WILEY

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Author(s): Alan G. Ogilvie

Source: *The Geographical Journal*, Vol. 45, No. 1 (Jan., 1915), pp. 46-61

Published by: geographicalj

Stable URL: <http://www.jstor.org/stable/1779985>

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CARTOGRAPHIC NEEDS OF PHYSICAL GEOGRAPHY.*

By ALAN G. OGILVIE.

THE increasing demand for sound regional descriptions induces the geographer to take stock of the cartographical documents of all kinds which exist to aid him in his task of writing these descriptions, and to aid people in general in reading them. As is well known, geography draws its material from the results of researches in many branches of science. The present paper is an attempt to discover to what extent these results—in so far as they affect physical geography—are expressed in maps; and to suggest ways in which the various sciences might farther assist geography by the more frequent employment of cartography.

TOPOGRAPHIC MAPS.

In the description of the surface relief of a region the aid of the topographic map is required. The representation of relief on topographic maps has recently been discussed by Captain Lyons† at a meeting of the Society and there is no need to enumerate here the various methods adopted on existing maps. There are, however, several points which it seems worth while to emphasize concerning the value of these maps to the student and teacher of physical geography. It must of course be recognized that the main object of official survey departments is and must be the publication of maps which will meet the requirements of the greatest number of interests—military, landed, travelling, etc.—in the country. The result of this is that features of special interest to physical geography are frequently obscured, or are indistinctly shown in order that they may not obscure other features.

ORDNANCE SURVEY MAPS.

This state of affairs exists in many countries. Let us consider the case of the Ordnance Survey maps of the British Isles, and the way in which they may be put to better use for the purpose in view.

We have in this country probably a greater number of different editions of official maps than is to be found in any other. Each of those editions has some special merit which makes it the best edition for some particular purpose. In nearly every case, however, editions are withdrawn from sale when superseded. I would urge strongly the advisability of making all old editions available for geographical work, and I believe that, so far as the maps were actually published, this could be done with little, if any, expense to the Government. Two illustrations must suffice to show the need for this reform.

For the study of physiography the wideness of the 100-foot contour interval of our maps renders the hachuring of the greatest importance.

* Royal Geographical Society, July 2, 1914.

† *Geographical Journal*, vol. 43, p. 233.

The subsidiary and frequently indistinct nature of this in the recent lithographed maps, however, compares most unfavourably with the clear and beautiful hachures of the old engraved map, at any rate in the majority of the sheets. For this reason the engraved map, preferably with hachures in brown, should be kept accessible to all.

Again, in regard to layered maps on the half-inch scale the Ordnance Survey have been met with the difficulty of finding a colour scale suitable to all sheets, and have now arrived at a scheme based on that of the International Map. If a sheet showing moderate relief be selected from the new edition—*e.g.* in S. England—and compared with the map recently withdrawn, which had a different colour scale and in addition a stippled hill-shading, it will be found that the latter gives a far clearer conspectus of the relief than the current edition. That the old edition was unsatisfactory for countries of greater altitude and relief does not seem to me a sufficient reason for withdrawing, at any rate, the sheets covering areas of moderate altitude and relief where it is for many purposes the best map which has appeared on the scale. If the features which are due to man have had to be altered on the new map, the old map might before being sold receive a stamp to indicate that those features are not up to date.

