Topographical surveys and maps

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TOPOGRAPHICAL SURVEYS AND MAPS.¹

By Colonel Sir DUNCAN JOHNSTON, K.C.M.G., C.B., R.E.,
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It has been usual for Presidents of this Section to make some allusion in their addresses to the principal matters of geographical interest which have occurred during the preceding year, and I propose to follow this custom before proceeding with the rest of my address, which would hardly be complete without some allusion to the great geographical achievements of the past year.

I doubt if there has ever been a year in which more important additions to geographical knowledge have been made than those resulting from the journeys of Dr. Sven Hedin, Dr. Stein, and Lieut. Shackleton.

Dr. Sven Hedin's previous explorations had deservedly gained him such a high reputation as an explorer that it seemed almost impossible for him to increase it, yet his recent expedition in Tibet, extending over two years, has enhanced his already great reputation.

Refused permission to enter Tibet from India, he was not to be deterred. Travelling round to Leh and making that place his starting point, he entered Tibet and traversed in various directions a considerable tract, previously unexplored, of that country, making a good reconnaissance survey of the country he passed through.

A large part of his journey was through a bleak and inhospitable region, where he encountered intense cold and very great privations. At one time he went for eighty-three days without meeting a living soul, and

¹ The Presidential Address delivered to Section E (Geography) at the Winnipeg meeting of the British Association.

the cold and hardships were such that out of ninety-seven ponies and mules with which he started only six came through. Yet in the following year, in the depth of winter, Dr. Sven Hedin again traversed this terrible country. In doing so he ran imminent risk of starvation, as his last sheep was killed a considerable time before he got through to country where he could obtain fresh supplies.

Dr. Sven Hedin's tact and resource were as great as his fortitude and courage. He made friends wherever he went, and, although the Tibetan Government sent orders over and over again that he should be turned back, he succeeded in spending two years in exploring the country, maintaining the most friendly relations with the Government officials and others whom he met. Besides exploring and surveying a large tract of previously unexplored country, he investigated the sources of the Brahmaputra, the Indus, and the Sutlej, and in the course of his journeys he accumulated a mass of geographical and other scientific information.

Next comes Dr. Stein's expedition to Chinese Turkestan, by which he has made a most noteworthy contribution to geographical knowledge and antiquarian research.

Dr. Stein, accompanied by that capable surveyor Rai Ram Singh, who was later on relieved by that equally skilful and energetic surveyor Rai Sahib Lal Singh, travelled from India via Chitral and Kashgar. He commenced survey work in the eastern part of the Mustagh-ata range, and carried it along the Kun Lun Mountains, skirting the southern side of the Takla Makan Desert and the Lob Nor Desert to Suchou and Kan-chou. He surveyed a large area of the mountainous region lying westward of Kan-chou, then crossing the desert from Anshi to Hami he returned north of the Tarim River, skirting the southern slopes of the Tian Shan range, to Kashgar. During this very long journey Dr. Stein came across the ancient frontier wall, built about the second century B.C. He traced it west of Suchou, till lost in the desert, for some 250 miles, and he made various incursions into and across the desert, making discoveries of the greatest antiquarian interest.

After his return to Kashgar he surveyed the last unexplored portion of the Kun Lun mountains and the country containing the sources of the Khotan or Yurungkash River, which proved to be flanked on the south by a magnificent range of snowy peaks rising to over 23,000 feet, thence, passing the sources of the Keriya River, he skirted the southern slopes of this snowy range and finished by connecting this survey with that to the north of this range. The privations and hardships undergone by Dr. Stein and his party were very great, and, just as he completed his last bit of survey, he was unfortunate enough to get his foot badly frost-bitten, and had to hasten to more civilised parts for medical treatment.

Dr. Stein, during his expedition, displayed all the best qualities of an explorer—enthusiasm, determination, skill, and tact. The modest account he has so far given us of his travels, which gives a mere outline of his work, shows that the geographical as well as the archaeological results of his expedition are of the greatest value.

The last completed exploration I propose to mention is Lieut. Shackleton's great journey in the Antarctic Circle, which has raised him to a high position among the gallant explorers of the Polar regions.

Lieut. Shackleton personally arranged and supervised all arrangements for the expedition, his experience in the British Antarctic expedition under Captain Scott standing him in good stead.

Having landed in M'Murdo Sound, a party consisting of Lieut. Adams, Prof. David, and others ascended Mount Erebus, which is over 13,000 feet high, all above snow-level.

