Ontario

We are committed to providing accessible customer service.
If you need accessible formats or communications supports, please contact us.

Nous tenons à améliorer l'accessibilité des services à la clientèle.
Si vous avez besoin de formats accessibles ou d'aide à la communication, veuillez nous contacter.

NORTH AMERICAN PALLADIUM

HIGH-RESOLUTION GROUND GRAVITY SURVEY

GREENFIELDS PROJECT

LAC DES ILES MINE AREA, THUNDER BAY MINING DISTRICT
ONTARIO, CANADA

LOGISTICS AND INTERPRETATION REPORT

17N093 **MAY 2018**

Abitibi Geophysics, Head Office
1740, Sullivan road, suite 1400
Val-d'Or, QC, Canada, J9P 7H1

Phone: 1.819.874.8800
Fax: 1.819.874.8801
info@ageophysics.com

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table 1. Maps Produced

Map number	High-Resolution Ground Gravity Survey	Scale
2.2	Bouguer Anomaly Contours (mGal) (Slab density: 2.85 g/cm^3)	1:20 000
2.3	Elevation Contours (m)	1:20 000
2.5	Residual Bouguer Anomaly Contours (mGal) (Upward continuation at elevation 5 km)	1:20 000
2.7	First Vertical Derivative Contours (mGal/m)	1:20 000
10.0	Geophysical Interpretation	1:20 000

1. GEOPHYSICAL INTERPRETATION

The area of investigation is located between longitudes 89˚50' W and 89˚36' W, and latitudes 48˚59' N and 49˚06' N. It is located south of the Lac des Iles Mines, northwestern Ontario. The objectives of the ground gravity survey are:

- lithological differentiation,
- mapping of the mafic-ultramafic units which host the PGE-Cu-Ni magmatic sulfide mineralization, and
- direct detection of possible dense magmatic PGE-Cu-Ni occurences.

At first, it was planned that the ground gravity project would consist in eight blocks to survey using two different meshes: 200 x 200 m (semi-detailed survey) and 500 x 500 m (regional-scale survey). Unfortunately, due to poor or lack of access and harsh winter, only the southern part of the Shelby Lake Fault with the Trumper-Wakinoo-Demars blocks were surveyed.

A total of 534 gravity measurements were recorded during this project. By employing standard reductions and a slab density of 2.85 g/cm^3 for the crustal rock, the Complete Bouguer anomaly (CBA) was produced (Figure 1).

The resulting CBA over the surveyed blocks range from 8.28 mGal to 19.44 mGal with an average of 13.64 mGal. The dominant feature on the Bouguer map is a broad and high gravity lineament trending NE-SW to NNE showing an arc-shaped end in the southwestern part of the Trumper-Wakinoo-Demars block.

❒ *QUALITATIVE INTERPRETATION*

Some features or trends may be difficult to see because of the complexity of the Bouguer map. If we are interested in analyzing local features in the Bouguer field, broad scale regional features may be distorting the picture. If we are only interested in deep seated features, the near surface anomalies may obscure them. By either isolating or enhancing portions of the gravity field, the analysis may be simplified. It is desirable to filter the data in such a way that certain features will be isolated.

Thus, three methods were used to resolve (i.e. isolate) the local gravity anomalies from the regional component at the Greenfields Project. These methods were: upward continuation, first-order polynomial surface fit (i.e. remove linear trend from background), and vertical gradient.

Despite differences in the amplitudes of the calculated residual anomalies, the first two interpretation methods have commonly identified most of the dense bodies that may relate to promising mafic-ultramafic structures hosting the PGE-Cu-Ni mineralization (Figures 3 and 4). As far as the vertical gradient is concerned (figure 5), this method mostly emphasizes shallow geological sources, leaving some intermediate wavelengths, and eliminating all the long ones. Note that none of these three residual anomalies should be considered to be more “accurate” than the others.

To further characterize the delineated features, the second vertical derivative (SVD) was also calculated. This method is routinely used as a supplement to geological mapping in the identification of lithological contacts, in addition to enhancing weaker local anomalies. The zero contour of the SVD gravity map generally coincides well with most lithological contacts (Figure 6).

These enhanced products successfully highlighted four distinctive gravity anomalies labelled **GF-01**, **GF-02**, **GF-03** and **GF-04.** Their amplitudes are ranging from 1.2 to 3.0 mGal above a background of approximately 0.45 mGal.

To improve the interpretation and the geological understanding of the delineated gravity anomalies, airborne total magnetic field and its tilt derivative have been introduced and analysed. As shown in Figure 7, an interesting correlation can be established between the gravity and magnetic fields.

Apparently, the identified gravity features **GF-01a**, **GF-03a** and the northern part of **GF-04**, appear spatially associated with high magnetic anomalies. However, other delineated anomalies such as **GF-02a**, **GF-02b**, **GF-03b**, **GF-03c** and the southern part of **GF-04,** do not exactly coincide with the high magnetic features.

❑ *3D UNCONSTRAINED GRAVITY INVERSIONS*

The next step in gravity data interpretation is the generation of a 3D density contrast model for the Greenfields Project. The resulting 3D map will provide a model of the architecture that should assist in the identification of favourable zones of PGE-Cu-Ni deposits, therefore helping in the design of a follow up drilling program.

An unconstrained 3D gravity inversion was performed on the 5 km upward continuation residual data, using VOXI GRAV3D Earth Modelling software of Geosoft.

The modelled earth-block was divided by 230 x 186 x 43 rectangular cells of 50 m in easting and northing, and 25 m in depth (downward). Margin elements (5 cell padding) were added to the sides of the model to move the effects due to model edges away from the bordering data points. Once the mesh is defined, the topography is discretized onto it. The 2 257 920 cells (with the padding) below this surface define the density model for the Greenfields project, and the inverse problem is therefore formalized by inverting 4667 data contaminated by a noise of 0.02 mGal to recover the density contrasts in those cells.

After setting up the data and the earth model, two numerical inversions were used to optimize the density contrast of the model elements in such a way that the synthetic (predicted) response fits the residual data.

At first, the VOXI 3D inversion generates a smooth solution. Subsequently, an Iterative Reweighting Inversion Focusing (IRIF) takes the obtained smooth model and uses it as a reweighting constraint. It is used to model sharper contacts in the inversion result, providing more refined targets.

Figure 9 shows the fit between inverted residual data and predicted response in grid plot format. In general, the fit is rather good. But, a close match between predicted and residual anomalies does not always guarantee a unique solution if no geological informations (constraints) are added. Rather, the solution is only one of a family of possible interpretations. This is because of the source ambiguity (non-uniqueness) of potential fields. Thus, only sampling by drilling through the rock formations may give the final answer to the origin of the excess mass zones (high density contrasts) and the stratigraphic position of the rocks causing it.

The final inversion result is illustrated in (Figure 8), as perspective views of the density contrast distribution plotted as transparent isosurfaces and voxels. Horizontal and vertical slices are provided in (Figures 12 to 16) to show the distribution of the density contrast with depth.

The recovered density model is also delivered in different formats (Autocad dxf, UBC and Geosoft voxel) for geophysical / geological data integration.

As shown in Figures 8 and 12, the 3D gravity inversion reveals the subsurface geometry of the major structures of the study sites. Calculated density contrast values range from **-0.21** to **+0.22 g/cm^3**:

- Density contrasts of the mass deficits causing the gravity lows (negative anomalies) are estimated between **-0.05** and **-0.21 g/cm^3**. Several gravity lows labelled **GF-A** to **GF-D** were characterized. As shown in Figure 10b, these gravity depressions correspond to:
  - massive granodiorite to granite rocks for the anomaly **GF-A**;
  - tonalite to granodiorite rocks for the anomaly **GF-B**;
  - metasedimentary rocks for the anomaly **GF-C**;
  - intermediate metavolcanic rocks (andesite flow, tuffs and breccias, etc.) for the anomaly **GF-D**.

Note:

We know in physics that *negative density* does not make sense and cannot exist. In our case, gravity inversion is performed on the residual anomaly obtained from the Bouguer anomaly after the regional component which represents the geological background is removed. In this case, gravity inversion models the contrast of the geophysical property and not the absolute value of the property. Hence, calculated *negative density contrasts* simply indicate mass deficits relative to the absolute density of the geological background and *positive density contrasts* indicate mass excess with respect to this background.

- Density contrasts of the excess mass causing the gravity highs (positive anomalies) are in turn estimated between **+0.05** and **+0.22 g/cm^3**. Four prominent gravity anomalies labelled **GF-01** to **GF-04** were highlighted with the 3D gravity inversion (Figure 12). The densest targets exceeding 0.12 g/cm^3 correspond to anomalies **GF-02a, GF-01a, GF-04** and **GF-03a**, respectively.

  - **GF-02a** is located within a fault zone and in contact of mafic to intermediate metavolcanic rocks with tonalite to granodiorite rocks (gneiss tonalite suite);
  - **GF-01a** is detected within a foliated tonalite suite;
  - **GF-04** is located within mafic to ultramafic rocks. This anomaly is affected with the known NE-SW fault.
  - **GF-03a** is located within metasedimentary rocks.

More details on the physical and geometrical parameters of all the prominent sources (mass excess) drawn from the interpreted density contrast model will be discussed in Table 2.

To determine whether the outlined high gravity anomalies are related to mafic-ultramafic rocks, we have calculated the magnetic susceptibility model of the study sites (Figure 10).

Table 2. Prominent gravity highs outlined within the Greenfields Project

Anomaly	Anomaly Location (NAD83 / Zone 16) Easting (m)	Northing (m)	station	Amplitude (mGal)	Density contrast (g/cm³)	Depth to top (m)	Dip (°)	Depth extension (m)	Comments
GF-01a	304 070 304 415	5 435 550 5 435 835	6019 & 6035	~2.1	0.065 to 0.12	~250	85° SE	~1500	Elliptical-shaped high gravity anomaly of 2.1 mGal in amplitude located within a foliated tonalite suite (tonalite to granodiorite). The surface expression of **GF-01a** is 1000 m long by 800 m wide. **GF-01a** and **GF-01b** form a same gravity lineament (**GF-01**) trending NE-SW. **GF-01** appears open ended to the NE. **GF-01a** is associated with a moderate magnetic lineament of 200 nT in amplitude trending in the same direction (NE). 3D gravity inversion shows that **GF-1a** is a rooted source (> 1000 m in depth extension), dips to the SE with an angle of about 85°, and its density contrast is estimated at 0.10 g/cm^3 (equivalent to ~2.95 g/cm^3). The depth to top of the causative source of GF-01a is estimated at 250 m. The source of **GF-01a** corresponds to the extension of Lac des Iles Mines mafic-ultramafic formation to the SW. The delineated anomaly **GF-01a** should be detailed with a mesh of 50 x 50 m in order to more characterize it. **This source has potential for PGE-Cu-Ni mineralization.**

Table 2. Prominent gravity highs outlined within the Greenfields Project (continued)

Anomaly	Anomaly Location (NAD83 / Zone 16)		station	Amplitude (mGal)	Density contrast (g/cm^3)	Depth to top (m)	Dip (°)	Depth extension (m)	Comments
	Easting (m)	Northing (m)							
GF-01b	305 080	5 437 160	6075	1.28	0.05 to 0.065	~150	75° SE	600	**GF-01b** is an elongated gravity high of moderate amplitude (~1.3 mGal) lying within a foliated tonalite suite. Open-ended to the NE. Form a same gravity lineament with GF-01a. Appears dipping to the SE with an angle of about 75°. The depth to top of **GF-01b** is about 150 m below the surface, its bottom is at 600 - 800 m and its width is around 100 m. **GF-01b** correlates with a magnetic lineament of 270 nT in amplitude. The source of **GF-01b** could corresponds to the LDI mafic-ultramafic formation that extends to the SW.

Table 2. Prominent gravity highs outlined within the Greenfields Project (continued)

Anomaly	Anomaly Location (NAD83 / Zone 16)		station	Amplitude (mGal)	Density contrast (g/cm³)	Depth to top (m)	Dip (°)	Depth extension (m)	Comments
	Easting (m)	Northing (m)							
GF-02a	301 545	5 433 115	6077	~2.90	0.07 to 0.20	~60	80° SE	>2000	Elongated-shaped high gravity anomaly of 2.90 mGal in amplitude located within a fault zone and in contact with tonalite-granodiorite and mafic to intermediate metavolcanic rocks. **GF-02a** and **GF-02b** form a same gravity lineament (**GF-02**) which is disrupted by a fault oriented NW-SE. According to the 3D gravity inversion, the source of **GF-02a** has approximately 2.6 km long and 200 to 400 m wide, its top is at a depth of 60 m. **GF-02a** is steeply dipping to the SE and appears as a rooted source. Its density contrast reaches 0.2 g/cm³ (equivalent to density 3.0 g/cm³). According to the regional airborne magnetic field map, **GF-02a** has no direct magnetic association. This gravity feature is rather associated with magnetic contact zone (edge of magnetic anomaly). A detailed magnetic survey is needed to better define the exact magnetic signature of this dense source. **This source is considered a potential target for PGE-Cu-Ni mineralization.** **GF-02a** could be tested with a drill-hole at station **6077**.

Table 2. Prominent gravity highs outlined within the Greenfields Project (continued)

Anomaly	Anomaly Location (NAD83 / Zone 16)		station	Amplitude (mGal)	Density contrast (g/cm^3)	Depth to top (m)	Dip (°)	Depth extension (m)	Comments
	Easting (m)	Northing (m)							
GF-02b	298 905	5 431 615	2021	1.70	0.055 to 0.075	140	85° NW	~500	Elongated-shaped gravity anomaly of moderate amplitude (1.7 mGal) located within mafic and ultramafic rocks, according to the geological map of the LDI region. **GF-02b** appears to be the extension of **GF-02a** to the SW; seems affected by 2 or 3 faults oriented NW-SE. 3D gravity inversion shows that **GF-2b** is not a rooted source. Steeply dipping to the NW by an angle of 85° and buried at a depth of 140 m. Its density contrast is 0.06 g/cm^3 (equivalent to ~2.91 g/cm^3) and its width is about 100-150 m. **GF-02b** is outlined in a low and quiet magnetic field (has no magnetic association). **This source has potential for PGE-Cu-Ni mineralization.**

Table 2. Prominent gravity highs outlined within the Greenfields Project (continued)

Anomaly	Anomaly Location (NAD83 / Zone 16)		station	Amplitude (mGal)	Density contrast (g/cm³)	Depth to top (m)	Dip (°)	Depth extension (m)	Comments
	Easting (m)	Northing (m)							
GF-03a	301 775	5 432 255	6143	~2.30	0.09 to 0.13	120	90° to 85° NW	>1000	**GF-03a**, **GF03b** and **GF-03c** are high gravity anomalies of 1.9 to 2.3 mGal in amplitude depicted 1 km SE and parallel to the gravity lineament **GF-02**. **GF-03a** forms with **GF03b** & **GF-03c,** a single high gravity lineament **GF-03** of approximately 7.5 km in length trending ENE. This lineament **GF-03** appears open ended to the Shelby south block (to the NE) and seems disrupted by several faults interpreted NW-SE. According to the regional geological map of the study area, gravity anomalies **GF-03a** and **GF-03b** are located in contact between metasedimentary rocks and mafic to intermediate metavolcanic rocks, while **GF-03c** is directly lying within the metasedimentary rocks. 3D gravity inversion shows that **GF-03** sometimes dips to the SE and sometimes to the NW. Its depth to the top varies from 120 m to 200 m below the surface, and its density contrast is likely to be in the range of 0.06 to 0.1 g/cm³. **GF-03** appears associated with the northern edge of magnetic lineament trending NE-SW. **GF-03 is considered a potential target.**
GF-03b	304 256 303 900	5 433 550 5 433 170	2123 & 2124	~1.90	0.05 to 0.10	200	65° SE	>1000	
GF-03c	299 505	5 431 160	4105	1.90	0.06 to 0.09	150	~90°	~500	

Table 2. Prominent gravity highs outlined within the Greenfields Project (continued)

Anomaly	Anomaly Location (NAD83 / Zone 16)		station	Amplitude (mGal)	Density contrast (g/cm³)	Depth to top (m)	Dip (°)	Depth extension (m)	Comments
	Easting (m)	Northing (m)							
GF-04	296 335 296 075	5 432 110 5 431 210	1037 to 4020	2.25 to 2.60	0.07 to 0.13	~150	~90°	>1500 (rooted)	Complex arc-shaped high gravity anomaly of 2.6 mGal in amplitude located within mafic and ultramafic rocks. **GF-04** appears disrupted by a probable fault interpreted WNW and open-ended to the SW. The northern part of GF-04 (at station 1037) correlates well with a moderate magnetic anomaly of 340 nT in amplitude, while its southern part (at station 4020) does not show any correlation. 3D gravity inversion shows that **GF-04** is a very deeply rooted source (> 1500 m in depth extension), dips almost vertically, its top is at a depth of 150 m, and its density contrast is estimated at about 0.1 g/cm³. From elevation -250 m and deeper, the causative source of GF-04 appears oriented NE. **This source has high potential for PGE-Cu-Ni mineralization.**

❑ CONCLUSION AND RECOMMENDATIONS

High-resolution gravity surveys have been used successfully in some Ontario districts to map PGE-Cu-Ni deposits. Overall, this method is used indirectly to search for geologic ore controls (mafic-ultramafic rocks, feeder faults, magma chambers, etc.) where PGE-Cu-Ni mineralization could be located. But, sometimes, detailed gravity surveys are able to locate directly the PGE-Cu-Ni deposits if they are of a large volume and are buried close to the surface (example of Voisy's Bay deposit in Canada, Bollinger deposit in Western Australia, etc.).

In this project, the interpretation of the ground gravity survey has improved understanding of the subsurface density contrast and its relationship to the geological setting of the Greenfields Project:

- High quality displays of the Complete Bouguer anomaly, the residual anomaly and its first vertical derivative were produced to highlight all subtle signatures and to improve the gravity image of the Shelby Fault Lake and Trumper-Wakinoo-Demars blocks.
- Characterization of the delineated anomalies was done through a 3D density contrast model, showing a possible 3D geometry of the mafic-ultramafic bodies hosting the PGE mineralization.
- The major faulting patterns have been interpreted mainly using the residual and the vertical gradient anomalies.

At least four prominent dense sources (**GF-01a**, **GF-02a**, **GF-03a** and **GF-04**) were identified from this study. A program following this report is not recommended unless a detailed gravity survey with a mesh of 50 x 50 m can be done to better characterize the dense sources. Integration of detailed geophysical surveys such as airborne magnetic and EM surveys with other geological informations (geological mapping, geochemical results, etc.) are paramount for planning subsequent exploration drilling programs (target prioritization).

The interpretation of the gravity data embodied in this report is essentially a geophysical appraisal of the Greenfields Project. As such, it incorporates only as much geoscientific information as the author had on hand at the time. Geologists thoroughly familiar with the studied area may be in a better position to evaluate the geological significance of the various recovered geophysical signatures. Moreover, as time passes and data provided by follow-up programs are compiled, the priority and significance of exploration targets reported in this study may be downgraded or upgraded

Respectfully submitted,
Abitibi Geophysics Inc.

