GeoFile 1-2022

Digital compilation of surficial point and line features for Manitoba, including ice-flow data

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Abstract

These Manitoba datasets provide an up-to-date digital compilation of historical and new point (ice-flow indicators, field sites, radiocarbon ages, outcrops, deltas, kettles, thermokarst) and line (streamlined landforms, eskers, Rogen moraines, moraines, meltwater channels, mass movements, dunes, crevasse ridges, beach ridges and trimlines, and lacustrine/marine submergence limits) features that are typically present on surficial geology maps. These data are useful for drift prospecting, land-use and Quaternary research projects in Manitoba. The datasets are available as a queryable layer in the Manitoba Geological Survey's GIS Map Gallery as a set of surficial geology compilation maps in PDF at 1:250 000 scale (https://www.manitoba.ca/iem/geo/surficial/digitalcompilation.html), and herein as shapefiles. An updated moraine-polygon shapefile is also provided.

Portions of these datasets will be updated herein, on the above website and the GIS Map Gallery once a year as new fieldwork is completed in those areas, or as new LiDAR imagery is available.

Résumé

Ces ensembles de données manitobaines fournissent une compilation numérique actualisée des objets ponctuels (indices d'écoulement glaciaire, données mesurées sur place, âges radiocarbone, affleurements, deltas, kettles, thermokarst) et linéaires (formes de relief profilées, eskers, moraines de Rogen, moraines, chenaux d'eau de fonte, mouvements de masse, dunes, crêtes de crevasse, crêtes et lignes de crête de plage et limites de submersion lacustre ou marine) historiques et nouveaux qui sont généralement présents sur les cartes de géologie de surface. Ces données sont utiles pour les projets de recherche sur la prospection glacio-sédimentaire, l'utilisation des terres et le Quaternaire au Manitoba. Les ensembles de données sont disponibles en couches interrogeables dans la collection de cartes SIG de la Direction des services géologiques du Manitoba, sous forme d'un ensemble de cartes de géologie de surface en format PDF à l'échelle 1:250 000 (https://www.manitoba.ca/iem/geo/surficial/digitalcompilation.html), et ici sous forme de fichiers de formes. Un fichier de formes (moraines-polygones) mis à jour est également fourni.

Des parties de ces ensembles de données seront mises à jour dans les présentes, sur le site Web susmentionné et dans la collection de cartes SIG une fois par an, à mesure que de nouveaux travaux sur le terrain seront réalisés dans ces domaines ou que de nou¬velles images LIDAR seront disponibles.

DIGITAL DATA

Zip file geofile1-2022.zip contains the following folders and content:

- GeoFile_1-2022_ReadMe.pdf (this file)

Point_and_line_features

- Geofile_1_2022_line_features shapefile and layer file
- Geofile_1_2022_major_moraines shapefile
- Geofile_1_2022_point_features shapefile and layer file
- GSC symbol standard 1 font file

Introduction

Up-to-date, queryable surficial-geological data are essential for the successful interpretation of ice flow and glacial history in Manitoba. These data are also used by agriculture, land-use, aggregate, groundwater, environment, hazard and exploration industries, which require current knowledge to make effective decisions.

These datasets are well suited for identifying individual ice-flow phases (i.e., flow-sets; see Clark, 1999) and regional deglaciation features (esker and meltwater-channel patterns), both of which are essential prerequisites for a detailed reconstruction of the regional glacial history. To further enhance this compilation, the author has published an interpretation of the ice-flow indicator and streamlined-landform database for northeastern Manitoba (Gauthier et al., 2019) and the deglaciation of Manitoba (Gauthier et al., in press).

Objectives

The objectives of this project are to

- digitize point and line features from all pre-existing Quaternary geology maps and compilations in Manitoba; and
- update mapping at a more detailed scale using remotely-sensed imagery (where available).

This GeoFile comprises the most recent data compilation for 48 of the 54 1:250 000 scale NTS map sheet areas in Manitoba. The remaining NTS map sheets (52E; 52L; 62G; 62H; 62I; 62J) will be published when available.

Methods

Compilation

All point and line features from pre-existing surficial geology maps in Manitoba were digitized (along with corresponding metadata) and edge-matched at the most detailed scales available. Line features were digitized to scale, whereas points represent features occurring at a site but are not to scale. Because this is a compilation, not all original data, such as site numbers, striae characteristics (type, position, abundance) and fossil radiocarbon lab numbers, are preserved. Instead, the compiled database serves as a guide and the reader is referred to the original maps and publications for more information. For areas south of 54°, additional data was compiled from aggregate resource maps (Manitoba Natural Resources and Northern Development, 2022a).

