Geological Map Data Management for the Bathurst Camp EXTECH-II Project: A Model to Assist Mineral Exploration Geologists

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ABSTRACT

The Bathurst Camp, located in Northeastern New Brunswick, is a well-established mining camp with at least 40 known massive sulphide deposits. There are a large amount of existing geoscience data, and new data being added through integrated studies and regional surveys conducted as part of the EXTECH-II project. To facilitate the distribution and interpretation of these data using GIS, they are being imported into a central database inventory housed on a GIS platform. Included in the inventory, so far, are bedrock geology compiled at 1:20 000 scale, bedrock geology compiled at 1:500 000 scale, surficial geology compiled at 1:50 000, Landsat TM imagery, airborne radar, regional stream sediment geochemistry, topographic, mineral deposits, and airborne high resolution magnetic, electromagnetic, and radiometric data.

GIS applications requiring selected information from bedrock geology maps have always faced the difficulty of breaking legend information from the maps related to the area of interest into significant elements for input into modelling exercises. In most instances, investigators have had to rely on manual extraction and coding of individual modelling layers, map by map. We are attempting to overcome this obstacle and assist automation by storing the legend attributes into a relational database that can be linked to the spatial features through GIS software. The relational structure that we are developing is based on a structure being developed at the Geological Survey of Canada for the Generalized Geology of the World project. This structure allows storage of age, rock type, zone or belt, unit name, and other information in separate tables and data element-fields from which they can be called using database query language commands, and thence made into mineral potential and landuse modelling input layers. The database structure also provides provisions for linking references to each feature, and for tracking updates, which will assist in long-term database maintenance operations.

Some examples of derived maps that can be generated using the linked database range from a simple thematic map showing all volcanic rock units that are chemically classified as tholeiites, a query based on information from a single field in the database, to a thematic map showing formations that are of Ordovician age and contain components of felsic volcanics and shales, making use of several fields in related tables.

INTRODUCTION

The Geological Survey of Canada has been involved in a number of multidisciplinary, multi-institutional initiatives aimed at developing new insights into geologic processes, and becoming more efficient in the use of expertise and resources. Two of these initiatives have had a strong focus on GIS data management, the National Mapping Program (Natmap), and the Exploration Science and Technology program (EXTECH).

Natmap was initiated in 1988 and consisted of two primary projects each with a duration of five years (Geological Survey of Canada, 1990). The Shield Margin Project explored new perspectives of the Flin Flon Snow Lake Belt and its continuation to the south below the Paleozoic cover (Leclair *et al.*, 1992), and the Slave Project investigated new concepts related to the metallogeny and tectonic history of the Slave Province (Hoffman and Hall, 1993). The EXTECH initiative began in 1989, and had the primary objective of improving concepts and technologies applicable to exploration for base metal deposits in the Snow Lake and Rusty Lake volcanogenic massive sulphide districts of Manitoba (Bonham-Carter *et al.*, 1996).

Each of these studies recognized the importance of a strong GIS component to organize and analyse the large amount of spatial and aspatial digital data acquired from a variety of sources in a wide range of formats. The primary need was for the data to be made available to all project

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participants in useable form as quickly as possible. The GIS component of the Natmap project emphasized standards for incorporating digital field data and existing paper geological maps into a central database to speed digital map production and provide bases for analysis (Broome *et al.,* 1993). The EXTECH-I project used GIS to build a multi-layered geoscience exploration data set, and to develop methods of weighting and combining the data to produce maps showing volcanic-hosted massive-sulphide favourability (Wright and Bonham-Carter, 1996).

A third multidisciplinary, integrated study, known as EXTECH-II, with similar overall objectives as EXTECH-I but focusing on volcanogenic massive sulphides in the Bathurst Camp, was started in 1994, and is to be completed in 1999 (Goodfellow, 1995). The GIS component of the EXTECH-II project has two main objectives.

The first is to gather and organize all of the data collected for the project plus selected sets of pre-existing data into one central computer facility, from which they can be redistributed in useful form to project participants who need them for their own work. These data sets include bedrock geology mapped at 1:20 000 scale, regional geology compiled at 1:500 000, Landsat TM imagery, airborne radar, regional stream sediment geochemistry, till geochemistry, surficial geology, mineral deposits and airborne high resolution magnetic, electromagnetic and radiometric data. Primary factors affecting the utility of the data sets are that: (1) they must be consistently georeferenced to fit the topographical bases chosen for the project; (2) they must be stored in consistent formats, structures, and resolutions; and (3) subsets of the data can be exported in formats that can be used by the project participants for their own purposes on their own computer platforms. The intention is that this database (the term database here referring to this organized, geo-referenced collection of digital data sets) be maintained beyond the life of the project.

The second objective is to preprocess the appropriate subsets of data from the central database to provide the input layers for mineral deposit favourability modelling using the GIS methods developed during the EXTECH-I project. For that project, several of the key input layers were derived from bedrock geology maps. Derivative maps were generated based on key elements extracted from the map legends, reports and personal communications from the maps' authors based on their field data. Because map legends differ from area to area, and author to author, input layer values had to be added piecemeal because no standard structure has yet been established to store this vital information.

