Building a geological and geochemical database for remapping the sub-Phanerozoic Flin Flon Belt, west-central Manitoba

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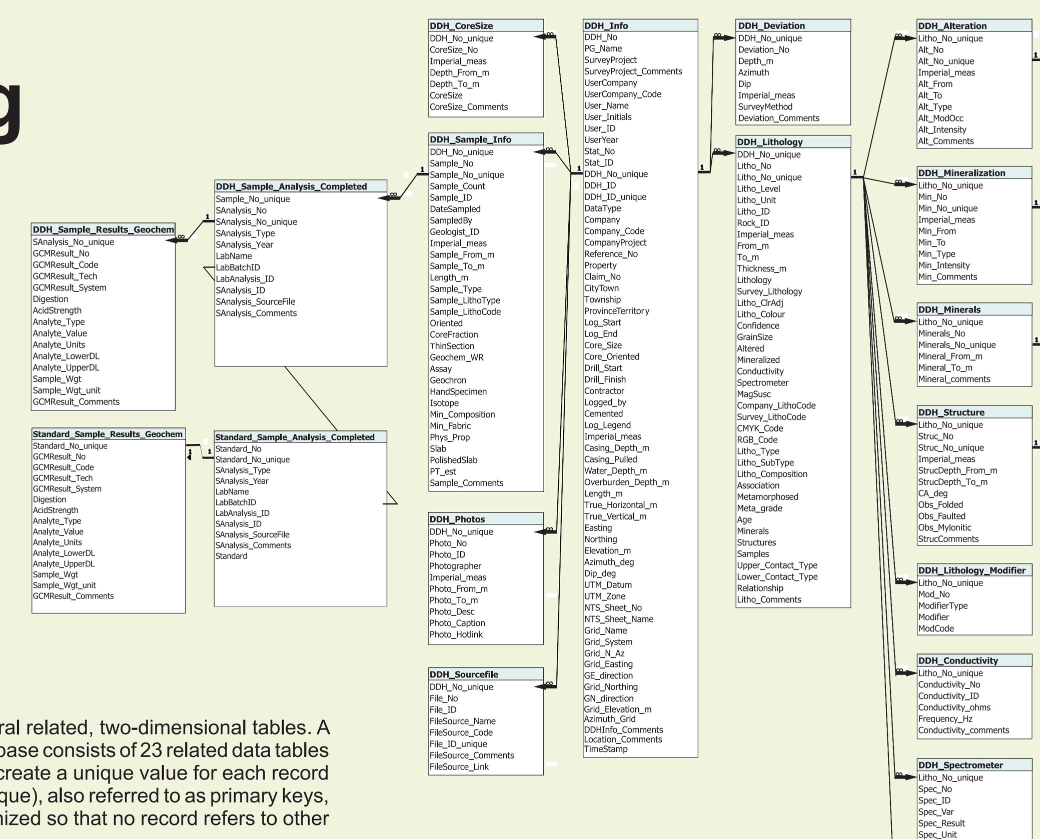
Building the tools for managing large 3D datasets

The Flin Flon Belt is one of the largest Paleoproterozoic volcanogenic massive sulphide (VMS) districts in the world. It is composed of a series of tectonostratigraphic assemblages (juvenile arc, juvenile ocean-floor back-arc, ocean plateau, ocean-island basalt, evolved plutonic arc) flanked to the north by gneisses of the Kisseynew Domain and extending south under the Phanerozoic rocks of the Western Canadian Sedimentary Basin. All VMS deposits found to date are located within the juvenile-arc volcanic rocks.

Remapping of the sub-Phanerozoic Flin Flon Belt was initiated in 2009 by the Manitoba Geological Survey (MGS) with the main objective of producing revised geological maps for the area (Simard and McGregor, 2009; Simard et al., 2010). Concurrent investigations in the Saskatchewan extension of the Flin Flon Belt (Flin Flon and Glennie domains) are being conducted by the Saskatchewan Geological Survey (Morelli and MacLachlan, 2008; Morelli, 2009, 2010a, b; Morelli et al., 2010).

A key portion of the remapping effort consists of building a comprehensive database of historical data (drillcore logs, geochemistry, etc.) for the sub-Phanerozoic Flin Flon Belt. Data compilation has become necessary so that the amount of available data (>2000 drillholes, >9000 geochemistry samples), which exist in different formats and media, can be manipulated for use in a Geographic Information Systems (GIS) environment. Once compiled, these data will be used for revising geological maps and for producing 3D models of areas of interest (exploration targets, deposits, etc.).



