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TECHNICAL REPORT
EP-124

A QUANTITATIVE SYSTEM FOR CLASSIFYING LANDFORMS

QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

FEBRUARY 1960 NATICK, MASSACHUSETTS

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Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report
EP-124

A QUANTITATIVE SYSTEM FOR CLASSIFYING LANDFORMS

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Foreword

Increasing use is being made of numerical terrain data which can be applied to the designing and testing of military equipment and logistical systems. Also, terrain information expressed in quantitative terms can be used to establish a simple landform code, or index, for describing world areas.

This report deals with a landform code based on six dimensions of terrain. Techniques for taking these measurements are described, along with methods of recording and codifying the data. As more information is discovered about the inter-relationships of terrain dimensions, it will be possible to become more definitive in selecting dimensions for quantification; the present six factors will continue to be used along with any additional ones.

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Contents

Abstract

A landform classification system based on quantitative terrain data has been devised, and tested in a part of Central Europe. Measurements for six terrain factors - grain, relief, average elevation, elevation-relief ratio, average slope and slope direction changes - were taken for 413 sample areas within a larger area of over 100,000 square miles. The individual samples were grouped into 25 homogeneous regions in accordance with the similarity of the above measurements.

A map of Central Europe delineating these 25 regions was drawn and was found to compare favorably with physiographic maps of the same area drawn solely from qualitative interpretations. The similarity of the quantitatively-described landform regions with those described qualitatively is further proof of the validity of quantitative terrain analysis and demonstrates the usefulness of earlier qualitative geographic work.

A QUANTITATIVE SYSTEM FOR CLASSIFYING LANDFORMS

1. Introduction

Numerically-expressed terrain data are being used increasingly for geomorphic analysis. Because numbers can be manipulated more easily than words and carry a preciseness of definition that qualitative terminology lacks, quantitative analysis has increased the value of terrain studies for both theoretical and practical purposes. A simple, but expressive, landform code, based on measurements made from topographic maps, is one application of quantified geomorphic data. Such a code permits accurate, concise descriptions of any part of the earth's surface and can serve as a terrain index or form a system for classifying landforms.

This report describes a quantitative system of landform classification and the techniques through which it evolved, and consists of two parts: (1) A discussion of the terrain features selected for quantification, which would give an adequate description of the surface geometry (measurements of these features by themselves would comprise an index of terrain); (2) A system for grouping individual sample areas into homogeneous regions according to similarity of the above measurements.

This classification system was devised and tested in that portion of Central Europe represented on World Aeronautical Chart 231, "Böhmer Forest", covering the area bounded by 48° to 52° North latitude and 7° to 16° East longitude. Most of Germany and parts of France, Austria, and Czechoslovakia are included on this chart. The area is characterized by a great diversity of landforms and has been studied extensively by geographers and geologists.

2. Quantified terrain data

a. Factors selected for quantification

Six terrain factors were selected for quantification:

(1) Grain - the size of area over which the other factors are to be measured. It is dependent on the spacing of major ridges and valleys and thus indicates texture of topography.

(2) Relief (or local relief) - the vertical difference between the highest and the lowest elevations within the sample area.

(3) Average elevation - average altitude of the surface above sea level.

(4) Elevation-relief ratio - proportion of upland and lowland within the area.

(5) Average slope - average angle at which the surface slopes away from the horizontal.

(6) Slope direction changes - number of ridges and valleys encountered on a length of traverse and thus a measure of dissection.

This is by no means a complete listing of all the dimensions which could be measured. However, they suffice as a first elementary description of landscapes; also, the necessary measurements and computations are easy to make. It is felt that as more is known about the inter-relationships of terrain dimensions, it will be possible to become more definitive in selecting dimensions for quantification, and that these six factors will continue to be used along with any additional ones.

b. Techniques for measuring terrain factors

Precise measurements of the six factors were taken for 413 individual sample areas within the larger area represented on World Aeronautical Chart 231. Data were gathered from topographic maps of the 1:100,000 U.S. Army Map Service, Central Europe Series, with a contour interval of 25 meters. Although a few of the sheets are larger, most of them are 1 degree of longitude by 30 minutes of latitude, or about 45 miles in the east-west dimension, by 35 miles north-south. Six circular-shaped sample areas were located on each sheet. These were centered on intersections of the Universal Transverse Mercator Grid about 17 miles apart north-south by 15 miles apart east-west.

The techniques for measuring the individual factors within the sample areas are as follows:

(1) Grain - Land surface grain is determined by the spacing of major ridges and valleys. This measure is an indication of topographic texture and can be likened to wood or soil grain. Hence it can be considered as coarse or fine. "Coarse-grained" topography is associated with widely-spaced major drainage ways and interfluves; more finely-dissected areas with closer spacing of these features may be termed "fine-grained." Examples of the two extremes of grain size can be drawn from the Vosges Mountains (fine-grained) and the Münster Plain (coarse-grained). (Fig. 1)

Not only does the knowledge of grain provide a single piece of information about an area, but it also dictates the size a sample should be to adequately represent the larger area of which it is a part. Arbitrary decisions concerning terrain sample size, such as 1 square mile or

