

## Modelling overburden thickness in glaciated terrain: Lac de Gras, Northwest Territories, Canada

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### ABSTRACT

*Many exploration techniques and drift prospecting methodologies are dependant to various degrees on the thickness of overburden to successfully locate potentially economic deposits. In glaciated terrain, base and precious metal occurrences, as well as kimberlites have been discovered using drift prospecting methods. The efficiency of these methods however relies on the overburden's ability to reflect underlying bedrock. Surface till sampling for geochemistry or indicator mineral analysis of a thick overburden cover may yield complex, difficult to interpret data for drift exploration. Therefore a basic knowledge of sediment thickness, as well as glacial sediment genesis and ice-flow history, is required. In the Lac de Gras area, modelling of overburden thickness begins with digital selection of polygons of the various surficial materials, obtained from surficial geology maps, which are used to trim data from the digital elevation model for the region. The trimmed data are then modified to reflect the depth below surface of each polygon. The resulting layer represents a best approximation of the bedrock surface. Subtraction of the bedrock surface from the digital elevation model results in an overburden thickness model. This model may be used for a number of applications such as planning regional geophysical or geochemical surveys where data quality is affected by variable overburden thickness. Model uncertainty arises however, and the user should be aware of the complexities in the modelling procedure prior to using a model at a scale that it was not intended for.*

### INTRODUCTION

In many glaciated regions of Canada, thick overburden cover often hampers mineral exploration as well as bedrock mapping and mining development together with related environmental issues. To assist these activities, methods such as drift prospecting, geochemistry, geophysical techniques, and hyperspectral surveys are often initiated. An overburden thickness model can assist in determining the type of survey and its corresponding geographic orientation that will produce the most reliable data, as in the case of electromagnetic surveys, which produce variable background noise related to overburden thickness. For drift prospecting, the success relies heavily on not only careful identification of glacial sediment genesis and ice-flow reconstruction, but also on a sound sampling methodology, which in turn is dependent on overburden thickness.

Most models of overburden thickness are developed from subsurface geological data in areas of abundant "depth-to-bedrock" information. This information is often in the form of water well logs, drill holes or seismic shot hole logs. However, overburden thickness models can also be developed in areas where there is limited or no primary "depth-to-bedrock" information, or where the primary information, such as that from diamond drill holes, is clustered and not appropriate for a

regional model. In these cases, a surficial geology map can provide an important source of overburden thickness data. The best approximate overburden thicknesses are derived from surface morphology of the surficial units, obtained from both air photo/satellite interpretation and traditional mapping activities.

Regardless of the type of depth-to-bedrock information used, the overburden thickness modelling process is based on the construction of a bedrock elevation database. The elevation data are subtracted from a digital elevation model (DEM) to provide an overburden thickness map. This modelling was applied to the Lac de Gras (NTS 76C) 1: 250 000 map sheet, Slave Geological Province, Northwest Territories, Canada. Data analyses and modelling were carried out using a PC Windows computer with MapInfo 7.5 and Vertical Mapper 3.0 software. MapInfo is a computer mapping tool that allows geographic analysis whereas Vertical Mapper works within the MapInfo application and allows interpolation and modelling of geographic data.

### METHODS

#### Overburden thickness modelling

Development of an overburden thickness model comprises five steps: (1) polygon preparation, (2) file buffering, (3) acquisition

and trimming of DEM data, (4) bedrock surface modelling, and (5) drift thickness modeling.

### 1) Surficial geology map polygon preparation

Prior to the acquisition of digital elevation data, surficial materials are assigned an average thickness based on the map legend (Ward et al., 1997). Common surficial units occurring in the Slave Geological Province are listed in Table 1. Each unit of the surficial geology map, including lakes, is selected from the map and pasted to a separate layer. Surficial geology polygons are trimmed to lake shorelines in order to avoid false elevation data where cartographers have used lakes to obscure broad sweeping polygon closures.

