

096711



**ASSESSMENT REPORT DESCRIBING  
A GEOPHYSICAL SURVEY ON THE KIRKMAN CLAIMS**

Claim Group:

YC23730-YC23743; YC30529-YC30554; YC86825-86873;  
YC87949-YC87976

NTS 115O/03, 115J/14

LAT: 63.02° N

LONG: 139.29° W

DAWSON MINING DISTRICT

Work Performed March 22, 2014 and May 28, 2014

Report prepared on June 18, 2014

by

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QD01883

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## **1.0 INTRODUCTION**

In 2009, Kaminak Gold Corp. acquired the Kirkman claims located 115 km south of Dawson City, Yukon. The project area is proximal to both the Golden Saddle and Coffee gold project, and is hosted in similar rocks. Historic work at Kirkman has highlighted a number of gold anomalies. Based on regional analogs, nature of the geochemical signature and trenching results, these anomalies potentially represent structurally hosted hydrothermal gold mineralization or VMS style mineralization. The purpose of the magnetic survey conducted was to try and delineate any coincident features suggestive of style and orientation of possible mineralization.

## **2.0 LOCATION AND ACCESS**

The Kirkman claims are located 115 kilometers south of Dawson City in west-central Yukon and approximately 15 km north of the Supremo Zone on Kaminak's Coffee property and 20 km south-southeast of the Golden Saddle deposit (Kinross Gold; Figure 1). The property is centered at latitude 63.02N and longitude 139.29W (NTS mapsheets 115O/03 and 115J/14). Direct access to the property is by helicopter from Dawson or Carmacks. An air strip located at Thistle Creek approximately 5 km away from Kirkman provides the best access to site, alternatively access from Coffee Camp is approximately 15km southwest of the property. River access to this region is provided by barge landings on the Yukon River near the thistle creek airstrip and Coffee Camp offer additional logistical support. River transport along the Yukon River from Dawson City to the barge landings is available for five months during the summer period when the river is free of ice.

## **3.0 CLIMATE AND PHYSIOGRAPHY**

The Kirkman area consists of rolling to locally steep hills incised by streams and the majority of the Kirkman area is covered by trees (spruce and poplar). The elevation range on the property is approximately 500m to 1200m. Western Yukon has a sub-arctic continental climate with a summer mean of 10° Celsius and a winter mean of minus 23° Celsius. Summer and winter temperatures can reach plus 35° and minus 55° Celsius, respectively. Dawson City, the nearest town, has a daily average above freezing for 180 days per year.

## **4.0 LAND TENURE**

The Kirkman block consists of a total of 116 claims (Figure 2; Appendix 1). The claims are staked under the Yukon Quartz Mining Act and are registered with the mining recorder in the name of Kaminak Gold Corp.

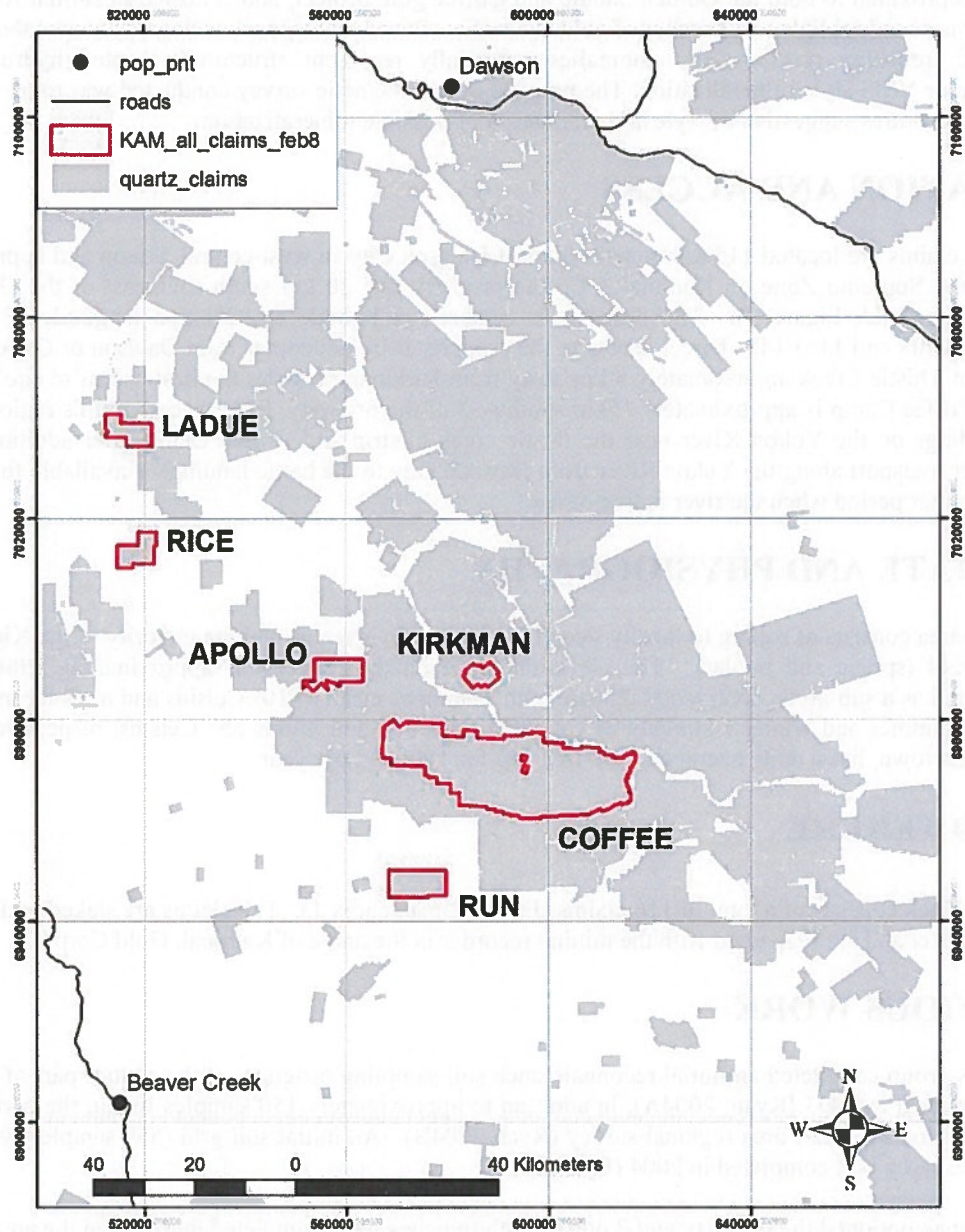
## **5.0 PREVIOUS WORK**

Shawn Ryan's group completed an initial reconnaissance soil sampling program on the central part of the Kirkman claims (14 samples) in 2003 (Ryan, 2004A), in addition to approximately 150 samples within the current property boundary as part of a Stewart area regional survey (Ryan 2004B). An initial soil grid (559 samples) with a ground magnetometer survey was completed in 2004 (Ryan, 2005).

In 2009, Kaminak optioned the property and 2 north-south trenches were completed that year in the area of the 2004 soil grid. Quartz veining, brecciation, carbonate/ankerite/silica alteration, barite mineralization and limonite/hematite were observed in the trench samples. Minor disseminated pyrite and arsenopyrite were also noted; however, geochemical results from these samples contained low gold. In 2009, Kaminak also completed a second soil sampling grid in the north-central part of the property with 640 samples collected, spaced 50 m apart along 100m-spaced lines.

In 2011, four hundred and ninety-six (496) ridgetop and contour soil samples were collected with sampling stations spaced at 50 metres. The crew was based out of the Groundtruth Thistle camp and they completed the work during July 28-29, 2011 (Figure 3).

The historic work indicates that various areas on the Kirkman claims have gold-in-soil values that are considered elevated for the region (see below). In addition to these Au anomalies there are Cu, Ag, Zn in-soil anomalies



**Figure 1** Location of the Kirkman claims, 115 km south of Dawson City, west-central Yukon. Coordinate system is UTM NAD83, zone 7.

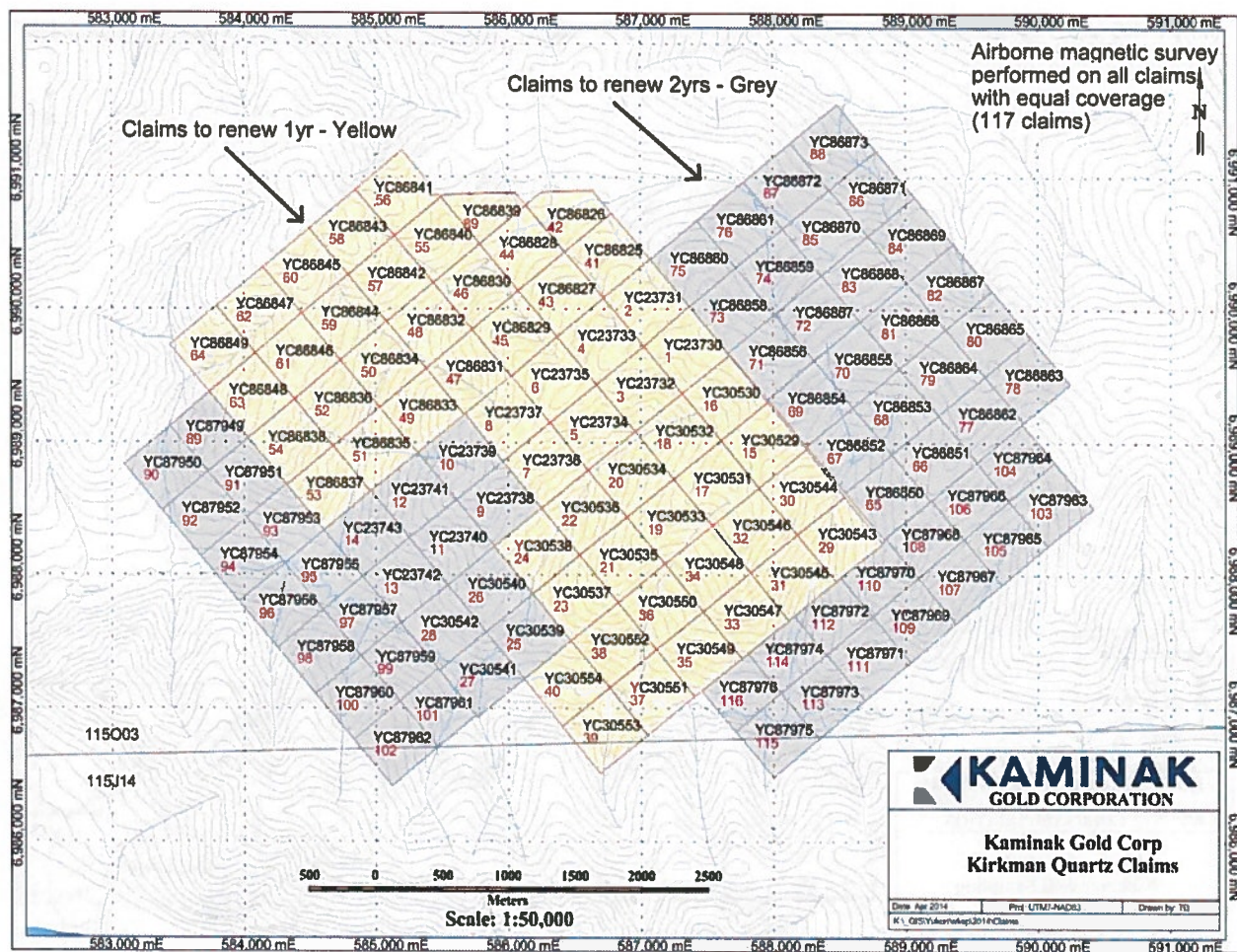
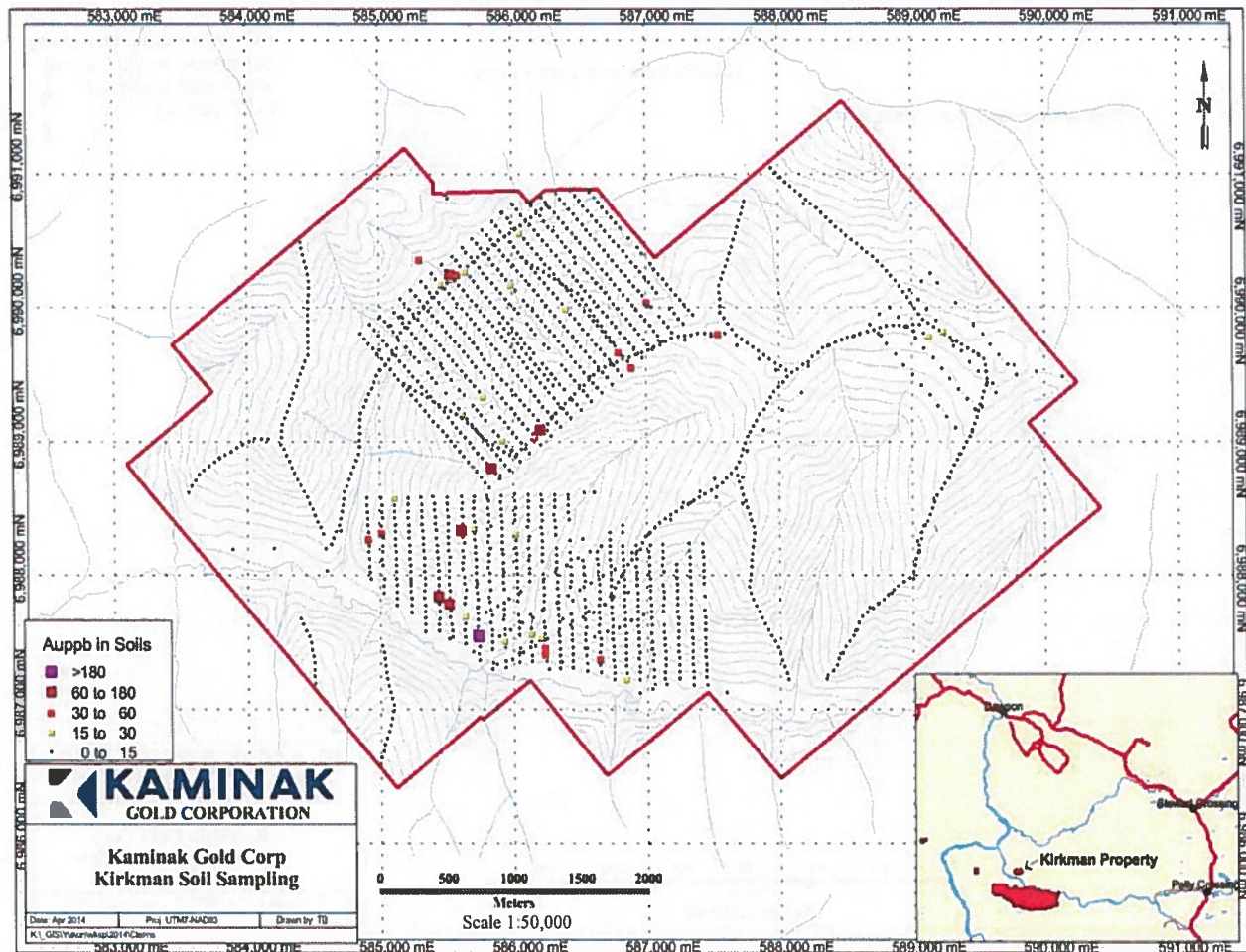


Figure 2 Kirkman claims. Coordinate system is UTM NAD83, zone 7.