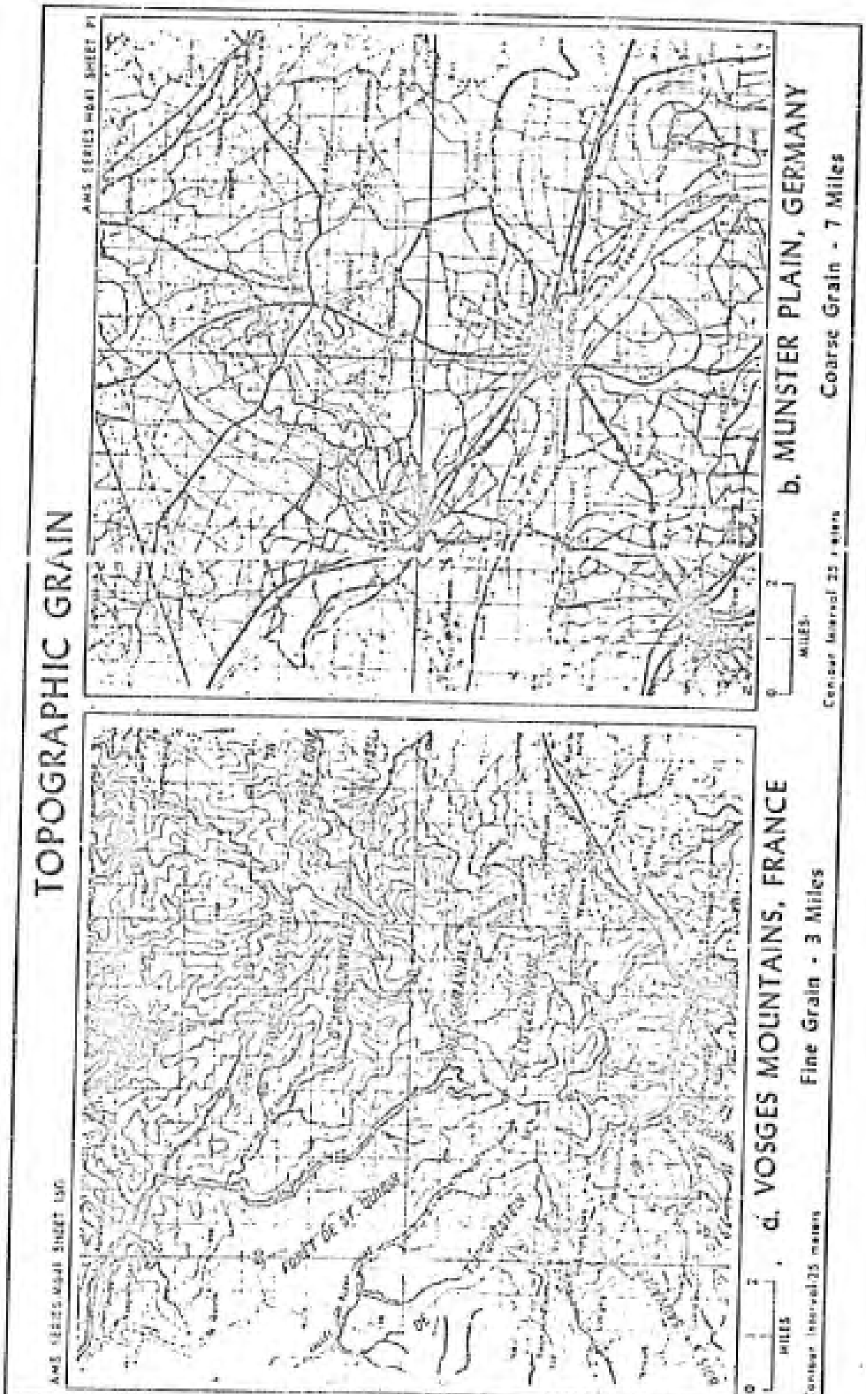
TOPOGRAPHIC GRAIN
a. VOSGES MOUNTAINS, FRANCE
Fine Grain - 3 Miles
b. MUNSTER PLAIN, GERMANY
Coarse Grain - 7 Miles

Figure 1

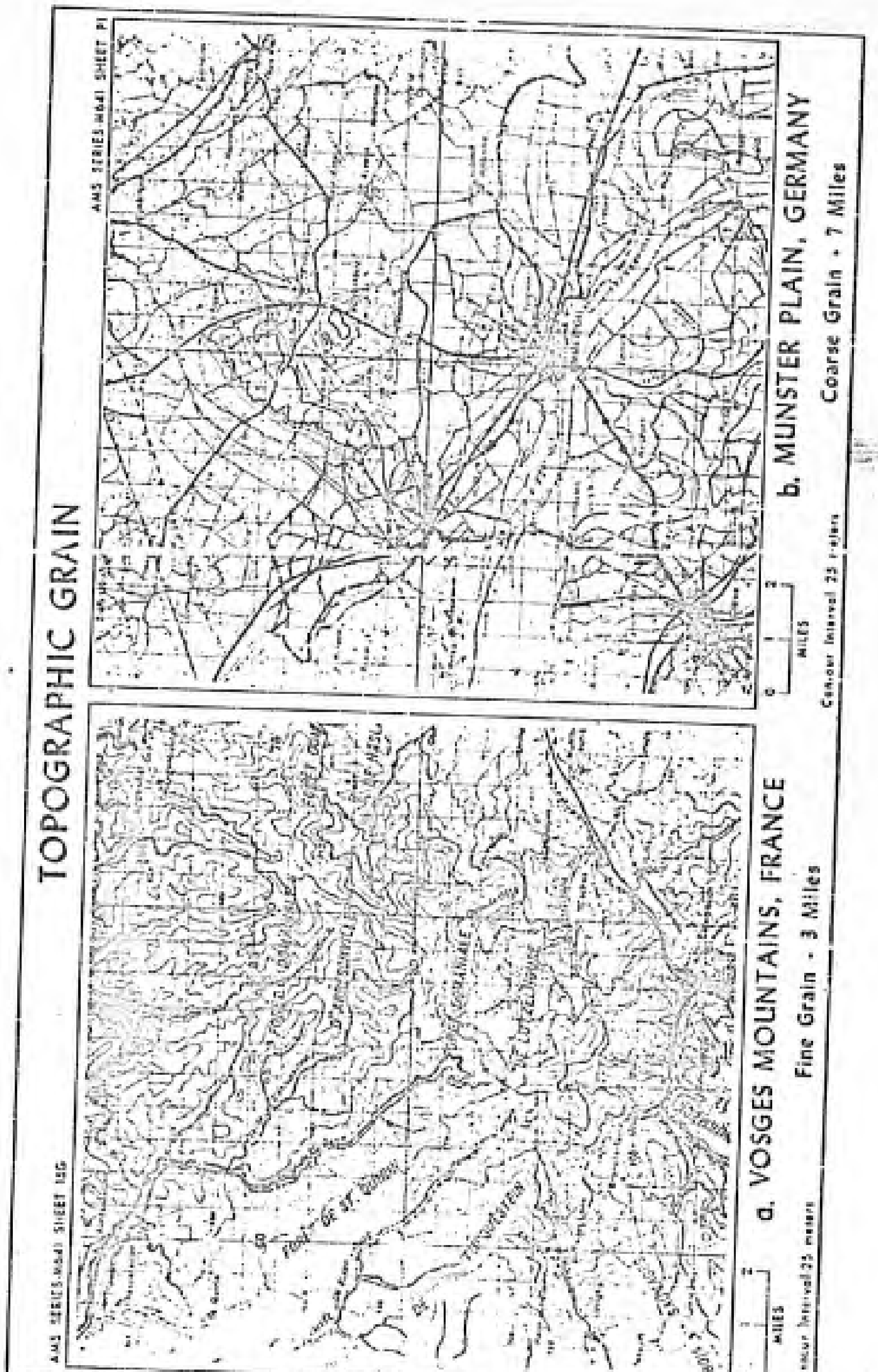
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Figure 1