Updating

Living product

Portions of these datasets will continue to be updated on the Manitoba Geological Survey's 'Digital compilation' webpage (Manitoba Natural Resources and Northern Development, 2022b), and the GIS Map Gallery. All PDF maps are labelled according to the Surficial Geology Compilation Map Series SG-GF*year_NTSsheet*. In this manner, the user will know that a PDF with the file name SG-GF**2013**_64N.pdf was released in 2013, while a PDF with the file name SG-GF**2022**_64N.pdf was released in 2022. After initial publication, PDF maps will only be updated when there are significant changes due to 1) fieldwork and/or 2) improved imagery resolution. Data from across the province may be updated annually within this GeoFile.

Major updates since 2020

Radiocarbon data has been updated across the province to reflect the updated compilation presented in Gauthier (2021).

Significant details have been added for parts of NTS areas 53M (Gauthier and Hodder, 2020a), 62P and 63A (Gauthier and Hodder, 2020b).

Data sources

The updated mapping of point and line features for Manitoba uses remotely-sensed imagery that includes detailed panchromatic SPOT 4/5 imagery (10 m resolution; GeoBase®, 2012a), permitted use of unpublished Shuttle Radar Topography Mission digital-elevation models (SRTM, 30 m resolution; U.S. Geological Survey, 2014), and Light Detection and Ranging imagery (LiDAR; Government of Manitoba, 2021). The data source for individual digitized features is included within the digital shapefile under the heading 'DATA_SOURCE'.

Existing northwestern (McMartin et al., 2010) and northern (Trommelen and Ross, 2010) Manitoba digital compilations have also been updated and included herein. These datasets are based on a mix of surficial geology map compilations, SRTM (30 m resolution; U.S. Geological Survey, 2014) satellite imagery, Landsat 7 Enhanced Thematic Mapper Plus (ETM+, 15 m resolution; GeoBase®, 2012b) satellite imagery and selected digital aerial photographs. This compilation also updates features from preliminary reconnaissance mapping originally captured as point features (e.g., streamlined features and drumlins from Klassen and Netterville, 1980), by converting them into line features that are consistent with the rest of the dataset.

Data reliability

This compilation is based predominantly on different types of remotely sensed imagery, incorporating data presented at various scales. The data are considered more accurate where detailed (1:50 000 scale) surficial geology maps were produced and where areas were updated using 1:40 000 scale aerial photography (north of 54°) and LiDAR (south of 54°). Digital features, such as striae, roches moutonnées, gravel pits, mines, radiocarbon ages, field sites, sample sites and some outcrops, are mapped directly from field observations (spatial co-ordinates are expected to be accurate). The locations of all other features, however, are digitized from remotely-sensed products, such as surficial maps (airphoto interpretation) or satellite imagery. As such, the spatial co-ordinates of these features are assumed to be reasonably accurate at their source scales, but misinterpretation is possible. Furthermore, the compilation does not attempt

to encompass every single landform due to the limited resolution of the data, but is meant to provide a regional overview of glacial landforms in Manitoba. Airphoto-based mapping, with supporting field data, is required to provide further local-scale details.

As with all remotely sensed imagery, information gleaned from fieldwork is more accurate. For example, in the Snyder Lake area of far northwestern Manitoba (Trommelen, 2011a, b), abundant secondary meltwater has modified the original landscape. This modification has tended to mask primary subglacial landforms on both aerial photographs and remotely sensed imagery; as discovered during fieldwork, this led to incorrect remotely sensed mapping. In these areas, fieldwork is necessary to determine the extent of secondary modification and to enable better recognition of primary features. Note that these meltwater corridors are best identified on aerial photographs and/or LiDAR and difficult to discern from other remotely sensed imagery.

Descriptions

The following is a description of digitized features and includes some basic assumptions that guided the remotely sensed data capture. Line features digitized herein outline the crest/middle of each feature and are not representative of feature width.