**Table 1: Average surficial unit thickness, buffered distance, and degree of uncertainty of estimated thickness.**

Surficial units	Thickness (m)	Buffered distance (m)	Uncertainty
Till veneer	2	100	low
Till blanket	8	100	high
Till hummocky	10	100	high
Marine veneer	2	100	low
Marine blanket	8	100	high
Glaciolacustrine	3	50	low
Esker	12	50	moderate
Alluvium	3	50	moderate
Delta	12	50	moderate
Organic	1	50	low
Bedrock	DEM value	none	low

### 2) Buffering polygons

In order to ensure that adjacent polygons from separate map units do not have conflicting elevations at common edges, all polygons except those corresponding to bedrock are buffered inwards. The bedrock polygon is omitted from this modification as it represents actual elevation data of the bedrock surface and not elevation data that will be modified due to the best approximation of a surficial unit thickness. Table 1 outlines the distance each unit was buffered prior to trimming of elevation data from the DEM.

### 3) Acquisition and trimming of DEM data

Digital elevation data used to create the DEM was obtained from the Federal Government of Canada GeoBase initiative, Canadian Digital Elevation Data, level 1 (CDED1). Depending on the latitude of the CDED1 section, the grid spacing varies in resolution from a minimum of 3 arc seconds to a maximum 12 arc seconds for adjacent 1:250,000 NTS map sheet. Elevations are recorded in meters relative to Mean Sea Level (MSL), and are based on the horizontal Geographic (lat/long), North American reference datum 1983 (NAD83). The files, with a cell

size of 30 meters, are re-projected to the projection of the digital surficial geology map (UTM zone 11, 12 or 13 NAD27). The DEM is then trimmed to the buffered extent of each modelled map unit. The resulting set of trimmed DEMs represents the surface elevations divided into map unit areas.

### 4) Bedrock surface modelling

Depth-to-bedrock is calculated by subtracting the best approximation map unit thickness (TABLE 1) from its corresponding trimmed elevation grid. For example, the corresponding bedrock elevation of a delta would be the DEM elevation value minus 12 meters, whereas the bedrock elevation of a till veneer polygon would be the DEM elevation value minus 2 meters.

In order to populate cells within the buffered areas with elevation data, a bedrock elevation grid is derived using a Natural Neighbour interpolation with a cell size of 100 meters. The resulting interpolation covers the entire map however the only information required is the bedrock elevation data corresponding to the buffered areas. To obtain bedrock elevation corresponding to these areas, the bedrock elevation model is overlain on the interpolated bedrock elevation data and the two files are merged together. The resulting model represents seamless bedrock elevation data for the entire map area.

Point source data such as depth-to-bedrock from diamond drill holes, seismic shot holes, and isolated outcrop data, are subsequently added to the bedrock elevation model grid table. A Natural Neighbour interpolation (Vertical Mapper 3.0) with a cell size of 100 meters is used to produce a new bedrock elevation model. In order for the model to honor the DEM values for bedrock polygons, the trimmed elevation data for these units are merged on the modelled bedrock surface.

Since much of the model relies on interpolated datasets, there is a possibility that elevation data could be at a higher elevation than elevation data obtained from the DEM for the same cell. In order to ensure that the bedrock elevation model adheres to an elevation below that of the DEM, both the bedrock elevation model and the DEM are merged using the minimum values obtained from each dataset. The resulting model corresponds to a best approximation bedrock surface.

### 5) Overburden thickness modelling

Overburden thickness represents the difference between the modelled bedrock elevation surface and the digital elevation model. This procedure is carried out in Vertical Mapper by subtracting the bedrock elevation file from the DEM.

Culshaw (2005) provides a framework for potential model uncertainty from the collection of data through the modelling process and classifies uncertainty into the following five broad categories: geological complexity, data accuracy, expert input, modelling software, and model usage. Evans (2003) also cautions that there is a risk in assuming the model represents the truth or “photograph of reality”.

