# APPLYING SWISS MOUNTAIN RELIEF SHADING TECHNIQUES WITHIN RUSSIAN SCHOOL OF CARTOGRAPHY

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**ABSTRACT:**
Inspired by the works of Eduard Imhof in shaded relief mapping and cartographic relief presentation the author reviews Imhof`s legacy and applies it to improvement of Russian school of mountain cartography. The aim of this paper is to expand the knowledge gained through learning the "Swiss Style Coloured Relief Shading" method and its adaptation to the Russian way of depicting relief and natural environment. The paper also focuses on developing new techniques of hypsometric tinting as well as cliff drawings. So far, there is a limited access to pictorial maps created by Russian institutions in the public domain on the Internet, which would demonstrate precise shaded relief of highlands regions of Russia. Development of Russian heritage and interaction with representatives of significant schools all over the world would give rise to mountaineering, widespread tourism, eco tourism around South and East Siberia, Far East, Ural, Caucasus regions. It is therefore concluded that there is a number of ways for Russian mountain relief mapping to be developed and enriched on the basis of Swiss cartographic tradition.

**Keywords:** *relief shading, hypsometric schemes, Swiss school of cartography*

From the very beginning of its history Swiss school of cartography has contributed a number of indispensable theoretical frameworks and practical approaches to the development of the cartographic science. Among the greatest cartographers of the Swiss school Eduard Imhof is one of the most prolific researchers and practicians. Despite the limits imposed on scientific interaction between the Soviet Russia and the non-communist countries in the 1930s-1980s advancements in relief shading techniques introduced by Imhof spurred the development of then novel relief shading techniques by Russian cartographers. Nonetheless there still exists a number of ways in which the Russian school of mountain cartography can be improved on the basis of Imhof's legacy. In order to present author`s view on this subject, the paper starts with an outline of the most important Imhof's contributions and the main principles of Swiss school of cartography that served as a theoretical basis of Imhof's works.

According to *Schertenleib* the main principles of Swiss-style relief shading are:

- The map's highest elevations are depicted by the brightest tones on the illuminated sides and the darkest tones on the shadow sides.
- The strength of the shading diminishes towards the valleys.
- Instead of white, a medium tone is used for valley floors that visually connect the two adjacent mountain slopes.
- The highest mountain peaks must be depicted with the strongest color contrast.
- Colors should be attenuated for lower areas to simulate the effect that aerial perspective has on colors. Color contrast must be reduced for the lowest terrain features (i.e. valley floors).
- Cast shadows should not be used. (*Schertenleib, U. (1997)*. *Fridolin Becker (1854-1922)*: Topograph, Kartograph, Innovator. Cartographica Helvetica, 15, pp.3-10).

Although Swiss-style relief principles represent a successful example of top-notch cartographic thought shaped into clear guidelines even during the times of their issue other

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mapping paradigms existed. One of Swiss paradigm strong rival was mapping methodology developed by Russian cartographers (among the most important contributors the names of *Skvortsov P., Koldaev P., Miroshnichenko A., Aleksandrova Z.* can be mentioned). In Russian practice highlands relief (e.g., Caucasus region) is characterized by sharp slopes, deep harsh dissection, and numerous cliffy peaks. In this case relief shading is made using north-west lightening. Solidity of the mountains arrives at drawing intensive shadows, high contrast of light and shade, especially in the ridges. Amongst basic features for enhancing the effect are thicker layer of shade in depressions, ravines, river valleys, dividing shadow and illuminated sides. Plasticity is reached by using Swiss style shading: the map`s highest elevations are depicted by the brightest tones on the illuminated sides and the darkest tones on the shadow sides. The better effect comes with using both shading and cliff drawing.