The potential for such a useful structure is inherent in those GIS software packages that allow the spatial representations of the geology to be linked to a relational database housing much more information than would ever be displayed on a map at one time. Such a relational database could thus house information that might traditionally have been collected as field or sample information and included in a report. Therefore, the EXTECH-II GIS project aims to develop a data model that adequately describes significant attributes of bedrock geology at the scales of the geological maps, and can accommodate key elements that are needed for mineral potential modelling in the Bathurst Camp. This data model is to be implemented as a data structure in the relational style attribute database that forms part of our central GIS software package.

The priorities of the data model and the resulting data structure are:

1. The structure (or structures) will be adequate to model the geology to the general satisfaction of project partners/database custodians;
2. The data elements can be retrieved reliably and on the fly for GIS analysis (e.g., mineral potential modelling and land use planning), as well as for on-the-fly production of a wide variety of frequently requested displays (maps, diagrams, posters) and simplified data subsets for PC-based software;
3. Data sources and update history can conveniently be stored.

The second goal necessitates not only a good data model and structure, but a method of ensuring that the data are entered in a consistent manner, in order to maintain data integrity, i.e., a graphical user interface. The third goal necessitates an effort to implement bibliographic and update history databases. A similar database structure is currently being developed for the World Map Project (Chorlton and Wright, 1996) and will be used for the upcoming revision of the Generalized Geology of the World (Kirkham *et al.,* 1994). Much of the database design used in this current study has been adapted from the work carried out for the World Map Project.

This paper describes a database model and its implementation on a GIS platform for the 1:20 000 bedrock geology maps.

OVERVIEW OF BEDROCK GEOLOGY DATABASE

The bedrock geology database (Figure 1) consists of several independent to partially independent data sets: (1) rock unit (or body) entities and their boundaries or contacts; (2) fault entities, and other extensive structural entities; (3) point observations or measurements; (4) a bibliographic system housing data source references; and (5) an update system. Each independent system has its own series of unique numerical primary keys, ideally assigned by custom data-entry application programs. For example, rock bodies, represented as polygons on the map, have unique numerical keys 1, 2, 3,…n; and faults have their own set of unique numerical keys 1, 2, 3…n. The bibliographic and update history system are linked with the other data sets using intersection tables.

The entire system is under progressive development, and structural changes to the way the tables are arranged and linked together, as well as data content, are still being made. The bedrock unit and bibliographic systems have been most fully developed, and will be described here.

FRAMEWORK OF ROCK UNIT AND BIBLIOGRAPHIC SYSTEMS

The relational attribute databases are the core of the system. For the rock-unit system, a master table representing rock unit entities is linked using its unique primary keys to numerous tables which describe different aspects (e.g., age, rock type, name, province, setting, etc.) of each entity (Figure 2). Each main rock unit entity (represented by one record) is linked to one or more data sources from the bibliographic system.

The rock-unit master table, as well as those for all of the other bedrock data sets, can be linked to spatial representations of the related geological features (or observations) stored in GIS software via line, point, or polygon feature identifiers included in the master table. Each master table record possesses only one geographical representation at the scale addressed by the attribute database. However, at the regional geological map scale, and especially at the provincial or national compilation map level, it is not unusual for a polygon to represent several exposed bedrock unit entities that are unresolvable in a meaningful way at the scale of the map. Therefore, one polygon may be linked to more than one master-table record. Similarly, one fault segment could be linked to

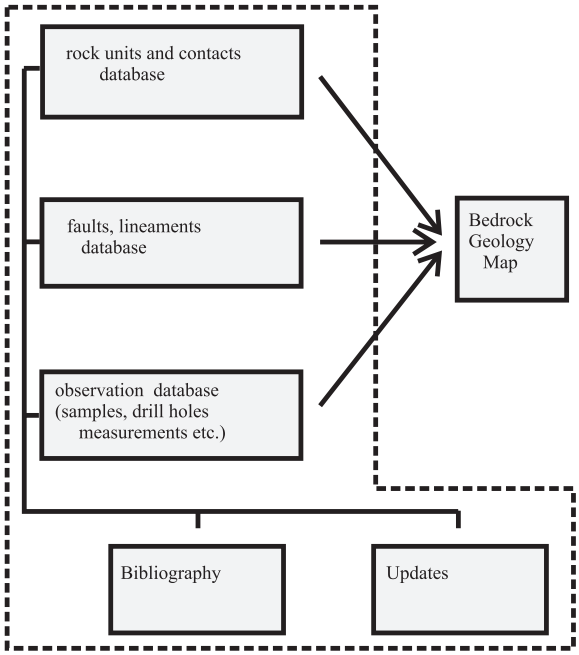


Figure 1: *Overview of the bedrock geology database consisting of five main data sets. The rock-unit/contacts, fault and observation data sets are the core of the database. A complete bedrock geology map could be generated using the information in this database.*

more than one *movement* record. It is important to note that this concept differs from the concept that a rock-unit entity may be composed of more than one lithologic component (e.g., sandstone and basalt) being more comprehensive. The bibliographic system is a standalone database with its own set of primary keys; it is linked with a system of intersection tables described below.

