GEOLOGICAL, GEOCHEMICAL, GEOPHYSICAL
REPORT ON THE
MT. JOHNSON PROPERTY

Skeena Mining Division
NTS 104 A/04, 05

NORANDA EXPLORTION COMPANY, LIMITED
(no personal liability)

By: Robert J. Baerg January 1991

LOG NO: 21-01	RD.
ACTION:	
FILE NO:	

REPORT OF WORK

GEOLOGICAL, GEOCHEMICAL, GEOPHYSICAL

ON THE

MT. JOHNSON PROPERTY

(MJ 1 TO 4 CLAIMS)

SKEENA MINING DIVISION
NTS 104 A/04, 05

Latitude - 56' 15' N
Longitude - 129' 49' W

NORANDA EXPLORATION COMPANY, LIMITED
(no personal liability)

By: Robert J. Baerg

January, 1991

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1.0 SUMMARY

The Mt. Johnson property is located within the Stewart Complex, a belt of Jurassic intermediate to felsic volcanics and sediments cut by Jurassic to Tertiary age intrusives. The property covers a portion of a narrow, northerly trending, belt of felsic volcanic flows and tuffs which appears to be part of the Mt. Dillworth Formation. The felsic rocks are extensively carbonate +/- sericite-pyrite altered. Soil geochemistry over the felsic rocks shows elevated As-Ba and local elevated Cu, Cd, Zn, Au values.

Airborne magnetics over the southern portion of the property indicates that the felsic horizon is marked by a narrow, NE-SW trending magnetic low. The magnetics also indicate that the horizon locally varies in width and orientation.

The work completed in 1990 has identified an area of hydrothermally altered Mt. Dillworth Formation felsic volcanics. A limited field program in 1990, due to extensive snow cover, indicates that the altered felsic rocks are geochemically anomalous in As-Ba +/- Cu, Cd, Zn, and Au.

Further ground follow up including prospecting/mapping, soil and rock sampling is recommended for 1991.

2.0 INTRODUCTION

The MJ 1-4 claims are located NE of Stewart, B. C. The claims were staked in 1989 and 1990 to cover favourable Jurassic Hazelton Group felsic volcanics (Mt. Dillworth Formation). The area has no previous exploration history and no reported mineral occurrences. In 1990 Noranda Exploration conducted reconnaissance geological, geochemical surveys on the claims and flew an airborne Mag survey over the felsic volcanic horizon.

3.0 LOCATION AND ACCESS

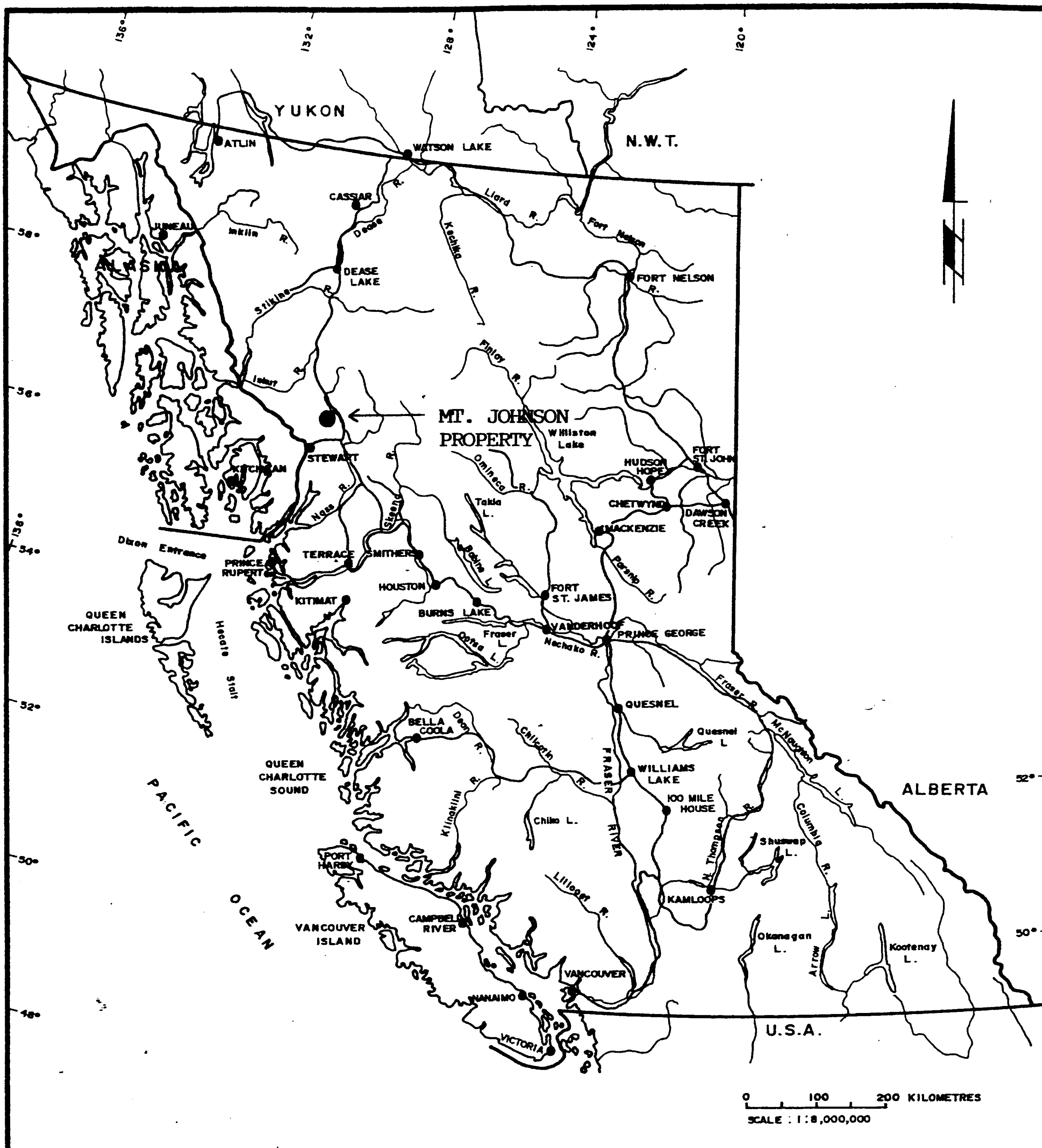
The property is located 40 km NE of the town of Stewart, B.C. (Figure 1) Access is via helicopter from Stewart.

4.0 CLAIM STATISTICS

The property is comprised of four (4) modified grid claims as listed below:

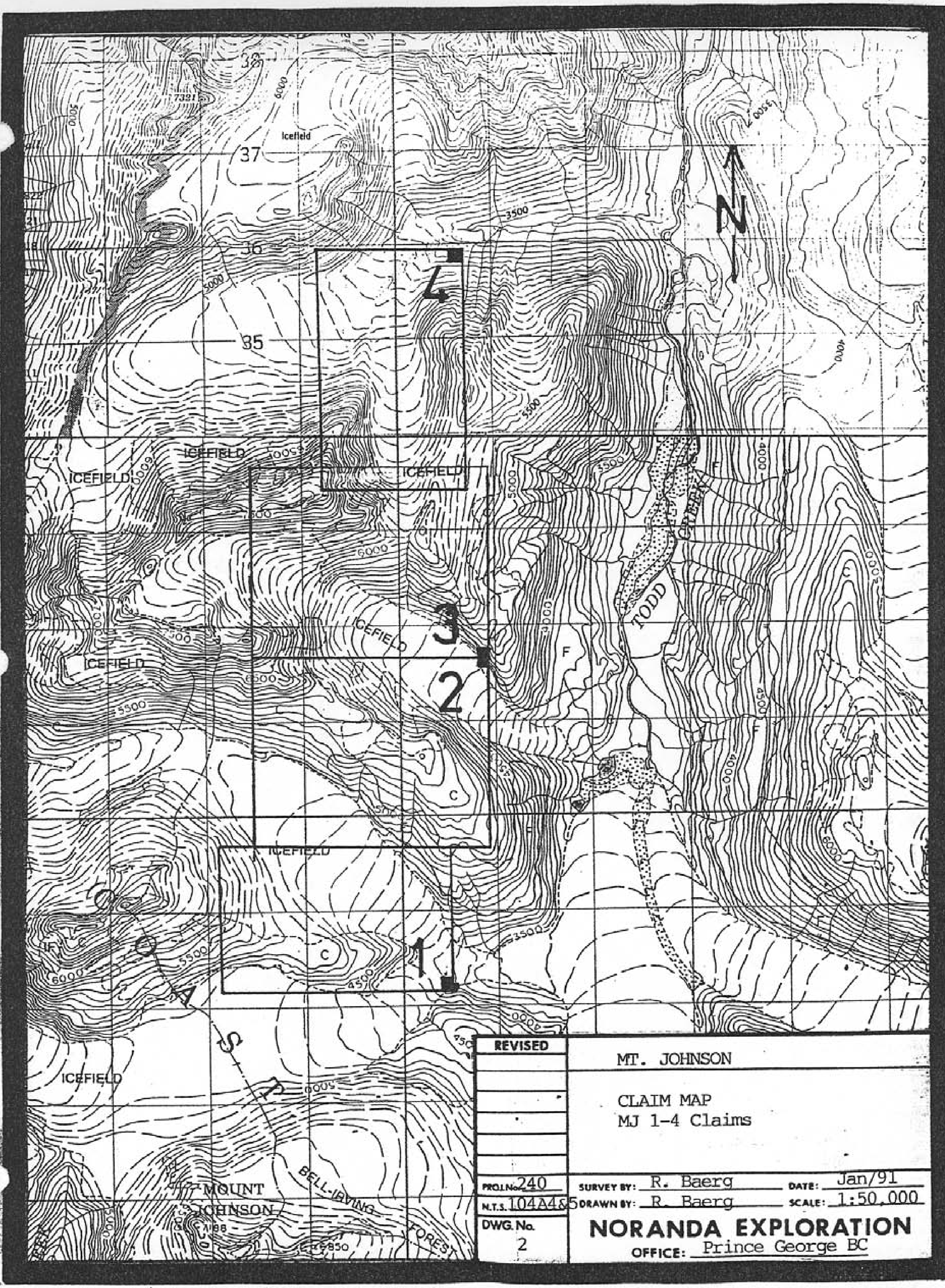
Name	Record #	Units	Expiry Date
MJ 1	8160	15	Nov. 8, 1991
MJ 2	8161	20	Nov. 8, 1991
MJ 3	8162	20	Nov. 8, 1991
MJ 4	9020	15	July 2, 1992

The claims are all located in the Skeena Mining Division (Figure 2).



REVISED	MT. JOHNSON
	LOCATION MAP
PROJ.No. 240	SURVEY BY: R. Baerg DATE: Jan/91
N.T.S. 104A	DRAWN BY: S.K.B. SCALE: 1:8,000,000
DWG. No. 1	**NORANDA EXPLORATION** OFFICE: PRINCE GEORGE, B.C.

VANCAL 11927



ICEFIELD
Icefield
37
36
35
4
3
2
1
N
TODD
CREEK
MOUNT
JOHNSON
BELL-IRVING
REVISED
MT. JOHNSON
CLAIM MAP
MJ 1-4 Claims
PROJ.No. 240
N.T.S. 104A4&5
DWG. No. 2
SURVEY BY: R. Baerg
DRAWN BY: R. Baerg
DATE: Jan/91
SCALE: 1:50,000
NORANDA EXPLORATION
OFFICE: Prince George BC

5.0 PHYSIOGRAPHY & VEGETATION

The property is characterized by steep ice filled valleys and open alpine ridges. The topography is generally quite rugged, elevations ranging from 1160 m to 2440 m. No vegetation of note occurs on the property.

6.0 REGIONAL GEOLOGY

The area has been mapped as being largely underlain by Lower Jurassic age Unuk River Formation volcanics and clastic sediments which are cut by numerous Jurassic and Tertiary age intrusive bodies ranging in size from narrow dykes and sills to large plutons. (Figure 3)

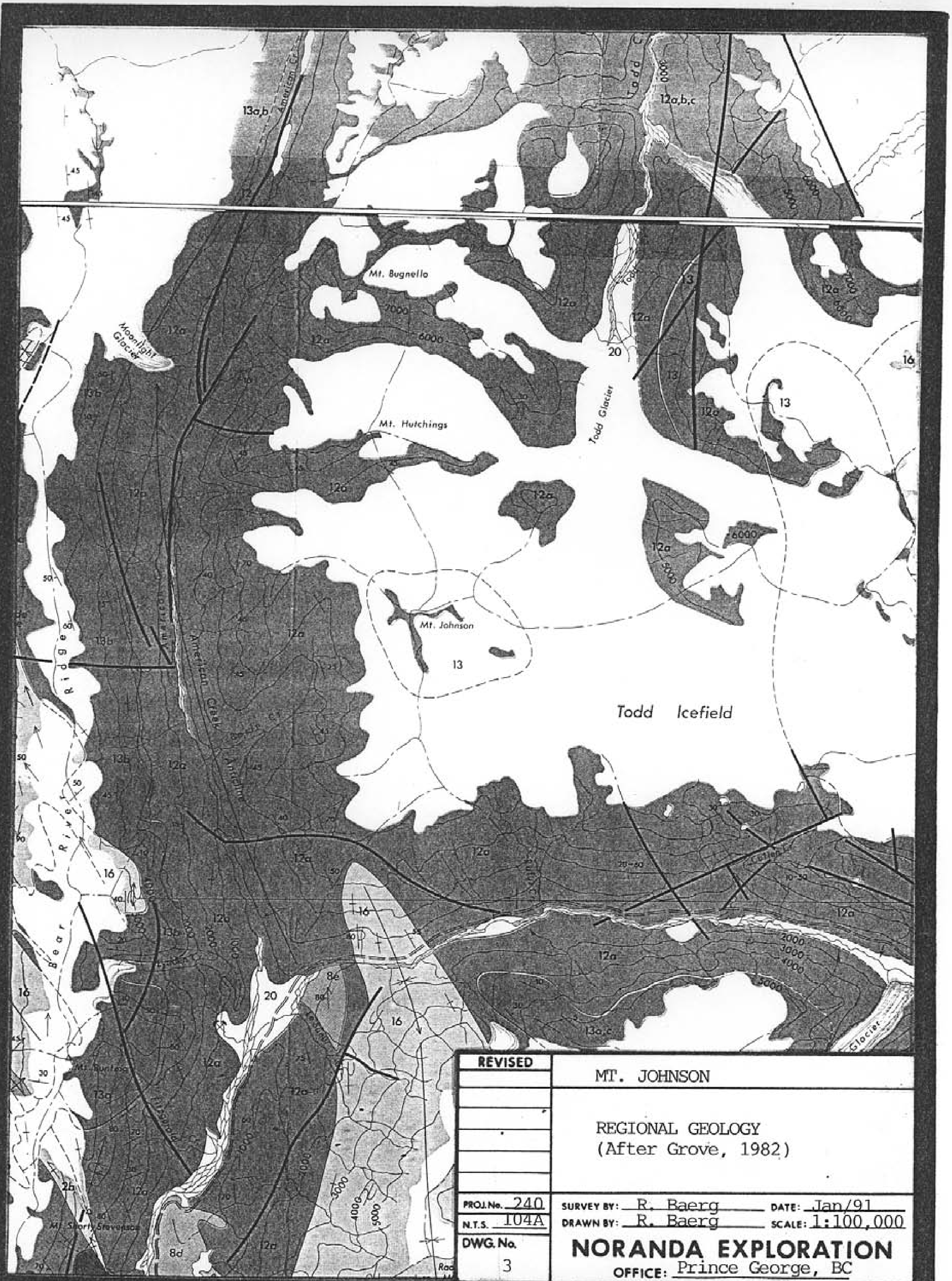
Reconnaissance property mapping indicates that much of the property is underlain by intermediate to felsic flows, tuffs, agglomerates and volcaniclastics with local areas of fine to coarse clastic sediments. Intermediate volcanics, andesite flows agglomerates, predominate with lesser but significant amounts of rhyolite-dacite flows and volcaniclastics along the west side of the Todd Creek valley and on the north side of Virginia Creek. The stratigraphy generally trends north to northwest with moderate northeasterly dips.

7.0 FIELD PROGRAM

During June and July, 1990, a short program of reconnaissance soil, rock, silt sampling and geological mapping was undertaken. Also, during July/August Dighem Surveys and Processing Inc. of Mississauga, Ontario flew an airborne EM-Mag survey over the property.