To depict special features of mountain landscape *Peter Skvortsov* offered to use light dashes which would stress irregularity, rugosity, cleavage of the forms. He also proved the possibility of simultaneous depiction of both shading relief and forest. *Peter Skvortsov* had reached harmony in combination of relief shading and depiction of forest with help of taking the dashed drawings of forest as a basis (semicircular dashes were used for deciduous forests and vertical dashes for coniferous forests) and admitting some exaggeration of sizes of forest dash drawing on educational, touristic maps. The hatching on shadowed slopes was usually much thicker, rather than one on sun-lit slopes. It increased the general plasticity of drawings.

*Peter Skvortsov* devoted many years of research to the development of hypsometric schemes. For instance, in 1930$^{th}$ he designed the scheme with tinting lightening to the both ends, which was used in creation of big mosaic map of USSR (1937, it was decorated with semi-precious stones and can be still found in Hermitage, St. Petersburg). In 1934 the first pocket atlas of USSR was published. It contained the relief shading with double brightness fracture, whereas this scale had been already widely used in Switzerland.

Building of hypsometric scheme together with relief shading consists of several stages:

1. Choosing from library or applying some elevation values for hypsometric scheme. For instance, we need to create a hypsometric scheme for a small-scale map. In general case that will be the scheme with non-equal grades. (see **Fig. 1a**)
2. Choosing (applying) "basic" colours for hypsometric scheme and building gradient passages between them. (see **Fig. 1b**)
3. Getting graduated scheme for hypsometric tinting when necessary. Colour for each grade is taken from the gradient scale (see **Fig. 1b**) as an averaged value of color parameters of a gradient within one grade. (see **Fig. 1c**)

There can be two sages only in case this is a pictorial map or we do not need to retrieve hypsometric characteristics from the map.

The next stage of relief depiction is analytical shading in grey scale and its combination with hypsometric tinting. In most cartographic software these stages go nearly simultaneously, as long as the characteristics are chosen within the same window where a piece of an output image is located. Nevertheless, it is worth to have a look on it. The intensity of grey colour can be set by default or can be chosen in an interactive mode by setting the lightning direction, sun level, and maximum intensity of white for illuminated sides and black (grey) for shadow ones.

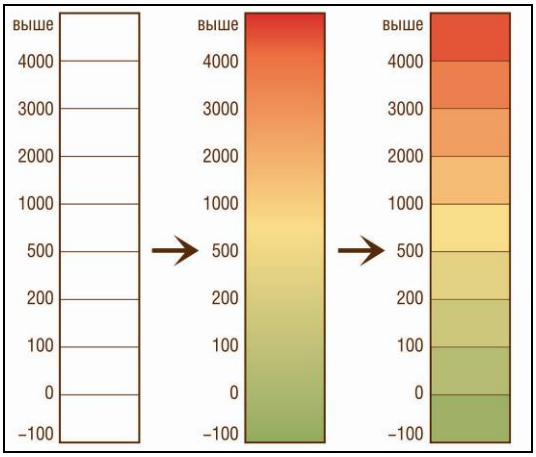


**Fig. 1 (a, b, c).** Stages of hypsometric scheme building

So the final relief image is actually created in two hypsometric schemes – for both illuminated and shadow sides. In the first case the original scheme is overlaid by semitransparent white gradient followed the principle that white is getting more opaque as a result of higher elevations.

Obviously, the maximum values of opaque white will suit to mountain slopes with the highest grade elevation perpendicular to the light direction in both vertical and horizontal planes (see **Fig. 2**). The rest of the areas of illuminated side will be darker.

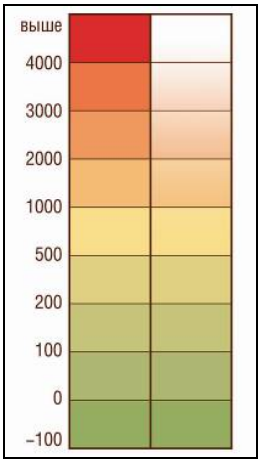


**Fig. 2** The original scheme (on the left) and starting from 500 m grade the white gradient with 100% opacity on the highest grade (on the right).