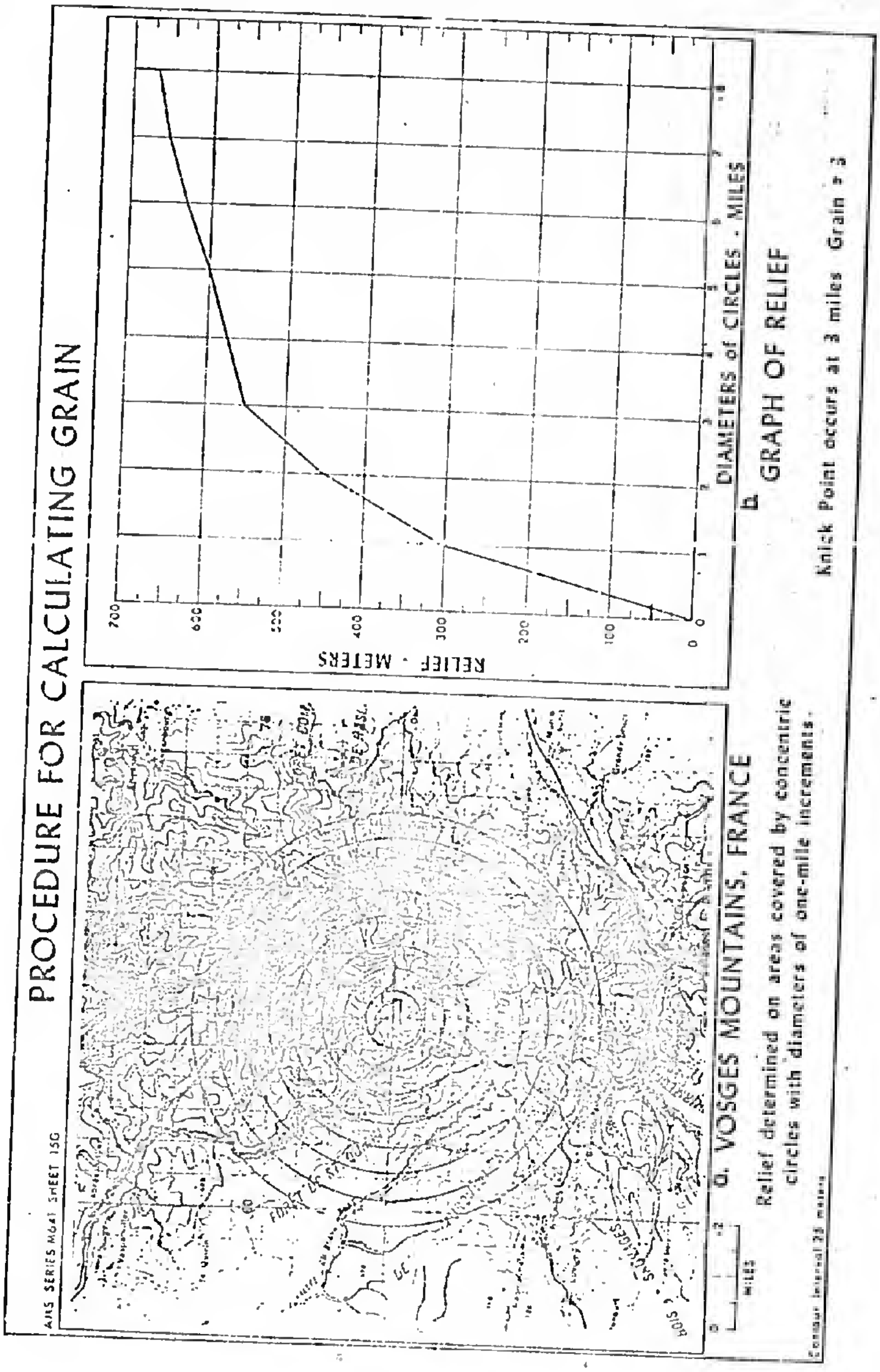
PROCEDURE FOR CALCULATING GRAIN
AMS SERIES M641 SHEET 15G
a. VOSGES MOUNTAINS, FRANCE
Relief determined on areas covered by concentric circles with diameters of one-mile increments.
Contour Interval 20 meters
MILES
RELIEF - METERS
700
600
500
400
300
200
100
0
DIAMETERS of CIRCLES - MILES
b. GRAPH OF RELIEF
Knick Point occurs at 3 miles Grain = 3

Figure 2

10 square miles, do not indicate the most suitable size area to study. A more logical approach is to let the earth itself determine how large a sample should be. An area which will contain a major ridge and valley will also contain the other smaller topographic features which are representative of that portion of the earth's surface. Thus, samples selected according to grain will give the analyst the optimum size area on which to take his measurements. This is particularly true when trying to delimit "local relief."

The diameter of a circle large enough to contain a major drainage divide and major valley is referred to as "grain size." The detailed method for calculating grain is as follows:

1. Select a random point on a topographic map of the area under consideration.

2. Draw a series of concentric circles having diameter increments of 1 mile.

3. Determine the relief for each circle.

4. Plot these values on graph paper with relief on the vertical axis and length of diameter on the horizontal axis. Draw a line to connect the points.

5. It will be found that a "knick point"* occurs on the line representing increase of relief with size of area, and from that point on, the line moves upward slowly. The length of the diameter indicated directly below the knick point is the grain of that area. (Fig. 2)

In some cases, the graphing of relief against diameter length of the circle on which relief is computed will give an uncertain value for grain size. If the analyst is not satisfied with the result he gets from measuring the grain from a single point, he should measure the grain from a number of different points within an area of apparent homogeneity, and graph the average relief obtained for each increment of diameter against the appropriate diameter. This technique will produce a definite knick point so that no doubt remains as to grain size. At

* Gutersohn, as referred to by Neuenschwander (3), found a definite knick point on a curve of relief values for progressively increasing size of areas. This knick point signified the occurance of maximum relief.

the present stage of quantitative terrain analysis, there is no need to refine this measure any further; any mean figure for grain size which might be applied to an area will necessarily be subject to some variation from place to place. There are two reasons for this. The first is that the point from which the circles should be drawn is random; the second reason results from the fact that although there is a regularity to the spacing of major ridges and valleys, ridges do join ridges, and valleys do join valleys and at the point of junction their spacing is 0. In spite of these shortcomings, the use of grain as the first measure of the system is better than choosing some pre-determined size for the sample area.

(2) Relief - Relief is merely the difference between the highest and lowest elevations within a unit area and is usually referred to as "local relief." The size of an area on which local relief should be computed has always been questionable. When grain size, which is determined by the surface itself, is used to delimit the unit areas, confusion resulting from the interpretation of local relief is eliminated, because relief based on grain size remains quite constant over large areas.

