58

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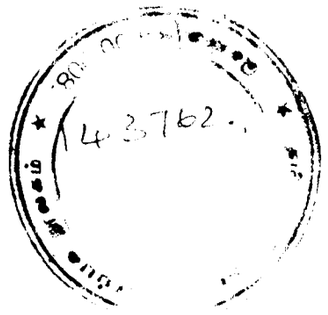

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CONTENTS

Foundations of College Geography

Vol. I: Physical, Economic and Mapwork Rs. 5 8 0
Vol. II: India „ 4 0 0
Vol. III: Asia (*In Press*)

BY

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The Editor takes no responsibility for the views expressed in the Journal. Authors alone are responsible for their respective statements.

Aerial Photographs as an Aid to the Scientific and Economic Development of India — with Special Reference to Economic Geology *

BY

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Photogeologist to the Burmah oil Company.

Specialization in science has become a necessity following the rapid expansion of knowledge. One of the greatest drawbacks of this is that the mind of the specialist tends to become a water-tight compartment; he is apt to leave other specialists to their own work, their methods do not penetrate to him because he is inclined to assume that these methods are designed and are usefully applied only in the particular branch for which, or in which they were developed.

Sometimes, however, a new technique is developed which is of significance to all science or to a large number of branches of it, and into this category we can assuredly place aerial photography and its interpretation.

Thus one object of this paper is to bring more to the notice of a large group of scientists some of the applications of this aid to their studies.

To those concerned in the scientific planning and development of the natural resources of India, aerial photographs are of special importance,

* A paper read before the Geography and Geology section of the Indian Science Congress, at Delhi in January 1947.

since there are few countries where the vast problems which confront us can be so greatly assisted by aerial photography. Apart from photographs taken for military use, several aerial survey projects have already been carried out in India, but the work so far done, with the exception of that in the petroleum industry, is quite insignificant in relation to the potential usefulness of such surveys.

It can be said without fear of contradiction that no planner, administrator, agricultural scientist, irrigation or soil erosion expert, forest controller, public works engineer, geologist or botanist can safely afford to neglect the possibilities of aerial photography. It should be noted that it has the tremendous advantages that photographs can be successively consulted by each scientist who can extract from them such information as helps him in his particular problems, and that they form a permanent record which can be referred to at any later date, or used as a standard for the observation of change over periods of time.

It will be admitted by all that it would be a great advantage if we could grow suddenly into giants, put on our " ten-league boots " and speed over the great distances of India to get a bird's-eye view of the actual country in which problems occur. Some may argue that the aeroplane allows us to do this, but in aerial reconnaissance we have to contend with the facts that from a height all details become small and many become invisible to our human eyes, and that even with a helicopter the length of our stay over one area to study its problems must be limited. The aerial photograph suffers from neither of these disadvantages. By a careful arrangement of the focal length of the camera and of flying height we can produce photographs on any scale we wish, and we can study them in our laboratory for as long as and as often as we may desire.

By planning exposures so as to give us overlapping prints we can, with the use of a simple stereoscope, obtain a three dimensional picture, and so be far better able to appreciate the details of the terrain in which we are interested than from the study of a printed map. The printed map must make a selection of which details to show and which to omit and it will of course inevitably occur that the details in which some scientists are interested will be omitted. The aerial photographs, on the other hand, records all the information and each scientist makes his own selection of the details which interest him

It must be pointed out that whereas a map shows features recorded in their correct positions, an aerial photograph is liable to show features in

distorted positions relative to one another, but this is a difficulty which can be overcome and mention will be made of this later.

It is not part of the purpose of this paper to describe in detail the extensive military use of aerial photography but it is interesting to note in passing that it is reliably estimated that the duration of the last war in Europe was shortened by at least one year by use of the intelligence information yielded by photographic interpretation. During the war period aerial photography came before the public eye considerably on account of its widespread use as a means of gathering information concerning enemy activity and in the selection of vulnerable points for attack, but in addition, one of its major uses was in the preparation of maps of enemy or other areas difficult of access to the ground surveyor. Exceptionally good and valuable work was done by mobilised Survey of India personnel in the preparation of maps of Burma, Siam, Malaya, Sumatra, etc. from air photographs taken by the R.A.F. and R.I.A.F.

Because of the possibility of obtaining a three dimensional image the maps constructed from aerial photographs can be contoured or form-lined, and can show all the detail a topographic map based on ground survey shows, with the exception, of course, of place names and other, like details.

At present it is still necessary to have at least the primary trigonometrical survey established so that the photographs can be located by recognition of an accurately fixed ground point on them. Provided two or three such points fall within the total area covered by the photographs, and are recognizable on them, a satisfactory map can be constructed, correctly scaled, and oriented. In the future, however, the possibility of radar fixing of the aircraft at the time of each camera exposure promises to make even the primary trigonometric ground survey unnecessary.

To the topographic surveyor then, the aerial photograph is a tool hardly less important than his theodolite, his compass and chain; by its aid he can speed up enormously the preparation of a detailed topographic map without the difficulty, expense and toil of an extensive ground survey. This has long been appreciated by the Survey of India, who some thirteen years ago undertook experimental work in the use of air photographs in the preparation of one-inch maps of country that is difficult of access.

Photographs can be of assistance to the irrigation engineer. They show in minute detail existing river courses and comparatively minor undulations in the ground which will affect the layout of feeding channels, but which are not sufficiently pronounced to appear on the topographic

map of the area. He can look for possible dam or weir sites, and determine the limits of the area which can be irrigated. When a new irrigation scheme is contemplated the engineer can plan the whole complex of channels, dams, etc. in his laboratory and so extensive field reconnaissance can be avoided at this stage.

For flood and river control, a series of photographs taken at intervals show accurately the behaviour of a river under different conditions, and the growth and movement of sandbanks and other hindrances to navigation, such as the surface growth of water weed e. g. the water-hyacinth in Bengal. Points where the river is cutting into its banks can be noted and places where trouble may start located.

By the study of gradients, river crossing sites, geological structure and soil patterns on aerial photographs, the road or rail engineer can consider the best routes for his new roads or railways, so as to make construction and maintenance as easy as possible and reduce the cost of both. This applies particularly to undeveloped areas where information is scanty, and even after months of ground reconnaissance the best route might be missed. From the photographs information can be gained concerning the nature of the soil profile; valleys and small *nullahs* assume characteristic shapes and so yield information as to the texture of the soil; surface drainage helps to indicate porosity; and marshy or water-logged areas can often be identified by tones on the photographs. By a comparison with known areas the road or rail engineer can assess the sort of probems he is likely to meet in a new area.

Similarly routes for oil-pipe lines can be planned. In Major Hart's book "Air Photography Applied to Surveying" an actual case is quoted; it was estimated that a saving of half a million dollars in the cost of construction of an oil-pipe line from Pecos County, Texas to the Gulf Coast of America was made as the result of the location from air photographs.

By similar methods the air-field engineer can select the most suitable location for a new landing ground.

For those whose task it is to deal with soil erosion, photographs will show the areas affected and they can judge which areas can most easily be dealt with and by what methods. The location and movement of dunes can also be observed. A few photographs have already been examined by the soil erosion experts in N.W. India but their studies have doubtless been severely restricted by the relatively small number of photographs at their disposal. Soil erosion on the scale that it exists in parts of India is a vast

and urgent problem and there is no doubt that all possible steps should be taken to solve it as speedily as possible. Aerial survey can assuredly make a vast contribution to this solution.

Photographs would seem to be a valuable aid to the town planner. It is generally agreed now that some attempt should be made to control the growth of towns so that they are not allowed to grow up as disorganized masses of 'conurbation'. Quite frequently towns tend to spread over the best agricultural land, while with planning and control they could be confined to the less fertile areas; this is particularly important in such countries as England where good agricultural land is very limited. In addition existing maps of urban (or other) areas can be checked and kept up to date very easily from air photographs.

In the same way as the town planner, the agricultural scientist will wish to advise on the most economic use of the land and a land utilization survey can be greatly assisted by aerial photography. He can assess the arable area and so form an estimate of probable harvest, and can select areas where cultivation might be extended. The following is an extract from a speech made in January 1946 by Mr. Marshall S. Wright who is Technical Assistant in the Office of the Secretary of Agriculture in the United States. He said "Few people apart from those directly concerned have any comprehension or conception of the vast scope and the magnitude of the contribution aerial photography makes toward the fulfilment of the Department's objectives relating to the growing marketing, and distribution of agricultural products, the protection and management of national forests, agricultural adjustment, conservation, land use, farm tenancy, rural rehabilitation, rural electrification, and other supplementary phases concerned with watershed protection, fire control, soil erosion control practices, and many others. It must appear obvious, even to the layman, that nothing devised by the ingenuity of man is more ideally suited to a study of the face of the earth than is an aerial photograph, nothing can portray the physiographic and cultural conditions on the ground, and as they actually exist, including the vegetative and forest coverage, as well as does an aerial photograph". Later in the same speech Mr. Wright disclosed that between 1926 and 1945 the United States Department of Agriculture had contracted for or executed directly no less than 2,945,000 sq. miles of photography. Here then you have a testimony of the value of aerial photographs to the Department of Agriculture in a country already so highly developed as the United States. It is surely true that in India the need and the promise of usefulness is far greater.

By using photographs the forestry officer can watch out for excessive deforestation, inspect damage done by forest fires, plan reafforestation, demarcate reserved forests and fire lines, and actually estimate the timber content of existing forests by recognition of trees on fairly large scale photographs. Some very early pioneer work of this description was done by the I.A.S. & T. Co. Ltd. for the Forestry Department in Burma as long as 20 years ago.

In a wider field the botanist can use photographs to determine distribution of numerous types of flora. When I was a student at the University I undertook a small piece of research into the relation between ecology and geology in a certain forested area of England; this entailed at the time very detailed ground inspection and mapping of various floral associations; it is only since then that I have come to realize how much I could have been assisted by air photographs and how much wider an area could my investigations have covered.

So one could go on outlining the uses of air photography in archaeology, in port development, in shore-line surveys, in water reservoir projects, in development of power transmission and distribution, and so on, but let us pass now to the uses of aerial photography in geological mapping and the exploitation of mineral resources.

Geological mapping from aerial photographs has been pioneered mainly by the large oil companies throughout the world, and they almost all now maintain a staff of technicians whom they call photogeologists to assist them in their search for oil. However the value of photogeology is not restricted to the search for petroleum; in all cases where a map of the surface geology is a necessary preliminary to development, air photographs will assist to a greater or lesser extent.

The photogeologist needs most of all to be a student of the topographical expression of geological factors. Unlike the field geologist he cannot examine exposures at close quarters, study a hand specimen with a pocket lens, or measure the strike and dip of beds with a compass and clinometer; what he can study far more effectively than the field geologist are the expressions of geological features in the geomorphology of the landscape, the patterns of drainage, the distribution of vegetation, of human settlement and activity, and it is to these features that he must direct his attention and from these that he must make his deductions.

It is well enough known that softer beds generally tend to form low lying areas by reason of the fact that they are more easily eroded, and that

alternations of relatively hard and soft bands of dipping sedimentary rocks will form a series of scarps and valleys. In detail however the effects of weathering and erosion on beds of even slightly different chemical or physical characteristics must be different, and the photogeologist has to train himself progressively in the study of even small geomorphological differences between the surface outcrops of various beds or rock types so that he can trace the outcrop or the limits of the outcrop of any one rock type across his photo and from photo to photo. It may well be of course that he will not know the actual characteristics of a hand specimen of the rock he is tracing, but if he can map this type over a wide area then his task will be adequately done, since one visit to the field will suffice to ascertain the types of rock which he has mapped. In actual fact the photogeologist himself has had, or should have had, some experience in the field and he can form a good idea of what types of rock he is mapping from the photographs. The surface drainage pattern should of course be closely studied since it helps not only in the differentiation of one rock type from another but also gives information on the chemical and physical characteristics of the rock; for example, one could seldom fail to note the special and different characteristics of the drainage pattern in limestone, sandstone, dominantly argillaceous or igneous rock outcrops in a humid climate.

