

Vol. XVIII

October—December, 1943

No. 4

52
The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION.

PUBLISHED QUARTERLY.

EDITOR

George Kuriyan, B.A., B.Sc.



THE INDIAN GEOGRAPHICAL SOCIETY,

Wellclose,

Cathedral P.O.,

Madras.



CONTENTS		PAGE
THE STRUCTURE OF INDIA—By M. S. KRISHNAN, M.A., PH.D., F.N.I.		137
THE RAJPUTANA FLOODS—By KEDAR NATH SRIVASTAVA, M.A., B.T.		156
SOMNAT AS NOTICED BY ARAB GEOGRAPHERS—By DR. S. MUHAMMAD HUSAYN NAINAR		165
A PLAN FOR THE DEVELOPMENT OF THE 'THAR' DESERT IN SIND—By MR. G. S. RAISINGHANI, B. AG. AND MANECK B. PITHAWALLA D.Sc., F.G.S.,		169
A STUDY OF THE RAINFALL REGIME AT VELLORE—By K. RAMAMURTHY		197
SOME ASPECTS OF THE PHYSICAL GEOGRAPHY OF THE NORTH ARCOT DISTRICT—By V. KALYANASUNDARAM		204

Approved by the Text-Book Committee.

DESCRIPTIVE GEOGRAPHY

For Elementary Standards 4-8 according to 1941 New Syllabus

By N. SUBRAHMANYAM.

Standard 4 ready for sale, Price 7 annas. Standards 5 to 8 will be ready shortly

For the Middle School

According to the latest syllabus

Prepared in accordance with the principles given in Scheme of Work and in accordance with the type syllabus, issued recently by the Madras Educational Department.

BY

N. SUBRAHMANYAM, M.A., L.T., F.R.G.S.

Lecturer in Geography, Teachers' College, Saidapet.

TAMIL, TELUGU AND MALAYALAM EDITIONS

Book I As. 10, Book II As. 12, Book III As. 12.

The following are some of the special features of the series:—

The treatment is throughout descriptive; and the influence of geographical environment on human activities have been well brought out everywhere. Physical, human and political geography have been taken in combination, so as to present a synthetic picture of human societies in the different regions of the world. Constant reference has been made to local conditions and examples, making the home region the standard of comparison throughout. The main geographical principles have been treated in an elementary way, each in relation to the region of which it is a characteristic. Attempt has been made to develop the chief geographical concepts in the course of the regional study.

The exercises at the end of each chapter have been very carefully prepared not only for the purpose of testing the subject matter learnt, but also in some way to supplement the matter taught. The volumes are copiously illustrated with pictures, maps and diagrams. The bold print on glazed paper makes the books attractive to the pupils.

P. VARADACHARY & CO.,

8. Lingha Chetty St., Madras.



The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

Vol. XVIII

OCTOBER—DECEMBER, 1943

No. 4

The Structure of India*

By

M. S. KRISHNAN, M.A., PH. D., F.N.I.,

Geologist, Geological Survey of India.

INTRODUCTION:—Three natural divisions can be recognised in India viz., the Peninsula, the Extra-Peninsula, and the Indo-gangetic alluvial plains separating the first two. These units have each distinct physiographic, structural and stratigraphic characters.

The Indo-gangetic plains occupy a region of depression between the Peninsula and the Extra-Peninsula and are filled up by thick deposits of alluvium. The maximum thickness of the alluvium is not known with accuracy but was thought to be as much as 15,000 to 20,000 ft. But recent geodetic observations in Bihar seem to show that it is of the order of 6,000 to 8,000 ft. Their basement is formed of the Peninsular rocks. But, for a few miles along the northern border, the alluvium is apparently underlain by a good thickness of the Siwaliks. The deepest part is nearer the northern edge than the southern.

The basement or floor is known to contain some zones of weakness which are occasionally the loci of earthquakes (e.g. the North Bihar earthquake of 1934, the Cutch earthquake of 1819, etc.). The deposits are of Pleistocene and Recent age and comprise

* Published by permission of the Director, Geological Survey of India.

sands and clays in which organic matter like peat is sometimes enclosed. The sand beds are often water-bearing and the water can be tapped from them for various purposes.

THE PENINSULA:—The Peninsula is composed mainly of ancient crystalline and metamorphic rocks. In certain parts, these rocks are covered by younger formations such as the Cuddapahs, Kurnools, Gondwanas and the Deccan traps. The Peninsula is a comparatively stable block of the earth's crust which has been very little affected by major earth movements since the Cambrian times except for faulting during the Mesozoic.

The Archaeans are exposed over more than half the area of the Peninsula and are prominently displayed in Madras, Mysore, Hyderabad, Orissa, Bihar, Central Provinces, Rajputana and Assam. Though Assam is now separated from the main Peninsular mass by the lower Ganges-Brahmaputra valley, it is undoubtedly a part of the Peninsula. There is also evidence that the Peninsula extends underneath the alluvium and part of the Himalayan belt which cover its northern edges.

The Cuddapah and Vindhyan rocks occur in the Cuddapah basin of Madras, the Jeypore-Baster area of Orissa, and the great Vindhyan basin of the United Provinces, Central India and Rajputana. They have been disturbed along parts of their margins. For instance the Cuddapah basin of Madras has a crescentic outline and the disturbance is greatest along the eastern concave margin.

The Gondwana rocks are seen along the Damodar valley and further west, and along the Mahanadi and Godavari valleys. They are all faulted down, one of the margins as a general rule let down more than the other, the downthrow of the fault sometimes amounting to 8,000 or 9,000 ft. It is to these faults that we owe, in a large measure, the preservation of the Gondwana coalfields. There are certain unimportant outcrops of the Gondwanas in the foot hill zone of the Eastern Himalaya, containing highly disturbed and inverted strata with crushed and sheared coal.

The Deccan Traps cover the greater part of Bombay and Kathiawar and parts of Hyderabad, Central India and Central Provinces. They are practically undisturbed except for a few normal faults and occasional gentle flexures. The Jurassic rocks of Cutch are found folded moderately but the Cretaceous and Tertiary rocks in the coastal tracts have suffered practically no disturbance.

The Archaean basement, on which the above-mentioned formations rest, is naturally highly folded and sometimes overthrust. The dominant sedimentary portions in them, known by various names such as the Dharwars, Aravallis, Champaners, Sausars, etc., occur as highly compressed and folded strips, parts of which have survived the denudation of ages. Typical outcrops of these are found in various parts of the Peninsula—e.g. in Mysore, Rajputana, Singhbhum and Chhindwara. There are, in addition, dominant igneous materials in the Archaeans, represented by one or more groups of gneisses and granites. The granites are generally of a late age, later than the periods of folding in the Archaean times, as they are devoid of banding or foliation.

The Archaean rocks exhibit certain regional trends which coincide with the directions of the fold-axes. These are (See Fig. 1):—

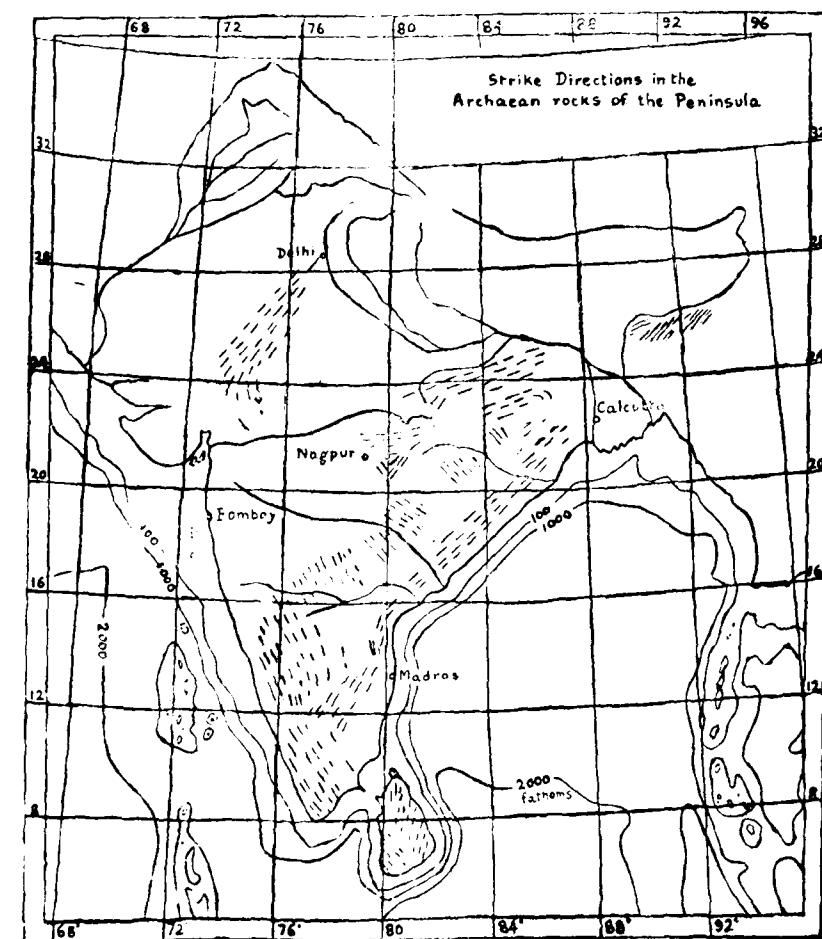


Fig. 1.

The Aravalli strike.—This has a NE.-SW. trend, well displayed in the Aravalli mountain belt stretching from Gujarat in the southwest to Delhi in the northeast. It is also detected in parts of Garhwal beyond the foot-hill zone of Dehra Dun. In Gujarat this strike shows a tendency to splay out, a part trending straight out to the sea towards the Laccadives, another towards the Mysore plateau and still another towards the Central Provinces. Recent geodetic work seems to point to the Aravallis continuing into the submarine banks in the Gulf of Cambay and into the Laccadives.

The Eastern Ghats strike.—The dominant trend along the eastern edge of the Peninsula from Salem and Arcot in the south to Orissa in the north has a NE.-SW. direction, parallel to the Eastern Ghats. It extends, under the Ganges alluvium, into the Assam plateau. The same trend is also seen in the northeastern parts of Ceylon where the rocks of the Eastern Ghats are duplicated to a large extent.

The Dharwarian strike.—This is the characteristic trend of the rocks of the Dharwar System in Southern Bombay, Mysore and the adjoining parts of Hyderabad. The general direction is NNW.-SSE. varying to N.-S.

The Mahanadi strike.—In parts of Orissa, and especially in parts of the Mahanadi valley, the regional trend has a NW.-SE. direction. This is also seen in the southernmost districts of Madras and in Travancore and southwest Ceylon. In many places it shows a tendency to grade into the Dharwarian direction.

The Satpura strike.—The central part of the northern border of the Peninsula is characterised by yet another strike direction viz. the Satpura strike (ENE.-WSW.). This is seen mainly in Bihar, Chota Nagpur and parts of the Central Provinces and also in the westernmost part of the Assam plateau.

Attention may be drawn to the fact that there is a rough parallelism between the strike directions of the Aravallis and the Eastern Ghats. The Dharwarian and Mahanadi strikes, though often distinct, sometimes tend to merge into each other as already mentioned. In certain areas, the major trend lines interfere with each other as in the Nilgiris, in the Sambalpur district of Orissa and in the Bhandara district of the Central Provinces.

In the present state of our knowledge it is not possible to state the relative ages of the compressive movements which

produced these trend lines. My observations in parts of Orissa seem to show that the Satpura strike is later than and superimposed on an earlier one, apparently that of the Eastern Ghats. Careful study of the structure and fabric of the rocks in other areas should provide data for the determination of their relative ages.

