CHAPTER 3

Further Basic Principles and Guidance

In this chapter, several additional skills and fields of knowledge that are of great value, perhaps even indispensable, to a map compiler, and especially to someone concerned with rendering the form of the terrain, will be considered. These are the *study of topography in both terrain and map,* a *training in drawing,* practice in the *interpretation of aerial photos* and *knowledge of geography and geomorphology.*

Even the *theory of colors* and the *knowledge of graphic reproduction* are among the basic facts required by any mapmaker. These will be discussed in later chapters.

A. The study of topography in terrain and maps

On account of the profession, cartographers are sedentary beings. Their work chains them to the drawing board, but their inspiration is the landscape and thus they should become acquainted with its characteristic forms and colors not only from books, but from nature itself; they should also be able to find their way around in the graphic thickets of the map they use just as they can in unfamiliar terrain. They should be able to read maps perfectly. Even with the most confusing contour map, they should be able to identify the terrain forms easily and confidently. They should not allow themselves to be misled by deficiencies in survey or by poorly generalized images. At least once in their early years, cartographers, topographers, geographers, and geologists should construct a terrain model based on an interesting contour plan. They should construct a series of corresponding cross sections and draw block diagrams and sketches of a number of landscapes. They should pursue the interpretations of maps and landscape views just as earnestly as one does today with regard to the flood of scientific literature concerning aerial photography. Thus, the great importance of map interpretation is emphasized; but this text will deal with it no further, since it is covered in detail in the author's book *Gelände and Karte,* which appeared in 1950 and 1968 (129 and 130).

B. On landscape drawing

A good cartographer should not only grasp landscape, in a map-drawing sense, but also through occasionally sketching from nature.

Drawing demands careful observation. Observation is a conscious viewing directed toward certain objects. "It makes a considerable difference if one views something *with* a sketching pen in hand than *without* the pen in hand" (Paul Valery).

Certainly, a serious sketcher is seldom satisfied with his results, in the face of nature. He wrestles tirelessly with form and expression. Despite or, perhaps, just as a result of this conflict, landscape sketching brings great satisfaction. It provides and also increases the interest in the activity of drawing maps. It develops judgment and fosters a taste for all things graphic.

The observation and sketching of land forms is one of the best introductions to their genesis and their morphology. Sketching forces us into objective and graphic abstraction, into the transformation of complex natural phenomena to a few simple lines and strokes. The task of sketching, the purpose of landscape sketching can be artistic, scientific, or topographic in nature. Accordingly, the results will appear to be entirely different.

Naturally, much artistic landscape sketching is also exemplary with regard to topography-morphology. Splendid examples are found in the work of Albrecht Dürer, Leonardo Da Vinci, Pieter Brueghel the Elder, Jan Hackaert, Joseph Anton Koch, Caspar David Friedrich, Alexandre Calame, Barthélemy Menn, Ferdinand Hodler, and many others.

On the other hand, many natural scientists, geographers, topographers, and cartographers themselves created artistic splendors in their purposeful landscape sketches and panoramas. In this context, one should mention the geographer Carl Ritter (watercolor of the Mont Blanc group, 1812), the geologist William Holmes (sketches of the Grand Canyon), the topographer Xavier Imfeld, the Tibetan explorer Sven Hedin, and the geologists Albert Heim and Hans Cloos.

Every cartographer should reach for his drawing pen during his travels. Anyone who cannot produce a respectable landscape sketch from nature will certainly also fail to become a Leonardo in map drawing. "Sketching encompasses subjective selection to an especially high degree, not merely the activity of noticing and deliberately omitting" (M. J. Friedländer, 74 in the bibliography). At first the beginner should produce line sketches, and not tonal representations. A line sketch demands crisp observation and decision. The "scientific" sketch should not be made over-complicated by incidental tone values, shading, etc.

Even the most careful line drawings and landscape sketches are quite different from the natural impression. It is not only a copy, but a personal, intellectual and new visual creation. This is especially illustrated by comparing sketches with corresponding photos of the landscape. Such a comparison allows us to recognize, more sharply and consciously, the specific characteristics of each of the two types of image, which may also be very instructive with respect to map drawing.

Figures 24 and 25 give an example of such a contrast of photo and sketch.

Photography is true to nature or objective down to the last detail. It can be evaluated from the most varied of viewpoints. Nevertheless, in many places, the composition of its image is vague and full of misleading features. On close examination, it appears to consist of a jumble of light and dark patches, whose tonal values often depend on all kinds of things that have no relation to form and position. In some places, insignificant objects become more accentuated than important objects. Cast shadows obscure interrelationship of forms. Distinct terrain areas situated far apart may, by the accident of similar tones, give the appearance of being all part of the same zone.

Views of nature and their photographic reproduction contain no lines. The drawn line is a human invention, a useful abstraction or fiction. Forms and their spatial relationships can be clarified by lines, the essential can be emphasized and the nonessential can be subdued. A good sketch is simpler, more expressive and aesthetically more satisfying than a photograph. A sketch, in contrast to photography, is always formed subjectively, which can be either an advantage or a disadvantage according to purpose and quality.

