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GSC FIELDLOG v3.0: SOFTWARE FOR COMPUTER-AIDED GEOLOGICAL FIELD MAPPING

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METHODOLOGY

Fieldlog is a software tool designed to aid geologists in the digital management of geologic field data. It provides the means to digitally record, retrieve, display and analyze field observations to supplement cartographic map preparation and geologic interpretation. The Fieldlog methodology involves equipping field geologists with notebook computers, digitizing tablets and small printers. At the outcrop, observations are recorded into standard field notebooks, onto preset forms or into hand-held computers. Location data may be recorded using a GPS (global positioning system) or manually drafted on air photographs or topographic base maps for later digitization. At the field camp, the site data are digitally transferred, typed or digitized into the notebook computer using the Fieldlog software. Fieldlog maintains the observations in a relational database for sophisticated data manipulation, and in a CAD (computer-aided drafting) environment for the display of site data and for the interpretive drafting of geological boundaries from which segments of working field maps are plotted on a regular basis. In this way the normal hand-drafting task is replaced by digital data entry. The relational database is especially tailored to accommodate a diversity of geological data types and spatial operations. The database structure and contents are defined by the geologist and modifiable at any time to accommodate the changing needs of a field survey. Fieldlog uses CAD software for visualizing and graphically adding or editing the field data, and provides export capability to GIS (geographic information systems) for further cartographic and analytic purposes such as map publication and the digital overlay of field data on remotely sensed and geophysical images. Fieldlog acts as a field-notes GIS, emphasizing data associated with discrete geologic stations. Although Fieldlog provides modest cartographic and analytic capability, sophisticated geological processing must be performed in conjunction with other cartographic or analytic systems.

HISTORY

Fieldlog was developed at the Ontario Geological Survey (Brodaric and Fyon, 1989), and later modified and used extensively at the Geological Survey of Canada (GSC) and at several other federal and provincial agencies, universities, field schools, and mining and mineral exploration companies. Recently at the Continental Geoscience Division of the GSC, a new version (v3.0) was developed and successfully field-tested.

GENERAL DATA MODEL

Underlying all Fieldlog components and functions is a data model which consists of geologic concepts and their rules of interaction. The data model is an abstraction of the geological mapping process where concepts common to most geologic mapping activities are identified and their general relationships defined. In this sense the mapping process is grossly distilled to a series of commonly performed activities with common objects of observation. Fieldlog provides this basic conceptual structure to the geologist and permits it to be implemented by individuals in very different ways by refining and adapting the concepts into a personalized database definition. The data model's geologic concepts are translated into relational database constructs for data processing. Relational databases, and thus Fieldlog, organize data in tables consisting of columns and rows. The data model is applied to this organization by classifying each table as a geologic concept (e.g., a site, a sample, an analysis, etc.) from the data model, and this classification causes the tables to inherit relational properties governing the database's behavior.

PLATFORM INDEPENDENCE

Fieldlog's geologic concepts are implemented using the logical constructs of the relational data model. Relational database activity is transacted using Structured Query Language (SQL) which is platform-independent. In this client-server environment, Fieldlog can communicate with a variety of relational databases such as dBase, ODBC (e.g., MS-Access), Oracle, etc. Geological terminology is used to create, append and query these databases as much as possible. The database environment is housed within the cartographic framework of AutoCAD, a computer-aided drafting software which operates on many platforms. Fieldlog will function in the AutoCAD environment on DOS and Windows 3.1, 95, and NT. Fieldlog v3.0 operates under AutoCAD release 12, and is expected to operate within AutoCAD release 13 by the 1997 summer field season. AutoCAD was initially chosen because of its wide usage, cartographic excellence, and liberal development environment.

DATA ENTRY

Fieldlog maintains field observations in a relational database which is linked to one or more digital AutoCAD maps. In a typical project most

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field data are stored in the relational database, and a subset of these data are displayed on the map. However, some map entities, such as geological boundaries, may optionally exist solely on the map without being additionally described in the database. Fieldlog permits map entities of any geometric shape (e.g., points, lines or polygons) and cartographic type (e.g., symbols, text, lines, etc.) to be described in the database. Furthermore, the data entry process allows point entities to be simultaneously added to the database and map as symbols or text. This procedure is reversed for other map entities such as lines or polygons: they must first be added to the map using AutoCAD's standard cartographic functions, and then linked to a database description during data entry. Each AutoCAD map, and thus each map entity, has positional information referenced to a previously established coordinate system taken from Fieldlog's catalog of projections. Positional information is copied from the map to the Fieldlog database only for designated points; positional information for other map entities remains in the AutoCAD map.