Variations in colour of the outcrop or its vegetational covering will produce tonal differences even on a black and white photograph to assist in mapping and correlation. The future quite definitely holds out the prospect of the widespread application of coloured aerial photography. Besides being of the utmost value in mapping desert country, coloured photographs will enable us better to elucidate the geology of jungle covered country by giving us a better appreciation of floral distribution. A whole book could be written on the relationship between distribution of flora and the underlying geology. Vegetation may indicate to the observant photogeologist the boundaries between rock types; it may show up the unconformable transgression of one series of beds upon another, the trace of an overthrust where rocks of different types are brought into juxtaposition, the presence of salt domes, the trace of igneous dykes and of faults or fault zones which may lead to the discovery of mineralized zones.

When mapping a considerable area it is sometimes possible to build up a sequence table of outcrop characteristics similar to a lithological table and to use this for correlation purposes over the whole area. As with the field geologist the photogeologist is greatly assisted if he can first examine an undisturbed succession of all or most of the rocks with which he will be

dealing; this will form his type section for that area. He must however take great care to note that the surface appearance of the same bed may be very different under different dip conditions.

The strike of beds on aerial photographs can be measured by the familiar method of joining two points of the contact on the same altitude. Dip can usually be seen in any country where there is active erosion since erosion will generally expose a considerable dip surface. Where this occurs the photogeologist must be careful in estimating the angle of dip by its appearance on the photograph because his sense of relief is greatly exaggerated owing to the fact that through a stereoscope he is looking at a relief model with his eye base extended to the distance between the successive camera exposures which may be one or two or more miles, consequently dips will appear steeper than they actually are. After some experience however the photogeologist comes automatically to allow for this exaggeration. If we require to do so, we can actually measure the angle of dip on a well exposed dip plane provided that we know the height of the aircraft above the ground at the time of exposure and the focal length of the camera used. A small instrument known as a stereometer enables us to do this since, with its aid we can measure the parallax of various points and so calculate their difference in height from the simple formula :—

$$\text{parallax} = \frac{\text{focal length X base length}}{\text{flying height—height of object}}$$

$$\text{or height of point} = \text{flying height above datum} - \frac{\text{focal length X base length}}{\text{parallax}}$$

The parallax of a point defined in this sense is the change in position of its image on two successive exposures of an overlap. This change is measured parallel to the baseline. By this means then we can calculate the difference in height between two points on the dip surface in the direction of dip, then measure the horizontal distance between them and so find the angle of dip of the surface. Very frequently of course a large dip surface will not be exposed, but a similar procedure may be carried out if a contact can be seen exposed on both sides of a river valley. A very high degree of accuracy cannot be obtained by this method but a close aproximation can be secured. Where it is not possible to measure the dip it can, with experience, be estimated quite well from its appearance, the extent of the V-shaped outcrop as the bed crosses a valley, the sinuosity of the outcrop or changes in the width of the outcrop of any particular bed or formation.

Now to turn to economic geology. Enough has been said already to indicate some of the uses of aerial photographs to those concerned with the development of mineral resources, we have seen that (*a*) the surface outcrops of mineral bearing rocks, be they sedimentary bedded rocks, igneous masses or dykes, can frequently be mapped; (*b*) the extent to which they are folded or faulted can be noted; (*c*) under favourable conditions dips can be measured in sedimentary rocks and the throw of faults can be calculated; (*d*) old stream courses can be picked out when searching for alluvial deposits; (*e*) the planning of schemes of development, such as the best way of getting into the area or the lay out of the plant on the site, can be worked out.

As has already been mentioned, it is in the search for petroleum that photogeology has been most used up to now. This search very soon comes down to the business of finding, within tracts of country known or thought to contain petroliferous rocks, areas where the oil my be found in sufficient quantities to be worth developing. Since oil will migrate upwards where it can, this amounts to finding areas where the oil will be trapped for one reason or another and will collect into pools. The most common type of trap is the structural one, though lithological traps are by no means infrequent. It is in the search for traps that photogeology is being so greatly utilized.

To give a specific example. In their efforts to assess the possibility of discovering additional petroleum resources in India and Burma the Burmah Oil Company and its Associates had before the war taken more than 20,000 photographs covering some 35,000 sq. miles in Burma and 24,000 sq. miles in India, and considering that the cost of photography varies between Rs. 20 and Rs. 35 per sq. mile it will be realized what an enormous expenditure this has involved; the exact cost per sq. mile depends on the scale and the distance of the area from the aircraft operating base. My colleagues and I are now busily engaged in working out the geology of those areas, and we expect soon to have some thousands of square miles more to examine, as plans are being discussed for photographing additional areas in the northwestern and north-eastern parts of India. The war has interfered a great deal with the Company's activities in prospecting for new oil fields but it is confidently hoped that, when the time comes for testing new structures, the effort and expense involved in all this photography will be found to have been worth while. The area covered by the B.O.C. photographs of India and Burma was, at the beginning of the war larger than all the areas photographed for all other purposes in the whole of India and Burma.

Already a large amount of useful information has been gathered from such photographs as have been worked out. We have been able to use them to help to assess merits of one structure as against another in order to find the best places to locate test wells to be drilled as soon as the necessary equipment and skilled personnel can be assembled, to gain valuable stratigraphical information by mapping unconformities, to judge the extent of major faulting, to find new structures, and also to satisfy ourselves that in some areas there are no potentially valuable structures.

The Burmah Oil Company photographs cover a wide range of country from the deserts of N.W. India, through the scrub country of central Burma to the dense jungle of Assam and Arakan. As a general rule of course we find that we can work out most detail in the barren lands of the N.W., but we consider that the amount of geological information we gain even from the areas of dense jungle justifies the expenditure involved in obtaining and interpreting the photographs.

All this of course does not dispense with the need for the field geologist since aerial photographs, like gravity or seismic surveys, palaeontology and sedimentary petrology, are merely an aid to him in his work. There are large number of very important geological facts which it may not be possible to resolve from photographs, and we never regard a photogeological map as final until it has been confirmed in the field. We can however decide which areas are worthy of examination in the field and which are not.

In our opinion the best way of utilizing air photographs is for the field geologist to go out armed with a photogeolgical map of his area, the actual photographs and a small stereoscope. After a day's work in the field he can sit down in his camp in the evening and study the photographs of the area of the day's work, confirm the opinions he has formed in the field or decide that he must have missed some vital piece of information. If it is sufficiently clear how the area he has examined that day correlate with other areas it will not be necessary for him to visit them and he can plan his next day's work so as to gain new information, and so on. In a country where outcrops are few and far between he can save himself a large measure of the exasperation of a long day's walk for little or no information by choosing on his photographs the most likely areas to look for exposures.

Quite apart from the geological information that the photographs give him, the topographical information is also of the utmost value, particularly

in unmapped or poorly mapped country. Where the photographs are of fairly large scale, he can often make a rapid reconnaissance visit to an area without a surveyor to record his observations, as he can note them direct on to the tracing of the topography from his photographs.

Very frequently trends in the geology which are not at all easily discernible in the field can be distinguished on the photographs. Even under a very light cover of alluvium the geologist can often trace a feature on photographs by the effect it exerts on some surface phenomenon. I have seen an area where the structure of a pitching nose of an anticline has been clearly picked out by the alignment of paddy field bunds where there were probably no actual surface exposures at all; it is most improbable that the significance of the paddy bund pattern would have been appreciated from the ground. Similar evidence of this use of air survey comes also from the field of archaeology; I have been reliably informed that more archaeological sites were discovered in England as a result of four day's air reconnaissance than were discovered in the previous fifty years of searching the ground.

Numerous instances could be given of particular information that has been gleaned from air photographs but time does not permit of this and we can only note that a very great deal of evidence of the value of photogeology does exist and can be drawn not only from India but from all over the world.

Before concluding, a slight reference to the problem of map-making from air photographs which involves a consideration of elementary photogrammetry would appear necessary. Just as the field geologist has to record his information in its correct geographical position and frequently calls in the aid of a surveyor to do this, so the photogeologist must be able to record his observations in their correct position and should understand the elements of surveying in the medium of photographs. Without going into details on this subject let it be said that for each photograph there is a point known as the isocentre from which photographic tilt distortions are radial and all angles are true, and a point known as the plump point from which all photographic height distortions are radial. In a photograph taken vertically these two points coincide and fall at the geometric centre of the photograph so that from this point we can draw true direction rays to all other points on the photograph. If we have prints overlapping by at least 50% all points except at the very beginning and very end of a run will occur on two photographs and so true direction rays can be drawn to them from two angle-true points. The scale distance

between these two angle-true points can be fixed and from them other points fixed on the same scale by the intersection of rays. Thus it is possible for the photogeologist to build up from his photographs a geological map showing his observations in their correct geographical positions.

There are many varied and some very complicated instruments which are designed to make surveying from aerial photographs more easy or more accurate, but these need hardly be the concern of the photogeologist who can do his work satisfactorily with a simple stereoscope and stereometer; the possibility of measuring heights and dips on a photograph by means of the latter instrument have already been mentioned.

In conclusion, an attempt has been made to draw attention to some of the possible uses of aerial photography in the development and planning of this country. There must be many more uses not directly concerned with economic development, for example the employment of photographs in teaching both in schools and universities, but these are not considered here. One legacy of the war is that there are now in existence a large number of air photographs of India and a considerable body of men trained in their general interpretation. Plans were under consideration some time ago to make these R.A.F. and R.I.A.F. photographs available to all government departments and approved private persons. These plans may now be complete or still under consideration but it would certainly seem to be an excellent idea that the photographs should be put into some government library where they could be consulted. The Burmah Oil Company welcomes this proposal for a Central Library and has offered to make its own collections of photographs available in due course, and has already been able to render assistance to various Government Departments by placing at their disposal air photographs of areas of special interest in connection with some particular problem, and of course the whole collection was available for use of the military forces during preparations for the Burma campaign. Because every department would not want to maintain its own experienced interpretors a small staff of qualified men might be stationed at the library to be consulted on any problem as it arises. This applies particularly to the future because the area covered by already existing photography is almost negligible in comparison with the extensive areas which could and should be photographed to make certain that planning goes on with the wealth of information available from air photographs at the disposal of those whose task it is to direct the efforts to improve or increase the development of the natural assets of India. We have before us the example of the United States where almost 3,000,000 sq. miles have been photographed by the department of Agriculture alone. In India as

elsewhere requests from various departments for photographs should be co-ordinated by a central control so that the maximum amount of useful information on the largest number of problems can be obtained from one air survey project.

Numerous persons and Government departments will doubtless say, "Yes, Yes. But all this costs money and in some cases the return for this expenditure in the form of increased revenue to the Exchequer may be long delayed, and in a few cases its effect may not even be felt as a financial benefit at all". To them the reply is surely that if by the expenditure even of lacs of rupees, our return comes partly or wholly in the form of a better standard of living, more freedom from the fear of want and the devastation of flood. or a happier existence for some of the four hundred millions of people in India; then who can begrudge the expense of the photography or the labour of its interpretation and utilzation of the information it provides. *

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* I thank the Burmah Oil Company for permitting me to deliver this paper, and for allowing me to pass on some of the infomation I have gained while in the service of the Company. Other information has been drawn from my experience of aerial survey during four year's service with the Army in India.

The Geographic Control of Population Distribution Over the Earth

(A Study in Human Ecology)

BY
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Importance of the Study of Population:

The study of the distribution and density of population over the face of the earth constitutes one of the fundamentals of Human Geography; and it goes without saying that population distribution over a region is intimately related to its ecology and is reflected in the economic and social life of that region. Since the days of Ritter, the central theme in the geographic ideas has been the man, and in our days the importance of the study of man's economic, social and political life as related in a reciprocating functional relationship to its environment has gained a popular recognition. This study aims at unravelling the geographic conditions of unequal habitability and its consequent effect on the general distribution and saturation of population over the earth as a whole. There is a delicate ecological equilibrium between the environmental conditions and the pattern of population, which often breaks down resulting in the lowering of standard of living, emigration, or even warfare. One of the fundamental objective of Human Ecology, as this paper will indicate, lies in the elucidation of geographic control of population disparities over the earth and in the analysis of the conditions responsible for such local or regional anomalies.

Regional and Local Anomalies in Population Density:

While the total land surface of the world is near about 56 million sq. miles, the exclusion of the uninhabitable areas of the Polar Region reduces the total available areas for human habitation to 50 million sq. miles and taking the total strength of human population to be near about 2000 million, the mean density of population over the habitable part of the earth comes to 40 persons per sq. mile. And assuming more or less correctly the total culturable area over the surface of the earth to be one-third of its total area, the mean world-density per sq.mile of cultivated land tends to be 120.