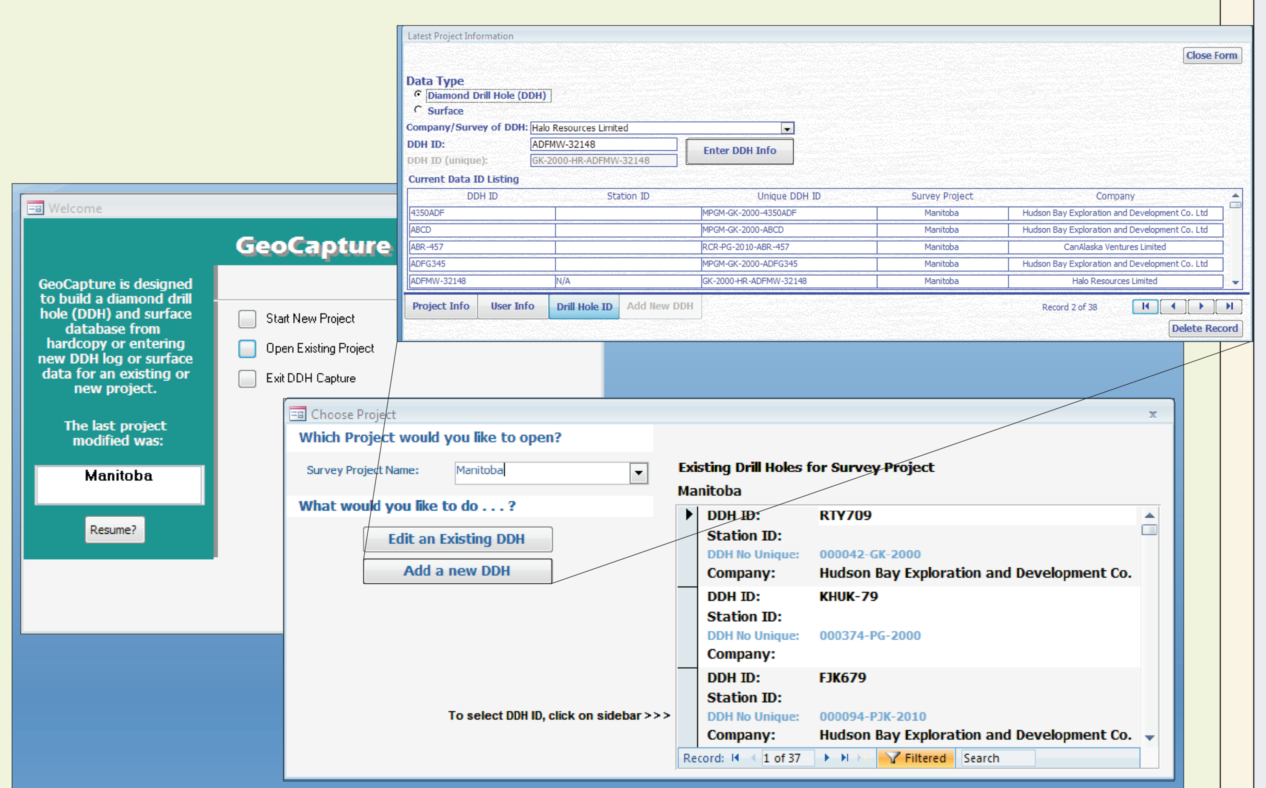
GeoCapture database structure (one-to-many table relationships)

