

Table of Contents

Chapter 1	
<i>Historical Developments</i>	1
Chapter 2	
<i>The Topographic Foundations</i>	15
A. Methods of topographic survey	15
1. Plane-table survey or plane-table tacheometry	15
2. Tacheometric survey	16
3. Leveling	17
4. Photogrammetry	17
B. Accuracy in surveying terrain surfaces	18
1. Positional and height accuracy of surveyed points	19
2. The accuracy of edge lines	22
3. The examination of contour lines	23
4. Types of errors in contour lines	26
a) Errors in the geometric components	26
b) Types of errors in contour lines according to origin and local distribution	27
5. Koppe's empirical test formula	28
6. Some additional methods of examining contour lines	31
7. The zone of mean positional error in contour lines	32
8. Contour accuracy in modern surveys	35
C. Status and quality of the topographic mapping of the earth's surface	38
D. General or derived maps at smaller scales as working bases	40
1. General	40
2. Stylized representation of land forms	41
Chapter 3	
<i>Further Basic Principles and Guidance</i>	43
A. The study of topography in terrain and maps	43

B. On landscape drawing 44

C. The aerial photograph and its interpretation 48

 1. Some technical information about photography 48

 a) Camera equipment 48

 b) Films and plates 48

 c) Organization of flight lines and photography 49

 2. Completion through field reconnaissance and identification 49

 3. Rectification and photomaps 50

 4. Aerial photo interpretation 50

 5. Some essential differences between the aerial photograph and the map 50

D. Binocular viewing of stereopairs 52

 a) Stereophotographs of the terrain from nature 53

 b) Stereophotographs of terrain models 53

 c) Anaglyphs of photographs of nature and of models 53

 d) Anaglyph maps 53

 First method 53

 Second, approximate method 53

E. Knowledge of geography and geomorphology 55

Chapter 4

The Theory of Colors 57

 1. Physical theory of color 57

 2. Chemical theory of color 58

 3. Physiological theory of color 58

 4. Psychological theory of color 59

 5. The classification of colors 62

 6. Observations on color reproduction 65

 a) Printing in three colors or more 65

 b) Cartography, as a special aspect of reproduction technology 66

 c) Further observations on the colors of linear and areal elements 67

 d) Printing colors and color charts for topographic and geographic maps 68

 e) Hints on some technical printing matters 68

 1. Screen patterns or moirés 69

 2. Changes taking place during the transfer processes 69

 3. Variations between impressions 69

 4. Standardized color samples on the margins of the map sheet 69

 7. On the harmony of colors and their compositions 69

 a) Combinations of two or more colors 70

 b) Color compositions 72

 8. On the symbolism of colors 73

 9. Selection of colors from physiological points of view 74

Chapter 5

The Problem and its Characteristics 75

 1. Statement of the problem 75

2. General appearance of the land surface in nature	75
3. The use of terrain models	76
4. Variations in the surface forms of models	76
5. Basic factors affecting the ability to see spatial depth and solidity	78
6. Which of the spatial depth or solidity effects can be used in map design?	79
7. The map is not only a picture: The differences between maps and pictures	79
8. The forms and their dimensions should be capable of comprehension and measurement: The fiction of the “contour blanket”	80
9. Further fictitious indirect methods of representation including combined techniques	80
10. An experiment	81
11. Conflict and interplay between both approaches to representation: The progress of the direct technique	83
12. Dualism and individuality of cartographic representation	84
13. The generalization and the interplay of the graphic elements	85
14. Different circumstances, different forms: The achievements to be sought after	86

Chapter 6

<i>Spot Heights and Soundings</i>	87
1. Concepts	87
2. The cartographic significance of spot heights	88
3. Units of measurement	88
4. Datum levels	89
5. The nature of spot height accuracies	92
6. The number and density of spot heights	93
7. Selection of spot heights – general	94
8. Some special cases	95
a) Passes	95
b) Tops of church steeples and other high points	95
c) Glaciers and inland ice	95
d) Streams and rivers	96
e) Lakes	96
1. Lake water level	96
2. Spot heights of points on lake bottoms, with reference to sea level	97
3. Lake depths or deepest points	97
f) Oceans	97
9. Graphic problems	97
a) Symbolizing the position of a point	97
b) Positioning of the spot height value	97
c) Styles of numerals for the values	99
d) Minimum type sizes for sheet maps	99
e) Differentiation of the form of numerals according to position or nature of measured heights	99
f) Grading of type sizes according to the importance of the points	99
g) Colors of spot heights and depths	100
10. Combination of the various height and depth data and the style of their symbols	101

