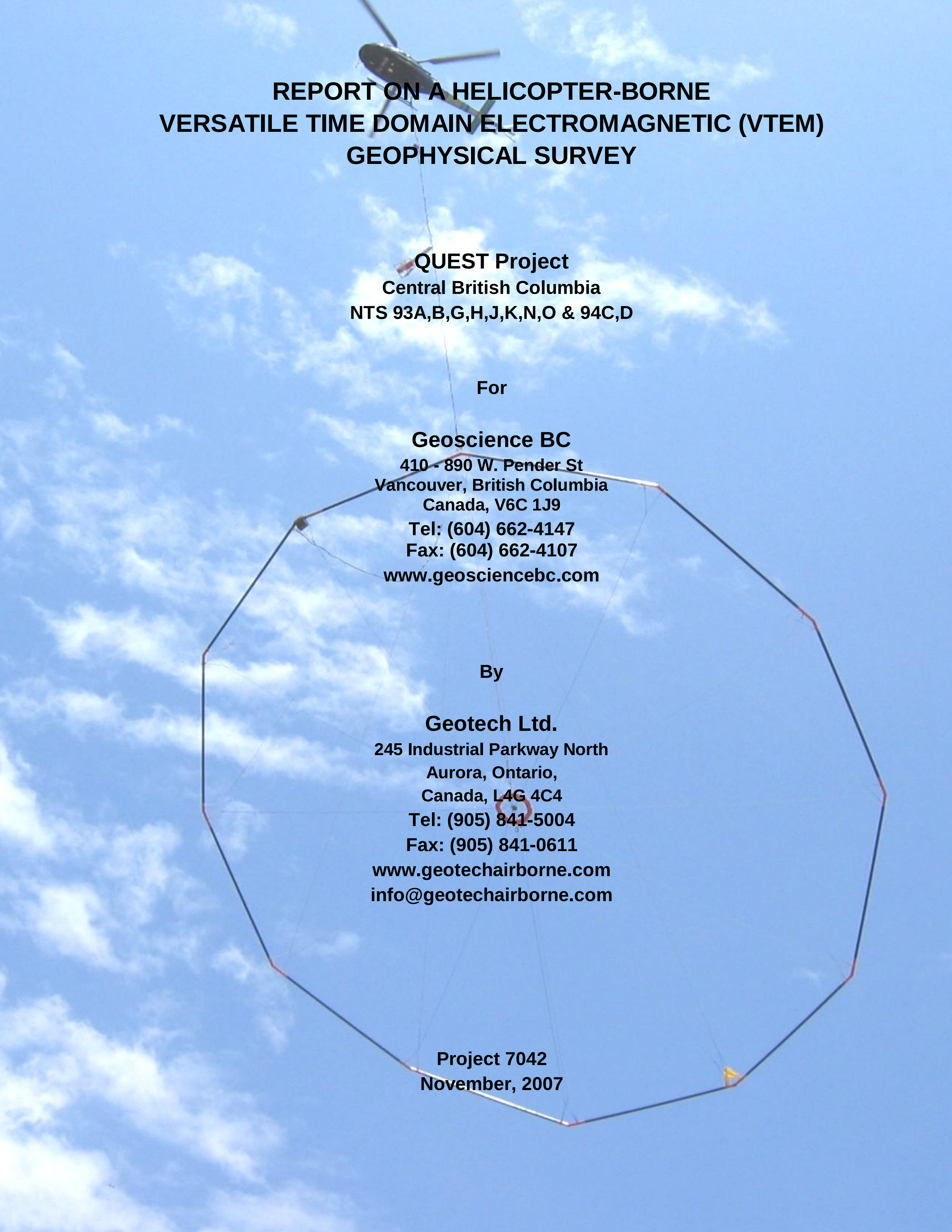


REPORT ON A HELICOPTER-BORNE VERSATILE TIME DOMAIN ELECTROMAGNETIC (VTEM) GEOPHYSICAL SURVEY

QUEST Project

Central British Columbia

NTS 93A,B,G,H,J,K,N,O & 94C,D

For

Geoscience BC

410 - 890 W. Pender St
Vancouver, British Columbia
Canada, V6C 1J9

Tel: (604) 662-4147
Fax: (604) 662-4107
www.geosciencebc.com

By

Geotech Ltd.

245 Industrial Parkway North
Aurora, Ontario,
Canada, L4G 4C4
Tel: (905) 841-5004
Fax: (905) 841-0611
www.geotechairborne.com
info@geotechairborne.com

Project 7042
November, 2007

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

REPORT ON A HELICOPTER-BORNE
VERSATILE TIME DOMAIN ELECTROMAGNETIC SURVEY

QUEST Project, Central British Columbia

1. INTRODUCTION

Between July 29th and November 1st, 2007, Geotech Ltd. carried out a helicopter-borne geophysical survey on behalf of GeoscienceBC as part of the QUEST project in central British Columbia.

The main survey covered a large block of ground over 46,500 km^2 in area extending from Williams Lake in the south to north of Mackenzie, B.C. A smaller detail survey was done in the Mt. Milligan area. In total, over 11,600 line kilometres of survey were achieved.

The primary geophysical sensors included the towed bird versatile time domain electromagnetic (VTEM) system and a towed cesium magnetometer. Ancillary equipment included a GPS navigation system and a radar altimeter as well as a ground magnetometer base station.

In-field data processing involved quality control and compilation of data collected during the acquisition stage. Due to the extent of the survey area, three different operations bases were used during the data collection phase of the survey.

The daily preliminary maps and databases as well as final data processing and final digital data products were generated at the office of Geotech Ltd. in Aurora, Ontario.

This report describes the survey logistics, the data processing and the final data products including databases and maps.

2. SURVEY AREAS

The survey consisted of a principal survey block and a second much smaller test block lying within the main block and flown at a closer line spacing.

The primary survey block covered a region, roughly 514 km in length by 124 km in width and exceeded 46,500 km^2 in surface area. The area, lying in central B.C., extended from just north of Williams Lake to approximately 100 km north of Mackenzie. There were 11,583.4 km of survey flown over this large block which covers both the Northern Trust survey and the Geoscience BC survey areas shown in Figure 1. The map also shows the proximity of the block to main population centres and highways.

Topographically, the survey area exhibits a challenging terrain in some areas of the block. The general range in elevation is 650 metres ASL to 1100 metres ASL, with the mean being approximate 1000 metres ASL. In the mountainous areas of the block, the elevation jumps to 2240 metres ASL.

