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GEOLOGICAL SURVEY OF CANADA
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Surficial Data Model: the science language of the integrated Geological Survey of Canada data model for surficial geology maps

Version 2.5.1

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Table of Contents

Introduction

The Geological Survey of Canada (GSC) through the Geo-mapping for Energy and Minerals Program (GEM) has undertaken a Geological Map Flow project (GMF) to develop protocols for the collection, management (compilation, interpretation), and dissemination of surficial and bedrock geology data and map information. This document presents the updated and combined versions 2.5.0 and 2.5.1 of the science language, as implemented in the geographical information system (GIS) data model and workflow used in the production of surficial geology maps and datasets. It represents an update by the GSC Surficial Geology Legend Committee to the previous Surficial Data Model (SDM) version 2.4.0 (Deblonde et al., 2019).

Background and objective

The science language for surficial geology maps was designed with the aim of facilitating the transition from the traditional way paper maps were compiled and published to a comprehensive GIS workflow that included the production of standardized digital datasets. Hence, the focus of this document is on symbolization and the effort to standardize scientific terminology used to describe various entities present on a surficial geology map.

The science language originated from an extensive review of existing geological data models and map legends (Canadian and international). It was then refined by the GSC Surficial Legend Review Committee working group, and through iterative consultations with GSC surficial geology mappers. The working group itself consists of surficial geology mappers, science editors, and GIS experts. The GIS data model and workflow are implemented using ESRI™ ArcGIS™ geodatabases and software. The first surficial data model was published as version 1.2 (Deblonde et al., 2012).

Since the implementation of version 1.2 of the data model and workflow, all comments and requests for changes from GSC surficial geology mappers and GIS users are evaluated by the GSC Surficial Legend Review Committee on a semi-regular basis, and then the model is updated as deemed necessary. This Open File presents the surficial data model updates agreed upon in versions 2.5.0 and 2.5.1. Table 1 briefly describes how the data model has evolved:

Table 1-A brief history of the Surficial Data Model.

Version	Description
1.2	First version available for GSC use; Deblonde et al. (2012)
2.0	Minor changes to the geodatabase schema and several additions and modifications to the geomorphological features and map units; Deblonde et al. (2014)
2.0.1/2.0.2	Minor typographical edits
2.1.0	Minor additions of new features; addition of geological terms in French in documentation only; Cocking et al. (2015)
2.2.0	Minor additions of new features; removal of redundant symbols between geomorphological points, field observations, and measurements; Cocking et al. (2016)
2.3.0	Minor additions of new features; addition of new fields to support transferring data to the Federal Geospatial Platform (FGP); Deblonde et al. (2017)
2.3.14	Minor additions of new features; Deblonde et al. (2018)
2.4.0	Minor additions of new features; Deblonde et al. (2019)
2.5.0	Addition of new features and geodatabase structure review; (this publication)
2.5.1	Same as 2.5.0 and removal of the map unit Tm2 and erosional crest; (this publication)

This Open File contains:

- Surficial Data Model science language (Appendix A): a detailed spreadsheet containing the attributes for map units and geomorphological features, along with a list of geological events.
- Surficial legend chart (Appendix B): a symbol chart (PDF format) providing a succinct overview of the map units and geomorphological features symbology in standardized legend order.
- Surficial data structure (Appendix C): a detailed spreadsheet of the structure of the feature datasets, feature classes and tables (field name, data type, length), and relationship classes.
- Surficial feature modification form (Appendix D): a form to submit new or updated features.

Science language and symbolization

This publication presents changes to the science language (Appendix A), data symbolization (Appendix B), and the data structure (Appendix C) required to produce standardized surficial geology data and maps at a scale of 1:100 000. For a detailed description of the symbols, please refer to Open File 8572 (Geological Survey of Canada, 2020). A new release of Open File 8572 is in press.

