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2022 Work Report
ATIKOKAN GOLD PROJECT
Helicopter Borne Airborne
Magnetic Survey
Atikokan Area, Ontario
Solstice Gold Corp.

Work Conducted: March 14 to March 29, 2022

NTS: 052B14, 052B15, 052G02, 052G03

Date Submitted: April 26, 2022

Work conducted by:

SHA Geophysics Ltd.

Work Report prepared by Steve Munro – SHA Geophysics Ltd

Report prepared by:

Bruce A. Barham, MSc., PGO

Senior Geologist

For: Solstice Gold Corp.

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1.0 SUMMARY

This report presents an airborne magnetic survey completed for Solstice Gold Corp over its Atikokan Gold Project located 26 km east of Atikokan, Ontario. Previous exploration results completed in the area of the property are also described. Additional exploration beginning with geological mapping, prospecting and a lidar survey is recommended.

A summary of the airborne survey parameters taken from the technical report in Appendix B is provided in Table 1 below.

Table 1: Atikokan Gold Project Helicopter Magnetic Survey Summary

Survey Statistics (see report Appendix B)		
Contractor: SHA Geophysics Ltd.		Survey Flown March 14-29 2022
Survey Size	5912	Line Km
Direction	110 and 290	Line Azimuths
Line Spacing	50	meters
Processing	10	cell size (meters), coordinates NAD 83 Zone 15

2.0 INTRODUCTION – EXPLORATION TARGET

This is the first report submitted by Solstice Gold Corp. (Solstice) on its recently acquired Atikokan Gold Project covering 262,268 Ha between Atikokan and Upsala, Ontario. Solstice is a gold explorer with expertise in the Precambrian geology of Northern Ontario and Nunavut, Canada. The Atikokan Gold Project claims cover underexplored portions of the Marmion Batholith and has only seen limited exploration in the past. The Atikokan Gold Project is transected by structures parallel or on strike with structures associated with recent gold discoveries in the Mercutio/Bedivere Lakes area. Solstice has initiated the exploration of the Atikokan Gold Project for its lode gold potential.

This report introduces the results of a helicopter borne airborne magnetic survey flown by SHA Geophysics Ltd. of Toronto, Ontario between March 14 and March 29, 2022. A technical report prepared by Steve Munro (SHA Geophysics Ltd, April 2022) provides the details of the survey. Figure 1 shows the location of the Atikokan Gold Project.

Personnel for the 2022 geophysical program were provided by the contractor, SHA Geophysics Ltd, and details are provided in Appendix B. This report is prepared by B. Barham, PGO, who assisted in the design of the survey, collated the acquired data and prepared the maps for this report.

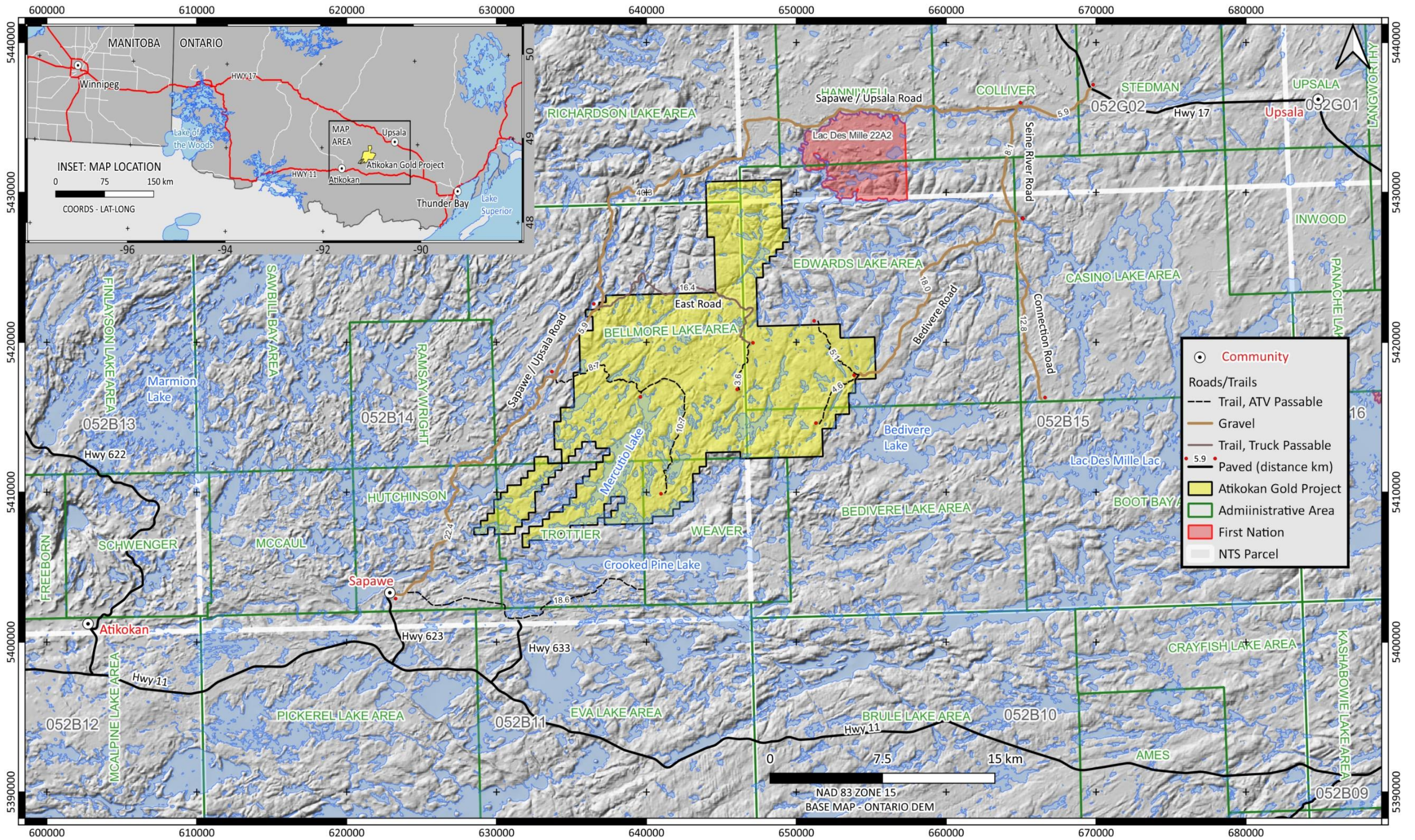


Figure 1: Atikokan Gold Project Location

3.0 PROPERTY DESCRIPTION, LOCATION

The Atikokan Gold Project is located about 26 kilometers east-northeast of the Atikokan townsite (Figure 1) and consists of single cell and multicell claims as shown on Figure 2 and listed in Appendix C.

The Atikokan Gold Project consists of 629 claims, including 583 single-cell mining claims and 46 multicell mining claims. All claims are active, 100% held by (10004221) Solstice Gold Corp. and recorded in the MLAS Ontario.

Twenty-nine cell claims (listed in Appendix C – Note *) were registered By Traxxin Resources Inc. (10002434) between July 30, 2020 and September 11, 2020. The claims were subject to different option and sales agreements with Traxxin Resources Inc., Gravel Ridge Resources Ltd. and 1544230 ONTARIO INC. whereby Solstice Gold Corp. became 100% owner and claims were transferred 100% to Solstice Gold Corp. by January 6, 2022.