The teaching of physiography in this country is greatly hampered by the high price of the official maps. The most which has been done up till now to make these maps more accessible, is the provision that a large number of copies of any sheet may be sold to schools at a reduced rate. It is probably impossible at present to reduce the general cost of Ordnance maps to a price approximating, for instance, that of the excellent topographic sheets of the United States Geological Survey. And yet it would seem to be a relatively easy matter to get over the difficulty by procuring the publication of selected sheets in the form of an atlas of typical landforms. It is a duty of the Geographical Societies of this country to procure the publication of such an atlas, and to ensure that it be accompanied by a satisfactory descriptive text. It is greatly to our shame that at present we have to turn for such documents to Germany and to the United States. While the materials now existing are quite sufficient for the publication of an atlas on the 1-inch scale, there are many types of landform which it is most advisable to include in such an atlas, but which cannot be shown on this scale. I suggest that the sheets of the "6-inch" scale of the Ordnance Survey on which the land features occur should have contour lines inserted sufficiently closely to illustrate the special features. In some cases an interval as small as 5 feet would be necessary, though in most cases 20 or 25 feet would be sufficient. The Ordnance Survey should be asked to do this contouring, as it would probably cause little trouble in districts where survey parties were in the vicinity. Wherever such work cannot be done officially the Geographical Societies should have it done by qualified persons.

In the case of coastal regions the co-operation of the Admiralty would be necessary, as it is most desirable to show the sea bottom by the same

method as that adopted for the land. Some idea of the scheme suggested may be gained from Fig. 1. It shows two overlapping wave-built forelands formed during a period of interrupted uplift. The contours in this case are approximate.

There is one other means by which the Ordnance Survey might greatly assist the study and teaching of physical geography in the future. The obscuring of one element by another in the complete colour-printed map has been referred to. It would be a great boon if it were possible to obtain the prints from each colour separately or copies showing a combination of printings, but without that printing which obscures the features it is desired to emphasize. It would appear that the only difficulty in the way of this being made possible is the increase of maps to be kept in stock.

LANDFORMS.

An essential part of physical geography is the description of landforms in the light of their genetic classification. Physiographers now agree that in order to describe landforms in this manner three things must be known, viz. structure, process, and stage.

The description of landforms, then, will be greatly aided by illustrations which will represent graphically what an author is trying to tell in words. Thus, block-diagrams, which show diagrammatically something of the surface relief and something of the structure, have been much employed in such descriptions in recent years. For some purposes it is desirable to show but one element in each illustration. Let us see to what extent the map may serve this purpose, and consider in turn whether it is possible to have a *structure* map, a *process* map, and a *stage* map.

STRUCTURE.

The structural features which influence the landforms are two, first the chemical and physical composition of the rocks—*e.g.* as in clay, limestone, or basalt; and secondly the posture of the rocks relative to the surface and to one another, *e.g.* horizontal, tilted, folded or faulted.

We naturally look for such facts upon geological maps. Do we find them there? and if so, are they in the most suitable form for use in explanatory description of landform? These are questions which we have to answer.

Geological maps are of two main kinds. The first, which is by far the less common, is a diagram showing tectonic lines—axes of anticlines and synclines, faults, directions of overthrusting, etc. Most of such data are of great importance in the discussion of landforms, they help to show the posture of rocks, and must therefore be included in the structure map.

The second type of geological map is much more familiar. It shows the distribution on the surface of the outcrop of rocks of different ages. By referring to the index, as a rule, the reader of such maps can discover no clue to the chemical and physical composition, *i.e.* the lithological

Fig. 1.

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character of the rocks.* The igneous rocks are an exception to this, and occasionally a sedimentary rock receives a name which is of direct use in this connection, *e.g.* Old Red Sandstone. But, generally speaking, the names convey no clue to the nature of the strata. They will be found to be classed as "Silurian" or "Ordovician" because rocks of similar age were first examined in the districts of certain Welsh tribes so named, or as 'Permian' because rock of the same age occupies extensive areas near *Perm* in Russia, or again as "Trias," so called from its *three* members—only two of which exist in Britain—or as "Tertiary," because the rock was formed in the *third* of the great geological epochs. No more need be said to show that these geological terms culled from so many sources have no geographical significance, since two rocks bearing the same name in different regions may be as different as black is from white. And yet the English student beginning geography is led, by the inaccessibility of lithological information, to assume for instance that a rock named "Silurian" since it is old must also be resistant; and he finds it difficult to believe in the existence of weak Silurian clay near St. Petersburg.