One should sketch natural contours, silhouettes, outlines and edge lines sharply and accurately, and attention should always be given to their form relationships, their overlap, and their varying distances. Neighboring regions of the landscape should be sketched more boldly than the more distant parts. Suggestive hachuring for regions of land (grass and scree slopes, etc.) are best drawn in the direction of the line of steepest gradient and, only in exceptional cases, at right angles to it. The main difficulty for the beginner is achieving the correct degree of generalization. It should never be forgotten that *sketching means leaving things out!* Leaving out, however, does not mean sketching inaccurately. Uncertain scribbling, formless or distorted hachuring, dot patterns, lines of scree dots, etc. betray inability. We should be able to see the wood in spite of the trees. We must force ourselves to use the line and to generalize with confidence. The detail should be carefully worked into the overall image. All this, however, requires good observations and careful thought. Only the person who has first learned to produce line drawings should try to reproduce modeled tone and color effects.

Selection of a good subject and point of observation is important. Distance and lighting influence the appearance of the image. The view point should not be chosen too close to the subject, as confusion will result from a superabundance of incidental and unimportant detail that can be seen.

Pen and pencil sketches should be drawn on strong, smooth and matte paper. The pencil is the ideal sketching medium. Nothing else offers such simple but manifold possibilities. However, only the best quality pencils of hardness F, HB, B, 2B, and 3B should be used. They should be sharpened to the finest chisel point so that one can sketch both the finest and the broadest lines without wasting time. For the backgrounds of pictures and for sky and clouds, the pencils to employ should be harder and lighter than those used for the foreground.

It is also interesting to produce sketches with a pen or brush using Indian ink or sepia water colors. The pen compels one, even more than does the pencil, into definite strokes and therefore to decisions about the drawing.

The forms of objects or differences in distance or color tones or surface structures can be expressed by line shading. Above all, however, this method provides a means of increasing the three dimensional effect in the image through use of light and shadow. Good hachure-like line shading, however, requires special experience. The beginner often becomes trapped within the confusing tangle of his helpless strokes. Occasionally, one should copy characteristic portions of the pen or pencil sketches of the great masters. This is one of the best ways to delve into the secrets of good line shading. In line shading, one should pay attention to the effects of illuminated edges. If a shaded area borders on a light, or on a lightly hatched area,