7.1 PROPERTY GEOLOGY

The property is underlain by a sequence of NE trending intermediate to felsic volcanic flows and volcaniclastics. (figure 4). The felsic volcanics consist of rusty, but to brown rhyolite-dacite tuffs and flows(?). They are generally weakly to moderately carbonate-sericite +/- pyrite altered.



REVISED	MT. JOHNSON
	REGIONAL GEOLOGY (After Grove, 1982)
PROJ.No. 240 N.T.S. 104A	SURVEY BY: R. Baerg DATE: Jan/91 DRAWN BY: R. Baerg SCALE: 1:100,000
DWG.No. 3	**NORANDA EXPLORATION** OFFICE: Prince George, BC

Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

GEOLOGY OF THE UNUK RIVER - SALMON RIVER - ANYOX MAP AREA

KILOMETRES 0 — 10 KILOMETRES

SCALE - 100 000

LEGEND

SEDIMENTARY AND VOLCANIC ROCKS

CENOZOIC

QUATERNARY

RECENT

20 UNCONSOLIDATED DEPOSITS: RIVER FLOODPLAIN, ESTUARINE, RIVER CHANNEL AND TERRACES, ALLUVIAL FANS, DELTAS AND BEACHES, OUTWASH, GLACIAL LAKE SEDIMENTS, TILL, PEAT, LANDSLIDES, VOLCANIC ASH, HOTSPRING DEPOSITS

19 BASALT FLOWS (a), CINDERS, ASH (b)

PLEISTOCENE AND RECENT

18 BASALT FLOWS

MESOZOIC

JURASSIC

HAZELTON GROUP

UPPER JURASSIC

NASS FORMATION

17 SILTSTONE, GREYWACKE, SANDSTONE, SOME CALCARENITE, ARGILLITE, CONGLOMERATE, MINOR LIMESTONE, MINOR COAL (INCLUDING EQUIVALENT SHALE, PHYLLITE, AND SCHIST)

MIDDLE JURASSIC

SALMON RIVER FORMATION

16 SILTSTONE, GREYWACKE, SANDSTONE, SOME CALCARENITE, MINOR LIMESTONE, ARGILLITE, CONGLOMERATE, LITTORAL DEPOSITS

15 RHYOLITE, RHYOLITE BRECCIA; CRYSTAL AND LITHIC TUFF

BETTY CREEK FORMATION

14 PILLOW LAVA, BROKEN PILLOW BRECCIA (a); ANDESITIC AND BASALTIC FLOWS (b)

13 GREEN, RED, PURPLE, AND BLACK VOLCANIC BRECCIA, CONGLOMERATE, SANDSTONE, AND SILTSTONE (a); CRYSTAL AND LITHIC TUFF (b); SILTSTONE (c); MINOR CHERT AND LIMESTONE (INCLUDES SOME LAVA (+14)) (d)

LOWER JURASSIC

UNUK RIVER FORMATION

12 GREEN, RED, AND PURPLE VOLCANIC BRECCIA, CONGLOMERATE, SANDSTONE, AND SILTSTONE (a); CRYSTAL AND LITHIC TUFF (b); SANDSTONE (c); CONGLOMERATE (d); LIMESTONE (e), CHERT (f), MINOR COAL (g)

11 PILLOW LAVA (a); VOLCANIC FLOWS (b)

TRIASSIC

UPPER TRIASSIC

TAKLA GROUP (?)

10 SILTSTONE, SANDSTONE, CONGLOMERATE (a); VOLCANIC SILTSTONE, SANDSTONE, CONGLOMERATE (b); AND SOME BRECCIA (c); CRYSTAL AND LITHIC TUFF (d); LIMESTONE (e)

PLUTONIC ROCKS

CENOZOIC

OLIGOCENE AND YOUNGER

9 DYKES AND SILLS (SWARMS), DIORITE (a); QUARTZ DIORITE (b); GRANODIORITE (c); BASALT (d)

EOCENE (STOCKS, ETC.) AND OLDER

8 QUARTZ DIORITE (a); GRANODIORITE (b); MONZONITE (c); QUARTZ MONZONITE (d); AUGITE DIORITE (e); FELDSPAR PORPHYRY (f)

7 COAST PLUTONIC COMPLEX: GRANODIORITE (a); QUARTZ DIORITE (b); QUARTZ MONZONITE, SOME GRANITE (c); MIGMATITE - AGMATITE (d)

MESOZOIC

JURASSIC

MIDDLE JURASSIC AND YOUNGER ?

6 GRANODIORITE (a); DIORITE (b); SYENODIORITE (c), MONZONITE (d); ALASKITE (e)

LOWER JURASSIC AND YOUNGER ?

5 DIORITE (a); SYENOGABBRO (b), SYENITE (c)

TRIASSIC

UPPER TRIASSIC AND YOUNGER ?

4 DIORITE (a); QUARTZ DIORITE (b); GRANODIORITE (c)

HORNBLENDE PREDOMINANT ....H
BIOTITE PREDOMINANT ....B

METAMORPHIC ROCKS

TERTIARY

3 HORNFELS (a); PHYLLITE, SCHIST (b); SOME GNEISS (c)

JURASSIC

2 HORNFELS (a); PHYLLITE, SEMI-SCHIST, SCHIST (b); GNEISS (c); CATACLASITE, MYLONITE (d), TACTITE (e)

TRIASSIC

1 SCHIST (a); GNEISS (b); CATACLASITE, MYLONITE (c)

HORNBLENDE OR AMPHIBOLE DEVELOPED ....H
BIOTITE DEVELOPED ....B
POTASSIUM FELDSPAR DEVELOPED ....K

AREA UNMAPPED

SYMBOLS

ADIT ....

ANTICLINE (NORMAL, OVERTURNED) ....

BEDDING (HORIZONTAL, INCLINED, VERTICAL, CONTORTED)

BOUNDARY MONUMENT .... Δ

CONTOURS (INTERVAL 1,000 FEET) 5000

Intermediate rocks consist of green to maroon andesite flows, tuffs and volcaniclastics. The volcaniclastics contain fine to coarse, predominantly andesitic, fragments in an andesitic tuffaceous matrix. At least one north trending shear zone, on MJ 1, was identified and several other strong northerly trending structures were observed on large inaccessible cliff faces.

7.2 MINERALIZATION

Mineralization observed to date consists of disseminated pyrite within the altered felsic volcanics. Local coarse boxwork textures resulting from weathered out pyrite were locally observed. No other sulphides have been observed.

7.3 GEOCHEMISTRY

A total of 18 rock samples and 40 soil samples were collected. Soil samples were collected at roughly 100 - 200 m intervals where possible. At the time of sampling there was 60-70% snow cover. Sample material, generally consisting of talus fines, was placed in a Kraft wet-strength paper bag, air dried and shipped to Noranda Labs in Vancouver. For analytical procedure, refer to Appendix III.

Tables 1 & 2 on Figure 4 list the sample results.

The only rock sample of note was 125271 which returned elevated Mo, Cu, Pb, Ag, Au values.

Soil samples returned generally elevated Ba, As values (to 1861 and 135 ppm respectively), with locally elevated Cu, Cd, Zn, and Au values (to 1660 ppm, 5.0 ppm, 272 ppm and 45 ppb respectively). The As-Ba-Cu values are generally associated with the felsic volcanics while the Cd-Zn-Au values have no apparent correlation with either felsic or mafic volcanics.

7.4 GEOPHYSICS

Dighem Surveys and Processing Inc. of Mississauga, Ontario was contracted by Noranda Exploration to fly a helicopter-borne magnetic survey over the Mt. Johnson property. The survey was flown during July and August 1990. The Dighem report, with maps, is included as Appendix VI.

The mag survey appears to have mapped out the felsic horizon as irregular, locally linear, narrow magnetic lows.

8.0 CONCLUSIONS

A sequence of hydrothermally altered and geochemically anomalous Mt. Dillworth Formation felsic volcanics has been located on the Mt. Johnson property. Airborne magnetic surveys have mapped out the felsic horizon as northerly trending, magnetic lows.

Further work is required to follow up the geochem anomalies.

9.0 RECOMMENDATIONS

It is recommended that further prospecting, geological mapping, rock and soil sampling be conducted on the property as a follow up on the 1990 soil geochemical anomalies.

10.0 BIBLIOGRAPHY

Alldrick, D.J., (1983): Salmon River Project, Stewart, B.C. BCDM Paper 83-1.

Grove, E.W. (1982): Geology of the Unuk River-Salmon River-Anyox Map Area.

APPENDIX I

STATEMENT OF QUALIFICATIONS

APPENDIX I

STATEMENT OF QUALIFICATIONS

I, Robert J. Baerg of the city of Prince George, Province of British Columbia, do certify that:

1. I have been employed as a geologist by Noranda Exploration Company, Limited since May, 1984.
2. I am a graduate of the University of British Columbia with a Bachelor of Science (Honors) in Geology (1984).
3. I am an Associate Fellow of the Geological Association of Canada.
4. I am a member of the Canadian Institute of Mining and Metallurgy.
5. I supervised and assisted with the work described in this report.

Robert J. Baerg
Geologist
Noranda Exploration Company, Limited
(No Personal Liability)

APPENDIX II

STATEMENT OF COSTS

PROJECT: MT. JOHNSON (MJ 1-4 CLAIMS)

A.	LABOUR	
	8 md at $150/md	$ 1,200.00
B.	SUPPLIES/LODGING	
	8 md at $100/md	$ 800.00
C.	TRANSPORTATION	
	3.0 hrs helicopter at $670/hr	$ 2,010.00
D.	ANALYSES	
	40 soil samples at $12.00/sample	$ 480.00
	18 rock samples at $15.00/sample	$ 270.00
E.	CONTRACTS	
	Dighem Mag survey - 40 km at $50/km	$ 2,000.00
F.	MISC.	
	Report preparation	$ 300.00
	Drafting	$ 150.00
	TOTAL COSTS:	**$ 7,210.00**

APPENDIX III

ANALYTICAL PROCEDURE

ANALYTICAL PROCEDURE

Soils, Silts, Rocks

The samples are dried and screened to -80 mesh. Rock samples are pulverized to -120 mesh. A 0.2 gram sample is digested with 3 ml of $HClO_4/HNO_3$ (4 to 1 ratio) at 203° C for four hours, and diluted to 11 ml with water. A Leeman PS 3000 is used to determine elemental contents by I.C.P. Note that the major oxide elements and Ba, Be, Ce, Ga, La and Li are rarely dissolved completely from geological materials with this acid dissolution method.

For Au analyses, a 10.0 gram sample of -80 mesh material is digested with aqua regia and determination made by A.A.

Heavy Mineral Concentrates

The entire concentrate is digested in aqua regia solution, and elemental concentrations of Au, Ag, Cu, Pb, and Zn are determined by A.A.

APPENDIX IV

LAB REPORTS

NORANDA VANCOUVER LABORATORY

PROPERTY/LOCATION: [redacted] Mt Johnson   CODE :9007-031

Project No. : [redacted] 240   Sheet:1 of 1   Date rec'd:JUL 9
Material :54 SOILS   Geol.:R.B.   Date compl:AUG 1
Remarks : 1 SILT

Values in PPM, except where noted.

T.T. No.		SAMPLE No.		PPB Au
15		51363		5
16		51364	-35 MESH	5
17		51365		5
18		51366		5
19		51367		5
20		51368		5
21		51369		5
22		51370		5
23		51371		5
24		51372		5
25		51373		5
26		51374		5
27C	Soil	51375		5

follow

Ju 26 AP

ACME ANALYTICAL LABORATORIES LTD.

Mt Johnson

240

GEOCHEMICAL ANALYSIS CERTIFICATE

Noranda Exploration Co. Ltd. PROJECT 9007-031 281 File # 90-2402

P.O. Box 2380, 1050 Davie St., Vancouver BC V6B 3T5

SAMPLE#	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm	Au* ppb
125255	2	11	19	251	.1	5	6	845	2.25	3	5	ND	4	50	1.2	2	2	12	2.80	.058	19	3	.10	166	.01	7	.54	.02	.24	1	1
125256	3	18	13	111	.1	4	5	368	2.09	13	5	ND	4	36	.5	3	2	13	1.35	.064	20	4	.39	293	.05	7	.92	.01	.22	1	2
125257	6	8	13	6	.1	9	7	206	2.58	14	5	ND	11	5	.2	3	2	7	.05	.037	22	5	.15	160	.01	6	.62	.01	.20	1	8
125258	8	40	18	12	.3	4	13	511	5.53	51	5	ND	3	17	.2	2	2	25	.59	.154	28	2	.34	79	.01	4	1.27	.01	.18	1	8
125259	3	5	10	29	.1	6	4	423	3.44	75	5	ND	3	56	.5	2	2	39	.77	.054	19	5	.98	418	.01	7	1.14	.03	.12	1	3
125260	1	39	22	52	.1	7	12	486	7.27	7	5	ND	2	13	1.2	2	2	64	.51	.153	8	4	1.17	25	.36	4	1.74	.01	.18	2	4
125261	2	8	12	35	.1	4	6	270	3.03	5	5	ND	8	10	.2	2	3	19	.15	.064	22	4	1.01	215	.01	2	1.37	.02	.18	1	3
125262	3	3	7	1	.1	4	3	75	2.35	56	5	ND	11	13	.2	2	2	6	.16	.038	30	3	.03	93	.01	5	.28	.01	.22	1	3
125263	3	14	4	31	.1	6	5	296	3.05	17	5	ND	4	35	.2	2	2	49	.58	.119	27	4	.98	383	.01	2	1.53	.02	.13	1	3
125264	4	22	14	8	.1	6	10	254	4.99	87	5	ND	8	18	.4	2	2	46	.24	.088	23	6	.93	143	.01	9	1.31	.03	.09	1	2
125265	5	6	17	4	.1	5	4	135	2.57	16	5	ND	11	5	.2	2	2	13	.02	.044	17	3	.02	271	.01	4	.32	.01	.18	1	1
125266	7	66	12	12	.1	4	3	236	3.56	292	5	ND	8	23	.2	10	2	17	.60	.041	21	4	.40	104	.01	2	.82	.02	.09	1	4
125270	4	11	3	15	.4	6	2	290	1.62	2	5	ND	15	5	.2	2	2	11	.09	.033	36	5	.02	115	.01	9	.32	.01	.21	2	2
125271	325	123	223	118	4.8	9	9	162	2.13	18	10	ND	8	5	.2	18	2	7	.04	.023	26	7	.07	135	.01	5	.42	.01	.14	1	32
125272	3	4	5	9	.4	7	2	652	1.75	2	5	ND	7	31	.2	2	2	22	2.25	.050	25	6	.03	63	.04	7	.23	.02	.14	1	1
125273	6	12	23	16	.9	5	5	257	3.43	19	5	ND	11	5	.2	2	2	6	.08	.053	19	4	.26	181	.01	6	.85	.01	.17	1	5
125274	2	60	31	84	.5	4	11	127	2.62	16	5	ND	11	8	.2	2	2	13	.09	.054	29	4	.29	88	.01	3	.81	.03	.13	1	1
125275	1	7	7	52	.8	6	9	962	4.96	6	5	ND	2	11	.2	2	2	80	.53	.074	7	6	1.44	68	.10	6	1.84	.03	.14	1	1
51363	1	13	17	48	.1	6	5	752	2.72	9	5	ND	1	5	.3	2	2	36	.05	.116	18	7	.19	104	.01	2	1.85	.01	.14	1	
51364	1	6	17	40	.1	2	5	1166	2.33	5	5	ND	1	5	.4	2	2	33	.04	.068	19	5	.21	117	.02	2	1.29	.01	.12	1	
51365	1	13	16	51	.1	4	9	973	3.30	7	5	ND	4	9	.5	2	2	48	.23	.062	29	8	.42	141	.04	2	.92	.01	.11	1	
51366	1	56	16	102	.1	18	21	3018	5.45	9	5	ND	1	15	1.0	4	3	96	.34	.116	31	21	2.12	388	.01	7	3.31	.01	.16	1	
51367	1	369	20	77	.3	6	24	3754	4.55	17	5	ND	1	20	.8	2	2	58	.41	.112	40	11	.73	1861	.01	7	2.49	.01	.19	1	
51368	1	31	23	82	.1	8	14	2113	4.16	19	5	ND	2	18	.8	2	2	54	.37	.113	43	11	.58	671	.01	2	2.32	.01	.15	1	
51369	1	11	42	53	.1	5	3	115	2.58	16	5	ND	1	5	.2	2	2	55	.03	.082	15	5	.17	77	.01	2	2.62	.01	.09	1	
51370	2	17	15	46	.1	4	11	1258	3.05	15	5	ND	4	5	.6	2	2	32	.09	.076	22	10	.22	531	.01	2	2.68	.01	.12	1	
51371	2	41	34	131	.1	12	18	1701	3.91	27	5	ND	1	8	.5	2	2	51	.10	.100	23	12	.54	140	.02	2	2.25	.01	.10	1	
51372	2	41	38	119	.2	11	16	1648	4.54	29	5	ND	1	12	1.5	2	4	59	.15	.072	22	12	.66	215	.03	2	2.04	.01	.10	1	
51373	1	33	21	78	.1	7	15	1227	4.65	22	5	ND	1	7	.7	2	2	54	.07	.100	17	10	.66	140	.02	2	2.71	.01	.08	1	
51374	2	30	33	148	.1	13	25	3522	3.41	28	5	ND	1	14	.9	2	2	46	.20	.192	35	15	.61	268	.01	3	2.81	.01	.16	2	
51375	1	58	37	91	.3	13	28	1992	5.72	39	5	ND	1	23	.8	4	2	83	.57	.103	22	15	1.29	133	.06	2	2.40	.02	.10	1	
STANDARD C	18	57	35	129	6.7	70	31	1038	3.75	42	19	6	38	52	18.8	11	21	56	.54	.095	38	58	.89	180	.07	31	1.89	.06	.14	12	

MJ

MJ

NORANDA VANCOUVER LABORATORY

Geochemical Analysis

Mt Johnson 240

AUG - 7 1990

Project Name & No.: [redacted]   Geol.: R.B.   Date rec'd: JULY 06 .... LAB CODE: 90074025

Material: 148 SOILS, 36 SILTS   Sheet: 1 of 5   Date compl: JULY 18

Remarks:

Au – 10.0 g sample digested with aqua-regia and determined by A.A. (D.L. 5 PPB)

ICP – 0.2 g sample digested with 3 ml HClO4/HNO3 (4:1) at 203 deg. C for 4 hours diluted to 11 ml with water. Leeman PS3000 ICP determined elemental contents.