In order to discover what is the lithological nature of the rocks one must have a detailed geological knowledge as well as a geological map. This may reasonably be exacted from advanced students of geography *in their own country*; but for the help of beginners at home and of all foreign students we must have a short cut to this knowledge. In other words, we must have a lithological map. If we make one for our own country we are doing only what we should like people abroad to do for us. For who is there among us who, desiring to study the surface form—say of Italy—would not save himself the trouble of reading much Italian geology by simple reference to a lithological map?

Maps showing rock type might of course be made on any scale; but probably the most generally useful would be on small scales such as 10, 16, or 25 miles to one inch. Of course, as the scale gets smaller more generalization becomes necessary, and in many cases the determination of rock type becomes arbitrary. In spite of this, I believe the map would be of the greatest service to teachers and students of geography at home and abroad, as well as to foreign geologists.

The following are the chief elements of the map required:—

(1) The broadest classification of rock types would be essential, *e.g.* limestone, sandstone, clay, granite, schist, etc., and, where possible, smaller differences should be indicated, *e.g.* between oolite and chalk.

(2) It should be a "drift" map in districts where the rocks are concealed by drift; it is as a rule of greater importance to the geographer that the drift be shown rather than the rock which underlies it.

If the map were not too crowded it should have other features of structure

* This is, of course, true mainly in the case of the smaller-scaled maps—the ones which are most used for geographical purposes. In such maps generalization of rock-type is necessary.

EAST YORKSHIRE, GEOLOGY. *Fig 2*

added, and might then be termed a structure map. These features are chiefly (1) the main lines of faulting; and (2) the direction and angle of dip of strata.

A portion of the map of Yorkshire drawn on such lines is given in illustration of the above. It is to be regarded only as approximately accurate.

Before leaving the more geological aspect of the paper it may be well to refer to two closely allied subjects which involve investigations by the geologist, researches which would throw considerable light on the origin of our landforms, and of which the results—if they were sufficiently definite—might well be expressed on maps.

The first task we should set is a determination of the permeability of the various rocks, which might result in a map with rocks tinted according to a scale of porosity. The second task is more difficult to perform, viz. to determine the degree of resistance of various rocks. In this case it is often said that an orographical map of a country gives a fairly accurate conspectus of the relative resistance of rocks. But it will be seen that this is not the case, if we take into account the possibility of various districts representing different stages in the cycle of erosion, a condition which may be produced by the greater uplift of one district than another.*

PROCESS.

The mapping of areas which are undergoing different processes of erosion or deposition would be profitable for certain purposes, and especially so in teaching. It is frequently the case that more than one geological process is at work on a region at one time, and in nearly every case existing landforms are to be traced to a number of these processes, which have acted in the past either simultaneously or successively. Thus it is difficult to determine whether a district should be shown as subject to river action, ice action, frost weathering, wind action, and so on. It will probably be best to select the process which seems to have had the greatest effect on the land, and since so much simplification is necessary the "process" map should take the form of the small-scale diagram of the continents or large portions of them. We have what practically answers this description in one of the Oxford Wall Maps, showing the distribution of "deposition and erosion" over the Earth.† Such facts might be expressed on somewhat larger scales than in this map, but between wall diagrams and maps on the scale of about 1:100,000 such mapping would be unprofitable. Its treatment on large-scale maps will be dealt with below.

STAGE.

We now come to the representation of the third element in physiography, namely the stage reached by a land surface in the cycle of its development,

* See note at the end of the paper.

† This map was based largely on the maps in Berghaus's Atlas.

