to very thin layers, as is the case in Sullivan-type exploration projects. The results of this sampling are tabulated in the drill logs (Appendix II) and in Appendix III.

Rock geochemical sampling was also conducted on the pyrrhotite laminated mudstone immediately below the LMC in Cominco drill hole Vu-79-1. Results are as follows:



LITHOGEOCHEMICAL RESULTS - COMINCO DDH Vu-79-1										
Sample ID.	From - To (m)	Thickness	Pb ppm	Zn ppm	Ag g/tonne	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
6312	119.00-120.52	1.52	35	63	0.7	44	1	1	3	6
6313	120.52-121.95	1.43	18	33	0.6	45	1	1	1	2
6314	121.95-123.17	1.22	21	41	0.9	38	1	1	1	3
6315	123.17-124.20	1.03	20	56	1.2	33	1	1	2	1
6316	124.20-125.30	1.10	75	128	1.4	34	1	1	1	3

No significant base metal anomalies were detected in this rock type in hole Vu-79-1.

A series of grab samples was taken through the best mineralized section of the Main Showing outcrop. Representative continuous sampling could not be conducted due to the friable nature of this outcrop. Results are as follows:

Sample ID.	Represented Width	Pb %	Zn %	Ag g/tonne	Cu %	Au ppb
6431	5 cm	1.72	3.63	25.7	0.005	1
6434	5 cm	1.45	4.03	22.0	0.003	1
6430	6 cm	1.20	2.59	20.1	0.006	1
6432	5 cm	0.86	3.20	17.3	0.003	1
6433	8 cm	0.53	2.72	15.0	0.004	2

Previous Cominco sampling of this outcrop indicated a 1.5 m interval grading 0.35% Pb, 1.25% Zn.

All of the analytical results are incorporated in Appendix III. All of the surface grab samples and split core were sent to Min-En Laboratories Ltd. for Pb, Zn, Ag, Cu, Ar, Sb, Mo, Au geochemical analysis. The analytical techniques are described in Appendix V.

### 4.3 Downhole Geophysics (UTEM)

Holes Vu-91-4 and 5 were surveyed by S.J.V. Consultants Ltd. using a downhole UTEM system and two surface loops. Attempts were made to survey holes Vu-91-2, 3 and Vu-79-1 but all these holes were found to be caved a short distance below the casing and could not be surveyed.

#### 4.3.1 Results

A sharp in hole UTEM anomaly was detected in Vu-91-4 and correlates with two bands of massive pyrrhotite-pyrite 3 cm and 7 cm thick, located approximately 22 m below the LMC. A broad off hole anomaly is also present near the LMC.

No downhole anomalies were detected in Vu-91-5.

#### 4.3.2 Interpretation

The consultants report is pending at the time of writing and will be included as Appendix VI.

### 4.4 Diamond Drilling

#### 4.4.1 Program

Five holes were drilled in the 1991 program for a total of 1003.04 m.

Hole No.	EOH Depth	Location/Purpose
Vu-91-1	60.98 m	- Diorite Lake Basin (West side); shallow test of Main Showing Area
Vu-91-2	227.13 m	- Diorite Lake Basin (West Side); intermediate depth test of Main Showing Area
Vu-91-3	276.52 m	- South side of Diorite Lake; intermediate depth test of "Sullivan Time" interval east of Main Showing

Hole No.	EOH Depth	Location/Purpose
Vu-91-4	279.57 m	- West of Mt. Patrick; intermediate depth test of "Sullivan Time" interval south of previous Cominco drill hole
Vu-91-5	158.84 m	- West Basin; between Main Showing and previous Cominco drill hole.
<b>Total</b>	<b>1003.04 m</b>	

The work was performed by Falcon Drilling Ltd. using a F-1000 unit, producing BGM size core. Down hole surveys were by acid test.

The program was completed in 10 days at an average rate of approximately 165 feet (50 m) per 12 hour shift (including moves). The best shift was 365 feet (111 m). A Hughes 500D helicopter was used to perform drill moves. At this elevation (+7,000 feet) temperatures of below 5°C are necessary to efficiently move the Falcon F-1000 drill unit. This is a major consideration in planning future programs, temperatures are suitable for helicopter supported moves using the above equipment in September/October. May temperatures are also suitable but the alpine areas remain heavily snow covered at that time.

The drilling was done using a zero-environmental impact approach with all sites left in a virtually undisturbed condition. Drill pads were cribbed and all materials removed after drilling. Short (<30 m) lengths of casing remains in holes 2, 3, 4 and 5. A spill of linseed oil (drill lubricant) occurred in Vu-91-2 and the oil entered a small pond west of Diorite Lake. The spill was skimmed using oil scavenging booms and no further action has been required by the Inspector of Mines at this time. The pond appeared to be clean and unharmed upon completion of the program.

The core was taken to the Cominco Cranbrook office for sampling. Very detailed sample intervals were selected in the first two holes, in order to document the distribution of metals in relation to rock-types and mineralization types. Sample breaks were based on geology. A minimum 0.5 m interval was used for later holes, except for thin units of exploration interest, and sample breaks continued to be based on geology wherever possible. All sampled

intervals were sawn and washed clean. The core is stored in racks at the Sullivan Mine site, near the old Open Pit. The storage area is covered, and boxes are individually accessible.

#### 4.4.2 Results

The drill holes successfully tested a Sullivan-style strata-controlled sulfide zone just below the Lower-Middle Aldridge Formation contact, at depths of from surface to approximately 300 m below surface. All holes encountered geochemically anomalous base metal and silver values below the LMC with the best intersection in Vu-91-2 (2.5 m @ 0.8% Pb-Zn combined and 15 grams/tonne silver). The "Sullivan Horizon" has now been defined by drilling over a strike length of 2.6 km.

The objectives of the program were to define the distribution of base metal sulfides and of the sub-basin which forms the sulfide host, in order that deeper drill tests can be planned. Two areas have been defined where such deep tests can be recommended based on Pb-Zn-Ag distribution, isopachs of the sub-basin facies, geophysical anomalies, and other geological observations in the drill core. Some simplifications and assumptions have been made in setting ranking criteria for the various holes. For example, isopachs of the pyrrhotite laminated wacke facies are corrected to true thickness based on average core to bedding angle, but no allowance can be made for the possible affects of post depositional folding on the apparent thickness of this unit. Also metal thickness products (used to rank geochemical indications in the various holes) are only based on the actual sampling. Continuous sampling was not conducted over sulfide-poor sections, which are presumed to have negligible (background) geochem values.

A fence diagram showing all the drill holes in long section and highlighting the main features of exploration significance is presented in Plan No. 12. The best indications of mineralization were found in Vu-91-1 and 2, drilled below the Main Showing and in Vu-91-4 at the south end of the drill fence, near Mt. Patrick. Holes Vu-91-3 at the east end and Vu-91-5, Vu-79-1 in the central part of the fence have fewer mineral indicators, and are classified as lower potential areas (based on geological/geochemical criteria).

Hole Vu-91-4 has a number of unique geological indicators which suggest enhanced mineral potential in this area. A broad zone of Pb, Zn, Ag, Cu, As geochemical anomalies extends for 35 m below the LMC. A mineralized sulfide/calc-silicate stringer network containing alteration assemblages similar to those observed in the footwall vent at Sullivan extends for approximately 60 m through massive wackes and the upper part of the fragmental. Lead, zinc, copper, arsenic enriched fine grained calc-silicate rocks of probable sedimentary origin occur on the LMC, at the top of the Pb-Zn anomalous pyrrhotite laminated wacke (sub-basin facies). This anomalous calc-silicate may represent the distal fringe of a Sullivan-type ore forming system. The combination of above noted features appears to be unique to the Vu-91-4 area.

A second area with indications of enhanced mineral potential is the Vu-91-1 and 2 area. Both holes have a thickened pyrrhotite laminated wacke sequence (sub-basin facies) suggesting possible proximity to the central parts of a sub-basin setting. The sub-basin sequence is approximately twice as thick as in the other holes at Vulcan. Strong variations in the stratigraphy occur between holes 1 and 2, as well as between holes 3 and 5 to the east and west. This suggests a very active basin environment. This is manifested in the conglomerate unit. Clastic sections are not well developed in Vu-91-2 which is dominated by massive wacke. This may also indicate a more central basinal setting, farther from the structures controlling fragmental development.

An attempt has been made to quantify some of the above noted geochemical and stratigraphic variables to aid in target selection. Measurements of the corrected thickness of the pyrrhotite laminated wacke/subwacke lithology between the LMC and the top of the fragmental are compared. Calc-silicate zones of replacement origin are included, as they overprint the laminated wacke unit. The holes are listed in order of their position along the drill fence, from east to west.

ISOPACH OF PYRRHOTITE LAMINATED WACKE LITHOLOGY	
Hole No.	Po Laminated Wacke, LMC - Top Frag
Vu-91-3	7.8 m
Vu-91-2	13.0 m
Vu-91-1	15.6 m
Vu-91-5	>6.0 m
Vu-79-1	8.7 m
Vu-91-4	8.1 m

These data clearly show a thickening of the sub-basin facies in holes 1 and 2 in the vicinity of the Main Showing. However pyrrhotite (+ pyrite) laminated units are also well developed within the fragmental in Vu-91-5, where they contain thin semi-massive sulfide laminations (without base metal anomalies). Such continuous laminations are rare in this rock-type, the sulfides normally being disseminated.

The base metal distribution is roughly quantified by summing the ppm x thickness products for all sampled intervals between the LMC and the top of the fragmental in each hole to produce a single number for ranking purposes. This procedure was also done for the interval from the LMC to the EOH. The same procedure was done for Pb + Zn and for Cu.

METAL DISTRIBUTION (ppm * thickness product)				
Hole No.	LMC to Top of Fragmental		LMC to End of Hole	
	Pb + Zn	Cu	Pb + Zn	Cu
Vu-91-3	2,770	593	3,300	650
Vu-91-2	59,700	851	72,700	1,480
Vu-91-1	7,280	807	10,600	1,650
Vu-91-5	<1,000?	<500?	~8,500	~1,000
Vu-79-1	<1,000?	<500?	n/a	n/a
Vu-91-4	4,390	917	8,700	3,700

n/a = not available, incompletely sampled.

The metal distribution clearly highlights the Vu-91-1, 2 and the Vu-91-4 areas. The importance of Cu in the footwall stringer system in Vu-91-4 is also highlighted.

## 5.0 CONCLUSIONS

- 1) At Vulcan the styles of mineralization, host rocks and alteration types all show strong similarities to the Sullivan Deposit, a world class sediment hosted stratiform sulfide deposit which up to 1988 had produced 144 million tons averaging 6.5% Pb, 5.6% Zn and 2.3 opt Ag. The target deposit at Vulcan is at depth, and can only be located by deep drill exploration.
- 2) The best sulfide mineralization at Vulcan is in a surface showing. Strata-controlled pyrrhotite-galena-sphalerite occurs on the "Sullivan Horizon" over 7.5 m which includes 1.5 m averaging 1.6% combined Pb-Zn. Grab samples of this zone assay up to 5.5% Pb-Zn and 22 opt Ag.
- 3) The drill program investigated a Sullivan-style strata-controlled sulfide zone on the Lower Aldridge-Middle Aldridge Formation contact, at depths of from surface to 300 m below surface. Geochemically elevated base metal and silver values were located on this contact with the best intersection in Vu-91-2 (2.5 m @ 0.8% Pb-Zn combined and 15 grams/tonne silver). The "Sullivan Horizon" has now been defined by drilling over a strike length of 2.6 km.
- 4) Deeper drill testing is warranted in two areas: The Vu-91-1, 2 area and the Vu-91-4 area. These areas are selected based on distribution of anomalous base metals, isopachs of the sub-basin facies and other geological indicators.
- 5) Other areas of the property also have potential for Sullivan type Pb-Zn-Ag deposits. In the southern part of the property the "Sullivan Horizon" remains untested by drilling, and occurs on or near weak UTEM and Pb-Zn geochemical anomalies. Previous drilling has located horizons of massive Fe (+ Cu) sulfide in Lower Aldridge rocks in this area, as well as Pb-Zn-Ag anomalous sedimentary rocks.

**6.0 RECOMMENDATIONS**

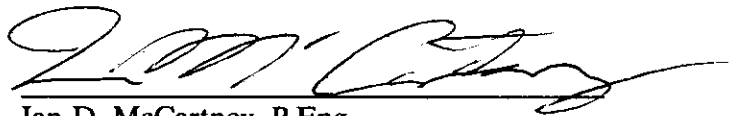
- 1) A program of deep drill testing should be completed in the area of Vu-91-1, 2 and also in the Vu-91-4 area. Three follow-up holes are proposed, each approximately 1,000 m deep. One deep hole is required on the same section as Vu-91-1, 2. A second deep hole should step out approximately 1,200 m to the west of Vu-91-2 and a third deep hole should be drilled on the same section line as Vu-91-4.

Proposed hole #1 requires helicopter support. The other holes can be accessed by 4-wheel drive road, and require some road building work.

- 2) Further work should be conducted along the projection of the Lower-Middle Aldridge contact in the southern part of the Vulcan claims. Geological mapping is required to establish Middle Aldridge marker control and to define the structural setting of the area. This should be followed by short hole drill testing of the Lower-Middle Aldridge contact.
- 3) Down hole geophysics (UTEM) should be conducted on all new drill holes. The drilling company should be required to insert plastic liners in all holes to prevent hole caving.

Respectfully submitted,

**KEEWATIN ENGINEERING INC.**



Ian D. McCartney, P.Eng.



7.0 **PROPOSED BUDGET** (Approximate)

<b>Pre-Field</b>		<b>\$12,000.00</b>
<b>Field Program</b>		
Personnel	\$ 65,000.00	
Down-hole Geophysics	20,000.00	
Diamond Drilling - 3,000 m @ \$85.00/metre	255,000.00	
Helicopter Support	25,000.00	
Geochemistry	3,000.00	
Cat Work	15,000.00	
Camp Costs	5,000.00	
Room and Board	10,000.00	
Truck and Equipment Rentals	7,000.00	
Transportation	2,000.00	
Supplies	5,000.00	
Fuel	6,000.00	
Miscellaneous	<u>4,000.00</u>	<b>\$422,000.00</b>
Contingency on Field Program (10%)		42,200.00
<b>Post-Field</b>		<u><b>20,000.00</b></u>
<b>TOTAL:</b>		<u><b>\$496,200.00</b></u>

**8.0**    **REFERENCES**

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**APPENDIX I**

**Statement of Qualifications**

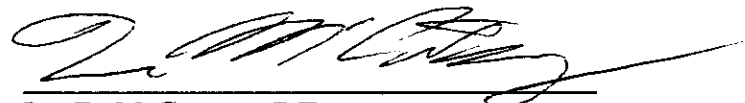
## STATEMENT OF QUALIFICATIONS

I, IAN DOUGLAS McCARTNEY, of 2242 Spruce Street in the City of Vancouver in the Province of British Columbia, do hereby certify that:

- 1) I am a graduate of Queens University, Kingston, Ontario with an Engineering Degree (B.Sc.) in Geology (1976).
- 2) I am a Member in good standing of the Association of Professional Engineers of the Province of British Columbia and a Member in good standing of the Institute of Mining and Metallurgy.
- 3) I am a consulting geologist with the firm of Keewatin Engineering Inc. with offices at Suite 800 - 900 West Hastings Street, Vancouver, British Columbia.
- 4) I am the author of the report entitled "Diamond Drilling Report, Vulcan Property, East Kootenay District, B.C.", dated October 30, 1991.
- 5) I directly supervised the exploration program carried out on the Vulcan property between September 3 and September 28, 1991.
- 6) I do not own or expect to receive any interest (direct, indirect or contingent) in the property described herein nor in the securities of Ascot Resources Ltd. in respect of services rendered in the preparation of this report.

Dated in Vancouver, British Columbia this 4th day of November, A.D., 1991.

Respectfully submitted,

  
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Ian D. McCartney, P.Eng.

**APPENDIX II**

**Drill Logs and Core Recoveries**

## DRILL HOLE LOG

LOCATION: Main Showing Area, Diorite (Jurak) Lake Basin						DRILL HOLE NO.: VU-91-1								
AZIMUTH: 167°		ELEVATION: 2,200 m (approx.)		PROPERTY: Vulcan										
INCLINATION: -45°		LENGTH: 61.3 m		CLAIM NO: Vulcan 2										
		CORE SIZE: BGM		SECTION:										
STARTED: September 12, 1991		58.5		-		-44		LOGGED BY: LD. McCartney						
COMPLETED: September 13, 1991								DATED LOGGED: September 14, 1991						
PURPOSE: To define the stratigraphic setting and style of mineralization at the Main Showing with a shallow drill test.								DRILLING CO.: Falcon Drilling Ltd.						
								ASSAYED BY: Min-En Laboratories Ltd.						
CORE RECOVERY: 95%.														
METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
0.00	3.00	<u>Overburden</u> : No core recovered. Casing												
3.00	7.50	<u>Broken Core - Mixed Lithologies</u> : Probably still in talus. Mixed sediment and gabbro rock types, many small doubly cored pieces, have rotated during coring. No correlative gabbro seen in outcrop.												
7.50	10.20	<u>Wacke</u> : Dark grey, very fine grained, thickly laminated to thin bedded. Some thin laminated sections. Dark laminations defined by biotitic concentrations. Thin bedding parallel quartz veins. Trace disseminated pyrrhotite (<1%). Core to bedding 60° @ 9.8 m. 8.2 - 9.2 - Rounded sediment rubble, possibly talus interval? 9.7 - 10.1 - 2-3% disseminated and discontinuous pyrrhotite laminations.												
10.20	13.50	<u>Quartzitic Wacke</u> : Light grey, fine grained to medium grained. A few thick to medium beds, otherwise thickly laminated to thin bedded. 2-3% fine grained disseminated pyrrhotite throughout, locally to 10% in strata-controlled laminations (e.g. 10.85, 12.30). Rare discordant pyrrhotite stringers with minor quartz. At 12.5 m a 0.4 cm quartz vein with coarse pyrrhotite clots. Core to bedding 60° @ 12.3 m.	6451	12.00	12.50	0.50	24	22	0.2	25	12	1	4	4
			6452	12.50	13.00	0.50	16	15	0.5	10	10	1	1	2
			6453	13.00	13.50	0.50	19	22	0.6	10	23	1	4	1

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES								
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb	
13.50	17.9	<b>Pyrrhotite Laminated Wacke:</b> Dark-light grey, 3-4% pyrrhotite as widely spaced streaky laminations and disseminations. Rare coarse pyrite-pyrrhotite clots and stringers associated with quartz veinlets and stringers. Quartz veins are usually bedding parallel, often truncated on fractures. Local acicular black very thin crystals (tourmaline?). Core to bedding angles: 64° @ 15.5 m. @ 13.6 - Pyrrhotite-quartz stringers. 16.4 - 17.9 - Bluish sheen on fractures 17.0 - 17.2 - Discontinuous irregular stringers of biotite-pyrrhotite-pyrite 17.5 - 17.9 - Pyrite in hairline fractures parallel to core axis.	6454	13.50	14.00	0.50	40	55	0.2	44	54	1	4	2	
			6455	14.00	14.50	0.50	61	42	0.1	58	34	1	5	2	
			6456	14.50	15.00	0.50	85	32	0.2	50	58	1	2	3	
			6457	15.00	15.50	0.50	61	88	0.4	33	57	1	5	1	
			6458	15.50	16.00	0.50	34	37	0.3	34	60	1	1	12	
			6459	16.00	16.50	0.50	31	53	0.5	39	62	1	4	2	
			6460	16.50	16.90	0.40	59	182	0.4	34	92	1	1	1	
			6461	16.90	17.30	0.40	93	29	0.4	51	40	1	4	2	
			6462	17.30	17.90	0.60	60	59	0.4	50	45	1	2	5	
17.90	17.90	<b>Lower-Middle Aldridge Formation Contact</b> (Top of "Sullivan Time" Interval)													
17.90	25.00	<b>Calc-Silicate Replacement Unit:</b> Medium to coarse grained mottled to banded. Dark grey/pink/white/green/cream color variations. Weak to strong HCl reaction throughout. Quartz-feldspar (pink)-epidote-calcite with minor chlorite + amphibole (tremolite?) and garnet. Quartz as irregular banding parallel zones and as crosscutting veinlets. Trace sericite(?) as highly reflective silvery platy mineral. Possibly a metamorphosed impure carbonate unit (exhalite?), but more likely a totally replaced fine grained siliciclastic (wacke?). Several large clots of black sphalerite on lower contact, where calc-silicate appears to be replacing a fine grained banded siliciclastic. 23.05 - 23.45 - 5 cm thick barren quartz vein, pale bluish white secondary mineral in matrix of calc-silicate. Weak zinc zap reaction at 20.5. Secondary zinc (+ lead) minerals?	6497	17.90	18.55	0.65	55	86	1.2	9	218	1	2	1	
			6409	20.20	20.80	0.60	0.02%	0.01%	0.3	0.001%	-	-	-	-	2
			6463	23.05	23.45	0.40	51	86	1.3	8	25	1	2	2	
25.00	26.45	<b>Silicified Wacke:</b> Dark grey, very hard, silicified, fine grained. Thin bedded to thickly laminated. Clots of biotite and amphibole alteration common. Amphibole as radiating, fibrous crystals (tremolite?). Core to bedding @ 50°. Irregular replacement patches of amphibole-silica with 3-4% pyrrhotite occur in lower 0.3 m and completely destroy all original siliciclastic textures. Approx. 1% disseminated pyrrhotite with trace pyrite occurs throughout. Alteration often similar to that seen in overlying calc-silicate unit. @ 25.1 - a thin discontinuous lamination with dark sphalerite development, apparently strata-controlled. 25.0 - 25.35 - Replaced by calc-silicate assemblage as in above unit. Bedding features well preserved.	6464	25.00	25.35	0.35	93	630	1.4	16	2426	7	5	10	
			6465	25.35	25.90	0.55	282	228	2.0	65	668	1	1	4	
			6466	25.90	26.45	0.55	0.01%	0.01%	0.9	0.002%	-	-	-	9	
26.45	27.05	<b>Banded Quartz-Albite(?) - Chlorite Rock:</b> Apparently an intense replacement of a fine grained, banded siliciclastic rock. White/cream/green colour banding. Predominantly quartz. Minor dark brown-grey biotite bands. No HCl reaction. Weakly developed dark brown-black sphalerite and pyrrhotite as discontinuous coarse grained laminae, blebs, and as crosscutting fracture controlled stringers. Very fine grained disseminated arsenopyrite-sphalerite in matrix.	6467	26.45	26.75	0.30	0.01%	0.06%	0.2	0.001%	-	-	-	146	
			6468	26.75	27.05	0.30	0.01%	0.05%	0.3	0.001%	-	-	-	2	

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
27.05	28.65	<b>Silicified Wacke:</b> Dark grey, very similar to 25.00 - 26.45. A few crosscutting carbonate-chlorite stringers. Thickly laminated to thin bedded. Local intense silica replacement along bedding, primary textures nearly destroyed in these sections. Occasional radiating amphibole and biotite replacement spots. 28.1 - 28.45 - Banded pink feldspar-quartz-chlorite replacement of original siliciclastics. Similar to 26.45 - 27.05 but feldspar predominates.	6469 6428 6498 6499 6500	27.05 27.50 28.45 28.65 29.08	27.50 28.45 28.65 29.08 29.65	0.45 0.95 0.20 0.43 0.57	0.01% 34 50 34 39	0.01% 39 106 71 37	0.9 1.3 1.3 1.3 0.9	0.001% 10 12 8 45	- 900 230 198 25	- 1 12 2 2	- 6 3 3 1	2 2 2 1 1
28.65	29.65	<b>Calc-Silicate Replacement of Sediment:</b> Intense silica, pink feldspar-amphibole (tremolite?) replacement. Local HCl reaction. Evidence of original sedimentary character locally preserved. Local coarse grained pyrrhotite clots in altered sections. Minor crosscutting pyrite stringers at lower contact. Local coarse radiating tremolite growth.												
29.65	31.75	<b>Pyrrhotite Lamiated Wacke:</b> Discontinuous lensy dark grey biotite + pyrrhotite laminations in a medium grey wacke. Local patches of light grey silicification near top. Core to bedding 50° @ 31.3 m. Pyrrhotite also occurs as clots in minor bedding parallel quartz stringers. 31.30 - 31.75 - Albitized, sheared @ 35° to core axis 30.50 - Very fine grained disseminated red sphalerite in biotitic laminations.	6429 6470 6471	29.65 30.20 30.75	30.20 30.75 31.25	0.55 0.55 0.50	134 157 95	164 742 368	0.9 1.3 0.7	41 50 51	45 111 41	1 1 1	2 5 1	1 1 2
31.75	32.30	<b>Alternating Laminated Wacke/Fragmental:</b> Fragmental predominates in upper part, laminated wacke in lower. <b>Laminated wacke</b> is light/dark grey colour banded, biotitic in dark bands. Locally contorted, possibly due to slump folding? Disseminated pyrrhotite replacement in biotitic laminations (5-7% pyrrhotite overall). Light grey bands possibly weakly albitized. Biotite-pyrrhotite laminations locally discontinuous, with thin white alteration selvages, similar to alteration style seen around sulfide mineralization in Main Showing outcrop. No Pb-Zn seen. <b>Fragmental</b> consists of approx. 10% rounded to ovoid dark biotitic clasts strongly replaced by pyrrhotite in a light grey fine grained wacke matrix. Matrix is sulfide free.	6472	32.00	32.30	0.30	0.01%	0.05%	0.2	0.004%	-	-	-	7
32.30	32.60	<b>Fragmental:</b> Identical to fragmental described in above unit.												
32.60	32.75	<b>Altered Laminated Wacke:</b> Similar to laminated wacke described in 31.75 - 32.30 but thicker laminations and bleached halos more strongly developed around biotite-pyrrhotite bands. Resembles mineralized interval at Main Showing.	6473	32.60	32.75	0.15	0.01%	0.01%	1.0	0.059%	-	-	-	24
32.75	38.77	<b>Fragmental:</b> 20-30% dark biotitic clasts in a light grey massive fine grained to medium grained wacke matrix. Heavy pyrrhotite replacement in clasts. Clasts floating in matrix, ovoid to subangular, 1 mm to 3 cm size range. Local weak biotitic lamination @ 65° to core axis. Possible weak albitization over upper 0.5 m. Trace sphalerite in lamination and clasts. 35.02 - 35.52 - Weak sphalerite (+ galena?) replacement in several clasts. Strong pyrrhotite also developed. Possible arsenopyrite? 37.48 - 37.86 - Biotite laminated wacke interval with strong pyrrhotite and minor reddish brown sphalerite in biotitic bands.	6474 6475 6476	33.28 35.02 37.48	33.65 35.52 37.86	0.37 0.50 0.38	63 67 162	87 89 576	0.6 0.5 1.3	31 49 35	37 105 34	1 1 1	2 1 3	7 2 1



METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES								
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb	
38.77	41.20	<u>Laminated Wacke</u> : Dark grey-brown biotite rich bands alternate with light grey wacke. Thin to thickly laminated. 5-10% disseminated pyrrhotite in biotitic bands. Silicified from 40.8 - 50.2. Possible trace sphalerite in biotitic bands. Sulfides strongly strata-controlled. 39.1 - 39.36 - Fragmental bed.	6408 6477 6311 6478	39.36 39.70 40.16 40.80	39.70 40.16 40.80 41.20	0.34 0.46 0.64 0.40	117 89 45 49	125 389 111 1172	0.7 1.1 1.0 1.1	42 26 30 41	76 105 36 129	1 1 1 1	4 1 2 4	2 1 3 3	
41.20	42.55	<u>Silica-Amphibole Replacement</u> : Also biotite-feldspar and carbonate. Similar to other replacement zones in this hole. Primary banding features are locally preserved. Banded wacke precursor? Coarse grained pyrrhotite clots in carbonate stringer/veinlet sub-parallel to core axis. Strongly developed biotitic alteration at base. Thin central zone resembles a gabbro and appears to be core of alteration system. Minor disseminated pyrrhotite, fracture pyrite.													
42.55	42.90	<u>Wacke</u> : Thin bedded, dark grey, very fine grained. 1-3% disseminated pyrrhotite, concentrated in darker (more biotitic) sections. Core to bedding 070°.													
42.90	44.10	<u>Quartzitic Wacke</u> : Fine grained to medium grained. Massive to faintly laminated. Light green bleaching (chlorite-sericite?) controlled by fractures. Biotite in laminations, around some crosscutting fractures and in ovoid clots. Minor disseminated pyrrhotite in biotitic sections.													
44.10	45.85	<u>Amphibole-Feldspar Alteration Zone</u> : Predominantly medium grained granular amphibole, minor biotite, quartz, feldspar, local weak HCl reaction, especially on fractures. Faint banding occasionally seen. Replacement of sediments. Trace galena in quartz stringer at 45.0 m.													
45.85	47.05	<u>Wacke</u> : Thin bedded. Silicified, laminated in upper 0.3 m. 1-2% pyrrhotite as disseminations and as clots in bedding parallel quartz veinlets. Core to bedding 30° @ 45.9, 54° @ 46.9 m.													
47.05	61.30	<u>Fragmental</u> : Clasts are often tabular and resemble streaky discontinuous laminations. Ovoid clasts elongated parallel to tabular ones. Massive wacke matrix. Both light grey (quartzitic) and dark grey (biotitic) clasts. Strong pyrrhotite replacement in biotitic clasts. Several intervals contain <10% tabular clasts (massive to conglomeratic wackes).													
61.30	61.30	END OF HOLE													

LOCATION: Main Showing Area, Diorite (Jurak) Lake Basin						DRILL HOLE NO.: VU-91-2							
AZIMUTH: 167°		ELEVATION: 2,170 m (approx.)		PROPERTY: Vulcan									
INCLINATION: -65°		LENGTH: 227.13 m		CLAIM NO: Vulcan 2									
CORE SIZE: BGM		SURVEYS				SECTION:							
		METREAGE	AZIMUTH	INCLINATION	CORR. INCLIN.								
STARTED: September 13, 1991		108.23	-	-69	-62	LOGGED BY: LD. McCartney							
COMPLETED: September 15, 1991		214.94	-	-65	-57.5	DATED LOGGED: September 15, 1991							
PURPOSE: To complete intermediate depth test of "Sullivan Time Horizon" directly down-dip of Main Showing						DRILLING CO.: Falcon Drilling, Prince George, B.C.							
CORE RECOVERY: 98%						ASSAYED BY: Min-En Laboratories Ltd.							
METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES						
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm
0	3.05	Casing: No core recovered											
3.05	37.73	Gabbro: Medium grained, dark green; amphibole feldspar mineralogy, local weak HCl reaction. Black biotitized sections, local fine grained garnet in matrix @ 5-10%. These areas texturally resemble some alteration zones seen in sediments and interpreted as replacement. Local weak fabric @ 60° to core axis. 3.05- 4.42 - Massive sucrosic quartz vein. Barren. Minor amphibole. 4.75- 5.79 - Massive sucrosic quartz vein with amphibole rich (gabbroic) bands and streaks. Barren. 16.62-16.81 - Sucrosic quartz vein with amphibole streaks. 3-4% pyrrhotite overall as clots and stringers, with minor associated chalcopyrite. 19.00-20.00 - Coarse grained mottled amphibole-calcite zone with approx. 5% pyrrhotite as clots and stringers. 25.50-26.00 - Epidotized. 37.32-37.73 - Black fine-grained - medium-grained biotitic selvage. May be replacement of sediments adjacent to gabbro contact. Phyllic crenulations.											
37.73	48.28	Thin Bedded - Laminated Quartzitic Wacke/Wacke: Also contains a few medium quartzitic wacke beds. Strong biotite spotting throughout, darker biotite rich beds. Disseminated pyrrhotite associated with all biotitic zones. Local zones of white silicification to approx. 0.3 m thick have bleached appearance. Core to bedding: 68° @ 39 m, 52° @ 44.5 m, 50° @ 50.5 m. Est. 2-3% pyrrhotite overall. Some of silicic alteration is probably albite (e.g. 39.8 m).											

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES						
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm
48.28	49.77	<b>Massive Amphibole-Biotite-Quartz Rock:</b> Fine-grained - medium-grained, uniform. Texturally resembles alteration zones within gabbro @ top of hole. Possibly a replacement of sediment by gabbro derived fluids or unit may have had a distinctive primary chemistry to explain metamorphic mineralogy? 1-2% fine grained disseminated pyrrhotite throughout. Sharp conformable contacts @ 40° to core axis. No evidence of internal bedding.											
49.77	58.70	<b>Thin Bedded to Laminated Quartzitic Wacke/Wacke:</b> Similar to 37.73-48.28. White to cream, bleached zones of silicification as crosscutting stringers and conformable bands. Core to bedding angle average 45° but variable, 20° @ 57.5 m. Minor quartz-feldspar-chlorite veining.											
58.70	124.85	<b>Gabbro:</b> Fine to medium-grained biotite-chlorite in upper margin, from 58.7-59.3. Mineralogy is amphibole-feldspar-biotite-chlorite. Medium to coarse-grained. Some black fine-grained strongly biotitic bands. Local epidote alteration bands. Common short zones with 1-5% disseminated pyrrhotite. Zones of silicification around quartz veins (e.g. 95.9-96.3). 96.15- 97.50 - Irregular quartz + chlorite vein network, containing angular gabbro inclusions. Barren. 97.50-118.50 - Minor quartz veins as above, approx. 3-5% overall, usually <0.2 m thick.											
124.85	139.05	<b>Thin Bedded Wacke:</b> Possibly distal turbidites. Light grey. Some quartzitic wacke beds. 124.85-131.50 - Strong cream-white albitic(?) alteration often with greenish coloration due to chlorite and heavy biotite spotting. Core to bedding: 50° @ 130 m, 60° @ 138 m.											
139.05	140.11	<b>Thick Bedded Quartzitic Wacke Turbidites:</b> Typical Middle Aldridge turbidites, thick quartzitic wacke bases with thin subwacke tops. Minor quartz-pyrrhotite stringers.											
140.11	145.57	<b>Thin to Medium Bedded Wacke, Quartzitic Wacke:</b> Distal turbidites. Dark grey biotitic bands and zones, often lensoidal in form. Local white bleached silicified zones with gradational irregular contacts. Light grey silicification often migrates out from hairline fractures, or along bedding planes.											
145.57	148.30	<b>Predominantly Thin Bedded Quartzitic Wacke:</b> Typical M.Ald turbidites. Diffuse silicification. Biotite along hairline fractures. Argillaceous beds are black, strongly biotitic. Minor pyrrhotite as disseminations in biotitic sections and as clots and stringers.											
148.30	148.30	<b>Lower-Middle Aldridge Formation Contact</b> (Top of "Sullivan Time" Interval)											
148.30	151.80	<b>Thin Bedded Wacke:</b> Locally laminated. Probably distal turbidites with short sections of laminated inter-turbiditic wacke. Pyrrhotite disseminations in dark biotitic beds and laminations. Minor bedding parallel quartz-biotite-pyrrhotite veinlets. Local strongly silicified zones to 0.3 m contain biotite as stringers and clots and coarse-grained disseminated pyrrhotite. Core to bedding 55° @ 150.5 m.											

