**TECHNICAL REPORT ON A FIXED WING**

**HORIZONTAL GRADIOMETER**

**AEROMAGNETIC SURVEY**

**SAN BERNARDINO VALLEY,**

**SAN BERNARDINO MOUNTAINS,**

**SAN BERNARDINO PROFILES**

**and**

**TWENTY-NINE PALMS, CALIFORNIA**

**BLOCKS**

**CONTRACT 01CRCN0040**

**February 2002**

**for**

**UNITED STATES GEOLOGICAL SURVEY**

**by**

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# TECHNICAL REPORT SAMPLE

# 1. INTRODUCTION

This report describes four airborne geophysical surveys carried out in the San Bernardino Mountains outside of Los Angeles, CA on behalf of the United States Geological Survey during February of 2002.

The survey blocks are named San Bernardino Valley (SBV), San Bernardino Mountains (SBM), San Bernardino Profiles (SBP), and Twenty-Nine Palms (29P).

The field crew for this set of blocks was based from Redlands, CA. The aircraft was based at the San Bernardino airport.

Aircraft equipment operated included three cesium vapor, digitally compensated magnetometers, a GPS real-time and post-corrected differential positioning system, a flight path recovery camera, VHS titling and recording system, as well as radar and barometric altimeters. All data was recorded digitally in GEDAS binary file format.

Reference ground equipment included a Geometrics G823B cesium vapor magnetometer set up at Redlands for the entire set of blocks. A GEM Systems GSM-19W Overhauser magnetometer was used as a remote reference station for SBM, SBP and 29P blocks. It was situated at the Twenty-Nine Palms civilian airport. A Novatel 12 channel GPS base station was used at Redlands for differential corrections.

The center of the SBV survey block is approximately centered over the city of Redlands, CA. One calibration flight and three survey flights where required to complete this area. All flights took place between February 6th and 8th.The center of the SBM block is approximately centered over the city of Banning, CA and abuts the east side of the SBV block. The SBP survey consists of two high altitude profiles that pass over the SBM block. Seven survey flights were required to complete these blocks. These flights took place between February 8th and 25th.

During a scheduled maintenance interval, while on production for the SBM block, a crack was detected in the left engine of the survey aircraft. The engine had to be removed and repaired. This caused a seven-day delay and the need for another calibration flight.

The 29P block is centered over Twenty-Nine Palms USMC training base. Four survey flights were required to complete this block. Flight planning for these flights had to be coordinated with the USMC operations personnel at the Twenty-Nine Palms base. These flights took place between February 25th and 28th.

# 2. SURVEY AREA LOCATION

The San Bernardino Valley block (SBV) is approximately centered over the city of Redlands, CA. The center of the area is at N 34°07’, W 117° 15’. The survey consisted of 1368 kilometers of lines oriented on an azimuth of 053°/233°T (true with respect to UTM North) with control lines at 143°/323°T.

The traverse lines where flown on a spacing of 530 meters with a control line separation of 5300 meters.

Aircraft height was specified at 245 meters above ground. A vertical navigation drape surface was prepared using USGS topographic data and a maximum climb / descent gradient of 6%.

The area is heavily populated with nearly 100% cultural coverage.The survey boundary is defined by the following WGS-84, UTM Zone 11N coordinates:

498984 3766277

489108 3753624

456178 3778335

463406 3787729

498985 3769954

### Illustration – San Bernardino Valley Ideal Flight Plan

The San Bernardino Mountains block (SBM) is approximately centered over the city of Banning, CA. The center of the area is at N 34°00’, W 116° 45’. The survey consisted of 2768 kilometers of lines oriented on an azimuth of 000°/180°T (true with respect to UTM North) with control lines at 090°/270°T.

The traverse lines where flown on a spacing of 530 meters with a control line separation of 5300 meters.

Aircraft height was specified at 245 meters above ground. A vertical navigation drape surface was prepared using USGS topographic data and a maximum climb / descent gradient of 6%.

The area is sparsely populated with approximately 15% cultural coverageThe survey boundary is defined by the following WGS-84, UTM Zone 11N coordinates:

 499000 3766240

 489139 3753624

 489134 3749226

 540072 3749304

 559098 3770509

 563511 3770537

 563454 3779094

 531004 3778931

 531046 3766291

The San Bernardino Profiles survey (SBP) is consists of two lines to be flown at 3050 meters ASL over the SBM block. The total volume of this survey is 108 kilometers.