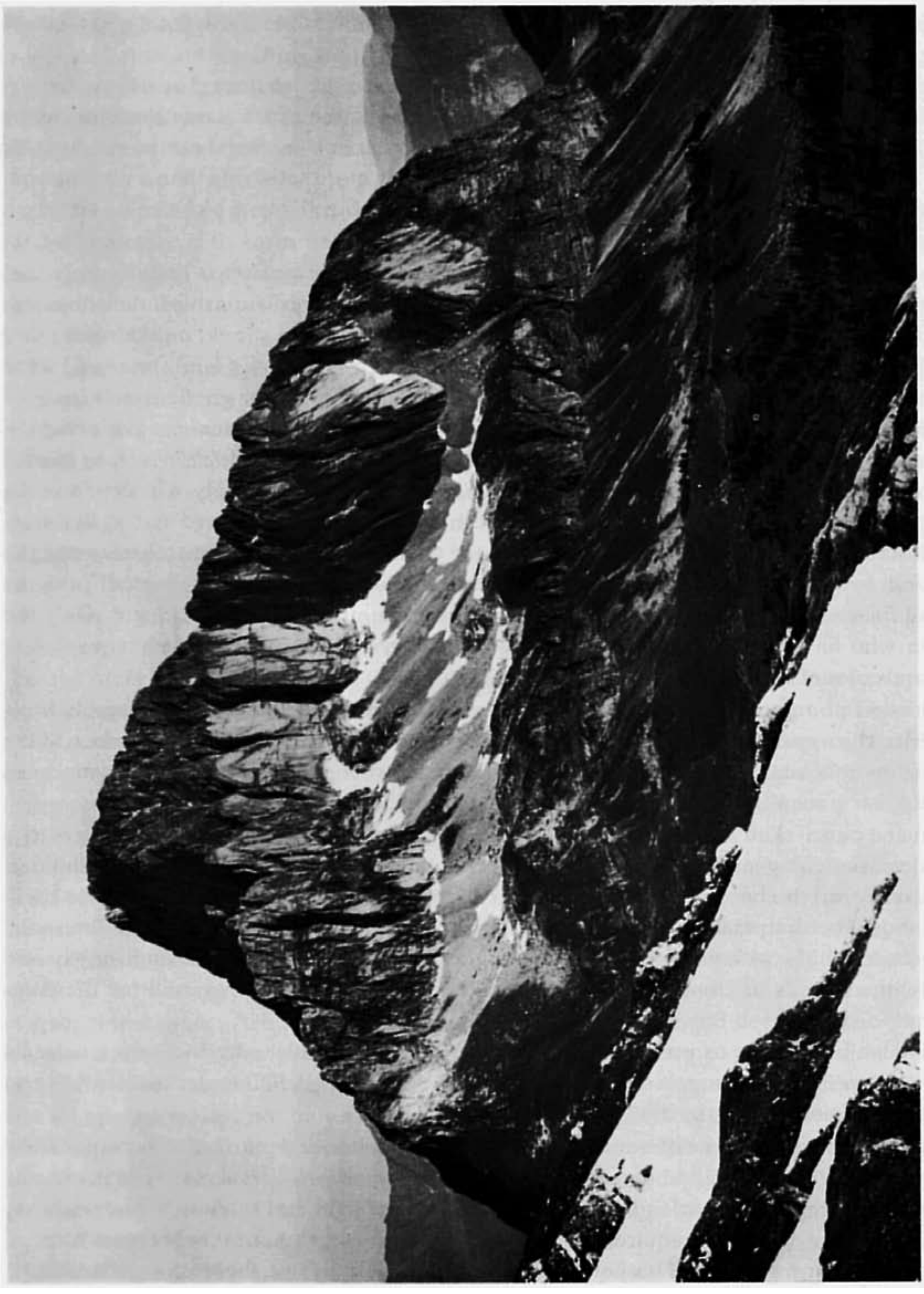

Figure 24. Mürtschenstock (Glarus Alps, Switzerland) viewed from the south. Photograph.

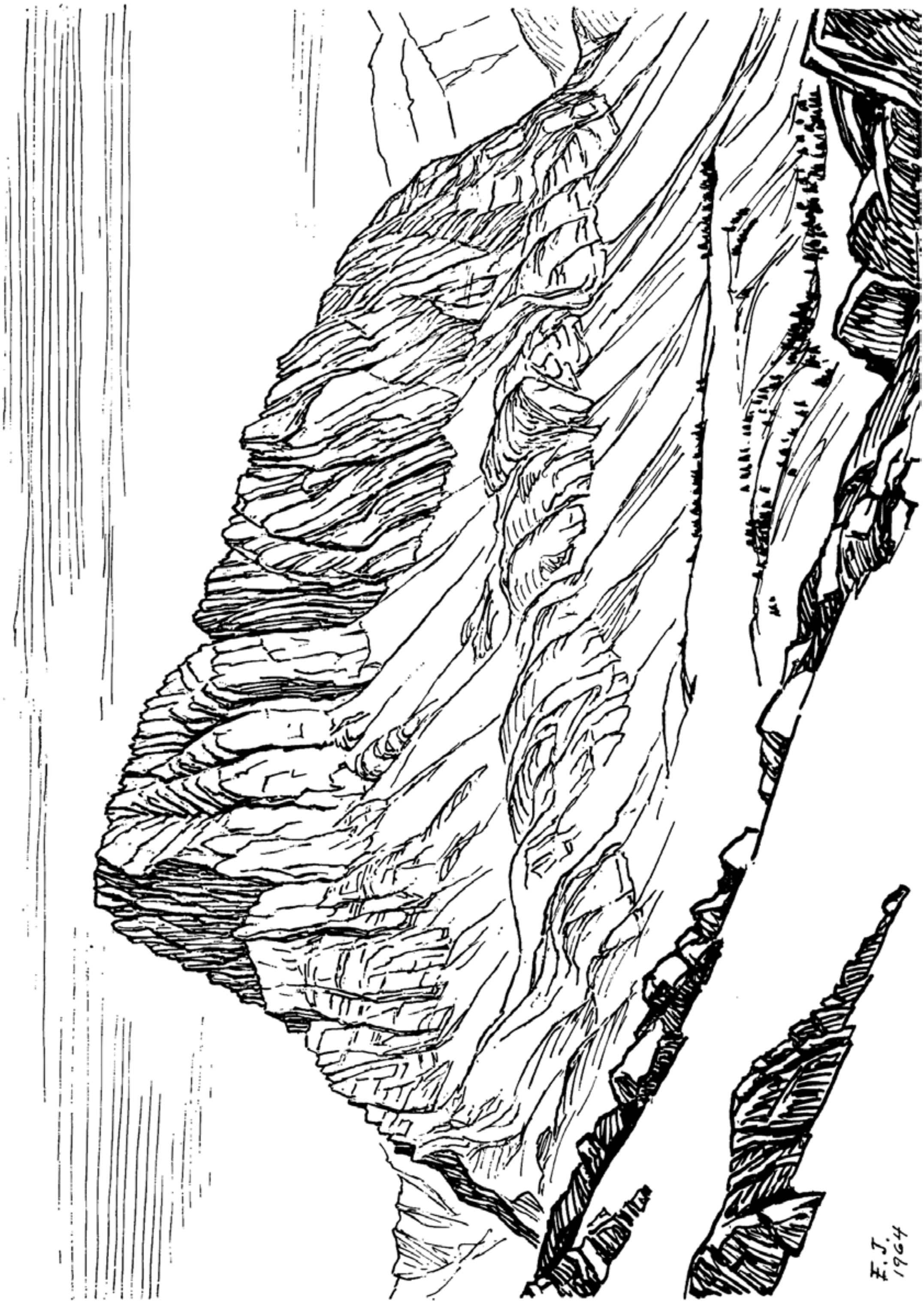

Figure 25. A drawing of the same view.

the boundary separating the areas should not, as a rule, be indicated by a heavy line, as this would be contrary to the natural impression.

