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Correcting Airborne Gravity Data for Overburden thickness:
A case study from the Nechako interior plateau, British Columbia

Raymond M. Caron¹, Claire Samson¹, Martin Bates², & Michel Chouteau³

¹ Carleton University
1125 Colonel By Drive
Ottawa, Ontario
K1S 5B6

Raymond Caron <raymond.caron@carleton.ca>
Claire Samson <claire.samson@carleton.ca>

² Sander Geophysics Limited
260 Hunt Club Road
Ottawa, Ontario
K1V 1C1

Martin Bates <mbates@sgl.com>

³ Polytechnique Montréal
2900, boul. Édouard-Montpetit
Campus de l'Université de Montréal
2500, chemin de Polytechnique
Montréal, Québec
H3T 1J4

Michel Chouteau <chouteau@geo.polymtl.ca>

Please correspond with: Raymond Caron
Tel : 613-265-2468
Alt. Tel: 819-457-9410
Raymond.caron@carleton.ca

Correcting Airborne Gravity Data for Overburden thickness:
A case study from the Nechako interior plateau, British Columbia

Abstract

Large areas of bedrock in Canada, such as in the interior plateau of British Columbia, are covered by a thick glacial overburden. Lateral variations in overburden thickness can create spurious anomalies in gravity data. These anomalies can be of similar size and amplitude as those associated with mineral bodies and can be mistaken for them. A methodology is introduced that corrects gravity data for changes in overburden thickness through the use of a bedrock topography map created by integrating information from a helicopter transient electromagnetic survey with geological survey data, well water data, and gravel pit locations. The approach is tested for a 68 x 38 km² area in the prospective Nechako interior plateau of British Columbia, Canada. The methodology extends the traditional Bouguer corrections by taking into account the gravitational contribution of the overburden. Results show that the capability of an airborne survey at detecting a change in overburden thickness depends primarily on survey line spacing, and to a lesser extent to the level of random noise in the gravity data. The bedrock topography correction has the capability to remove the gravitational attraction of overburden for the purpose of revealing, through interpretation, geological structures in the gravity data that originate from the bedrock and were otherwise concealed.

Keywords:

Gravity
Electromagnetic
Bouguer correction
Overburden
Interpretation

Introduction

Many prospective areas for mineral exploration in Canada, such as the Interior Plateau of British Columbia (Levson and Giles 1997, Stumpf et al. 2000), are covered by a thick overburden that was deposited during and after the Wisconsin-Fraser glaciation (c. 25–10 ka) and can obscure bedrock and complicate exploration (Stumpf et al. 2000, Ferbie 2010, Caron et al. 2015). The overburden not only masks geological information, it also reduces the reliability of potential-field geophysical methods by concealing changes in bedrock topography, defined here as variations in elevation of the bedrock surface immediately beneath the unconsolidated sediment which makes up the overburden. While bedrock topography often imitates the features expressed by surface topography, it can vary independently, for example, when basins or riverbeds are covered by sediment.

With respect to the gravity method, a reduction in overburden thickness can create an anomaly of a similar magnitude to that associated with a mineral body (Fig. 1 a), while an increase in overburden thickness can conceal the response of a mineral body (Fig. 1 b) (Chen and Macnae 1997, Caron et al. 2013). Published measurements show a distinct contrast between the density of unconsolidated sediment (1.6-2.24 g/cm³), volcanic bedrock (2.16 > 3.2 g/cm³), and sulphide mineral bodies (2.6 ≲ 5.0 g/cm³) (Killeen et al. 1995, Balco et.al 2005, Morgan 2012, Mitchinson et al. 2013). Overburden thickness is often measured using seismic methods, as overburden has lower seismic impedance than bedrock. It can also be measured using electromagnetic (EM) methods which exploits a contrast in resistivity between the relatively conductive unconsolidated sediments (1-360 Ωm) compared to the relatively resistive bedrock

($1 < 10k + \Omega m$) (Telford et al. 1990, Killeen et al. 1995, Best et al. 1997, Palacky 1990, Kushnir et al. 2012).