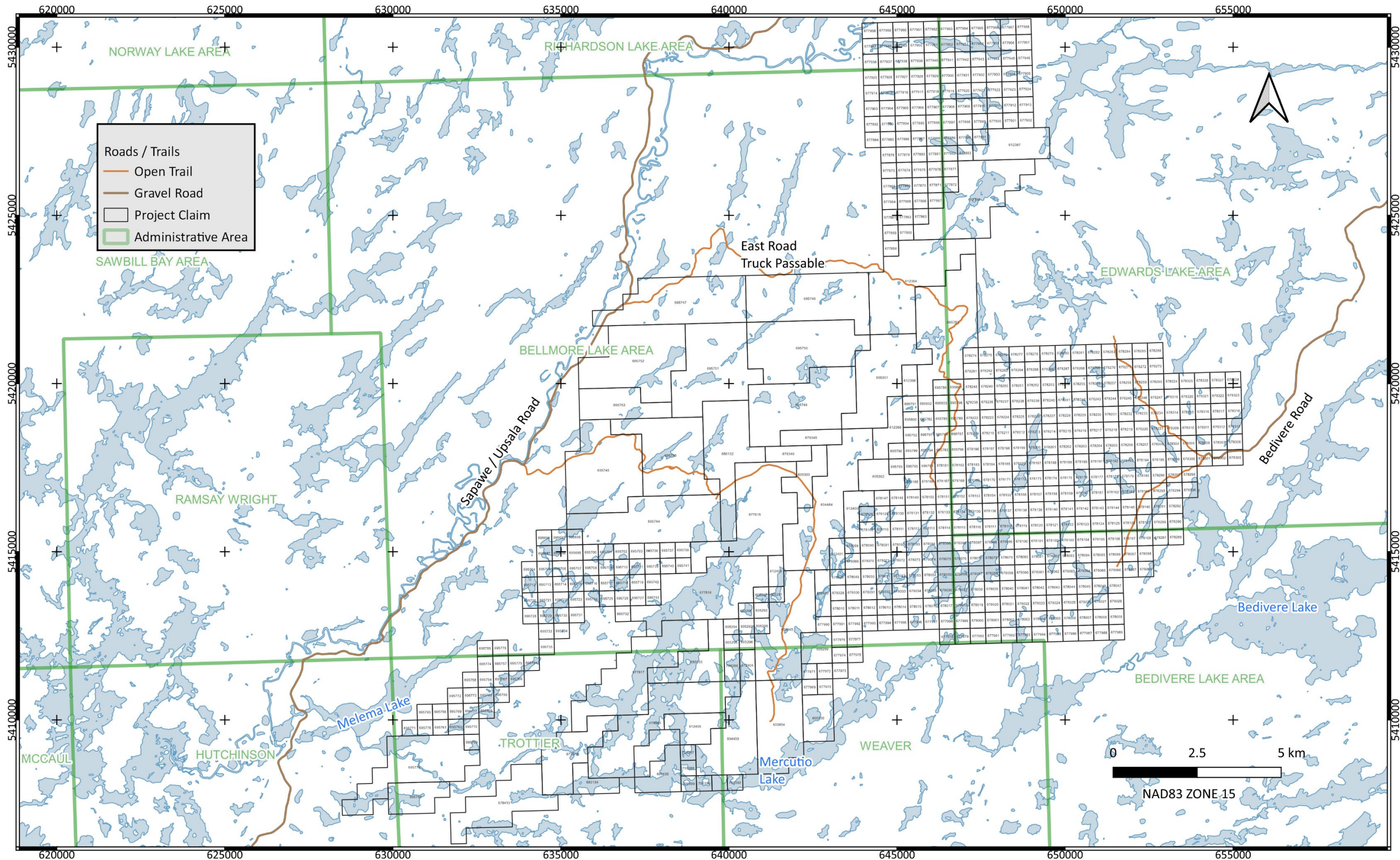
Twelve cell claims (listed in Appendix C – Note **) were registered by PERRY ENGLISH (129617) between September 23, 2021 and October 2, 2021 and transferred 100% to (10004221) Solstice Gold Corp on January 7, 2022. These cell claims are subject to an active option agreement dated December 10, 2021 between 1544230 ONTARIO INC., a company owned by Perry English, and operator Solstice Gold Corp.

Five hundred eighty-eight cell claims (listed in Appendix C – Note ***) were registered by (10004221) Solstice Gold Corp. Four hundred seventy-one of these cell claims were registered on September 24, 2021 with one hundred seventeen registered on December 8, 2021.

4.0 ACCESS, PHYSIOGRPAHY, CLIMATE, LOCAL RESOURCES

Atikokan and Upsala, Ontario are full-service communities where lodging, groceries, field gear, and shipping can be arranged. Vehicles can be rented in Thunder Bay, Ontario, about 2 hours' drive to the east-southeast.

The Atikokan Gold Project is located within the Thunder Bay Mining Division in northwestern Ontario, approximately 27 km northeast of the town of Atikokan. From Atikokan travel to Sapawe via Highway 11 and Route 623 (Figure 1). From Sapawe, follow the Sapawe / Upsala Road for 22.4 km to where an ATV passable trail leads east to Mercutio Lake. To access the northern part of the Property, follow the Sapawe / Upsala Road another 5.9 km to where the East Road, recently brushed and truck passable, leads east. From Upsala, follow Highway 17 west to the turn off for the Sapawe / Upsala Road. The East Road turn off is 46 km from the turn off on Highway 17. The eastern part of the property can be accessed from Upsala by turning south on the Seine River Road 5.9 km west of the Highway 17 turn off.



2: Atikokan Gold Project Claims

Figure

Follow the Seine River Road for 8.1 km south to the intersection with the Bedivere Lake Road. Follow the Bedivere Lake Road southwest for 18 km to the end of the road. Here the road has been trenched but ATV passable trails continue into the property.

The Property can also be accessed by float plane from the airbase in Atikokan. Larger lakes such as Mercutio Lake provide good access to the southern part of the property but larger lakes accessible by float plane are rare in the northern part of the property.

The Property drains west towards Lake of the Woods and then to the north through Lake Winnipeg to Hudson’s Bay. The landscape consists of gently rolling topography with vegetation typical of mixed mature and logged boreal forest. The Property is covered by unconsolidated glacial till and glacio-fluvial sand. Outcrop exposure is moderate and common on lakeshores.

Climate in the area is typical of Northern Ontario, with cold winters and warm summers. Average January minimum temperatures range from -18°C to -32°C, and average July temperatures are between 24°C and 32°C. Mapping, mechanized stripping, and soil sampling activities are best performed from spring to fall, whereas drilling can occur any time of the year.

5.0 HISTORY

The map of Stone (2010) includes a table listing historical mining activity in the map area with details taken from Wilkinson’s (1982) review of Gold Deposits of the Atikokan area and other references listed on his map. Four properties are listed from within the Marmion Batholith with historic gold production (Table 2).

Table 2: Marmion Batholith Historic Production – Hammond Reef Resources

PRODUCTION					
Property	Year(s)	Commodity	Tonnes	Grade g/t Au	Au Oz
Sapawe	1964-66	Au	38,009	5.09	6198
Sunbeam	1904	Au	589	14.7	277
Sawbill	1897-99	Au	2,192	8.6	604
	1940-41	Au	2,679	6.51	559
Hammond Reef	1897-98	Au	2,072	7.2	478
HAMMOND REEF RESOURCE (Agnico-Eagle Mines Ltd. 2021)					
Proven / Probable	2021	Au	123,473,000	0.84	3,323,000
Measured / Indicated	2021	Au	133,367,000	0.54	2,298,000

The location of these past gold producers are shown on Figure 3. The potential of the Marmion Batholith is shown by the large low-grade resource listed by Agnico-Eagle Mines Ltd (2021) for the

Hammond Reef Gold Deposit (Table 2). This deposit was largely delineated by Osisko Mining Corporation with Agnico-Eagle Mines Ltd acquiring a 100% interest in 2018.

Fenwick (1976) and Wilkinson (1982) describe Marmion-type gold deposits as formed by quartz veins hosted by shear zones associated with north-east trending lineaments. Wilkinson (1982) further indicates that carbonatized, sericitized and sheared lenses of massive trondhjemite adjacent to and within north-east lineaments are favoured host rocks. Complex gneissic rocks within the batholith are less favoured. A comprehensive discussion of these topics can be found in Wilkinson (1982).