Later on Lieut. Shackleton and a sledge-party set off southward, and after an arduous journey succeeded in reaching $88^{\circ} 33'$ South latitude, over six degrees nearer the Pole than any previous explorer. His party travelled altogether about 1700 miles, including relays, in 126 days, a splendid performance in a rough and difficult country under very trying climatic conditions. Soon after passing $83^{\circ} 33'$ South latitude they lost their last pony, and from this point they had to drag their sledges themselves, although their journey involved the ascent of a plateau 10,000 feet high. They only turned back when their diminishing stock of provisions rendered it imperatively necessary to do so. They were for a considerable time on short rations, and found several times that they had expended their food supplies before reaching their next depôt. Had they missed one of these depôts—no unlikely contingency in such a country—they must have perished by starvation. Altogether the sledge journey was a great feat of pluck and endurance.

Lastly, Lieut. Shackleton's colleague, Prof. David, with others, made a sledge journey to the north-west, reaching the south magnetic pole. A good deal of triangulation was carried out, many geological specimens were collected and much scientific information was obtained.

Whether we consider Lieut. Shackleton's skill and energy in organising the expedition, the courage and determination displayed in carrying it out, or the results obtained, his expedition will stand out as one of the greatest of the many great efforts to reach the Poles, and as a British expedition it is one that specially appeals to us.

At first sight it would seem that these great journeys belie the opinion so often expressed of late years that the days of the explorer are numbered, and that in future geographers will have to deal with surveys rather than exploration; but, in fact, these splendid achievements only strengthen this opinion. These explorers have considerably reduced the comparatively small area still unexplored, and other expeditions are helping to diminish the unexplored area.

Among those which are in progress I may mention the following:—Col. Kozlof's expedition to Mongolia, which has already visited Kuku Nor and which is exploring the upper course of the Huang Ho and other parts of Mongolia. Lieut. Boyd Alexander is exploring in West Africa. The Duke of the Abruzzi is investigating part of the mountainous region across our Indian frontier; Dr. Longstaff is exploring another part of that mountain system; Capt. R. E. Peary, U.S.A., and Capt. E. Mikkelsen are leading expeditions in different parts of the Arctic regions, and M. Charcot is exploring in the Antarctic circle.

Lastly, an important British expedition will start before long to explore part of the island of New Guinea, one of the largest still unexplored land areas. There are other expeditions, either in progress or projected, too numerous to mention.

The best modern explorers are not now content with exploration or even with a rough route traverse and an occasional observation for latitude; they either themselves make careful reconnaissance surveys of the country adjoining their route or they are accompanied by trained surveyors, who make such surveys.

Again, every year the area surveyed on correct scientific principles is extended. The interesting address of my predecessor, Major Hills, will have told you what is being done in this way in the British Crown colonies. In the British self-governing colonies and in the colonies and dependencies of other Powers the area of regular survey is being continually extended, and in more remote regions surveys are being carried out by Boundary Commissions or for railways or other purposes. Along with the increasing appreciation of the value of geography which has taken place of late years, there has been an increasing recognition of the need for regular surveys, and it is probable that the next generation will find that not only is no considerable area of the earth's surface unexplored, but that the area not yet surveyed at least geographically, or for which a regular survey has not been projected, is getting limited.

I propose in the rest of my address to deal with the regular survey and mapping of new areas, and to discuss various questions connected therewith; if I am right in believing that large areas will be regularly surveyed in the near future, such questions merit careful consideration. I shall state on these points the practice of some of the great national surveys, because their experience seems the best guide for future work; but I recognise that methods suitable for rich and populous countries, such as Germany, France, or Great Britain, may be too costly for many countries and provinces whose survey has still to be made, and mention will be made of less expensive methods which are likely to be much in demand in future.

It would be difficult to say anything new on the subject I propose to deal with, and I lay no claim to do so, still less do I wish to dogmatise as to the best methods. When I express opinions I shall also state the practice of some of the principal surveys of the world, and my hearers having weighed the matter can accept my opinions or not according to their judgment. In either case my object will have been attained if careful consideration is given to the points raised.

Maps may be roughly divided into three classes :—

(1) Geographical maps, *i.e.* those on very small scales.

(2) Topographical maps. The dividing line between these and geographical maps is not very clearly defined. For the purpose of this Address maps between the scales of 4 miles to the inch and $\frac{1}{25000}$ scale will be considered as topographical.

(3) Cadastral maps, *i.e.* maps on large scales mainly for property purposes.