**Figure 3** Summary map of historic soil sampling on the KIRKMAN property. Coordinate system is UTM NAD83, zone 7.

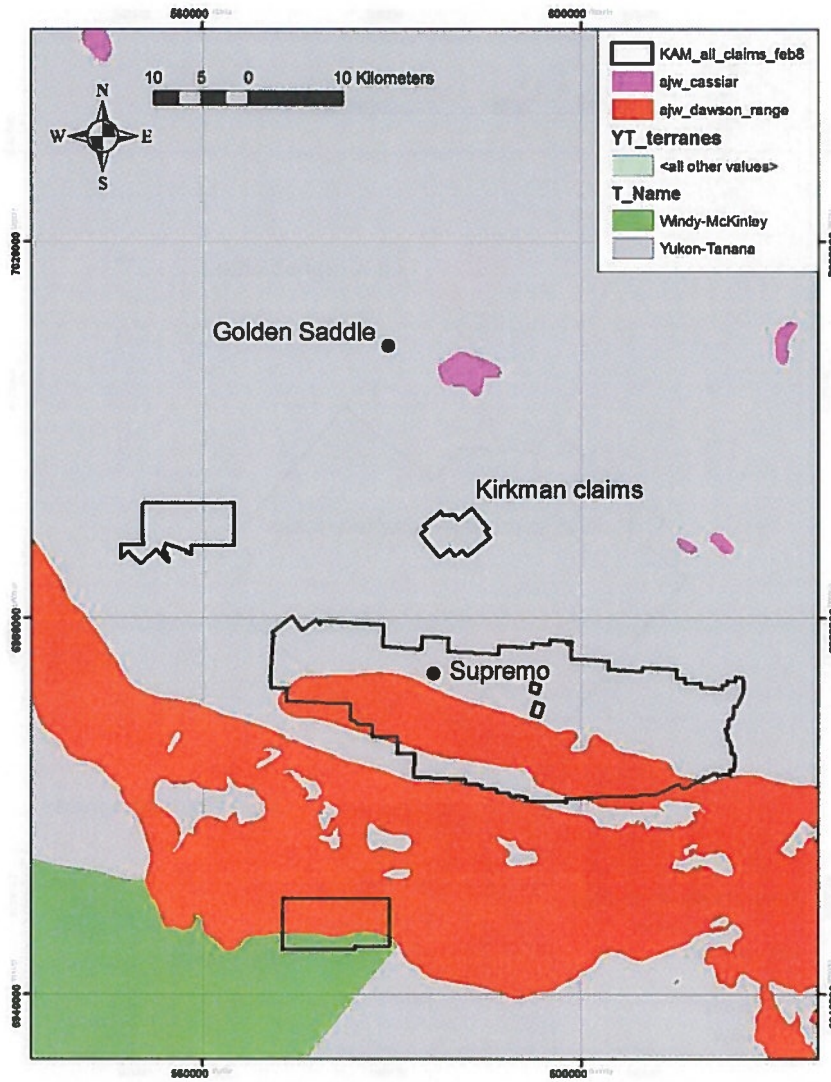
## 6.0 GEOLOGICAL SETTING

### 6.1 Regional Geology

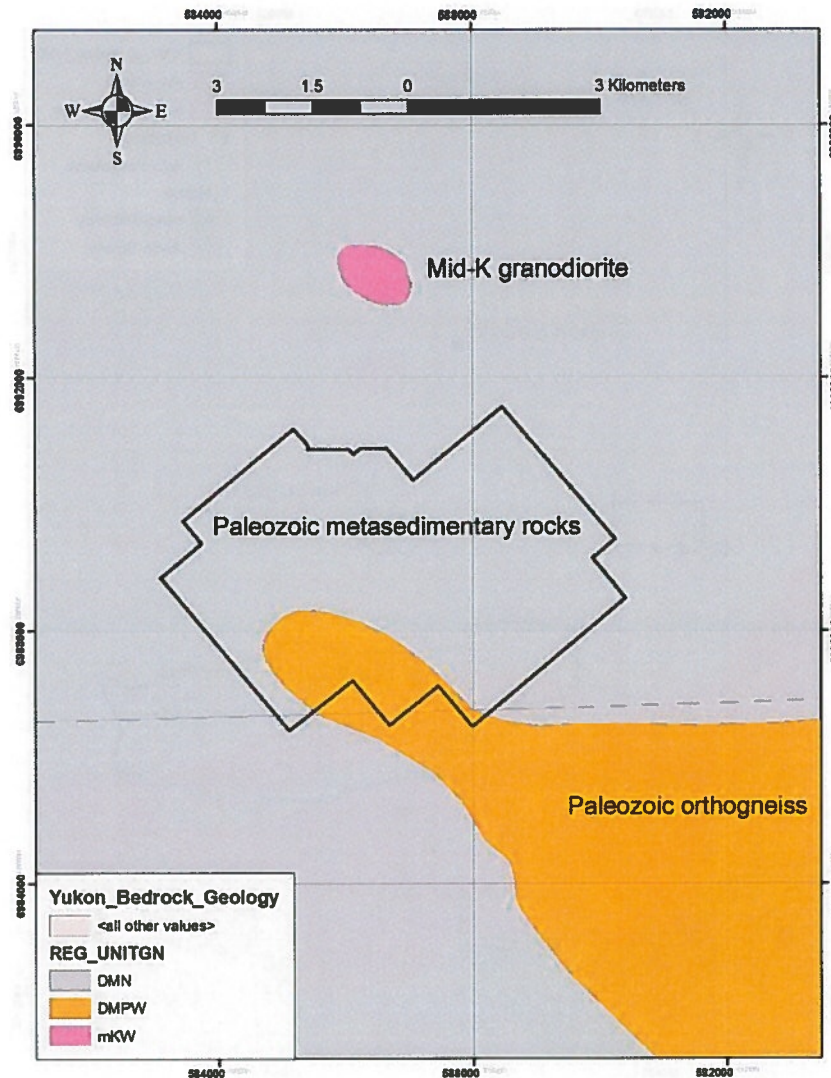
The KIRKMAN claims region is underlain by the Yukon-Tanana terrane, which is the basement for Mesozoic to Cenozoic plutons and batholiths including those from the Dawson Range and Cassiar intrusive suites (Figure 4). Cretaceous intrusive rocks are spatially associated with the White Gold and Coffee projects, in addition to a number of other gold-bearing mineral deposits in the region such as Sonora Gulch, Freegold Mountain and Casino.

### 6.2 Property Geology

Rocks from the Kirkman area are assigned to the Yukon-Tanana terrane on regional geological maps and the claims cover two different rock units. The northeast part of the claim block is underlain by quartz-mica schist, and the southern part of the claim block is underlain by augen gneiss (Figure 5).



**Figure 4** Regional geological setting of the Kirkman claims (after Gordey and Makepeace, 1999). Coordinate system is UTM NAD83, zone 7.



**Figure 5** Local geological map for the Kirkman area (after Gordey and Makepeace, 1999). Coordinate system is UTM NAD83, zone 7.

## 7.0 EXPLORATION

### 7.1 Geophysics

The September 2011 soil sampling program yielded new areas with anomalous gold geochemistry. To further delineate and constrain the target areas within the soil anomalies, a horizontal-gradient magnetic intensity airborne survey was conducted over the entire property. The survey consisted of 100m spaced survey line direction oriented at 140°/320° with 1000m spaced tie-lines for data leveling oriented at 50°/230°. The survey consisted of 237.9 km of survey lines and 25.8 km of tie lines, for a total of 263.6 line km surveyed. The survey was conducted on March 22<sup>nd</sup> and May 28<sup>th</sup>, 2014 with the survey crew staging out of Dawson City. Further details of the equipment utilized can be found in appendix A.



## 8.0 DISCUSSION AND RECOMMENDATIONS

The information collected from the survey provides high quality and resolution coverage across the property. The magnetic signature of the ground associated with the southern soil anomalies suggests a number of narrow discrete lineaments which may represent discrete structures hosting hydrothermal mineralization. With further post-processing and interpretation this data collected can help streamline the previously proposed trenching program (Finnigan, 2011). With the ground conditions encountered in the 2009 trenching campaign, it is further recommended that although the accuracy of the trenching targets will be refined by the aid of the magnetic data, the additional metres that would be saved by tightening of the trenches be utilized to trench along strike of interpreted lineaments to give greater control on drill targeting. Additional soil sampling is also recommended to be conducted over the two broad magnetic lows to the east of the northerly grid as there are several discrete

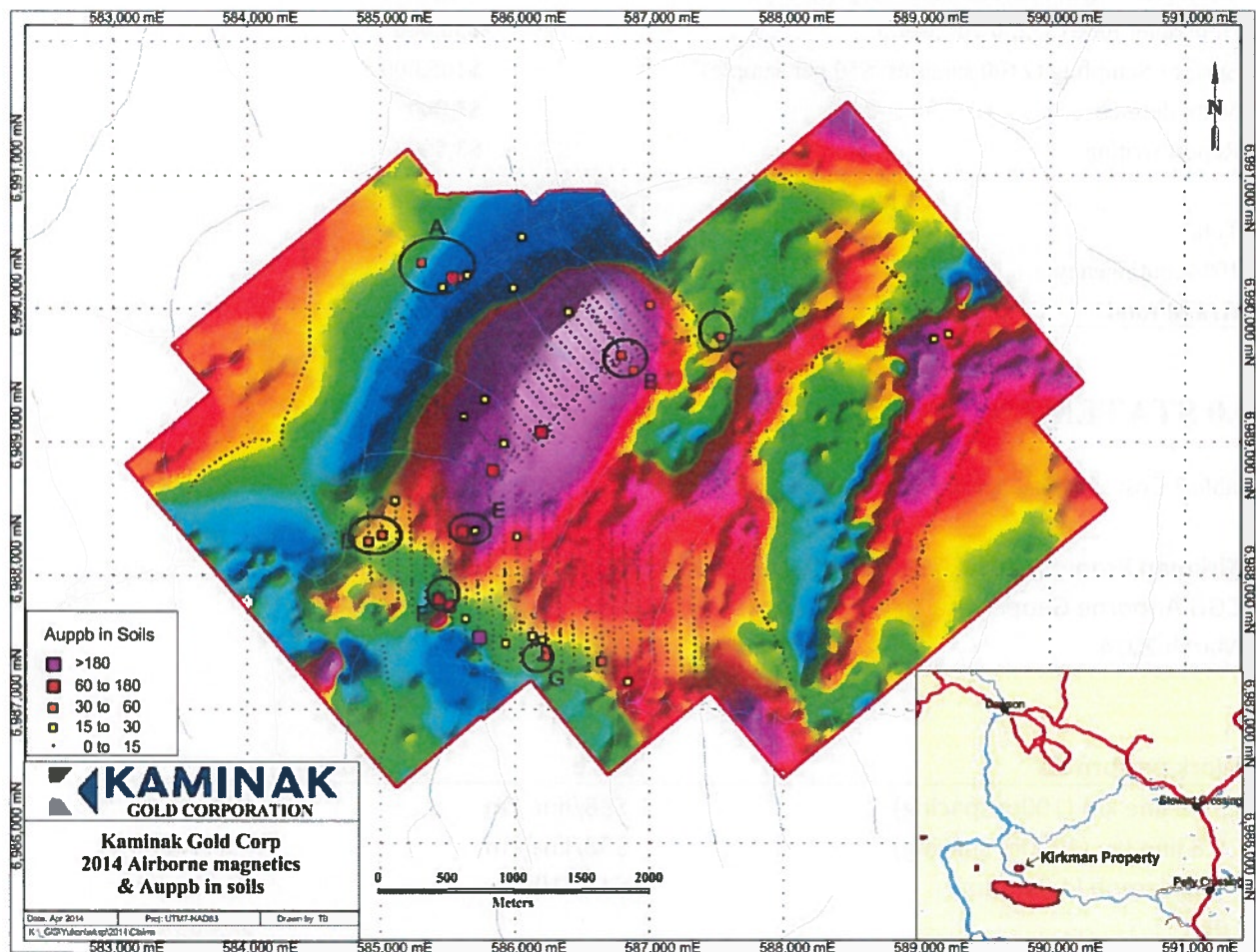


Figure 6 All gold-in-soil data available for the Kirkman claim block. Coordinate system is UTM NAD83, zone 7.

1. 500 meters of trenching is recommended (approximately 100m at anomalies A to E on Figure 6).
2. A prospecting geologist/field assistant team should follow-up the trenching at anomalies A to E (Figure 6) and prospect other anomalies on the claims.
3. 2,000 additional soil samples across the eastern portion of the property extending the grid at 50m sample spacing on lines space 100m apart.

Trenching has been attempted at areas F and G in 2009, yielding rock material with textures consistent with White Gold style mineralization, however with poor geochemical results. The 2009 sampling may have encountered low-grade shoulder areas, adjacent to a more strongly mineralized structure. The deep overburden at areas F and G may limit the trenching technique, and drill-testing at these locations will be required if the project is advanced to that point. In the meantime, the NE-trending river-cut in between anomalies F and G should be prospected.

Table 1 Estimated cost for the proposed Kirkman program.

<b>Item</b>	<b>cost</b>
Can-dig trenching (\$800/day; 15 days)	\$12,000
Geologist + field assistant (\$850/day; 15 days)	\$12,750
Helicopter time (\$2250/Hr "wet")	\$30,000
Surface Sampling (2100 samples; \$50 per sample)	\$105,000
Mob; de-mob	\$5,000
Report writing	\$3,500
<b>Total</b>	<b>\$168 250</b>
10% contingency	\$16,825
<b>Grand total</b>	<b>\$185,075</b>

## 9.0 STATEMENT OF EXPENDITURES

Table 2 Cost summary for the 2014 work at Kirkman.

### Kirkman Property 2014 Airborne Magnetics Survey Expenditures CGG Airborne Geophysical and Great Slave Helicopter March 2014

<b>Work performed</b>	<b>Rate</b>	<b>Cost</b>
237.9 line km (100m spacing)	\$38/line km	\$9,040.20
25.8 line km (1000m spacing)	\$38/line km	\$980.40
Mob/demob (4.8 hours)	\$1650/hr	\$7,920.00
Fuel		\$2,860.00
Accommodations and Meals		\$812.00
	<b>Total</b>	<b>\$21,612.60</b>

## 10.0 REFERENCES CITED

- Finnigan, Craig S., 2011 Assessment report describing geochemical work on the Kirkman claims 096219
- Gordey, S.P. and Makepeace, A.J., 1999, Yukon bedrock geology in Yukon digital geology, S.P. Gordey and A.J. Makepeace (comp.), Geological Survey of Canada Open File D3826 and Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-1(D).
- Ryan, S., 2004A, Geochemical report Kirkman 1-14 claims, Yukon Mining Incentive Program report 094490, 14 pages.
- Ryan, S., 2004B, Stewart regional soil survey 2003, YMIP # 03-082, 56 pages.
- Ryan, S., 2005, Geochemical/geophysical report Kirkman 1-40 claims, Yukon Mining Incentive Program report 094698, 59 pages.

## 11.0 STATEMENT OF QUALIFICATIONS

### GEOLOGIST'S CERTIFICATE

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I, Rory Kutluoglu, am Exploration Manager of Kaminak Gold Corp., with offices at Suite 1020–800 West Pender Street in the City of Vancouver, B.C., in the Province of British Columbia.

I am a Practising Geoscientist, with offices at #1020–800 West Pender Street in the City of Vancouver, B.C., in the Province of British Columbia.

I am a registered Geoscientist with the Association of Professional Engineers and Geoscientists of BC and have been a practising member since November of 2011.

I am a graduate of Lakehead University (2004) with a Bachelor of Science degree in Geology and I have practiced my profession continuously since 2004.

Since 2004 I have been involved in mineral exploration for gold, silver, copper, nickel, PGEs, lead, diamonds, uranium, iron and zinc in Canada, USA and Mexico.

I am presently a full time employed Geologist and have been so since April 2004.

Dated at Vancouver, British Columbia, this 13<sup>th</sup> day of February, 2014.



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Rory Kutluoglu, B.Sc Geology, P.Geo.

## 12.0 APPENDIX 1 – KIRKMAN Claims

Grant#	Claim#	Expiry Date	Claim Owner	Recorded Date	Staking Date	District
YC23730	1	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23731	2	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23732	3	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23733	4	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23734	5	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23735	6	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23736	7	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23737	8	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23738	9	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23739	10	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23740	11	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23741	12	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23742	13	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC23743	14	2016 04 14	Kaminak 100%	2003 04 14	2003 04 10	Dawson
YC30529	15	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30530	16	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30531	17	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30532	18	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30533	19	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30534	20	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30535	21	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30536	22	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30537	23	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30538	24	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30539	25	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30540	26	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30541	27	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30542	28	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30543	29	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30544	30	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30545	31	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30546	32	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30547	33	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30548	34	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30549	35	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30550	36	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30551	37	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30552	38	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30553	39	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC30554	40	2016 04 14	Kaminak 100%	2004 04 21	2004 04 16	Dawson
YC86825	41	2016 04 14	Kaminak 100%	2009 05 19	2009 05 08	Dawson
YC86826	42	2016 04 14	Kaminak 100%	2009 05 19	2009 05 08	Dawson
YC86827	43	2016 04 14	Kaminak 100%	2009 05 19	2009 05 08	Dawson
YC86828	44	2016 04 14	Kaminak 100%	2009 05 19	2009 05 08	Dawson
YC86829	45	2016 04 14	Kaminak 100%	2009 05 19	2009 05 08	Dawson
YC86830	46	2016 04 14	Kaminak 100%	2009 05 19	2009 05 08	Dawson
YC86831	47	2016 04 14	Kaminak 100%	2009 05 19	2009 05 08	Dawson



Grant#	Claim#	Expiry Date	Claim Owner	Recorded Date	Staking Date	District
YC87957	97	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87958	98	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87959	99	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87960	100	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87961	101	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87962	102	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87963	103	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87964	104	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87965	105	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87966	106	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87967	107	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87968	108	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87969	109	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87970	110	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87971	111	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87972	112	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87973	113	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87974	114	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87975	115	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson
YC87976	116	2015 04 14	Kaminak 100%	2009 06 18	2009 06 12	Dawson

### 13.0 APPENDIX 2 – Geophysical Survey Report – Midas High Resolution Magnetic Survey





**GEOPHYSICAL SURVEY REPORT  
MIDAS HIGH RESOLUTION MAGNETIC SURVEY  
KIRKMAN AREA  
PROJECT 14013  
KAMINAK GOLD CORP.**

**May 28, 2014**

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## Disclaimer

1. The Survey that is described in this report was undertaken in accordance with current internationally accepted practices of the geophysical survey industry, and the terms and specifications of a Survey Agreement signed between the CLIENT and CGG. Under no circumstances does CGG make any warranties either expressed or implied relating to the accuracy or fitness for purpose or otherwise in relation to information and data provided in this report. The CLIENT is solely responsible for the use, interpretation, and application of all such data and information in this report and for any costs incurred and expenditures made in relation thereto. The CLIENT agrees that any use, reuse, modification, or extension of CGG's data or information in this report by the CLIENT is at the CLIENT's sole risk and without liability to CGG. Should the data and report be made available in whole or part to any third party, and such party relies thereon, that party does so wholly at its own and sole risk and CGG disclaims any liability to such party.
2. Furthermore, the Survey was performed by CGG after considering the limits of the scope of work and the time scale for the Survey.
3. The results that are presented and the interpretation of these results by CGG represent only the distribution of ground conditions and geology that are measurable with the airborne geophysical instrumentation and survey design that was used. CGG endeavours to ensure that the results and interpretation are as accurate as can be reasonably achieved through a geophysical survey and interpretation by a qualified geophysical interpreter. CGG did not perform any observations, investigations, studies or testing not specifically defined in the Agreement between the CLIENT and CGG. The CLIENT accepts that there are limitations to the accuracy of information that can be derived from a geophysical survey, including, but not limited to, similar geophysical responses from different geological conditions, variable responses from apparently similar geology, and limitations on the signal which can be detected in a background of natural and electronic noise, and geological variation. The data presented relates only to the conditions as revealed by the measurements at the sampling points, and conditions between such locations and survey lines may differ considerably. CGG is not liable for the existence of any condition, the discovery of which would require the performance of services that are not otherwise defined in the Agreement.
4. The passage of time may result in changes (whether man-made or natural) in site conditions. The results provided in this report only represent the site conditions and geology for the period that the survey was flown.
5. Where the processing and interpretation have involved CGG's interpretation or other use of any information (including, but not limited to, topographic maps, geological maps, and drill information; analysis, recommendations and conclusions) provided by the CLIENT or by third parties on behalf of the CLIENT and upon which CGG was reasonably entitled or expected to rely upon, then the Survey is limited by the accuracy of such information. Unless otherwise stated, CGG was not authorized and did not attempt to independently verify the accuracy or completeness of such information that was received from the CLIENT or third parties during the performance of the Survey. CGG is not liable for any inaccuracies (including any incompleteness) in the said information.