METADATA

Each database should have a full description of the database tables, fields, and values in tablular form. This metadata can be used as standard documentation, as well as in pick lists for data entry and for query, and status bar explanations of fields and tables in Windows-based database management and viewing software.

These tables include: 1) a catalogue of all the tables in the database listing their functions, type of table, subsystem, primary and foreign keys; 2) for each data table, a field-definition table listing each field name, its data types and size, where the data should come from, (i.e., pick list, assigned by system applications, or typed in freely), and the intended use of the field; 3) for each non-numerical field for which values should be restricted, a pick list table of values allowed for that field.

ROCK UNIT SYSTEM

An overview of the organization of the bedrock unit system is shown in Figure 2. In a GIS that uses a vector-based topological data structure, a

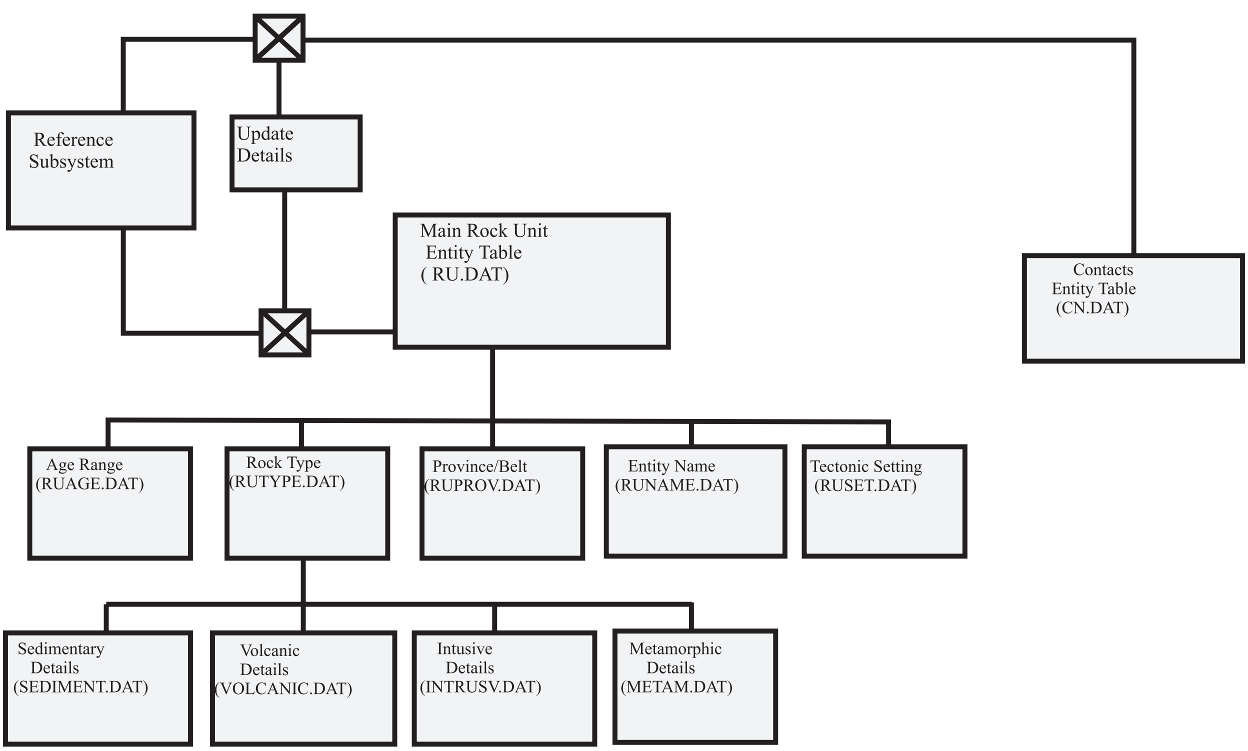


Figure 2: *Framework of rock-unit/contacts and bibliographic system. The master table (RU.DAT) is linked to uniquely labelled polygons on a map and to numerous tables that describe different aspects of each entity. Tables referred to in the text are shown in brackets.*

map with polygons, such as a geological map must have an arc component in order to define the areas. In this model, two attribute databases are used to 1) describe the bedrock units (areas), and 2) describe the boundaries between the units. The names of the tables described next and the way they are linked in the data structure are shown in Figure 2.

MAIN ROCK UNIT ENTITY TABLE

The main rock unit entity table, RU.DAT (Figures 2 and 3), is the hub of the rock-unit entity data set. A rock-unit entity, as represented by each record, means a body or component of bedrock with one age range and sharing the same geological province names, stratigraphic names, depositional settings, rock-type components, and geographic bedrock surface area. Two or more such entities may be contained within a single polygon. Such situations are increasingly frequent with decreasing scale of survey and increasing level of generalization. For geological maps at 1:20 000 scale in the Bathurst Camp this situation is rare. A combination of polygon number, RUNO, and a secondary record number, ID2, is applied to this entity as a primary key, RUNO-ID2, unique within the database.