Effective results can be achieved by using light Indian ink over simple, broad outlines of the subject. This requires simplification and arrangement of the individual parts of the picture by applying monochromatic, graduated area tints with water colors. In this case, line drawing and area tints should, in general, have the same color, but varying richness.

Creating a multicolored watercolor painting is quite a different matter. Here, a light preliminary sketch serves only as a guide for painting, and the pencil lines are usually erased at the end. The watercolor does not have lines drawn in to serve as borders for area colors. Studies of nature in watercolor reveal to the cartographer how the colors of an object interplay with light and shadow, and how this creates new tints. They illustrate how landscape colors are graduated through aerial perspective with increasing distance. They teach us to pay attention to contrast and to the effects of placing colors side-by-side, and they train our sense of color harmony.

C. The aerial photograph and its interpretation

In recent times, geographic source material has been considerably enriched through aerial photography, and this is not a reference to its significance in surveying alone. The aerial photo and its interpretation shall therefore be included in our consideration of cartographic fundamentals.

1. Some technical information about photography

Aerial photographs can be taken with any handheld camera from an aircraft or a balloon. However, the high demands made on the photos in the exploration and mapping of the earth's surface have led to the development of specialized equipment, materials, and processes.

a) Camera equipment. Special cameras are in use that are mounted in the floor of the aircraft. The changing and exposure of film and plates are carried out automatically and can be regulated to adjust them to the desired photo overlap. A partial overlap of the pictures is required to provide for stereo effects. It depends on the flying height, flying speed, time interval between consecutive exposures and the field of view of the camera lens.

Lenses: Extraordinarily high-quality, distortion-free, fast lenses with wide angles are preferred. Examples of this are the Aviotar, Aviogon and Super Aviogon lenses of the Wild Heerbrugg Company, Heerbrugg (Switzerland). Details are provided in the table on page 49.

b) Films and plates. The best possible image resolution and therefore the finest emulsion grain is required. The finer the grain, however, the longer is the exposure time required. The latter is limited, of course, by the movement of the aircraft itself. Thus, photogrammetric surveys require as slow-flying an aircraft as possible and also photosensitive emulsions

	Normal Angle Lens: Aviotar		Wide Angle Lens: Aviogon		Super Wide Angle Lens: Super Aviogon	
Emulsion carrier	Film	Plate	Film	Film	Plate	Film
Image format in cm	18 × 18	14 × 14	18 × 18	23 × 23	14 × 14	23 × 23
Focal length in cm	21	17	11.5	15	10	9
Maximum lens aperture	f:4	f:4	f:5.6	f:5.6	f:5.6	f:5.6
Field of view	67^g	67^g	106^g	100^g	100^g	132^g

that permit short exposure time in spite of their fine grain. Special emulsions are used for particular purposes (panchromatic films, infrared films, color films, etc.). Special development and copying processes can also be employed for a richer and clearer differentiation of picture content.

c) Organization of flight lines and photography. Normally aerial photography is taken in strips. The most efficient (most economical) overlap of consecutive pictures is about 60% for flat and hilly terrain. For greater differences in elevation, the overlap is increased to 70–80%.

Flying height above the ground:

for cadastral survey 1:500	minimum 1,000 meters
for topographic plans 1:5,000 and 1:10,000	2,000 to 4,000 meters
for topographic maps 1:25,000	5,000–6,000 meters
for topographic maps 1:100,000	8,000 meters

Flying speed also depends primarily on flying height. The lower the flying height, the lower should be the flying speed. For an altitude of 1,000 meters for instance, it should be about 150 kilometers per hour. Further conditions are steady flight without vibration and no exhaust gases from the engine in the field of view of the camera.

Exposure times: About $^1/_{250}$ to $^1/_{1,000}$ second (about $^1/_{10}$ to 60 seconds for terrestrial photogrammetry).

The *sharpness* or *quality of the image* in such photos is extraordinarily high *(figure 26)*. The *selection of the time* for this photography (season, time of day, weather) has great influence on the photographic results. For special purposes (e.g., vegetation research), optimum image definition is sought by a wise selection of the time.