## Introduction

This report describes the logistics, data acquisition, processing and presentation of results of a MIDAS magnetic airborne geophysical survey carried out for Kaminak Gold Corp. over one property near Dawson City, Yukon. Total coverage of the survey block amounted to 263.6 km. The survey was flown on March 22, 2014.

The purpose of the survey was to map the geology and structure of the area. Data were acquired using a MIDAS magnetic system with two high-sensitivity cesium magnetometers. The information from these sensors was processed to produce maps and images that display the magnetic properties of the survey area. A GPS electronic navigation system ensured accurate positioning of the geophysical data with respect to the base map coordinates.

The survey was performed by CGG Canada Services Ltd., Toronto office. Maps and data in digital format are provided with this report.

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## Survey Area Description

### Location of the Survey Area

One block near Dawson City, Yukon (Figure 1) was flown on March 22, 2014, with Dawson City, Yukon as the base of operations. Survey coverage consisted of 237.8 km of traverse lines flown with a spacing of 100 m and 25.8 km of tie lines with a spacing of 1000 m for a total of 263.6 km.

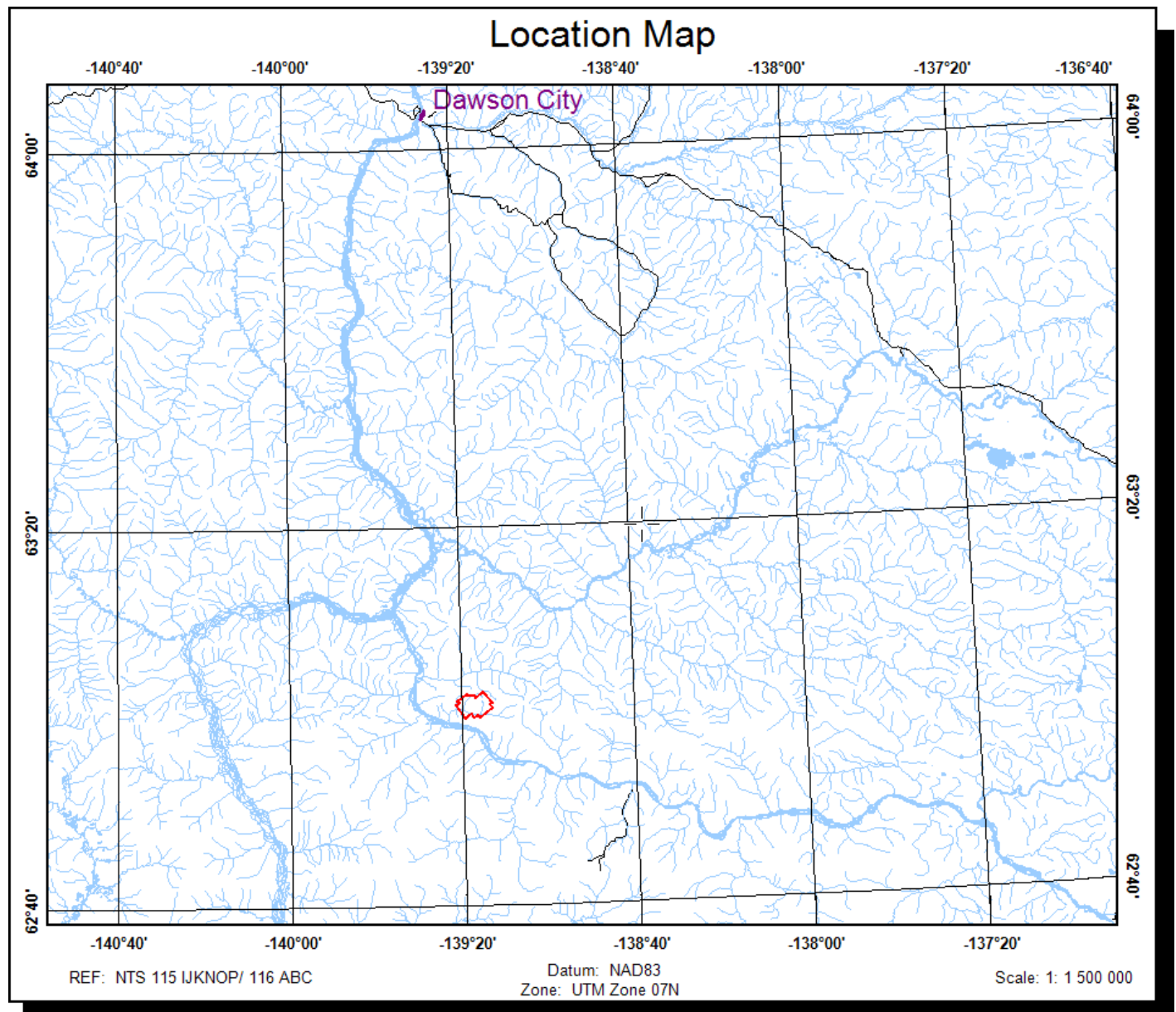


Figure 1 Kirkman Area - Location Map

Table 1 contains the coordinates of the corner points of the survey blocks.

Block	Corners	X-UTM (E)	Y-UTM (N)
14013-2	1	588000	6986485
Kirkman Block	2	587458	6987131
	3	586695	6986511
	4	586407	6986865
	5	586118	6987219
	6	585763	6986931
	7	585746	6986944
	8	585119	6986418
	9	583095	6988831
	10	583740	6989372
	11	583444	6989727
	12	585200	6991191
	13	585493	6990841
	14	585516	6990860
	15	586061	6990874
	16	586138	6990784
	17	586253	6990880
	18	586645	6990890
	19	587075	6990376
	20	588480	6991547
	21	590240	6989444
	22	589881	6989145
	23	590413	6988510

Table 1 Area Corners NAD83 UTM Zone 7N

Block	Line Numbers	Line direction	Line Spacing	Line km
2	20010 – 20590	140°/320°	100 m	237.9 km
Kirkman Block	29010 – 29060	50°/230°	1000 m	25.8 km

Table 2 Planned line kilometre summary

During the survey GPS base stations were set up to collect data to allow post processing of the positional data for increased accuracy. The location of the GPS base stations are shown in Table 3.

Status	Location Name	WGS84 Longitude (deg-min-sec)	WGS84 Latitude (deg-min-sec)	Orthometric Height (m)
Primary	Dawson City, Yukon	139° 07' 12.85" W	64° 02' 49.46" N	385.2
Secondary	Coffee Camp, Yukon	139° 05' 32.77" W	62° 54' 42.79" N	384.7

Table 3 GPS Base Station Location

The location of the Magnetic base stations are shown in Table 4.

Status	Location Name	WGS84 Longitude (deg-min-sec)	WGS84 Latitude (deg-min-sec)
Primary	Coffee Camp, Yukon	139° 05' 32.77" W	62° 54' 42.79" N

Table 4 Magnetic Base Station Location



## System Information



Figure 2 MIDAS System

The MIDAS system is composed of a horizontal boom fixed to the belly of a helicopter containing two magnetometers, a fluxgate magnetometer and a GPS antenna for flight path recovery. The helicopter has a tail boom mounted GPS antenna for in-flight navigation, radar, laser and barometric altimeters, video camera and data acquisition system.

### **Aircraft and Geophysical On-Board Equipment**

Helicopter:	AS350 B2
Operator:	Great Slave Helicopters
Registration:	C-GDCV
Average Survey Speed:	85.64 km/h (23.79 m/s)
Digital Acquisition:	CGG HeliDAS.
Video:	Panasonic WVCD/32 Camera with Axis 241S Video Server. Camera is mounted to the exterior bottom of the helicopter between the forward skid tubes
Magnetometer:	2-Scintrex Cesium Vapour (CS-2 and CS-3), mounted on a transverse boom (13.3 m separation);  Operating Range: 15,000 to 100,000 nT Operating Limit: -40°C to 50°C Accuracy: $\pm 0.002$ nT Measurement Precision: 0.001 nT Sampling rate: 10.0 Hz
Fluxgate:	Billingsley TMF100 Triaxial fluxgate, mounted on one of the booms;  Axial alignment: $< \pm 1$ degree Sensitivity: 100 $\mu$ V per nT Sampling rate 10.0 Hz
Radar Altimeter:	Honeywell Sperry Altimeter System. Radar antennas are mounted to the exterior bottom of the helicopter between the forward skid tubes  Operating Range: 0 – 2500ft Operating Limit: -55°C to 70°C 0 to 55,000 ft Accuracy: $\pm 3\%$ (100 – 500ft above obstacle) $\pm 4\%$ (500 – 2500ft above obstacle) Measurement Precision: 1 ft Sample Rate: 10.0 Hz
Laser Altimeter:	Optech G-150 mounted on the belly of the helicopter;  Operating Range: 0.2 to 250 m

Operating Limit: -10°C to 45°C  
Accuracy:  
    ±5 cm (10°C to 30°C)  
    ±10 cm (-10°C to 45°C)  
Measurement Precision: 1 cm  
Sample Rate: 10.0 Hz

Aircraft Navigation: NovAtel OEM4 Card with an Aero antenna mounted on the tail of the helicopter;

Operating Limit: -40°C to 85°C  
Real-Time Accuracy:  
    1.2m CEP (L1 WAAS)  
Real-Time Measurement Precision: 6 cm RMS  
Sample Rate: 2.0 Hz

Barometric Altimeter: Motorola MPX4115AP analog pressure sensor mounted in the helicopter

Operating Range: 55 kPa to 108 kPa  
Operating Limit: -40°C to 125°C  
Accuracy:  
    ± 1.5 kPa (0°C to 85°C)  
    ± 3.0 kPa (-20°C to 0°C, 85°C to 105°C)  
    ± 4.5 kPa (-40°C to -20°C, 105°C to 125°C)  
Measurement Precision: 0.01 kPa  
Sampling Rate = 10.0 Hz

Temperature: Analog Devices 592 sensor mounted on the camera box

Operating Range: -40°C to + 75°C  
Operating Limit: -40°C to + 75°C  
Accuracy: ± 1.5°C  
Measurement Precision: 0.03°C  
Sampling Rate = 10.0 Hz

## **Base Station Equipment**

Primary Magnetometer: CGG CF1 using Scintrex cesium vapour sensor with Marconi GPS card and antenna for measurement synchronization to GPS. The base station also collects barometric pressure and outside temperature.

Magnetometer Operating Range: 15,000 to 100,000 nT  
Barometric Operating Range: 55kPa to 108 kPa  
Temperature Operating Range: -40°C to 75°C  
Sample Rate: 1.0 Hz

GPS Receiver: NovAtel OEM4 Card with an Aero antenna

Real-Time Accuracy:  
    1.8m CEP (L1)

Sample Rate: 1.0 Hz

Secondary Magnetometer:

GEM Systems GSM-19

Operating Range: 20,000 to 120,000 nT

Operating Limit: -40°C to 60°C

Accuracy:  $\pm 0.2$  nT

Measurement Precision: 0.01 nT

Sample Rate: 0.33 Hz

## Quality Control and In-Field Processing

Digital data for each flight were transferred to the field workstation, in order to verify data quality and completeness. A database was created and updated using Geosoft Oasis Montaj and proprietary CGG Atlas software. This allowed the field personnel to calculate, display and verify both the positional (flight path) and geophysical data. The initial database was examined as a preliminary assessment of the data acquired for each flight.

In-field processing of CGG survey data consists of differential corrections to the airborne GPS data, filtering of all geophysical and ancillary data, verification of the digital video, and diurnal correction of magnetic data.

All data, including base station records, were checked on a daily basis to ensure compliance with the survey contract specifications. Re-flights were required if any of the following specifications were not met.

### Navigation

A specialized GPS system provided in-flight navigation control. The system determined the absolute position of the helicopter by monitoring the range information of twelve channels (satellites). The Novatel OEM4 receiver was used for this application. In North America, the OEM4 receiver is WAAS-enabled (Wide Area Augmentation System) providing better real-time positioning.

A Novatel OEM4 GPS base station was used to record pseudo-range, carrier phase, ephemeris, and timing information of all available GPS satellites in view at a one second interval. These data are used to improve the conversion of aircraft raw ranges to differentially corrected aircraft position. The GPS antenna was set-up in a location that allowed for clear sight of the satellites above. The set-up of the antenna also considered surfaces that could cause signal reflection around the antenna that could be a source of error to the received data measurements.

### Flight Path

Flight lines did not deviate from the intended flight path by more than 25% of the planned flight path over a distance of more than 1 kilometre. Flight specifications were based on GPS positional data recorded at the helicopter.

### Clearance

The survey elevation is defined as the measurement of the helicopter radar altimeter to the tallest obstacle in the helicopter path. An obstacle is any structure or object which will impede the path of the helicopter to the ground and is not limited to and includes tree canopy, towers and power lines.

Survey elevations may vary based on the pilot's judgement of safe flying conditions around man-made structures or in rugged terrain.

The average survey elevation achieved for the helicopter and instrumentation during data collection was:

Helicopter	35 metres
Magnetometer	35 metres

Survey elevations did not deviate by more than 20% over a distance of 2 km from the contracted elevation.

---

## **Flying Speed**

The average calculated ground speed was 85.64 km/h ranging between 38 to 129 km/h. This resulted in a ground sample interval of approximately 1.1 to 3.6 metres at a 10 Hz sampling rate.

## **Airborne High Sensitivity Magnetometer**

To assess the noise quality of the collected airborne magnetic data, CGG monitors the 4<sup>th</sup> difference results during flight which is verified post flight by the processor. The contracted specification for the collected airborne magnetic data was that the non-normalized 4<sup>th</sup> difference would not exceed 1.6 nT over a continuous distance of 1 kilometre excluding areas where this specification was exceeded due to natural anomalies.

## **Magnetic Base Station**

Ground magnetic base stations were set-up to measure the total intensity of the earth's magnetic field. The base stations were placed in a magnetically quiet area, away from power lines and moving metallic objects. The contracted specification for the collected ground magnetic data was the non-linear variations in the magnetic data were not to exceed 10 nT per minute. CGG's standard of setting up the base station within 50 km from the centre of the survey block allowed for successful removal of the active magnetic events on the collected airborne magnetic data.

## **Compensation System**

The presence of the helicopter in close proximity to the sensors causes considerable interference on the readings. The orientation of the aircraft with respect to the sensors and the motion of the aircraft through the earth's magnetic field are contributing factors. A special calibration flight is flown to record the information necessary to remove these effects.

The manoeuvre consists of flying a series of calibration lines at high altitude to gain information in each of the required line directions. During this procedure, the pitch, roll and yaw of the aircraft are varied. Each variation is conducted in succession (first vary pitch, then roll, then yaw).

A three-axis fluxgate magnetometer measures the orientation and rates of change of the aircraft's magnetic field with respect to the earth's magnetic field. A compensation algorithm is applied to generate a set of coefficients for each line direction and for each magnetometer sensor to compensate for permanent, induced and eddy current magnetic noise generated by the aircraft.

## Data Processing

### Flight Path Recovery

To check the quality of the positional data the speed of the bird is calculated using the differentially corrected x, y and z data. Any sharp changes in the speed are used to flag possible problems with the positional data. Where speed jumps occur, the data are inspected to determine the source of the error. The erroneous data are deleted and splined if less than five seconds in length. If the error is greater than five seconds the raw data are examined and if acceptable, may be shifted and used to replace the bad data. The GPS-Z component is the most common source of error. When it shows problems that cannot be corrected by recalculating the differential correction, the barometric altimeter is used as a guide to assist in making the appropriate correction. The corrected WGS84 longitude and latitude coordinates were transformed to NAD83 using the following parameters.

Datum:	NAD83
Ellipsoid:	GRS80
Projection:	UTM Zone 7N
Central meridian:	141° West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996
WGS84 to Local Conversion:	Molodensky
Dx,Dy,Dz:	0, 0, 0

Recorded video flight path may also be linked to the data and used for verification of the flight path. Fiducial numbers are recorded continuously and are displayed on the margin of each digital image. This procedure ensures accurate correlation of data with respect to visible features on the ground. The fiducials appearing on the video frames and the corresponding fiducials in the digital profile database originate from the data acquisition system and are based on incremental time from start-up. Along with the acquisition system time, UTC time is also recorded in parallel and displayed (Figure 3).

### Altitude Data

Radar altimeter data are despiked by applying a 1.5 second median and smoothed using a 1.5 second Hanning filter. The radar altimeter data are then subtracted from the GPS elevation to create a digital elevation model that is gridded and used in conjunction with profiles of the radar altimeter and flight path video to detect any spurious values.