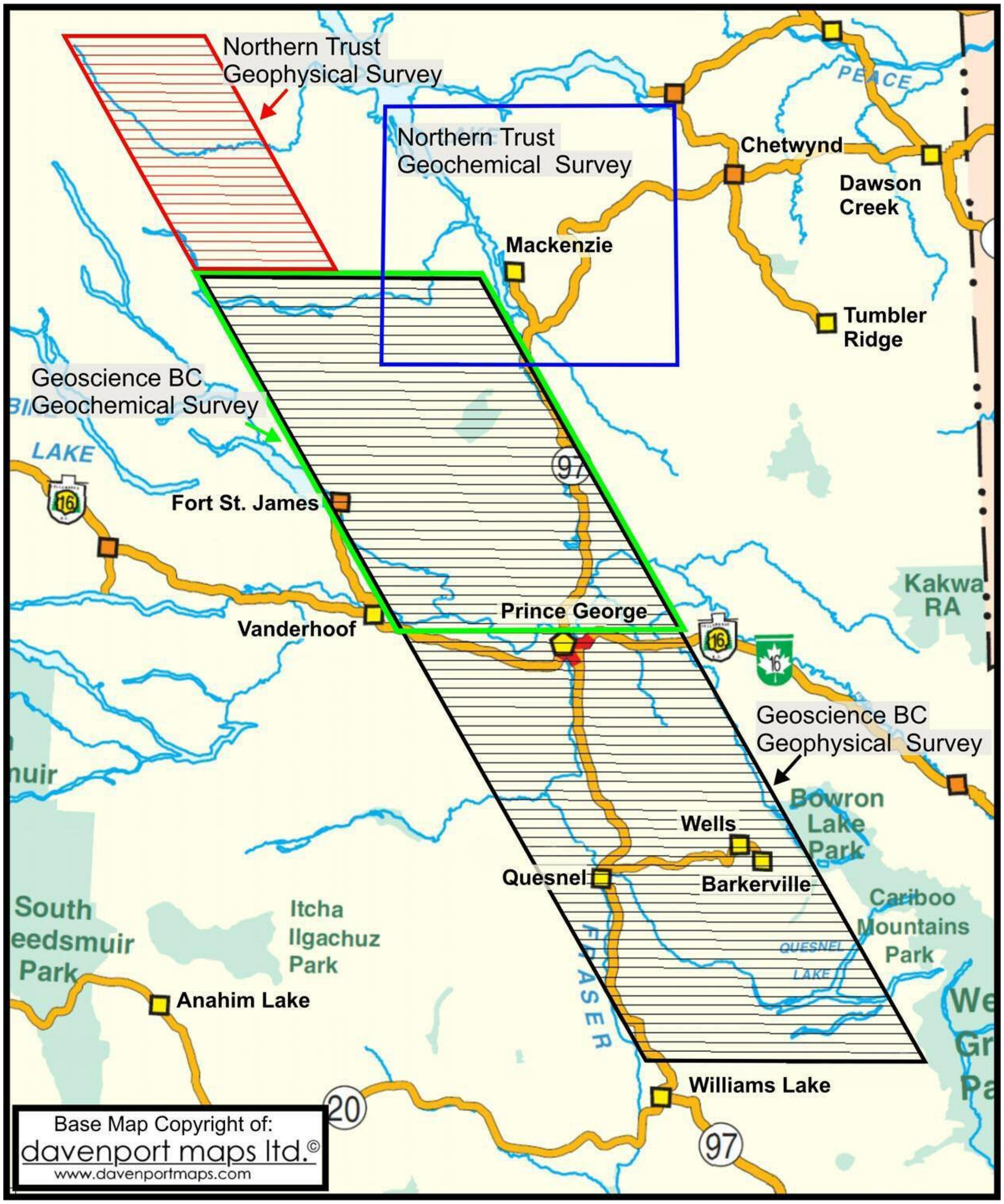


Figure 1 – Main Block Location Map

A small detailed survey of 13 lines, each 2.7 km in length, over the Mt. Milligan area was also carried out. A total of 37.5 line-km were flown on this block. The location of the Mt. Milligan block may be seen in Figure 2.

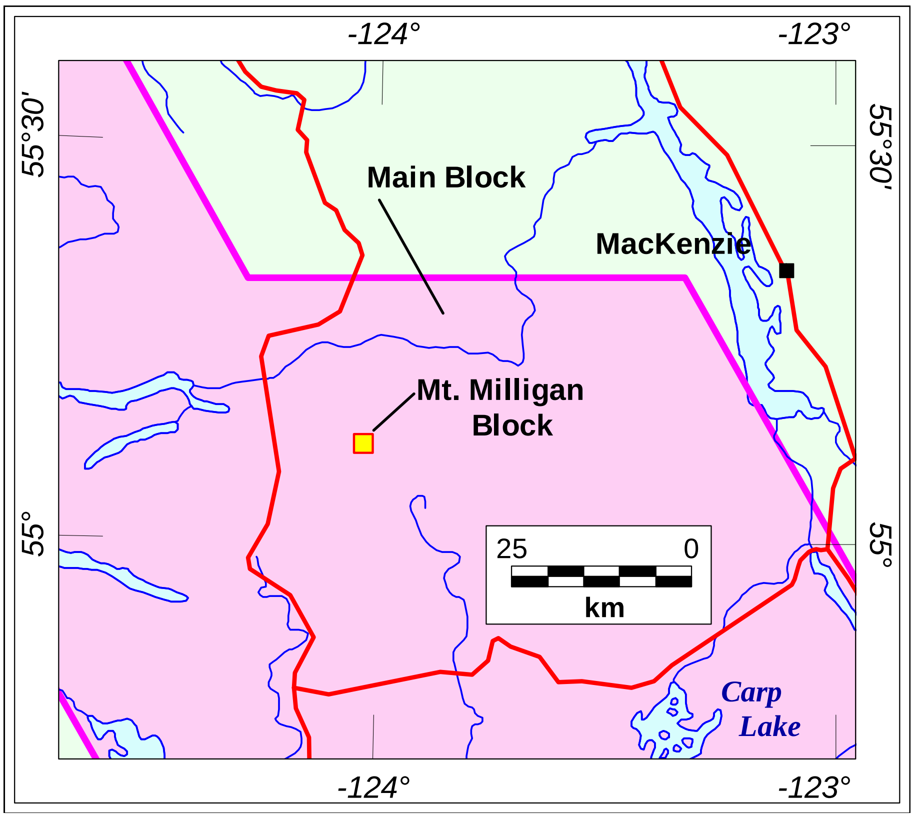


Figure 2 - Mt. Milligan Location Map

A listing of the corner vertices in NAD83 UTM Zone 10N coordinates for each of the two blocks may be found in Appendix B.

The large extent of the survey area required that the survey crew establish three operations bases from which to execute the survey with a minimum of non-productive ferry flying. They were chosen with consideration to the proximity to the block as well as to fuel supply and suitable locations for fuel caches. The operations bases used were at Prince George, Williams Lake, and Mackenzie.

Access to the block is excellent through the central region which is traversed by a main north south transportation corridor. The corridor includes Provincial Highway 97 which links the southern part of the province with Williams Lake on through to Prince George and Fort St. John. This corridor also contains a railway line as well as pipelines and high voltage electrical transmission lines. The northern Trans-Canada Highway ("Yellowhead" Hwy 16) traverses the block in an east-west direction at Prince George. In addition to the major highways, various parts of the block are reachable by unimproved logging access roads.

Major population centres within the block or near to the block include Prince George, Fort St. James, Williams Lake, Quesnel, Vanderhoof, and Mackenzie.

The survey area lies within the boundaries of National Topographic Series (NTS) maps 93A,B,G,H,J,K,N,O & 94C,D.

3. SURVEY SPECIFICATIONS AND PROCEDURES

3.1 Survey Specifications

The survey parameters for each block are described in the table below:

Survey block	Line spacing (m)	Area (Km^2)	Line-km's	Flight direction
Main Block	4000	46,517.4	11583.4	N90^{o}E
Mt. Milligan	200	6.8	37.5	N90^{o}E
		Total	11620.9	

Table 1 - Survey Parameters

No tie lines were planned or flown. There were ten lines in the northern reaches of the principal block (L1000-L1090) that were foreshortened at the western ends. This was due to the poor weather conditions and the rugged terrain. Other parts of particular lines could not be flown due to presence of towns. Therefore the total km flown over the main block falls slightly short of the planned flying of 11810.5 km.

One other survey feature to note is the fact the lines were split in two parts, west and east, each part approximately 62 km in length. The lack of easily accessible locations for fuel caches on the edges of the block in combination with the 2.5 hour flying time and the rugged terrain precluded flying the 124 km long lines in a single flight.