As the time at my disposal will not admit of my discussing all three classes of maps, and as I have on a previous occasion read a paper to this Association on "Cadastral Surveying," I propose to limit my remarks to topographical surveys and maps.

In most of the older countries topographical surveys have originally been made to meet military needs, and as a rule they are carried out under military supervision. In order that they may be useful in case of war such surveys must have been made before war breaks out. The use, however, of topographical maps is not limited to military purposes; on the contrary, they have invariably proved of great value for civil requirements. In one respect they are more useful for civil than for military purposes, as a state of war occurs rarely, and hence while the maps are only occasionally used in connection with war, they are constantly used in connection with civil administration and with public and private business of all kinds. The topographical maps of the Ordnance Survey, prepared originally solely for military requirements, have proved extremely useful for civil purposes. Directly or indirectly all the numerous maps prepared by the trade in Great Britain for civil use are based on them. I believe the experience of all other countries is similar to that of the Ordnance Survey. In most countries in which land is of any value, a cadastral survey for land transfer purposes is needed, as well as a topographical survey. In some cases, indeed, the need for a property survey has first made itself felt; thus in the Transvaal and in the Cape colony, neither of which yet has a topographical survey, there has for many years been a Government Survey Department for making property surveys. The question arises whether there should be two separate surveys, one for topographical and one for cadastral maps, or whether there should be only one survey, the topographical maps being prepared by reducing the cadastral survey. Incidentally the further question arises whether if two separate surveys are made they should be under one head.

In most countries—the Ordnance Survey of the United Kingdom being an exception—not only are entirely separate surveys made for these two classes of maps, but these surveys are generally under different departments. In some cases the cadastral surveys are isolated farm surveys, showing little detail except property boundaries. Such surveys would, of course, not answer as a basis for topographical maps. In other cases, however, the cadastral surveys show all necessary detail except ground form, which can be added by a separate survey. The only cadastral survey, so far as I know, which shows ground forms is the Ordnance Survey, whose 6-inch maps are contoured.

A difficulty in the way of utilising the cadastral survey for the smaller scale maps arises from the fact that a cadastral survey is, from its large size, much slower than a topographical survey. It is often found advisable to take up the survey of the former somewhat irregularly, while it is important for the proper progress of the latter that it should be taken up regularly and methodically. The Ordnance Survey 1-inch map has, since 1824, not had a separate survey of its own, but

has been based on the cadastral survey. Ordnance Survey experience has shown that the delays in completing the topographical map due to this course have been much greater than one would have expected, and that there are grave disadvantages in having the scale of survey very much larger than that of the finished map. These objections do not apply, or can be overcome, if the cadastral survey of any locality is completed before the topographical map is taken up. This is a condition not likely to be often fulfilled in the case of future topographical surveys. I advocate therefore that, following the general practice, there should be entirely separate topographical and cadastral surveys. I should advocate this even where it is essential to keep the expense as low as possible. More economy would probably result from the adoption of a fairly small scale for the topographical map, from curtailing the small detail to be shown on it, and from showing on the cadastral maps only such detail as is needed for property purposes, than would result from making one survey do for both classes of maps.

On the other hand, I consider that even when separate surveys are made for the two classes of maps, it is advantageous that both should be made under the same head. The more usual course is, however, to have the two surveys independent, and in some cases local circumstances may make the course I advocate inadvisable.

TRIANGULATION.

The first preliminary to any survey should be a triangulation. It is the most satisfactory course, and the best economy in the long-run, to carry out with the greatest accuracy possible the primary triangulation on which the survey is to be based. Such a triangulation will remain good for a very long period. For example, the primary triangulation of the Ordnance Survey was commenced in 1791; while some doubts have been expressed whether it is accurate enough to combine with other more recent work for the purpose of investigating the figure of the earth, no one has questioned that even the earliest part of this triangulation is amply accurate enough for map-making purposes.

On the other hand, I do not advocate carrying out a primary triangulation until arrangements have been made for basing a survey on it. In South Africa an excellent and very accurate primary triangulation has been carried out. This triangulation was undertaken largely no doubt for scientific purposes. While answering its purpose in that respect, it has so far had no surveys of any great extent based on it. An accurate triangulation is now a much quicker and less expensive operation than it used to be. The introduction of Invar tapes and wires has largely expedited and simplified the accurate measurement of base lines, while the improvements effected in theodolites enable equal or greater accuracy to be obtained with the comparatively small and handy instruments now made than could be got formerly with large and cumbersome instruments, such as the 36-inch theodolites, with which most of the primary triangulation of Great Britain and Ireland was carried out. Unless observations are rendered difficult by numerous buildings, by

trees or by a hazy or smoky atmosphere, a good primary triangulation should not now be very expensive. It is usual to base on the primary triangulation a minor triangulation of several orders, the object being to have an accurate framework of trigonometrical points on which to base the survey. If it is important to keep the expense low, the trigonometrical points may be rather far apart, intermediate points being fixed by plane table; but it should be remembered that it is the truest economy to make the best triangulation which funds admit of. In forests or in wooded and rather flat country, where triangulation would be very expensive, lines of traverse made with every possible accuracy, and starting and closing on trigonometrical points, may be used instead of minor triangulation.