Laser altimeter data are despiked and filtered using an alpha-trim filter. The laser altimeter data are then subtracted from the GPS elevation to create a digital elevation model that is examined in grid format for spurious values. The laser does a better job of piercing the tree canopy than the radar altimeter.

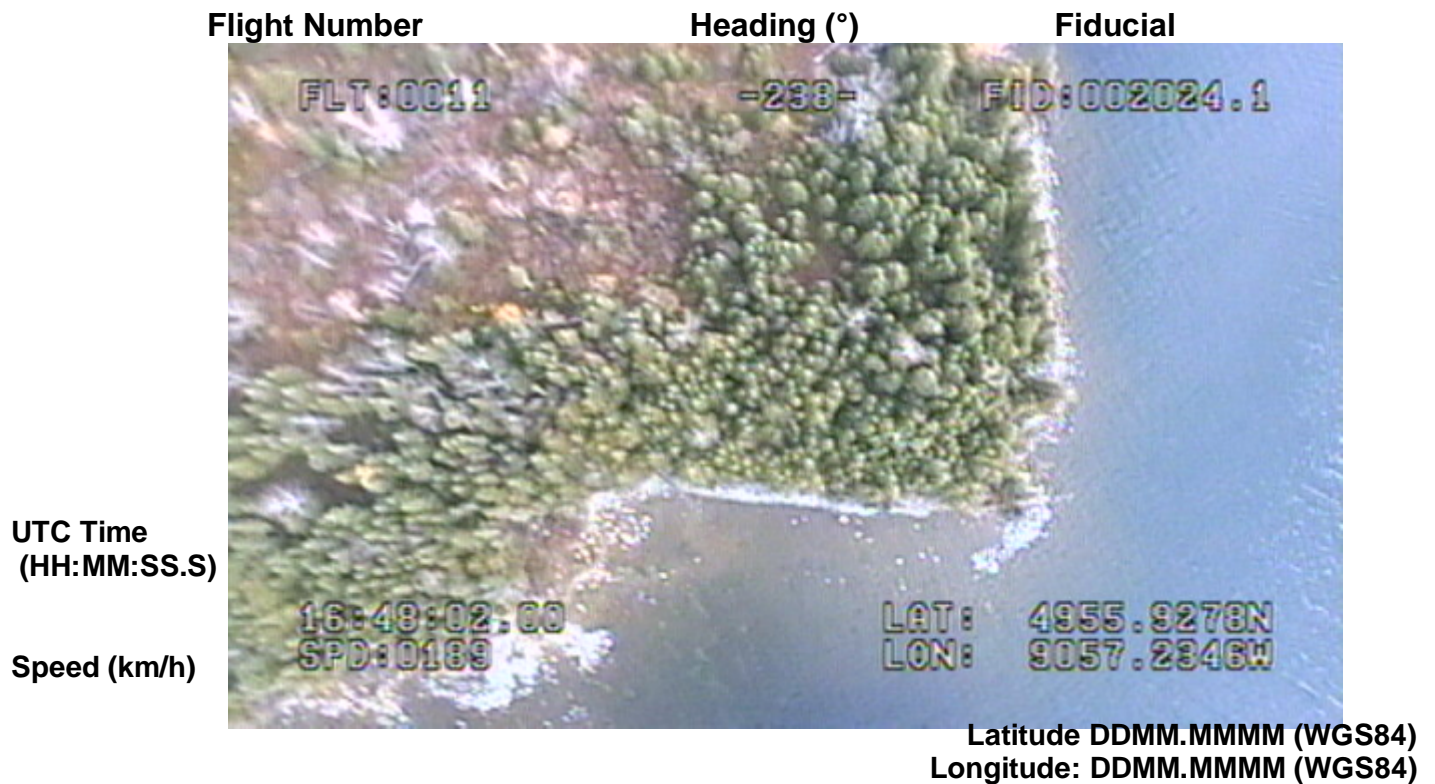


Figure 3 Flight path video

### Magnetic Base Station Diurnal

The raw diurnal data are sampled at 1 Hz and imported into a database. The data are filtered using a long wavelength filter to retain wavelengths longer than 51 seconds. A non linear variation is then calculated and a flag channel is created to indicate where the variation exceeds the survey tolerance. Acceptable diurnal data are interpolated to a 10 Hz sample rate and the local regional field value of 56992.5, calculated from the average of the first day's diurnal data, was removed to leave the diurnal variation. This diurnal variation is then ready to be used in the processing of the airborne magnetic data.

### Total Magnetic Field

The Total Magnetic Field (TMF) data collected in flight were profiled on screen along with a fourth difference channel calculated from the TMF. Spikes were removed manually where indicated by the fourth difference. The despiked data were then corrected for lag by 2.0 seconds. The diurnal variation that was extracted from the filtered ground station data was then removed from the despiked and lagged TMF. Once, the diurnal was removed, a magnetic value for the centre of the measurement platform was calculated by taking the average of the lagged and diurnally corrected, port and starboard magnetic sensors. The results were then levelled using tie and traverse line intercepts. Manual adjustments were applied to any lines that required levelling, as indicated by shadowed images of the gridded magnetic data. The manually levelled data were then subjected to a microlevelling filter.

### Transverse Magnetic Gradient

Transverse magnetic gradient data was calculated from the lag corrected port and starboard sensors of the MIDAS system. The gradient was calculated with respect to the flight line direction with the median removed on a line-by-line basis. The results were then subjected to a microlevelling filter to remove any short wavelength residual line-to-line discrepancies.



## **Enhanced Total Magnetic Field**

Bi-directional gridding with the transverse gradient should produce a surface that correctly renders both the measured data and the measured horizontal gradient at each survey line. This can be an advantage when gridding data that include features approaching the line-separation in size and also for rendering features that are not perpendicular to the line direction, particularly those which are sub-parallel to the line direction

Final transverse magnetic gradient data were used in conjunction with the Total Magnetic Field to create a Horizontal Gradient Enhanced grid of the Total Magnetic Field. This grid was created using the enhanced bi-directional gridding tool in proprietary CGG Atlas software.

## **Calculated Vertical Magnetic Gradient**

The Enhanced Total Magnetic Field grid was subjected to a processing algorithm that enhances the response of magnetic bodies in the upper 500 metres and attenuates the response of deeper bodies. The resulting vertical gradient grid provides better definition and resolution of near-surface magnetic units. It also identifies weak magnetic features that may not be quite as evident in the TMF data. Regional magnetic variations and changes in lithology, however, may be better defined on the Total Magnetic Field.

## **Digital Elevation**

The laser altimeter values are subtracted from the differentially corrected and de-spiked GPS-Z values to produce profiles of the height above mean sea level along the survey lines. These values are gridded to produce contour maps showing approximate elevations within the survey area. Any subtle line-to-line discrepancies are manually removed. After the manual corrections are applied, the digital terrain data are filtered with a microlevelling algorithm.

The accuracy of the elevation calculation is directly dependent on the accuracy of the two input parameters, laser altimeter and GPS-Z. The GPS-Z value is primarily dependent on the number of available satellites. Although post-processing of GPS data will yield X and Y accuracies in the order of 1-2 metres, the accuracy of the Z value is usually much less, sometimes in the  $\pm 5$  metre range. Further inaccuracies may be introduced during the interpolation and gridding process.

Because of the inherent inaccuracies of this method, no guarantee is made or implied that the information displayed is a true representation of the height above sea level. Although this product may be of some use as a general reference, THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.

### **Contour, Colour and Shadow Map Displays**

The magnetic are interpolated onto a regular grid using a modified Akima spline technique. The resulting grid is suitable for image processing and generation of contour maps. The grid cell size is 20% of the line interval.

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.

## Final Products

This section lists the final maps and products that have been provided under the terms of the survey agreement. Other products can be prepared from the existing dataset, if requested. Most parameters can be displayed as contours, profiles, or in colour.

### Maps

Base maps of the survey area were produced by converting published raster image topographic maps to a bitmap (.bmp) format. This process provides a relatively accurate, distortion-free base that facilitates correlation of the navigation data to the map coordinate system. The topographic files were combined with geophysical data for plotting some of the final maps. All maps were created using the following parameters:

#### Projection Description:

Datum:	NAD83
Ellipsoid:	GRS80
Projection:	UTM Zone 7N
Central meridian:	141° West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996
WGS84 to Local Conversion:	Molodensky
Dx,Dy,Dz:	0, 0, 0

Maps depicting the survey results have been plotted and provided as a PDF at a scale of 1:10,000. Each parameter is plotted on one map sheet.

Final Map Products	No. of Map Sets Plotted
Total Magnetic Field	2
Calculated Vertical Magnetic Gradient of Total Magnetic Field	2
Horizontal Gradient Enhanced Total Magnetic Field	2
Calculated Vertical Gradient of Horizontal Gradient Enhanced Total Magnetic Field	2
Measured Transverse Magnetic Gradient	2

Table 5 Final Map Products

### Digital Archives

Line and grid data in the form of a Geosoft database (\*.gdb) and XYZ file and Geosoft grids (\*.grd) have been written to DVD. The formats and layouts of these archives are further described in Appendix B (Data Archive Description).

### Report

Two paper copies of this Geophysical Survey Report plus a digital copy in PDF format.

## **Flight Path Videos**

All survey flights in BIN/BDX format with a viewer.

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## CONCLUSIONS AND RECOMMENDATIONS

This report provides a very brief description of the survey results and describes the equipment, data processing procedures and logistics of the airborne survey over the Fort Selkirk Area, near Dawson City, Yukon. The various maps included with this report display the magnetic properties of the survey area.

The Kirkman block (block 2) shows a magnetic dipole to the North. The total magnetic field shows a North-East trending feature to the East, which coincides with a topographic valley and could indicate a contact or possible fault. The measured transverse magnetic gradient and calculated vertical gradient show a magnetic active East-West trend in the South, which coincides with a road.

It is recommended that the survey results be assessed and fully evaluated in conjunction with all other available geophysical, geological and geochemical information. In particular, structural analysis of the data should be undertaken and areas of interest should be selected. An attempt should be made to determine the geophysical “signatures” over any known zones of mineralization in the survey areas or their vicinity.

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 that define subtle, but significant, structural details.

Respectfully submitted,

CGG

R14013

## Appendix A List of Personnel

### List of Personnel:

The following personnel were involved in the acquisition, processing, interpretation and presentation of data, relating to a MIDAS magnetic airborne geophysical survey carried out for Kaminak Gold Corp. over the Fort Selkirk Area near Dawson City, Yukon.

Duane Griffith	Manager, Geophysical Services
Brett Robinson	Project Manager
Chris Sawyer	Flight Planner
Aaron Rampersad	Electronics Technician
Glenn Charbonneau	Pilot (Great Slave Helicopters)
Jason Howes	AME (Great Slave Helicopters)
Amanda Heydorn	Data Processor
Patrice Marchesi	Data Processor
Nigel Stack	Data Processor
Alex Zlojutro	Data Processor

All personnel were employees of CGG, except where indicated.

## Appendix B Data Archive Description



## Data Archive Description:

### Survey Details:

Survey Area Name: Kirkman Area  
 Project number: 14013  
 Client: Kaminak Gold Corp.  
 Survey Company Name: CGG  
 Flown Dates: March 22, 2014  
 Archive Creation Date: May 28, 2014

### Geodetic Information for map products:

Datum: NAD83  
 Ellipsoid: GRS80  
 Projection: UTM Zone 7N  
 Central meridian: 141° West  
 False Easting: 500000 metres  
 False Northing: 0 metres  
 Scale factor: 0.9996  
 WGS84 to Local Conversion: Molodensky  
 Dx,Dy,Dz: 0, 0, 0

### Grid Archive:

#### Geosoft Grids:

File	Description	Units
14013_2_TMI_NAD83Z7	Total Magnetic Field	nT
14013_2_CVG_NAD83Z7	Calculated Vertical Magnetic Gradient of Total Magnetic Intensity	nT/m
14013_2_TMI_HE_NAD83Z7	Horizontal Gradient Enhanced Total Magnetic Field	nT
14013_2_CVG_HE_NAD83Z7	Calculated Vertical Magnetic Gradient of Horizontal Gradient Enhanced Total Magnetic Intensity	nT/m
14013_2_MHG_NAD83Z7	Measured Transverse Magnetic Gradient	nT/m

## Linedata Archive:

### Geosoft Database Layout:

Field	Variable	Description	Units
1	x	Easting NAD83 Zone 7	m
2	y	Northing NAD83 Zone 7	m
3	fid	fiducial	-
4	longitude	Longitude WGS84	degrees
5	latitude	Latitude WGS84	degrees
6	flight	Flight number	-
7	date	Flight date	yyyy/mm/dd
8	altrad_heli	Helicopter height above surface from radar altimeter	m
9	altlas_heli	Helicopter height above surface from laser altimeter	m
10	gpsz	Helicopter height above geoid	m
11	dtm	Digital terrain model (above geoid)	m
12	diurnal	Measured ground magnetic intensity	nT
13	diurnal_cor	Diurnal correction – base removed	nT
14	magport_raw	Total magnetic field, port sensor – spike rejected	nT
15	magstar_raw	Total magnetic field, starboard sensor – spike rejected	nT
16	magport_comp	Total magnetic field, port sensor - compensated	nT
17	magstar_comp	Total magnetic field, starboard sensor - compensated	nT
18	mag_ave	Total magnetic field, average of port and starboard sensors	nT
19	mag_ave_lag	Total magnetic field, average of port and starboard sensors – corrected for lag	nT
20	mag_tmi	Total magnetic intensity	nT
21	transgrad	Measured transverse horizontal magnetic gradient	nT/m
22	fx	Fluxgate magnetometer, component 1	nT
23	fy	Fluxgate magnetometer, component 2	nT
24	fz	Fluxgate magnetometer, component 3	nT

Note – The null values in the GDB and XYZ archives are displayed as \*.

### Maps:

File	Description	Units
14013_2_TMI_10000_NAD83Z7	Total Magnetic Field	nT
14013_2_CVG_10000_NAD83Z7	Calculated Vertical Gradient of Total Magnetic Field	nT/m
14013_2_TMI_HE_10000_NAD83Z7	Horizontal Gradient Enhanced Total Magnetic Field	nT
14013_2_CVG_HE_10000_NAD83Z7	Calculated Vertical Gradient of Horizontal Gradient Enhanced Total Magnetic Field	nT/m
14013_2_MHG_10000_NAD83Z7	Measured Transverse Magnetic Gradient	nT/m

**Report:**

A logistics and processing report for Project #14013 in PDF format:

*R14013.pdf*

**Video:**

Digital video in BIN/BDX format for all survey flights including a viewer.

*CGGSurveyReplay*

## Appendix C Map Product Grids

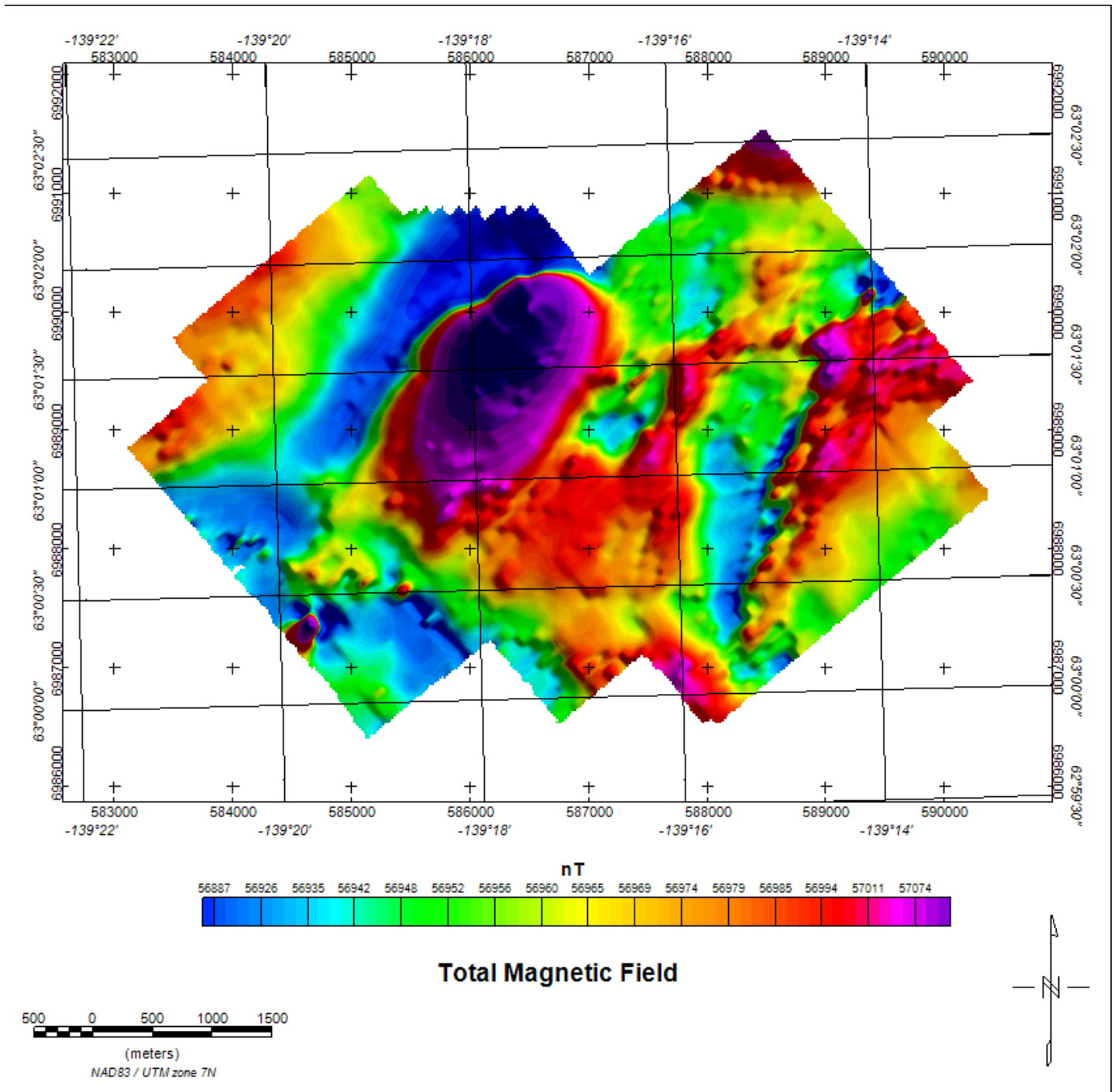


Figure 4 Total Magnetic Field for Kirkman Area (Block 2)