GeoCapture

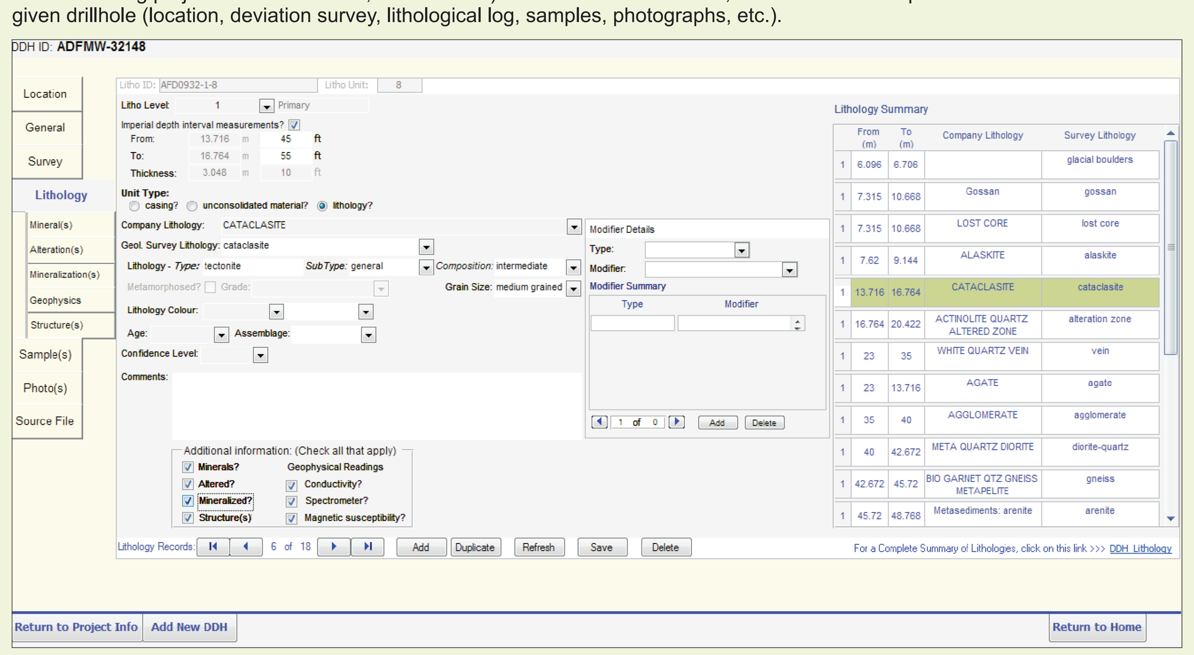
GeoCapture was built in Microsoft® Access® 2007, which is a relational database management system (RDBMS) that stores data in several related, two-dimensional tables. A RDBMS was chosen because tables can be 'normalized' so that the vast amount of data are not repeated more often than necessary. The database consists of 23 related data tables (figure to the right) and 45 lookup tables and lists. The tables are related using composite keys—two or more fields in combination used to create a unique value for each record stored in the table—which are hard-coded in GeoCapture. These composite keys (e.g., DDH_No_unique, Litho_No_unique, Sample_No_unique), also referred to as primary keys, cannot be edited by the user, which would result in loss of referential integrity. Referential integrity ensures internal references are synchronized so that no record refers to other records that no longer exist.

Two sets of 'entry forms' were developed to allow manual entry of data by the user; one capturing project information and the other drillhole information (figures below). Because this database is intended to capture data that can later be manipulated in a GIS, some fields are mandatory (DDH_ID, Easting, Northing). Data are systematically stored in metric units in the database, but can be entered using imperial units. Although GeoCapture was primarily designed to capture drillhole information, one can also capture surface data. This feature is still a work in progress.

An 'export form' has been developed to allow data, such as geology and/or geochemistry, to be exported into Excel® and shared with others and/or imported into other software (e.g., GIS or geochemistry software; see yellow box, this poster). An 'import form' for GeoCapture is currently being developed to support batch importing of digital data (e.g., collar information, geology and geochemistry).



Examples of entry forms from the GeoCapture database: ABOVE) project forms, which allow the user to create a new project or edit an existing project and its drillholes, and BELOW) drillhole information form, which is used to capture information about a given drillhole (location, deviation survey, lithological log, samples, photographs, etc.).