DETAIL SURVEY.

Provided the detail survey is based on triangulation, it may be made by any recognised method. Plane tabling is now almost universally resorted to, and is probably as cheap and convenient as any other method. The vertical heights of the trigonometrical points will have been fixed by vertical angles with reference to some datum. The height of intermediate points can be fixed by clinometer lines, especially down spurs and valleys, and even by aneroid, and from these heights the contour lines can be sketched in. Altitudes can be more accurately fixed by spirit-levelling, but this is an expensive method not likely to be much used in the case of topographical surveys. It is possible that in exceptional cases photographic surveying may be resorted to with advantage, and undoubtedly photographic methods sometimes enable work to be done which would not otherwise be feasible. The photographic method suggested by Captain F. V. Thompson, R.E., is an advance on previous methods. In Canada, I understand that a good deal of photographic surveying has been done, and presumably the conditions in Canada have been found suitable for this method. It has been little used elsewhere.

SCALE OF MAP.

The next point for consideration is the scale on which the map is to be published, and it is an important one. Speaking generally, the cost increases with the scale, and cost is therefore one of the main determining considerations. The physical and artificial character of the country, the amount of detail it may be decided to show on the map, the method adopted for representing hills and other detail, and the method of reproduction to be used, all affect the question.

Clearness and legibility are among the first essentials of a good map, and it is desirable that the scale should be such that all detail it may be decided to show on the map can be inserted without overcrowding, or conversely, if the scale is fixed, the amount of detail and method of showing it should be such as to avoid the common fault of overcrowding the map.

In populous countries, such as Belgium, France, and Germany, where buildings, roads, railways, etc., are numerous, a larger scale is, *caeteris paribus*, desirable, than in less populous countries.

All important detail such as roads, railways, canals, forests, woods, etc., should appear on the map, as should the more important names, but it is a matter for consideration how far minor detail such as orchards, marshes, rough pasture, state of cultivation, etc., should be inserted on the map, and to what extent the less important names should be omitted.

In hilly country hachures and contours, especially if in black, tend to obscure the detail and names, and the smaller the scale the greater this tendency.

Methods of reproduction will be dealt with later, but I may here say that more detail and names can be shown clearly on a given scale if the map is engraved on copper than if reproduced in any other way. The scales adopted by different countries vary very much—I give below the scales adopted by some of the principal surveys.

$\frac{1}{250000}$ scale—Switzerland (the more populous parts), Prussia, Baden, Saxony, Bavaria, and Württemberg (these German maps, although called maps of position, are practically topographical).

$\frac{1}{400000}$ scale—Belgium and Denmark.

$\frac{1}{500000}$ scale—France (the new topographical map), Algeria, Tunis, Holland, Japan, Spain, Switzerland (the less populous parts).

$\frac{1}{625000}$ scale—the United States (the more populous parts).

$\frac{1}{633600}$ scale (1 inch to a mile)—Great Britain and Ireland, and Canada.

$\frac{1}{750000}$ scale—the Austrian Empire.

$\frac{1}{800000}$ scale—the old staff map of France.

$\frac{1}{1000000}$ scale—the German Empire, Italy, Norway, Portugal, Sweden, and Switzerland (Dufour atlas).

$\frac{1}{1250000}$ scale—the United States (less populous parts).

$\frac{1}{1280000}$ scale—Russia.

$\frac{1}{2500000}$ scale—the United States (barren districts).

The introduction of cycles, motors, and other rapid means of locomotion has led to a demand for a scale which will show a considerable tract of country on a sheet of moderate size. If the standard map is already on rather a large scale, this demand is best met by publishing a reduction of the standard map. This course is followed by Great Britain and Ireland and by Canada, whose 1-inch map is reduced to and published on the $\frac{1}{2}$ -inch scale; but if only one scale is used a compromise must be arrived at which will meet the reasonable requirements of rapid locomotion, as well as the other essentials of a topographical map.