In the case of the Vosges, which furnished the data for Figure 2, the grain is spoken of as "3" because the knick point occurs at the 3-mile diameter. Computing the relief of areas smaller than 3 miles in diameter in the Vosges will produce results which would have great variation among them. Relief values computed on areas larger than 3 miles in diameter would be representative, it is true, but some meaning would be concealed, since equally stable values of relief will occur on areas which are 3 miles in diameter.

(3) Average elevation - The general height of a land surface above sea level is described as the average elevation. It is obtained by finding the mean elevations of a number of random points. In this study, 9 points selected from all parts of a sample circle were found to produce adequate results. Besides furnishing a piece of descriptive information, average elevation is necessary for solving an equation which expresses another terrain element, the elevation-relief ratio.

(4) Elevation-relief ratio - The relative proportion of upland and lowland within an area is expressed by the elevation-relief ratio. This measure is derived from the equation: $ER = \frac{E - L}{R}$ where ER is the elevation-relief ratio; E is the average elevation of the sample; L is the lowest elevation within the area; and R is the relief of the area. Because the average elevation minus the lowest elevation can approach the relief in value but never reach it, the elevation-relief ratio must always be greater than 0 and less than 1.

Two areas may have the same relief, grain or other features, and yet be quite dissimilar in appearance, due to their different ER's. Figure 3 illustrates three land surfaces, all having the same relief, but different ER's. In 3a the ER is .90 and shows that in such cases the flatland is located on divides, and valleys are likely to be steep. Figure 3c represents an area with broad, open valleys and widely spaced, isolated hills; ER in this case is .20. Figure 3b indicates an intermediate case, ER .50, with sharp crests and deep valleys.

The examples in Figure 3 typify the landscapes that are usually associated with these particular elevation-relief ratios. However, it would be possible to have landscapes with both flat summits and flat valleys yielding identical ER's, but the proportion of upland and lowland would be the same as that in the cases illustrated.

(5) Average slope - As yet, no quick method has been devised for obtaining the data needed to describe the statistical and spatial distribution of slopes within an area. Therefore, the only indication of the angle at which the surface departs from the horizontal is the average slope.

A measure for average slope is obtained by drawing traverses across the area in several directions, counting the number of contours which cross these traverses, and computing the slope tangent by the Wentworth equation (5): $S \tan = \frac{I \times M}{3361}$, where S tan is the slope tangent; I is the contour interval in feet; and M is the number of contours crossed per mile of random traverse. When traverses are confined to an area indicated by grain size, the resulting slope will be representative, as far as an average can be representative. To compute the average slope of the terrain represented on World Aeronautical Chart 231, the traverses along which the contours were counted were four diameters of circles drawn at grain size (east to west, northeast to southwest, north to south and northwest to southeast).

(6) Slope direction changes - Slope direction changes denote the dissection of an area and are another expression of topographic texture. Whereas grain connotes the spacing of the major ridges and valleys, slope direction changes indicate all the fluctuations of configuration along a line of random traverse. If one were to walk a straight compass course over the surface of the earth, a slope direction change would be encountered every time the route altered from an uphill to a downhill direction, or vice versa. On a topographic map, direction changes are identified at places along a line of random traverse where the traverse line cuts off loops of contour lines, crosses streams and crosses troughs lying between two ridges. (Fig. 4)

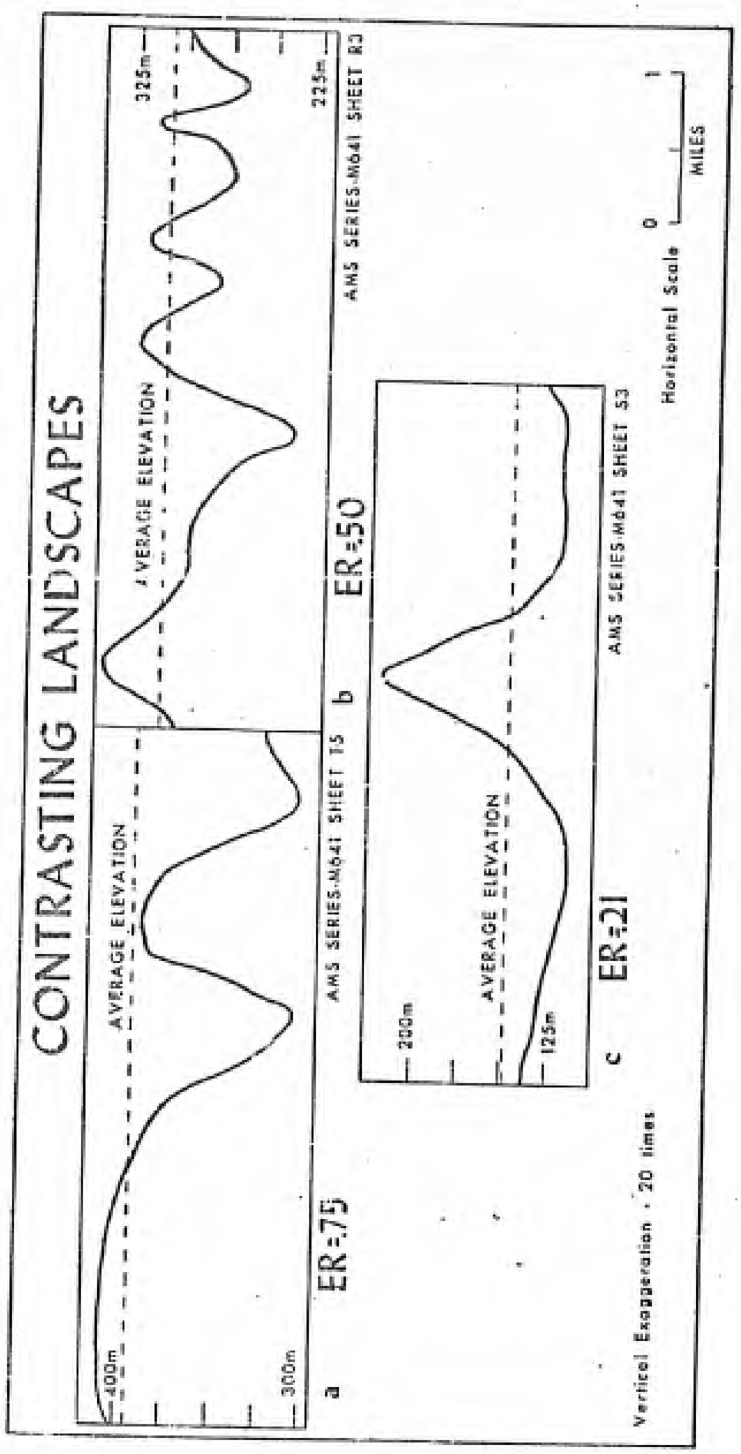
CONTRASTING LANDSCAPES
AVERAGE ELEVATION
400m
300m
ER:75
a
AMS SERIES-M641 SHEET 75
AVERAGE ELEVATION
325m
225m
ER:50
b
AMS SERIES-M641 SHEET 83
200m
AVERAGE ELEVATION
125m
ER:21
c
AMS SERIES-M641 SHEET 53
Vertical Exaggeration - 20 times
Horizontal Scale
0
1
MILES