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
151.80	152.83			<b>Pyrrhotite Laminated Subwacke:</b> Massive subwacke matrix. 10% biotite-pyrrhotite as 1 mm scale laminations, pyrrhotite slightly remobilized into weak cleavage.										
152.83	156.90	<b>Thin Bedded Wacke/Subwacke:</b> Distal turbidites predominate. Alternating with short sections of inturbidite subwacke similar to overlying unit. Core to bedding 30° to core axis. 155.60-155.85 - Pink albite(?) alteration around a quartz-impregnated fracture zone.												
156.90	164.26	<b>Altered Laminated Wacke:</b> Thin to thick laminations defined by biotite and disseminated pyrrhotite in dark laminations. Primary laminated textures preserved despite intense silicification and possibly albitization. 158.38-158.80 - Thin to medium bedded quartzitic wacke. 160.0-161.63 - Much more intensely silicified. Green-white-brown-cream colour banding due to alternating silica, biotite and feldspar bands. Coarse grained pyrrhotite-pyrite clots associated with quartz veinlets. A massive pyrrhotite-sphalerite clot from 160.10-160.25. 163.16-164.26 - Weak galena mineralization as disseminations in pyrrhotite-rich laminations and in crosscutting stringers. Intense silica, albite(?) alteration. Core to bedding 45°. Galena in stringers and hairline fractures at 90° to bedding. Minor calcite (+ fluorite?) as parallel stringers from 163.55 - 163.65, also at 90° to bedding.	6401 6402 6403 6494 6495 6496 6493 6404 6405 6406 6407	159.70 160.10 160.25 160.60 161.00 161.63 162.05 162.66 163.16 163.50 163.93	160.10 160.25 160.60 161.00 161.63 162.05 162.66 163.16 163.50 163.93	0.40 0.15 0.35 0.40 0.63 0.42 0.61 0.50 0.34 0.43 0.33	0.02% 0.09% 0.02% 85 88 76 80 0.03% 0.35% 0.19% 0.03%	0.01% 0.90% 0.04% 54 93 101 31 0.01% 0.01% 0.01%	0.4 3.0 0.7 0.6 1.1 0.7 0.6 0.3 2.2 1.2 0.5	0.002% 0.034% 0.001% 43 29 40 19 0.004% 0.003% 0.002% 0.002%	- - - 29 25 53 19 - - - -	- - - 1 3 1 1 3 - - -	- - - 3 3 1 1 3 - - -	3 2 2 1 3 2 3 1 2 1 2
164.26	165.04	<b>Massive Pink Feldspar/Quartz Rock:</b> Coarse to medium-grained feldspar-quartz-biotite aggregate with quartz (+ galena) veining concentrated in top of unit. Coarse galena-pyrrhotite aggregates in quartz. Quartz stockwork veinlets with pyrrhotite and trace galena occur in lower part of unit.	6410 6411	164.26 164.66	164.66 165.04	0.40 0.38	3.97% 0.09%	0.12% 0.01%	84.6 1.3	0.019% 0.003%	- -	- -	- -	1 1
165.04	166.68	<b>Silicified Fragmental:</b> Very hard, cream to dark grey, banded, intensely silicified (possibly albitized?). At top of unit, a 0.3 m section of silicified, laminated wacke similar to 156.9-164.26. Evidence of clasts below 165.34 m. 165.34-165.64 - Cream feldspar-quartz aggregate and quartz veining with fine-grained to medium-grained disseminated galena in quartz veins. 166.30-166.51 - Zone of intense silica replacement. Original sedimentary textures not apparent. Contains disseminated pyrrhotite-arsenopyrite and chlorite-biotite-sericite disseminations and stringers. Fragments are highly elongated and imbricated at 50° to core axis.	6412 6413 6414 6415	165.04 165.34 165.64 166.24	165.34 165.64 166.24 166.51	0.30 0.30 0.60 0.27	0.08% 0.14% 0.02% 0.01%	0.01% 0.03% 0.01% 0.01%	0.9 1.4 0.2 0.4	0.002% 0.003% 0.002% 0.001%	- - - -	- - - -	- - - -	3 2 3 1
166.68	167.10	<b>Silicified Laminated Wacke:</b> Dark laminations of biotite-sericite-pyrrhotite. Strongly silicified, light grey to white to cream colorations. Sedimentary contacts are blurred/diffuse due to alteration overprinting. A few conglomeratic sections with fragments strongly elongated parallel to bedding. Core to bedding @ 50°.	6416 6417	166.51 166.79	166.79 167.10	0.28 0.31	0.04% 0.13%	0.01% 0.01%	0.2 1.1	0.002% 0.003%	- -	- -	- -	2 5
167.10	168.58	<b>Silicified Fragmental:</b> Clots, bands, and stringers of dark biotite-sericite alteration (approx. 20-30%), formed by recrystallization of more argillaceous clasts/bands. Extremely hard silicified host. Minor disseminated pyrrhotite in biotitic sections. Elongated, imbricated dark grey and cream coloured clasts in a medium grey, fine grained groundmass.	6418 6419 6420	167.10 167.64 168.10	167.64 168.10 168.58	0.54 0.46 0.48	1388 1437 130	156 976 106	2.3 2.6 0.7	43 40 75	438 556 592	14 12 1	1 4 1	2 3 1

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
168.58	169.04	<u>Silicified Laminated Wacke</u> : Similar to 166.68-167.10. Irregular dark medium-grained to coarse-grained biotite-sericite-pyrrhotite zones form as stockwork and also extend along bedding planes.	6421	168.58	169.04	0.46	146	118	0.2	94	861	4	1	1
169.04	170.96	<u>Silicified Fragmental</u> : Similar to 167.10-168.58. Minor biotite bands, some biotite rich clasts. Less intensely silicified than overlying units.	6422	169.04	169.50	0.46	143	91	0.5	38	1236	5	1	2
170.96	173.27	<u>Pyrrhotite Laminated Wacke</u> : Dark brown biotite-sericite-pyrrhotite laminations 1-2 mm thick comprise approx. 20%. Light grey fine grained wacke matrix. Core to bedding - 45°.	6423	170.96	171.45	0.49	37	78	0.6	38	650	4	3	1
			6424	171.45	172.00	0.55	37	373	0.4	39	1052	6	3	2
			6425	172.00	172.50	0.50	32	441	0.5	41	1012	5	1	1
			6426	172.50	173.00	0.50	41	71	0.5	33	717	3	2	2
173.27	173.51	<u>Silicified Laminated Wacke</u> : Dark grey, strongly silicified. Border zone of underlying alteration units.												
173.51	174.62	<u>Amphibole-Feldspar Rock/Gabbro</u> : Medium-grained green tremolite(?) - pink feldspar aggregate. Locally coarse-grained and gabbroic in texture. Irregular calcite veins with coarse biotite selvages. Minor disseminated pyrrhotite in biotite zones. Sharp upper contact. Gradational lower contact. Appears to be a gabbro sill with a strongly replacive lower contact.												
174.62	176.10	<u>Banded to Massive Quartz-Amphibole-Feldspar Rock</u> : 174.62-175.60 - Cream/white mottling and colour banding, quartz-amphibole-feldspar mineralogy. An intense alteration-replacement of a laminated sediment. Trace disseminated galena-sphalerite in quartz-amphibole-biotite stringers. 175.60-176.10 - White bleached silicified laminated sediment. Strongly replaced by amphibole-pyrrhotite. Replacement radiates out from stringers and follows bedding planes. Interpreted as an altered contact zone of a gabbro sill.	6427	174.62	174.91	0.29	192	474	1.9	8	1521	27	3	2
			6447	174.91	175.45	0.54	618	72	3.2	6	2624	1	1	1
			6448	175.45	176.10	0.65	171	49	1.9	28	1122	1	2	1
176.10	179.03	<u>Pyrrhotite-Biotite Laminated Wacke</u> : Medium grey, very hard, silicified to 176.8. Dark pyrrhotite-biotite laminations are continuous and planar. Pyrrhotite is disseminated along the laminations. Host wacke also has faint internal laminations. Some coarse pyrrhotite clots. 2-3% pyrrhotite overall. Core to bedding 50°.	6449	176.10	177.10	1.00	95	85	0.9	33	52	1	1	1
			6450	177.10	178.20	1.10	63	80	0.8	30	73	1	1	2
			6301	178.20	179.45	1.25	49	76	1.1	39	83	1	1	1
179.03	183.00	<u>Massive Wacke</u> : Medium grey. Same matrix as above but not laminated. 2-3% pyrrhotite as coarse clots. Commonly very short (0.3 m) laminated sections resemble overlying unit. Pyrrhotite clots in lower part of unit may be replacing clasts?	6302	179.45	180.65	1.20	47	83	1.2	41	60	1	1	1
183.00	184.00	<u>Fragmental</u> : 50% clasts in a medium grey-brown wacke matrix. Dark grey biotitic and light grey mudstone clasts. Some black carbonaceous clasts with light grey alteration rims. Clasts imbricated @ 35-40°.												
184.00	187.90	<u>Thin to Medium Bedded Wacke</u> : Occasional dark biotite-pyrrhotite laminations, often lensoidal. Pyrrhotite is disseminated in these laminations.												

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
187.90	192.10			<u>Massive Biotite Spotted Wacke</u> : Prominent biotite spotting approx. 1 x 4 mm, imbricated @ 45° throughout unit. Massive wacke matrix. Biotite probably replacing mud-chips. Larger clasts occasionally seen. Biotite-pyrrhotite in large irregular clots and as stringers. Probably a mud chip fragmental. Average 7-10% clasts (biotite spots). @ 190 m minor chalcopyrite in biotite-pyrrhotite stringers. Strong biotite replacement in adjacent wackes.										
192.10	193.55	<u>Fragmental</u> : Similar to 183.00-184.00. Biotite-pyrrhotite replacement of dark clasts. Most clasts strongly flattened, imbricated @ 45° to core axis.												
193.55	206.22	<u>Massive Biotite Spotted Wacke</u> : Same as 187.90-192.10.												
206.22	208.12	<u>Laminated Wacke</u> : Thick to thinly laminated. Dark biotitic laminations with disseminated pyrrhotite. Minor quartz-pyrrhotite stringers. Core to bedding @ 45°. 206.50-206.77 - Fragmental bed.												
208.12	210.40	<u>Massive Conglomeratic Wacke</u> : Similar to above biotite spotted wackes, but biotite is more obviously replacing clasts. <10% clasts overall. Massive wacke matrix.												
210.40	222.50	<u>Laminated to Thin Bedded Wacke</u> : Similar to 206.22-208.12. Some conglomeratic intervals (biotite spotted). Core to bedding 30° @ 213 m. Local evidence of slumping. 215.30-216.00 - Strongly silicified, bleached. Coarse-grained pyrrhotite clots, minor chalcopyrite associated with calcite veining. 216.60-220.65 - Strongly silicified, light grey-white, locally massive. Probably a medium-thick bedded quartzitic wacke or arenite section. Minor quartz-pyrrhotite veinlets, stringers. Silicification partly controlled by fracturing. Sericite flakes, fine-grained disseminated pyrrhotite in strongly silicified sections.												
222.50	227.13	<u>Thinly Laminated Wacke</u> : Rapidly alternating dark grey biotitic/light grey lamination @ 52° to core axis. Disseminated pyrrhotite in biotitic laminations.												
		END OF HOLE												

## DRILL HOLE LOG

LOCATION: South Shore of Diorite (Jurak) Lake				DRILL HOLE NO.: VU-91-3			
AZIMUTH: 213°		ELEVATION: 2,095 m (approx.)		PROPERTY: Vulcan			
INCLINATION: -67°		LENGTH: 276.52 m		CLAIM NO: Vulcan 2			
CORE SIZE: BGM		SURVEYS				SECTION:	
		METREAGE	AZIMUTH	INCLINATION	CORR. INCLIN.	LOGGED BY: LD. McCartney	
STARTED: September 15, 1991		137.20	-	-71	-65	DATED LOGGED: October 1, 1991	
COMPLETED: September 17, 1991		276.52	-	-70	-63	DRILLING CO.: Falcon Drilling Ltd.	
PURPOSE: To complete intermediate depth test of "Sullivan Time Horizon" east of the Main Showing in Diorite Lake Basin.				ASSAYED BY: Min-Pa Laboratories Ltd.			

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
0	1.52			Casing: No core recovered.										
1.52	8.65	Gabbro: Coarse-grained feldspar amphibole intergrowth with local coarse grained biotite. Minor quartz veining, pyrrhotite clots.												
8.65	32.50	Thick Bedded Quartzitic Wacke: Strongly silicified, probably re-crystallized, white bleaching to 11.55 m, becoming medium grey to light brownish grey with decreasing silicification. Biotite spotting. 1-2% fine-grained disseminated pyrrhotite throughout. A few quartz (+ biotite-sericite) stringers and veins. Few bedding features apparent. Becomes bleached, more strongly silicified from 30.0 - 32.5 towards gabbro sill below.												
32.50	39.05	Gabbro: Strongly altered, heavy chlorite-biotite development in some sections. Possibly albitic in sections. Irregular quartz veins comprise 15-20% of unit, contain chlorite-biotite lenses, quartz veins up to 0.7 m thick. 36.45 - 36.90 - Coarse pyrrhotite clots with minor chalcopyrite associated with quartz veining and strong chlorite-biotite alteration. 37.10 - 37.45 - Possible albite alteration, massive, possibly some replaced sediments in this section. 37.45 - 39.05 - Fine-grained massive chlorite-biotite rock, sharp lower contact with sediments.												

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES						
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm
39.05	48.55	<u>Thin to Medium Bedded Quartzitic Wacke-Turbidites:</u> Albite-chlorite alteration to 39.75 m. Alternating quartzitic wacke and laminated wacke/subwacke. Quartzitic wacke beds recrystallized to silica-biotite. 42.54 - 43.43 - Laminated to thin bedded wacke, minor pyrrhotite as disseminations and clots, distal turbidites and interturbidite sediments. 45.40 - 45.90 - Bleached white. Silicified. Black biotitic stringers. 47.40 - 48.20 - Silicified, possibly albitized. Black biotitic stringers. Core to bedding 60° @ 42.5 m, 68° @ 46.0 m.											
48.55	53.46	<u>Thick Bedded Quartzitic Wacke:</u> Typical M.Ald. turbidites. Dark argillaceous tops. Often faint parallel lamination within quartzites. Recrystallized.											
53.46	61.50	<u>Thin to Medium Bedded Quartzitic Wacke Turbidites:</u> Similar to 39.05 - 48.55 m. Some chlorite on fractures. Core to bedding 52° @ 60.0 m.											
61.50	66.14	<u>Thick Bedded Quartzitic Wacke:</u> Similar to 48.55 - 53.46, tops poorly developed. Chlorite alteration, minor bleaching in short fractured intervals. Faint internal lamination in quartzites.											
66.14	67.60	<u>Thin Bedded to Laminated Wacke/Subwacke:</u> Very distal turbidites and interturbidite material. 1 mm sericite flakes developed.											
67.60	75.50	<u>Thick to Medium Bedded Quartzitic Wacke:</u> Typical Middle Aldridge turbidites. Albite alteration with minor chlorite from 74.0 - 75.5 m.											
75.50	83.80	<u>Predominantly Thin Bedded Quartzitic Wacke/Wacke:</u> Strong silicification, possibly albitization increasing towards lower contact. Typical distal turbidites. Core to bedding 50° @ 78 m, 55° @ 83 m. Clots of pyrrhotite with minor disseminated chalcopyrite @ 83.5 m.											
83.80	197.40	<u>Gabbro:</u> 83.80 - 111.50 - Medium to coarse-grained amphibole-feldspar intergrowth. Massive, fresh and unaltered. 101.20 - 101.60 - Quartz vein with minor feldspar-chlorite. Cassiterite(?) Strongly chloritized selvages. 111.50 - 144.00 - Gabbro is much harder, albite rich, with 2-3% disseminated pyrrhotite, locally 5-8% pyrrhotite. Coarse pyrrhotite (+ chalcopyrite) clots associated with chlorite stringers, coarsening of grain size. Where intensely albitized (111.5 - 112.5) gabbro texture is obliterated. Albite content decreases with depth. Suspect albite is primary feldspar in coarse-grained gabbro phase, which extends down to approx. 114 m. Pyrrhotite is best developed in the upper part of the interval, where albite is strongest. Suspect albite may be a primary phase of the gabbro, rather than alteration overprint. Garnet first appears @ 139 m. Massive pyrrhotite stringer @ 127 m is 2 mm thick.											



METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
83.80	197.40 Cont'd	144.00 - 156.00 - Garnets as 1-3 mm porphyroblasts form 5-15% of rock. Gabbro host is fine grained with chloritic matrix; dark green coloration. Calcite-chlorite on hairline fractures. Minor disseminated pyrrhotite (<1%). 156.00 - 197.40 - Occasional weak garnet development to 164.00 m. Dark green massive medium-grained gabbro. Occasional thin quartz-chlorite-calcite alteration patches and stringers often with minor disseminated pyrrhotite. Trace disseminated pyrrhotite throughout. Fresh, unaltered.												
197.40	199.00	<u>Fault Zone:</u> Albitized bleached angular fragments in a sericite-clay gouge. No sulfide. Core loss.												
199.00	203.30	<u>Thin Bedded to Thickly Laminated Wacke:</u> Bleached, light grey. Sericite well developed. Thin distal turbidites predominate. Minor chlorite-calcite in hairline fractures. Core to bedding 45° @ 201.5 m.												
203.30	217.00	<u>Thick Bedded Quartzitic Wacke:</u> Typical Middle Aldridge turbidites. Tops poorly developed. Faint internal banding in quartzitic wacke beds. Biotite re-crystallized (fine grained). Bleaching in upper part along bedding planes and hairline fractures. No sulfides.	6479 6480	216.10 216.60	216.60 217.00	0.50 0.40	17 24	56 48	0.2 0.4	7 12	8 30	1 1	2 8	1 1
217.00	217.00	<u>Lower-Middle Aldridge Formation Contact</u> (Top of "Sullivan Time" interval)												
217.00	223.50	<u>Pyrrhotite Laminated Wacke:</u> Extremely hard, silicified to 218.0. Approx. 5% thin discontinuous biotite-pyrrhotite laminations in a massive fine grained wacke host. A few pyrrhotite clots with traces of chalcopyrite. Pyrrhotite is fine grained, disseminated in biotite laminations. Core to bedding, 45°.	6481 6482 6483 6484 6485 6486 6487 6488 6489 6490 6491 6492	217.00 217.20 217.54 218.00 218.50 219.00 219.50 220.07 220.57 221.07 221.42 221.77 222.27	217.20 217.54 218.00 218.50 219.00 219.50 220.07 220.57 221.07 221.42 221.77 222.27	0.20 0.34 0.46 0.50 0.50 0.50 0.57 0.50 0.50 0.35 0.35 0.50	98 52 46 48 40 43 28 25 27 44 28 67	79 104 50 100 50 92 82 61 56 103 72 52	0.7 0.7 0.7 0.7 0.9 0.8 0.4 0.8 0.3 0.9 0.7 2.2	30 29 36 41 51 32 39 33 40 38 28 36	49 5 8 10 19 33 15 14 12 12 24 50	1 1 1 1 1 1 1 1 1 1 1 1	4 2 2 1 4 2 3 1 3 2 2 3 2	2 2 1 3 2 2 1 3 2 1 4 5
223.50	226.50	<u>Massive Wacke, Quartzitic Wacke:</u> Massive fine-grained to medium-grained with no obvious turbidite tops. Faint planar lamination in quartzitic wacke sections. A few biotitic bands in upper part, possibly weakly developed fragmental textures in upper 1 m. Contorted diffuse biotite-rich zones may be evidence of slumping. Minor quartz veinlets with disseminated pyrrhotite clots in vein margins. Fine-grained disseminated pyrrhotite in biotitic zones.												

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
226.50	230.05	<b>Thin Bedded Quartzitic Wacke/Wacke:</b> Sericitic. Diffuse lensey bedding character, does not resemble distal turbidites of M.Ald. Pyrrhotite clots in quartz veinlets. Minor galena in 1/2 cm quartz vein with pyrrhotite at 228.77 m. Minor disseminated galena-sphalerite in margin of quartz-pyrrhotite veinlet at 227.20. Trace disseminated sphalerite around biotite rich zones at 228.20, evidence of slumping at 228.2 - 228.7 m. Core to bedding 45° @ 229.2 m.	6303	226.50	227.75	1.25	226	75	1.9	28	20	1	1	1
			6304	227.75	229.00	1.25	261	172	1.9	22	31	1	1	1
			6305	229.00	230.05	1.05	115	63	1.5	21	519	1	2	1
230.05	234.54	<b>Laminated Wacke:</b> Lamination defined by dark biotitic bands/laminations in a light grey fine-grained sericitic wacke matrix. Core to bedding @ 40° to core axis. Trace galena-sphalerite associated with quartz stringers @ 231.25 m. A few pyrite rich laminations are thin but continuous, and appear to be stratiform layers. Disseminated pyrrhotite in biotitic laminations, clots. Trace sphalerite associated with bleached chlorite-quartz zone 3 cm thick at 231.85 m.	6306	230.05	231.30	1.25	68	101	1.2	33	112	1	1	1
			6307	231.30	232.50	1.20	31	126	1.1	25	13	1	2	1
			6308	232.50	233.78	1.28	25	63	0.8	31	18	1	1	1
234.54	246.00	<b>Fragmental:</b> Approximately 25-35% clasts. Elongated, imbricated @ 45°. Dark biotitic clasts, light cream flat clasts. Massive medium grey wacke matrix. Fine-grained, heavily disseminated pyrrhotite common in dark biotitic clasts. Pyrite-pyrrhotite aggregate in quartz veinlet at 243.1 m.												
246.00	254.45	<b>Thin Bedded Wacke/Subwacke:</b> Numerous short conglomeratic intervals to 0.4 m form approx. 40% and decrease in importance towards base of unit. Lensey bedding features. Black biotitic bands contain finely disseminated pyrrhotite. A few pyrite-pyrrhotite clots in minor bleached patches associated with hairline fractures, quartz.												
245.45	257.70	<b>Delicately Laminated Subwacke:</b> Core to bedding @ 45° to core axis. Lamination is defined by biotite content. Very fine-grained disseminated pyrrhotite in biotite rich laminations. 255.30 - 255.60 - Traces galena-sphalerite associated with bedding parallel quartz veining and thin pyrite quartz stringers @ 15° to core axis.	6309	255.00	256.20	1.20	159	114	1.3	28	22	1	1	1
			6310	256.20	257.30	1.10	96	157	1.1	26	4	1	1	1
257.70	261.40	<b>Massive Wacke, Locally Conglomeratic:</b> Fine-grained, medium to dark grey. Variable biotite content. Sericitic. Disseminated pyrrhotite in biotitic bands and clasts. Pyrite-pyrrhotite as clots in quartz veinlets. 259.69 - 260.00 - Lensey laminated wacke interval.												
261.40	276.45	<b>Fragmental:</b> Same as 234.54 - 246.00. Fragments imbricated/flattened @ 40° to core axis. Local cleavage development parallel to imbrication. Minor pyrrhotite in quartz veinlets and as fine-grained disseminations in biotite rich clasts.												
276.45	276.45	END OF HOLE												

## DRILL HOLE LOG

LOCATION: Small tarn basin immediately west of Mt. Patrick						DRILL HOLE NO.: VU-91-4								
AZIMUTH: 106°		ELEVATION: 2,300 m (approx.)		SURVEYS				PROPERTY: Vulcan						
INCLINATION: -60°		LENGTH: 279.57 m						CLAIM NO: Vulcan 1						
		CORE SIZE: BGM		METREAGE	AZIMUTH	INCLINATION	CORR. INCLIN.	SECTION:						
STARTED: September 18, 1991				139.94		-66	-58	LOGGED BY: LD. McCartney						
COMPLETED: September 20, 1991				279.57		-64	-57	DATED LOGGED: October 5, 1991						
PURPOSE: To complete intermediate depth test of "Sullivan Time" horizon to the south of the previous Cominco hole Vu-79-1.								DRILLING CO: Falcon Drilling Ltd., Prince George, B.C.						
								ASSAYED BY: Min-En Laboratories Ltd.						
CORE RECOVERY: 99%														
METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Ag ppb
0.00	3.28	Casing: No core recovered.												
3.28	49.72	Gabbro: Massive, medium-grained. Medium greenish-grey. No HCl reaction. Non-magnetic. Amphibole-feldspar-biotite mineralogy. Trace disseminated pyrite. 3.28 - 5.10 - Dark grey, very hard, silicified. 13.78 - 16.66 - Strong chloritic alteration, quartz veining. Heavily disseminated to semi-massive pyrrhotite bands associated with quartz veined sections. Minor chalcopyrite associated with pyrrhotite. Resembles quartz-pyrrhotite-chalcopyrite zone seen in Lower Aldridge in this hole. Black, very hard tourmaline rich zones/bands. Pyrrhotite bands are slightly magnetic. 32.50 - 36.50 - Chloritic alteration weakly developed around fracture subparallel to core axis. 2-3 cm tourmaline rich band at 15° to core axis at 35.7. Trace magnetite from 35.7 - 36.3 m. Weakly disseminated pyrrhotite associated with chlorite altered sections. 39.93 - 41.06 - Chlorite-quartz-biotite alteration zone. Locally banded @ 25° to core axis. Minor tourmaline + pyrrhotite. 49.30 - 49.72 - Fine grained chilled margin at base of gabbro.	6251 6252	13.87 15.40	14.12 16.23	0.25 0.83	20 14	71 37	1.4 0.5	2280 556	94 159	1 1	2 1	2 3
49.72	51.52	Thin Bedded Wacke: Locally silicified. Silicification favours sandier beds and is accompanied by disseminated biotite-pyrrhotite.												

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES									
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Ag ppb		
51.52	75.56	<p><b>Silicified Quartzitic Wacke:</b> Thick quartzitic beds to 0.6 m are white, very hard and recrystallized. Local biotite + pyrrhotite bands associated with silicification. Thin bedded wacke intervals alternate with thick quartzitic wacke beds. Some concretion-like silica-biotite-pyrrhotite zones in wacke intervals. Typical Middle Aldridge turbidite sequence. Local mafic dykes of apparently random orientation. Core to bedding 70° @ 50 m, 65° @ 65.8 m, 65° @ 72.8 m.</p> <p>69.00 - 2 cm thick porphyritic mafic dyke. Altered feldspar and amphibole phenocrysts to 1 cm. Chloritic fine-grained matrix. Strong dark green chloritic alteration selvages extend along bedding planes.</p> <p>69.41 - 69.58 - Porphyritic mafic dyke, as above.</p> <p>70.88 - 4 cm thick porphyritic mafic dyke, as above.</p>														
75.56	77.65	<p><b>Thin Bedded to Laminated Wacke/Subwacke:</b> Also minor thin light grey quartzitic wacke beds. Quartzitic bands are dark grey to black due to recrystallized biotite and usually contain disseminated pyrrhotite. Minor bedding parallel quartz stringers with disseminated pyrrhotite. Pyrrhotite and fine tourmaline needles (&lt;&lt;1%) well developed in laminated wacke over lower 25 cm.</p>	6253	77.40	77.65	0.25	20	21	0.7	55	227	1	2	1		
77.65	127.20	<p><b>Medium-Thick Bedded Quartzitic Wacke:</b> Typical Middle Aldridge turbidite sequence. Thick to medium beds of quartzitic wacke alternating with shorter intervals of thin bedded wacke/subwacke. Quartzitic wacke beds are recrystallized to medium-grained silica-biotite rock with minor muscovite and pyrrhotite-pyrite. Wacke/subwacke intervals apparently unaltered, possibly more permeable quartzites were subject to silicification/hydrothermal alteration? Core to bedding 70° @ 91 m, 67° @ 77 m.</p> <p>89.10 - a 15 cm quartz vein with minor coarse-grained tourmaline.</p> <p>89.70 - a 3 cm quartz vein with minor tourmaline and pyrite at 25° to core axis.</p> <p>92.15 - a pyrrhotite stringer with minor arsenopyrite at 25° to core axis.</p> <p>92.80 - a 2 cm porphyritic mafic dyke, similar to 69.41 - 89.58 m.</p> <p>93.30 - 93.70 - a few pyrite stringers at 40-50° to core axis</p> <p>99.00 - 103.00 - a few thin pyrite stringers @ variable angles to core axis. A coarse biotite + pyrrhotite alteration patch @ 100.7. A few quartz veinlets with minor disseminated pyrite.</p> <p>99.25 - 100.14 - Thin bedded to laminated wacke/subwacke. Pyrite-pyrrhotite laminations from 99.7 - 100.14. Minor very fine grained needle tourmaline.</p> <p>111.70 - 3 cm quartz vein with minor chlorite, feldspar. Silicified selvage with medium-grained disseminated pyrrhotite.</p> <p>112.10 - 112.30 - A few pyrite laminations and approx. 5% fine-grained needle tourmaline in a wacke inter-turbidite band.</p>														

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Ag ppb
77.65	127.20 Cont'd	118.00 - 125.00 - Area of more intense quartz veining and silicification. Coarse pyrrhotite clots associated with quartz veining, occasionally with minor chalcopyrite. Minor chlorite-biotite in quartz veins. A few pyrrhotite stringers @ 30-40° to core axis. Coarse black biotite spotting becomes apparent in silicified quartzitic wacke beds below 115 m.	6254	99.70	100.14	0.44	31	29	0.7	48	92	1	1	2
127.20	135.40	<u>Thin Bedded Wacke:</u> Core to bedding 65° @ 129.4, 80° @ 135 m. 5 cm quartz vein @ 133.8 m with coarse pyrrhotite clots and trace chalcopyrite. A few bedding parallel quartz-pyrrhotite stringers. Appears to be a sequence of thin distal turbidites. Apparently strata controlled pyrrhotite occasionally present in turbidite subwacke tops as disseminations, in 1-2 mm thick layers. Pyrrhotite is remobilized into weak cleavage @ approx. 30° to bedding.												
135.40	150.10	<u>Medium-Thick Bedded Quartzitic Wacke:</u> Turbidites. Quartzitic wacke bases with wacke/subwacke tops. Tops often laminated with up to 3% disseminated pyrrhotite. Quartzitic wacke bands appear to be silicified, locally recrystallized. Minor quartz veining at varied orientations with trace chlorite and locally coarse grained pyrrhotite clots.												
150.10	160.53	<u>Massive Wacke/Subwacke:</u> Slightly greenish grey. Very fine recrystallized matrix sprinkled with approx. 5% medium quartz grains. Stubby to needle tourmaline crystals approx. 3-5%, fine grained. Traces pyrrhotite + arsenopyrite replacing quartz grains. 2 cm quartz-pyrrhotite-arsenopyrite vein @ 150.14. Unit is relatively unaltered, unsilicified. Occasional weakly developed bedding features @ 50° to core axis, but has a massive character overall. 155.00 - 155.80 - Thin bedded section, contains a few black tourmaline-rich beds with sharp contacts. Approx. 30% tourmaline as recrystallized stubby needles. Strong strata-control to tourmaline distribution. 156.00 - 159.00 - Strong cleavage development @ 30° to core axis, phyllitic. Bedding @ 60° to core axis. Fault gouge @ 156.3 (3 cm), 156.6-156.85 and 157.1-157.55 m.	6255	155.00	155.80	0.80	12	4	2.0	12	24	1	1	1
160.53	170.43	<u>Thin to Medium Bedded Wacke/Quartzitic Wacke:</u> A few thick quartzitic wacke beds (bases of turbidite couplets). A turbidite sequence similar to 135.4-150.1 but thinner bedded with a higher proportion of wacke beds (tops of turbidite couplets). Turbidite bases locally very hard, glassy, silicified. 2-3% very fine-grained to fine grained disseminated pyrrhotite. Minor pyrrhotite also occurs in thin stringers @ 20-30° to core axis and as clots in bedding parallel quartz veins. Core to bedding 65° @ 168 m. Evidence of slumping (contorted bedding planes), may also be due to turbidity current activity.												
170.43	173.87	<u>Thick-Medium Bedded Quartzitic Wacke Turbidites:</u> Thick bedded at bottom of unit, medium bedded in upper half. Strong silicification and biotite spotting of quartzitic wacke beds. 10% quartz-calcite (+ chlorite) veining in quartzitic wacke. Approx. 1-2% very fine grained arsenopyrite(?) + minor pyrrhotite in silicified sections. Pyrrhotite as clots in and adjacent to quartz veins.	6256 6257 6258	171.82 172.60 173.29	172.60 173.29 173.87	0.78 0.69 0.58	12 16 14	24 23 21	1.1 1.2 1.1	20 13 12	32 38 36	1 1 1	3 1 3	2 1 5

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Ag ppb
173.87	178.90	<b>Thin Bedded Wacke:</b> Distal turbidites. Incipient rip-up clasts, contorted bedding locally developed. Minor bedding parallel quartz veins with pyrrhotite clots and bedding parallel pyrrhotite stringers. Minor disseminated pyrrhotite in sediments is remobilized into cleavage. Core to bedding 65° @ 176 m.												
178.90	180.65	<b>Medium Bedded Quartzitic Wacke Turbidites:</b> Divergent core to bedding angles, average 65°. Quartzitic wacke beds are highly silicic, recrystallized. 2-3% disseminated pyrrhotite in sediments and in minor bedding parallel and crosscutting quartz veinlets/stringers.												
180.65	191.42	<b>Thick-Medium Bedded Quartzitic Wacke Turbidites:</b> Similar to above but thicker bedded. Pyrrhotite as above. Occasional black biotitic beds to 20 cm thick.	6259	191.12	191.42	0.30	10	43	1.4	17	1	1	4	1
191.42	191.42	<b>Lower - Middle Aldridge Formation Contact</b> (Top of "Sullivan Time" interval)												
191.42	192.85	<b>Massive Calc-silicate:</b> Fine grained amphibole-biotite-feldspar rock with 5-10% disseminated pyrrhotite and minor pyrite and arsenopyrite. Approx. 5% fine grained calcite as disseminated grains. Apparently a sedimentary unit, showing evidence of primary banding. Thin calcite stringers at base. Sharp conformable upper contact.	6260 6261 6262	191.42 191.90 192.37	191.90 192.37 192.85	0.48 0.47 0.48	9 413 245	176 386 154	0.6 3.0 1.4	116 146 142	343 826 793	1 1 1	1 1 1	1 2 1
192.85	200.78	<b>Pyrrhotite Laminated Wacke:</b> 192.85 - 194.00 - Mostly thin bedded wacke/quartzitic wacke with some dark biotitic bands/laminations containing 5% disseminated pyrrhotite. This section resembles distal turbidites of the Middle Aldridge Formation. Below 194.00 - Laminated wacke with 2-5% pyrrhotite overall, pyrrhotite concentrated in darker biotitic bands. Slightly recrystallized altered fine grained matrix. Some pyrrhotite occurs as stringers in cleavage, at a shallow angle (approx. 10°) to bedding. (Remobilized from strata controlled pyrrhotite). Some hard, very siliceous bands (possibly cherty precursor). Minor pyrite with same habit as pyrrhotite. Trace arsenopyrite as large subhedral disseminations. Locally phyllitic. Core to bedding 60° @ 199 m. @ 199.30 - Trace disseminated sphalerite in bedding fracture. @ 200.30 - possibly minor sphalerite in pyrrhotite stringer @ 200.70 - Strata-controlled dark reddish brown sphalerite in pyrrhotite lamination.	6263 6264 6265 6266 6267 6268 6269 6270 6271 6272 6273 6274 6275	192.85 193.42 194.00 194.63 195.20 195.80 196.50 197.16 197.76 198.32 198.95 199.60 200.17 200.78	193.42 194.00 194.63 195.20 195.80 196.50 197.16 197.76 198.32 198.95 199.60 200.17 200.78	0.57 0.58 0.63 0.57 0.60 0.70 0.60 0.66 0.56 0.63 0.65 0.57 0.61	30 30 14 66 45 155 127 41 30 100 56 48 215	103 36 18 17 17 12 63 81 79 223 152 39 1208	1.0 1.1 1.4 1.4 1.2 1.3 1.4 1.3 1.2 1.5 1.4 1.3 1.3	51 54 41 46 38 46 30 25 32 28 33 43 46	6 1 40 1 1 1 5 36 6 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 2 1 1 1 2 1 3 2 1 1 1	1 1 1 1 1 1 2 1 3 2 1 1 1
200.78	204.40	<b>Conglomeratic Wacke:</b> Very fine grained locally phyllitic altered matrix similar to above unit. Pyrrhotite laminations present, but not as well developed. Evidence of clasts, rounded to ovoid approx. 5%, clasts highlighted by fine grained disseminated pyrrhotite. Laminations and clast elongation @ 60° to core axis. Minor arsenopyrite associated with pyrrhotite, trace reddish sphalerite with pyrrhotite @ 201.25 m. Minor calcite associated with pyrrhotite-rich areas, as very fine grained disseminations and occasionally in hairline fractures.	6276 6277 6278 6279 6280 6281	200.78 201.20 201.60 202.35 203.07 203.07 203.76	201.20 201.60 202.35 203.07 203.76 204.40	0.42 0.40 0.75 0.72 0.69 0.64	120 87 39 36 165 88	79 155 44 51 107 106	1.0 0.5 0.7 0.5 0.9 1.3	31 37 40 46 38 42	7 9 5 8 18 89	1 1 1 1 1 1	1 2 1 2 1 1	2 2 4 3 4 1

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Ag ppb
204.40	206.13			<b>Coarse Grained Calc-Silicate:</b> Predominantly coarse grained amphibole (tremolite?) with irregular feldspar-calcite-quartz-biotite zones. Light green/white mottled. Trace disseminated red sphalerite at top of unit. Texturally similar to stratabound calc-silicate unit in basin to south of Mt. Patrick. Local crumbled/phyllitic zones may be faults.	6282		204.40	204.90	0.50	537	1413	2.9	24	114
206.13	209.70	<b>Thin Bedded to Thick Laminated Pyrrhotite Rich Quartzitic Wacke:</b> Core to bedding 70° @ 210 m. 2-4% pyrrhotite as fine grained disseminations and concentrated in pyrrhotite-rich laminations throughout unit. Minor fine-grained disseminated calcite and localized traces of reddish sphalerite within pyrrhotite-rich laminations (e.g. 207.53). A few pyrite-calcite stringers. A quartz-pyrrhotite veinlet (1 cm) with trace chalcopyrite @ 208.5. Matrix in a fine grained biotitic quartzitic wacke.	6283	207.33	207.66	0.33	221	539	1.6	71	219	1	2	2
209.70	217.34	<b>Massive Silicified Quartzitic Wacke/Wacke:</b> Dark grey coloration due to silicification. Light grey to white bleached zones contain pyrrhotite-chalcopyrite stringers and clots, sometimes as massive to semi-massive pyrrhotite bands to 5 cm thick. Chlorite and radiating amphibole (tremolite?) + calcite + arsenopyrite associated with bleached sections and appear to be intimately intergrown with pyrrhotite-chalcopyrite mineralization. Host rock was apparently a massive medium-grained quartzitic wacke/wacke. No strongly developed bedding features seen. Possibly a footwall stringer zone related to overlying calc-silicate units. Local short concentrations of approx. 7% euhedral coarse grained disseminated arsenopyrite in silicified sediment. Local weak pervasive chloritization (e.g. 215 m) imparts a green coloration. 211.50 - 211.80 - Massive quartz vein. Barren. <b>Massive pyrrhotite-pyrite bands @ 213.0 (3 cm), 215.6 (7 cm)</b>	6284 6285 6286 6287 6288 6289	211.10 212.00 213.11 214.13 215.16 216.16 217.34	212.00 213.11 214.13 215.16 216.16 217.34	0.90 1.11 1.02 1.03 1.00 1.18	18 13 13 11 8 17	146 43 29 34 40 38	0.8 0.1 0.5 1.0 0.2 0.8	102 426 192 138 410 211	3748 79 370 1 1 4	1 1 1 1 1 1	3 1 1 1 1 1	10 19 11 1 1 1
217.34	279.57	<b>Fragmental:</b> Conglomeratic quartzitic wacke to 219 m. Below here clasts are strongly attenuated and a strong tectonic fabric at 40-50° to core axis is developed. Quartz (+ chlorite - biotite - pyrrhotite - chalcopyrite) stringer network with random orientations forms approx. 5% from 219.5 - 223.0. Clast content generally <25% but occasional thin beds of tightly packed clasts occur (e.g. 221.61-222.12). Intervals of quartz-chlorite-biotite-pyrrhotite-chalcopyrite development extend down to 226.65 m, generally parallel to fabric @ 50° to core axis. Clasts are usually free floating in a biotitic wacke matrix. Darker biotite rich clasts often contain disseminated pyrrhotite. Clasts imbricated at 50-60° to core axis. Massive matrix. Calcite in hairline fractures @ 45° to core axis, approx. perpendicular to bedding. Weak cleavage development parallel to imbrication. Minor thin stringers of chlorite-biotite-quartz-pyrrhotite-chalcopyrite-arsenopyrite persist throughout unit.	6290 6291	222.26 225.53	223.38 226.65	1.12 1.12	49 27	22 30	0.5 0.7	717 269	78 45	1 1	1 1	4 1
279.57	279.57	END OF HOLE												

## DRILL HOLE LOG

LOCATION: West Basin, between top of road and Vulcan ridge				DRILL HOLE NO.: VU-91-5			
AZIMUTH: 124°		ELEVATION: 2,295 m (approx.)		PROPERTY: Vulcan			
INCLINATION: -50°		LENGTH: 158.84 m		CLAIM NO: Vulcan 1			
CORE SIZE: BGM		SURVEYS				SECTION:	
		METREAGE	AZIMUTH	INCLINATION	CORR. INCLIN.	LOGGED BY: LD. McCartney	
STARTED: September 20, 1991		158.8	-	-52	-43	DATED LOGGED: September 28, 1991	
COMPLETED: September 22, 1991						DRILLING CO.: Falcon Drilling Ltd.	
PURPOSE: To test the "Sullivan Time" Horizon midway between Vu-79-1 and the Main Showing. To get a deeper test of the footwall fragmental.						ASSAYED BY: Min-En Laboratories Ltd.	

