

## METHANA RELOADED: RESTRUCTURING AND REFINING DATED CAD DATA FOR MODERN GIS-BASED CARTOGRAPHY OF A MOUNTAINOUS AREA

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### 1. BACKGROUND AND OBJECTIVES

In the early days of fully digital cartographic workflows, CAD systems such as Intergraph/Bentleys Microstation were used to digitise maps in graphically attributed vector mode. One of the first fully digitally produced topographic (mountain) maps containing even sophisticated map elements such as analytical shading, transparent land-use tints and digital cliff drawing was the map of the mountainous Methana peninsula/Greece published in 1995 (Hurni, 1993 and Hurni, 1995).

Methana was selected for the project because the peninsula represents an ideally sized object (approx. 9 x 10 km), and it has high morphological contrasts within very short distances. It raises from sea level up to 740 m altitude. A series of volcanoes are situated along major fault zones, sitting on a folded basement of Mesozoic Limestones. The volcanic structures comprise lava fields and volcanoclastic flows. Furthermore there are many plugs, necks and domes with easily recognisable geological boundaries (after Hurni et al., 1992).

This map consisted of about 120 object layers which were structured in a way to achieve an optimal priority-driven representation. It included special graphical properties such as transparency, selective masking and overfilling. Table 1 shows an extract of the screen table which was used at that time: The first column is the numbering of the layers, the second one indicates whether an overprint or (selective) masking should be applied, and the third column whether the layer is representing line art/screened parts or an invisible mask. The RGB and CYMK+2 values at the right represent the colour and screening percentages for computer screen display and offset printing.

Layer	Depth	Mask/print	Layer name	R	G	B	CYN	YEL	MAG	BRN	BLK	GRY
10	0	s	passkreuze	0	0	0	100	100	100	100	100	100
20	x	m	titmass	100	100	100	0	0	0	0	0	0
21	0	s	titltrah	0	0	0	0	0	0	0	100	0
22	0	s	titeltit	0	0	0	0	0	0	0	100	0
60	x	m	uebland	100	100	100	0	0	0	0	0	0
(...)												
105	0	s	rahmenkont	0	0	0	0	0	0	0	100	0
106	0	s	blautext	0	85	100	100	0	15	0	0	0
107	0	s	mettext	0	0	0	0	0	0	0	100	0
108	0	s	rotttext	100	0	100	0	0	100	0	0	0
110	0	s	blausymb	0	85	100	100	0	15	0	0	0
34	0	s	uebkonmas	0	0	0	0	0	0	0	100	0
(...)												

*Table 1: Extract of the screen table of the Methana map*

The map data was mainly adapted to the requirements for printed output (offset printing) and had for instance only reduced GIS suitability, i.e. topology and geometrical precision were somewhat limited. A number of features were only introduced to give the final, printed map the optimal graphical appearance, neglecting for instance proper topological nodes. Figure 1 shows an example of an automatically dashed line (left) with many gaps at the graphically unsuitable places (e.g. bends). In the middle, those have been filled with small, specifically digitised line pieces. On the right, a correct manual digitisation and design is shown. From today's point of view, the overall CAD data set is therefore not very useful for analytical GIS applications, but neither for database cartography. A recent Master's thesis project at ETH Zurich (Romer, 2009) aimed at restructuring and refining the dated CAD dataset in order to meet the requirements of modern cartographic database-driven production systems. The aim is to recreate the topographical and geological maps 1:25'000 of Methana with the same graphical appearance as the original maps. This paper describes the structure of the input data and the improved model of the output data in detail and provides information about the necessary manual effort vs. automated processing in such transformation projects.