Where possible, the helicopter maintained a mean terrain clearance of 75 metres, which translated into an average height of 60 metres for the magnetic sensor. The 75 metre ideal figure was often exceeded in the rugged mountains where it was deemed unsafe to drape fly the terrain. The ideal altitude was also exceeded in the vicinity of major high voltage powerlines and or built-up areas.

3.2 Survey Operations

Including system installation in Prince George and the decommissioning of the system in Mackenzie, the system was engaged on this project from July 29th to Nov 1st, 2007. A detailed breakdown of the day to day activity follows in Table 2.

Date	Flight #	Flown KM	Block	Crew location	Comments
29-Jul-07				Prince George, B.C.	Mobilization
30-Jul-07				Prince George, B.C.	Reconnaissance
31-Jul-07				Prince George, B.C.	System assembly, reconnaissance
01-Aug-07				Prince George, B.C.	System assembly complete
02-Aug-07				Prince George, B.C.	Installation complete
03-Aug-07				Prince George, B.C.	Test flight
04-Aug-07				Prince George, B.C.	Test flight
05-Aug-07	1-3	356.4	EAST	Prince George, B.C.	Production
06-Aug-07	4-7	482.8	E & W	Prince George, B.C.	Production
07-Aug-07	8-10	364.4	WEST	Prince George, B.C.	Production
08-Aug-07				Prince George, B.C.	No production – due to weather
09-Aug-07	11-13	363.7	E & W	Prince George, B.C.	Production
10-Aug-07	14, 15	241.3	E & W	Prince George, B.C.	Production
11-Aug-07	16, 17	243.2	E & W	Prince George, B.C.	Production
12-Aug-07				Prince George, B.C.	No production – due to weather
13-Aug-07	18, 19	239.3	EAST	Prince George, B.C.	Production
14-Aug-07	20	121.3	WEST	Prince George, B.C.	Production halted – helicopter maintenance
15-Aug-07	21 - 23	361.0	E & W	Prince George, B.C.	Production
16-Aug-07	24, 25	241.1	E & W	Prince George, B.C.	Production
17-Aug-07				Prince George, B.C.	No production – due to weather
18-Aug-07	26	120.7	WEST	Prince George, B.C.	Production
19-Aug-07				Prince George, B.C.	No production – due to weather
20-Aug-07	27, 28	240.7	WEST	Prince George, B.C.	Production
21-Aug-07	29 - 31	360.9	E & W	Prince George, B.C.	Production
22-Aug-07	32, 33	240.5	E & W	Prince George, B.C.	Production
23-Aug-07	34 - 37	482.5	E & W	Prince George, B.C.	Production
24-Aug-07	38 - 39	240.7	E & W	Prince George, B.C.	Production
25-Aug-07				Prince George, B.C.	No production – due to weather
26-Aug-07				Prince George, B.C.	No production – due to weather
27-Aug-07				Prince George, B.C.	No production – due to weather
28-Aug-07				Prince George, B.C.	No production – due to weather Helicopter switch
29-Aug-07				Prince George, B.C.	No production – due to weather System installation complete
30-Aug-07				Prince George, B.C.	No production – due to weather
31-Aug-07	40	61.6	WEST	Prince George, B.C.	Production aborted – due to weather
01-Sep-07	41	123.5		Prince George, B.C.	Production aborted – troubleshooting
02-Sep-07				Prince George, B.C.	Test flights
03-Sep-07	42	123.7	WEST	Prince George, B.C.	Production aborted – due to helicopter maintenance
04-Sep-07	43 - 45	372.2	WEST	Prince George, B.C.	Production
05-Sep-07				Prince George, B.C.	No production – due to weather

06-Sep-07	46 - 48	374.1	WEST	Prince George, B.C.	Production
07-Sep-07	49, 50	187.7	WEST	Prince George, B.C.	Production aborted – due to weather
08-Sep-07	51	116.6	EAST	Prince George, B.C.	Production delayed – due to system maintenance
09-Sep-07	52 - 55	468.0	EAST	Prince George, B.C.	Production
10-Sep-07	56, 57	234.9	EAST	Prince George, B.C.	Production
11-Sep-07	58 - 61	471.7	EAST	Prince George, B.C.	Production
12-Sep-07				Williams Lake, B.C.	Relocation
13-Sep-07	62 - 65	464.9	EAST	Williams Lake, B.C.	Production
14-Sep-07	66 - 69	231.5	EAST	Williams Lake, B.C.	Production
15-Sep-07	70 - 72	242.4	WEST	Williams Lake, B.C.	Production and reflights
16-Sep-07				Williams Lake, B.C.	No production – due to weather
17-Sep-07	73 - 75	253.3	WEST	Williams Lake, B.C.	Relocation
18-Sep-07	76	126.1.	WEST	Williams Lake, B.C.	Production
19-Sep-07	77 - 79	315.1	WEST	Williams Lake, B.C.	Production
20-Sep-07				Williams Lake, B.C.	No production – due to weather
21-Sep-07				Williams Lake, B.C.	No production – due to weather
22-Sep-07				Williams Lake, B.C.	No production – due to weather
23-Sep-07	80 - 82	251.0	WEST	Williams Lake, B.C.	Production
24-Sep-07				Mackenzie, B.C.	Mobilization – no production
25-Sep-07	83	121.4		Mackenzie, B.C.	Production
26-Sep-07	84, 85	60.9	EAST	Mackenzie, B.C.	Production
27-Sep-07				Mackenzie, B.C.	No production – due to weather
28-Sep-07				Mackenzie, B.C.	No production – due to system maintenance
29-Sep-07				Mackenzie, B.C.	Troubleshooting
30-Sep-07				Mackenzie, B.C.	No production – due to weather
01-Oct-07				Mackenzie, B.C.	No production – due to weather
02-Oct-07	88	122.0	EAST	Mackenzie, B.C.	Reflights
03-Oct-07				Mackenzie, B.C.	No production – due to weather
04-Oct-07	89 - 93	539.5	E & W	Mackenzie, B.C.	Production
05-Oct-07	94	118.6	WEST	Mackenzie, B.C.	Production aborted – due to weather
06-Oct-07	96	118.4	WEST	Mackenzie, B.C.	Production delayed – due to weather
07-Oct-07				Mackenzie, B.C.	No production – due to weather
08-Oct-07	97, 98	237.0	WEST	Mackenzie, B.C.	Production
09-Oct-07	99	118.7	WEST	Mackenzie, B.C.	Production aborted – due to weather
10-Oct-07	101, 102	237.8	WEST	Mackenzie, B.C.	Production aborted – due to weather
11-Oct-07	103, 104	238.3	WEST	Mackenzie, B.C.	Production
12-Oct-07	105	119.3	WEST	Mackenzie, B.C.	Production, troubleshooting
13-Oct-07				Mackenzie, B.C.	No production – due to weather
14-Oct-07				Mackenzie, B.C.	No production – due to weather

15-Oct-07				Mackenzie, B.C.	No production – due to weather
16-Oct-07				Mackenzie, B.C.	No production – due to weather
17-Oct-07				Mackenzie, B.C.	No production – due to weather
18-Oct-07				Mackenzie, B.C.	No production – due to weather
19-Oct-07				Mackenzie, B.C.	No production – due to weather
20-Oct-07				Mackenzie, B.C.	No production – due to weather
21-Oct-07				Mackenzie, B.C.	No production – due to weather
22-Oct-07				Mackenzie, B.C.	No production – due to weather
23-Oct-07				Mackenzie, B.C.	No production – due to weather
24-Oct-07				Mackenzie, B.C.	No production – due to weather
25-Oct-07	106 - 108	239.1	WEST	Mackenzie, B.C.	Production
26-Oct-07	109 - 111	359.5	WEST	Mackenzie, B.C.	Production and reflights
27-Oct-07				Mackenzie, B.C.	No production – due to weather
28-Oct-07				Mackenzie, B.C.	No production – due to weather
29-Oct-07	112	33.8	Mt. Milligan	Mackenzie, B.C.	
30-Oct-07				Mackenzie, B.C.	No production – due to weather Equipment removal
31-Oct-07				Mackenzie, B.C.	VTEM disassembly
01-Nov-07				Mackenzie, B.C.	Demobilization