Ceylon is a part of the Peninsula and its geology bears a close resemblance to that of parts of Southern India. Ceylon was probably separated from the Peninsula in geologically recent times, perhaps about the middle Tertiary.

The Himalayas are moulded on the northern edge of the Peninsula and the trend of the ranges is probably largely dependent upon the shape of this edge.

THE EASTERN COAST:—The eastern coast and the continental shelf bordering it are irregular because of their comparative antiquity with reference to the western coast. The continental shelf includes the Island of Ceylon but there is a northward indentation in it off the western coast of Ceylon. The east coast of India probably took shape in the Jurassic (Upper Gondwana) times when the Gondwanaland began to break up. Along its borders are the ancient rocks forming the Eastern Ghats, covered over in places by Gondwana sediments. Marine incursions in the Upper Cretaceous and in the Tertiary have left deposits in the coastal regions.

In Cretaceous times the Bay of Bengal stretched into Assam, Arakan and Burma. Later on, perhaps in late Eocene times, this region was separated into two arms of the sea (an Assam Gulf and a Burma Gulf) by the uplift of the Arakan Yomas. This Yoma belt is continued into the Andamans, Nicobars, Sumatra and other islands and is apparently overfolded in the direction of the convexity of this arc.

THE WESTERN COAST:—The western coast, and especially its continental shelf, is remarkably straight. The latter slopes down rapidly from 100 fathoms to 1000 fathoms. This straightness is part of the evidence for our belief that this coast is a faulted one, the faulting having taken place in post-Deccan Trap times. The Traps, as is a well-known, are thickest in the Bombay Presidency and cannot have terminated abruptly at this coast but for this

fault which must have been the cause of submergence of its westward extension. The age of this fault is probably post-Eocene. There is a ridge off the west coast on which are situated some banks in the Gulf of Cambay, the Angria and Adas Banks (west of Goa), and the Laccadives west of Malabar. The Maldives rise further south, separated from the Laccadives by a deep channel at about latitude 8° N. The alignment of the Maldives is slightly to the east of the Laccadives, which may be due either to faulting or to the Maldives being structurally unconnected with the Laccadives (7, Part VII).*

THE EXTRA-PENINSULA:—The Extra-Peninsula comprises the Himalayan arc in the north, the Burma arc in the north-east and east and the Baluchistan arc in the northwest and west, all of which have something in common, though they may differ in the details of their stratigraphy and other particulars. Each of these is characterised by arc-like mountains arranged one behind the other, all convex towards the side of India. The convexity tends to become gradually less in the mountains which are more and more distant from the Indian border. This can be well seen particularly in the ranges of the Himalayas and those lying to their north. The Himalayan arc is one of immense radius and shows a broad sweep between the Nanga Parbat and Namcha Barwa peaks which occur at its western and eastern terminations respectively. The Arakan-Andaman-East Indies arc is also similar but shows one slight concavity in the Arakan region. The north-western arc is smaller than the north-eastern and consists of three units—the Hazara, Sulaiman and Kirthar ranges—each forming a festoon within the general arc which sweeps from Hazara to Southern Iran through Baluchistan.

The Himalayan Arc.—The Himalayas comprise a series of mountain ranges—the Himalayas proper, and the Zaskar, Ladakh and Kailas ranges. Further north are the Aling Kangri and the Karakoram Mountains. The latter are continuous with the Hindu Kush to their west. These are the most northerly ranges in which the influence of the Himalayan movements can be detected (See Fig. 2).

* References at the end of the paper.

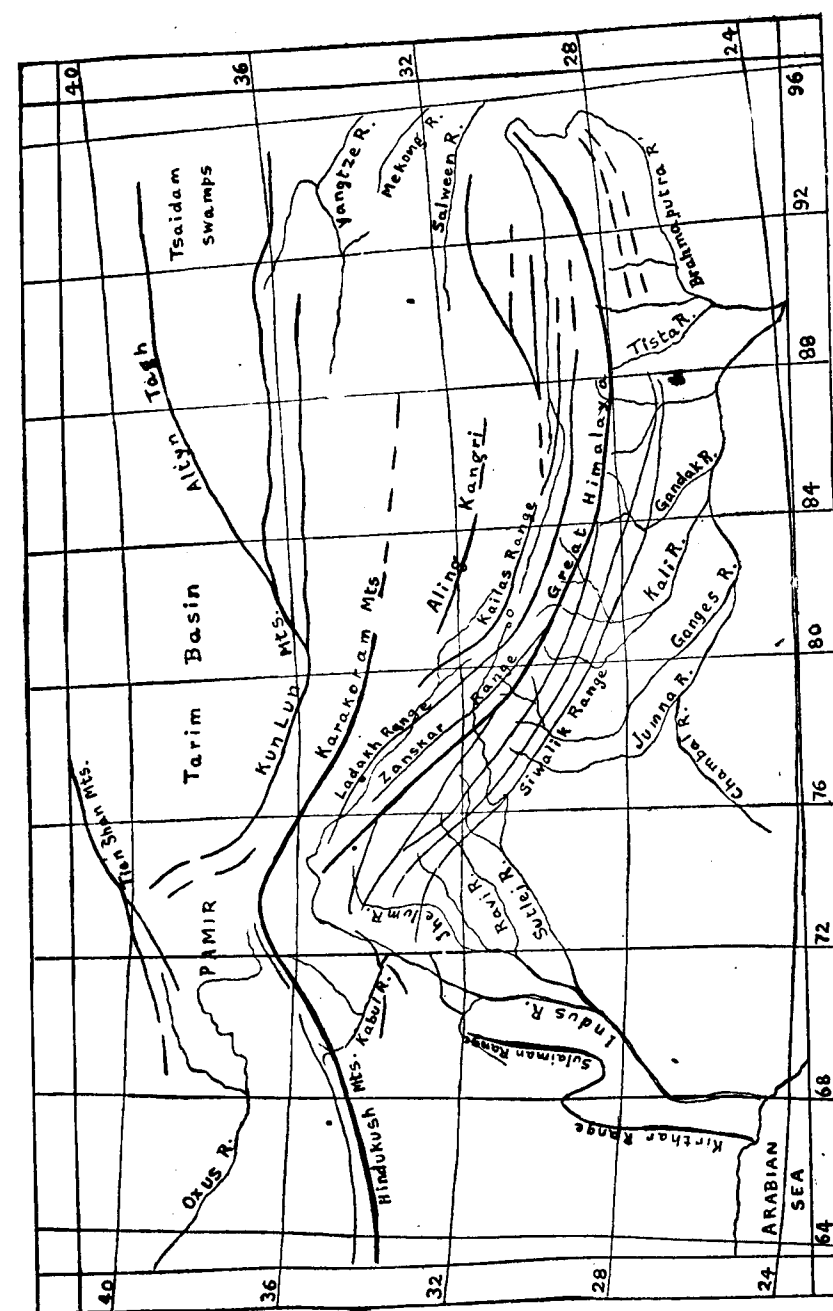


Fig. 2. Himalayan and Central Asian Mountain Ranges (after Burrard).

The Himalayas proper can be divided into four longitudinal zones parallel to their length (1,85). The southernmost zone bordering the alluvial plains is the belt of Siwalik rocks, of Upper Tertiary age, which is about 25 to 30 miles wide and rises up to a height of some 3000 ft. To the north of this is the **Sub-Himalayan zone** (Lesser Himalayas) having a width of 40 to 50 miles and an altitude of around 10,000 ft. This zone is largely made up of unfossiliferous rocks formed along the northern coast of the portion of the Gondwanaland which later became the Indian Peninsula. In this region there are several overthrusts and nappes, the strata being highly disturbed and often inverted in sequence. Further north is the **Central Himalayan zone** (Great Himalayas) of high ranges with snow-clad peaks. This contains sedimentaries which have been much intruded by igneous rocks. The fourth and the northernmost is the **Trans-Himalayan zone**, having a width of 20-25 miles in which the great sedimentary succession of Tibetan marine facies is found.

At the two extremities of the Himalayas there are wedge-like projections of the Peninsula around which the geological formations execute very sharp bends. It is at these bends that the Himalayas terminate geographically, for the high ranges are not continued beyond the bends into the respective northwestern and northeastern arcs.

The North-eastern Arc.—The north-eastern or Burmese arc commences in the little-known territory of the Sadiya frontier region, some distance east of the peak Namcha Barwa and the gorge of the Brahmaputra through the mountains. North of this lies the region where the great rivers of south-east Asia—the Irrawaddy, the Salween, the Mekong and the Yang-tse-Kiang—have parallel courses close to each other. The major ridge of this arc comprises the Arakan Yomas, Andamans, Nicobars and Sumatra, Java and other islands. This ridge exposes mainly Cretaceous and Eocene rocks. To its west is another ridge on which are situated the small islands (Nias, Mentawai etc.) south of Sumatra. The Barren Island and Narcondam are on a ridge to the east of the Andaman one and its continuation is to be looked for in the northern margin of mountain belt of Sumatra and Java and in the region containing the well-known volcano Krakatoa in the Sunda Strait (7, Pt. 1).

East of the above mentioned belt of ridges is the Central Tertiary belt of Burma in which are situated the oil-fields. It

shows folded Tertiary rocks and is faulted against the Arakan belt. The eastern belt of Burma comprises the Shan Plateau and Tenasserim and continues into Malaya. Its junction with the Central (Tertiary) belt is marked by overthrusts and is liable to seismic activity. It contains ancient crystalline rocks and later sedimentaries, often intruded by gneisses and granites.

The early Palaeozoic strata of Burma shows little resemblance to those of the Himalayan region but are distinctly related to those of Northern Europe. It is only after the Permo-Carboniferous, that connection seems to have been established between the Burmese and Himalayan regions. This can be easily grasped if it is realised that the site of the present day Himalayan deposits lay much further south and that perhaps a barrier existed between the sea connecting Burma and Northern Europe on the one hand and the Himalayan sea on the other and that the barrier broke down probably as a result of earth movements in the Upper Palaeozoic. It is thought that some of the mountains in northern Asia, including probably the Tien Shan and Karakoram ranges are of this (Upper Palaeozoic) age (2).

The North-western Arc.—There is a prominent wedge-like projection of the Peninsula from the Punjab into Kashmir. Beyond the Nanga Parbat, the geological formations of the Himalayan region change their direction abruptly from a north-westerly to a southern one as described by Mr. D. N. Wadia (8). This arc consists of three distinct units or festoons presumably formed because of the presence of two wedges of the Peninsula projecting into the Extra-Peninsular area in the Dehra-Ismail-Khan and Sibi-Quetta regions. The three units are respectively the Hazara, Sulaiman and Kirthar ranges, from north to south. But for the two wedges, this arc should have a broad sweep from Hazra to the Makran coast as is the case with the north-eastern arc (See Fig. 3).

Three main zones are also recognised in this arc. The outer zone (bordering on India) is called the Calcareous zone, consisting mainly of Cretaceous and Eocene rocks more or less similar to the rocks of the Arakan-Andaman belt. The middle zone is made up of large thicknesses of Tertiary strata mainly of the 'flysch' facies (unfossiliferous, often greenish, sands and sandy clays) of Oligocene age. The innermost zone found in the interior of Baluchistan and in Afghanistan, consists of rocks of various ages, including igneous



Fig. 3. Mountain Arcs of Southern Asia.

intrusions. This last therefore corresponds to the Shan-Tenasserim belt of Burma.

