Not just a pretty picture: the database behind GGU's Thematic Map Series

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One of the tasks of a modern geological survey is to build the geoscientific databases on which exploration companies make decisions, thus confronting them with data handling problems which involve many different types of complex spatial data. Geoscience data, characterised as it is by its large volume, variable nature, inherent uncertainty and lack of completeness, has always presented challenges. These challenges are particularly acute when a demanding client base requires and expects access to this data in digital form and in standard formats. The Geological Survey of Greenland's (GGU) own mandate to provide industry with data has been previously described (Ghisler, 1990; Dawes, 1994) and the importance of GGU's database and the benefits of Greenland's unique 'underexplored/good geodata base' duality has been discussed by Dawes (1994). A tangible result of GGU's attempt to deliver data from its databases to external clients is seen in the *Thematic Map Series*, first published in 1990 as one of several new initiatives aimed at increasing interest in mineral exploration in Greenland.

The first *Thematic Map Series* volume (Steenfelt *et al.*, 1990) contained 57 maps displaying basic regional compilations of geological, geophysical, geochemical and mineral occurrence data from the Nuuk–Maniitsoq region of southern West Greenland. A continuation of the series was seen in 1994 with publication of the second volume covering the Kap Farvel–Ivituut area of South Greenland (Thorning *et al.*, 1994). The third volume published in early 1995 covers the Paamiut–Buksefjorden region (Ady & Tukiainen, 1995), and represents a shift towards stronger linkages between the graphic display of the data and GGU's digital databases. The fourth volume in the series is under compilation and scheduled for release later in 1995. Future publications will complete a continuous coverage of digital regional data, including satellite imagery and geological maps, from southernmost Greenland to north of Disko (Fig. 1). Other areas of high scientific interest or industry activity may also appear as compilations in the series.

The thematic maps in these volumes are produced entirely from digital data and are proof that regional compilations of geoscience data are possible from well-maintained high-quality archives and databases even in an underexplored region. Their production is continuing in tandem with studies to develop an integrated geoscience information system using a geographic information system (GIS) and linked relational database management system (RDBMS) and other third party software. This system is being developed for the retrieval, display and analysis of all types of scientific data required by the Survey including map data. Data sets in the system will include geological and topographic map data, satellite images, cartographic, geophysical, geochemical, and descriptive data and publications. The Satellite Imagery Database described by Thorning & Tukiainen (this report) is part of this inititaive.

Fig. 1. Location map showing the completed *Thematic Map Series* coverage.

Why thematic maps?

The traditional paper map is unlikely to be abandoned by geologists in the foreseeable future; however a growing number of users have requirements that demand access to digital data. Distribution of large amounts of digital data on CD-ROM is one of the cheapest and most effective methods of data dissemination and CD-ROM products from GGU databases should become available in late 1995 or early 1996. In the meantime the *Thematic Map Series*, in addition to providing clients intermediate access to regional compilations of geoscience data, provides a way to:

- organise and structure large volumes of geoscience digital data and update digital databases;
- show clients the range of data sets that are available and provide access to them;
- compile data and test display and visualisation procedures prior to initiating a CD-ROM series;
- prepare data to harness future advances in technology such as 3-D GIS.

The *Thematic Map Series* must therefore be viewed as both a means to disseminate data in the short term as well as a contribution towards the longer term database building and database research effort.

The first two issues of the *Thematic Map Series* solved many of the problems of data integration and display, while work on the third volume has involved a change in software environment to one that ties the thematic maps closer to GGU's existing databases and allows stronger integration of spatial and non-spatial data. The move to a combination of Arc/INFO GIS and Ingres RDBMS for both the production of the series and the storage of data thus marks a move to the development of a fully integrated *information* system rather than a purely *cartographic* system. The system will be used to generate non-standard customer-specific output, and provide data for anlaysis and export to other third party software such as cartographic and desk-top publishing software.

Towards a geoscience information system

An illustration of the information aspect of geoscience information systems is shown as a collage in Fig. 2 of just some of the data sets covering the Paamiut–Buksefjorden area. From this illustration it is easy to see how the system could respond to a simple request to view, for example, arsenic in stream sediment anomalies superimposed on a map delineating both supracrustal rocks and magnetic anomalies.