It is clear, that it is possible to define elevation on this map only counting the quantity of grades, since terrain points located within one grade but having different slope exposition will not be illuminated in a similar way. The same thing relates to the slopes of different steepness. On the shadow sides we have the same situation (see **Fig. 3**).

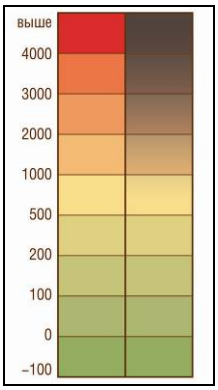


**Fig. 3** The original scheme (on the left) and starting from 500 m grade the black gradient with 70% opacity on the highest grade (on the right).

If quite intensive colours are chosen as parameters of analytical shading for the light and shade, we will see the contrast relief shading, but colour hypsometric scheme will almost disappear. In the opposite case the scheme will not disappear, but shading will be pure and inexpressive. It especially concerns the high-altitude regions. (see **Fig. 4**)

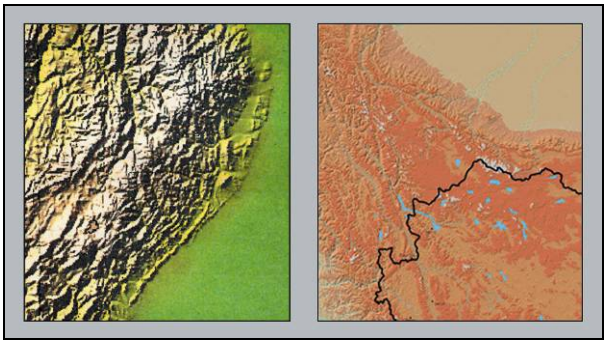


**Fig. 4** Wrong choice of parameters for analytical shading:
**a** – the light and shade are too contrast, **b** – the light and shade are not contrast

That means that to create significant relief on small-scale maps, special software has to be used by high-qualified cartographer who knows how to build a hypsometric scheme properly and set the correct parameters of analytical shading. For reference maps with sufficient amount of elements relief could be presented using light scheme and shading (with horizontal lines, if necessary). In case of wallpaper maps it is advisable to use neither too dark, nor too light shading and replace black to a chromatic colour.

This leads us to another unconventional conclusion: modern computer programs blur the meaning of hypsometry yet they do not deny hypsometric approach to relief design. In today's cartography schemes that do not require measurements have received a wide recognition. Basically, these schemes are not truly hypsometric from the classical definition's point of view. At the same time such tinting, though not showing distinct

grades is designed with relief in mind the same way classical hypsometric schemes are. It can be assumed that such approach to tinting («gradient hypsometric scheme») will be used even more widely in the future because of its aim to increase the maps' readability. Having in mind that the use of this scheme is widespread within modern cartographic software suites, it is clear that its development and wide recognition will not cease in the near future.

Despite its popularity gradient hypsometric scheme has its drawbacks: 1) in hypsometric schemes currently used the sequences vary only by colour tones, with standard spectral scale applied in most cases; 2) in analytical tinting gray scale serves as a default one which, on the one hand, diminishes maps' presentation, and, on the other hand, allows for a higher risk of either too light, or too dark shading (especially in the highlands) when wrong characteristics are chosen; 3) on small-scale maps highlands' shading is done almost automatically and thus tends to look unimpressive. At least two methods can be used to overcome the abovementioned. First, these drawbacks are of minimum level of influence when controlled by a well-experienced cartographer who is able to choose optimal parameters, first and foremost, those of shading. Second, whenever top notch design is a requirement a variety of scales should be used; spectral scale should be applied instead of gray one. It is especially true for small-scale maps. To produce a more pictorial shading of highlands' relief on such maps vertical scale in «classical» cartography is enlarged in comparison with horizontal one, thus a half-perspective mountain peaks' appearance is introduced (see **Fig. 5**).