Madjid Chemam, P.Geo.,
OGQ # 1259
Geophysicist

MC/jg

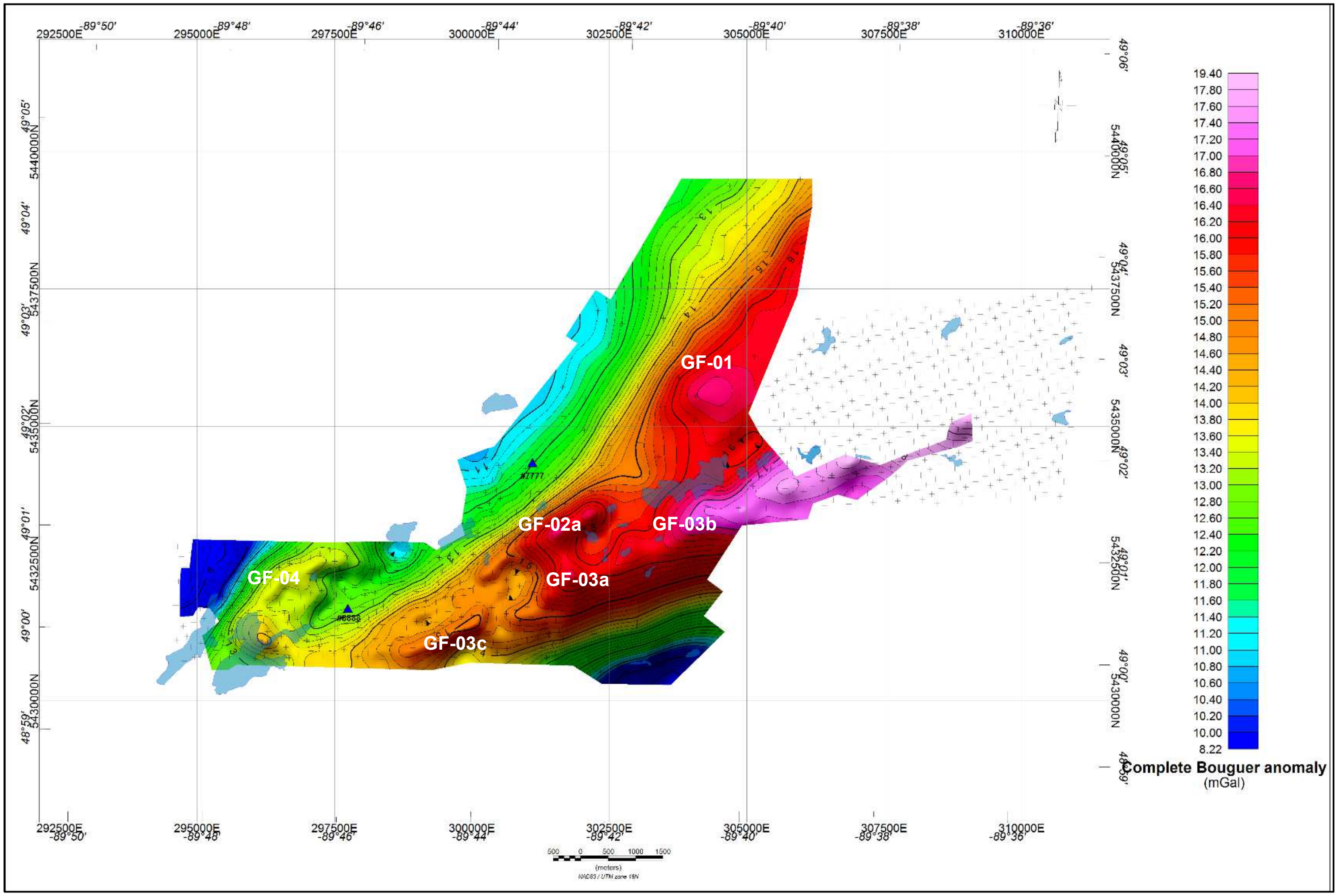


Figure 1. Complete Bouguer anomaly derived from a slab density of 2.85 g/cm3, Greenfields Project

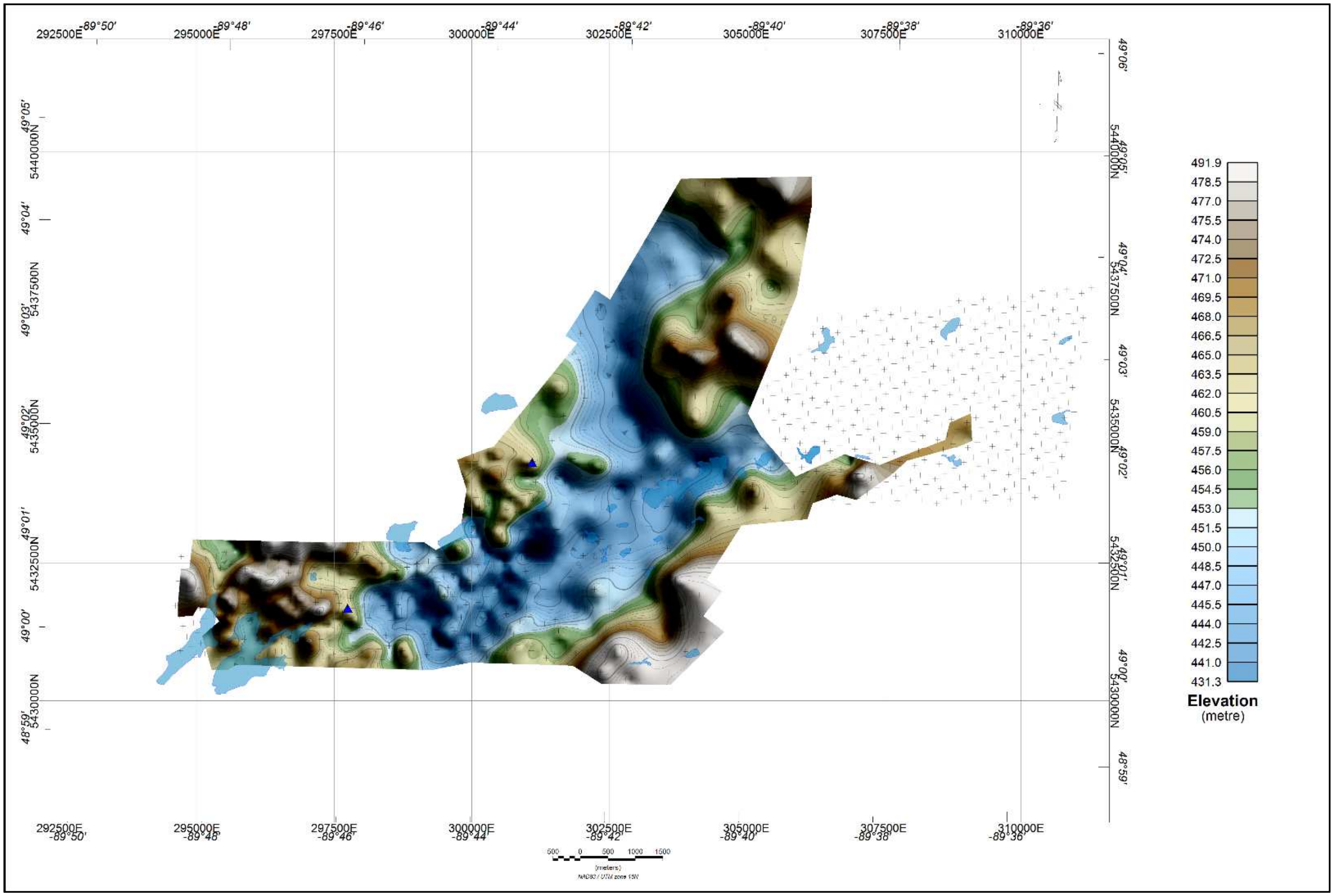


Figure 2. Elevation contour map of the Greenfields Project

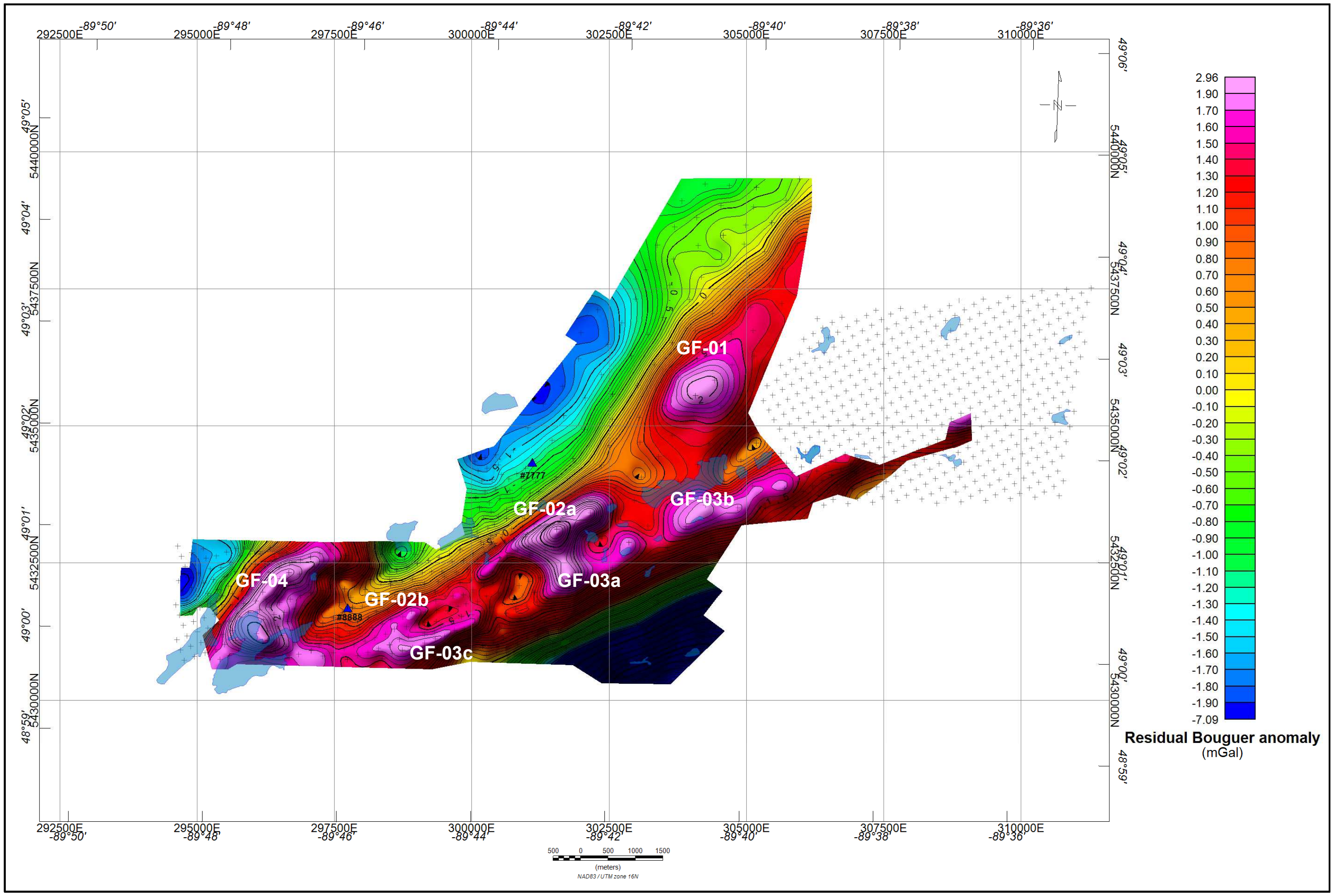


Figure 3. Upward 5 km residual Bouguer anomaly, Greenfields Project

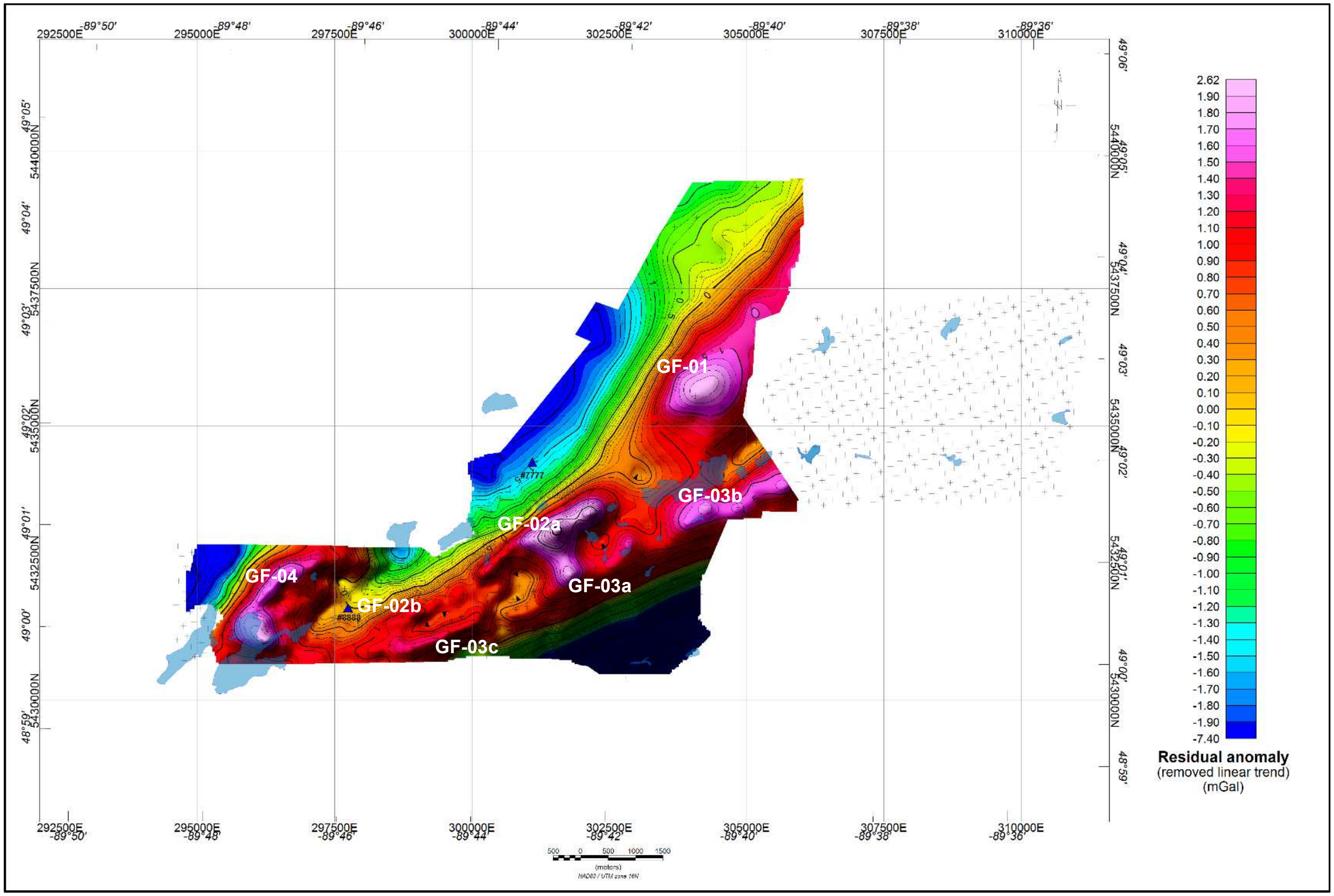


Figure 4. 1st Order polynomial trend residual Bouguer anomaly, Greenfields Project

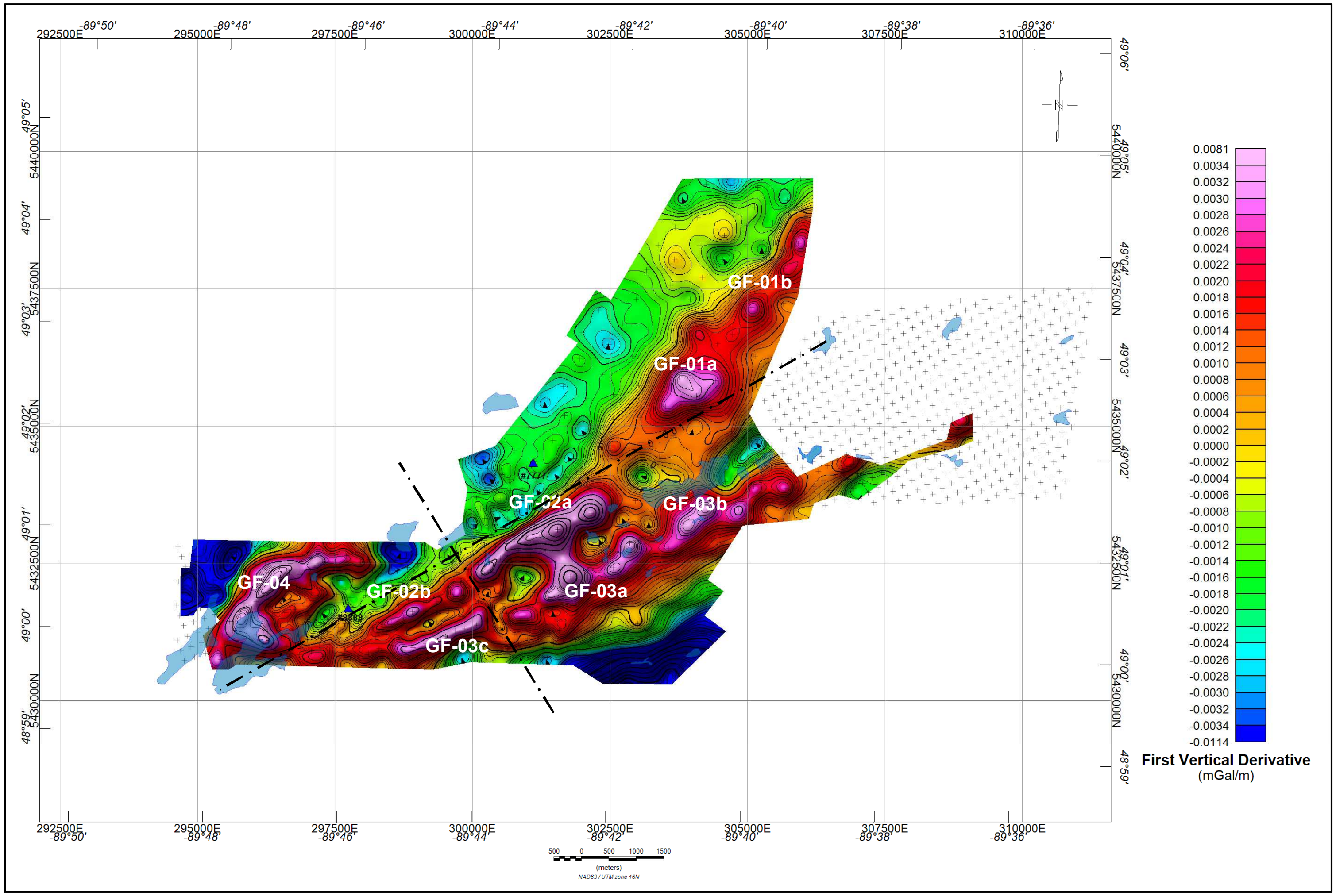


Figure 5. Calculated first vertical derivative of the Bouguer anomaly, Greenfields Project

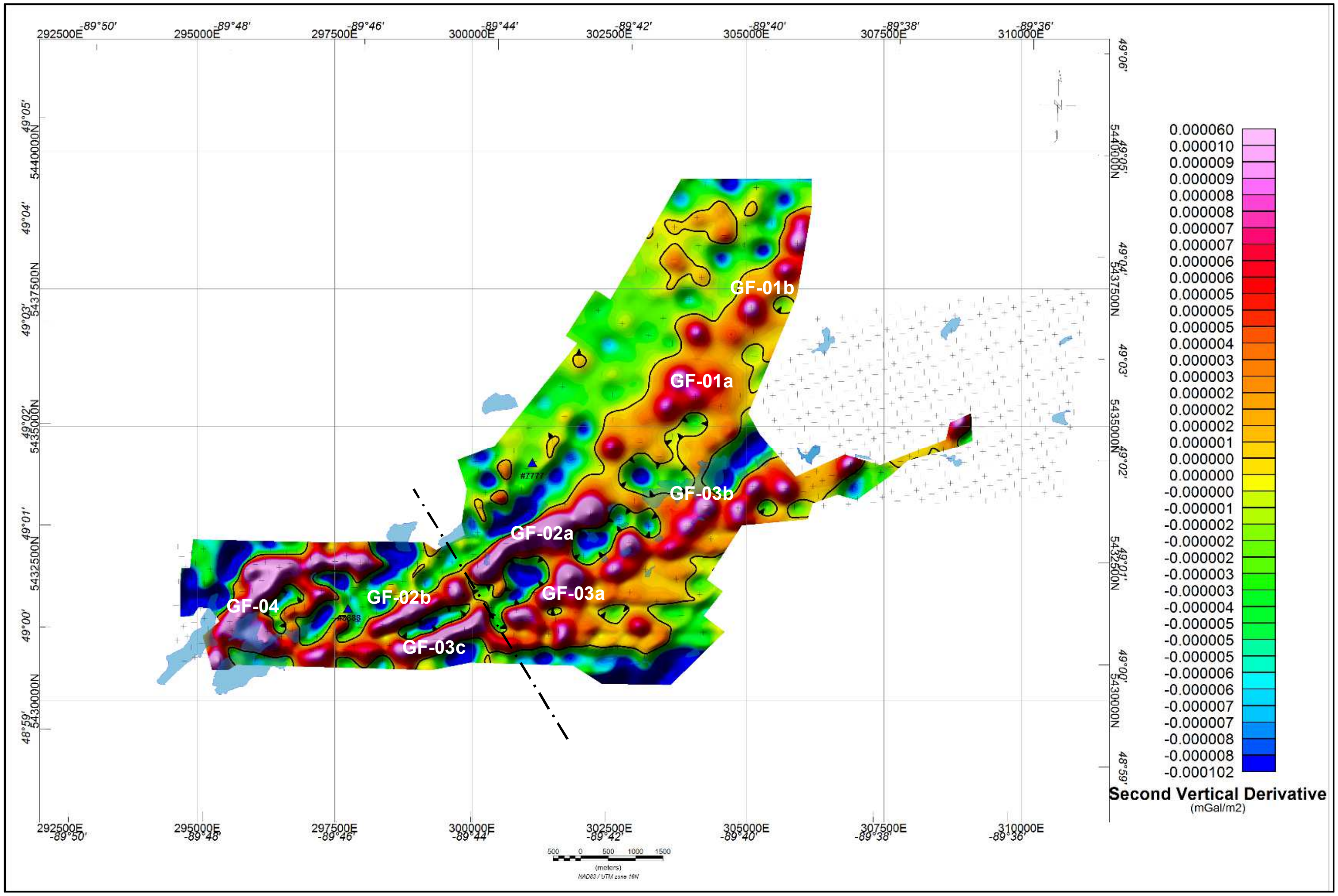
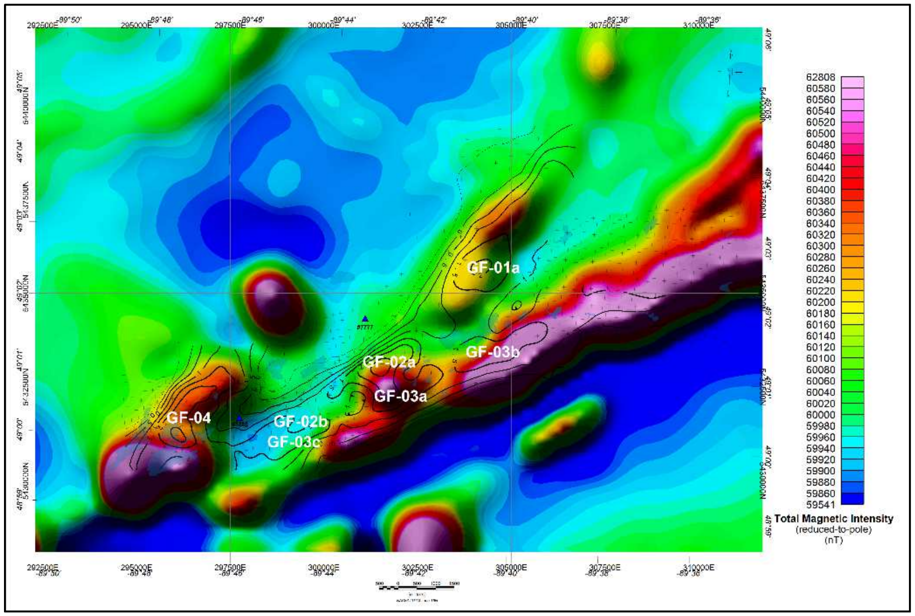