2. Completion through field reconnaissance and identification

Even with the best visibility, much detail in an aerial photograph appears veiled or distorted. For topographic mapping, therefore, the results of plotting are checked and completed, as a rule, by *field traverses.*

In many cases, it is useful to carry out the field check even before plotting from the photography has begun. If this is done, the photos are annotated as far as possible to eliminate lack of clarity. Such “identification” (as it is called in Switzerland) simplifies and improves the work on the plotting instrument.

3. Rectification and photomaps

Aerial photographs of level areas, and high oblique photography, can be transformed photographically into plans and at any desired scale with special *rectifying equipment.* An assemblage of such rectified pictures is called a *photomosaic, photomap, mosaic map* or *mosaic.* They represent, for some purposes, a rapidly reproduced alternative to topographic maps.

All possible combinations of map and photographic image have been employed at some time. They originate when individual map elements, such as hydrology, contour lines, boundaries, names, spot height values, etc., are added to the photomaps. When well executed, they combine the natural appearance and the richness of detail contained in the aerial photo with the metric and other properties of the map, but as a rule, such a mixture of graphically alien material provides little satisfaction.

4. Aerial photointerpretation

There already exists a well-founded body of theory and quite considerable literature on the subject of *aerial photointerpretation.* Interpretation guides and simple plotting methods have been developed. However, more important than the special methods of instruction and the legends are a natural talent for observation and a firm knowledge of the objects to be interpreted for research (geology, plant geography, etc.). *There is no such thing as general interpretation of landscape or landscape photography: every interpretation is directed toward a definite goal or field of knowledge.*

5. Some essential differences between the aerial photograph and the map

The aerial photograph is a particularly valuable addition to the map, but it can never replace it. The reverse is also true. Aerial photographs and maps are complementary *(figures 26 and 27).* Their essential and characteristic differences are briefly summarized below:

1. The aerial photograph, like any photograph, has central perspective; the map has parallel perspective (apart from grid distortion).

2. Normally, an aerial photograph corresponds spatially only to those large-scale maps and plans, that cover very small areas of the terrain. The map, in contrast, provides images of the surface from the largest to the smallest scale and of any desired extent of country.

3. The larger the scale of the representation, the more the advantages of the aerial photograph outweigh those of the map. The smaller the scales, the more the power of expression and legibility move in favor of the map.

4. Within the limits of photographic resolution capabilities and under suitable conditions of good lighting, etc., aerial photographs (especially in color) are realistic, instantaneous pictures of the earth's surface, albeit only its superficial aspects. However, such pictures are often full of deceptive features and obscuring conditions. Similar things may frequently appear to be different. Important objects may not be visible, while incidental or unimportant things may stand out clearly. The topographic map, on the other hand, is a generalized image, conditioned by its scale, its purpose, conventions and the artifice of its

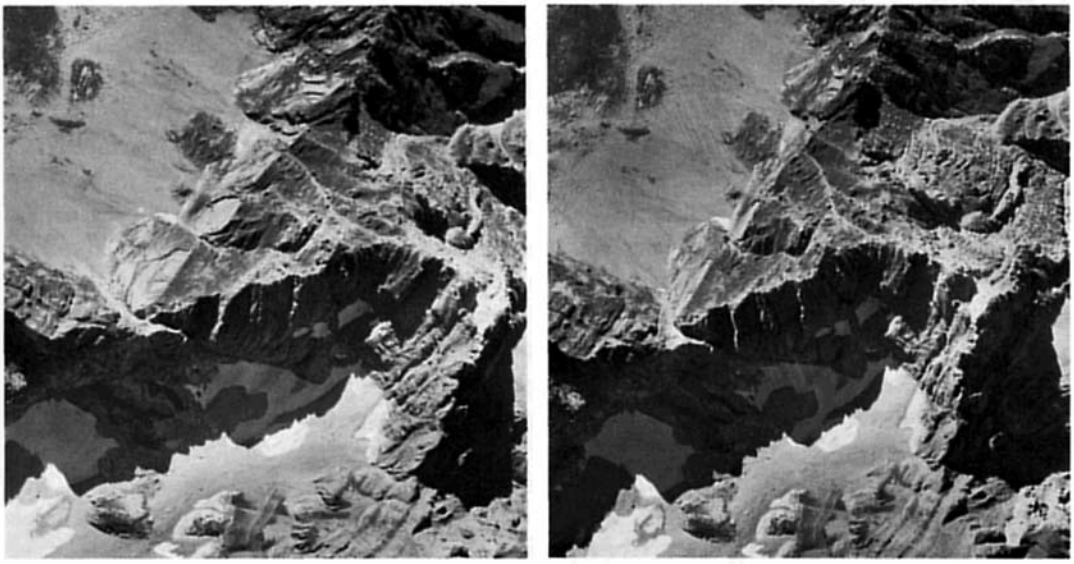

Figure 26 a and b. A stereoscopic pair of aerial photographs. Mürtschenstock-Ruchen (Glarus Alps, Switzerland). Approximately 1:10,000. Photography by the Bundesamt für Landestopographie, Switzerland.