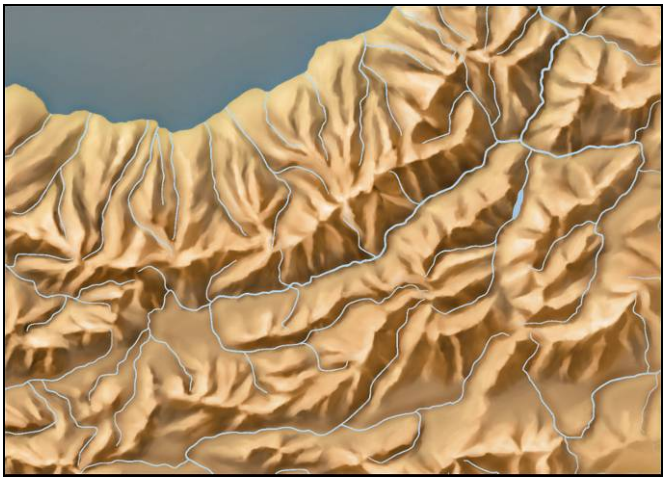

**Fig. 5** Making highlands' relief more pictorial

Another interesting approach is to create a highlands' relief by hand and then to combine it with computer-generated one (see **Fig. 6**).

When used by a well-experienced professional this technique produces impressive results. This approach is more human-resources intensive and assumes re-drawing a new hand-made layer every time a different map projection is needed. The latter drawback can be mitigated with use of computer tablets.

The amount of interactive work required from cartographer depends on the desired results. In general, it is at least a number of hypsometric schemes and colour shading. This leads to another question: whether mountains' zone needs to be included in hypsometric

scheme when colour shading is used throughout the map. It is possible to first create gray-scale shading and then colour it according to the scheme used. It is needless to say that using such a multi-colour makes the map more pictorial. Such a technique can be used for both sun-lit and shadowed slopes (see **Fig. 7**).