One field, named USE, in this table indicates which records are the default plot records for the polygon, and another, named OFFSHORE, indicates whether the entity is exposed onshore or offshore. This table also carries a field, RUCODE, to capture the legend code or codes from input source maps as a convenience in verification.

Each main entity record is linked in a many-to-many relationship to one or more data sources from the bibliographic system. The intersection table representing this relationship also stores as logical fields what types of data (e.g., age, rock type, setting, stratigraphic name, etc.) were derived from the reference for each master entity record.

AGE TABLES

Each record in the main entity table is linked by the main entity primary key, RUNO-ID2, to an age table, RUAGE.DAT (Figure 2) which records the start and end ages of the entity in terms of the time stratigraphic scale as precisely as possible. If the age is entirely unknown, the entity may have no record in this table.

A provisional lookup table lists the start and end ages of time stratigraphic subdivisions, or terms, in millions of years, rounded. This table is now used to assist in picking age terms from radiometric ages. It also serves as a tool for querying for age ranges in a database in which the time stratigraphic terminology used varies widely, by using the start and end ages in Ma, rather than the terms themselves, to compose selection sets requested by the user.

ROCK TYPE AND AUXILIARY TABLES

Each rock-unit entity is linked in a one-to-many relationship through the primary key RUNO-ID2 to a table, RUTYPE.DAT, recording the basic rock categories represented as components of this entity. This table is the centre of a rock-unit subsystem developed around attributes pertinent to rock type, and contains its own unique primary key, RUNO-ID2-COMPNO, which is made up of a combination of the entity number and a component number, COMPNO, assigned at this level. In other words, these rock-type components can be considered entities in themselves. The basic rock type categories that are recorded in the RXTP field are sedimentary, volcanic, intrusive, and metamorphic. The metamorphic component option has not been used in the Bathurst area, as most rock units have been dealt with in protolith form. Volcanisedimentary, tectonic (mélange and shear) and crystalline domains are included as choices at national to global scale.

Different parameters are used to describe adequately each different rock type category. Therefore, each component can be linked to a table or tables specific to its rock type category for additional attributes. A sedimentary component could be linked through the entity-component key to a record in a sedimentary table, SEDIMENT.DAT, a volcanic component could be linked to a record in a volcanic table, VOLCANIC.DAT, and an intrusive component could be linked to an record in an intrusive table, INTRUSIV.DAT. In each case, if no further information is available, no record is present in the more detailed, category-specific tables.

Attributes in the specialized tables consist, aside from key fields, of one general class, corresponding to the most suitable classification for the general rock type category and generalization level of the database, plus a number of more specific qualifying fields. For outcrop and small mining property databases, the general classifier could be merely rock type names, such as *rhyolite* or *picrite*, as meaningful contacts can be drawn between individual rock types at that scale, whereas these contacts may be unmappable for many rock assemblages at smaller scale or higher generalization level. For higher generalization levels, as in regional mapping, these classifiers would be defined on the basis of assemblage, natural grouping, or suite, rather than at the level of individual rock types.

In the situation of the volcanic rocks table, VOLCANIC.DAT (Figure 4), general classifiers, in field MAFRANGE, would be ultrama-

Runo	Id2	Rucode	Use	Offshore	Runo_id2
1	1	OFp	Y	N	110
2	1	OF	Y	N	210
3	1	OFvb	Y	N	310
4	1	Obd	Y	N	410
5	1	OFvb	Y	N	510
6	1	OFOvb	Y	N	610

Fieldname	Fieldtype	Meaning
RUNO	FOREIGN KEY	FEATURE ID OF THE ROCKUNIT ENTITY AREA OR VOLUME FROM THE GIS DATA SET
ID2	SECONDARY KEY	SECONDARY ID UNIQUE THIS ROCKUNIT ENTITY
RUCODE	ATTRIBUTE	CODE OR LABEL TEXT FROM INPUT SOURCES, IF ANY
USE	ATTRIBUTE	LOGICAL TAG INDICATING WHETHER OR NOT THIS ENTITY IS TO BE USED AS A DEFAULT F(
OFFSHORE	ATTRIBUTE	LOGICAL TAG INDICATING WHETHER THIS ENTITY IS NOW UNDER WATER
RUNO-ID2	PRIMARY KEY	UNIQUE ROCKUNIT ENTITY KEY

Figure 3: *Partial listing of RU.DAT and its field definitions.*

fic-mafic, mafic, mafic-intermediate, intermediate, intermediate-felsic, felsic, and bimodal. In the example of intrusive rocks, a suite name, such as tonalite-granodiorite suite, anorthosite suite, gabbro-anorthosite suite, gabbro suite, etc., would be the most suitable classifiers, in field INTCLASS. Both intrusive and extrusive magmatic rocks could be further described by magma series, in field CHEMGRP, where that information is available. A depositional-setting field, DEPSET, is provided in the volcanic table. True/false fields are available to indicate whether or not subvolcanic intrusions, SUBVOLC, or metalliferous sediments, METSED, are associated with the volcanic rocks, or extrusive equivalents, EXTEQUV, are associated with the intrusive component, and for both tables, whether the components are dated, DATED, or geochemically analysed, GEOCHEM. Internal structures (e.g., pillows, massive flows, layering), textures (e.g., ophitic, megacrystic), and external form (e.g., dykes, domes, laccolith) are also attributes of both the volcanic and intrusive tables; however, because we have found that many, not just one, of these descriptors can be applied to each component at regional scale, these are being separated into auxiliary tables linked by the entity-component number, as described for the actual rock name fields next.