The line designated Profile 1 runs between N 33° 45’ 27.47”, W 116° 46’ 52.86” and N 34° 14’ 53.08”, W 116° 47’ 13.54”.

The line designated Profile 2 runs between N 33° 45’ 14.40”, W 116° 46’ 08.40” and N 34° 11’ 15.76”, W 116° 29’ 36.38”

### Illustration – San Bernardino Mountains / Profiles Ideal Flight Plan

The Twenty-Nine Palms block (29P) is approximately centered over the Twenty-Nine Palms USMC training base. The center of the area is at N 34°15’, W 116° 15’. The survey consisted of 2277 kilometers of lines oriented on an azimuth of 090°/270° (true with respect to UTM North) with control lines at 000°/180°T.

The traverse lines where flown on a spacing of 530 meters with a control line separation of 5300 meters.

Aircraft height was specified at 245 meters above ground. A vertical navigation drape surface was prepared using USGS topographic data and a maximum climb / descent gradient of 6%.

The area is sparsely populated with approximately 15% cultural coverage

The survey boundary is defined by the following WGS-84, UTM Zone 11N coordinates:

563096 3774787

563099 3778748

553531 3778694

553408 3808501

578999 3808665

597625 3775086

### Illustration – Twenty-Nine Palms Ideal Flight Plan

# 3. DATA SPECIFICATION

The nominal traverse line separation for all blocks was 530 meters, with a control line spacing of 5300 meters. The tolerance for horizontal line navigation was a maximum deviation of 50% nominal line spacing. Additionally, a maximum inter-line gap over a 3200-meter distance was 150% nominal line spacing.

Altitude control was accomplished by the GEDAS auto-drape system. Digital topographic data for the area was obtained from the USGS and used to compute a smooth surface that cleared the high points in the terrain by the specified clearance and directed a safe rate of climb and descent to the flight crew. The climb / descent rate, or gradient used was 6%. This rate allows safe operation of the survey aircraft.

The specified terrain clearance altitude was 245 meters with a tolerance of ± 60 meters from an ideal drape surface over a 1000-meter distance, with the usual exceptions made for rugged terrain, regulatory compliance or aircraft safety considerations

Diurnal activity tolerance was specified as maximum 5nT change in 5 minutes. Pulsations of 5 minutes of less were limited to 2nT; 5-10 minutes 4nT and 10-20 minutes 8nT.

The flight data magnetic noise tolerance was specified as not to exceed ± 0.1 nT over a maximum of 10% of the line.

The aircraft maneuver noise was specified as a maximum of 3nT per pitch or roll maneuver of up to 20°. The maximum heading error was specified as 1nT. The survey aircraft easily meets this specification with GSC FOMs of less than 1.0nT.

The Geological Survey of Canada FOM specification is ±5° pitches, ±10° rolls and ±5° yaws on all four cardinal headings. The FOM is then the arithmetic sum of the mean peak-to-peak response for all 12 maneuvers.

# 4. AIRCRAFT AND EQUIPMENT

## 4.1 Aircraft

The aircraft used was a Piper PA-31 Navajo, registration C-GJBA, owned and operated by Goldak Exploration. The aircraft is fitted with a 3-meter stinger attached to the rear fuselage on the centerline of the aircraft. The attitude sensing fluxgate magnetometer is positioned at the midpoint of the stinger. The primary cesium sensor is mounted in the aft end of the tail stinger. The aircraft also has magnetometers installed in composite pods on each wingtip. The pods mount the sensors 1.2 meters outboard of the aircraft wingtip. The three magnetometers form a two-axis horizontal gradiometer with following dimensions:

Lateral 584" 14.834m

Longitudinal 384" 9.754

The aircraft has been extensively modified, both mechanically and electrically to minimize the effects of maneuvering on the measured magnetic field. The aircraft has a demonstrated Figure of Merit of less than 0.7 nT as measured to GSC (Geological Survey of Canada) specification. Typical FOMs under less than ideal calibration environments are 0.9 nT for the tail magnetometers. This low level of magnetic noise is considered to be exceptional by experts at the National Research Council.