This paper will first introduce a novel methodology to correct airborne gravity data for changes in overburden thickness using helicopter transient electromagnetic (HTEM) data and will describe the Canadian site chosen to demonstrate the new approach. This will be followed by two sections on HTEM and gravity data processing, after which results are presented and discussed with a focus on gravity noise, survey line spacing, and gravity anomaly detection. The paper concludes on the merits and limitations of the proposed methodology.

Proposed methodology

Traditionally, a Bouguer anomaly map is produced by reducing the observed gravity data by applying instrumental drift, Earth tides, latitude, free-air, Bouguer, and terrain corrections (Nabighian et al. 2005, Reynolds 2011). For airborne data, corrections for the acceleration of the airborne platform and for the motion of the platform over the Earth's surface (Eötvös effects) are also required. Terrain contributions to gravity are taken into account by measuring topographic elevation changes within 161 km of each data point and applying a Bullard C correction (Fig. 2 a). The Bullard C correction assumes that terrain has a homogenous density and can be modelled as bedrock to the depth of the geoid. Where bathymetry data is available the terrain correction can be extended to include a correction for the presence of lower density water bodies.

We propose an extension to the terrain correction such that overburden thickness and density data can be used to correct for the lower gravitational contribution of the overburden

(Fig. 2 b) in a manner similar to how bathymetry data can be used to correct for the lower gravitational contribution of a body of water. This gravity correction will be referred to as the bedrock topography or ‘BedTopo’ correction, as the correction attempts to account for both overburden and water bodies in order to reduce the gravitational contribution of the observed gravity to units within the bedrock (Caron, 2016)

The BedTopo correction is based on the determination of the depth of the consolidated bedrock surface hidden beneath overburden composed of unconsolidated sediment and bodies of water. This surface can be measured at multiple locations and interpolated to create an overburden thickness map. A bedrock topography map can then be created by subtracting overburden thickness from a digital elevation model (DEM). While a bedrock topography map can be created using various different methods, this paper focuses on the correction of airborne gravity data collected over large survey areas. This important requirement led to the creation of a bedrock topography map primarily through inversions of HTEM data. The HTEM method was chosen as it has demonstrated the capability to distinguish between overburden & bedrock, and can potentially be acquired simultaneously with airborne gravity data collection.

Study site

The study site (Fig. 3) selected to test the practicalities of the BedTopo method is a 68 x 38 km² area located in the Nechako Plateau of the Interior Plateau in British Columbia (situated at approximately 53°58`N, 125°34`W). The plateau has a high mineral potential but exploration efforts have been hampered by a thick overburden that covers 90-95 % of the bedrock (Levson and Giles 1997, Mate and Levson 2001, Andrews et al. 2011). The area has seen a large amount

138 of porphyry mining activity including the Blackdome gold mine (closed), the Gibraltar copper-
139 molybdenum mine (open), and the Endako molybdenum mine (closed), as well as extensive
140 lumber industry activity.

141 The geology of the study site is heavily influenced by the Wisconsin-Fraser glaciation.
142 East-west trending glacial scouring of the bedrock is widespread (Plouffe 1997, Stumpf et al.
143 2000). The terrain is mountainous and includes Francois Lake, Tchesinkut Lake, Uncha
144 Mountain, Takysie Lake Ridge, and Anzus Lake Ridge. Local terrain features include glacial
145 drumlins and volcanic necks. Topography varies rapidly from gentle to moderately steep (up to
146 39°) slopes (Caron 2016).

147 Overburden geology is complex and includes a variety of sediment types including:
148 glacial, alluvium, colluvium, aeolian, fluvial, and lacustrine, ranging in grain size from clay to
149 gravel (Levson et al. 1999, Mate and Levson 2001). Glacial till and wet silty-sand are the most
150 common types of sediment (Plouffe and Levson 2001). Roughly 55 % of the bedrock in the
151 study site is mapped as volcanogenic andesite or basalt. Volcanic tuff, conglomerate, and granite
152 are also present, accounting each for roughly 15 % of the bedrock surface.