The maps in any one thematic map issue are at a common scale (1:1 000 000) and cover the same geographical area, and simple compilations could, of course, be performed in the traditional way with a light table and drafting equipment. However, manual integration and compilation tasks often become too complicated, too time-consuming and too costly for traditional techniques as more and more data and information is introduced. The ideal situation would be to sit down at a computer and, after minimal training and with no knowledge of the complex syntax of Structured Query Language (SQL) or underlying database structures, pull up a map of Greenland, point to an area and ask the following or some similar question of the database in order to tease out underlying patterns in the data:

"Show all rock types X that belong to the Structural Province Y with mineralisation Z that are associated with concentrations of A greater than B ppb from stream sediment samples close to faults younger than age I"

Although there are many research issues from a range of disciplines to be resolved before the realisation of a system that could, for all practical purposes, respond to a query as complex as the example above, advances in technology are driving all information systems towards this type of capability. It is the role of the modern geological survey, therefore, to be ready to harness these developments and to prepare, organise and structure large volumes of geoscientific data in such a way as to take full advantage of technological developments. At GGU the approach to develop a fully integrated geoscience information system will be through a number of well-defined and self-contained, yet integrated, projects such as the *Thematic Map Series* and the Satellite Imagery Database.

Map data model – adding geoscientific meaning to the digital map

How can data be structured in order to take advantage of the technology changes that promise more 'intelligent' and more 'intuitive' systems? In order to add more geoscientific meaning or more intelligence to geoscience information systems containing vector geological map data as a fundamental data set, data structures need to be developed that are sufficiently expressive to represent the complex spatial and temporal nature of geoscience map data and its interrelationionships with other geoscience data. Such research now finds its place within institutions such as GGU, and in this regard development of a map data model is part of the applied research work that is being undertaken. The choice of an appropriate data model influences the types of relationships that can be effectively stored or derived from data elements. It is a necessary first step in the evolution of any database to build a conceptual model of the relationships inherent in the data. This exercise forces us to examine the fundamental nature of geoscience data, the way that geologists use that data, and the way that geological map data

