AUTOMATED PRODUCTION OF A LARGE SCALE THEMATIC ATLAS

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I. Introduction

Users of large scale maps are frequently faced with the problems of comparing and interpreting data from several maps representing different characteristics of the same area. For example, a given area in the United States might be covered by a topographic map at 1:24,000, a soil map at 1:20,000, and a geologic map at 1:48,000. The person who must integrate information from such diverse documents must contend not only with differences in scale, but also with varied map sizes, coverages, accuracies, and symbols. The usual optical and manual methods of changing scale, registering maps, then resolving differences in generalization and symbolization are often so tedious and expensive that it may be impractical to make full use of even the most commonplace data. The atlas described here illustrates how computer graphics can be applied to the presentation and interpretation of map information acquired from varied cartographic sources.

This atlas consists of a set of thematic maps of a single area in eastern Kansas; each map depicts one or more aspects of the physical environment. A total of twelve atlas maps were generated from three source maps by means of changes in scale, superpositioning of two or more maps, generation of new distributions, and other operations completed entirely by means of digital computers. The final products are four-color maps, printed at a common scale and format, with detail, legibility, and accuracy comparable to high-quality conventional maps generated by manual methods. Although map topics focus upon needs of local planning officials, the techniques described here could equally well serve the needs of others.

This work is a joint effort of the Kansas Geological Survey (KGS), Lawrence, Kansas, and the Experimental Cartography Unit (ECU), London, England, organizations that both have long histories of applying automated cartography to mapping the environment. The KGS selected the study area, supplied the source materials and designed the content and general format for the atlas maps. The ECU was responsible for production of the maps.

II. Atlas Map Area

The atlas map area shows the northern half of the Wakarusa, Kansas U.S. Geological Survey 7.5 Minute Quadrangle, an area measuring approximately 8 by 11 kilometers (about 5 by 6.5 miles) covering about 88 square kilometers (33 square miles). Located just south of the city of Topeka, the area has experienced numerous changes in land use during recent years. Development has been greatest along the northern edge of the map area, and along the main highways. Land use in most of the remaining portion of the area has been changing from agricultural land to suburban residential housing.

III. Source Maps

Information for the atlas is derived from three source maps. The Wakarusa, Kansas 7.5 Minute Topographic Quadrangle was the source for topographic, hydrographic, and cultural detail. Because of its high planimetric accuracy, this map was selected as the base for all of the atlas maps. The Wakarusa Quadrangle was first published in 1955 by the U.S. Geological Survey (USGS) at a scale of 1:24,000; it was later revised to update cultural information.

The second source map is the *Geologic Map of Eastern Shawnee County Kansas and Vicinity* (Johnson and Adkison, 1967), and the corresponding report published by the U.S. Geological Survey. In the atlas map area 13 geologic mapping units are shown at a scale of 1:48,000.

The geologic map uses a USGS topographic base, so its locational accuracy is roughly comparable to that of the topographic map.

The third source map is the soil map published as part of a county soil survey by the U.S. Soil Conservation Service (Abmeyer and Campbell, 1970). This map shows boundaries between soil mapping units plotted on a 1:20,000 base derived from aerial photographs.

This soil map is the source not only for soil information, but also for engineering interpretations of each soil unit. These interpretations provided information concerning a variety of potential uses, ranging from suitability for foundation support for low buildings to suitability for septic tank waste disposal. As a result, the soil information forms the base not only for the soil information itself but also for other maps based upon interpretations of the soil information. Although 33 categories are shown on the original soil map, the atlas soil map (published at much smaller scale) was generalized to show only 15 categories. However, all 33 categories were digitized to permit all of the original categories to be used for generating other distributions.

IV. Atlas Maps

The atlas contains 12 map plates (Table 1); these are best described in groups organized according to the manner in which they were generated from the source maps.

The first group consists of those atlas maps generated by a simple change of scale, accompanied by appropriate generalization, and changes in symbolization. Information for Maps 1 and 2, for example, has been simply selected and generalized from the topographic source map. Likewise, Map 4 -- Soils -- is generalized from the soils source map. And Map 3 -- Geology -- presents essentially the same information presented on the geology source map. For the latter, no change in scale was necessary, although the map was slightly generalized.