153 Bathymetry data for lakes deeper than 10 m (Fig. 3) were digitized and geo-referenced
154 from surveys conducted by the Government of British Columbia in the 1980's (British Columbia
155 2014). Shallow lakes (< 10m depth) in the area were not surveyed.

156 Airborne gravity and HTEM data acquired simultaneously was not readily available. Data
157 from two separate helicopter surveys acquired along non-coincident E-W flight lines using the
158 Sander Geophysics (SGL) AIRGrav airborne gravity system and the Aeroquest AeroTEM III

HTEM system are used as the best available option, both are publicly available from the Geoscience BC web portal. The AIRGrav survey was flown using a flight line separation of 2 km at a nominal drape altitude of 200 m and an average velocity of 46 m/s (Meyer and Bates 2008). The AeroTEM survey was flown using a triangle waveform with a peak moment of 183,131 Am², with flight line separation of 4 km. The EM system was suspended at a nominal altitude of 30 m (Aeroquest Limited 2009).

HTEM Data processing

Inversions of HTEM data were conducted in order to determine the thickness of overburden. Inversions were calculated using AirBeo software, which is part of the P233F suite of inversion programs written by the Commonwealth Scientific and Industrial Research Organisation (Raiche et al. 2008), as a plug-in for Maxwell, written by ElectroMagnetic Imaging Technology (ElectroMagnetic Imaging Technology 2010). Forward models composed of simple (2-layers) to more complex (5-layers) were used for inversion where water wells provided ground truth (Fig. 3). Finding a suitable forward model for inversion was difficult due to the wide variation in surficial geology, water table, and topography within the study site where as many as 12 different depositional types of sediment were identified (Struik et al. 2007, Ferbey 2014). This leads to a situation where overburden is heterogeneous, due to the range in clast size and composition, can be a range of different thicknesses, due to the various depositional forces, and can have variable water content. As overburden is generally more conductive and less dense than bedrock, primarily due to higher porosity and water content, overburden and bedrock were modelled as separate homogeneous layers. Initial resistivity values for the overburden, bedrock and halfspace were 100 Ωm, 500 Ωm, and 1500 Ωm, respectively. Inversions were conducted

with the goal of finding one or more resistivity models that are successful in returning overburden thickness values consistent with the ground truth provided by the water wells while also having the lowest goodness of fit symmetric root-mean square percentage (% sRMS) error among all models attempted. Inversion results with a sRMS % error lower than 10 % were kept. The chosen resistivity models are then used to invert the HTEM data throughout the study site (Caron 2016).

The resulting resistivity of the overburden can be expected to vary widely as it changes from a conductive thick and wet cover to a more resistive thin and dry cover. Another complication occurs with surficial geology in the bedrock, as large variation in rock type, composition, and porosity can lead to variation in bedrock resistivity with depth. A conductive anomaly buried within the bedrock could appear as an equivalent layer and may lead to an overestimation of overburden thickness as the inversion algorithm may not be able to discriminate between the response of the overburden from that of conductive bedrock (Caron 2016).

HTEM inversion accuracy estimated using water wells as ground truth within the study site had an sRMS % error of 60 % (Caron 2016). This error was improved to 30 % by removing from the dataset HTEM stations that coincided with locations where a conductive unit was hosted in the bedrock. Specially, stations were removed for which the adaptive late time Tau were 350 μ s or longer. The adaptive late time Tau is calculated from the last three recording channels that occur before the secondary electromagnetic field decays below noise level (~ 5 nT/s) (Aeroquest Limited 2009). Tau is estimated from the signal decay when amplitude hits a