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
0.00	7.62			Casing: No core recovered.										
7.62	13.40	<u>Laminated Wacke/Subwacke:</u> Lower Aldridge Formation. Phyllitic with strong cleavage development. Approximately 35° cleavage to bedding angle, 30° cleavage to core axis. Variable core axis to bedding angles 20-60°, suggest folding. Very thin to thickly laminated throughout. Dark/light grey colour banding. Dark-grey bands are biotite and pyrrhotite rich. Although biotite and pyrrhotite is strata-controlled, crystals are elongated in cleavage direction. Common limonitic stringers to ½ cm may have been iron-sulfide. Trace sphalerite? at 11.65 m. Below 11.80 m, rock is less bleached, fresher. A few sections of tight tectonic folding (chevron style).	6292 6293 6294 6295 6296 6297	7.62 8.54 9.45 10.40 11.35 12.35	8.54 9.45 10.40 11.35 12.35 13.40	0.92 0.91 0.95 0.95 1.00 1.05	18 13 13 13 16 23	10 45 12 13 79 98	1.0 0.9 1.0 0.8 0.7 0.8	21 43 50 28 38 28	26 39 15 20 20 25	1 1 1 1 1 1	3 4 3 2 2 3	1 2 1 2 2 4
13.40	40.67	<u>Fragmental:</u> High proportion of flat black mudstone chips suggests fragmental is derived from a slumped, thin bedded to laminated sequence containing carbonaceous mudstone layers. Contains short (to 0.25 m) sections of laminated subwacke with evidence of slump folding. Core to bedding angles 40-80°, variable. Matrix is fine grained wacke. Interpreted as a true slump conglomerate. Phyllitic. Sericite well developed. Some carbonaceous mudstone fragments strongly attenuated in cleavage. Occasional bands of dark brown biotite to 2 cm. Fine grained disseminated pyrrhotite preferentially developed in dark biotitic zones and clasts. Minor pyrite associated with pyrrhotite. 2-3% sulfides overall with semi-massive zones over 2-3 cm. Trace disseminated sphalerite at 13.8 m	6298 6299 6300 6435	13.40 14.50 15.55 33.00	14.50 15.55 16.60 33.80	1.10 1.05 1.05 0.80	18 16 26 19	95 54 69 66	0.5 0.6 0.5 0.8	35 27 31 31	24 20 40 31	1 1 1 1	2 2 1 2	1 2 1 1



METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
13.40	40.67 Cont'd	33.0- 33.8 - Slightly contorted thick laminated carbonaceous mudstone/wacke. Pyrrhotite laminations approx. 5%. Black carbonaceous mudstone interlaminated with quartzitic wacke/wacke. Probable precursor lithology to the slump conglomerate/fragmental. 39.0- 40.67 - Large scale slump contorted beds @ base of unit.												
40.67	53.50	<b>Pyrrhotite Laminated Subwacke:</b> Soft massive subwacke/wacke host. Approx. 1 mm thick pyrrhotite-pyrite laminations (approx. 1 per 2 cm core length). Occasional dark brown biotite-rich bands to 15 cm. Trace disseminated sphalerite @ 51.0 at edge of biotite rich band. Core to bedding approx. 65°, fairly uniform. 49.3- 50.3 - Massive wacke, no laminations.	6436 6437 6438	41.83 48.10 50.30	42.99 49.30 51.40	1.16 1.20 1.10	14 29 26	53 64 59	0.6 0.4 0.5	31 35 34	47 22 21	1 1 1	1 2 1	2 1 2
53.50	60.80	<b>Massive Conglomeratic Wacke:</b> Approx. 7% dark biotitic clasts strongly replaced by disseminated pyrrhotite. Light grey, fine grained wacke matrix. A few weak pyrrhotite laminations locally developed, similar to those in overlying unit. 58.00- 60.80 - Thin bedded wacke, evidence of slump folding. A few clasts in some massive sections. Truncated laminations. Biotite + pyrite bands, clots. Represents partially slumped base of massive conglomeratic unit.												
60.80	71.80	<b>Thin Bedded Wacke/Subwacke:</b> Mostly thin bedded with some laminated sections. Locally strongly silicified. Silicification strongest in more quartzitic beds. Dark biotitic beds contain fine grained disseminated pyrrhotite to 10%. 65.0, 70.7 - Concentrations of strata-controlled tourmaline as disseminated needles and semi-massive aggregates. Disseminations and clots of pyrrhotite and some very fine grained arsenopyrite in bleached, strongly silicified zones. 60.80- 60.95 - Massive coarse grained <b>quartz-tremolite-feldspar-chlorite rock</b> with 2-3% disseminated sphalerite, +5% pyrrhotite. Appears to be a conformable unit. Sediments in base of unit are altered to a mottled granular quartz-feldspar rock over 15 cm, bedding features are still apparent in this section, and tourmaline stringers also present. 64.00- 64.25 - Bedding parallel quartz vein, minor chlorite, coarse pyrrhotite clots. 65.1 - 65.7 - Approx. 50% bleached white irregular zones of recrystallized wacke with 1-2% disseminated pyrrhotite and trace chalcocopyrite, arsenopyrite. Stubby tourmaline needles. Appears to be an in-situ recrystallization process involving coarsening of original constituents and loss of carbonaceous material. Core to bedding angles: 70° @ 61.5 m, 55° @ 70.5 m.	6440 6439 6441	59.70 60.75 61.23	60.75 61.23 62.28	1.05 0.48 1.05	26 37 95	35 2291 125	0.7 0.7 1.0	37 39 45	1051 815 112	16 20 4	2 3 1	1 2 1

METREAGE		DESCRIPTION	SAMPLE NO.	METREAGE		LENGTH	ANALYSES							
FROM	TO			FROM	TO		Pb ppm	Zn ppm	Ag g/t	Cu ppm	As ppm	Sb ppm	Mo ppm	Au ppb
71.80	80.65			<p><b>Amphibole-Biotite-Garnet Replacement Zone:</b> Massive to faintly banded uniform, medium-grained amphibole-garnet-biotite-quartz rock. Up to 5% blastic coarse grained garnets. Original sedimentary rock types not apparent, possibly quartzitic wacke? Pyrite and minor arsenopyrite as disseminations and clots average 5-7%, uniformly distributed throughout unit. Upper contact sharp, conformable. Traces of coarse grained euhedral arsenopyrite.</p> <p>76.45 - 1 cm massive pyrrhotite-chalcopyrite stringer @ 30° to core axis  76.50 - 5 cm massive pyrrhotite veinlet with quartz and minor chalcopyrite  77.60 - 6 cm quartz vein @ 25° to core axis in 5% pyrrhotite overall concentrated in vein margins  79.88- 80.65 - Weaker replacement, evidence of original bedding. Thin bedded wacke host?</p>	6442 6446		73.50 76.40	74.40 76.87	0.90 0.47	18 24	195 47	1.2 0.1	86 238	148 973
80.65	158.84	<p><b>Fragmental:</b> Patchy biotite replacement over upper 0.4 cm is similar to biotite in overlying replacement zone. Average 25% clastic component floating in a medium grey massive wacke matrix. No bedded sedimentary intervals, massive throughout. Dark biotite-rich clasts heavily replaced by pyrrhotite. Light grey very fine grained mud chips also present. Clasts angular to highly rounded, often imbricated. Imbrication orientation variable suggestive of folding, usually &gt;45° to core axis. Sericite strongly developed in matrix.</p> <p>121.74-122.10 - Large (to 10 cm) tightly packed rounded fragments, clast supported in a black biotite rich matrix. Red disseminated sphalerite in matrix, disseminated galena in a quartzitic clast.</p> <p>Occasional clasts of massive pyrite below 122.1, appear to be a sulfide replacement of original sedimentary clasts.</p>	6443 6444 6445	120.95 121.74 122.10	121.74 122.10 122.86	0.79 0.36 0.76	73 1454 92	90 2384 216	0.9 3.4 0.7	31 24 49	30 98 35	1 1 1	2 2 4	3 1 8
158.84	158.84	END OF HOLE												

CORE RECOVERIES  
D.D.H. Vu-91-1  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
0.00	3.00	OVERBURDEN		0%
3.00	5.80	2.80	1.10	39%
5.80	7.20	1.40	1.00	71%
7.20	8.20	1.00	1.00	100%
8.20	9.00	.80	.30	37%
9.00	10.10	1.10	1.10	100%
10.10	11.90	1.80	1.80	100%
11.90	13.40	1.50	1.50	100%
13.40	16.50	3.10	3.10	100%
16.50	19.50	3.00	3.00	100%
19.50	22.60	3.10	3.10	100%
22.60	25.60	3.00	3.00	100%
25.60	28.70	3.10	3.10	100%
28.70	31.70	3.00	3.00	100%
31.70	34.70	3.00	3.00	100%
34.70	37.80	3.10	3.10	100%
37.80	40.80	3.00	3.00	100%
40.80	43.90	3.10	3.10	100%
43.90	46.90	3.00	3.00	100%
46.90	50.00	3.10	3.10	100%
50.00	53.00	3.00	3.00	100%
53.00	56.10	3.10	3.10	100%
56.10	59.10	3.00	3.00	100%
59.10	60.10	1.00	1.00	100%
60.10	60.30	.20	.20	100%
		57.30	54.70	95%
OVERBURDEN		3.00		
		60.30		

CORE RECOVERIES  
D.D.H. Vu-91-2  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
0.00	3.05	OVERBURDEN		0%
3.05	4.42	1.37	.75	55%
4.42	5.79	1.37	.74	54%
5.79	6.71	.92	.25	27%
6.71	7.47	.76	.45	59%
7.47	10.06	2.59	.55	21%
10.06	11.43	1.37	.70	51%
11.43	12.04	.61	.05	8%
12.04	12.65	.61	.12	20%
12.65	13.72	1.07	.60	56%
13.72	16.76	3.04	3.00	99%
16.76	19.81	3.05	3.05	100%
19.81	22.86	3.05	3.00	98%
22.86	25.91	3.05	3.05	100%
25.91	28.96	3.05	3.00	98%
28.96	32.00	3.04	3.04	100%
32.00	35.05	3.05	3.05	100%
35.05	38.10	3.05	3.05	100%
38.10	41.15	3.05	3.00	98%
41.15	44.20	3.05	3.00	98%
44.20	47.24	3.04	3.04	100%
47.24	50.29	3.05	3.05	100%
50.29	53.34	3.05	3.05	100%
53.34	56.39	3.05	3.05	100%
56.39	59.44	3.05	3.05	100%
59.44	62.48	3.04	3.04	100%
62.48	65.23	2.75	2.75	100%
65.23	68.28	3.05	3.05	100%
68.28	71.32	3.04	3.04	100%
71.32	74.37	3.05	3.05	100%
74.37	77.42	3.05	3.05	100%
77.42	80.47	3.05	3.05	100%
80.47	83.52	3.05	3.05	100%
83.52	86.56	3.04	3.04	100%
86.56	89.61	3.05	3.05	100%
89.61	92.66	3.05	3.05	100%
92.66	95.71	3.05	3.05	100%
95.71	98.76	3.05	3.05	100%
98.76	100.28	1.52	1.52	100%
100.28	102.11	1.83	1.83	100%
102.11	105.16	3.05	3.05	100%
105.16	108.20	3.04	3.04	100%
108.20	111.25	3.05	3.05	100%
111.25	114.30	3.05	3.05	100%
114.30	117.35	3.05	3.05	100%
117.35	120.40	3.05	3.05	100%
120.40	123.44	3.04	3.04	100%
123.44	126.49	3.05	3.05	100%
126.49	129.54	3.05	3.00	98%
129.54	132.59	3.05	3.00	98%
132.59	135.64	3.05	3.00	98%
135.64	138.68	3.04	3.00	99%
138.68	141.73	3.05	3.00	98%
141.73	144.78	3.05	3.00	98%
144.78	147.83	3.05	3.00	98%
147.83	150.88	3.05	3.00	98%

CORE RECOVERIES  
D.D.H. Vu-91-2  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
150.88	153.92	3.04	3.00	99%
153.92	156.36	2.44	3.00	123%
156.36	158.80	2.44	3.00	123%
158.80	161.54	2.74	3.00	109%
161.54	164.59	3.05	3.00	98%
164.59	167.64	3.05	3.00	98%
167.64	169.16	1.52	3.00	197%
169.16	172.21	3.05	3.00	98%
172.21	175.26	3.05	3.00	98%
175.26	178.31	3.05	3.00	98%
178.31	181.36	3.05	3.00	98%
181.36	184.40	3.04	3.00	99%
184.40	187.45	3.05	3.00	98%
187.45	190.50	3.05	3.00	98%
190.50	193.55	3.05	3.00	98%
193.55	196.60	3.05	3.00	98%
196.60	199.64	3.04	3.00	99%
199.64	202.69	3.05	3.00	98%
202.69	205.74	3.05	3.00	98%
205.74	208.79	3.05	3.00	98%
208.79	211.84	3.05	3.05	100%
211.84	214.94	3.10	3.10	100%
214.94	217.99	3.05	3.05	100%
217.99	220.98	2.99	2.99	100%
220.98	222.20	1.22	1.15	94%
222.20	224.03	1.83	1.83	100%
224.03	227.13	3.10	3.10	100%
		224.08	219.01	98%
OVERBURDEN		3.05		
		227.13		

CORE RECOVERIES  
D.D.H. Vu-91-3  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
0.00	1.52	OVERBURDEN		0%
1.52	5.18	3.66	1.40	38%
5.18	8.23	3.05	3.05	100%
8.23	11.28	3.05	3.05	100%
11.28	14.33	3.05	3.05	100%
14.33	17.37	3.04	3.04	100%
17.37	20.42	3.05	3.05	100%
20.42	23.48	3.06	3.06	100%
23.48	26.52	3.04	3.04	100%
26.52	29.57	3.05	2.85	93%
29.57	32.62	3.05	3.05	100%
32.62	35.67	3.05	3.05	100%
35.67	38.71	3.04	3.04	100%
38.71	41.76	3.05	3.05	100%
41.76	44.80	3.04	3.04	100%
44.80	47.85	3.05	3.05	100%
47.85	50.90	3.05	3.05	100%
50.90	53.95	3.05	3.05	100%
53.95	57.00	3.05	3.05	100%
57.00	60.00	3.00	3.00	100%
60.00	62.03	2.03	2.03	100%
62.03	64.16	2.13	1.98	93%
64.16	66.14	1.98	1.90	96%
66.14	69.19	3.05	3.05	100%
69.19	70.71	1.52	1.52	100%
70.71	73.15	2.44	2.21	91%
73.15	75.29	2.14	1.78	83%
75.29	78.33	3.04	3.04	100%
78.33	81.38	3.05	3.05	100%
81.38	84.43	3.05	3.05	100%
84.43	87.48	3.05	3.05	100%
87.48	90.53	3.05	3.05	100%
90.53	93.57	3.04	3.04	100%
93.57	96.62	3.05	3.05	100%
96.62	99.67	3.05	3.05	100%
99.67	102.72	3.05	3.05	100%
102.72	105.77	3.05	3.05	100%
105.77	108.81	3.04	3.04	100%
108.81	111.86	3.05	3.00	98%
111.86	114.91	3.05	3.05	100%
114.91	117.96	3.05	3.05	100%
117.96	121.01	3.05	3.05	100%
121.01	124.05	3.04	3.04	100%
124.05	127.10	3.05	3.05	100%
127.10	129.84	2.74	2.67	97%
129.84	132.89	3.05	3.05	100%
132.89	135.94	3.05	3.05	100%
135.94	138.99	3.05	3.05	100%
138.99	142.04	3.05	3.05	100%
142.04	145.08	3.04	3.04	100%
145.08	145.39	.31	.31	100%
145.39	148.44	3.05	3.05	100%
148.44	151.49	3.05	3.05	100%
151.49	154.53	3.04	3.04	100%
154.53	157.58	3.05	3.05	100%
157.58	160.63	3.05	3.05	100%

CORE RECOVERIES  
D.D.H. Vu-91-3  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
160.63	163.68	3.05	2.65	87%
163.68	166.73	3.05	3.05	100%
166.73	169.77	3.04	3.04	100%
169.77	172.82	3.05	3.05	100%
172.82	175.87	3.05	3.05	100%
175.87	178.92	3.05	3.05	100%
178.92	181.97	3.05	3.05	100%
181.97	185.01	3.04	3.04	100%
185.01	188.06	3.05	3.05	100%
188.06	191.11	3.05	3.05	100%
191.11	194.16	3.05	3.05	100%
194.16	197.21	3.05	3.05	100%
197.21	200.23	3.02	1.90	63%
200.23	203.30	3.07	1.90	62%
203.30	206.34	3.04	2.90	95%
206.34	209.40	3.06	3.06	100%
209.40	212.45	3.05	3.05	100%
212.45	213.51	1.06	.82	77%
213.51	215.49	1.98	1.95	98%
215.49	218.08	2.59	2.59	100%
218.08	220.07	1.99	1.82	91%
220.07	221.59	1.52	1.50	99%
221.59	224.64	3.05	3.05	100%
224.64	227.69	3.05	3.05	100%
227.69	230.73	3.04	3.04	100%
230.73	233.78	3.05	3.05	100%
233.78	236.83	3.05	3.05	100%
236.83	239.88	3.05	3.05	100%
239.88	242.93	3.05	3.05	100%
242.93	245.98	3.05	3.05	100%
245.98	249.02	3.04	3.04	100%
249.02	252.07	3.05	3.05	100%
252.07	255.12	3.05	3.05	100%
255.12	259.69	4.57	4.57	100%
259.69	261.21	1.52	1.50	99%
261.21	264.26	3.05	3.05	100%
264.26	267.31	3.05	3.05	100%
267.31	270.36	3.05	3.05	100%
270.36	273.41	3.05	3.05	100%
273.41	276.45	3.04	3.04	100%
		274.93	268.22	98%
OVERBURDEN		1.52		
		276.45		

CORE RECOVERIES  
D.D.H. Vu-91-4  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
0.00	3.28	OVERBURDEN		0%
3.28	5.79	2.51	2.51	100%
5.79	8.84	3.05	2.90	95%
8.84	11.89	3.05	3.05	100%
11.89	13.87	1.98	1.85	93%
13.87	16.63	2.76	2.43	88%
16.63	17.99	1.36	1.36	100%
17.99	21.04	3.05	3.05	100%
21.04	24.09	3.05	3.05	100%
24.09	27.13	3.04	3.04	100%
27.13	30.18	3.05	3.05	100%
30.18	33.23	3.05	3.05	100%
33.23	36.27	3.04	3.04	100%
36.27	39.33	3.06	3.00	98%
39.33	42.38	3.05	3.05	100%
42.38	45.43	3.05	3.05	100%
45.43	48.48	3.05	3.05	100%
48.48	51.52	3.04	3.04	100%
51.52	54.57	3.05	3.05	100%
54.57	57.62	3.05	2.95	97%
57.62	60.67	3.05	3.05	100%
60.67	63.72	3.05	3.05	100%
63.72	66.79	3.07	3.07	100%
66.79	69.82	3.03	3.03	100%
69.82	72.87	3.05	3.05	100%
72.87	75.91	3.04	3.04	100%
75.91	78.96	3.05	3.05	100%
78.96	82.01	3.05	3.05	100%
82.01	85.06	3.05	3.05	100%
85.06	88.11	3.05	3.05	100%
88.11	91.16	3.05	3.05	100%
91.16	94.21	3.05	3.05	100%
94.21	95.73	1.52	1.52	100%
95.73	100.30	4.57	4.57	100%
100.30	103.35	3.05	3.05	100%
103.35	106.40	3.05	2.90	95%
106.40	109.45	3.05	2.94	96%
109.45	112.50	3.05	3.00	98%
112.50	115.55	3.05	2.50	82%
115.55	118.60	3.05	3.05	100%
118.60	121.65	3.05	3.05	100%
121.65	124.70	3.05	3.05	100%
124.70	127.74	3.04	3.02	99%
127.74	130.79	3.05	3.05	100%
130.79	133.84	3.05	3.05	100%
133.84	136.89	3.05	3.05	100%
136.89	139.94	3.05	3.05	100%
139.94	142.99	3.05	3.05	100%
142.99	146.03	3.04	2.89	95%
146.03	148.78	2.75	2.75	100%
148.78	151.83	3.05	3.05	100%
151.83	152.13	.30	.30	100%
152.13	155.12	2.99	2.99	100%
155.12	156.10	.98	.80	82%
156.10	156.70	.60	.53	88%
156.70	157.62	.92	.75	82%



CORE RECOVERIES  
D.D.H. Vu-91-4  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
157.62	159.91	2.29	2.02	88%
159.91	161.28	1.37	1.37	100%
161.28	164.33	3.05	3.05	100%
164.33	167.38	3.05	3.05	100%
167.38	170.43	3.05	3.05	100%
170.43	173.48	3.05	3.05	100%
173.48	176.52	3.04	3.04	100%
176.52	179.57	3.05	2.83	93%
179.57	182.62	3.05	3.05	100%
182.62	185.67	3.05	3.05	100%
185.67	188.72	3.05	2.90	95%
188.72	191.77	3.05	3.00	98%
191.77	194.82	3.05	3.05	100%
194.82	197.87	3.05	3.05	100%
197.87	200.91	3.04	3.04	100%
200.91	203.96	3.05	3.05	100%
203.96	207.01	3.05	3.05	100%
207.01	210.10	3.09	3.09	100%
210.10	213.11	3.01	2.95	98%
213.11	216.16	3.05	3.00	98%
216.16	219.21	3.05	3.05	100%
219.21	222.26	3.05	3.05	100%
222.26	225.30	3.04	3.04	100%
225.30	228.35	3.05	3.05	100%
228.35	230.18	1.83	1.83	100%
230.18	232.93	2.75	2.52	92%
232.93	234.45	1.52	1.52	100%
234.45	237.50	3.05	3.01	99%
237.50	240.55	3.05	3.05	100%
240.55	243.60	3.05	3.05	100%
243.60	246.65	3.05	3.05	100%
246.65	249.70	3.05	3.05	100%
249.70	252.74	3.04	3.04	100%
252.74	255.79	3.05	3.05	100%
255.79	258.84	3.05	3.05	100%
258.84	260.82	1.98	1.98	100%
260.82	263.41	2.59	2.59	100%
263.41	264.94	1.53	1.53	100%
264.94	267.99	3.05	3.05	100%
267.99	271.04	3.05	3.05	100%
271.04	274.10	3.06	3.06	100%
274.10	276.52	2.42	2.42	100%
276.52	279.57	3.05	3.05	100%
		276.29	273.00	99%
OVERBURDEN		3.28		
		279.57		

CORE RECOVERIES  
D.D.H. Vu-91-5  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
0.00	7.62	OVERBURDEN		0%
7.62	9.45	1.83	1.25	68%
9.45	12.50	3.05	3.05	100%
12.50	15.55	3.05	3.05	100%
15.55	18.60	3.05	3.05	100%
18.60	20.12	1.52	1.35	89%
20.12	21.65	1.53	1.53	100%
21.65	24.70	3.05	3.05	100%
24.70	27.74	3.04	1.60	53%*
27.74	30.79	3.05	3.05	100%
30.79	33.84	3.05	3.05	100%
33.84	36.89	3.05	3.05	100%
36.89	39.94	3.05	2.90	95%
39.94	41.58	1.64	1.64	100%
41.58	44.21	2.63	2.63	100%
44.21	47.26	3.05	3.05	100%
47.26	50.30	3.04	3.04	100%
50.30	53.35	3.05	3.05	100%
53.35	56.40	3.05	3.05	100%
56.40	58.23	1.83	1.83	100%
58.23	61.28	3.05	3.05	100%
61.28	62.80	1.52	1.52	100%
62.80	64.32	1.52	1.52	100%
64.32	67.38	3.06	3.06	100%
67.38	70.42	3.04	3.04	100%
70.42	73.47	3.05	3.05	100%
73.47	76.52	3.05	3.05	100%
76.52	79.57	3.05	3.05	100%
79.57	82.62	3.05	3.05	100%
82.62	85.67	3.05	3.05	100%
85.67	88.72	3.05	3.05	100%
88.72	91.77	3.05	3.05	100%
91.77	94.81	3.04	3.04	100%
94.81	97.87	3.06	3.06	100%
97.87	100.91	3.04	3.04	100%
100.91	102.74	1.83	1.83	100%
102.74	105.18	2.44	2.44	100%
105.18	108.23	3.05	3.05	100%
108.23	110.06	1.83	2.15	117%**
110.06	112.20	2.14	2.10	98%
112.20	114.63	2.43	2.30	95%
114.63	116.16	1.53	1.53	100%
116.16	119.21	3.05	3.05	100%
119.21	122.26	3.05	3.05	100%
122.26	125.30	3.04	3.04	100%
125.30	128.35	3.05	3.05	100%
128.35	131.40	3.05	3.05	100%
131.40	132.46	1.06	1.06	100%
132.46	134.45	1.99	1.99	100%
134.45	137.50	3.05	3.05	100%
137.50	140.55	3.05	3.05	100%
140.55	143.60	3.05	3.05	100%
143.60	146.64	3.04	3.04	100%
146.64	149.70	3.06	3.06	100%
149.70	152.74	3.04	3.04	100%
152.74	155.79	3.05	3.05	100%

CORE RECOVERIES  
D.D.H. Vu-91-5  
VULCAN PROPERTY

FROM	TO	INTERVAL	RECOVERED	%
155.79	158.84	3.05	3.05	100%
		151.22	149.03	99%
	OVERBURDEN	7.62		
		158.84		

\* CANT FIND EVIDENCE OF LOST CORE, ALL ENDS MATCH.  
ERROR CARRIED FOR REST OF HOLE

\*\* PROBABLE BLOCK PLACEMENT ERROR, CARRIED FOR REST OF HOLE.

**APPENDIX III**

**Geochem/Assay Results**

ASCOT RESOURCES LTD. - VULCAN PROJECT  
 COMPLETE 1991 ASSAY AND GEOCHEM RESULTS

IDMcC/OCT 1991

SAMPLE	HOLE	FROM	TO	THICKNESS	PB	ZN	AG	CU	AS	SB	MO	AU-FIRE
L.D.	NO				ppm	ppm	g/tonne	ppm	ppm	ppm	ppm	ppb
6312	79-1	119.00	120.52	1.52	35	63	0.7	44	1	1	3	6
6313	79-1	120.52	121.95	1.43	18	33	0.6	45	1	1	1	2
6314	79-1	121.95	123.17	1.22	21	41	0.9	38	1	1	1	3
6315	79-1	123.17	124.20	1.03	20	56	1.2	33	1	1	2	1
6316	79-1	124.20	125.30	1.10	75	128	1.4	34	1	1	1	3
6431	MAIN SHOWING				1.72 %	3.63 %	25.7	0.005 %	-	-	-	1
6434	MAIN SHOWING				1.45 %	4.03 %	22.0	0.003 %	-	-	-	1
6430	MAIN SHOWING				1.20 %	2.59 %	20.1	0.006 %	-	-	-	1
6432	MAIN SHOWING				0.86 %	3.20 %	17.3	0.003 %	-	-	-	1
6433	MAIN SHOWING				0.53 %	2.72 %	15.0	0.004 %	-	-	-	2
6451	1	12.00	12.50	0.50	24	22	0.2	25	12	1	4	4
6452	1	12.50	13.00	0.50	16	15	0.5	10	10	1	1	2
6453	1	13.00	13.50	0.50	19	22	0.6	10	23	1	4	1
6454	1	13.50	14.00	0.50	40	55	0.2	44	54	1	4	2
6455	1	14.00	14.50	0.50	61	42	0.1	58	34	1	5	2
6456	1	14.50	15.00	0.50	85	32	0.2	50	58	1	2	3
6457	1	15.00	15.50	0.50	61	88	0.4	33	57	1	5	1
6458	1	15.50	16.00	0.50	34	37	0.3	34	60	1	1	12
6459	1	16.00	16.50	0.50	31	53	0.5	38	62	1	4	2
6460	1	16.50	16.90	0.40	59	182	0.4	34	92	1	1	1
6461	1	16.90	17.30	0.40	93	29	0.4	51	40	1	4	2
6462	1	17.30	17.90	0.60	60	59	0.4	50	45	1	2	5
6497	1	17.90	18.55	0.65	55	86	1.2	9	218	1	2	1
6409	1	20.20	20.80	0.60	0.02 %	0.01 %	0.3	0.001 %	-	-	-	2
6463	1	23.05	23.45	0.40	51	86	1.3	8	25	1	2	2
6464	1	25.00	25.35	0.35	93	630	1.4	16	2426	7	5	10
6465	1	25.35	25.90	0.55	282	228	2.0	65	668	1	1	4
6466	1	25.90	26.45	0.55	0.01 %	0.01 %	0.9	0.002 %	-	-	-	9
6467	1	26.45	26.75	0.30	0.01 %	0.06 %	0.2	0.001 %	-	-	-	146
6468	1	26.75	27.05	0.30	0.01 %	0.05 %	0.3	0.001 %	-	-	-	2
6469	1	27.05	27.50	0.45	0.01 %	0.01 %	0.9	0.001 %	-	-	-	2
6428	1	27.50	28.45	0.95	34	39	1.3	10	900	1	6	2
6498	1	28.45	28.65	0.20	50	106	1.3	12	230	12	3	2
6499	1	28.65	29.08	0.43	34	71	1.3	8	198	2	3	1
6500	1	29.08	29.65	0.57	39	37	0.9	45	25	2	1	1
6429	1	29.65	30.20	0.55	134	164	0.9	41	45	1	2	1
6470	1	30.20	30.75	0.55	157	742	1.3	50	111	1	5	1
6471	1	30.75	31.25	0.50	95	368	0.7	51	41	1	1	2
6472	1	32.00	32.30	0.30	0.01 %	0.05 %	0.2	0.004 %	-	-	-	7
6473	1	32.60	32.75	0.15	0.01 %	0.01 %	1.0	0.059 %	-	-	-	24
6474	1	33.28	33.65	0.37	63	87	0.6	31	37	1	2	7
6475	1	35.02	35.52	0.50	67	89	0.5	49	105	1	1	2
6476	1	37.48	37.86	0.38	162	576	1.3	35	34	1	3	1
6408	1	39.36	39.70	0.34	117	125	0.7	42	76	1	4	2
6477	1	39.70	40.16	0.46	89	389	1.1	26	105	1	1	1
6311	1	40.16	40.80	0.64	45	111	1.0	30	36	1	2	3
6478	1	40.80	41.20	0.40	49	1172	1.1	41	129	1	4	3

ASCOT RESOURCES LTD. - VULCAN PROJECT  
 COMPLETE 1991 ASSAY AND GEOCHEM RESULTS

IDMcC/OCT 1991

SAMPLE HOLE		FROM	TO	THICKNESS	PB	ZN	AG	CU	AS	SB	MO	AU-FIRE
I.D.	NO				ppm	ppm	g/tonne	ppm	ppm	ppm	ppm	ppm
6401	2	159.70	160.10	0.40	0.02 %	0.01 %	0.4	0.002 %	-	-	-	3
6402	2	160.10	160.25	0.15	0.09 %	0.90 %	3.0	0.034 %	-	-	-	2
6403	2	160.25	160.60	0.35	0.02 %	0.04 %	0.7	0.001 %	-	-	-	2
6494	2	160.60	161.00	0.40	85	54	0.6	43	29	1	3	1
6495	2	161.00	161.63	0.63	88	93	1.1	29	25	3	3	3
6496	2	161.63	162.05	0.42	76	101	0.7	40	53	1	1	1
6493	2	162.05	162.66	0.61	80	31	0.6	19	19	1	3	2
6404	2	162.66	163.16	0.50	0.03 %	0.01 %	0.3	0.004 %	-	-	-	3
6405	2	163.16	163.50	0.34	0.35 %	0.01 %	2.2	0.003 %	-	-	-	1
6406	2	163.50	163.93	0.43	0.19 %	0.01 %	1.2	0.002 %	-	-	-	2
6407	2	163.93	164.26	0.33	0.03 %	0.01 %	0.5	0.002 %	-	-	-	2
6410	2	164.26	164.66	0.40	3.97 %	0.12 %	84.6	0.019 %	-	-	-	1
6411	2	164.66	165.04	0.38	0.09 %	0.01 %	1.3	0.003 %	-	-	-	1
6412	2	165.04	165.34	0.30	0.08 %	0.01 %	0.9	0.002 %	-	-	-	3
6413	2	165.34	165.64	0.30	0.14 %	0.03 %	1.4	0.003 %	-	-	-	2
6414	2	165.64	166.24	0.60	0.02 %	0.01 %	0.2	0.002 %	-	-	-	3
6415	2	166.24	166.51	0.27	0.01 %	0.01 %	0.4	0.001 %	-	-	-	1
6416	2	166.51	166.79	0.28	0.04 %	0.01 %	0.2	0.002 %	-	-	-	2
6417	2	166.79	167.10	0.31	0.13 %	0.01 %	1.1	0.003 %	-	-	-	5
6418	2	167.10	167.64	0.54	1388	156	2.3	43	438	14	1	2
6419	2	167.64	168.10	0.46	1437	976	2.6	40	556	12	4	3
6420	2	168.10	168.58	0.48	130	106	0.7	75	592	1	1	1
6421	2	168.58	169.04	0.46	146	118	0.2	94	861	4	1	1
6422	2	169.04	169.50	0.46	143	91	0.5	38	1236	5	1	2
6423	2	170.96	171.45	0.49	37	78	0.6	38	650	4	3	1
6424	2	171.45	172.00	0.55	37	373	0.4	39	1052	6	3	2
6425	2	172.00	172.50	0.50	32	441	0.5	41	1012	5	1	1
6426	2	172.50	173.00	0.50	41	71	0.5	33	717	3	2	2
6427	2	174.62	174.91	0.29	192	474	1.9	8	1521	27	3	2
6447	2	174.91	175.45	0.54	618	72	3.2	6	2624	1	1	1
6448	2	175.45	176.10	0.65	171	49	1.9	28	1122	1	2	1
6449	2	176.10	177.10	1.00	95	85	0.9	33	52	1	1	1
6450	2	177.10	178.20	1.10	63	80	0.8	30	73	1	1	2
6301	2	178.20	179.45	1.25	49	76	1.1	39	83	1	1	1
6302	2	179.45	180.65	1.20	47	83	1.2	41	60	1	1	1