Actual rock names, when available, and structural descriptors, mentioned previously, are from a practical standpoint, applied in a one-to-many relation to the components described in the rock-type specific tables. Originally, they were placed in concatenated, slash delimited strings to keep the data entry and query interfaces simple, although this broke accepted guidelines for relational database design. This practice forced limits on how many descriptors, such as rock names, can be entered, and created possible errors in querying the database because of the need for string searching. For example, searching for 'marine' retrieves records with fields containing 'nonmarine'. Therefore, these fields are being restructured as independent tables linked by the compound entity-component key.

UNIT NAMES

Zero or more unit names at any level can be entered in the unit-name table, RUNAME.DAT. The unit name(s) must apply to the entire master-table entity with primary key RUNO-ID2. The unit name can be typed in by the person building or modifying the database, or it can be picked from a unique list of previously entered names in the database. The latter will assist in spelling consistency.

Name-equivalent and name-contained-within lookup tables may be added to extend the querying capability, as with provinces.

PROVINCE, ZONE, OR BELT NAMES

Zero or more geological province, zone, or belt names can be entered in the province table, RUPROV.DAT. The province, zone, or belt name(s) must apply to the entire entity as with names, and can be typed in or picked from a list of previously entered names.

CONTACT SUBSYSTEM

Rock-unit body entities are separated spatially from one another by boundary surfaces, which will be represented in a 2-D GIS data set as arcs. The contact system in the database is less fully developed than the rock-unit system. When the contacts are added to the GIS initially, each contact arc will be given a unique key, and its data will be added to the contact database. Each contact can have one or more descriptive records, representing a contact entity, in the main database table, CN.DAT (Figure 2). Records consist of a primary key, CONTNO-ID2, composed of the unique arc feature identifier, CONTNO, from the GIS

Runo	Id2	Mafrang	Chemgrp	Magtext	Volstruc	Volform	Depset	Inteq	Proxf	Mets	Dat	Geo	Runo_id2	Compno
5	1	MAFIC	THOLEIITIC		MASSIVE/PILLOWS/PYROCLAST	FLOWS/SILLS/DYKES/STRATAFO		Y	Y	N	U	U	510	1
6	1	MAFIC	THOLEIITIC		MASSIVE/PYROCLASTICS/VOLC	FLOWS/SILLS/STRATAFORM ASS		Y	Y	N	U	U	610	1
7	1	FELSIC	CALCALKALIN	PORPHYRI	MASSIVE/BRECCIA/PYROCLAST	FLOWS/SILLS/STRATAFORM ASS		Y	U	Y			710	1
9	1	FELSIC	CALCALKALIN		MASSIVE/BRECCIA/PYROCLAST	FLOWS/SILLS/STRATAFORM ASS		Y	U	Y			910	2
9	1	MAFIC	THOLEIITIC		MASSIVE	FLOWS/SILLS/DYKES		U	U	U	U	U	910	3
10	1	MAFIC	THOLEIITIC		MASSIVE/PYROCLASTICS/VOLC	FLOWS/SILLS/STRATAFORM ASS		Y	Y	N	U	U	1010	1
11	1	MAFIC	THOLEIITIC		MASSIVE/PYROCLASTICS/VOLC	FLOWS/SILLS/STRATAFORM ASS		Y	Y	N	U	U	1110	1
12	1	MAFIC	THOLEIITIC		MASSIVE/PYROCLASTICS/VOLC	FLOWS/SILLS/STRATAFORM ASS		Y	Y	N	U	U	1210	1

Fieldname	Fieldtype	Meaning
RUNO	FOREIGN KEY	FEATURE ID OF THE ROCKUNIT ENTITY AREA OR VOLUME FROM THE GIS DATA SET
ID2	SECONDARY KEY	SECONDARY ID FOR THIS ROCKUNIT ENTITY
MAFRANGE	ATTRIBUTE	CLASSIFIER OF VOLCANIC ROCKS IN TERMS OF MAFICITY
CHEMGRP	ATTRIBUTE	MAGMA SERIES
MAGTEXT	ATTRIBUTE	MAGMATIC TEXTURE
VOLSTRUC	ATTRIBUTE	INTERNAL VOLCANIC STRUCTURES, SUCH AS PILLOWS
VOLFORM	ATTRIBUTE	EXTERNAL VOLCANIC FORM, SUCH AS CALDERA COMPLEX
DEPSET	ATTRIBUTE	DEPOSITIONAL SETTING
INTEQUIV	ATTRIBUTE	INDICATES WHETHER OR NOT THIS COMPONENT IS THOUGHT TO INCLUDE OR BE ASSOCIATED WITH INTRUSIVE
PROXFACIES	ATTRIBUTE	INDICATES WHETHER OR NOT THIS COMPONENT IS INTERPRETED AS PROXIMAL TO VOLCANIC CENTRE
METSED	ATTRIBUTE	INDICATES WHETHER OR NOT THIS COMPONENT IS THOUGHT TO INCLUDE METALLIFEROUS SEDIMENTARY ROC
DATED	ATTRIBUTE	INDICATES WHETHER OR NOT THIS COMPONENT HAS BEEN RADIOMETRICALLY DATED
GEOCHEM	ATTRIBUTE	INDICATES WHETHER OR NOT THIS COMPONENT HAS BEEN GEOCHEMICALLY ANALYSED
RUNO-ID2	FOREIGN KEY	ROCKUNIT ENTITY KEY
COMPNO	FOREIGN KEY	COMPONENT NUMBER FOR THIS COMPONENT OF THE ROCKUNIT ENTITY
RUNO-ID2-COMPNO	PRIMARY KEY	PRIMARY KEY CONCATENATED FROM RUNO-ID2 AND COMPNO