value of $1/e \sim 37\%$ of its initial value. This step resolved some local discrepancies between mapped HTEM inverted overburden thickness with indicated thickness from water wells, surficial geology data, and satellite photos. For instance, Takysie Lake Ridge (Fig. 3) was initially inverted and interpreted to have a highly variable overburden thickness ranging from 10 – 180 m, however surficial geology data showed till veneer, while satellite photos showed a rocky ridge. Takysie Lake Ridge has an adaptive late time Tau is above 500 μs , and so the HTEM inversion results for the ridge were removed from the dataset. Water well inversions estimated that the overburden has an average resistivity of 50 Ωm with a range of 5-150 Ωm . Bedrock immediately below the overburden was often found to have a variable resistivity with a range of 445-878 Ωm . Conductive layers within the bedrock were also detected and was found to have a resistivity with a range of 10-197 Ωm , while the bedrock halfspace had an average resistivity of 1723 Ωm with a range of 700-6548 Ωm (Caron 2016). After the adaptive Tau discrimination was applied, the HTEM dataset had an average sRMS % error of 5.2 %. To further augment survey accuracy, the HTEM overburden thickness dataset was integrated with surficial geology data, well water data, and locations of industrial gravel pits in order to create an overburden thickness map, and a bedrock topography map (Caron, 2016).

Gravity Data processing

The application of the BedTopo correction requires the following data sets: 1) processed gravity data uncorrected for terrain effects, 2) two DEM's (with and without bathymetry), and 3) a bedrock topography map. Together, the maps represent the overburden thickness, bathymetry, and bedrock to a reference datum. The geology of the study site was modelled using 3 distinct

230 layers - bedrock, overburden, and water – with a constant density of 2.65 g/cm^3 , 1.8 g/cm^3 , and
231 1.0 g/cm^3 , respectively.

232 Bouguer gravity corrections were applied using the principles of the Bullard
233 methodology (Bullard 1936, Nowell 1999, and Hinze et al. 2005), and the BedTopo correction
234 was performed as the additional final step. The study site was modelled using a mesh of 3D
235 prisms created from the DEM, bathymetry, and bedrock topography maps. Corrections were
236 calculated by integrating the gravity contribution of each prism, for each medium they represent,
237 in the 3D mesh.

238 Single profile gravity data was filtered to remove residual high-frequency random noise
239 mostly attributed to errors in the airborne platform accelerations as determined from GPS data.
240 The chosen low-pass filter had a midpoint with a full wavelength of 56 s and a cosine taper from
241 100 % pass at 84 s to 0 % pass at 42 s, and was applied to the gravity data sampled at 2 Hz. At
242 the average speed of the helicopter during the survey, this is equivalent to applying a low-pass
243 filter with a 2576 m midpoint. The data was then gridded to create a two-dimensional Bouguer
244 anomaly map. Various low-pass cosine tapered filters were then applied to the gridded Bouguer
245 gravity data. A low-pass filter with a midpoint of 4 km was selected, with a cosine taper from
246 100 % pass at 6 km to 0 % pass at 3 km. Filtering the grid further reduces residual random noise
247 whilst enhancing common geological signal from adjacent lines. The wavelengths of the low-
248 pass filters were chosen as a trade-off between desired resolution and acceptable noise levels
249 since the amplitude of the random noise increases exponentially at shorter wavelengths (Elieff
250 and Ferguson 2008). The result is a data set with a half wavelength resolution of 3 km designed
251 to achieve a noise level estimated to be 0.2 mGal RMS using the method of Sander et al. 2002.

The relatively wide line spacing of the survey places a limitation on the resolution of the measured gravity signal (Sander et al. 2003).

Results: BedTopo Bouguer gravity anomaly maps

A visual comparison between the standard Bouguer and the BedTopo Bouguer anomaly maps (Figs. 4. a, b) shows similar features in both maps, as do the first vertical derivative (FVD) of these maps (Figs. 5 a, b). A map created by subtracting the Standard Bouguer gravity data from the BedTopo Bouguer gravity data (Fig. 6 a), however, reveals local differences between them. These differences are 1.02 mGal on average, up to a maximum of 2.04 mGal. Larger differences are mostly confined to areas of lower elevation where modelled overburden is thickest (Fig. 6 b). Variations in overburden thickness are hardly visible on Bouguer gravity maps (Figs. 4 a, b) except as small shifts, and are barely perceptible on FVD maps (Fig. 5 a, b) where the difference is <1.6 Eötvös. The areas of greatest difference are identified by black circles on Fig. 6, where gravity differences of 2 mGal occur and correspond to 4 km² of overburden roughly 35-45 m thick. Even though these are the largest gravity differences that can be attributed to overburden thickness, the difference is not visible as an anomaly on the Bouguer anomaly maps (Fig. 4 a, b), and is barely perceptible on the FVD maps (Fig. 5 a, b). This suggests that a larger volume of overburden is required to create detectable anomalies in this area.