Illustration – Horizontal Gradient Configuration at San Bernardino, CA

## 4.2 Magnetometer and Compensation

The airborne magnetometers used are a matched set of Geometrics G-822A optically pumped cesium vapor types with sensitivity of 0.005 nT. The magnetometer’s Larmor signal is decoupled and counted by a RMS Instruments AADCII compensator, and data produced at a rate of either 10 Hz with a resolution of 0.001 nT. The data bandwidth is from 0 to 0.9 Hz with an internal noise level of less than 0.002 nT.

The AADCII compensates for magnetic noise due to aircraft motion and heading. Prior to the survey, the aircraft is taken to an area of low magnetic gradient at a high altitude (7000’ AGL +) and put through a series of rolls, pitches and yaws on each of the survey’s cardinal headings.

 This is done so that the AADCII can form a model of the aircraft’s magnetic characteristics without the near influence of the local geology. The remaining magnetic distortion is quantified by a term known as the Figure of Merit, or FOM. A figure of merit of 2.0 or less is used by the Geological Survey of Canada as standard survey criteria. As stated above, this aircraft has an exceptional typical FOM of approximately 0.9 nT.

The following tables represent the digital analysis of the FOM data taken prior to this survey in the vicinity of the survey area. The results are generally typical and are indicative of good compensation fits to the aircraft maneuver noise.

The compensation and FOM flight was performed near the survey area over an area of low magnetic gradient. This area was selected using a coarse gridded image of total magnetic intensity obtained from the USGS website. The flight was accomplished on February 25. The results are as follows:

**RMS AADCII Compensator Statistics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Un-comp Std Dev | Comp Std Dev | Improvement Ratio | Solution Norm |
| Right Wing | 1.532 e0 | 6.254 e-2 | 24.5 | 38.8 |
| Left Wing | 1.423 e0 | 5.402 e-2 | 26.3 | 44.2 |
| Tail  | 2.553 e-1 | 3.563 e-2 | 7.2 | 16.5 |
| Lateral Gradient | 4.461 e0 | 1.078 e-1 | 41.4 | 42.6 |
| Long Gradient | 8.076 e0 | 6.802 e-2 | 118.7 | 35.5 |
| Memory Slot | 13 |

Figure of Merit # 1 – Tail Magnetometer (MBc)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | North | East  | South | West | Sum |
| Pitch | 0.07 | 0.09 | 0.07 | 0.07 | 0.30 |
| Roll | 0.06 | 0.07 | 0.06 | 0.04 | 0.23 |
| Yaw | 0.08 | 0.12 | 0.07 | 0.11 | 0.38 |
| Sum | 0.21 | 0.28 | 0.20 | 0.22 | FOM=0.91 nT |

Figure of Merit #4 – Longitudinal Gradient (GYc

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | North | East  | South | West | Sum |
| Pitch | 0.08 | 0.05 | 0.13 | 0.05 | 0.31 |
| Roll | 0.05 | 0.18 | 0.05 | 0.12 | 0.40 |
| Yaw | 0.05 | 0.10 | 0.04 | 0.05 | 0.24 |
| Sum | 0.18 | 0.33 | 0.22 | 0.22 | FOM =0.95nT |

The following plots are graphical representations of the FOM data taken immediately prior to this survey.

### Illustration - C-GJBA Gradients Figure of Merit

After the engine change at the San Bernardino airport, the aircraft was re-compensated with the following results.

**RMS AADCII Compensator Statistics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Un-comp Std Dev | Comp Std Dev | Improvement Ratio | Solution Norm |
| Right Wing | 1.533 e0 | 7.792 e-2 | 19.7 | 39.3 |
| Left Wing | 1.380 e0 | 6.216 e-2 | 22.2 | 40.5 |
| Tail  | 2.591 e-1 | 4.031 e-2 | 6.4 | 16.6 |
| Lateral Gradient | 5.081 e0 | 1.422 e-1 | 35.7 | 41.5 |
| Long Gradient | 8.438 e0 | 1.108 e-1 | 76.1 | 36.9 |
| Memory Slot | Slot 1 |

**Figure of Merit # 1 – Tail Magnetometer (MBc)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | North | East  | South | West | Sum |
| Pitch | 0.10 | 0.15 | 0.09 | 0.12 | 0.46 |
| Roll | 0.04 | 0.05 | 0.06 | 0.03 | 0.18 |
| Yaw | 0.05 | 0.13 | 0.05 | 0.10 | 0.33 |
| Sum | 0.19 | 0.33 | 0.20 | 0.25 |  |

4.3 Magnetic Base Station

Two magnetic base stations were used for most of the surveys described herein to meet the reference station proximity requirements set out in the contract.