EAST YORKSHIRE, LITHOLOGY. Fig 3

where certain processes are acting upon certain structures. Physiographers are not yet in complete agreement as to the exact features which shall define the various stages—young, mature, and old—in the case of lands affected by the various processes. Physiography and geography are greatly indebted to W. M. Davis for his clear definition and arrangement of this whole subject; and though his method still has its opponents, it seems likely that some classification such as that adopted by him in his recent work * will eventually be upheld. When a uniform system has been adopted and the lands examined in the light of it, it will be a simple matter to plot the areas on maps. But as in the case of “process” it will not be profitable to do so on all scales. Thus we might tint an ordinary atlas map of England so as to show the lowland of the Oxford clay as a peneplain and the oolitic upland as a maturely dissected plateau. It will, however, be more profitable to consider all the land together which has undergone the same process for the same length of time, and this larger area may be mapped as mature as a whole, though its resistant rock surfaces may be young and its weak rock surfaces old. As in the case of “process” then the maps of “stage” should mainly be small-scale diagrams.

LANDFORM MAPS.

While maps of the last two classes must probably be very limited in their uses, there would be general recognition of the value of some forms of maps showing the distribution of landform types, where structure, process and stage have been taken into account in examining the features. The writer would advocate the construction and use of two types of diagrammatic maps of landform. The one small-scaled, the other large-scaled.

(a) *Small Scale*.—To appreciate the value of the small-scaled map let us consider a concrete case.

Let us suppose, for example, that we wish to find out from the maps of Russia what are the main physiographical features of that land. A geological map shows us that rocks varying in age from the pre-Cambrian to Tertiary crop out in very irregular belts extending generally from north-east to south-west, with the oldest on the north-west and youngest on south-east. We have no lithological map. We must therefore go to geological books, some of them in Russian, to get a satisfactory account of the nature of these rocks of varying age.

If we now examine an orographical map of Russia we find that in spite of the great variety in the ages of the rocks, and presumably in their lithological character, the land is not far removed from being an immense plain. We are therefore probably justified in assuming that this is a peneplain. To obtain confirmation we may look at large-scale topographical maps such as the Russian map 1 : 126,000 or the Austrian map 1 : 200,000.

* ‘Die Erklärende Beschreibung der Landformen.’ 1912.

If we examine sheets which show any of the great southern rivers we shall probably find that these are flowing in valleys with entrenched meanders, and with the spurs more or less truncated and flood plains more or less developed according as the rivers are greater or smaller. It is now apparent that we are not dealing with a peneplain, but with a dissected and probably therefore uplifted peneplain. But if before leaving the topographical maps we glance at sheets showing the mouths of these same rivers, we find that arms of the sea enter the valleys, and that these estuaries are practically shut off from the open sea by sand bars. In other words, this *liman* coast of South Russia tells us of subsidence of the land—or, at any rate, of a raising of the base-level of erosion with regard to the land. Thus, by examining various maps we may arrive at a simple and explanatory description of physical features which, though slight, yet determine in large measure the routes and settlements in much of Russia in Europe—viz. *a peneplain somewhat uplifted, tilted, and dissected, with its southern edge slightly submerged.*

Now, this deductive process is undoubtedly educative, but I submit that it should not be necessary for every one to go through it in the case of all known lands of the Earth. Moreover, the conclusion reached may be wrong. When satisfactory information has been obtained as to the land-forms of a region—not, of course, by the method just described, but on the ground—it ought to be recorded in a form which admits of easy reference. The most concise form is the map; and the physical atlas of the future ought, I believe, to give maps of this character for all lands of which the physiography has been described.*

(b) *Large Scale.*—The identification of landforms on large-scale maps can never be completely satisfactory even on the very best contoured and hachured maps. But when the true nature of the features and their origin have been investigated on the ground, the results of the work ought to be expressed on a map so that any one can recognize the landforms with the help of the map. Two sheets of a map of this kind have recently been published by A. Allix, to accompany a study on Alpine landforms.†

On these sheets the French 1 : 80,000 map is taken as the basis. This map, it will be remembered, shows the relief by black hachuring without contours. Over it are printed a number of conventional signs of different forms and colours to distinguish the special landforms which are described in the memoir. The colours are selected according to the process to which the feature is due, and the shape of the conventional sign bears a general

* Since the above was written, the first part of a new systematic atlas of Europe has appeared ('Methodischer Atlas zur Länderkunde von Europa,' by Dr. Max Friederichsen, pub. Hahn, Hannover and Leipzig, 1914). The first part happens to deal with Russia. On Plate I. a "morphological-tectonic" map is given. It is practically a tectonic map distinguishing mountains and plains dating from different geological periods. There is no map such as I have described.

