A DATABASE OF THE CONTENT OF GEOLOGICAL MAPS (GEOMAP) AND THE COMPUTER-ASSISTED PRODUCTION OF THE GEOLOGICAL MAP 1:50,000 OF AUSTRIA AS A MAJOR PART OF THE AUSTRIAN GEOLOGICAL INFORMATION SYSTEM.

Werner R. Janoschek, Gunther A. Pascher, and Udo R. Strauss
Geological Survey of Austria, Rasumofskygasse 23, A-1031 Vienna, Austria

Abstract: The Geological Survey of Austria is charged with the task of providing the public with all types of geological information to the fullest possible extent. Starting in 1990 the survey has been actively engaged in the development of a data-storage system of the contents of geological maps and in their computer-assisted printing. The current map production process employs both manual and computer-assisted techniques, including ARC/INFO, PostScript, Linotronic 530 and several PC-based software packages. On the whole, the introduction of computer-assisted technology to the map-printing process, by the ADP and Cartography sections, has been beneficial. The paper describes the conceptual framework involved as a result of the experience gained over the years 1990-1992.

(1 ARC/INFO is a registered trademark of Environmental Systems Research Institute, Inc.)
(2 PostScript is a registered trademark of Adobe Systems, Inc.)

Key words: Database, Geological map, Computer-assisted mapping, Geological information system

INTRODUCTION

One of the principal tasks of the Geological Survey of Austria is the production of (printed) geological maps in conformity with the scale and pattern of the official topographic map of Austria, requiring 213 sheets at the scale of 1:50,000. Map production includes geological mapping, basic research, compilation, pre-press assembly, cartography and color-proof (Cromalin). Only the offset-printing activity is done outside of the Geological Survey of Austria. Approximately one third of the sheets have been printed to date. The field and compilation work of an additional 12 maps is completed and the maps are either in preparation for printing or preparation will soon start. To accelerate the rate of publication of geological maps and to create better access to geological manuscript maps, the Departments for Mapping, Cartography, and ADP began integrating computer-assisted production by the end of 1989. The Geographical Information System (GIS) ARC/INFO was selected as the software-tool to build up the data base of geological maps and to support the printing process of these maps, which has been done manually until now. Additional hardware (work-stations, X-terminals, scanners, photo-type setters) and software products have since then been acquired and developed.

GIS ARC/INFO is used to build various layers of geological information and selected data into an "integrated" data base and thus to provide support to the printing process. The project consists of two phases:

1) Build-up of the data-base pertaining to the content of the geological map (1:50,000)
2) Printing the geological map (1:50,000)

SOURCES OF THE DATA-BASE ON THE CONTENT OF GEOLOGICAL MAPS (GEOMAP)

Usually geological manuscript - maps on recently mapped areas are usually available in large numbers. Generally they fall into the following categories:

a) Maps that are already printed
b) Complete manuscript maps prepared for printing
c) Assorted sketch - maps prepared at various scales

The task is to locate, comprehend, utilize, integrate and print rapidly. It was found that this could be carried out by using the Geographical Information System (GIS), which in this case was ARC/INFO 6.0.1.

1. Printed maps

For most of the geological maps at the scale of 1:50,000 printed over the last 20 years black plate (i.e. offset films) are still on tile. These plates show all known geologic and tectonic structures, as well key symbols (dips, fossil localities, springs, wells, quarries etc.). These films were scanned with a B/W low-cost scanner and semi-automatically vectorized. With such a semi-automated process the geologist or draftsman can identify the particular thematic information required (geology, tectonics, etc.) and then to assign it to separate layers (i.e. coverages in ARC/INFO terminology).

2. Complete manuscript maps ready for printing

The fine-drawn, hand-colored completed sheets at the scale of 1:25,000 are checked by the editor and then assigned to the particular layers as mentioned above; These layers are scanned and vectorized.

3. Sketch - maps at various Scales

A large number of sketch-maps (i.e. fine-drawn
versions of the maps prepared in the field) are received by the Geological Survey at the end of the field season. They are usually at the scales of 1:10,000 or 1:25,000 and can be processed in the same manner as the completed manuscript maps.

**Sample layers in the geologic data base of the Austrian Geological Survey demonstrated by the geologic map 1:50,000 (ÖK 153, GROSSGLOCKNER)**

Fig.1. Layers of the Geological Map 1:50,000
THE DATA BASE

Every effort is made at an early stage of GIS implementation to keep the data base design as simple as possible and to focus on user-defined needs. The approach in the geological map data base is to separate thematic information into layers to separate topological data (i.e. geology) from point-referenced data (e.g. wells) and to introduce additional layers for cartographic purposes (textures, shades, etc.). An example for the layered structure of the data base is given in Figure 1.

The local area of Austria is covered by 213 mapsheets at a scale of 1:50,000. The data base is organized in tiles, corresponding to the maps. The maps are stored under real-world coordinates e.g. the Austrian BMN (Bundesmeldenetz) system, a Cartesian Gauss-Krüger projection.

DATA DIGITIZATION

Preparation, revision and re-interpretation of maps was traditionally carried out either manually on paper or on scale-stable base materials and thus prepared for printing. However, this is a long drawn-out process; for the 1:50,000 geological map the preparatory work required prior to printing in the traditional manner ordinarily takes 8 to 15 months. In order to utilize GIS as a tool for the automation of this task, all pertinent data must be included in the data base.

Criteria for applying GIS to geological maps are:

a) Speed
b) Economy
c) Accuracy
d) No loss of information during processing

Recent advances in scanning technology and the use of algorithms for conversion from scanning to vectorial analysis provide new opportunities to use scanning for data input automation. Scanning has proven to be often more efficient than manual digitization or other conversion methods, saving as much as 80 percent of automation costs.