In the Bedivere Lake area, prospecting and sampling by Traxxin Resources Inc. (and associated companies) began in 2011 and culminated in the 2016 discovery of a quartz vein with visible gold assaying 1,281 g/t Au (41 oz/t Au, Puumala et al 2017, Figure 3). This property is currently held in joint venture with Bold Ventures Inc. and Lac Des Mille Lac First Nations where recent results continue to expand a northeast trending gold zone (Bold Ventures, 2022).

West of the Atikokan Gold Project, Traxxin Resources Inc. prospected their Melema West Property beginning in 2017 resulting in the discovery of two new gold zones (Schneider and Frymire, 2018). The property is under joint venture with Agnico-Eagle Mines Ltd. and recent channel sampling of 4.29 g/t Au over 4.4 meters (Figure 3) has been reported by Dix (2021).

These recent results are from quartz veins in carbonatized north-east trending structures confirming the observations of Fenwick (1976) and Wilkinson (1982). This Marmion deposit description, modified by later work, is the target of exploration for Solstice Gold Corp.

Other assessment records for the Atikokan Gold Project are listed on Table 3.

Table 3: Atikokan Gold Project – Assessment Records

Year	Record	Sponsor	Target	Note
1978	52B155E0014	Rio Tinto	Gold, Base Metals	Airborne Magnetometer Survey
1982	52G03SE0016	Mining North Explorations Ltd.	Gold, Base Metals	Airborne VLF-EM, Magnetometer
1985	52B14SE0017	Interquest Resources Corporation	Gold, Base Metals	Airborne VLF-EM, Magnetometer
1989	52B14SE8115	Rogi Exploration	Gold, Base Metals	Airborne VLF-EM, Magnetometer
1989	52B155W0003	MCS Capital Ltd	Gold, Base Metals	Airborne VLF-EM, Magnetometer
1992	52G10NW0001	Southampton Ventures Inc	Kimberlite	Lake Sed Anomalies, Magnetic spot highs, 6 Winkie DH - Negative
1999	MRD043	Ontario Geological Survey	General	Atikokan-Lumby Lake Area - Lake Sediment Geochemistry
2003	GDS1029	Ontario Geological Survey	General	Atikokan - Mine Centre - Airborne VLF-EM, Magnetometer
2012	20000006569	J. Clark Prospector	Gold	Lake Sediment Gold Anomalies, Lost Moose Claims

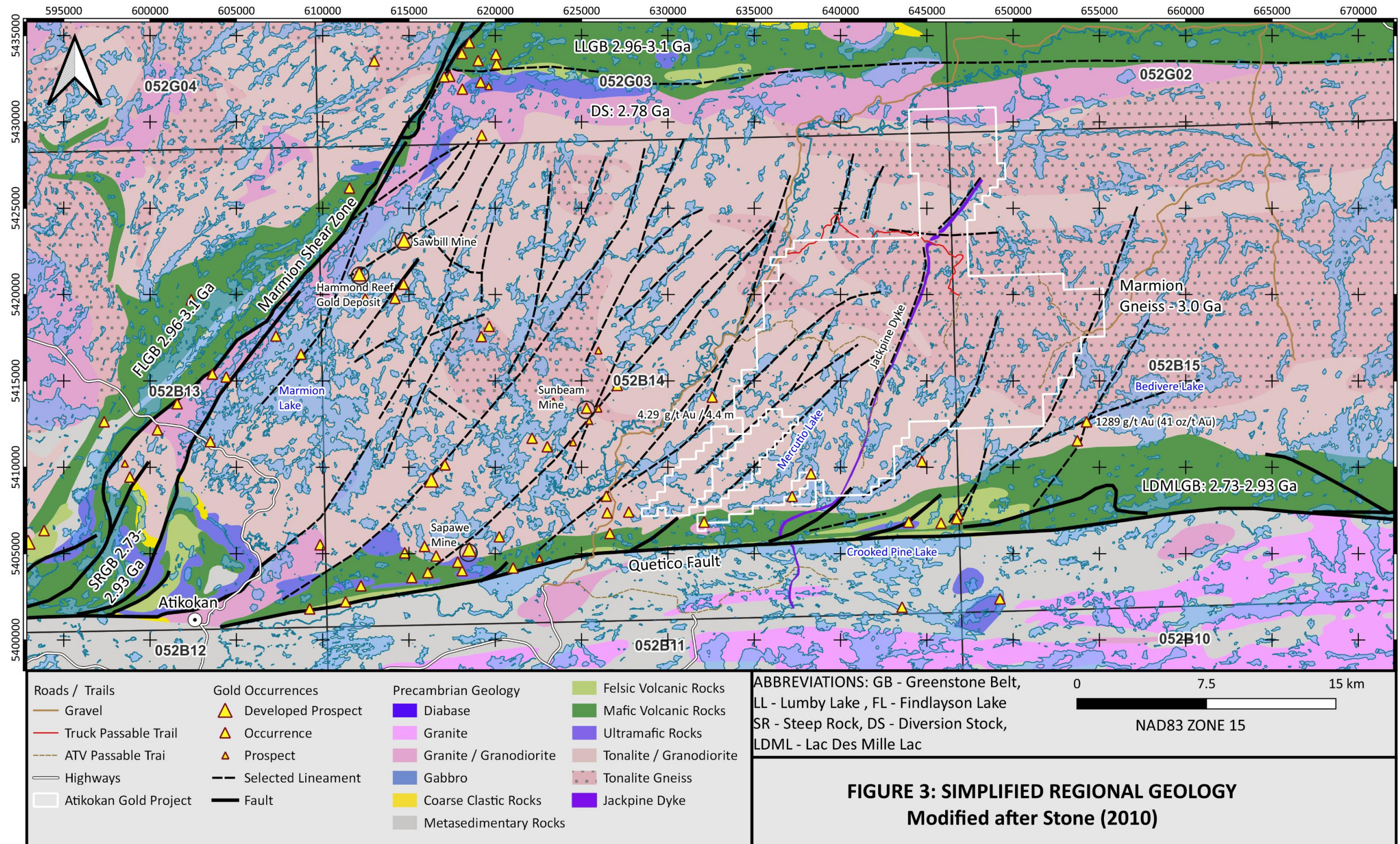


Figure 3: Atikokan Area, Regional Geology

Very little work has been filed within the boundaries of the Atikokan Gold Project. Exploration has focused on the Lac des Mille Lac greenstones with airborne surveys sometimes covering the southern claims of the current Atikokan Gold Project. This data is not covered further as the data is supplanted by Ontario Geological Survey magnetometer – EM survey GDS1029 (2003) that provides continuous high-quality coverage of the property. This survey is reviewed later in this report. In 2006, Southampton Ventures Ltd tested potential kimberlite targets on the basis of lake sediment chemistry and bulls-eye magnetic anomalies. Six Winkie drill holes were drilled to test for kimberlite with negative results (Boyd, 2006). Puumala et al (2017) drew attention to a cluster of gold in lake sediment anomalies (Lost Moose anomalies, see Figure 4) that Clark (2012) investigated. Clark (2012) confirmed the gold in lake sediment anomalies but was unable to locate a bedrock source.

The airborne survey described in this report was initiated to refine the resolution of prospective structures within the Marmion Batholith.

6.0 REGIONAL AND LOCAL GEOLOGY

6.1 Regional and Property Geology

Important bedrock geology maps for the Atikokan area were published by Shklanka (1972), Fenwick (1976), Pirie (1978) and more recently by Stone (2010). Stone (2010) is compiled and modified from years of mapping (Stone 2005, Stone 2008a, 2008b, 2008c). The source maps are important as they typically include outcrop locations not shown on Stone (2010). Some mappers such as Fenwick (1976) include an interpretation of lineaments along with a discussion in the accompanying text. Lineaments shown on Figure 3 are a combination of those highlighted on historic maps, private company press releases, and include some interpreted from a preliminary interpretation of provincial airborne magnetic and digital elevation data performed by the author.