† "La Morphologie Glaciaire en Vercors," in 'Receuil des Travaux de l'Institut de Géographie Alpine,' vol. 2, Pt. I., 1914.

relation to the landform to which attention is to be directed. Thus by signs of various shapes printed in *blue* we have certain features attributed to *solution* and identified as grikes, swallets, polyes, etc., or again, the signs in another colour direct our attention to drumlins, moraines, ice-worn troughs and thresholds, etc. In reading these maps it is advisable to have copies of the hachured map without overprinting, as the signs inevitably mask the relief to some extent. For this reason it might be well if the map or diagram bearing the conventional signs were issued as a separate print on transparent paper, which might be laid over the ordinary topographic map.

These two sheets, by their clearness and by the great help which they give in reading the description they illustrate, prove definitely that there is room for such large-scaled landform maps.

HYDROGRAPHY.

Some of the most useful documents in the study of British regional geography are the Memoirs of the Geological Survey on Water Supply. More recently these have had included in them accounts and maps of the rainfall of the areas described by the pen of Dr. H. R. Mill, Director of the British Rainfall Organization. Except for the unfortunate fact that the areas dealt with are the extremely unnatural county divisions, these memoirs are, from the geographical standpoint, entirely satisfactory, so far as they go. They would, however, be greatly assisted by maps showing areas supplied by (a) wells, distinguishing those where the wells periodically dry up; (b) surface streams; and (c) stored rainwater. These data might be plotted on an outlined lithological map on which the zones in which water is thrown out could also be indicated.

The representation of surface streams upon large-scale maps deserves consideration. The sources of streams frequently lie at different points at different seasons, with the result that many valleys are wet and dry alternately. In Britain this is mainly true in the pervious rocks, and is due to the raising and lowering of the water-table. These periodic stream courses should be accurately represented on all large-scale maps, at any rate down to the "one-inch" map. At present they are either shown as permanent streams or are left out altogether. The importance of the whole question of river flow in the British Isles is now fully recognized. The small river-basins and the large rainfall of Britain make the study particularly interesting in these Islands. We now await the final report upon the first serious investigation in the matter; but it may not be out of place here to refer to the graphic representation of the results of such work. On all the smaller-scaled maps rivers are shown by the conventional line which thickens gradually from source to mouth. It may not be assumed that the thickness is proportional either to the width of the river or to its volume. It will, I think, be agreed that some method of showing more accurately the average volume of water flowing at any point would be

useful for special purposes, and the comparison of such a map with maps showing river-basins, lithology, rainfall, and evaporation would be of high educational value. To make the thickness of line proportional to volume would in most cases be impracticable, as the lines might give a false impression of the width of rivers. But would it not be possible in such special maps as these, to employ a scale of graded colours such as is used in bathymetrical maps, using the lighter tints for small volume and the darker for large volume ?

CLIMATE.

Meteorologists now provide us with full series of daily, monthly, and yearly charts on small scales, showing temperature, pressure, rainfall, etc. for all countries in which stations exist in sufficient numbers to provide the data. They also provide the valuable pilot charts of the oceans. In countries, then, with great wealth of data, the need for development from the geographer's point of view does not lie in the direction of more mapping of general temperature and pressure conditions reduced to sea-level ; but rather in the more frequent plotting of actual meteorological conditions on our rugged land surfaces. For instance, in our own Islands we require data for the temperature variations and ranges, and rainfall and evaporation records at different altitudes and exposures, in different parts of the country. All such data when obtained should be plotted on large-scale maps, and the generalized maps reduced from these. The scientific value of such maps is greatly enhanced by the close relationship which their lines would have to the vegetation zones now being mapped by the plant ecologists, and it is certain that these two types of map studied together will be of the highest value in determining to what extent the economic regeneration of our waste lands may be undertaken.