Linear features, such as polygonal boundaries or tectonic lineaments on monochromatic map manuscripts, lend themselves well to this method. As previously pointed out, this is the preferred method in the data capture process, as the requirements stated above are nearly all satisfied. The geological map at the scale of 1:50,000 being a vector-based map, scanned raster images require vectorization. This is accomplished through the use of PC-based CAD Core 4.0 package, which permits operator intervention during the vectorization process. In quality, the results obtained with this semi-automatic method is superior to fully automatic methods although there are drawbacks in time requirements and in personal costs.

<table>
<thead>
<tr>
<th>GIS-Unit Hard- and Software</th>
</tr>
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<tbody>
<tr>
<td>Software</td>
</tr>
<tr>
<td>ARC/INFO 6.0.1 and 6.1. (Geographic Information System from ESRI)</td>
</tr>
<tr>
<td>TIN (Triangulated irregular Network integrated with ARC/INFO)</td>
</tr>
<tr>
<td>GRID (Raster- and cell-based geoprocessing toolbox integrated with ARC/INFO)</td>
</tr>
<tr>
<td>CADCore Version 4.0 (CAD-Program with built in vectorizing Software)</td>
</tr>
<tr>
<td>Hardware</td>
</tr>
<tr>
<td>2 Hewlett-Packard 9000/730 Workstations (48Mb main memory each, 5GB mass storage)</td>
</tr>
<tr>
<td>4 X-Terminals</td>
</tr>
<tr>
<td>Contex DIN A0 Black/White Scanner (256 Grayscale, up to 400dpi resolution)</td>
</tr>
<tr>
<td>Output Devices</td>
</tr>
<tr>
<td>QMS PS810 Laser Printer</td>
</tr>
<tr>
<td>Hewlett-Packard Draftmaster II Penplotter</td>
</tr>
<tr>
<td>CalComp 5835XP Electrostatic Plotter</td>
</tr>
<tr>
<td>Linotronic 530 film recorder</td>
</tr>
</tbody>
</table>

Fig.2. GIS Hardware and Software in Use by the Geological Survey of Austria
Users can also bring scanned data into ARC/INFO, as raster data for visual reference, or as an accurate backdrop for interactive heads-up digitizing. With this method of digitizing, raster field viewed on a workstation monitor are used as a reference to update the vector data base. This method of digitizing can be faster and more accurate than table digitizing, which is rarely used. A flow-chart of the data capture is given in Figure 3.

Fig. 3. Flow Chart of the Data Capture Process

<table>
<thead>
<tr>
<th>Output Device</th>
<th>Type</th>
<th>Format</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>QMS PS810</td>
<td>Laser-Printer</td>
<td>DIN A4</td>
<td>300dpi</td>
</tr>
<tr>
<td>Linotronic 530</td>
<td>Imagesetter</td>
<td>18&quot;</td>
<td>2540dpi</td>
</tr>
</tbody>
</table>

Fig. 4. PostScript output devices used for proofing and printing
A database of the content of geological maps

HARDCOPY OUTPUT OPTIONS

One of the benefits derived from the use of GIS is the ability to visualize spatial information, using screen displays and plots. The ambition, to support the printing-process with this tool became apparent. To be successful, a map must meet traditional standards of quality in design and reproduction. With a GIS and pre-press color separation software, high quality maps can be produced in various ways.

The decision, to use the PostScript interface of ARC/INFO to produce the color separated films, was made for the following reasons:

PostScript is an interpretive programming language used to describe the appearance and location of shapes on a page (Adobe Systems, Inc. 1986). Each PostScript device comes with a PostScript interpreter, which converts the PostScript programs instruction into low-level raster data for the specific output device. PostScript is designed to work with raster-output devices. The types of output devices that support PostScript range from low-cost laser printers up to high end film recorders. A raster-device prints (or displays) images consisting of individual dots. ARC/INFO has been capable of generating PostScript files since version 4.0. The types of PostScript output devices used in the printing process of the geological map 1:50,000 are described in Fig. 4. A typical PostScript document will have two parts: a prologue and a script. The prologue contains definitions that match the output functions of the application program used. The script contains the program the user wants to print.

Introduction of the Color Separator Utility, ARC/INFO 6.0.1 allows us to generate separates in the form of Encapsulated PostScript (EPS) files. These separate EPS files contain the color-imaging information to produce the films and plates used for offset printing. The color-model used by this process is the Cyan-Magenta-Yellow-Black (CMYK) model. Each color is printed from a separate plane, hence the use of the term separates. The second method of printing is use of spot color. This method uses a single ink or a pre-mixed combination of inks to produce a custom color. These colors are used in the 1:50,000 geological map for the hydrology-layer and topographic-layer, special cartographic symbols, etc.
PRE-PRINT PREPARATION

The PostScript conversion can be used to generate the set of PostScript files, namely for cyan, magenta, yellow, black and the additional custom colors gray, brown, red, blue and green. The PostScript files were then manipulated directly by a word-processor, to change the values of the raster angles and raster widths. This is necessary because the raster angles and the raster widths typically used in printing will deliver films with moire-patterns and visible structures. Extensive testing was done to find proper values for these parameters.

In the next step, these files were proof-printed on a laser-printer. This ensures, that the PostScript interpreter does not run into any limits, like polygons with too much vertices. If the PostScript separates are verified, the files are sent to the Linotronic 530 image-setter, to produce the offset films. As the gray scale (gray curve) of the films is often not linear, an adjustment of this parameter is necessary.

The CROMALIN process is used for color-proofing. If the colors are shown to be correct, the films are ready for printing. These is the only process which is done outside the Survey.