## RESULTS

Having applied the proposed modelling procedure for the Lac de Gras, including 152 drill holes, an overburden thickness model is presented in FIGURE 1. A coloured gradational scale allows easy identification of the variability of the overburden thickness.

At one extremity of the thickness scale, the grey regions represent bedrock outcrop with a thin discontinuous veneer of overburden. Much of the central and western areas (light blue) are characterized by shallow bedrock with a surficial cover of less than 2 m. Broad regions south of Lac de Gras are overlain by 2 to 8 m of overburden, as indicated by various shades of blues and greens. Throughout the map area but more prevalent in the northeast quadrant, the yellow to red hues reflect the areas of thickest overburden, from 9 to 25 m or more. Depending on local elevation data, they may represent glacial landforms rising above local topography, or buried infilled valleys. Certain northwest trending bands of thicker sediment are parallel to regional ice flow (see below).

From a drift prospecting perspective, areas with lower till sampling suitability and meaningful potential are identified for glacial dispersal studies. These generally correspond to areas of thickest overburden, where there is a greater chance that uppermost sediments are unrelated in origin to underlying bedrock. In the Lac de Gras region, surficial materials consist primarily of till which is divided into three subunits based on surface morphology, reflecting both thickness and glacial processes: veneer, blanket, and hummocky. Only one stratigraphic unit of till has been observed (Kerr et al., 1996). The secondary components of the overburden are glaciofluvial deposits (eskers, kames), and restricted glacial lake sediments, alluvium and organics. This region was last glaciated by the Laurentide Ice Sheet during the Late Wisconsin about 18 ka BP (Dyke and Prest, 1987). Ice flow was initially a southwestward movement, followed by a regionally dominant westward flow and a final northwestward flow (Dredge et al 1999).

## CONCLUSIONS

Producing an overburden thickness model based on the integration of traditional mapping techniques with the integration of DEM data adds a degree of uncertainty beyond a typical geological map. Potential sources of model uncertainty may arise from:

**Surficial geology complexity:** Geological environments are often complex and at a 1:250 000 scale, many details of the surficial polygons have been grouped and smoothed for a clean presentation. This practice is acceptable for a regional overview of overburden thickness. However at a property scale, where the model may be used to target drill locations, surficial polygons must be mapped at a scale appropriate to capture the complexity of the local geology.

**Data accuracy:** The current model has a variable degree of uncertainty relative to ground data depending on the type of data modelled. For example bedrock exposure reflects no overburden coverage and is thus limited in uncertainty to the complexity, size, and location of the polygons as well as the accuracy of the DEM. However both blanket and hummocky till could vary considerably in thickness and thus have a higher

degree of uncertainty than bedrock and veneer till polygons. Degrees of uncertainty for each surficial unit can be found in Table 1.

**Background knowledge:** Although many surficial geology maps are ground-truthed where possible, much of the surficial geology map is based on air-photo interpretation, where a degree of individual subjectivity by qualified mappers is involved.

**Modelling software:** Most of the bedrock elevation model is produced by stamping trimmed polygons together, however the buffered boundary between polygons is interpolated. Modelling programs often contain multiple methods to interpolate data. For this study, a 'Natural Neighbour' interpolation with a cell size of 100 meters and an aggregation distance of 250 meters was selected. The visual nature of the model is also subjective due to the color ramp chosen to best represent the data.

**Model usage:** Despite the above uncertainties, a 1:250 000 scale overburden thickness model can provide a regional context for thickness trends. Thickness models may look simplistic to some users, and the latter should be aware of the complexities in the modelling procedure prior to using a model at a scale that it was not intended for.