11. Assigning height values to special river charts for large shipping rivers.....	101
12. Assigning height values to ocean shipping charts: “nautical charts” or “nautical maps”.....	101
 Chapter 7	
<i>Skeletal Lines</i>	105
1. General	105
2. The skeletal line as a constructional aid in terrain representation	107
3. The skeletal line as a supplementary element in terrain representation.....	107
4. The skeletal line as an independent form of terrain representation	108
 Chapter 8	
<i>Contour Lines</i>	111
A. Concepts and terminology.....	111
B. The vertical intervals between contour lines	113
1. Simple equal-interval systems	113
2. Combined interval systems	122
3. Intermediate contours	123
C. Generalization of contours	126
1. Maps at scales of 1:5,000 and larger	127
2. Maps at scales of 1:10,000 to 1:100,000	128
3. Maps at scales smaller than 1:100,000.....	130
D. Relationships between survey accuracy and generalization	134
E. Relationships between contour structure and contour interval.....	136
F. Graphic conventions and forms	137
1. Index contours	137
2. Intermediate contours	140
3. Uncertain contour lines.....	140
4. Additional aids to orientation.....	140
5. Contour colors	140
a) Differentiation of contour color according to the type of ground	141
b) Variations of contour color according to elevation layer	143
c) Variations of contour color according to illuminated and shaded sides	143
6. Line weights, the form of broken lines	143
G. Clarity of contours and the untenable theory of vertical lighting	145
H. Variations of line weight, and three-dimensionally shaded contours.....	148
1. Increasing the line weight as elevation increases	149
2. Three-dimensional line strengthening without area tones	149
3. Local increases of line weight	150
4. Differentiation of the color of contours according to whether slopes are illuminated or shaded.....	150
5. Three-dimensionally shaded contours with flat area tones.....	150
I. The employment of contours for elevations and depressions	154

Chapter 9

<i>Shading and Shadows</i>	159
A. General aspects	159
B. Slope shading	162
1. Its gradations from light to dark and a reexamination of the theory of vertical illumination	162
2. Graphic procedure	164
C. Oblique hillshading, or shadow depiction under oblique light	166
1. Light and shadow in nature, on the model and in the map	166
2. Geometric and topographic models	168
3. The drawing of forms	169
4. Shadow tones in flat areas	171
5. Cast shadows	171
6. Illumination by reflected light	171
7. Highlights	172
8. Aerial perspective	172
9. The direction of the light and its local adjustment	173
10. Untenable theories	177
11. South lighting	178
12. Leonardo da Vinci: The master	185
13. Four difficult cases. Illustrating the importance of impression	186
14. The accuracy of shading	186
15. Small details in the land surface	187
16. The emphasis on large land forms	187
17. Generalization of three-dimensionally shaded land forms	188
18. Shading color and shading strength	190
19. Shading tones on glaciers and permanent snowfields	192
D. Combined shading	194
1. The influence of shading hachures	194
2. Graphic representation	195
3. Misrepresentation of form	195
E. Drawing material and drawing techniques	196
1. Requirements of the originals	196
2. Graphic framework	196
3. Scale of the drawing	196
4. Drawing surfaces	196
5. Working with drawing pencil, watercolor brush or airbrush	198
6. Lightening: Adding light to flat surfaces	199
7. Shading originals on gray-tone film	200
8. The uniform impression and good photographic and reproductive quality of shaded originals	200
9. Transfer to the printing plates	201
F. Practical considerations: The advantages and disadvantages of shading and shadow tones	202
1. Slope shading	202
2. Combined shading	203
3. Oblique hillshading	204

G. Oblique hillshading of the ocean floor	205
H. Hillshaded images by model photography	205
1. General aspects	205
2. Preparation of models	205
3. Photography of models	207
4. Advantages and disadvantages of shading by photography	208
I. Oblique hillshading with computer	209
1. The experiments of Yoeli	209
2. The experiments of Brassel	209
3. The experiments of Hügli	210
4. Some difficulties	210