When entering data, field observations may be typed, locations may be digitized, and either can be imported from external text or database tables. A digital topographic map is usually obtained as a backdrop onto which the observations are plotted. When observations are imported from external sources such as mobile data collection devices, they are retrieved from the database and plotted to the map via a query process. When observations reside in paper notebooks or forms, they are manually entered by selecting a table and entering information into the columns of a new row. Column contents are verified according to various parameters configured by the geologist. If verified, the new row is inserted into the table and the values of selected columns are optionally positioned on the digital map through visual location, or via digitization from some source such as a topographic map or air photograph. When several observations occur at a site, the data may be stored in more than one table or in more than one row in a table. In this case Fieldlog will then propagate critical values between rows or from one table to the other to reduce data entry time, and enforce referential integrity constraints. For example, site identifiers will propagate to all rows and tables until a new site is specified. Fieldlog also permits customizable dictionaries of geological terms to be created and attached to columns for data entry purposes and for the maintenance of semantic integrity of terminology. Once a dictionary is attached to a column, the contents of the column are restricted to one or optionally more terms from the dictionary. Dictionaries are unlimited in the number of terms they may contain.

MOBILE COMPUTING

Fieldlog v3.0 takes advantage of the affordable pen-based data entry technology offered by the Apple Newton by exporting a field database structure to the Newton and importing collected data from it. The Fieldlog database format is transferred to the Apple Newton PDA (Personal Digital Assistant) where it is displayed intact, including all relevant hierarchical profiles. Commercial software (Fieldworker) operates on the Newton to receive the Fieldlog project template and present it for data entry. Data may be hand-written on a touch-sensitive screen, or typed on a small, screen-based keypad. GPS can be connected to the Newton and its locations directly read by the Fieldworker software, permitting complete data entry to occur in the field. The resultant data are exported to Fieldlog in specialized text file format, where they are merged into the project database.

DATABASE QUERY

Queries are performed using a visual interface which permits the user to thematically filter the database and present the results in tabular form. Database filters are constructed using conditional statements which are composed of thematic, spatial or hierarchical components and which are connected with 'AND' or 'OR' logical operators. The conditions are expressed in the form of X verb Y, where X represents a column, Y a valid value and the verb may be a standard SQL arithmetic (<, >, =, etc.) or string (LIKE, NOT LIKE) operator, as well as an enhanced hierarchical or spatial operator. Spatial operators include 'INSIDE', 'OUTSIDE' for inclusion/exclusion of a point within a polygon and 'NEAR' which specifies a buffer radius around some line. The hierarchical operators 'IS' and 'HAS' allow generalization and specialization, respectively, to be specified when a column is attached to a hierarchical profile. For instance, all 'Igneous' rocks could be found by using the 'IS' operator on a column whose contents are associated to a rock type profile that contains an igneous classification. This is in marked contrast to most GIS and database systems, which require a query to contain a condition for each member of a classification.

Through its knowledge of the underlying data model, Fieldlog transforms query expressions into SQL statements which are then passed to the database for execution. Complex relationships between the tables are managed by the data model, allowing users to concentrate on the geologic content of the query and not its syntactical or relational constructions. Sophisticated analytic querying can be performed relatively easily and without undue technical knowledge.

Query results are displayed as a virtual table. Row contents in the resulting table may be browsed, deleted and modified singly or globally. The results may also be plotted to the active AutoCAD map, manipulated to produce custom diagrams (stereonets, geochemical plots, etc.) and exported to a variety of formats. Supported query export formats include tabular representations as text files and database tables, as well as direct translations to GIS using the following exchange mechanisms: ArcInfo/ArcView E00, MapInfo MIF, and SPANS TBA formats. The user can designate which columns to export and can scale the symbology or alter the coordinate system for each type of format.