But a statistical study of the world's population strikingly reveals that two-third of the world's population is confined only to one-seventh of its area, and that Europe, India, China share more than half of the burden of humanity. At the same time, even a cursory glance at the population-maps of the world, such as those prepared by Hubner, la Blache, or Jefferson, is sufficient to indicate the extreme unevenness of actual distribution of mankind over the terrestrial surface, where the High Polar latitudes and Low Rainy Tropical lands constitute some of the largest blank-spaces of the world only to be separated by some of the most congested dens with teeming millions. Added to this is the remarkable dispersion of population in the southern Hemisphere, which though larger than Europe by several times, contains a few millions of human souls.

In addition to such regional anomalies, the local variations in population density are no less significant in the entire pattern of population over the earth. While Lancashire has a density of 2,600 per sq. mile, its surroundings have only 83; Manhattan has 100,000 per sq. mile of area, but Neveda has less than 1; and while some parts of rural China have a staggering figure of over 6,500 per sq. mile, North China and Tibet each has a density of less than 2 per sq. mile of land. Such kinds of stupendous disparity in the density and distribution of population in the different terraines of the earth invariably invokes the problem of unequal habitability of the different segments of the earth, which according to Dr. Newbigin, constitutes the fundamental question in Human Geography. Since habitability in any particular area is governed by definite geographic environmental conditions, aided by no less powerful social and political factors, the problem of inequality of human settlement turns to be a problem of geographic determinism. It may be argued that present day uneven distribution of population was merely due to an early chance of development. But this has been strongly refuted by la Blache, who asserted the 'quasiubiquity' of early man and indicated that Quarternary man and even Palæolithic man was pretty well distributed oll over the globe including such backward and hostile areas as S. Africa, Australia and S. America. Hence, we have no other way but to accept a number of specific geographical conditions as being responsible for segregation and congestion of humanity in some of the more favoured tracts of the earth.

Geographic Factors Determining Population Pattern:

All the geographic factors which more or less control the unequal habitability over the earth's surface, can be enumerated as follows: firstly, influence of climate; secondly, influence of relief; thirdly, natural fertility

of land and mineral wealth including power-resources; fourthly, geographical location; and lastly, existing cultural stage in the ecological-cycle of the region.

Climate is a great dictator of human settlement. Climate directly affects the life of all the living organisms and sets a marked limit in the living conditions within which man must seek his abode to live in. The fact that the early man's settlement was confined approximately to a zone bounded by the Tropic of Cancer and 40° parallel of latitude, clearly indicates the controlling influence of climate on the settlement of man, which invariably flourished in a region which was neither too hot and humid, nor too dry and cold and had neither a paucity nor an excess of rainfall. Surely, the meagre traces of human settlement in the Tropical jungles of Amazonia, Congo and East Indies with density of population hardly exceeding 8 persons per sq. mile, and that in Antarctic and Arctic lands having a density of less than 1 per sq. mile, are all due to the debilitating, benumbing and hostile climates that render human life intolerable and insecure. On the other hand, in Humid Sub-tropical lands the moderately warm and rainy season of 4-5 months duration following a winter of moderate cold and precipitation, made it possible for two cycles of plant life to be completed in a solar year with the prospect of two harvests and a guarantee against the nightmare of frequent famines and this was perhaps the most propitious environmental condition which stimulated vigorous growth and concentration of early human settlements in such a region. Indo-Gangetic plains etc. have been over-saturated with teeming population since the earliest times in history. Besides this, the Temperate Marine Climate of north-western Europe and Humid Continental climate of eastern United States, with their stimulating and invigorating effects on the physiological and mental frame-work of man, are among climates par excellence the best ones for maximum concentration of human settlements. Thus Belgium supports 700 persons per sq. mile of land, England and Wales 685, Holland 660 and New England over 500, Prof. Huntington's contention that the lands of highest material culture and civilisation coincide remarkably with the zones of maximum 'climatic energy' and that the materialistic civilisation is in a way a product of physical health and mental energy imparted by the climatic environment, is now an accepted truth. The regions showing maximum degree of materialistic culture and mechanised civilisation, such as in eastern U. S. A. and north-western Europe, exert a strong pull on the population of the adjoining lands and have gradually become some of the most congested spaces on the earth's surface. Of course, the existing cultural stage in the ecological-cycle of these regions has a significant role to play.

The influence of physiographic relief on the spatial distribution and segregation of human settlements is clearly indicated by the fact that approximately nine-tenths of the world's population dwells on plains, having an average elevation of less than 2000 ft. above the sea, though only half the earth's surface may be classed as plains. In a plain habitat, the superior facilities for carrying on higher means of livelihood, such as arable farming and manfacturing industries and the high degree of mobility for transportation and communication purposes have undoubtedly induced man to settle and to congregate together. In fact all the important centres of early civilisations, teeming with swarming population, were born and nourished in the cradle of Tigris-Euphrates plain, Nile valley, Indo-Gangetic plain, or of Yangtze basin. Even the present day foci of modern civilisation grew up and developed in plain lands, and all the great centres of human agglomerations of our time are located in plains. Hardly there is strictly a montane city with one hundred thousand population. Thus, while high Himalayas or lofty Alps are shunned by man, Gangetic plain or Rhineland is swarming with humanity. Southern Norway, though enjoying the same exhilarating and stimulating climate of Temperate Marine Europe, has a very meagre population with a density of only 21 persons per sq. mile. The extreme ruggedness and dissected nature of the land with no plains available for settlement has invariably resisted any growth and development of large cities.

Unquestionably, the natural fertility of the soil, which gives a heavy return in agricultural enterprises and offers good prospect of harvests, is one of the most potent factors for the congestion of agrarian population on the productive lands of the earth. Once again the coastal plains and the Yangtze basin of China, Indo-Gangetic plain of India, and the Nile Valley of Egypt come into prominence, where mighty rivers issuing from the central Asian Massif or Central African highland, and fed by Monsoonal rainfall in summer, succeeded in depositing enormous layers of alluvia only to respond readily to the call of the plough, and certainly this was one of the most favourable geographic conditions for the abelong 'sedimentation of human alluvium' in those lands. Certainly, the high degree of agricultural productivity, besides other factors, can justifiably account for the concentration of about 300 millions of human beings within the natural border of Indo-Gangetic valley, 75 millions in Southern Chinese lands 15 millions in the island of Java, and 10 to 15 millions in Siam and Indo-China. Naturally, it is the inherent fertility of the soil which only can sustain a heavy demographic burden of about 1000-2000 persons per sq. mile of land in some parts of East Bengal, and over 600 heads per sq. mile of area in some parts of rural China. The same is true of the north-western plains of

Europe, where the high productivity of the land effectively maintains an enormous agricultural population. Indeed, the agricultural lands of Monsoonal south-east Asia and Temperate Europe supports about two-thirds of the world's population on not more than one-seventh of its habitable area, while the sterile lands in between them contains a sixth of that population on four times the area.

The mineral wealth together with the power-resources of a region has assumed a tremendous importance in the national life of our times, as the civilisation of man has undergone an entire evolution from her primitive agricultural stage to the modern industrial technicism. In our present age of machine-culture, the extractive manufacturing industries based on the raw material resources of the land, provide the main occupation for the majority of inhabitants in an industrial country, and as such the direct influence of industrialisation on the spatial distribution and pattern of population cannot lose its significance. The process of concentration and segregation of population due to gradual industrialisation of a land operates through two definite ways. While there is a gradual depopulation of the area where such fuels and minerals are absent, entirely new urban conurbations grow up resulting in gradual concentration or settlements on such hitherto uninhabited lands. Thus, Birmingham and New Castle became great centres of human agglomeration but East Anglia and Pennine foot-hills gradually became depopulated. Any population map of Europe would strikingly reveal the close coincidence of extremely congested areas of man with the well-developed industrial regions of Donetz, Silesia, Ruhr, Saar and Lorraine, pre-eminently noted for their raw materials and manufacturing industries. Even in the vast lands of the United States, where settlement is in general sparsely and evenly distributed density of population shoots up high around the Appalachian coalfields and Pennsylvanian industrial regions. In Great Britain, the exploitation of coal and iron deposits since the earliest times, has invariably resulted in the complete segregation of her population to a number of mining and industrial zones, where the mean density often exceeds thousand persons per sq. mile of land. As a matter of fact, in Great Britain, the distribution of her population is the distribution of her mining areas, and as such the population pattern of Britain can be well read in a map of her coalfields and industries. The influence of mining development and manufacturing enterprises on the spread and growth of settlements in parts of Australia is an outstanding example in the colonial geography of the last century.

Geographical location with respect to important trade-routes, traffic lines and communication links, to and from the world's market is a predominating criterion for the growth and expansion of almost every important conurbation of the world. London, Paris, Humburg, Tokyo, New York etc. have become notable nuclei of human agglomerations teeming with millions of lives, only due to their favourable and advantageous geographic location with respect to the world's commercial zones and markets. Prof. Mark Jefferson's laborious study regarding the growth and distribution of the world's principal cities has strikingly brought out the fact that the concentration of more than a tenth of the world's population within the narrow confines of less than a hundred great cities, is in large part due to the geographical factor of favoured location.

Thus, the world supremacy of Denmark in mixed farming and dairying, coupled with her very favourable location with respect to the vast markets of the New and Old World is responsible for a dense layout of agrarian population in Danish plain, while New Zealand, enjoying the same temperate marine climate, with the same degree of success in livestock farming, and dairying, is still a land of wilderness because of her geographic isolation. While the coal mining in Pennsylvania and potash mining in western Germany gave rise to definite industrial regions, swarming with thousands of human lives, coal mining near Spitzbergen and nitrate extraction in Chilean highlands have remained almost inert in attracting and concentrating human settlement around them. The inability on the part of New Zealand or Chile to become densely peopled lands of the world is surely more due to their unfortunate geographical position with respect to the industrial and agricultural markets of Europe and America than to any other cause.

One of the important conditions responsible for unequal distribution and uneven concentration of population over the face of the earth is the 'supporting capacity' of different regions, which is in large measure dependent upon the existing cultural stage in the 'ecological cycle' of the region. Thus, while the 'hunting and fruit gathering stage' of culture in the Tropical jungles of Congo and Malay, in the desertic lands of Kalahari or in the Tundra land of Siberia will not even in the most favourable circumstances maintain a population density of only one person in 50-100 sq. mile of land, the 'pastoral stage' of culture in the Sudanese land, Central Asiatic Steppes, or in the Manchurian plain, is able to sustain a population density of 2-5 persons per sq. mile. Under the next higher stage of agricultural adjustment an optimum population burden of 500 per sq. mile of land can be easily supported by a typical agricultural region. Tilled lands of Iowa, Denmark or Romania support a population density of 20-80

persons, and can easily afford to support more. In the Gangetic valley of Bengal, local density rises to 1000 to 2000 persons per sq. mile of land, often exceeding 3000 persons in East Bengal, and in some riverine tracts of China, population pressure often reaches a staggering figure of 6000 persons per sq. mile of area. All those stupendous pressure of population in the oriental lands is maintained solely by agricultural adjustments, though not without serious lowering in the standard of living. The next successive stage, of industrial and commercial ecesis in the cultural ecology of a region are associated with tremendous increase in the supporting capacity of demographic pressure, and some of the largest industrial regions of the world, such as of Saar, Ruhr, Lancashire, Pennsylvania, etc. easily support some of the highest pressure of population over the earth, the density being well over 1000 persons per sq. mile. The ultimate stage in the ecological cycle of a region, as represented by its commercial activities, is associated with the highest population-supporting capacity, and as a matter of fact, a number of giant 'dinosaur' cities have sprung up in recent times, each of which has received a heavy 'precipitation' of as much as 8 to 10 millions of human lives within its narrow confines. London and Hamburg each contains more than 7. 5 millions of human lives, while New York city bears a population burden of 10 million citizens, raising the density in the Manhattan Island to the bewildering figure of 1,000,000 persons per sq. mile of land. It hardly needs elucidation that the prevailing stage in the cultural ecesis of a terraine has a determining influence on the degree of concentration of population in the area.