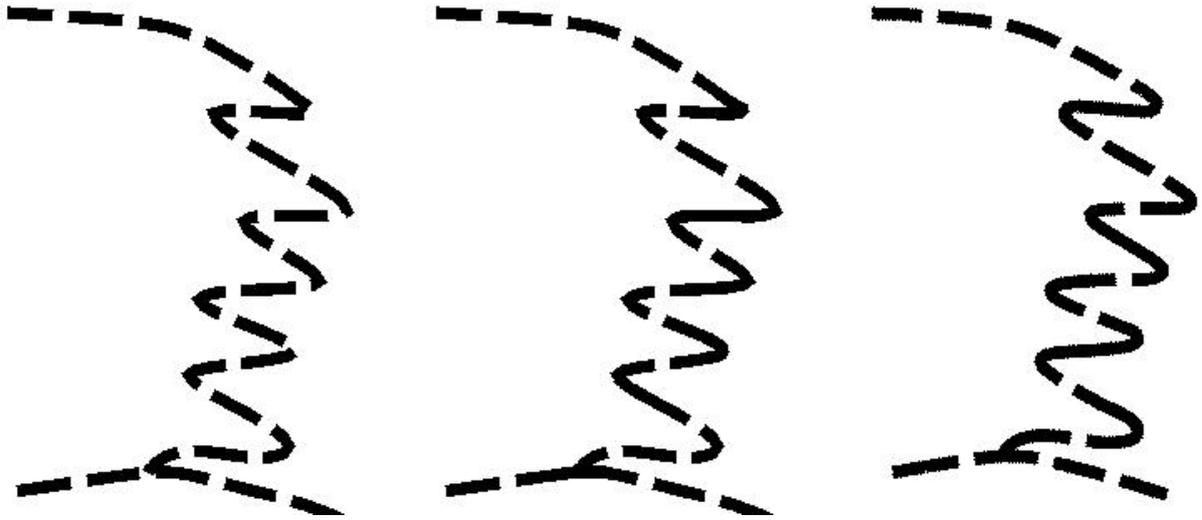


Figure 1: Automatically dashed lines (left), partially corrected lines (centre), manually designed dashed line (right)

## 2. APPROACH AND METHODS

### 2.1 Data structuring and symbolisation by representations

First, a thorough analysis of the original data must be achieved in order to match data layers which were originally structured according to graphical output criteria with a new, thematically oriented layer structure. This results in a kind of conceptual lookup-table incorporating the link between the two “perspectives” and this facilitates also the import of the semantically attributed and geometrically cleaned data in the spatial database.

The next step consists of re-attributing graphical properties to the vector data. This is done using cartographic representations in ArcGIS releases 9.2 ff. (Actually ArcGIS 9.3.1 was used for this work). For that, the original graphical specifications of the CAD-based map need to be transferred into the new definitions of cartographic representations. They allow for storing not only the geometry, but also the (changeable) symbology in a database supported by ArcGIS. Symbologies can be converted in to so-called “feature class representations”, this happens typically in ArcMap. In the database table, two new attribute columns are generated: The first one contains the representation rule, the second one a possible (individually chosen) override of the rule.

Figure 2 shows the graphical user interface, which allows for access to all properties of a representation. In the left field, all feature class representations are listed. The example of a road consists of two representations, which differ in the two versions of the Methana map (topography and geology). In the centre, the corresponding representation rules, together with a preview, are shown. In the example the various road classes are listed. The definition of the rule is done using the functions on the right. The point (“marker”), line (“stroke”) and area (“polygon”) symbols can be edited using special cartographic functions (“geometric effects”). It is for example possible, to displace an element by keeping its original placement information in the data base.

Point elements (“markers” in the ESRI representation nomenclature) can be designed using a special editor. These rules are generally applied to all elements within the object group. However, in cartography, not all elements, and especially not in the specific graphic context, can be described in one common rule. Representations offer a way out: For selected elements, the parameters in the entry field (Figure 2, right) can be individually changed; such a parameter can also be linked to the regular attribute table (also possible for several elements). Furthermore, if those rules are not sufficient, a single element can be geometrically and graphically changed and individually stored as a “free representation”.