Table 2 - Survey Schedule

3.3 Survey Procedures

Nominal survey airspeed was 100 km/hour. The data recording rates of the data acquisition was 0.1 second for the electromagnetics and the magnetometer, 0.2 second for the altimeter and the GPS. This equates to a geophysical reading about every 2-3 metres along flight track. Navigation along survey line was assisted by a GPS receiver and navigation system, which reports system co-ordinates as WGS84 latitude/longitude and directs the pilot over a pre-programmed survey grid.

The on-board survey operator was responsible for monitoring of the system integrity. He also maintained a detailed flight log during the survey, tracking the times of the flight as well as any unusual geophysical, cultural or topographic feature.

On return of the aircrew to the base camp the aircraft survey data and ground base station data was transferred from the data storage media (compact flash card (PCMCIA)) to the data processing computer.

The survey data was processed daily using both Geosoft OASIS Montaj and programmes proprietary to Geotech Ltd. The airborne data was merged with the ground base station mag data, geographic coordinates were projected, pre-processing routines were applied, the flight was parsed by survey line and preliminary grids and profiles prepared.

Operations issues to be noted include

- One flight, Flight 11 (Aug 9/07), consisting of lines 1615 and 1625, was flown without the magnetometer.
- Several lines were broken due to the terrain and then were picked up with some overlap.
- Several sections of lines were not flown over built-up areas or in particularly difficult terrain with poor existing weather conditions.

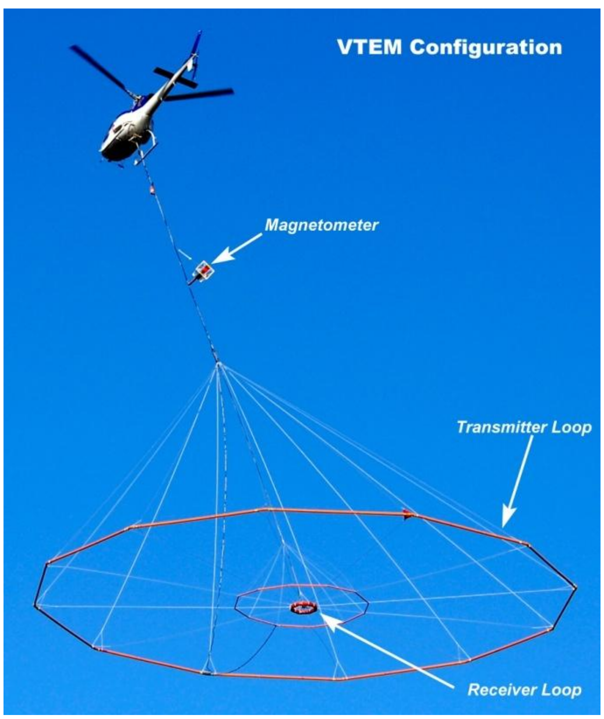
4. AIRCRAFT AND EQUIPMENT

4.1 Survey Aircraft

The survey was flown using two different helicopters. From the beginning of the survey until Aug 27th an AStar350-B2, registration C-GTSZ was used. On the 28th of August the helicopter was exchanged for the more powerful AStar350-B4, registration C-GTXK. Both machines were owned and operated by TRK Helicopters (BC) Ltd. of Langley, B.C. Both installations of the geophysical and ancillary equipment were carried out by Geotech Ltd. in Prince George.

4.2 Electromagnetic System

The electromagnetic system was a Geotech Time Domain EM (VTEM) system. The configuration is as indicated in Figure 3 below.



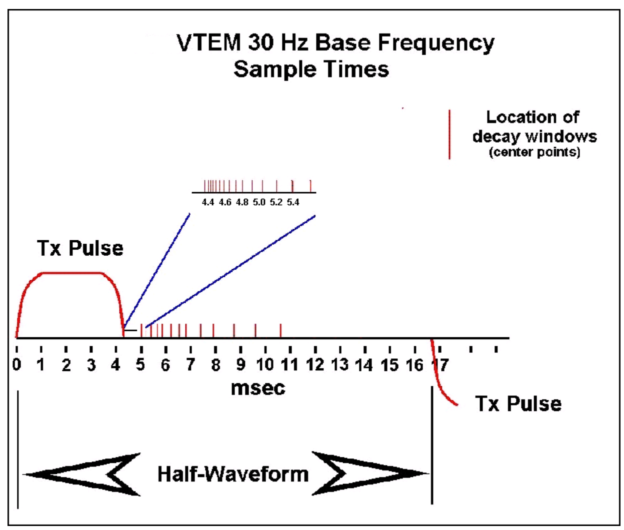


Figure 4 - VTEM Waveform

Figure 3 - VTEM Configuration

The EM bird was towed 42 m below the helicopter.

Receiver and transmitter coils are concentric and Z-direction oriented. The receiver decay recording scheme is shown diagrammatically in Figure 4.

The VTEM system parameters are:

Transmitter Coil
- Transmitter coil diameter: 26 m
- Number of turns: 4
- Transmitter frequency: 30 Hz
- Peak current: 235 A
- Pulse width: 4.5 ms
- Duty cycle: 27%
- Peak dipole moment: 503,000 NIA

Receiver Coil
- Receiver coil diameter: 1.1 m
- Number of turns: 100.
- Effective coil area: 113.1 m^2
- Wave form shape: trapezoid.
- Sampling frequency: 10 Hz

Twenty-seven measurement gates were used in the range from 99 µs to 9245 µs, as shown in Table 3.

VTEM Time Gates				
Array	(Microseconds)			
Index	Time Gate	Start	End	Width
9	99	91	110	19
10	120	110	131	21
11	141	131	154	24
12	167	154	183	29
13	198	183	216	34
14	234	216	258	42
15	281	258	310	53
16	339	310	373	63
17	406	373	445	73
18	484	445	529	84
19	573	529	628	99
20	682	628	750	123
21	818	750	896	146
22	974	896	1063	167
23	1151	1063	1261	198
24	1370	1261	1506	245
25	1641	1506	1797	292
26	1953	1797	2130	333
27	2307	2130	2526	396
28	2745	2526	3016	490
29	3286	3016	3599	583
30	3911	3599	4266	667
31	4620	4266	5058	792
32	5495	5058	6037	979
33	6578	6037	7203	1167
34	7828	7203	8537	1334
35	9245	8537	10120	1584

Table 3 - Time Gates

4.3 Airborne Magnetometer

The magnetic sensor utilized for the survey was a Geometrics optically pumped cesium vapour magnetic field sensor, mounted in a separate bird, towed 15 metres below the helicopter, as shown in Figure 3. The sensitivity of the magnetic sensor is 0.02 nanoTesla (nT) at a sampling interval of 0.1 seconds. The magnetometer sends the measured magnetic field strength digitally to the data acquisition system via the RS-232 port.

4.4 Radar Altimeter

A Terra TRA 3000/TRI 40 radar altimeter was used to record terrain clearance. The antenna was mounted beneath the bubble of the helicopter cockpit.