The Marmion Batholith forms part of the Marmion Terrane, a subarea of the granite-greenstone Wabigoon Subprovince. The Wabigoon Subprovince forms a fundamental tectonic block of the Superior Province of the Canadian Shield (Percival, 2007). The Marmion Batholith consists of +/- 3.0 Ga principally tonalite to granodiorite foliated basement complex divided into gneissic hornblende-biotite variants and more massive granitoids with minor ferromagnesian minerals (Figure 3). Surrounding volcanic dominated greenstones of the Lumby Lake, Findlayson, Steep Rock and Lac des Mille Lacs greenstone belts have similar maximum ages. Chemical sediments dominated by carbonate and iron

formation occur locally with some providing important sources of historic iron ores (Shklanka, 1972). Both Archean and Proterozoic diabase dykes are widely reported but few are shown on any published maps.

The thesis of Backeberg (2015) documents the geologic history of the Findlayson Lake Greenstone Belt and Marmion Batholith and integrates the results with a detailed study of the mineralization at the Hammond Reef Gold Deposit. Table 4 summarizes relationships documented by Backeberg (2015).

Table 4: Geologic Relationships, Hammond Reef (Modified from Backeberg, 2015)

	PRIMARY	WABIGOON		SUTURE FLGB-MT	SUPERIOR ASSEMBLY		
+/- Ga	3.00	2.93		2.78			2.68
Defm	FINDLAYSON	D1	D2	D3	D4		QUETICO FAULT
Defm Detail		Schist	Sin Trans	Flat	brittle faults, reactivation		
Short Dir			NNW	NW	NW		
Chlorite			Chlorite				
	MARMION	MSZ	7-13 km throw	Suture	minor movement		
GOLD					Disseminated	Veins	
Sericite					sericite		
Chlorite				Chlorite			
Defm			Gneissosity	D3	D4		
Defm Detail		Mineral Align	Flat	Fault	Foliation	Thrust	
Short Dir			NW		NW	NW	
ABBREVIATIONS: FLGB - Findlayson Lake Greenstone Belt, MT - Marmion Terrane, Defm - Deformation							QUETICO FAULT
Dir -- Direction, MSZ - Marmion Shear Zone, Align - Alignment, Sin Tran - Sinistral Transpression, Flat - Flattening							QUETICO SEDIMENTS

Compiled and Modified after Backeberg (2015).

Backeberg (2015) provides plagioclase-hornblende pair thermobarometry suggesting that prior to D3 the Findlayson Lake Greenstone Belt (FLGB) was buried some 10 km deeper than the Marmion Batholith. D3 involved widespread retrogressive chloritization and dip slip movement of the FLGB up relative to the Marmion Batholith. This deformation was accompanied by the intrusion of the Diversion Stock at 2.78 Ga after which the Marmion Shear Zone is dormant and alteration becomes localized in anastomosing sericite-rich zones that record flattening (D4). Lower grade disseminated gold is introduced with pyrite within the sericitic zones. Late D4 is marked by higher grade quartz carbonate veining associated with west directed thrusting. At Hammond Reef, the Az 050° east-dipping Lynx Head Thrust Fault brings unaltered Marmion granitoids over chlorite and sericite altered granitoids. Backeberg (2015) remarks on the persistent NE-SW lineaments within the Marmion Batholith he that are parallel to the Lynx Head Fault that could be surface expressions of similar thrust faults recording late NW-SE shortening.

The Marmion Batholith's south contact is marked by the crustal scale Quetico Fault with metasedimentary rocks of the +/- 2.7 Ga Quantico Subprovince to the south. Stone (2010) lists many authors who have examined this structure stating that most agree the fault postdates other deformation and has dextral displacement of the order of 150 kilometers. This fault zone can be up to 1 km in width and is characterized by intense and steeply dipping foliations.

On lithoprobe sections, the Quetico metasedimentary belt is modeled as a thin wedge overlying shallowly north dipping reflectors representing the upper surface of the underlying Wawa subprovince or related oceanic type crust (Percival et al 2006). Beckeberg (2015), Stone (2010) and Percival (2006) agree the Quetico Fault is part of the surface expression of the +/- 2.7 Ga north dipping subduction of the Wawa subprovince beneath the Wabigoon (Marmion) Terrane.

Little is known beyond what is shown on regional maps. Stone (2010) indicates several splay faults rooted on the Quetico Fault arcing to the north-east into the Atikokan Gold Project. A central magnetic anomaly within the property has been identified as corresponding to a north-east trending mafic dyke (Jackpine Dyke).

6.2 Mineralization

The Atikokan Gold Project is flanked by recent discoveries that support the basic properties of a Marmion type gold occurrence as defined by Wilkinson (1982) and whose basic characteristics are reiterated by Beckeberg (2015). The area under claim has not had any substantial exploration work filed for assessment. North-east trending lineaments coupled with lake sediment anomalies (Figure 4) suggest the possibility for the discovery of new mineralized zones as has been demonstrated on adjacent properties. Figure 4 compares the first vertical derivative of the Ontario Geological Survey dataset GDS1029 (2003) covering the Marmion Batholith with the first vertical derivative of the survey completed by SHA Geophysics Ltd over the Atikokan Gold Project (Appendix B).

A central magnetic feature trends north north-east across the Atikokan Gold Project (Figure 4). cursory examination of this anomaly by the vendor of the claims identified a mafic dyke (Jackpine Dyke) with reports of carbonate altered outcrops with quartz veins and pyrite. This prompted the initial acquisition of the claim group.

Initial examination of the airborne survey (Figure 4) reveals north-east linear trends. Gold in lake sediment anomalies at the 85th percentile are clearly aligned along some structures. Structures mapped by Stone (2010) splay off the Quetico Fault trending into the Atikokan Gold Project. Additional

interpretation and ground mapping and prospecting along north-east trends and ground truthing lake sediment anomalies is required. The Lost Moose area mentioned previously is shown on Figure 4.