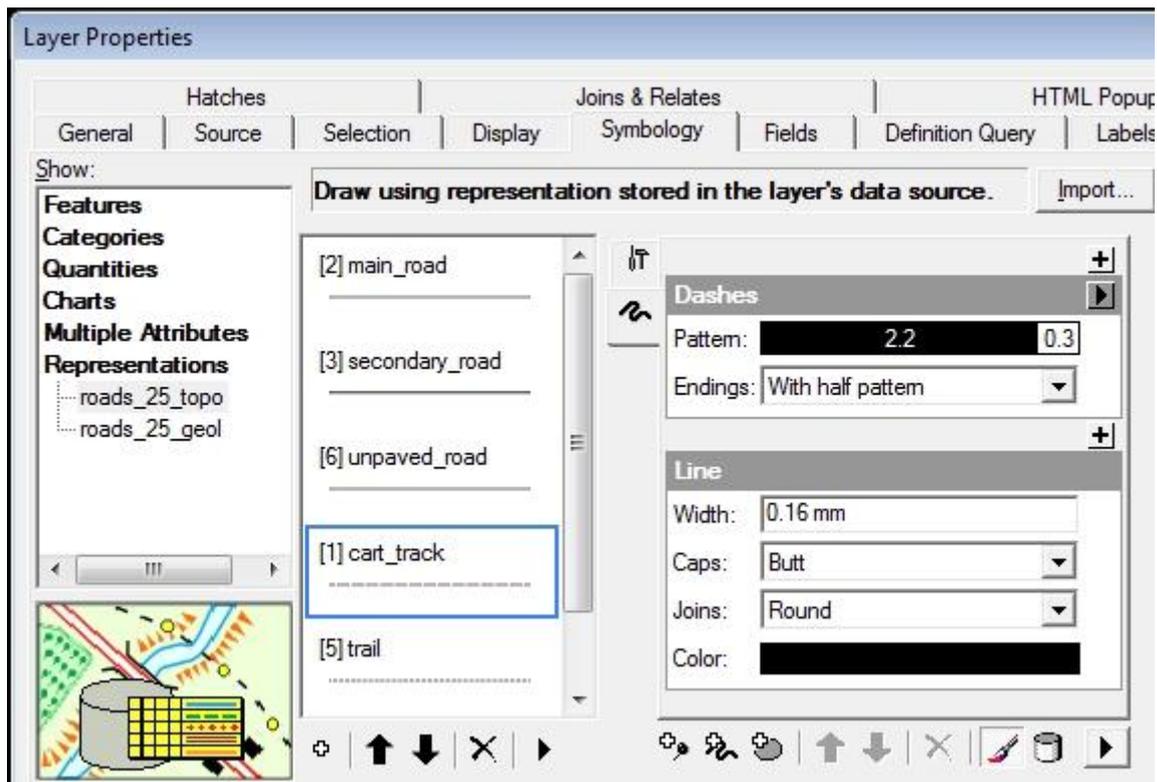


Figure 2: ArcGIS interface for representations

The data set has been imported in the ArcGIS geo database at an earlier stage in the framework of other student works. Since then the data is no longer structured according to (carto)graphical needs (as shown in Table 1), but in object classes (layers and “feature classes”). They are first processed in order to provide clean, topological data, however this is not the topic of this paper.

## 2.2 Implementation of representations

Based on the conventional signs of the printed map, the new symbology library is built up, using the tools provided by ArcGIS. Figure 3 shows the interface for designing point symbols (“markers”). Some symbols must be designed twice; with a white filling (topo map) and with a transparent filling (geological map). Some feature classes need only one representation rule, since they appear in both maps the same way. Figure 4 shows an example of a “geometric effect”: The geological fault lines are available only as polygons (centre), although they were smooth depictions in the original map (left). ArcGIS allows for the smoothing of such objects (right). Figure 5 shows the filling of a polygon with point dots representing scree dots by applying the function “Randomly inside polygon”.