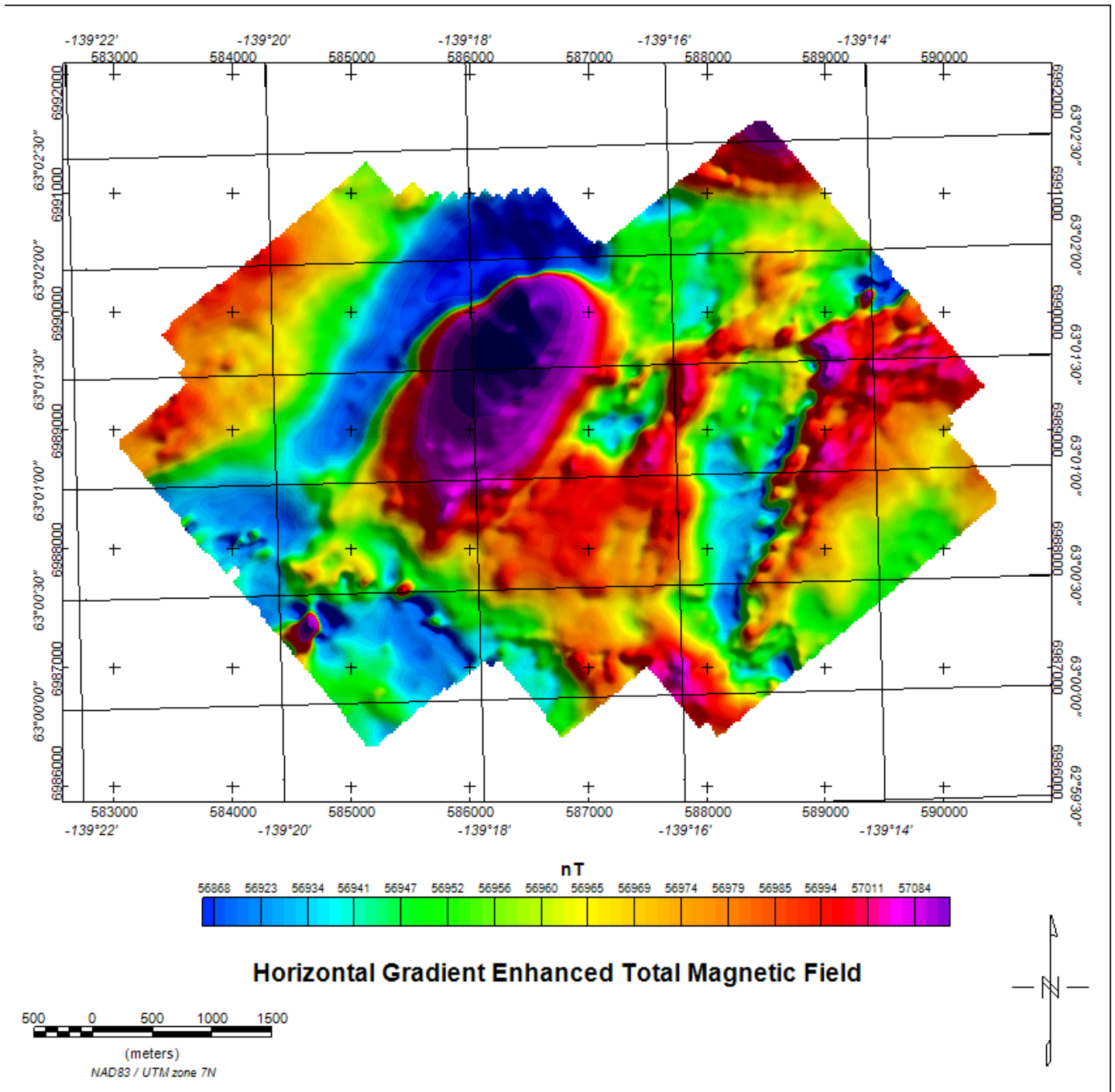


Figure 5 Horizontal Gradient Enhanced Total Magnetic Field for Kirkman Area (Block 2)

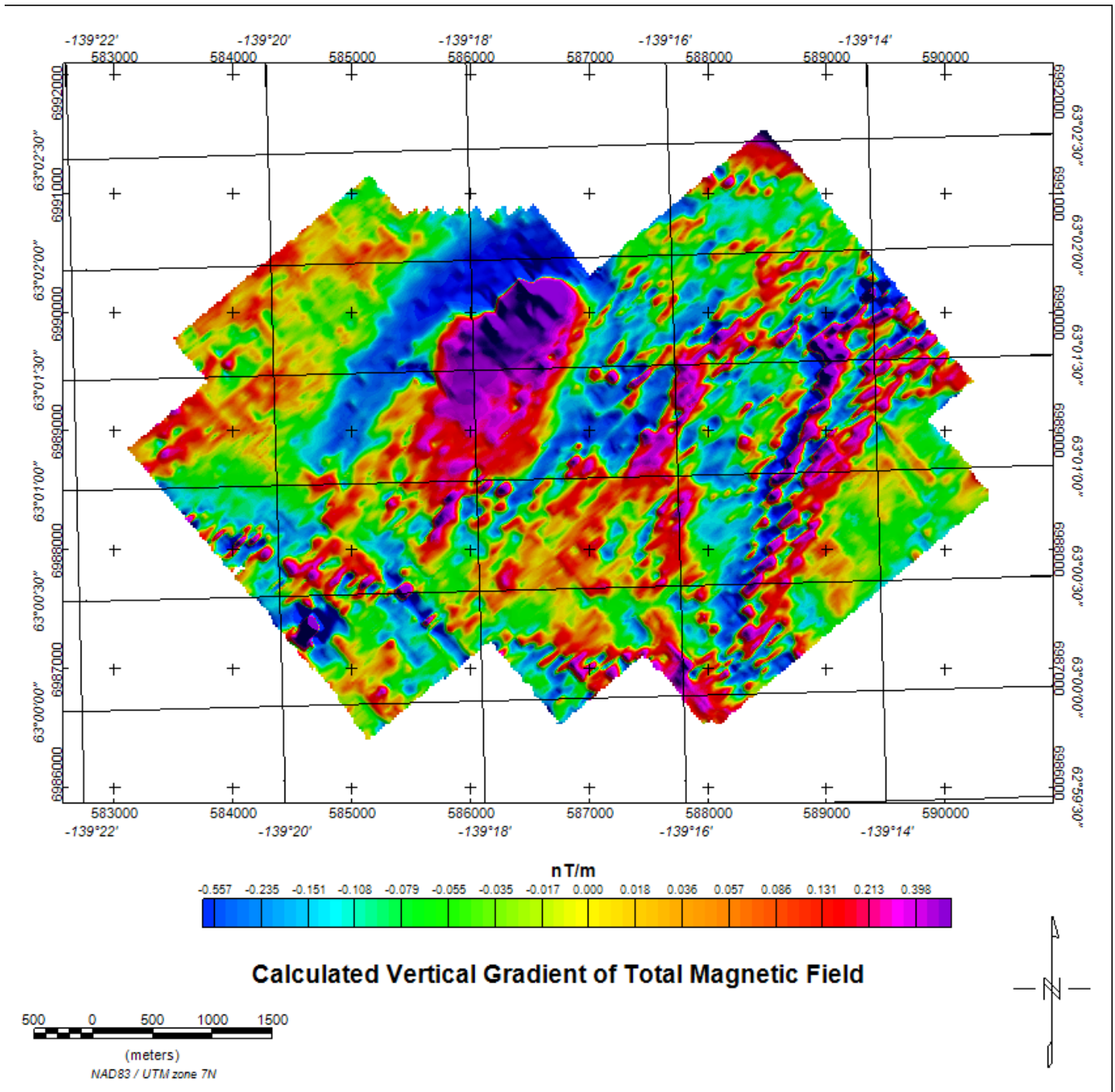


Figure 6 Calculated Vertical Gradient of Total Magnetic Field for Kirkman Area (Block 2)

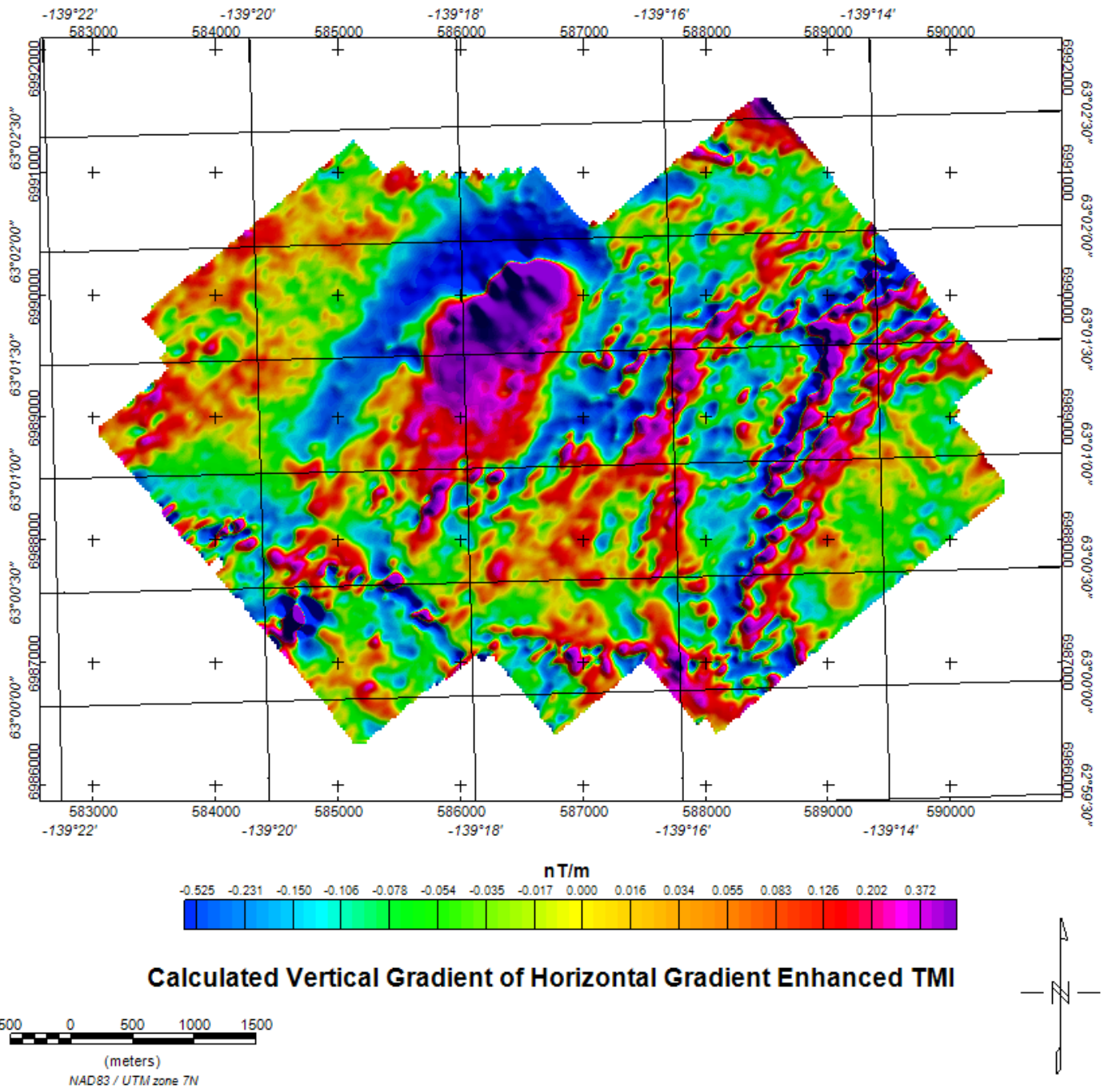


Figure 7 Calculated Vertical Gradient of Horizontal Gradient Enhanced Total Magnetic Intensity for Kirkman Area (Block 2)



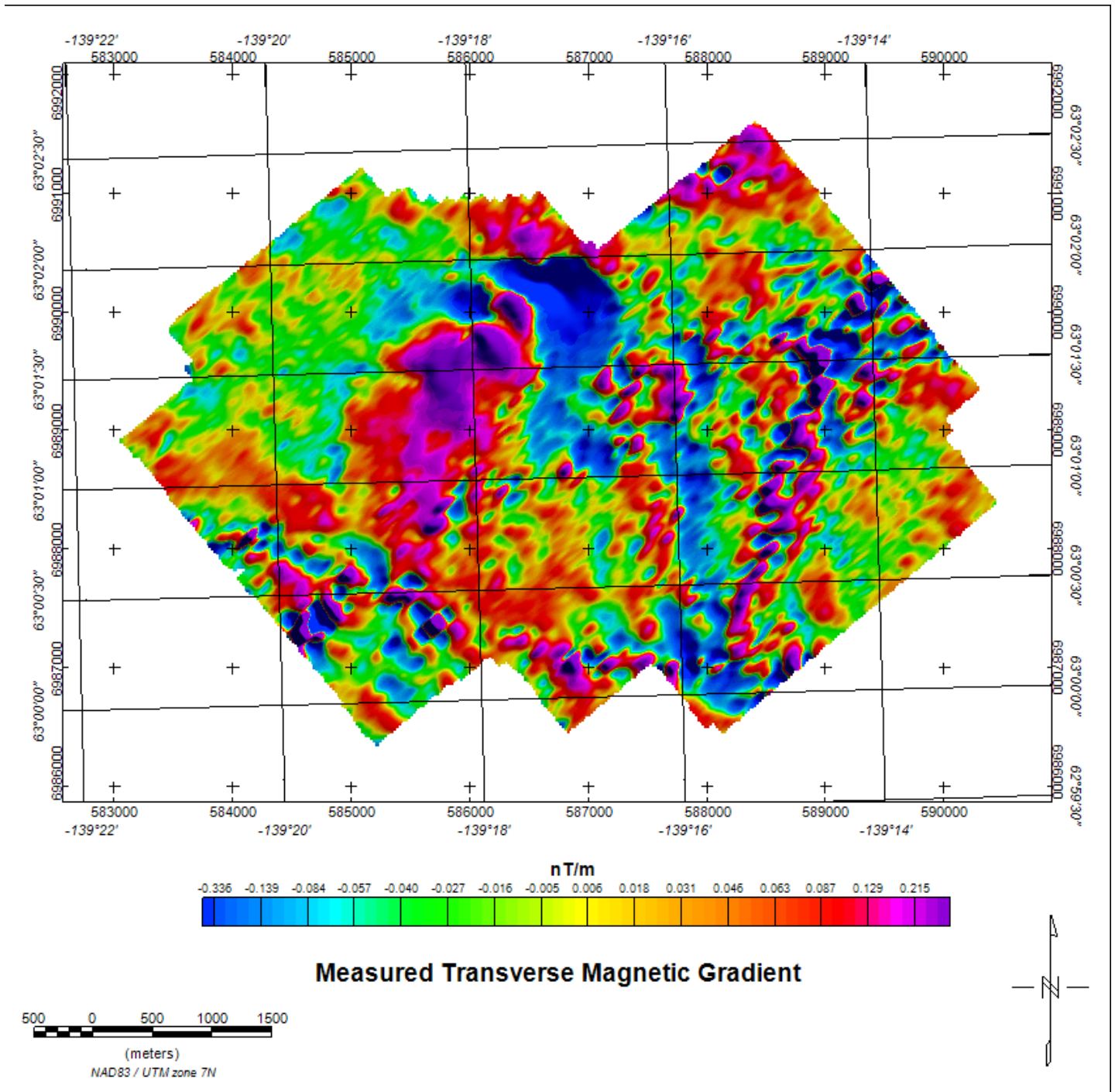


Figure 8 Measured Transverse Magnetic Gradient for Kirkman Area (Block 2)

