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CAGC (COMPUTER AIDED GEOLOGICAL CARTOGRAPHY)- 3-DIMENSIONAL MODELLING OF THE METHANA VOLCANOES

L.HURNI, V.J.DIETRICH, P.GAITANAKIS.

ABSTRACT

Modern interactive CAD and computer graphics systems offer the opportunity to require data from aerial and satellite image and field measurements, to process them for generating 3-dimensional models, and to produce graphical outputs. An interdisciplinary project in Methana has been undertaken to apply such systems with methods from volcanology, structural geology, digital cartography, photogrammetry, computer graphics, digital image processing, model calculus, data base applications, and geographic information processing.

INTRODUCTION

Computers are used in cartography for digital map design in an increasing number of cases. Only vector systems, which support points and linear data were available in the first 20 years. The graphic elements "area" and "color" also have to be included in this workflow, to replace the whole conventional reprographic map production process. This has only been possible for about ten years since the introduction of hybrid vector/raster map production systems. Areas can be digitized (vector mode) or scanned (raster mode) from existing sources. Combined processing and switching between the two modes is possible.

At the Institute for Cartography at the Swiss Federal Institute of Technology (ETH Zürich), a hybrid map production system of the American INTERGRAPH company was installed in 1989/90. It consists of 6 powerful UNIX workstations, a file server, two high precision digitizer tables, a vector pen plotter, a high quality OPTRONICS 5040 scanner/laser/raster-plotter with a resolution up to 2032 dpi and a color thermotransfer-plotter. About 30 software packages support the fully digitized map production.

* Institute for Cartography, Swiss Federal Institute of Technology (ETH), CH-8093 Zürich, Switzerland.

** Institute for Mineralogy and Petrography, Swiss Federal Institute of Technology (ETH), CH-809[illegible] Zürich.

*** IGME, 70 Messoghión Str., Athens 11527. Greece.

WORKING PROCEDURE

The following steps have been taken during the geologic map production process:

1) Topographic data input, either digitally or manually from photogrammetric compilation or existing maps.
2) Geologic data input, manually from field sketches.
3) Layout design, on screen adjustments, addition of text, symbols and legend (all in vector mode).
4) Definition of the map element symbolisation.
5) Rasterisation of the whole map contents, separated into different file layers.
6) Transformation of the file layers into color separated files according to a priority with a color table.
7) High quality film plot of the color separated files and printing.

Since the data sets also contain height information, they can be used for 3-dimensional analyses. Combinations of digital elevation models with geological surface data is very easily possible. Shaded perspective views can be obtained, using ray-tracing software. Even aerial images can be draped over the surface and added to the model. Software for 3-D geologic depth analysis will be developed.

The 3-dimensional geological map offers a great spectrum of geographic, geological, environmental, agricultural and engineering applications:
- Visualization and interpretation of conventional 2-dimensional geological maps is very difficult and often requires years of experience. In contrast, the recognition of geological structures in 3-D maps needs no experience.
With the use of the INGERGRAPH-CAD system, perspective views of an area or a geological body from all directions and angles can be created.
- Strip or exploded view procedures can be applied to show underground structures and geometric complexities in a 3-dimensional and self-explanatonary way. Potential applications are the estimation of: size and volume of geological bodies, land slides and rock falls, groundwater circulation and paths, geometry of faults and hydrothermal systems.

WHY METHANA ?

Methana has been chosen for the following reasons:

The peninsula represents an ideal geometric object with limited dimensions, approx. 9 x 10 km, and exhibits high morphological contrasts within short distances from sea level to 740 m altitude. In Methana, a series of volcanoes are aligned along major fault zones on a folded basement of Mesozoic limestones (WASHINGTON, 1894/95; LEYDEN, 1940; DAVIS, 1957; FYTIKAS et al., 1984). The volcanic structures consist of lava and volcanoclastic flows as well as of plugs, necks and domes with simple geological boundaries. Complex pyroclastic products, such as cinder, pumice and pyroclastic flows are uncommon.

Several sequential steps have been undertaken to meet the requirement of the pilot project:

- A full topographic image, with 20 m equidistant contour lines, has been derived by digital data flow from aerial image compilation. The result is a new digital topographic map of the Methana peninsula with a high flexibility in choosing different scales as well as a very efficient and automated process for corrections. The CAGC replaces the time consuming conventional methods of scribing, lettering, color processing and correcting. In addition, it permits the visualization of new inside information and its usage for further interpretations.

- On the detailed topographic map, including correct drawings of tectonic and volcanologic structures, a geological map has been created (see enclosed figure: the historical Kaimeno volcano as a selected area. Field observations, and inferred cross sections, permit the estimation of the thickness of the different geological units with high precision.

- 3-D models of volcanic bodies, tectonic planar structures and the Mesozoic basement can be achieved as the result of interactive operations between model calculations and geological experience. Thus, mathematical recognition of underground structures, as well as the geometry of folds, faults and thrusts is feasible.

In the case of Methana, a quantitative study of magmatic activity related to tensional tectonics is envisaged using CAGC techniques. Crustal thickness and neotectonic activity seem to be the major factors controlling the ascent of the dacitic and andesitic magmas. The volcanic edifice was built up within the last 4 million years. Approx. 2200 years ago the most recent volcanic phase produced the Kameno volcano (STRABO,2052 y.b.p.; PAUSANIUS, ~1820 y.b.p.). A prediction of such a volcanic eruption and related mechanisms might be possible by calculating the magma volumes and geometric features of eruption during each period.

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Figure: Selected area (Kaïmeno volcano, ca. 2200 y.b.p.) as an example of the Geological Map of Methana 1:25 000. Enlargement approx. 105 % (1:23 800).
The final map is multicoloured and will be printed in different layouts (e.g. 3-dimensionally with perspective views from different angles).