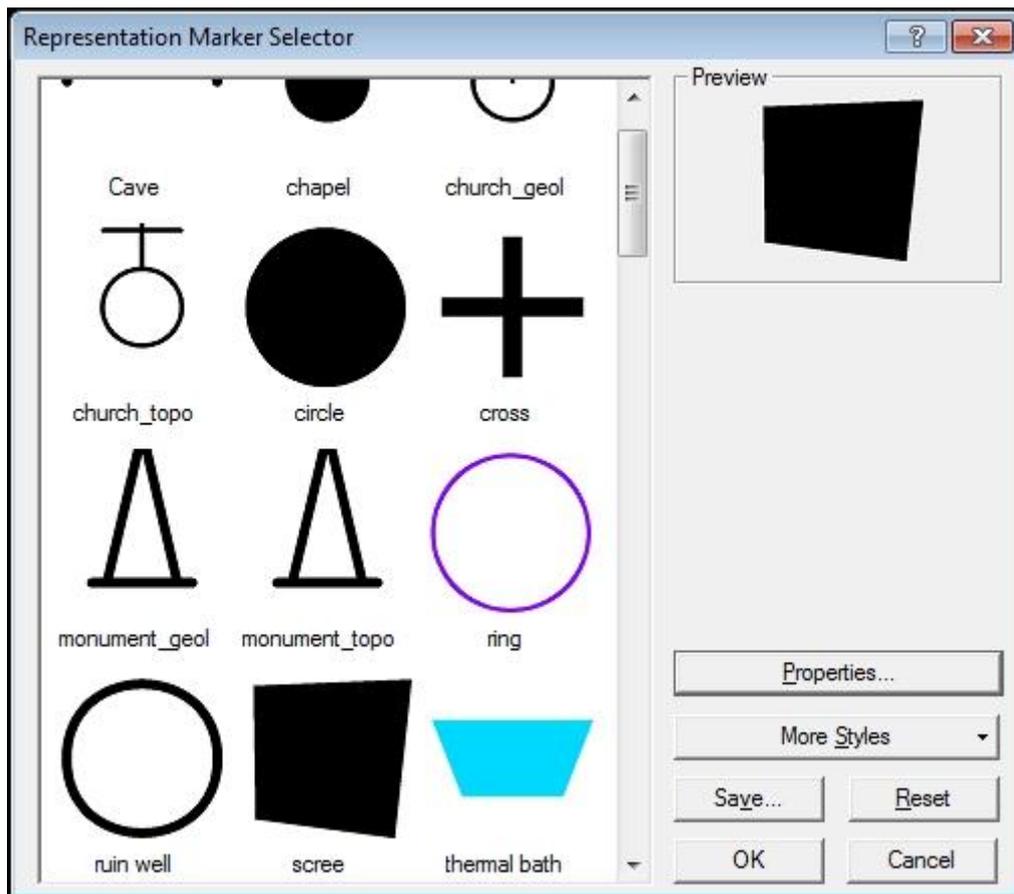


Figure 3: ArcGIS interface for designing point symbols (“markers”)

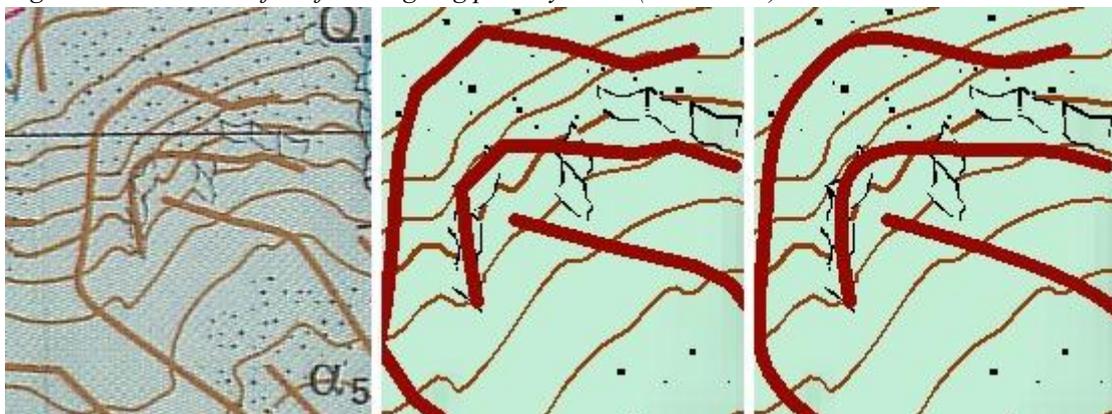


Figure 4: Geological fault lines in original map (left), as imported polygons (centre) and smoothed (right)

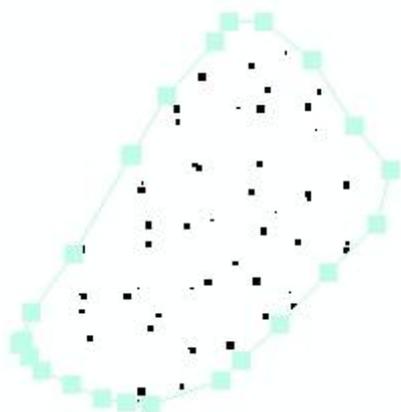


Figure 5: Scree dots generated the “Randomly inside polygon” function

Cemeteries are depicted with their wall, a white filling, a cross-shaped filling and usually also with a chapel symbol which is aligned to the main direction of the wall. ArcGIS offers a tool “Calculate polygon main angle”; the angle of the longest side of the object are stored in the attribute table of the area and the chapel symbol can be aligned to that angle (Figure 6). However, currently, the assignment of an angle to the chapel still needs to be done manually. The filing crosses are created as a marker layer within the cemetery polygon and need to be replaced manually by the aid of an individual override.