N.B. The major oxide elements and Ba, Be, Ce, Ga, La, Li are rarely dissolved completely from geological materials with acid dissolution methods.

T.T. No.	SAMPLE No.	Au ppb	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Ga ppm	K %	La ppm	Li ppm	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P %	Pb ppm	Sr ppm	Ti %	V ppm	Zn ppm
2	SOIL 51176	6	0.2	4.08	43	292	1.1	2	0.13	0.7	46	10	10	22	3.38	3	0.95	20	22	0.46	888	2	0.02	8	0.12	16	31	0.11	91	91
3	51177	5	0.2	4.30	51	235	0.9	2	0.15	0.4	44	9	8	21	3.37	5	0.98	19	23	0.54	483	2	0.02	8	0.11	16	35	0.14	98	74
4	51178	6	0.2	4.18	49	303	1.2	3	0.19	0.7	45	10	10	18	3.63	10	1.13	17	26	0.52	746	3	0.02	8	0.15	17	30	0.16	101	97
56	51351	5	0.2	6.20	121	473	2.1	6	0.15	0.8	70	21	2	73	4.23	11	2.65	35	27	0.63	1230	4	0.02	8	0.08	29	10	0.03	81	60
57	SOIL 51352	5	0.6	5.95	113	367	2.2	6	0.20	1.6	68	149	3	1660	4.31	9	2.49	35	29	0.64	1667	6	0.02	12	0.10	[illegible]	12	0.04	91	149
15	51211	6	0.2	4.80	62	697	1.3	6	0.31	1.0	67	18	9	29	4.85	18	1.28	23	29	0.68	1151	2	0.04	14	0.14	18	112	0.19	147	119
16	SOIL 51212	6	0.2	5.19	58	521	1.4	4	0.20	0.9	52	16	14	28	4.55	13	1.40	22	30	0.70	1250	2	0.04	12	0.16	23	109	0.19	150	100
17	SOIL 51213	201	0.2	3.94	56	374	1.0	6	0.22	1.0	52	21	11	43	5.00	8	1.12	21	23	0.65	1165	2	0.03	12	0.13	23	41	0.13	134	106
18	51214	5	0.2	5.47	59	564	1.4	5	0.12	0.9	67	16	19	32	4.95	9	1.31	24	28	0.69	1406	2	0.03	12	0.15	24	30	0.14	140	104
19	51215	5	0.2	4.24	56	423	1.3	3	0.24	0.8	63	18	12	53	4.42	9	1.31	27	27	0.98	1615	1	0.02	11	0.10	19	28	0.13	136	95
20	51216	5	0.2	4.58	64	342	1.1	5	0.12	0.8	47	14	12	27	4.25	5	1.32	19	29	0.67	1123	2	0.02	10	0.14	19	23	0.10	125	97
21	SOIL 51217	5	0.2	3.91	53	254	1.6	2	0.18	0.8	48	10	7	36	3.13	7	1.16	20	23	0.49	726	2	0.02	8	0.13	12	27	0.08	101	63
22	SOIL 51218	5	0.2	4.41	67	271	1.2	4	0.08	0.8	57	12	4	28	4.02	8	1.34	18	28	0.45	1093	2	0.02	8	0.10	18	16	0.07	86	66
23	51219	10	0.2	6.76	187	288	1.6	15	0.15	1.4	64	26	3	77	5.41	19	3.01	28	15	0.56	951	4	0.02	10	0.13	31	9	0.03	116	48
24	51220	6	0.2	5.93	69	360	1.6	5	0.18	0.8	61	13	2	32	4.27	7	2.11	25	29	0.43	1150	3	0.02	7	0.15	13	12	0.03	118	61
25	51221	5	0.2	6.04	71	500	1.7	2	0.14	0.6	55	9	2	21	3.20	11	2.22	22	17	0.40	834	2	0.02	6	0.11	15	11	0.03	85	44
26	SOIL 51222	6	0.2	5.67	108	421	1.7	8	0.12	1.1	56	18	5	68	4.78	12	1.57	25	30	0.49	1263	6	0.02	9	0.16	27	16	0.06	105	94
27	SOIL 51223	5	0.2	7.46	66	600	2.9	11	0.22	1.0	71	15	3	23	3.86	25	3.19	34	24	0.69	1505	3	0.02	8	0.10	26	9	0.04	90	67
28	51224	5	0.4	7.31	135	1406	2.3	16	0.23	2.2	98	23	5	49	6.29	28	2.96	48	26	0.60	4555	12	0.03	12	0.14	46	24	0.03	135	131
29	51225	5	0.2	6.84	92	792	2.1	12	0.24	1.1	74	20	4	28	4.14	30	3.14	30	19	0.64	2365	5	0.02	9	0.09	32	14	0.02	81	63
133	SOIL 125081	5	0.2	4.00	49	277	1.3	2	0.23	1.2	60	12	6	22	3.62	14	1.21	22	25	0.63	1209	3	0.04	10	0.12	24	45	0.15	106	105
134	SOIL 125082	5	0.2	3.96	52	267	1.2	3	0.24	1.3	54	13	8	28	3.82	15	1.13	25	24	0.68	944	3	0.03	12	0.09	29	48	0.16	103	106
135	SOIL 125083	5	0.2	5.14	56	678	2.2	11	0.15	5.0	62	33	8	37	7.28	23	1.69	35	43	0.74	3602	6	0.02	16	0.19	47	23	0.09	212	272
136	125084	45	0.2	8.67	59	607	2.5	4	0.21	1.9	63	15	2	11	4.52	20	2.87	29	10	0.64	894	4	0.02	9	0.11	21	20	0.07	101	66
137	125085	5	0.2	5.67	56	362	1.5	3	0.07	1.3	51	16	6	113	4.30	13	2.01	22	27	0.71	1120	3	0.02	10	0.16	21	17	0.10	142	82
138	SOIL 125086	5	0.2	5.67	47	606	2.1	2	0.16	1.3	58	9	4	10	3.84	16	2.29	30	17	0.61	638	2	0.02	8	0.12	16	19	0.07	93	56
139	SOIL 125087	5	0.2	6.72	60	785	1.5	2	0.23	1.2	50	7	3	12	3.39	17	2.36	23	13	0.40	439	5	0.02	7	0.13	15	20	0.06	91	64

APPENDIX V

SAMPLE DESCRIPTIONS

NORANDA EXPLORATION COMPANY, LIMITED

N.T.S. 104A/4,5

PROPERTY Mt Johnson (above 1988 camp)

DATE June 29/90

ROCK SAMPLE REPORT

PROJECT: 240

SAMPLE NO.	LOCATION & DESCRIPTION	% SULPHIDES	TYPE	WIDTH	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	SAMPLED BY
125255	490m along traverse at 1655m elv orange/grey andesitic volcanoclastic. clasts were .5 to 4cm in size and the matrix was medium to fine grained local zonation of gossen	?	?	?								T. Rehill P. Turnbull
125256	650m along traverse at an elevation of 1650m, orange/grey andesitic volcanoclastic. Clasts were ranging from .5cm to 4cm in size, the matrix was medium grained.	?	?	?								
125257	1230m along traverse at elev. of 1700m was o/c sample of altered (rusty grey) andescite w/ rusty porphyroclasts. - sulfurous smell and partially hematized - no visible sulfides		Rock o/c	10cm								
125258	≈ at 1660m distance and elev. of 1760m on edge of glacial saddle was o/c sample of altered (orange/grey, rusty) rhyolite; intensly fractured; very gossinous surface weathering; silver	≈5	Rock o/c	10 cm								T. Rehill P. Turnbull

NORANDA EXPLORATION COMPANY, LIMITED

N.T.S. 104 A/4,5

PROPERTY MJ Claims (above 1988 camp)

DATE June 29, 90

ROCK SAMPLE REPORT

PROJECT:

SAMPLE NO.	LOCATION & DESCRIPTION	% SULPHIDES	TYPE	WIDTH	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	SAMPLED BY
125259	≈ 2550m along traverse at elev. of 1770m	—	Rock o/c	10cm								Paul Turnbull
	- rusty surface alteration in green/grey											+ Trent Rehill
	andescitic rock											
	- no visible sulfides											
	- some large hornblende (10 cm) porphyoclasts											
	in nearby andesc.											

G — GEOCHEM A — ASSAY

NORANDA EXPLORATION COMPANY, LIMITED

N.T.S. 104 A/4,5

PROPERTY MJ Claims (Mnt. Johnson traverse)

DATE June 30, 90

ROCK SAMPLE REPORT

PROJECT 240

SAMPLE NO.	LOCATION & DESCRIPTION	% SULPHIDES	TYPE	WIDTH	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	SAMPLED BY
125260	- 230 m West on Northern ridge above 1988 Noranda Camp; altered (rusty) orange, grey rhyodacite clasts w/ disseminated pyrite, in an andescitic volcanoclastic host. -intense fracturing present; elev. = 1475 m -clasts range b/w 2mm → 20cm in size	6-8	Rock o/c	10 cm								Paul Turnbull + Doug Doll
125261	- 745 m along traverse was an o/c of semi-altered rhyodacite w/ disseminated pyrite; sample at 20° az. from opposing gossinous cliff (to South); elev. = 1575 m	<5	Rock o/c	10 cm								
125262	- 820 m along traverse at elev. = 1615 m - intensely fractured/altered, rusty orange/grey rhyolite w/ trace pyrite visible -near shear zone	trace	Rock o/c	10 cm								
125263	- 1150 m along traverse at 1645 m elev. - cherty rhyolite w/ disseminated pyrite - not as altered (only patchy surface alteration) - finely laminated; fractures at 120° 48°NE	5	Rock o/c	10 cm								

NORANDA EXPLORATION COMPANY, LIMITED

N.T.S. 104 A/4,5

PROPERTY MJ claims (Mnt Johnson traverse)

DATE June 30, 90

ROCK SAMPLE REPORT

PROJECT 240

SAMPLE NO.	LOCATION & DESCRIPTION	% SULPHIDES	TYPE	WIDTH	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	SAMPLED BY
125264	- at 1185 m along traverse at 1650m elev.	trace	Rock O/c	10 cm								Paul Turnbull
	- altered volcanoclastic (andesitic) w/ trace											and Doug Doll
	pyrite and rusty crystals											
125265	- at 1450m distance and 1740 m elev.	?	Rock O/c	10 cm								
	- highly fractured, altered rhyolite (rusty											
	orange/grey) ; sulfurous smell											
	- part of a gossinous cliff											
125266	- at 1660m along traverse at 1750 m elev.	5	Rock O/c	10 cm								
	- altered orange/grey rhyolite/dacite											
	w/ disseminated pyrite											

NORANDA EXPLORATION COMPANY, LIMITED

N.T.S. 104 A/4,5

PROPERTY MJ South claim (near Todd Glacier)

DATE July 3, 90

ROCK SAMPLE REPORT

PROJECT: 240

SAMPLE NO.	LOCATION & DESCRIPTION	% SULPHIDES	TYPE	WIDTH	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	SAMPLED BY
125270	-150m along traverse (Westward) at 1400m elev.	2	Rock o/c	10cm								Paul Turnbull
	- purple/green, silicious andes./dac.											+ Doug Doll
	- specular hematite in qtz. veins											
	- sulfurous, orange/rusty crystals; some white											
	clay alteration											
125271	-125 m along traverse at 1370 m elev.	2	rock o/c	10cm								
	-rusty orange feldspathic rhyodacite w/ some											
	lead grey stringers											
	- sulfurous, fractured; Mn weathering											
125272	- 50 m along traverse at 1350m elev.	?	rock o/c	10cm								
	- jasperized rhyodacite tuff											
	- two tone purple w/ 1→5cm thick layers											
	- sulfurous, feldspathic, semi vesicular											
125273	-700m along traverse at 1515 elev.	5	Rock o/c	10cm								
	- gossinous qtz./rhyodacite vein at 290° az.											
	w/ disseminated pyrite											
	- near intensely fractured cliff face											

G = GEOCHEM A = ASSAY

NORANDA EXPLORATION COMPANY, LIMITED

N.T.S. 104A/4,5

PROPERTY MJ South Claim (near Todd Glacier toe)

DATE July 3, 90

ROCK SAMPLE REPORT

PROJECT: 240

SAMPLE NO.	LOCATION & DESCRIPTION	% SULPHIDES	TYPE	WIDTH	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	G☐ A☐	SAMPLED BY
125274	- 851 m along traverse at 1530m elev. - pyrite bearing rhyolite zone (1m wide) - surrounding rock is dacitic volcanoclastic - patchy gossin	3	rock o/c	10cm								Paul Turnbull
125275	- 1480 m along traverse at 1650m elev. - gossinous orange/rusty/grey rhyolite w/ pyrite and chalcopyrite → some rusty crystals - this mineralized band of 2m width is sandwiched inside feldspathic, green/grey andesitic clastic → some mineralization near band of rhyolite (outside also) - fractures are parallel at 60° 65°NW	15	rock o/c	10 cm								

G - GEOCHEM A - ASSAY

APPENDIX VI

AEM REPORT (DIGHEM)

Report #1090B

DIGHEM^{IV} SURVEY

FOR

NORANDA EXPLORATION COMPANY, LIMITED

MT. JOHNSTON/TODD CREEK AREA

BRITISH COLUMBIA

NTS 104A/4, 104A/5

DIGHEM SURVEYS & PROCESSING INC.
MISSISSAUGA, ONTARIO
December 3, 1990

A1090DEC.91R

Paul A. Smith
Geophysicist

SUMMARY

This report describes the logistics and results of a DIGHEM^{IV} airborne geophysical survey carried out for Noranda Exploration Company, Limited, over a property located in the Todd Creek area of British Columbia. Total coverage of the survey block amounted to 40 km. The survey was flown from July 28 to August 11, 1990.

The purpose of the survey was to detect zones of conductive mineralization and to provide information that could be used to map the geology and structure of the survey area. This was accomplished by using a DIGHEM^{IV} multi-coil, multi-frequency electromagnetic system, supplemented by a high sensitivity Cesium magnetometer and a two-channel VLF receiver. The information from these sensors was processed to produce maps which display the magnetic and conductive properties of the survey area. An electronic navigation system, operating in the UHF band, ensured accurate positioning of the geophysical data with respect to the base maps in only a few portions of the survey block. Visual flight path recovery techniques were used in areas where transponder signals were blocked by topographic features.

The project area is underlain by highly resistive ground. Only a few of the anomalies detected by the survey have been attributed to possible bedrock conductors. Most of

these EM anomalies warrant further investigation using appropriate surface exploration techniques. Areas of interest may be assigned priorities on the basis of supporting geophysical, geochemical and/or geological information. After initial investigations have been carried out, it may be necessary to re-evaluate the remaining anomalies based on information acquired from the follow-up program.