If I may venture an opinion in a matter in which practice varies so much, it is that for countries using British measures in which, owing to dense population, the detail is close the 1-inch scale ($\frac{1}{633600}$) is a very good one, and that for more open parts the $\frac{1}{2}$ -inch scale may with advantage be adopted. For countries using metrical measures I should advocate $\frac{1}{625000}$ and $\frac{1}{1250000}$ respectively. These scales do not differ

largely from those adopted by most of the principal countries, the majority of which use scales between $\frac{1}{50000}$ and $\frac{1}{100000}$ for fairly close countries.

Where it is important to keep the cost down I should advocate a half-inch to the mile or a $\frac{1}{125000}$ scale. All except the most closely populated country can be shown clearly on such scales provided the maps do not show too many names or too much small detail.

The United States have scales of $\frac{1}{62500}$, $\frac{1}{125000}$, and $\frac{1}{250000}$, the general closeness of detail in any area determining which of these three scales is adopted. This arrangement is a good one, and would be still better if the areas published on the $\frac{1}{62500}$ scale were also reduced to and published on the $\frac{1}{125000}$ scale, and if the whole country were published on the $\frac{1}{250000}$ scale. The principle here advocated of having each scale as far as possible complete for the whole country has been carried out by Great Britain, where the whole country, except some uncultivated areas, is published on the 25-inch ($\frac{1}{25000}$) scale, and the whole country on the 6-inch, the 1-inch, the $\frac{1}{2}$ -inch, the $\frac{1}{4}$ -inch, and other smaller scales.

SCALE OF FIELD SURVEY.

It is usual to make the field survey for small scale maps on a larger scale than that on which the map is to be published with a view to securing greater accuracy of detail, but this should not be overdone. If the field survey is on too large a scale it entails needless expense; also when the surveyor is working on too large a scale he is apt not to realise the effect of reduction on his survey, and is likely to survey so much detail as to overcrowd the map, thus increasing the cost of the work and injuring the map.

When the map is reproduced by photographic methods the fair drawing is usually on a larger scale than the finished map so as to get finer results on reduction, but in this case also for somewhat similar reasons to those stated above, there are limits to the amount of reduction which can be made with advantage.

In these respects the practice of different countries varies considerably.

In Austria the field survey is on the $\frac{1}{25000}$ scale; this is reduced to and drawn on the $\frac{1}{60000}$ scale, and this drawing is reproduced by heliogravure on the $\frac{1}{75000}$ scale.

In France the field survey is on the $\frac{1}{10000}$ or $\frac{1}{20000}$ scale. The survey is reduced to and drawn on the $\frac{1}{40000}$ scale. In Algeria and Tunis, both field survey and drawing are on the $\frac{1}{40000}$ scale. In all cases the French maps are now reproduced by heliogravure on the $\frac{1}{50000}$ scale from the $\frac{1}{40000}$ scale drawings.

In Germany the field survey is on the $\frac{1}{25000}$ scale. This is reduced to the $\frac{1}{100000}$, on which scale the maps are engraved on copper.

In Great Britain the 1-inch map is based on the 25-inch and 6-inch survey. These were reduced, and a fair drawing was made on the 2-inch

scale in a manner suitable for reduction to the 1-inch scale—*i.e.* the detail, lettering, etc., were drawn so that when reduced to the 1-inch scale they should be in proper proportion. This drawing was reduced and printed by heliozincography on the 1-inch scale, and from these prints was engraved on copper.

In America the field surveys are on the scales of $\frac{1}{48000}$, $\frac{1}{96000}$, and $\frac{1}{192000}$ for the $\frac{1}{62500}$, the $\frac{1}{125000}$, and the $\frac{1}{250000}$ scale maps respectively. The drawings, on the same scale as the field survey, are reduced by photography and engraved on copper.

I consider that the best results are obtained when the field survey is made on double the scale of the finished map; that if reproduction is to be by engraving, the fair drawing should be on the same scale as the finished map; that if, on the other hand, reproduction is to be by photographic methods, the fair drawing should be on the same scale as the survey, *i.e.* double that of the finished map. The reduction I advocate should conduce to accuracy of detail and, if reproduced photographically, to fineness of detail, while it is not so great that the surveyor and draughtsman should be unable to realise the effect of reduction.

DETAIL.

The need of considering the amount of detail, etc., to be shown is not always sufficiently realised. The way in which detail is to be represented also needs consideration, as on small scale maps much detail has to be represented conventionally.