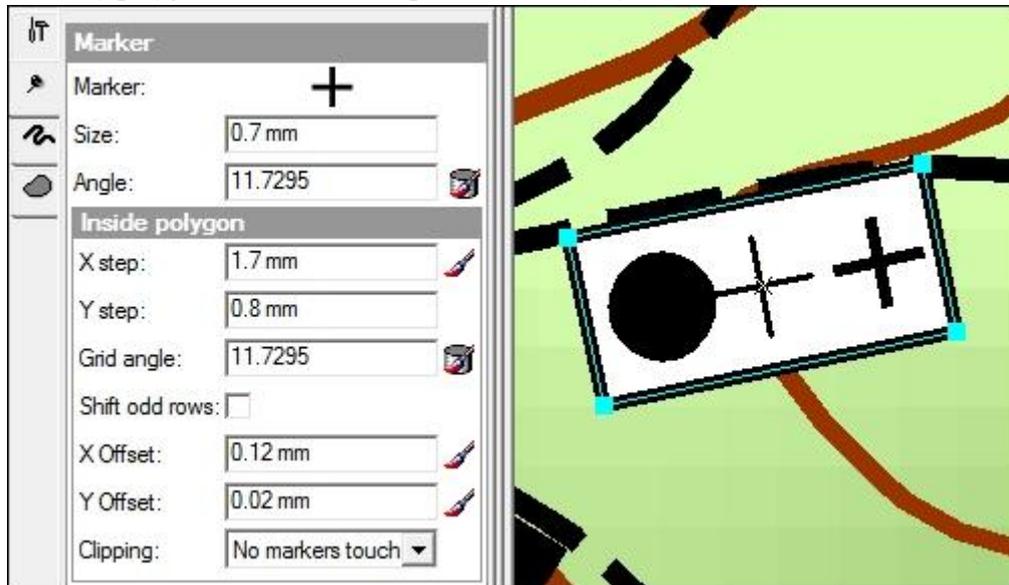


Figure 6: Aligning of chapel symbol to cemetery polygon

A special case is a rock field in a forest area. The latter have besides the green filling also a dark green contour, which however should not show up around the rocks. The use of “symbol layers” (comparable to the numbering according to level priorities in Figure 1) allows to draw the filling on top of the contours, which are then shown as half contours; a double line thickness needs therefore to be chosen. The rock mask covers the overlapping half contour (Figure 7).

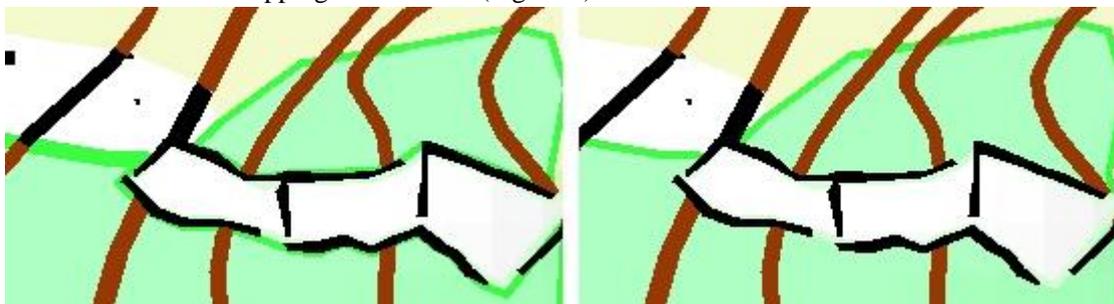


Figure 7: Application of symbol levels (left: without, right: with levels) in order to suppress forest contours in rock areas

Double line roads are created by using two stroke layers, a large black stroke in the background and a smaller white filling. This works well for the topographical map (Figure 8, left). For the geological map, the colours of the geological units should also be seen below the road. The filling is therefore set to transparent. However, now, unwanted parts of crossing or incoming roads can be seen (centre). No solution could be found for this problem. In the original screen table (Figure 1), the selective masking function could be used to avoid such cases (Figure 8, right).