One unit, Geometrics G823B cesium vapor sensor with integral counter and serial interface was placed just outside of Redlands in an area free from cultural effect.

A local data logger is used to store the continual field measurements and a radio modem used to transmit the readings to the field office. At the field office the data is plotted graphically and checked automatically for diurnal activity tolerance.

The cesium base station was set up near the property of a Mr. Barry Glendrange, telephone number 1-800-235-9672 at a location 3.7km bearing 113 degrees from the field office. The coordinates of this base station instrument setup are:

N 36 39 38.4

W 121 36 29.9

### Illustration - Base Magnetometer Redlands Site – North View

A GEM Systems GSM-19W Overhauser magnetometer was used as a remote reference station for SBM, SBP and 29P blocks. It was situated at the Twenty-Nine Palms civilian airport.

It was located at a point approximately 500 meters south of the airport terminal building and approximately 100 meters to the south east of a large windsock. The WGS-84 coordinates of the setup are:

N 34 07 59.6

W 115 56 45.4

### Illustration - Base Magnetometer Twenty-Nine Palms Site – South View

Both the aircraft data acquisition system and the base magnetometer are synchronized to UTC time derived from the aircraft GPS system and recorded in the form of seconds after midnight.

Simultaneously collected data from both magnetometers was averaged over a period of 12 hours of quiet magnetic activity to estimate the “normal” field value at those points. These values will be used in all subsequent diurnal corrections.

## 4.4 VLF-EM System

The VLF-EM system was not recorded for this survey.

**4.5 GPS Positioning System**

The GPS receiver in the survey aircraft is a Novatel 3151R Propak 12 channel differential unit that communicates directly with the GEDAS system. The base station GPS is also a Novatel 3151R Propak whose data is logged by a battery powered industrial portable computer. A survey grade GPS base antenna and choke ring is used to minimize multi-path errors. The system can be used for differential positioning in either real-time, or post-corrected mode.

The positioning system also incorporates a Racal Landstar real-time DGPS system that receives real-time differential corrections from an orbiting geo-synchronous communications satellite. These corrections from this device allow 2-5 meter positioning accuracy in real-time. A GPS base station is also recorded during the survey flight to provide a higher level of accuracy and an independent confidence check to the Landstar RT DGPS system.

GPS signals are occasionally “dithered” by the US Department of Defense for security reasons. This dithering can cause positioning errors of up to 100 meters. In addition to dithering, atmospheric and ionospheric effects typically reduce the accuracy of the non-differential positioning to approximately 10 meters RMS. If a suitable stationary GPS receiver on a known, or assumed position, is used to record the apparent errors in the satellite range data, those errors can be used to correct the moving receiver in the aircraft to a an accuracy of 2-5 meters RMS. This compensation process is called differential correction and can be either applied to the moving receiver in real time for higher dynamic accuracy, or applied later to find out where the aircraft *was* with high accuracy. This is called real-time and post-corrected differential positioning respectively.

The field crew was based from the Dynasty Suites in Redlands, CA. The address of the motel is:

Dynasty Suites

1235 West Colton Ave.

Redlands, California

92374

(909) 793-6648

The GPS base station was setup on the roof above room 123. After acquiring data for 14 hours, the averaged position was given as

Latitude: 34 03 42.27316 ρ = 0.514m

 Longitude: -117 12 04.80048 ρ = 0.441m

 Elevation (MSL): 392.991m ASL ρ = 1.106m

This position was further corrected using the program “GrafNav” and data acquired from a base station located nearby (approx 14km). The station location is published as:

Station: RTHS

Service: IGS

Latitude: 34 05 20.93810

Longitude: -117 21 11.99710

Elevation: 328.708(m) above ellipsoid

The RTHS base station data was used to differentially correct approximately 20 hours of data acquired at our base station location Dynasty Suites.