ASCOT RESOURCES LTD. - VULCAN PROJECT  
 COMPLETE 1991 ASSAY AND GEOCHEM RESULTS

IDMcC/OCT 1991

SAMPLE HOLE		FROM	TO	THICKNESS	PB PPM	ZN PPM	AG g/tonne	CU PPM	AS PPM	SB PPM	MO PPM	AU-FIRE PPB
I.D.	NO											
6479	3	216.10	216.60	0.50	17	56	0.2	7	8	1	2	1
6480	3	216.60	217.00	0.40	24	48	0.4	12	30	1	8	1
6481	3	217.00	217.20	0.20	98	79	0.7	30	49	1	4	2
6482	3	217.20	217.54	0.34	52	104	0.7	29	5	1	2	2
6483	3	217.54	218.00	0.46	46	50	0.7	36	8	1	2	1
6484	3	218.00	218.50	0.50	48	100	0.7	41	10	1	1	3
6485	3	218.50	219.00	0.50	40	50	0.9	51	19	1	4	2
6486	3	219.00	219.50	0.50	43	92	0.8	32	33	1	2	2
6487	3	219.50	220.07	0.57	28	82	0.4	39	15	1	3	1
6488	3	220.07	220.57	0.50	25	61	0.8	33	14	1	1	3
6489	3	220.57	221.07	0.50	27	56	0.3	40	12	1	3	2
6490	3	221.07	221.42	0.35	44	103	0.9	38	12	1	2	1
6491	3	221.42	221.77	0.35	26	72	0.7	28	24	1	3	4
6492	3	221.77	222.27	0.50	67	52	2.2	36	50	1	2	5
6303	3	226.50	227.75	1.25	226	75	1.9	28	20	1	1	1
6304	3	227.75	229.00	1.25	261	172	1.9	22	31	1	1	1
6305	3	229.00	230.05	1.05	115	63	1.5	21	519	1	2	1
6306	3	230.05	231.30	1.25	68	101	1.2	33	112	1	1	1
6307	3	231.30	232.50	1.20	31	126	1.1	25	13	1	2	1
6308	3	232.50	233.78	1.28	25	63	0.8	31	18	1	1	1
6309	3	255.00	256.20	1.20	159	114	1.3	28	22	1	1	1
6310	3	256.20	257.30	1.10	96	157	1.1	26	4	1	1	1

ASCOT RESOURCES LTD. - VULCAN PROJECT  
 COMPLETE 1991 ASSAY AND GEOCHEM RESULTS

IDMcC/OCT 1991

SAMPLE HOLE					PB	ZN	AG	CU	AS	SB	MO	AU-FIRE
I.D.	NO	FROM	TO	THICKNESS	PPM	PPM	g/tonne	PPM	PPM	PPM	PPM	PPB
6251	4	13.87	14.12	0.25	20	71	1.4	2280	94	1	2	2
6252	4	15.40	16.23	0.83	14	37	0.5	556	159	1	1	3
6253	4	77.40	77.65	0.25	20	21	0.7	55	227	1	2	1
6254	4	99.70	100.14	0.44	31	29	0.7	48	92	1	1	2
6255	4	155.00	155.80	0.80	12	4	2.0	12	24	1	1	1
6256	4	171.82	172.60	0.78	12	24	1.1	20	32	1	3	2
6257	4	172.60	173.29	0.69	16	23	1.2	13	38	1	1	1
6258	4	173.29	173.87	0.58	14	21	1.1	12	36	1	3	5
6259	4	191.12	191.42	0.30	10	43	1.4	17	1	1	4	1
6260	4	191.42	191.90	0.48	9	176	0.6	116	343	1	1	1
6261	4	191.90	192.37	0.47	413	386	3.0	146	826	1	1	2
6262	4	192.37	192.85	0.48	245	154	1.4	142	793	1	1	1
6263	4	192.85	193.42	0.57	30	103	1.0	51	6	1	1	1
6264	4	193.42	194.00	0.58	30	36	1.1	54	1	1	1	1
6265	4	194.00	194.63	0.63	14	18	1.4	41	40	1	2	1
6266	4	194.63	195.20	0.57	66	17	1.4	46	1	1	1	1
6267	4	195.20	195.80	0.60	45	17	1.2	38	1	1	1	1
6268	4	195.80	196.50	0.70	155	12	1.3	46	1	1	1	1
6269	4	196.50	197.16	0.66	127	63	1.4	30	5	1	1	2
6270	4	197.16	197.76	0.60	41	91	1.3	25	36	1	1	1
6271	4	197.76	198.32	0.56	30	79	1.2	32	6	1	1	3
6272	4	198.32	198.95	0.63	100	223	1.5	28	1	1	1	2
6273	4	198.95	199.60	0.65	56	152	1.4	33	1	1	1	1
6274	4	199.60	200.17	0.57	48	39	1.3	43	1	1	1	1
6275	4	200.17	200.78	0.61	215	1208	1.3	46	1	1	1	1
6276	4	200.78	201.20	0.42	120	79	1.0	31	7	1	1	2
6277	4	201.20	201.60	0.40	87	155	0.5	37	9	1	2	2
6278	4	201.60	202.35	0.75	39	44	0.7	40	5	1	1	4
6279	4	202.35	203.07	0.72	36	51	0.5	46	8	1	2	3
6280	4	203.07	203.76	0.69	165	107	0.9	38	18	1	1	4
6281	4	203.76	204.40	0.64	88	106	1.3	42	89	1	1	1
6282	4	204.40	204.90	0.50	537	1413	2.9	24	114	7	3	2
6283	4	207.33	207.66	0.33	221	539	1.6	71	219	1	2	2
6284	4	211.10	212.00	0.90	18	146	0.8	102	3748	1	3	10
6285	4	212.00	213.11	1.11	13	43	0.1	426	79	1	1	19
6286	4	213.11	214.13	1.02	13	29	0.5	192	370	1	1	11
6287	4	214.13	215.16	1.03	11	34	1.0	138	1	1	1	1
6288	4	215.16	216.16	1.00	8	40	0.2	410	1	1	1	1
6289	4	216.16	217.34	1.18	17	38	0.8	211	4	1	1	1
6290	4	222.26	223.38	1.12	49	22	0.5	717	78	1	1	4
6291	4	225.53	226.65	1.12	27	30	0.7	269	45	1	1	1



ASCOT RESOURCES LTD. - VULCAN PROJECT  
 COMPLETE 1991 ASSAY AND GEOCHEM RESULTS

IDMcC/OCT 1991

SAMPLE HOLE		FROM	TO	THICKNESS	PB ppm	ZN ppm	AG g/tonne	CU ppm	AS ppm	SB ppm	MO ppm	AU-FIRE ppb
I.D.	NO											
6292	5	7.62	8.54	0.92	18	10	1.0	21	26	1	3	1
6293	5	8.54	9.45	0.91	13	45	0.9	43	39	1	4	2
6294	5	9.45	10.40	0.95	13	12	1.0	50	15	1	3	1
6295	5	10.40	11.35	0.95	13	13	0.8	28	20	1	2	2
6296	5	11.35	12.35	1.00	16	79	0.7	38	20	1	2	2
6297	5	12.35	13.40	1.05	23	98	0.8	28	25	1	3	4
6298	5	13.40	14.50	1.10	18	95	0.5	35	24	1	2	1
6299	5	14.50	15.55	1.05	16	54	0.6	27	20	1	2	2
6300	5	15.55	16.60	1.05	26	69	0.5	31	40	1	1	1
6435	5	33.00	33.80	0.80	19	66	0.8	31	31	1	2	1
6436	5	41.83	42.99	1.16	14	53	0.6	31	47	1	1	2
6437	5	48.10	49.30	1.20	29	64	0.4	35	22	1	2	1
6438	5	50.30	51.40	1.10	26	59	0.5	34	21	1	1	2
6440	5	59.70	60.75	1.05	26	35	0.7	37	1051	16	2	1
6439	5	60.75	61.23	0.48	37	2291	0.7	39	815	20	3	2
6441	5	61.23	62.28	1.05	95	125	1.0	45	112	4	1	1
6442	5	73.50	74.40	0.90	18	195	1.2	86	148	1	1	3
6446	5	76.40	76.87	0.47	24	47	0.1	238	973	21	1	19
6443	5	120.95	121.74	0.79	73	90	0.9	31	30	1	2	3
6444	5	121.74	122.10	0.36	1454	2384	3.4	24	98	1	2	1
6445	5	122.10	122.86	0.76	92	216	0.7	49	35	1	4	8

**APPENDIX IV**

**Statement of Expenditures**

**STATEMENT OF EXPENDITURES**

<b><u>Staking</u></b>		<b>\$ 4,548.00</b>
<b><u>Pre-Field</u></b>		<b>\$ 6,075.00</b>
<b><u>Field Program</u></b>		
Personnel	\$32,617.00	
Camp Support	19,910.00	
Helicopter	41,173.00	
Truck Rental	3,010.00	
Geochemical/Assays	2,855.00	
Geophysical Surveys	10,535.00	
Diamond Drilling	<u>92,634.00</u>	<b>\$202,734.00</b>
<b><u>Post-Field</u></b>		
Geophysicists Report	\$ 1,500.00	
Personnel	2,900.00	
Word Processing, Drafting, Reproduction	<u>3,225.00</u>	<b>\$ 7,625.00</b>
<b>Sub-Total:</b>		<b>\$220,982.00</b>
<b><u>Management Fee - 10%</u></b>		<b>22,098.00</b>
<b><u>Ascot Personnel Field &amp; Office Supervision</u></b>		<b><u>10,000.00</u></b>
<b>TOTAL EXPENDITURES:</b>		<b><u>\$253,080.00</u></b>

**APPENDIX V**

**Summary of Field Personnel**

SUMMARY OF FIELD PERSONNEL

Name	Position	No. of Days
R. Nichols	Project Supervisor	6.00
I. McCartney	Project Geologist	67.90
T. Termuende	Geologist	16.00
C. Kauss	Field Assistant	14.00
S. Chandler	Cook	18.00
F. Ferguson	Draftsman	58.50
T. Hutchings	Draftsman	12.25
B. Whelan	Land Tenure Administrator	2.25
M. Mees	Word Processor	33.00

**APPENDIX VI**

**Analytical Techniques**

## **ANALYTICAL PROCEDURES USED BY MIN-EN LABORATORIES LTD.**

Samples were analyzed by Min-En Laboratories at 705 West 15th Street, North Vancouver, B.C., employing the following procedures.

### **ICP Analysis for Cu, Pb, Zn, Ag, As, Sb, Mo**

The rock samples are crushed by a jaw crusher and pulverized on a ring mill pulverizer.

0.50 gram of the sample is digested for two hours with an aqua regia mixture. After cooling samples are diluted to standard volume.

The solutions are analyzed by computer operated Jarrall Ash 9000 ICAP or Jobin Yvon 70 Type II Inductively Coupled Plasma Spectrometers.

### **Au Fire Geochem**

A suitable sample weight; 15.00 or 30.00 grams is fire assay pre-concentrated. The precious metal beads are taken into solution with aqua regia and made to volume.

For Au only, samples are aspirated on an atomic absorption spectrometer with a suitable set of standard solutions.

### **Pb-Zn-Cu-Ag Assay**

Assays were performed on selected samples using standard wet chemical techniques.

**APPENDIX VII**

**Geophysical Report**



BOREHOLE UTEM SURVEY

ON THE

VULCAN 1 TO 3 CLAIMS

FOR

KEEWATIN ENGINEERING INC.

SURVEY BY

SJ GEOPHYSICS LTD. AND LAMONTAGNE GEOPHYSICS LTD.

FORT STEELE M.D., B.C.

N.T.S. 82F/16W

NOVEMBER 1991

REPORT BY

DR. YVES LAMONTAGNE  
LAMONTAGNE GEOPHYSICS LTD.

SYD J VISSER  
SJ GEOPHYSICS LTD.

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APPENDIX III	A time domain EM system measuring the step response of the ground
APPENDIX IV	Loop location map (MAP-1) Data sections Vector plots (Fig 1-5)

## INTRODUCTION

A large loop time domain electromagnetic (UTEM-3) Borehole survey was completed by SJ Geophysics Ltd. and Lamontagne Geophysics Ltd., for Keewatin Engineering Inc. on the Vulcan 1 to 3 Claims. The Vulcan Claims are located approximately 50 km west of Kimberley, B.C., in the Fort Steele M.D., of B.C. (N.T.S. 82F/16W).

The purpose of the survey was to more accurately locate the source of the weak extensive conductor located in the 1984 surface UTEM survey by Cominco Ltd. and to search for local increases in conductivity which would indicate thickening of the sulphide zone. Two boreholes VU-91-4 and VU-91-5, were surveyed from two separate loops (Map-1). The remaining three boreholes were not surveyed because they were blocked.

## DESCRIPTION OF UTEM SYSTEM

UTEM is an acronym for "University of Toronto ElectroMagnetometer". The system was developed by Dr. Y. Lamontagne (1975) while he was a graduate student of that University.

The following is a short description of the UTEM system used in the field. A paper (A time-domain EM system measuring the step response of the ground) by G.F. West, J.C. Macnae and Y. Lamontagne, giving a more complete description with an overview of interpretations is located in Appendix III.

The field procedure consists of first laying out a large loop, which can vary in size from less than 100M X 100M to more than 2Km X 2Km, of single strand insulated wire and energizing it with current from a transmitter which is powered by a 2.2 kW motor generator. During a surface survey the lines are generally oriented

perpendicular to one side of the loop and surveying can be performed both inside and outside the loop. For Borehole survey the sensor coil is placed down the borehole measuring the axial component of the electromagnetic field from a minimum of 2 separate loops.

The transmitter loop is energized with a precise triangular current waveform at a carefully controlled frequency (30.97 Hz for this survey). The receiver system includes a sensor coil and backpack portable receiver module which has a digital recording facility. The time synchronization between transmitter and receiver is achieved through quartz crystal clocks in both units which are accurate to about one second in 50 years.

The receiver sensor coil measures the vertical horizontal, or axial magnetic component of the electromagnetic field and responds to its time derivative. Since the transmitter current waveform is triangular, the receiver coil will sense a perfect square wave in the absence of geologic conductors. Deviations from a perfect square wave are caused by electrical conductors which may be geologic or cultural in origin. The receiver stacks any pre-set number of cycles in order to increase the signal to noise ratio.

The UTEM receiver gathers and records 10 channels of data at each station occupied. The higher number channels (7-8-9-10) correspond to short time or high frequency while the lower number channels (1-2-3) correspond to long time or low frequency. Therefore, poor or weak conductors will respond on channels 10, 9, 8, 7 and 6. Progressively better conductors will give responses on progressively lower number channels as well. For example, massive, highly conducting sulfides or graphite will produce a response on all ten channels.

The Borehole system consists of a normal surface UTEM-3 transmitter and receives along with special receiver coil (1 1/4" in diameter). The coil is connected to the receiver through a controller and fibre optic cable.

### **FIELD WORK**

Syd Visser (chief geophysicist) with SJ Geophysics Ltd., and the equipment were mobilized from Vancouver to Kimberley. The work on the Vulcan was completed between September 21, 1991 and October 1, 1991. The survey area was accessed daily by helicopter and road from Kimberley and Cranbrook. The field parameters and local geology were discussed in the Vancouver office and the field with Keewatin Engineering Inc. geologists, (Ron Nichols, Dave Dupre and Ian McCartney) before commencing the survey and during the survey period.

The first day September 22, 1991 was used to inspect the survey area, discuss the geology, possible loop locations, training and helping a technician supplied by Keewatin Engineering Inc. in laying out a transmitter loop and plotting the location for additional loops. Weather conditions (snow) narrowed the availability loop locations.

The survey was commenced on September 25, 1991 by dummy probing VU-91-3 which was found to be blocked directly below the casing. It did not appear that the casing was solidly placed into bedrock. Since VU-91-2 did not have a drill platform it was decided to attempt a survey on VU-91-4 which proved to be successful. On completion of VU-91-4 a short hole VU-91-5 was surveyed successfully. The system was then moved to VU-91-2 which was also blocked directly below the casing. An attempt was also made to survey a 1976 Cominco Ltd. hole which was also blocked.

The equipment was demobilized and the wire from the loops retrieved on September 28, 1991.

### DATA PRESENTATION

The results of the 1991 UTEM survey are presented on 4 data sections. The loop locations are shown on the loop location map (Map-1) and vector plots of the primary electromagnetic field, used for interpretation, are shown on fig 1 - fig 5 (APPENDIX IV)

Legends for the UTEM data sections are also attached (Appendix II).

In order to reduce the field data, the theoretical primary field of the loop must be computed at each station. The normalization of the data is as follows:

a) For Channel 1:

$$\% \text{ Ch.1 anomaly} = \frac{\text{Ch.1} - \text{PC}}{\text{PT}} \times 100$$

Where:

PC is the calculated primary field in the direction of the component from the loop at the occupied station

Ch.1 is the observed amplitude of Channel 1

PT is the calculated total field

b) For remaining channels (n = 2 to 9)

$$\% \text{ Ch.n anomaly} = \frac{(\text{Ch.n} - \text{Ch.1})}{\text{Ni}} \times 100$$

where Ch.n is the observed amplitude of Channel n (2 to 9)

N = Ch.1 for Ch1 normalized

N = PT for primary field normalized

i is the data station for continuous normalized (each reading normalized by different primary field)

i is the station below the arrow on the data sections for point normalized (each reading normalized by the same primary field)

Subtracting channel 1 from the remaining channels eliminates the topographic errors from all the data except ch.1.

If there is a response in channel 1 from a conductor then this value must be added to do a proper conductivity determination from the decay curves. Therefore channel 1 should not be subtracted indiscriminately.

### **INTERPRETATION**

The follow interpretation, with consultation by the writer, was provided by Dr. Yves Lamontagne, Lamontagne Geophysics Ltd., who developed and supplied the Borehole UTEM system.

#### **Hole D-91-4**

In this hole the sulphide horizon is cut by the borehole. The in-hole response leading to the intersection is broader for loop 1 (section loop No 4 Hole 4) than for loop 2 because the larger loop is located right above the horizon and energize a larger part of the conductive layer. This is also correlated with a longer decay time.

The intersection anomaly indicates that there is migration in the induced current taking place in conductor. The currents near the intersection of hole 4 are return currents for all channels except channel 1. At the time of channel 1, the current pattern is broad enough that forward current of the same polarity as at the conductor edge is flowing around the hole. This means that the current have migrated (from the edge) by about 400M in 12 ms. Since this 'slowness' of migration is

basically the conductance of the horizon multiplied by  $H_0$ , this gives a conductance of 25S.

This is in general agreement with the decay time. The horizon does not seem to be much more conductive than average where hole 4 was drilled.

#### **Hole D-91-5**

The main feature of this hole is the prominent in-hole channel 1 (section loop No 51 hole 2 and loop no 52 hole 2) response increasing towards the bottom of the hole. There is only a vague suggestion of slight decay in the other channels. Whenever a response is seen only on channel 1, one has to rely on the geometry and calibration of the equipment to a greater extent than for decaying responses. In this case, the anomaly shows up with both loops (section loop No 51 hole 2 and loop no 52 hole 2) and it has a well defined shape which is less broad in the loop 2 data, which is what we would expect for a real response.

There is then good evidence that there is a conductor below the bottom of the hole, and the very long decay suggest that the conductivity is much higher than around hole 4. Based on the rate of increase of the response, the conductor should be within approximately 50 m of the hole bottom. The conductor size is poorly defined, but a minimum size of 200 m would be needed to explain the anomaly amplitude observed. If the conductor size is less than 500m, the conductance of the body would need to be more than 400 S.

#### **Background response**

The 'background' response can also be explained as the response of the same horizon originating near the loops: this is the induction taking place in the part of the horizon in between the two holes which is much nearer to both loops. For loop 1, since the source is 'above'



the conductor, the response consists of a migrating current ring which is negative at early times (relative to the primary field) and turns positive at the later times particularly in the data of hole 5. The migration rate inferred from the background response indicates that the conductivity of the horizon in between the holes is not much greater than around hole 4 and much poorer than below hole 5.

#### **RECOMMENDATIONS**

The developing in-hole response measured in hole 5 is of great potential interest and should be followed up.

Because the anomaly is mainly a channel 1 response, the geometry should be checked thoroughly. The surface line 7N (1984 Cominco Ltd.) shows a local channel 1 anomaly near the location. It may be useful to run a surface line above the location of the bottom of hole 4 with a medium size loop situated east of the inferred contact, and about 600 m from the hole. If this was done, it would be important to locate the loop and line very accurately to detect underlying response precisely.

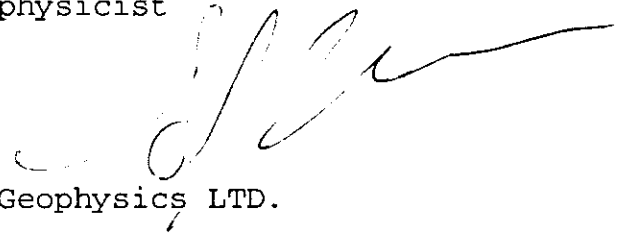
Depending on the cost difference, it may be better to simply deepen hole 5 to attempt to intersect the zone. An extra 100m should be amply sufficient for this. If the conductor is intersected and found geologically interesting, the hole should be continued at least 100m past the zone if the size and geometry of the zone is to be interpreted using subsequent borehole UTEM measurements.

**CONCLUSION**

The Borehole survey on hole VU-91-4 indicates that the weak extensive conductor located on lines 7N through 5N (1984 UTEM survey) is continuous through this borehole but likely terminates a few hundred metres to the south. This is no indication of a large increase in conductivity near the borehole.

The short borehole VU-91-5 indicates a strong conductor below the end of the hole. It is recommended to follow up this anomaly with further surface UTEM work or drilling.

Syd Visser B.Sc., F.G.A.C.  
Geophysicist



SJ Geophysics LTD.

REFERENCES

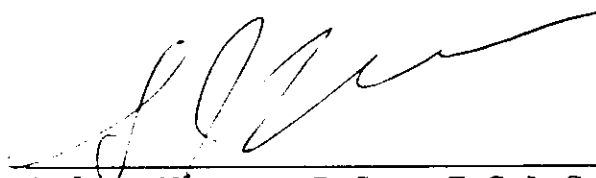
- Dr. Yves Lamontagne      Personal communications
- Syd J Visser              1984 Assessment Report on the  
Jovan Silic                UTEM Survey on Vulcan 1 to 3  
                                  claims

APPENDIX I

STATEMENT OF QUALIFICATIONS

I, Syd J. Visser, of 11762 94th Avenue, Delta, British Columbia, hereby certify that,

- 1) I am a graduate from the University of British Columbia, 1981, where I obtained a B.Sc. (Hon.) Degree in Geology and Geophysics.
- 2) I am a graduate from Haileybury School of Mines, 1971.
- 3) I have been engaged in mining exploration since 1968.
- 4) I am a Fellow of the Geological Association of Canada.



---

Syd J. Visser, B.Sc., F.G.A.C.  
Geophysicist

APPENDIX II

**UTEM SYSTEM MEAN DELAY TIME**

<b>Channel Number</b>	<b>Delay Time(msec)</b>	<b>Symbol</b>
1	12.8	
2	6.4	\
3	3.2	/
4	1.6	□
5	0.8	∩
6	0.4	△
7	0.2	∇
8	0.1	×
9	0.05	△
10	0.025	◇

**Base Frequency = 31 Hz**

APPENDIX III



## A time-domain EM system measuring the step response of the ground

G. F. West\*, J. C. Macnae\*†, and Y. Lamontagne‡

### ABSTRACT

A wide-band time-domain EM system, known as UTEM, which uses a large fixed transmitter and a moving receiver has been developed and used extensively in a variety of geologic environments. The essential characteristics that distinguish it from other systems are that its system function closely approximates a step-function response measurement and that it can measure both electric and magnetic fields. Measurement of step rather than impulse response simplifies interpretation of data amplitudes, and improves the detection of good conductors in the presence of poorer ones. Measurement of electric fields provides information about lateral conductivity contrasts somewhat similar to that obtained by the gradient array resistivity method.

### INTRODUCTION

This article describes the design of the UTEM system and its development at the Geophysics Laboratory of the University of Toronto by Y. Lamontagne and G. F. West from 1971 to 1979. UTEM is a wideband, time-domain, ground EM system with a step-function system response. It was designed to try to achieve the sensitivity and interpretability necessary to handle problems of deep exploration, conductive environments, and a variety of terrain conditions, in an economically viable manner. As with most EM systems, effective exploration for massive sulfide ores was the principal objective. The method was conceived in 1971, and the first UTEM I instrument was operational in 1972. It was an analog electronic system, and was used in a number of surveys which have been described by Lamontagne (1975). An improved UTEM II which incorporated a digital recording system was then designed and constructed at the University of Toronto with financial aid from a consortium of mining companies. It was first used in 1976. To fall 1980, about 1000 line-km had been surveyed with the system from 144 loops in 35 areas. UTEM III, which is a microprocessor-controlled system with expanded capabilities, is now produced commercially by Lamontagne Geophysics Ltd. Some of the field results obtained using the UTEM II system have been described in Lamontagne et al. (1977, 1980), Macnae (1977, 1980, 1981), Lodha (1977), and Podolsky and Slankis (1979). Data from all

three UTEM systems are identical insofar as geophysical characteristics are concerned. The differences affect only data noise levels and operational convenience. Some of the noise rejection features of UTEM III are discussed by Macnae et al. (1984).

### THE UTEM SYSTEM

#### Design philosophy

UTEM uses a large, fixed, horizontal transmitter loop as its source. The field of the loop is mapped in the quasi-static zone with the receiver system; the vertical component of the magnetic field is always measured, and in some circumstances the horizontal magnetic and electric field components may be measured as well (Figure 1). The size of the transmitter loop depends on the prospecting problem; loops may range from about 2 km x 1 km in resistive terrain to 300 m x 300 m in a conductive area. Lines are typically surveyed to a distance of 1.5 to 2 times the loop dimensions.

The large loop transmitter-field mapping receiver configuration was chosen in order to give the system the deepest possible exploration for orebody sized conductors, without sacrificing the ability to resolve shallower structures (depth < 50 m). This dictates a very large transmitter moment, and makes an extended source desirable. The virtue of an extended source is that the coupling between the source and a receiver or the source and a nearby conductive zone is not so many orders of magnitude larger than the coupling to a distant receiver or deep target as is the case with a confined source.

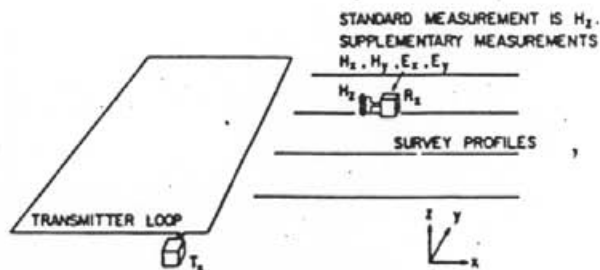


FIG. 1. Schematic layout of a UTEM survey.

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S. J. V. CONSULTANTS LTD.

SYD J. VISSER B.Sc. FGAC.

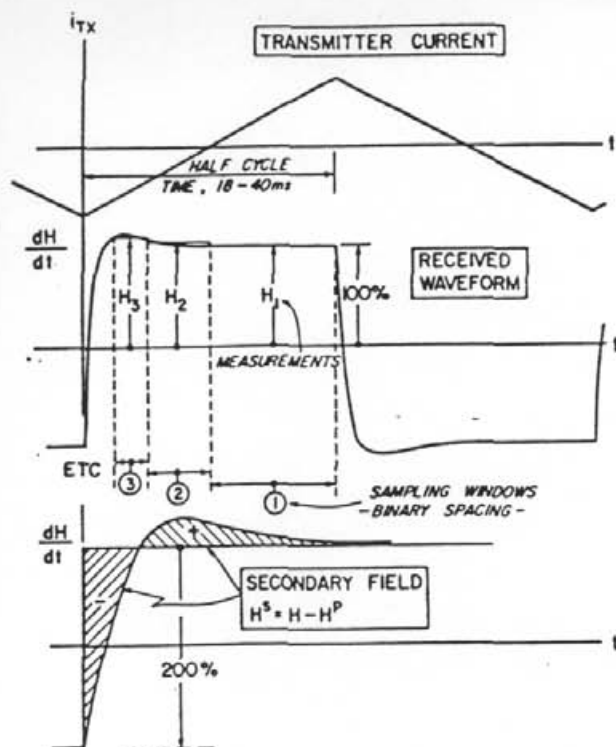


FIG. 2. Transmitted and received UTEM waveforms. Note that the measurement channels are numbered from the latest to the earliest. Sampling is repeated, with due regard to sign, in every half-cycle.

Given a large transmitter and a large Tx-Rx separation, it is inevitable that induction in extensive conductive overburden and in large formational conductors will contribute more to the response than with a small scale system. Also, as the separation becomes larger it becomes increasingly likely that the system will be responding to several nearby conductors at once. However, a fixed transmitter-moving receiver system offers a basis for separating the signal contributions from the various conductors and resolving the geometry of deep-seated conductors. At any time instant, the magnetic field of the current system induced in the ground is a potential field (within the quasi-static zone), and if it is mapped on a profile or over a surface, there is a firm theoretical basis for separating it into parts and estimating the current systems which caused it. When the transmitter and hence the eddy current system move for each observation, it is more difficult to find a theoretical basis for stripping of responses into component parts.

There are negative aspects to using a fixed transmitter method. In addition to the aforementioned enhancement of anomalies due to formational conductors, the transmitter can be positioned badly for induction in small plate-like conductors, and a large good conductor can screen a smaller, shorter time-constant conductor which lies behind it. For these reasons it may be desirable to have survey coverage from more than one transmitter location.

The UTEM II transmitter passes a low-frequency current of precise triangular waveform through the transmitter loop. The magnetic field is sensed with a coil, which responds to the time

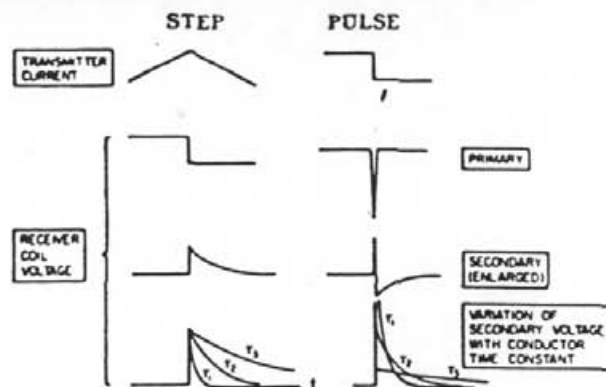


FIG. 3. Comparison of transient signals in step and pulse type systems.

derivative of the local magnetic field, so in "free space" a precise square-wave voltage would be induced in the receiver. In the presence of conductors the waveform is substantially distorted. The UTEM receiver measures this distortion by determining amplitudes at 10 delay times (actually, averages over time windows) which are spaced in a binary geometric progression between the waveform transitions. The sample scheme is shown in Figure 2. Note that the UTEM channel numbers are conventionally numbered in reverse order of time. This is because the latest time measurement often serves as a reference to which the other measurements are compared, whereas the number of earlier time measurements which can be made accurately may change if base period or instrument bandwidth is altered. The base frequency of the system is selectable, usually about 30 or 15 Hz (25 or 12.5 Hz in countries with 50 Hz power). A common practice is to set the base frequency (adjustable in 0.1 percent steps) about 0.5 Hz from a subharmonic of the power line in order that power line interference can be detected by slow beating in the data. The base frequency is usually set low enough that all ground response has nearly vanished by the end of the half-cycle. When this is the case, the UTEM system determines the step response of the ground in the time range 25 $\mu$ s to 12.8 ms (30 Hz base frequency).

#### Time-domain systems

Time-domain systems have some advantage over frequency-domain systems in that simultaneous measurement is easier to achieve over the whole spectrum and, at the same time, it is possible to check the phase synchronization of the transmitter and receiver time bases. Most time-domain systems employ an on-off type of transmitter current and confine all measurements to the off-period, as this automatically separates the secondary from the primary field. However, when a coil is used as a sensor, the time derivative of the signal is observed. Thus, if the transmitter loop is energized with a step current, it is the impulse response of the ground which is observed.

When prospecting for conductive mineral deposits, it is generally more desirable for interpretation purposes to observe the step response than any other time response. The reason for this lies in the characteristics of eddy current decay. For the step

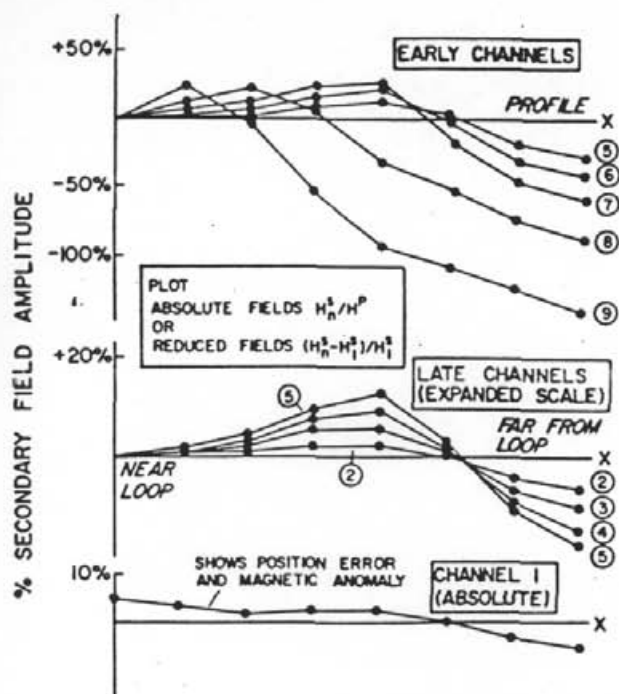


FIG. 4. Standard presentation of UTEM vertical component magnetic field data.

response, the early-time limit of response is identical to the frequency-domain inductive limit, and for a simple conductor in free space this is a function of geometry alone. For the impulse response, the early time limit is scaled from the step response limit by the inverse of the transient decay time constant (Figure 3). Thus, the decay rate must first be determined in order to interpret amplitude information in terms of geometry. This may present little difficulty in simple cases, but when complex or overlapping responses are observed it can be a serious problem. Also, even in the case of the step response, overburden anomalies which generally are of short time constant have early time amplitudes which are very much larger than the anomalies of target conductors with long time constant. Any further amplification caused by measuring the impulse rather than step response is clearly undesirable.

Although a system with a step response is usually desirable for interpretation purposes, the UTEM system is only one implementation of such a system. In fact a system using a magnetometer receiver with a square-wave transmitter instead of an induction coil (referred to as MSW system in the following sections) would have an identical system response. The foregoing rationale of the interpretational advantages of step response does not consider the other important factors which enter the design of actual systems such as signal-to-noise (S/N) efficiency and transmitter-sensor design constraints which in fact guide the choice of the actual transmitter waveform and sensor used. This is a complex topic discussed by Lamontagne et al. (1980). For example, the UTEM III system actually uses a modified triangular transmitter waveform and deconvolution in the receiver to improve its S/N performance but has a system response identical to the UTEM I and UTEM II systems (Macnae et al., 1984), i.e., a square-wave response. Thus the UTEM I/II systems, the conceptual MSW system, and the

UTEM III system all make identical measurements although they excite the ground differently. To avoid any confusion, discussions in this paper of actual induced current waveforms in the ground will be limited to the UTEM system with a purely triangular waveform and to the MSW system.

The sampling scheme of Figure 2 was chosen so that virtually all measuring time is utilized and time scaling of the measurements is permitted. In the frequency domain, inductive responses may be characterized by dimensionless parameters of the form

$$\theta_f = \sigma\mu\omega L^2,$$

which demonstrates that scale changes of conductivity, frequency or (length)<sup>2</sup> are equivalent to one another. The analogous parameter for the time domain is

$$\theta_t = \sigma\mu L^2/t.$$

In interpreting frequency-domain data, it is common to compare observed frequency response data with dimensionless model response data. This is convenient because it avoids the necessity of rescaling the model data for all frequencies and physical scale lengths that might be encountered in the field cases. The same sort of scaling is possible with time-domain data, but only if the system function of the apparatus is a pure discontinuity response. If this is not the case, for instance when the apparatus has a characteristic ramp shut-off time, model response curves cannot be rescaled in time to match field data as this would imply rescaling the shut-off time to a value different from that used by the apparatus.