The mountain ranges of Baluchistan (Kirthar and parallel ranges) are continued into Iran through land and towards the Arabian coast as submerged ridges under the sea. The Mekran Sea is streaked with a series of parallel ridges which proceed towards the Gulf of Oman. The sea floor is here 1700 fathoms deep and the ridges rise to within 1600 ft. of sea-level. These ridges are undoubtedly a continuation of the Zagros mountains of Southern Iran. The Kirthar range, which terminates at Cape Monze, appears to continue under the waters of the Arabian Sea as a double ridge, proceeding in a south-westerly direction. One of these ridges is called the Murray ridge and its highest peak (situated about half way between Cape Monze and the Arabian coast) rises to within 500 fathoms of sea-level from the floor of the sea which is here 1700 fathoms deep. The Murray ridge and its companion probably join the Carlsberg ridge which runs south-eastward from Socotra towards Rodrigues and the Chagos Archipelago (11).

The Potwar and Assam Plateaux.—The Potwar plateau in the north-west and the Assam plateau in the north-east occupy the regions behind the two important wedges which are responsible for the appearance of the remarkable syntaxes at either end of the Himalayas. The Potwar plateau is covered largely by Murree and Siwalik strata (Miocene-Pliocene in age) which have been subjected to some folding. The plateau shows a faulted scarp in the south. There is little doubt that this plateau is underlain by peninsular Archaean rocks and that a projection of these rocks extends as a wedge northwards into Kashmir (8).

The corresponding region in the east is the Assam plateau consisting of ancient crystalline rocks, covered on the east and south by Tertiary sediments. This region is traversed by an important fault, the Haflong-Disang fault, along which rocks are thrust towards the south in Lower Assam and towards the north-west in Upper Assam. There is thus evidence here of an apparent southerly movement from the side of the Himalayas and a north-westerly movement from the side of Burma. The southern border of the plateau also shows a monocline whose southern limb dips steeply into the alluvial plains of the Surma valley.

ORIGIN OF THE HIMALAYAS AND THE GANGETIC PLAINS

Though geographically the Himalayas are to be considered as

terminating near the Nanga Parbat in the west and near the Namcha Barwa in the east, the geological formations execute sharp hair-pin bends at each end and continue southward. The geology of the Kashmir-Hazara region has been elucidated by Mr. D. N. Wadia (8) but that of the north-eastern region is still to be worked out. In all cases the overthrust movement is from the surrounding tracts towards the Peninsula. In the Himalayan arc the movement is apparently towards the south; in the Baluchistan and Burma arcs it is roughly towards the east and west respectively, the exact direction at any point being at right angles to the trend of the arc. Apparent contradictions, i.e., movement in an opposite direction, are noticed especially near the sharp bend, at the northernmost part of the Baluchistan arc, where, in the Garhi Habibullah region of Hazara, an apparent north-easterly movement is discernible. (10, 232). Though we do not know the details of the geology of the region around the tip of the Assam wedge, we can with some confidence expect a similar feature there, i.e., an apparent north-westerly or northerly movement of strata in the eastern limb of the hair-pin bend in the Assam-China frontier.

The effect of the presence of the Punjab wedge is apparently felt as far north as the Pamir Plateau whose southern part shows this influence distinctly. Here the trend of the eastern portion (Karakoram) is to the south-east and that of the western portion (Hindu Kush) to the south-west (5, 274). What corresponds to this north of the Assam wedge is a matter of speculation; the region may be somewhere near the borders of Szechwan-Kansu-Tibet. The Pamir region is one of high density and of deep-focus earthquakes. Perhaps the corresponding eastern area may have the same characters too.

In front of the overthrust mass of the Himalayas there is the 'fore-deep' or sag in the crust filled up by Pleistocene and recent sediments. This may have been formed by a sort of buckling down of the crust along a belt roughly parallel to the Himalayas as a result of the compression exerted on the Peninsular margin by the opposition of the Indian Peninsula and Central Asia.

The region north of the Himalayas has, in recent years, received the attention of several scientific expeditions. Though all the mountains up to and including the Karakoram conform roughly to the Himalayan trend, some of them are probably of an earlier age. The Karakoram mountains are regarded by E.

Trinkler and H. de Terra as of Hercynian (Upper Carboniferous) age (2). Their present parallelism with the Himalayas may be an original feature or may have been imposed on an earlier structure. The gradual flattening of the curve of the Himalayas in the ranges situated progressively more and more to their north is in accord with the supposition that the effects of the Himalayan trend gradually die down in a northward direction. It is obvious, however, that the pre-Tertiary rocks in the area affected by the Himalayan movements had other trend lines but they must have been modified appreciably by the great Tertiary disturbance. It is obvious also that the Tertiary belt of the Zagros Mountain belt of Iran and the Makran Ranges continues into the Arakan-Andaman-East Indies belt but the portion bordering on India has been stretched and pushed up northwards. Eocene rocks are known along the western and north-western borders of India up to about Naini Tal and have not been recorded in the parts of the Eastern Himalaya which have so far been visited. But they are present prominently both in the Arakan-Andaman arc and in parts of the Assam plateau. It is not known whether the absence of Eocene rocks in the Eastern Himalaya is due to the absence of sedimentation or to obliteration of such rocks by overthrust or other means. The trend of the Zagros mountains leads to the Malayan part of the Arakan-Andaman arc and the marked indentation in this belt, which should otherwise have been smooth-flowing, is to be attributed to a northerly movement of India or a southerly movement of the regions on either side of India.

Throughout this arc, the strata are overfolded to the south (towards India in the portion immediately around it). This may be thought of as due to a general movement of Asia in a southerly direction or of India in a northerly direction. It is impossible, from structural studies of the borders of India, to decide which of the alternatives is true, for the ultimate mechanical effect should be the same in either case.

It is known that the Pacific coast of Eastern Asia is overfolded eastwards towards the ocean just as the strata in the Himalayan region are overfolded southwards towards India. Both these mountain systems are of Tertiary age. As pointed out by P. Lake in his interesting paper on mountain building (6) it is difficult to conceive of Central Asia as having moved out both to the east and to the south at the same time. But an underthrust from one side at least, if not from both, is likely. Secondly, Central Asia is

known, from geodetic observations, to be a region of high density, which indicates that there has been a compression of the sub-crustal rocks beneath it (1, 77). Perhaps the most important argument is that India is a part of the Gondwanaland whose component parts lie far to the south, India drifting away roughly in a north-easterly direction since the Jurassic times.

The relative northward movement of India is apparently of the order of 10 degrees of latitude, for this is roughly the distance indicated by the interrupted trend of the Tertiary arc. This gives us a rough measure of the tremendous compression undergone by the segment of the earth's crust now forming the region of the Himalaya and connected mountain systems.

This leads us to a consideration of the theory of continental drift propounded by Wegener (9, 3). According to this, there was a large continent, the Gondwanaland, forming the southern hemisphere in the Palaeozoic era. The component parts of this continent were South Africa, South America, Antarctica, Australia and India. There are remarkable stratigraphical similarities amongst them, especially in the Gondwana strata, which are best explained as due to their having been part of one huge continent.

The connection of India with Madagascar and Eastern and Southern Africa is not readily apparent probably because some strips of the crust have been lost by faulting during the long time which has elapsed since the drifting began. Madagascar appears to have lain contiguous to Tanganyika and Kenya (3, 120-121) with which it has close structural and stratigraphic relationship. The time of the separation of Madagascar from Africa was probably in the Jurassic, for marine rocks similar to the Jurassics of Cutch occur on the Kenya and Madagascar coasts. Madagascar, Ceylon and the southernmost parts of India bear a great deal of resemblance in their geology. The N.-S. strike of the rocks in Madagascar assumes a NNW.-SSE. (or NW.-SE.) strike in Ceylon and Travancore because of an anti-clockwise motion imparted to India during the drift (see Fig. 4). The presence of a suite of rocks of similar nature in these different areas, including charnockites, crystalline marbles and rocks containing graphite,

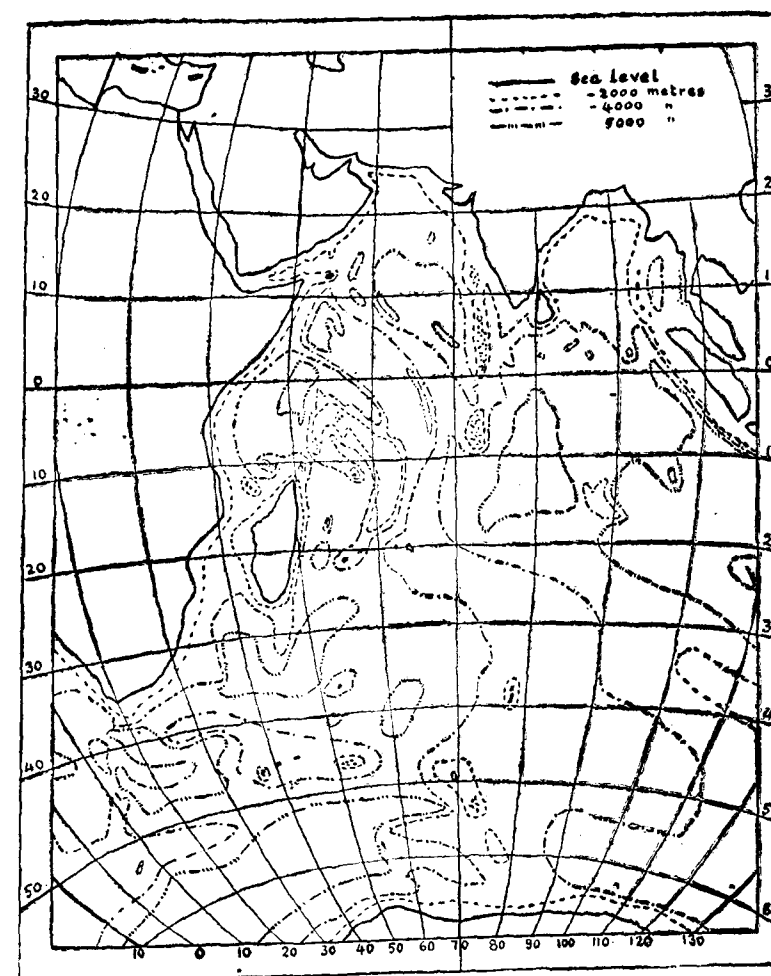


Fig. 4. Configuration of the Indian Ocean
(adapted from Wiseman and Sewell).

sillimanite, garnet, phlogopite, monazite and related radio-active minerals, supports the idea that these areas all formed part of one land mass formerly. India and Madagascar separated from each other probably in early Tertiary times for the only marine strata known on the western coasts of Travancore and Ceylon are of Middle Tertiary age.