Figure 3

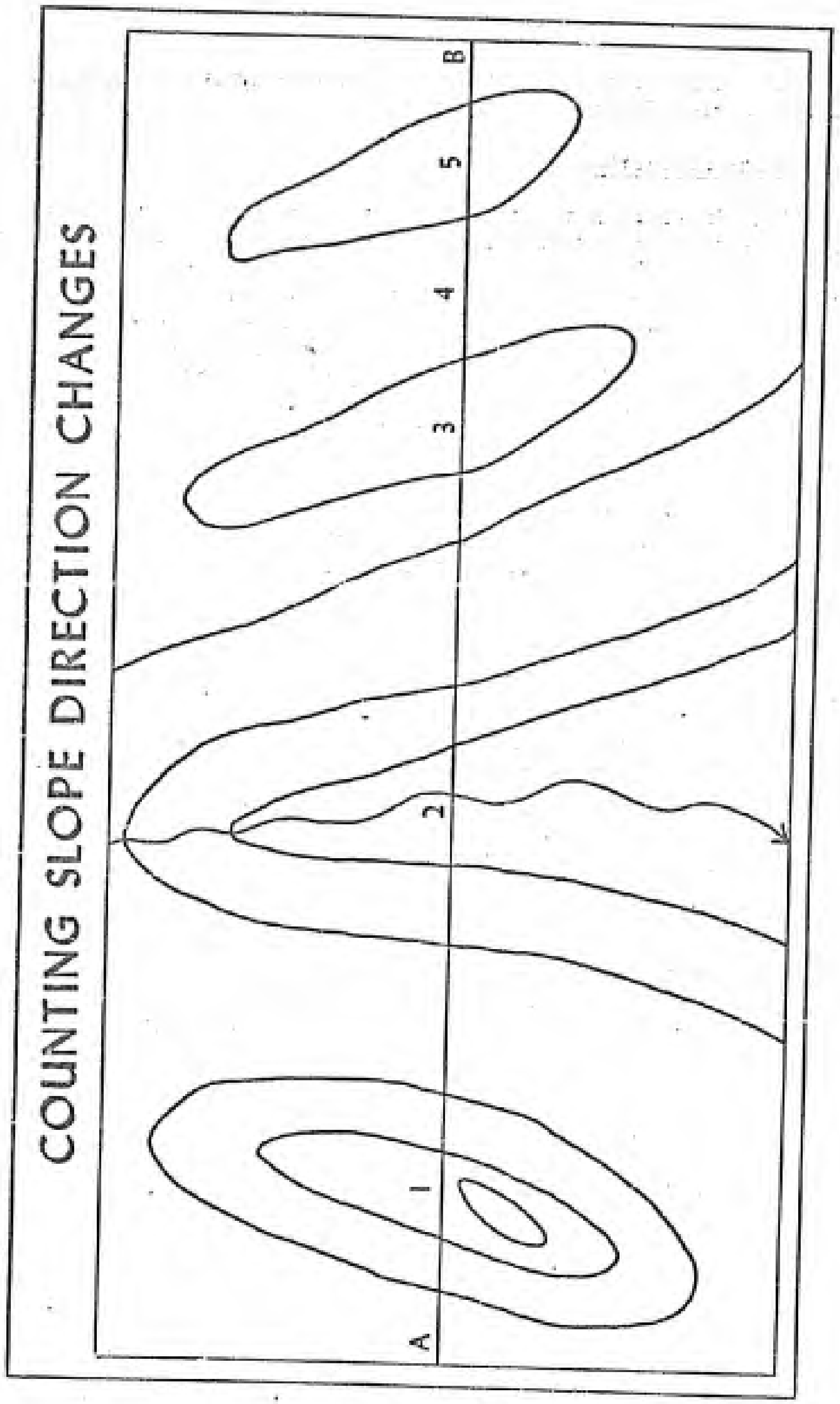

Figure 4

For this study, slope direction changes were measured along the same traverses used for counting contours.

c. <u>Index of terrain</u>

The six terrain factors discussed above constitute a realistic index of terrain characteristics which indicates the distance between the major ridges and valleys, the degree of dissection, the general elevation, the relief, the average slope, and the relative proportion of upland and lowland within an area. Similar data could be gathered for other areas, recorded by machine methods, and conveniently stored to be available for reference at any time. There is no room for misinterpretation in this system, a fact which makes it possible to compare one area with another, regardless of the distance between them.

The Central European data were arranged as a code and recorded on EAM cards. Space was allowed on each card for sample identification, also in code, designating the map sheet of AMS 1:100,000 and the location of the sample on that sheet. An example of one of the data cards is as follows:

EAM column number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Terrain data	1	5	0	5	1	2	1	8	1	6	0	3	1	8	2	2	4	7

<u>Column</u>	<u>Terrain Feature</u>	<u>Unit of Measure</u>
1-3:	Identification of map sheet in the series	
4:	Identification of sample on the sheet	
5-6:	Physiographic province	
7-8:	Average elevation	(hundreds of feet)
9-10:	Relief	(hundreds of feet)
11-12:	Grain	(miles)
13-14:	Average slope	(degrees)
15-16:	Slope direction changes	(number per 10 miles of traverse)
17-18:	Elevation-relief ratio	(2-digit percent)

An observer investigating this particular card could, in addition to locating the sample in the Vosges Mountains, determine that the general altitude of the land is 1,800 feet, local relief is 1,600 feet, major ridges and valleys are 3 miles apart (grain), average slope is 18°, a change of slope direction is encountered 22 times in 10 miles of cross-country traverse (in other words, 11 ridges and 11 valleys will be crossed), and that the elevation-relief ratio is 47% (that is, the proportion of hilltops to valley bottoms is about equal, with slightly more of the surface comprising valleys).

In contrast to the above quantitative description, a qualitative account of the same sample might read: "The area lies at high elevations in the Vosges Mountains of France. It is greatly dissected with steep slopes and narrow valleys and has strong local relief."