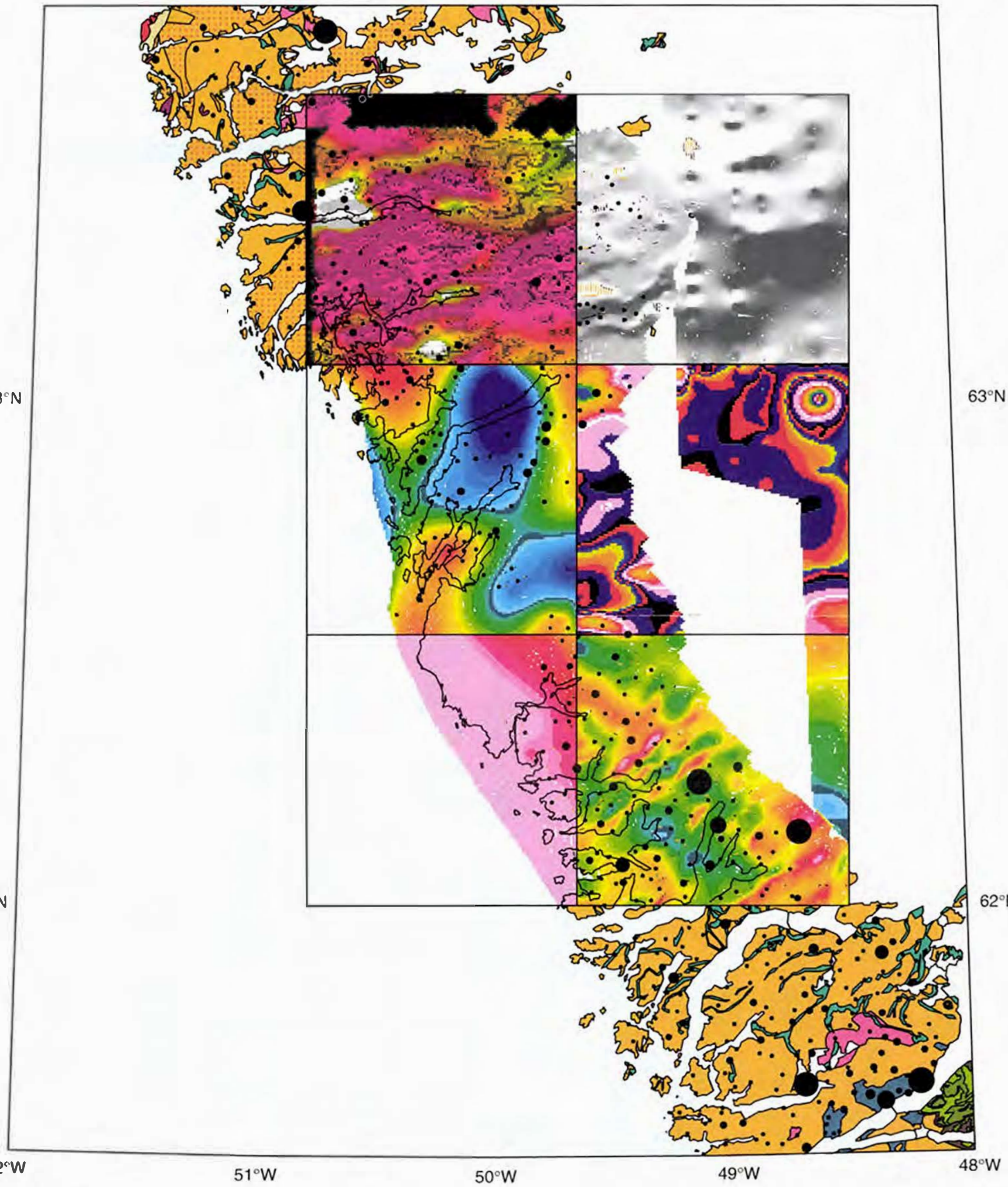

Fig. 2. Illustration of the information aspect of geoscience information systems. The collage shows just some of the data sets covering the Paamiut–Buksefjorden area, as well as differing views of the same data set, superimposed over the general geology. In a clockwise direction starting from the upper left, the data sets in the boxes are: (1) Aeromagnetic total intensity shaded anomaly; (2) Aeromagnetic total intensity shaded relief; (3) Aeromagnetic total intensity hue component; (4) Aeromagnetic total intensity anomaly; (5) Bouguer anomaly; (6) Residual bouguer anomaly. The black dots represent relative Au concentrations in stream sediment fine fraction samples.

spatially inter-relates. Thoughtful database design is the key to the project, as the outcome of incorrect data modelling will be an inefficient database structure with unnecessary redundancy in data storage and a poor match to the user's requirements for data access and retrieval.

The data modelling element is considered fundamental and draws inspiration from several sources, notably: the Ontario Geological Survey – GEOSIS project (Currie & Ady, 1989a, 1989b; Ady & Currie, 1989); the Geological Survey of Canada – NATMAP project (Broome *et al.*, 1993); and the British Geological Survey – Digital Map Production System (Bain & Giles, 1993; Laxton, 1993). The general approach to data modelling is to develop a conceptual model that mimics the user's view of the data. However, although the fundamental nature of geoscience map data does not change, the different requirements of each organisation are sufficient to warrant development of individual conceptual models. Yet each map data model should provide answers to the question: "What are the fundamental spatial and temporal properties of geological objects needed to describe their relations?"

The data modelling of geological maps for the *Thematic Map Series* is an exercise that extends beyond the realm of mere digital map reproduction and into the realm of the 'map as data'. Within a geoscience information system a geological map becomes part of a visual display of geoscience data that can be queried, manipulated and transformed in an intelligent manner.

Final comment

In the 1990s many countries, especially those with frontier regions, are competing in an unprecidented way to encourage oil and mineral exploration. One of the ways in which Greenland can compete is by offering a comprehensive, well-organised, easily accessible digital geoscientific information base to its clients. Data in these databases must be accurate and packaged in such a way as to help highlight new areas with promising economic potential. The *Thematic Map Series* is a product which gives industry an insight into GGU's geoscientific database while creating an environment in which techniques and methods for the input, search, retrieval, dissemination and eventual analysis of different types of data may be tested.

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