GLACIERS.

Glaciers are now recognized as extremely sensitive indicators of climatic change. For this reason alone it would be most desirable that all glaciers be carefully mapped on a large scale (*e.g.* 1 : 10,000) with frequent contours. It is doubly important that this should be done on account of the many scientific problems which glaciology has to solve. In Britain we have no glaciers, but in the British Empire we have ; and we should do all in our power to cause the mapping of the glaciers of Canada, India, and New Zealand on the model of the work already done in the Alps by the German-Austrian Alpine Club. A good beginning has been made by the Canadian Alpine Club, under the able leadership of Mr. A. O. Wheeler, by the New Zealand Geological Survey, and in the Himalaya by several private expeditions. In this task the mountain climber has an opportunity to render a signal service to science.

VEGETATION.

In recent years the mapping of plant associations as opposed to the distribution of species has made great strides. We have a school of plant

ecologists happily as active in Britain as anywhere—who have shown by their work that by more or less generalization, useful vegetation maps can be constructed on any scale. Thus we have “6-inch” maps for special purposes, “1-inch” sheets scattered over Great Britain, the highlands of Scotland on the scale 1 : 633,600, and the vegetation maps of the continents on various scales in the series of Oxford Wall Maps. Geographers should do everything in their power to encourage this excellent cartographical work by the ecologists. In the British Isles means should be sought for publishing the survey on the “1-inch” scale sheet by sheet as soon as the work has been done. It is greatly to be regretted that the Board of Agriculture has not long ago undertaken this work.

SOIL.

In this country the department responsible for topographic mapping is the Board of Agriculture and Fisheries. It is remarkable that British investigations relating to agriculture and fisheries have resulted in so little cartographic representation of data. The scientific study of soils is actively carried on, and it is to be hoped that ere long we may have a systematic soil survey publishing its results in map form. The value of such maps in making agricultural statistics intelligible is evident, and it must be remembered that the ecologist requires a soil map, and at present he must construct his own. Further, the soil map is as essential as the climate and vegetation maps referred to above in discussing the regeneration of waste land. The construction of large-scale soil maps is obviously a matter for the co-operation of the Geological Survey and the Board of Agriculture. The lithological map described above should be studied in conjunction with the soil map to make the latter completely intelligible.

SEA.

In the Government fishery investigations we have a valuable source of oceanographical information, and it is to be hoped that the physical conditions of British waters at different seasons will receive increasing attention in the future, and that the results will receive full cartographical treatment.

SUMMARY.

It may be useful to tabulate the suggestions made above :—

Features shown.

Requirements.

Topography.	(1) Ordnance Survey : maintenance of all editions on sale.
	(2) Ordnance Survey : Sale of separate prints from colour-printed maps.
	(3) Atlas of landform types, “1-inch.”
	(4) Atlas of landform types, “6-inch.”
Landform.	(1) Lithological or structure maps.
	(2) Porosity maps.
	(3) Maps showing degree of resistance.
	(4) “Process” maps, small scale.

<i>Features shown.</i>	<i>Requirements.</i>
	(5) "Stage" maps, small scale.
	(6) Distribution maps of various landform types— (a) as small-scale diagrams ; (b) as large-scale maps.
Hydrography.	(1) Maps showing areas with various types of water-supply. (2) Accurate representation of variable headwaters. (3) Representation on maps of river volume : method suggested —lines on graduated colour scale.
Climate.	Detailed mapping of actual meteorological conditions in different altitudes and exposures in different parts of the land.
Glaciers.	Detailed large-scaled maps of British Empire glaciers.
Vegetation.	Official publication of "one-inch" vegetation maps of British Isles.
Soil.	Official publication of results of soil surveys.
Sea.	Mapping of all oceanographical data collected on Fishery researches.