The northern part of the eastern coast of Africa and the western coast of India are faulted. Similarly also the whole of the coast of Arabia is faulted. These are a consequence of the separation of these different masses from each other by rupture. The drifting of India north-eastwards relative to Africa is also thought to have produced the Rift Valley system, which includes

14324. Um2, N26 GLE
N42.18.2

also the Red Sea and the Dead Sea (see Fig. 5). In the Arabian Sea there is a series of volcanic ridges composed to a large extent of basic volcanic rocks. These ridges may also have resulted from the drift, but the mechanism of their origin does not seem to have been satisfactorily explained. It may be that, as a result of the

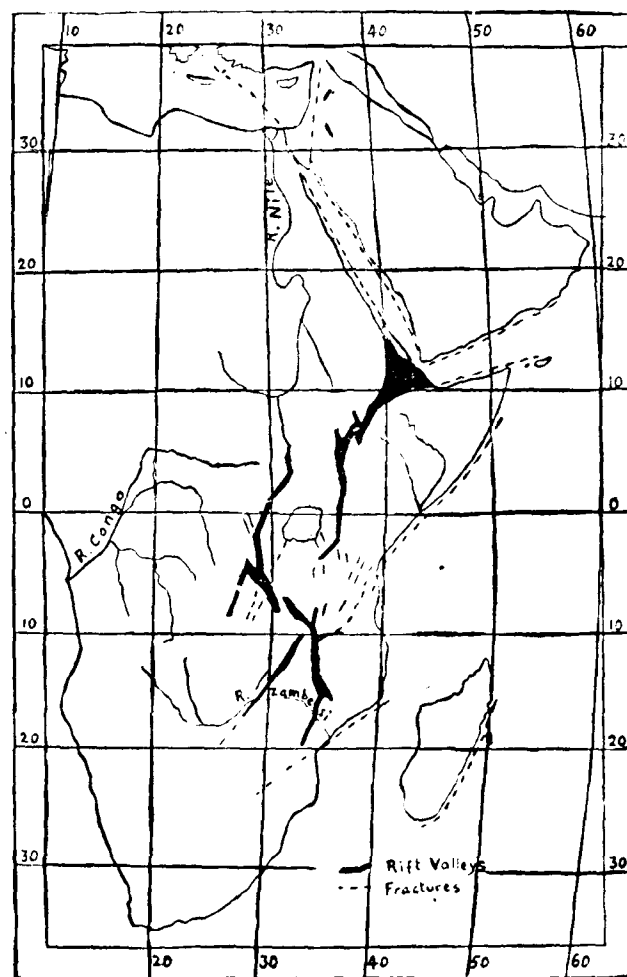


Fig. 5. Rift Valleys of Africa (after Gregory and Du Toit).

drifting of the upper portion of the crust, the sub-crust was in places domed up by basic magma rising from the interior to compensate for the deficiency of matter caused by the drift. In the western part of the Indian Peninsula basic magma has been poured out through fissures in the crust and has spread over a large area of the surface.

Wiseman and Sewell (11 p. 226) call attention to the similarity of the Rift Valley system to the ridge system in the Arabian Sea and to the two forming a rough mirror image of each other along 50° East longitude (see Fig. 4). It appears probable that both these systems have resulted from the same cause but the symmetry, if it does exist in detail, is probably merely accidental, for there does not appear to be any symmetry in the landmasses around these features nor in their movements.

The effect of the drift of the Indian Peninsula northwards or northeastwards has been to compress a large strip of the crust and raise it up into a series of mountain ranges of great magnitude. In these movements a variety of rocks have been involved—fossiliferous rocks of the open ocean (called the Tethys); unfossiliferous rocks which were apparently formed in partly enclosed basins bordering on the Peninsula, the basins being either devoid of life or supporting only a very limited fauna; and coarse sediments of fluvial or lacustrine nature formed on the borders of India in the quiescent periods between the major movements of compression and uplift. In addition to these sedimentary groups, a variety of igneous intrusives of various ages, including Tertiary granites, are involved.

If the present dispositions of the Tertiary arcs is an indication of the north-easterly drift of India, then the horizontal compression in a NE.-SW. (or say N.-S.) direction is of the order of 500 miles or more and the vertical uplift of the order of some 25,000 to 30,000 ft.

The drift apparently commenced in the Upper Gondwana (Jurassic) times and is probably still in progress. Whether it was a steady or pulsating movement it is not possible to say, but the three or four phases which are generally recognised in the Himalayan upheaval may be regarded as the periods when violent adjustments were made in the crust to relieve the stresses accumulated gradually or rapidly as the case may be. In movements of this magnitude we should naturally expect a great deal of irregularity in the effects produced on the various inhomogeneous stratigraphic units. Some parts have moved bodily southward along the several thrust planes while others have been intensely folded, faulted and inverted in complex ways. The effects of compression are felt most in front of the two wedges at the two ends of India, but at the sides of these wedges the rocks have flowed round as if in whirls, clockwise in the eastern limb of the north-east syntaxis on the China border, and anticlockwise in

the western limb of the north-west syntaxis on the Hazara border (3, 184).

There is another feature, less noticeable, but nevertheless real and important. Roughly parallel to the advancing front edge of India and perpendicular to the general direction of movement there are two belts of country noticeable, one of high density and the other of low density. The former, called Burrard's 'Hidden Range' lies under a narrow belt connecting Sambalpur-Jubbulpore-Jodhpur. The latter, the zone of low density ('Hidden Trough') is that obtained by connecting Nellore-Bellary-Belgaum. It will be noticed that these cut across a variety of formations and have no relation to the rocks exposed at the surface and must therefore be connected with sub-crustal peculiarities brought about by the drifting movements. Under the 'Hidden Range', the heavy rocks of the basaltic layer have probably risen up to near the surface whereas under the Hidden Trough they have been depressed far below the surface with the concomitant thickening of the lighter upper granitic layer. Where the peninsular margin is buried deep below the Himalayan rocks there are great thicknesses of light sediments as well granitic and other igneous materials that have risen from underneath. Some distance in front of it is the Central Asian mass of high density. Behind it is the Gangetic trough filled with a good thickness of light sediments. Still further behind are the 'Hidden Range' and 'Hidden Trough'. All these may be likened to the crests and troughs of waves produced in the sub-crust by the drifting mass of India. An interesting question in this connection is whether the ridge and trough system of the Arabian Sea between India and Africa conform to a series of crests and trough (of the sub-crust) left in the wake of a moving continental mass.

Geodetic observations in recent years have also brought to light the existence of a few other regions of high and low density described respectively as **upwarps** and **downwarps** by Col. E. A. Glennie of the Survey of India (4). The chief upwarps are:—Along the Laccadives and the ridge near the western coast, continued into the Aravallis up to Dehra Dun; along the eastern coast of Ceylon, Madras and Orissa; along the Shillong Plateau and the southern border of the alluvium in Bihar; from Delhi to the eastern end of the Salt Range; from Karachi along the Kirthar Range; along the major belt of Dharwarian rocks of Mysore; from the mouth of the Kistna River to Chhindwara in the Central Provinces.

The prominent downwarps are the following:—Through Ceylon; the Cuddapah basin of Madras and of Chhattisgarh; along the Maldives and the Western Ghats up to Gujarat; the Vindhyan basin of Central India; along the Ganges valley and the Upper Punjab plains; along the valley of the Indus down to the junction with the Sutlej and then down to the Rann of Cutch.

An examination of the above shows that the upwarps coincide roughly with Archaean (Dharwarian) mountain ranges and fold axes and the downwarps with Cuddapah and Vindhyan basins and the Indus and Ganges valleys. They are obviously therefore effects connected with the distribution of surface rocks.

I have summarised in this short paper the chief facts known at present having a bearing on the structure of India. The picture is yet deficient in detail and much remains to be done in India and other countries before full information becomes available on all aspects of this question and a complete and satisfactory explanation can be offered for features which are still obscure.

REFERENCES.

1. Burrard, S.G., Hayden, H.H., and Heron, A.M. *The Geography and Geology of the Himalaya Mountains and Tibet*, (2nd Ed.) Dehra Dun, 1934.
2. De Terra, H. *Geologische Forschungen in westlichen Kun Lun und Karakoram Himalaya*. Berlin 1932.
3. Du Toit, A.L. *Our wandering continents*. London, Oliver and Boyd, 1937.
4. Glennie, E.A. Gravity anomalies and the structure of the Earth's crust. *Survey of India Prof. Paper* 27, 1932.
5. Hayden, H.H. Notes on the Geology of Chitral, Gilgit and the Pamirs. *Rec. Geol. Surv. India*, 45, 271-335, 1916.
6. Lake, P.—*Geogr. Journ.* 78, 149, 1931.
7. Sewell, R.B.S. Geographic and oceanographic researches in Indian waters. *Mem. Asiatic Soc. Bengal*, IX. Parts I-VIII. 1925-38.
8. Wadia, D.N. The syntaxis of the N.W. Himalayas—their rocks, Tectonics and orogeny. *Rec. Geol. Surv. India*, 65, 189-220, 1932.
9. Wegener, A. (Transl. by J.G.A. Skerl) *The Origin of Continents and Oceans*. London.
10. West, W. D. Some recent advances in Indian Geology. 3—*The Geology of the Himalaya*. *Current Science*, III, 231-231. 1934.
11. Wiseman, J.D.H. and Sewell, R.B.S. The floor of the Arabian Sea. *Geol. Mag.* 74, 219-230. 1937.

The Rajputana Floods

By

KEDAR NATH SRIVASTAVA, M.A., B.T.,

Lecturer in Geography.

Teachers' Training College, Vidya Bhawan, Udaipur.

The modern science of Hydrography which made little progress until the nineteenth century is based upon a firm basis of reason. Man has realised the essential relation between the water-flow and the slope of ground. Unlike the absurd mystic explanations given by the classical writers how the floods resulted, the present Geographers dig deeper to reach the root of the cause. It is, of course, no consolation to those who have suffered from the floods to be told that there were good reasons for it. Some of the chief reasons for the great havoc caused by the floods have been in existence for a long time, yet no flood of any magnitude has occurred in the annals of Rajasthan.

The Aravalli ranges which serve as a water-parting of the region give rise to a number of consequent streams on both of its flanks. Mewar lies on the east and several rivers rise from the upper reaches of the hilly tract; of these the Khari, Nekati, Mansi, Kothari and Banas are the chief. All these rivers are tributaries of Banas which joins the Chambal before it meets the Jamuna and the Ganges river-system. Except for the elevated belt in the west, the whole region lies almost entirely under 1600 ft. above sea-level, while the lowland area along the rivers consists of alluvial soils and is so low as to be subject to inundation by the slightest rise of the rivers.

The region under consideration is fortunate enough, a rare privilege, to be under the influence of the Bay of Bengal as well as the Arabian Sea branches of the S.W. Monsoons. The north-easterly trend of the ranges, all the more, serves as a barrier for those moisture-laden winds particularly from the Bay of Bengal. On July 28 and 29 1943 there was very heavy downpour of rains—over 20 inches—in the hilly regions of Deogarh and Bhim in Mewar. Unfortunately meteorological records are not available due to the war, yet it may be suggested that the 20 inches of rain in two days, in the 20-to-40 inches mean annual rainfall zone

of India, must be associated with the passage of very strong depressions, comparable with those of the westerlies. An eye witness in Deogarh described that the rain was falling in copious tropical downpours. At length, with a blinding flash and earth shaking reverberations the clouds burst upon them. The sky opened and water crashed down in torrents to save the people and their land from the agony of thirst. On account of the abnormally incessant cyclonic rainfall of a spasmodic type over a large part of the region, about 200 artificially dammed storage tanks in the adjoining lower regions received a water supply far beyond their capacity, and were breached. As wave impels wave, so tank overflowed tank and the water imprisoned for centuries escaped, rushing along in danger of being rearrested with the speed of a galloping horse, sliding at 10 or 12 miles an hour, pushing down hundreds of houses and trees and scraping away colossal tons of field soil. This additional water which swelled to such unheard-of heights sent the greatest volume of flood water into these rivers which were already otherwise flooded as a consequence of the heavy downpour.

Another geographical factor which augmented the ferociousness of floods was the immediate run off of the rain water from the bare hills devoid of vegetational carpet and forests. Forests have been destroyed in these regions to the greatest intensity by the unintelligent natives who could not foresee the future consequences. The roots of the trees serve to bind the soil while the decayed vegetable matter increases its depth; the consequence is that the rainfall is held in the soil instead of running off the surface immediately. Cutting down forests, overgrazing and ploughing up grass, all tend to increase the local floods. Here, exceptionally heavy downpours and the like, washed away the soil from the treeless hills. The floods lasted for eight hours from the dead of night till morning and it could pick up huge quantities of rock material lying ready on the surface; the result was to lay coarser sand, one to three feet deep over the whole area, burying and ruining the fertile plains and completely altering the physical geography of the region. The lowlands have been completely reconstituted by flood debris, but the uplands have retained their pre-flood form. Intermittent flooding can spread finer-grained alluvium which is of great fertility. Contents of the debris are variable. It has received a large contribution from the far-travelled debris and also from the rocks on which it rests. At one place, portions of a dam have been carried away very far.