Figure 6. Calculated second vertical derivative of the Bouguer anomaly, Greenfields Project



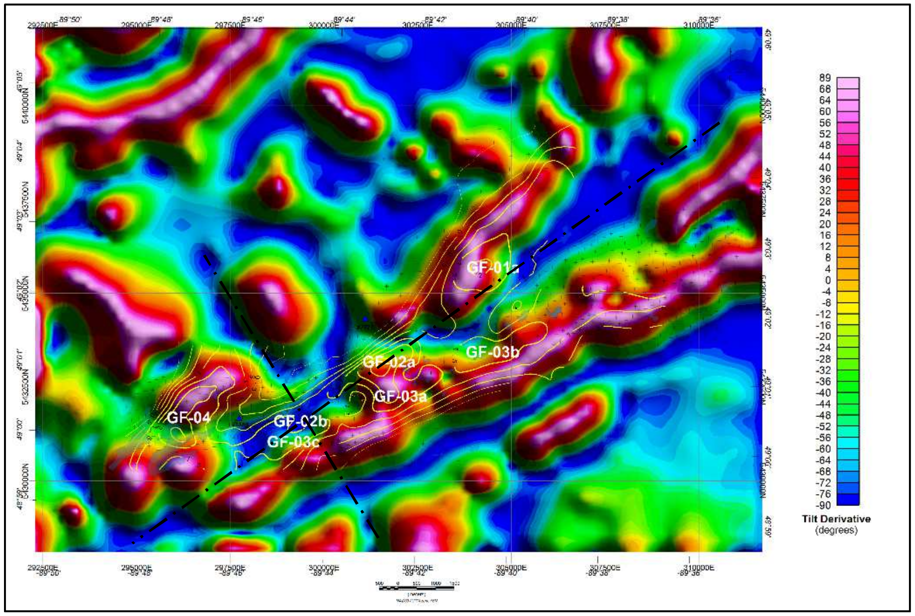


Figure 7. Residual Bouguer isocontours superimposed on the total magnetic intensity (left) and on Tilt derivative (right), Greenfields Project

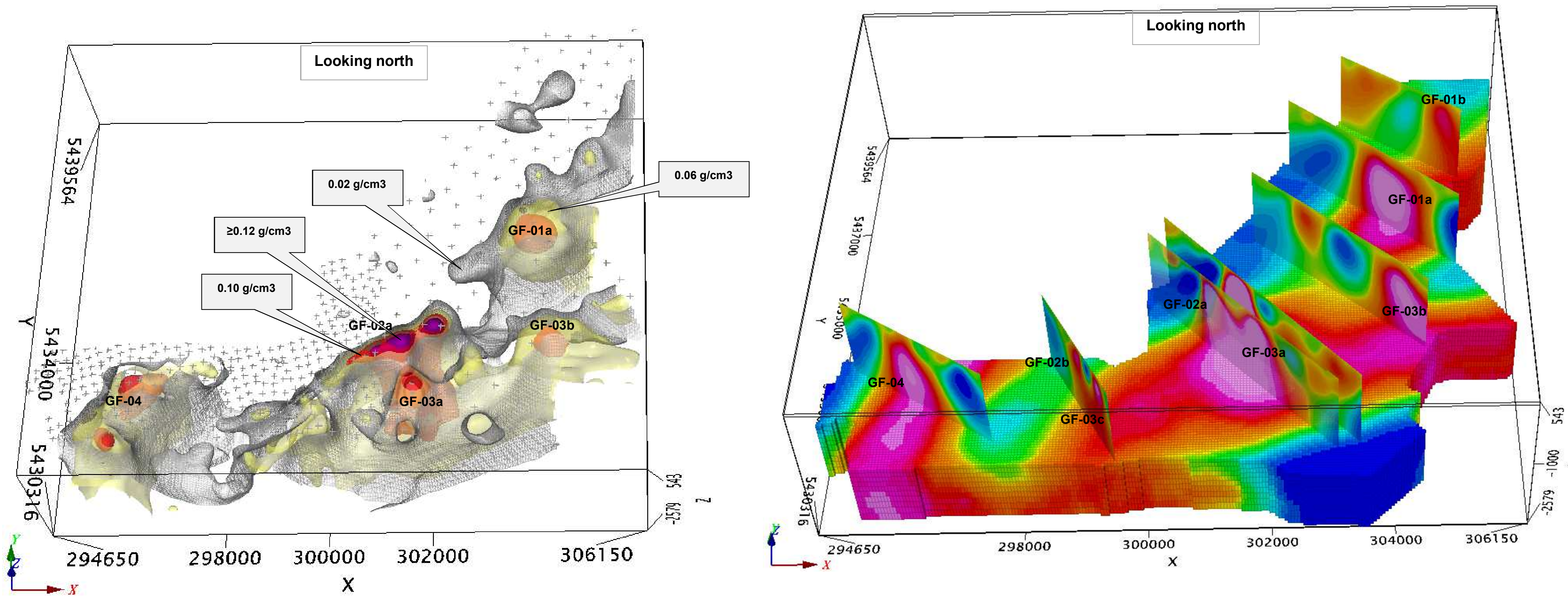


Figure 8. Transparent density contrast isosurfaces (left) and voxel plan and vertical section views (left), Greenfields Project

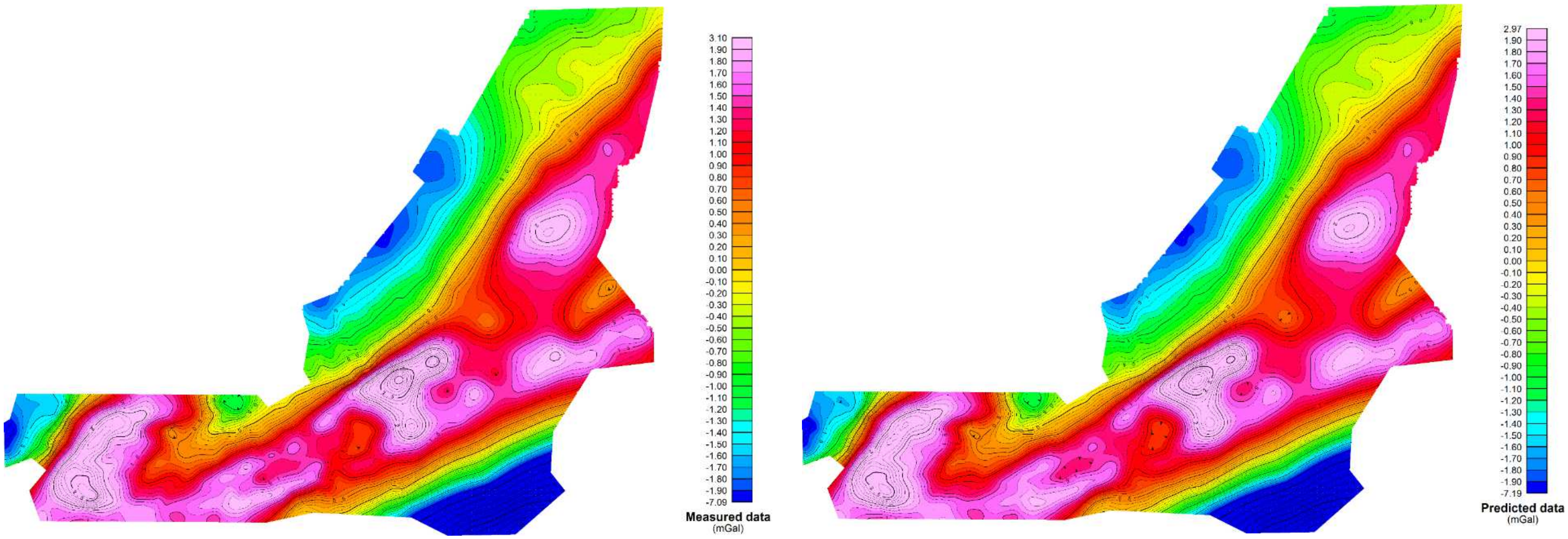


Figure 9. Measured residual data (left) versus predicted data (right) from VOXI GRAV3D inversion, Greenfields Project

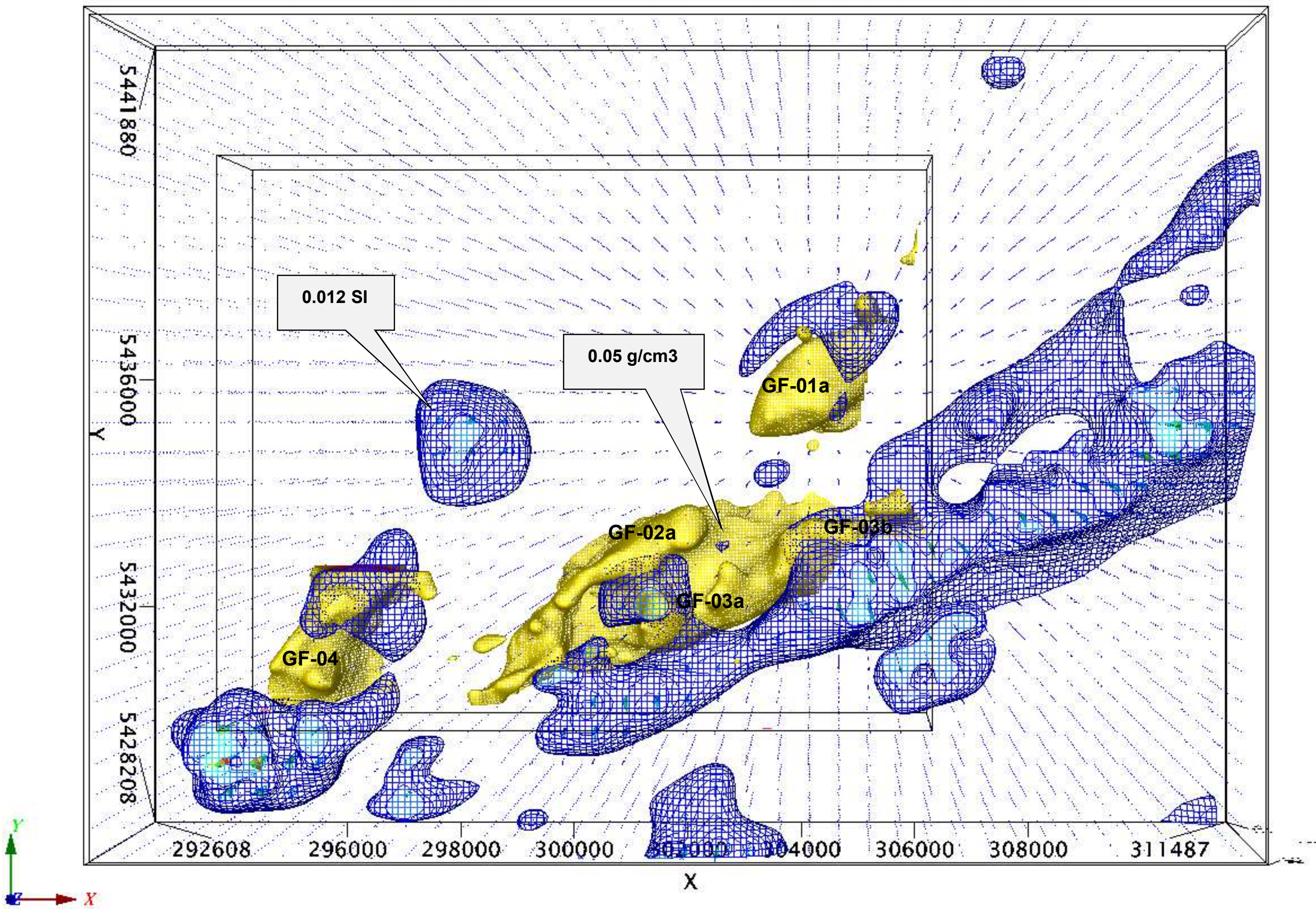
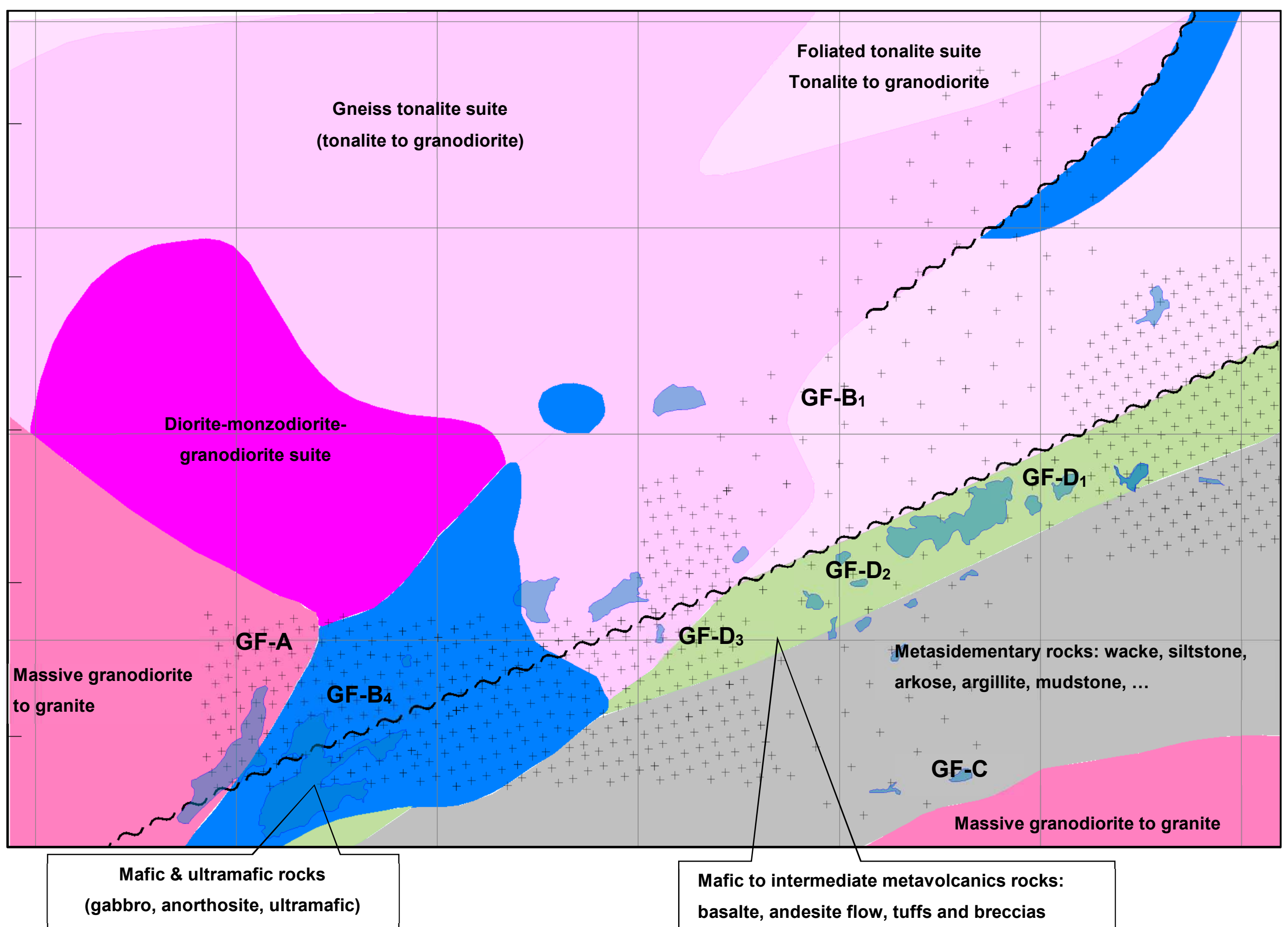
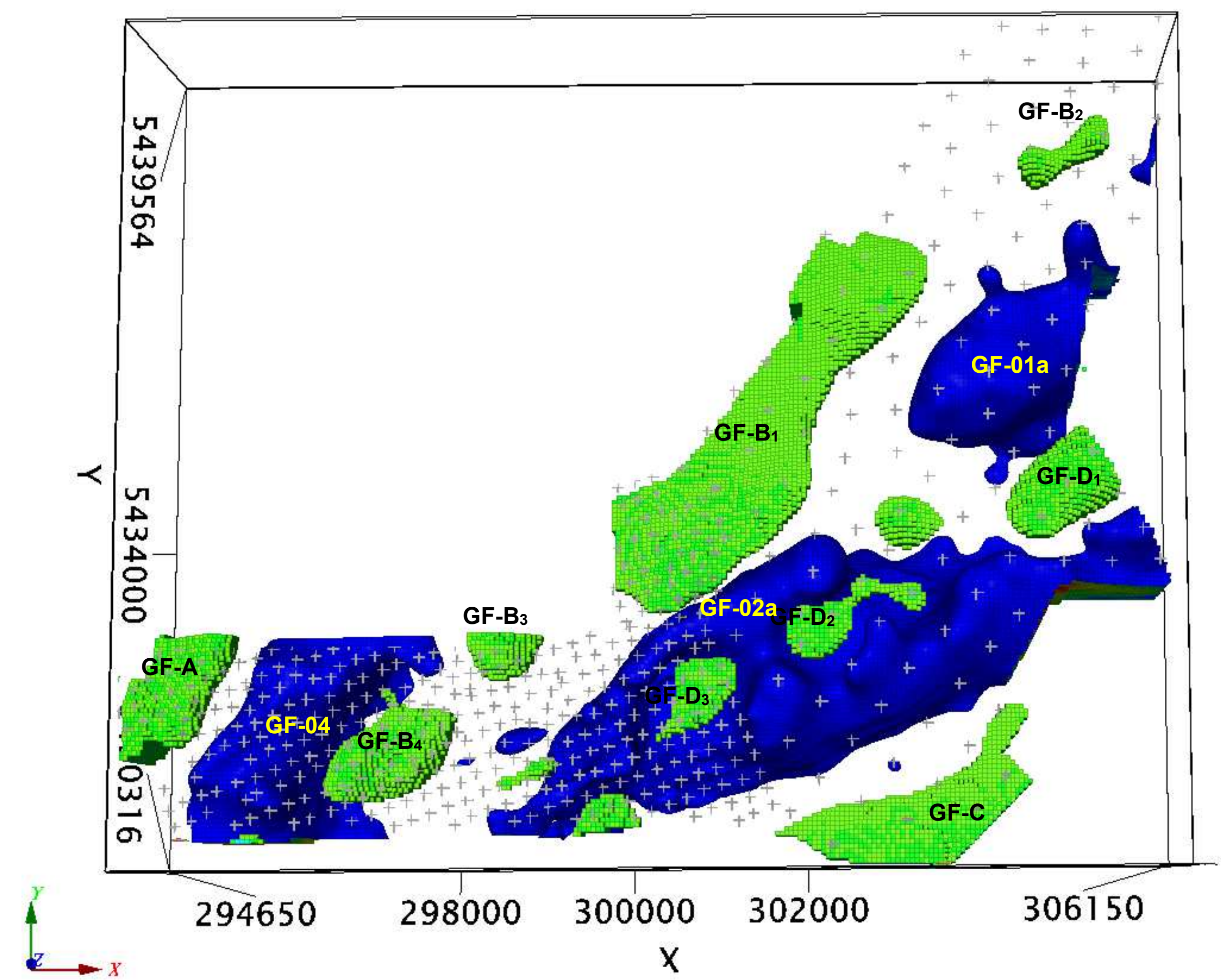


Figure 10. Top view showing the density contrast model (in yellow) versus magnetic susceptibility model (in blue) from MVI 3D inversion, Greenfields Project



(A)



(B)

Figure 11. Interpreted mass deficits (in green) and excess mass (in blue) versus the corresponding geological formations of the Greenfields Project