The differentially corrected antenna position was computed to be:

Latitude: 34 03 42.24055 ρ = 0.093m

Longitude: -117 12 04.74850 ρ = 0.132m

Elevation: 390.996m ASL\* ρ = 0.199m

\*The USGS Geoid99 model was used to transform Height Above Ellipsoid to Height Above Sea Level

Illustration - Base GPS Redlands Site – Southwest View

## 4.6 Radar Altimeter

The radar altimeters used were a Terra TRA-3000 digital unit with accuracy of ±3 meters in the range of typical survey altitudes, and a Thompson CSF ERT-160 with an accuracy of 1 meter over a range of 0 to 2500 meters.

## 4.7 Barometric Altimeter

The barometric altimeter monitored by the system is a Setra model 270 with accuracy of ±1 meters.

## 4.8 Flight Path Camera

The flight path is recorded by a Panasonic GP-KR222 SV hi-resolution color video camera located in the lower rear fuselage of the aircraft. The video is recorded by a Panasonic AG-1980P SVHS recorder. Data pertaining to position, time, speed, altitude, line number and direction are superimposed in the videotape by a Horita SCT-50 video tilte.

## 4.9 GEDAS Digital Recorder

All data is processed and recorded digitally by our GEDAS system. The GEDAS is an industrial rack-mount Intel Pentium based PC computer operating at 233 MHz with multiple hard-drives, IO ports and ADAC devices.

The GEDAS system records time, magnetic, and VLF data at 10 Hz. All positioning data is recorded at 2Hz. Data files are organized on a flight-by-flight basis in a proprietary binary format. The data is then converted post-flight to a Geosoft compatible format.

Data can be downloaded from the system by either floppy disk or Iomega ZIP disk. Data can be delivered in the field by floppy, ZIP disk, Iomega JAZ disk or CD-ROM.

# 5. DATA PROCESSING AND PRESENTATION

All positions in the databases are represented in both the WGS-84 (NAD-83) datum as well as the NAD-27 datum. UTM coordinates are calculated in Zone 11N. All maps are presented in the WGS-84 datum.

## 5.1 Total Field Leveling and Magnetic Gradient Processing

The post-survey data processing was performed by Patterson, Grant and Watson (PGW) of Toronto, Ontario. PGW has been involved in geophysical data processing internationally for many years. We have used them for our data processing for more than three years.

The contact at PGW with respect to this data set is Mr. Karl Kwan. He may be reached at:

Paterson, Grant & Watson Limited
8th Floor, 85 Richmond Street West
Toronto, Ontario, M5H 2C9
CANADA

Telephone: (416) 368-2888
Fax: (416) 368-2887
e-mail: pgw@pgw.on.ca
www.pgw.on.ca

The following are the processing steps documented by PGW.

1. Trimming of overlapping lines.

Leveling and microleveling of two measured horizontal gradients (not required in the contract) Gxn and Gyn. The leveling of measured horizontal gradient channels is done using base level shifts (pulling up or down) technique, or static correction. After that, microleveling was applied. The final horizontal gradient channels are named gxn\_final and gyn\_final. Since the flight line direction is EW, gxn is actually the horizontal derivative in Cartesian +Y direction, and gyn is the horizontal derivative in Cartesian +X direction.

1. Two horizontal gradient grids were made from final processed channels. These two grids were used to compute a pseudo magnetic total field (not required in the contract), using griddxdy2tf.gx developed by PGW. The calculated total field magnetic grid is called sg\_ctf.grd.
2. Tie line leveling of mbc\_dc1 channel. Starting off with statistical leveling of all tie lines, and then the traverse lines were leveled using all intersections. The level corrections were checked at each intersection, and no extremes were allowed in. The tie line leveled data were stored in mbc\_dc1\_lev channel.
3. Microleveling of mbc\_dc1\_lev channel. The final mag channel is mbc\_final. A grid was generated from this channel, using the minimum curvature algorithm.
4. Microleveling of differentially corrected GPS heights, stored in dgpsz\_final, and grid dgpsz\_final.grd.
5. Microleveling of radar altimeter data, stored in ralt\_final, and grid ralt\_final.grd.
6. Microleveling of digital elevation or pseudo topography, stored in topo\_final, and grid topo\_final.grd.
7. Calculation if IGRF, and stored in IGRF channel.
8. IGRF removed final total field magnetics, store in mbc\_res\_final channel, and grid mbc\_res\_final.grd.