Non-Geographic Factors Influencing Distribution of Population :

In addition to all these environmental conditions a number of non-geographic forces relating to the social tradition and planned governmental policies are also responsible for the dispersion and accumulation of population in different parts of the earth. The agelong socio-religious outlook accepting large families as the principal units of social solidarity and the aims at maintaining large families with inherent insistence on early marriage and need of progeny, together with a strong social cohesive tendency to keep all the members of the family near to the ancestral lands by strong discouragement of outward migration, have all undoubtedly led to intense congestion of human lives in the agricultural lands of China, Japan and some parts of India as well. Of course, the condition of high child-bearing capacity of oriental women is still an important factor in the crises of over-population of her lands. Though this point is to be left for the study of world eugenists, experts opine that the very ignorance of the techniques of artificial control of birth as also the absence of continent habits in life, contribute greatly towards the over-saturation of population in all these Oriental lands.

Further, the political forces operating through the governmental policy of systematic encouragement of emigration or restriction towards foreign immigration are none the less significant factors in the spatial distribution of human life over the earth. While the after effect of the restriction on foreign immigration to the U. S. A. in the year 1921 and '24 led to a gradual congestion of population in Great Britain and particularly in Japan, a free and encouraged emigration from over-populated Britain to the New lands of Canada and Australia subsequently resulted in great relief to the former. The progressive growth and expansion of settlements in the numerous Pacific Islands and in Manchurian plains is due only to constant encouragement and advocacy of large scale emigration from over-burdened soils of Japan. Nowhere in the earth, the problem of 'living-space' is so acute as in Japan and the constant governmental policy of emigration to the new lands has surely brought a change in the layout of population over the East-Asiatic islands.

Perhaps, the final finishing touch to the whole problem of population disparity over the surface of the globe is given by the 'time-lag' factor. Though, as we have already indicated, the earliest human settlements were more or less evenly distributed over the earth's habitable surface, they were, it must be admitted, nevertheless confined within the borders of the Old World, and that the concentration of dense agrarian population on the riverine tracts of Monsoonal Asia is the direct result of many centuries of growth. It must be taken for granted that the great difference in the length of time during which Old and New World have been accessible for settlement to the civilised man, is one of the fundamental considerations explaining why the Old World contains more than three-fourths of the human race on half the total area of the earth and why the inviting lands of the New World, especially of the U. S. A., though often lavishly bestowed with natural resources, are sharing only less than one-fourth of world's population burden.

Conclusion :

In conclusion, it would be wrong to assume that the fertile and resourceful lands of the U.S.A. or of Australia will be in due time as densely peopled as the corresponding regions of Asia and Europe. With the marching progress of machine-culture and revolutionary developments in scientific technicism as applied to the problem of production, transportation and distribution of foodstuffs and manufactured products, conditions of

143762 JL

population growth have changed within the last 2 or 3 decades; for, it has been possible to increase the food production enormously without a proportional increase in the agricultural population and to support thereby a huge mass of people in far off lands through the lightning speed of transportation. As a result, the age long tendency of population to concentrate near the fertile agricultural lands or near the mining areas has lost much of its strength, and it is hardly possible that the fertile and resourceful lands of the New World will in future prove a match to the Old world as a congested home for human race.

Lastly, it should be borne in mind that the pattern of population over the entire surface of the earth with her local and regional anomalies, is a function of a variety of causes in which the geographical elements play a very prominent part, while the social and political forces are contributing factors of no less significance. It must be conceded that none of these factors is individually responsible for the disparity in population distribution over different parts of the earth, and also that with the progressive evolution in scientific civilisation of our time, some of these factors will lose their significance altogether, while new and complex conditions will emerge out, rendering the whole problem of population-anomaly over the habitable surface of the earth very unstable and in a 'state of constant flux'.

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Place of Geology and Geography in Planning and the Economic Development of India.

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The economic development of India is still so meagre and her idle resources in men and material so vast, the internal market so extensive that there seems considerable scope for development along the familiar road of '*Laisses faire*' without any State intervention. No doubt, this will, although very slowly and haphazardly, improve somewhat the economic condition of the masses under policies of economic nationalism. But need we take the same road which took many a country to the brink of an abyss? Should we not benefit from the experience of others and hasten the pace of economic and social progress?

The purpose of the present discussion is not to demonstrate that successful economic planning from the point of view of the peoples welfare in a thickly populated country like India, is only possible[1] under conditions of socialism. But it is proposed to examine some aspects of the scientific effort which should go to make planning successful.

There is almost an unanimous demand in the country for planning our economic growth. But Planning itself as understood by progressive men means production and distribation with a social purpose. A planned economy in this sense implies a system by which broad decisions as to what will be produced both for internal and export markets, what will be imported, the amount of capital needed and its utilisation will be made collectively in the interests of the whole society. After this elementary yet fundamental question with regard to the purpose of planning has been answered, next follow the essentials pertaining to its method and execution.

Planning Essential

Planning is essential, but it is an intricate business. It should be attempted from a scientific point of view. That presupposes a collaboration of scientists. But it is not fully realized by many administrators and politicians, especially in our country that the realisation of this aim would demand the discarding of much of our traditional outlook in education and

1. This is what the writer believes in

technological approach. The cultivation of the physical sciences will continue to have an important claim in our educational and national programme, but it is the biological and the social sciences and the political arts of new industrial regional and community planning, that will most urgently need cultivation. To achieve the new methods of production and development, the services of a few scientists who are supposed to dabble in every thing would not be enough. No longer do we live in an age when a bunch of 'experts' in economics, physics, chemistry and mathematics assisted by a handful of engineers with the over-all benidictions of their politician friends can bring about the miracle of scientific economic planning. It will require the services of the geographer and the regional planner, the psychologist, the educator, the sociologist and a host of other scientists who will have to be assisted by skilled political administrators of a new type. We are on the threshold of a vast material and economic development but we must realise that to plan and to rationalize does not merely mean increased mining of coal or building more dynamos and raising a crop of towering chimneys. It, in fact, involves the social approximation of natural resources, the replanning of agriculture, redistribution of industry and the maximum utilisation of those regions where are located the modern sources of power.

What is meant to be emphasised is the important role that trained geologists and geographers will be required to play along with other specialists in this intricate business of planning. For, it must be recognised that the plans of political leaders, government officials and industrial magnates for target achievements in schemes of planning for economic development must be co-related to regional realities the essence of which is the full consideration of the entire life-circumstances of environment rather than mere giganticism and 'get-rich-quick' attitude.

Thus in schemes of material development the liason between the geographer and the engineer must be very close.

The Geologist

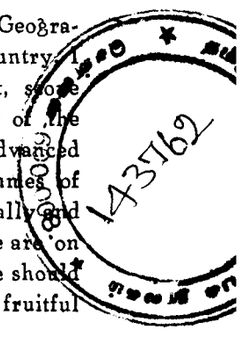
With regard to the indispensable services of the geologist in planning and economic development. I need only add a few words as our geologist friends will indeed themselves point out all that need be said.

As archaeologists and historians labour to unearth man's past and study his developing life through the ages, so the geologists are concerned with the history, shape and forms of the rocks and the treasure of the earth itself that lie on the surface and beneath it, for man to use and work upon.

All the metals and most of the materials which are of service to man, other than to provide him with food and clothing are obtained from the earth's crust mainly in the form of minerals. But in spite of this vital usefulness and geological knowledge and its implications on the development of our natural resources, scanty attention has been paid to the expansion of this branch of scientific knowledge as has already been forcefully pointed out from the platform of the Indian Science Congress.[2] The small number of trained personnel and the limitations of the Indian Geological Survey are too well known to be mentioned here. It was only the stress of war resulting in a shortage of supply of minerals needed for essential industries that made the Government think of the importance of this science and proposals for some expansion of the existing Government department were formulated. What is essential is the realization that we would need hundreds of Geologists to carry through successfully a great deal of our planned programme for economic development.

It would not be out of place here to point out that both in Europe and the U. S. A. most leading geographers have had training as geologists.

Before I speak of some aspects of the indispensable role of Geographers in tasks of economic development and planning in this country, I would like to make a digression ; firstly, to emphasise the concept, scope and method of modern geography and secondly, to refer to some of the services performed by trained geographers of late, in some of the advanced countries in connection with the war effort as well as programmes of economic, cultural and social developments. Ours is an economically and educationally backward country, though with a glorious past. We are on the threshold of national emancipation, and I see no reason why we should not benefit from the experience of other peoples in the field of fruitful scientific effort.



Modern Geography.

A word about modern geography need be said because the study of the subject as a social science had been greatly neglected in the past. It is but natural, therefore, that few of our fellow workers in other fields are able to appreciate the important role that geographers can play in education, citizenship and planning.

Geography is not what it used to be—a boring tiresome job of enumeration of a mass of unrelated facts. It is drawing closer to biology on the

2. N. N. Chatterji: Presidential Address, Section of Geology and Geography, Indian Science Congress, 1945, P. 116.

one hand and to sociology on the other. Human communities and groups continue to endeavour to achieve a certain equilibrium between an 'internal' environment and an 'external' one. To the geographer this 'external' environment is the natural one and the 'internal' can be said to be that complex historical, ethnic, social, religious and economic elements which no less than climate and geology condition the life of communities. Greater consideration need be given to the understanding of this duality of environmment. The geographer is increasingly, concerned with the study of the internal environment and correlates its features with those of the external. As it has been well said, "Physicians have endeavoured to define it for individual humans, sociologists for tribes; geographers should undertake it for regions. Geography could better handle the study of processes without ceasing to be a science of interrelations."[3] The geographer is no doubt dependent for his material to a large extent upon other sciences. But this obvious 'borrowing' should not underrate the independent role of geography as a discipline and method of its own. This kind of borrowing of material is, indeed, a common practice in all scientific and technical work. For example, doctors daily avail themselves of the knowledge of the chemist, electrical engineer, precise instrument maker and radiologist etc. Similar is the task of the geographer. But none of the helping scientists cover the geographers field. In spite of remaining in the position of a 'bridge' subject, it has a discipline and technique of its own leading to a correlation between the intellectual and the practical aspects.

I cannot do better than quote briefly a leading British and an American geographer about the modern concept of this science. "After all is said, the business of the geographer is to assess the importance, in time and place of environment in human affairs and to apply his findings to contemporary problems, by bringing the study of man down to earth. In this way he (geographer) claims, not to be able to offer a self-contained system of explanations for man's social behaviour and institutions but to provide a vantage point from which to regard these things. The geographer may be compared to a spectator of a silent, captionless film. He sees all there is to see of man's relation with his environment, and with experience and training he can usually get the gist of what he sees. The rest of the task of understanding can be facilitated by the labours of the historian, the economist and the technologist."[4] The American colleague adds, "Every geographer must be trained to understand the structure of human societies and how they work, for the social and economic system of a nation expresses the knowledge, idealism, standards and dynamism of its people. It is in fact the chief national power plant."[5]

3. Geographical Review (New York) January 1946, p 87.
4. G.H.T. Kimble: Modern Geography, Geographical Magazine, London, June 1944.

There is a growing tendency to leave physiography and geomorphology to the geologist. But it requires the help of a trained geographer to interpret the interwoven pattern of relationship between human communities and their varying national surroundings. Geography is no mere memorising of place phenomena and names, however useful these may be. It offers a special training in observation direct or indirect and in regional comparison. Finally, the modern applications of science and the economic demands of industry have given to most problems a world setting and geography besides its humanistic character is a discipline which is meant to lead to the understanding of the peoples of the world as a result of the appreciation of their problems. And we should not forget that planning itself is not merely a matter of rupees, annas and pies.

Foreign Geographers Work

U. S. A: A great geographic achievement was the completion last year of the Map of Hispanic America on a Scale of 1 : 1,000,000 by the American Geographical Society which took 25 years to complete. From February 1942 to the spring of 1946, the Society carried out various kinds of work for the U. S. Department of State, which terminated with the completion of the drawing for a new general reference map of the world on the Miller Cylindrical projection.