To ensure that time scaling can readily be applied to data that have been sampled and averaged over a time window, it is also necessary that the window widths be proportional to time after the discontinuity. UTEM has such sampling. It should be noted that time scaling may only be applied to UTEM anomalous responses which are short enough so as to have vanished in the interval between the two successive transitions of the step which form the square wave.

#### Data presentation

Because the field intensity falls off rapidly with increasing distance from the transmitter loop, it is often desirable to normalize the secondary field observations in some manner. One suitable normalizing factor is the primary vertical magnetic field signal ( $H_1^p$ ). If the positions of the transmitter loop and the receiver are known reasonably accurately, a calculated value of  $H_1^p$  may be employed. If the ground response vanishes by late time, the channel 1 measurement is a direct measure of  $H_1^p$ . Normal survey data plotting practice encompasses both procedures.

Figure 4 is an example of a standard plot of UTEM secondary vertical magnetic field data ( $H_1^s$ ). Channel 1 is plotted as secondary field ( $\text{Ch } 1 - H_1^s/H_1^p$ ) (where  $H_1^p$  is the calculated primary field) and all other channels are normalized to Ch 1 [ $(\text{Ch } n - \text{Ch } 1)/\text{Ch } 1$ ] to correct for any position error in calculation of  $H_1^p$  and also to remove the effect of induced magnetic anomalies (for further details see Lamontagne, 1975). The late channels on the example plot show a crossover type of anomaly, indicative of a concentration of (changing) induced current, as will be discussed. The amplitude variation with channel number indicates that these induced currents are decaying with

time. A small component of response appears to have persisted to Ch 1 and, for quantitative analysis, it should be remembered that the data reduction process will have caused subtraction of this amount from profiles of Ch 2-Chn. On the early-time channels, the migration of crossover location from one channel to another indicates that the secondary current flow at these times is not fixed in geometry, a characteristic which is indicative of an extensive conductor (here extensive overburden) rather than a localized conductor such as that responsible for the late time crossovers.

Since at any delay time, the secondary field is a potential field, interpretation of geometrically fixed current systems is best performed using absolute secondary fields normalized by the primary field intensity at a single point rather than continuously along the profile. Although only one case presented in this paper has this absolute or "point normalization," recent routine field practice is to point normalize all survey profiles exhibiting discrete anomalies, in order to simplify interpretation.

Horizontal magnetic field measurements may be made by

reorienting the receiver coil. Normalization is done using the vertical primary magnetic field (calculated or vertical Ch 1 measurement). Unfortunately, horizontal field measurements frequently suffer a somewhat higher noise level than vertical fields, due to the predominantly horizontal orientation of spheric interference.

The electric field waveform is, like the voltage from the coil sensor, a square wave if the ground is very resistive. It is distorted in much the same way as the coil signal when the ground is conductive. Electric field observations are usually plotted as  $E_i/E_T^p$ —the observed channel voltage between the electrodes divided by the maximum expected late time voltage between electrodes at the observation point in any horizontal direction, i.e.,  $E_T^p = (E_x^2 + E_y^2)^{1/2}$ . "Expected" here refers to the electric field produced by a loop on a laterally uniform, resistive half-space. This normalization facilitates intercomparison of x and y component data. The geologic noise level in electric field data is usually high, so plotting on expanded scales is rarely justified. All channel data are usually plotted on the same axes, as shown in Figure 5.

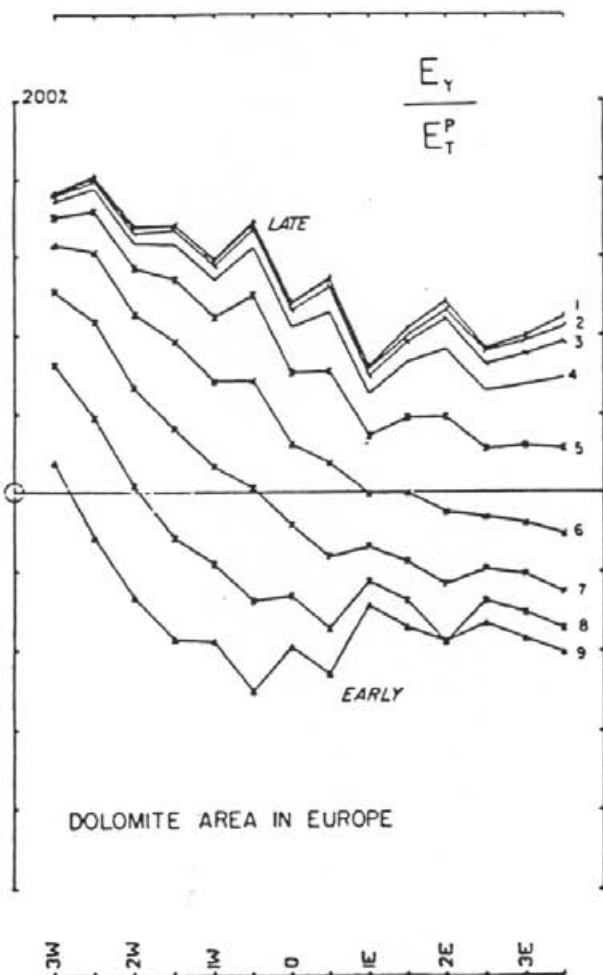


FIG. 5. Standard presentation of electric field data. The observed component is normalized to the total primary electric field of the transmitter loop.

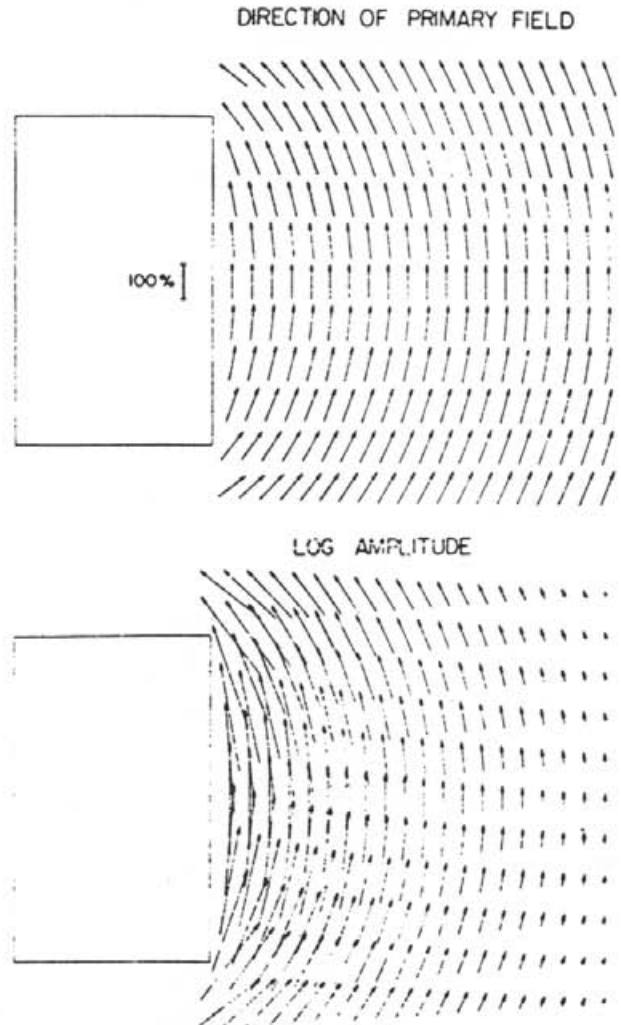


FIG. 6. Vector plots of late time electric field. (a) Direction information only. (b) Showing direction and intensity of the primary field.

The reference state for electric field data is usually described as a "laterally uniform, resistive half-space," rather than free space. By resistive is meant a case where all inductive transients have died out. The free-space electric field of a horizontal loop is horizontal, so introduction of a resistive half-space does not affect the field. However, for any other orientation of the transmitter loop or the earth-air interface, the free-space electric field will be directed across the interface and a strong distortion of the field will occur. Since the conductivity of air is virtually zero, the earth-air interface almost always has a high conductivity ratio, even if the earth is resistive in terms of induction. The charge which arises on the interface essentially doubles the vertical component of the  $E$  field in the air near the boundaries and annuls the vertical component in the ground. Thus the  $E$  field in the ground is (almost always) virtually horizontal. The nomenclature for the reference state serves to remind one that the earth-air interface has an important role in the physics of

the electric field and is always assumed to be present, but no lateral inhomogeneity or induction is permitted in the reference model.

The electric field of a heterogeneous, conductive earth does not normally become constant at late time, as the EM transients vanish. At the same time, the rate of change of magnetic field becomes constant. However, the observed late-time  $E$  limit is usually found to be different from the free-space or uniform resistive half-space value, due to lateral inhomogeneity of the earth's conductivity structure. The late-time electric field around a loop greatly resembles what might be seen in a gradient resistivity survey. The field weaves about, deflected around the more resistive areas and through the more conductive ones. A vector display of the late-time  $E$  field is an interesting reflection of the relative conductivity of various parts of the ground. It is impractical to plot the unnormalized  $E$  vectors, since the true field intensity falls off rapidly with increasing distance from the loop. The lengths of the plotted vectors are therefore proportioned to the normalized field of the loop, as for profile plots. Vector plots of the free-space field of a loop are shown in Figure 6. Examples of field data are given in the following section.

Errors caused by the presence of EM noise or by poor geometrical control are discussed for the magnetic ( $H$ ) field case in Lamontagne (1975). For the electric ( $E$ ) case, details of the measurement and sources of error are discussed in appendix G of Macnae (1981). As in the dc resistivity method, topographic features can seriously distort local electric fields, and local conductivity contrasts such as overburden patches and minor lithological changes can have quite large effects on the amplitude of measured  $E$  fields.

## INTERPRETATION

We shall describe briefly the responses from a number of simple geologic models and how these can be identified and interpreted.

### Layered earth responses

The problem of EM induction in a layered earth is very well treated in the literature, particularly for frequency-domain systems (e.g., Wait, 1962). Time-domain cases have also been studied for some specific problems, for example the infinite thin sheet was solved by Maxwell (1891) and the half-space response is discussed by Nabighian (1979). A general, layered earth solution for UTEM geometry and waveforms was given in Lamontagne (1975). Figure 7 shows three examples of computed responses for different layer conductivities. Figure 8 shows three examples of a thin layer at different depths. There are several common characteristics of layered earth responses. The shapes of the anomalous profiles are generally similar, becoming broader at later times. The migration of crossovers with time, with positive lobes toward the loop and negative lobes away from the loop, seems to indicate that the induced current system is migrating away from the loop. This is the type of behavior described by Nabighian (1979) as an expanding smoke ring.

If the UTEM system employed a magnetometer as receiver and a square current waveform in the transmitter, the smoke ring analogy would be exact, as the crossovers would indicate

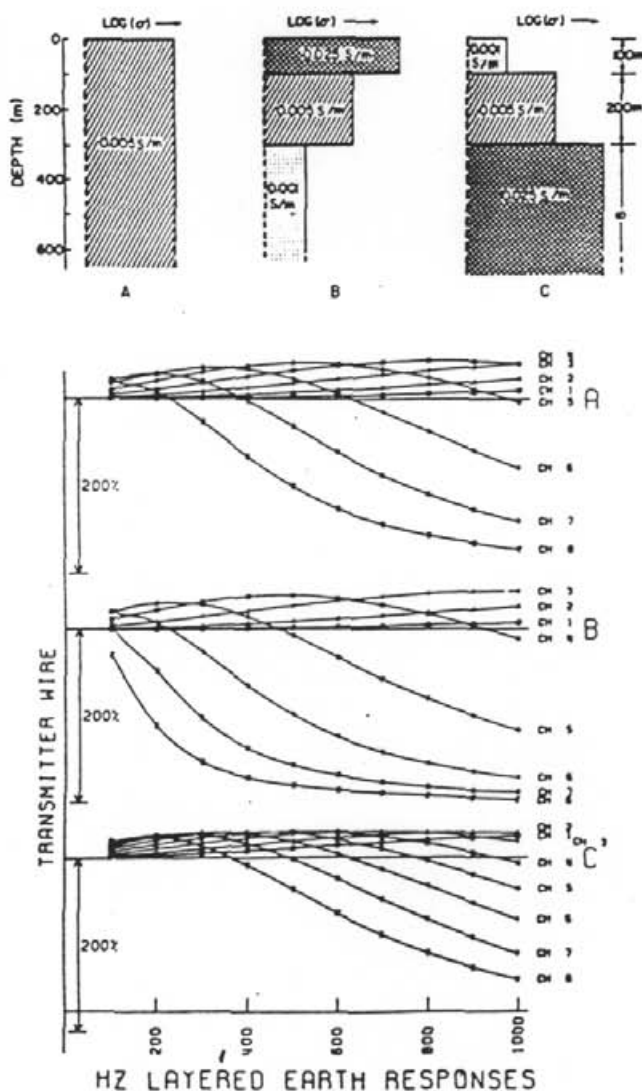


FIG. 7. UTEM layered earth response.

the position of the main current concentrations. However, the UTEM receiver is a coil which is sensitive only to  $dH/dt$ , and thus to the rate of change of induced and transmitter loop current. Thus the moving pattern of crossovers is actually indicating outward migration of changes in the induced current pattern. Toward the end of each half-cycle, the induced current system at any point in the survey area tends to a constant value, as indicated by the electric field measurements, but this steady current is invisible to the coil receiver.

When interpreting UTEM magnetic field data, it can often be simpler to think of the data in terms of the magnetometer receiver, square-wave transmitter current (MSW) analogy. Because the analogy is *exact* for a linear process like EM induction, there is no approximation in using it. It is very convenient to think of the field measurements of secondary signal at any delay time as describing the Biot-Savart magnetic field of a changing and decaying (analogous) induced current system. However, when electric field data are being analyzed and compared with magnetic field ( $dH/dt$ ) data, it is necessary to revert to the true picture of the induced currents (or take a time derivative of the  $E$  data) to maintain a consistent relationship. UTEM magnetic field data are usually symbolized as  $H_{zi}^p$  (alphabetic subscript = component direction, superscript =  $p$  primary,  $s$  secondary,  $T$  total, numeric subscript = channel number) to accord with the magnetometer analogy; and in most discussions of simple induction, it is the time history of the *analogous* induced current which is described.

An important feature of layered earth  $H_z^p$  data is the early-time limit of continuously normalized  $H_{zi}^p/H_z^p$  data. If the ground is sufficiently conductive near the surface, the early-time secondary field data at points remote from the transmitter loop will approach  $-200$  percent; i.e., one finds that the voltage in the receiver coil has had insufficient time to change from the steady value attained at the end of the previous half-cycle (Figure 2). This situation may be pictured in the magnetometer-square wave current analogy as an induced current system forming near the surface of the ground under the transmitter loop such as prevents the total (analogous) magnetic field from entering into the ground anywhere except very close to the transmitter wire. The  $-200$  percent anomaly thus represents response at the inductive limit.

#### Finite thin plate in free space

A convenient modeling method for thin finite plate conductors in free space is the integral equation solution of Annan (1974). Annan computed the best set of polynomial eigenpotentials of order 4, and used these to represent the induced current flow in the plate as a sum of 15 "eigencurrents." The solution for the eigencurrents themselves is quite complicated, but needs only to be done once for a plate of given width to length ratio. After that, any induced current system can be described in terms of 15 coefficients in the eigenpotential summation. The secondary field at a receiver can then be simply computed in terms of these induced eigencurrents. One great advantage of Annan's method is that each eigencurrent has a frequency or time-domain response identical to a simple loop circuit. Thus the solution for a broad frequency range or many time windows is very easy to calculate. Routines for simple, interactive application of Annan's algorithms to a number of EM systems have been programmed by Dyck (Dyck et al., 1980).

Examples of type curves generated with Annan's solution may be found in Lodha (1977) and Lamontagne et al. (1980). Figure 9 shows the results of a set of computed UTEM type curves for the geometry shown in Figure 10. Also shown in Figure 10 is the geometry of the primary magnetic field, which controls the nature of induction in the plate. For the zero dip case, the primary field is mostly perpendicular to the plate. The induction in the plate tends to cancel this field at early times, leading to a negative  $H_z$  anomaly directly over the plate. Positive shoulders on each side show the secondary magnetic field of the "forward (analogous) current" near the front edge of the plate nearest the loop and the "reverse current" near the rear edge. The normalization scheme used in plotting this data is to divide the total secondary field by the calculated primary field at the measuring point. It has the undesirable effect of making asymmetric a secondary anomaly that is symmetric in terms of absolute amplitude by increasing the relative amplitude away from the loop. In fact, the absolute secondary amplitude of the positive shoulder near the loop is usually larger than the one on the side away from the loop. As the dip of the plate is increased, the positive shoulder moves away, and by the time a 30-degree dip is reached the reverse crossover is off the end of the plotted line. From dips of 30 to 135 degrees, the anomaly maintains a basic shape in the form of a simple crossover. The amplitude

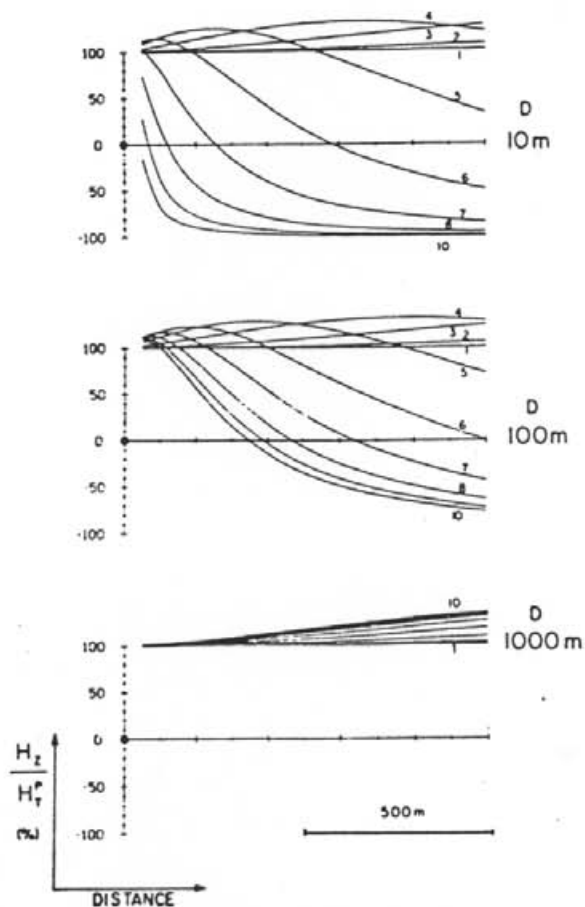


FIG. 8.  $H_z$  response of a thin horizontal sheet at various depths. The conductivity-thickness of the sheet is 2 S. The front of the transmitter loop is at the origin of coordinates.

does vary somewhat, however, being controlled by the primary field component normal to the plate which becomes a smaller and smaller fraction of the total field as the plate rotates from 30 to 150 degrees (Figure 10). The case at a dip of 150 degrees shows a very interesting behavior. The primary field can be seen to be *down* in the upper half of the plate and *up* in the lower half. The result of this is that the anomaly changes location and amplitude dramatically. For a very small plate, an anomaly could conceivably disappear completely. This phenomenon has been discussed by Bosschart (1964) for the Turam

method. For a large planar conductor, however, an anomaly is always present since a curving primary field must cut it somewhere, except in the special case when a vertical conductor is located directly under the center of a horizontal transmitting loop. The 165-degree dip case of Figure 9 shows a clear reverse crossover on the edge of the conductor far from the loop. The normal crossover is very small, due in part to the reduced induction at the near edge as shown in Figure 10, and also the large primary field used as a divisor for normalization.

The electric field anomaly generated by a plate conductor in

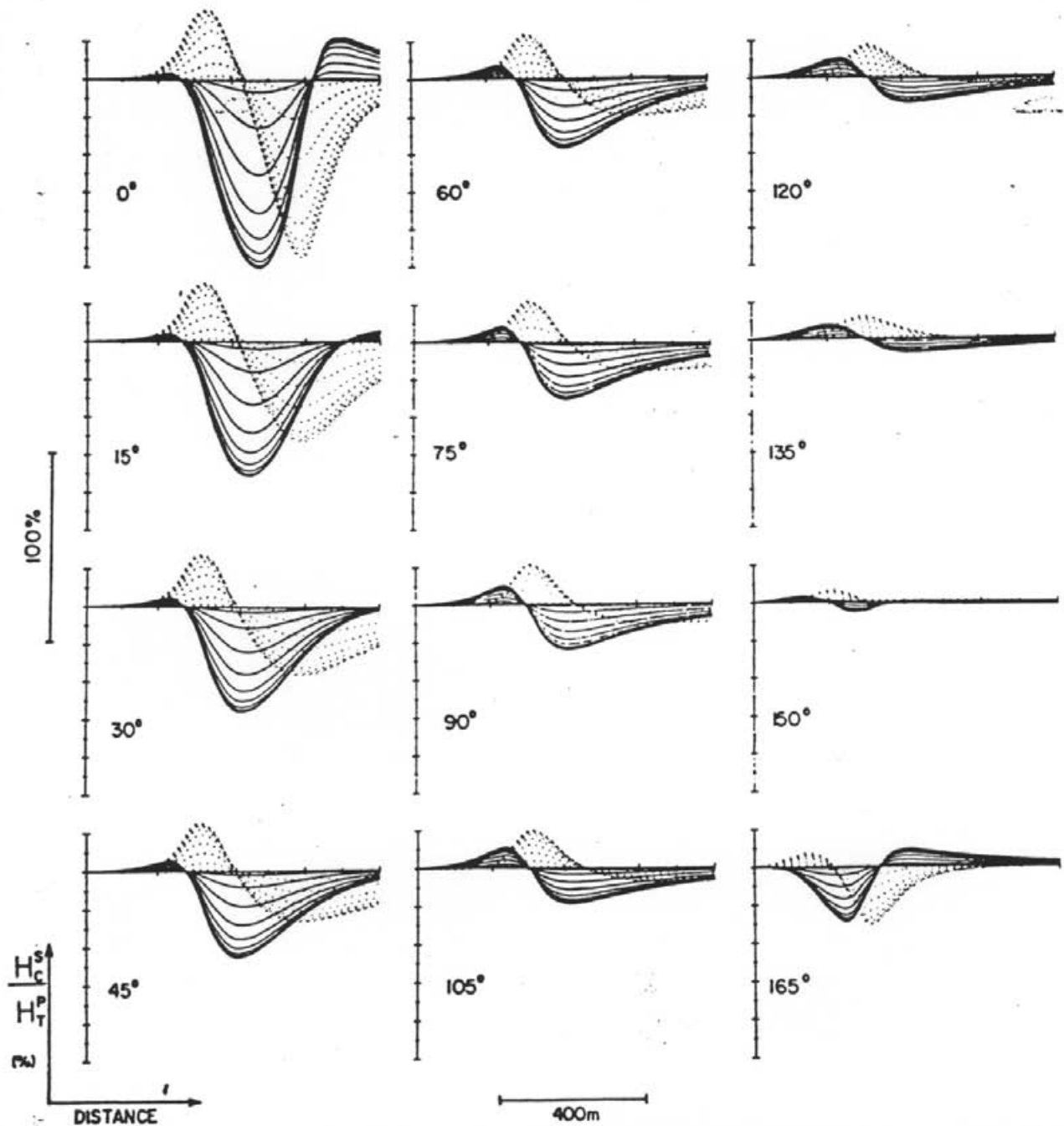
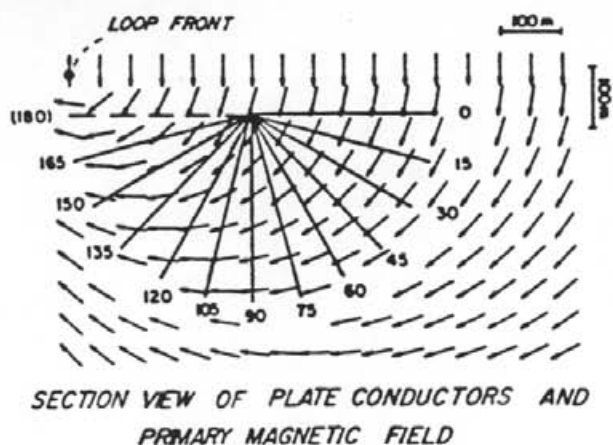


FIG. 9. UTEM  $H_z$  (solid) and  $H_z$  (dotted) profiles over a dipping plate (continuous normalization). (Geometry shown in Figure 10.)



GEOMETRY FOR 90° CASE

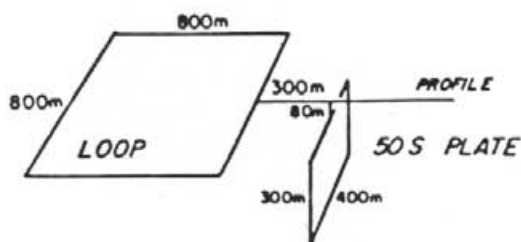


FIG. 10. Geometry and dimensions of the models shown in Figure 9. Also shown is the configuration of the primary field in the vicinity of the target conductor.

a resistive half-space is caused by charge on the plate as well as eddy currents flowing in it, and is affected by the earth-air interface. Annan's algorithm does not determine the charge distribution, so analog scale modeling methods were employed to produce type profiles. Figure 11 shows an example for a vertical plate. The longitudinal electric field is greatly reduced over the body at all times (i.e., there is a strong reduction in the late time limit). The dynamic (time-varying) part of the anomaly has the same time variation as the magnetic field but has a different geometrical pattern. The electric field is highly vulnerable to distortion by any conductivity contrast and the intensity of the static, late-limit anomaly over a conductor may therefore be reduced by any stratification between the conductor and the surface.

Other simple anomaly shapes

A set of simple schematic models is shown in Figure 12, for each of which the main features of the vertical magnetic field are sketched. The set of sketches was derived from quantitative scale model experiments by Lamontagne (1975). For the simple models illustrated where the host rock is completely non-conducting, the general anomaly shape for one body remains quite constant for the whole time range. The changes in anomaly from one channel to another are mostly in the amplitude and smoothness of the anomalies.

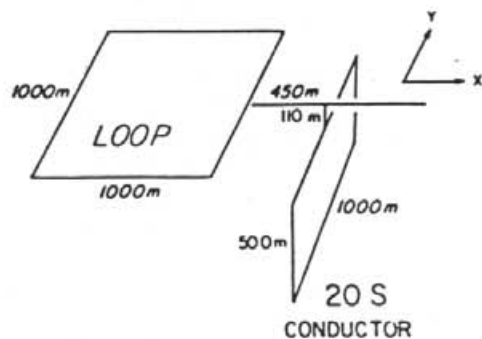
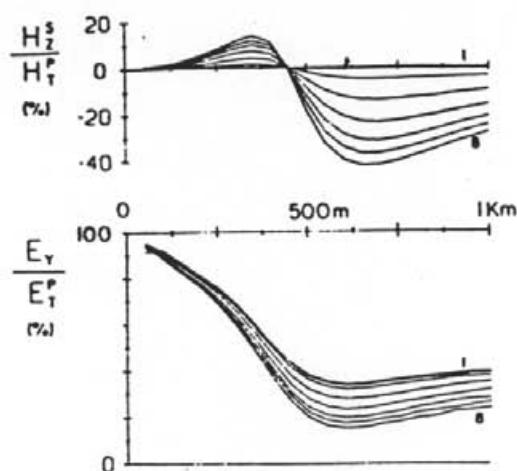


FIG. 11. Scale model UTEM secondary magnetic  $H_z^s$  and total electric  $E_y$  data over a vertical plate conductor.

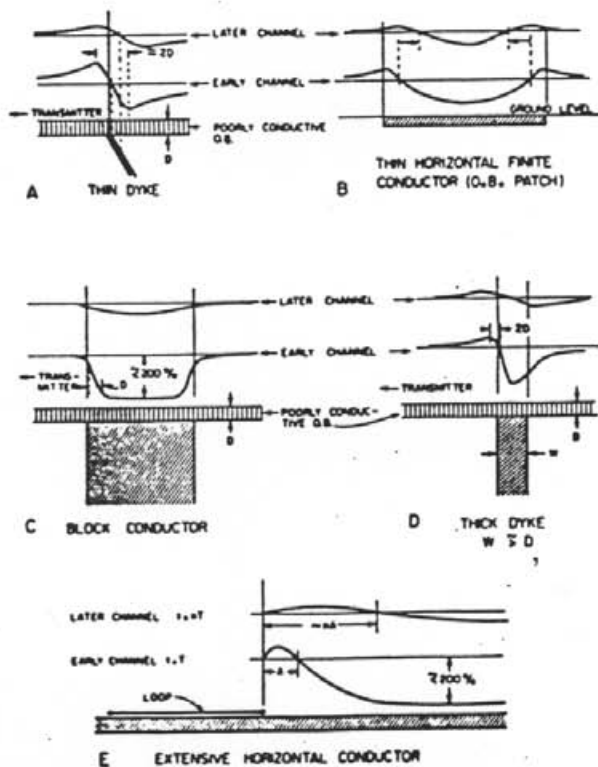


FIG. 12. The form of continuously normalized UTEM  $H_z^s$  anomalies over some simple shapes. All conductors are in free space.



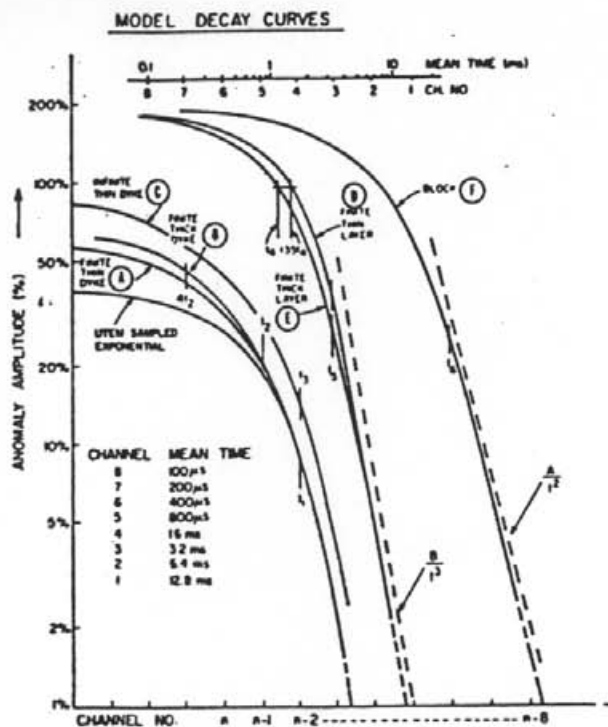


FIG. 13. The amplitude decay curves for the simple models of Figure 12. Mean sampling times are given for a base frequency of 30 Hz. The curve UTEM sampled exponential is a calculated function included for comparison. Lamontagne (1975) gives simple approximation formulas for interpreting target conductance from reference times  $t_1, \dots, t_6$  determined by translational curve matching.

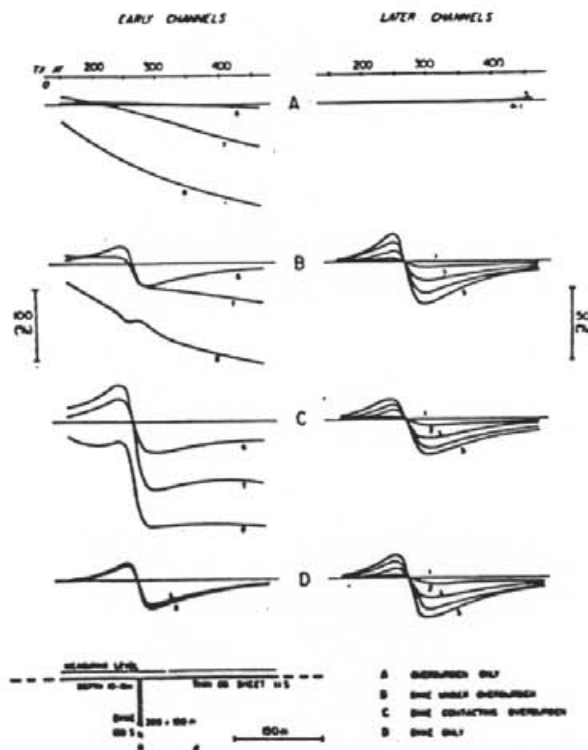


FIG. 14. Scale model UTEM  $H'$  profiles over a conductive thin dike with overburden present.

**Thin dike.**—A conductive, steeply dipping body gives an  $H'$  crossover shape similar to the plate model just discussed. The point where the anomaly changes sign indicates approximately the top edge of the conductor. The anomalies at later times tend to be broader and shifted slightly downdip from those at early times. The inductive decay rate of the anomalies will be discussed in a following section.

**Surface horizontal finite conductor.**—A thin horizontal conductor of limited dimensions (not extending under the loop) produces an anomaly consisting of a low over its central area, with large positive shoulders near its edge. The shoulders become rounded at later times and migrate towards the center of the conductor. Note that the thin horizontal plate shown in Figure 9 has a fairly deep location and thus the inward migration of the crossover points is less evident, although present.

**Shallow block conductor.**—This type of conductor produces a negative anomaly over its top having an amplitude of close to 200 percent at early times. An important characteristic of a block-like conductor is the absence of large positive flanking anomalies. The amplitude of the positive shoulders is less than 1/10 of the central negative, in contrast to the thin horizontal layer where the shoulders have amplitudes of order half the central negative. The sharpness of the crossovers at early time can be used as an indication of depth of burial. This type of anomaly is called a top anomaly and is due to a horizontal current pattern flowing around the top of the block.

**Thick dike.**—As might be expected, this is an intermediate case between a block and a thin dike where the width of a tabular body is of the same order as its depth of burial. In such cases the response is a combination of crossover and top anomaly due to vertical and horizontal current patterns, the top anomaly being more evident on the early-time channels and the crossover anomaly on later-time channels. The difference in decay rates results from the different scales of induced current flows, the top anomaly being controlled by the width of the dike, and the crossover by the depth extent.

**Extensive horizontal conductors.**—All the models with restricted lateral extent give rise to localized anomalies which simply change amplitude with time (approximately). The response of a very large conductor such as that shown in Figure 12e is included for comparison. In this case, the induced currents are not confined and they migrate horizontally with time.

**Time response of simple free-space models.**—Figure 13 shows example decay plots of log anomaly amplitude versus log time (channel number). The responses shown in Figure 13 are the UTEM sampled step responses that are only strictly valid for interpretation of actual field data when the observed anomalous response has effectively vanished at late times. Time scaling by lateral translation of the graphs is permitted for these cases, as previously discussed. The applicability of these time decays to interpretation is discussed by Lamontagne (1975), including the use of characteristic parameters to estimate conductance. A significant point to note is that simple induction in finite bodies eventually exhibits exponential decay at late time, whereas induction in infinite features takes the form of an inverse power law (Kaufman, 1978). Therefore, for models D, E, and F, the very late portion of the decay should ultimately show an exponential behavior if measured with sufficient sensitivity.

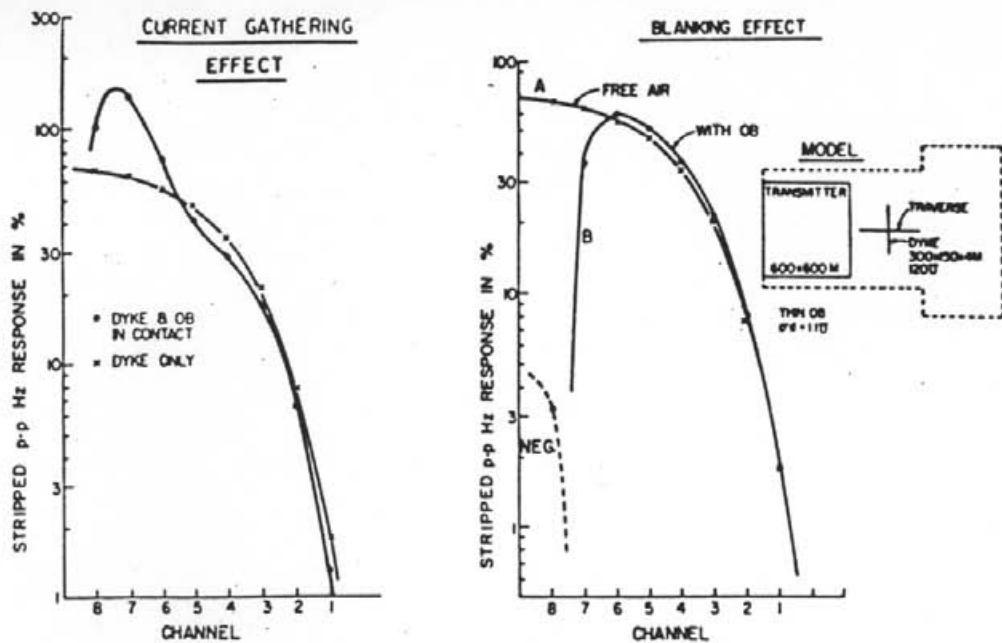


FIG. 15. Decay plots for the  $H_z$  anomalies of Figure 14.