Discussion

Gravity data noise

While the EM dataset is limited in terms of spatial coverage between flight lines, it provides closely-spaced measurements along EM flight lines, some of which are coincident with gravity flight lines. A comparison between the BedTopo and standard Bouguer anomaly profiles along gravity flight line L4029 (Fig. 7) shows that overburden thickness variations result in a small static shift change in the gravity data as opposed to a distinct anomaly. This can be seen by comparing the BedTopo and standard Bouguer anomaly profiles after application of the 56 s (2576 m) low-pass filter. When random noise is filtered out (see the blue and red profiles), only a small static shift remains. It is possible that high frequency changes that would appear as an anomaly in the gravity data due to overburden thickness variations were filtered and smoothed into an average, and became a static shift change during noise removal. A static shift in gravity data is usually a minor change that would not interfere with the interpretation of individual map features such as a bedrock hosted gravity anomaly.

In order to reduce residual noise levels in the gravity data, filtering both along profiles and on a gridded data set may be applied. Such filtering will remove random uncorrelated noise, but does not address any systematic errors common to all the data. The residual noise is assumed to be essentially white in nature, with all frequencies equally present. This approximation has been tested and found to be valid for the frequency range of interest by analysis of many over-sampled AIRGrav data sets (Sander et al. 2002).

The SGL AIRGrav system is capable of rendering gravity data with noise levels as low as 0.2 mGal for half-wavelengths as low as 700 m. To achieve this, low pass filtering is applied to gridded data to stack common signal from adjacent lines and cancel out random noise. The tighter the survey line spacing is, the less filtering is required to achieve equivalent degrees of

299 noise reduction (Sander et al. 2003), for example, halving the line spacing results in a reduction
300 of noise by a factor of $\sqrt{2}$ if the filter length is not changed. For a single profile of airborne
301 gravity data that does not benefit from this process noise levels are reduced by low pass filters
302 applied to the single profile only, with no noise cancellation from adjacent lines applied. Under
303 these circumstances, a 56 s low-pass filter typically results in data with a standard deviation of
304 0.537 mGal from a previously established air truth average calculated from multiple passes along
305 the same test line (S.Elief pers. comm. 2017). Two-standard deviations of noise, ~ 1 mGal, is
306 roughly equal to the average modelled change in gravity intensity due to overburden thickness
307 (Fig. 6, a). Since this study only marginally benefitted from stacking of common gravity signal,
308 due to large survey line spacing, it is reasonable to assume that some gravity features created
309 from changes in overburden may have been filtered from the data along with gravity noise. There
310 is therefore a limit to the sensitivity of airborne gravimeter data to changes in overburden
311 thickness that is determined by survey parameters such as line spacing and nominal altitude.
312 Signal will exceed noise if there is a sufficiently large contrast between the gravitational
313 attraction of the overburden and bedrock, which is a function of the extent, thickness, and density
314 of each medium. Forward modelling shows that a 200 m² depression filled with a 30 m thick
315 overburden would create a Bouguer gravity anomaly approximately 1 mGal in amplitude. This
316 suggests that the presence of an overburden less than 30 m in thickness would not have any
317 discernible effect on a Bouguer anomaly map where the data does not benefit from the process of
318 common signal stacking from adjacent lines.

