PHOTOGRAPHIC MAPS OF MOUNTAIN AREAS - CAN THEY BE USEFUL?

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Abstract

Usefulness of a popular photomap of the mountain region is analyzed on the basis of the Polish Tatra tourist photomap at scale 1:20,000 issued in 2002. Strong and weak points of the result and the difficulties during compilation are displayed and discussed. Paper presents the resulting photomap and the chain of decisions and choices included in the compilation process.

Concept of the Tatra photomap presented during our Silvretta workshop in 1998 was brought to reality as a government-sponsored project in years 2000-2002. Mountainous region of Tatra showed to be extremely difficult for making a photomap. Routine photogrammetric flight over Tatra in 1999 was delayed to mid-September producing poor photographs and bad weather conditions of the next season prevented acquisition of good Ikonos images. In spite of all obstacles the color photomap was digitally produced and offset-printed on one sheet of paper 141 cm by 100 cm folded to pocket size 13 x 25 cm.

The photomap was assembled from 50 aerial photographs covering the map area in 4 strips. For their orthorectification DTM was created from contours redrawn from the 1:10,000 topographic map. Image of the terrain was made radiometrically uniform after necessary retouch. The main landscape components were distinguished by slightly new coloration, some concealed fragments of objects were completed artificially, and considerable number of cartographic symbols and places names added. Top-south photomap orientation was forced by natural hill-shading and the location of cast shadows.

Preliminary stage

Two questions were asked before the project started. Is the photographic representation of a terrain fascinating only to some devotees or can it be interesting as well to others because of its special advantages. And if so, why there is so few photomaps on sale. Second question was about the graphic form of a supposed photomap made available to the wider public. How should this graphic form look like to make the photomap more useful than a poster. Several conclusions were made that time.

The main advantage of the supposed photomap is the real look of the terrain at the moment of taking photographs. It is a unique image equal to the real view from height, which could never be drawn by any cartographer and which could be fixed accurately only recently (with the use of color aerial photography or satellite scanners equipped with the blue band sensor).

Not every area is worth making a photomap of it. Only areas interesting for some reasons count in this case, and good reason can be a strange look or a variety of forms or colors, difficult to draw on a line map. Usually such areas are the remains of natural environment protected at present as national parks or reserves. Their dominant features are either landscaping or an extensive plant life or a diversification of the water system or all of these features together. Photographic representation of a terrain is only interesting when all this natural diversity is shown exactly and in detail. By the detail it is assumed a "human measure" detail which is 1.5 - 2 m in ground resolution or in terms of a scale, something around 1:20 000. Exactness means natural colors without loss of saturation, sharp detail without haze and no technical faults.

A photomap can be interesting at least for people looking for contact with natural environment, especially these with contemplative attitude which climb the mountain to admire the view. The only way to learn the truth is to make it and check. Low presence or lack of photomaps in shops results from several reasons. It is risky to offer something quite new nowadays. Until very recently there was no easy available machine which would be efficient enough to process gigabytes of data. The copyrights for satellite images are very high. Also to get a good image of a mountain area, without clouds and with little snow is extremely difficult. Additionally, not without importance is the opinion of cartographers who criticize photomaps for lack of coded graphic language (the same color - objects of different...
categories, the same category - different colors) and for chaotic appearance of colors and contrasts (barely visible difference of colors on the border land - water and strong color contrast between lots of arable land). The weak point of photomaps is also incomplete content. Some important objects are missing entirely or partially either because they are screened or they are too small to be seen at a given scale and the same time some other objects of no importance appear quite distinctively.

**Beginning of the project**

It was easy to start with strong confidence that something good may be done. The image can be "improved" to a degree that there will be no base for cartographic criticism. A photomap of the Tatra Mountains can have positive influence on tourists, students and even school children making them more interested in natural environment and more sensitive to its protection. Producing a prototype of a "popular" photomap can also encourage others to do it.

Several decisions had to be made at the beginning. The photomap was to be offset-printed and made available to tourist community. It was to cover the entire area of the Polish part of Tatra Mountains and was to be printed on one sheet of paper folded to pocket size. It was planned to make an edition of 3000 copies put on sale to map shops at moderate price. After checking that there was B0 printing machine available in Poland the scale was decided to 1:20 000 which is the largest possible for this size of paper and the area planned. This scale is rarely used presently but it allows for better enlargement than 25 000 and distance calculations are easier. It was made no checking about the paper of B0 format that time and this was a mistake because at the end of the project there was no time to order in advance the right kind of paper.