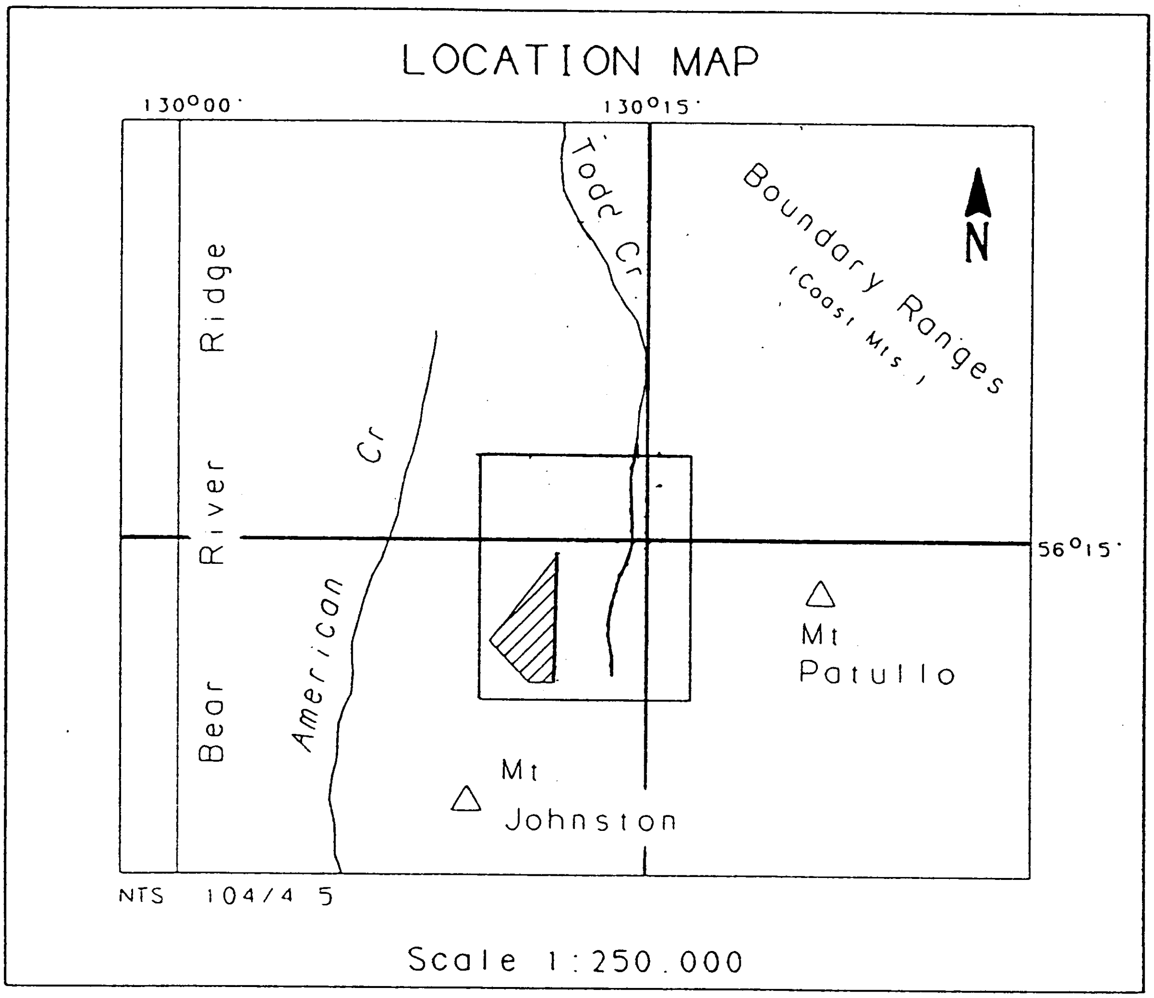


FIGURE 1
MT. JOHNSTON/TODD CREEK AREA

CONTENTS

INTRODUCTION

A DIGHEM^{IV} electromagnetic/resistivity/magnetic/VLF survey was flown for Noranda Exploration Company, Limited from July 28 to August 11, 1990, over a survey block in central British Columbia. The property, designated the Mt. Johnston Project, is located in the Cambria Icefield, about 40 km northeast of Stewart. The property is situated on NTS map sheets 104A/4 and 104A/5, with its center near latitude 56°14'00"N/longitude 129°47'30"W.

Survey coverage consisted of approximately 40 line-km, including tie lines. Flight lines were flown east/west with a line separation of 100 metres.

The survey employed the DIGHEM^{IV} electromagnetic system. Ancillary equipment consisted of a magnetometer, radar altimeter, video camera, analog and digital recorders, a VLF receiver and an electronic navigation system. Details on the survey equipment are given in Section 2.

The instrumentation was installed in an Aerospatiale AS350B turbine helicopter (Registration C-GNIX) which was provided by Questral Helicopters Ltd. The helicopter flew at an average airspeed of 120 km/h with an EM bird height of approximately 30 m.

Section 2 also provides details on the data channels, their respective sensitivities, and the navigation/flight path recovery procedure. Noise levels of less than 2 ppm are generally maintained for wind speeds up to 35 km/h. Higher winds may cause the system to be grounded because excessive bird swinging produces difficulties in flying the helicopter. The swinging results from the 5 m^2 of area which is presented by the bird to broadside gusts.

In some portions of the survey area, the extremely rugged topography forced the pilot to exceed normal terrain clearance for reasons of safety. It is possible that some weak conductors may have escaped detection in areas where the bird height exceeded 120 m. In difficult areas where near-vertical climbs were necessary, the forward speed of the helicopter was reduced to a level which permitted excessive bird swinging. This problem, combined with the severe stresses to which the bird was subjected, gave rise to aerodynamic noise levels which are slightly higher than normal. Where warranted, reflights were carried out to minimize these adverse effects.

SURVEY EQUIPMENT

This section provides a brief description of the geophysical instruments used to acquire the survey data:

Electromagnetic System

Model: DIGHEM^{IV}

Type: Towed bird, symmetric dipole configuration operated at a nominal survey altitude of 30 metres. Coil separation is 8 metres for 900 Hz and 7200 Hz, and 6.3 metres for the 56,000 Hz coil-pair.

Coil orientations/frequencies:
coaxial / 900 Hz
coplanar/ 900 Hz
coplanar/ 7,200 Hz
coplanar/56,000 Hz

Channels recorded:
4 inphase channels
4 quadrature channels
2 monitor channels

Sensitivity:
0.2 ppm at 900 Hz
0.4 ppm at 7,200 Hz
1.0 ppm at 56,000 Hz

Sample rate: 10 per second

The electromagnetic system utilizes a multi-coil coaxial/coplanar technique to energize conductors in different directions. The coaxial transmitter coil is vertical with its axis in the flight direction. The coplanar coils are horizontal. The secondary fields are sensed simultaneously by means of receiver coils which are maximum coupled to their respective transmitter coils. The system yields an inphase and a quadrature channel from each transmitter-receiver coil-pair.

Magnetometer

Model:	Picodas 3340
Type:	Optically pumped Cesium vapour
Sensitivity:	0.01 nT
Sample rate:	10 per second

The magnetometer sensor is towed in a bird 15 m below the helicopter.

Magnetic Base Station

Model:	Scintrex MP-3
Type:	Digital recording proton precession
Sensitivity:	0.10 nT
Sample rate:	0.2 per second

A digital recorder is operated in conjunction with the base station magnetometer to record the diurnal variations of the earth's magnetic field. The clock of the base station is synchronized with that of the airborne system to permit subsequent removal of diurnal drift.

VLF System

Manufacturer: Herz Industries Ltd.

Type: Totem-2A

Sensitivity: 0.1%

Stations: Seattle, Washington; NLK, 24.8 kHz
Lualualei, Hawaii; NPM, 23.4 kHz

The VLF receiver measures the total field and vertical quadrature components of the secondary VLF field. Signals from two separate transmitters can be measured simultaneously. The VLF sensor is towed in a bird 10 m below the helicopter.

Radar Altimeter

Manufacturer: Honeywell/Sperry

Type: AA 220

Sensitivity: 1 ft

The radar altimeter measures the vertical distance between the helicopter and the ground. This information is used in the processing algorithm which determines conductor depth.

Analog Recorder

Manufacturer: RMS Instruments

Type: DGR33 dot-matrix graphics recorder

Resolution: 4x4 dots/mm

Speed: 1.5 mm/sec

The analog profiles were recorded on chart paper in the aircraft during the survey. Table 2-1 lists the geophysical data channels and the vertical scale of each profile.

Digital Data Acquisition System

Manufacturer: RMS Instruments

Type: DGR 33

Tape Deck: RMS TCR-12, 6400 bpi, tape cartridge recorder

The digital data were used to generate several computed parameters. Both measured and computed parameters were plotted as "multi-channel stacked profiles" during data processing. These parameters are shown in Table 2-2.

In Table 2-2, the log resistivity scale of 0.06 decade/mm means that the resistivity changes by an order of magnitude in 16.6 mm. The resistivities at 0, 33 and 67 mm up from the bottom of the digital profile are respectively 1, 100 and 10,000 ohm-m.

Table 2-1. The Analog Profiles

Channel Name	Parameter	Scale units/mm	Designation on digital profile
1X9I	coaxial inphase (900 Hz)	2.5 ppm	CXI (900 Hz)
1X9Q	coaxial quad (900 Hz)	2.5 ppm	CXQ (900 Hz)
3P9I	coplanar inphase (900 Hz)	2.5 ppm	CPI (900 Hz)
3P9Q	coplanar quad (900 Hz)	2.5 ppm	CPQ (900 Hz)
2P7I	coplanar inphase (7200 Hz)	5 ppm	CPI (7200 Hz)
2P7Q	coplanar quad (7200 Hz)	5 ppm	CPQ (7200 Hz)
4P5I	coplanar inphase(56000 Hz)	10 ppm	CPI (56 kHz)
4P5Q	coplanar quad (56000 Hz)	10 ppm	CPQ (56 kHz)
ALTR	altimeter	3 m	ALT
CMGC	magnetics, coarse	25 nT	MAG
CMGF	magnetics, fine	2.5 nT	
VF1T	VLF-total: primary stn.	2%	
VF1Q	VLF-quad: primary stn.	2%	
VF2T	VLF-total: secondary stn.	2%	
VF2Q	VLF-quad: secondary stn.	2%	
CXSP	coaxial sferics monitor		CXS
CPSP	coplanar sferics monitor		
CXPL	coaxial powerline monitor		
CPPL	coplanar powerline monitor		CPP

Table 2-2. The Digital Profiles

Channel Name (Freq)		Observed parameters	Scale units/mm
MAG		magnetics	10 nT
ALT		bird height	6 m
CXI	(900 Hz)	vertical coaxial coil-pair inphase	2 ppm
CXQ	(900 Hz)	vertical coaxial coil-pair quadrature	2 ppm
CPI	(900 Hz)	horizontal coplanar coil-pair inphase	2 ppm
CPQ	(900 Hz)	horizontal coplanar coil-pair quadrature	2 ppm
CPI	(7200 Hz)	horizontal coplanar coil-pair inphase	4 ppm
CPQ	(7200 Hz)	horizontal coplanar coil-pair quadrature	4 ppm
CPI	(56 kHz)	horizontal coplanar coil-pair inphase	10 ppm
CPQ	(56 kHz)	horizontal coplanar coil-pair quadrature	10 ppm
CXS		coaxial sferics monitor	
CPP		coplanar powerline monitor	
		Computed Parameters	
DFI	(900 Hz)	difference function inphase from CXI and CPI	2 ppm
DFQ	(900 Hz)	difference function quadrature from CXQ and CPQ	2 ppm
RES	(900 Hz)	log resistivity	.06 decade
RES	(7200 Hz)	log resistivity	.06 decade
RES	(56 kHz)	log resistivity	.06 decade
DP	(900 Hz)	apparent depth	6 m
DP	(7200 Hz)	apparent depth	6 m
DP	(56 kHz)	apparent depth	6 m
CDT		conductance	1 grade

Tracking Camera

Type: Panasonic Video

Model: AG 2400/WVCD132

Fiducial numbers are recorded continuously and are displayed on the margin of each image. This procedure ensures accurate correlation of analog and digital data with respect to visible features on the ground.

Navigation System

Model: Del Norte 547

Type: UHF electronic positioning system

Sensitivity: 1 m

Sample rate: 2 per second

The navigation system uses ground based transponder stations which transmit distance information back to the helicopter. The ground stations are set up well away from the survey area and are positioned such that the signals cross the survey block at an angle between 30° and 150°. The onboard Central Processing Unit takes any two transponder distances and determines the helicopter position relative to these two ground stations in cartesian coordinates.

The cartesian coordinates are transformed to UTM coordinates during data processing. This is accomplished by correlating a number of prominent topographical locations with the navigational data points. The use of numerous visual tie points serves two purposes: to accurately relate the navigation data to the map sheet and to minimize location errors which might result from distortions in uncontrolled photomosaic base maps.

PRODUCTS AND PROCESSING TECHNIQUES

The following products are available from the survey data. Those which are not part of the survey contract may be acquired later. Refer to Table 3-1 for a summary of the maps which accompany this report, some of which may be sent under separate cover. Most parameters can be displayed as contours, profiles, or in colour.

Base Maps

Base maps of the survey area have been produced from published topographic maps. These provide a relatively accurate, distortion-free base which facilitates correlation of the navigation data to the UTM grid. Photomosaics are useful for visual reference and for subsequent flight path recovery, but usually contain scale distortions. Orthophotos are ideal, but their cost and the time required to produce them, usually precludes their use as base maps.

Electromagnetic Anomalies

Anomalous electromagnetic responses are selected and analysed by computer to provide a preliminary electromagnetic anomaly map. This preliminary map is used, by the

Table 3-1 Plots Available from the Survey

MAP PRODUCT	NO. OF SHEETS	ANOMALY MAP	PROFILES ON MAP	CONTOURS INK	CONTOURS COLOUR	SHADOW MAP
Electromagnetic Anomalies	1	10,000	N/A	N/A	N/A	N/A
Probable Bedrock Conductors		-	N/A	N/A	N/A	N/A
Resistivity (900 Hz)	1	N/A	-	10,000	10,000	-
Resistivity (7,200 Hz)	1	N/A	-	10,000	10,000	-
Resistivity (56,000 Hz)	1	N/A	-	10,000	10,000	-
EM Magnetite		N/A	-	-	-	-
Total Field Magnetics	1	N/A	-	10,000	10,000	-
Enhanced Magnetics		N/A	-	-	-	-
1st Vertical Derivative Magnetics	1	N/A	-	10,000	10,000	-
2nd Vertical Derivative Magnetics		N/A	-	-	-	-
Filtered Total Field VLF	1	N/A	-	10,000	10,000	-
VLF Profiles		N/A	-	N/A	N/A	N/A
Electromagnetic Profiles(900 Hz)		N/A	-	N/A	N/A	N/A
Electromagnetic Profiles(7200 Hz)		N/A	-	N/A	N/A	N/A
Multi-channel stacked profiles		Worksheet profiles				-
		Interpreted profiles				10,000

N/A Not available
- Not required under terms of the survey contract
* Recommended
20,000 Scale of delivered map, i.e, 1:10,000

Notes:

- Inked contour maps are provided on transparent media and show flight lines, EM anomalies and suitable registration. Three paper prints of each map are supplied, in addition to three colour plots of each contour map.

geophysicist, in conjunction with the computer-generated digital profiles, to produce the final interpreted EM anomaly map. This map includes bedrock, surficial and cultural conductors. A map containing only bedrock conductors can be generated, if desired.

Resistivity

The apparent resistivity in ohm-m may be generated from the inphase and quadrature EM components for any of the frequencies, using a pseudo-layer halfspace model. A resistivity map portrays all the EM information for that frequency over the entire survey area. This contrasts with the electromagnetic anomaly map which provides information only over interpreted conductors. The large dynamic range makes the resistivity parameter an excellent mapping tool.

EM Magnetite

The apparent percent magnetite by weight is computed wherever magnetite produces a negative inphase EM response.

Total Field Magnetics

The aeromagnetic data are corrected for diurnal variation using the magnetic base station data. The regional IGRF can be removed from the data, if requested.

Enhanced Magnetics

The total field magnetic data are subjected to a processing algorithm. This algorithm enhances the response of magnetic bodies in the upper 500 m and attenuates the response of deeper bodies. The resulting enhanced magnetic map provides better definition and resolution of near-surface magnetic units. It also identifies weak magnetic features which may not be evident on the total field magnetic map. However, regional magnetic variations, and magnetic lows caused by remanence, are better defined on the total field magnetic map. The technique is described in more detail in Section 5.