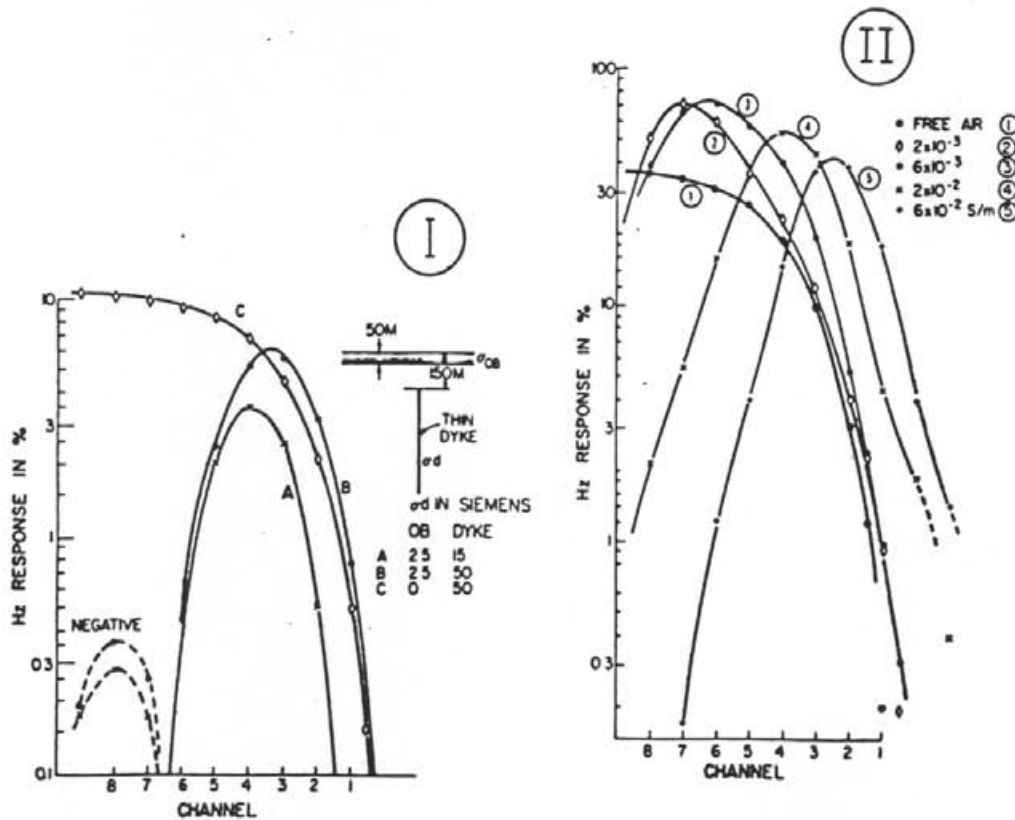


FIG. 16. Decay plots of  $H_z$  anomalies over a thin dike (I) under a conductive overburden and (II) in a conductive half-space.

## Overburden effects

We will restrict the discussion of overburden and host-rock effects to the case of a simple vertical finite dike conductive target, which was studied by Lamontagne (1975) using a scale model. Conductive overburden cover can modify the responses of underlying conductors in two main ways. Let us consider a dike target whose response in free space is given in Figure 14d. If overburden is now placed over this target conductor, the resultant response (Figure 14b) is not just the sum of the overburden and dike response. At early times it can be seen that there is very little response from the dike. This is because the magnetic field (MSW analogy) has not yet penetrated the overburden, and it leads to the name "overburden blanking" for this characteristic. At later times (Ch 6-1), when we can see from Figure 14a that the field has completely penetrated the overburden layer, the dike and overburden response (14b) is virtually indistinguishable from that of the dike alone (14d). The time decay pattern of the peak-to-peak amplitude of the crossover is plotted in Figure 15. It clearly shows the blanking effect of the overburden at early times (right-hand figure). The minute negative response at earliest time is present only when the

overburden extends under the loop, and appears to result from the complicated way in which the field first reaches the hidden target.

A second effect occurs when the dike is in conductive contact with the overburden. The results are quite different from those where the dike was not in contact (Figure 14c). In this case, regionally induced (analogous) current flow in the overburden has been "gathered" or "channeled" into the dike which is of higher conductivity. This accounts for the large-amplitude crossover anomalies at early times. Because the conductance of the dike greatly exceeds that of the overburden, the amount of current gathering is virtually independent of the dike's depth extent. The gathering effect at early times of just a "line conductor" remaining attached to the overburden after most of the dike was removed was found to be over 80 percent of that of the complete dike. At later times, when the (analogous) current flow in the overburden has migrated away (i.e., the real overburden current is no longer time-varying), the response is again almost identical to that of the dike alone. The time decay of the response is plotted on Figure 15, and in addition to the enhancement at early times a slight attenuation of the response at intermediate times can be seen.

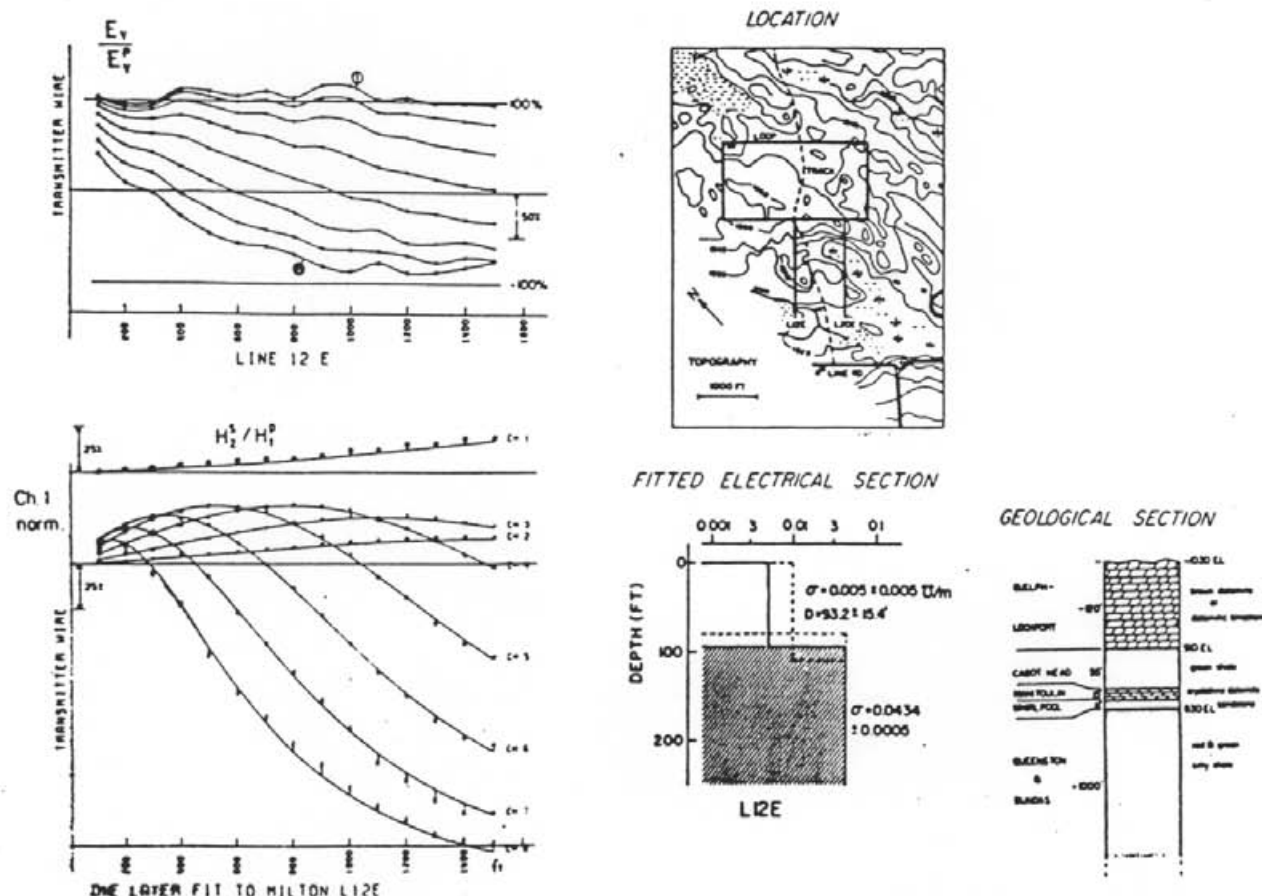


FIG. 17. Field example of  $E_v$  and  $H_z^2$  data from a well-stratified earth. The electrical section was obtained from inversion of the  $H_z^2$  data. The curves on the  $H_z^2$  graph are the theoretical model; the points are the field data. The bottom axis is at -150 percent. The geologic section is from nearby gas drilling exploration.

Host rock effects

Figure 16 II shows the time variation in response of a 60 S vertical plate located in a half-space. The results were calculated by Lamontagne (1975) by Fourier transformation of the frequency-domain numerical modeling of Lajoie and West (1976). At early times the response is reduced from the free-air response: this corresponds to blanking by the conductive region above the target. At later times the response is enhanced indicating that the regional (analogous) current in the host rock is being gathered into the plate at these times. For poorly conducting host rock, the response at late times is close enough to the free-space response that simple interpretation of the target using a plate in free-space model is valid. For the higher host conductivities (case 4, 5) this is no longer the case.

FIELD RESULTS

Milton, Ontario

This area was surveyed to demonstrate what data from a conductive, well-stratified earth looks like. The area is one where 650 m of flat-lying Paleozoic sediments overlie the Precambrian basement. The predominant member of the stratigraphy is a uniform and thick sequence of shale. Other beds are mostly resistive calcareous and sandstone formations. The survey area is covered by a mixed forest and marshy streams, with occasional outcrops. The top of the bedrock is a dolomite formation which is everywhere more than 20 m thick. Topographic relief is minor (< 10 m), with occasional rough spots near outcrop. Overburden is probably less than 10 m every-

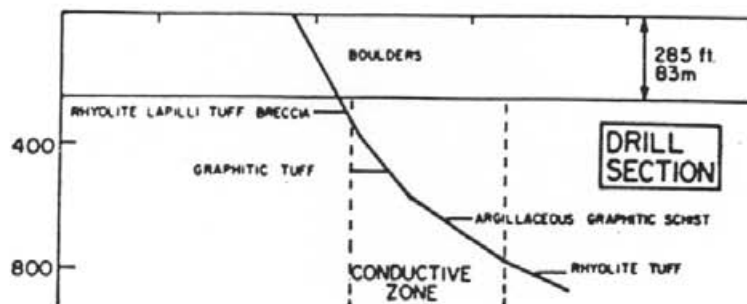
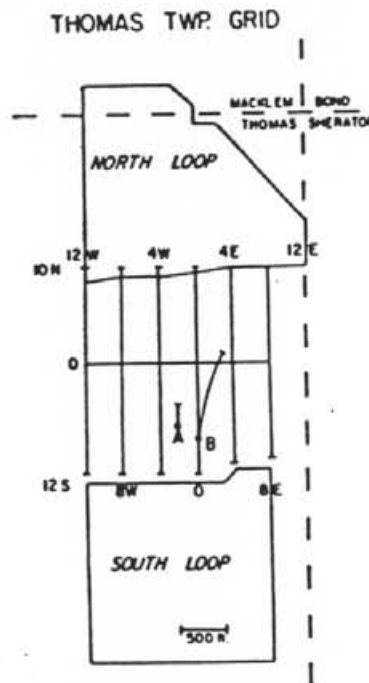
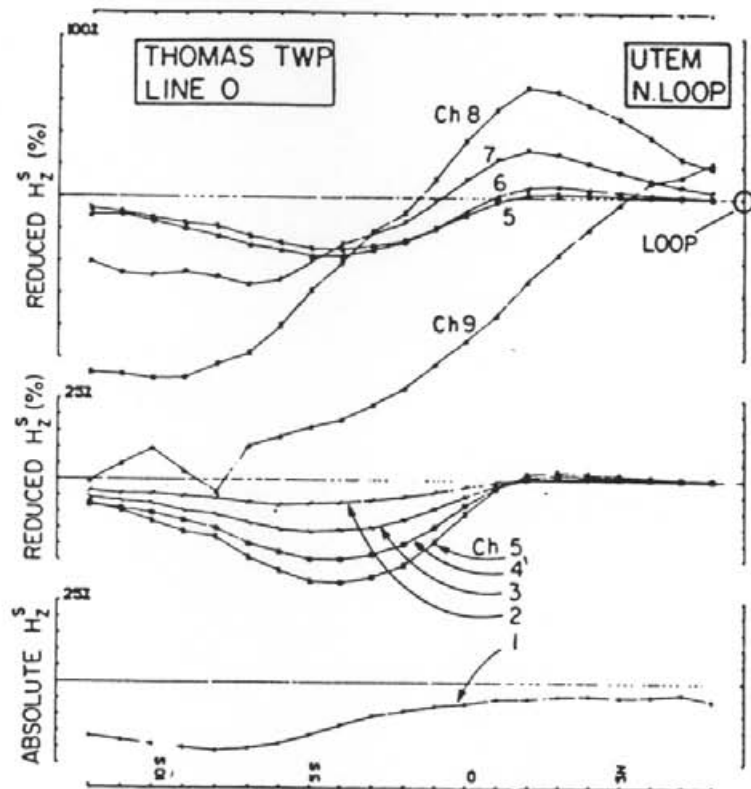


FIG. 18. A profile of  $H_z^s$  data from the north transmitter loop across the Thomas Twp test site. A map of the survey is included (different scale).

where and much less on average. It is mostly humus or thin glacial soil. Surface water is fresh, and likely quite resistive ( $> 100 \Omega\text{m}$ ). Figure 17 shows some of the data with a layer and half-space model fitted to it by iterative minimization of squared error. Also shown is a stratigraphic section from a well a few kilometers distant. The dolomite layer is too resistive for its conductivity to be determined by data whose earliest time sample is at  $100 \mu\text{s}$ . (The survey was done with UTEM I.) At first glance, the data look just like that for any conductive earth, as the early-time data at the end of profiles have the usual strong negative anomaly, and there is a regular outward progression of crossovers as time progresses (decreasing channel number). However, the resistive surface layer does reveal itself in the limited approach of the early time curves to  $-200$  percent anomaly. The convergence of  $E_z$  at late time to 100 percent of the primary field confirms the excellent lateral homogeneity of the site.

#### Thomas Township, Northern Ontario

This site has become an interesting test range for electrical methods, and a new grid has been cut and named the Night-hawk Lake geophysical test range. It is a graphitic zone that has many of the geometrical and electrical characteristics of a massive sulfide body. It is covered by 83 m of only moderately conductive overburden. It was found originally by airborne EM and has been intersected by two boreholes.

A UTEM II survey with 30 Hz base frequency was carried out on 6 lines of length 2200 ft and spacing 400 ft using transmitter loops to the north and south of the grid. Figure 18 shows a profile across the middle of the conductive zone.

At  $50 \mu\text{s}$  (Ch 9), the regionally induced (analogous) current is only 500 ft from the loop. The field has not penetrated the overburden at the target site. From  $100 \mu\text{s}$  to about  $500 \mu\text{s}$  (Ch 8-6), a crossover response is observed over the target. At about

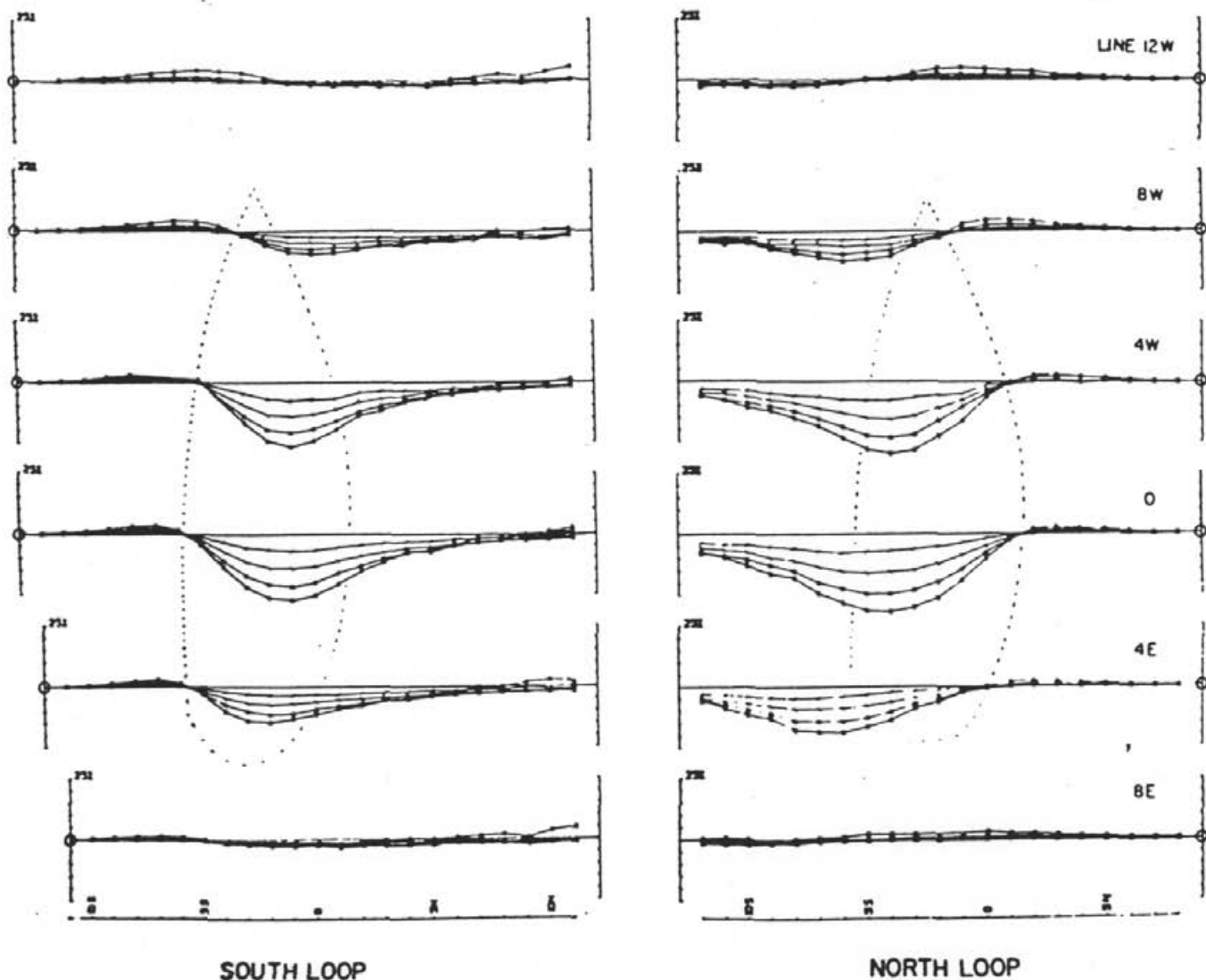


FIG. 19. Later time  $H_z$  profiles (Ch 5-2) outline the perimeter of the conductor.

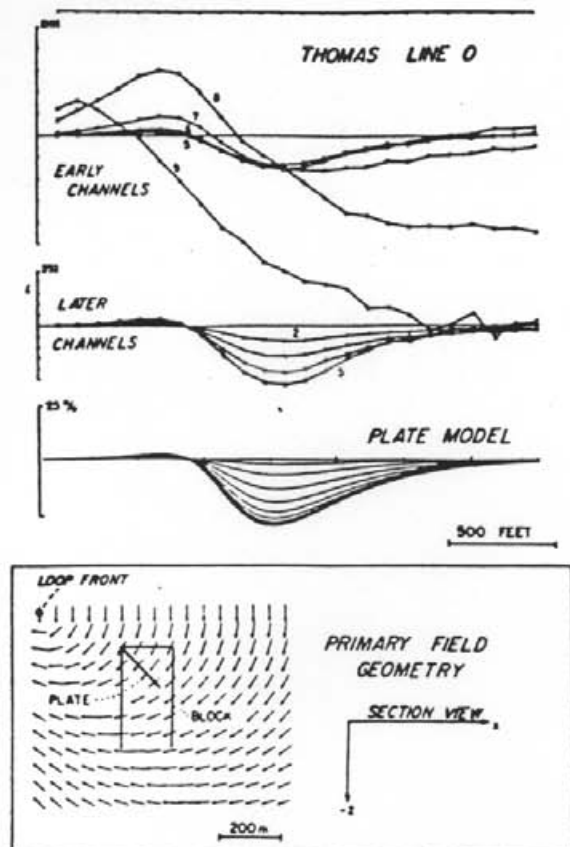


FIG. 20. Comparison of  $H_z$  data from the south transmitter loop with a free-space plate model. The configuration of the primary field is also shown.

500  $\mu$ s the response changes to an asymmetric negative anomaly which decays much more slowly than the crossover response. The early-time crossover response is a current gathering or channeling anomaly where the (analogous) anomalous current flows along the length of the zone, while the longer time constant response is a local induction anomaly, where induced currents flow in a vortex within the target conductor.

Figure 19 shows a map of all the late-time profiles. They clearly delineate the edge of the target body. Figure 20 shows how a rectangular plate model can be found which models the observed results from one transmitter loop quite accurately, but which has to be rotated in order to match the results from the other loop. The late-time induced (analogous) current system in the actual conductor appears to be a tightly defined normal current in the front upper (near-loop) edge of the conductor with a more diffuse, return current deep in the rear of the body. A survey with the transmitter loop located on the other side of the body was similarly fitted by a plate dipping away from that loop, indicating the conductor to be a thick zone in which currents can flow in a variety of directions.

Electric fields were measured at the Thomas site. The late time vector map is shown in Figure 21, along with a rough numerical model. The conductive zone shows very clearly, although its edge is ill defined. Figure 22 shows a profile of the longitudinal component of electric field over the body. The field

intensity is almost constant from channel 6 onward, and the main feature of the response is the aforementioned broad reduction in the field strength over the conductor. It is helpful, when looking at  $E$  field profiles, to imagine a plot on the same axes of the negative of the observed channel 1 response. This is the value the field starts from at the half-cycle transition. Even as early as 50  $\mu$ s (Ch 9), the electric field has made most of its polarity reversal. In fact, between the loop to the target body it has overshoot, while from the target body outwards it is changing relatively slowly. The time changes in  $E$  are actually very similar to those in  $H$ . There are two dominant decay times, a short one corresponding to the overburden and the channeling target response (Ch 8-6) and a long one corresponding to the local induction response (Ch 5-1). Also, these two  $E$ -field responses have a different geometrical form corresponding with the different forms of the magnetic anomalies. The scaled up version of the  $E$  data in Figure 22 shows the slowly decaying anomaly. Considerable noise is apparent in the data at this magnification.

#### Bedrock conductor beneath overburden

Figure 23 shows the measured secondary  $H_z$  fields at a site in Australia. The slow outward migration of the early-time channels and the -200 percent early-time limit away from the transmitter loop are characteristics of the response of a near-surface conductive weathered layer. This layer has a total conductance of about 4 S.

Around station 210W a more local superimposed crossover anomaly is evident which is fixed in location. This feature is evident over a great strike length. When the visually estimated overburden response is stripped from the anomaly and the peak-to-peak crossover response is plotted on a decay plot (Figure 26), the characteristics of early time blanking, time delay, and enhancement are clearly displayed. Corresponding to the model data of Figure 16, the early time blanking attenuates the local anomaly as the (analogous) magnetic field has not had time to penetrate the weathered layer. At intermediate times (Ch 5, 4) the response lies above a fitted free-space, half-plane conductor decay curve. This is partly an amplitude enhancement from current gathering and partly due to a small delay in time while the (analogous) magnetic field penetrates the near-surface conductor. It is not clear whether any of the L400S response can be identified as due to local induction. Nevertheless, the plotted induction curve for a half-plane in free space serves as a useful reference and establishes an upper limit on the conductance of the feature (7S in this case).

On two survey lines about 1 km away, the same local feature is observed, but the response has changed to one of longer time constant. As shown in Figure 24, a clear response persists through channels 2 and 1. These data are replotted with "point normalization" on Figure 25 to show the absolute secondary field. Absolute normalization preserves the true anomaly shape, but has the disadvantage of scaling up strongly those anomalies which lie near the transmitter. The stripped peak-to-peak response is plotted in decay form in Figure 26 and clearly shows the difference in time constant at the two locations.

The increase in time constant seen on line 600N is very significant, since little change is seen in the background response and only a lesser change in the blanking time. It indicates that the L600N late-time response is due to local induc-

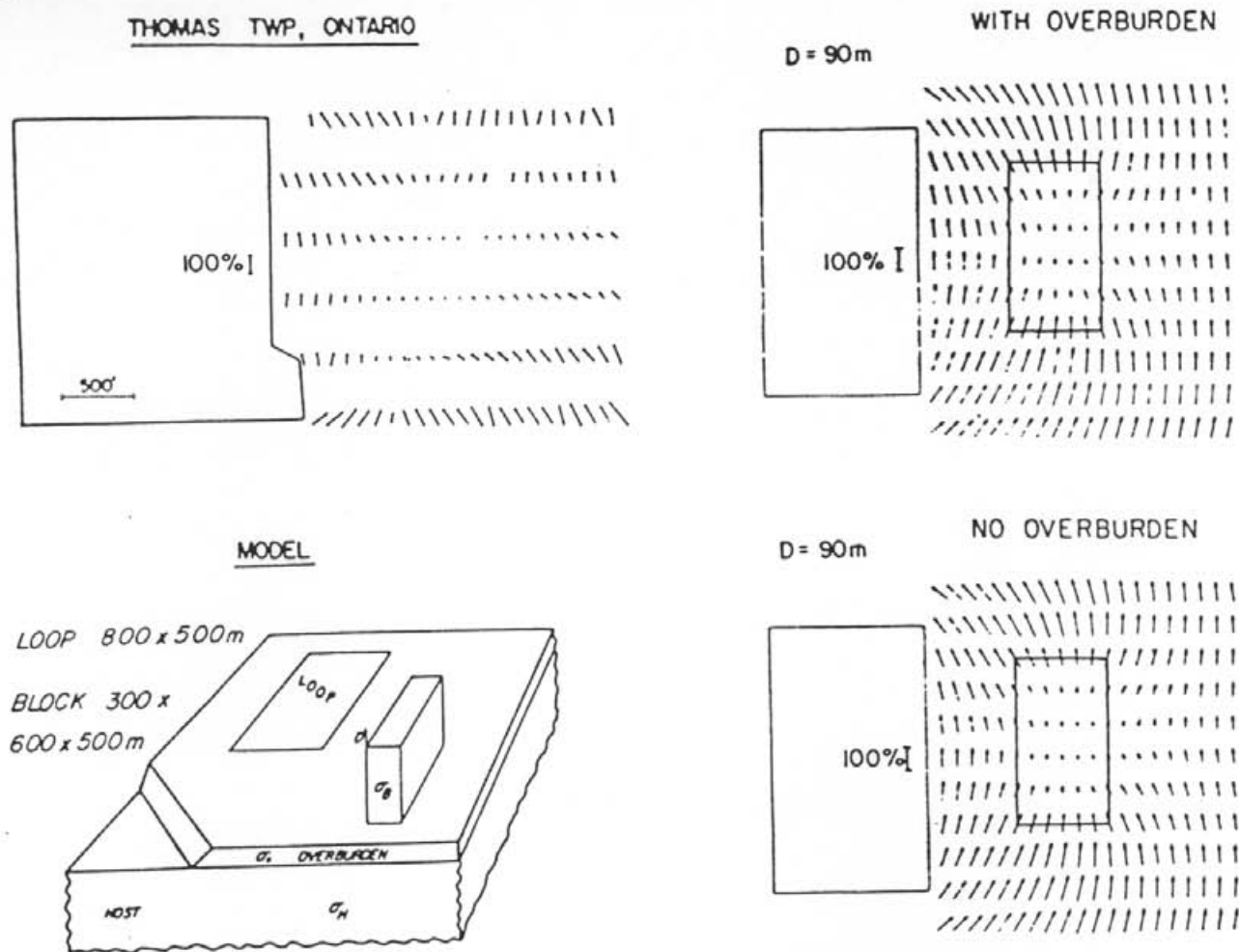


FIG. 21. Vector map of the late-time  $E$  field at Thomas Twp. A block model is included for comparison. The example is for a case where  $\sigma_B \gg \sigma_O \gg \sigma_H \gg \sigma_{AIR}$ .

tion. Model fitting of the decay, taking into account the limited strike extent of the long time constant response, leads to an interpretation of this feature as a local thickening of the half-plane conductor. The local conductance needed to produce the longer time constant is 120 S in contrast to the 7 S maximum of the rest of the bedrock conductor.

Drilling indicated that the extensive conductor was a 50 m thick calc-silicate zone containing both carbonates and sulfide lenses within a talc-sericite host. The locally more conductive part consisted chiefly of nearly massive noneconomic sulfides.

#### CONCLUSIONS

Experience with UTEM demonstrates that a wideband, time-domain EM system which measures the step response of the ground is electronically feasible and practical. Considerable field and modeling experience has shown that it is simple to use the amplitude information from such a system to aid significantly in interpretation. In our opinion the step response has a

significant advantage over the impulse response for detection and interpretation of good conductors in the presence of poorer ones. Electric field data measured with the system can provide independent information about lateral conductivity contrasts and may be a useful aid in interpretation.

#### ACKNOWLEDGMENTS

Development of the UTEM system and its interpretational capability was funded from a number of sources. UTEM I was developed with support from the National Research Council of Canada. UTEM II instrumentation was supported by UMEX Ltd., Texasgulf Inc., and Cominco Ltd., with interpretational studies funded by a consortium of companies consisting of Aquitaine, Asarco, Cominco, Geotrex, Gulf Minerals, Inco, Newmont, Noranda, Phelps Dodge, Selco, Shell Canada Resources, Texasgulf, and Umex. Graduate students, Y. Lamonagne, G. Lodha, J. Macnae, and M. Vallée, who worked on the project received stipendary and computing support from the

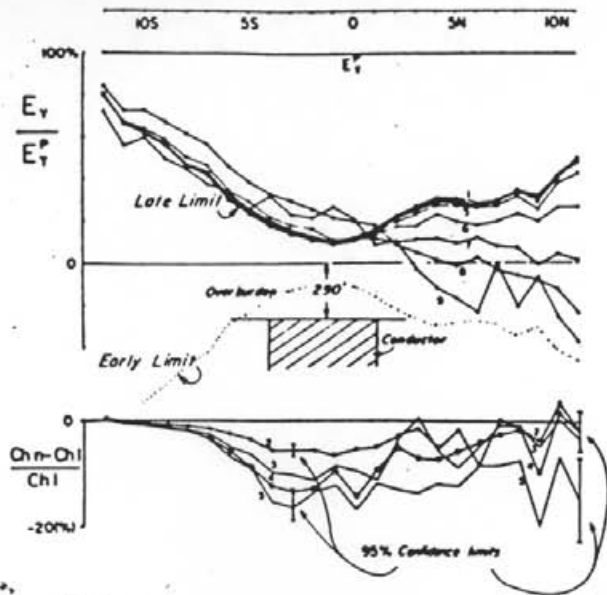


FIG. 22. Thomas Twp  $E_y$  data for line 0 from the south transmitter loop. The expanded scale data on the lower axes show that a very weak dynamic  $E$  field anomaly is associated with the main  $H_z^t$  late time response (Ch 5-1).

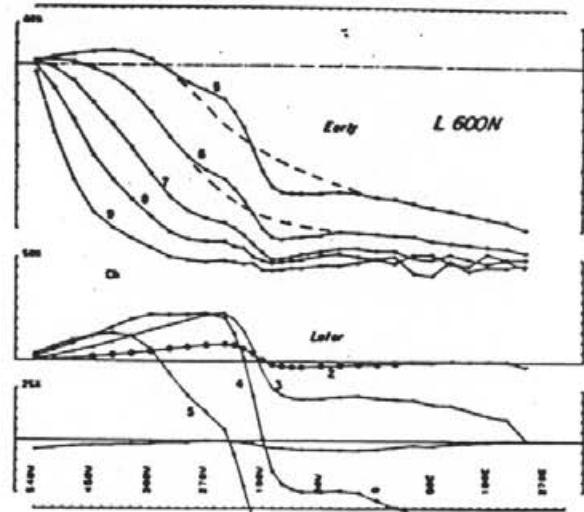


FIG. 24.  $H_z^t$  data on line 600N 1 km away from the previous figure showing a time decay of the local anomaly lasting to much later times. Re-measurement of the profile at 13 Hz gave virtually identical profiles (shifted one channel) with no visible Ch 1 anomaly.

Natural Sciences and Engineering Research Council of Canada and the University of Toronto. All this assistance is gratefully acknowledged. We also thank an anonymous reviewer for a very careful, helpful review.

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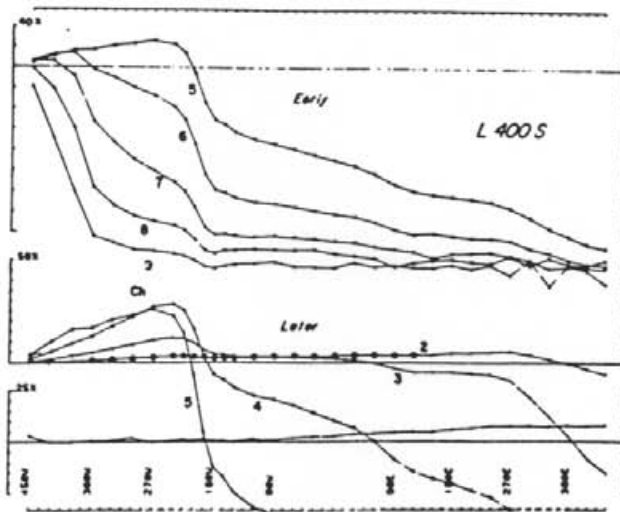


FIG. 23.  $H_z^t$  data from New South Wales showing the migrating crossovers of the overburden near the loop and a local anomaly around station 210 W. (Survey frequency 26 Hz.)

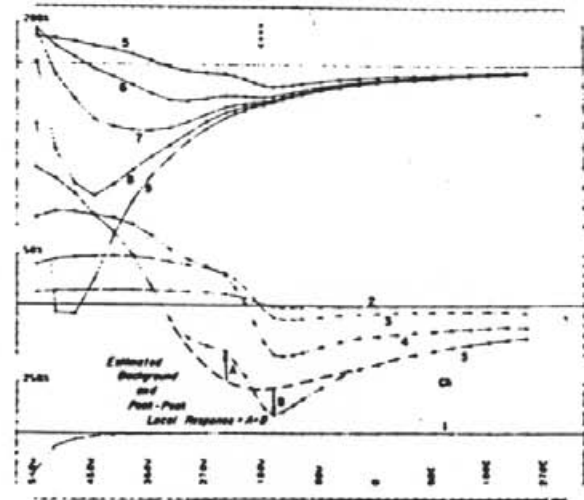


FIG. 25. Point normalized  $H_z^t$  from line 600N. The local secondary fields have been normalized to the constant primary field at station 210W and show how stripped peak-to-peak local anomaly amplitude is estimated.



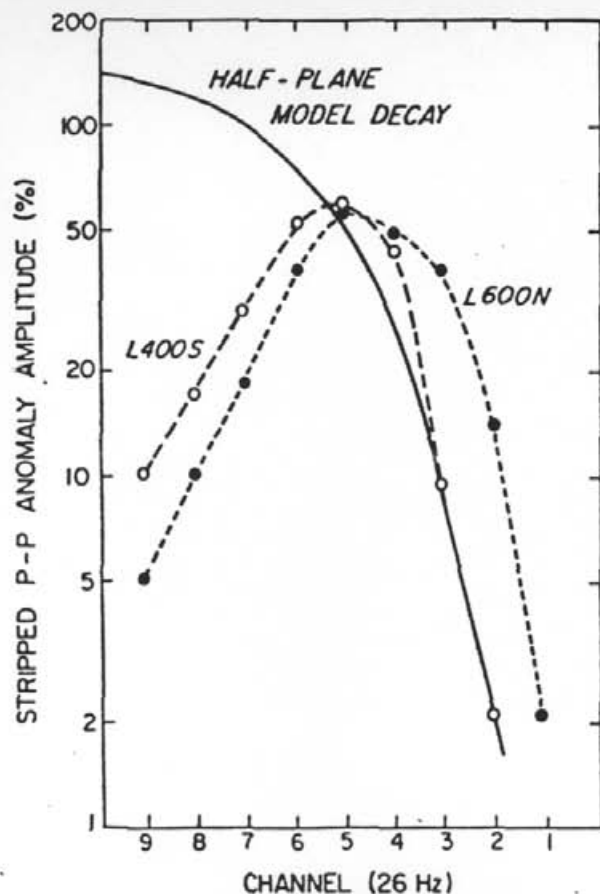


FIG. 26. Amplitude decay plot of stripped anomaly on lines 400S and 600N of the New South Wales survey.