The Department of State has a Section under it called the Division of Geography and Cartography. Under the important National Research Council is the Division of Geology and Geography with its Committee on Asiatic Geography. Professor George B. Cressey, a leading American Geographer is the Chairman of this Committee. Mr. Stanley F. Smith, Cartographer for the Geographical Review was consultant to the Department of State for several prolonged periods in 1944 and 1945 and attended the San Francisco Conference in the spring of the latter year as Cartographic Officer in charge of the map-making unit attached to the International Secretariat. Prof. John W. Coulter of the University of Hawaii during the war served on the General Staff Corps of the War Department reaching the rank of Colonel and later received that department's citation. Robert Bowman, Assistant Professor of Geography at the University of Iowa was asked to do field work for the U. S. Soil Conservation Service in Puerto Rico and later served with the Army Air Forces. Dr. J. Gottmann formerly

5. Dr. Isiah Bowman, Geographical Review (New York), Jan. '46, Op. Cit., p. 87.

of Sarbonne and now Assistant Professor of Geography at Johns Hopkins University, last year served for six months in France in the service of the Ministry of National Economy. Dr. Fischer a native of Austria, has now been working for U. S. Government as a geographer. S. Whittemore Boggs is the official Geographer of the State Department which also employs another geographer as Map Librarian. Professors Thomas Smith and Lloyd Black, both of whom served with the armed Forces are not attached to the Map Intelligence and Cartography of the State Department. Dr. Smith is the chief of the Far Eastern Section, while Dr. Black holds the same appointment for the European Section. Indeed, instances of the American geographer at work both in war and peace can be multiplied several fold to explain the rightful importance of this training.

Britain

British geographers were also called upon to contribute their expert knowledge to the winning of the War and now figure prominently in planning for peace.

The Council of the Royal Geographical Society awarded the Victoria Medal for 1946 to one of the leading British geographers Professor H. J. Fleure, for his distinguished service in the advancement of geographical education and his valuable researches into the human aspects of Geography. The work of far reaching importance in connection with the Land Utilization Survey in Britian is being carried on under the overall guidance of a noted geographer Dr. L. D. Stamp, G. H. T. Kimble formerly of the Reading University served for four years in the Royal Navy as Lt. Commander in the Naval Meteorological Service and is now Chairman of the newly created department of Geography at the McGill University. Dr. H. Thomas who was formerly Vice President of the Calcutta Geographieal Society has recently been appointed as Regional Research Officer for the Northern Region, England (North Riding, Durham and Northumberland).

Soviet Union.

From the very beinning the Soviet Government directed its geographers to undertake the task of collection of basic facts. All regions of the vast Soviet realm received attention. Geographers explored, plotted maps, studied climatic, human and animal distributions and indicated the relationship that existed between them[6]. Soviet science explored the possibilities of Soviet wealth. An inventory was prepared of all national wealth in raw materials and power possibilities and industry was redistributed according to plan.

6. Dr. Hewlett Johnson (Dean of Canterbury): Secret of Soviet Strength, p. 40.

In the Union there is an Institute of Geography and an All-Union Geographical Society. The governments of a number of republics of the U. S. S. R. have commissioned the Institute to help them draw up plans for the development of various branches of national economy in accordance with natural resources. The Universities of Moscow, Voronezh and Irkutsk have well-known research Institutes and the Leningrad University has one for economic geography. A notable recent example was the deliberations of scientists in connection with the 220th Anniversary of the Russian Academy of Sciences, Jubilee Celebrations at Moscow, in June 1945 when many trained geographers and geologists participated to discuss matters of common interest[7].

France

In 1938 there were chairs of Colonial Geography at several French Universities, including one at Sarbonne held by Professor Robequain. In 1945 Prof. Dion was appointed to the Chair of Political Geography at Sarbonne and Prof. Andre Siegfried was elected to the Academie Francaise in the same year, the first contemporary geographer. There was a Geographical Section of the French General Staff in the first phase of the last war, from September 1939 to June 1940 under the direction of Prof. Cholley and after the American landings in North Africa a number of Algerian geographers took an active part in the War effort[8].

The work of French geographers was considered of such importance in national life that after 1940 the German hand fell heavily on them. When the German grip tightened on France, teachers of geography were not the last to suffer; their school embodied the traditional resistance to the pseudoscientific theories of "Anthropogeographie" and "Geopolitik" which had acquired a new purpose with the coming into power of the Nazis. Between 1942 and 1944 the Gestapo took severe action against French geographers. Prof. Th. Lefebvre was shot. J. Ancel of Sarbonne died in the Drancy concentration camp. R. Musset Caen was clamped in Buchenwald for two years. H. Baulig of Strasbourg was put in prison for several months and E. Colin, Editor of the Bibliographie Geographie Internationale was also arrested and a host of lesser figures were arrested, interned or excuted.[9]

7. Nafis Ahmad: Task Before Indian Geographers, Culcutta Geographical Review, No. 4 1945, p. 114.
8. Geographical Review (New York) Jan. 1946, p. 90.
9. Geographical Journal (London) Jan. & Feb. 1946, pp. 50-51. Also, Geog. Review New York) Jan '46.

Many of the 'Maquis' of the Limousin, the Jura, Vercors and Ile-de-France were regularly supplied with large scale maps indispensable for their operations by teachers of Geography. The National Committee of Geography continued to produce sheets of 'Atlas de France' throughout the War. Among others two geographers were put into positions of great responsibility by the Liberation Movement i.e. Prof. P. Gouron of Bordeaux University, became Vice-President of the Comite Regional de Liberation and J.Blache of Nancy University was raised to the Prefectship of Meuthe-et-Moselle after the exit of the Germans.

Since the Liberation, several research missions have been able to leave for distant countries. Almost all have included one or more geographers. At present geographical studies are enjoying renewed favour and it is in this branch of knowledge that the majority of the great Universities have registered the biggest increase in the enrolment of students of both sexes. Specialised and advanced geographical studies are figuring as a significant feature of the efforts to rebuild France.[10]

Germany

Geography in Germany made direct and important contributions to the Nazi War-effort. This was by no means confined to Haushofer, the apostle of geopolitics and his pupils but many noted geographers were intimately associated with war work needing their expert services and now they are helping to chalk out plans for economic reconstruction.[11]

Many German geographers described geopolitics as catering to the emotions of the day, yielding to sensationalism and using quack methods. They were, in fact, active in geographical research as well as mapping organisations within a number of military and governmental agencies, including the four high military commands. As the war progressed, geographers remaining in civilian positions were increasingly drawn into war work through research programmes administered by a central office called the "Reichsforschungsrat"[12]. The geographical work was done under the following categories:- (1) Military Geography (2) Marine Geography (3) Supreme Command of the Armed Forces. Of course, in addition, there was the psuedo-scientific work of Haushofers Geopolitical Institute at Munich.

Firstly there was extensive field work for collection of basic facts in order to prepare handbooks and maps. By the end of 1943 the section of

10. Ibid., P.56
11. Geographical Review (New York) Jan 1946, pp. 92-100.
12. Ibid., July 1946, P. 398

Military Geography had produced 102 volumes covering 39 areas in Europe, Africa and Asia. Among the well-known geographers working in this organization were Professors Panzer of Heidelberg, Lehman and Bobek of Berlin, Harkke of Frankfurt-on-Maine, Troll of Boun and several others. The Staff of Marine Geography which did still more scientific work included a nucleus of professional geographers. Among these was Professor Gottfried Pfeifer of Boun who has been described as the "scientific conscience of Marine Geography"[13]. Among the tasks for the geographers associated with OKW was terrain evaluation and mapping of occupied and remote areas. Other projects were related to the long-term administration of the occupied areas for the Speer ministry, the Todt organisation and the eastern occupied areas. Early in the summer of 1943 an office was established at Riga and work was begun on a vegetation map of Lithuania on a scale of 1 : 1,000,000 and a vegetation and ground water survey of the oil shale area in the Narva region. A group based at Kiev worked on drainage problems along the Pripet, irrigation possibilities in S. Ukraine and the general question of German settlements in south Russia.

Some of the research projects of the German geographers now include[14] (1) Correction of the physiographic map of Germany published by the Regional Planning Institute. (2) Preparation of maps to solve demographical problems, which is spread over the following items. (a) Professional structure of population in 1938 and 1945 (b) Relationship of urban and rural populations (c) Shifts of population during and end of the war. (3) Cartographical representation of settlement problems, especially those pertaining to the destruction of Cities and consequent housing shortages. (4) Preparation of maps relating to agricultural problems such as, field consolidation, surplus production areas, inter-zonal exchange of commodities and the agricultural structure of different regions. (5) Study of problems in industrial geography and (6) Examination of transportation problems.

China.

Even among some of the less advanced countries geographical work is being regarded as indispensable to national planning. In China the subject has been introduced at several noted Universities and many foreign trained teachers occupy Chairs at those institutions. In 1945 no less than 9 Chinese geographers were either under training at various American Universities or employed by the U. S. War Department[15].

13. Ibid., p. 401
14. Ibid., p. 407
15. Annual Report, 1945, National Research Council's Committee on Asiatic Geography. Appendix 5.

The Geographical Society of China was established in 1934 and the China Institute of Geography was organised in 1940. To-day, many leading geographers are associated with the work of the Central Planning Board. With the collaboration of statisticians, economists, cartographers and a geographer, was brought out the valuable 'Atlas of Land Utilization' in 1937. In 1943 and 1944 Professor George B. Cressey, Chairman of the Committee on Asiatic Geography was invited by the Chinese Government as an exchange Professor under Cultural Relations Programme of the U. S. Department of State; to help in educational as well as national planning schemes.

It is needless to add the 'geography conscious' countries of our day to this list as the role of this unifying social science is being universally recognized.

India

But how has geographical work and expert knowledge therewith been utilized in our own country? It is a sad commentary on the mentality of these who have planned our efforts both in War and Peace. No geographer was associated with any branch of War effort nor has anyone, so far, figured in the schemes of Planning and economic development now in hand. Only three Indian Universities teach[16] the subject up to the post-graduate stage and many important ones do not take up the studies beyond Matriculation. Hundreds of Indian students are being sent by the Central and the Provincial governments to acquire scientific and technical training abroad, but, with the exception of Bengal and Bihar[17], none have thought of sending people out to acquire specialised training in this science.

The Task Ahead

The problem of personnel, especially a technical one, is of exceptional difficulty which a plan of economic development in a backward country has to face and overcome. This is apart from an army of technicians employed in the building up of basic industry. Indian Planners will have to embark on a colossal task, to feed, clothe and house over 400 million people scattered over a vast sub-continent. Therefore, to give them scope for mental and moral as well as physical growth, demands wide resources. To appraise the natural resources of the country would be the

16. K. N. Srivastava: Progress of Geographical Education in Indian Universities (though much out of date) Monograph No. II. of the Indian Geographical Journal (Madras) 1944,

17. A couple of qualified geographers have been sent by each of these Provinces to United Kingdom in 1946.

primary task. An inventory of national wealth will have to be made, and this will involve widespread exploration, and intensive scientific examination of basic facts. Do we in India know about all our territorial riches both human and natural? Do we have full knowledge of our vast mountain ranges and their contents, coasts, deserts and forests? Below may be mentioned in the barest outline, only some of the tasks which have a direct or an indirect bearing on planning and economic development in which geographers help would be indispensable.

Regional and Local Studies.

To bring out the composite personality of smaller units of the country as a result of thorough study of its physical and human environment is now regarded as basic to any national stock-taking of resources and possibilities. Therefore, a more legitimate field of planning is that of the preparation of a scheme of geographical regions. This would involve the preparation of atlases (maps) texts etc., from physiographic descriptions to present economic conditions especially bringing out the draw-backs of a haphazard development. Because the development and utilization of regions must be considered with regard to not only the economic advantages but the consequent result on life within the region. It is now commonly accepted that the national point of view as well as the local and regional point of view ought to be introduced into planning.

Mapping.

(Base map, topographic and coastal surveys and soil map)

A big base map of India on the lines of the famous Hispanic American map, incorporating a knowledge of a variety of known facts may be contemplated. Such a map is envisaged to provide an ordered assembly of cartographical source material-a completely new and original compilation. For areas covered by our systematic Survey of India topographic sheets, it would be an accurate reduction and simplification and for other areas a display of much needed information of a descriptive and statistical character. It would indicate the topography of both land surfaces and sea floor, details of human occupation (agricultural, industrial and commercial etc.) location and status of political boundaries. It would also show the position, population and administrative and commercial and industrial importance of towns and cities, pattern of rail and road communications, location of wireless and telegraph systems, air fields and sea-plane anchorages - hydrographic information with regard to navigational facilities, perennial and non-perennial streams and irrigation systems. An additional series can be started under the name of Geographical Atlas of India consisting of sheets incor-

porating the most up-to-date geographical information. Such maps are to provide a host of basic facts needed in regional studies which would be indispensable to schemes of National Planning. It will also be useful to make another series of relief maps carved in specially hard cardboard by a new mechanical process. These plates would give an excellent idea of topography so helpful in research and planning schemes.