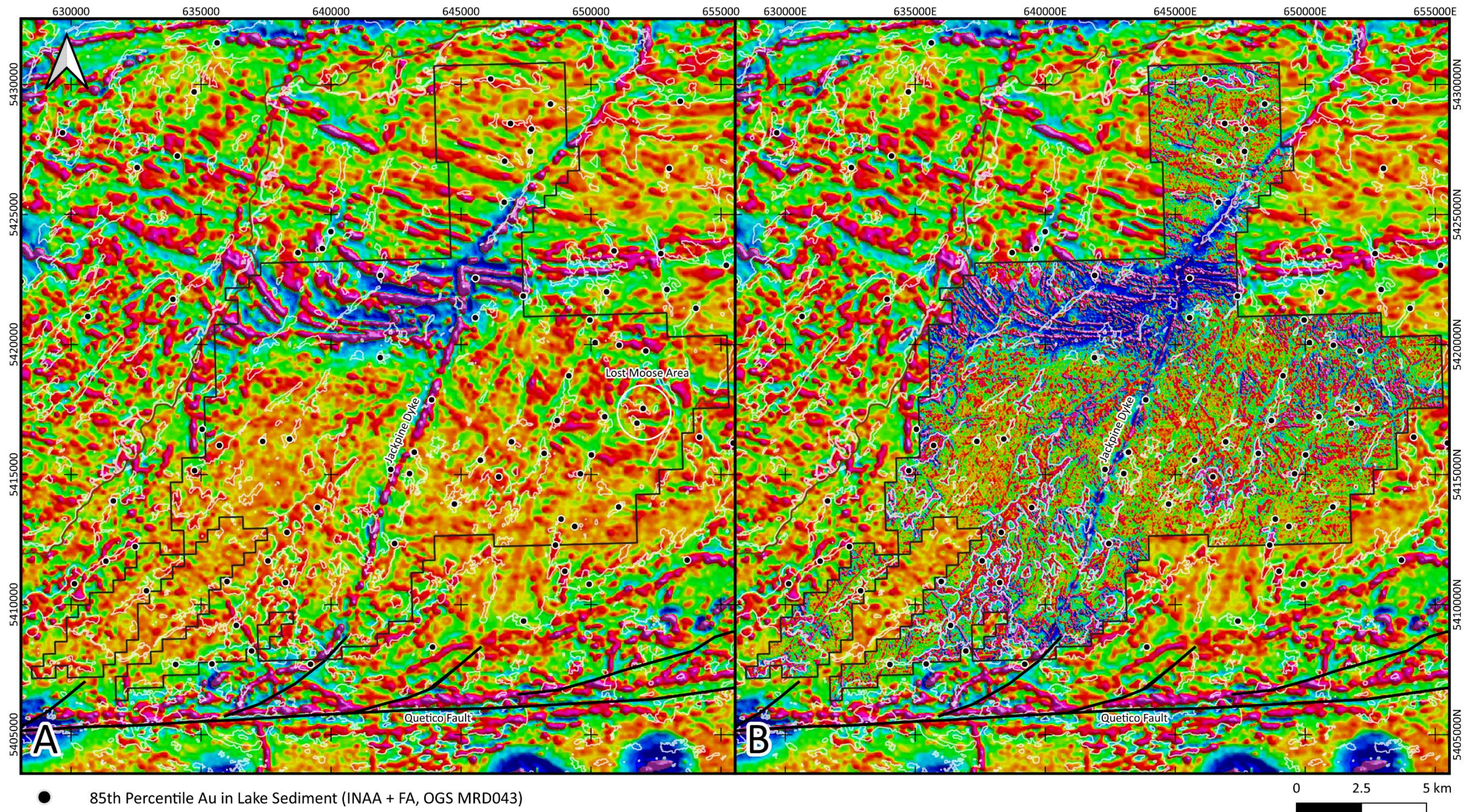


Figure 4: Ontario Geological Survey 1st Vertical Derivative (4A), First Vertical Derivative of SHA Magnetic Survey (2022: This Report) (4B)

7.0 EXPLORATION

Exploration of the property is limited to the historical description provided above. The airborne magnetic survey described here constitutes the initial exploration conducted by Solstice Gold Corp. Appendix B (Munro, 2022) describes the survey and the products resulting from the helicopter airborne survey. In addition to the first vertical derivative map shown on Figure 4, other products include a digital terrain model, total field magnetic map, tilt derivative map, analytical signal map, horizontal gradient map and second vertical derivative map.

A brief summary of SHA Geophysics' flight specifications is provided below. More details are presented in Table 1.

- Traverse Direction: 110° – 290°
- Traverse Spacing: 50 m
- Control Direction: 30° – 210°
- Control Spacing: 1,000 m
- Terrain Clearance: 30 m
- Block Production: 5,912 km

8.0 INTERPRETATION

An interpretation of the main elements of the magnetic survey awaits careful examination of the provided maps and integration with digital elevation products. A prominent mafic dyke, visible in government surveys, dominates the central portion of the survey. Detailed magnetic data sharply define prospective north-east trending lineaments. The north-central portion of the survey reveals an area of repeated curvilinear stronger magnetic anomalies with complex structure not revealed by public domain, wider-spaced surveys. There is a strong correspondence of anomalous gold in lake sediment anomalies with some clearly defined magnetic trends. A Digital Elevation Model (“DEM”), derived from the 50m-spaced flight lines provides additional detail since many structural features have topographic expression.

9.0 RECOMMENDATIONS

The magnetic and DEM survey provides a powerful base for further exploration of the Atikokan Gold Project. Ground geological mapping and prospecting are recommended to aid in the development of a comprehensive exploration program. North-east and north-north-east lineaments require mapping and prospecting. Lake sediment anomalies help delineate prospective lineaments. Lidar and high resolution

orthophotography could further aid in the identification of prospective lineaments / structures.

Induced polarization test surveys should be considered to identify buried sulphidic segments of prospective targets. Wilkinson (1982) cautions that mineralized fault structures within the Marmion Batholith rarely outcrop.

Costs of the recommended work are included in Table 5.

Table 5: Costs of Recommended Future Work

Work Program	Approximate Cost (\$CDN)
Prospecting & Mapping Program	\$200,000
Ground IP Survey	\$100,000
Lidar and Orthophotography	\$45,000
TOTAL	\$345,000

10.0 REFERENCES

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APPENDIX A: Statement of Qualifications

April 26, 2022

I, Bruce Alexander Barham, do hereby certify that:

- 1 – I hold a Bachelor of Science, Honours in Geology from the University of Manitoba (1984) and a Master of Science, Geology from Carleton University, Ottawa, Ontario, 1987.
- 2 – I am a Professional Geoscientist (PGO number 3406) registered with the Professional Geoscientists of Ontario.
- 3 – I am employed by Solstice Gold Corp. whose head office is Suite 550 - 800 West Pender Street Vancouver, BC, Canada, V6C 2V6
- 4 – I am the author of this Technical Report on the Atikokan Gold Project, Atikokan, Ontario.
- 5 – I supervised the work reported on in this report.
- 6 – This report is complete and correct to the best of my knowledge.

Signed,



Bruce A. Barham, PGO

Senior Geologist

Solstice Gold Corp.

Calgary, Alberta

APPENDIX B: Report

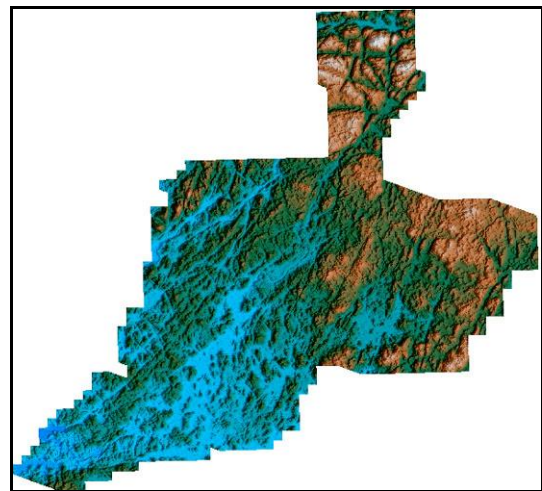
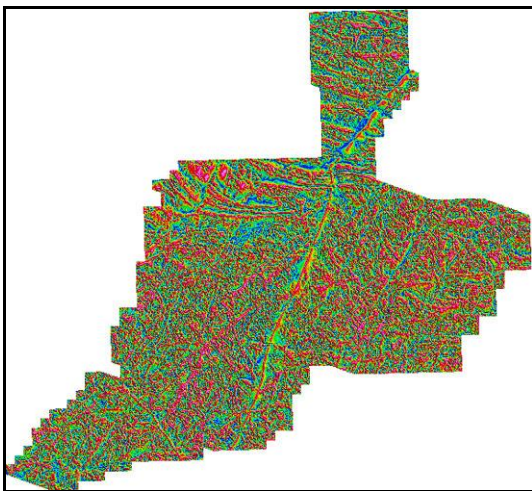
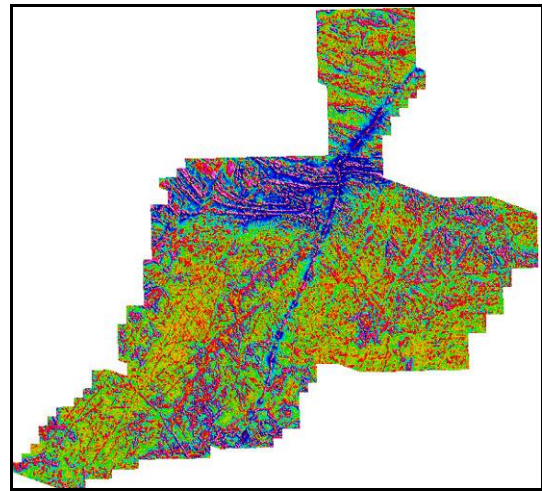
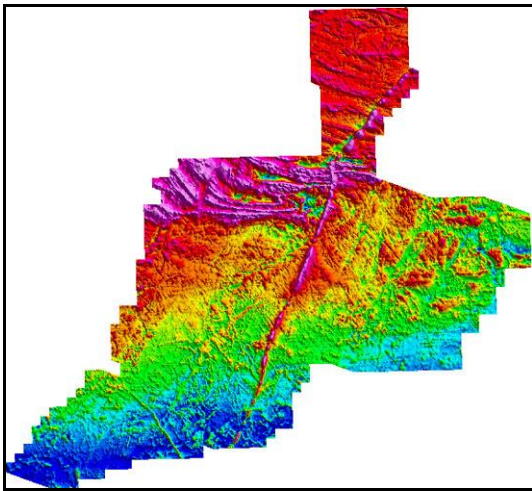
**High-Resolution Heliborne Magnetic Survey
Atikokan Gold Project, Atikokan Area
Thunder Bay Mining Division, Ontario
Technical Report prepared by S. Munro, BSc. April 2022**