Chapter 10

<i>Hachures and Other Related Techniques</i>	213
A. Some introductory remarks	213
B. Slope hachures	214
1. The five rules of construction	214
2. Some details of formation	221
3. The use of darkening for slope hachures	221
4. The misrepresentation of form by slope hachures	222
C. The shadow hachure	224
1. The five rules of construction	224
2. Misrepresentation of relief impression through shadow hachuring	224
D. General mountain hachuring in small-scale maps	224
E. The colors of hachures	226
F. Graphic techniques used in production	227
G. Deficiencies and advantage; combinations with other elements	228
1. The deficiencies	228
2. Advantages and applicability	229
3. Combinations	229
H. Horizontal hachures	230
I. Plan views of oblique, parallel planes intersecting the terrain	232
J. Eckert's dot method	234

Chapter 11

<i>Rock Drawing</i>	235
A. Evolution and potential	235
B. Geomorphological examination of some rock formations	236
1. Origin of large formations	236
2. The importance of geological structure on the forms produced by weathering	238
3. Erosion gullies and depressions	243
4. Some other distinctive features	246
5. The debris mantle	247
6. Chemical weathering of rocks and karst forms	248
7. Wind erosion	250
8. The plan view depiction of rock areas at small scales	250

C. Form analysis	251
1. Demarcation lines	251
2. Ravine or gully lines	251
3. Crest lines	251
4. Skeletal line structure of erosional features at large	252
D. Graphic construction	252
1. Rock contours	252
a) Equal vertical intervals	252
b) Numbered or index contours	253
c) Vertical walls and overhangs	253
d) Sequence of drawing contours	253
e) Generalization of contours	253
f) Stroke widths and colors of rock contours	256
g) A special technical case	256
2. Skeletal lines	257
3. Rock shading	257
a) Rock shading as an aid to drawing rock hachures	257
b) Rock shading as an element of the final cartographic product	258
4. Rock shading under so-called vertical illumination	258
5. Shaded rock hachuring	259
a) General	259
b) Additional remarks on figure 178, 1–17	259
c) Alignment or attitude of the strokes	261
d) Three-dimensional shading effects	262
e) The strength and distances between the strokes	262
f) Ridgelines, gullies, stroke character and other factors	262
g) Aerial perspective	263
h) Fitting the small into the large	263
i) Standardization, generalization and local distortion	263
6. Rock hachures following the principle “the steeper, the darker”	266
7. The color of rock hachures	266
8. Rock representation by means of area tints	266
9. Combinations of several elements	266
a) Combinations of linear elements	266
b) Combinations of linear elements and area tints	270
10. Karren regions (regions of tints), regions of roches moutonnées and slopes with protruding rocks: Particular design problems	270
11. Portrayal of rocks in smaller-scale maps	272
12. What training is required for cartographic rock drawing?	273
E. Tools and techniques used in rock drawing	273
1. Pen and black ink work on drawing paper	273
2. Ink drawing on transparent film (Astralon, Kodatrace, Mylar, etc.)	274
3. Scribing on coated plastic films or on coated glass plates	274
F. Examples from older and newer maps	274
G. Critical examination and application of the different methods of rock drawing	279
1. Plans, 1:5,000 and larger	281

2. Plans, 1:10,000	281
3. Maps, 1:20,000 and 1:25,000	281
4. Maps, 1:50,000	281
5. Maps, 1:100,000	282
6. Maps between 1:100,000 and about 1:500,000	282
7. Maps smaller than 1:500,000	282
 Chapter 12	
<i>Symbols for Small Landforms and Other Supplementary Elements</i>	283
General	283
1. Artificial slopes	285
2. Clay pits, gravel pits and quarries.	289
3. Landslides, torrent gullies	289
4. Dolines and other karst forms, sink holes, etc	291
5. Scree slopes and debris mounds	291
6. Landslide mounds.	292
7. Young moraines.	292
8. Small features on ice surfaces	292
9. Dunes.	293
10. Small volcanic forms	293
11. Brandstätter's proposals.	293
 Chapter 13	
<i>Area Colors</i>	295
A. The purpose and possibilities of area color tinting in maps	295
B. Natural and conventional colors	296
C. Colors for hypsometric tinting	299
Type 1: The contrasting color sequence.	300
Type 2: Gradation based on the principle "the higher, the lighter"	301
Type 3: Gradation based on the principle "the higher, the darker"	302
Type 4: Modified spectral scale, standard form.	302
Type 5: Modified spectral scale with omission of the yellow step.	303
Type 6: Modified spectral scale with gray or violet steps for the highest regions	304
Type 7: Karl Peucker's color scale.	304
Type 8: Further variations and extensions of spectral color scales	305
Type 9 and 10: Color gradations with optimum elevation modeling effects	306
Type 11: Elevation color gradation for relief maps at large and medium scales with hillshading.	307
Type 12: Softened, modified spectral color sequence.	308
Type 13: Color sequences for three-dimensional hillshaded relief maps at small scales.	309
Color sequences for spectral hypsometric maps	310
Further possibilities	310
Depressions	311
D. Color tones for the zones between bathymetric contours	311
E. Heights of hypsometric steps on land.	312