Magnetic Derivatives

The total field magnetic data may be subjected to a variety of filtering techniques to yield maps of the following:

- vertical gradient
- second vertical derivative
- magnetic susceptibility with reduction to the pole
- upward/downward continuations

All of these filtering techniques improve the recognition of near-surface magnetic bodies, with the exception of upward continuation. Any of these parameters can be produced on request. Dighem's proprietary enhanced magnetic technique is designed to provide a general "all-purpose" map, combining the more useful features of the above parameters.

VLF

The VLF data are digitally filtered to remove long wavelengths such as those caused by variations in the transmitted field strength.

Multi-channel Stacked Profiles

Distance-based profiles of the digitally recorded geophysical data are generated and plotted by computer. These profiles also contain the calculated parameters which are used in the interpretation process. These are produced as worksheets prior to interpretation, and can also be presented in the final corrected form after interpretation. The profiles display electromagnetic anomalies with their respective interpretive symbols. The differences between the worksheets and the final corrected form occur only with respect to the EM anomaly identifier.

Contour, Colour and Shadow Map Displays

The geophysical data are interpolated onto a regular grid using a modified Akima spline technique. The resulting grid is suitable for generating contour maps of excellent quality.

Colour maps are produced by interpolating the grid down to the pixel size. The parameter is then incremented with respect to specific amplitude ranges to provide colour "contour" maps. Colour maps of the total magnetic field are particularly useful in defining the lithology of the survey area.

Monochromatic shadow maps are generated by employing an artificial sun to cast shadows on a surface defined by the geophysical grid. There are many variations in the shadowing technique. These techniques may be applied to total field or enhanced magnetic data, magnetic derivatives, VLF, resistivity, etc. Of the various magnetic products, the shadow of the enhanced magnetic parameter is particularly suited for defining geological structures with crisper images and improved resolution.

SURVEY RESULTS

GENERAL DISCUSSION

The survey results are presented on 2 separate map sheets for each parameter at a scale of 1:10,000.

The anomalies shown on the electromagnetic anomaly maps are based on a near-vertical, half plane model. This model best reflects "discrete" bedrock conductors. Wide bedrock conductors or flat-lying conductive units, whether from surficial or bedrock sources, may give rise to very broad anomalous responses on the EM profiles. These may not appear on the electromagnetic anomaly map if they have a regional character rather than a locally anomalous character. These broad conductors, which more closely approximate a half space model, will be maximum coupled to the horizontal (coplanar) coil-pair and should be more evident on the resistivity parameter. Resistivity maps, therefore, may be more valuable than the electromagnetic anomaly maps, in areas where broad or flat-lying conductors are considered to be of importance.

Excellent resolution and discrimination of conductors was accomplished by using a fast sampling rate of 0.1 sec and by employing a common frequency (900 Hz) on two orthogonal coil-pairs (coaxial and coplanar). The resulting "difference channel" parameters often permit differentiation of bedrock and surficial conductors, even though they may exhibit similar conductance values.

Anomalies which occur near the ends of the survey lines (i.e., outside the survey area), should be viewed with caution. Some of the weaker anomalies could be due to aerodynamic noise, i.e., bird bending, which is created by abnormal stresses to which the bird is subjected during the climb and turn of the aircraft between lines. Such aerodynamic noise is usually manifested by an anomaly on the coaxial inphase channel only, although severe stresses can affect the coplanar inphase channels as well.

Magnetics

A Scintrex MP-3 proton precession magnetometer was operated at the survey base to record diurnal variations of the earth's magnetic field. The clock of the base station was synchronized with that of the airborne system to permit subsequent removal of diurnal drift.

The background magnetic levels have been adjusted to match the International Geomagnetic Reference Field (IGRF) for the survey area. The IGRF gradient across the survey block is left intact. This procedure ensures that the magnetic contours will match contours from any adjacent surveys which have been processed in a similar manner.

The total field magnetic data have been presented as contours on the base maps using a contour interval of 5 nT where gradients permit. The maps show the magnetic properties of the rock units underlying the survey area.

The total field magnetic data have been subjected to a processing algorithm to produce maps of the calculated first vertical derivative. This procedure enhances near-surface magnetic units and suppresses regional gradients. It also provides better definition and resolution of magnetic units and displays weak magnetic features which may not be clearly evident on the total field maps. Maps of the second vertical magnetic derivative can also be prepared from existing survey data, if requested.

There is some evidence on the magnetic maps which suggests that the survey area has been subjected to deformation and/or alteration. These structural complexities are evident on the contour maps as variations in magnetic intensity, irregular patterns, and as offsets or changes in strike direction. Some of the more prominent linear features are also evident on the topographic base maps.

The magnetic relief on the Todd Creek Project is moderate, ranging from a low of about 57,130 nT to a high of almost 57,710 nano Teslas. The 57,500 nT contour outlines several irregularly-shaped units of moderate magnetic intensity which are interlayered with relatively non-magnetic units. The magnetic contours appear "smoother" in the areas covered by ice. The individual units which comprise the magnetic trends are more clearly defined on the vertical gradient maps. The latter product also identifies several faults, in addition to the geological contacts.

If a specific magnetic intensity can be assigned to the rock type which is believed to host the target mineralization, it may be possible to select areas of higher priority on the basis of the total field magnetic data. This is based on the assumption that the magnetite content of the host rocks will give rise to a limited range of contour values which will permit differentiation of various lithological units.

The magnetic results, in conjunction with the other geophysical parameters, should provide valuable information which can be used to effectively map the geology and structure in the survey area.

VLF

VLF results were obtained from the transmitting stations at Lualualei, Hawaii (NPM - 23.4 kHz) and Seattle, Washington (NLK - 24.8 kHz). The VLF maps show the contoured results of the filtered total field from Seattle. Gaps in coverage are evident on a few reflown lines such as 20151.

The VLF method is quite sensitive to the angle of coupling between the conductor and the propogated EM field. Consequently, conductors which strike towards the VLF station will usually yield a stronger response than conductors which are nearly orthogonal to it. The general north/south strike in the survey area provides good coupling with the VLF field from Seattle.

The VLF parameter does not normally provide the same degree of resolution available from the EM data. Closely-spaced conductors, conductors of short strike length or conductors which are poorly coupled to the VLF field, may escape detection with this method. Erratic signals from the VLF transmitters can also give rise to strong, isolated anomalies which should be viewed with caution. Regardless of these limitations, however, the VLF results have provided some additional information, particularly within the more resistive portions of the survey area. The VLF method could probably be used as a follow-up tool in most areas, although its effectiveness will be somewhat limited in areas of moderate to high conductivity. The filtered total field VLF contours are presented on the base maps with a contour interval of one percent.

Electromagnetics

The EM anomalies resulting from this survey appear to fall within one of two general categories. The first type comprises moderately broad responses which exhibit the characteristics of a half space and do not yield well-defined inflections on the difference channels. Anomalies in this category are usually given an "S" or "S?" interpretive symbol. The lack of a difference channel response usually implies a broad or flat-lying conductive source such as overburden. Some of these anomalies may reflect conductive rock units or zones of deep weathering.

The second class consists of moderately broad quadrature anomalies which are associated with negative inphase responses. The negative inphase is due to magnetite. The positive quadrature can be due to conductive material which overlies, or is contained within, the magnetite-rich rock unit. Most of these anomalies have been given an "S?" or "B?" interpretive symbol.

In areas where EM responses are evident primarily on the quadrature components, zones of poor conductivity are indicated. Where these responses are coincident with magnetic anomalies, it is possible that the inphase component amplitudes have been suppressed by the effects of magnetite. Most of these poorly-conductive magnetic features give rise to resistivity anomalies which are only slightly below background. If it is expected that poorly-conductive economic mineralization may be associated with magnetite-rich units, most of these weakly anomalous features will be of interest. In areas where magnetite causes the inphase components to become negative, the apparent conductance and depth of EM anomalies may be unreliable.

The effects of conductive overburden are evident over portions of the survey area. Although the difference channels (DFI and DFQ) are extremely valuable in detecting bedrock conductors which are partially masked by conductive overburden, sharp undulations in the bedrock/overburden interface can yield anomalies in the difference channels which may be interpreted as possible bedrock conductors. Such anomalies usually fall into the "S?" or "B?" classification but may also be given an "E" interpretive symbol, denoting a resistivity contrast at the edge of a conductive unit.

As economic mineralization within the area may consist of massive to weakly disseminated sulphides, which may or may not be hosted by magnetite-rich rocks, it is difficult to assess the relative merits of EM anomalies on the basis of conductance. It is recommended that an attempt be made to compile a suite of geophysical "signatures" over areas of interest. Anomaly characteristics are clearly defined on the computer-processed geophysical data profiles which are supplied as one of the survey products.

A complete assessment and evaluation of the survey data should be carried out by one or more qualified professionals who have access to, and can provide a meaningful compilation of, all available geophysical, geological and geochemical data.

CONDUCTORS IN THE SURVEY AREA

The electromagnetic anomaly maps show the anomaly locations with the interpreted conductor type, dip, conductance and depth being indicated by symbols. Direct magnetic correlation is also shown if it exists. The strike direction and length of the conductors are indicated when anomalies can be correlated from line to line. When studying the map sheets, consult the anomaly listings appended to this report.

There are no strong anomalous responses in the Todd Creek survey area which display the characteristics of massive sulphide responses. The few anomalies which have been attributed to possible bedrock sources are generally weak and poorly-defined. Most occur as single-line responses, indicating very limited strike length. (20160B).

CONCLUSIONS AND RECOMMENDATIONS

This report provides a very brief description of the survey results and describes the equipment, procedures and logistics of the survey over the Todd Creek project.

No strong bedrock conductors, which are typical of massive sulphide responses, were identified in the survey area. However, the survey was successful in locating a few weak or poorly defined conductors of limited strike extent, which may warrant additional work. The various maps included with this report display the magnetic and conductive properties of the survey area. It is recommended that the survey results be reviewed in detail, in conjunction with all available geophysical, geological and geochemical information. Particular reference should be made to the computer generated data profiles which clearly define the characteristics of the individual anomalies.

Most anomalies in the Todd Creek area have been given an "S?" designation. Many have been attributed to conductive overburden or deep weathering, and several appear to be associated with magnetite-rich rock units. Others coincide with VLF anomalies, resistivity gradients, and/or magnetic gradients, which may reflect faults or shears. Such structural breaks are considered to be of particular interest as they may have influenced mineral deposition within the survey area.

The interpreted bedrock conductors defined by the survey should be subjected to further investigation, using appropriate surface exploration techniques. Resistivity anomalies are also considered to be potential areas of interest. Anomalies which are currently considered to be of moderately low priority may require upgrading if follow-up results are favourable.

It is also recommended that image processing of existing geophysical data be considered, in order to extract the maximum amount of information from the survey results. Current software and imaging techniques often provide valuable information on structure and lithology, which may not be clearly evident on the contour and colour maps. These techniques can yield images which define subtle, but significant, structural details.

Respectfully submitted,
DIGHEM SURVEYS & PROCESSING INC.

Paul A. Smith
Geophysicist

PAS/sdp

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APPENDIX A

LIST OF PERSONNEL

The following personnel were involved in the acquisition, processing, interpretation and presentation of data, relating to a DIGHEM^{IV} airborne geophysical survey carried out for Noranda Exploration Company, Limited, over the Todd Creek property, B.C.

Steve Kilty	Vice President, Operations
Dave Pritchard	Survey Operations Supervisor
Phil Miles	Senior Geophysical Operator
Luke Kukovica	Pilot (Questral Helicopters Ltd.)
Gordon Smith	Data Processing Supervisor
Paul A. Smith	Interpretation Geophysicist
Reinhard Zimmerman	Drafting Supervisor
Lyn Vanderstarren	Draftsperson (CAD)
Susan Pothiah	Word Processing Operator
Albina Tonello	Secretary/Expeditor

The survey consisted of 555 km of coverage, flown from July 28 to August 11, 1990.

All personnel are employees of Dighem Surveys & Processing Inc., except for the pilot who is an employee of Questral Helicopters Ltd.

DIGHEM SURVEYS & PROCESSING INC.

Paul A. Smith
Geophysicist

PAS/sdp

Ref: Report #1090B

A1090DEC.91R

BACKGROUND INFORMATION

This section provides background information on parameters which are available from the survey data. Those which have not been supplied as survey products may be generated later from raw data on the digital archive tape.

ELECTROMAGNETICS

DIGHEM electromagnetic responses fall into two general classes, discrete and broad. The discrete class consists of sharp, well-defined anomalies from discrete conductors such as sulfide lenses and steeply dipping sheets of graphite and sulfides. The broad class consists of wide anomalies from conductors having a large horizontal surface such as flatly dipping graphite or sulfide sheets, saline water-saturated sedimentary formations, conductive overburden and rock, and geothermal zones. A vertical conductive slab with a width of 200 m would straddle these two classes.

The vertical sheet (half plane) is the most common model used for the analysis of discrete conductors. All anomalies plotted on the electromagnetic map are analyzed according to this model. The following section entitled **Discrete Conductor Analysis** describes this model in detail, including the effect of using it on anomalies caused by broad conductors such as conductive overburden.

The conductive earth (half space) model is suitable for broad conductors. Resistivity contour maps result from the use of this model. A later section entitled **Resistivity Mapping** describes the method further, including the effect of using it on anomalies caused by discrete conductors such as sulfide bodies.

Geometric interpretation

The geophysical interpreter attempts to determine the geometric shape and dip of the conductor. Figure 5-1 shows typical DIGHEM anomaly shapes which are used to guide the geometric interpretation.

Discrete conductor analysis

The EM anomalies appearing on the electromagnetic map are analyzed by computer to give the conductance (i.e., conductivity-thickness product) in siemens (mhos) of a vertical sheet model. This is done regardless of the interpreted geometric shape of the conductor. This is not an unreasonable procedure, because the computed conductance increases as the electrical quality of the conductor increases, regardless of its true shape. DIGHEM anomalies

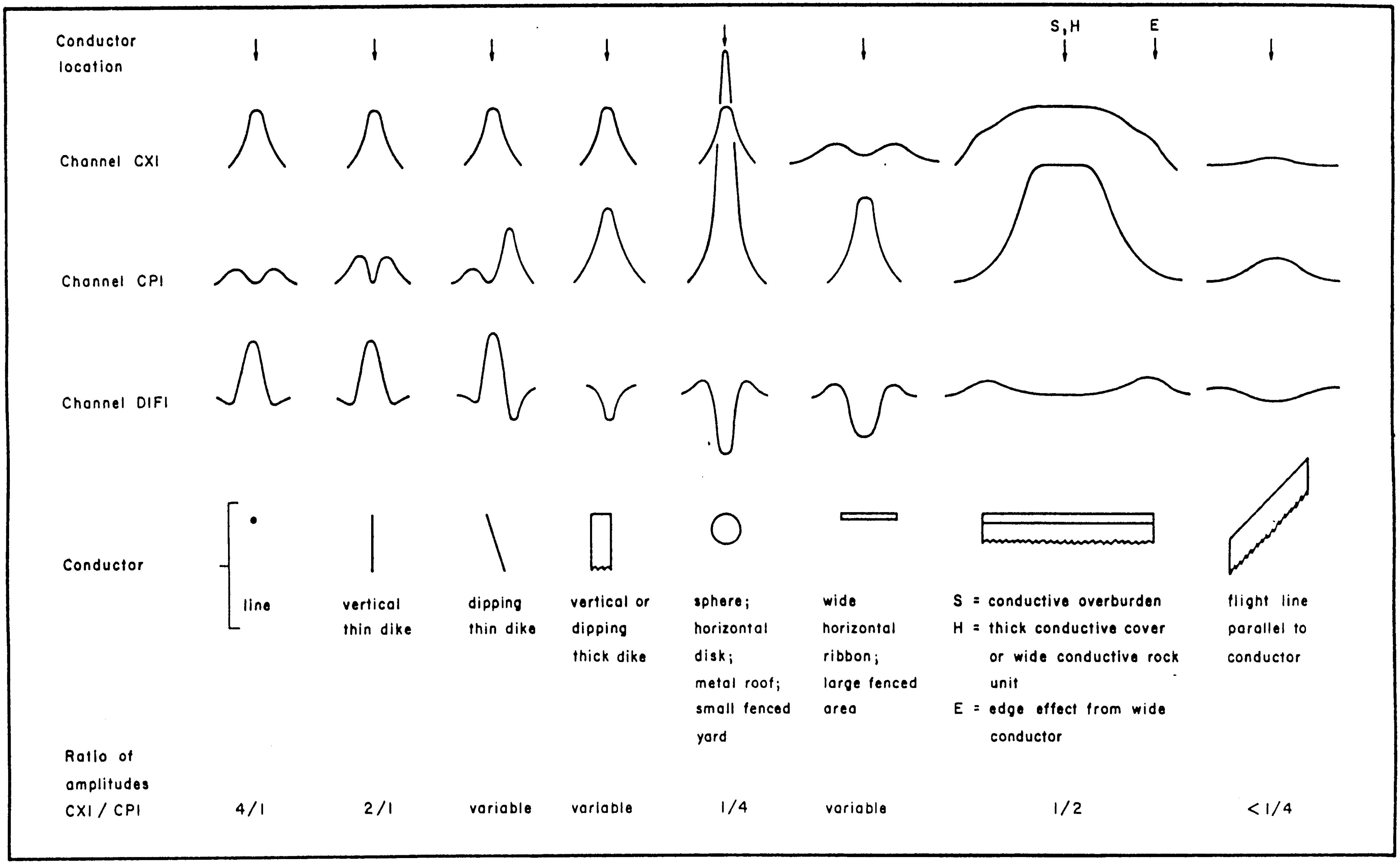

Fig. 5-1 Typical DIGHEM anomaly shapes

are divided into seven grades of conductance, as shown in Table 5-1 below. The conductance in siemens (mhos) is the reciprocal of resistance in ohms.