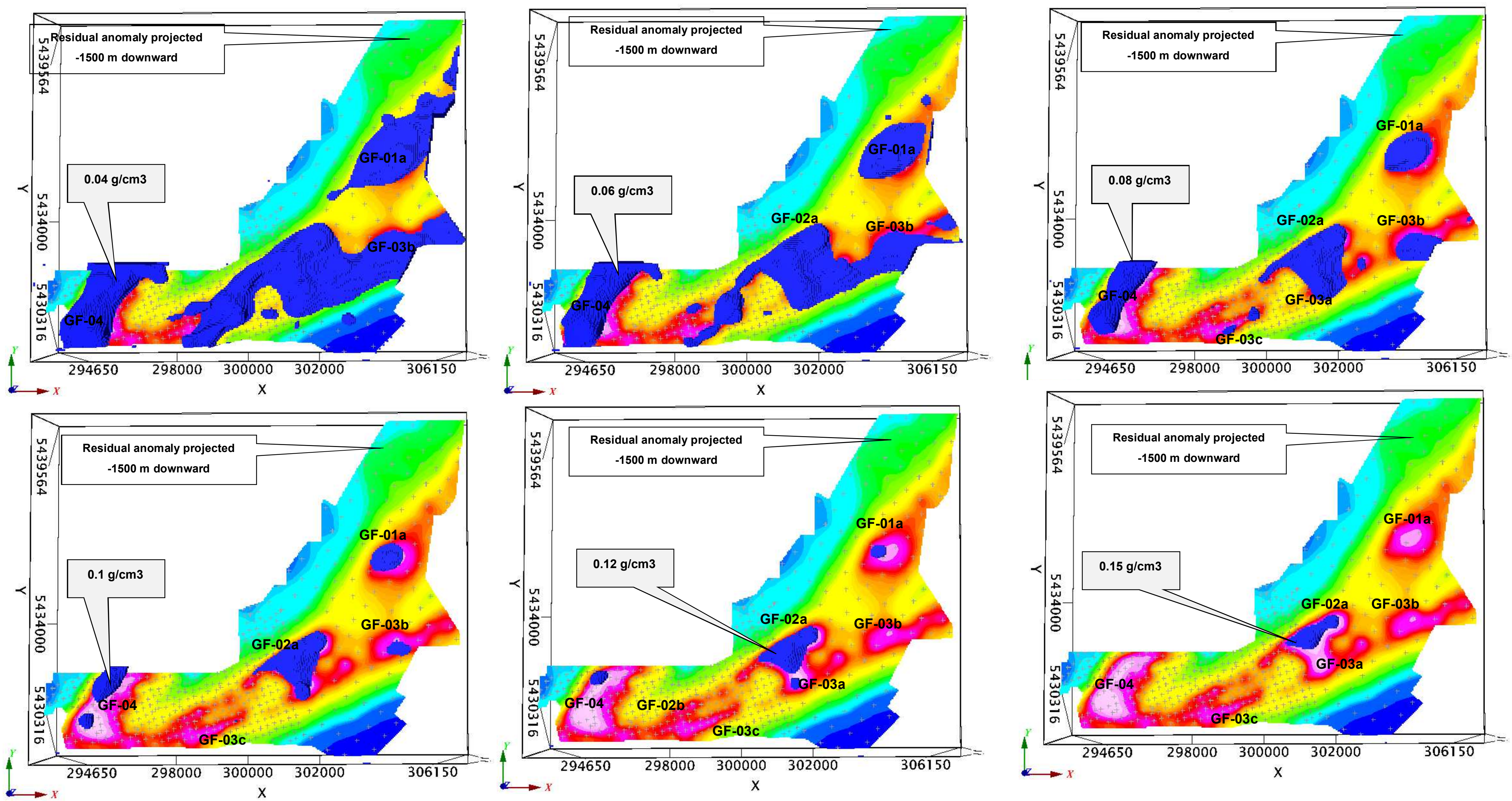


Figure 12. Density contrast distributions overlaying the residual Bouguer anomaly projected at 1500 m downward, Greenfields Project

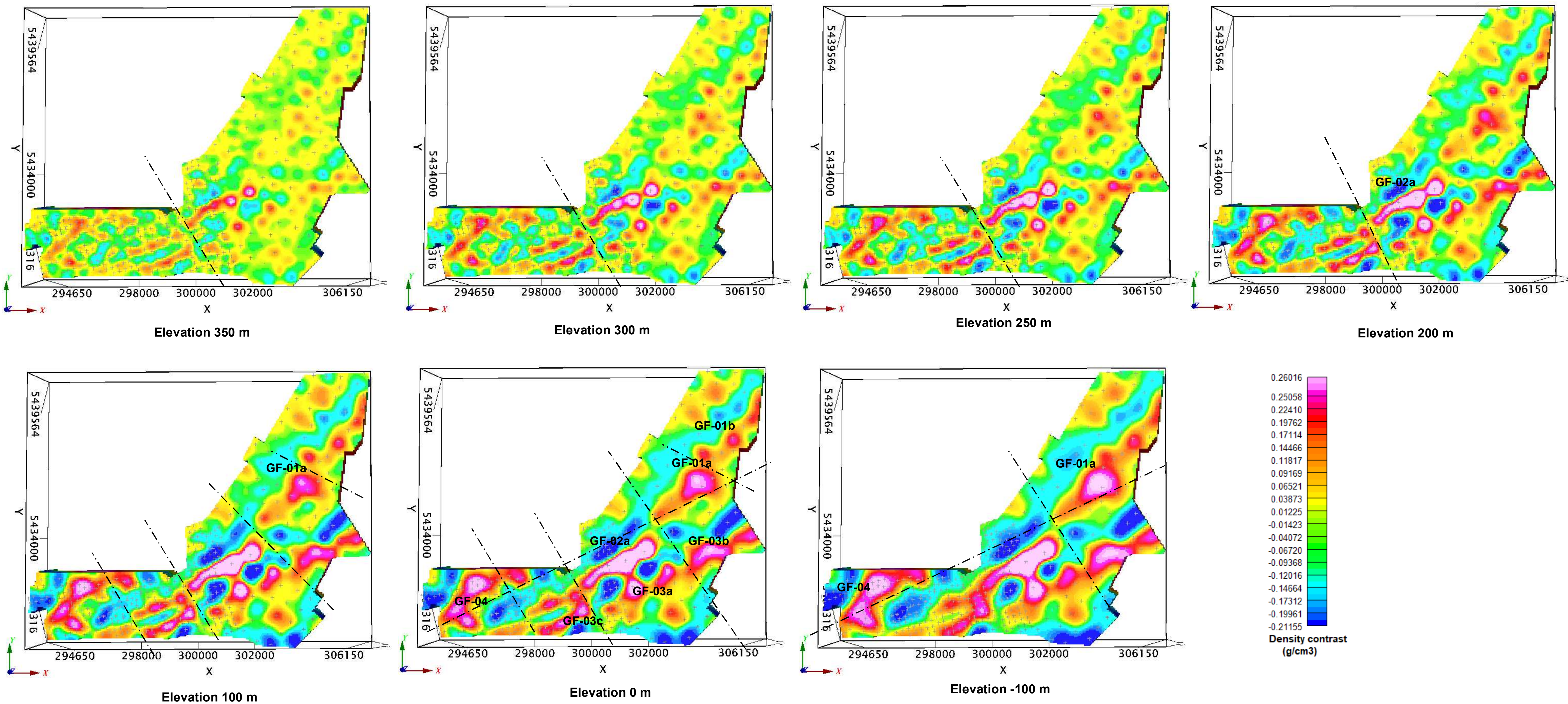


Figure 13. Horizontal slices of the subsurface density contrast extracted at elevations of 350 m, 300 m, 250 m, 200 m, 100 m, 0 m and -100 m, Greenfields Project

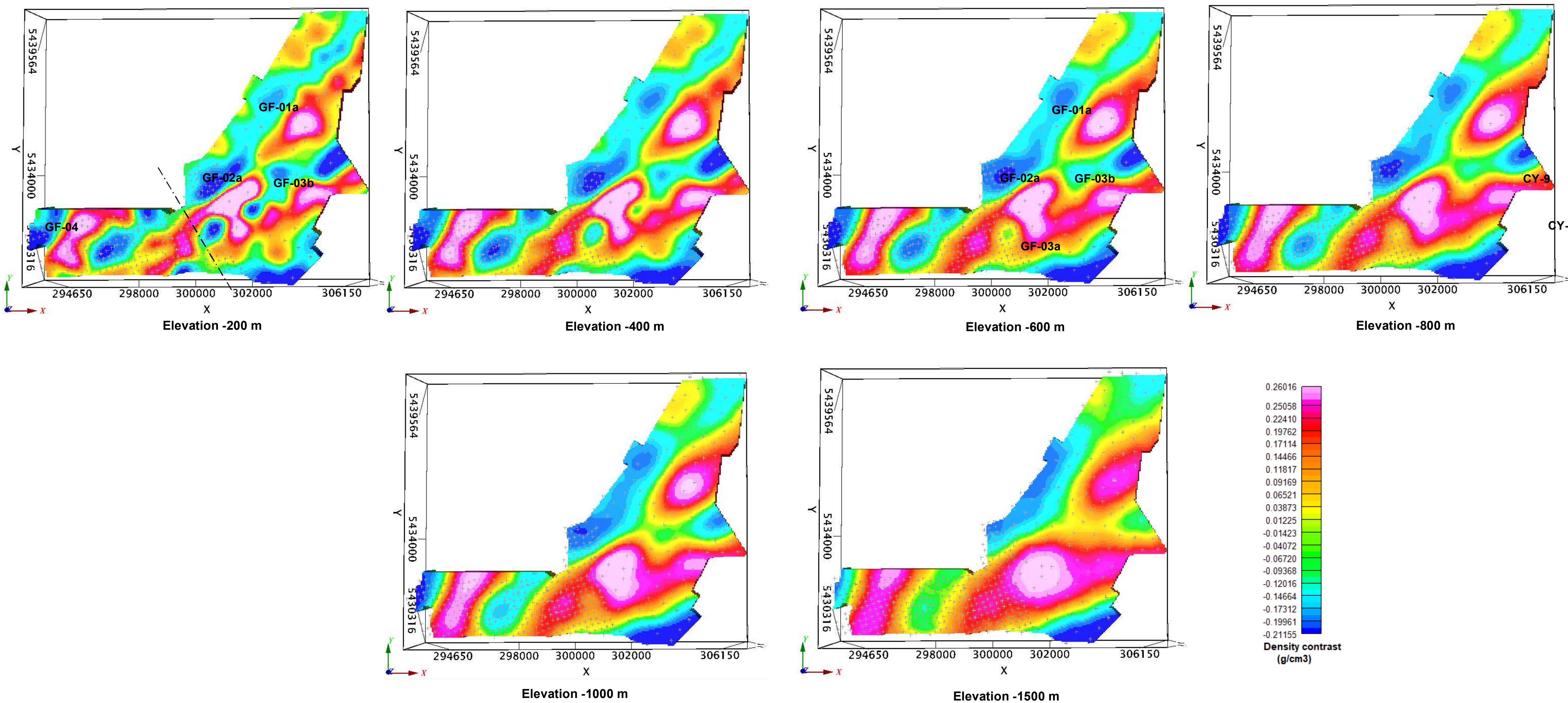


Figure 14. Horizontal slices of the subsurface density contrast extracted at elevations of -200 m, -400 m, -600 m, -800 m, -1000 m and -1500 m, Greenfields Project

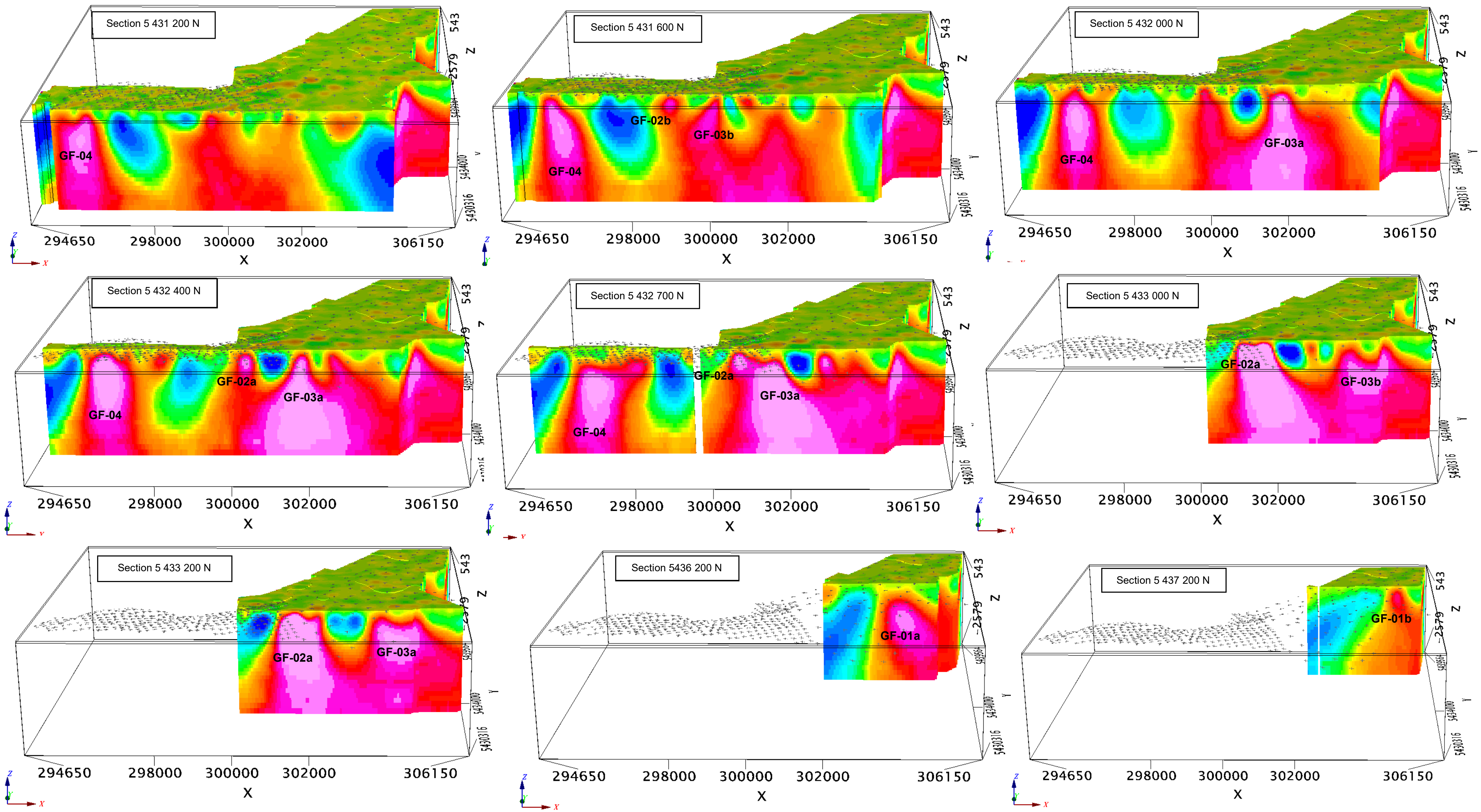


Figure 15. Longitudinal sections showing density contrast distributions with depth (looking north), Greenfields Project

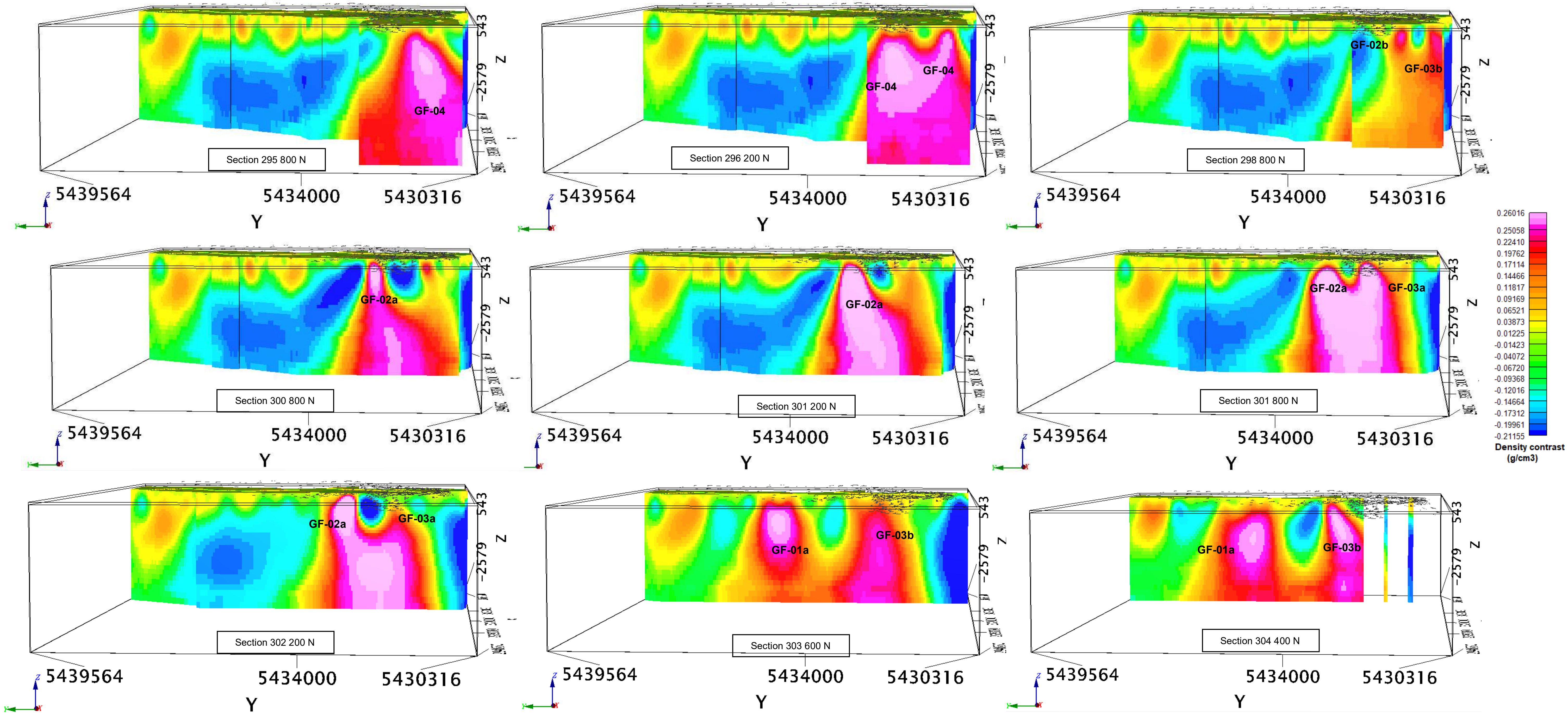


Figure 16. Transverse sections showing density contrast distributions with depth (looking east), Greenfields Project

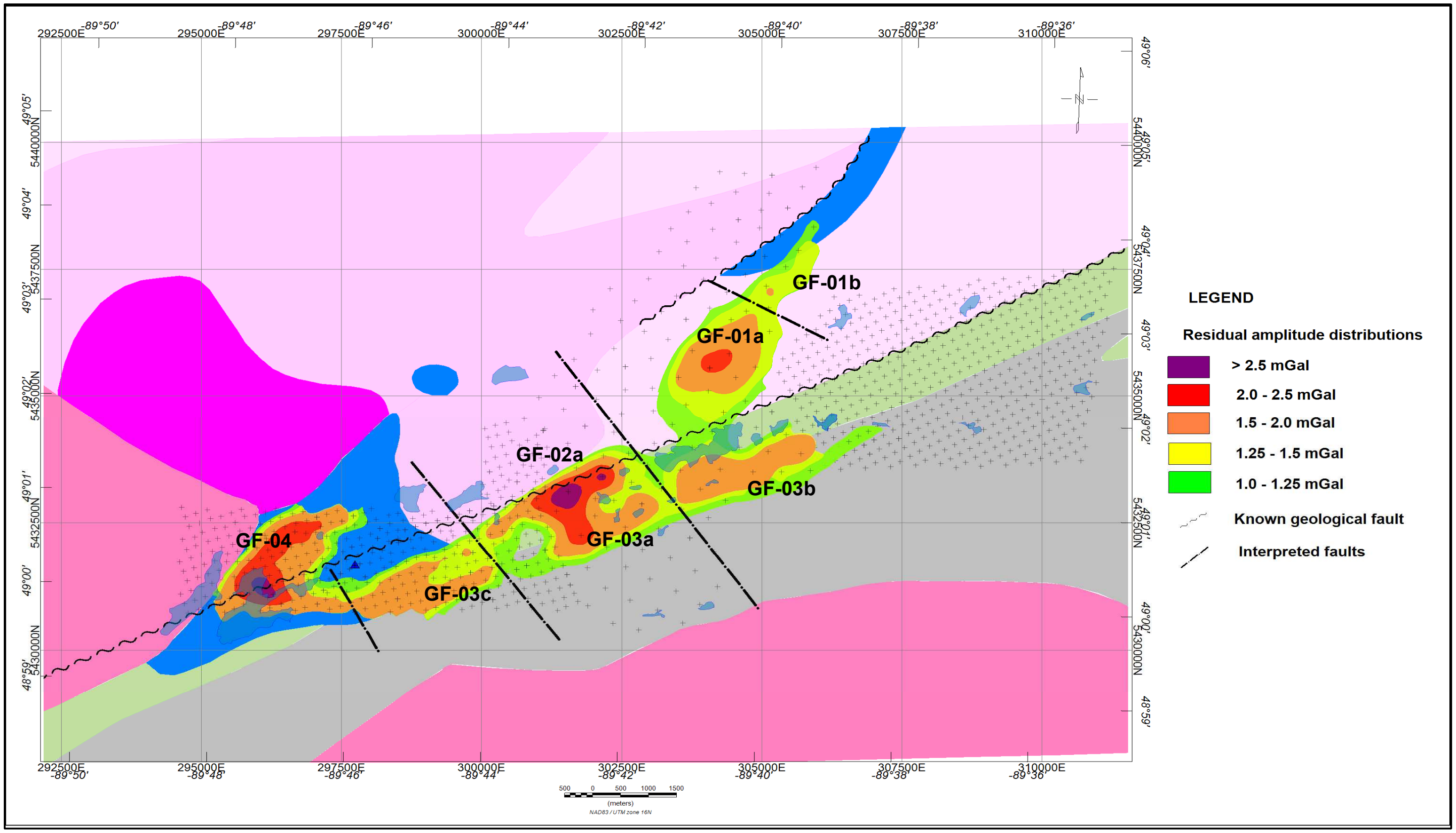


Figure 17. Geophysical interpretation map of the Greenfields Project

2. MANDATE

- ❑ *PROJECT ID* — **Greenfields**
  (Our reference: **17N093**)
- ❑ *GENERAL LOCATION* — Lac des Iles Mine area, Northwestern Ontario, Canada
- ❑ *CUSTOMER* — **North American Palladium**
  556, Tenth Ave.
  Thunder Bay, Ontario P7B 2R2
  www.nappaladium.com
- ❑ *REPRESENTATIVE* — **Mr. David Benson, P.Geo.,**
  Exploration Manager
  davebenson@nap.com

  Mobile phone: (204) 223-2281
- ❑ *SURVEY TYPE* — High-Resolution Ground Gravity survey with a 200 and 500 m nominal sampling
- ❑ *GEOPHYSICAL OBJECTIVES*
  - To improve the geological understanding of the Greenfields blocks (lithological discrimination and structural mapping)
  - To delineate gravity highs possibly related to mafic-ultramafic intrusive rocks hosting the PGE-Cu-Ni mineralization

Figure 18. General location of the Greenfields Project

3. GREENFIELDS PROJECT

❑ *LOCATION*	**Thunder Bay Mining District, Ontario.** Centred on: Latitude: 49°02' 08" N, Longitude: 89°42' 39" W NAD83 / UTM zone 16N : 301 850 mE, 5 434 950 mN NTS sheets: **52H/04 and 52A/13**
❑ *NEAREST SETTLEMENT*	**Thunder Bay:** 80 km to the SE as the crow flies.
❑ *ACCESS*	In November 2017, the crews were accommodated at Shabaqua outfitter, and from February 2018, the crews were accommodated at Lac des Iles Mine (LDIM) site. The Shelby Lake Fault and Trump-Wakinoo-Demars grids were accessible by trucks and snowmobiles.
❑ *GEOMORPHOLOGY*	The terrain of the Greenfields Project shows moderate to flat topographic relief in the center of the survey grids, while the relief in the southwestern part is rather rugged. Average elevation in the survey grids ranges from 430 m to 494 m, above sea level (average 458 m). Vegetation is classified as thick boreal forest typified by black spruces, birch, poplar, and jack pine. Hydrographically, small lakes, river, a few streams and swamps were encountered throughout the survey grids.
❑ *CULTURAL FEATURES*	No cultural features have affected the quality of the geophysical data.
❑ *LAND STATUS*	The claim numbers encompassed in the present survey are illustrated on page 32. The claims are 100% owned by North American Palladium.
❑ *UNEXPECTED DIFFICULTIES*	Poor access, dense vegetation and cold winter slowed down the survey production.
❑ *SURVEY GRIDS*	Gravity readings were gathered as close as possible to a 200 x 200 m nominal sampling at the Trumper-Wakinoo-Demars grid and with a mesh of 500 x 500m at the Shelby Lake Fault grid. Refer to Figure 19 for a plan view of the zones covered by the present survey.