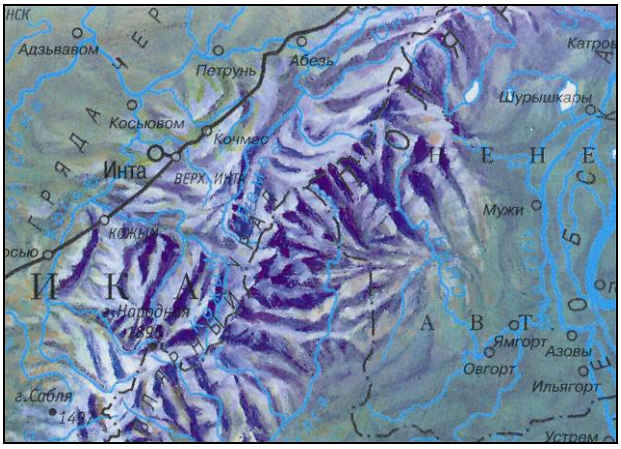


**Fig. 6** Combining computer-generated and hand-made layers

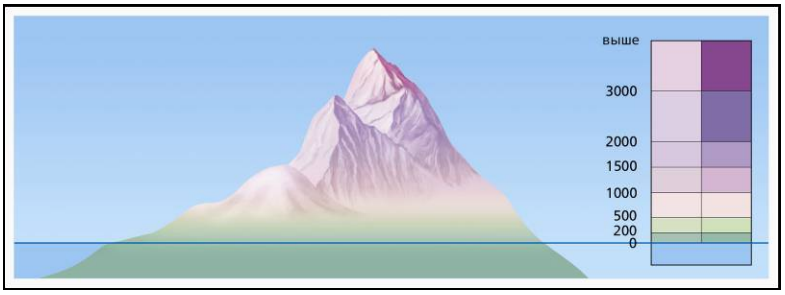


**Fig. 7** Example of a hypsometric scheme where colour shading is used throughout the map (*Author: O. Kovalyova*)

Before applying hypsometric tinting the shading itself should be split into three zones: lowlands-highlands, sun-lit slopes, and shadowed slopes. Lowlands and highlands' shading should be done simultaneously. In this case there are no sharp shadows or well-exposed slopes. Special attention should be paid to areas around rivers and coastal lines of lakes and seas. When shading is done automatically errors are extremely rare, with exception of areas situated alongside the light source. These areas should be dealt with interactively, with geographical verisimilitude in mind. In lowland areas (e.g., West Siberia) shading should not be done. This is an especially important point to remember when shading is done manually, with or without computer tablet. Shadowed mountain slopes' shading should be done separately and then combined with lowlands during the tinting stage. Same advice is true for the lightened mountain slopes. Indeed, lightened slopes and shadowed slopes' shading should be done with the same parameters *mutatis mutandis* (light propagation angle is increased by 180° in the latter case; see **Fig. 8**).

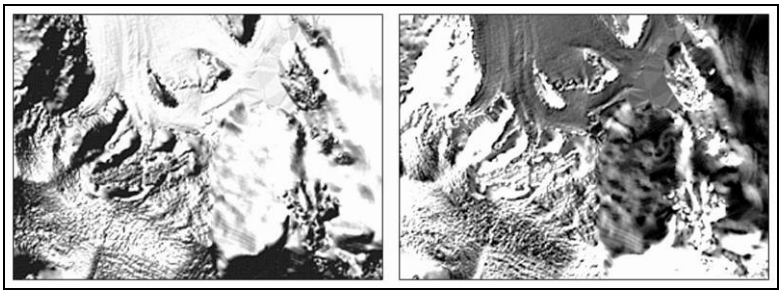

**Fig. 8** Relief shading of sun-lit (on the left) and shadowed (on the right) slopes

Shading for both lightened and shadowed slopes should be done using transparent layers in order to combine perfectly with lowlands' and highlands' shading without sacrificing an option to colour these parts separately (see **Fig. 9**).

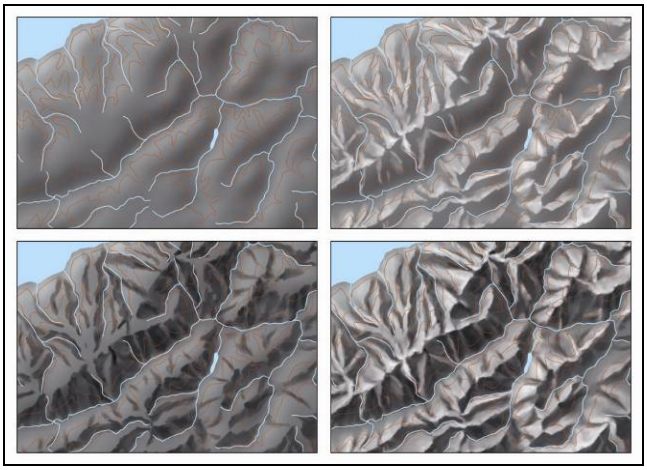

**Fig. 9** Separate shading for each of the three components and the combined version

In many countries and in Switzerland in particular spatial information is readily available on the internet while in Russia absence of nation-wide web sources with highlands maps seems one of the most important problems. Such freely available resources would allow Russian people to take full advantage of the heritage Russia had acquired over the course of its history. This would be of great help in promoting mountaineering, mountain tourism, and ecotourism especially among the younger generation of Russians. Another advantage of having spatial information sources on Russian relief in public domain would be the invaluable help it would represent to Earth scientists and students from Kaliningrad to Vladivostok.

In aggregate, when looking at all of the abovementioned techniques used to depict relief, it can easily be seen that all of them has stemmed from the principles outlined by the great predecessor of Eduard Imhof, Fridolin Becker. Therefore such techniques can only be improved through a more careful implementation of the principles that serve as their basis, e.g., by means of constructing tinting algorithms more advanced that those already in use.

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