Table 5-1. EM Anomaly Grades

Anomaly Grade	siemens
7	> 100
6	50 - 100
5	20 - 50
4	10 - 20
3	5 - 10
2	1 - 5
1	< 1

The conductance value is a geological parameter because it is a characteristic of the conductor alone. It generally is independent of frequency, flying height or depth of burial, apart from the averaging over a greater portion of the conductor as height increases. Small anomalies from deeply buried strong conductors are not confused with small anomalies from shallow weak conductors because the former will have larger conductance values.

Conductive overburden generally produces broad EM responses which may not be shown as anomalies on the EM maps. However, patchy conductive overburden in otherwise resistive areas can yield discrete anomalies with a conductance grade (cf. Table 5-1) of 1, 2 or even 3 for conducting clays which have resistivities as low as 50 ohm-m. In areas where ground resistivities are below 10 ohm-m, anomalies caused by weathering variations and similar causes can have any conductance grade. The anomaly shapes from the multiple coils often allow such conductors to be recognized, and these are indicated by the letters S, H, and sometimes E on the electromagnetic anomaly map (see EM map legend).

For bedrock conductors, the higher anomaly grades indicate increasingly higher conductances. Examples: DIGHEM's New Insco copper discovery (Noranda, Canada) yielded a grade 5 anomaly, as did the neighbouring copper-zinc Magusi River ore body; Mattabi (copper-zinc, Sturgeon Lake, Canada) and Whistle (nickel, Sudbury, Canada) gave grade 6; and DIGHEM's Montcalm nickel-copper discovery (Timmins, Canada) yielded a grade 7 anomaly. Graphite and sulfides can span all grades but, in any particular survey area, field work may show that the different grades indicate different types of conductors.

Strong conductors (i.e., grades 6 and 7) are characteristic of massive sulfides or graphite. Moderate conductors (grades 4 and 5) typically reflect graphite or sulfides of a less massive character, while weak bedrock conductors (grades 1 to 3) can signify poorly connected graphite or heavily disseminated sulfides. Grades 1 and 2 conductors may not respond to ground EM equipment using frequencies less than 2000 Hz.

The presence of sphalerite or gangue can result in ore deposits having weak to moderate conductances. As an example, the three million ton lead-zinc deposit of Restigouche Mining Corporation near Bathurst, Canada, yielded a well-defined grade 2 conductor. The 10 percent by volume of sphalerite occurs as a coating around the fine grained massive pyrite, thereby inhibiting electrical conduction.

Faults, fractures and shear zones may produce anomalies which typically have low conductances (e.g., grades 1 to 3). Conductive rock formations can yield anomalies of any conductance grade. The conductive materials in such rock formations can be salt water, weathered products such as clays, original depositional clays, and carbonaceous material.

On the interpreted electromagnetic map, a letter identifier and an interpretive symbol are plotted beside the EM grade symbol. The horizontal rows of dots, under the interpretive symbol, indicate the anomaly amplitude on the flight record. The vertical column of dots, under the anomaly letter, gives the estimated depth. In areas where anomalies are crowded, the letter identifiers, interpretive symbols and dots may be obliterated. The EM grade symbols, however, will always be discernible, and the obliterated information can be obtained from the anomaly listing appended to this report.

The purpose of indicating the anomaly amplitude by dots is to provide an estimate of the reliability of the conductance calculation. Thus, a conductance value obtained from a large ppm anomaly (3 or 4 dots) will tend to be accurate whereas one obtained from a small ppm anomaly (no dots) could be quite inaccurate. The absence of amplitude dots indicates that the anomaly from the coaxial coil-pair is 5 ppm or less on both the inphase and quadrature channels. Such small anomalies could reflect a weak conductor at the surface or a stronger conductor at depth. The conductance grade and depth estimate illustrates which of these possibilities fits the recorded data best.

Flight line deviations occasionally yield cases where two anomalies, having similar conductance values but dramatically different depth estimates, occur close together on the same conductor. Such examples illustrate the reliability of the conductance measurement while showing that the depth estimate can be unreliable. There are a number of factors which can produce an error in the depth estimate, including the averaging of topographic variations by the altimeter, overlying conductive overburden, and the location and attitude of the conductor relative to the flight line. Conductor location and attitude can provide an erroneous depth estimate because the stronger part of the conductor may be deeper or to one side of the flight line, or because it has a shallow dip. A heavy tree cover can also produce errors in depth estimates. This is because the depth estimate is computed as the distance of bird from conductor, minus the altimeter reading. The altimeter can lock onto the top of a dense forest canopy. This situation yields an erroneously large depth estimate but does not affect the conductance estimate.

Dip symbols are used to indicate the direction of dip of conductors. These symbols are used only when the anomaly shapes are unambiguous, which usually requires a fairly resistive environment.

A further interpretation is presented on the EM map by means of the line-to-line correlation of anomalies, which is based on a comparison of anomaly shapes on adjacent lines. This provides conductor axes which may define the geological structure over portions of the survey area. The absence of conductor axes in an area implies that anomalies could not be correlated from line to line with reasonable confidence.

DIGHEM electromagnetic maps are designed to provide a correct impression of conductor quality by means of the conductance grade symbols. The symbols can stand alone with geology when planning a follow-up program. The actual conductance values are printed in the attached anomaly list for those who wish quantitative data. The anomaly ppm and depth are indicated by inconspicuous dots which should not distract from the conductor patterns, while being helpful to those who wish this information. The map provides an interpretation of conductors in terms of length, strike and dip, geometric shape, conductance, depth, and thickness. The accuracy is comparable to an interpretation from a high quality ground EM survey having the same line spacing.

The attached EM anomaly list provides a tabulation of anomalies in ppm, conductance, and depth for the vertical sheet model. The EM anomaly list also shows the conductance and depth for a thin horizontal sheet (whole plane) model, but only the vertical sheet parameters appear on the EM map. The horizontal sheet model is suitable for a flatly dipping thin bedrock conductor such as a sulfide sheet having a thickness less than 10 m. The list also shows the resistivity and depth for a conductive earth (half space) model, which is suitable for thicker slabs such as thick conductive overburden. In the EM anomaly list, a depth value of zero for the conductive earth model, in an area of thick cover, warns that the anomaly may be caused by conductive overburden.

Since discrete bodies normally are the targets of EM surveys, local base (or zero) levels are used to compute local anomaly amplitudes. This contrasts with the use of true zero levels which are used to compute true EM amplitudes. Local anomaly amplitudes are shown in the EM anomaly list and these are used to compute the vertical sheet parameters of conductance and depth. Not shown in the EM anomaly list are the true amplitudes which are used to compute the horizontal sheet and conductive earth parameters.

Questionable Anomalies

DIGHEM maps may contain EM responses which are displayed as asterisks (*). These responses denote weak anomalies of indeterminate conductance, which may reflect one of the following: a weak conductor near the surface, a strong conductor at depth (e.g., 100 to 120 m below surface) or to one side of the flight line, or aerodynamic noise. Those responses that have the appearance of valid bedrock anomalies on the flight profiles are indicated by appropriate interpretive symbols (see EM map legend). The others probably do not warrant further investigation unless their locations are of considerable geological interest.

The thickness parameter

DIGHEM can provide an indication of the thickness of a steeply dipping conductor. The amplitude of the coplanar anomaly (e.g., CPI channel on the digital profile) increases relative to the coaxial anomaly (e.g., CXI) as the apparent thickness increases, i.e., the thickness in the horizontal plane. (The thickness is equal to the conductor width if the conductor dips at 90 degrees and strikes at right angles to the flight line.) This report refers to a conductor as thin when the thickness is likely to be less than 3 m, and thick when in excess of 10 m. Thick conductors are indicated on the EM map by parentheses "( )". For base metal exploration in steeply dipping geology, thick conductors can be high priority targets because many massive sulfide ore bodies are thick, whereas non-economic bedrock conductors are often thin. The system cannot sense the thickness when the strike of the conductor is subparallel to the flight line, when the conductor has a shallow dip, when the anomaly amplitudes are small, or when the resistivity of the environment is below 100 ohm-m.

Resistivity mapping

Areas of widespread conductivity are commonly encountered during surveys. In such areas, anomalies can be generated by decreases of only 5 m in survey altitude as well as by increases in conductivity. The typical flight record in conductive areas is characterized by inphase and quadrature channels which are continuously active. Local EM peaks reflect either increases in conductivity of the earth or decreases in survey altitude. For such conductive areas, apparent resistivity profiles and contour maps are necessary for the correct interpretation of the airborne data. The advantage of the resistivity parameter is that anomalies caused by altitude changes are virtually eliminated, so the resistivity data reflect only those anomalies caused by conductivity changes. The resistivity analysis also helps the interpreter to differentiate between conductive trends in the bedrock and those patterns typical of conductive overburden. For example, discrete conductors will generally appear as narrow lows on the contour map and broad conductors (e.g., overburden) will appear as wide lows.

The resistivity profiles and the resistivity contour maps present the apparent resistivity using the so-called pseudo-layer (or buried) half space model defined by Fraser (1978)[1]. This model consists of a resistive layer overlying

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[1] Resistivity mapping with an airborne multicoil electromagnetic system: Geophysics, v. 43, p.144-172

a conductive half space. The depth channels give the apparent depth below surface of the conductive material. The apparent depth is simply the apparent thickness of the overlying resistive layer. The apparent depth (or thickness) parameter will be positive when the upper layer is more resistive than the underlying material, in which case the apparent depth may be quite close to the true depth.

The apparent depth will be negative when the upper layer is more conductive than the underlying material, and will be zero when a homogeneous half space exists. The apparent depth parameter must be interpreted cautiously because it will contain any errors which may exist in the measured altitude of the EM bird (e.g., as caused by a dense tree cover). The inputs to the resistivity algorithm are the inphase and quadrature components of the coplanar coil-pair. The outputs are the apparent resistivity of the conductive half space (the source) and the sensor-source distance. The flying height is not an input variable, and the output resistivity and sensor-source distance are independent of the flying height. The apparent depth, discussed above, is simply the sensor-source distance minus the measured altitude or flying height. Consequently, errors in the measured altitude will affect the apparent depth parameter but not the apparent resistivity parameter.

The apparent depth parameter is a useful indicator of simple layering in areas lacking a heavy tree cover. The DIGHEM system has been flown for purposes of permafrost mapping, where positive apparent depths were used as a measure of permafrost thickness. However, little quantitative use has been made of negative apparent depths because the absolute value of the negative depth is not a measure of the thickness of the conductive upper layer and, therefore, is not meaningful physically. Qualitatively, a negative apparent depth estimate usually shows that the EM anomaly is caused by conductive overburden. Consequently, the apparent depth channel can be of significant help in distinguishing between overburden and bedrock conductors.

The resistivity map often yields more useful information on conductivity distributions than the EM map. In comparing the EM and resistivity maps, keep in mind the following:

(a) The resistivity map portrays the absolute value of the earth's resistivity, where resistivity = 1/conductivity.

(b) The EM map portrays anomalies in the earth's resistivity. An anomaly by definition is a change from the norm and so the EM map displays anomalies, (i) over narrow, conductive bodies and (ii) over the boundary zone between two wide formations of differing conductivity.

The resistivity map might be likened to a total field map and the EM map to a horizontal gradient in the direction of flight[2]. Because gradient maps are usually more sensitive than total field maps, the EM map therefore is to be preferred in resistive areas. However, in conductive areas, the absolute character of the resistivity map usually causes it to be more useful than the EM map.

Interpretation in conductive environments

Environments having background resistivities below 30 ohm-m cause all airborne EM systems to yield very large responses from the conductive ground. This usually prohibits the recognition of discrete bedrock conductors. However, DIGHEM data processing techniques produce three parameters which contribute significantly to the recognition of bedrock conductors. These are the inphase and quadrature difference channels (DIFI and DIFQ), and the resistivity and depth channels (RES and DP) for each coplanar frequency.

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2 The gradient analogy is only valid with regard to the identification of anomalous locations.

The EM difference channels (DIFI and DIFQ) eliminate most of the responses from conductive ground, leaving responses from bedrock conductors, cultural features (e.g., telephone lines, fences, etc.) and edge effects. Edge effects often occur near the perimeter of broad conductive zones. This can be a source of geologic noise. While edge effects yield anomalies on the EM difference channels, they do not produce resistivity anomalies. Consequently, the resistivity channel aids in eliminating anomalies due to edge effects. On the other hand, resistivity anomalies will coincide with the most highly conductive sections of conductive ground, and this is another source of geologic noise. The recognition of a bedrock conductor in a conductive environment therefore is based on the anomalous responses of the two difference channels (DIFI and DIFQ) and the resistivity channels (RES). The most favourable situation is where anomalies coincide on all channels.

The DP channels, which give the apparent depth to the conductive material, also help to determine whether a conductive response arises from surficial material or from a conductive zone in the bedrock. When these channels ride above the zero level on the digital profiles (i.e., depth is negative), it implies that the EM and resistivity profiles are responding primarily to a conductive upper layer, i.e., conductive overburden. If the DP channels are below the zero level, it indicates that a resistive upper layer exists, and this usually implies the existence of a bedrock conductor. If the low frequency DP channel is below the zero level and the high frequency DP is above, this suggests that a bedrock conductor occurs beneath conductive cover.

The conductance channel CDT identifies discrete conductors which have been selected by computer for appraisal by the geophysicist. Some of these automatically selected anomalies on channel CDT are discarded by the geophysicist. The automatic selection algorithm is intentionally oversensitive to assure that no meaningful responses are missed. The interpreter then classifies the anomalies according to their source and eliminates those that are not substantiated by the data, such as those arising from geologic or aerodynamic noise.

Reduction of geologic noise

Geologic noise refers to unwanted geophysical responses. For purposes of airborne EM surveying, geologic noise refers to EM responses caused by conductive overburden and magnetic permeability. It was mentioned previously that the EM difference channels (i.e., channel DIFI for inphase and DIFQ for quadrature) tend to eliminate the response of conductive overburden. This marked a unique development in airborne EM technology, as DIGHEM is the only EM system which yields channels having an exceptionally high degree of immunity to conductive overburden.

Magnetite produces a form of geological noise on the inphase channels of all EM systems. Rocks containing less than 1% magnetite can yield negative inphase anomalies caused by magnetic permeability. When magnetite is widely distributed throughout a survey area, the inphase EM channels may continuously rise and fall, reflecting variations in the magnetite percentage, flying height, and overburden thickness. This can lead to difficulties in recognizing deeply buried bedrock conductors, particularly if conductive overburden also exists. However, the response of broadly distributed magnetite generally vanishes on the inphase difference channel DIFI. This feature can be a significant aid in the recognition of conductors which occur in rocks containing accessory magnetite.

EM magnetite mapping

The information content of DIGHEM data consists of a combination of conductive eddy current responses and magnetic permeability responses. The secondary field resulting from conductive eddy current flow is frequency-dependent and consists of both inphase and quadrature components, which are positive in sign. On the other hand, the secondary field resulting from magnetic permeability is independent of frequency and consists of only an inphase component which is negative in sign. When magnetic permeability manifests itself by decreasing the measured amount of positive inphase, its presence may be difficult to recognize. However, when it manifests itself by yielding a negative inphase anomaly (e.g., in the absence of eddy current flow), its presence is assured. In this latter case, the negative component can be used to estimate the percent magnetite content.