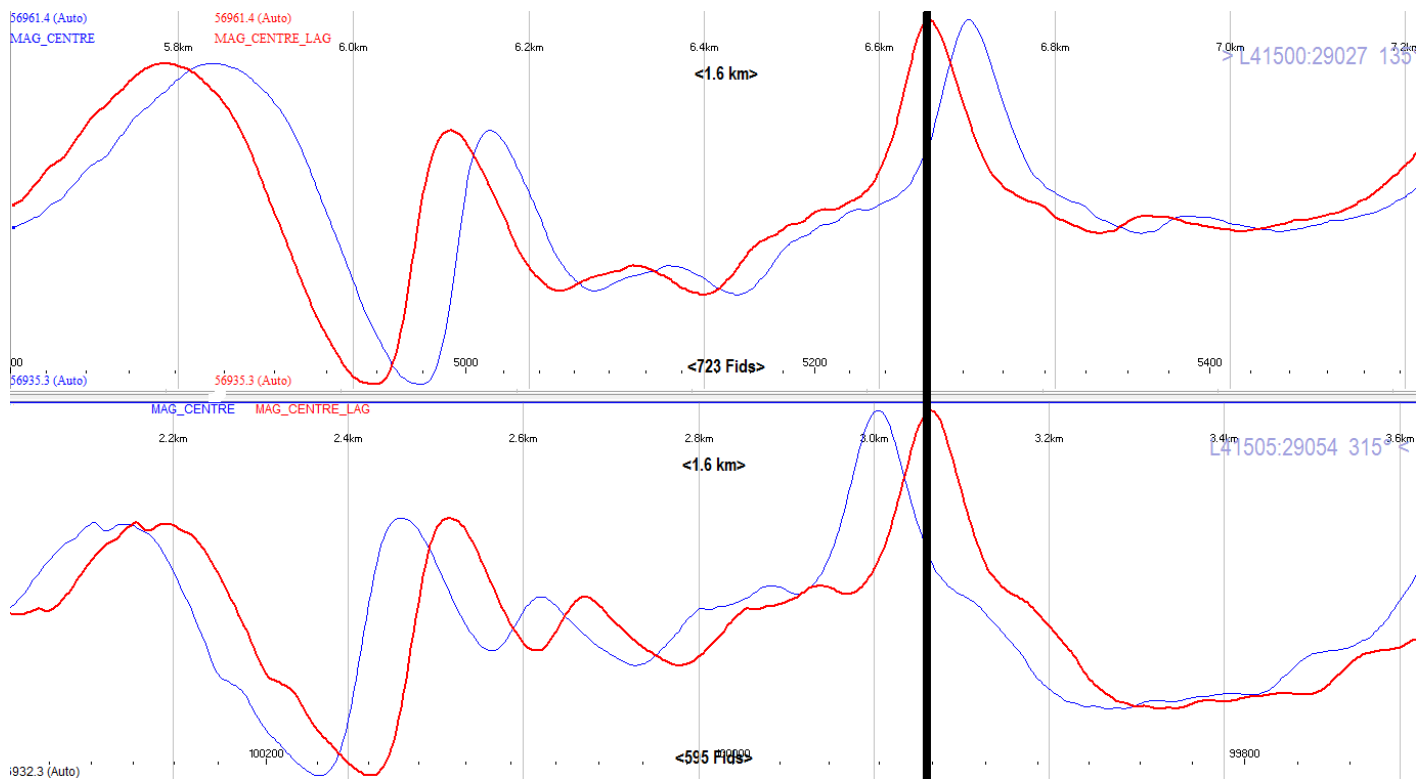
## Appendix D Calibration and Tests

# Magnetics Lag Test

**Project Number: 14013**  
**Date Flown: March 26, 2014**  
**Flight Number: 29027**

**Survey Type: MIDAS Magnetic Survey**  
**Aircraft Registration: C-GDVC**  
**Location: Fort Selkirk Area**

**Correction Lag Applied: 20 seconds**

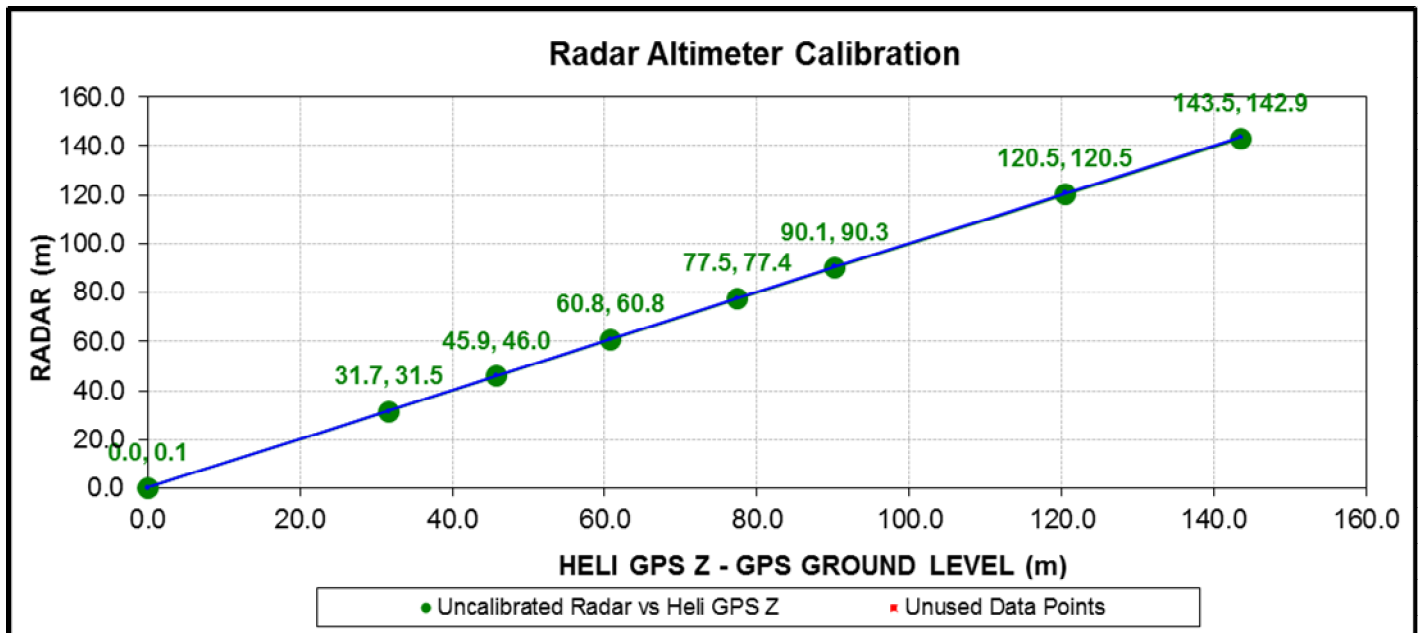


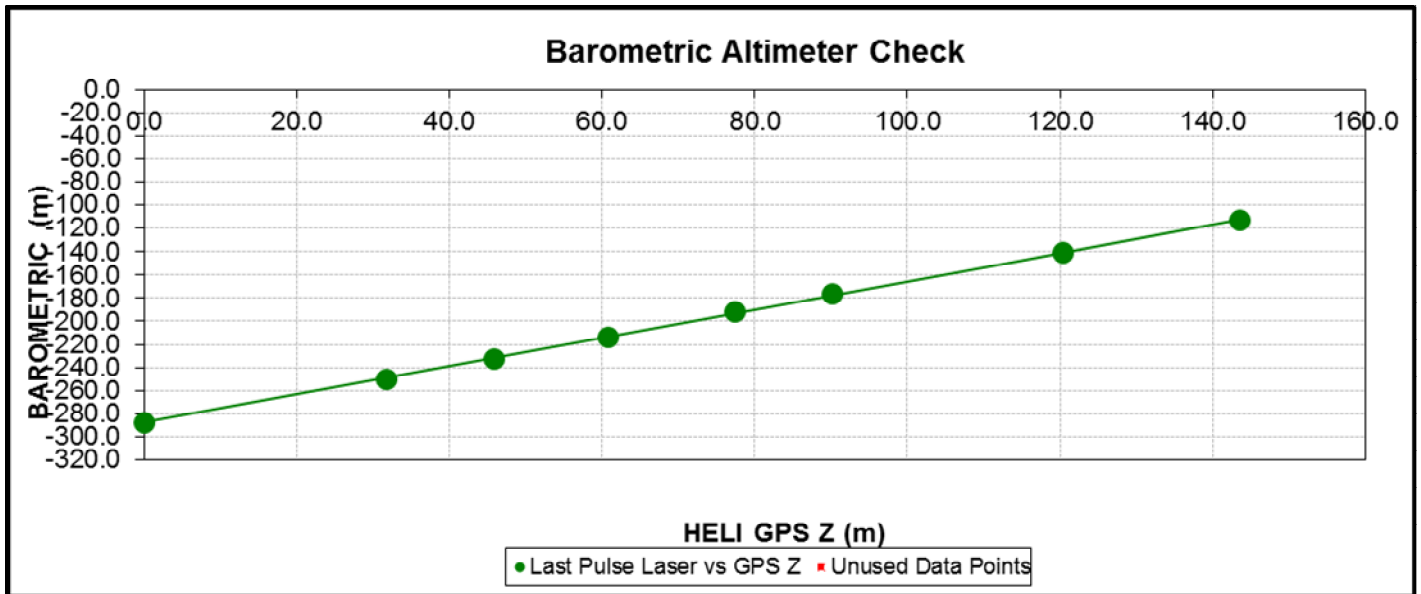
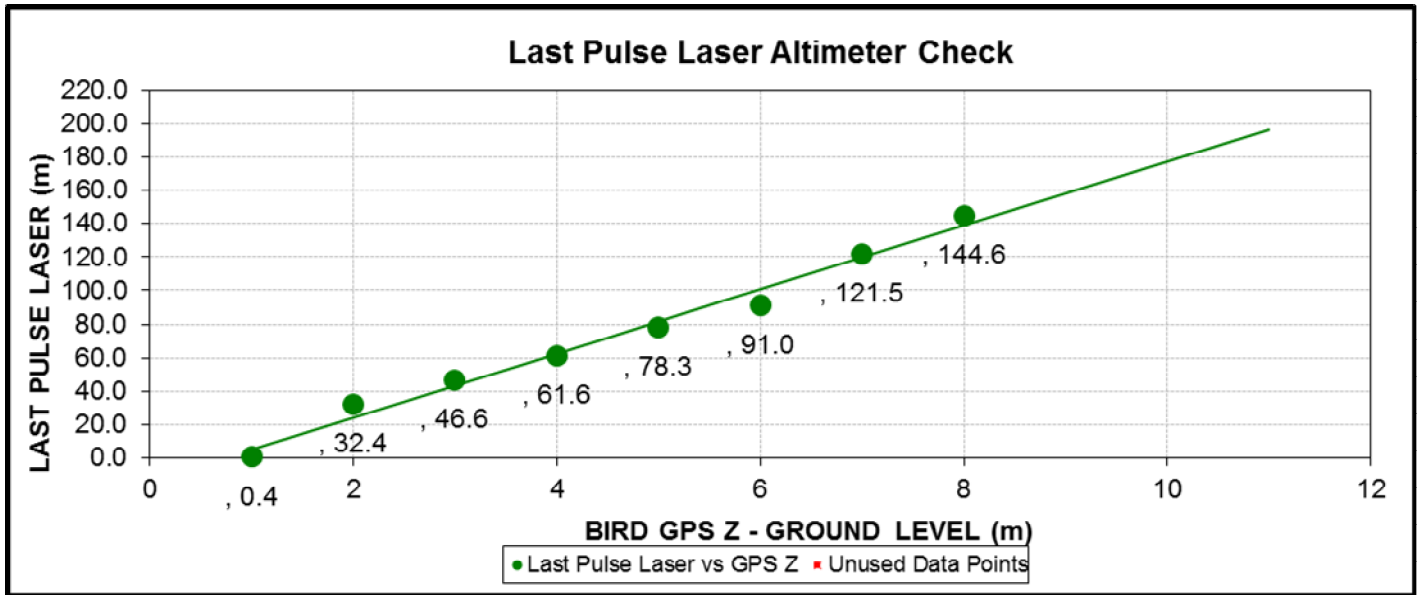
## Altimeter Test

**Project Number: 14013**  
**Date Flown: March 23, 2014**  
**Flight Number: 29017**

**Survey Type: MIDAS Magnetic Survey**  
**Aircraft Registration: C-GDVC**  
**Location: Fort Selkirk Area**

LINE	TARGET RADAR (ft)	ZHG_HELI	ALTRAD_FT	ALTLASLP_M	ALTBAR_M
1	000	382.44	000.36	000.42	094.76
100	100	414.16	103.35	032.43	132.55
150	150	428.31	150.84	046.62	150.08
200	200	443.20	199.34	061.63	169.15
250	250	459.92	253.89	078.34	190.37
300	300	472.59	296.22	91.018	206.01
400	400	502.93	395.34	121.54	241.85
500	500	525.98	468.72	144.57	269.59





## Figure of Merit

Project Number: 14013  
 Date Flown: March 22, 2014  
 Flight Number: 29013

Survey Type: MIDAS Magnetic Survey  
 Aircraft Registration: C-GDVC  
 Location: Fort Selkirk Area

BOX 1	Sensor Position: STAR		Pitch	Roll	Yaw	Total	Figure of Merit
	Raw Mag Channel: MAG2U		Residual Peak to Peak	Residual Peak to Peak	Residual Peak to Peak		
	Line Number	Heading					
Direction 1:	452	45	0.09	0.14	0.19	0.43	<b>1.69</b>
Direction 2:	1352	135	0.06	0.14	0.14	0.34	
Direction 3:	2252	225	0.10	0.10	0.16	0.36	
Direction 4:	3152	315	0.13	0.19	0.25	0.57	

BOX 2	Sensor Position: PORT		Pitch	Roll	Yaw	Total	Figure of Merit
	Raw Mag Channel: MAG3U		Residual Peak to Peak	Residual Peak to Peak	Residual Peak to Peak		
	Line Number	Heading					
Direction 1:	452	45	0.10	0.13	0.26	0.49	<b>1.64</b>
Direction 2:	1352	135	0.11	0.10	0.16	0.37	
Direction 3:	2252	225	0.12	0.11	0.16	0.39	
Direction 4:	3152	315	0.07	0.12	0.20	0.39	

## Appendix E Background Information

## Magnetic Responses

The measured total magnetic field provides information on the magnetic properties of the earth materials in the survey area. The information can be used to locate magnetic bodies of direct interest for exploration, and for structural and lithological mapping.

The total magnetic field response reflects the abundance of magnetic material in the source. Magnetite is the most common magnetic mineral. Other minerals such as ilmenite, pyrrhotite, franklinite, chromite, hematite, arsenopyrite, limonite and pyrite are also magnetic, but to a lesser extent than magnetite on average.

In some geological environments, an EM anomaly with magnetic correlation has a greater likelihood of being produced by sulphides than one which is non-magnetic. However, sulphide 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).

Iron ore deposits will be anomalously magnetic in comparison to surrounding rock due to the concentration of iron minerals such as magnetite, ilmenite and hematite.

Changes in magnetic susceptibility often allow rock units to be differentiated based on the total field magnetic response. Geophysical classifications may differ from geological classifications if various magnetite levels exist within one general geological classification. Geometric considerations of the source such as shape, dip and depth, inclination of the earth's field and remanent magnetization will complicate such an analysis.

In general, mafic lithologies contain more magnetite and are therefore more magnetic than many sediments which tend to be weakly magnetic. Metamorphism and alteration can also increase or decrease the magnetization of a rock unit.

Textural differences on a total field magnetic contour, colour or shadow map due to the frequency of activity of the magnetic parameter resulting from inhomogeneities in the distribution of magnetite within the rock, may define certain lithologies. For example, near surface volcanics may display highly complex contour patterns with little line-to-line correlation.

Rock units may be differentiated based on the plan shapes of their total field magnetic responses. Mafic intrusive plugs can appear as isolated "bulls-eye" anomalies. Granitic intrusives appear as sub-circular zones, and may have contrasting rings due to contact metamorphism. Generally, granitic terrain will lack a pronounced strike direction, although granite gneiss may display strike.

Linear north-south units are theoretically not well-defined on total field magnetic maps in equatorial regions due to the low inclination of the earth's magnetic field. However, most stratigraphic units will have variations in composition along strike that will cause the units to appear as a series of alternating magnetic highs and lows.

Faults and shear zones may be characterized by alteration that causes destruction of magnetite (e.g., weathering) that produces a contrast with surrounding rock. Structural breaks may be filled by magnetite-rich, fracture filling material as is the case with diabase dikes, or by non-magnetic felsic material.

Faulting can also be identified by patterns in the magnetic total field contours or colours. Faults and dikes tend to appear as lineaments and often have strike lengths of several kilometres. Offsets in narrow, magnetic, stratigraphic trends also delineate structure. Sharp contrasts in magnetic lithologies may arise due to large displacements along strike-slip or dip-slip faults.



## Appendix F Glossary

## CGG GLOSSARY OF AIRBORNE GEOPHYSICAL TERMS

**accelerometer:** an instrument that measures both acceleration (due to motion) and acceleration due to **gravity**.

**altitude attenuation:** the absorption of gamma rays by the atmosphere between the earth and the detector. The number of gamma rays detected by a system decreases as the altitude increases.

**AGG:** Airborne **gravity gradiometer**.

**AGS:** Airborne **gamma-ray spectrometry**.

**amplitude:** The strength of the total electromagnetic field. In **frequency domain** it is most often the sum of the squares of **in-phase** and **quadrature** components. In multi-component electromagnetic surveys it is generally the sum of the squares of all three directional components.

**analytic signal:** The total amplitude of all the directions of magnetic **gradient**. Calculated as the sum of the squares.

**anisotropy:** Having different **physical parameters** in different directions. This can be caused by layering or fabric in the geology. Note that a unit can be anisotropic, but still **homogeneous**.

**anomaly:** A localized change in the geophysical data characteristic of a discrete source, such as a conductive or magnetic body: something locally different from the **background**.

**apparent- :** the **physical parameters** of the earth measured by a geophysical system are normally expressed as apparent, as in “apparent **resistivity**”. This means that the measurement is limited by assumptions made about the geology in calculating the response measured by the geophysical system. Apparent resistivity calculated with **HEM**, for example, generally assumes that the earth is a **homogeneous half-space** – not layered.

**attitude:** the orientation of a geophysical system relative to the earth. Some surveys assume the instrument attitudes are constant, and other surveys measure the attitude and correct the data for the changes in response because of attitude.

**B-field:** In time-domain **electromagnetic** surveys, the magnetic field component of the (electromagnetic) **field**. This can be measured directly, although more commonly it is calculated by integrating the time rate of change of the magnetic field **dB/dt**, as measured with a receiver coil.