Solstice Gold Corp.

Heli-GT Three-Axis Magnetic Gradiometer Survey

Atikokan Gold Project
Ontario, Canada

Operations and Processing Report



By

SHA GEOPHYSICS LTD

April 2022

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1 INTRODUCTION

In February 2022 Solstice Gold Corp. (SGC) contracted SHA Geophysics Ltd. (SHA) to carry out a Heli-GT helicopter-borne, three-axis magnetic gradiometer survey over an area of interest to the company in the vicinity of Atikokan, Ontario, Canada. Equipment and crew mobilized to the base of operations on Monday, March 14th, 2022 and during the period March 14th to March 29th, 2022 a total of 5912 km of data was collected. Details of the airborne survey and compilation are documented in this report.

2 LOCATION

The survey block was located in Northwestern Ontario, approximately 40 kilometers east-northeast of the town of Atikokan, Ontario. See Figure 1 below.

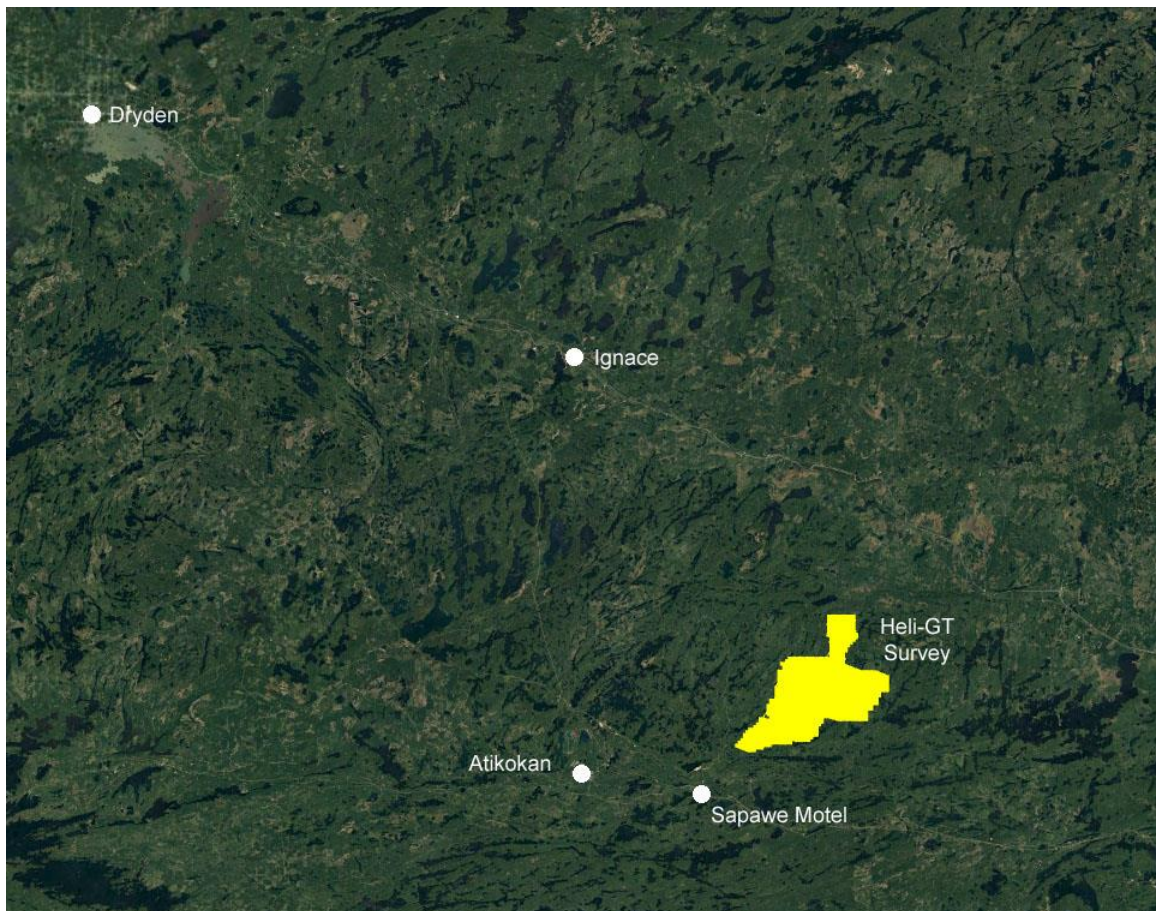


Figure 1 - Location Map.

3 AIRBORNE SURVEY

The survey was based out of the Sapawe Motel, located along Highway 17, approximately twenty kilometers east of Atikokan, Ontario. Crew and equipment mobilized to the base of operations on Monday, March 14th, 2022. Surveying was conducted during the period March 14th to March 29th, 2022. The following table summarizes flight specifications of the block.

3.1 Flight Specifications

Traverse Direction	110° – 290°
Traverse Spacing	50 m
Control Direction	30° – 210°
Control Spacing	1000 m
Terrain Clearance	30 m
Block Production	5912 km

3.2 Helicopter

Helicopter Owner / Operator	Expedition Helicopters, Cochrane, Ontario
Helicopter Model	A-Star 350BA+
Helicopter Registration	C-FODI

3.3 Personnel

The following personnel were involved in the survey:

Field

Technical Operations Manager	Frazer Hogg
Project Geophysicist	Steve Munro
Pilot	Nick Greenfield
Fuel Truck Driver	Lance Gunter

Office

Compilation and Reporting	Steve Munro
Project Management	Scott Hogg

4 GEOPHYSICAL SYSTEM

The airborne geophysical Heli-GT system consists of a towed bird that contains all of the geophysical sensors as well as altimeter and GPS antennae. A computer based recording and navigation system is located in the helicopter.

