Geological and geotechnical logging of kimberlite into a relational database management system, EKATI Diamond Mine, Canada

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Introduction

Drilling is the cornerstone of mineral deposit evaluation, including diamond deposits. Through analysis and modelling, drillhole data flows into all key exploration, mining, processing, and financial decisions. For this reason, it is imperative that drillhole data be captured and managed in a manner that is efficient, consistent, descriptive, and free of error.

To achieve this goal, a relational database management system was implemented at the EKATI Diamond Mine to manage all drillhole data. Data are digitally collected, stored, processed, exported, and shared between departments at the remote mine site and a satellite office.

EKATI's drillhole database contains data relating to all aspects of drilling, including collar information, downhole survey data, sample collection and results, geological and geotechnical logging, grade data, and sample plant information and results. This contribution will focus on the geological and geotechnical logging components of the database. It will describe the system and the standards developed to ensure the collection of reliable and descriptive logs, including the tables and fields used to capture relevant data, the routines built to ensure reliable and consistent logging, and the templates constructed to take data from the field into reports and resource models.

Paper, Spreadsheets, and Cut-and-Paste

Since the discovery of the first EKATI kimberlite in 1992, information science has progressed rapidly; drillhole data at EKATI existed in a multitude of formats, including paper, digital spreadsheets, and various *ad hoc* databases. During the review of each kimberlite pipe, its collection of data was recompiled and verified for use in three-dimensional modelling software. This practice was inconsistent, prone to error, and time-consuming.

Several attempts were made to standardise data collection. As speed, power, and disk space of computers improved, data collection moved from paper to digital format, primarily in spreadsheet form. Unfortunately, spreadsheets have no hard controls and can frequently contain errors (Panko, 1998). Through various compilations and cut-and-paste exercises, the chance of error increased.

GBIS and a Relational Database

To address these issues, a Structured Query Language (*SQL*) database system with a Geologic Borehole Information System (*GBIS*) front-end was implemented to manage all drillhole data at EKATI. *GBIS* is a Micromine Pty Ltd product that includes and allows for customizable profiles, fully configurable data validation procedures, import and export routines, a macro builder for automating routine tasks, and a graphic report generator. *GBIS* requires a well-designed, stable relational database to function at its full potential.

The Database Structure

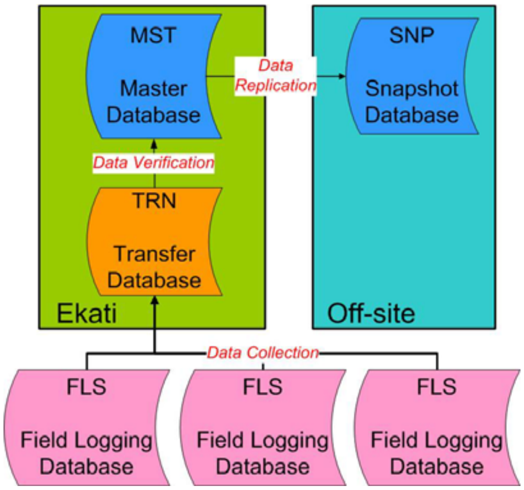
The database system implemented at EKATI was designed by St Arnaud Data Management Pty Ltd. There are four main components to the system: the Field Logging Systems (*FLS*'s), Transfer Database (*TRN*), Master Database (*MST*), and Snapshot Database (*SNP*). The relationship between each of these databases is illustrated in Figure 1.

An *FLS* is any mobile computer with an individual Microsoft *SQL* database and *GBIS* front-end installed. The portability of the data capture system allows the user to collect data away from a network connection at various locations, such as at the drill rig or in the field. Data collection is standardized into set templates with required fields, controlled data inputs, and various other data quality controls. Records are dated and the collector is identified.

The *TRN* temporarily stores data that is transferred from the various *FLS*'s. It allows multiple data collectors to collate data from different sources. Senior data collectors verify data for completeness and accuracy, correct errors, and check for duplicated data before the dataset is transferred to *MST* for use by data customers.

The *MST* is the final data repository and is read-only for all but data administrators. At this stage, data are considered final and additional changes are dated, user-identified, and logged in an audit table. Data can be viewed, exported, and reported from this location for use in multiple mining and exploration packages.

Figure 1: The relationships between each of the four databases of the *GBIS* system at EKATI.



As EKATI is a remote site, drillhole data users who work in an off-site location are subjected to slower connection speeds. To reduce the effect of network lag caused by satellite communication to the mine site, all updates and inserts to the *MST* are replicated to an off-site database, the *SNP*, allowing remote users to view the database more readily. The *SNP* is read-only to ensure consistency with the *MST*.

Transfers between each of these databases are controlled by a series of flags and macros, making data transfer a seamless exercise.

Geological Logging

Historically, geological logging has been captured in a variety of formats depending on the time of collection and level of detail required. The lack of standardization led to different levels of detail or changes in focus depending on the individual logger. To remove potential bias and improve data flow into resource models, data capture was standardized by developing a *GBIS* logging template.

The *GBIS* logging template is based on a spreadsheet previously developed by EKATI geologists Barbara Crawford, Sara Harrison, and Joe Heimbach, and Tom Nowicki of Mineral Services Canada. The template is descriptively based and was designed to enable the logger to identify key rock characteristics rather than focusing on a rock name. It is flexible enough to allow several levels of data capture, from quick-logs to detailed analysis, and to be easily transferred and used at different kimberlite projects.

The logging template is divided into different tabs based on common lithological properties. The various tabs, and the data collected in each, are listed in Table 1.