Railways have to be shown conventionally, and should be so marked that they catch the eye without being too heavy.

Roads also should be clearly marked. Where different classes of roads exist they should be distinctively shown, main roads being more prominent than others. It is important to know what roads are fit for fast-wheeled traffic in all weathers, and which are fit only for slow traffic. The exact classification of roads must depend on the conditions obtaining in the country. The most elaborate classification is that shown on the French maps, and next that shown on the maps of Great Britain. Provided that important distinctions are represented, the simpler the classification the better.

Forests, woods, marshes, and in some cases pasture, rough pasture, orchards, vineyards, gardens, etc., are shown by conventional signs. While forests, woods, and marshes should certainly be distinguished on the maps, I incline to the opinion that the state of cultivation is better omitted, and that the less small detail shown the better. Such small detail increases the cost and often overcrowds the map. The German $\frac{1}{100000}$ scale shows much small detail, and although the maps are beautifully and delicately engraved on copper, the detail is rather crowded on some sheets. The French Carte Vicinale is, in my opinion, rather crowded with names.

The most difficult question, and that on which opinions differ most, is the method of representing ground forms. Methods which answer

well on steep ground are less satisfactory on gentle slopes, and *vice versa*, and each method is open to some objection.

Ground forms may be indicated by contours, hill shading in stipple, vertical hachures, horizontal hachures, the layer system, or by a combination of some of these.

Ground forms are represented by contours on the $\frac{1}{250000}$ scale maps of the German States, the Swiss Siegfried Atlas, the maps of the United States, the 1-inch map of Canada, the $\frac{1}{400000}$ scale map of Denmark, and the maps of Japan. Where the slopes are steep the contours give almost the effect of hill-shading. Some of these maps give a very good representation of the ground, the best being those in which the contours are in colour.

Hill features are shown by stipple shading on the French Carte Vicinale and the Ordnance Survey four-mile map. In mountainous country stipple shading gives a good pictorial representation of the ground, but it fails in flatter country, and it is often difficult to tell from it which way slopes run.

The Swiss Dufour Atlas ($\frac{1}{100000}$ scale) is a good example of vertical hachuring, as are some of the German $\frac{1}{100000}$ scale maps. Vertical hachures are also used on the Austrian and Swedish maps, and in conjunction with contours on the maps of several other countries.

Vertical hachures when well executed give an artistic and graphic representation of the hills. In the Swiss and British maps the pictorial effect is enhanced by assuming a light from the left hand top corner. In steep ground, especially when the hachures are in black, these are apt to obscure detail and names. I think hachures are better when printed in colour, but many will disagree with me on this point.

Horizontal hachuring, while having some advantages, is less effective and is little used.

The system generally known as the layer system has been used in Great Britain by the well-known Scotch firm of J. Bartholomew and Co., has recently been adopted by the Ordnance Survey for its $\frac{1}{2}$ -inch maps, and is used in the $\frac{1}{2}$ -inch maps of Canada. It consists in indicating by various shades of colour the area lying between certain contours; thus one shade may be given to all ground below the 50-foot contour, another shade to ground between the 50 and 100 foot contour, and so on. This system gives a general indication of ground form and enables the contour lines to be followed more easily. Its shades of colour enable the eye to pick out more easily all land lying at about the same level. It is most effective in ground with a small range of vertical height, as the vertical depth of layers can then be small and the distinction in colour between successive layers marked. In hilly ground the depth of the layer must be increased, which means that many ground features are ignored on the map, or the number of layers on the map must be large, in which case the distinction in shade between successive layers will be less marked. This method is popular in Great Britain, and enables those who are not versed in reading contours and hachures to realise something of the nature of the ground forms.

A combination of these methods has been used as follows:—

France on her $\frac{1}{300000}$ scale maps shows ground forms by contour lines and stipple shading. This gives a very fair representation of the ground, but where the contours are very close together the effect of the coloured contours on the stipple is not pleasant. Nor does the stipple always look well when it falls on colour.

The German coloured $\frac{1}{100000}$ scale map, the Italian $\frac{1}{100000}$, and the British 1-inch show both contours and vertical hachures.

The Norwegian $\frac{1}{100000}$ scale map shows the features by contours, vertical hachures and shading.

The new British $\frac{1}{2}$ -inch scale map has both contours, layers and stipple shading.