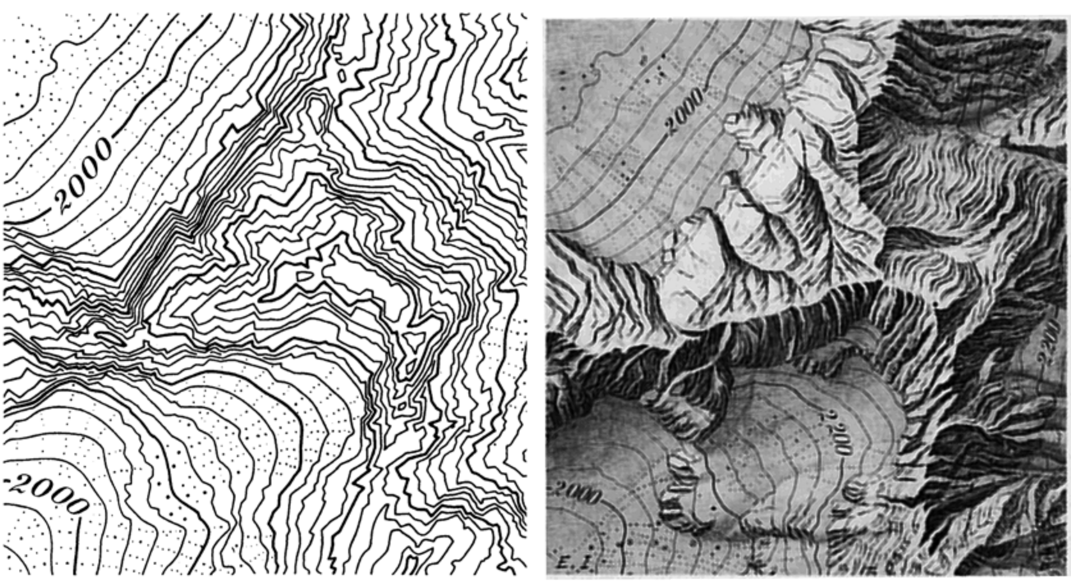

Figure 27 a and b. Mürtschenstock-Ruchen. Topographic maps 1:10,000. *27 a* – Contours, a rigorously metrical, abstract representation. *27 b* – A clearer representation by drawing the skeletal framework of the rock formations and introducing shading tones. All four figures are oriented toward the south.

maker, and portraying significant and, more or less, permanent conditions and objects. Similar things appear the same. Important things are emphasized; unimportant things suppressed. Even if the map image is made to resemble nature as closely as possible, it remains, in essence, abstract and more or less subjective, i.e., dependent on its maker.

The common conventions of cartographic experience are also subjective in nature; that is, the expression of a *collective subjectivity.*

5. As already noted, the aerial photograph reproduces, in every case, only the superficial momentary aspects of the earth's surface. The map, however, is a drawing constructed on the basis of measurements, computation and other observations and determinations. It is an image explained by symbols and lettering. Dimensions can be taken directly from it, whereas this can only be done from the aerial photo with the aid of special supplementary data, equipment, and constructions, and, in general, only when stereo pairs are available that can be positioned in space. The following section deals with the latter.

D. Binocular viewing of stereopairs

Stereoscopic vision depends largely on the automatic, physiologically conditioned fusion of the two different views, which are presented to the left eye and the right eye. Both these views (projections on the retinae of both eyes) are central perspectives which, at first glance, may appear to be similar but whose image details deviate from each other to an increasingly greater extent as the objects being viewed approach the eyes.

If we replace the direct views of the object – one for each eye – by a corresponding photographic image, for example, the apparatus of human vision will similarly fuse these two images to form a stereoscopic impression in exactly the same way as occurred in the direct viewing of the object.

The formation of a spatial model utilizing two corresponding, flat, central perspective images is referred to as *stereoviewing.* The corresponding images represent a *stereo pair.* These two images can be photographs or specially constructed drawings.

For any exploration of the earth's surface and for cartography, *stereo aerial photographs* are of the greatest significance, since their three-dimensional spatial effects immeasurably facilitate plotting and interpretation.

An undistorted appearance of the three-dimensional impression is only achieved when the relationship between the stereo-base (i.e., the distance between the center points of corresponding photographs) and the stereo-distance (i.e., the distance from that plane of the photograph to the object being taken) is the same as that between the eye base (interpupillary distance) and the distance from eye to picture. By extending the stereo-base or by increasing the viewing distance from the picture, the three-dimensional effect can be increased.

The conveying of stereoscopic, three-dimensional effects through a physiologically conditioned fusion of two perspective images (photos) related to each other can be achieved both by separation in space and time, or additionally by filter and by screening. The *stereoscopes* serve to create spatial separation. Separation by filter happens either by the so-called anaglyphic process or by means of polarized light (projection process and the vectograph principle).