Figure 4: *Partial listing of VOLCANIC.DAT and its field definitions.*

and a secondary key, ID2, to distinguish that record, a contact type derived from a pick-list, an assessment of its spatial accuracy from a pick list, an onshore or offshore tag, and a tag indicating which record would be used for a default display. Possible contact types might include depositional contacts, fault contacts, unconformities, intrusive contacts, or metamorphic isograds.

Each contact record, representing a contact entity, is linked using CONTNO-ID2 through an intersection table to one or more records in the bibliographic system. The intersection table has true/false fields to indicate what type of data, geopositioning or contact type, was derived from that reference, and also contains a field to insert an update number, which will link the addition or modification of data to a person responsible, a date, and update type.

APPLICATION OF THE DATABASE TO MINERAL POTENTIAL MODELLING

One of the most important features of this database design is that it will allow geologists to apply bedrock geology criteria, and combinations of criteria, to target areas of high mineral potential and generate a *predictor* map. Because it is not solely built around stratigraphic naming conventions and legend codes of individual maps, almost always inconsistent among maps and map areas, the database relieves the user of the task of customising such criteria on a map-by-map basis. It also accommodates the frequent situation of areas recognized as containing more than one rock-type component, or even mixtures of components (or entities) of contrasting age, rock type, stratigraphic position, or other basic descriptors. The ability to execute compound queries, such as 'felsic volcanics of Middle Ordovician age mixed with a sedimentary component and containing iron formation or metalliferous sediment' or 'Ordovician gabbroic intrusions with ophitic or subophitic texture and nearby volcanic equivalents', and showing their spatial distribution, is critical.

Some examples of maps derived from the 1:20 000 bedrock geology database that may be useful for investigating mineral potential in the Bathurst camp are shown in Figure 5. Mapping the distribution of magmatic rocks based on their geochemical classification might be of interest to identify areas of elevated favourability for massive sulphide deposits. This can be achieved through a simple query because a field, CHEMGRP, in the VOLCANIC.DAT (Figure 4) table has been specifically assigned to indicate the chemical classification of the rock unit associated with that record. The distribution of alkaline, calcalkaline and tholeiitic magmatic rocks are shown in Figure 5a. Iron formations in the Bathurst Camp are known to have a spatial association with volcanic massive sulphides in the Bathurst Camp. Iron Formations can be located in units whose primary component is either sedimentary or volcanic. Figure 5b shows the distribution of these associations. Finally, Figure 5c illustrates a relatively complex query that involves age,