4.5 GPS Navigation System

The navigation system used was a Geotech PC based navigation system utilising a NovAtel's WAAS enable OEM4-G2-3151W GPS receiver, Geotech navigate software, a full screen display with controls in front of the pilot to direct the flight and a NovAtel GPS antenna mounted on the helicopter tail. The UTM co-ordinates of the block were established prior to the survey and the information entered into the airborne navigation system.

4.6 Digital Acquisition System

A Geotech data acquisition system recorded the digital survey data on an internal compact PCMCIA flash card. Data is displayed on an LCD screen as traces to allow the operator to monitor the integrity of the system. The data type and sampling interval are described in Table 4.

DATA TYPE	SAMPLING
EM	0.1 sec
Magnetometer	0.1 sec
GPS Position	0.2 sec
Radar Altimeter	0.2 sec

Table 4 – Acquisition Sampling Rates

4.7 Base Station

A combined magnetometer/GPS base station was employed on this project. A Geometrics Cesium vapour magnetometer was used as a magnetic sensor with a sensitivity of 0.001 nT. The base station was recording the magnetic field together with the GPS time at 1 Hz on a base station computer.

The base station magnetometer sensor was installed near the operations bases away from electric transmission lines and moving ferrous objects such as motor vehicles. At the end of each survey day the base station data was backed-up to the data processing computer.

5. PERSONNEL

The following Geotech Ltd. personnel were involved in the project.

Field:

Project Manager:	Shawn Grant
Engineer:	Igor Tsirkot
Crew chief:	Calin Cosma Alex Dumyn
Operator:	Robert Rus Alex Smirnov Kevin Boyer Adrian Sarmasag
Logistics:	Peter Cholewa Andrew Hawkins

The survey pilots and the mechanical engineers were employees of the helicopter operator – TRK Helicopters Ltd.

Pilot:	Pierre Forand Randy Marks Roy Stevenson Mark Rayner
AME:	Greg Ross Chris Ware Andrew Hawkins

Office:

QC/Final Processing:	Neil Fiset
Data Technician:	Maria Jagodkin

Data acquisition and processing phases were carried out under the supervision of Andrei Bagrianski, Surveys Manager. Overall management of the project was undertaken by Edward Morrison, President, Geotech Ltd. Peter Kowalczk and Colin Barnett acted as technical overseers on behalf of the client.

6. DATA PROCESSING AND PRESENTATION

All in-field and post-survey data processing was carried out using Geosoft Oasis Montaj as well as Geotech proprietary data processing software. Each day the raw data collected in the aircraft and in the ground magnetic base station were imported into a Geosoft database and then processed into a form from which preliminary databases and maps could be constructed. A general description of the data processing procedures carried out follows:

6.1 Flight Path, DEM & Topography

The aircraft position, recorded by the acquisition system as WGS 84 latitude/longitude at 0.2 Hz, was resampled to 0.1 Hz and then projected into UTM Zone 10N coordinates expressed as UTM eastings (x-metres) and UTM northings (y-metres). The datum used was NAD83.

The new flight path was drawn on the maps using linear interpolation between the projected x,y positions.

The DEM was simply calculated as the difference between the GPS altitude and the radar altimeter.

The topographic vectors which form the base layer of the final geophysical maps were derived from the 1:250,000 scale digital National Topographic Series database. They are free and publically available from the Federal Government portal website at http://www.geogratis.cgdi.gc.ca.

6.2 Electromagnetic Data

A three stage digital filtering process was used to reject major sferics events and to reduce system noise. Local sferics activity can produce sharp, large amplitude events that cannot be removed by conventional filtering procedures. Smoothing or stacking will reduce their amplitude but leave a broader residual response that can be confused with geological phenomena. To avoid this possibility, a computer algorithm searches out and rejects the major sferics events. The filter used was a 4 point non-linear filter.

The signal to noise ratio was further improved by the application of a low pass linear digital filter. This filter has zero phase shift, which prevents any lag or peak displacement from occurring. It suppresses only variations with a wavelength less than about 2 second or 40 metres. This filter is a symmetrical 2 sec linear filter.

The final EM data is presented as multi-gate offset profiles at linear-logarithmic scale.

6.3 Magnetic Data

The processing of the magnetic data involved the correction for diurnal variations by using the digitally recorded ground base station magnetic values. The base station magnetometer data was edited and merged into the Geosoft GDB database on a daily basis. The aeromagnetic data was corrected for diurnal variations by subtracting the observed magnetic base station deviations.

The corrected magnetic line data from the survey was interpolated between survey lines using a random point gridding method to yield x-y grid values for a standard grid cell size of approximately 0.25 cm at the mapping scale. The Minimum Curvature algorithm was used to interpolate values onto a rectangular regular spaced grid.

7. DELIVERABLES

The final deliverable products consist of two copies of a logistical report, maps and a digital database. The report and maps are provided in both paper and digital versions.

The maps accompanying this report are as follows:

Main Block
- Plate 1N - Flight Path with topographic base, 1:250,000, North Sheet
- Plate 1S - Flight Path with topographic base, 1:250,000, South Sheet
- Plate 2N - EM Offset Profiles with topographic base, 1:250,000, North Sheet
- Plate 2S - EM Offset Profiles with topographic base, 1:250,000, South Sheet
- Plate 3N - Total Magnetic Intensity grid with topographic base, 1:250,000, North Sheet
- Plate 3S - Total Magnetic Intensity grid with topographic base, 1:250,000, South Sheet

Mt. Milligan
- Plate 1 - EM Offset Profiles with topographic base, 1:10,000
- Plate 2 - Total Magnetic Intensity grid with topographic base, 1:10,000

The digital database and digital versions of the report and maps have been archived on a DVD-ROM. In addition to the survey data a Google Earth file showing the survey flight path has been included. This file may be viewed with the free version of Google Earth software which can be downloaded at http://earth.google.com/download-earth.html. A *readme.txt* file may be found on the disc that describes the contents in more detail.

8. CONCLUSIONS

Between July and November, 2007, a helicopter-borne versatile time domain electromagnetic (VTEM) geophysical survey has been completed over the QUEST Project area in Central British Columbia.

The total area coverage was 46,517 km^2 and total survey line length was 11620.9 line kilometres. The principal sensors included a Time Domain EM system and a magnetometer.