Formating data

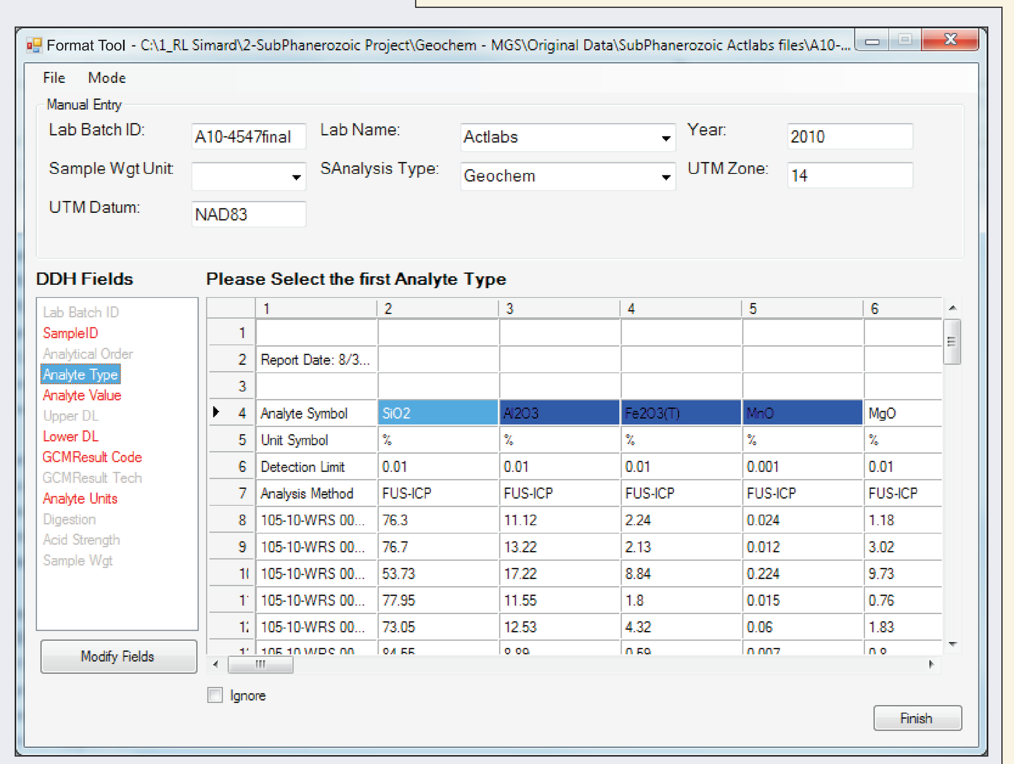
Due to the vast amount of existing digital data (e.g., geochemistry) and wide range of available file formats and storage media, a user-friendly and reliable 'Format Tool' was needed to efficiently import data into the GeoCapture database. The Format Tool was created to minimize the need for users to manipulate the original data file, thereby reducing the possibility of user-introduced errors.

Using Visual Basic® in Visual Studio® 2010 Express, the Format Tool transforms data from any Excel® (or comma-space delimited text, .CSV) file into a standardized format and outputs it to a comma-space delimited text (.TXT) file. These .TXT files can be imported directly into GeoCapture, the Microsoft® Access® database, using a simple 'append query' or 'import form'. The program can be run on any Windows system that is running the Microsoft® .NET Framework 3.5 and up.

In the case of geochemical data, the Format Tool was specifically designed to capture the metadata associated with each 'Analyte Value' for all samples (e.g., units, analytical methods, detection limits, laboratory, source file, etc.) and import these data into GeoCapture for future references. The Format Tool also separates the 'Standards' sample analyses from the others (based on the pre-existing pick-list of suffix/prefix/template provided by the user) and allows users to reformat some of the field information (e.g., field names) of the output file, if needed.

The Format Tool is very simple to use. The opened Excel® (or .CSV) data file is displayed in a grid viewer window (See figure to the right). The subwindow to the left of the grid viewer window lists the fields to be populated. For each field choice, the user selects the starting cell of the row or column of data that the program will begin processing from to populate the field (blue cells). Once all fields are chosen, that is populated from the grid viewer window (red text) or ignored (grey text), the user clicks 'Finish' and the program retrieves and reformats the data from the Excel® or CSV file.