Ice-flow indicators

Streamlined landform

Streamlined landforms form parallel to the direction of ice flow. The mapped landforms include various types of drumlins and other more elongated ridges (sediment or bedrock cored), as well as crag-and-tail landforms (a tadpole-shaped landform developed by glacial erosion of rocks of unequal resistance). Landforms were coded as 'drumlinoid ridge or fluting' unless a drumlin or crag-and-tail form was clearly visible at the scale of digitization. Streamlined bedrock was only mapped where surficial mapping confirmed the predominance of bedrock outcrops. Care was taken to ensure that bedrock structures were not mapped as glacial landforms by referring to published bedrock maps.

Micro ice-flow indicators

Striae

These multiple glacial scratches, inscribed on a rock surface, include other small, erosive, ice-flow indicators on bedrock (e.g., nail-head striae, grooves, crescentic scours, rat tails and gouges). They can be well or poorly defined, and may or may not indicate the direction of ice movement.

Till fabric

Till fabrics provide an estimate of ice-flow orientation derived from clasts within till, based on the assumption of preferential rotation of elongated clasts parallel to the prevailing stress orientation. This is measured by averaging the a-axis or a-b plane of a statistically significant number of elongate clasts within till.

Roche moutonnée

These small elongate knobs of bedrock are oriented parallel to the ice-flow direction, with a gently inclined, smoothly rounded and striated upstream side and a steep and rough downstream side.

Subglacial landforms

Rogen moraine

Rogen moraines are sinuous ridges and intervening troughs that are thought to form perpendicular to former ice-flow direction, subglacially far back beneath the ice sheet. Rogen moraines that are not significantly drumlinized are coded as pristine Rogen moraines, whereas Rogen moraine ridges that have been overridden by actively flowing ice, resulting in streamlining of their surfaces, are coded as drumlinized Rogen moraines (Trommelen and Ross, 2010).

Esker

Eskers are long, narrow, sinuous sand and/or gravel ridges that record the dendritic interconnected drainage network that existed underneath the Laurentide ice sheet. Some of these features are quite large and are delineated as polygons on surficial geology maps. These ridges are coded as 'direction known' or 'direction unknown', with the 'known' direction usually assumed to be southeast, south or southwest for the majority of northern Manitoba. Eskers coded as 'washed' have been significantly modified by waves and currents from proglacial lakes or the postglacial Tyrrell Sea, typically resulting in lowered ridge heights and a removal or redistribution of sediment.

Subglacial or proglacial landforms

Meltwater channel (major, minor)

Meltwater channels are formed by glacial meltwater in a subglacial or proglacial environment. These channels may contain underfit modern drainage networks, or consist of a network of bogs, fens and marshes. Major meltwater channels are typically 0.5–3 km wide.

Moraine (major, minor)

Moraines are formed from the collection of unconsolidated debris that gets pushed to the front, sides and base of a glacier. Minor moraines are narrow, arcuate to sinuous ridges and include minor transverse moraines (undetermined formation), terminal (end) recessional moraines (formed at the front edge of a glacier) and medial moraines (formed between two coalescent ice masses). Major moraines are defined as obvious land-

scape features, often mapped as polygons on surficial geology maps (and included as a separate shapefile herein). In northern Manitoba, most major moraines are interlobate or radial kame moraines—broad, massive ridges consisting of till and coarse gravel, separated by zones of predominately sand (Dredge and Nixon, 1992)—that are thought to have formed between coalescent ice masses. These large sediment masses usually include a mix of ridges, hummocks, kames and kettles.

De Geer moraine

De Geer moraine is the term applied to a succession of discrete narrow ridges, ranging from short and straight to long and undulating, that are found in areas of former lake or sea cover (Linden and Moller, 2005). These ridges are formed transverse to the former ice-flow direction, ice marginally at the grounding line between an ice margin and a standing body of water. They are typically narrow and 1–5 m high, commonly display a uniform spacing over large areas and consist of a mixture of diamicton, silt, sand and gravel.

Crevasse ridge

Crevasse ridges are rectilinear (60° and 120° angles), sometimes crosscutting, pebbly sand or till ridges formed at or near the ice margin. They are the imprint of crevasses within the ice that were subsequently widened during stagnation of the ice sheet and then filled with sediment during the early part of a quiescent phase. As the glacier sank into its bed, subglacial material may have filled basal crevasses by squeezing up into them (Benn and Evans, 1998). In contrast, supraglacial crevasses may have filled with sediment derived from the glacier's surface during ablation (Sharp, 1985). Crevasses that penetrated the entire ice thickness may have filled with both subglacial and supraglacial sediment.