Table 1: The geological logging tabs, the rock type they pertain to, and the data collected in each.

Logging Tab	Rock Type	Description of Data
Lithology Main		Main rock type logging tab with properties pertaining to all rock types (e.g. grain-size, hardness, fabric, colour)
Alteration	All	Altered attribute (can be multiple) and alteration type, intensity, and spatial extent
Bedding		Bedding descriptor, scale, frequency, and defining feature
Xenoliths		Xenolith type (can be multiple) and abundance, size, shape, and general alteration
Kimberlite Characteristics		Kimberlite type and general kimberlitic properties (e.g. olivine abundance, sorting, packing, matrix type)
Xenocrysts	Kimberlite Specific	Xenocryst type (crustal or mantle), mineralogy, abundance, and size
Magmaclasts		General magmaclast type, abundance, size, and shape
Autoliths		Kimberlitic type, abundance, size, and alteration
Markers		Point observations or interval changes less than 2 m in length. Categorized by a general type, but otherwise free-text
Point Counts	All	Point counting and description of various specific components at continuous intervals (e.g. abundance, shape, size)
Sulphide Counts		Specific information about sulphide content and form
Magnetic Susceptibility		Magnetic susceptibility readings
Geology Photographs		Log and link digital photos taken of specific geological features

Geological logging is interval-based. Interval definitions are pre-defined depending on the project requirements, but at EKATI are in general are no less that 2 m in length. The *Marker* tab accommodates descriptions of intervals that are less than 2 m in length, or point observations. Other depth-based tabs are used to capture repeating measurements.

Required fields are pre-defined by the senior geologist based on the project requirements. This ensures that the logger is focused on the appropriate level of detail and key characteristics.

Logging codes are limited to ensure standardization of the geological terms used. However, comment fields are abundant to allow the logger the freedom to add additional information as they see fit. Codes are lithologically-based, yet are drawn from EKATI-specific terminology. Codes are easily modified to suit the requirements of other kimberlite projects.

Once logging is complete and data has been transferred through to the *MST*, it can be viewed and exported in a variety of formats. Data can be viewed in the same format as captured to allow the user to search specific intervals and characteristics. Data can be exported to *CSV* format via a set of configured exports, which can then be directly imported into geological modelling software. Exports can also be created, configured, and edited as necessary for specific uses. Lastly, data can be viewed in either detailed or summary graphic reports.

Geotechnical Logging

Geotechnical logging in *GBIS* is structured in a similar format to geological logging in that different tabs collect different data types (Table 2). Data collection and logging standards are based on the Laubscher Scale (Laubscher, 1990) with rock mass rating (RMR) and a numerical description of each structural feature being the goals of logging.

RMR intervals are defined on rock type, at times on structural domains, and are limited to 15 m in length. Each structure is logged at a given depth in the *Structural Measurements* tab, where its orientation and Laubscher rating are collected.

Table 2: The geotechnical logging tabs and the data collected in each.

Logging Tab	Description of Data
RMR	Interval-based RQD, fracture frequencies, joint conditions, and RMR calculations
Recovery	Interval-based core recovery measurements
Orientation	Orientation information (e.g. orientation tool used, reading depth, test reliability, and line reliability)
Structural Measurements	Individual structural measurements including joint type, alpha and beta angles, and conditions
Geotechnical Photography	Log and link digital photos taken of specific geotechnical features

GBIS auto-calculates designated fields, such as core recovery, rock quality designation (RQD), fracture frequency, and RMR, allowing the logger to visually compare the results with the actual core. This reduces the amount of erroneous data due to improperly measured fields; erroneous data can be corrected while logging is still in progress.

Designated fields have limited data selection codes to ensure that all data are recorded according to Laubscher. Other fields are constrained to be within given requirements (e.g. alpha angles are limited to between 0° and 90°, beta angles are limited to between 0° and 360°). This lowers the chance of technician error and increases data confidence.

With previous data-collection methods, it was not uncommon to see incomplete data with certain fields missing. With *GBIS*, the technician is unable to proceed to the next data record if required data is missing, adding hard controls to data collection.

Once logging is complete and data is transferred to the *MST*, it again can be viewed as captured, as either a configured or free export, or as a graphical log.

Discussion and Conclusions

Geological and geotechnical logging are only two components of the relational database system implemented at EKATI. Since the implementation of *GBIS*, data has been compiled to a single location, making it easier to find and less susceptible to error.

One of the key advantages of *GBIS* is its ease of use. Data is accessible to all, from the field personnel to management level. Large quantities of drillhole data are easy to manage and configured exports make integration with other software packages seamless. Its flexibility makes it easily customisable for kimberlite projects.

However, nothing comes without its challenges. Although key parts of the system were pre-defined and easily implemented, designing a system to meet a variety of departmental and individual project needs required several iterations. *GBIS* management is an on-going process as the requirements of EKATI evolve.

The single greatest challenge now facing the system is importing large amounts of legacy data. To receive full benefits from the system, as much legacy data as possible should be imported. However, as this data is not in a standard format, checking, compiling, and importing data is time-consuming. A system such as this should be implemented as early in a project as possible to limit the amount of legacy data to import.

Depending on the depth of system required and number of users, software and development costs can vary. It may not be feasible for smaller projects to justify the cost of a database such as this; however, as a project grows, the initial cost may be worthwhile compared to the potential time and data lost due to non-centralization.

The development of a relational drillhole database at EKATI, including geological and geotechnical logging, has been a worthwhile process. The combination of a relational database with a *GBIS* front-end has proved to be an easy-to-use, efficient, accessible, and versatile information system.

References

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