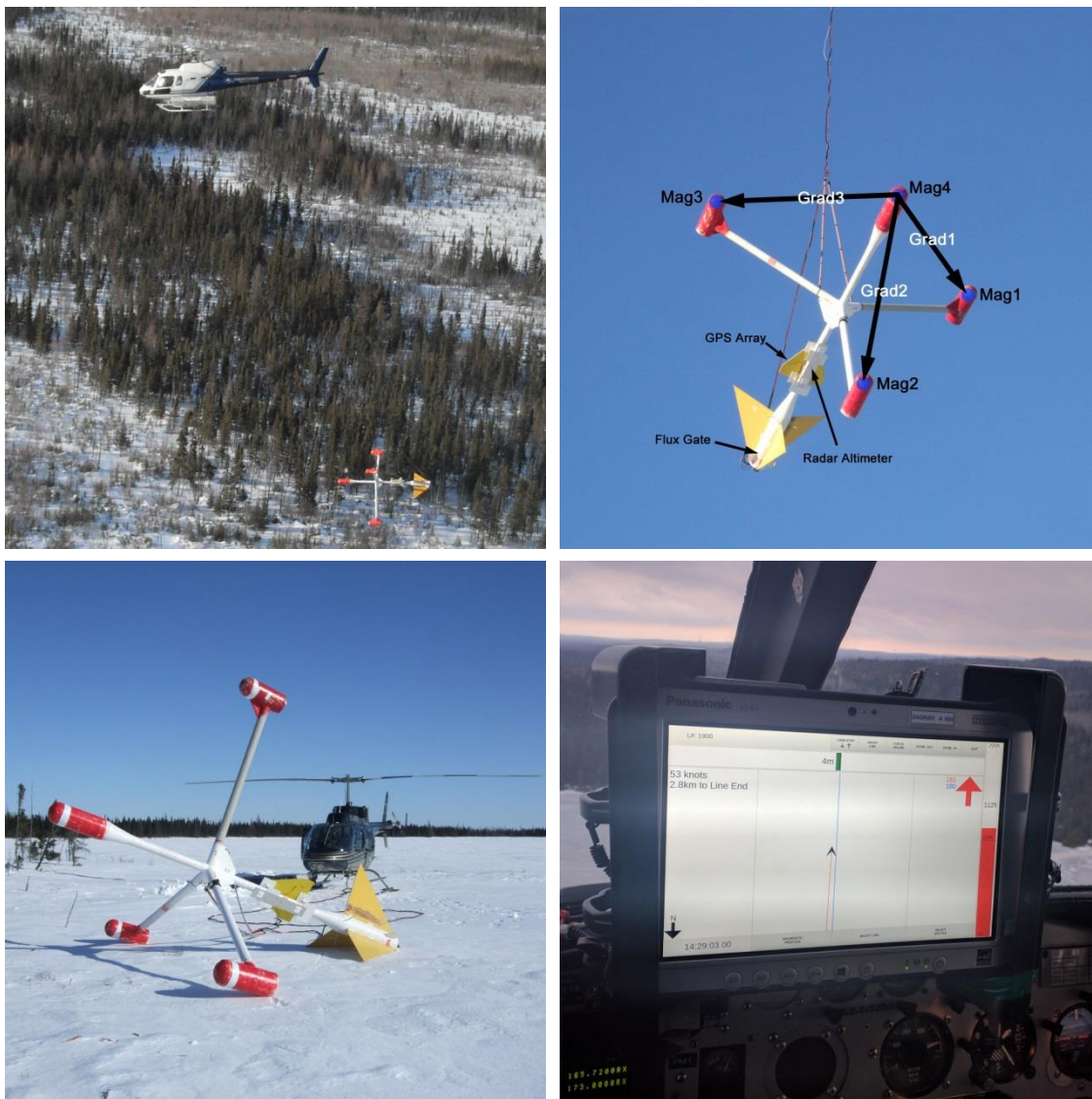


Figure 2 – The Heli-GT bird is towed 25 m below the helicopter. The basic orthogonal magnetic gradients G1, G2 and G3 are measured on 3 metre baselines. A radar altimeter and 4 GPS antennae are mounted on the towed bird. In the helicopter a touch screen computer tablet logs the data and directs navigation.

4.1 Bird

All of the geophysical and ancillary equipment is housed in a towed bird designed by SHA Geophysics Ltd. The bird is manufactured from non-magnetic FRP and breaks down for ease of transportation.

4.2 Magnetic sensors

Four Scintrex CS-3 cesium sensors are arranged in an orthogonal array with 3 m sensor separation from the nose sensor to those at the end of each arm. The output from each sensor was processed by a KVS KMAG4 unit to resolve the magnetometer output to a resolution of about 0.005 nT at a rate of ten samples per second. The Heli-GT bird was flown at a nominal altitude of 30m.

4.3 Radar Altimeter

A Terra TRA 3500 / TR 140 radar altimeter was used to measure bird height above ground. The range of operation was from 0 to 2500 ft.

4.4 Fluxgate Magnetometer

A Billingsley TFM100G2 3-axis fluxgate magnetometer was used to record the orientation of the bird with respect to the earth's magnetic field. The range of each component of the fluxgate was +/- 100,000 nT.

4.5 Analog to Digital ADC

The analog output of the radar altimeter and fluxgate magnetometer were digitized with a KVS KANA8 eight-channel differential ADC. The device provides 24 bit resolution and was operated at 10 Hz.

4.6 GPS System

GPS positional information was recorded using an array of four 12-channel receivers mounted on the Heli-GT bird. In addition to the measurement of Latitude, Longitude and Altitude a calculation of bird pitch, roll and yaw was calculated from differences between antennae with an accuracy better than 1 degree.

4.7 Navigation and Recording System

The navigation and recording system used was the DAQNAV, developed by SHA Geophysics. Both navigation and data recording are carried out using a tablet computer mounted in the helicopter cockpit. The tablet's touch screen provides an operator with an interface for monitoring the geophysical and ancillary instrumentation, as well as presenting graphic navigation information for the pilot.

The PPS pulse from the GPS system was recorded and tied to each of the sensors with an accuracy of about +/- 0.05 seconds.

Data recorded included the following:

Magnetic sensors:	10 Hz
Fluxgate sensors:	10 Hz
Radar Altimeter:	10 Hz
GPS X / Y / Z:	5 Hz
GPS Pitch / roll / yaw:	5 Hz

4.8 Base Station

A magnetic and GPS base station was established at the base of operations. A GEM SSM19TW proton magnetometer recorded the diurnal magnetic variation at 1 Hz with a resolution of 0.1 nT. A Ublox EVK-M8 GPS receiver provided a GPS time reference and recorded a differential correction file.

5 DATA COMPILATION

5.1 Basic Processing

The data collected during flight, in the air and from the base station, was aligned with reference to GPS time. Each of the four magnetometer channels was compensated to remove magnetic error associated with bird orientation. The basic magnetic gradient components; G1, G2 and G3, measured from the nose sensor (mag4) to each of the radial sensors (mag1, mag2 and mag3) were calculated. Any noise spikes, if present, were identified and removed.

A low-pass filter was applied to the base station data to eliminate short wavelength artifacts. A median value was removed from the base station profile to create a diurnal correction profile, which was subtracted from the compensated mag4 profile. The base station corrected total field profile was stored as *mag_diur*. A small lag was applied to the diurnally-corrected profile and stored as *mag_lag*.

5.2 Gradient Processing

The recorded pitch, roll and yaw of the bird were used to mathematically rotate the measured basic gradient components to true G-north, G-east and G-down.

The GPS altitude of the bird was used to calculate a smooth drape surface. This is a smooth theoretical surface above the terrain that the bird would follow under ideal conditions. There would be only smooth altitude changes, line to line and along the flight line. The difference between the GPS altitude of this smooth drape surface and the actual GPS altitude of the bird was combined with the measured vertical gradient to calculate an altitude correction. The altitude correction was applied to *mag_lag* and the resulting profile was stored as *mag_alt_cor*.

5.3 Magnetic Levelling

The channel *mag_alt_cor* was used as input to the control line levelling process.

The intersections between traverse and control lines were calculated and the differences between the magnetic values were measured. Ignoring unreliable differences in locations of steep magnetic gradient, a correction was calculated to eliminate the measured differences at the intersections. This correction profile was a piecewise linear function between intersections. The control line leveled magnetic profile was stored as *mag_TL_lev*. A final microlevel correction was calculated and applied. The final data channel was stored as *mag_fin*.