3. Landform classification

a. Regional basis

Geography is often studied on a regional basis whereby different areas of the world are grouped into homogeneous units according to similarity of vegetation types, climate, soils, landforms, political units, economic traits or some other unifying characteristic. Physiographers also divide the earth into physiographic provinces, regions which exhibit similarity of topographic features. In the past, these regions have usually been described in qualitative terms.* However, it is possible to group areas into homogeneous landform regions according to quantitative measures derived solely from topographic maps. This was done for the area of Central Europe represented on World Aeronautical Chart 231. The six terrain characteristics described in the first part of this report were the criteria for establishing regional boundaries.

b. A quantitative system

(1) Maintaining objectivity of the system - Each of the 413 samples cited above was located, and its terrain data recorded, on an overlay of World Aeronautical Chart 231. The chart was then put aside so that the analyst was confronted with only a sheet of tracing paper marked with 413 dots and an index of six terrain factors accompanying each dot. With this information alone, boundaries were to be drawn grouping all samples which exhibited similar topography.

* With the exception of Hammond (1) who devised a quantitative classification of landforms for use in drawing small-scale landform maps.

It was anticipated that during the grouping process, samples would be found to agree with one another in some features but not in others. For instance, it might happen that two samples would agree in slope and grain, but relief would be radically different. Would these two cases belong together or should they be separated? To maintain the objectivity of the grouping system, a "relative importance" was attached to each of the six factors. It must be remembered that every individual terrain factor is an important contribution to the differences existing among landscapes, but some factors make more significant contributions to these differences than others. It is the combination of all factors which distinguishes one area from another, for often certain single dimensions may be identical for widely contrasted landscapes. Another consideration, when weighing the relative values of factors, is the reliability of measurements. A measurement based on a single random point may produce an extreme or accidental case, whereas measurements involving many points or lengthy traverses become more reliable. Evaluation of these facts led to the selection of significant values as a guide for grouping as follows:

1. Average Slope - considered the feature most likely to distinguish one area from another; measurements taken on traverses in all directions were regarded as very reliable. (Significance value: 6)

2. Grain - the basis of sample size and a feature which also greatly distinguishes one area from another. (Significance value: 5)

3. Average elevation - less significant than either of the above, since it is possible to have both plains and mountains lying at the same elevation. However, it was considered a reliable measure, since a number of random points went into the calculation. (Significance value: 4)

4. Slope direction changes - the accuracy of this measure would be limited by contour interval and precision of drafting, hence it is placed lower on the scale. (Significance value: 3)

5. Relief - the most accidental measure, since it is based on a single random point. For individual samples it was considered of minor importance. (Significance value: 2)

6. Elevation-relief ratio - derived in part from a relief value, it too is subject to variation and thus least likely to represent an individual sample. (Significance value: 1)

Thus, if two adjacent samples were alike according to all six dimensions of the classification system, they would be similar at a total significance value of 21(6 + 5 + 4 + 3 + 2 + 1 = 21). If they were alike only with regard to slope and grain (6 + 5), the significance value would be 11.

One other preliminary consideration, before actual grouping took place, was to divide the values of the various factors into classes. Class intervals were selected in accordance with the range and distribution of the various values. The following classes were appropriate for the Central European data. However, data from another area having a different range and distribution of values, might more logically be divided into different intervals.

Class intervals for 6 terrain factors - Central European data

AVERAGE SLOPE	GRAIN	AVERAGE ELEVATION	SLOPE DIRECTION CHANGES	RELIEF	ELEVATION-RELIEF RATIO
(degrees)	(miles)	(feet)	(*)	(feet)	(percent)
0-3	2-4	0-500	0-9	100-500	0-9
4-7	5-7	600-1100	10-19	600-1000	10-19
8-11	8-10	1200-1700	20-29	1100-1500	20-29
over 12	11-13	over 1800	over 30	over 1600	30-39
	over 14				40-49
					50-59
					60-69
					70-79

* Number per ten miles of traverse

(2) Grouping the samples - "Core areas" were delineated whenever three or more adjacent samples agreed as to slope, grain and average elevation (significance value: 15). Thirty-one small homogeneous areas were distinguished in this way. When located on a topographic map, it was found that these cores were coincident with prominent landform regions such as the Vosges Mountains, Haardt Mountains and Baltic Plain.

Taking into consideration the relative importance and significance value of the six terrain factors, the remaining samples were attached to analogous core areas. The majority of cases were so well-defined that placement with the appropriate core could be decided on the basis of slope, grain or average elevation alone. For example:

Sample A lies between Cores I and II

	Core I		Sample A		Core II
Slope	0 - 3 (6)	←	3		4 - 7
Grain	8 - 10 (5)	←	8	→	8 - 10 (5)
Av. Elev.	6 - 11		5		6 - 11
Significance:	(11)				(5)

Sample A is joined to Core I

Sample B lies between Cores III and IV

	Core III		Sample B		Core IV
Slope	over 12 (6)	←	13	→	over 12 (6)
Grain	5 - 7		3	→	2 - 4 (5)
Av. Elev.	over 18 (4)	←	19		12 - 17
Significance:	(10)				(11)

Sample B is joined to Core IV

There were cases, however, when it was necessary to evaluate all six factors before conclusively deciding where a sample rightly belonged. Such a case might be:

Sample C lies between Cores V and VI

	Core V		Sample C		Core VI
Slope	0 - 3 (6)	←	2	→	0 - 3 (6)
Grain	8 - 10		11		5 - 7
Av. Elev.	12 - 17 (4)	←	13	→	12 - 17 (4)
Sl. Dir. Ch.	0 - 9 (3)	←	8		10 - 19
Relief	6 - 10 (2)	←	6	→	6 - 10 (2)
ER	20 - 29		34	→	30 - 39 (1)
Significance:	(15)				(13)

Sample C is joined to Core V

When the grouping of samples was completed, 25 distinct regions were delineated. Some of the original core areas coalesced to cover a larger area. Three regions were delimited, not on the basis of a core, but rather on a dissimilarity with surrounding regions. These were the Slate Mountains, Harz Mountains and the transition zone between the Baltic Plain and Bohemian Mountains.

(3) Landform regions map - The final drawing of actual boundaries between regions was accomplished by placing the work sheet, outlining the core areas with their satellite samples, over the World Aeronautical Chart. Regional boundary lines were drawn in accordance with contour lines on the chart. A closer network of samples would no doubt eliminate this reliance on an existing map, but it is difficult to judge just where a demarcation would actually occur between two unlike sample points 20 miles apart. The six terrain factors were averaged for each region and the mean values of these recorded. (Table I and Fig. 5)

c. Comparison with qualitative systems

The above map of landform regions compares favorably with previously-drawn physiographic maps of the area. (Fig. 6) Lobeck's (2) nine physiographic provinces are easily distinguished and the subprovinces to which he refers, but does not demarcate, are obvious. Also, the 25 regions derived from quantitative measures are practically identical to Van Valkenburg's regions.(4) The only noteworthy discrepancy among the systems is that the Odenwald is not defined on the quantitative map. Because the Odenwald is a small area, it was not isolated by the coarse sample net which was used.