**background:** The “normal” response in the geophysical data – that response observed over most of the survey area. **Anomalies** are usually measured relative to the background. In airborne gamma-ray spectrometric surveys the term defines the **cosmic**, radon, and aircraft responses in the absence of a signal from the ground.

**base-level:** The measured values in a geophysical system in the absence of any outside signal. All geophysical data are measured relative to the system base level.

**base frequency:** The frequency of the pulse repetition for a **time-domain electromagnetic** system. Measured between subsequent positive pulses.

**base magnetometer:** A stationary magnetometer used to record the **diurnal** variations in the earth’s magnetic field; to be used to correct the survey magnetic data.

**bird:** A common name for the pod towed beneath or behind an aircraft, carrying the geophysical sensor array.

**bucking:** The process of removing the strong **signal** from the **primary field** at the **receiver** from the data, to measure the **secondary field**. It can be done electronically or mathematically. This is done in **frequency-domain EM**, and to measure **on-time** in **time-domain EM**.

**calibration:** a procedure to ensure a geophysical instrument is measuring accurately and repeatably. Most often applied in **EM** and **gamma-ray spectrometry**.

**calibration coil:** A wire coil of known size and dipole moment, which is used to generate a field of known **amplitude** and **phase** or **decay constant** in the receiver, for system calibration. Calibration coils can be external, or internal to the system. Internal coils may be called Q-coils.

**coaxial coils:** [CX] Coaxial coils in an HEM system are in the vertical plane, with their axes horizontal and collinear in the flight direction. These are most sensitive to vertical conductive objects in the ground, such as thin, steeply dipping conductors perpendicular to the flight direction. Coaxial coils generally give the sharpest anomalies over localized conductors. (See also **coplanar coils**)

**coil:** A multi-turn wire loop used to transmit or detect electromagnetic fields. Time varying **electromagnetic** fields through a coil induce a voltage proportional to the strength of the field and the rate of change over time.

**compensation:** Correction of airborne geophysical data for the changing effect of the aircraft. This process is generally used to correct data in **fixed-wing time-domain electromagnetic** surveys (where the transmitter is on the aircraft and the receiver is moving), and magnetic surveys (where the sensor is on the aircraft, turning in the earth's magnetic field).

**component:** In **frequency domain electromagnetic** surveys this is one of the two **phase** measurements – **in-phase or quadrature**. In “multi-component” electromagnetic surveys it is also used to define the measurement in one geometric direction (vertical, horizontal in-line and horizontal transverse – the Z, X and Y components).

**Compton scattering:** gamma ray photons will bounce off electrons as they pass through the earth and atmosphere, reducing their energy and then being detected by **radiometric** sensors at lower energy levels. See also **stripping**.

**conductance:** See **conductivity thickness**

**conductivity:** [ $\sigma$ ] The facility with which the earth or a geological formation conducts electricity. Conductivity is usually measured in milli-Siemens per metre (mS/m). It is the reciprocal of **resistivity**.

**conductivity-depth imaging:** see **conductivity-depth transform**.

**conductivity-depth transform:** A process for converting electromagnetic measurements to an approximation of the conductivity distribution vertically in the earth, assuming a **layered earth**. (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)

**conductivity thickness:** [ $\sigma t$ ] The product of the **conductivity**, and thickness of a large, tabular body. (It is also called the “conductivity-thickness product”) In electromagnetic geophysics, the response of a thin plate-like conductor is proportional to the conductivity multiplied by thickness. For example a 10 metre thickness of 20 Siemens/m mineralization will be equivalent to 5 metres of 40 S/m; both have 200 S conductivity thickness. Sometimes referred to as conductance.

**conductor:** Used to describe anything in the ground more conductive than the surrounding geology. Conductors are most often clays or graphite, or hopefully some type of mineralization, but may also be man-made objects, such as fences or pipelines.

**continuation:** mathematical procedure applied to *potential field* geophysical data to approximate data collected at a different altitude. Data can be continued upward to a higher altitude or downward to a lower altitude.

**coplanar coils: [CP]** In HEM, the coplanar coils lie in the horizontal plane with their axes vertical, and parallel. These coils are most sensitive to massive conductive bodies, horizontal layers, and the *halfspace*.

**cosmic ray:** High energy sub-atomic particles from outer space that collide with the earth's atmosphere to produce a shower of gamma rays (and other particles) at high energies.

**counts (per second):** The number of *gamma-rays* detected by a gamma-ray *spectrometer*. The rate depends on the geology, but also on the size and sensitivity of the detector.

**culture:** A term commonly used to denote any man-made object that creates a geophysical anomaly. Includes, but not limited to, power lines, pipelines, fences, and buildings.

**current channelling:** See current gathering.

**current gathering:** The tendency of electrical currents in the ground to channel into a conductive formation. This is particularly noticeable at higher frequencies or early time channels when the formation is long and parallel to the direction of current flow. This tends to enhance anomalies relative to inductive currents (see also *induction*). Also known as current channelling.

**daughter products:** The radioactive natural sources of gamma-rays decay from the original "parent" element (commonly potassium, uranium, and thorium) to one or more lower-energy "daughter" elements. Some of these lower energy elements are also radioactive and decay further. *Gamma-ray spectrometry* surveys may measure the gamma rays given off by the original element or by the decay of the daughter products.

**$dB/dt$ :** As the *secondary electromagnetic field* changes with time, the magnetic field [**B**] component induces a voltage in the receiving *coil*, which is proportional to the rate of change of the magnetic field over time.

**decay:** In *time-domain electromagnetic* theory, the weakening over time of the *eddy currents* in the ground, and hence the *secondary field* after the *primary field* electromagnetic pulse is turned off. In *gamma-ray spectrometry*, the radioactive breakdown of an element, generally potassium, uranium, thorium, into their *daughter* products.

**decay constant:** see time constant.

**decay series:** In *gamma-ray spectrometry*, a series of progressively lower energy *daughter products* produced by the radioactive breakdown of uranium or thorium.

**depth of exploration:** The maximum depth at which the geophysical system can detect the target. The depth of exploration depends very strongly on the type and size of the target, the contrast of the target with the surrounding geology, the homogeneity of the surrounding geology, and the type of geophysical system. One measure of the maximum depth of exploration for an electromagnetic system is the depth at which it can detect the strongest conductive target – generally a highly conductive horizontal layer.

**differential resistivity:** A process of transforming *apparent resistivity* to an approximation of layer resistivity at each depth. The method uses multi-frequency HEM data and approximates the effect of shallow layer *conductance* determined from higher frequencies to estimate the deeper conductivities (Huang and Fraser, 1996)

**dipole moment:** [NIA] For a transmitter, the product of the area of a *coil*, the number of turns of wire, and the current flowing in the coil. At a distance significantly larger than the size of the coil, the magnetic field from a coil will be the same if the dipole moment product is the same. For a receiver coil, this is the product of the area and the number of turns. The sensitivity to a magnetic field (assuming the source is far away) will be the same if the dipole moment is the same.

**diurnal:** The daily variation in a natural field, normally used to describe the natural fluctuations (over hours and days) of the earth's magnetic field.

**dielectric permittivity:** [ $\epsilon$ ] The capacity of a material to store electrical charge, this is most often measured as the relative permittivity [ $\epsilon_r$ ], or ratio of the material dielectric to that of free space. The effect of high permittivity may be seen in HEM data at high frequencies over highly resistive geology as a reduced or negative *in-phase*, and higher *quadrature* data.

**dose rate:** see **exposure rate**.

**drape:** To fly a survey following the terrain contours, maintaining a constant altitude above the local ground surface. Also applied to re-processing data collected at varying altitudes above ground to simulate a survey flown at constant altitude.

**drift:** Long-time variations in the base-level or calibration of an instrument.

**eddy currents:** The electrical currents induced in the ground, or other conductors, by a time-varying *electromagnetic field* (usually the *primary field*). Eddy currents are also induced in the aircraft's metal frame and skin; a source of *noise* in EM surveys.

**electromagnetic:** [EM] Comprised of a time-varying electrical and magnetic field. Radio waves are common electromagnetic fields. In geophysics, an electromagnetic system is one which transmits a time-varying *primary field* to induce *eddy currents* in the ground, and then measures the *secondary field* emitted by those eddy currents.

**energy window:** A broad spectrum of *gamma-ray* energies measured by a spectrometric survey. The energy of each gamma-ray is measured and divided up into numerous discrete energy levels, called windows.

**equivalent (thorium or uranium):** The amount of radioelement calculated to be present, based on the gamma-rays measured from a *daughter* element. This assumes that the *decay series* is in equilibrium – progressing normally.

**exposure rate:** in radiometric surveys, a calculation of the total exposure rate due to gamma rays at the ground surface. It is used as a measurement of the concentration of all the *radioelements* at the surface. Sometimes called “dose rate”. See also: **natural exposure rate**.

**fiducial, or fid:** Timing mark on a survey record. Originally these were timing marks on a profile or film; now the term is generally used to describe 1-second interval timing records in digital data, and on maps or profiles.

**Figure of Merit: (FOM)** A sum of the 12 distinct magnetic noise variations measured by each of four flight directions, and executing three aircraft attitude variations (yaw, pitch, and roll) for each direction. The flight directions are generally parallel and perpendicular to planned survey flight directions. The FOM is used as a measure of the **manoeuvre noise** before and after **compensation**.

**fixed-wing:** Aircraft with wings, as opposed to “rotary wing” helicopters.

**flight:** a continuous interval of survey data collection, generally between stops at base to refuel.

**flight-line:** a single line of data across the survey area. Surveys are generally comprised of many parallel flight lines to cover the survey area, with wider-spaced **tie lines** perpendicular. Flight lines are generally separated by **turn-arounds** when the aircraft is outside the survey area.

**footprint:** This is a measure of the area of sensitivity under the aircraft of an airborne geophysical system. The footprint of an **electromagnetic** system is dependent on the altitude of the system, the orientation of the transmitter and receiver and the separation between the receiver and transmitter, and the conductivity of the ground. The footprint of a **gamma-ray spectrometer** depends mostly on the altitude. For all geophysical systems, the footprint also depends on the strength of the contrasting **anomaly**.

**frequency domain:** An **electromagnetic** system which transmits a harmonic **primary field** that oscillates over time (e.g. sinusoidal), inducing a similarly varying electrical current in the ground. These systems generally measure the changes in the **amplitude** and **phase** of the **secondary field** from the ground at different frequencies by measuring the **in-phase** and **quadrature** phase components. See also **time-domain**.

**full-stream data:** Data collected and recorded continuously at the highest possible sampling rate. Normal data are stacked (see **stacking**) over some time interval before recording.

**gamma-ray:** A very high-energy photon, emitted from the nucleus of an atom as it undergoes a change in energy levels.

**gamma-ray spectrometry:** Measurement of the number and energy of natural (and sometimes man-made) gamma-rays across a range of photon energies.

**GGI:** gravity gradiometer instrument. An airborne gravity gradiometer (AGG) consists of a GGI mounted in an inertial platform together with a temperature control system.

**gradient:** In magnetic surveys, the gradient is the change of the magnetic field over a distance, either vertically or horizontally in either of two directions. Gradient data can be measured, or calculated from the total magnetic field data because it changes more quickly over distance than the **total magnetic field**, and so may provide a more precise measure of the location of a source. See also **analytic signal**.

**gradiometer, gradiometry:** instrument and measurement of the gradient, or change in a field with location usually for **gravity** or **magnetic** surveys. Used to provide higher resolution of **targets**, better **interpretation** of **target** geometry, independence from drift and absolute field and, for **gravity**, accelerations of the aircraft.

**gravity:** Survey collecting measurements of the earth’s gravitational field strength. Denser objects in the earth create stronger gravitational pull above them.

**ground effect:** The response from the earth. A common **calibration** procedure in many geophysical surveys is to fly to altitude high enough to be beyond any measurable response from the ground, and there establish **base levels** or **backgrounds**.

**half-space:** A mathematical model used to describe the earth – as infinite in width, length, and depth below the surface. The most common halfspace models are **homogeneous** and **layered earth**.

**heading error:** A slight change in the magnetic field measured when flying in opposite directions.

**HEM:** Helicopter ElectroMagnetic, This designation is most commonly used for helicopter-borne, **frequency-domain** electromagnetic systems. At present, the transmitter and receivers are normally mounted in a **bird** carried on a sling line beneath the helicopter.

**herringbone pattern:** A pattern created in geophysical data by an asymmetric system, where the **anomaly** may be extended to either side of the source, in the direction of flight. Appears like fish bones, or like the teeth of a comb, extending either side of centre, each tooth an alternate flight line.

**homogeneous:** This is a geological unit that has the same **physical parameters** throughout its volume. This unit will create the same response to an HEM system anywhere, and the HEM system will measure the same apparent **resistivity** anywhere. The response may change with system direction (see **anisotropy**).

**HFEM:** Helicopter Frequency-domain ElectroMagnetic, This designation is used for helicopter-borne, **frequency-domain** electromagnetic systems. Formerly most often called HEM.

**HTEM:** Helicopter Time-domain ElectroMagnetic, This designation is used for the new generation of helicopter-borne, **time-domain** electromagnetic systems.

**in-phase:** the component of the measured **secondary field** that has the same phase as the transmitter and the **primary field**. The in-phase component is stronger than the **quadrature** phase over relatively higher **conductivity**.

**induction:** Any time-varying electromagnetic field will induce (cause) electrical currents to flow in any object with non-zero **conductivity**. (see **eddy currents**)

**induction number:** also called the “response parameter”, this number combines many of the most significant parameters affecting the **EM** response into one parameter against which to compare responses. For a **layered earth** the response parameter is  $\mu\omega\sigma h^2$  and for a large, flat, **conductor** it is  $\mu\omega\sigma h$ , where  $\mu$  is the **magnetic permeability**,  $\omega$  is the angular **frequency**,  $\sigma$  is the **conductivity**,  $t$  is the thickness (for the flat conductor) and  $h$  is the height of the system above the conductor.

**inductive limit:** When the frequency of an EM system is very high, or the **conductivity** of the target is very high, the response measured will be entirely **in-phase** with no **quadrature** (phase angle =0). The in-phase response will remain constant with further increase in conductivity or frequency. The system can no longer detect changes in conductivity of the target.

**infinite:** In geophysical terms, an “infinite’ dimension is one much greater than the **footprint** of the system, so that the system does not detect changes at the edges of the object.

**International Geomagnetic Reference Field: [IGRF]** An approximation of the smooth magnetic field of the earth, in the absence of variations due to local geology. Once the IGRF is subtracted from the measured magnetic total field data, any remaining variations are assumed to be due to local geology. The IGRF also predicts the slow changes of the field up to five years in the future.

**inversion, or inverse modeling:** A process of converting geophysical data to an earth model, which compares theoretical models of the response of the earth to the data measured, and refines the model until the response closely fits the measured data (Huang and Palacky, 1991)

**layered earth:** A common geophysical model which assumes that the earth is horizontally layered – the **physical parameters** are constant to **infinite** distance horizontally, but change vertically.

**lead-in:** approach to a **flight line** outside of survey area to establish proper track and stabilize instrumentations. The lead-in for a helicopter survey is generally shorter than required for fixed-wing.

**line source, or line current:** a long narrow object that creates an **anomaly** on an **EM** survey. Generally man-made objects like fences, power lines, and pipelines (**culture**).

**mag:** common abbreviation for **magnetic**.

**magnetic:** (“mag”) a survey measuring the strength of the earth’s magnetic field, to identify geology and targets by their effect on the field.

**magnetic permeability:** [ $\mu$ ] This is defined as the ratio of magnetic induction to the inducing magnetic field. The relative magnetic permeability [ $\mu_r$ ] is often quoted, which is the ratio of the rock permeability to the permeability of free space. In geology and geophysics, the **magnetic susceptibility** is more commonly used to describe rocks.

**magnetic susceptibility:** [ $k$ ] A measure of the degree to which a body is magnetized. In SI units this is related to relative **magnetic permeability** by  $k = \mu_r - 1$ , and is a dimensionless unit. For most geological material, susceptibility is influenced primarily by the percentage of magnetite. It is most often quoted in units of  $10^{-6}$ . In HEM data this is most often apparent as a negative **in-phase** component over high susceptibility, high **resistivity** geology such as diabase dikes.

**manoeuvre noise:** variations in the magnetic field measured caused by changes in the relative positions of the magnetic sensor and magnetic objects or electrical currents in the aircraft. This type of noise is generally corrected by magnetic **compensation**.

**model:** Geophysical theory and applications generally have to assume that the geology of the earth has a form that can be easily defined mathematically, called the model. For example steeply dipping **conductors** are generally modeled as being **infinite** in horizontal and depth extent, and very thin. The earth is generally modeled as horizontally layered, each layer infinite in extent and uniform in characteristic. These models make the mathematics to describe the response of the (normally very complex) earth practical. As theory advances, and computers become more powerful, the useful models can become more complex.

**natural exposure rate:** in radiometric surveys, a calculation of the total exposure rate due to natural-source gamma rays at the ground surface. It is used as a measurement of the concentration of all the natural **radioelements** at the surface. See also: **exposure rate**.

**natural source:** any geophysical technique for which the source of the energy is from nature, not from a man-made object. Most commonly applied to natural source **electromagnetic** surveys.

**noise:** That part of a geophysical measurement that the user does not want. Typically this includes electronic interference from the system, the atmosphere (**sferics**), and man-made sources. This can be a subjective judgment, as it may include the response from geology other than the target of interest. Commonly the term is used to refer to high frequency (short period) interference. See also **drift**.

**Occam’s inversion:** an **inversion** process that matches the measured **electromagnetic** data to a theoretical model of many, thin layers with constant thickness and varying resistivity (Constable et al, 1987).