- *ENVIRONMENTAL HEALTH AND SAFETY*

As part of the Abitibi Geophysics Inc. EHS program crew members received first aid training and are provided with safety equipment and specialized training for the geophysical technique utilized on this project. In addition, the crew was provided with a satellite telephone for emergency communication.

In addition to the Abitibi Geophysics Inc. EHS program, daily health and safety directives were given by NAP staff.

Two incidents were reported during this project. The gravity operator Claude Ouedraogo was injured by a tree branch near the eye during snowmobile trip and the operator Charles Massé had a knee ache which resulted in a 7 days off from hospital.

- *COORDINATE SYSTEM*

Local datum : NAD83
Projection type: Universal Transverse Mercator (UTM)
Zone : 16N

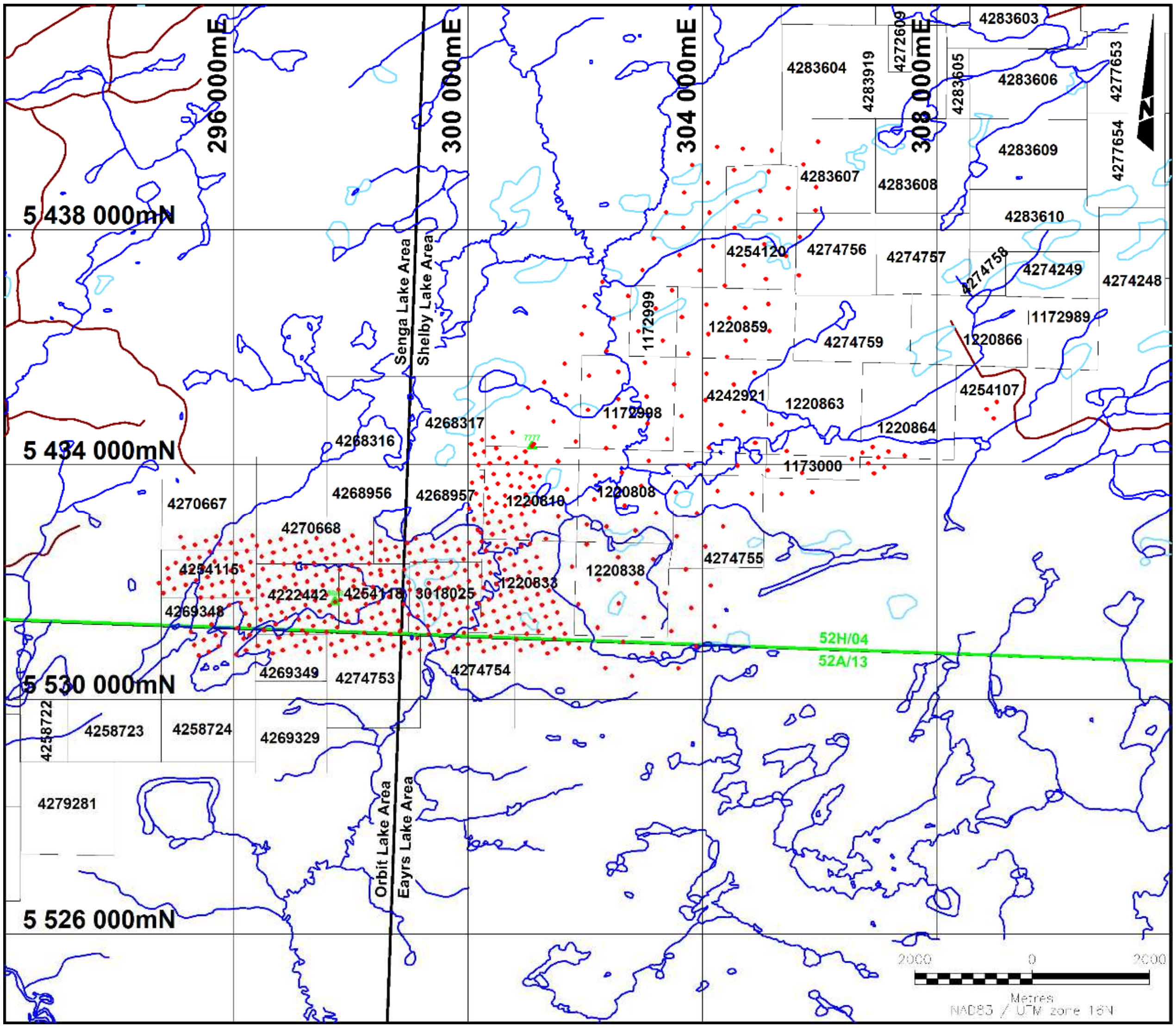


Figure 19. Index of claims and geophysical survey coverage over the Greenfields Project

4. GRAVITY DATA ACQUISITION

- *TYPE OF SURVEY* — Semi-detailed to regional-scale gravity surveys with expected Bouguer anomaly accuracy better than 0.05 mGal (before terrain corrections).

- *PERSONNEL*

<u>Phase-I:</u>

Marcel Naud,	Crew Chief, gravity operator
Beki Ngwenya,	Gravity operator
Mutombo Kanda,	Gravity operator
Pierre O. Nicol, B.Sc.,	GPS operator
Claude Ouedraogo,	GPS operator
Denis Morino,	GPS operator

<u>Phase-II:</u>

Guillaume O. Poirier	Crew Chief, gravity operator
Felipe Morant,	Gravity operator
Claude Ouedraogo,	Gravity operator
Pierre O. Nicol, B.Sc.,	GPS operator
Dominic Gagnon,	GPS operator
Denis Morino,	GPS operator
Simon Jourdain, B.Sc.,	GPS operator
Charles Massé,	GPS operator
Ugo Negroni,	GPS operator
Jonathan Simoneau,	Logistics
Carole Picard, Tech.,	Plotting
Madjid Chemam, P.Geo.,	QA/QC, processing and report
Langis Plante, P.Eng.,	Final quality control

- *SURVEY COVERAGE* — **535** stations, including one base station but excluding all the re-visited stations.

- *DATA ACQUISITION* — **November 10th to 15th, 2017**
February 19th to March 12th, 2018

❑ *INSTRUMENTATION*	Type: **Scintrex CG-5u AutoGrav**	
	Fused Quartz	
	Reading resolution:	0.001 mGal (digital recording)
	Stand. Field Repeatability:	< 0.005 mGal
	Operating Range:	8000 mGal without resetting
	Residual Long Term drift:	< 0.02 mGal/day (static)
	Operating Temperature:	-40°C to +45°C
	Serial numbers:	071040**300** (300) 080440**371** (371) 080740**418** (418)
	Calibration constants:	K_{300} = **0.9997082** mGal / unit K_{371} = **0.9994625** mGal / unit K_{418} = **0.9996420** mGal / unit
	Seismic filter:	Enabled
	Continuous tilt correction:	Enabled
	Auto rejection:	Enabled (*threshold is 6 x std. deviation with seismic filter on)*
	Tide correction:	Enabled
	Read time:	4 to 6 cycles of 30 seconds

❑ *SOFTWARES*

SCTutil and **USB Stick Interface** for data transfer to a PC. **Gravity** and **Terrain Correction** (Oasis Montaj ver 9.3.3 module from Geosoft) for all remaining gravity processing.

❑ *BASE STATIONS*

The survey is not tied to the Canadian Gravity Standardization Network (CGSN). Two primary bases **99999-2017** and **9999-2018** established respectively at the Shabaqua-Outfitter and at the LDIM site were used daily during this project (refer to the description at pages 36 and 37). To avoid drift problems that can arise during the trip, two other secondary drift bases #**8888** and **#7777** established inside the survey grids, were also used daily during this project

❑ *FIELD PROCEDURES*

Each loop began and ended with a reading at the primary base 99999-2017 or 9999-2018, and at one of the secondary drift bases #8888 or #7777. The primary base was used as the main control base to calculate the instrumental drift if the closer error is acceptable (< 0.1 mGal). If not, the secondary drift base will be used.

A drift correction was linearly applied to the data included within the loop.

At each station, the following parameters were recorded in the field book:

- Station identification;
- UTC time;
- Instrument readings;
- Standard deviation of each gravity reading;
- Instrument height above ground.
- Slopes to the centre of each four Hammer zones sectors; B (2-12 m) and C (12-50 m);

The following data were recorded in the instrument's memory:

- Station identification;
- Instrument readings;
- The standard deviation of each reading;
- Tilt - X axis in arc-seconds, at the end of the reading;
- Tilt - Y axis in arc-seconds, at the end of the reading;
- The gravity sensor temperature compensation factor;
- The tide correction for each reading;
- The number of samples that were read;
- The number of rejected samples;
- UTC time;
- Date.

The first step in data acquisition is to locate the most appropriate site for both GPS and gravity readings within 25 m of the planned station. The gravimeter is then placed on the tripod; the meter is levelled with the tripod levelling screws. Before the reading is to be initiated the operator stands still to avoid inducing ground motion that could affect the gravity meter. Once the above requirements have been met, the reading is taken.

The gravimeter was put in its padded and insulated carrying bag immediately after each reading.

At the end of each day, the data were downloaded from the CG-5u Autograv through an USB cable to a pc hard drive. The Scintrex **USB Stick Interface** was used to facilitate the data transfer.

North American Palladium		Oskondaga #99999-2017 gravity base
Station number:	**#99999-2017**	
Name:	**Oskondaga**	
Area:	Shabaqua Corners, Thunder Bay.	
NTS Sheet:	-	
Geodetic system:	NAD83, Zone 16N	
Longitude:	89°54' 11.97" W	
Latitude:	48° 35' 54.47" N	
Easting:	285 953.000 ± 0.01 m	
Northing:	5 386 890.00 ± 0.01 m	
Elevation:	386.860 ± 0.017 m	
$g_{ABS\ (FIXED)}$:	**980 890.0000** mGal	
Primary station:	Not tied to the CGSN	
Positioning:	DGPS Leica Viva	
The base #99999-2017 is located on a concrete platform, 1.4 m from the first wooden stair step of the Oskondaga river outfitters. The base is not permanently marked.		

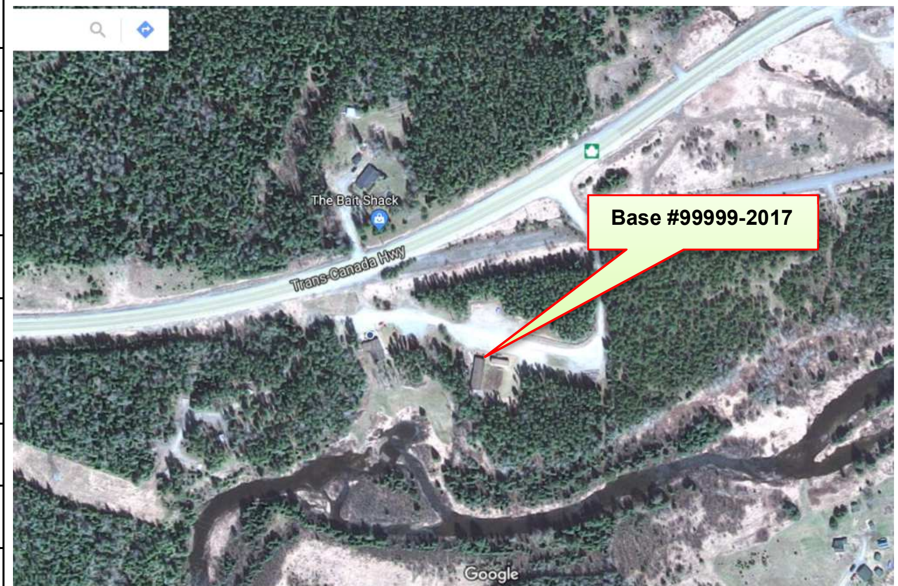


Figure 20. Oskondaga #99999-2017 gravity base description

North American Palladium		LDIM #9999-2018 gravity base
Station number:	**#9999-2018**	
Name:	**LDIM**	
Area:	Lac des Iles Mine site, Ontario	
NTS Sheet:	52H/04	
Geodetic system:	NAD83, Zone 16N	
Longitude:	89°36' 42.87" W	
Latitude:	49° 09' 56.32" N	
Easting:	309 602.328 ± 0.01 m	
Northing:	5 449 154.573 ± 0.01 m	
Elevation:	508.965 ± 0.017 m	
$g_{ABS\ (CALCULATED)}$:	**980 920.620** mGal	
Primary station:	Tied to 99999-2017	
Positioning:	DGPS Leica Viva	

The base #9999-2018 is located on a concrete platform inside the core shack building. The base was installed left of the vertical sliding door, 30 cm from the wall. The base is not permanently marked.

Figure 21. LDIM #9999-2018 gravity base description

- *GRAVITY QC'S*

Before the survey:

- ✓ The gravimeter had been heated and stabilized for more than a week.
- ✓ All the internal constant values had been checked.
- ✓ The X and Y tilt offsets and sensitivities had been calibrated and did not require any adjustments.
- ✓ A new Long Term Drift (drift rate) was calculated and set for each gravimeter during each survey phase.
  New Drift Constants: K_{300} = -0.036 and 0.108
  K_{371} = 0.152
  K_{418} = 0.339 and 0.200

During the survey:

- ✓ The drift was controlled after each loop. The absolute average closure errors were found to be:

Table 3. Absolute average closure error

Drift (mGal)	Contract Requirements	Absolute drift		
		Meter 300	Meter 371	Meter 418
Per loop	0.100	**0.045**	**0.053**	**0.036**
Per hour	0.010	**0.004**	**0.005**	**0.004**

Chart of the daily closure errors (drift) of the gravimeters 300, 371 and 418 are presented in Figures 22-a, 22-b and 22-c, on pages 39 and 40.

- ✓ While readings were recorded, the operator observed the tiltmeter to ensure that the instrument stayed levelled well within ± 15 arcseconds range.
- ✓ At least two readings were taken at every station. A third and even a fourth were recorded if the first two were more than 0.005 mGal apart.

At Operation Headquarters:

- ✓ Dump files (YYMMDD_#Grav.txt) were inspected to detect any spurious readings, for instance:
  - reading time: < 25 seconds
  - rejected samples: > 5
  - SD: > 0.1

Re-visited stations were processed daily to identify any possible weakness in the survey method. **51** stations out of **535** were randomly repeated for quality control (9.6%).

The average repeat error of the absolute gravity g_A was **0.013** mGal and the standard deviation was **0.018** mGal.

The maximum error value was found to be **0.032** mGal at the station 2027.

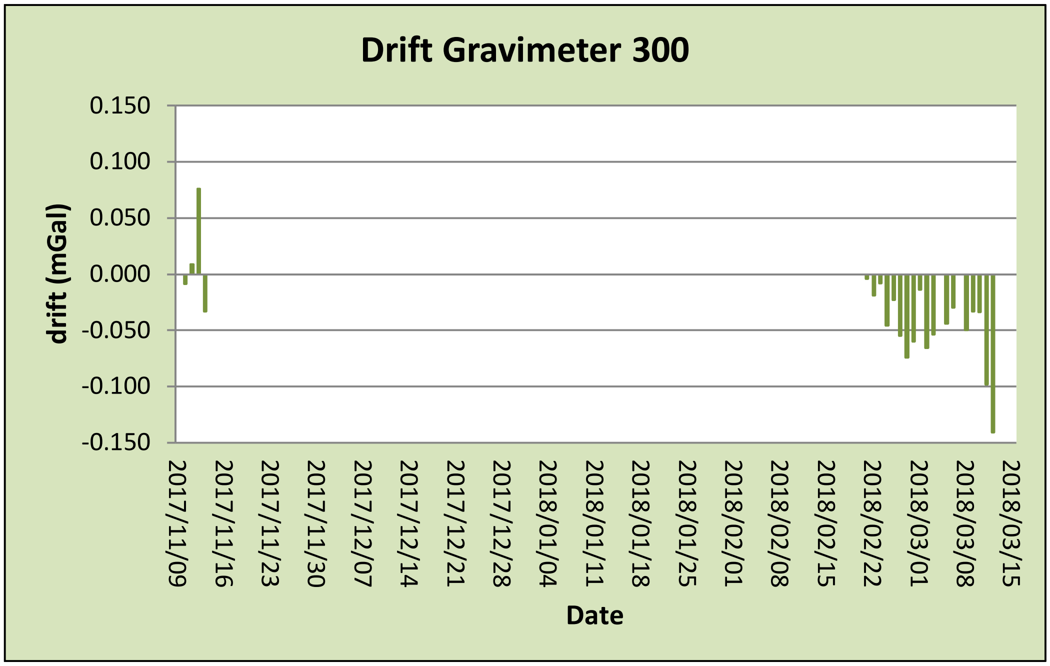


Figure 22a. Daily closure errors of the gravimeter 300

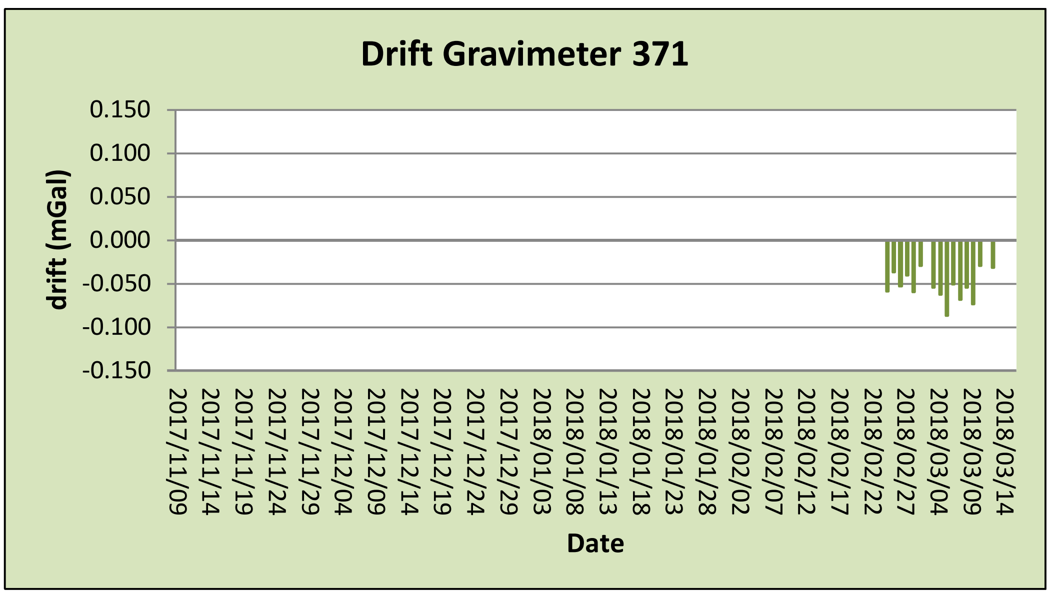


Figure 22b. Daily closure errors of the gravimeter 371

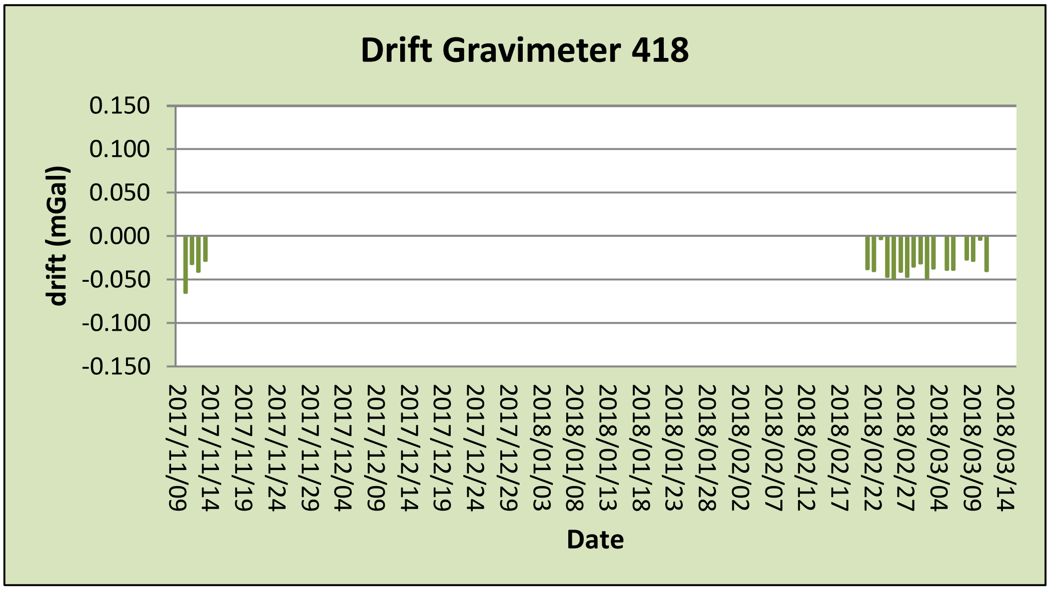


Figure 22c. Daily closure errors of the gravimeter 418

5. GPS DATA ACQUISITION

- *TYPE OF SURVEY*

  Real Time Kinematic (RTK) GPS surveying from an unknown geodetic point with an expected accuracy better than 5 cm in elevation and horizontal positioning.