The various forms of relief representation that have a stereoscopic effect are described briefly below:

a) Stereophotographs of the terrain from nature. Pairs of pictures of terrestrial views and aerial views. Through stereoscopic observations, the effects of stereo picture-pairs in color come closer to the impression of nature than would any other method of representation.

b) Stereophotographs of terrain models.

c) Anaglyphs of photographs of nature and of models. The two pictures are printed, one on top of the other, the picture on the left in green, for example, and the one on the right in red. In order to study the pictures one uses a pair of spectacles with the left lens red and the right lens green. The red lens removes the red image and makes the green image appear gray. The green lens removes the green image and makes the red image appear gray; so, each eye sees only its own respective image in gray tones. In this way, the desired three-dimensional spatial effect is achieved.

d) Anaglyph maps. We know of two methods for the simple and accurate production of anaglyphic maps. *First method:* an accurate relief model is made. On the surface of the model are drawn all the desired lines and features of the topography – the drainage lines, contour lines, roads, paths, buildings, etc. In doing this, great care must be taken to ensure the contour lines are horizontal. A sufficiently accurate contour line image can be achieved by producing a layered model. The edges of the layer steps correspond to the contour lines. The model is then photographed from almost vertically above, from two different points but at the same elevation. The “interpupillary distance” or “stereo baseline” of both photos and the photo distance (distance from the lens to the model) should be adjusted together so that the two images produce the desired stereo effect. Next, an exact line tracing of all the desired elements from each photo is made. These are then copied or printed, one in green and one in red, and superimposed in the correct manner. An identical point in the center of the field is brought into coincidence, and both images are brought into the same orientation. This orientation should be carried out in such a way that the photographic baseline (the distance between the camera stations) is parallel to the connecting line between both eyes (pupils) during viewing. Portions of the pictures, which belong to one or the other central perspective, are masked by a green or red filter, respectively.

Second, approximate method: One line-map image, the green for example, is drawn, copied or printed, with unchanged planimetry. This planimetric image should contain, among other things, the contours in sharp, clear lines. The second, red image, should also contain each individual contour line unchanged in planimetry. However, the relative position of the red contours is changed. These red contours should be numbered from the bottom to the top, 0, 1, 2, 3, 4, etc. The red contour, 0, is placed in its planimetrically correct position on the corresponding green contour, the two lines covering each other. Contour no. 1 is shifted in its entirety horizontally to the right by exactly the amount x. For contour no. 2, the shift is 2x. Contour no. 3 is shifted by the amount 3x, etc. The extent of the shift of contour no. 18 is 18x. The distance x is extremely small. It is derived from a simple construction of the vertical situation. If H is the flying height (or the photo distance on an assumed spatial model), B the photographic baseline distance (distance between camera stations) and A the contour interval, the following relationship exists:

$$\frac{x}{A} = \frac{B}{H} \text{ or } x = \frac{B \cdot A}{H}$$

Since the surface of the relief is not level, the flying height or the level of the eye above ground varies to a certain extent. On the other hand, as the variable distance H is very large in comparison with A, it is sufficient to assume a constant mean value for H (corresponding roughly to the flying height above the lowest contour line). Distance B represents the normal distance between the pupils of the eyes, about 6.3 centimeters. The best range of vision, viewing distance or eye level H comes to about 30 to 50 centimeters in anaglyphic image viewing. The remaining lines and symbols on the terrain can then be placed with relative ease in their proper places, in the red (successively shifted) contour line network. When the unchanged green and the red images, shifted to the right from contour to contour by the amount x, are placed on top of one another, they give, when viewed through the anaglyphic glasses (left lens red, right lens green), an approximately correct three-dimensional effect. If the viewing distance is increased, the mountains appear to grow in height; if decreased, they become flatter.

Example: A map or anaglyphic model has a scale of 1:25,000 and a contour interval of 20 meters, which corresponds to an interval A = 0.8 millimeters in a stereo model at 1:25,000. The interpupillary distance B is 6.3 cm, the mean viewing distance H = 40 cm. Hence, the following:

$$x = \frac{B}{H} \cdot A = \frac{6.3}{40} \cdot 0.8 \text{ mm} = 0.126 \text{ mm}$$

The three-dimensional impression of anaglyphic maps constructed in this manner is slightly distorted. In this technique, in contrast to that with centrally perspective images, as the terrain comes closer to the eye with increased elevation, no enlargement of the image takes place. On the other hand, the eye, nevertheless, automatically interprets each stereo image as having central perspective and thus the higher, or closer surfaces of the terrain appear somewhat reduced. A high, cube-shaped skyscraper, represented and viewed in this manner, would give the impression of an obelisk tapering slightly toward the top. However, since models of the earth's surface are always relatively flat with low features, this misrepresentation is of little significance in anaglyph maps.

A further distortion of the model results from shifts to the right of the red contour line system, mentioned above. By doing this, the central axis of binocular vision is inclined slightly toward the right. Steep mountains appear to lean over slightly toward the right. This illusion, which is barely perceptible in flatter models, can be increased if the lowest fixed contour lines, in both the red and the green images, are shifted away from each other successively and symmetrically, and each one by half the value of x.