They now stand like gigantic 'erratic blocks' on the coarser sand beneath.

The greatest source of mischief and unprecedented catastrophe has been the Khari which emerges from among the hills near Deogarh, the region of highest abnormal rainfall, and which was also largely fed by the majority of tanks. The river rolled along in high floods, the swelling brown torrent eddying with ruthless sweep, spread along miles of its bed bringing down a heavy suspended load of floating trees and man's property. The river broke its banks spreading destruction for miles on each side of its normal bed along the whole of its course. Village after village was swallowed in fury. One may think of Khari floods as a force, tornado like in lateral pressure, sweeping all before it. It performed far more work in corrosion and transport during the short phase of the floods. It swelled notoriously to about 20 feet above its mean level and near Asind the floods had a breadth measurable in miles. Its whole winding course was a boiling torrent of muddy brown water clogged with smashed houses, trees, fences, lumberyards including men and animals, struggling to survive. South of Asind this furious stream broke her bank in the dead of night and struck a new course sweeping away the prosperous town of Bara-Khera. Pushed by the flood waters, the structures collapsed and turned crazily over and over and moved off down the stream. In the new course, double-storeyed buildings were washed away to such an extent that the roots of the hilly hummocks have been exposed with the silvery mica layers, over which the homes of hundreds of happy farmers stood. Approximately 170 people and 1700 animals were drowned. Asind Town was struck from the north and the east where the small but equally enraged Nekati, which rises from the hills of Bhim—another region of abnormal rainfall—spreading far beyond her banks joined the new offshoot of the Khari and they devastated a number of villages. In Asind alone about 150 human and 2100 animal lives were lost and 400 houses were demolished. Parasoli, which stood just above the confluence of the Khari and Nekati, suffered the same fate. The prosperous village was attacked by the main stream of the Khari and the Nekati from the south-west and the new stream from the north and east leaving only 18 houses out of 256 still standing. After their confluence, the waters of these streams spread over a wide expanse of several miles with portions of hills projecting through the waters like 'inselberges' which provided high spots of rescue for the bewildered people,

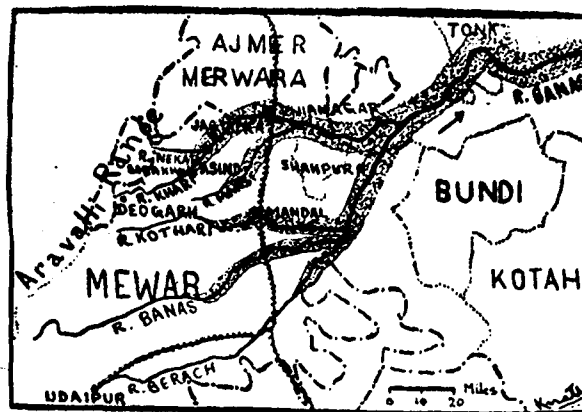
animals, snakes and reptiles alike. The whole area represented a heavy monsoon-tossed sea with stormfilled skies. Jagpura, a town on low level with a population of about 800, suffered most by a new river-offshoot and the waters of the furious Khari. Nearly 400 people were carried away in their sleep at dead of night, in the twinkling of an eye. The river on its downward march continued its catastrophic activity with exceptional violence and destructiveness. Its notoriety is implied in its name. Scores of villages have been wiped off beyond recognition. Back waters unlike the swift currents swept no property, but their prolonged soaking effect involved enormous loss to buildings.

On July 30 at 6-30 A.M. the floods descended on Vijianagar in Ajmer-Merwara. The town which lies to the north of the river on the B.B. & C.I. Railway was beset by the angry waters, and as the railway embankment checked the easterly movement of water in mass, the pulsating town with its cotton mill, ginning press and other lucrative business activities was engulfed with the greatest ferocity. In addition to the loss of property and animals, about 2,500 people out of 10,000 were massacred in a few hours and the whole town was a city of the dead. It was the most anxious time for the engineer and bridge maker. Here the Khari made a breach in the railway line. The prosperous town of Rajnagar was wiped out in less than half an hour. Gulabpura also on the other side of the river lost heavily in men, money and buildings. Kadera and Deomand in Ajmer-Merwara also suffered equally. About 50 villages in Jaipur, 15 in Shahpura and a few in Tonk have been affected by the floods. Other villages suffered in part. The railway bridge on Kothari south of Mandal was thrown miles away by the flood waters.

Mewar is reputed for its great flocks of sheep and goats, the hardiest of animals, which are capable of thriving under most severe conditions and which graze the semi-arid regions and mountain shrubbery. The number of sheep and goats which fell victims to the fury of the rivers amounts to 50,000 in addition to the loss of a few thousands of cattle. The total loss of human life reaches the colossal figure of 8,000 including 2,000 in Mewar State alone. Compare this with the 10,000 lives lost in the last disastrous Bihar earthquake! Damage to private property, buildings, railway lines, wells and other things runs into several millions.

All along the river courses the deserted huts and uprooted trees are eloquent evidence of the late tragedy. Grotesquely the

grass and bushes hang high in the tree tops tossed there by the floods' crests. These streams were the arteries which pumped life into the neighbouring countryside. Since centuries, man has worked to cultivate the fertile fields along the rivers which have been particularly buried and ruined under knee-deep sand. The regions which presented a striking panorama of scenic beauty are nothing but a shimmering landscape. The gusts of wind are impregnated with the fine sand that is swept off the barren land. The Khari which rose to unheard-of heights in floods is now nothing but a wide expanse of glittering sand with a narrow ribbon of gleaming water, one foot at the deepest, offering no difficulty to the passers-by. The rivers have changed their courses and migrated their meanders.



FLOOD-AFFECTED AREAS IN RAJPUTANA

Time was a fourth dimension in the floods. Length width and depth are the familiar old three, but time and the rate of the movement of water were another. The tragedy started from the dead hour of night when the people were taken unawares from the momentary to the eternal sleep. Had the floods in which 8,000 human lives were lost occurred in day time, the toll of life would have been greatly diminished. One more example will clarify the viewpoint. The cotton mill in Vijianagar works on double-shift basis due to the exigencies of war and as the floods reached the town at 6-30 a.m., approximately the time of morning shift, the double mill population was entangled. Had the floods occurred at mid-day, or at night, the toll of mill population would have been nearly halved.

Another factor controlling the damage to property was the nature of the buildings. At first glance one is puzzled to see

only two solitary buildings out of 95, and both of them temples standing haughtily amidst the desolate ruins of Bara-Khera. Mystic ideas first begin to rush in. Does nature distinguish between religious and non-religious structures? How can we, then, explain this unusual occurrence? The only possible reason to which may be attributed their safety, is their strength in basic foundations and materials, resistant enough to fight against the mad currents. Such buildings, particularly the abodes of gods, are constructed out of public funds and are therefore more secure while the other private buildings of a poorer type easily crumbled down. Nature treats all alike without distinction of professions, castes and creeds. All fell victim to the floods equally—the Hindus and the Muslims, the rich and the poor, the butchers and the Pujaries.

After eight hours' struggle against human interests, at length, the floods receded and left desolation and ruin everywhere. The floods made the land a region of the dead, a mecca of destitutes. It was heart-rending to see bewildered men, women and children, wet and ill-clothed, parents separated from children, wives from husbands, some losing all the members of their family, and only dead bodies here and there. As soon as the news spread, rescue parties, both Government and private from Beawar, Ajmer, Udaipur, Jaipur etc., dashed towards the flood-affected areas. They ministered to the flood victims, reunited separated families and doctored the sick. The rescuers buried the dead beneath some spadeful of sand and gravel, not near their ancestors—a custom most sacred to Indians—but a few miles away from their homes, having been carried by the swift currents. Most of the dead bodies got buried by the flood debris, hundreds provided food for crocodiles and some were given 'cannibal' burial, all but the bones being eaten, by the swarms of eagles and vultures, the so-called enemies of the dead. In spite of quick disposal of dead bodies, some were exposed to the sun and rain, and being decomposed emitted foul odours. There was never seen a more pathetic spectacle than the lines of hungry and distressed men, women and children waiting for food and clothing.

These floods caused great havoc among the people. Many thrilling tales were told—some of which contain accounts of unusual bravery against heavy odds. On the other hand tales of woes are not uncommon. An eye-witness narrated that some ten or twelve bewildered people took refuge on a tender branch of a tree standing amidst the roaring currents and as it crashed, down

went the hoping inmates to be engulfed by the hungry waves beneath. The closer the enquiry, the keener the disappointment and sorrow.

Spirit of despair and defeatism does not prevail over a large section of the flood-affected population. There is a belief, which in some form seems to be universal among the people, that as these floods are God-sent calamities on mankind, or have descended on earth due to Nature's caprice, the appalling sorrows have to be borne in entirety. Like the people in older lands, such as Egypt, Iraq and China, where for thousands of years man has wrestled with river problems, these people are courageously facing the heavy odds. No one can discover on their faces signs of dismay and defeatism. The laborious farmer with his daily toil is seen engaged in the tremendous task of removing the knee-deep sand from his cultivable fields. Some people go even so far as to reject free food and clothing offered by the relief workers. They argue for debts rather than alms.

To dwell upon a few aspects of flood control will not be a digression from the real topic. The causes of the tremendous havoc wrought by the floods may be classified into two groups—the natural and the economic. Man has no direct control over the natural ones, but for other factors which added to the fury of the rivers man is responsible. Deforestation and over-grazing may be considered first. The importance of vegetational carpets and forests as a means of preventing immediate run off and soil-erosion needs no further elucidation. These States should do a great deal to help the people to see the disadvantages of their unsystematic ways of deforestation and introduce drastic changes for effective improvements. Before the floods occurred, the Mewar State even in the face of bitter criticism, revolt and opposition by the unintelligent masses, took an encouraging initiative, though it was too late. Other States should follow suit. The colossal tons of sand burying the fertile agricultural land provide the best occasion for these people to understand the cause and the effect. As regards the storage tanks, only the synclinal rock-basins should be dammed to impound water with strong pucca structures in order to prevent easy breaching. Otherwise, the construction of artificial dams, barrages and other obstructions, in spite of other economic advantages, intensifies the danger from such abnormal conditions, and the record of bursting dam catastrophe such as the present one, is a warning of the wide margin that must be allowed for Nature's caprice.

In spite of the immediate relief being rendered by the philanthropic organisations the whole region is passing through a great crisis, though conditions have greatly eased. Committees have been formed in different States to concert measures for affording relief to the victims of the floods, yet hundreds of poor families are still homeless, penniless and destitutes. Relief centres have opened shops to supply grain at concession rates. But what about those who are penniless? The meagre help is altogether insufficient to sustain people in any degree of efficiency. It can just keep body and soul together. People who are shyly asking for help consist of those who once possessed a bit of land and capital before the present disaster overtook them. Those who lived in double-storeyed buildings are now under shady trees and the huts built on piles and roofed with thatch. One is reminded of the days when the uncivilized man roamed in the state of nakedness, ill-clothed, living in the primitive huts like the Tasmanian's wind-screen. The villages which hustled with human activity before the floods now represent piles of stones with desolate looks, the survivors having fled to new places for maintenance.