Improved Topographic Sheets

The resulting development dependent upon increased sources of raw materials, expanding communications and industrial growth in many parts of the country has produced a variety of basic facts the recognition and enumeration of which far outweigh all that had been accomplished before. It cannot be denied that good mapping and systematic surveys are indispensable in planning schemes for national development. It calls for the expert services of the geographer. Much superimposition and over printing will have to take place on many of our topographic series.

Coastal Surveys

In view of our growing commercial, industrial and strategic needs, it is necessary to conduct coastal surveys, at least in selected areas. Thus alone will be revealed many evils of ribbon-development, erratic concentration of urbanization, lack of communications etc. In short, after such a study will be revealed examples of faulty and indiscriminate development. It must be urged that the coasts are a great national asset and, therefore, need a proper utilization. The access to the coasts is essential for millions of people. Their development must be planned with a national and not a mere local perspective. For ordinary military uses other than vital strategic points, geographical surveys would disclose sites other than, 'beauty spots', which though useful remain unoccupied. With increasing industrialization and growing urbanization many parts of India will be faced with limitations of space. Holidays for workers of all categories, well spent along the coast (apart from hills and sanatoriums) will be of vital importance. Indeed, unless the coast is visualised as a whole, no correct picture of its possibilities of development would emerge. If the full extent of these areas be reckoned and proper allowance made for their recreational and scientific value, a very different assessment of value would emerge. Therefore, up-to-date geographical surveys must be undertaken before such planning commences.

Classification of soils and reconaissance mapping is indispensable if Indian agriculture is to contribute to its utmost for feeding the country's hungry millions as well as helping the rehabilitation of a war weary world.

Agricultural Planning

Agriculture occupies a dominating place in our national economy and will continue to be of vital importance inspite of the much desirable and accelerated pace of industrialization. Therefore, the problem of agricultural land utilization comes to the forefront. Its various aspects include climate (chiefly water supply) and edaphic control (soils etc.) Climatic and soil survey reports would be essential and much thought should be given to agricultural climatology.

Soil Surveys imply not only the delimitation of types but also study of soil erosion and the problems of its conservation. These surveys need be conducted by pedologists and geographers and should be supported by laboratory tests by the agricultural chemists. The modern view with regard to the character of the mature soils lays more stress on the geographical factors of climate and vegetation rather than underground geology. One of the most serious problems facing agriculture in many parts of India is soil erosion. This erosion has been greatly accelerated by thoughtless human activity. Reckless destruction of forest cover, persistence of 'Monoculture' and over grazing have led to a dangerous form of soil erosion. Its effects on agriculture in particular and social, economic and settlement activity of rural India have been far reaching. Various factors make up the agricultural environment and it is the function of the geographer to correlate the relationships existing between it aud the cultural practices.

Land Utilization Survey

Land utilization being a problem of human adjustment to the natural environment, is primarily a geographical one. A land utilization survey is essential because it would show the uses or misuses to which land is put. It involves, firstly, a minute and detailed survey of any given area as regards land use, secondly, the large scale mapping indicating details with convenient and interesting cartographical aids and finally, a geographical interpretation of such maps correlating the present nature of land use to the physical settings and human conditions, *i.e.* physiographic, structural, hydrographic, climatic. soil. social, economic and cultural conditions. This interpretation would indicate the proportion of land put to various uses and will dilate on the possibility and advantage of altering these proportions obtainable in order to secure a proper balancing of the varied needs of all sections of the community.[18]

18. E. Ahmad : Scope of Land Utilization Survey in India, Indian Geog. Journal (Madras) No. 2, 1945 op. cit., p.63.

Such a survey is most essential for an agricultural country like India which must seek improvement on rational and scientific lines. Unless there are maps giving a fuller knowledge of the variety of uses to which land is put, a careful agricultural organization would be impossible. The present information in such matters is based upon the district reports of the 'Quanungos' which contain sweeping generalizations, hopelessly inadequate information unaccompanied by maps of any kind.[19] The Indian problem of growing more food for its fast increasing millions cannot be easily ignored. Similarly, there is the need for feeding cattle by grazing and fodder crops. Afforestation is yet another crying need. But the emergence of a picture of all this is impossible without land use surveys. For this kind of work it will be necessary to bear in mind the peculiar conditions and the size of India. Governmental initiative and help on a large scale and the co-operation of local institutions and administration will be indispensable. Such opportunities and facilities will have to be put at the disposal of trained geographers and their statisticians and educated agriculturist helpers.

Industrial Distribution And Localization

In the phase of accelerated industrial development fore-shadowed for the country there are going to arise many problems the solution of which cannot simply be left to profit seeking agencies and haphazard chaotic growth. At present the attitudes of the industrialists and the state are almost entirely unco-ordinated, because their aims are different; one is only concerned with profits while the other struggles to create social facilities. This anarchy must be ended. Both sites and location must be based on sound lines advancing industrial progress as well as social well-being of the community as a whole. Effective and conscious steps will have to be taken against the evils of ugly concentration and localization arising from preventable human reasons. Dispersal and regionalization of industry would be a primary task of planning. Building schemes or location of new industries should not encroach upon rich agricultural land. Each region is to aim at diversity of industry with a proper proportion of primary and secondary industries and with due regard to proportions of urban and rural population. This can only be done when planning in our country will be accompanied by some form of regulatory action on national lines and in the national interest. Any plan of balanced development of industry must be based on the knowledge of industrial potentialities of different regions; and a preliminary examination by a small committee of the problems and potentialities of each small area (say, a district) can provide the first approximation to a survey of the country's industrial resources. The

19. Ibid., p.64

local plans will of course, need scrutiny and coordination from the provincial, regional and national angles. In India, the regional principle has not yet been introduced into reconstruction and planning. The Creation of regional Councils of experts is essential. It is in such bodies that geographers can play an important role. This envisages the formation of a National Industrial Board the personnel of which should in no case be packed with captains of industry alone. Among other technical and expert re-presentation geographers would be eminently suited to this task. Action on these lines has already been suggested in a comparatively conservative country like Britain.[20]

Town Locations And Town Planning

An allied and overlapping problem to the tendencies inherent in industrial growth is the question of town locations and their planning. The sites of many of our towns have a historical significance, an adjustment made under bygone conditions with later consequent and necessary adjustments often costly and difficult to meet the requirement of later times. The rise and fall of Cities are not wholly due, and in some cases not primarily due to the initiative and enterprise of the citizens or to their lack of it. Today, most of our industrial towns suffer from overgrowth. During 1921-41 no fewer than eight cities showed over 100 per cent increase in population. This has manifested itself in excessive inward concentration without plan, encroachment cn valuable agricultural land and other evils of a social nature. Such industrial concentrations are serious handicaps and in some respects dangerous to the nation's life and development. Facing similar situations other countries are taking positive scientific steps to prevent this harmful development. In Britain, the Town Planning Act of 1919 and later the Town and Country Planning Act of 1932 have made possible the reshaping of existing towns and the determination of the lines of their future growth. The object of the committees thus formed was to lay down in general the lines of road development, housing schemes and localization of industries. In our country the haphazard growth of centres of population should be checked, pushful and 'profit mad' industry should be allowed no longer, like an advancing flood to swallow up all other regional functions. Towns are organisms closely linked with life inside the region. Thus the building of new towns and improvement of older ones must be based upon a study of their distribution, position, site, function and anatomy. Town planning cannot be thought of merely in terms of engineering, architectural perfection and housing. The planners should

20. Vide. Report of the Royal Commission on the Distribution of Industrial Population of Great Britain.

include besides engineers and architects, sociologists, economists and geographers. The resultant work of coordination is the special field of the last named.

Ports

Lastly it may be pointed out that with regard to the development of new ports a similar rational policy will have to be followed. They should not be developed simply because for long distances on that coast there are no ports or worse, because they need be developed in Indian States for the sake of ugly commercial and political motives. Their geographical value (Site, location, hinterland in relation to natural resources, communication facilities, climate etc,) must be fully investigated before schemes are finalized.

Conclusion

If, as a result of the study of modern Geography Indian scholars take an intelligent interest in their own land and other parts of the world, the inclusion of this subject as a discipline worthy of study at the University level will be amply justified. Geography in our education to-day is more important than ever. The Government should not only help in establishing such departments at all important Universities but also send scholars abroad for specialized training as "geographers" and then utilize their services in the tasks of planning, mapping, commerce, industry and political administration. It will not be too much to say that many of the home and international problems can be solved only by those who have had some geographical training. But that training must rest on sound scientific and real foundation. Geographical knowledge should be used to plan and build a world of peace based on the maximum and rational utilization of natural resources for common good and social justice; and not as the task of mercenaries preserving privilege and facilitating exploitation.

The Topography of Rajputana

BY

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(*Continued from Vol. XXI. No. 3, Page 147*)

Similarly, Jodhpur State, as its name Marwar[1] implies, is sterile, sandy and inhospitable. It is a dreary waste, covered with sand-hills, rising some times to a height of 200 or 300 feet, and the desolation becomes more absolute and marked as one proceeds west-wards. The desert in the west and north west of the State is known as 'Thal' in which, it has been truly said, 'there are more spears than spear-grass heads, and blades of steel grow better than blades of corn"[2] The country here resembles an undulating sea of sand : an occasional oasis is met with, but water is exceedingly scarce and often 200 to 300 feet below the surface. The sub-montane eastern districts and some central portions of the State, however, are comparatively fertile. Towards the south we find several small off-shoots of the Aravallis which do not permit the extension of cultivation.

Jaisalmer State, too, is almost entirely a sand-drifted waste. It is also covered by sand-dunes of the transverse type, that is with their longer axes at right angles to the prevailing winds. In the neighbourhood of the capital [3], and within a circuit of about forty miles, the soil is very stony, and numerous low rocky ridges and hard undulating plains occur ; but with this exception the general aspect is that of an interminable sea of sand-hills of all shapes and sizes, some rising to a height of 150 feet. Locally the shifting sands are termed 'Dhrians'. In the dry season the tract is sparsely clothed with stunted shrubs and tufts of coarse grass, and in many respects, resembles the wildest parts of Arabia. Nothing can well bear a more desolate appearance.

Jaipur State consists of two great plains divided by the Sheikhawati hills. The northern plain—the semi-arid tract of Sheikhawati-slopes

1. Marwar is a corruption of Maroo-war, classically Marusthala or Marusthan, also called Marudesa. The word means the 'region of death', and hence is applied to a desert.

2. Imp. Gazt. of India, 1908, Vol. XIV, pp. 179-180.

3. Tod has written, 'Jaisalmer town is, in fact, an oasis, everywhere insulated by immense masses of 'Thul' some of which are 40 miles in breadth, without the trace of man, or aught that could subsist him.' op. cit., p, 283. '*Thul*' is the general term for the sand ridges of the desert.

gently north-westward from the base of the rugged, barren hills towards the Jodhpur and Bikaner frontiers[4], and is drained by the Kantli and other minor streams which disappear into the sands within the confines of the State. Describing his interesting expedition through Sheikhawati to Kabul (1808) Elphinston wrote, "We come to sand-hills, which at first were covered with bushes, but afterwards were naked piles of loose sand, rising one after another like the waves of the sea, and marked on the surface by the wind-like drifted snow. There were roads through them, made solid by the treading of animals; but off the road our horses sank into the sand above the knee.....After we left Sheikhawati, our journey was over hills and valleys of loose and heavy sand. The hills were exactly like those which are sometimes formed on the sea shore, but far exceeding them in height, which was twenty to a hundred feet".[5]

The villages within the desert, though always known by local names, cannot be reckoned as fixed habitiations, for their permanence depends entirely on the supply of water in the wells which is extremely scarce and deep. Moreover, it frequently fails or turns brackish. As soon as the water gives out, the village must shift. The paramount importance of water supply in such a region can be easily understood by the fact that wherever villages have sprung up, they have generally received a name ending in 'sar', 'sara', 'kor', 'par', or 'tala', all denoting a well.[6]

Rivers play a very subordinate part in moulding the surface features of the region. The only river of any consequence in Western Rajputana is Luni ('salt river', the Lonavari or Lovanavari of Sanskrit writers) which flows for about 200 miles from the Pushkar valley to its embouchure in the great western salt marsh—the Rann of Cutch. It receives the drainage brought by the mountain torrents down the western slopes of the Aravalli hills between Ajmer and Abu, and is a veritable blessing to the southern districts of Jodhpur State. There is a saying in Marwar that about half of the agricultural produce of the country is the gift of the Luni. Here there are as many as seven other streams, *viz.*, the Lilri, the Raipur Luni, the Guhiya, the Bandi, the Sukri, the Jawai and the Jojri, but all of them are quite useless as they are mere rain gutters. In addition to the three important lakes at Sambhar, Didwana

4. Records of the Geological Survey of India, Vol. LIV, pt. 4, Calcutta, 1923, p. 348.

5. Quoted by Tod, op. cit., pp. 282-283,

6. A. W. T. Webb, op. cit., p. 7. Also see Tod: 'Of the numerous terms used to designate water in these arid regions, as 'par', 'rar', 'tir', 'de', or 'day', 'bah', 'bawa', 'wah', all but the latter are chiefly applicable to springs or pools of water, while the last (wah), though used in a like sense, applies more to a water-course or stream'. op. cit., p. 284.

and Pachbhadra there are a few other *Jhils* or marshes, notably one near Bhatkini in the southwest of Jodhpur State, which covers an area of 40 or 50 square miles in the rainy season, and the bed of which, when dry, yields fairly good crops of wheat and gram.