The science language is divided into three components:

1. Map units (polygons and boundaries)
2. Geomorphological features (overlay polygons, lines, and points)
3. Field observations and measurements

Map Units

Map-unit definition

A map unit is defined as an area of ground distinguishable from surrounding areas by field observation and/or remotely sensed data (e.g., aerial photographs). Map units are based on the physical extent and geometry of the surficial geology, its sediment properties and characteristics (composition, stratigraphy, surface morphology, thickness, and other properties), and their relationship to other map units. Map units are delineated either in the field or on imagery based on characteristics such as morphology, thickness, tone, texture, pattern, landform association, vegetation, or feature orientation. These attributes are then used to infer the environment of deposition, genesis, modification, and relative geological age. Ground observations identified on a map show where the unit has been verified.

Map-unit designators

A map unit is defined as a combination of upper- and lower-case letters that constitute the map-unit designators (e.g., Cz, Ap; Fig. 1). One or two upper-case letters defines the dominant primary genesis of the sediments, process and/or environment of deposition, for example: GL = glaciolacustrine sediments, and A = alluvial sediments. The genesis is followed by one or two lower-case letters that define the category and reflect one of the following (Fig. 1a): morphology, environment of deposition, thickness of deposit, secondary processes. If required, the category is followed by a number that defines the subcategory of the map unit (Fig. 1b). The subcategory reflects the following: a geological process, a depositional environment, sediment composition, or a structure.

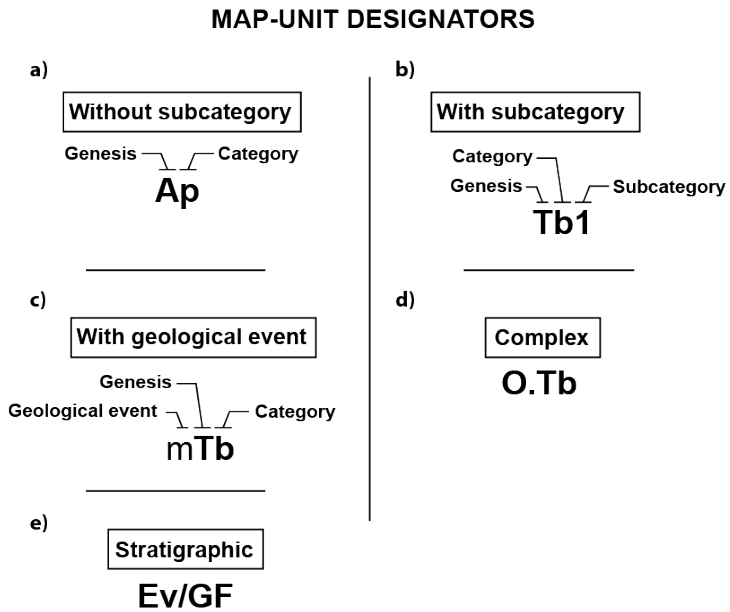

Figure 1 – Map-unit designators as labelled on maps.

If for a given map unit, there is only one subcategory present within the map area (for example, all landslides are retrogressive thaw flows, Cz3), the subcategory is not necessary for the map unit designator but is captured in the database and described in the map's Descriptive Notes.

In addition to subcategories, map units might need to be differentiated based on geological events. Geological events are defined based on time, provenance, and depositional or erosional events, and can be divided according to one of the four following characteristics:

1. Chronostratigraphy (e.g., Late Wisconsinan versus Holocene)
2. Ice provenance (e.g., Laurentide versus Cordilleran ice sheets)
3. Glacial and nonglacial intervals of known or unknown absolute age (e.g., Amundsen Glaciation and Liverpool Bay Interglacial)
4. Ice readvance (e.g., Tuk Phase readvance)

The geological-event attribute can be depicted on a map as a prefix in front of the map-unit designator (Fig. 1c). Appendix A presents the current list of geological-event prefixes for map-unit designators. Each prefix is unique.

If a single geological-event attribute is present within a map area, the prefix is not necessary for the map-unit designator but is captured in the database and described in the map's Descriptive Notes. A prefix is only used for maps with two or more identical map units that have different geological event attributes (e.g., Late Wisconsinan (lw) till versus Neoglacial (n) till). In such a case, the geological-event prefix is mandatory for at least one of the map-unit designators to permit differentiation on the map.