It gives the writer the very greatest pleasure, as one occupied with the relatively young study of geography, to acknowledge the great debts which geographers owe to others. The oldest debt of all is to the surveyor and cartographer, who gives definition to what, without him, must be vague statements ; a long-standing debt also there is to the geologist, and especially to his younger brother the physiographer. To the botanist, and especially to the plant ecologist, he owes much and will owe still more. He is also in high degree the debtor of meteorologist, oceanographer, biologist, anthropologist, and ethnologist. While fully recognizing that this is so the writer ventures to put forward these few suggestions in the hope that the discussion of them may lead to an increase in the cartographical expression of results obtained by the various sciences. Such an increased wealth of map types must surely help to spread the knowledge of the interdependence of earth sciences which is the spirit of geography.

NOTE.

Since the above was written my attention has been drawn to two recent papers which bear on this subject, and farther, a third work of the kind has since appeared. They are as follows:—

1. W. Behrmann, "Die Oberflächengestaltung des Harzes," in *Forschungen zur Deutschen Landes- und Volkskunde*, vol. 20, No. 2, 1912.
2. E. Wunderlich, "Die Modernen Vorschläge für kartographische Morphologische Darstellungen," in *Kartographische und Schulgeographische Zeitschrift*, vol. 2, No. 1, 1913.
3. S. Passarge, 'Morphologischer Atlas,' Lieferung I., "Morphologie des Messtischblattes Stadtremda ;" 8 sheets with explanation. Pub. L. Friederichsen & Co., Hamburg, May, 1914. Price 10 marks.

Of these the first is an important morphological study, and it contains, among others, maps showing what the Harz contours would be without marginal valleys, a pre-glacial contour map, and a morphological map in which the various physiographical divisions are plotted.

The second paper is a brief but interesting *résumé* of work done and arguments adduced.

In the third an interesting attempt has been made by Passarge to analyze the land-forms of a small district and to represent the results of the examination in a series of eight maps on the scale of 1:50,000. The features shown are as follows:—

1. *Contours and vegetation cover*—viz. Closed, open, or wanting.
2. *Slopes*—represented by a scale of four colours marking areas having gradients respectively of 0° – 5° , 5° – 20° , 20° – 35° , over 35° .

3. *Valley form*. Different types of valley are represented by different tints and by conventional signs.

4. *Geology*. Strata are coloured according to age. The lithological character is made clear in most, though not in all cases.

5. *Power of resistance to mechanical processes*. Account is taken of various qualities, e.g. cohesion and firmness, jointing, porosity, capacity for physical change when wet, etc. The scales for each of these are superimposed on the map.

6. *Power of resistance to chemical process*. The rocks are divided into three grades.

7. *Soils*. Not only the chemical and physical composition of the soils is here considered, but also origin and position. Thus, for instance, detritus beds at different levels have different signs.

8. *Historical development of the landforms*. The areas of land surface formed at different periods are distinguished by different colours.

To obtain an estimate of the true value of these maps it is necessary to examine in detail the monograph which accompanies them. And I shall comment here only on such features of the maps as appear to suggest either additions to the matter treated above or modifications of the treatment.

Map 1. Maps showing the thickness of vegetation cover would be useful, especially on the borders of arid or polar regions, and in high mountains.

Map 2. It is obvious that the degree of the slopes must be clearly represented on the map used in discussing landforms; and if the topographic map does not show it, then some such diagram as this must be made. But a carefully hachured map with vertical lighting serves as a diagram of slopes, and gives the plastic effect as well.

Map 3. This map in its character closely resembles that published by Allix, and described above. Maps of this kind will be most useful.