Towards the north there are two other rivers: the Ghaggar and the Kantli. The former once flowed through the northern part of Bikaner State, and, according to Tod, joined the Indus; but it is now dry, except in the rains, and even then the water rarely flows more than a mile or two west of Hanumangarh.[7] Similarly, in years of good rainfall Kantli river flows for a few miles only.

In contrast to the sandy plains which are, generally speaking, the uniform feature of Western Rajputana, the southern and eastern divisions of Rajputana have a very diversified character. As we have seen, wind-blown sand always lies conspicuous on the northern slopes of the long straight lines of rocky ridges; but on the southern and south-eastern sides the desert aspects of Rajputana are gradually lost merged in the comparatively fertile forest-clad high-lands of peninsular India. Southern Rajputana contains extensive hill ranges and long ranges of rocky wold and wood-land. In many parts there are fertile table-lands. Whereas the descent of the western slopes of the Aravallis is abrupt towards Jodhpur, on the eastern or Udaipur side the land falls very gradually as it recedes from the long parallel ridges which mark the water-parting until it spreads out and settles down into an open champaign. The whole of the region is watered by the drainage of the Aravalli hills, carried north-eastward by the Banas and Chambal rivers.

Rich in variety of rock types as it is, a considerable portion of central Mewar (Udaipur State) is essentially an elevated plain, either entirely bare and rocky with granitic exposures or more or less covered with low scrubby vegetation. The plain lies, on an average, at about 1,500 feet above sea-level, sloping with a steady and moderate gradient to the east or north-east. In this plain two important topographical variations are noticeable; in the north-east the extensive flat country has got a soil mantle of varying thickness whereas the rugged region froming the northern hill-tracts has got a preponderance of granitic intrusives.

The south-west portion of Udaipur State embraces the wildest spurs of the Aravallis, and presents a strong contrast in topography to the

7. There is incontrovertible evidence that the drying up of the lower reaches of the Sarasvati (Ghaggar) is to be attributed merely 'to the north-ward march of the Rajputana desert. See article on 'The Sarasvati', published in 'Science and Culture', Vol. 12. pp, 473-474.

plains of the north. The country in the south is extremely rugged; it presents 'a tangled wilderness of shallow valleys with veritable networks of narrow *nalas* and deep gorges, and is a typical dissected peneplain.' [8]

The junction of the rocky and rugged region of the south, and the flat, more or less alluvium-covered expanse of the north marks a very definite water-shed, a section of the great water-shed of India. With a height of over 1,600 feet above sea-level, it extends from the vicinity of Udaipur City to the Mewar-Partabgarh frontier on the south east, a distance of over fifty miles To the immediate north of this, the plain is drained by the tributaries of the Berach; while to its south, the highly dissected rocky region is drained by a network of streamlets converging towards the great artificial Dhebar lake or Jai Sagar, and farther south the drainage is to the Jakham and Som, near the southern border of the area. The surplus waters of the Dhebar lake flow into the Som, which after absorbing the Jakham replenishes the Mahi. Thus while the water of the northern plains ultimately reaches the Bay of Bengal by way of the Banas, the Chambal, the Jumna and the Ganges, that of the southern tracts discharges finally into the Gulf of Cambay through the Som and the Mahi.

The chief physiographic feature of the Sirohi [9] State is the range of hills extending from near Erinpura in the north past Abu in the south. The general level of Abu hill station is only about 4,000 feet, but rising sheer from the plains on the east and west, the Abu massif is an impressive sight. Both the eastern and western parts of the State are intersected by numerous water-courses, which become torrents of greater or lesser volume in the rainy season, but which are dry during the greater part of the year. The chief river is the Western Banas which, rising in the eastern flanks of the hills east of Sirohi, flows for some fifty miles in the valley between Abu and the Aravalli hils, and eventually loses itself in the sand at the head of the Rann of Cutch. The other streams, discharging into the Luni, are the Krishnauti, the Khari, the Kachnauli, and the Kapalganga. The main water-shed of the State trends approximately east and west.[10]

The greater portion of Partabgarh State consists of fine open land; but the north-west is wild, rocky and hilly, and a range, which in places attains an elevation of 1900 feet, forms the entire western boundary.

8. Memoirs of the Geological Survey of India, Vol. LXV, pt, 2, The Geology of Central Mewar, Calcutta, 1934, p, 108.
9. According to Tod the name Sirohi has been derived from its position at the head (Sir) of the desert Rohi.
10. See Memoirs of the Geological Survey of India, Vol. LXIII, Sirohi State, Calcutta, 1933, p. 4.

The western portion of Banswara [11] State is comparatively open and well cultivated; whereas the southern and eastern portion is covered with rugged hills, rocks, scrub jungle and wood land. The country has been described as the most beautiful portion of Rajputana. It looks best just after the rains when 'the varied hues of the foliage, the luxuriant growth of the tall grasses, and the streams dashing down the hill-sides or pushing through shady glens, between banks fringed with ferns and flowers, present a most pleasing picture. [12]

In Dungarpur State the country is fairly open in the south and in the east. Otherwise, it consists, for the most part, of stony hills covered with a low jungle of cactus and jujube trees.

The important rivers in Southern Rajputana are the Banas (Hope of the Forest), the Chambal, the Mahi, the Berach and the Kotari. The Banas rises in the Aravalli hills in Udaipur State, and after a tortuous course of about 300 miles falls into the Chambal which is also noted for its sinuosity. The Mahi (the Mophis of Ptolemy and Mais of the Periplus) enters Southern Rajputana, and flows in a northerly direction with a somewhat tortuous course, intersecting the eastern half of Banswara State, till it reaches the Udaipur frontier where it is soon turned by the Mewar hills to the south-west. Among un-important rivers we can include the Airan, the Chap, the Jakam, the Majam, the Vatrak, the Bhadar the Moran etc.

The Topography of Rajputana

Although the surface of Eastern Rajputana is crossed and diversified by groups and ranges of hills, by isolated peaks and by elevated tablelands, yet many parts of this region are fairly level and open. Towards the west the region consists in a great measure of broad, open, treeless plains, and in the east and south-east the region is mostly covered with alluvium and bush jungles.

The district of Ajmer [13] has got a large open plain which is very sandy in parts, specially to the west in the neighbour-hood of Pushkar, At intervals it is studded with hills that rise boldly from the plain. Merwara [14], on the other hand, is a net-work of hills. In the northern corner of the territory of Ajmer-Merwara there are several parallel hill ranges, the highest point being 2,855 feet above the sea level. On the

11. The word 'Banswara' means a 'country of the bamboo'.
12. Imb. Gazt. of India, 1908, Vol. VI.
13. Ajmer stands for 'Ajaya' (invincible) and 'Meru' (hill).
14. Merwara is a compound of 'meru' (hill) and 'are' (barrier).

Jodhpur or western side. the hills become bolder and more precipitous, and the highest elevation is 3,075 feet above sea level. Owing to its elevated position at the centre of the water shed, the territory does not possess any rivers of importance.

The northern part of the Kishangarh State is for the most part sandy and is crossed by three parallel ranges of hills running from south-west to north-east, whereas the southern portion is generally flat and fertile.

The central plain of Jaipur State has its greatest elevation on a line running due north from Jaipur City along the western foot of the hilly country on the Alwar frontier. Its drainage finds its way into the salt lakes of Sambhar and Kuchor-Rewassa northwards into the sands by the Kantli and the Basi rivers, through gaps in the Sheikhawati hills, and south-wards flows into the Banas by an extensive system of tributaries [15]. The water- shed is quite independent of the hill ranges, and the rivers have often cut their way through great belts of quartzite, *e.g.*, the Banganga at Ramgarh and the Banas at Raj Mahal, to mention two of the more striking instances. Curving round the north of the central plain are the intricate ranges forming the Sheikhawati and Torawati hills, and the wild country extending along the Alwar border from Torawati as far south as Jaipur city. The southern portion of the plain is open but traversed by several low interrupted ridges with a general N.E.-S.W. trend and dotted with various clusters of hills and isolated summits.

Throughout the State of Alwar ridges of rocky and precipitous hills, for the most part parallel, are observable. These generally run from south to north and are a continuation of the Aravallis. The highest peak is 2,542 feet above the level of the sea, and the hills decrease in height and breadth from south to north, and from west to east. In the north and in the east the country is comparatively open and fertile.

The general aspect of Bharatpur State resembles an alluvial plain, fairly wooded and cultivated, with detached hills in the north and hilly and broken districts in the south. The highest hill in the State is in the West. The central portion is a level tract.

The northern portion of the eastern-most State of Rajputana, Dholpur, is open and level, but elsewhere the country consists for the most part of low hills or ravines. A range of sand-stone hills runs from near the capital in the south-westerly direction, attaining at one place an altitude of 1,171 feet above sea-level. These hills, as well as those

15. Records Geolg. Sur. India, Vol. LIV, pt, 4,1923, p. 348.

farther to the west, are mostly bare of vegetation and rocky. The tract along the Chambal is termed as the Dang, and is deeply intersected by ravines, some of which are 100 feet deep. To-wards the south and east of the State some portions are covered with the alluvium of the Chambal which has excavated a broad valley through an extensive plateau formed of nearly horizontal upper Vindhyan sand stones.

Hills and broken ground characterise almost the whole territory of Karauli State which lies within a tract locally termed as the Dang, a name given to the rugged region immediately above the narrow valley of the Chambal. The principal hills are on the northern border, and towards the southern border along the valley of the Chambal an irregular and lofty wall of rock separates the lands on the river bank from the uplands. In the neighbourhood of the capital, the low ground is cut into a labyrinth of ravines.

The northern and south eastern portions of Tonk State are flat and open, with here and there a ridge of rocky hills coverd with scrub jungle The country to the south west is high table-lands, and the district of Nimbahera lying towards the south of Berach river is intersected by a broken range of hills.

In Kotah State the country slopes gently northwards from the high table-land of Malwa. An important feature of the landscape is the Mukandwara range of hills (1,400 to 1,600 feet above sea-level) running across the southern portion of the State from northwest to southeast. We find a curious double formation of two separate ridges parallel at a distance of more than a mile, the interval being filled with dense jungle or, in some parts, with cultivated lands. In some places the bare protruding rock presents not a trace of vegetation.

The State of Bundi is traversed through-out its whole length from southwest to northeast by a double line of hills which divides the country into two almost equal portions. For many miles the precipituous scarp on the southern face of this range forms an almost impassable barrier between the plain country of either side. The highest peak of the range is 1,793 feet above the sea-level. The northern half of the State is rugged and stony.

A narrow range of low and fairly wooded hill runs southeast past the town of Jhalrapatan in the north of Jhalawar State. The southern half is generally hilly and intersected by small streams. The rest of the country, however, though rising in some places to more than 1,000 feet above sea-level, is a rich undulating plain.

The two principal rivers of this region are the Chambal and the Banas. Among other rivers are the Bauganga, the Dain, the Mashi, the Dhil, the Galwa, the Morel, the Bandi etc. Almost all the minor streams are dry during the hot months.

Soil Conservation and the Kudzu.