**off-time:** In a **time-domain electromagnetic** survey, the time after the end of the **primary field pulse**, and before the start of the next pulse.



**on-time:** In a *time-domain electromagnetic* survey, the time during the *primary field pulse*.

**overburden:** In engineering and mineral exploration terms, this most often means the soil on top of the unweathered bedrock. It may be sand, glacial till, or weathered rock.

**Phase, phase angle:** The angular difference in time between a measured sinusoidal electromagnetic field and a reference – normally the primary field. The phase is calculated from  $\tan^{-1}(\textit{in-phase} / \textit{quadrature})$ .

**physical parameters:** These are the characteristics of a geological unit. For electromagnetic surveys, the important parameters are *conductivity*, *magnetic permeability* (or *susceptibility*) and *dielectric permittivity*; for magnetic surveys the parameter is magnetic susceptibility, and for gamma ray spectrometric surveys it is the concentration of the major radioactive elements: potassium, uranium, and thorium.

**permittivity:** see *dielectric permittivity*.

**permeability:** see *magnetic permeability*.

**potential field:** A field that obeys Laplace's Equation. Most commonly used to describe *gravity* and *magnetic* measurements.

**primary field:** the EM field emitted by a transmitter. This field induces *eddy currents* in (energizes) the conductors in the ground, which then create their own *secondary fields*.

**pulse:** In time-domain EM surveys, the short period of intense *primary* field transmission. Most measurements (the *off-time*) are measured after the pulse. **On-time** measurements may be made during the pulse.

**quadrature:** that component of the measured *secondary field* that is phase-shifted 90° from the *primary field*. The quadrature component tends to be stronger than the *in-phase* over relatively weaker *conductivity*.

**Q-coils:** see *calibration coil*.

**radioelements:** This normally refers to the common, naturally-occurring radioactive elements: potassium (K), uranium (U), and thorium (Th). It can also refer to man-made radioelements, most often cobalt (Co) and cesium (Cs)

**radiometric:** Commonly used to refer to *gamma ray* spectrometry.

**radon:** A radioactive daughter product of uranium and thorium, radon is a gas which can leak into the atmosphere, adding to the non-geological background of a gamma-ray spectrometric survey.

**receiver:** the *signal* detector of a geophysical system. This term is most often used in active geophysical systems – systems that transmit some kind of signal. In airborne *electromagnetic* surveys it is most often a *coil*. (see also, *transmitter*)

**resistivity: [ $\rho$ ]** The strength with which the earth or a geological formation resists the flow of electricity, typically the flow induced by the *primary field* of the electromagnetic transmitter. Normally expressed in ohm-metres, it is the reciprocal of *conductivity*.

**resistivity-depth transforms:** similar to *conductivity depth transforms*, but the calculated *conductivity* has been converted to *resistivity*.

**resistivity section:** an approximate vertical section of the resistivity of the layers in the earth. The resistivities can be derived from the **apparent resistivity**, the **differential resistivities**, **resistivity-depth transforms**, or **inversions**.

**response parameter:** another name for the **induction number**.

**secondary field:** The field created by conductors in the ground, as a result of electrical currents induced by the **primary field** from the **electromagnetic** transmitter. Airborne **electromagnetic** systems are designed to create and measure a secondary field.

**Sengpiel section:** a **resistivity section** derived using the **apparent resistivity** and an approximation of the depth of maximum sensitivity for each frequency.

**sferic:** Lightning, or the **electromagnetic** signal from lightning, it is an abbreviation of “atmospheric discharge”. These appear to magnetic and electromagnetic sensors as sharp “spikes” in the data. Under some conditions lightning storms can be detected from hundreds of kilometres away. (see **noise**)

**signal:** That component of a measurement that the user wants to see – the response from the targets, from the earth, etc. (See also **noise**)

**skin depth:** A measure of the depth of penetration of an electromagnetic field into a material. It is defined as the depth at which the primary field decreases to 1/e of the field at the surface. It is calculated by approximately  $503 \times \sqrt{(\text{resistivity}/\text{frequency})}$ . Note that depth of penetration is greater at higher **resistivity** and/or lower **frequency**.

**spec:** common abbreviation for *gamma-ray spectrometry*.

**spectrometry:** Measurement across a range of energies, where **amplitude** and energy are defined for each measurement. In gamma-ray spectrometry, the number of gamma rays are measured for each energy **window**, to define the **spectrum**.

**spectrum:** In **gamma ray spectrometry**, the continuous range of energy over which gamma rays are measured. In **time-domain electromagnetic** surveys, the spectrum is the energy of the **pulse** distributed across an equivalent, continuous range of frequencies.

**spheric:** see **sferic**.

**stacking:** Summing repeat measurements over time to enhance the repeating **signal**, and minimize the random **noise**.

**stinger:** A boom mounted on an aircraft to carry a geophysical sensor (usually **magnetic**). The boom moves the sensor farther from the aircraft, which might otherwise be a source of **noise** in the survey data.

**stripping:** Estimation and correction for the gamma ray photons of higher and lower energy that are observed in a particular **energy window**. See also **Compton scattering**.

**susceptibility:** See **magnetic susceptibility**.

**tau:** [ $\tau$ ] Often used as a name for the **decay time constant**.

**TDEM:** **time domain electromagnetic**.

**thin sheet:** A standard model for electromagnetic geophysical theory. It is usually defined as a thin, flat-lying conductive sheet, **infinite** in both horizontal directions. (see also **vertical plate**)

**tie-line:** A survey line flown across most of the **traverse lines**, generally perpendicular to them, to assist in measuring **drift** and **diurnal** variation. In the short time required to fly a tie-line it is assumed that the drift and/or diurnal will be minimal, or at least changing at a constant rate.

**time constant:** The time required for an **electromagnetic** field to decay to a value of  $1/e$  of the original value. In **time-domain** electromagnetic data, the time constant is proportional to the size and **conductance** of a tabular conductive body. Also called the decay constant.

**Time channel:** In **time-domain electromagnetic** surveys the decaying **secondary field** is measured over a period of time, and the divided up into a series of consecutive discrete measurements over that time.

**time-domain:** **Electromagnetic** system which transmits a pulsed, or stepped **electromagnetic** field. These systems induce an electrical current (**eddy current**) in the ground that persists after the **primary field** is turned off, and measure the change over time of the **secondary field** created as the currents **decay**. See also **frequency-domain**.

**total energy envelope:** The sum of the squares of the three **components** of the **time-domain electromagnetic secondary field**. Equivalent to the **amplitude** of the secondary field.

**transient:** Time-varying. Usually used to describe a very short period pulse of **electromagnetic** field.

**transmitter:** The source of the **signal** to be measured in a geophysical survey. In airborne **EM** it is most often a **coil** carrying a time-varying electrical current, transmitting the **primary field**. (see also **receiver**)

**traverse line:** A normal geophysical survey line. Normally parallel traverse lines are flown across the property in spacing of 50 m to 500 m, and generally perpendicular to the target geology. Also called a **flight line**.

**turn-arounds:** The time the aircraft is turning between one **traverse** or **tie line** and the next. Turn-arounds are generally outside the survey area, and the data collected during this time generally are not useable, because of aircraft **manoeuvre noise**.

**vertical plate:** A standard model for electromagnetic geophysical theory. It is usually defined as thin conductive sheet, **infinite** in horizontal dimension and depth extent. (see also **thin sheet**)

**waveform:** The shape of the **electromagnetic pulse** from a **time-domain** electromagnetic transmitter.

**window:** A discrete portion of a **gamma-ray spectrum** or **time-domain electromagnetic decay**. The continuous energy spectrum or **full-stream** data are grouped into windows to reduce the number of samples, and reduce **noise**.

**zero, or zero level:** The **base level** of an instrument, with no **ground effect** or **drift**. Also, the act of measuring and setting the zero level.

## Common Symbols and Acronyms

<b>k</b>	Magnetic susceptibility
$\epsilon$	Dielectric permittivity
$\mu, \mu_r$	Magnetic permeability, relative permeability
$\rho, \rho_a$	Resistivity, apparent resistivity
$\sigma, \sigma_a$	Conductivity, apparent conductivity
$\sigma t$	Conductivity thickness
$\tau$	Tau, or time constant
<b><math>\Omega m</math></b>	ohm-metres, units of resistivity
<b>AGS</b>	Airborne gamma ray spectrometry.
<b>CDT</b>	Conductivity-depth transform, conductivity-depth imaging (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)
<b>CPI, CPQ</b>	Coplanar in-phase, quadrature
<b>CPS</b>	Counts per second
<b>CTP</b>	Conductivity thickness product
<b>CXI, CXQ</b>	Coaxial, in-phase, quadrature
<b>FOM</b>	Figure of Merit
<b>fT</b>	femtoteslas, common unit for measurement of B-Field in time-domain EM
<b>EM</b>	Electromagnetic
<b>keV</b>	kilo electron volts – a measure of gamma-ray energy
<b>MeV</b>	mega electron volts – a measure of gamma-ray energy 1MeV = 1000keV
<b>NIA</b>	dipole moment: turns x current x Area
<b>nT</b>	nanotesla, a measure of the strength of a magnetic field
<b>nT/s</b>	nanoteslas/second; standard unit of measurement of secondary field dB/dt in time domain EM.
<b>nG/h</b>	nanoGreys/hour – gamma ray dose rate at ground level
<b>ppm</b>	parts per million – a measure of secondary field or noise relative to the primary or radioelement concentration.
<b>pT</b>	picoteslas: standard unit of measurement of B-Field in time-domain EM
<b>pT/s</b>	picoteslas per second: Units of decay of secondary field, dB/dt
<b>S</b>	siemens – a unit of conductance
<b>x:</b>	the horizontal component of an EM field parallel to the direction of flight.
<b>y:</b>	the horizontal component of an EM field perpendicular to the direction of flight.
<b>z:</b>	the vertical component of an EM field.

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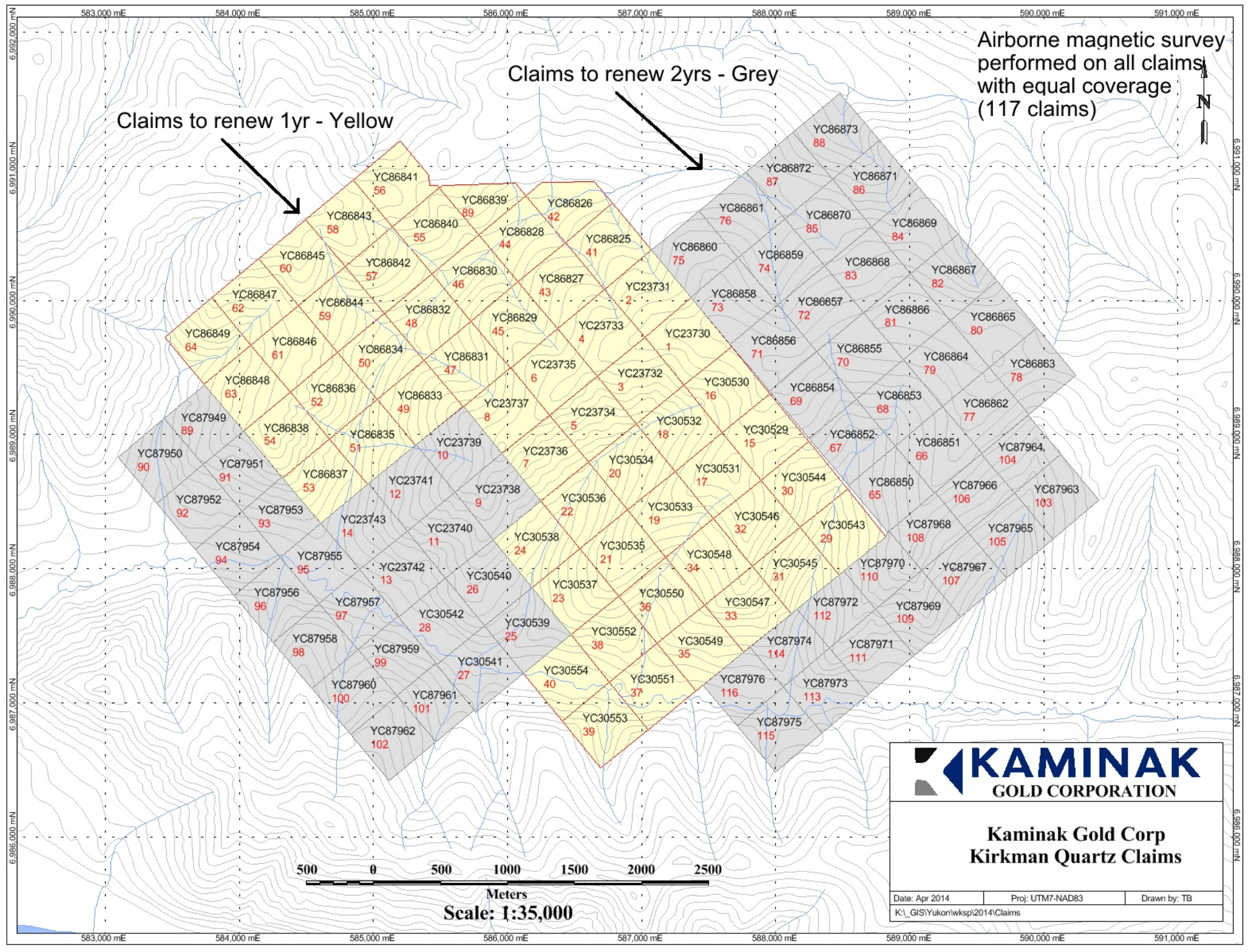
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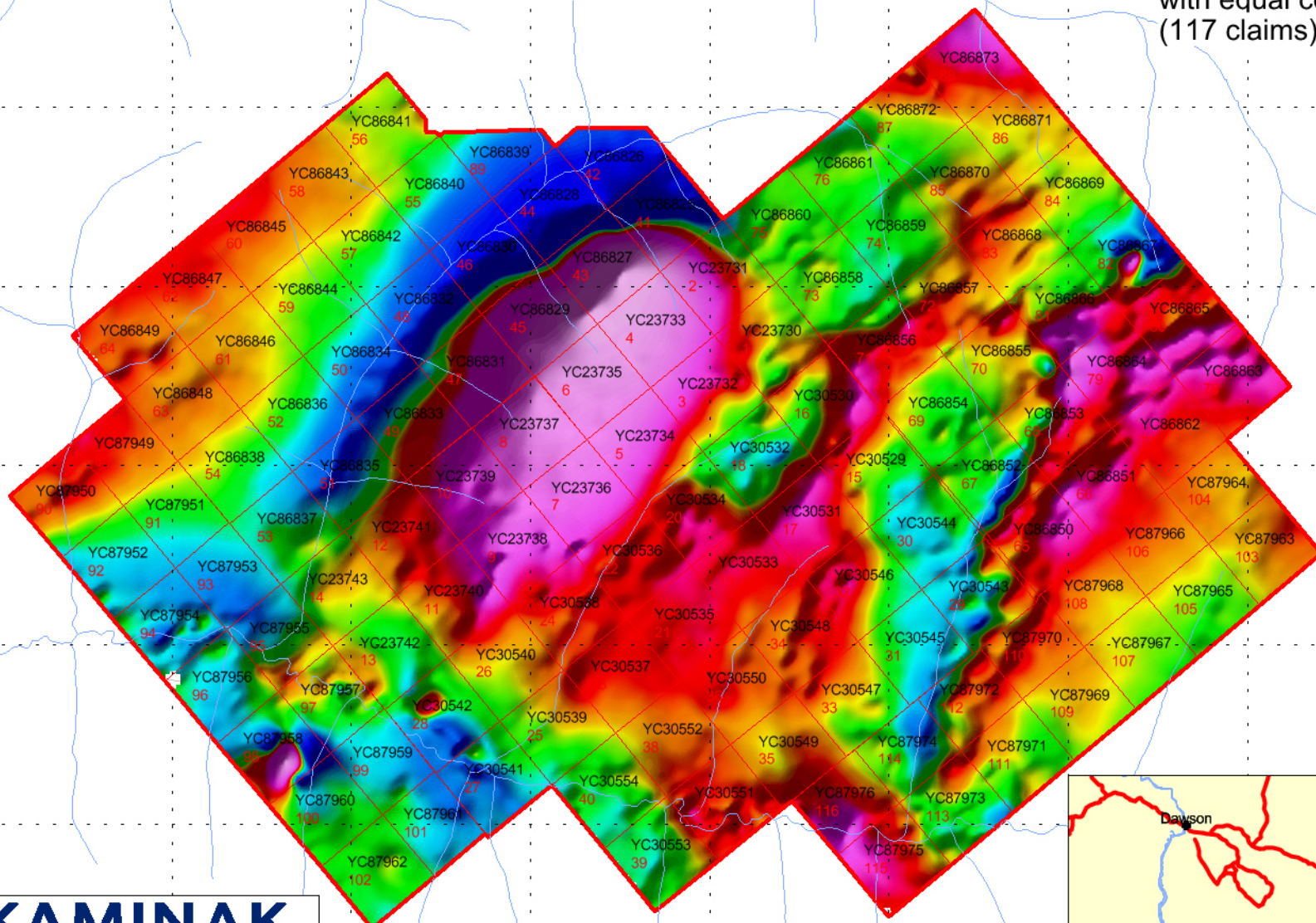
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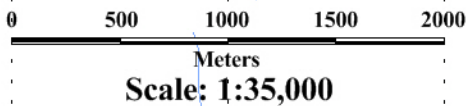
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Airborne magnetic survey performed on all claims with equal coverage (117 claims)



**Kaminak Gold Corp  
Kirkman Quartz Claims**



Date: Apr 2014    Proj: UTM7-NAD83    Drawn by: TB

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