## 5.2 Map Presentations

A map with flight path, survey boundary and magnetic contours has been produced for the San Bernardino Valley block at a scale of 1:50,000. This map has been plotted on opaque film. The final map and a grid image is shown below.

Illustration – San Bernardino Valley Final Map

### Illustration – San Bernardino Valley TMI Image

A map with flight path, survey boundary and magnetic contours has been produced for the San Bernardino Mountains block at a scale of 1:100,000. The final map and a grid image is shown below.

A map with flight path, survey boundary and magnetic contours has been produced for the Twenty-Nine Palms block at a scale of 1:50,000. The final map and a grid image is shown below.

## 5.3 Multi-parameter Analog Profiles

Selected channels have been presented in analog chart style on continuous thermal paper. Included in these channels are Total Field Mag, course and fine scales, corrected GPS, barometric and radar altitudes as well as the magnetic fourth difference noise for the tail sensor.

## 5.4 Digital Data Files

Digital data has been provided on CDROM in ASCII XYZ with format and content as stipulated in the contract. The grids have also been provided in ASCII GXF format.

In addition to the data formats above, a standard Geosoft Montaj GDB database and standard GRD grids provided.

The following is a primary channel definition list for the Geosoft GDB database. Note that additional temporary, work and special system channels may exist in the database and may be ignored.

BALT BAROMETRIC ALTIMETER

BaseMag1 DIURNAL BASE MAGNETIC FIELD 1, DE-SPIKED, FILTERED

BaseMag1R DIURNAL BASE MAGNETIC FIELD 1, RAW

BaseMag2 DIURNAL BASE MAGNETIC FIELD 2, DE-SPIKED, FILTERED

BaseMag2R DIURNAL BASE MAGNETIC FIELD 2, RAW

BPRESS BAROMETRIC PRESSURE MEASURED IN AIRCRAFT

DGPSZ DIFFERENTIALLY CORRECTED GPS ALTITUDE (MSL)

DiurX1 DIURNAL TOLERANCE EXCEPTION LEVEL

DLat DIFFERENTIALLY CORRECTED GPS LATITUDE

DLon DIFFERENTIALLY CORRECTED GPS LONGITUDE

Fid LINE FIDUCIAL COUNTER

GHoriz TOTAL HORIZONTAL GRADIENT (SUM OF SQUARES)