There was no ready images of the terrain. The only color aerial photographs of the Tatra were made in 1994 and were of poor quality. New photogrammetric flight was planned for 1999 but there was no good weather conditions during summer. Ikonos image of 1m ground resolution was available since 24 September 1999 and one image of the cheapest version was ordered for evaluation. The image was acquired on August 25, 2000. It appeared to be of good geometrical quality but "small" cloud coverage of 7% plus shadows excluded it from the project (Fig. 1 left). More than clouds it was the cost of the copyright which canceled the potential use of satellite images in such projects.

Fig. 1. Ikonos image of Tatra with cloud coverage of 7% (left) and an aerial photograph with cast shadows (right).

The photogrammetric flight over Tatra fortunately took place on September 15, 1999. It was decided to use images from this flight. Fifty color diapositives at scale 1:30 000 covering the area in 4 strips were scanned with resolution 25 µm giving digital images of pixel ground resolution 0.75 m.

Because of long cast shadows present on these September images (Fig. 1 right) a mixing of images from different flights was considered. Finally in spite of "good" results the idea was dropped. It was noticed that one of advantages of such a photomap is also its documentary character, and to use one flight images is the best solution even if cast
shadows are present. Each photographic image depends on the sun position and each sun position gives slightly different image of the same area of land.

Reverted map orientation, with south at the top was decided to benefit from natural hill-shading in the representation of relief. There is no other choice if we want to see an illusion of reality which is essential in this kind of photomaps. It is impossible at scale 1:20 000 and larger, especially in mountainous areas, to impose customary 'north at the top' orientation by replacing natural hill-shading with artificial. The light-and-shadow nature of photography entirely depends on one light rays direction and the image is "sun-oriented" in every detail.

Orthorectification of the aerial images of mountains is a necessity. Radial displacements of summits reach 2 cm at scale 1:20 000, making mosaicing of neighboring photographs impossible (Fig. 2). But the orthorectification doesn’t solve the problem entirely, as appeared later. The process was performed with the use of the DTM produced from the 1:10 000 topographic map made by the Polish Army in 1984. This solution was less laborious and allowed to start with DTM before images were ready to process. In fact, this easier model had to be corrected couple of times from stereograms to give acceptable results in processing of images.

![Fig. 2. Aerial photograph before (left) and after orthorectification (right) with the summit noticeably moved.](image)

It was decided that the technical quality of the whole image produced from 50 pieces must be condition *sine qua non* before any other activities could be performed on it. One technical problem which needed quick solution was a kind of vigneting present on each image. It was making substantial radiometric difference between consecutive images and would make mosaicing very difficult. Another problem was found in orthorectified images. There were slopes where pixels had to be artificially repeated to fill the gap and this was easily noticeable as something odd (Fig. 3)

![Fig. 3. Aerial photograph before (left) and after orthorectification (right) with artificially repeated pixels.](image)
Making one image of the area

To make an image of the whole area it was necessary to mosaic fifty orthorectified aerials arranged in 4 strips. The geometric and radiometric problems had to be solved. Mosaicing had to be seamless and sharpness of the image preserved. Connecting images of a mountainous terrain appears to be extremely difficult because even after ortho correction images do not match ideally in overlapped area. In a strip the common area is big enough to find good line of cut, but joining strips is more complicated with longer cut line and narrower common area of the overlap. It is even more complicated when radiometric differences appear.

To avoid such cases all images were radiometrically corrected before mosaicing. So called vignetting was largely eliminated from each image with an approximate method based on filtering of low spatial frequencies. Few cases of radiometric difference along cut lines had to be fixed manually. The reason of radiometric problems is perhaps poor quality camera, but not only. The flight over Tatra lasts around half an hour and this is long enough for light conditions to change. This means that colors may change as well as shades and shadows. Despite problems the mosaicing of considerable number of color aerial photographs is possible even in mountainous area. It is a laborious alternative but in present economic conditions the only real one (Fig. 4).

Fig. 4. Image of the area mosaiced from fifty aerial photographs before (left) and after radiometric correction (right).

Cartographic stage

Following the general cartographic model of a topographic map several changes were made in the image. The main landscape elements such as waters, forests, arable lands and built-up areas were to be easy noticeable as categories of similar objects. The association was to be created by changing different colors of objects in one category to one color common for all: blue for waters, red for houses and light green for fields. Cartographic symbols and names were to be placed where necessary to make the photomap more similar to a line map and more useful.

To achieve the first goal a couple of masks was made to work with each category separately (Fig. 5). They were made manually by interpretation of the image displayed on the screen. When changing color in a group of objects it was usually enough to change its hue component. Generally, when working with colors it is easier to change the color space from RGB to IHS or Lab. To make the water mask it was necessary to work with a topographic map to draw missing fragments of streams and sometimes to learn where to look for a stream or small lake. Forest mask was not used for changing color but to enhance the texture of the area or to raise saturation. Inverse mask was used for arable lands to lower color contrasts. Marking the main landscape components with colors is a good way to save the results of interpretation of the image. However it is easy to exaggerate and to make the image artificial.