Table 1.--List of atlas maps

	Title	Computer Operations	Source Maps
1.	Cultural features	selection and generalization	topography
2.	Elevation	selection and generalization	topography
3.	Geology	generalization	geology
4.	Soils	scale change, generalization	soil
5.	Soil capability	interpretation of source map	soil
6.	Slope	new map generated from source map	topography
7.	Land surface elements	visual overlay	soil, geology, topography
8.	Depth to bedrock	interpretation of source map	soil
9.	Suitability for recreational land use	interpretation of source map	soil
10.	Permeability of surface materials	interpretation of source map	soil
11.	Foundation support	interpretation of source map	soil
12.	Suitability of surface materials for road fill	logical overlay	soil, geology

A second category consists of those maps generated by transforming data presented in the original source maps. An example is Map 6 -- Slope. Topographic elevations, digitized as a series of discrete values from the contour map, were gridded to form a regular array; this array was then used to calculate slope values. Slope data were generated at the Department of Geography, University of Nottingham, using the department's PDP-11 computer and the MAPCAT mapping and data analysis system (McCullagh, 1977). Slope information was then supplied to the ECU to generate final masters for the atlas map.

The third group consists of maps created by combining information from two or more maps. Map 12 -- Suitability of Surface Materials for Road Fill -- is an example of taxonomic addition of information selected from the soil and geology maps. Another example is Map 7 -- Land Surface Elements -- formed by the visual addition of information from topographic, soil, and geology maps. The complex symbolization on this map required publication at a scale of 1:24,000, rather than the 1:48,000 scale used for the other atlas maps.

The last group consists of interpretations of data presented on the source maps. Each of the general purpose mapping units on the soil map can be interpreted with respect to engineering properties important in low or medium density commercial and residential development. These interpretations have been published as a portion of the original soil survey (Abmeyer and Campbell, 1970) and therefore are readily available in a form keyed to the soil mapping units. Map 10 -- Permeability of Surface Materials -- is simply a plot of each soil mapping unit in respect to permeability. In this instance, permeability is represented by quantitative values (inches per hour), but other interpretations could be qualitative ratings of each mapping unit in respect to certain uses. For example, Suitability for Foundation Support for Low Buildings (Map 12), consists of mapping units defined as "good," "excellent," "poor," and so on.

V. Production Sequence

The most important steps in the production sequence can be outlined as follows.

The first step was the generation of a preliminary list of map topics using information presented on the source maps and a knowledge of information requirements of planners. This list was further modified after consultations with the ECU to eliminate maps that present difficulties in legibility or symbolization. Legibility of some of the proposed maps was tested by manual and photographic compilation at the KGS. This provisional compilation approximated the visual complexity of each map, and provided a guide to the amount of generalization required to produce legible maps. During this phase it became clear that it would not be practical to publish maps at the planned scale of 1:24,000 without using either foldout pages or an impractically large format. Therefore it was decided to print each atlas map at a 1:48,000, and reserve the centerfold for a single map (Map 7) at 1:24,000.

At the conclusion of this phase, the ECU was supplied with a list of the atlas maps, with complete descriptions of legend items, titles, map detail, and all data to appear on completed map sheets. This information was keyed to the source documents. For example, category "A" on the atlas map might be formed from categories "1" and "4" from specified source maps.

The second step was the acquisition of source maps. The atlas area was selected partially on the basis of the availability of up-to-date source maps, so this step did not present significant problems. Because of the requirement for accurate digitization and registration, it was necessary to procure stable-base copies to be sent to the ECU for digitization. During digitization, each class of map feature, and each form of line symbol, was separately coded to permit selective recall of each kind of feature on the map.

Following preliminary editing and checking by the ECU, proof copies of the digitized point and line data were shipped to the KGS. These proofs were separate plots of the source data plotted on transparent plastic material at a common scale of 1:24,000. Errors were marked on copies returned to the ECU for correction.

The ECU then began production of Cromalin color proofs for each atlas map. These proofs included complete map data, legend and title information, as well as the assignment of colors to each mapping unit. Following acceptance of the color proofs, the final masters were shipped to the KGS, where the map sheets were printed, integrated with the text, then bound.

VI. References

1. Abmeyer, W. and H. V. Campbell (1970), Soil, Survey of Shawnee County Kansas. U.S. Soil Conservation Service, Washington, D.C., 77 p., (with map at 1:20,000).

2. Evans, Ian S. (1971), "The Implementation of an Automated Cartography System," in Cutbill, J. L., ed. Data Processing in Biology and Geology. Academic Press, New York, p. 39-55.

3. Johnson, William D., and W. L. Adkison (1967), Geology of Eastern Shawnee County, Kansas and Vicinity. U.S. Geological Survey Publication 1215-A Washington, U.S. Government Printing Office, 123 p., (with map at 1:48,000).

4. Margerison, T. A. (1976), Computers and the Renaissance of Cartography. National Environmental Research Council, Experimental Cartography Unit, London, 20 p.

5. McCullagh, M. J. (1977), A Data Mapping and Analysis System for Mini-Computers. Department of Geography, University of Nottingham, Nottingham, England, 115 p.

6. U.S. Geological Survey (1955), Wakarusa, Kansas 7.5 Minute Topographic Quadrangle. Map at 1:24,000, Washington, D.C., (revised 1970 and 1975).