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<http://www.geobase.ca/geobase/en/index.html>

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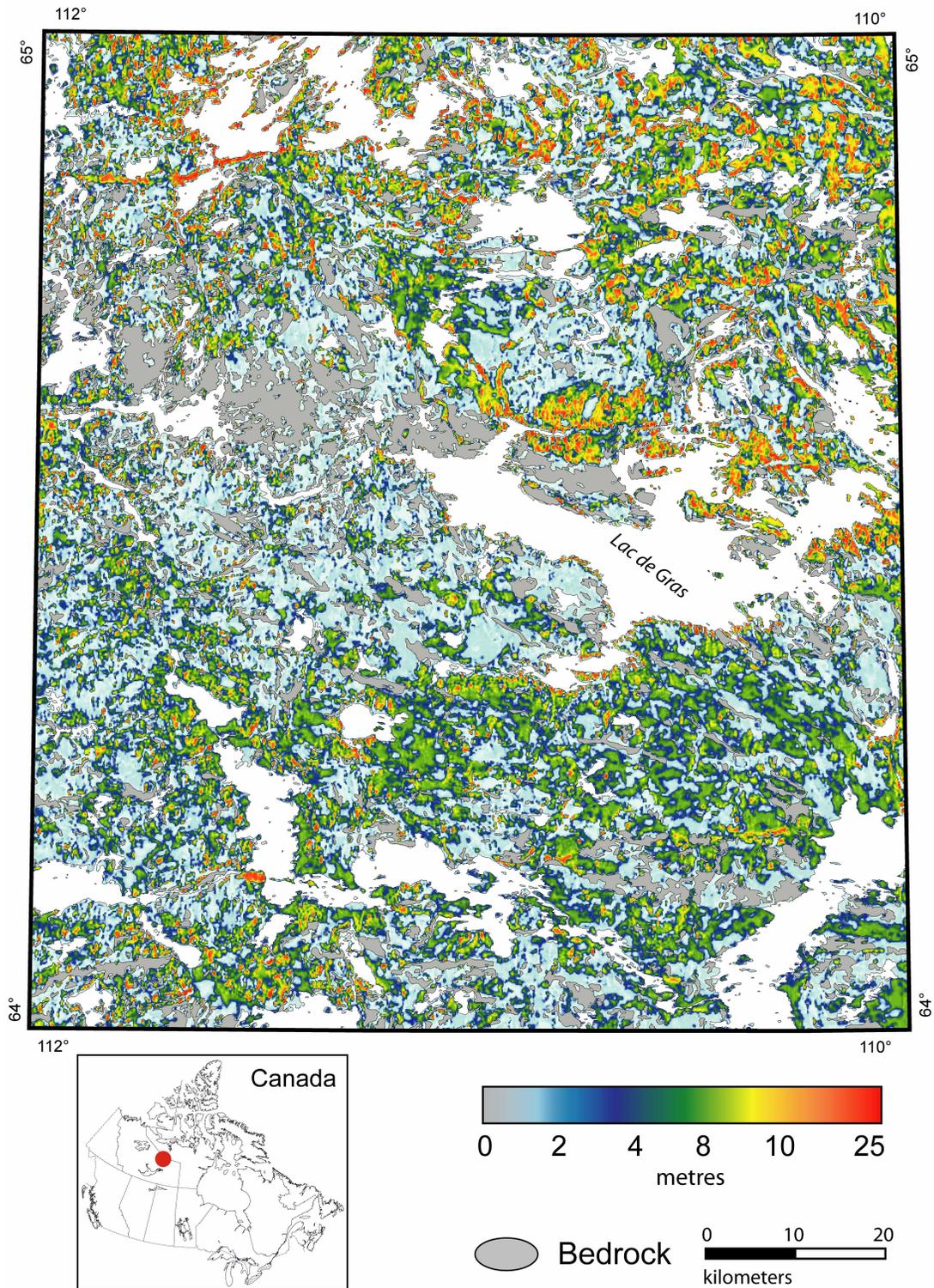


Figure 1: Modelled overburden thickness, Lac de Gras.