The task of re-settlement and rehabilitation is very tremendous, needing a comprehensive scheme and immense co-operation between the Government forces and philanthropic bodies. The pioneer efforts of such agencies read almost like a romance. At a moment when the country is in so dire need of food, when hundreds of lives are daily lost in Bengal due to food crisis, the miseries and hardships left by these floods are beyond one's imagination. The cold weather is fast approaching and unless proper care for their accommodation and clothing is taken, the flood affected people will die in large numbers. If the 400 square miles of the agricultural land under sand is not reclaimed very soon, the question of 'no food' is sure to arise by the next harvest. Grain at cheap rates cannot be provided for an indefinite period of time. Free distribution of rations cannot be continued. These temporary provisions can only keep death at a hand's length. The real solution of the problem lies in reclamation and rehabilitation alone. People at present need food, water and shelter; houses have to be re-constructed; seeds, implements and draught animals for agriculture in addition to the vast material help for removing the sand and the like have to be provided. Remission of land revenue needs no emphasis. Bara-Khera alone needs Rs. 25,000 in cash for all these necessities. As most of the wells have been filled up with river sand beyond recognition, or partly

damaged, the problem of water supply is very acute and thus requires immediate attention. Those which are left with decaying vegetation under the ardent sun generate miasma, the consequence being fever, dysentery and not infrequently cholera among the people.

Before concluding the review it would not be out of place to throw some light on the problems of reclamation. The bulk of the sand was dropped near the banks of the rivers during the process of deposition of the coarser debris, which is generally laid down in excess, in or near the river courses. Unfortunately that is the area which was most intensively cultivated, although the debris was spread as an extensive sheet over the whole flood plain. It is three feet or more in depth near the rivers, but the depth decreases transversely. The broad stretches of cultivable land look like flat sand dunes shimmering under the ardent sun. What little cultivable land there is must support the people who cannot possibly subsist on this meagre produce. How to reclaim the land; how to remove the sand and how to bury the colossal tons of coarser debris; these are the most urgent problems of the hour. On the average Rs. 15/- are required to clear off one bigha if sand is one foot deep, Rs. 25/- if two feet deep and Rs. 35/- if three feet or more. For a moment, imagine the incalculable cost that has to be incurred. Either the sand should be removed in mass or big holes like wells should be dug in the fields to bury some of the sand and the new fertile soil should be spread over, knee-deep. If it is shifted to the sides of the fields about 20% of the precious land would be lost. Even in such cases the active sand will migrate with aeolian action to destroy the growing crops again. This is the real problem which is taxing the authorities. To attempt all this is beyond manual labour, except when the services of huge tractors from some concerns are borrowed. However, a close collaboration is urged to prepare comprehensive plans for the removal of the sand dragon. The floods descended, swelled and passed, but the tremendous miseries and hardships they left behind will need a score of years to vanish before normal conditions are restored.

Somnat as Noticed by Arab Geographers

By

DR. S. MUHAMMAD HUSAYN NAINAR,
Madras University.

The account of Somnat which follows is taken from the books of Arab Geographers dating from the 10th century. It is from the Tenth century A.D. that we observe the development of a literary geographical school which was to exert a lasting influence on succeeding generations of writers, Muslim as well as Christian. The conquests of Islam and greater intercourse with foreign countries have enriched the knowledge of Arab and Muslim writers from the 10th century onwards.

Biruni (970-1039 A.D.) a client of the Sultan Mahmud of Ghazna and a Persian by race was the greatest geographer of his age. His famous description of India is unparalleled. In stating the distances from one city to another he says that marching from Bazana, towards the south-west you come to Somnat on the sea coast (50 parasangs); Kach and Barvi to Somnat (14 parasangs). Somnat to Kanbaya is thirty parasangs. The pirates of Kach and Somnat are called Bawarij, because they commit their robberies on sea sailing in ships called *Bira*.

After Biruni no geographer makes mention of Somnat till we come to Yaqut (1179-1229 A.D.); Yaqut, in his big geographical dictionary which gives all geographical names in alphabetical order, says that Somnat is the most famous temple in the whole of India for the Hindus. It is analogous to the city of Makka with the Muslims.

Qazwini (1203-1288 A.D.) is the author of a book on cosmography and geography. He gives a long account about Somnat.

Somnat, a celebrated city in Hind, is situated on the shore of the sea and washed by its waves. Among the wonders of that place was the temple with the idol called Sumnat placed in the middle of it without any prop. It was held in great veneration by the Hindus; whoever beheld it floating in the air was overwhelmed with wonder whether he was a Muslim or an unbeliever.

The Hindus used to go on a pilgrimage to that temple whenever there was an eclipse of the moon, and assembled there in large numbers, more than a hundred thousand. They believed that souls of departed men met there after separation from their body, and the idol incorporated the souls with other bodies in accordance with the doctrine of transmigration. The ebb and flow of the tide was considered to be reverent homage paid by the sea to the idol. All kinds of precious articles were presented to the idol by way of offering; the temple also derived permanent income from more than ten thousand villages.

There is a river held sacred among the Hindus at a distance of two hundred parasangs from Somnat, and every day the idol is washed with the water brought from that river. One thousand Brahmans were employed for the temple services and for attending upon pilgrims; five hundred damsels danced to music and sang the praises of the deity. All of them were maintained by the income from the temple endowments.

The edifice rested upon fifty-six pillars of teak wood, covered with lead. The sacrarium which was dark, was lighted by a jewelled chandelier of great value. A gold chain weighing two hundred *mann* was hung near the sacrarium. When a part of the night was finished, this chain was shaken quickly to wake up a fresh batch of Brahmans for service.

When Sultan Yaminu'd-Dawla Mahmud ibn Subuktigin went out to wage war with India, he exerted strenuously to capture and destroy Somnat hoping that the Hindus would become Muslims. He reached Somnat in the middle of Dhu'l-Qada of the year 416 A.H. (Dec. 1025 A.D.). The Hindus offered desperate resistance. They would go into the temple weeping and wailing and then come out and fight till all were killed. The number of the slain exceeded fifty-thousand.

The Sultan looked upon the idol with amazement and gave orders for plundering the temple treasures. There were many idols of gold and silver, and vessels set with jewels, which had been sent there as presents by great personages of India. The value of things found in the temple exceeded twenty-thousand dinars.

When the Sultan asked his companions what they had to say about the marvel how the idol was floating in the air without any support, several asserted that it was suspended by some hidden

support. The Sultan directed a man to go and strike down the whole area with a spear. But the man met with no obstacle. One of the companions stated that the canopy was made of load-stone, and the idol, of iron and the ingenious architect had contrived skilfully that the magnet should not exercise a greater force on any one side. Hence the idol was hanging up in mid-air. With this view some agreed, while others differed. Then permission was obtained from the Sultan to remove a few stones from the canopy to settle the dispute. When two stones were removed from the summit, the idol swerved in the air; some more stones were taken away and the idol went off further in changed direction until at last it came to the ground.

Dimishqi (vers 1325 A.D.) gives the account that Somnat is a spacious city on the sea-coast. Among its inhabitants there are many learned Hindus and devotees. Its port is full of ships that reach there from Aden.

There is a temple in this city and the celebrated idol is worshipped by Hindus. The idol represents the genitals of man and woman; it is made of stone, or of gold, or of iron. It is placed on a throne of gold, anointed with musk, and ornamented with necklaces of various kinds of precious gems and pearls, while gold vases filled with stones of great value are arranged in front of it. The throne itself rests on a dais large enough for ten men. The dais is reached by a set of nine stairs, each one containing an idol. Most of the idols represent kings or illustrious men.

One thousand measures of rice are cooked daily and offered hot to the idol in the temple. Young unmarried women play on cymbals, stringed musical instruments and blow trumpets of brass or of shell or of horn. At the time of offering the food they close the doors, lest the vapour going up from the hot food should escape, and they say that this vapour is the food for the idol and for the departed souls which surround the idol. Then the gates are opened and the food is distributed among the ministers in religion of both the sexes, the poor and the infirm.

Abul-Fida (1273-1331 A.D.) assigns Somnat to the second climate. He says that it is a city in the territory of pirates, and it has a well-known idol. This town was subjugated by Mahmud ibn Subuktigin who broke the idol there as related in history.

Quoting from Qanun he gives the longitude as 97°-10' and latitude as 22°-15'.

It is said in Qanan that Somnat is on the coast in the land of pirates.

Ibn Sa'id¹ says that Somnat is well-known in the mouths of navigators. It is one of the cities of the Jazrat (Guzerat) also known as the country of al-Lar. It is situated on the side of land which projects into the sea, which is dashed upon by ships from Aden, because it is not a bay. One notices a delta whose alluvium descends from the big mountain situated to the north-east of the town.

A Plan for the Development of the 'Thar' Desert in Sind:

A Study in Applied Geography

By

MR. G. S. RAISINGHANI, B. AG.,

AND

MANECK. B., PITHAWALLA, D.S.C., F.G.S.

Introduction.—Post-war planning of every kind in India will have to be done with the aid of the science of Geography. Even those parts of the country, which are condemned as desert waste land, can be developed and cultivated to a certain extent and their resources utilised by scientists for introducing new industries and improving the old.

The food situation, with which India is confronted, is unprecedented in respect of its causes and character. The food crisis in Bengal is a glaring example of it. A very large production of food stuff is, therefore, required to maintain the morale of the civil population and to sustain health, nutrition and spirits of the fighting forces in the present war. A well-concerted plan with regard to agricultural and industrial productions is, therefore, an integral part of the successful war efforts.

In the absence of normal transport facilities, the movement of agricultural as well as industrial products has become a very difficult proposition. It is, therefore, a sane policy to make each region a self-sufficient unit, as far as possible, by growing more food to meet its own requirements and by reviving small cottage industries to satisfy its own needs for industrial goods and to spare the surplus for other regions.

The Thar desert of Sind has been, since long known to be a very fertile tract if the monsoon rains come. Otherwise, it is a desert, when there are no rains and consequently there is famine with its worst effects and results. In the month of August last, the writers surveyed the Thar tract and investigated the agricultural, industrial, economic and social conditions with a view to

(1) Abul Fida has given his information from Ibn Sa'id and Qanun, the most valuable work for astronomy and geography written by Biruni d. 1039 A.D.

find out the possibility of developing the Desert Section. After examining the local geographical conditions, a plan for an improved water supply, agricultural progress, industrial development and economic and social uplift in the Thar desert has been prepared with the aid of the science of Geography, so that it may help to supplement the production of food stuff and industrial goods in Sind to a certain extent.

The Thar as a section of Physiographic Divisions of Sind.—The Lower Indus Basin (Sind) has been divided by Prof: Pithawalla* into a number of physiographic divisions, which have been further sub-divided into Provinces and Sections with a view to planning of their resources, as follows:—

Division.	Province.	Section.
1. Extra-Peninsular Mountains.	I. Western Highlands.	A. Kirthar Mountains. B. Kohistan Section.
2. Indo-Gangetic Plain.	II. Lower Indus Valley.	A. Western Valley Section; B. Eastern Valley Section; C. Deltaic Area;
3. Indo-Gangetic Plain.	III. Desert.	A. The 'Pat'. B. The 'Thar'.