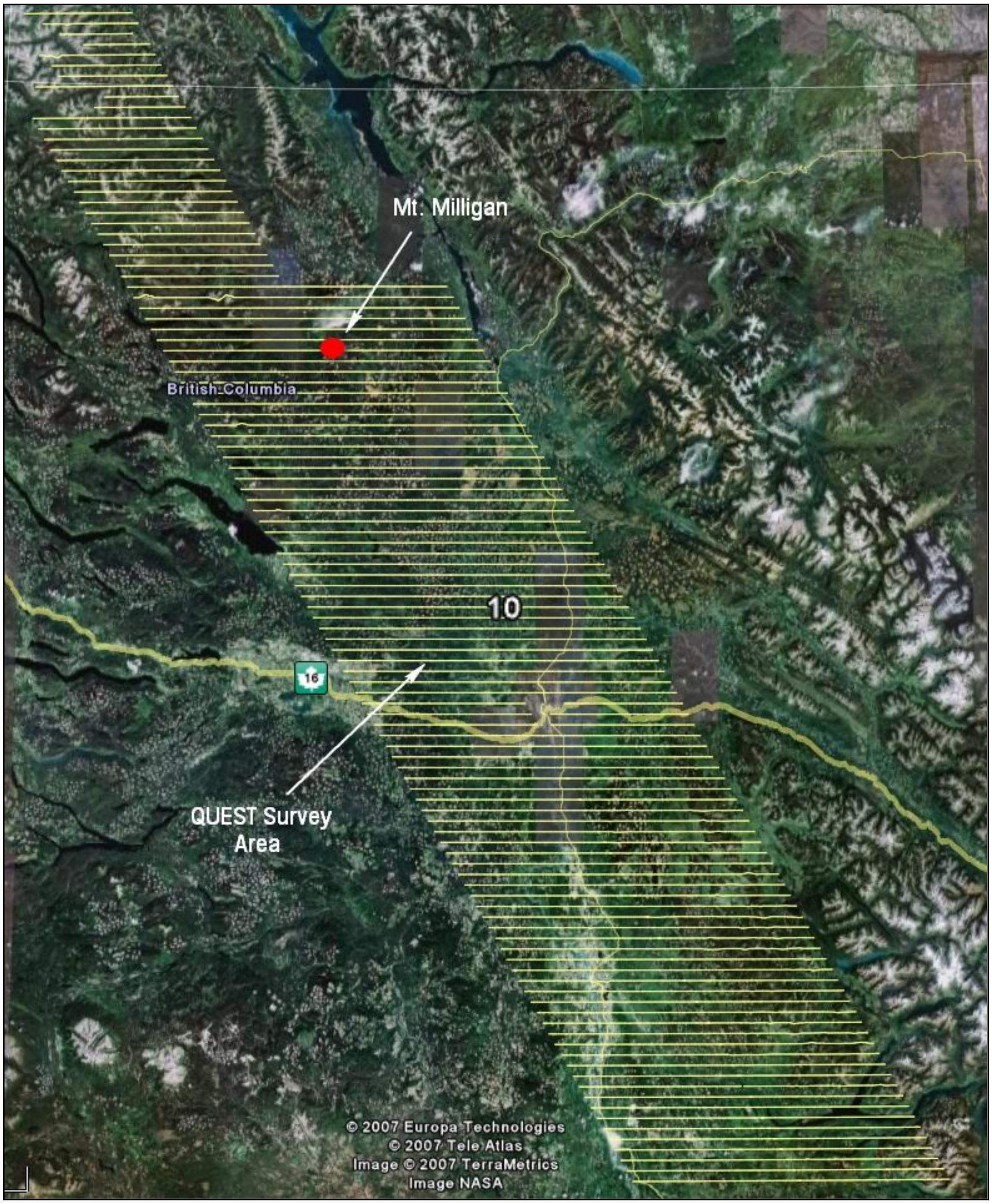
The survey results have been presented as digital databases as well as offset profile maps and colour contour maps at scales of 1:250,000 over the Main Block and 1:10,000 over the detailed Mt. Milligan Block.

Respectfully submitted,

Neil Fiset
Geotech Ltd.
December, 2007

APPENDIX A

SURVEY BLOCKS LOCATION MAP



Google Earth Imagery

APPENDIX B

SURVEY BLOCK COORDINATES

(NAD83, UTM zone 10 north)

Main Block

X	Y
479000	6132000
669000	5796000
549000	5796000
300191	6236000
360191	6236000
418180	6132000

Mt. Milligan Block

X	Y
433000	6110200
435600	6110200
435600	6107600
433000	6107600

APPENDIX C
DIGITAL DELIVERABLES

The logistical report and the survey data in the form of databases and maps have been archived onto DVD-ROM in two copies. The contents of the folders found on the DVD are described below:

\Report:

7042-GBC.pdf :	Logistical report in Adobe PDF format
7042-FlightPath.kmz	Flight path in a Google Earth File

\Data:

7042-Main.gdb:	The main block database containing positional and geophysical data.
7042-MtMill.gdb:	The Mt. Milligan database containing positional and geophysical data.
7042_106_wform.gdb:	The waveform of the receiver at 10 µs intervals
7042_106_wform.xyz:	The waveform of the receiver at 10 µs intervals in xyz format

A description of the database channels may be found in Appendix D.

\Maps:

Main Block: All maps at 1:250,000 scale with topographic base

FP_250k_MainNorth.map	Plate 1N - Flight Path, North Sheet
FP_250k_MainSouth.map	Plate 1S - Flight Path, South Sheet
EMB_250k_MainNorth.map	Plate 2N - EM B-Field Offset Profiles, North Sheet
EMB_250k_MainSouth.map	Plate 2S - EM B-Field Offset Profiles, South Sheet
Mag_250k_MainNorth.map	Plate 3N - TMI grid and contours, North Sheet
Mag_250k_MainSouth.map	Plate 3S - TMI grid and contours, South Sheet
Mag_Main.grd	Main Block TMI grid with *gi* file

Mt. Milligan: All maps at 1:10,000 scale with topographic base

EMB_10k_MtMill.map	EM B-Field Offset Profiles
Mag_10k_MtMill.map	TMI grid and contours
Mag_MtMill.grd	Mt. Milligan Block TMI grid with *gi* file

Each Geosoft grid file *(*.grd*) has an associate **.gi* metadata file containing grid projection information.

Included is a subdirectory **\pdf_maps:** containing pdf filesof each of the above maps

APPENDIX D

DATABASE CHANNELS

Channel Name	Description
X	X positional data (metres – NAD83, UTM zone 10 north)
Y	Y positional data (metres – NAD83, UTM zone 10 north)
Longitude	Longitude data (degree – NAD83)
Latitude	Latitude data (degree – NAD83)
Z	GPS antenna elevation (metres – GPS ellipsoid)
Date	Flight Date (DD/MM/YYYY)
FltNo	Flight Number
Radar	Helicopter terrain clearance from radar altimeter (metres - AGL)
DEM	Digital elevation model (metres)
gTime	GPS time (seconds of the day)
Mag1	Raw Total Magnetic field data (nanoTesla)
Basemag	Magnetic diurnal variation data (nanoTesla)
Mag2	Total Magnetic field diurnal variation corrected data (nanoTesla)
SF[9]	dB/dt 99 microsecond time channel (pV/(A*m^4))
SF[10]	dB/dt 120 microsecond time channel (pV/(A*m^4))
SF[11]	dB/dt 141 microsecond time channel (pV/(A*m^4))
SF[12]	dB/dt 167 microsecond time channel (pV/(A*m^4))
SF[13]	dB/dt 198 microsecond time channel (pV/(A*m^4))
SF[14}	dB/dt 234 microsecond time channel (pV/(A*m^4))
SF[15]	dB/dt 281 microsecond time channel (pV/(A*m^4))
SF[16]	dB/dt 339 microsecond time channel (pV/(A*m^4))
SF[17]	dB/dt 406 microsecond time channel (pV/(A*m^4))
SF[18]	dB/dt 484 microsecond time channel (pV/(A*m^4))
SF[19]	dB/dt 573 microsecond time channel (pV/(A*m^4))
SF[20]	dB/dt 682 microsecond time channel (pV/(A*m^4))
SF[21]	dB/dt 818 microsecond time channel (pV/(A*m^4))
SF[22]	dB/dt 974 microsecond time channel (pV/(A*m^4))
SF[23]	dB/dt 1151 microsecond time channel (pV/(A*m^4))
SF[24]	dB/dt 1370 microsecond time channel (pV/(A*m^4))
SF[25]	dB/dt 1641 microsecond time channel (pV/(A*m^4))
SF[26]	dB/dt 1953 microsecond time channel (pV/(A*m^4))
SF[27]	dB/dt 2307 microsecond time channel (pV/(A*m^4))
SF[28]	dB/dt 2745 microsecond time channel (pV/(A*m^4))
SF[29]	dB/dt 3286 microsecond time channel (pV/(A*m^4))