Discrete changing of natural appearance of the terrain on the image has good explanation if serves to make the image more legible. However, it demands great care to preserve natural character of the image. It takes many trials to find an appropriate form for a change which would look as naturally as if it was not made at all. The fragments of
streams and roads which on photographs were covered by trees have been complemented artificially. To make them look not so artificially they were designed with "light-and-shadow" matching the sun-light orientation of the whole image.

Fig. 5. Masks for making local changes in the image: waters, built-up areas and forests.

The same rule was obeyed when designing special form of letters and cartographic symbols. Point and line symbols were placed to indicate marked paths, summits, passes, caves, springs, waterfalls, national park boundary, national boundary, parking places, petrol stations, and cable railway (Fig. 1). Different type faces were used to make distinctions of object categories such as summits, valleys, passes, clearings, forests, caves, streams or lakes. For hydrographic names blue color was used and the settlements were named with capitals.

Somehow strange rule was set and followed when adding symbols or letters to the image. Image was assumed to be the subject and all the artificial objects should hide as much as possible not to screen the image too much and even not to draw attention with its artificial regularity. Minimization and decreased contrast of letters made the graphical solution of the problem. It was thus possible to place a considerable number of symbols and names in the photomap (Fig. 6) the same time preserving its appearance of a bare image at first sight.

Fig. 6. Line and point symbols (left) together with names (center) occupy significant area of the photomap (right).

As a result of all changes and additions a photomap of the Polish part of Tatra Mountains was compiled (Fig. 7). It was huge both digitally (600 Mb) and on paper (141x100 cm). Raw data together with all partial results and analysis occupied around 200 Gb of memory and it would be difficult to have any control over these data if 70 Gb hard disks were not introduced that time. The image looked properly without technical faults. Low contrast of the whole map was criticized together with small letters in names. The final day of the project was approaching and a problem occurred with the paper for printing. Fortunately some strange kind of paper was found and the map was printed but it was in a rush. The photomap was printed on four color offset printing machine on one sheet of paper, of the size of 141 cm x 100 cm, with the legend and cover on the reverse. After folding its size is 13 cm x 25 cm. In one side version printed on a plotter as a wall map, the legend is placed on the left side of the map and the overall size is 153 cm x 100 cm.
To compare the result with a line map four small fragments were selected from the best topographic map available for Polish Tatra. The map at scale 1:10 000 was made by the Polish Army in 1984 and its scale was reduced to match the scale of the photomap. Fragments were selected intentionally to find advantages of photographic representation.

It is difficult to draw a bare land which is not even a solid rock. Where single stones are visible on a photograph contours must fulfill the gap on a line map (Fig. 8). Only on a color aerial photograph from September the name of the mountain range "Red Tops" becomes clear (Fig. 9). Upper limit of forests is in reality more complicated when single trees are visible (Fig. 10). When contours are not parallel the image of a terrain on a line map becomes confusing (Fig. 11).

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Fig. 7. Polish Tatra Tourist Photomap at scale 1:20 000

Fig. 8. It is difficult to draw a bare land which is not even a solid rock. Where single stones are visible on a photograph contours must fulfill the gap on a line map.
Fig. 9. Only on a color aerial photograph from September the name of the mountain range "Red Tops" becomes clear.

Fig. 10. Upper limit of forests is in reality more complicated when single trees are visible.

Fig. 11. When contours are not parallel the image of a terrain on a line map becomes confusing.

Conclusions

Photographic maps have unique capacity of representing landscape features and deserve greater popularity in the area of tourist cartography. With the aid of digital image processing techniques cartographic solutions of map making may be at last applied to photomaps for improvement of the results. It is risky job to rearrange the image colors but still it seems the only way to make the image clear. Small letters applied for places names are perhaps the right solution for popular photomaps because names are very important and avoiding them makes the map less useful. Raw photographic image rather confusing at first sight, after being methodically changed becomes legible and discloses significant details missing on traditional maps. Popular version of a photomap can serve both as a clear reconnaissance map and as up-to-date evidence of the state of the environment.

Only under the current technical conditions it was possible to compile a detail photographic map of Polish Tatra. In areas valued mainly for natural qualities, the advantages of photographic representation of the terrain are clearly evident. It is really hard to imagine better than photographic, detail representation of the region where physical features dominate and the evidence of existence or extent of even small feature matters. Such representation seems particularly suitable for maps of National Parks and other protected areas.
References

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