A magnetite mapping technique was developed for the coplanar coil-pair of DIGHEM. The technique yields a channel (designated FEO) which displays apparent weight percent magnetite according to a homogeneous half space model.[3] The method can be complementary to magnetometer mapping in certain cases. Compared to magnetometry, it is far less sensitive but is more able to resolve closely spaced magnetite zones, as well as providing an estimate of the amount of magnetite in the rock. The method is sensitive to 1/4% magnetite by weight when the EM sensor is at a height of 30 m above a magnetitic half space. It can individually resolve steep dipping narrow magnetite-rich bands which are

[3] Refer to Fraser, 1981, Magnetite mapping with a multi-coil airborne electromagnetic system: Geophysics, v. 46, p. 1579-1594.

separated by 60 m. Unlike magnetometry, the EM magnetite method is unaffected by remanent magnetism or magnetic latitude.

The EM magnetite mapping technique provides estimates of magnetite content which are usually correct within a factor of 2 when the magnetite is fairly uniformly distributed. EM magnetite maps can be generated when magnetic permeability is evident as negative inphase responses on the data profiles.

Like magnetometry, the EM magnetite method maps only bedrock features, provided that the overburden is characterized by a general lack of magnetite. This contrasts with resistivity mapping which portrays the combined effect of bedrock and overburden.

Recognition of culture

Cultural responses include all EM anomalies caused by man-made metallic objects. Such anomalies may be caused by inductive coupling or current gathering. The concern of the interpreter is to recognize when an EM response is due to culture. Points of consideration used by the interpreter, when coaxial and coplanar coil-pairs are operated at a common frequency, are as follows:

1. Channel CPS monitors 60 Hz radiation. An anomaly on this channel shows that the conductor is radiating power. Such an indication is normally a guarantee that the conductor is cultural. However, care must be taken to ensure that the conductor is not a geologic body which strikes across a power line, carrying leakage currents.

2. A flight which crosses a "line" (e.g., fence, telephone line, etc.) yields a center-peaked coaxial anomaly and an m-shaped coplanar anomaly.[4] When the flight crosses the cultural line at a high angle of intersection, the amplitude ratio of coaxial/coplanar response is 4. Such an EM anomaly can only be caused by a line. The geologic body which yields anomalies most closely resembling a line is the vertically dipping thin dike. Such a body, however, yields an amplitude ratio of 2 rather than 4. Consequently, an m-shaped coplanar anomaly with a CXI/CPI amplitude ratio of 4 is virtually a guarantee that the source is a cultural line.

3. A flight which crosses a sphere or horizontal disk yields center-peaked coaxial and coplanar anomalies with a CXI/CPI amplitude ratio (i.e., coaxial/coplanar) of

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[4] See Figure 5-1 presented earlier.

1/4. In the absence of geologic bodies of this geometry, the most likely conductor is a metal roof or small fenced yard.[5] Anomalies of this type are virtually certain to be cultural if they occur in an area of culture.

4. A flight which crosses a horizontal rectangular body or wide ribbon yields an m-shaped coaxial anomaly and a center-peaked coplanar anomaly. In the absence of geologic bodies of this geometry, the most likely conductor is a large fenced area.[5] Anomalies of this type are virtually certain to be cultural if they occur in an area of culture.

5. EM anomalies which coincide with culture, as seen on the camera film or video display, are usually caused by culture. However, care is taken with such coincidences because a geologic conductor could occur beneath a fence, for example. In this example, the fence would be expected to yield an m-shaped coplanar anomaly as in case #2 above. If, instead, a center-peaked coplanar anomaly occurred, there would be concern that a thick

---

[5] It is a characteristic of EM that geometrically similar anomalies are obtained from: (1) a planar conductor, and (2) a wire which forms a loop having dimensions identical to the perimeter of the equivalent planar conductor.

geologic conductor coincided with the cultural line.

6. The above description of anomaly shapes is valid when the culture is not conductively coupled to the environment. In this case, the anomalies arise from inductive coupling to the EM transmitter. However, when the environment is quite conductive (e.g., less than 100 ohm-m at 900 Hz), the cultural conductor may be conductively coupled to the environment. In this latter case, the anomaly shapes tend to be governed by current gathering. Current gathering can completely distort the anomaly shapes, thereby complicating the identification of cultural anomalies. In such circumstances, the interpreter can only rely on the radiation channel CPS and on the camera film or video records.

MAGNETICS

The existence of a magnetic correlation with an EM anomaly is indicated directly on the EM map. In some geological environments, an EM anomaly with magnetic correlation has a greater likelihood of being produced by sulfides than one that is non-magnetic. However, sulfide ore bodies may be non-magnetic (e.g., the Kidd Creek deposit near Timmins, Canada) as well as magnetic (e.g., the Mattabi deposit near Sturgeon Lake, Canada).

The magnetometer data are digitally recorded in the aircraft to an accuracy of one nT (i.e., one gamma) for proton magnetometers, and 0.01 nT for cesium magnetometers. The digital tape is processed by computer to yield a total field magnetic contour map. When warranted, the magnetic data may also be treated mathematically to enhance the magnetic response of the near-surface geology, and an enhanced magnetic contour map is then produced. The response of the enhancement operator in the frequency domain is illustrated in Figure 5-2. This figure shows that the passband components of the airborne data are amplified 20 times by the enhancement operator. This means, for example, that a 100 nT anomaly on the enhanced map reflects a 5 nT anomaly for the passband components of the airborne data.

The enhanced map, which bears a resemblance to a downward continuation map, is produced by the digital bandpass filtering of the total field data. The enhancement is equivalent to continuing the field downward to a level (above the source) which is 1/20th of the actual sensor-source distance.

Because the enhanced magnetic map bears a resemblance to a ground magnetic map, it simplifies the recognition of trends in the rock strata and the interpretation of geological structure. It defines the near-surface local

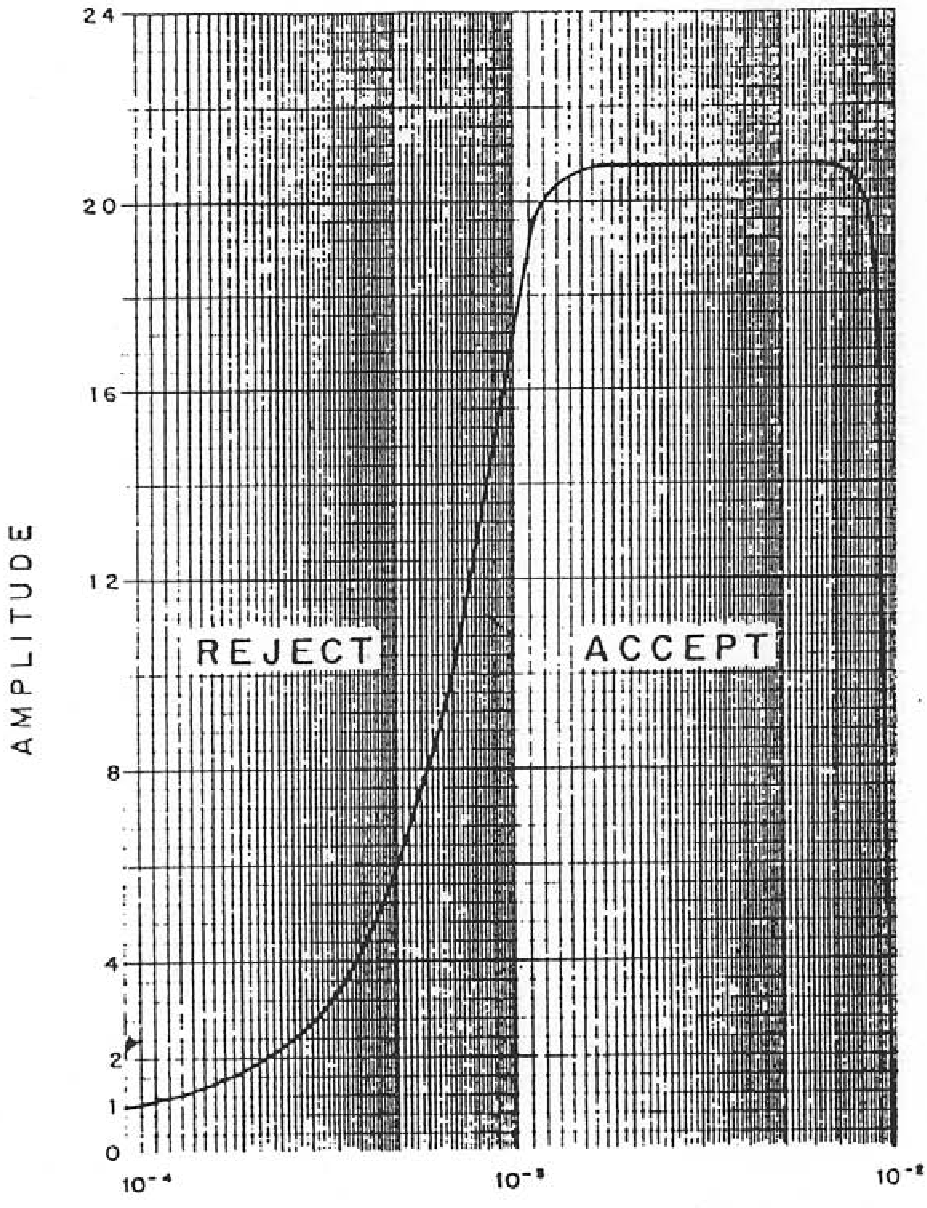


Fig. 5-2 Frequency response of magnetic enhancement operator.

geology while de-emphasizing deep-seated regional features. It primarily has application when the magnetic rock units are steeply dipping and the earth's field dips in excess of 60 degrees.

Any of a number of filter operators may be applied to the magnetic data, to yield vertical derivatives, continuations, magnetic susceptibility, etc. These may be displayed in contour, colour or shadow.

VLF

VLF transmitters produce high frequency uniform electromagnetic fields. However, VLF anomalies are not EM anomalies in the conventional sense. EM anomalies primarily reflect eddy currents flowing in conductors which have been energized inductively by the primary field. In contrast, VLF anomalies primarily reflect current gathering, which is a non-inductive phenomenon. The primary field sets up currents which flow weakly in rock and overburden, and these tend to collect in low resistivity zones. Such zones may be due to massive sulfides, shears, river valleys and even unconformities.

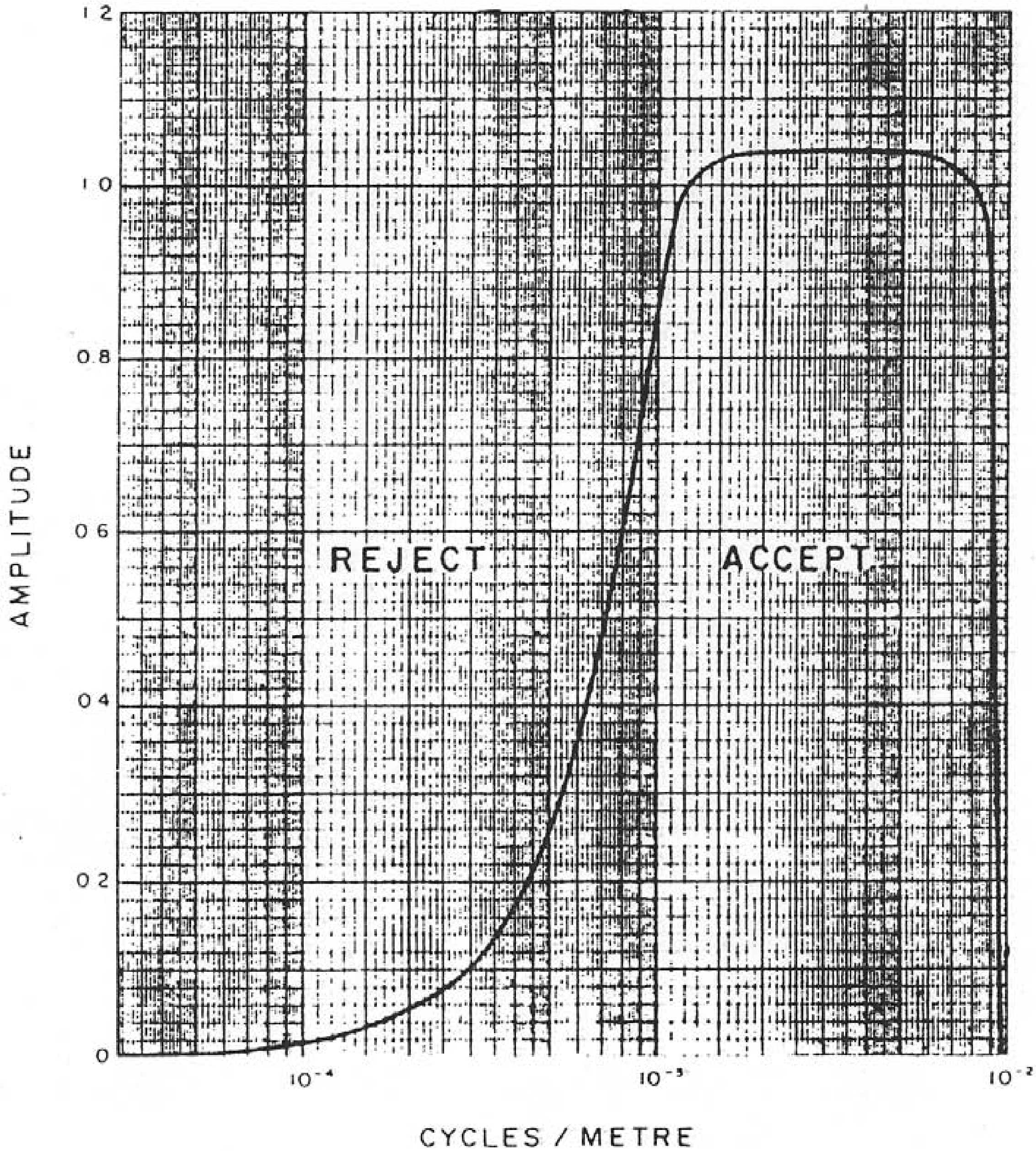


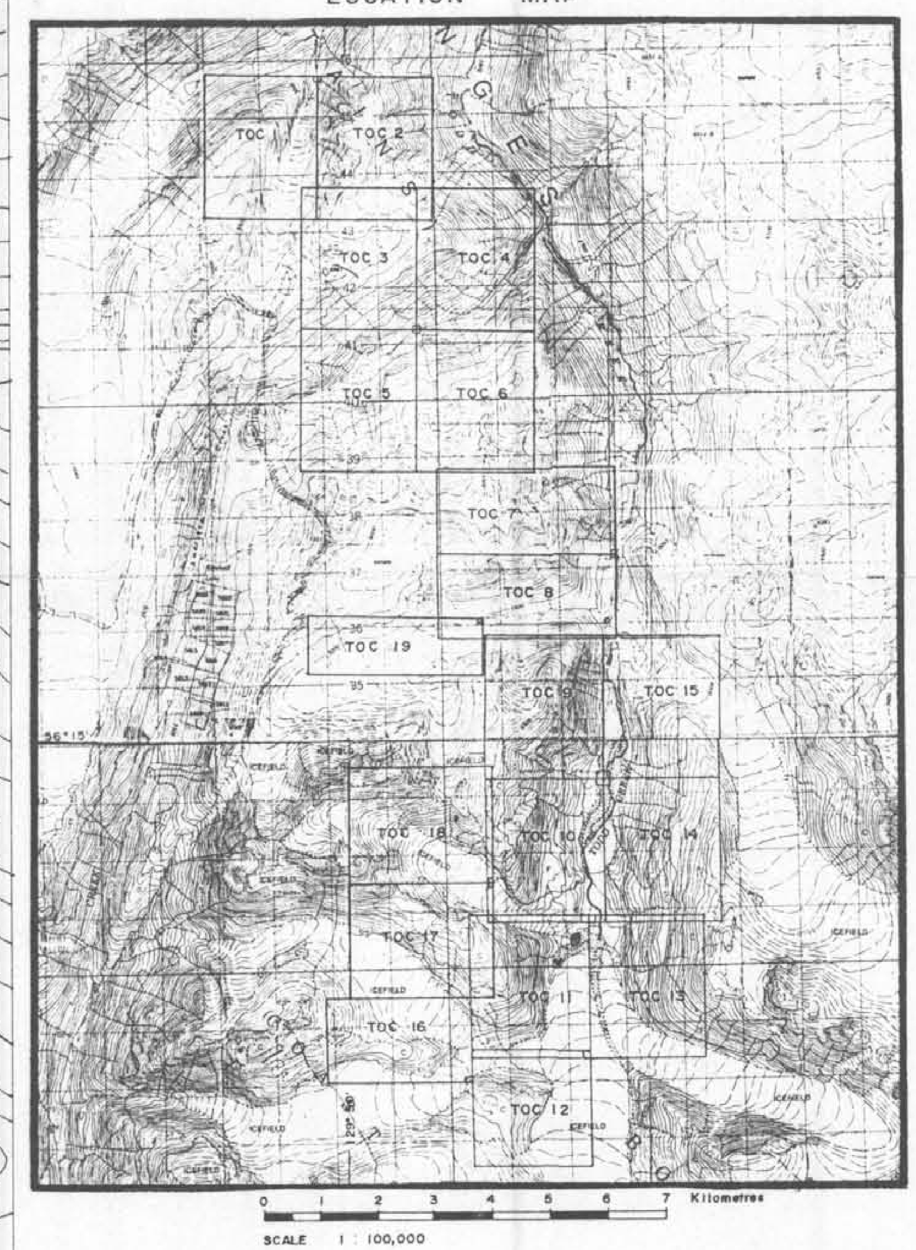
Fig. 5-3 Frequency response of VLF operator.