SF[30]	dB/dt 3911 microsecond time channel (pV/(A*m^4))
SF[31]	dB/dt 4620 microsecond time channel (pV/(A*m^4))
SF[32]	dB/dt 5495 microsecond time channel (pV/(A*m^4))
SF[33]	dB/dt 6578 microsecond time channel (pV/(A*m^4))
SF[34]	dB/dt 7828 microsecond time channel (pV/(A*m^4))
SF[35]	dB/dt 9245 microsecond time channel (pV/(A*m^4))
BF[9]	B-field 99 microsecond time channel ((pV*ms)/(A*m^4)
BF[10]	B-field 120 microsecond time channel ((pV*ms)/(A*m^4))
BF[11]	B-field 141 microsecond time channel ((pV*ms)/(A*m^4))
BF[12]	B-field 167 microsecond time channel ((pV*ms)/(A*m^4))
BF[13]	B-field 198 microsecond time channel ((pV*ms)/(A*m^4))
BF[14]	B-field 234 microsecond time channel ((pV*ms)/(A*m^4))
BF[15]	B-field 281 microsecond time channel ((pV*ms)/(A*m^4))
BF[16]	B-field 339 microsecond time channel ((pV*ms)/(A*m^4))
BF[17]	B-field 406 microsecond time channel ((pV*ms)/(A*m^4))
BF[18]	B-field 484 microsecond time channel ((pV*ms)/(A*m^4))
BF[19]	B-field 573 microsecond time channel ((pV*ms)/(A*m^4))
BF[20]	B-field 682 microsecond time channel ((pV*ms)/(A*m^4))
BF[21]	B-field 818 microsecond time channel ((pV*ms)/(A*m^4))
BF[22]	B-field 974 microsecond time channel ((pV*ms)/(A*m^4))
BF[23]	B-field 1151 microsecond time channel ((pV*ms)/(A*m^4))
BF[24]	B-field 1370 microsecond time channel ((pV*ms)/(A*m^4))
BF[25]	B-field 1641 microsecond time channel ((pV*ms)/(A*m^4))
BF[26]	B-field 1953 microsecond time channel ((pV*ms)/(A*m^4))
BF[27]	B-field 2307 microsecond time channel ((pV*ms)/(A*m^4))
BF[28]	B-field 2745 microsecond time channel ((pV*ms)/(A*m^4))
BF[29]	B-field 3286 microsecond time channel ((pV*ms)/(A*m^4))
BF[30]	B-field 3911 microsecond time channel ((pV*ms)/(A*m^4))
BF[31]	B-field 4620 microsecond time channel ((pV*ms)/(A*m^4))
BF[32]	B-field 5495 microsecond time channel ((pV*ms)/(A*m^4))
BF[33]	B-field 6578 microsecond time channel ((pV*ms)/(A*m^4))
BF[34]	B-field 7828 microsecond time channel ((pV*ms)/(A*m^4))
BF[35]	B-field 9245 microsecond time channel ((pV*ms)/(A*m^4))
PLinef	Power line monitor

EM unit abbreviations:

ms: milliseconds pV: picoVolt A: Amperes m:metres

APPENDIX E

GENERALIZED MODELING RESULTS OF THE VTEM SYSTEM

Introduction

The VTEM system is based on a concentric or central loop design, whereby, the receiver is positioned at the centre of a 26.1 metres diameter transmitter loop that produces a dipole moment up to 625,000 NIA at peak current. The wave form is a bi-polar, modified square wave with a turn-on and turn-off at each end. With a base frequency of 30 Hz, the duration of each pulse is approximately 4.5 milliseconds followed by an off time where no primary field is present.

During turn-on and turn-off, a time varying field is produced (dB/dt) and an electro-motive force (emf) is created as a finite impulse response. A current ring around the transmitter loop moves outward and downward as time progresses. When conductive rocks and mineralization are encountered, a secondary field is created by mutual induction and measured by the receiver at the centre of the transmitter loop.

Measurements are made during the off-time, when only the secondary field (representing the conductive targets encountered in the ground) is present.

Efficient modeling of the results can be carried out on regularly shaped geometries, thus yielding close approximations to the parameters of the measured targets. The following is a description of a series of common models made for the purpose of promoting a general understanding of the measured results.

Variation of Plate Depth

Geometries represented by plates of different strike length, depth extent, dip, plunge and depth below surface can be varied with characteristic parameters like conductance of the target, conductance of the host and conductivity/thickness and thickness of the overburden layer.

Diagrammatic models for a vertical plate are shown in figures A and G at two different depths, all other parameters remaining constant. With this transmitter-receiver geometry, the classic **M** shaped response is generated. Figure A shows a plate where the top is near surface. Here, amplitudes of the duel peaks are higher and symmetrical with the zero centre positioned directly above the plate. Most important is the separation distance of the peaks. This distance is small when the plate is near surface and widens with a linear relationship as the plate (depth to top) increases. Figure G shows a much deeper plate where the separation distance of the peaks is much wider and the amplitudes of the channels have decreased.

Variation of Plate Dip

As the plate dips and departs from the vertical position, the peaks become asymmetrical. Figure B shows a near surface plate dipping 80º. Note that the direction of dip is toward the high shoulder of the response and the top of the plate remains under the centre minimum.

As the dip increases, the aspect ratio (Min/Max) decreases and this aspect ratio can be used as an empirical guide to dip angles from near 90º to about 30º. The method is not sensitive enough where dips are less than about 30º. Figure E shows a plate dipping 45º and, at this angle, the minimum shoulder starts to vanish. In Figure D, a flat lying plate is shown, relatively near surface. Note that the twin peak anomaly has been replaced by a symmetrical shape with large, bell shaped, channel amplitudes which decay relative to the conductance of the plate.

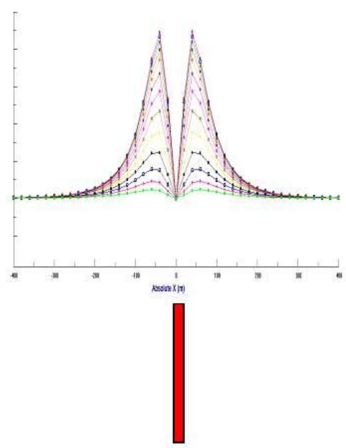
Figure H shows a special case where two plates are positioned to represent a synclinal structure. Note that the main characteristic to remember is the centre amplitudes are higher (approximately double) compared to the high shoulder of a single plate. This model is very representative of tightly folded formations where the conductors where once flat lying.

Variation of Prism Depth

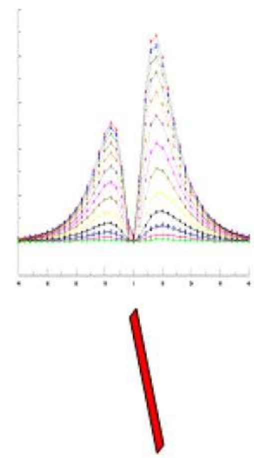
Finally, with prism models, another algorithm is required to represent current on the plate. A plate model is considered to be infinitely thin with respect to thickness and incapable of representing the current in the thickness dimension. A prism model is constructed to deal with this problem, thereby, representing the thickness of the body more accurately.

Figures C, F and I show the same prism at increasing depths. Aside from an expected decrease in amplitude, the side lobes of the anomaly show a widening with deeper prism depths of the bell shaped early time channels.