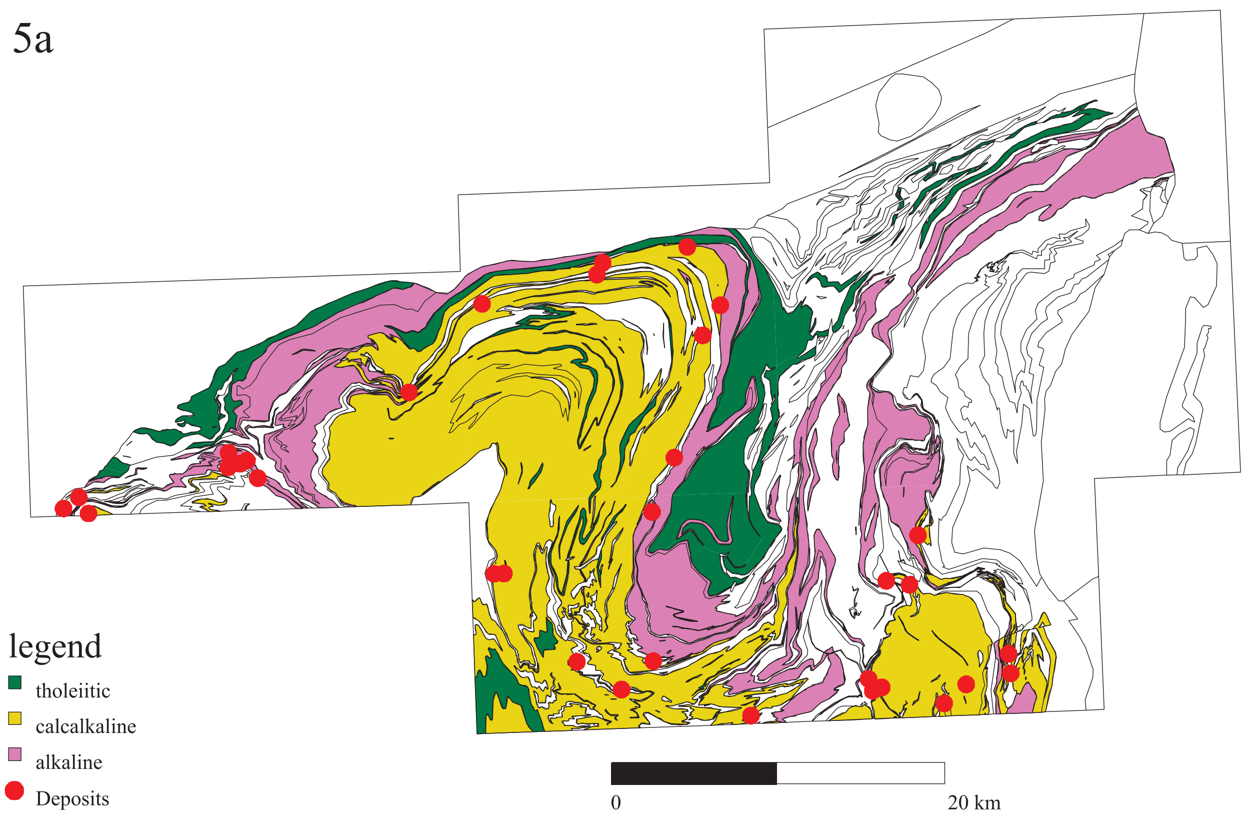
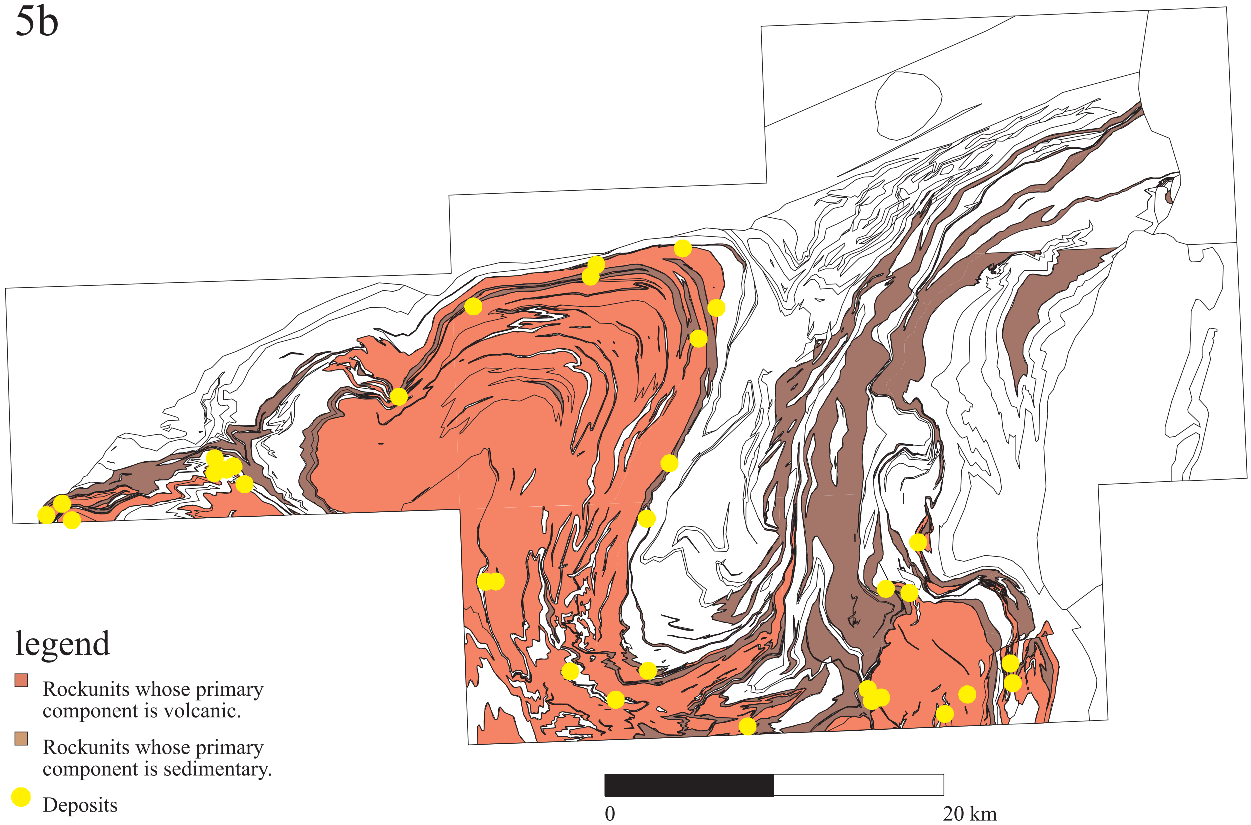
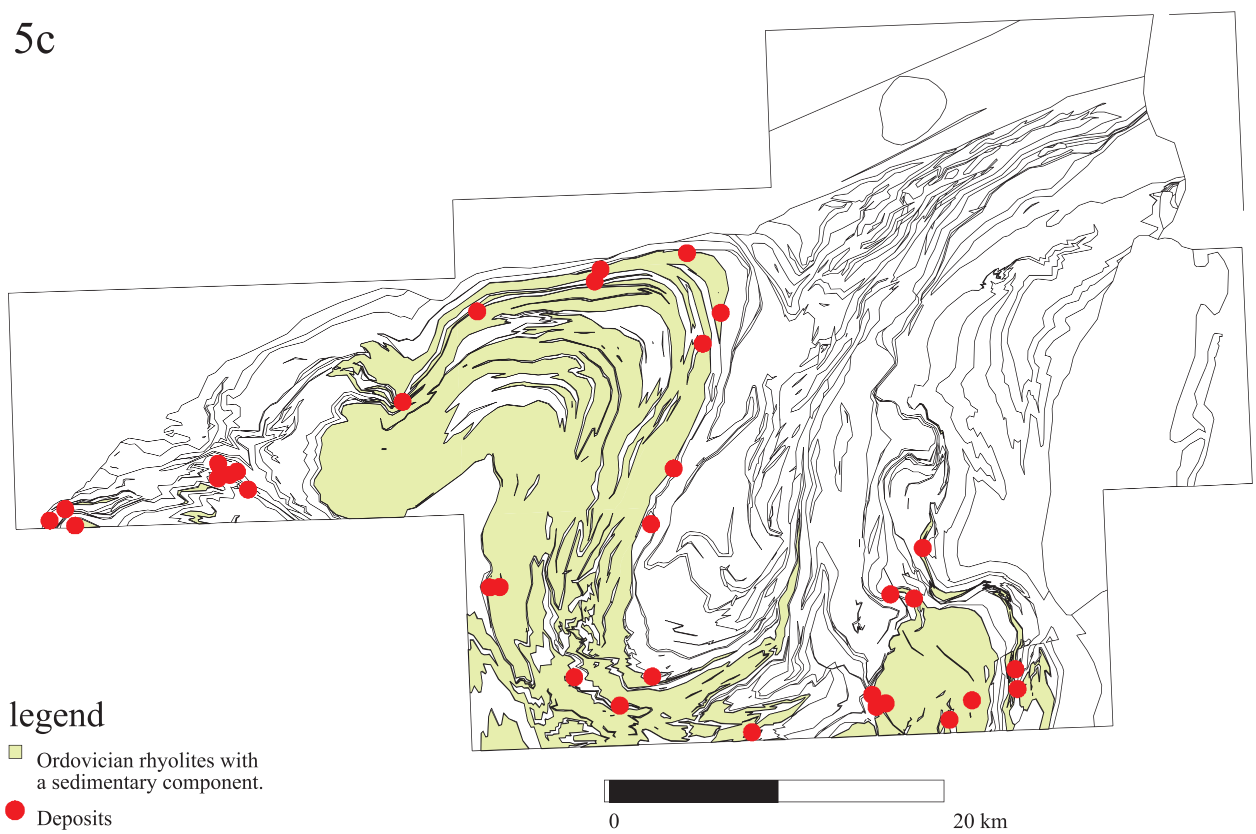