GPSQ GPS QUALITY INDICATOR

GPSZ0 REAL-TIME GPS ALTITUDE

GPSZCorr POST-CORRECTION APPLIED TO GPS Z

GPSZDiff POST-CORRECTION GPS Z NOISE

GTIME GPS TIME

GXc LATERAL GRADIENT, COMPENSATED

GXc\_Lag LATERAL GRADIENT, LAGGED

GXn LATERAL GRADIENT, NORMALIZED

GXu LATERAL GRADIENT, UNCOMPENSATED

GYc LONGITUDINAL GRADIENT, COMPENSATED

GYc\_Lag LONGITUDINAL GRADIENT, LAGGED

GYn LONGITUDINAL GRADIENT, NORMALIZED

GYu LONGITUDINAL GRADIENT, UNCOMPENSATED

GZc VERTICAL GRADIENT, COMPENSATED

GZc\_Lag VERTICAL GRADIENT, LAGGED

GZn VERTICAL GRADIENT, NORMALIZED

GZu VERTICAL GRADIENT, UNCOMPENSATED

LAT0 REAL-TIME GPS LATITUDE

Line LINE NUMBER

LON0 REAL-TIME GPS LONGITUDE

MBc LOWER TAIL MAG, COMPENSATED

MBc\_D4 LOWER TAIL MAG, 4TH DIFF NOISE

MBc\_DC1 LOWER TAIL MAG, COMPENSATED, DIURNAL CORRECTED

MBc\_Lag LOWER TAIL MAG, COMPENSATED, LAGGED

MBc\_Lev TIE LINE LEVELED TOTAL FIELD

MBu LOWER TAIL MAG, UNCOMPENSATED

MLc LEFT WING MAG, COMPENSATED

MLc\_D4 LEFT WING MAG, 4TH DIFF NOISE

MLu LEFT WING MAG, UNCOMPENSATED

MRc RIGHT WING MAG, COMPENSATED

MRc\_D4 RIGHT WING MAG, 4TH DIFF NOISE

Mru RIGHT WING MAG, UNCOMPENSATED

MTc UPPER TAIL MAG, COMPENSATED

MTc\_D4 UPPER TAIL MAG, 4TH DIFF NOISE

MTu UPPER TAIL MAG, UNCOMPENSATED

ONLINE IN / OUT GRID LOGICAL FLAG

RadarTopo RADAR ALTIMETER / GPS DERIVED TOPOGRAPHIC ALTITUDE

RALT1A RADAR ALTIMETER NUMBER 1

RAlt1A\_Lag RAD ALT 1, LAGGED

RALT2 RADAR ALTIMETER NUMBER 2

RAlt2\_Lag RAD ALT 2, LAGGED

RAlt\_Err RADAR ALTIMETER 1 DIFFERENCE FROM IDEAL

Velocity AIRCRAFT VELOCITY IN M/S

VLFLQ VLF, LINE QUAD

VLFLQ\_Lag VLF, LINE QUAD, LAGGED

VLFLT VLF, LINE TOTAL

VLFLT\_Lag VLF, LINE TOTAL, LAGGED

VLFOQ VLF, ORTHO QUAD

VLFOQ\_Lag VLF, ORTHO QUAD, LAGGED

VLFOT VLF, ORTHO TOTAL

VLFOT\_Lag VLF, ORTHO TOTAL, LAGGED

VMl RMS AADC VECTOR MAG, LONGITUDINAL

VMt RMS AADC VECTOR MAG, TRANSVERSE

VMtf RMS AADC VECTOR MAG, TOTAL FIELD

VMv RMS AADC VECTOR MAG, VERTICAL

X X CHANNEL IN USE

X\_27 NAD 27 E

X\_84 WGS 84 E

X0 REAL-TIME WGS 84 E

Xtr X CHANNEL TRIMMED TO BLOCK

Y Y CHANNEL IN USE

Y\_27 NAD 27 N

Y\_84 WGS 84 N

Y0 REAL-TIME WGS 84 N

Ytr Y CHANNEL TRIMMED TO BLOCK

The following channels have been imported to the database as a result of the PGW processing.

GXn\_Final PGW leveled lateral gradient

GYn\_Final PGW leveled longitudinal gradient

MBc\_DC2\_Lev PGW leveled, diurnally corrected total field

MBc\_Final Final total field after microleveling

DGPSZ\_Final Microleveled GPS altitude

Ralt\_Final Microleveled radar altitude

Topo\_Final Computed topography DEM

IGRF IGRF field removed

MBc\_Res\_Final Final total field after IGRF residual removed

The following is a list of channels defined in the ASCII XYZ data file as produced by USGS contract.

Channel Units Description

Line N/A Line number

Dlon Geographic Post-corrected Longitude, WGS-84 datum

Dlat Geographic Post-corrected Latitude, WGS-84 datum

X\_84 mete UTM easting, WGS-84 datum

Y\_84 meter UTM northing, WGS-84 datum

X\_27 meters UTM easting, NAD-27 datum

Y\_27 metersUTM northing, NAD-27 datum

Fiducial N/A Database fiducial counter

Date N/A Date YYYY:MM:DD

Time\_HMS N/A Time in HH:MM:SS

RALT1A meters Radar altitude (AGL)

BALT meter Barometric altitude (ASL)

DGPSZ meters GPS altitude (ASL)

BaseMag1nT Diurnal base measurement

MBc\_LagnT Lagged tail magnetometer

MBc\_DC1nT Diurnally corrected tail magnetometer

mbc\_resnT Tail magnetometer with IGRF residual field removed

mbc\_res\_final nT Microleveled tail magnetometer with IGRF residual field removed

## 5.5light Path Video

Flight path video for this survey is supplied on VHS tapes, one per flight. Times, positions, direction and speed are overlain on the tape for detailed flight path recovery if required.