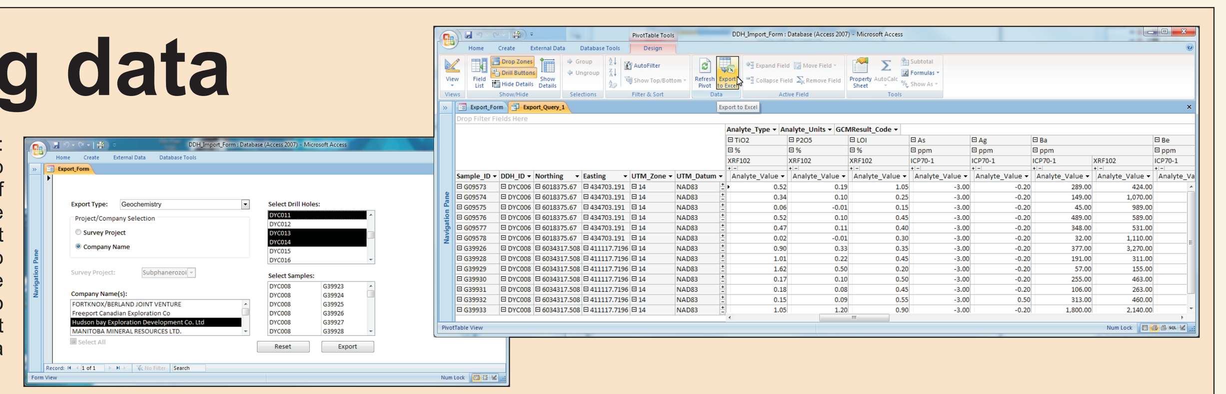
The program outputs three TXT files: 1) an 'Analyses' file containing the valid data that was collected from the Excel® (or .csv) file, 2) a 'Standards' file containing all of the valid standards data from the Excel® (or .csv) file, and 3) an 'Errors' file containing all records in error due to missing required data. Each row in the outputted files is a record of an Analyte Value with all of its metadata. For example in a geochemical file, each row contains one Analyte Value for a specific sample and all of its metadata, such as Analyte Type, Detection Limits, Analytical Methods and so forth.



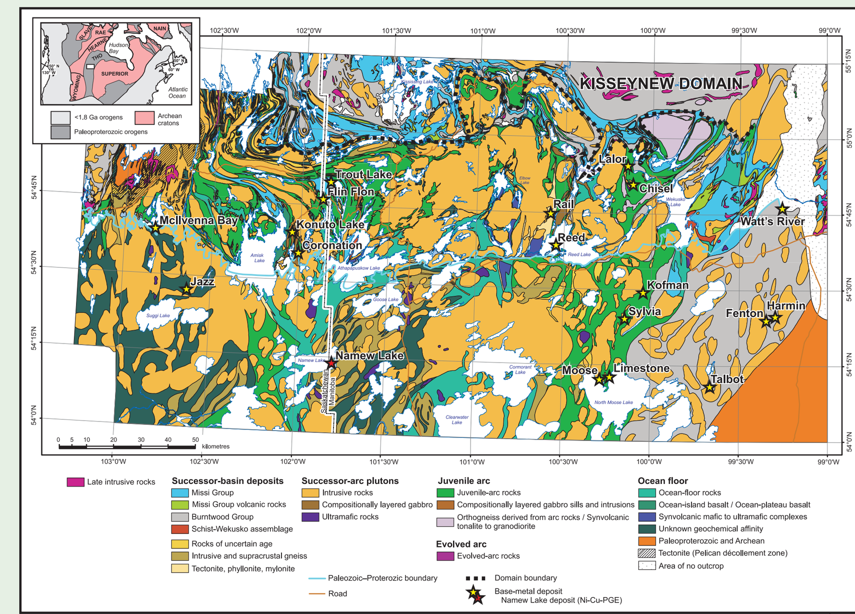
RIGHT: View of the main screen of the Format Tool. The upper portion of the screen shows fields that can be manually filled or left blank, the subwindow on the left contains the list of fields to be populated, and the grid viewer window to the right displays the Excel® or CSV data. The light blue cell is the 'data retrieval' start point followed by dark blue cells to highlight the direction in which the data will be processed, as selected by the user. If a field that is listed in the subwindow on the left side of the screen is not contained in the open Excel® (or .csv) file, then the field must be omitted by checking the 'Ignore' box. Otherwise, the field is highlighted red when data are present. The user can add or delete a field using the 'Modify Fields' button.

Exporting data

Example of the Export Form for the GeoCapture database: LEFT) the export tool allows the user to choose the type of data to be exported (geochemistry, geology, collar, etc.) for a selection of drillholes/samples, and RIGHT) example of a pivot table generated for the data (e.g., geochemistry) using the Export Form (N.B.: if an analyte, e.g., Ba, was analyzed using two different methods, both set of results will be exported). To save the results of this pivot table, the user clicks on the 'Export to Excel' button in the Ribbon at the top of the screen. The pivot table will re-appear in Excel® where the user may save the data in their preferred file format (e.g., .XLS or .CSV).