- *INSTRUMENTATION*

  - *BASE STATION:*
    Leica 1200: s/n: 352824
  - *ROVER:*
    Leica Viva GS15: s/n: 2811264
    s/n: 1509492
    s/n: 1509537

- *GNSS PERFORMANCE AND ACCURACY*

  - Advanced measurement engine.
  - Jamming resistant measurements.
  - Excellent low elevation tracking.
  - Very low Noise GNSS carrier phase measurements with < 0.5 mm precision.
  - 120 channels.
  - Up to 60 Satellites simultaneously on two frequencies.
  - Tracking Satellite signals:
    - GPS: L1, L2, L2C, L5
    - GLONASS: L1, L2
    - Galileo (Test): Glove-A, Glove-B
    - Galileo: E1, E5a, E5b, Alt-BOC
  - GNSS measurements:
    - Fully independent code and phase measurements of all frequencies.
    - GPS: Carrier phase full wave length.
    - GLONASS: Carrier phase full wave length, Code (C/A, P narrow Code).
  - Reacquisition time: < 1 sec.

  Accuracy (rms) with Real-Time (RTK):
  - Rapid static (phase): Horizontal: 5 mm + 0.5 ppm
  - Static mode after initialization: Vertical: 10 mm + 0.5 ppm
  - Kinematic (phase): Horizontal: 10 mm + 0.5 ppm
  - Moving mode after initialization: Vertical: 20 mm + 0.5 ppm

  Accuracy (rms) with Post-Processing:
  - Static (phase) with log observations:
    - Horizontal: 3 mm + 0.1 ppm
    - Vertical: 3.5 mm+0.4 ppm
  - Static and rapid static (phase):
    - Horizontal: 5 mm + 0.5 ppm
    - Vertical: 10 mm + 0.5 ppm
  - Kinematic (phase):
    - Horizontal: 10 mm + 1 ppm
    - Vertical: 20 mm + 1 ppm

- *SOFTWARE* — *LEICA Geo-Office 8.2*

- *RECORDED COORDINATE SYSTEM*

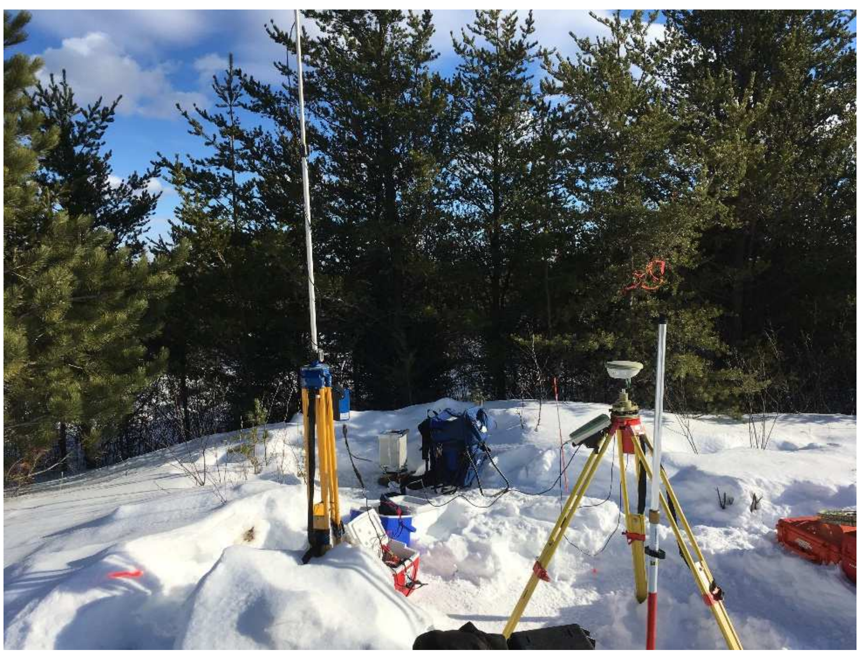
Projection:	UTM zone 16N
Type:	Universal Transverse Mercator
Datum:	NAD83
Central meridian:	87°00' W
Central scale factor:	0.9996
False easting:	500 000 m
False northing:	0 m
Ellipsoid:	GRS 1980
Geoïd model:	HT v.2.0

- *GPS BASE STATIONS*

Three unmarked GPS base stations were established at the survey grids in specific locations to have a better GPS signal coverage.

Table 4. GPS base stations

Base	NAD83 / Zone 16N		Elevation (m)
	Easting (mE)	Northing (mN)	
99	309602.81	5449177.82	508.68
101	297731.29	5431653.04	466.10
103	301091.88	5434314.66	467.26
105	309046.48	5435003.48	468.05



- *GPS PROCESSING*

The coordinates were processed and recorded in real-time (in the field) with the radio information transmitted by the base station. Data were downloaded from the GPS SD cards to a PC hard drive and checked after each survey day. Secondary post processing was performed every day at Val-d'Or office.

- *GPS QC'S*

Before the survey:

- ✓ The GPS units were verified and calibrated.
- ✓ Level and graduated staff accuracies were checked.

During the survey:

- ✓ The distance between the antenna and the ground was measured to a precision of 1 millimetre and was then entered on the keypad.
- ✓ The base station unit provided real-time corrections of the satellites time-tagged information to the mobile unit every second.
- ✓ The base station unit also took a recording automatically every 5 seconds for static post processing.
- ✓ The receiver is re-initialized after every shot to ensure each observation is independent.

At Operation Headquarters:

- ✓ The average precision of the elevation values as estimated by LEICA Geo-Office in this project is ±1.7 cm.
- ✓ The average precision on the horizontal positions (X and Y) is ±1.0 cm.

49 stations out of **535** were randomly re-visited for quality control (~9.5%). The average absolute error of the elevation was calculated to be **0.8 cm** with a root mean square (RMS) error of **1.4 cm**. The maximum error value was found to be **2.3 cm** at stations 1001 and 6015.

6. DATA PROCESSING

6.1 HIGH-RESOLUTION GROUND GRAVITY SURVEY

- *ABSOLUTE GRAVITY (G_A)*

The observed gravity values were first imported into Geosoft *Xcelleration* along with the elevation data. In view of the high accuracy of the gravity readings, the absolute RMS error of the observed gravity repeat values was **0.018** mGal.

Tidal correction is re-calculated in *Xcelleration* using the station location and measuring time. The accuracy of this correction is better than **0.001** mGal.

Within the study grids, the value of the instrument height is typically accurate within ± 2.0 cm which is equivalent to an error of ± **0.006** mGal.

The residual drift of the gravimeter is assumed linear between two readings at the base station. The closure error was linearly distributed on the data in the corresponding loop, taking into account the instrument height and the tidal correction. Non-linear drifting could introduce an error of up to **0.005** mGal in the middle of a loop.

The maximum error of $\mathbf{g_A}$ is therefore estimated to be ± **0.030** mGal. Only one repeat (2027) has exceeded this value.

- *BOUGUER ANOMALY (G_B)*

Density "ρ": A mean crustal rock density of **2.85 g/cm³** was used in the calculation of the Bouguer anomaly. As regards the terrain correction, a density of **2.67 g/cm³** was taken.

Latitude Correction: both the rotation of the Earth (generating centripetal acceleration) and its slight equatorial bulge produce an increase of gravity with latitude. This effect is corrected when computing the theoretical value of gravity at the surface of the reference ellipsoid using the Geodetic Reference System GRS67:

$$g_L(\phi) = 978\,031.846\,\{1.0+0.005278895 \sin^2(\phi) + 0.000023462 \sin^4(\phi)\}\ \text{mGal}$$

For local surveys, only the gradient due to latitude is important:

$$g_L = 0.0000812132 \sin(2\phi)\, Y_i \quad \text{mGal/m}$$

With dual frequency DGPS, the horizontal (latitude) position is accurate to better than ± 5.0 cm, so the error is less than **0.001** mGal.

Free Air Anomaly: since gravity varies with the inverse of distance squared, it is necessary to correct for changes in elevation between stations so that all field readings are reduced to a datum surface. The Free Air anomaly at elevation "h" is:

$$g_F = g_A - g_L + 0.308596 * h$$

Simple Bouguer Anomaly: it accounts for attraction of bedrock of density "ρ" between the station and the datum plane, which was ignored in the Free Air calculation. The Bouguer anomaly is:

$$g_B = g_F - 0.0419088 * \rho * h$$

Using a density of **2.75 g/cm³** and a typical accuracy of **± 1.7 cm** in elevation, the error on the combined Free Air and Bouguer correction is **± 0.003** mGal.

- *ACCURACY OF G_B*

Table 5. Accuracy of g_B

Step	Source / Evaluation Method	Error (mGal)	
		Maximal	Typical
g_A	Re-occupied stations	0.030	0.018
g_L	Latitude correction	0.001	0.000
g_B	Free Air and Bouguer	0.009	0.003
Estimated error ε_{g_B} on g_B *		**0.031**	**0.018**
Contract requirement *		**0.050**	**0.050**

* excluding terrain correction

$$\varepsilon_{g_B} = \pm\sqrt{\varepsilon_{g_A}^2 + \varepsilon_{g_L}^2 + \varepsilon_{g_B}^2} \text{ , mGal}$$

- *COMPLETE BOUGUER ANOMALY (G_{CB})*

Terrain correction: allows for surface irregularities in the vicinity of the station, not terrain accounted for in the Simple Bouguer anomaly calculation. An excess mass in the form of a positive topographic feature adjacent to a gravity station exerts an upward pull on the gravity meter, thus lowering the observed reading. A mass deficiency in the form of a valley adjacent to a gravity station causes the gravity field to be lower than it would be where the terrain is flat. Terrain corrections compensate for these effects and are therefore always positive.

The complete Bouguer anomaly is defined as Simple Bouguer anomaly (g_B) with terrain corrections (g_T) includes:

$$g_{CB} = g_B + g_c + g_T$$

- *CURVATURE (BULLARD B) CORRECTION (G_C)*

The purpose of the curvature correction as a step in producing the Bouguer anomaly is to convert the geometry for the Bouguer correction from an infinite slab to a spherical cap whose thickness is the elevation of the station and whose radius (arc length) from the station is 166.735 km.

In the case of the Greenfields Project the Bullard B correction values vary from -0.68 to -0.60 mGal with an average of -0.64 mGal.

- *TERRAIN CORRECTION (G_T)*

Inner Terrain Correction (ITC):
The ITC, which corrects for local topographic features (terrain effect up to 50 m from the station), is performed using the Hammer method (Geophysics, 1939). This method involves creating a set of concentric rings, or zones, as they are referred to here, each of which are divided into a specified number of equal-sized segments. The average elevation for each of these segments is entered relative to the elevation specified for a given station. In this way, the topography immediately surrounding each station can be defined and the inner terrain correction calculated:

$$g_T = \gamma * 0 * \theta * \left(r_2 - r_1 + \sqrt{r_1^2 + z^2} - \sqrt{r_2^2 + z^2} \right)$$

Where γ = 6.67x10^{-8} dyne cm^2/g^2
θ = sector angle (in radians)
ρ = average density (2.67 g/cm^3)
r_1, r_2 = inner and outer sector radius (in cm)
z = average height difference between the station and the sector (in cm)

	Zone B	Zone C
r_1:	2 m	12 m
r_2:	12 m	50 m
Number of sectors:	4 (θ = 1.57)	4 (θ = 1.57)

On the Greenfields Project, the slopes of hammer Zones B and C were collected at each gravity station during the fieldwork operations. Only terrain correction of Zone B (2 – 12 m) was included in the Immediate gravity terrain correction. The attraction effect of Zone C (segment: 12 – 50 m) is compensated in the Inner terrain Correction calculation using a detailed local DEM of 30 m resolution.

Outer Terrain Correction (OTC):
Terrain corrections are calculated using the GRREGTER and GRTERAIN GXs of Geosoft based on a combination of the method described by Nagy, 1966 and Kane, 1962.

This algorithm requires a coarse regional Digital Elevation Model (DEM) and a detailed local DEM.

- *TERRAIN CORRECTION (G_T) (CONTINUED)*

GRREGTER GX is designed to produce a "regional correction grid" that represents terrain corrections beyond the local correction distance; while GRTERAIN GX produces full terrain corrections at each gravity station by extracting an interpolated milligal value from the regional correction grid and adding the local correction calculated from a local, more highly sampled DEM grid. The Inner Terrain Correction (Zone B: 2 – 12 m) is manually added in the database

In this project, a regional DEM (SRTM World Elevation 3 Arc-Second) sampled at a 92 m and a detailed local DEM gridded to a 30 m cell size, downloaded from *Geosoft Public DAP Server* site were used in the Terrain Correction calculation (Figure 23).

Regional DEM covers an area up to 55 km beyond the survey grid; while the local DEM covers the entire survey grid plus a Local Correction Distance of 5.5 km.

The Gravity Terrain Correction algorithm first generates the regional terrain correction then adding the immediate (local) correction from a local DEM grid to give the Outer terrain correction (OTC). Thus, the total Terrain Correction is obtained by adding the Inner Terrain Correction (ITC, Hammer zone B) values.

In the case of the Greenfields Project the total terrain correction values vary from 0.015 to 0.176 mGal (average of 0.045 mGal) with a standard deviation of 0.021 mGal (Figure 24).

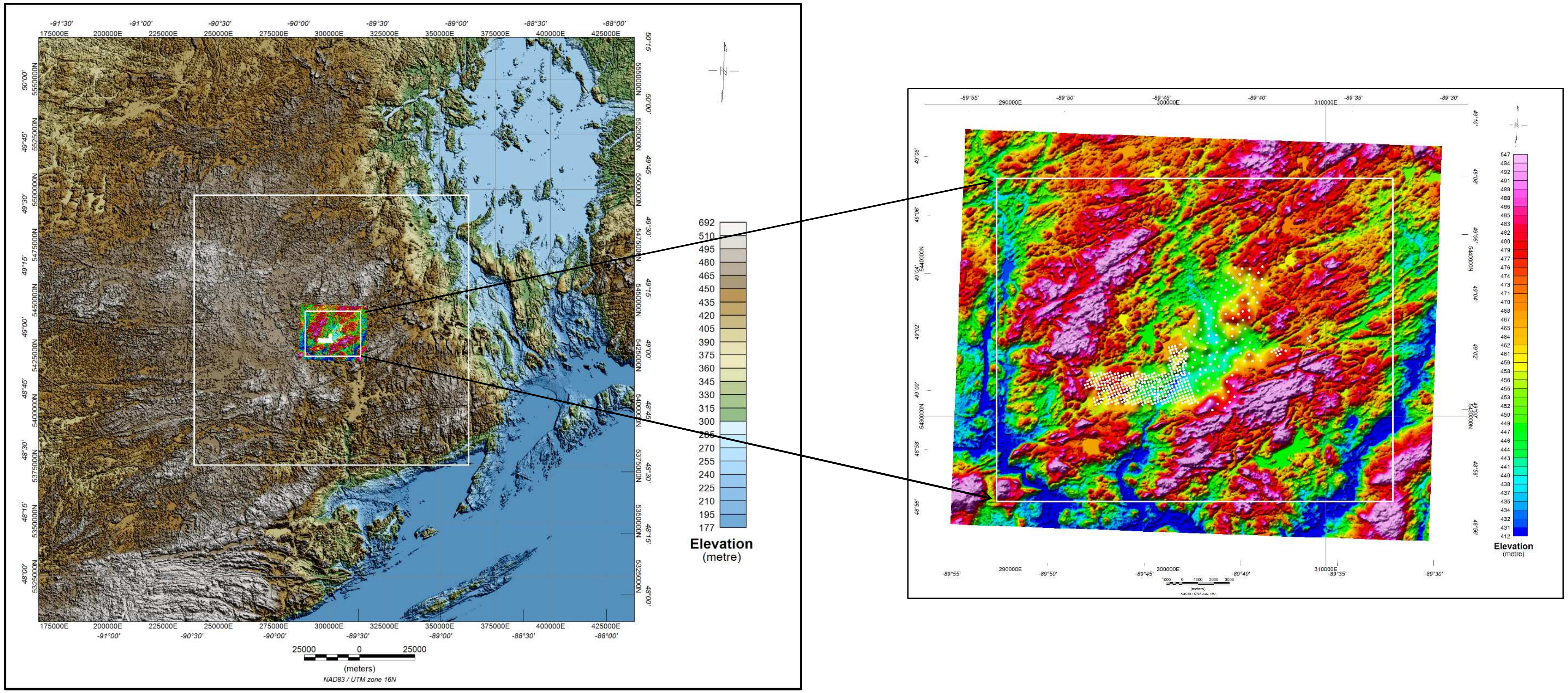


Figure 23. Digital Elevation Models used in the terrain correction calculation; Regional SRTM-92 m resolution (left); Local SRTM-30 m resolution (right), Greenfields Project

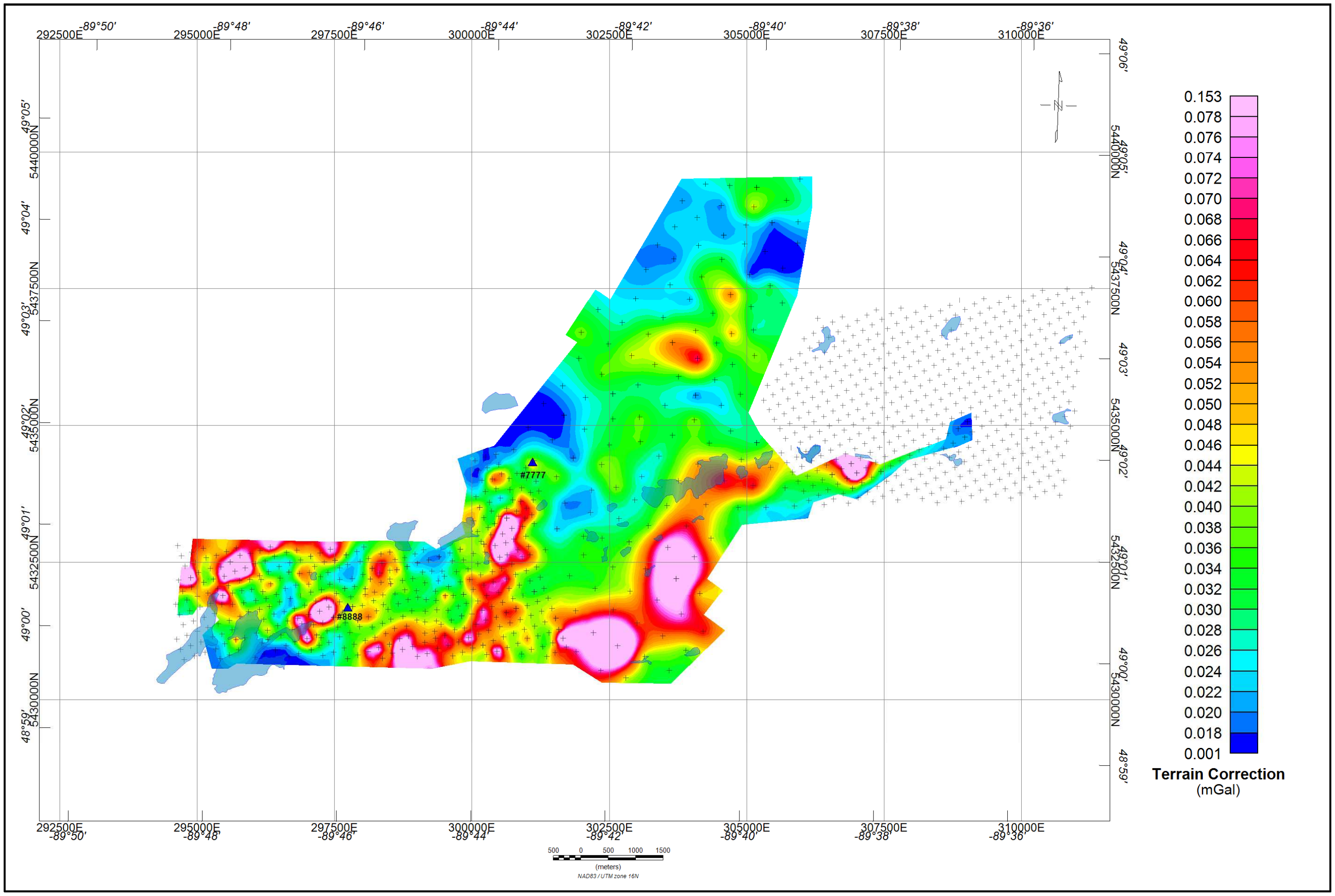


Figure 24. Terrain correction calculation, Greenfields Project

7. DELIVERABLES

➢ GRAVITY DATA PRESENTATION

❑ *BOUGUER ANOMALY*	The reduced data are interpolated to a square grid of 100 m cell size, using Kriging method based on statistical analysis of the entire data set to create spatial gravity map (2.2). The Oasis Montaj color table Clra64.tbl was used with linear interval of 0.20 mGal from 10.0 mGal to 18.0 mGal.
❑ *ELEVATION*	The *Elevation Contours* map (2.3) was gridded with using the same method and parameters used for the Complete Bouguer anomaly. The Oasis Montaj color table Clra64.tbl was used with linear intervals of 1.0 m from 430 to 490 m.
❑ *RESIDUAL BOUGUER ANOMALY*	Regional component was obtained after an upward continuation up to 5 km of the Bouguer field. The residual anomaly was then generated in a straightforward way by subtracting the regional field from the *Complete Bouguer values* (2.5). The Oasis Montaj color table (Clra64.tbl) was used with linear intervals of 0.10 mGal from -2.0 mGal to +2.0 mGal.
❑ *FIRST VERTICAL DERIVATIVE*	Using a convolution filter method, the first vertical derivative (vertical gradient) of the Complete Bouguer anomaly was calculated. To improve the overall appearance of the final map, one pass of a 3 x 3 Hanning filter was applied to the resulting grids (2.7). The Oasis Montaj color table (Clra64.tbl) was used with linear intervals of 0.0005 mGal/m from -0.0100 mGal/m to +0.0100 mGal/ft.