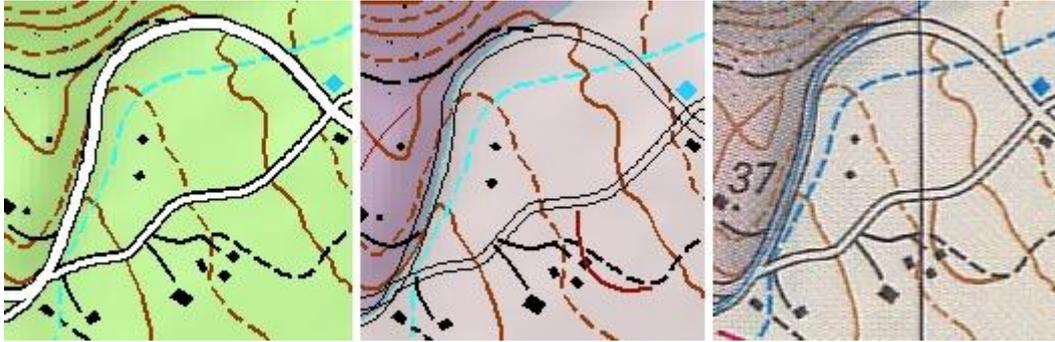


Figure 8: Road symbolisation on topographic (left) and geological map (centre). Comparison to original map (right)

The symbolisation of dashed lines as described earlier can be solved by the functions “Set representation control point at intersect” and “Set representation control point by angle”. Automatically set control points at critical places help to avoid unwanted gaps. Figure 9 shows the original dashed line (left), and the automatically corrected line (right). It can be seen, that not all cases can be solved automatically. For such situations, some free representations should be added.

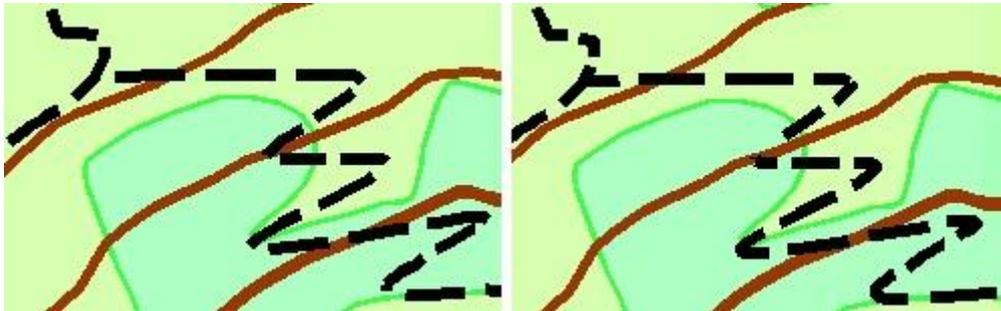


Figure 9: Automatic correction of unwanted gaps in dashed lines.

### 3. RESULTS

The result is at first a complete reconstruction of the original Methana maps at the scale of 1:25000, with the exception of the text labelling and the coordinate lines. Figure 10 shows a corresponding extract of the original map (left) compared to the newly, entirely data base driven representation of the new map (right). With the exception of the road crossing problem with transparent fillings which applies only for the geological map, the two versions are almost identical. The proof of concept (“recreating the ma with the same quality level”) was therefore successful.

A second result of the Masters thesis is the elaboration of a handbook (Romer, 2009a) which describes the various cartographic functions in detail and which also provides a number of exercises in order to train those functions.