# 6. DETAILED EQUIPMENT SPECIFICATIONS

Our detailed equipment technical specifications are as follows:

Aircraft

 C-GJBA Piper PA-31 Navajo

 4m composite tail stinger w/ vertical gradiometer

 Demonstrated Figure of Merit = 0.9nT

 Sensor Separation

Lateral 584" 14.834m

Longitudinal 384" 9.754

Aircraft Magnetometers:

 Manufacturer: Geometrics

 Type and Model Number: Cesium G-822A

 Range in nT: 20,000 to 90,000

 Sensitivity in nT: 0.005

 Sampling Rate: 20Hz

Base Station Magnetometer:

 Manufacturer: GEM Systems

 Type and Model Number: Overhauser GSM-19W

 Range in nT: 20,000 to 120,000

 Sensitivity in nT: 0.01

 Sampling Rate: 5Hz maximum (0.5Hz typical)

Solar Power Supply: 1 - Solarex MSX50

Real-time Magnetic Compensator:

 Manufacturer: RMS Instruments

 Type and Model Number: AADCII

 Range in nT: 20,000 to 100,000

 Resolution in nT: 0.001

 Sampling Rate: 20Hz

Digital Acquisition System:

 Manufacturer: Goldak Exploration Technology

 Type and Model Number: GEDAS

 Sampling Rate: 20Hz

 Data Format: GEDAS binary

Positioning Cameras:

Manufacturer: Panasonic

Model: GPKR402 HRSV

Lens: WV-LR4R5 4.5mm

 FOV at 1000 feet AGL is 1040 x 1300 feet

Barometric Altimeter:

Manufacturer: Setra

Type and Model Number: 270

Range: -1000 to 10,000 feet

Resolution: 1 meter

Radar Altimeter 1:

Manufacturer Thompson CSF

Type and Model Number: ERT-160

Range: 0-8000 feet

Resolution: 1 meter

Accuracy: 1-2%

Radar Altimeter 2:

Manufacturer Terra

Type and Model Number: TRA300 – TRI40

Range: 0-2500 feet

Resolution: 1 meter

Accuracy: 5-7%

Positioning System:

Manufacturer: Goldak Exploration Technology Ltd.

Type and Model Number: GEDAS

Displays: 10” color LCD graphical display

 Graphic LCD pilot indicator

GPS Subsystem:

GPS Receiver:

Manufacturer Novatel

Type and Model Number: 3151R Propak

GPS Real Time Differential Receiver:

Manufacturer Racal

Type and Model Number: Landstar

GPS Base Station:

Manufacturer Novatel

Type and Model Number: 3151R Propak

System Resolution: 1 meter

Overall accuracy: 3 m in real-time, <1m post-corrected

Computers:

Manufacturer: Compaq

 Type and Model Number: Pentium 400, laptop PC

Manufacturer: Toshiba

 Type and Model Number: Pentium 200, 100CS laptop PC

Plotters and Printers:

 Manufacturer: Canon

Type and Model Number: Bubblejet, BJC10 color page printer

Data backup:

 Manufacturer: Iomega

 Type and Model Number: 100Mb Zip drive

Manufacturer: Iomega

 Type and Model Number: 1.0Gb Jaz drive

 Manufacturer: Hewlett Packard

 Type and Model Number: Sure Store CD-ROM writer

Software

 Manufacturer: Geosoft

 Function: Geophysical data processing

 Type and Model Number: Oasis Montaj

 Manufacturer: Waypoint Consulting

 Function: GPS post-processing

 Type and Model Number: GrafNav

Manufacturer: Geomatics Canad

Ben Goldak

I reside at 25 Duncan Crescent in Saskatoon, Saskatchewan.

I hold a B.Sc. Adv. in Computer Science from the University of Saskatchewan.

I have been active in the field of geophysics since 1980.

I have examined the data referred to in this report and find it to be of suitable quality for purposes of geological interpretation.

I am President of Goldak Exploration Technology Ltd.

Ben Goldak April 24, 2002

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