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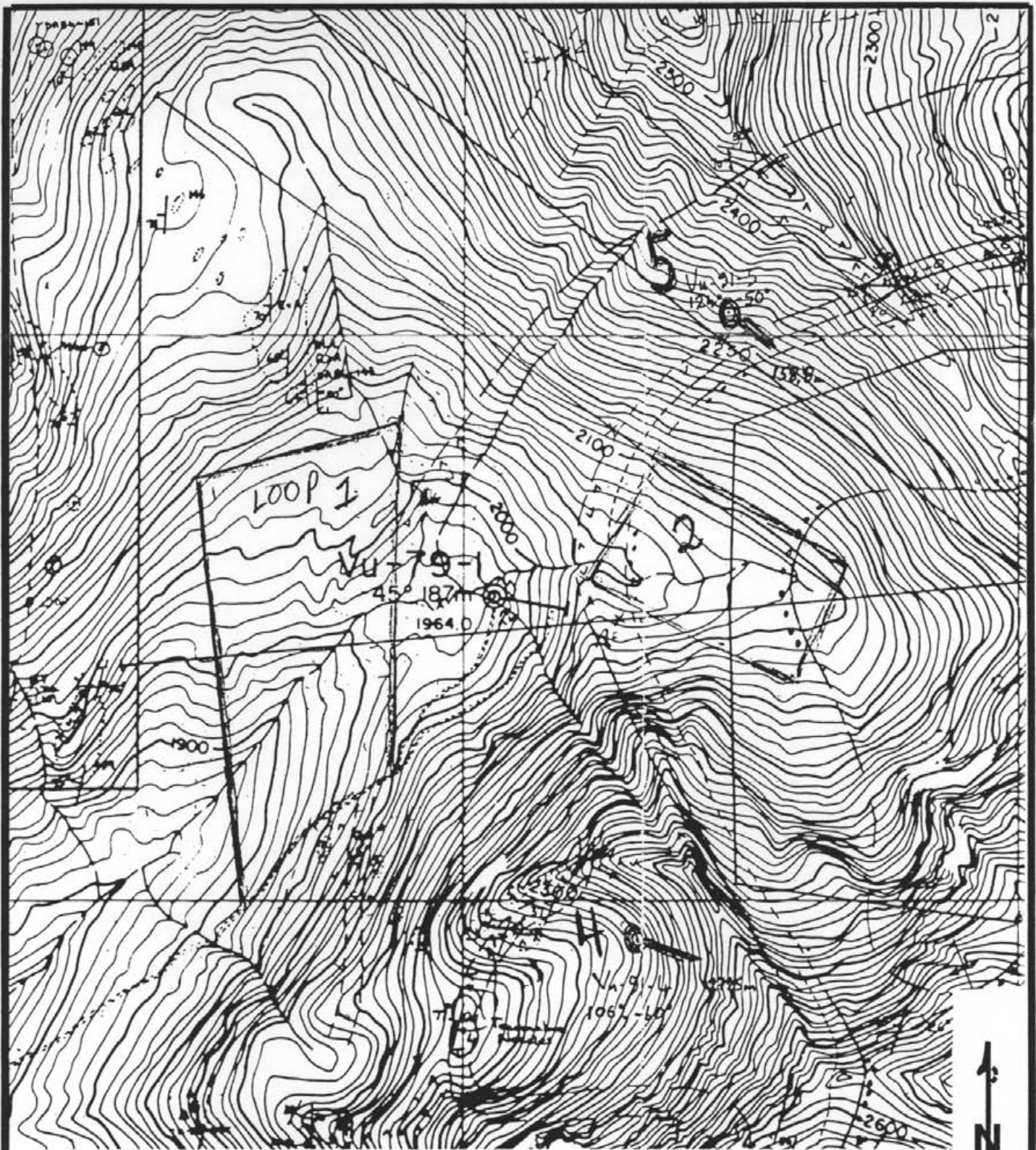
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APPENDIX IV



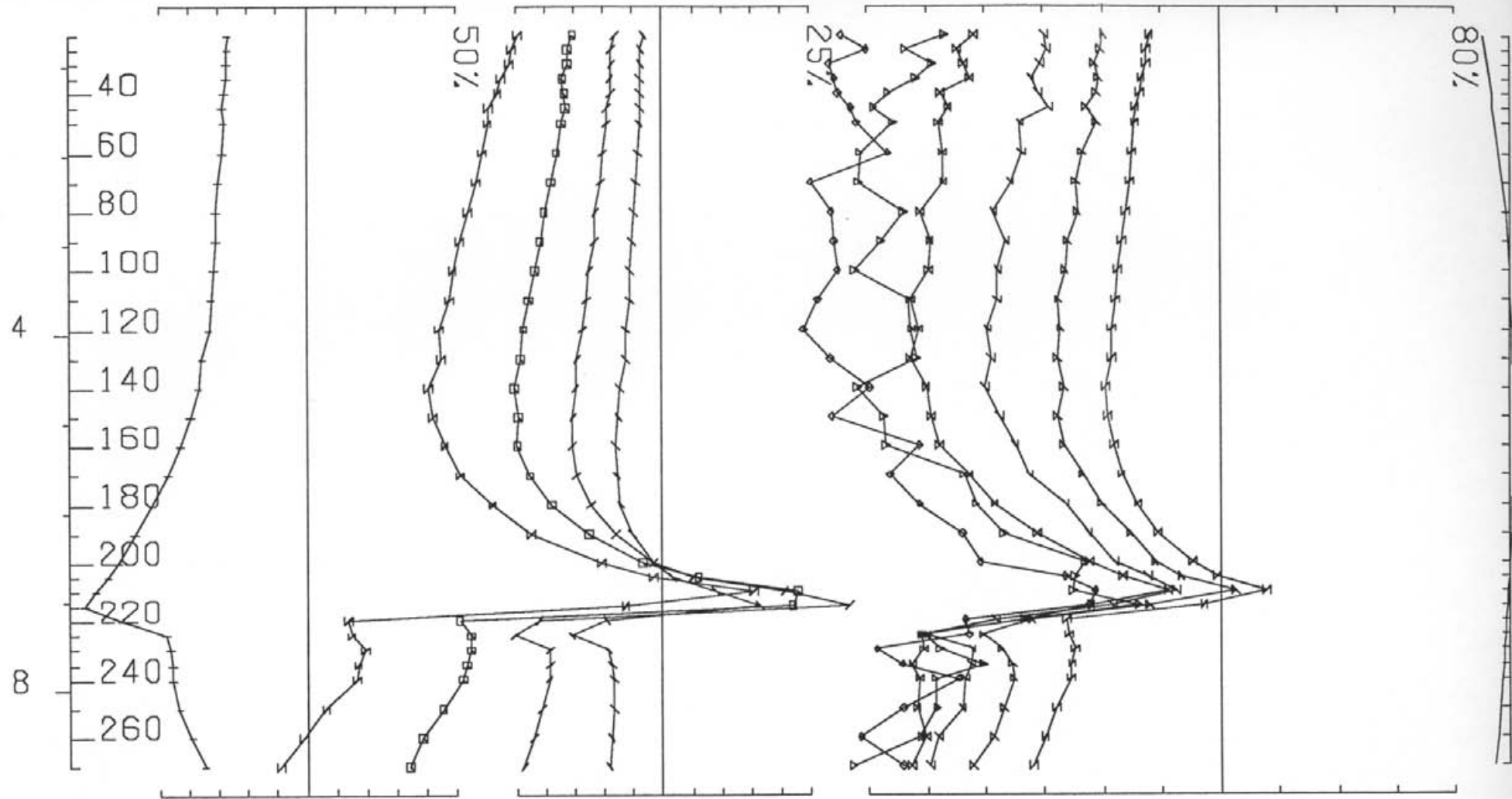
SCALE 1:10,000

NTS : 82F/16W  
FORT STEELE M.D. B.C.

# VULCAN PROPERTY LOOP LOCATION MAP

NOV. 1991

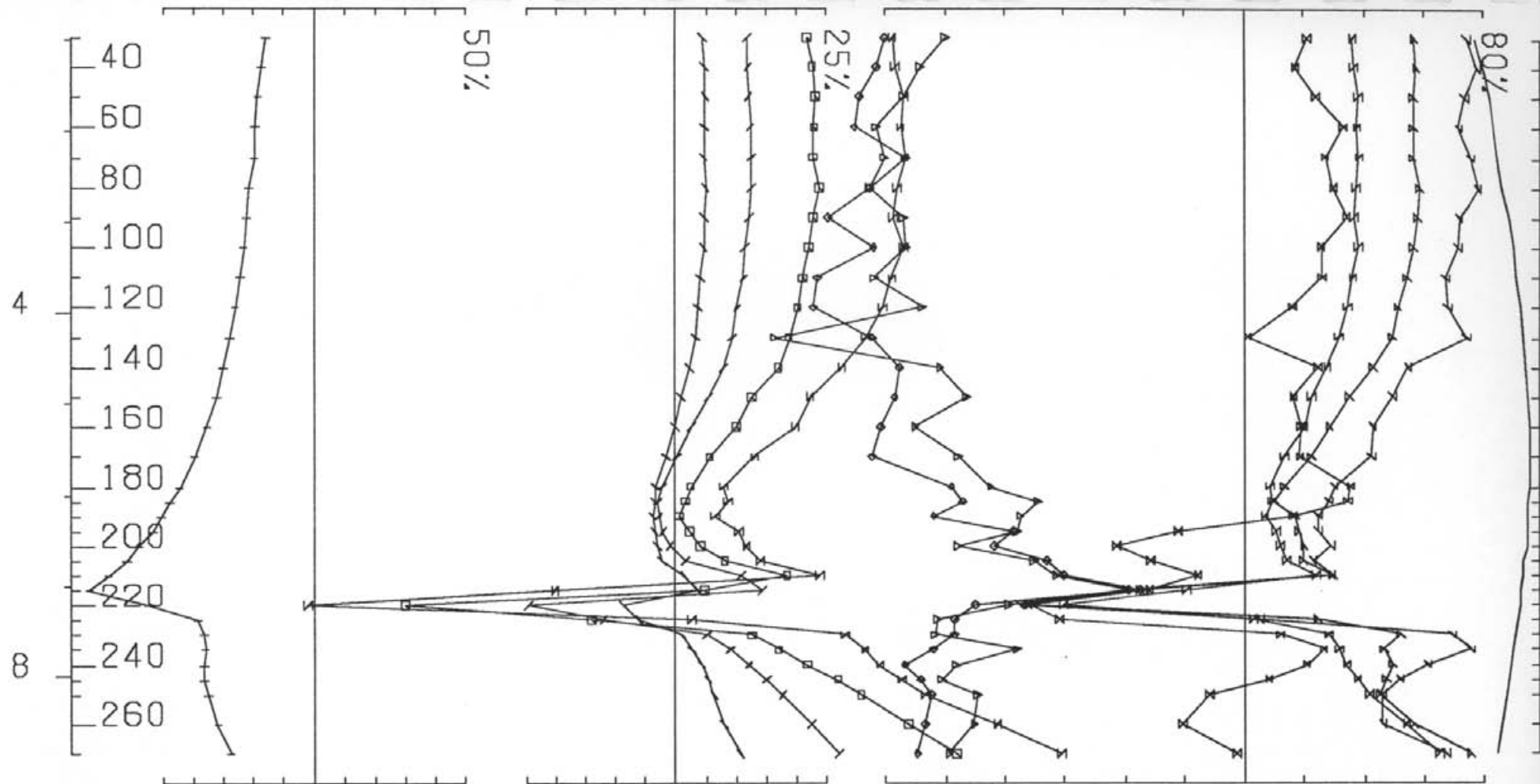
MAP-1



UTEM SURVEY AT VULCAN FOR KEEWATIN ENGINEERING INC.

CONDUCTED BY SJ GEOPHYSICS LTD. JOB 1 BASE FREQ (HZ) 30.97

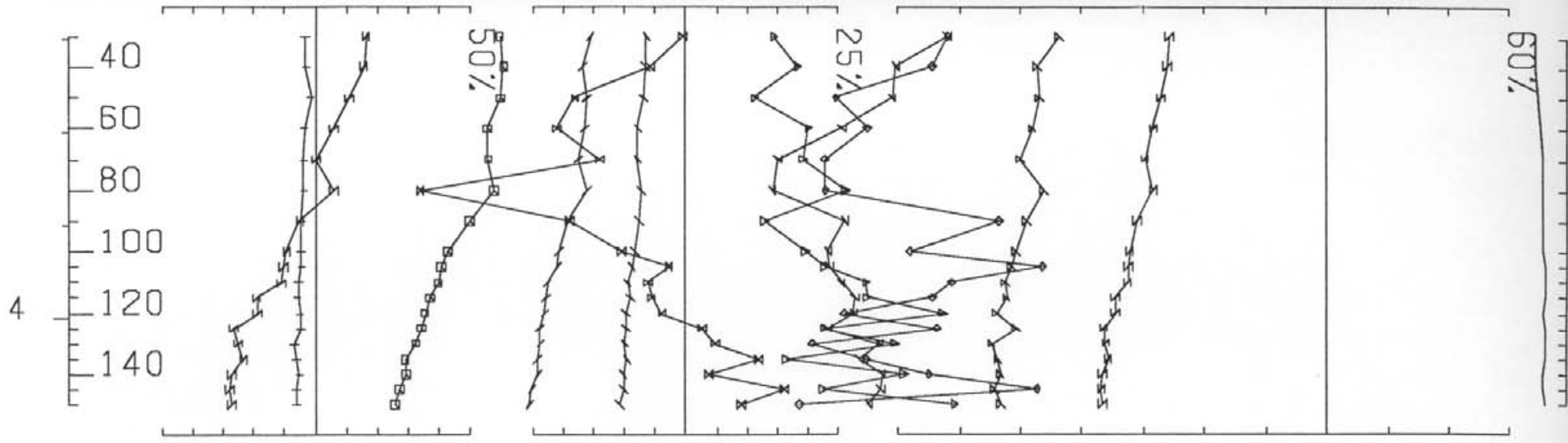
LOOP NO 41 HOLE 4 AXIAL COMPONENT SECONDARY FIELD CH1 CONTIN. NORM.



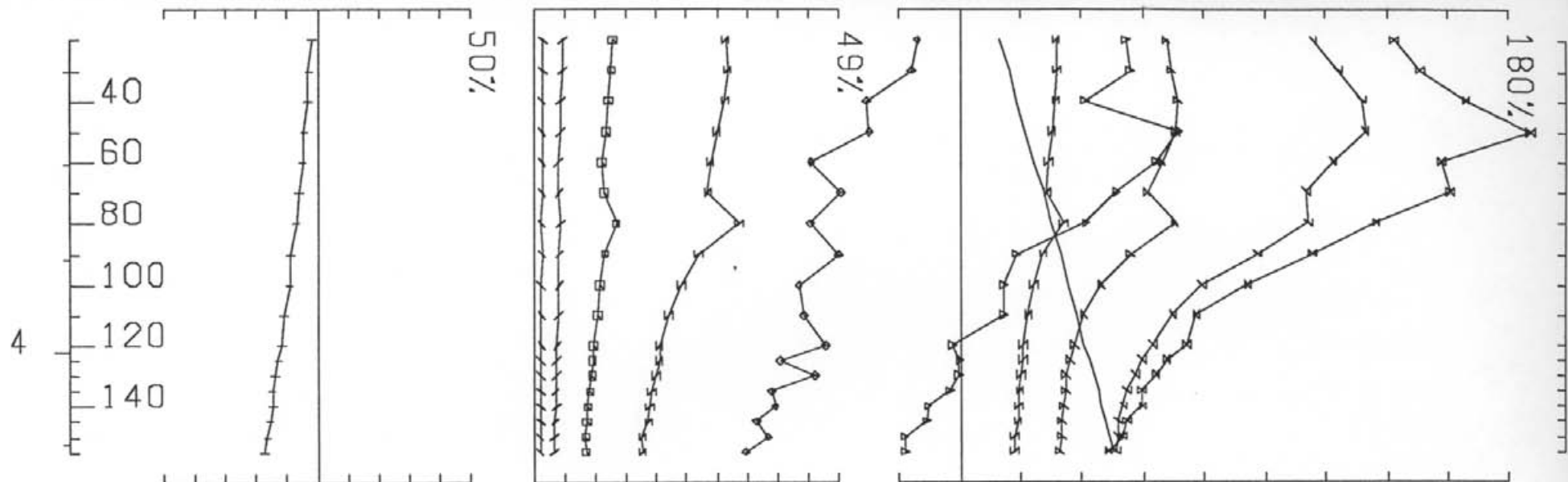
UTEM SURVEY AT VULCAN FOR KEEWATIN ENGINEERING INC.

CONDUCTED BY SJ GEOPHYSICS LTD. JOB 1 BASE FREQ (HZ) 30.97

LOOP NO 42 HOLE 4 AXIAL COMPONENT SECONDARY FIELD CH1 CONTIN. NORM.



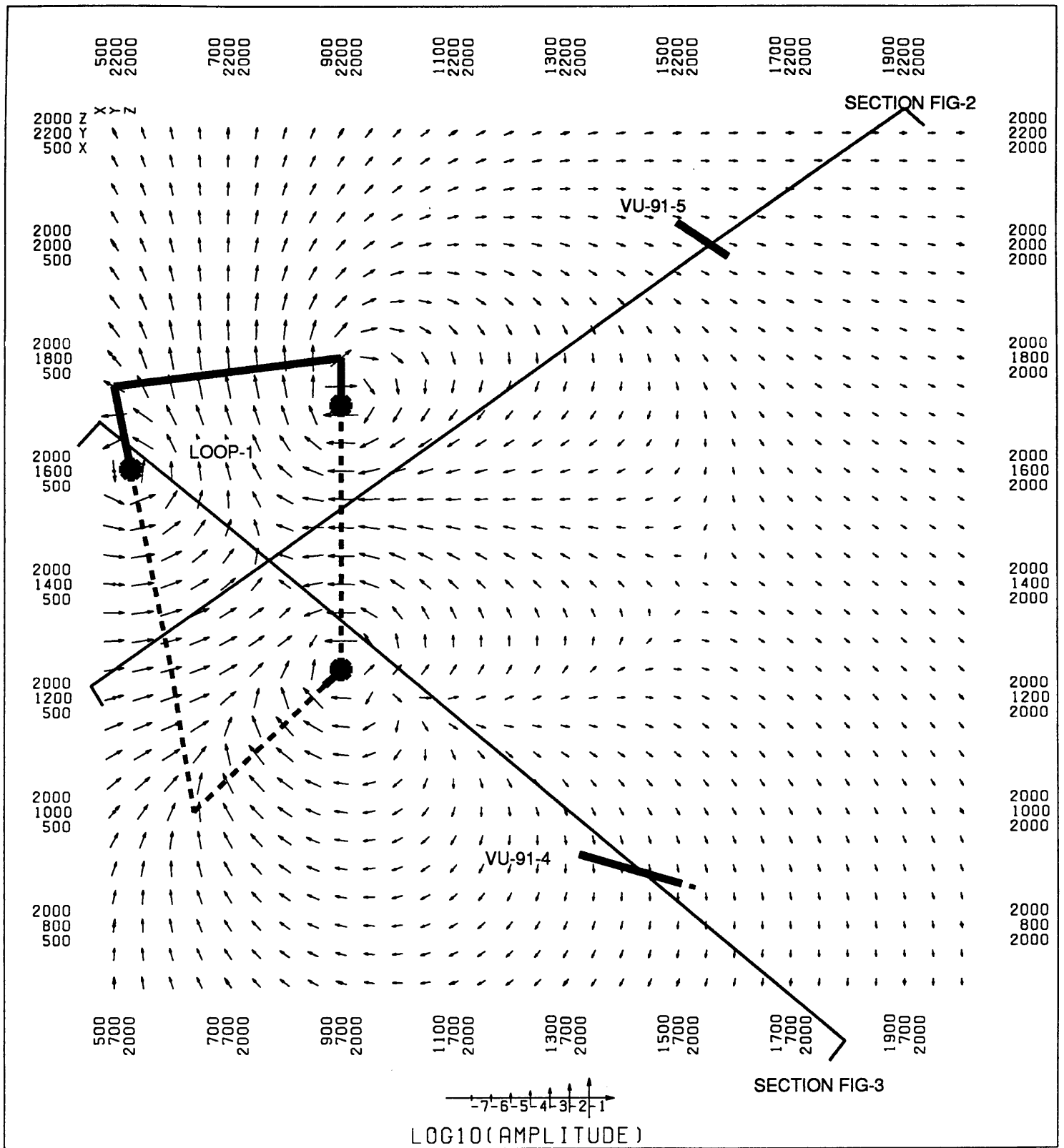
UTEM SURVEY AT VULCAN FOR KEEWATIN ENGINEERING INC.  
 CONDUCTED BY SJ GEOPHYSICS LTD. JOB 1 BASE FREQ (HZ) 30.97  
 LOOP NO 51 HOLE 5 AXIAL COMPONENT SECONDARY FIELD CH1 CONTIN. NORM.



UTEM SURVEY AT VULCAN FOR KEEWATIN ENGINEERING INC.

CONDUCTED BY SJ GEOPHYSICS LTD. JOB 1 BASE FREQ (HZ) 30.97

LOOP NO 52 HOLE 5 AXIAL COMPONENT SECONDARY FIELD CH1 CONTIN. NORM.

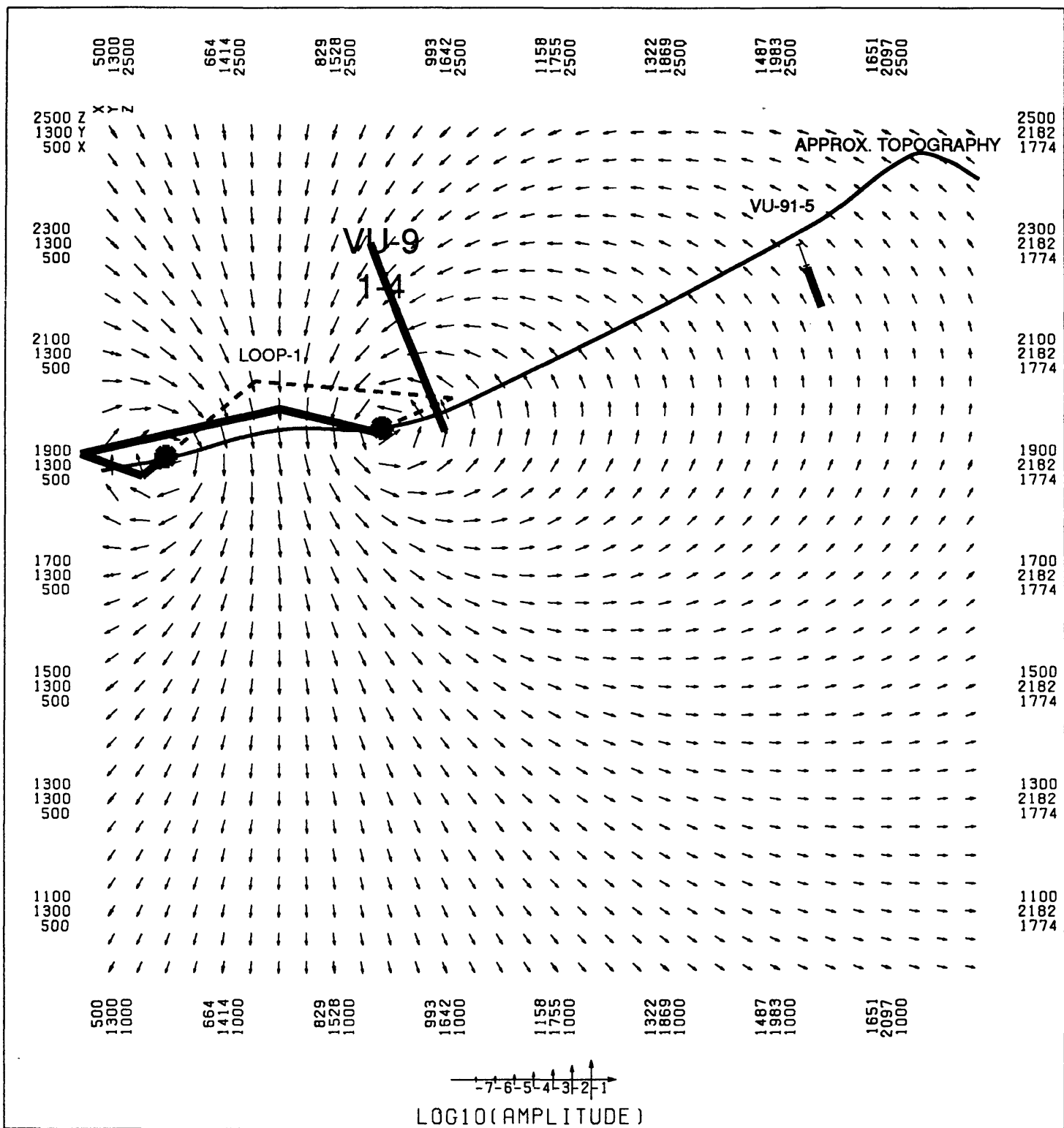


# VECTOR PLOT

HORIZONTAL SECTION THROUGH LOOP-1 AT ELEVATION OF 2000M  
 ARROWS IN DIRECTION OF PRIMARY FIELD

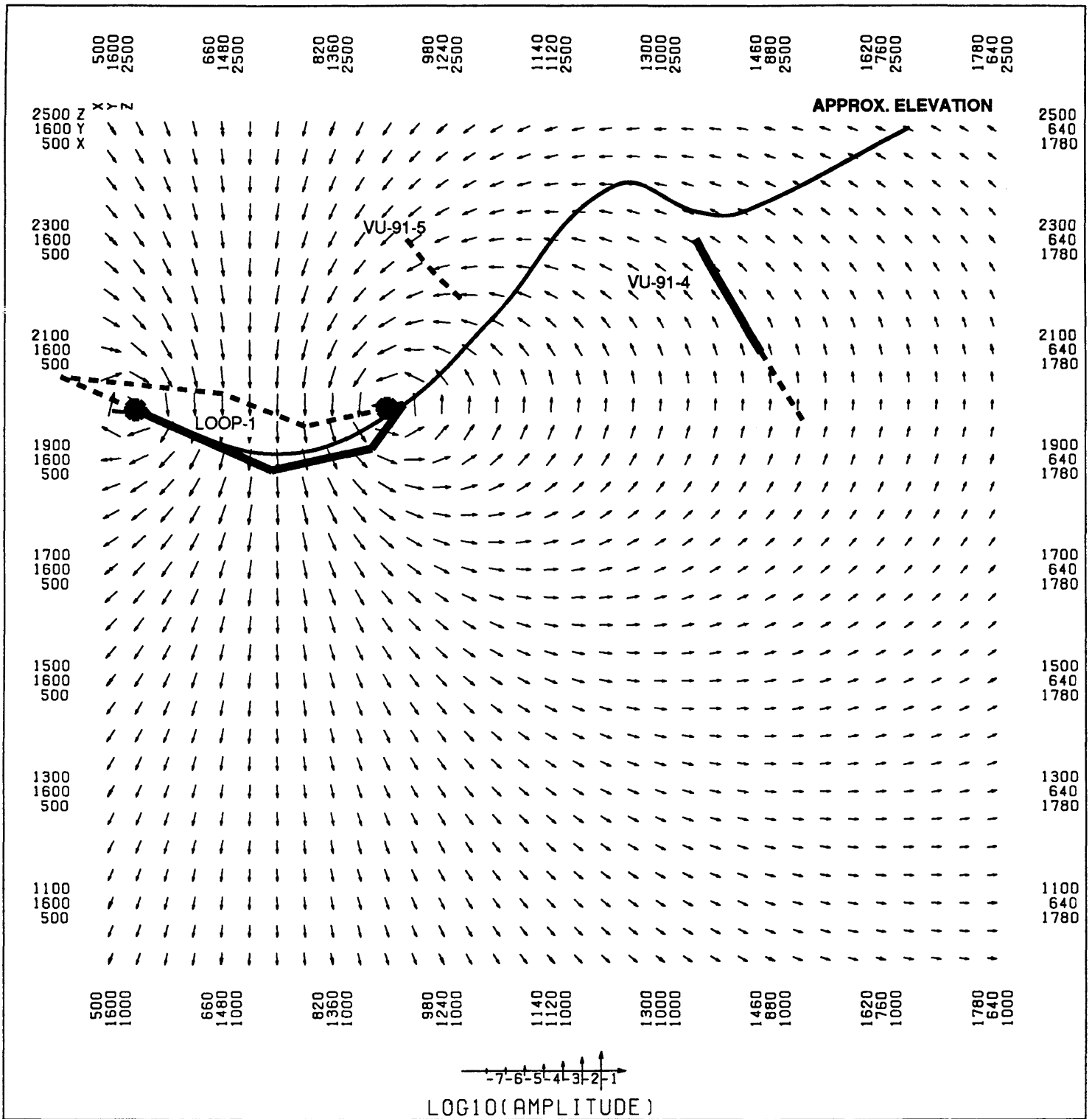
**FIG-1**





**VECTOR PLOT**  
 VERTICAL SECTION THROUGH LOOP-1 AND BOREHOLE VU-91-5 AS SHOWN ON PLAN FIG-1  
 ARROWS IN DIRECTION OF PRIMARY FIELD.

**FIG-2**

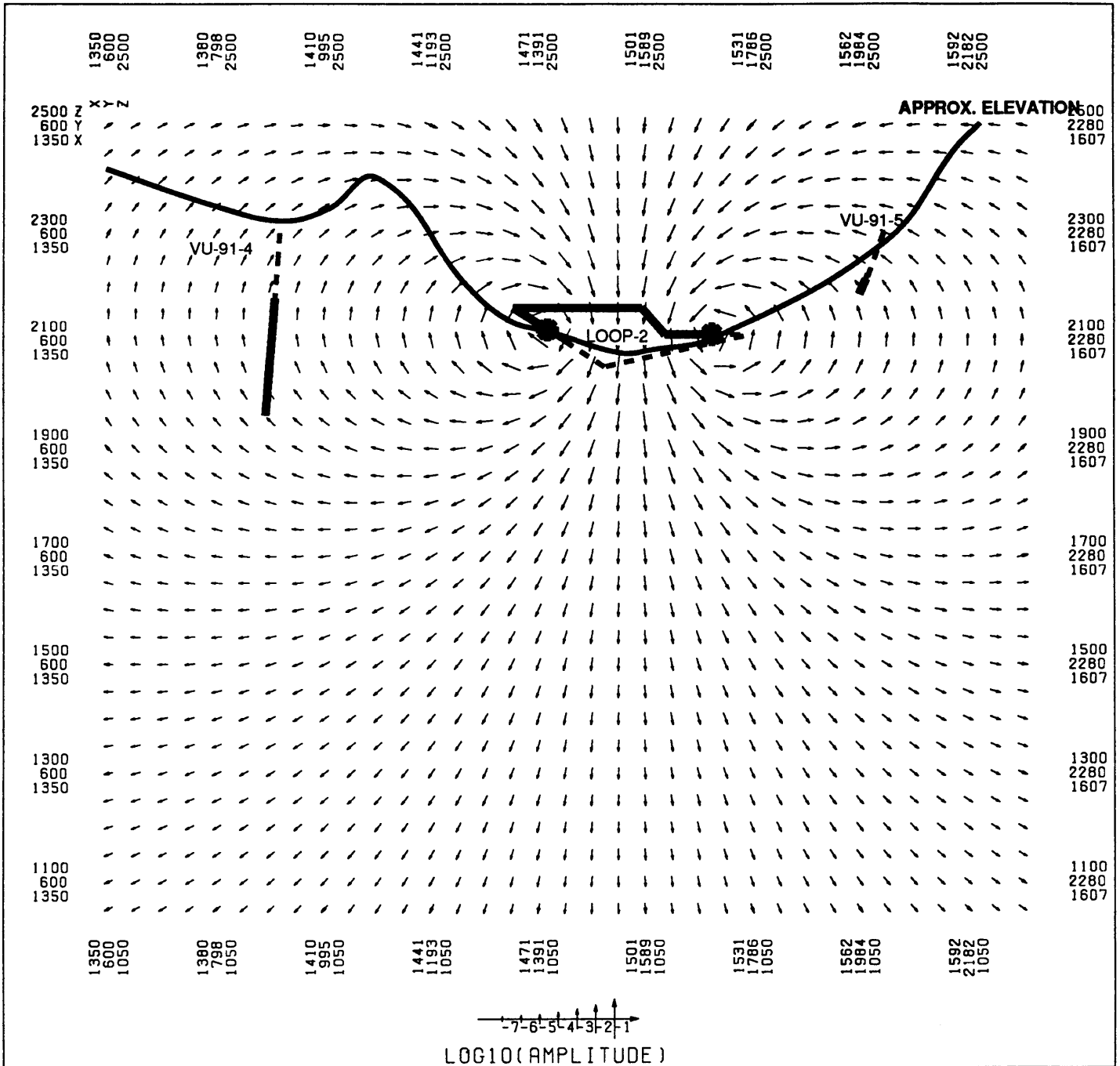


### VECTOR PLOT

VERTICAL SECTION THROUGH LOOP-2 AND BOREHOLE VU-91-4 AS SHOWN ON FIG-2  
 ARROW IN DIRECTION OF PRIMARY FIELD

FIG-3











## VECTOR PLOT

VERTICAL SECTION THROUGH LOOP-2 AND BOREHOLES VU-91-4 AND VU-91-5  
AS SHOWN IN FIG-4.









ARROWS IN DIRECTION OF PRIMARY FIELD

FIG-5





Bedding Thickness - Column I

-  Massive
-  Thick - Very Thick Bedded
-  Medium Bedded
-  Thin Bedded
-  Very Thin Bedded
-  Laminated






Lithology - Column I

-  Quartz Arenite
-  Quartzitic Wacke
-  Wacke
-  Subwacke/Argillite
-  Fragmental/Conglomerate
-  Conglomeratic Wacke
-  Gabbro
-  Calc-Silicate

Alteration Types - Column 2

-  Silica Alteration
-  Albite Alteration
-  Tourmalinization
-  Quartz Veining

Mineralization Types - Column 2

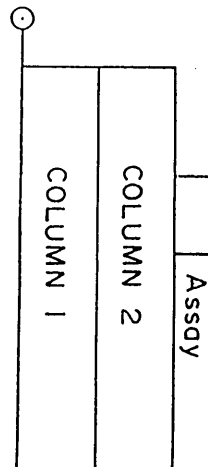
-  Disseminated Sulfides
-  Sulfide Stringers
-  Strata Controlled Sulfide Disseminations (Laminated)
-  Massive to Semi-Massive Sulfide Laminations
-  Massive to Semi-Massive Sulfide Bands/Beds

- gn. galena
- sph sphalerite
- cpy chalcopyrite
- py pyrite
- po pyrrhotite
- aspy arsenopyrite

**GEOLOGICAL BRANCH  
ASSESSMENT REPORT**

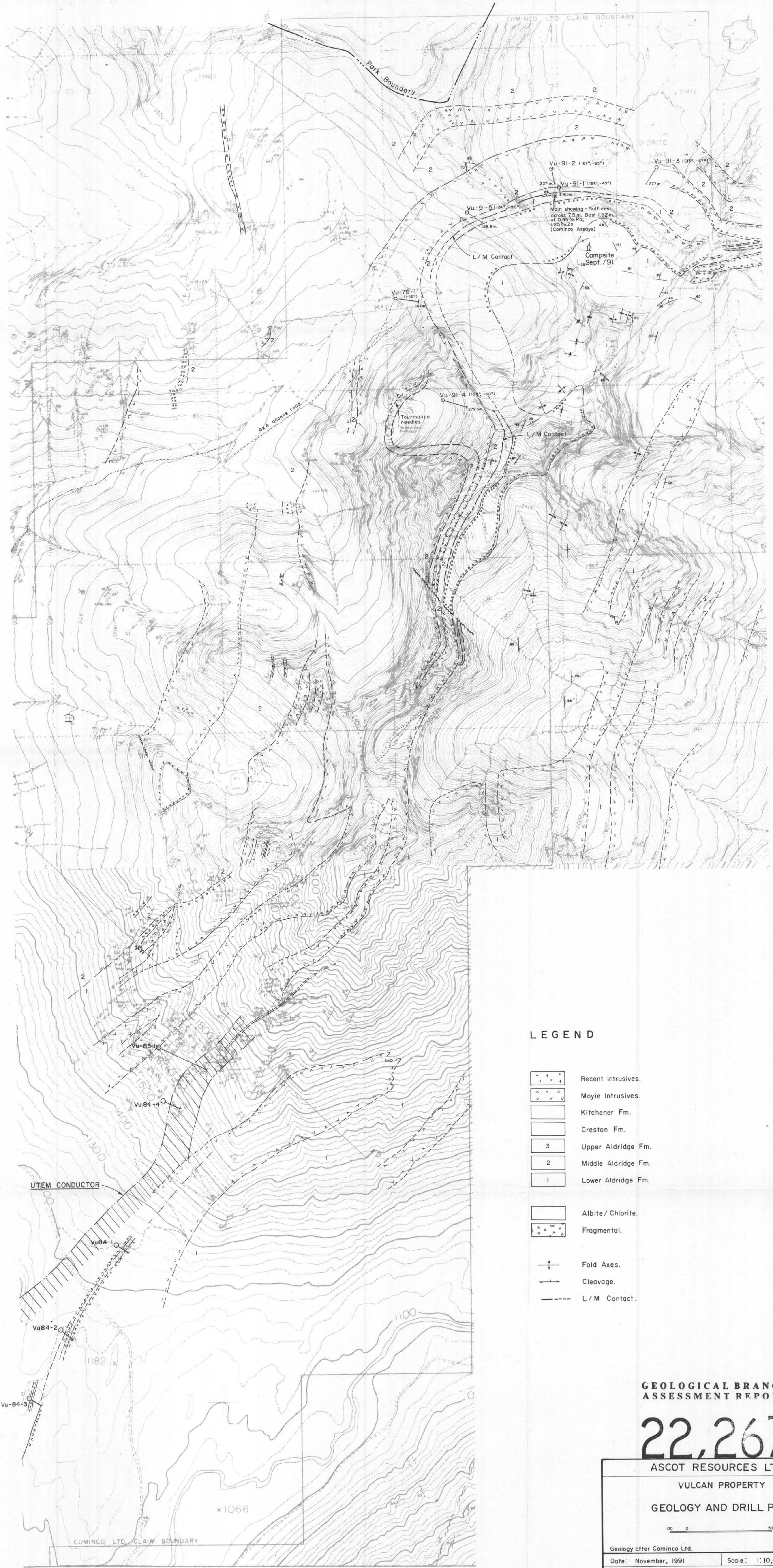
22,267

LEGEND FOR VULCAN PROJECT STRIPLOGS  
Vu-91-1 to Vu-91-5



IDMc/Oct. 91

PLAN NO. 6



**LEGEND**

- Recent Intrusives.
- Moyie Intrusives.
- Kitchener Fm.
- Creston Fm.
- Upper Aldridge Fm.
- Middle Aldridge Fm.
- Lower Aldridge Fm.
- Albite/Chlorite.
- Fragmental.
- Fold Axes.
- Cleavage.
- L/M Contact.