The misrepresentations of form that arise from such simplified, approximate constructions, are of little importance, since anaglyphic maps serve only to evoke easily appreciated and reliable three-dimensional concepts of the earth's surface relief.

In some countries so-called anaglyphic stereoplotters are in use. In these instruments, the stereo pair of aerial photographs are projected with the red or blue light on to the plotting table. The principle of this system is as described above.

E. Knowledge of geography and geomorphology

Between topography and cartography on one side and the sciences dealing with the earth's surface on the other, there exists the very closest, reciprocal relationship.

The topographic maps of the last hundred years constituted the basis for extensive geographic-thematic mapping of all types. They made possible an extraordinary development of the most varied branches of science, a development that is, as yet, far from complete and that receives new life with every new effort in topographic mapping. But on the other hand, topographers and mapmakers obtain great use from geographic knowledge; for, without such knowledge, every critical evaluation of the fundamental aspects of the work, every selection, generalization, emphasis or suppression of elements contained in a map, becomes uncertain. Within the framework of an approach to cartographic relief representation, *geomorphology* is of primary interest. Its significance has already been emphasized many times but many times, too, it has been disputed. "God protect us from mapmakers trained in morphology," was the warning given by very able geomorphologist not very long ago. The topographer has to reproduce, as accurately as possible, the objective form of the earth's surface as obtained from measurements without allowing himself to be influenced in the process by any, perhaps disputed, theories of form. Such contradictions of concepts arise from different basic assumptions and generalizations that are too extensive.

As explained earlier, many large-scale topographic maps – new as well as old – contain poorly formed contour lines or unrealistic, pattern-like hachured and/or shaded images. Such deficiencies were caused by inadequate accuracy in the survey on which the maps were based and a lack of understanding of form on the part of many mapmakers. Without doubt, geomorphological training could have led to significantly better results in circumstances like these.

The question must be asked whether or not geomorphological guidance is both necessary and useful for modern topographic surveys as well.

One thing is certain: in general, today's photogrammetric surveys render more accurate and characteristic contour lines than ever a good geomorphologically influenced plane-table survey could have done. Within the scope of modern, high-quality mapping at large scale, there is little room for the application of geomorphological knowledge. This changes, however, with decreasing scale or with refinement of the forms being represented. Rocky and karst regions, moraine landscapes, dune areas, volcanic regions, various forms of recent erosion and deposition, glacier surfaces, etc., demonstrate very finely detailed forms. Here graphic simplifications are required, often even in the largest-scale maps. Moreover, the smaller the scale, and the finer the articulation of the relief, the more this situation is likely to arise. The generalized form is no longer identical to the original form. The shortcomings brought about by every such change in form, however, can be significantly eased and retarded, from the point of view of scale dependency, if the generalization of form is guided by an understanding of geomorphological principles. A conscious emphasis of such geomorphological characteristics in no way reduces the metric value of the map in such cases. The point is to carry out the unavoidable simplifications in such a way that typical characteristics are least affected. Often, especially in very flat terrain, the carefully considered simplification of contour lines may prove to be useful.

What has been said here with respect to contour lines applies, with even fewer reservations, to hachuring and shading, which cannot be picked up in a rigorously geometric manner.

Examples of morphologically influenced transformations are found in later chapters in this book.

There are several good textbooks on geomorphology available today, some of which appear in the references listed at the end of this chapter.

Introductory instruction in geomorphology should not be presented to topographers and cartographers in a way that is different from instruction for geographers and natural scientists. Once the fundamental concepts and knowledge have been taught, training should be introduced that is directed toward professional requirements. In this case, the main concern of the topographers and cartographers should be to sharpen their eyes for the recognition of terrain forms and to learn to achieve some reliability in the geomorphological interpretation of these forms. It is very useful to make frequent comparison and interpretation of different maps of the same area at different scales. Comparative study such as this should include small-scale maps and landform types found in large landscape regions.

We are not involved here with either a new teaching in its own right, nor with a "geomorphology for cartographers." It is simply a matter of transferring the learning to the methods, materials and professional activities of the mapmaker. What has been learned will prove valuable in the map drawing exercises of transformation or generalization.

Since we are speaking here of geomorphology, it may not be out of context to include a critical note on the misuse of this term in the recent professional literature, especially of Germany.

In cartographic circles today, we speak often and freely of morphological terrain representation, morphological relief forms, morphological contours, morphological map editions, etc., where in each case the concern is not with morphology, but rather with the terrain and relief forms alone. But this is senseless, since geomorphology is the science of the origin of landforms and is the explanatory description of the forms. The topographic image indeed shows the forms, but does not explain them. True geomorphological maps are special thematic representations designed to explain the development of forms.

References: 4, 6, 23, 34, 41, 44, 52, 65, 68, 74, 129, 130, 153, 161, 199, 200, 202, 203, 204, 205, 207, 210, 212, 221, 222, 259, 273, 289.