I. A SURVEY OF THE EXISTING GEOGRAPHICAL CONDITIONS

Origin of the Desert and Topography.—The present paper deals with the Thar Section as it has the characteristics of a natural physical unit and is a vast expanse covered with sand and overlain with 'bhits' or sand hills, which are sometimes 500 feet high. It lies between the latitudes 24 N and 27 N and between the Longitudes 68 E and 71 E and covers an area of about 10,650 square miles. The 'bhits' run more or less parallel to the prevailing wind direction, from N.E. to S.W., slope on their southern side,

*Pithawalla, M.B.—"Physiographic Divisions of India, Burma and Ceylon," Science and Culture, Vol. VII, No. 2, May 1942, pp. 533-43.

and are vertical on their northern side on account of wind erosion from south to north. The loose sand of 'bhits' has attained a stage of fair consolidation due to the binding action of the plant roots and the addition of organic matter of the dead plant tissues.*

Soils, Sub-soils and Water table.—The valleys lying between two parallel sand hills called the 'marhos' are cultivable since the soils vary from sandy loam to clay loam and they receive more rain water and retain more soil moisture. An area of about 400 acres was taken and the area of the valley portions was found to be about 60 acres. The cultivable area, therefore, works out to be about 15% of the total area, the remaining being under 'bhits'.

The sand layers extend to about 5 to 6 feet below the ground level, where sandstone and lime nodules are met with. The lime nodules contain sometimes as much as 80% to 85% lime as CaCO_3 . Thereafter, the layers of sand and sandstone alternate at varying depths till the water table is reached at about 120 to 150 feet and sometimes even at 500 feet depth. The sub-soil water is invariably saline or brackish containing 665 parts of soluble salts per 100,000 parts of water as at Mithi. This water is used for drinking and other domestic purposes on account of a paucity of good water. The sub-soil water is often used for irrigating small vegetable gardens called 'waries' and in spite of its rather high soluble salt contents, the soil takes it without showing any harmful effects on account of its light porous texture and good drainage, due to which soluble salts do not accumulate but are leached down readily.

The mechanical and chemical composition of the Thar soils is given below: (These soils were collected from a field near Mithi).

	I. Mechanical Analysis.			II. Chemical Analysis.		
	Sand %	Silt %	Clay %	K_2O %	P_2O_5 %	N %
Surface soil	79.82	15.10	5.08	0.20	0.12	0.045
Sub-soil	78.40	16.30	5.30	0.15	0.12	0.045
Soil from a Marho	44.50	35.25	20.25	0.31	0.21	0.15

*For other details regarding origin of the Thar, refer to Prof: Pithawalla's thesis, Part I.

It will be seen that surface soils do not vary much from the sub-soils with regard to their mechanical or chemical composition. But the soil of 'marho' is definitely richer in the plant food materials and is finer in physical composition.

Minerals.—There is only one Karonjhar hill consisting of an Archaean ore in Nagar Parkar, which also supplies lime and sandstone in fair quantities. There are salt deposits near the Rann of Cutch and two lakes of large salt deposits at Saran and Dilyar. There is a soil near Mithi, Chachro and Diplo which contains washing soda and people actually use it for washing their clothes.

Climatic Conditions.—The rainfall in the Thar ranges from 4 inches in Sanghar to about 15 inches in Nagar Parkar. While at one time there is practically no shower e.g. only 4 cents at Khipro in 1899, at another, there is heavy rainfall e.g. 41 inches at Mithi in 1913. The monsoon period is generally cloudy, cool and humid and the climate is equable and bracing particularly in the south. A table showing Rainfall in the Thar section is given below:

Station	Average of 12 years (1931-1942)
	Inches
Khipro	4.51
Umarkot	7.72
Chachro	8.86
Mithi	8.10
Diplo	9.15
Nagar Parkar	13.90

Thus there is greater rainfall in the south than in the north, as the monsoon current moves upwards it is greatly reduced as it moves in the northern direction. In view of the above rainfall figures, dry farming is quite possible in the Thar, for which about 8 to 10 inches of rain is enough, provided it is well distributed.

Natural Vegetation.—Wild seasonal flora spontaneously spring up as soon as there is a little sprinkling of rain water. A list of the typical natural vegetation of the Thar Section along with their industrial or other economic uses and medicinal properties is given in the Appendix I. It will be seen from the table that there

is a great variety of excellent fodder grasses for grazing as 'murt' for example, which grows to 5 to 6 feet in height. In addition there is quite a good number of plants which can be exploited for industrial or other economic uses, or for their therapeutic properties.

Animal Life.—There are very few animals and birds in the Thar section. The domestic quadrupeds are cows, buffaloes, goats, sheep, horses, donkeys and camels. As communication is very bad and the tract is sandy, horses, donkeys and camels serve as the most important means of transport. Deer and jackals are the wild animals, besides lizards, rats, hare and hedgehogs. Deers furnish hides and meat and provide an excellent shooting sport.

Among the birds, sparrows, crows, kites, ring doves, pigeons, partridges, vultures and 'wahios' are important and common. The partridges provide a very good hunt and are caught in snares for taming and rearing for a popular pastime of the partridge fighting in the Thar as well as in Sind. 'Wahio' is a migratory bird of great economic importance, as it destroys locusts in swarms with great speed and efficiency. But it is a water-loving bird and stays in the Thar so long as there is rain water in the 'tarais'; otherwise it migrates to the central valley sections of Sind.

A few more common animals are dung-roller beetles, snakes, scorpions, white ants and locusts. Scorpions and snakes are a serious menace to human and animal life in the Thar. Snakes are of a number of species and there occur cases of deaths due to snake bite. White ants and locusts cause the most serious damage to crops, the former damages the plant roots and the latter feeds on the plant shoots. Locusts too are a grave menace to the Thar as the periodic recrudescence of swarms is so regular that crops are completely destroyed every time they come if measures are not taken to destroy them beforehand.

Irrigation.—On account of the sandy nature of the soils and sand-hills there is no irrigation system in the Thar, nor can it be developed in any way except by well irrigation. Some irrigational improvements have been extended to the Khipro and Umarkot talukas, since the construction of the Lloyd Barage. In the remaining parts, agriculture has inevitably to depend upon the precipitation, which is precarious and inadequate for normal agriculture as shown above.

Agriculture and Methods and System of Cultivation.—As soon as the first shower comes, the 'marhos' are superficially ploughed by means of a country plough, driven by a camel and the seed is drilled simultaneously in one single operation by tying a hollow drilling tube behind the plough and dropping seeds through it, in rows 6 to 9 inches apart. The crop is then allowed to grow, maturing and ripening depending upon the adequacy of rainfall and sufficiency of soil moisture. Weeding and inter-culturing is done now and then to conserve soil moisture and reduce competition for moisture and growth between the crop and the weeds.

There being scanty and irregular rainfall and soils being poor and sandy, only **bajri**, **jowar**, **guar**, **mung** and **moth** are cultivated all over the area, though **til** is also grown as a mixed crop. But where the soils are of heavier type and retentive of more moisture, **wheat** is grown successfully, just as near Diplo and Nagar Parkar.

The seed-rate of 4-6 lbs of **Bajri** and **til** and 8-10 lbs of **jowar**, **mung** and **moth** per acre is employed. It has not been possible to ascertain the yields per acre; the figures vary widely from year to year due to vagaries of precipitation and unsteady agriculture, which results in enormous fluctuations in the crop yields.

Crop Pests and Diseases.—On account of the cool, humid climate and low temperature **bajri** is the worst affected by loose smut and green ear-head diseases, which adversely affect the crop yields. The **til** crop suffers root rot and mal-formation, which are physiological diseases. Again locusts find the best breeding grounds on account of the cool climate, light rains and soft sandy soil for burrowing to lay eggs, and cause a huge loss of crops and yields. The locusts migrate from Egypt, Persia, Afghanistan, Rajputana and Sind and cover a regular and definite belt of different countries for swarming and breeding, white ants also cause a lot of damage to the plant roots as they find burrowing easy in the soft, loose sandy soil.

Industries.—Apart from agriculture, which is the chief industry, there are six other existing industries which flourish in the Thar: (1) Dairying; (2) Embroidery; (3) Weaving; (4) Leather works; (5) Carpentry; and (6) Gold and Silver Smithery.

(1) **Dairying.**—The main occupation of the Tharis is agriculture and cattle-breeding, rearing and dairying. On account of good natural grasslands and pasture grounds, there are large numbers of cattle in the Thar as will be seen from the following

figures of Livestock as ascertained by the Census held in January 1941 in the Thar Parkar District: *

Breeding bulls.	..	1,922
Working bullocks.	..	84,896
Bulls and Bullocks not in use.	..	2,397
Young stock, under one year.	..	17,538
Young stock, under three but over one year.	..	14,147
Breeding cows.	..	1,49,903
Young stock, under one year.	..	18,925
Young stock, one to three years.	..	15,338
Breeding buffalo bulls.	..	976
Working " "	..	980
Bulls and Bullocks not in use.	..	50
Young stock under one year.	..	3,508
Young stock one to three years.	..	2,054
Breeding buffalo cows.	..	28,903
Breeding buffalo cows not in use.	..	63
Buffalo cows used for work.	..	69
Young stock, under one year.	..	4,415
Young stock, one to three years.	..	3,247
Sheep	..	1,32,546
Goats	..	3,93,170

The breeding and rearing is, therefore, a natural and hereditary profession of Tharis on account of which very good pedigreed dairy animals are bred and sold at fancy prices. As there are no good communications and efficient means of transport and as settlements are few and far between, there is no market for milk produced in the Thar. Every herdsman therefore curdles milk to realize butter which he sells as such to ghee merchants who further clarify it into ghee. Consequently there is a very large export of ghee from the Thar to different parts of Sind, Gujerat and Kathiawar.

(2) **Embroidery.**—It is confined to Mithi, Chachro, Chelhar and Gadro as there are merchants who buy pieces of embroidery and deal in them. Besides this, requisites for embroidery such as thread mirror-pieces, beads and needles are available at the above mentioned places. Women generally fetch water, cook meals and take it to their men in the fields and help them in the work

*Crop Report of Sind for the year 1938-39 of the Department of Agriculture, Sind, pp. 55-56.

of sowing, weeding and inter-culturing. They have to look after their children and other house-hold affairs. Embroidery, therefore, is done by women-folk in spare time. Tea-poy covers, bed sheets, pillow and cushion covers, door curtains and ladies' blouses of a very artistic and excellent quality are embroidered. Threads of assorted colours are used on red 'hulwan' poplin cloth and round mirror-pieces and beads are knitted in effective flowery patterns frequently. There are a few expert women in each of the above places who do designing only for payment. A batch of women would sit in a circle and sing melodious folk songs in a chorus while doing embroidery work with speed and enthusiasm. A good embroidered bed sheet measuring $4\frac{1}{2} \times 7\frac{1}{2}$ feet may cost Rs. 40 to Rs. 50. This industry proves the industrious and hard-working nature of a 'Thari' woman.

(3) **Weaving:**—According to the Census of 1941, there are about 1,32,546 sheep mostly in the Thar area, which provide wool but it is rather of poor quality since the wool clipped from the same sheep is of a number of qualities with regard to colour, strength, staple and lustre. One obvious reason is that the herdsmen pay attention to the breeding of cows and buffaloes and neglect sheep. The wool after clipping is collected, sorted and refined by means of brushes. The women-folk then spin it into yarn which is then dyed and woven into woollen cloth, coverings such as blankets, 'khathas' and 'lohis' and carpets which are sent to Mirpurkhas, Hyderabad and Karachi for sale. The woollen goods, though rough and coarse, are very warm and durable.

The weaving of cotton cloth known as 'pichhori' is also done in almost every village, but this weaving both of the cotton and woollen cloth and other goods is mainly confined to Mithi and Chachro, where there are Government looms; to Gadro, where there are All-India Spinners' Association's looms and also to Satidera and Islamkot.