Opinions differ so much on this subject, and there is so much to be said for and against each method, that I will confine myself to the opinion that contours reasonably close together should form the principal feature of any method of representing ground forms; that contours by themselves give a very fair representation of the ground; that vertical hachures, if printed so as not to obscure the detail and names, or stipple shading when there is not too much colour on the maps, increase the pictorial effect and are useful additions to contours; that ground forms should preferably be in colour, and that where hachures or stipple are used as well as contours both should be in the same colour.

The German coloured $\frac{1}{100000}$ scale map (brown hachures and contours), the British 1-inch scale copper-plate printed map (brown hachures and black contours), the British 1-inch coloured map (brown hachures and red contours), and the French $\frac{1}{300000}$ scale (grey stipple and brown contours), all give a good representation of the ground, and there are other maps which might be named almost, if not quite, as good.

Vertical Interval of Contours.

The vertical interval between contours should depend partly on the scale, partly on the steepness of the ground. Practice varies considerably in this matter.

The $\frac{1}{250000}$ scale maps of Switzerland and of Germany, except Prussia, are contoured at 10-metre intervals.

The $\frac{1}{300000}$ scale maps of France are contoured at 10-metre intervals.

The $\frac{1}{300000}$ scale maps of Japan and Spain are contoured at 20-metre intervals.

On the Swiss $\frac{1}{300000}$ scale contours are 30 metres apart.

On the United States $\frac{1}{625000}$ scale the contour interval varies from 20 to 100 feet.

On the British 1-inch map there are contours at 50 feet, at every 100 feet up to 1000 feet, and thence at 250 feet intervals.

On the Canadian 1-inch and $\frac{1}{2}$ -inch maps the contour interval is only 25 feet, but the sheets published have been in ground with only moderate elevations.

On the German $\frac{1}{100000}$ scale map the contour interval is 50 metres.

I consider that if the contours are printed in colour the vertical interval may with advantage be such that on steep ground the contours

are reasonably close together, every fourth or fifth contour being printed heavier so as to be more easily followed. If the contours are in black they cannot with advantage be so close.

It is, in my opinion, best if the contour interval is uniform all over a country. Failing this, it seems desirable that it should be uniform over considerable areas and at least throughout a sheet; but this view is not universally held. I do not like the varying interval adopted by the Ordnance Survey. The contours on the Ordnance Survey maps are surveyed with great accuracy and at great expense. For topographical maps much cheaper and more rapid methods will suffice.

CARTOGRAPHY.

I have, with a view to clearness, kept the question of the method of reproduction separate, but it has a bearing on some of the points already considered. Thus the fine engraving of the German $\frac{1}{100000}$ scale map enables an amount of small detail and ornament to be shown on that map which could not have been clearly shown if any other method of reproduction had been used.

The older maps were generally engraved on copper, or sometimes on stone, and printed in black and white. Subsequently photographic methods, such as the photogravure of the Austrian and the more recent $\frac{1}{50000}$ scale French maps were used, and colour printing is now largely resorted to.

In some cases the colour-plates are prepared by engraving on copper, stone, or zinc. The maps of the United States and Switzerland are engraved on copper. In other cases, for instance, the 1-inch Ordnance Survey colour-plates are prepared on stone by transfers and offsets from the engraved copper plate. In other cases, *e.g.* the $\frac{1}{50000}$ scale map of France—the colour-plates are prepared by photographic methods.

For clearness, delicacy of outline, and artistic effect, nothing equals engraving on copper. It forms also the best basis for colour-printing. Unfortunately it is very slow and costly.

Engraving on stone is quicker and less expensive than copper engraving. It is inferior in delicacy to the latter, but some of the best stone engraving is very good.

Photographic methods are the most rapid and the cheapest, and with care give very fair results. As good examples I may quote the $\frac{1}{75000}$ scale maps of Austria, prepared by heliogravure, and the 6-inch maps of the Ordnance Survey, prepared by heliozincography, both black and white maps.

Of colour-printed maps I may instance the new $\frac{1}{50000}$ scale map of France prepared by heliogravure, and the $\frac{1}{2}$ -inch Ordnance Survey map hitherto prepared by photo-etching, although I understand that in future the outline will be engraved on copper.

When rapid reproduction and moderate cost are desired I do not hesitate to recommend photographic methods which, although not so good as engraving, give, when carefully executed, reasonably good results.