319

Detectable overburden thickness

While the BedTopo correction did not lead to a visible anomaly in either the Bouguer anomaly map (Fig. 4 a) or its FVD (Fig. 5 a), it did result in local changes of colour intensity that can be correlated to overburden thickness. The absence of visible anomalies is primarily a result of the size of the various anomalies (< 2.04 mGal) relative to the range in gravity (52 mGal) of the study site. The large range in gravity is due to the complex geological history and terrain. It stands to reason that areas with less complex bedrock geology with a relatively small range in measured gravity may benefit from a BedTopo correction. This can be achieved by surveys flown with wide-line spacing over areas where both overburden and measured gravity vary within a small range, or by scaling the survey to a local perspective where close line-spacing provides an increase in survey resolution to enable the delineation of small variations in gravity.

The ~ 4.5 km² body of 36-75 m thick overburden, shown along gravity flight line L4029 did not produce a significant anomaly in either of the Bouguer anomaly maps or their FVD maps (see black square in Figs. 4, 5, 6, 7). This could be due to the lens-like shape of overburden (Fig. 7). Such a feature has a long-wavelength signature as opposed to being a discrete anomaly. The point at which overburden thickness could interfere with the interpretation of bedrock hosted gravity anomalies for this survey was tested using simulations. Results showed that a 100 m thick overburden covering roughly 4 km² would generate an anomaly of ~ 3.5 mGal in amplitude, which could affect interpretation, while a 200 m thick overburden with the same extent would create an anomaly of ~ 7 mGal which has a reasonable possibility of being misinterpreted.

342 *Line spacing*

343 A challenge in the integration of the gravity and EM airborne datasets was the difference
344 in line survey resolution between surveys. The EM survey was gathered using twice the line
345 spacing as the gravity data. This problem was somewhat mitigated through the incorporation of
346 surficial geology data, water wells, and gravel pits, which increased both the distribution and
347 density of data points allowing for an overburden thickness map with a 500 m cell size. This was
348 achieved, however, at the cost of sacrificing the along-line resolution of the HTEM data. The
349 overburden thickness map (Fig. 6 b), is a hybrid map that is an interpolation between point and
350 line data. During calculation of the Bouguer corrections, the gravity data is input into the
351 processing stream as high-resolution, 2 Hz (~23 m sampling rate), along-line data and is filtered
352 following corrections, whereas the overburden thickness data has been pre-filtered to a 500 m
353 cell size. While this approach led to a boost in overburden thickness map resolution and accuracy
354 it also set a lower limit on the size a change in overburden needs to be in order to create a visible
355 anomaly on a Bouguer anomaly map as the higher resolution along-line EM overburden
356 thickness data is averaged before Bouguer corrections are applied.

357
358 While random noise was shown to be a limiting factor on airborne gravimeter resolution,
359 flight line spacing had a larger effect. While forward modelling showed that the system should
360 be able to resolve overburden thickness changes larger than 30 m with dimensions of 200 m²
361 (infinite in Y-axis), mapping the study site showed that an overburden thickness change of 36-75
362 m over 4.5 km² (see black square in Fig. 4-7) is not visible on Bouguer anomaly map or on its
363 FVD map and represents only a small static shift in profile data. Closer line spacing would not

only boost the signal on each respective line, it would provide another line to reference, reveal, and add resolution to the location of the overburden feature.

Conclusion

A novel methodology for correcting gravity data for variations in overburden thickness is presented. The terrain correction is applied as a map layer where DEM, bathymetry, and overburden thickness measurements are used to create a bedrock topography map that can be used to correct for the gravitational attraction from bedrock, bodies of water, and overburden down to the geoid or another reference datum.

The discussion above focused on the scenario of a thick overburden generating a gravity anomaly of sufficient amplitude to hide the response of a mineral body hosted in the bedrock (Fig. 1 b). The scenario of a sudden decrease in overburden thickness being confused for a mineral body may also be likely (Fig. 1 a). Unfortunately, there is no area within the study site where a large enough reduction in overburden thickness is present to test this hypothesis. For both scenarios, however, the application of a BedTopo correction would result in improved signal resolution as assigning a lower density to the overburden relative to that of the bedrock would increase the amplitude of local Bouguer anomalies.