BY

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The importance of soil to plant growth needs no special mention here, as it is a well-recognised fact. Soil keeps the plant erect and at the same time feeds it. Methods of giving new fertility to exhausted soils have been studied for quite some years now. The use of green, animal and mineral fertilisers has become a common practice in all those regions where intensive cultivation has been adopted. Something that is more fundamental and equally important for consideration is soil conservation. It is only within recent years that the agricultural departments of the various countries and independent investigators have realised the seriousness of soil erosion in many extensive cultivable lands of the world. Investigators like Dr. Dudley Stamp, Mr. Russel Lord and Mr. Hugh Bennett have freely expressed their opinion on the seriousness of the soil erosion going on in different parts of the world. Ll. R. Jones and P. W. Bryan sound a warning note when they say that "a loss of any of the top soil is a loss of a vital something which it has taken nature very many centuries to accumulate for man's use, and for which there is no easily prepared substitute".[1]

Soil erosion is generally due to wind or water movement along the surface of the soil, where rainfall is low wind erosion is more dominant. In Australia regions receiving less than fifteen inches of rainfall per year are generally characterised by wind erosion and dune formations. Where rainfall is greater, sheet erosion of soil by moving water, helped by the slope of the land, occurs; such regions being characterised by innumerable gullies, rugged barren surfaces and silted up lakes.

Regional Survey of Soil Erosion

In U. S. A. the first person to protest against the reckless utilisation of soil for cultivation was, according to Russel Lord, Henry Wallace, grandfather of the present Henry. He " preached mighty sermons pleading for

1. 'North America'—by Jones and Bryan, Page 177.

better care of what he always called 'the voiceless land"[2] even before his death in 1916. By 1943 soil erosion had gone to such an extent that the Soil Conservation Service, after a survey in 1942-43, estimated that more than ninety percent of the farm-land of U. S. A. needed some type of conservation treatment to protect it from erosion. Out of a total of about four-hundred million acres of crop-land, nearly forty millions were declared to be so seriously eroded as to make them unfit for cultivation any more. Such a serious position is really the result of a policy of rapid deforestation and utilisation of the land for crops like maize and tobacco (cultivated with considerable intervals between the individual plants), where erosion is not effectively checked.

In South America soil erosion has been observed and conservation schemes have been started in Colombia, Venezuela, Chile and Brazil.

In Britain serious erosion in some parts of the uplands, the result of ploughing for potatoes and other crops for war food, was noted and reported by soil surveyors, in 1943. As late as 1945 we find Dr. Dudley Stamp saying " We have not yet learned that the dangers of soil erosion are quite near to us—dangers resulting[3] from increased cultivation". According to Dr. Stamp soil erosion was particularly great during the 1940-1945 period in Britain. He speaks of ' brussels sprouts being blown out of the ground'.

In the Union of South Africa recent investigations, conducted by Mr. Hugh Bennett of the U.S. Soil Conservation Service, show soil erosion going on at a rapid pace. Between Drakensberg mountains and Pietersburg, in Northern Transvaal, more than one hundred thousand acres had lost practically all the original top soil, when the investigating party visited the region. 'In the Karroo,[4] whole districts of formerly good veld were so eroded that carrying capacity was estimated as approximately 1/10 of what it was before abusive land-use practices became common' The investigators, led by Mr. Hugh Bennett, attribute the serious soil position to the following practices :—

Indiscriminately allowing the animals to graze over the slopes,

Up-and-down ploughing of the slopes,

Repeated cultivation of soil-depleting crops, without proper rotation.,

2. 'The Geographical Journal'—Vol. CV. page 159.,
3. do. do. do. do. page 169.,
4. 'Britannica—Book of the Year, 1945'—page 648.,

Most of South Africa's reservoirs, it was observed, were partially filled with sediment as the result of erosion of the top soils in the slopes.

In Australia both wind and water erosion have been noticed over extensive areas, not only in the less productive west but also in the more important eastern provinces. The Mallee districts of New South Wales, South Australia and Victoria were spending £ 60,000 to £ 100,000 annually for the removal of sand from the water channels alone, till the late nineteen-thirties, when conservation methods were adopted. War and the serious drought in 1944 put back the efforts considerably in this area, resulting in the following erosion position in the two main provinces :—

New South wales, western division,	... 70 %	of land affected.[5]
do. do. eastern division, & central division,	... 40 %	do. do.
Victoria	... 50 %	do. do.

Generally, in Australia, wind erosion is dominant in regions with an annual rainfall of less than 15 inches; areas of greater rainfall experience mainly water erosion.

In India erosion has been going on in different parts of the country for quite a long time. Experiments at the Dry Farming Station, Hagari, Madras, have revealed an annual loss of 1/20th. of an inch of fertile soil, due to water erosion. In the Gangetic basin also soil erosion is considerable during the monsoon rainfall season, when much of the unprotected top soil is carried by the surface flow of water into the Ganges and its many tributaries. It is difficult to estimate the annual loss of top soil in the whole country as no survey has been made so far by authorised commissions on systematic lines.

Soil Conservation Methods

Different methods of soil conservation have been tried in various countries. Australia has been experimenting with the following methods ; broad-base terraces in the Darling Downs ; widespread use of cereal rye and sand-binding grasses (like Pyp grass and Marram grass) in regions of wind erosion; contour listing and stubble mulching on cultivated lands.

U.S.S.R. in the period 1942-44 was working intensively to establish correct crop rotations, specifically to prevent erosion and improve soil fertility.

5. 'The Geographical Journal'—Vol. CV. pages 121-125.,

Canada has been trying to check soil-drift in the prairies, adopting strip farming combined with use of crop residues and autumn-sown spring cereals.

U.S.A. has gone far ahead of other countries in the variety of methods adopted and in the extensiveness of the area brought under soil conservation schemes. By the end of 1944 there were 1169 soil conservation districts including some three million farms. 'The acreage within these districts represented one half of all the agricultural lands in the U.S.A.[6]. Soil Conservation nurseries provided 61 million plants and 1.2 million lbs. of grass and legume seeds for plantings in these districts. Two million shrubs had been planted on eroded areas, more than a third of them being species which produce fruits valuable for food !

The Kudzu.

Probably the most successful and remarkable experiment in the U.S. Soil conservation schemes is that with the Kudzu. This is a Japanese vine that has been introduced into some of the larger farms in U.S.A. with considerable success. It spreads rapidly over the ground. The leaves are big and delicate. The roots reach even such depths as twelve feet from the surface of the ground. The crown 'puts out form one to four vines and new crowns form in the joints and nodes '.[7]

Kudzu protects as well as enriches the soil. It spreads out into a mate of protective cover to the soil. The mat, thus woven, is about three feet in thickness and is close-textured. Because the roots reach deeper into the soil than the roots of the ordinary grass this plant holds the soil together better than grass. The ground temperature under the mat is kept down during the hot season while in the open field it is rising rapidly. In some fields temperature differences exceeding fifty degrees have been noted between the open ground and the ground under kudzu.

This plant has been very useful in soil conservation work in U.S.A., The success of kudzu as a soil conserving agent is attributable to its following qualities :—

It grows very rapidly, as much as hundred feet in a year. Normally it takes three years for the kudzu to take full possession of the land. So in three years a highly eroded region can be brought back to a cultivable condition with this plant.

It stands drought very well. It should be possible to utilise it in wind-eroded regions.

6. " Britannica—Book of the Year " 1945., page 647.
7. " The Reader's Digest "—Russel Lord. page 95. (Jan : 1945.)

Because of its deep roots it is able to hold soil together very well and check erosion in the field.

It keeps down ground temperature very effectively during the hot season and thus prevents the soil cracking up. In this way humidification is helped.

It is able to draw atmospheric nitrogen from the surrounding air and fix it up for the use of the plant that follows it in the field. A kudzu field, it is estimated, used for raising corn increases the corn yields by about 30 %.

The dead leaves of the kudzu provide good material for the formation of a rich humus.

The kudzu field may be used as pasture, the plant being a good fodder. Kudzu may be removed from the field with a mower and used as hay

Mr. Russel Lord describes this kudzu as a " plant that grows like honeysuckle, yet feeds like clover or alfalfa, with approximately the same protein and carotene content".

Mr. Hugh Bennett, Chief of the U. S. Soil Conservation Service, says "it is not only a crop for gouged-out land. it is a splendid crop for good lands, too. It will cover a corn-field in one year; the next spring or early summer it can be ploughed and the land planted to corn; then after the last cultivation of the corn it will again spread over the field, stop erosion, store more nitrogen and at the first hard frost lay down a carpet of rich leaf litter, at least the equal of forest litter. All this in one year !".

There is a Kudzu Club of America, where the members are all kudzu growers. This Club has set as its goal according to Mr. Russel Lord, a million acres of kuzdu in Georgia by 1950 and eight million acres for the south as a whole. Members of this Club have reported remarkable achievements with kudzu. One member has reported the raising of eggs at three cents a dozen in the kudzu hen pasture. Another has observed corn yields rising from fourfold to sevenfold on fields that had been under kudzu for some years.

India has not progressed much in soil conservation work. What she needs is a plant like kudzu - a plant that will protect and, at the same time, enrich her soil. Indian climate is not very different from the climate of the south-eastern states of U.S.A. And if kudzu is really as adaptable as it is described to be, then it must do as much good to the agriculture of India as it is doing in U.S.A. Will this kudzu be tried by the Department of Agriculture in India?

Letters to the Editor

Dear Sir,

I hope that you may be able to find space for some further inquiries of, An Inquiring Mind, stimulated by reading Mr. K. S. Srivastava's comprehensive " Progress of Geographical Education in Indian Universities." My appreciation of his work is, I must own, heightened by the feeling that it confirms my original diagnosis, made on much scantier data, all along the line. In particular my remarks as to the top-heavy and lopsided organisation of the subject are amply re-inforced.

I appreciate the thought and care which have gone to Mr. Srivastava's report, but cannot help feeling that the suggested plan is a little too much of a revolution from above. I think a few years of regional spade-work in the various Universities is needed before the personnel for such ambitious projects can be fully trained; then by all means let us have a synthetic work on Indian geography. After all, France is the parent of modern regional geography and the French are only now producing the *Geographie Universelle* volumes on France. I fail to see how an Institute for which " the Central Government shall take the responsibility for the efficient conduct of its affairs for all expenditure and future development " can well be called " independent ", and this seems to indicate a certain hastiness in the recommendation, doubtless seduced by the current atmosphere of Planning; I am not at the moment arguing either for or against large scale planning of research as such. Then the high officials of Government Departments proposed for the Governing Body are busy men; they would presumably appoint deputies but these again might not have sufficient time to give their best to this ponderous Committee; I feel myself that a smaller inter-University liaison group would be more effective than the rather bureaucratic organisation proposed.

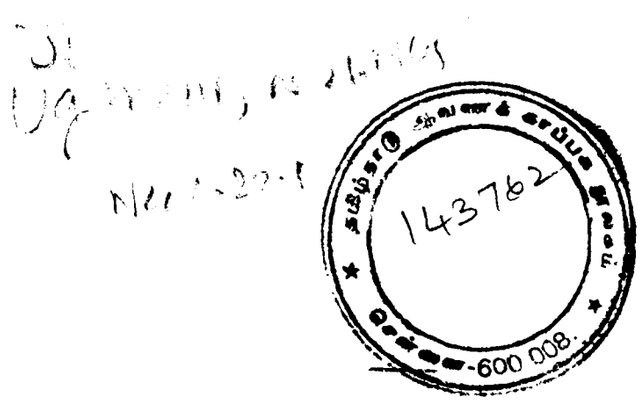
I confess also to a feeling of doubt as to the desirability of delimiting research regions—at least at this early stage of Indian geographical evolution. Naturally each University will concentrate primarily on its home ground; but, as Mr. Srivastava himself points out, provincialism is a serious danger and there is a very great need for more inter-regional contact between the few centres of Geographical study in India—a need which the Indian Geographical Journal clearly recognises, as one can see by comparing recent issues with the old Madras Geographical Journal

(which was a necessary stage and did very useful work in its time). Might not the premature assignation of regional units to research centres tend to reinforce the provincial bias? It would be a tragedy if any idea of research rights in particular regions were to grow up.

I do not wish to be understood as in any way depreciating Mr. Srivastava's very useful work; only to suggest points on which I feel a fuller deliberation is necessary. At any rate, the survey of the present state of the subject is a valuable contribution, indeed an essential step to any advance. It is also a great advantage to have such a clearly formulated programme as a basis for discussion. Mr. Srivastava deserves the hearty thanks of all who are interested in the advance of Indian geography: he has put his finger on many of the reasons for the present weakness of the subject, and that is the first step to removing them.

Yours sincerely

"An Inquiring Mind"



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