- *DIGITAL DATA*

The above-described maps are delivered in the Oasis Montaj map file format on DVD-Rom.

A copy of all survey acquisition data (ASCII text format) and processed data (Geosoft Montaj databases) are also delivered on DVD-Rom.

- *MAPS PRODUCED*

A plot of five maps at scale 1:20 000, is inserted in pouches at the end of this report.

All plan maps are registered to the NAD83 / UTM zone 16N, grid coordinate system as collected in the field.
Our Quality System requires that at least two qualified persons inspect every final map before being approved and included in a final report.

Additional Appendices:

The following appendices contains outstanding items required under ‘Technical Standards for Reporting Assessment Work’ guidelines; namely Section 7. Ground Geophysical Survey Work.

Appendix A: Property Exploration History - 7. (vii)

Appendix B: Permit - 7. (viii)

Appendix C: Regional and Local Geology - 7. (ix)

Appendix D: Mineral Deposit Model and Rationale for Survey – 7. (x)

Appendix E: Recommended Work – 7. (xxvi)

Appendix A: Property Exploration History - 7. (vii)

The following excerpt was taken and modified from Wagner (2003):

1970-72: V.R. Henbid and T.A. Gustafson conducted a survey which covered the western third of the South Legris property, northern half of the Shelby Lake Property, and the majority of the Lac Des Iles River Property. It identified several weak EM anomalies in and immediately northeast of the northeastern corner of the South Legris Property. Ground follow-up indicated that these anomalies were associated with the gabbro contact in this area and topographic lineaments. No significant mineralization was identified.

1975: Texas Gulf Inc. conducted a regional airborne EM and Magnetic survey which included the western third of the South Legris property, northern half of the Shelby Lake Property and majority of the Lac Des Iles River Property. This survey identified and defined the magnetic high associated with the Shelby Lake Intrusion.

1986: American Platinum Incorporated conducted an airborne EM and Magnetic survey over the western half of the Lac Des Iles River Property and conducted ground exploration and drill testing on the adjacent Demars and Wakinoo Lake Properties.

1989: An assessment report by B. Fowler noted the presence of chalcopyrite mineralization within mafic volcanic rocks on the south side of Shelby Creek at the eastern edge of the South Legris Property. Assays of up to 5.4% Cu, 33 ppm Ag and 50 ppb Au were returned from several small pits and trenches. This is the only recorded occurrence of mineralization on the three properties prior to Platinum Group Metals Ltd. involvement.

2000: The *Ontario Government*, as part of their Operation Treasure Hunt initiative, released a detailed airborne magnetic and electromagnetic survey which covered the extension of the Towle Lake Intrusive Complex onto the Shelby Lake property.

Also in June 2000, *New Millennium Metals* discovered geologically significant PGM mineralization at Powder Hill on the south-central portion of the property through mapping and prospecting. Grab samples from this isolated outcrop returned grades of up to 2.25 g/t Pd+Pt+Au and 0.3% copper. A follow-up trenching program (0.9 hectares in two trenches) was conducted during the fall 2000. Trenching subsequent channel sampling across this zone returned two mineralized intervals averaging 0.39g/t Pd+Pt+Au and 0.12 g/t Pd+Pt+Au over 2 metres.

Between late 2000 and early 2001, *Platinum Group Metals Ltd* and *New Millennium Metals Corp* conducted an Induced Potential (IP)/Magnetometer survey and drill program in the Powder Hill area. Twelve holes totaling 1,043 metres were completed. Nine intersected an open-ended, stratiform zone of Pt-Pd-Au-Cu mineralization over a strike length of 600 metres. Mineralization in excess of 1 g/t Pd, with a high of 2.83 g/t Pd over 1.2 metres, occurs over a maximum width of 5.65 metres.

2001: *Platinum Group Metals Ltd.'*s mapping and detailed prospecting program, focused on the Towle Lake magnetic trend, resulted in the discovery of the high-grade Stinger Zone located 6.5-km northeast of Powder Hill on the Shelby Lake Property. Grab samples from the discovery outcrop at Stinger returned up to 7.95 g/t Pt+Pd+Au, 130 ppb Rh and 0.6% Cu. Subsequent trenching of the Stinger Zone in the fall of 2001 identified similar mineralization over a strike length of 55 metres in the Main Trench area with grades from saw cut channel samples of up to 4.19 g/t Pt+Pd+Au over 1.7 metres and mineralized widths of up to 1.35 g/t over 6.4 metres.

Also in 2001, Platinum Group Metals discovered the Vande Zone through mapping and prospecting on their South Legris Property. Channel sampling at the discovery outcrop reportedly resulted of 0.36g/t Pd+Pt+Au over 50 metres including 1.22g/t Pd+Pt+Au over 2 metres. Follow-up drilling returned thick intersections of low grade Pt+Pd+Au mineralization (including separate intervals of 9.36 metres grading 0.13 g/t Pt+Pd+Au and 8.48 metres grading 0.24 g/t Pt+Pd+Au in hole ST03).

2002: *Platinum Group Metals Ltd.* completed a two-part diamond drilling and trenching program on the Shelby Lake intrusion. Highlights of the 2002 exploration program included drill intercepts grading 1.06 g/t Pt+Pd+Au over 19.2 metres including 4.92 g/t Pt+Pd+Au over 3.1 metres from the Stinger Zone, in addition drill intercepts grading 0.45g/t Pt+Pd+Au over 13.7 metres including 1.23 g/t Pt+Pd+Au over 3.7 metres from the Vande Zone. A 10-14 m wide PGM mineralized zone grading 0.24 to 0.36 g/t Pt+Pd+Au is associated with the northern contact of the Shelby Lake Intrusion (Shelby Contact Zone) and extending the strike length of the PGM mineralized systems in the Stinger and Vande areas to 700 metres respectively. Surface trenching and drilling has traced the Shelby Contact Zone for 2.3 km along the northern contact of the Shelby Lake Intrusion.

2003: *Platinum Group Metals Ltd* undertook a 3040 metre diamond drilling program which tested the extensions of the Powder Hill and Stinger mineralized zones. The program was successful in extending the Powder Hill PGM Zone for 1800 metres to the northeast for a total strike length of 2.4 kilometres and the PGM mineralized Stinger Zone for 700 metres to the northeast for a total strike length of 1.4 kilometres. A single hole drilled to test an IP anomaly along the projected strike extension of the Shelby Contact Zone failed to intersect any significant mineralization.

2006-2007: *Platinum Group Metals Ltd* completed seven diamond drill holes for a total of 1729 meters. These holes were designed to test the extension of the Stinger stratigraphy in the Stinger Area and intrusive contact within the Shelby Lake shear zone. Hole SH07-07 contained 2.45 g/t Pd+Pt+Au over 5.90 metres including 4.30 g/t Pd+Pt+Au over 1.50 metres.

2009: Two 679 metre and one 300 metre diamond drill holes were completed in the Vande and Stinger zones respectively. Clark Exploration was contracted by *Platinum Group Metals* to manage the program. No significant intervals were intersected.

2010 (Modified from Patrie 2010): The magnetometer and induced polarization (IP) surveys on the Shelby Lake grid were carried out between 27 April 2010 and 6 May 2010. The geophysical surveys were carried out by *Dan Patrie Exploration Ltd.*, an experienced geophysical contractor.

The magnetometer survey identified a NNE-trending linear, positive magnetic feature varying in width from about 250 m to 400 m. The IP survey chargeability results show anomalous zones of increased chargeability from 2 to 4x background charge across significant widths, and with two apparent trends, NNE and northeasterly (060°).

References

Patrie, Dan. 2010. Geophysical Survey Report on the Lac Des Iles Property Shelby Lake Grid for Platinum Group Metals Inc. NTS 52 H/4; Shelby Lake Area (G2512).

Wagner, Darin. 2003. Technical Report on the Lac Des Iles pt-Pd Project; Lac Des Iles River, Shelby Lake and South Legris Properties. NTS 52 H/4, Shelby and Orbit Lake Map Sheets.

Appendix B: Permit - 7. (viii)

This work is covered under the permit: PR-14-10482.

Appendix C: Regional and Local Geology - 7. (ix)

Property Geology

The Shelby Lake Property comprises the Towle Lake and Shelby Lake intrusive complexes which are relatively narrow, elongate gabbro-dominated intrusions, occurring along the eastern and southern margins of the Lac des Iles district. Intrusions appear to have been emplaced along pre-existing zones of structural weakness and exhibit marginal breccia zones and multiple intrusive events. Exploration programs confirmed the presence of three geologically significant zones of PGM mineralization closely associated with disseminated sulphide within the Towle Lake Intrusion including the Powder Hill, the Stinger and the Vande zones. The Vande zone mineralization is at 3.5 km northeast of Stinger and exhibits a geologically complex series of PGE bearing gabbro breccias and gabbro intrusive phases.

Regional Geology

Much of the following information presented in this section is sourced from the Open File Report OFR6120 Project Unit 95-014; Regional Geology of the Lac des Iles Area (Stone et al., 2003). Information presented here was also sourced from NI 43-101 Technical Report: Feasibility Study Incorporating the Life of Mine Plan for Lac des Iles Mine, Thunder Bay, Ontario, Canada (Buss et al., 2017). Additional sources are referenced appropriately.

The Greenfields Project area covered part of the eastern Central Wabigoon Subprovince and the northern margin of the Quetico Subprovince of the Superior Province of the Canadian Shield. This area can be further subdivided into crustal blocks including the Winnipeg River terrane, Marmion terrane and Western Wabigoon terrane that are thought to have developed independently through the late Mesoarchean and Neoarchean and were tectonically amalgamated 2.71 Ga (Stone et al., 2003).

The Winnipeg River terrane refers to the gneissic-plutonic domain north and east of the western Wabigoon terrane (Percival et al., 2012). Regionally, the Winnipeg River terrane includes the Winnipeg River Subprovince and north-central parts of the Wabigoon Subprovince as well as part of the Lac des Iles area. Old crustal material has been intruded and assimilated by voluminous Neoarchean felsic magmas represented by batholiths of tonalite and granite as well as mafic magmas that erupted to form greenstone belts.

The Marmion terrane consists of tonalite basement rocks (3010-2999 Ma) upon which greenstone belts formed at 2990-2715 Ma (Percival et al., 2012). Based on neodymium isotopic data, the Marmion terrane extends eastward through the Lac des Iles area despite contrary geochronological evidence. Therefore, plutonic suites in the Greenfields exploration region likely represent at least partly recycled Marmion batholith and associated 3-billion-year-old plutonic rocks.

The Western Wabigoon terrane is dominated by 2745–2720 Ma mafic volcanic rocks with large tonalitic plutons (2735–2720 Ma) and younger clastic metasedimentary sequences (2711 to <2702 Ma) carrying ancient (>3 Ga) detrital zircons that are preserved in narrow belts within volcanic sequences, and may have been deposited during deformation (Percival et al., 2012). The Lac des Iles greenstone belt extends from south of Legris Lake to south of Wakinoo Lake and also includes an east-trending sequence 2km north of Legris Lake. The greenstone sequences are typical sequences that include mafic pillowed to massive flows with minor feldspar-phyric, fragmental felsic volcanic rocks interspersed within a metasedimentary sequence of dominantly wacke-siltstone with minor conglomerate and iron formation.

The Lac Des Iles mine area is underlain by mafic to ultramafic rocks of the Lac des Iles intrusive complex (LDI-IC). The LDI-IC is the best documented of a suite of Neoarchean mafic to ultramafic intrusive bodies occurring within a sub-circular area of approximately 35 km by 40 km in the Wabigoon Subprovince (Fig. 1). The intrusions are located immediately to the north of the Quetico Subprovince and directly west of the Nipigon embayment of the Mid-continent Rift System. At the time of writing, the Company owned or had options to acquire a majority interest in most of the known Lac des Iles suite intrusions including parts or all of the following bodies: LDI-IC, Legris Lake intrusive complex, Wakinoo Lake intrusion, Demars Lake intrusion, Taman Lake intrusion, Dog River intrusion, Buck Lake intrusion, Shelby Lake Intrusion, Towle Lake intrusion and Tib Lake intrusive complex. The easternmost bodies of the Lac des Iles suite of intrusions are the LDI-IC and the Legris Lake complex. Both the LDI-IC and the Legris Lake complex appear to have been emplaced along northeast-trending splay structures (e.g., Shelby Lake fault) emanating from the Quetico Fault Zone (Fig. 1). The Quetico Fault Zone is a collisional structural boundary between the Quetico and Wabigoon subprovinces that formed during the Shebandowanian orogeny at approximately 2,695 Ma (Corfu and Stott 1986). Similarly, many of the Lac des Iles suite intrusions located in the western part of the Lac des Iles area are spatially associated with northeast to north striking faults that splay off this collisional boundary.

The intrusions range in size from 1 to 10 km and vary compositionally from leucogabbro and gabbronorite with rare anorthosite to peridotite and pyroxenite. The intrusions crosscut most rock types except for biotite granite dikes and Proterozoic-aged intrusions. Archean rocks are observed to be intruded by Proterozoic-aged (~1100 Ma) diabase dikes and sills of the Nipigon Sill Complex of the Mid-Continent Rift (MCR). They are typically medium-grained, massive, and dark grey weathering brown and locally pyroxene phyric.

Uranium-lead age determinations for zircons contained in the mafic rocks show that the Lac des Iles suite intrusions were likely emplaced between 2,699 and 2,686 Ma (Stone and Davis 2006). This age overlaps with regional sanukitoid magmatism in both the Wabigoon Terrane and the Quetico Subprovince.

References

Buss, B; Roney, C; Peck, D; Decharte; Marrs, G; Canosa, J; Hutton, K; Ritchie, L; Therrien, L; (2017). NI 43-101 Technical Report: Feasibility study incorporating the life of mine plan for Lac des Iles Mine. North American Palladium and Nordmin Resource and Industrial Engineering.

Corfu, F. and Stott, G. M. 1986. U-Pb ages for late magmatism and regional deformation in the Shebandowan Belt, Superior Province, Canada. Canadian Journal of Earth Sciences, v. 23, p. 1075-1082.

Mumin, Ahmad. 2015. Assessment Report – 2013 Diamond Drilling Assessment Report on the Wakinoo/Demars Property. NTS: 052A13, 052H04; Senga Lake, Shelby Lake, Orbit Lake, Eayrs Lake Claim Area.

Stone, D., Lavigne Jr, M. J., Schnieders, B. R., Scott, J. F., and Wagner, D. 2003. Regional Geology of the Lac des Iles area; Ontario Geological Survey, Open File Report OFR6120.015, Project Unit 95-014.

Stone, D. and Davis, D.W. 2006. Revised tectonic domains of the south-central Wabigoon Subprovince; in Summary of Field Work and Other Activities 2006, Ontario Geological Survey, Open File Report 6194, p.11-1 to 11-18.

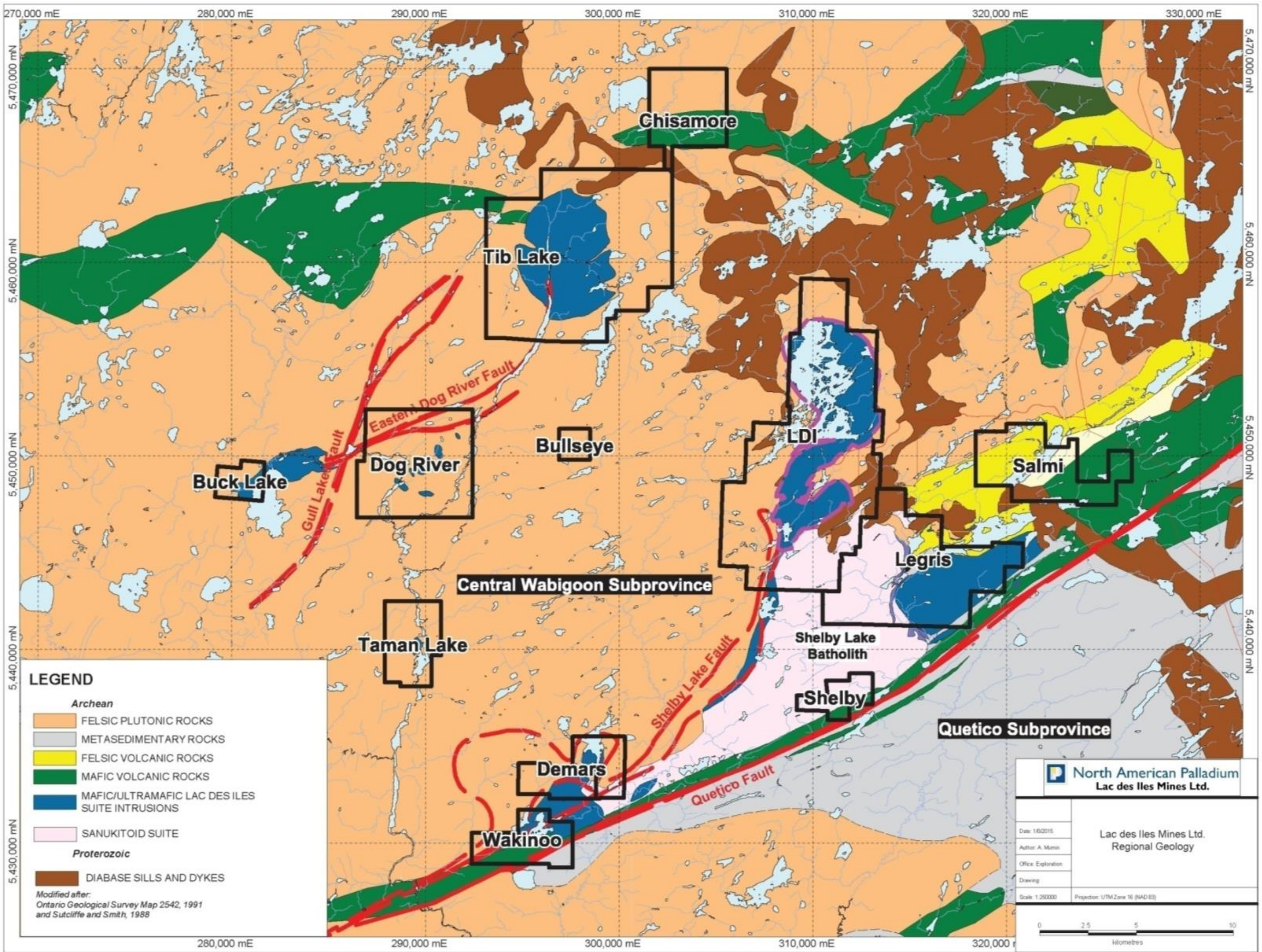


Figure 1: Regional geology of the Lac De Iles suite intrusions (Mumin 2015).