1. Equidistant steps	312
2. Two sequences of equally vertical interval steps in combination	312
3. Steps of equal area	314
4. Irregularly changing step heights	314
5. Steps based on an arithmetical progression or additive steps (figure 205)	316
6. Steps based on a geometric progression	317
F. The depths of bathymetric steps	318
G. Adjusting the color tones to the steps	320
H. Further remarks on the representation of elevation steps	321
1. Contours in colored areas	321
2. Graphic design and generalization	322
3. Practical application	322
4. Legends for layer-tinted maps	323
5. Color chart for use at the reproduction stage	323
 Chapter 14	
<i>Interplay of Elements</i>	325
A. The nature and effect of interplay	325
1. The necessity for and the careful development of good interplay	325
2. Conceptual, graphic and technical aspects of interplay	326
3. Consistent generalization and good standardization	327
4. Careful emphasis and restraint. Mutual relationships between things	328
5. Overlapping, discontinuities, substitution	329
6. Displacement, narrow passes	331
7. Changes in tint value resulting from combination	332
8. Terrain representation and textual matter	333
B. Combination of various elements of terrain representation	333
a) Combinations for large- and medium-scale maps	334
1. Contours and slope- or shading-hachures	334
2. Rock depiction by means of contours, skeletal lines and hachures	335
3. Contours and slope shading	335
4. Contours with oblique hillshading or with combined shading	335
5. Rock drawing and oblique hillshading	336
6. Shaded hachures and shading tones	336
7. The landscape painting in plan view	336
8. Hillshaded and colored maps of medium and large scales, without contours	337
9. Contours and rock portrayal combined with hillshading and color tones	340
b) Combinations for small-scale maps	342
10. Slope hachures produced according to the principle “the steeper, the darker” and hypsometric tints	342
11. Shaded hachures and hypsometric tints	343
12. Slope shading following the principle “the steeper, the darker” combined with hypsometric tints	343
13. Combined shading and traditional hypsometric tinting. Methods used up to the present time, with suggestions for ways in which they might be improved	343
14. Oblique hillshading combined with hypsometric tints in small-scale maps	344

15. Relief shading combined with ground and vegetation colors in small-scale maps	344
16. Contours with equal vertical intervals, hachures and hypsometric tints.....	345
17. Contours with equal vertical intervals, shading tones and hypsometric tints	345
Chapter 15	
<i>Observations on Map Reproduction Techniques</i>	347
1. General	347
2. Cartographic reproduction by photomechanical or electronic color separation of multicolored originals.....	348
3. Some observations on drawing technique.....	350
4. The drawing sequence.....	350
a) Adjustment of hypsometric layer outlines to the forms of relief shading.....	351
b) The registration of the first, second and possibly the third shading	351
5. Considerations of inaccuracies in register	351
6. The printing sequence	353
Chapter 16	
<i>Future Developments</i>	355
1. Present status of the topographic-cartographic record of the earth's surface.....	355
2. Increased requirements for topographic maps at all scales.....	355
3. Is the map production technology of today equal to such requirements?	356
4. Automation in cartography.....	356
5. The modern photomap.....	356
6. On the nature of cartographic representation.....	357
7. On art in cartography.....	359
8. Reform in map design	359
9. Good maps are not always more expensive than bad maps.....	360
10. The key to progress.....	361
 <i>Bibliography</i>	 363
<i>Supplementary Bibliography</i>	375
<i>Index</i>	381
 <i>Color plates 1-14</i>	 389