Spatial analysis



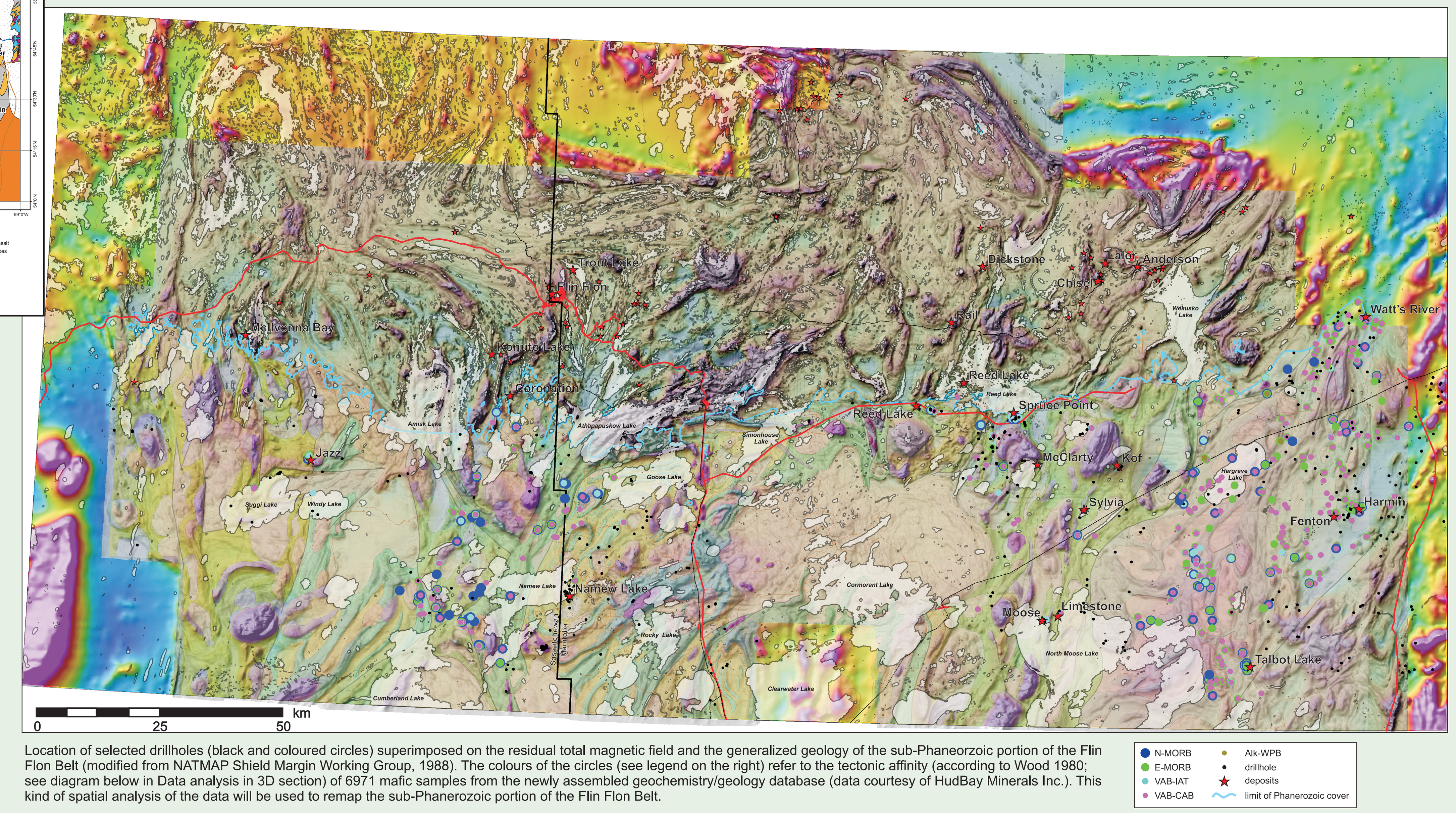
Generalized geological map of the Flin Flon Belt with emphasis on its sub-Phanerozoic southern extension (modified from NATMAP Shield Margin Project Working Group, 1998). Stars show the location of some of the deposits in the belt.