Opinions differ as to the extent to which colour should be used, the modern tendency being to use it very freely. I can hardly be accused of prejudice against colour, as during my tenure of office at the Ordnance Survey colour-printing was largely developed, but I think it is often overdone. I consider that a moderate amount of colour is a great improvement to a map. Ground forms, however indicated, can, in my opinion, be better shown by colour than in black; it is advantageous also to distinguish water by colour, to give prominence to main roads by colouring them and to colour woods and forests, but I do not advocate going much beyond this. It is difficult to choose colours which are suitable, distinctive, and harmonious, and the more numerous the colours used the greater the difficulty of doing so.

Colour-printing introduces possible sources of error. Colour maps are based on a drawing on which all detail to appear on the map is shown. A plate is prepared for each colour on which there should be only such detail as shall be printed in its particular colour. In preparing this plate there is a risk that detail which should appear may be omitted, or that detail be inserted which should be on another plate, or that the detail may be slightly out of position. Again, owing to change of temperature and to the varying amount of moisture in the air, paper contracts or expands. Registration can rarely be mathematically correct, and with every care may sometimes be appreciably out. While with care errors such as I have indicated can be minimised so as not appreciably to affect the map, it is difficult to ensure that they should be altogether absent.

To recapitulate my views, I advocate for a topographical map a scale between $\frac{1}{62500}$ and $\frac{1}{125000}$ ($\frac{1}{2}$ -inch to a mile), according to circumstances. The scale of survey to be double that of the finished map; ground forms to be shown by contours reasonably close together, the exact interval depending on the scale of the map and the nature of the country, also, if funds are available, by vertical hachures; both contours and hachures, if shown, to be in colour, the same colour being used for both. If considerations of time and cost do not admit of reproduction by engraving on copper, the map to be reproduced by some photographic method and printed in not more than five colours. I put forward these opinions rather as a basis for consideration than as having special weight in themselves. With the increasing recognition of the importance of geography an increasing demand for maps is sure to come, and good maps can only be satisfactorily designed after considering the points here discussed.

It is not yet, I think, generally recognised that a really good topographical map, based on triangulation, may be produced on a scale of about $\frac{1}{2}$ -inch to the mile at very moderate expense if unimportant detail is left out and survey and reproduction carried out as economically as possible. Such a survey has recently been carried out in the Orange River Colony, a country mainly agricultural with generally poor land. There must be few parts, other than barren and mountainous regions, under settled government where such a survey would not be of value. I believe that in future still further economy in surveying and mapping will be attained, and this will stimulate the undertaking of fresh surveys.

Meeting, as we are privileged to do this year, in Canada, I should like to say a few words on the surveying and mapping of the Dominion. Until recently the only maps published have been on very small scales and have shown no ground forms. During the last few years, however, a regular topographical survey has been undertaken by the Militia Department. I am glad that for this topographical survey the scales of 1 inch and $\frac{1}{2}$ -inch to the mile, both standard scales in Great Britain and Ireland, have been adopted. They are, in my opinion, suitable scales for Canada, and it is to be hoped that for any new mapping within the British Empire these or similar scales may be adopted as they have been in many parts. Uniformity in scales is very desirable.

Without committing myself to praise in every respect of the maps prepared by the Militia Department, I may say that they appear to me excellent, well-executed maps. Not many sheets have yet been issued, and they are probably not yet well known even in Canada; but I have little doubt that when known their value will be appreciated, and that the area mapped will be rapidly extended. There are no doubt large areas in Canada for which a smaller scale than one inch will suffice, but there can be few, except waste and barren regions, for which maps on some scale will not be needed. To a country like Canada, which has made wonderful progress already, and which has a great future before it, adequate mapping must be of importance, specially so in view of the vast area of the country. I have misread the character of the Canadian people if they will be content with any except first-rate maps for the whole settled area of the Dominion.

I should like to have said a few words on the aid which good maps give to geographical education, but my address is already too long. I will only say that while good maps and geographical education are of use to all countries, they are of special value to the British Empire, whose different parts are geographically so scattered, but which are so closely bound together by common ties of kinship, interest, sentiment, and loyalty.

BRITISH DIPLOMATIC AND CONSULAR REPORTS.

THE Society's Library has lately been enriched by the addition of a large number of the Reports made to His Majesty's Government by the British Diplomatic and Consular agents resident in foreign countries. From the high standing of these agents, their intimate acquaintance with the countries in which they reside, and their being able, from their official positions, to ascertain facts which ordinary visitors or passing travellers could not arrive at, these Reports are of the utmost value to all desiring to form an accurate and impartial opinion regarding many questions connected with the various countries described. We shall very briefly mention some of the leading features in the Reports, and, to facilitate reference by members of the Society, shall give the countries dealt with by the Reports in alphabetical order:—