MAP SYMBOLS

Fieldlog plots symbols to the map during data entry, when editing map data or from a database query. Map symbols are complex objects that are composed of several parts: a symbol or text value, and font, colour, scale, rotation angle, spatial offset, position and layer attributes. Symbols may be defined in text or graphic form. Graphic symbols are housed in libraries which are stored in the AutoCAD shape format, whereas text is generated from AutoCAD's selection of fonts. Fieldlog initially provides three geological symbol libraries which may be fully customized. New personalized symbol libraries may also be constructed. Symbols may be designated for plotting as AutoCAD shape or block entities, and this designation may be reversed at any time; i.e., shapes may be converted to blocks and vice versa. Layering is also an important symbol element. It permits database contents to be grouped on the map in geologically relevant layers, allowing data to be selectively visualized.

Generating symbols for geologic usage is a complex task requiring both static and dynamic symbology. Static symbols are symbols whose appearance is fixed for every data occurrence in a table or column. Dynamic symbols, on the other hand, may vary their appearance according to the content of the database, from one row to the next, depending on the particular column contents. An example of static symbology would be the depiction of sample locations as uniformly sized circles. If these circles were to vary their sizes according to the contents of a column, or if the actual circles themselves were replaced by other symbols related to the type of sample, then the symbology would be dynamic. Fieldlog permits both static and dynamic symbols to be defined by enabling each symbol component to be assigned either absolute or indirect values. Absolute values are indifferent to the database contents, whereas indirect values are determined by the contents of the database and are evaluated each time a symbol is plotted to the map. For instance, outcrop locations are commonly designated by an 'x' with a constant rotation angle of zero degrees, but structural symbols vary their angle of rotation according an actual measurement typically stored in the database. The former is static, and the latter dynamic. Dynamic symbols cannot, of course, be calculated until an entity is to be plotted to the map.

GEOLOGICAL DIAGRAMS

In addition to plotting database contents as geological symbols or text onto the active map, Fieldlog will generate a variety of geological diagrams. Stereonet, Rose, Binary and Ternary and Pie diagrams, as well as the projection of drill hole traces to the surface, are available from the query result window. It is possible to modify the appearance of the diagrams, scale them appropriately and position them on the active map. Having originated from the database, each relevant diagram component maintains a link to the database. For instance, on a pole to plane stereo diagram the database contents of any pole could be immediately queried. The ability to position a diagram on the map in relative proximity to its source data, and the capacity to then retrieve and potentially modify the database contents from the diagram, adds particular power to the geological decision-making process. It has been used particularly effectively to re-classify lithologic units using geochemical binary and ternary diagrams in the Bathurst Mining Camp (Rogers and Brodaric, 1996).

GIS EXPORT

The ability to link the field database to existing GIS systems, and undergo no loss of data, is critical for cartographic and analytic reasons. It is important to transfer map contents as accurately as possible to a cartographic environment, in order to avoid re-constructing the map and thereby potentially altering its geologic content and incurring unnecessary additional cartographic labor. Thus Fieldlog permits database and map content, including text, symbols, lines and polygons, to be transferred with minimal loss of cartographic or information content to the ArcInfo/ArcView, MapInfo and SPANS GIS. Once in these systems, sophisticated overlay and modeling techniques can augment the mapping process and influence the geologic interpretation. Changes to the interpretation, performed in the GIS environment, may subsequently be returned to the field system as map and database modifications.

COORDINATE SYSTEMS

Fieldlog permits ellipsoids, projections and transformations to be created and modified. In this way it is possible to create a personalized catalog of coordinate systems. Projections are restricted to variations of the following basic kinds: geographic, transverse mercator, universal transverse mercator, lambert conformal conic, double stereographic, and user-defined coordinate systems. Coordinates and map entities may be converted from one projection to another. Transformations may further be defined to convert coordinates from a user grid to other grids or orthogonal projections. Fieldlog supports nth degree polynomial transformations, though for most purposes a first order transformation suffices. Fieldlog has the internal capability to simultaneously store multiple projection and/or user coordinate systems, and maintains the link between these automatically. This is especially useful when using data from both user grids and regional data providers.

DISTRIBUTION

Fieldlog is distributed electronically, on an 'as is' basis, at no cost from the following Internet address: http://gis.nrcan.gc.ca. The Internet site presents a registration form which must be completed prior to downloading the software. A bound version of the user's guide and tutorial will also be available for purchase from the GSC Publications Office in time for the 1997 summer field season. This manual is available, and will remain available in the future, in electronic formats on the Internet site. Formal software support is not provided by the GSC, but the author will respond to questions and comments regarding the software, and short courses on its usage are occasionally presented.

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