Using the example above, a map with abundant Late Wisconsinan till-blanket polygons and few Neoglacial till-blanket polygons will preferably depict the former as Tb and the latter as nTb. Use of the lwTb prefix would not be preferable, as the Late Wisconsinan time and/or provenance attribute (lw) would be the dominant and default geological-event attribute on the map; however, the author has the option to include the attribute prefixes for both types of time and/or provenance on all such polygons, although it is not recommended.

As a general principle, using of a single map-unit designator per polygon is preferred. A maximum of two map-unit designators can be used in cases where the surficial cover forms a complex pattern and the map units are too small to be mapped individually, yet constitute a significant areal extent of the total polygon (e.g., O.Tb designates an area of organic deposits with numerous outcrops of till blanket). In such instances a period ('.') is used to separate the map-unit designators (Fig. 1d).

Also, a stratigraphic relationship (Fig. 1e) can be shown with a maximum of two map-unit designators separated by a forward slash ('/'; e.g., Ev/GF indicates Ev (eolian veneer) overlying GF (glaciofluvial sediments, undifferentiated); Fig. 1e). In both cases of using multiple map-unit designators, the first, or the overlying, designator determines the map-unit colour. The use of complex designators is not recommended where it is otherwise implicit (e.g., Tv.R or Tv/R). When used, a second designator must also be included in the map legend. **Surficial geology mappers are encouraged to limit the use of complex designators and to avoid mapping large areas with complex designators.**

Map-unit legend description

In the legend, map-unit descriptions should be presented in the following order: map-unit name, grain size, structure, colour, minimum and maximum thickness, morphology, stratigraphic relationships, depositional environment, and other characteristic features.

Map-unit legend order

Map-units in the legend should generally follow a chronological order of formation with the oldest at the bottom and youngest at the top. The order might need to be adapted to an individual map area.

Map-unit boundaries

Five types of geological boundaries are available to mappers: **defined**, **approximate**, **inferred and**, **concealed** (where it is concealed by water, snowpack, or ice). Defined, approximate, and inferred boundaries are used, in decreasing order, to define the level of confidence of the location of a map-unit boundary. A concealed boundary can be used, for example, where a defined boundary is now under water since the area was flooded following the construction of a water reservoir.

Geomorphological Features (polygons, lines, and points)

Geomorphological feature definition

Geomorphological features are landforms, sediments, or locations where specific data were collected. Depending on the mapping scale and the size of the feature on the ground, the observation will be represented as a polygon, a line, or a point superimposed on the map-unit polygon. Like map units, geomorphological features are characterized by the environment of deposition, genesis, and relative geological age. These characteristics may be identical or different from the underlying map unit. For example, drumlins (geomorphological feature) could have the same environment of deposition, genesis, and relative age as the underlying till unit, but an active dune field could have different temporal characteristics than the underlying glaciolacustrine map unit. Furthermore, for certain features (e.g., terrace scarp, beach crest) the environment of formation can generally be deduced from the underlying and surrounding polygons. Regardless, it is specified in the database.

Similar to map polygons, geological events can be associated with points, lines, overlay polygons, and field observations. They are not labeled on the map but captured in the database in the 'Geological Event Name' field.

Overlay Polygon (GEM_OVPOLYS)

An overlay polygon feature can either delineate a grouping of common thematic features that are too small to be mapped individually, or a feature that is large enough to be shown as an area and represented by an overlay pattern (e.g., eolian lag) or outline (e.g., area of sinkhole) as shown in Appendix B.

Line (GEM_LINES)

A geomorphic line is used if the feature is too small to be shown as an area, but large enough to show its true length (e.g., Appendix B, drumlinoid ridge). The location, length, and orientation of the central axis are shown. The linear axis of the feature is digitized to be represented as a linear symbol. All line symbols are drawn to scale using the right-side rule: the arrow appears at the end of the line, and the ornamentation appears on the right-side of the line (Fig. 2).