Figure 5: *Examples of using the database to generate thematic maps. The bedrock geology map for the northern portion of the Bathurst Mining Camp, showing: (**a**) distribution of volcanic rocks based on their chemical classification, (**b**) rock units that have associated iron formation, and (**c**) selection of rock units whose primary rocktype is rhyolite, secondary rocktype is sedimentary and whose age is Ordovician.*

5b


legend
Rockunits whose primary component is volcanic.
Rockunits whose primary component is sedimentary.
Deposits
0
20 km

5c


legend
Ordovician rhyolites with a sedimentary component.
Deposits
0
20 km

rock-types and components. In this example, a query was made to find all rock units that are of Ordovician age, have a primary rock type of rhyolite and a secondary component of sediment. It is interesting to note that this query is the same as selecting all rock units belonging to the Flat Landing Brook Formation, an important horizion associated with massive sulphide deposits in the Camp.

SUMMARY

A relational database has been developed to represent the information frequently occurring on a geological map including age ranges, unit names, geological belt or province and rock types. The database structure also allows provisions for linking source references and update information to all the entities in the database. To represent all the information fully requires a complex system of related tables. The advantage of such a comprehensive data structure is that it allows flexibility in the way that attribute data can be used to produce derived maps. Also, because each entity in the database has a unique identifier and the structure is relational, updating and modifying the database is efficient. The database structure has proved to be effective for geological maps with a relatively large scale (1:20 000). However, it should be adaptable to smaller scale maps with little modification.

The complexity of the database structure makes it essential to have a dedicated database manager if it is to be maintained, and it is difficult at this stage of the database development for a casual user to make effective use of the database without significant effort. These impediments could be alleviated by developing customized interfaces for data entry, query, and display. This would only be worthwhile if a long-term commitment is made to develop and maintain the database structure.

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