Table II shows the generic comparison of these two qualitatively described systems with the regionalization based on the quantitative system. The quantitatively-described regions have been named in accordance with accepted terminology. For the additional regions, distinguished by the new system, other well-known appelations have been applied.

4. Conclusion

A quantitative system for realistically describing landforms has been proposed, and it has been demonstrated that this system can be used to identify homogeneous landform regions. Techniques, to obtain precise numerical terrain data, have been devised; the objectivity and accuracy of these techniques offer proof of the merits of a quantitative approach to terrain study.

The similarity of the quantitatively-described landform regions with those based on qualitative criteria is further evidence of the

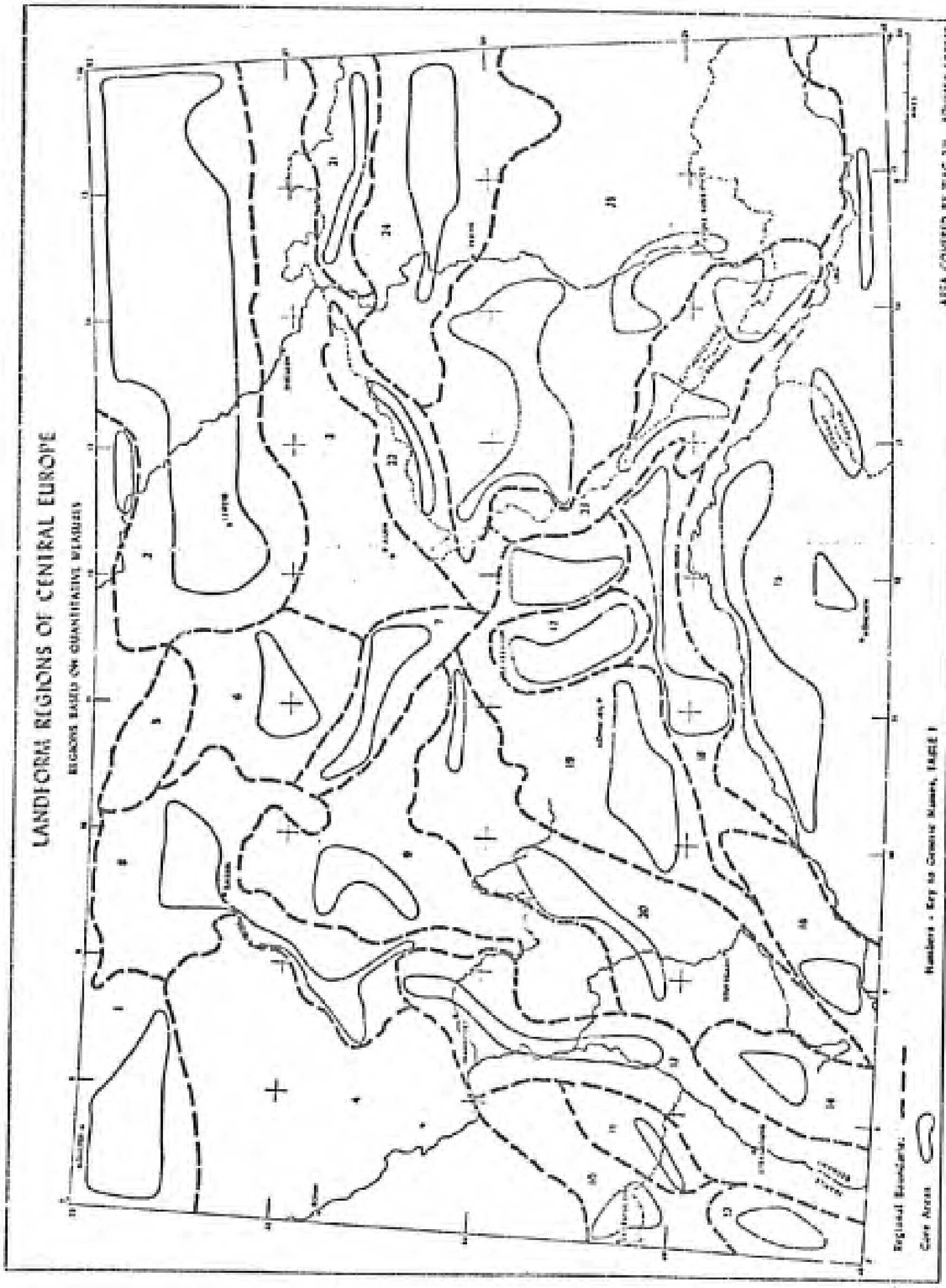
LANDFORM REGIONS OF CENTRAL EUROPE
REGIONS BASED ON QUANTITATIVE MEASURES

Figure 5

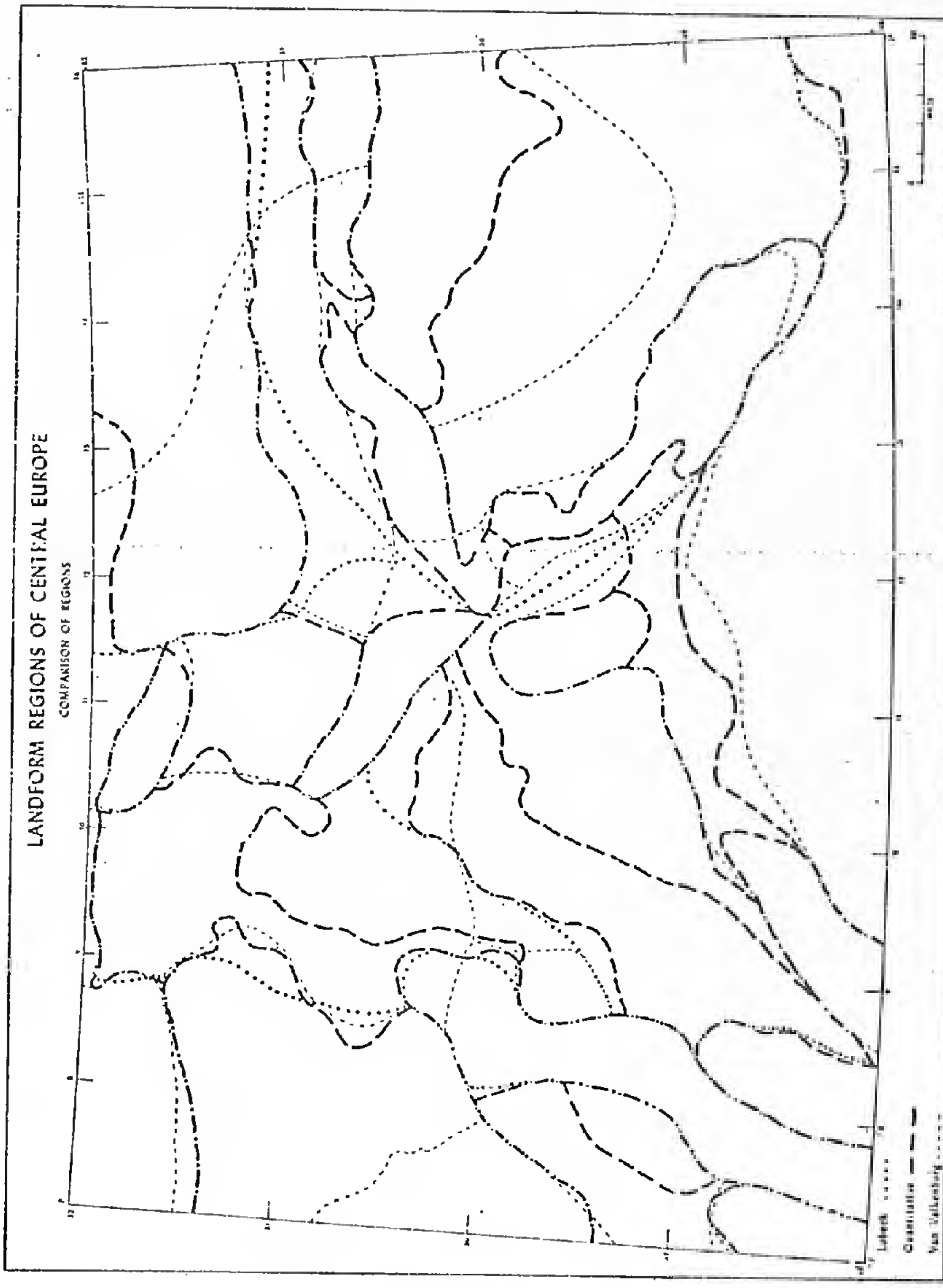

Figure 6

TABLE I

QUANTIFIED TERRAIN DATA FOR 25 LANDFORM REGIONS OF CENTRAL EUROPE

Region	Average Slope (degrees)	Grain (miles)	Average Elevation (feet)	Slope Direction Changes (*)	Relief (feet)	Elevation-Relief Ratio (percent)	Number of Cases
1. Münster Plain	1	14	300	4	400	24	14
2. Saxonian Lowland	1	9	400	5	300	35	40
3. Saxonian Upland	4	7	1200	12	700	45	22
4. Slate Mountains	8	6	1200	17	1000	45	32
5. Harz Mountains	7	9	1500	17	1500	51	4
6. Thuringian Basin	3	10	800	11	700	40	9
7. Thuringian Forest	10	3	1700	22	1000	45	7
8. Hessian Lowlands	5	9	900	14	900	38	25
9. Hessian Highlands	7	6	1300	13	1100	44	17
10. Palatinate Upland	5	6	1000	16	600	50	6
11. Haardt Mountains	13	6	1000	27	1000	36	4
12. Vosges	18	3	2200	23	1900	53	[illegible]
13. Rhine Graben	1	9	500	4	400	24	10
14. Black Forest	12	3	2200	18	1400	56	6
15. Bavarian Basin	3	6	1400	10	400	40	50
16. Swabian Jura	9	6	2300	15	900	57	6
17. Franconian Jura	6	6	1500	15	700	42	6
18. Jura Uplands	5	6	1600	12	700	42	12
19. Frankenhöhe-Steigerwald	3	7	1300	10	500	37	19
20. Main-Neckar Basin	5	6	1100	14	700	47	22
21. Sudetes	9	3	1800	17	1200	40	10
22. Erzgebirge	9	4	2000	17	1100	53	5
23. Bohemian Forest	8	3	2400	14	1200	45	11
24. Bohemian Basin	2	6	900	8	400	36	17
25. Bohemian Plateau	4	4	1600	15	600	43	55