**GEOLOGICAL BRANCH  
ASSESSMENT REPORT**

**22,267**

ASCOT RESOURCES LTD.

VULCAN PROPERTY

GEOLOGY AND DRILL PLAN

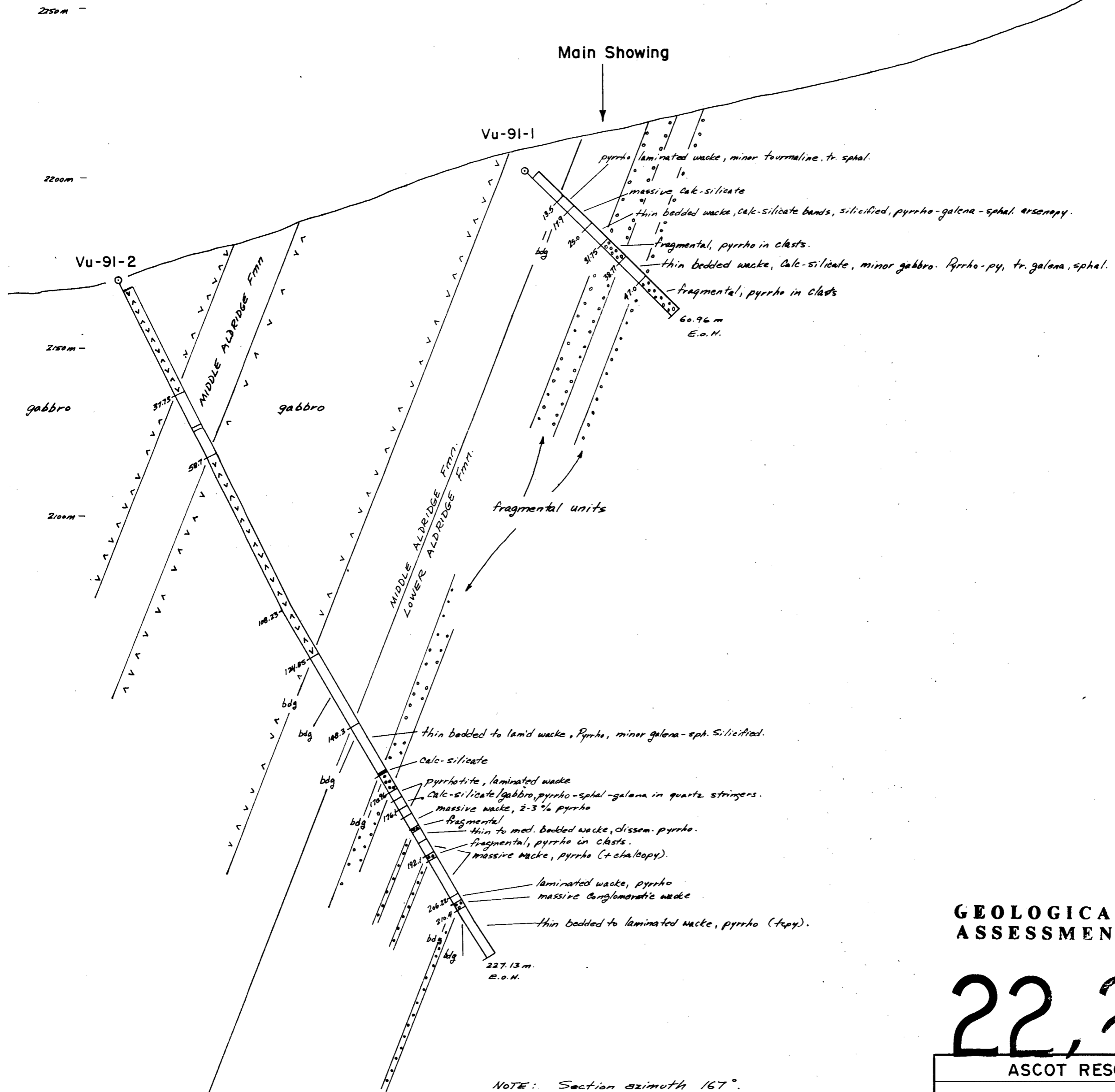


Geology after Cominco Ltd. I.D. McCartney  
Date: November, 1991 Scale: 1:10,000

KEEWATIN ENGINEERING INC. MAP No. 1

North

South



**GEOLOGICAL BRANCH  
ASSESSMENT REPORT**

**22,267**

ASCOT RESOURCES LTD.

VULCAN PROPERTY  
DRILL SECTION  
DDH Vu-91-1,2

25 0 50 metres

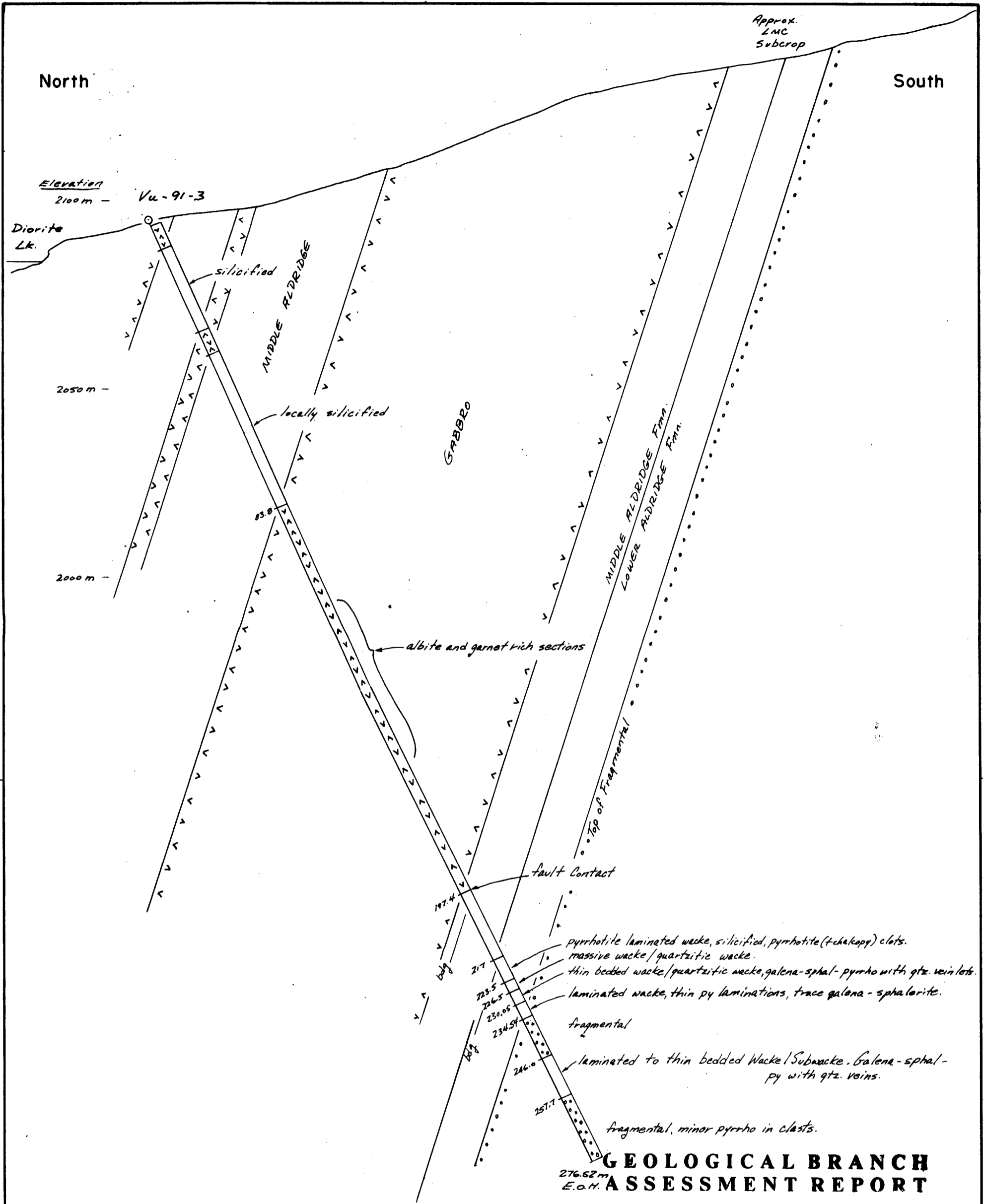
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Drawn by: I.D. McCartney

Date: November, 1991.

KEEWATIN ENGINEERING INC.

PLAN No. 2

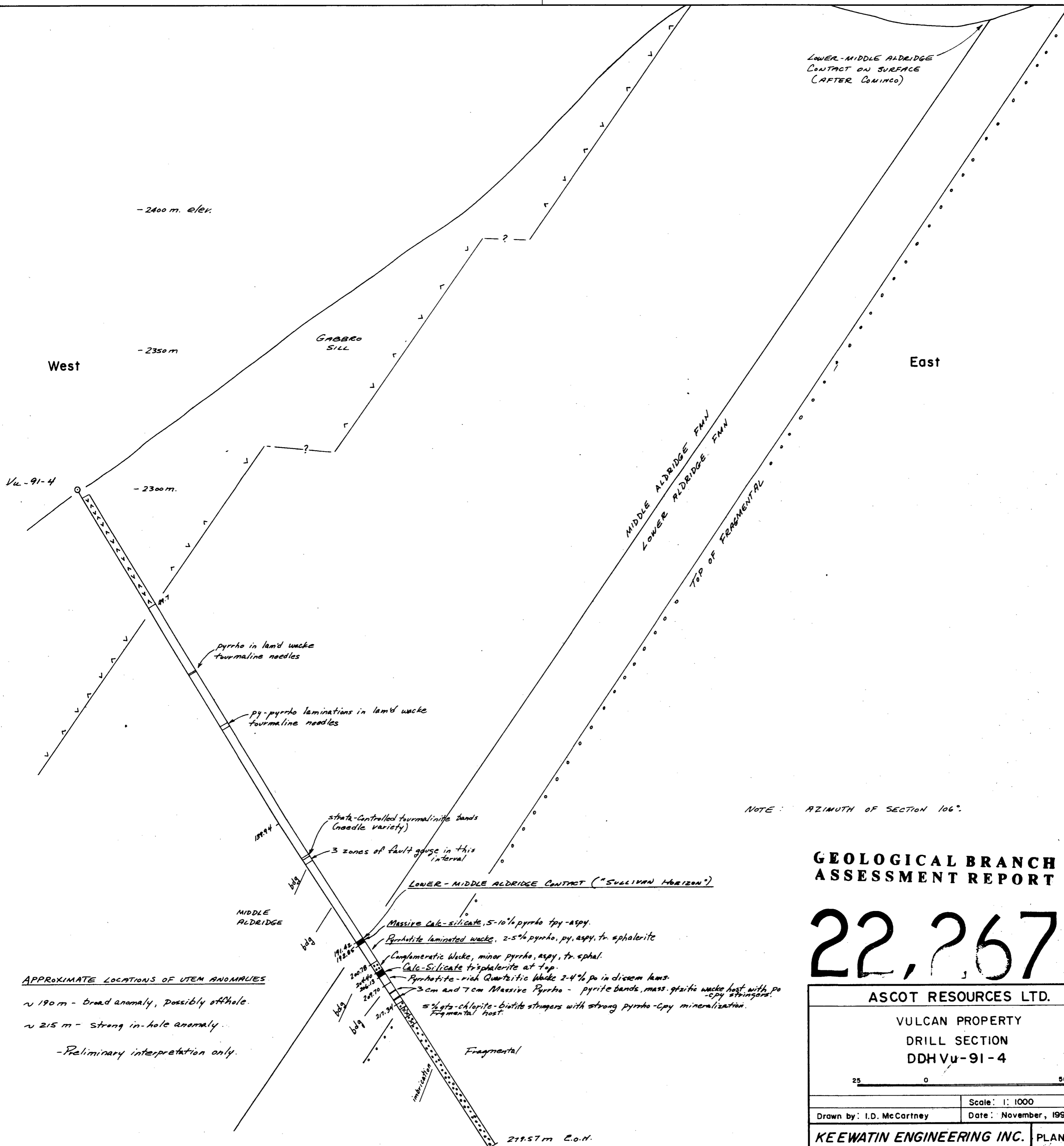


NOTE: Section azimuth 213°.

# 22,267

ASCOT RESOURCES LTD.	
VULCAN PROPERTY DRILL SECTION DDH Vu-91-3	
Scale: 1:1000	Drawn by: I.D. McCartney
Date: November, 1991.	
<b>KEEWATIN ENGINEERING INC.</b>	PLAN No. 3





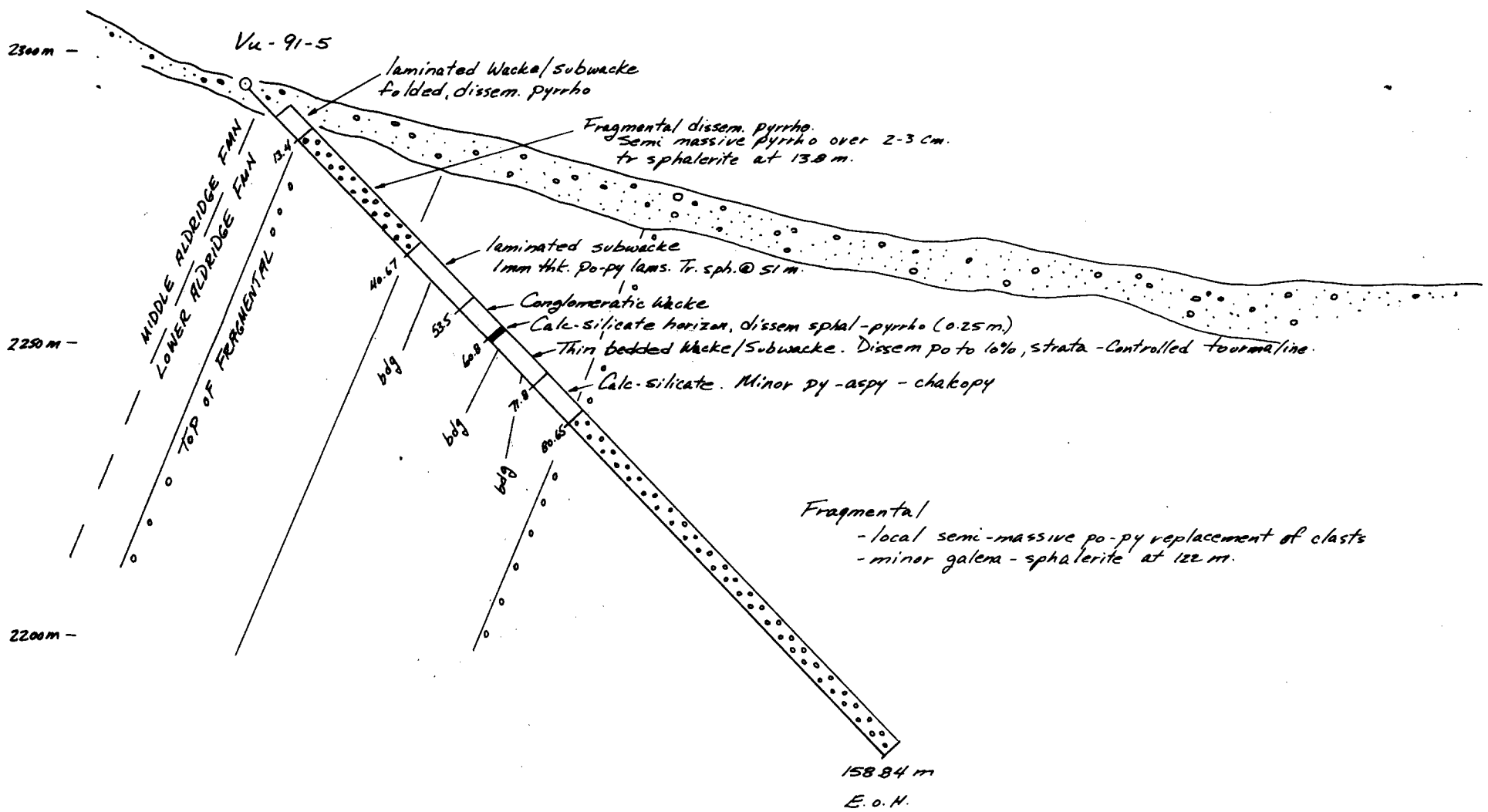
**GEOLOGICAL BRANCH  
ASSESSMENT REPORT**

**22,267**

ASCOT RESOURCES LTD.	
VULCAN PROPERTY DRILL SECTION DDHVu-91-4	
25 0 50 metres	
Scale: 1:1000	Date: November, 1991.
Drawn by: I.D. McCartney	
KEEWATIN ENGINEERING INC.	PLAN No. 4

West

East



NOTE: AZIMUTH OF SECTION 124°.

**GEOLOGICAL BRANCH  
ASSESSMENT REPORT**

**22,267**

ASCOT RESOURCES LTD.

VULCAN PROPERTY  
DRILL SECTION  
DDH Vu-91-5

25 0 50 metres

Scale: 1:1000

Drawn by: I.D. McCartney

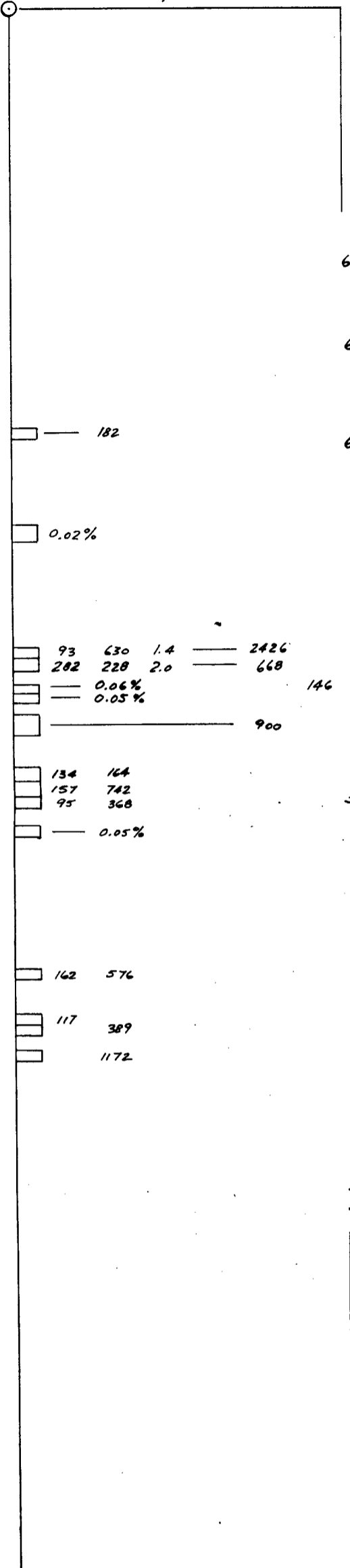
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KEEWATIN ENGINEERING INC.

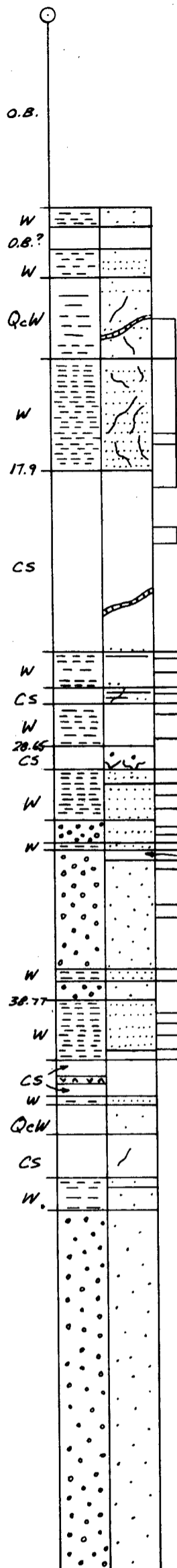
PLAN No. 5

**ANOMALOUS GEOCHEM VALUES**

Pb Zn Ag Cu As Au



**VU-91-1**



po  
 po dissems + discontinuous lams.  
 po as dissems, strata controlled lams, stringers.  
 Qtz. vn. with coarse po clots.  
**LOWER-MIDDLE ALDRIDGE Fm CONTACT**  
 po as wide spaced streaky lams + dissems.  
 occ. c.g. po, py clots, stringers assoc. with qtz. veins.  
 local needle tourmaline.  
 - weak zinc zap reaction  
 qtz. vein.  
 - black sph clots in lower CS Contact.  
 - black sph termination.  
 - Silicified, fr. dissem. po, py.  
 - tremolite, quartz-po replacement in lower 0.3 m.  
 - black sph-po as discontinuous c.g. laminae, blebs, stringers. vfg dissem. aspy - sph.  
 - Silicified, carbonate-chlorite stringers, tremolite - biotite replacement clots.  
 - c.g. pyrrhotite clots.  
 - py stringers @ lower Contact.  
 po dissems as laminations, and as clots in bdg parallel quartz stringers.  
 dissemin sph. in lams at 30.5 m.  
 some lamd sections with po.  
 po in lams.  
 albite attr.  
 R replacement of clasts throughout unit.  
 - sph-gn - aspy replacement in clast.  
 - po + sphal in lams.  
 dissemin po in lams, tr. sph.  
 c.g. po in carbonate stringers, minor dissemin po, frac py.  
 po  
 po  
 trace gn in qtz. stringer  
 po  
 po replacement of biotitic clasts.

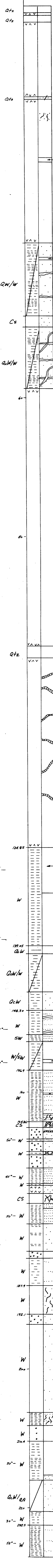
61.3 m. (E.O.H.)

**GEOLOGICAL BRANCH  
ASSESSMENT REPORT**

**22,267**

ASCOT RESOURCES LTD.	
VULCAN PROPERTY STRIPLOG DDH Vu-91-1	
5 0 10 metres	
Scale: 1:200	Drawn by: I.D. McCartney
Date: November, 1991.	
<b>KEEWATIN ENGINEERING INC.</b>	PLAN No. 7

Vu-91-2



Qtz vein  
Qtz vein  
po clots, stringers, minor ep. qtz vein  
po clots, stringers, calcite  
epidote  
albite?  
2-3% dissem po local silicification (to 0.3 m thick)  
1-2% f.g dissem po  
silicification as crosscutting stringers and conformable bands dissem po  
Qtz vein, silicification  
minor qtz veins, usually < 0.3 m thick  
albite + chlorite alteration  
local silicification  
diffuse silicification, minor dissem po  
**LOWER MIDDLE ALDRIDGE Fm. CONTACT**  
po bedding in biotitic beds and lams. bedding parallel qtz-bio-po veinlets coarse po in silicified zones.  
po-bio dissem in lams.  
predominantly distal turbidites.  
pink albite alt.  
intense silicification, possible albite alt?  
massive sph-po clst from 160.10 - 160.25.  
minor calcite + fluorite in stringers  
po line or dissem in po-rich lams + crosscutting stringers 163.10 - 164.26.  
feldspar-gtz-biotite replacement. con-po in qtz veins.  
silicified, albite dissem in qtz veins. po-assy dissem, stringers.  
silicified, po in lams.  
silicified, dissem po.  
silicified, po-bio structure.  
silicified, dissem po.  
strong dissem po in lams.  
silicified.  
po-sph-gn qtz stringers  
silicified.  
dissem po in lams.  
2-3% po as coarse clots.  
dissem po in bio-rich lams.  
bio-po as large clots, stringers, tr. cpy  
po replaces clasts  
po in clots  
dissem po in lams. Qtz-po stringers.  
c.g. po, minor cpy assoc. with calcite veins. silicified.  
strongly silicified, dissem po  
dissem po in biotitic lams

**ANOMALOUS GEOCHEM VALUES**

Pb	Zn	Ag	Cu	As	Au
0.02%	0.9%	3.0	0.03%		
0.01%					
0.02%	0.18%	26.6	0.01%		
0.01%					
138	976		438		
187			536		
186			572		
183			861		
			1299		
	373		650		
	441		1052		
			1012		
			717		
192	474	3.2	1521		
171			2459		
95			1112		

**GEOLOGICAL BRANCH ASSESSMENT REPORT**

**22,267**

ASCOT RESOURCES LTD.  
VULCAN PROPERTY STRIPLUG  
DDH Vu-91-2

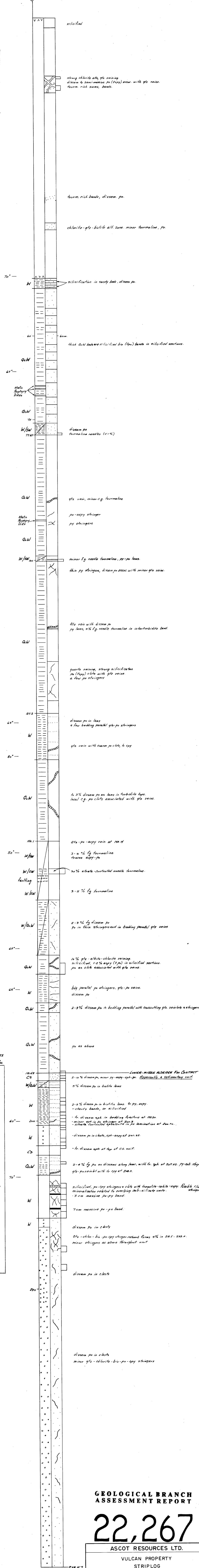
Scale: 1:200  
Date: November, 1991.

KEEWATIN ENGINEERING INC. PLAN No. 8

ANOMALOUS GEOCHEM VALUES

Pb	Zn	Ag	Cu	As	Au
				2280	
				556	

Vu-91-4



ANOMALOUS GEOCHEM VALUES

Pb	Zn	Ag	Cu	As	Au
176	116	363			
413	396	3.0	46	826	
245	154		142	773	
185	127				
100	223				
	132				
219	120.8				
120	135				
165					
537	143	2.9		114	
221	539			219	
	146		182	3748	10
			426		19
			188	370	11
			410		
			211		
				7.7	
					269

GEOLOGICAL BRANCH ASSESSMENT REPORT

22,267

ASCOT RESOURCES LTD.  
 VULCAN PROPERTY  
 STRIPLUG  
 DDH Vu-91-4

Scale: 1:200  
 Drawn by: I.D. McCartney Date: November, 1991.  
 KEEWATIN ENGINEERING INC. PLAN No. 10

Vu-91-5

LOWER-MIDDLE ALDRIDGE Fm CONTACT

30-60°  
(Folded)

W/SW

po dissem. in biotite-rich bands  
tr. sph at 11.65.

13.40

40-80°

dissem po (sp) in clasts of biotite rich zones.  
semi massive po over 2-3 cm.  
tr. dissem sph at 13.8 m.

40.67

-slumped at base

65°

SW

1 mm thick po-py. lams (1 per 20 cm core length).  
tr. dissem sph at 51.0.

W

SW

53.50

dissem po replacing biotite rich clasts.  
a few weak po laminations.

W

W

slumping

70° CS

2-3% dissem sph, 5% po in gtz-tremolite-feld-chlorite band, tourm stringers.  
conformable unit.

W/SW

fg dissem po to 10%

bedding parallel gtz vln, coarse po clots.

strata controlled tourmaline needles.

silicified, 1-2% dissem po, tr. cpy aspy.

fg dissem po to 10%

70.0

strata controlled tourmaline needles.

71.88

CS

amphibole-garnet-biotite-gtz. Py-assy dissem/clots 5-7%.  
po (topy) stringers, po-gtz-cpy inlets.  
gtz vln, 5% po.

80.65

heavy po replacement in bio-rich clasts.

gn-sph in matrix and clasts.

occ. massive py clasts.

ANOMALOUS GEOCHEM VALUES

Pb Zn Ag Cu As Au

2291			1051		815

195			148		
	238	973		19	

1454	2384	3.4
92	216	

130

150

158.40  
(E.O.M.)

GEOLOGICAL BRANCH  
ASSESSMENT REPORT

22,267

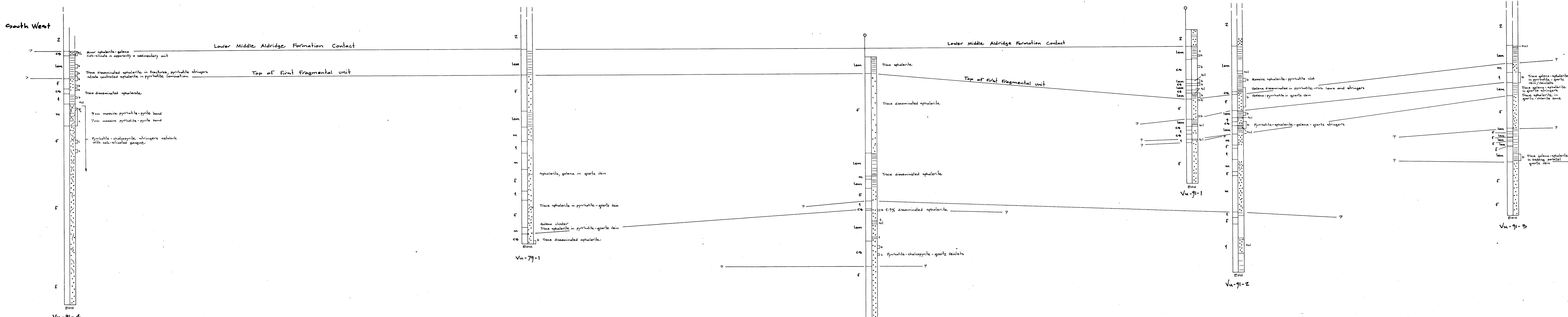
ASCOT RESOURCES LTD.

VULCAN PROPERTY  
STRIPLOG  
DDH Vu-91-5

Scale: 1:200

Drawn by: I.D. McCartney Date: November, 1991.

KEEWATIN ENGINEERING INC. PLAN No. 11



**EXPLANATION**

**ROCK TYPES - COLUMN 1**

- [2] Normal middle Aldridge Formation sediments
- [1] Normal Lower Aldridge Formation sediments
- [9] Massiv Intrusions - Gabbro

**ANOMALOUS LOWER ALDRIDGE FORMATION ROCK TYPES**

- [F] Fragmental (conglomerate), conglomeratic units and slumped units.
- [m] Massive wacke/subwacke
- [lam] Laminated to thin bedded pyrrhotite bearing wacke to subwacke. Sub-basin Facies
- [co] Calc-silicate units

**ALTERATION TYPES - COLUMN 2**

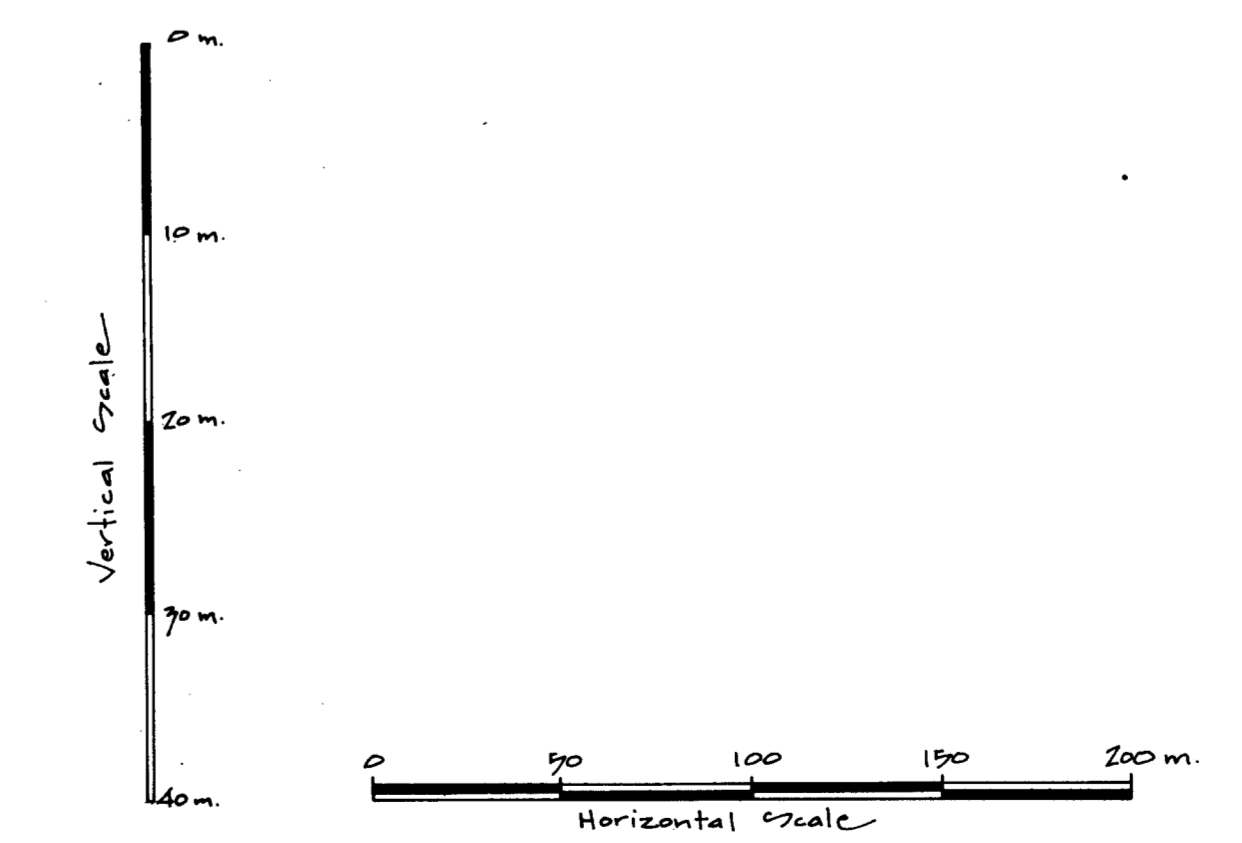
- [+ ] Tourmaline needles
- [sil] Silicification

**MINERALIZATION TYPES - COLUMN 2**

- [Dotted] Disseminated Fe-sulfides
- [Laminated] Laminated Fe-sulfide and strata controlled Fe-sulfide disseminations
- [Stringer] Stringer Fe-sulfides

**GEOCHEMICAL ANOMALIES - COLUMN 3**

- [C] Anomalous Cu geochemical zones
- [Zn] Anomalous Pb-Zn geochemical zones



**GEOLOGICAL BRANCH ASSESSMENT REPORT**

**22,267**

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VULCAN PROPERTY  
**INTERPRETIVE FENCE DIAGRAM**  
 LOWER-MIDDLE ALDRIDGE CONTACT SEQUENCE

DATE: Nov. 1991	NTS: 82F/16W
PROJECT: 2156	PRD: GEOL. 1DM
SCALE: 1:2000 / V 1:400	
KeeWatn Engineering Inc. MAP No. 12	