Gravity is used at ever higher resolutions to map geological structures. While some targets can generate a large and easily detectable gravity anomaly (eg. the Darnley Bay gravity anomaly (Reford 2012)), other targets are more subtle but still can be identified above the noise level (eg. the Podolsky Mine gravity anomaly (Sander et al. 2011)). Small gravity anomalies with amplitudes close to the noise level can still stand out due to their shape, especially if they

are elongate. Therefore, even relatively small corrections that result from the removal of overburden effects by application of the BedTopo method can be significant with respect to interpretation of the gravity data.

This study showed that while changes in overburden less than 30 m in thickness are difficult to resolve by airborne gravimeters due to random noise, line spacing is more critical with respect to survey resolution and feature accuracy and will affect the survey results before gravimeter resolution becomes a concern. Flight line spacing should therefore be of primary concern when attempting to resolve changes in gravity caused by a physical feature such as overburden.

A BedTopo gravity correction can be significant for high-resolution airborne gravity surveys that have close line spacing such that signal processing techniques are more effective at reducing noise in order to resolve fine changes in gravitational attraction created by variation in overburden thickness. It is expected to be particularly beneficial in cases where the variation in gravity due to density changes in the bedrock is small relative to the amplitude of overburden effects.

Research into both improving the accuracy of airborne GPS and correcting for position to reduce random noise during gravity surveying will only increase the need for a BedTopo correction for high-resolution gravity data. The BedTopo correction might also be of interest for gravity gradiometry and ground gravity surveys, as these applications either have a strategy to reduce random noise, or are less affected by random noise.

412

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414

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Captions

Fig. 1.

Gravity modelling conducted using GM-SYS showing depth (Z-axis) below ground level and distance (X-axis) in meters. The overburden and mineral body features are modelled to continue to infinity in the Y-axis direction. **a)** The positive gravity anomaly created from a 60 m reduction in overburden thickness is similar in amplitude to that created by a mineral body, with dimensions 200 m x 200 m. **b)** The negative gravity anomaly created by the presence of a 200 m thick overburden is similar in amplitude to the positive anomaly caused by a mineral body, with dimensions 200 m x 350 m.

Fig. 2.

Simplified cross-sections illustrating the **a)** Bullard C and **b)** BedTopo corrections. **a)** Bullard C accounts for bedrock height h_{bed} and density ρ_{bed} , as well as for bathymetry h_w and water density ρ_w . **b)** BedTopo accounts for the additional thickness h_{ovb} and density ρ_{ovb} of overburden. Bedrock topography surface is indicated in purple. Figure is modified from Caron et al. (2015).

Fig. 3:

DEM with bathymetry of the study site. Gravity survey flight lines are indicated on the left.

Fig. 4:

a) BedTopo Bouguer anomaly map. **b)** Standard Bouguer anomaly map. Differences between maps can be attributed to variations in overburden thickness.

Fig. 5:

a) BedTopo FVD map. **b)** Standard FVD map. Differences between maps can be attributed to variations in overburden thickness. They are: **1)** more yellow colour in the dashed oval in map **a)** indicating an overall slightly higher FVD; **2)** the additional blue colour in the circle in map **b)** corresponding to a localized area with a lower FVD; and **3)** a deeper green colour in the dashed square in map **a)** indicating an overall slightly lower FVD.

Fig. 6:

(a) Difference between the BedTopo and Bouguer gravity maps. (b) Overburden thickness map.

Fig. 7:

Comparison of BedTopo and standard Bouguer gravity anomaly (BA) profiles (left vertical axis) along a portion of line L4029, for data filtered with a 56s filter. Gravity line L4029 is coincident with HTEM line 7380 and is shown in purple in the map (bottom) along with supporting surficial data for overburden thickness. Differences in gravity between BedTopo and standard data profiles is due to the presence of a thick overburden, which is shown by the difference between bedrock topography (black) and the DEM (gold) profiles (right vertical axis). Bedrock topography and DEM profiles are at a 100 m resolution, overburden thickness map has a cell size of 500 m.