From database to map to exploration

Extensive mineral exploration spanning almost a century in the exposed parts of the Flin Flon Belt have led to the discovery of more than 25 ore deposits (as well as 40 subeconomic deposits; Syme et al., 1999), the most recent being the Lalor Lake deposit (2007) in the Snow Lake area.

Whereas successful mineral exploration in the sub-Phanerozoic Flin Flon Belt is still viable by applying standard geophysical techniques and diamond drilling, the newly acquired ability to bring such historical data into a GIS environment will also help achieve a better understanding of the regional distribution of the various tectonostratigraphic assemblages and geological domains, in particular the location of favourable host rocks within juvenile-arc assemblages, and thus provide valuable guidance for current and future mineral exploration programs.

The development of a user-friendly but comprehensive database of all existing geoscientific data in the sub-Phanerozoic Flin Flon Belt will be of great assistance in revising the geological maps of the area, as well as in producing 3D models of areas of interest (exploration targets, deposits, etc.).



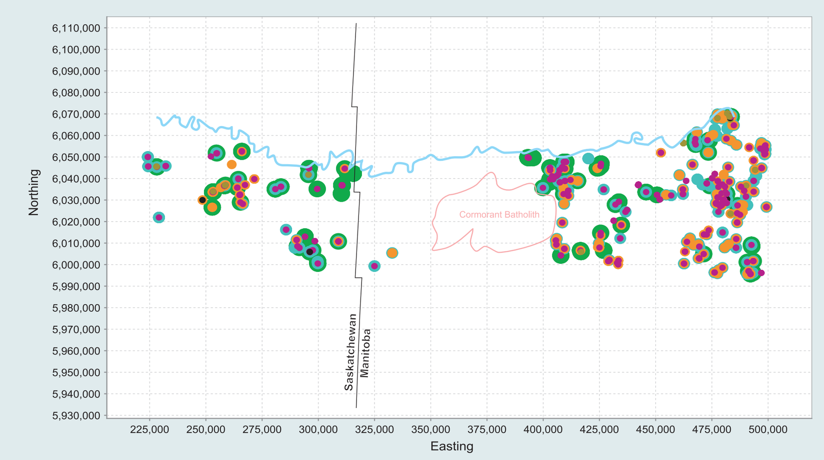
Location of selected drillholes (black and coloured circles) superimposed on the residual total magnetic field and the generalized geology of the sub-Phaneorzoic portion of the Flin Flon Belt (modified from NATMAP Shield Margin Working Group, 1988). The colours of the circles (see legend on the right) refer to the tectonic affinity (according to Wood 1980; see diagram below in Data analysis in 3D section) of 6971 mafic samples from the newly assembled geochemistry/geology database (data courtesy of HudBay Minerals Inc.). This kind of spatial analysis of the data will be used to remap the sub-Phanerozoic portion of the Flin Flon Belt.

Data analysis in 3D

Once data has been formatted and imported into the GeoCapture database, one can "export" portions of it back into various softwares to visualize/analyse it in 3D.

For each drill core log, GeoCapture "translate" the various "Company Lithologies" entered by the various loggers into a standard suite of 270 "Survey Lithologies" (e.g. basalt, granite, enderbite, etc.) that are in turn broken down into "lithology type" (e.g. volcanic, metamorphic, sedimentary, etc), sub-type (e.g. volcaniclastic, clastic, etc.), and composition (e.g. mafic, felsic, calcareous). That information can be exported using the GeoCapture "export tool" along with geochemistry, which allows the user to visualize/model the data in 3D at various geological scale and details (examples to the left).