5.4 Gradient Tensor Gridding (GT-GRID)

GT-Grid is a proprietary gridding program developed by SHA Geophysics that uses total magnetic field data as well as the measured horizontal gradient data to produce a total magnetic field grid. The total magnetic field grid produced by GT-Grid is a fully conformal process that simultaneously honours the total field as well as the measured horizontal gradient profile data.

The final, leveled total field magnetic channel (*mag_fin*) and the G-east (*Ge*) and G-north (*Gn*) gradient channels, were used by the GT-GRID process to calculate a total field magnetic grid.

5.5 Pole Reduction

The anomaly shape associated with a vertically dipping magnetic source varies with the inclination of the earth's magnetic field. At the north and south magnetic pole, the inclination is vertical and the anomaly is positive, symmetrical and centered directly over the source. At the equator, with a horizontal inducing field, the anomaly is negative, symmetrical and centered directly over the source. Between 0 and 90 degrees of inclination the anomaly is asymmetric, with a positive and negative component, and is not centered over the source. The pole reduction process reshapes the anomaly measured at intermediate inclinations to resemble the shape that would have been measured at vertical inclination. Thus a steeply dipping source, without remanent magnetization, would be transformed to a simple positive peak above the source. A pole-reduced TMI grid was calculated.

5.6 First and Second Vertical Magnetic Gradient

The vertical gradient accentuates shorter wavelengths and attenuates longer wavelengths. As a result, the map enhances the anomalies associated with small near-surface magnetic sources while suppressing large-scale regional variations. The vertical gradient presentation provides added visual detail, particularly for small anomalies superimposed on or adjacent to larger anomalies.

The measured or calculated vertical magnetic gradients are also sensitive to the inclination of the earth's magnetic field. In the same manner as the total field, the asymmetry and peak displacement, arising from an inclined field, is removed by the pole reduction process. The horizontal width of the vertical gradient anomaly is about one half of that of the total field anomaly. If the width of the magnetic source is significant, greater than the sensor height above the source, the zero contour of the pole reduced vertical gradient reflects the location of the magnetic contact and the response peak will lie directly above a steeply dipping source.

Using an FFT filter, a pole-reduced first and second vertical derivative grid was created.

5.7 Horizontal Gradient

This is the scalar amplitude of the horizontal gradient vector, calculated from the total magnetic field GT-Grid. The horizontal gradient grid is useful for highlighting geological contacts.

$$\text{HGrad} = \left(\left(\frac{dB}{dx} \right)^2 + \left(\frac{dB}{dy} \right)^2 \right)^{\frac{1}{2}}$$

5.8 Analytic Signal

The analytic signal grid presents the scalar magnitude of the full magnetic gradient vector. The analytic signal reflects proximity to the magnetic source, independent of source dip, magnetic field inclination or remanent magnetization.

$$\text{ANS} = \left(\left(\frac{dB}{dx} \right)^2 + \left(\frac{dB}{dy} \right)^2 + \left(\frac{dB}{dz} \right)^2 \right)^{\frac{1}{2}}$$

5.9 Tilt Derivative Angle

The tilt angle of the magnetic derivative is calculated in radians.

$$\text{TDrv} = \tan^{-1} \left[\frac{dB/dz}{\left(\left(\frac{dB}{dx} \right)^2 + \left(\frac{dB}{dy} \right)^2 \right)^{\frac{1}{2}}} \right]$$

The tilt angle is independent of magnetization and helps emphasize weak anomalies.

5.10 Digital Terrain Model

The digital terrain model was calculated by subtracting the radar altimeter profile from the GPS altitude. Errors in GPS altitude were corrected by microlevelling. The digital terrain was gridded for the survey block using a bi-directional Akima interpolation.

6 DIGITAL DATA ARCHIVE

All of the maps, grids and profile data have been provided in digital form.

6.1 Profile Data

The profile data for the survey block is provided in Geosoft "gdb" format, including the following channels.

Channel	Units	Content
gpstime	seconds	GPS time
x	metres	UTM easting NAD83, Zone 15n
y	metres	UTM northing NAD83, Zone 15n
lon	degrees	GPS Longitude WGS84
lat	degrees	GPS Latitude WGS84
gpsalt	metres	GPS altitude NAD83
radalt	metres	radar altimeter (bird height)
DTM	Metres	levelled Digital Terrain elevation
fx	nT	Fluxgate axis x (forward)
fy	nT	Fluxgate axis y (port)
fz	nT	Fluxgate axis z (up)
heading	degrees	Bird heading
pitch	degrees	Bird pitch
roll	degrees	Bird roll
basemag	nT	Filtered base station magnetometer
mag1_raw	nT	Raw upper port magnetometer
mag2_raw	nT	Raw down magnetometer
mag3_raw	nT	Raw upper starboard magnetometer
mag4_raw	nT	Raw nose magnetometer
mag1_comp	nT	Compensated upper port magnetometer
mag2_comp	nT	Compensated down magnetometer
mag3_comp	nT	Compensated upper starboard magnetometer
mag4_comp	nT	Compensated nose magnetometer
G1	nT/m	Magnetic gradient: mag4 to mag1
G2	nT/m	Magnetic gradient: mag4 to mag2
G3	nT/m	Magnetic gradient: mag4 to mag3
GT	nT/m	Measured magnetic Transverse gradient
GL	nT/m	Measured magnetic Longitudinal gradient
GD	nT/m	Measured magnetic Down gradient
GE	nT/m	Measured magnetic East gradient
GN	nT/m	Measured magnetic North gradient
GV	nT/m	Measured magnetic Vertical gradient
mag_diur	nT	Base station corrected magnetic profile
mag_lag	nT	Lagged magnetic profile
mag_alt_cor	nT	Altitude-corrected magnetic profile
mag_TL_lev	nT	Tie line network leveled magnetic profile
mag_fin	nT	Final microlevelled magnetic profile

6.2 Gridded Data

The grids, projected in NAD83 UTM Zone 15n coordinates, are in Geosoft format. The cell size is 10 metres. The following is a description of the grid set provided.

Grid Name	Units	Description
AT_DTM	metres	Levelled digital terrain model
AT_GT-TMI	nT	Total magnetic field GT-Grid
AT_GT-TMIRTP	nT	Total magnetic field GT-Grid, reduced to pole
AT_GT-CVGRTP	nT/m	Calculated vertical derivative GT-Grid reduced to pole
AT_GT-2VGRTP	nT/m ²	Second vertical derivative GT-Grid reduced to pole
AT_GT-HGrad	nT/m	Total horizontal magnetic gradient
AT_GT-ANS	nT/m	Analytic Signal
AT_GT-Tdrv	radians	Tilt derivative angle.

GeoTIFF image files (with pixel size of 2m) are also included for each grid type.

6.3 Map Files

Geosoft format mapsets for each of the grid types have been prepared. There are four maps in each set. The maps are presented at a scale of 1:20,000, in a NAD83, UTM Zone 15n projection. The following is a description of the map sets provided.

Map Name	Units	Description
AT_DTM_??	metres	Levelled digital terrain model
AT_GT-TMI_??	nT	Total magnetic field GT-Grid
AT_GT-TMIRTP_??	nT	Total magnetic field GT-Grid, reduced to pole
AT_GT-CVGRTP_??	nT/m	Calculated vertical derivative GT-Grid reduced to pole
AT_GT-2VGRTP_??	nT/m ²	Second vertical derivative GT-Grid reduced to pole
AT_GT-HGrad_??	nT/m	Total horizontal magnetic gradient
AT_GT-ANS_??	nT/m	Analytic Signal
AT_GT-TDR_??	Radians	Tilt derivative angle.

Where ?? is either NW, SW, NE or SE. Corresponding sets of JPEG and PDF images (at a resolution of 200 dpi) are also included.

Respectfully submitted,



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Toronto, Canada
April 11, 2022

APPENDIX C: Claim List