Postglacial meltwater-related features

Beach ridge and trimline

Beach ridges are low, narrow, wave-swept or wave-deposited ridges that run parallel to paleoshorelines. In northern Manitoba, these ridges are typically formed from cannibalization of nearby sediment, so they may consist of sand or cobbles (till parent material where fines have been completely washed away).

A trimline is a line between eroded and non-eroded sediment that marks the limit of wave-washing at the edge of a water body.

In northern Manitoba, these features are associated with retreat of the postglacial Tyrrell Sea and glacial Lake Agassiz (Dredge, 1983; Klassen, 1983; Thorleifson, 1996).

Iceberg scour

Iceberg scours are crosscutting grooves, 300–1800 m long, created by the dragging of iceberg keels along shallow regions of glacial lake beds (Dredge, 1982).

Submergence limit—lacustrine, marine

Submergence limits are the maximum (highest) limits of lacustrine or marine levels in an area. They are only mapped where well established by detailed field and airphoto mapping.

Delta

Deltas are deposits of sediment that form where a stream enters a standing body of water. Ice-contact deltas, which formed where glacial streams entered a proglacial water body at the ice front, can be used to mark a former ice-margin position.

Kettle

Kettles are small and steep-sided depressions in glacial sediment that result from the melting of buried stagnant ice.

Nonglacial features

Outcrop

Outcrops are visible exposures of bedrock protruding through the soil. By convention, outcrops are not mapped within surficial geology 'bedrock' polygons, so the user is directed to surficial geology maps in order to view the full extent of bedrock exposure. The location of outcrops has been sourced from existing surficial maps and consists of a mixture of field-verified outcrops and remotely sensed outcrops mapped on aerial photos (see 'source' attributes). The user is cautioned that outcrops identified on older maps (especially at 1:100 000 or 1:250 000 scale) are not field verified and possibly predate GPS; thus, the GPS co-ordinates presented herein may not be accurate at the level required for property exploration, and should serve only as a guideline.

Sample analysis results (dating)

Sample analysis results refers to sites where radiocarbon (^{14}C) ages have been obtained from fossil material (shell, bone, wood, organic matter, gyttja), or where optically-stimulated luminescence (OSL) ages have been obtained from sediment. Details have been included when possible, but the reader is referred to the original publications for more information. The radiocarbon and OSL ages herein are reported as 'ka' (thousand) calendar years.

Holocene features

Dune

Dunes consist of wind-deposited medium to fine sand that forms low-lying linear to parabolic ridges. In northern Manitoba, the parent material is derived from esker ridges. Most of the dunes in northern Manitoba are oriented toward the east-southeast, meaning wind directions were between 310° and 320°. As such, these dunes probably did not experience the anticyclonic (glacial) wind regime (S.A. Wolfe, pers. comm., 2011) but are

related to winds of the postglacial (Holocene) wind regime that are no longer active (David, 1981; Pfeiffer and Wolfe, 2002).

Mass movement

Mass movement refers to the gravity-driven downslope movement of surficial materials, bedrock fragments, and snow and ice, often mixed with vegetation debris.

Thermokarst

Thermokarst are small pits and hummocks formed when permafrost melts and the ground settles unevenly. In northern Manitoba, these sites are collected from existing detailed surficial maps but were not included in the digital updating due to the abundance of locations.

Anthropogenic features

Field site

Field sites are areas that were visited by Quaternary geologists during a field-mapping and/or aggregate-resource project. Field sites in the study area were digitized opportunistically, and are not all-encompassing.

Sample site

Sample sites are where a till sample was taken for further analysis. Sample sites in the study area were digitized opportunistically, and are not all-encompassing.

Gravel pit

Gravel pits in the study area were digitized opportunistically, and are not all-encompassing.

Mine

Mine sites in the study area were digitized opportunistically, and are not all-encompassing.

Economic considerations

Surficial geological mapping and its associated point and line feature data is essential for effective land-use planning, as well as groundwater, hydrocarbon and industrial-mineral development. In glaciated terrain, the exploration industry will be able to use the locations of outcrops for field mapping, and will benefit from a greater understanding of ice-flow history (orientation, patterns, strength of erosion/deposition). The location of eskers, kame-moraines, deltas and beaches provides targets for aggregate—essential for furthering infrastructure development in remote regions.

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