* Number per 10 miles of traverse

TABLE II

COMPARISON OF REGIONS, GENERIC TERMS

QUALITATIVE: Lobeck	QUALITATIVE: Van Valkenburg	QUANTITATIVE
1. Baltic Plain		
Münster Basin	1. Münster Plain	1. Münster Plain
Cologne Basin	2. Harz Foreland	
Leipzig Basin	3. Saxonian Lowland	2. Saxonian Lowland
	4. Southern Moraine Zone	
	5. Saxonian Upland	3. Saxonian Upland
	6. Sudetes Foreland	
2. Slate Mountains		4. Slate Mountains
Hunsruck	7. Western Rhine Upland	
Taunus		
Westerwald	8. Eastern Rhine Upland	
Steigerwald		
3. Highlands of Central Germany		
Harz Mountains	9. Harz Mountains	5. Harz Mountains
Thuringian Basin	10. Thuringian Basin	6. Thuringian Basin
Thuringian Forest	11. Thuringian Forest	7. Thuringian Forest
Hessian Highlands	12. Hessian Depression	8. Hessian Lowland
		9. Hessian Upland
4. Paris Basin	13. Palatinate Upland	10. Palatinate Upland
		11. Haardt Mountains
5. Vosges	14. Vosges	12. Vosges
6. Rhine Graben	15. Upper Rhine Valley	13. Rhine Graben
7. Black Forest	16. Black Forest	14. Black Forest
Odenwald	17. Odenwald	
8. Bavarian Plateau		
Basin of Bavaria	18. Alpine Foreland	15. Bavarian Basin
Swabian Jura	19. Jura Upland	16. Swabian Jura
Franconian Jura		17. Franconian Jura
		18. Jura Uplands
Frankenhöhe-Steigerwald	20. Triassic Depression	19. Frankenhöhe-Steigerwald
		20. Main-Neckar Basin
9. Bohemian Massive		
Sudetes	21. Sudetes	21. Sudetes
Erzgebirge	22. Erz Mountains	22. Erzgebirge
Bohemian Forest	23. Bohemian Forest	23. Bohemian Forest
Bohemian Basin	24. Bohemian Basin	24. Bohemian Basin
	25. Bohemian Plateau	25. Bohemian Plateau

validity of quantitative analysis and demonstrates the usefulness of earlier geographic work. Even though geographic elements are now being expressed in numerical terms, the work that has been done on a qualitative basis should not be overlooked. The feasibility of delineating landform regions by quantitative measures supports the theory that a few randomly chosen samples from homogeneous areas, already identified by physiographers, will produce adequate information about the region as a whole.

Although this system of classifying landforms has been applied to Central Europe, all the methods and techniques described could be applied to other areas of the world as well.

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