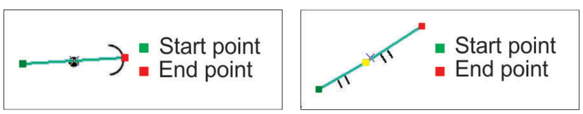

Figure 1 - Line digitizing direction.

Point (GEM_POINTS)

A geomorphology point is used if the feature is too small to be shown to scale as an area or a line. The centre location and direction of the feature are digitized to be represented as a point symbol. All point symbols are aligned (using the Azimuth field) from the centre of the symbol. Oriented point symbols are designed to represent zero degrees pointing to the north (Fig. 3).

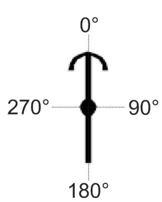

Figure 3 - Point digitizing direction

Geomorphological feature order in the map legend

Within the Legend (Appendix B), line and point symbols should be placed below the map units and listed in order of age with the youngest at the top. Generally, features on bedrock are assumed to be oldest. Features formed in subglacial settings are older than those associated with subaerial ice-contact processes, which are assumed to be older than features associated to proglacial sedimentation. Proglacial outwash features are assumed to be older than glacial-lake features. Items that do not have a geological time connotation (e.g., sampling site, gravel pit, field station) are placed at the bottom of the list.

Field Observations and Measurements Symbolized on Maps

Field observations and measurement information is recorded using a field data collection tool (i.e., GanFeld), or input from hand-written notes into an established spreadsheet file. Only the information that can be represented as a symbol on a map is shown in Appendix A and B. Field observation sites are referred to as stations and all related information is stored in a suite of relational tables (Appendix C).

Submitting changes to the Surficial Data Model

The science language for surficial geology maps produced by the GSC will continue to evolve in accordance with the requirements of surficial geology mappers. The science language can be annually updated if required. Submission for additions, deletions, or changes by GSC mappers should be made using the available editable PDF form (Appendix D). Completed forms should be sent via email to the "Surficial Geology Legend/Légende des formations superficielles" available in the Natural Resources Canada internal email address list, the Surficial Legend Review Committee chairperson, or any of the authors of this publication. Questions, comments, and suggested changes by collaborators outside the GSC are welcome. The annual deadline for submitting suggested changes or additions is generally November 1st. As a reminder, a call for submissions will be put out by the chairperson prior to this date.

All submissions will be reviewed by the Surficial Legend Review Committee by December 1st of that year, and approved changes will be implemented in the surficial data model by February 1st of the following year. Requested changes should be submitted as soon as they are identified by mappers to avoid a large number of review requests in November of each year.

Summary

The science language integrated data model presented here is an evolving document aimed at standardizing the science language, data structure and symbolization of surficial geological features. Procedures are described for 1) defining, labeling, and describing map units, 2) representing geomorphologic features according to their geometry (overlay polygons, lines and points) and 3) recording field data observations. Detailed descriptions of the surficial features are given in Appendices A and B along with the changes between versions 2.4.0, 2.5.0 and 2.5.1. Data structure is outlined in Appendix C, and Appendix D provides a form for feature additions or modifications.

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The science language presented here is the result of years of research and collaboration by many research scientists and GIS specialists across the GSC. The GMF project through the GEM Program has been the catalyst for the accrued interest and involvement of the GSC community.

The current surficial legend review committee includes surficial geologists J.E. Campbell (committee chair), D.H. Huntley, M. Parent, J.M. Rice and I.R. Smith; scientific editor A. Weatherston; surficial data model developer C. Deblonde, documentation specialist R. Cocking; and GIS specialists W. Chow, L. Robertson and K. Zawadzka.

Comments and suggestions can be forwarded to any member of the surficial legend review committee.

Appendix A. Surficial Data Model Detailed Feature and Geological Event Lists

OF_8236_v2_5_1 _appendixA.xlsx

Appendix B. Surficial Data Model Legend Chart v2.5.0/2.5.1

OF_8236_v2_5_1 _appendixB.pdf

Appendix C. Surficial Geodatabase Structure

OF_8236_v2_5_1 _appendixC.xlsx

Appendix D. Surficial feature modification form

OF_8236_v2_5_1 _appendixD.pdf