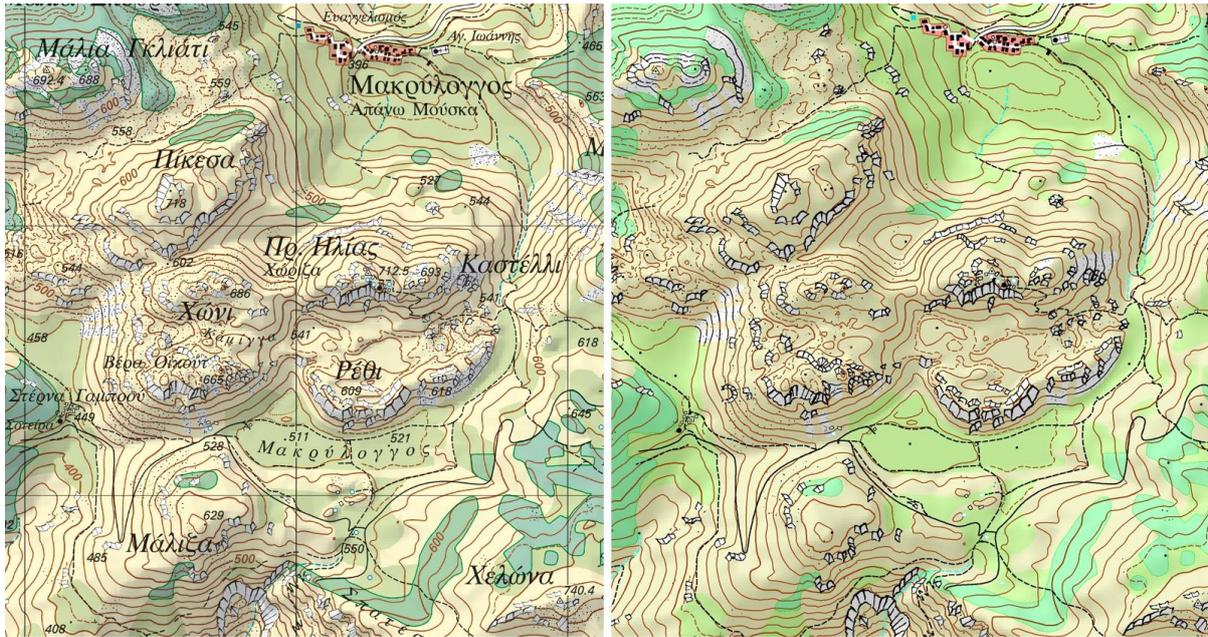


Figure 10: Comparison of original map (left) and database map (right)

#### 4. CONCLUSIONS, OUTLOOK

The available data set was one hand problematic, since many data and topology cleaning tasks needed to be carried out (not covered by this paper). But on the other hand, the most demanding tasks such as generalisation functions could be omitted, since the data set was already available at the final scale of 1:25'000. Nevertheless, many specific problems such as layer priority conflicts and individual symbology adjustments needed to be solved. The cartographic functions of ArcGIS helped to solve a major number of those challenges. The final result is a graphical output of the topographical map of Methana 1:25'000. A detailed visual analysis of the new map with the original map (Figure 10) shows that with the new technology, almost the same graphical quality, geometrical accuracy, but a much improved topological correctness and suitability for deriving further paper and interactive map products can be achieved. It also reveals design cases – especially due to the increased graphical complexity due to the mountainous nature of the area covered– where the rigid structure of GIS modelling is a drawback compared to flexible manual intervention. This represents a major challenge for the future. Furthermore the use of these data for interactive applications would need an additional enrichment of the data model in order to be able to implement future functions connected to the data model and to the thematic content.

#### REFERENCES

- Hurni, L.; Dietrich, V. and P. Gaitanakis (1992): CAGC (Computer-aided Geological Cartography) – 3 dimensional mapping of the Methana volcanoes. Proceedings of the 6th Congress of the geological Society, Athens
- Hurni, L. (1995): Modellhafte Arbeitsabläufe zur digitalen Erstellung von topographischen und geologischen Karten und dreidimensionalen Visualisierungen. PhD thesis, Institute of Cartography, ETH Zurich (<http://e-collection.ethbib.ethz.ch/cgi-bin/show.pl?type=diss&nr=11066>, accessed 15.02.2011)
- Romer, S. (2009): Kartografische Funktionen in ArcGIS. MS thesis, Institute of Cartography, ETH Zurich (<http://www.ika.ethz.ch/teaching/Diplomarbeit-Romer.pdf>, accessed 15.02.2011)
- Romer, S. (2009a): Übungshandbuch Cartographic Representations. Part of MS thesis, Institute of Cartography, ETH Zurich ([http://www.ika.ethz.ch/teaching/Diplomarbeit-Romer\\_handbuch.pdf](http://www.ika.ethz.ch/teaching/Diplomarbeit-Romer_handbuch.pdf), accessed 15.02.2011)