The VLF field is horizontal. Because of this, the method is quite sensitive to the angle of coupling between the conductor and the transmitted VLF field. Conductors which strike towards the VLF station will usually yield a stronger response than conductors which are nearly orthogonal to it.

The Herz Industries Ltd. Totem VLF-electromagnetometer measures the total field and vertical quadrature components. Both of these components are digitally recorded in the aircraft with a sensitivity of 0.1 percent. The total field yields peaks over VLF current concentrations whereas the quadrature component tends to yield crossovers. Both appear as traces on the profile records. The total field data are filtered digitally and displayed as contours to facilitate the recognition of trends in the rock strata and the interpretation of geologic structure.

The response of the VLF total field filter operator in the frequency domain (Figure 5-3) is basically similar to that used to produce the enhanced magnetic map (Figure 5-2). The two filters are identical along the abscissa but different along the ordinant. The VLF filter removes long wavelengths such as those which reflect regional and wave transmission variations. The filter sharpens short wavelength responses such as those which reflect local geological variations.

LOCATION MAP



ABLE 1

SAMPLE	TYPE	Au ppb	Ag ppm	As ppm	Ba ppm	Cd ppm	Cu ppm	Pb ppm	Zn ppm
51363	Soil	5	0.1	9	104	0.3	13	17	48
51364	Soil	5	0.1	5	117	0.4	6	17	40
51365	Soil	5	0.1	7	141	0.5	13	16	51
51366	Soil	5	0.1	9	388	1	56	16	102
51367	Soil	5	0.3	17	1861	0.8	369	20	77
51368	Soil	5	0.1	19	671	0.8	31	23	82
51369	Soil	5	0.1	16	77	0.2	11	42	53
51370	Soil	5	0.1	15	531	0.6	17	15	46
51371	Soil	5	0.1	27	140	0.5	41	34	131
51372	Soil	5	0.2	29	215	1.5	41	38	119
51373	Soil	5	0.1	22	140	0.7	33	21	78
51374	Soil	5	0.1	28	268	0.9	30	33	148
51375	Soil	5	0.3	39	133	0.8	58	37	91
51176	Soil	5	0.2	43	292	0.7	22	16	91
51177	Soil	5	0.2	51	235	0.4	21	16	74
51178	Soil	5	0.2	49	303	0.7	18	17	97
51211	Soil	5	0.2	52	597	1.0	29	18	119
51212	Soil	5	0.2	58	521	0.9	28	23	100
51213	Soil	20	0.2	58	374	1.0	43	23	105
51214	Soil	5	0.2	59	564	0.9	32	24	104
51215	Soil	5	0.2	58	423	0.8	53	19	95
51216	Soil	5	0.2	64	342	0.8	27	19	97
51217	Soil	5	0.2	53	254	0.8	35	12	63
51218	Soil	5	0.2	67	271	0.8	28	18	66
51219	Soil	10	0.2	157	288	1.4	77	31	48
51220	Soil	5	0.2	69	360	0.8	32	13	61
51221	Soil	5	0.2	71	500	0.6	21	15	44
51222	Soil	5	0.2	108	421	1.1	68	27	94
51223	Soil	5	0.2	66	600	1.0	23	26	67
51224	Soil	5	0.4	135	1406	2.2	49	46	131
51225	Soil	5	0.2	92	762	1.1	28	32	63
51351	Soil	5	0.2	121	473	0.8	73	29	60
51352	Soil	5	0.6	113	367	1.5	1660	32	149
125081	Soil	5	0.2	49	277	1.2	22	24	105
125082	Soil	5	0.2	52	267	1.3	28	29	106
125083	Soil	5	0.2	56	678	5.0	37	47	272
125084	Soil	45	0.2	59	607	1.9	11	21	66
125085	Soil	5	0.2	56	362	1.3	113	21	62
125086	Soil	5	0.2	47	606	1.3	10	16	56
125087	Soil	5	0.2	60	785	1.2	12	15	64

TABLE 2

SAMPLE #	TYPE	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	As ppm	Sb ppm	Ba ppm	Au ppb
125255	ROCK	2	11	19	251	0.1	3	2	166	1
125256	ROCK	3	18	13	111	0.1	13	3	293	2
125257	ROCK	6	8	13	6	0.1	14	3	160	8
125258	ROCK	8	40	18	12	0.3	51	2	79	8
125259	ROCK	3	5	10	29	0.1	75	2	418	3
125260	ROCK	1	39	22	52	0.1	7	2	25	4
125261	ROCK	2	8	12	35	0.1	5	2	215	3
125262	ROCK	3	3	7	1	0.1	56	2	93	3
125263	ROCK	3	14	4	31	0.1	17	2	383	3
125264	ROCK	4	22	14	8	0.1	87	2	143	2
125265	ROCK	5	6	17	4	0.1	16	2	271	1
125266	ROCK	7	66	12	12	0.1	292	10	104	4
125270	ROCK	4	11	3	15	0.4	2	2	115	2
125271	ROCK	325	123	223	118	4.8	18	18	135	32
125272	ROCK	3	4	5	9	0.4	2	2	63	1
125273	ROCK	6	12	23	16	0.9	19	2	181	5
125274	ROCK	2	60	31	84	0.5	16	2	88	1
125275	ROCK	1	7	7	52	0.8	6	2	68	1

GEOLOGICAL BRANCH
ASSESSMENT REPORT

20,835

LEGEND

Rock Types

[1] Feldspar Porphyry, pale brown

1a. quartz-pyrite altered
1b. quartz-sericite pyrite altered

[2]

2a. dark green, maroon, grey andesite flows, agglomerate, tuff, breccia
2b. black siltstone, minor silty limestone, greywacke, volcaniclastics

[3] Light grey-green feldspar porphyry flows, tuff and tuff breccia

[4] Rhyolite, massive, breccia, lapilli tuff, ash tuff, locally quartz-sericite-pyrite altered

[5] Dark green, grey hornblende porphyry intrusive dykes, magnetic

[6] Quartz-pyrite '/. sericite altered zone

Abbreviations

ba	-	barite	mal	-	malachite
bn	-	bornite	py	-	pyrite
cal	-	calcite	q	-	quartz
chl	-	chlorite	sc	-	sericite
cpy	-	chalcopyrite	sp	-	sphalerite
gn	-	galena	stk. wk.	-	stock work
hem	-	hematite	Tt	-	tetrahedrite

Symbols

Outcrop Area
Geologic Contact: defined, inferred
Mineralized Vein
x . ⊗ . • Rock, Float Soil Sample Locations
Silt Sample Location
Glacial Till
Icefield
Trench or Chip Sample Line
Strike and Dip
Fault
D.D.H. Location

0 500 1000 metres
SCALE 1 : 10,000

REVISED	
JAN 1991	P.J.L.

Mt. Johnson
MJ 1-4
Geology & Sample Locations

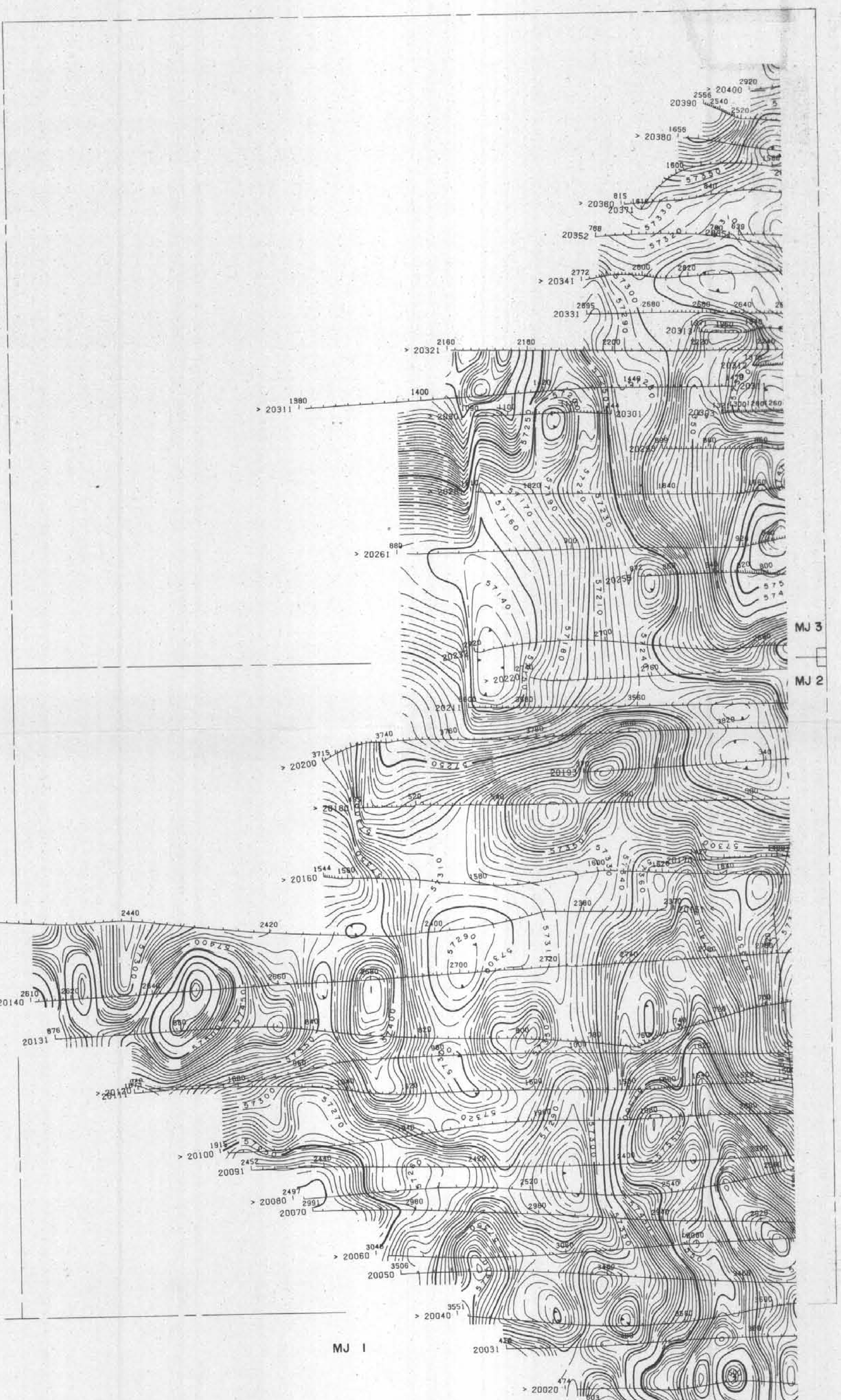
PROJ. No. 240
N.T.S. 104A/4,5
DWG. No. Fig. 4

SURVEY BY: .... DATE: ....
DRAWN BY: S.K.B. SCALE: 1 : 10,000

NORANDA EXPLORATION
OFFICE: PRINCE GEORGE, B.C.

GEOLOGICAL BRANCH
ASSESSMENT REPORT

20,835



EM LEGEND

Grade	Anomaly	Conductance
7	●	≥100 siemens
6	◕	50-100 siemens
5	◒	20-50 siemens
4	⊕	10-20 siemens
3	⊕	5-10 siemens
2	○	1-5 siemens
1	( )	<1 siemens
-	✳	Questionable anomaly

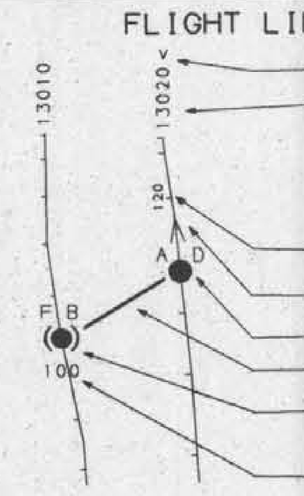
Anomaly identifier — Interpretive symbol — C|H

Depth is greater than
· 15 m
: 30 m
⁝ 45 m
⁞ 60 m

Inphase and Quadrature of coaxial coil is greater than
. 5 ppm
.. 10 ppm
... 15 ppm
.... 20 ppm

Interpretive symbol	Conductor ("model")
B.	Bedrock conductor
D.	Narrow bedrock conductor ("thin dike")
S.	Conductive cover ("horizontal thin sheet")
H.	Broad conductive rock unit, deep conductive weathering, thick conductive cover ("half space")
E.	Edge of broad conductor ("edge of half space")
L.	Culture, e.g. power line, building, fence

FLIGHT LINES WITH EM ANOMALIES



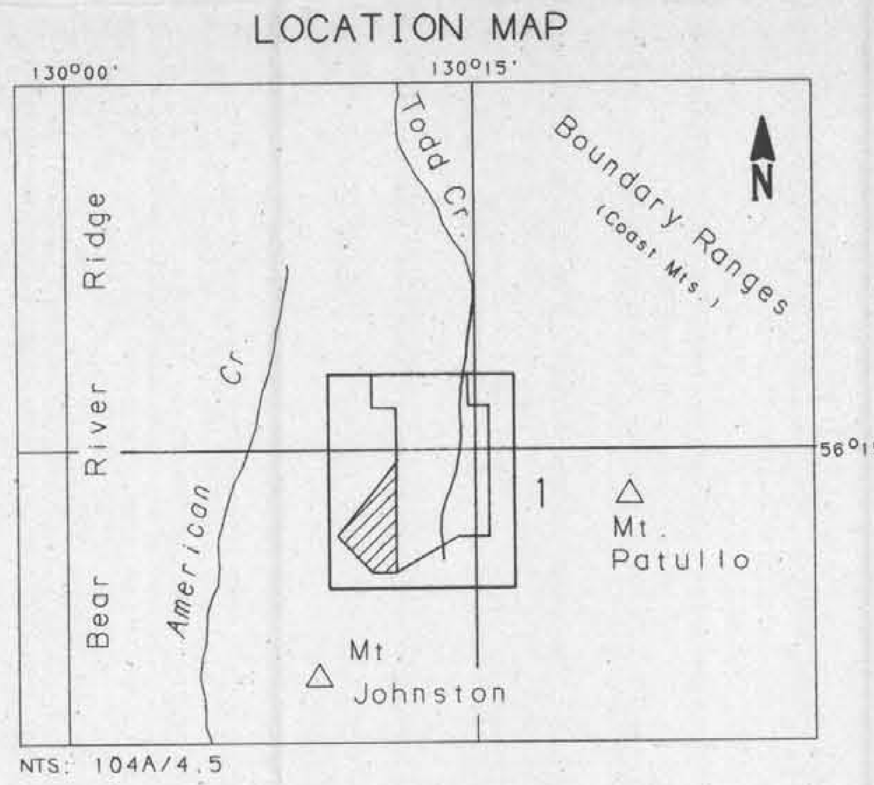
Flight direction
Flight line number
11020
Reflight Number
Line Number
Area Number
Fiducials identified on profiles
Dip direction
EM anomaly (see EM legend)
Conductor axis (on EM maps only)
Arcs indicate the conductor has a thickness > 10m
Magnetic correlation in nT (gammas)

CONTOUR INTERVALS

- 250nT
- 50nT
- 10nT
- 5nT
- magnetic low

Magnetic inclination within the survey area: 74 degrees

LOCATION MAP



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NORANDA EXPLORATION COMPANY LTD.
MT. JOHNSON

TOTAL FIELD MAGNETICS

SYSTEM: DIGHEM™ SURVEY	NTS: 104A/4,5	GEOPHYSICIST:
DATE: July 1990	JOB: 1090	SHEET: 1

DIGHEM SURVEYS & PROCESSING INC.

0 0.5 1.0 Km
0 0.5 Mi
Scale 1:10,000

Dighem