Appendix D: Mineral Deposit Model and Rationale for Survey – 7. (x)

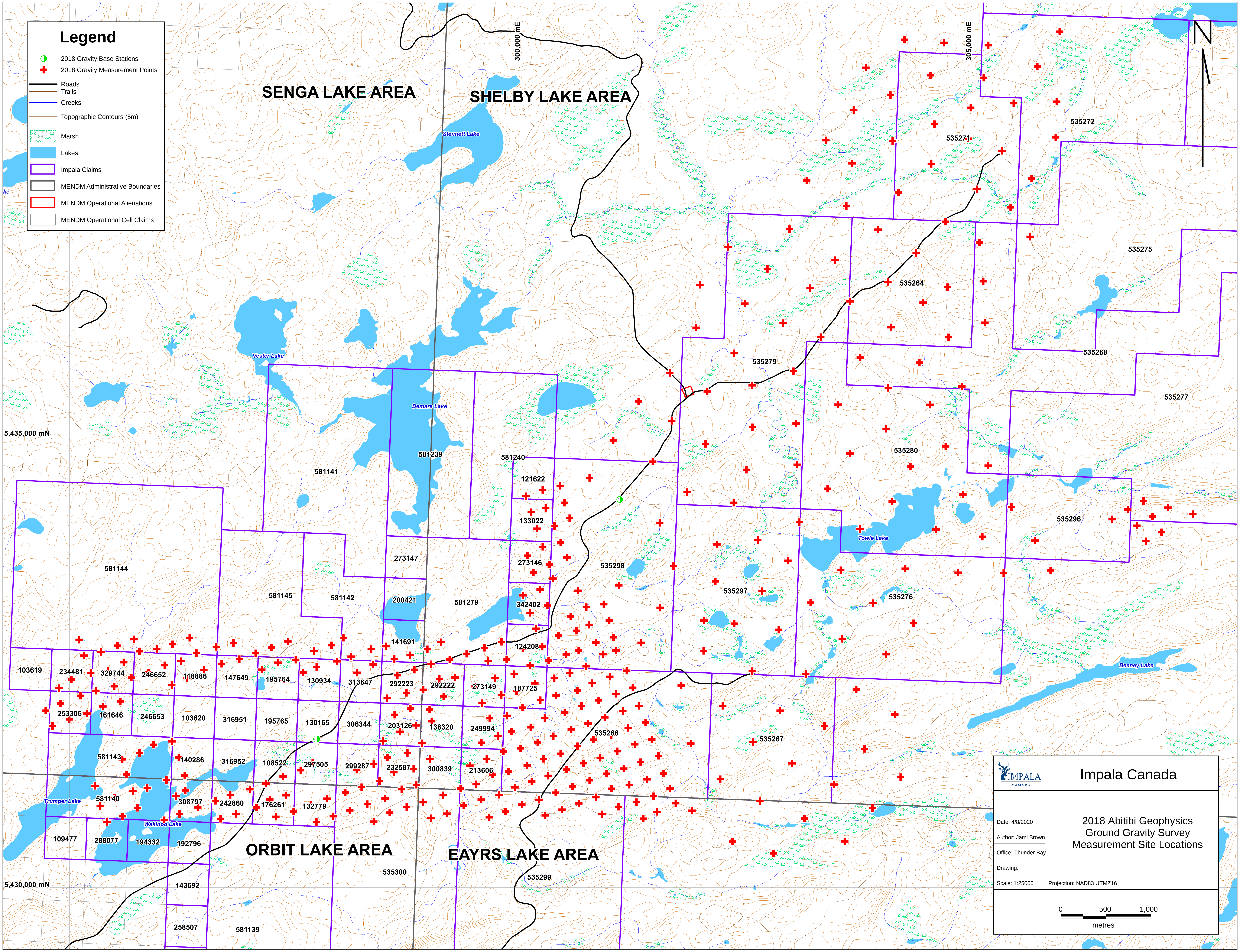
North American Palladium explores for magmatic Ni-Cu-PGE mineralization hosted within Archean-aged mafic to ultramafic intrusions related to the Lac des Iles suite. Zones of PGE-rich disseminated sulfide mineralization typically occur in discrete zones along the margins of these intrusions. A gravity survey allows for the identification and delineation of mafic intrusions based on contrasting density compared to surrounding rocks, typically granitic plutons. Ground surveys provide better quality data compared to current airborne surveys.

The objectives of the survey were two-fold:

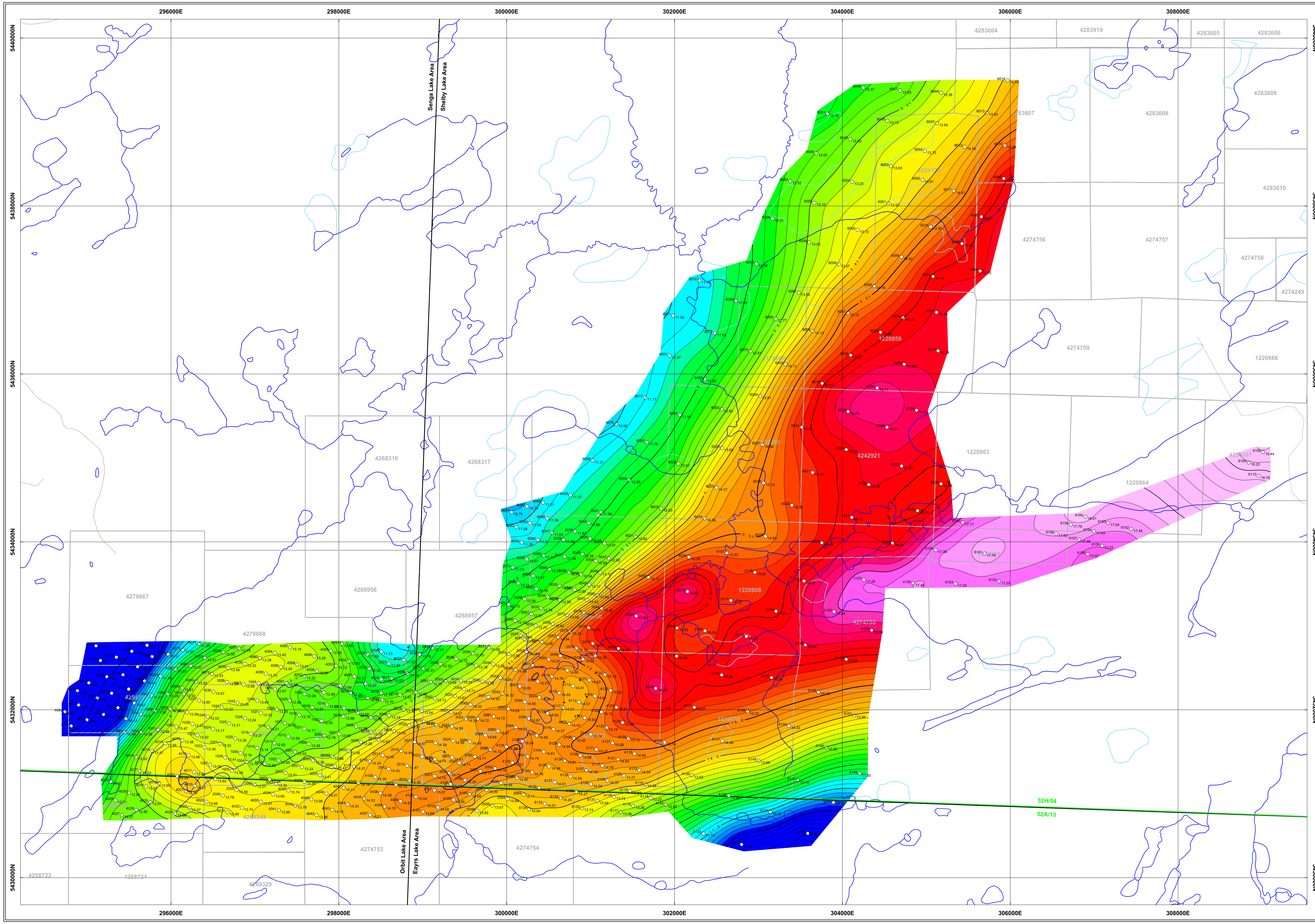
1) map the extents of mafic to ultramafic intrusions which are known to host economically interesting PGE-Cu-Ni magmatic sulfide mineralization and
2) to discover new prospective dense bodies in the area of interest

Appendix E: Recommended Work – 7. (xxvi)

No additional work is recommended at this time.



Legend
2018 Gravity Base Stations
2018 Gravity Measurement Points
Roads
Trails
Creeks
Topographic Contours (5m)
Marsh
Lakes
Impala Claims
MENDM Administrative Boundaries
MENDM Operational Alienations
MENDM Operational Cell Claims
SENGA LAKE AREA
SHELBY LAKE AREA
ORBIT LAKE AREA
EAYRS LAKE AREA
300,000 mE
305,000 mE
5,435,000 mN
5,430,000 mN
N
Stennett Lake
Vester Lake
Demars Lake
Towle Lake
Beeney Lake
Trumper Lake
Wakinoo Lake
535272
535271
535275
535264
535268
535279
535277
535280
535296
535298
535297
535276
535267
535266
535300
535299
581239
581240
581141
581144
581145
581142
581279
581143
581140
581139
121622
133022
273147
273146
200421
342402
141691
124208
103619
234481
329744
246652
118886
147649
195764
130934
313647
292223
292222
273149
187725
253306
161646
246653
103620
316951
195765
130165
306344
203126
138320
249994
140286
316952
108522
297505
299287
232587
300839
213606
308797
242860
176261
132779
109477
288077
194332
192796
143692
258507
Impala Canada
2018 Abitibi Geophysics
Ground Gravity Survey
Measurement Site Locations
Date: 4/8/2020
Author: Jami Brown
Office: Thunder Bay
Drawing:
Scale: 1:25000
Projection: NAD83 UTMZ16
0
500
1,000
metres



Legend

Bouguer Anomaly Contours

Unit: mGal

Instruments: Gravity Meter: Scintrex CG-5u AutoGrav
DGPS: Leica Viva

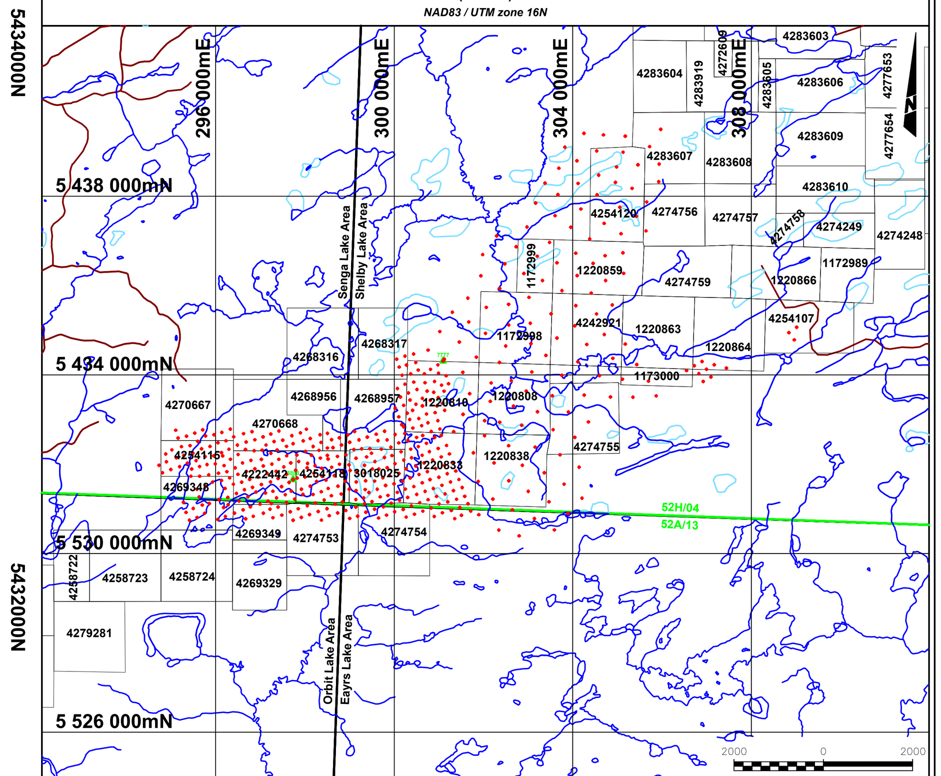
Base # — Gravity Base Station

Station # / Bouguer — Gravity Station

Bouguer Anomaly (mGal): 10.2 – 17.8

Scale 1:20 000

(meters) NAD83 / UTM zone 16N



North American Palladium
Greenfields Project
Lac des Iles Mine Area, Ontario

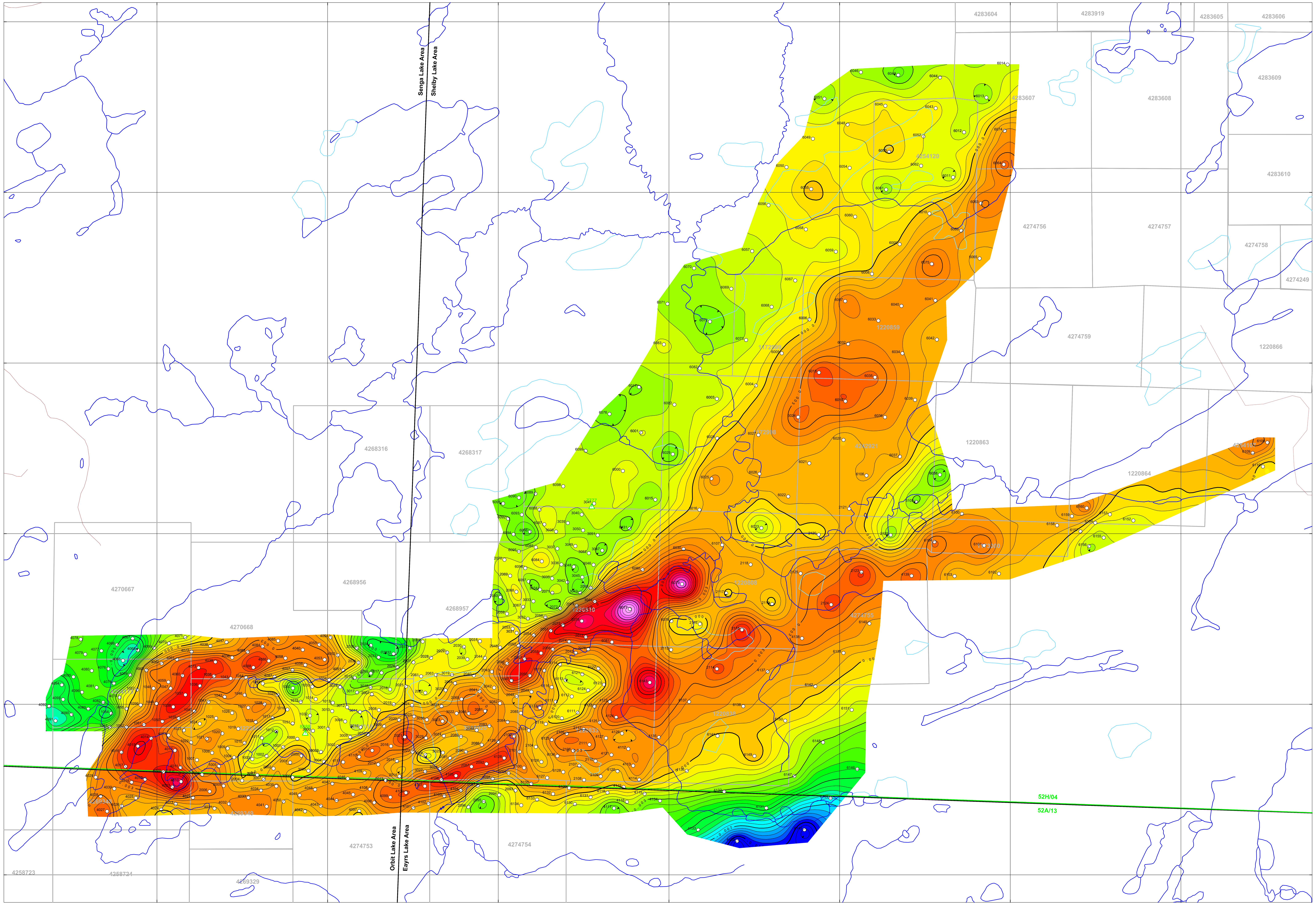
High-Resolution Ground Gravity Survey
Bouguer Anomaly Contours (mGal)
(Slab density: 2.85 g/cm³)

Interpreted by:	M. Chemam, P.Geo.	2018/05
Surveyed by:	Abitibi Geophysics Inc.	2018/02
Verified by:	L. Plante, P.Eng.	2018/05
Reference maps: 52H/04 and 52A/13		Scale 1:20 000
Project no: 17N093		Map no: 2.2

ABITIBI GEOPHYSICS

Legend
Elevation Contours
Unit: m
Instruments: Gravity Meter: Scintrex CG-5u AutoGrav
DGPS: Leica Viva
Base #
Gravity Base Station
Station #
Elevation
Gravity Station
Elevation (m)
Scale 1:20 000
(meters)
NAD83 / UTM zone 16N
Senga Lake Area
Shelby Lake Area
Orbit Lake Area
Eayrs Lake Area
52H/04
52A/13
296000E
298000E
300000E
302000E
304000E
306000E
308000E
5430000N
5432000N
5434000N
5436000N
5438000N
5440000N
North American Palladium
Greenfields Project
Lac des Iles Mine Area, Ontario
High-Resolution Ground Gravity Survey
Elevation Contours
(m)
Interpreted by: M. Chemam, P.Geo. 2018/05
Surveyed by: Abitibi Geophysics Inc. 2018/02
Verified by: L. Plante, P.Eng. 2018/05
Reference maps: 52H/04 and 52A/13
Scale 1:20 000
Project no: 17N093
Map no: 2.3
ABITIBI GEOPHYSICS


North American Palladium
Greenfields Project
Lac des Iles Mine Area, Ontario
High-Resolution Ground Gravity Survey
Residual Bouguer Anomaly Contours (mGal)
(Upward continuation at elevation 5 km)
Legend
Residual Bouguer Anomaly Contours
Unit: mGal
Instruments: Gravity Meter: Scintrex CG-5u AutoGrav
DGPS: Leica Viva
Base #
Gravity Base Station
Station #
Gravity Station
Residual Bouguer Anomaly
(mGal)
Scale 1:20 000
Interpreted by: M. Chemam, P.Geo. 2018/05
Surveyed by: Abitibi Geophysics Inc. 2018/02
Verified by: L. Plante, P.Eng. 2018/05
Reference maps: 52H/04 and 52A/13
Scale 1:20 000
Project no: 17N093
Map no: 2.5
ABITIBI GEOPHYSICS
296000E
298000E
300000E
302000E
304000E
306000E
308000E
5440000N
5438000N
5436000N
5434000N
5432000N
5430000N
Senga Lake Area
Shelby Lake Area
Orbit Lake Area
Eayrs Lake Area
52H/04
52A/13



Legend

First Vertical Derivative Contours

0.0005 0.0025 0.0100 0.0100 0.0025 0.0005

Unit: mGal/m

Instruments: Gravity Meter: Scintrex CG-5u AutoGrav
DGPS: Leica Viva

Base # – Gravity Base Station

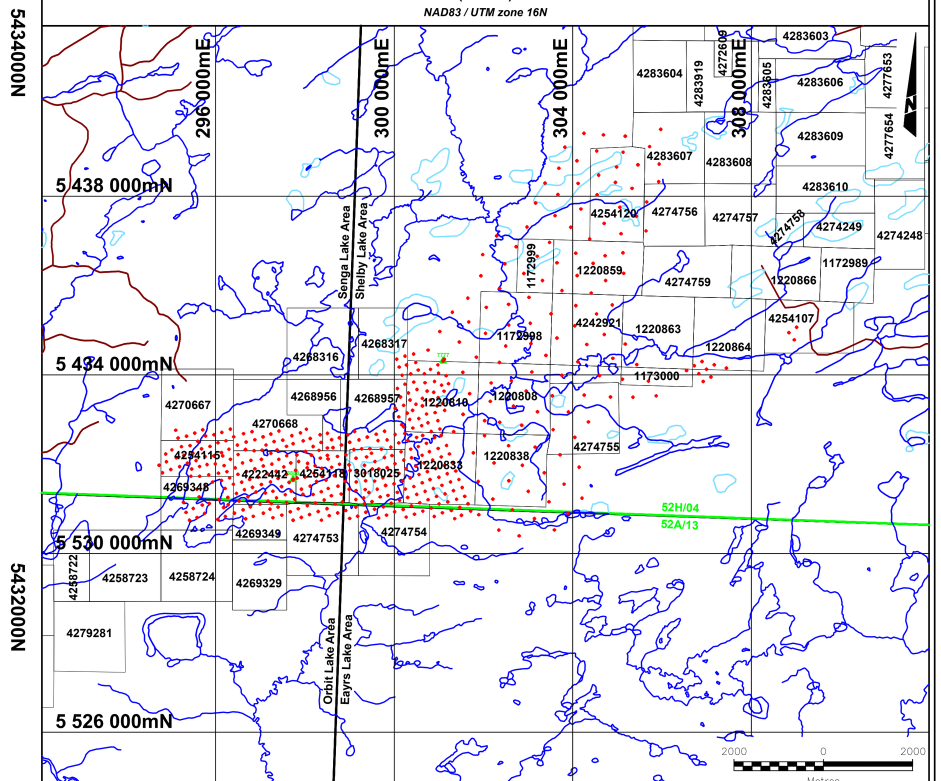
Station # – Gravity Station

First Vertical Derivative (mGal/m)

0.0095, 0.0090, 0.0085, 0.0080, 0.0075, 0.0070, 0.0065, 0.0060, 0.0055, 0.0050, 0.0045, 0.0040, 0.0035, 0.0030, 0.0025, 0.0020, 0.0015, 0.0010, 0.0005, 0.0000, -0.0005, -0.0010, -0.0015, -0.0020, -0.0025, -0.0030, -0.0035, -0.0040, -0.0045, -0.0050, -0.0055, -0.0060, -0.0065, -0.0070, -0.0075, -0.0080, -0.0085, -0.0090, -0.0095

Scale 1:20 000

250 0 250 500 750 1000 1250 1500
(meters)
NAD83 / UTM zone 16N



North American Palladium
Greenfields Project
Lac des Iles Mine Area, Ontario

High-Resolution Ground Gravity Survey
First Vertical Derivative Contours
(mGal/m)

GÉOLOGUE / GEOLOGIST MADJID CHEMAM # 1259 QUÉBEC

Interpreted by:	M. Chemam, P.Geo.	2018/05
Surveyed by:	Abitibi Geophysics Inc.	2018/02
Verified by:	L. Plante, P.Eng.	2018/05

Reference maps: 52H/04 and 52A/13 — Scale 1:20 000

Project no: 17N093 — Map no: 2.7

ABITIBI GEOPHYSICS