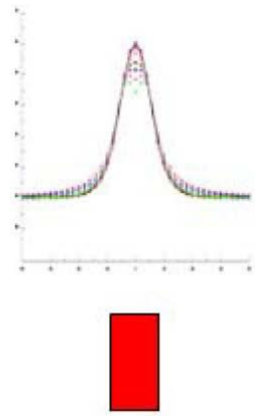
A



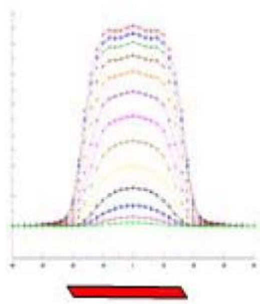
B



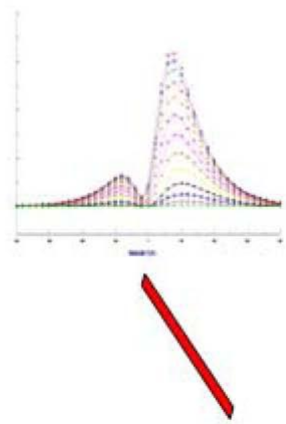
C



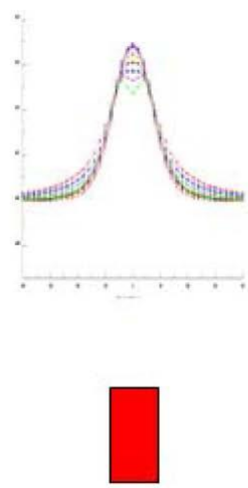
D



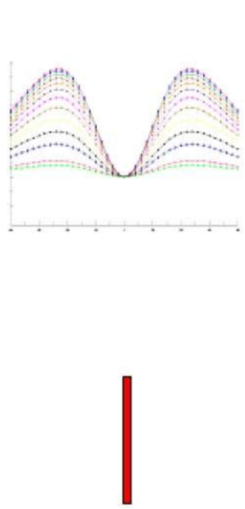
E



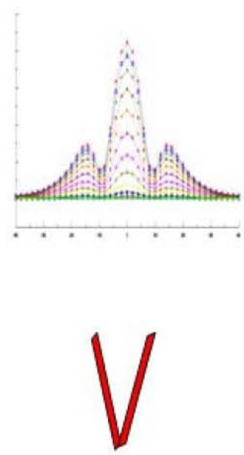
F



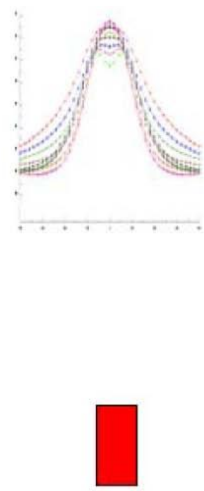
G



H



I



General Modeling Concepts

A set of models has been produced for the Geotech VTEM® system with explanation notes (see models A to I above). The reader is encouraged to review these models, so as to get a general understanding of the responses as they apply to survey results. While these models do not begin to cover all possibilities, they give a general perspective on the simple and most commonly encountered anomalies.

When producing these models, a few key points were observed and are worth noting as follows:

- For near vertical and vertical plate models, the top of the conductor is always located directly under the centre low point between the two shoulders in the classic **M** shaped response.
- As the plate is positioned at an increasing depth to the top, the shoulders of the **M** shaped response, have a greater separation distance.
- When faced with choosing between a flat lying plate and a prism model to represent the target (broad response) some ambiguity is present and caution should be exercised.
- With the concentric loop system and Z-component receiver coil, virtually all types of conductors and most geometries are most always well coupled and a response is generated (see model H). Only concentric loop systems can map this type of target.

The modeling program used to generate the responses was prepared by PetRos Eikon Inc. and is one of a very few that can model a wide range of targets in a conductive half space.

General Interpretation Principals

Magnetics

The total magnetic intensity responses reflect major changes in the magnetite and/or other magnetic minerals content in the underlying rocks and unconsolidated overburden. Precambrian rocks have often been subjected to intense heat and pressure during structural and metamorphic events in their history. Original signatures imprinted on these rocks at the time of formation have, it most cases, been modified, resulting in low magnetic susceptibility values.

The amplitude of magnetic anomalies, relative to the regional background, helps to assist in identifying specific magnetic and non-magnetic rock units (and conductors) related to, for example, mafic flows, mafic to ultramafic intrusives, felsic intrusives, felsic volcanics and/or sediments etc. Obviously, several geological sources can produce the same magnetic response. These ambiguities can be reduced considerably if basic geological information on the area is available to the geophysical interpreter.
In addition to simple amplitude variations, the shape of the response expressed in the wave length and the symmetry or asymmetry, is used to estimate the depth, geometric parameters and magnetization of the anomaly. For example, long narrow magnetic linears usually reflect mafic flows or intrusive dyke features. Large areas with complex magnetic patterns may be produced by intrusive bodies with significant magnetization, flat lying magnetic sills or sedimentary iron formation. Local isolated circular magnetic patterns often represent plug-like igneous intrusives such as kimberlites, pegmatites or volcanic vent areas.

Because the total magnetic intensity (TMI) responses may represent two or more closely spaced bodies within a response, the second derivative of the TMI response may be helpful for distinguishing these complexities. The second derivative is most useful in mapping near surface linears and other subtle magnetic structures that are partially masked by nearby higher amplitude magnetic features. The broad zones of higher magnetic amplitude, however, are severely attenuated in the vertical derivative results. These higher amplitude zones reflect rock units having strong magnetic susceptibility signatures. For this reason, both the TMI and the second derivative maps should be evaluated together.

Theoretically, the second derivative, zero contour or colour delineates the contacts or limits of large sources with near vertical dip and shallow depth to the top. The vertical gradient map also aids in determining contact zones between rocks with a susceptibility contrast, however, different, more complicated rules of thumb apply.

Concentric Loop EM Systems

Concentric systems with horizontal transmitter and receiver antennae produce much larger responses for flat lying conductors as contrasted with vertical plate-like conductors. The amount of current developing on the flat upper surface of targets having a substantial area in this dimension, are the direct result of the effective coupling angle, between the primary magnetic field and the flat surface area. One therefore, must not compare the amplitude/conductance of responses generated from flat lying bodies with those derived from near vertical plates; their ratios will be quite different for similar conductances.

Determining dip angle is very accurate for plates with dip angles greater than 30º. For angles less than 30º to 0º, the sensitivity is low and dips can not be distinguished accurately in the presence of normal survey noise levels.

A plate like body that has near vertical position will display a two shoulder, classic **M** shaped response with a distinctive separation distance between peaks for a given depth to top.

It is sometimes difficult to distinguish between responses associated with the edge effects of flat lying conductors and poorly conductive bedrock conductors. Poorly conductive bedrock conductors having low dip angles will also exhibit responses that may be interpreted as surfacial overburden conductors. In some situations, the conductive response has line to line continuity and some magnetic correlation providing possible evidence that the response is related to an actual bedrock source.
The EM interpretation process used, places considerable emphasis on determining an understanding of the general conductive patterns in the area of interest. Each area has different characteristics and these can effectively guide the detailed process used.

The first stage is to determine which time gates are most descriptive of the overall conductance patterns. Maps of the time gates that represent the range of responses can be very informative.

Next, stacking the relevant channels as profiles on the flight path together with the second vertical derivative of the TMI is very helpful in revealing correlations between the EM and Magnetics.

Next, key lines can be profiled as single lines to emphasize specific characteristics of a conductor or the relationship of one conductor to another on the same line. Resistivity Depth sections can be constructed to show the relationship of conductive overburden or conductive bedrock with the conductive anomaly.

APPENDIX F

VTEM WAVEFORM