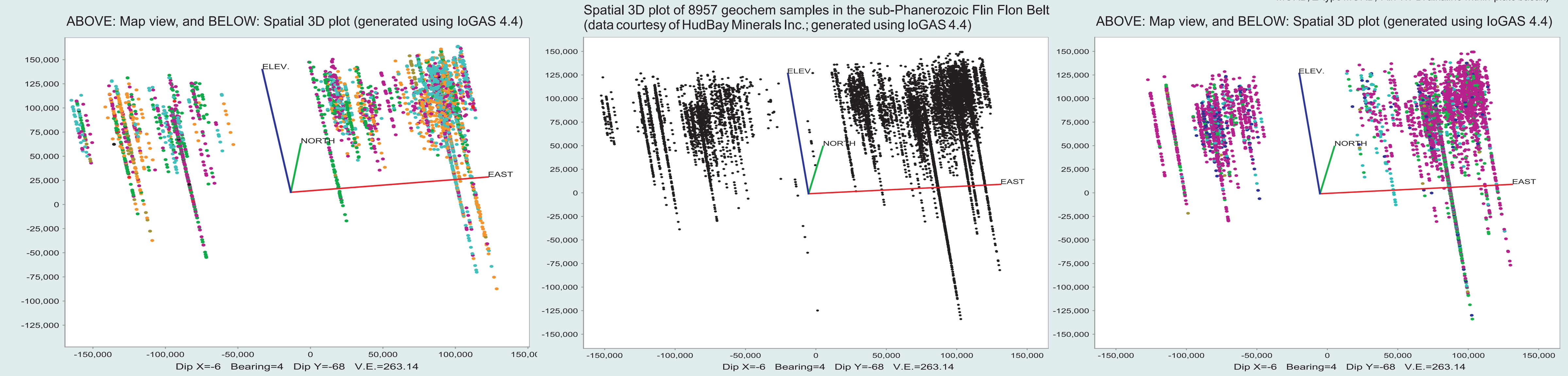
The GeoCapture "Format Tool" allow the user to bring in all kind of digital geochemistry surveys from various sources/labs all in one cohesive database, and keep the metadata associated with it, all with minimum "user" intervention. The GeoCapture "Export Tool" export the geochemistry information (sample number, analyte values, etc.) along with Drill Hole number, UTM coordinates, sampling depth, and the corresponding "Survey Lithology". This newly created excel table can then be used in various softwares (IoGAS, GeoSoft, GoCAD) to do 3D data analysis (see examples on the right).

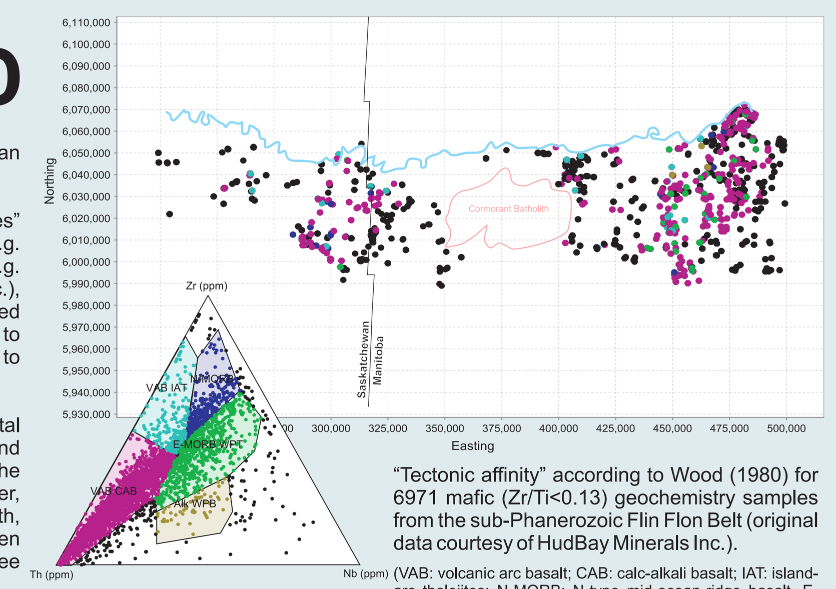


"Lithology Type" distribution of 3260 geochemistry samples from the sub-Phanerozoic Flin Flon Belt (original data courtesy of HudBay Minerals Inc.).

ABOVE: Map view, and BELOW: Spatial 3D plot (generated using IoGAS 4.4)

Spatial 3D plot of 8957 geochem samples in the sub-Phanerozoic Flin Flon Belt (data courtesy of HudBay Minerals Inc.; generated using IoGAS 4.4)





"Tectonic affinity" according to Wood (1980) for 6971 mafic (Zr/Ti<0.13) geochemistry samples from the sub-Phanerozoic Flin Flon Belt (original data courtesy of HudBay Minerals Inc.).

(VAB: volcanic arc basalt; CAB: calc-alkali basalt; IAT: island-arc tholeiites; N-MORB: N-type mid-ocean-ridge basalt, E-MORB, E-type MORB; Alk-WPB: alkaline within-plate basalt)

ABOVE: Map view, and BELOW: Spatial 3D plot (generated using IoGAS 4.4)