Map 5. The superimposition on this map of the scales for different qualities gives a somewhat confused effect—there are three tints and seven different types of shading. But the map is an interesting experiment; and it and the method of its construction might well form a basis for the discussion by geologists of the possibility of registering the power of resistance of rocks. It must be remembered that the scales are not absolute, but relative for this one district. Only one who knows the ground and the rocks can say if they are reasonable for the district.

Map 6. “Power of resistance” is given two separate maps (5 and 6) for its expression. Of these the second (chemical) is much the simpler; and the determination upon which the map is based also appears to be simple. There is no map of average power of resistance, combining the facts expressed in maps 5 and 6; but in the text (p. 156) the author attempts to give numerical values to this quality in the case of each stratum.

Map 7. For purely geographical purposes it is unnecessary to add anything to the distribution of soils of different chemical and physical composition. The distinction of soils according to level and origin is mainly geological in its purpose.

Map 8. It seems to me that the two most important cartographical tasks of the physiographer are the construction of maps of this type and of the type of Map 3. Map 8 is really his *geological* map; on it he expresses the *history* of the surface development. Map 3 is his *geographical* map; on it he plots diagrammatically the *actual forms* which he has classified.

Sir THOMAS HOLDICH (Vice-President): Before asking you to join in a discussion on the rather technical subject which Mr. Ogilvie has set before us in his address, I have first of all to express my regret for the absence of Colonel Close, who was unable to be here, and also of Mr. Beckett. Both of them have written letters regretting they are unable to be present. I had the advantage some little time ago of reading the paper which Mr. Ogilvie has prepared, which is in all essentials the same as the address he has given us now, and I made a few notes at the time on the subject, which, with your permission, I will read, as they may assist discussion. They refer chiefly to the practical question of attaining such maps as Mr. Ogilvie has suggested.

Mr. Ogilvie does good service in calling attention to the educational value of maps in scientific fields which are not all of them purely geographical. He points out that it is the duty of the geographical societies of this country to procure the publication of selected sheets of the Ordnance Survey in the form of an atlas of typical landforms such as may be found in Germany or the United States. Incidentally he advocates the maintenance of all editions of Ordnance Survey Topographical maps on sale, as well as the sale of separate prints from colour-printed maps. The atlas of landform types he would have on two scales, 1 inch and 6 inch, and then he proceeds to divide his landform maps into six different classes. So far we agree entirely. The value of such maps, if we could get them, no one will question. The question is how to get these maps. To what extent are the geographical societies of this country to be held responsible for their production and maintenance. Up to a certain point there can be no doubt that geographical societies can lend valuable assistance by advice and suggestion. For if the Geographical Society is not an official surveying department itself, it is of little use if it does not foster and encourage the very first elements of map making, and bring all its influence to bear on good map-production. Mr. Ogilvie draws attention to the debt which is owed by the geographer to the cartographer and the surveyor, but it should not be forgotten that it is a debt, and that the opportunity for the geographer, apart from the surveyor, to supply the basis of such technical maps as he recommends (*i.e.* the simple topographical sheets) is very limited indeed. Such maps are not geographical maps at all in the ordinary sense; they are the finished product of a Government department, and all the geographer can do is to criticize methods and results, and occasionally perhaps reproduce for special purposes. As a matter of fact, on the production of the initial maps on which is to be finally grafted all that special information concerning sciences such as geology, botany, meteorology, and the like, the geographer, apart from the official Government surveyor, is not really in it, and all the Geographical Society can do is to bring its influence to bear on the Government Survey Department.

Having obtained the 1-inch and 6-inch sheets required for the landform atlas series, *i.e.* the simple cartographical expression of those forms either by contour or other method of relief, it is obviously necessary to call on the geologist for the elaboration of those further details which are to represent lithology, porosity, resistance, "process," and "stage." I may go further: hydrography, climate, glaciers, vegetation, soil, and sea all demand the treatment of specialists, and all are based on that work