(4) **Leather works:**—On account of a large number of cattle, hides are available in large quantities and at very cheap prices. The manufacture of shoes, nats, tals, tobras, khurzeens, ropes, water bags and bottles and leather cans for ghee and oil is a typical industry of the Thar and flourishes wherever people of the 'menghwar' caste live.

(5) **Carpentry:**—Saddles for camels and horses of an excellent quality are made of wood at Mithi and Herar (Chachro) where

hard wood is available from the 'Konbhat' trees which abound near Chachro. The wood of konbhat tree has been found to be very useful for this industry and other building purposes.

(6) **Gold and Silver Smithery:**—Gold and silver are imported from Hyderabad, Karachi and Bombay and gold and silver smiths mostly at Mithi, Chhor and Chachro prepare ornaments and trade in them with the wholesale merchants of Sind, Gujarat and Kathiawar. The women of Kathiawar, and Marwar specially are fond of wearing heavy as well as too many ornaments. It is on account of this reason that this industry is flourishing in the Thar which is near these countries and is connected with them by means of a number of communications in the interior.

Human Settlements:—Due to the hard conditions of life, uncertain agriculture and lack of good communications and efficient means of transport, settlements are few and far between. There are about a dozen fixed villages of which Gadro, Mithi, Chachro, Diplo, Khipro, Umarkot, and Nagar Parkar are the most important. All other settlements are nomadic. They have to depend on agriculture and dairying for subsistence and shift camps from place to place depending upon the area cultivated, quantity of grass for grazing and of drinking water. There are Maheshwari, Thakur, Kolhi, Lohana, Bhil, Menghwar Bhambhan and Brahman sub-castes of Hindus and Memon and Bajeer sub-castes of Mahomedans living together in peace and harmony. Many other tribes along with their cattle migrate from Sind, Gujarat, and Kathiawar to the Thar during the monsoon season for grazing.

A table showing population in each taluka of the Thar section for the last 5 decennial periods is given below:

Taluka	1901	1911	1921	1931	1941
Nagar Parkar	25355	47548	40668	41726	32458
Diplo	16886	25969	17489	25242	34001
Mithi	26154	41472	40886	45709	46698
Chachro	40925	53501	50836	61974	74727
Umarkot	49118	51859	45147	43469	67515
Khipro	54681	46171	36072	51030	64494

The population of Nagar Parkar has decreased on account of bad communications and long tedious camel journeys for about 80 miles from Naokot which is the nearest railway station to Nagar Parkar, inspite of good climatic and agricultural conditions.

Umarkot and Khipro have developed recently to a great extent on account of irrigational improvements since the Lloyd Barrage construction. Mithi, Chachro and Diplo are also expanding on account of more favourable agricultural and industrial conditions.

'Hari' of the Thar:—The Hari, though poor, thin and lean, is typically a shrewd clever and smart cultivator and herdsman. Poverty is obviously reflected in his famished body, dirty tattered clothes and hand-to-mouth living; but shrewd cleverness in his eyes and smartness in his habits are clearly visible as a natural result of the hard conditions of life and the uncertain state of agriculture in which he has been placed by Nature to face and fight against adversity. Generally he has no cash but he owns a few pairs of cows, bullocks and buffaloes and cultivates a few acres of land at least.

An estimate of rich commonsense and shrewd understanding of a 'Thari' peasant in grasping problems connected with land and its culture, cattle breeding and his own living, can be made from the facts that he sows seeds thinly in view of the soil poverty and low soil moisture, reserves light soils for bajri and heavier ones for jowar and wheat, knowing the soil requirements of different crops, ploughs land and drills seeds simultaneously to gain time and to take immediate advantage of rainfall without losing any soil moisture uses soil containing washing soda for washing his clothes and for staunching beds of the 'tarais' to check percolation losses, ploughs and sows higher pieces of land first, as they retain less rain water and cultivates across the slopes in one season and again the slopes in the next season to utilize idle land by rotation.

As the herdsmen are moving along with their cattle from place to place in search of grazing areas, veterinary aid is not available to them in the case of illness of or accident to their cattle. They have to depend upon a few renowned herdsmen whose hereditary profession is to treat cattle diseases in the case of complications. As regards ordinary ailments of the cattle, every herdsman generally knows how to treat them. A few instances were cited during the present investigation of an adept herdsman who had removed tumours from a few cows' and buffaloes' uteruses by means of a razor blade.

Livestock:—On account of natural grasslands and grazing grounds, there are large numbers of cattle in the Thar as shown

above. The Thari herdsman is an adept in the art of animal husbandry and the practice and the science of cattle breeding and rearing has passed on from one generation to another. Due to this continuous chain of adept breeding, the Thari cow is an excellent pedigree animal and is known for high milk yield and suitability for cross-breeding.

When rains come, there is a great variety of wild rich fodder grasses growing on the sand hills and in the valleys and providing an excellent grazing ground for the cattle. But when famine breaks out consequent upon the failure of rains, a very large number of animals succumb to hunger and starvation and the peasantry migrates to the central valley parts of Sind round about Mirpurkhas, Hyderabad and Nawabshah, with their livestock to preserve their body and soul together.

Communications and Transport:—There are no regular or well-defined lines of communication possible on account of wind-borne sand and huge numberless and shifting sand-hills all over the Thar area. The only possible and efficient means of transport at present, therefore is the camel, though the horse and the donkey too are frequently used. There are, however, camel paths, and small 'bastis' (temporary and migratory settlements) and 'bhits' which on account of their different shapes, size and alignment serve as milestones and guide-posts on the way.

II. A PLAN FOR THE DEVELOPMENT OF THE THAR.

The present plan for the development and reconstruction of the Thar aims to provide for:

- (A) Improved Water Supply;
- (B) Agricultural development;
- (C) Industrial progress;
- (D) Social and Economic uplift;
- (E) Communication and Transport facilities.

(A). **Improved Water Supply:**—There is a paucity of good water for drinking and other domestic purposes. The sub-soil water is either saline or brackish. Cultivation, therefore, depends on the rainfall which is sometimes scanty and sometimes badly distributed as regards the duration and degree of precipitation. But there is a possibility of storing rain water in the large-sized reservoirs, so that the supply of rain water may last longer and be used for irrigating crops as well as for domestic purposes,

There is quite a large number of elongated valleys with extensive stretches of catchment areas for rain water running down the sand hills, which can be accumulated in reservoirs for lift irrigation. The wind velocity being 22 to 32 miles per hour, a number of small-sized wind mills can be used for lifting water. With the aid of lift-irrigation, crops like wheat, jowar, groundnuts and potatoes and other green vegetables can be grown with success.

(B). **Agricultural development:**—This should comprise the following items: i. Soil husbandry; ii. More economic and useful crops; iii. More and better fodder; iv. Control of crop pests and diseases; v. Mixed Farming; and vi. Utilization of culturable waste lands.

(i). **Soil husbandry:**—As cultivation has to depend on rain water from the time of sowing of seed to the maturity of crop, the aim of soil husbandry should be to receive as much rain water as possible and to retain it and conserve soil moisture as much and as long as possible to enable seeds to germinate and then the crop may grow and mature successfully. To achieve this, the following improved practices are suggested.

(a) Deep ploughing, mulching and bunding to catch more rain water and conserve more moisture and prevent soil-erosion;

(b) Green manuring to improve soil texture in order to increase its water holding capacity and moisture retentivity;

(c) Introduction of more efficient implements for ploughing and interculturing to preserve soil moisture effectively and to yield better economic returns and crop yields;

(d) Trenching round about pieces of agricultural land to be resorted to, to prevent the surface soil run-off when rain falls in torrents;

(e) In order to maintain the soil fertility, wind-breaks by planting tall and thick xerophytic trees like 'kandi' or 'loheero' in rows to be provided to check the loss of soil by wind erosion and blowing away of the infirm seedlings;

(f) The addition of organic manure or sheep folding or any other cattle folding may be tried to improve soil texture.

(ii). **More economic and useful crops:**—At present bajri is grown all over the Thar area which, from the point of view of its

nutritive value is a poor food crop. But it suits the local conditions as regards poor sandy soils of the tract and low soil moisture. But the crop planning should aim at growing more nutritive food grains like jowar and wheat by evolving early maturing and drought-resisting varieties, as suggested below.

(a) To resort to vernalization of seeds for their early and quick sprouting and germination to gain time and utilize moisture in the soil for growth and maturity in the field;

(b) To obtain early maturing varieties of crops by selection and breeding so that the crops may ripen in the minimum period and for the limited soil moisture available;

(c) To grow more economic and nutritive crops like jowar, wheat, guar, groundnuts, til and maize and if possible tuber crops like potatoes and sweet potatoes.

(d) To improve the quality of 'murt' and 'bhurt' which are acclimatised and yield edible grains and grow wild, by selection or by cross-breeding for cultivation in the fields.

(e) To hasten maturity and increase crop yield by manuring to escape or tide over the periods of drought;

(f) To introduce and obtain drought-resistant cereals to suit the local desert conditions of loose sandy soils and irregular and inadequate rainfall;

(g) To obtain disease-resistant varieties of cereals and strains which could possibly withstand any disease or pest;

(h) To encourage mixed cropping so that if one crop fails, another survives to yield some out-turn; or the side crop may serve as a trap for the pests of the main crop which may therefore be saved.

(iii) **More and better fodder.**—The health and prosperity of the peasants is as important as the welfare and good condition of their livestock. It is, therefore, essential that provision should be made for fodder to be available for the cattle throughout the year and if possible even for a bad year of famine on the following lines:

(a) A number of suitable fodder grasses like bhurt, murt, daman, phamo, kuri, limb cheeho, mandhani, ghetio, etc., grow wild and spontaneously. But due to the indiscriminate and

unrestricted grazing, these grasses hardly attain the full stature before they are grazed and consequently it results in the ruthless despoliation of grasslands and pasture grounds. To avoid this, migration of cattle from the neighbouring countries into the Thar should be restricted and a system of rotational grazing must be enforced.

(b) The nutritive value as well as the feeding standard of the above grasses for grazing, hay and ensilage should be assessed.

(c) The above wild fodder grasses may be grown by culturable methods in the fields to supplement the natural supply;

(d) To introduce xerophytic tress like shevri, spineless cactus, pangara, Parkinsonia to serve as emergency fodder.

(e) The silos may be prepared at main places where ensilage may be prepared and preserved for use as green fodder, if and when rains fail and famine breaks out. The cultivated fodder grasses and those which grow wild in abundance and spontaneously, may be experimented with, for this purpose.

(iv) **Control of Crop Pests and Diseases.**—Much more crop yields can be obtained by avoiding its loss or decrease on account of crop pests and diseases. The loose smut disease and the green earhead disease, which are rampant in the Thar, may be controlled by the well-known process of sulphur dusting or the copper sulphate immersion treatment or the hot-water soaking of the seed before sowing.

The locusts in their breeding phase are very lethargic and inactive and egg-laying can be effectively prevented by killing them by beating in the early morning hours when they are resting. However the breeding places must be marked out so that as soon as hoppers emerge, they can be killed by collecting them in trenches dug around them or by encircling them with fires. In the adult stage, the swarms can be destroyed by beating them in the early morning hours when they are sluggish or by dusting or spraying insecticides. Of course, when aeroplanes are made available, the Tharis will easily get rid of these pests in years to come.

As regards the white ants, they can be killed by fumigants or destroyed by catching and killing the queen.

(v) **Mixed Farming.**—The Thari peasant is already well-known for his art and science of cattle-breeding and mixed-

farming comprising of the cultivation of land, cattle-breeding, rearing and dairying on scientific lines and co-operative basis have got a very good scope for development. A Peasants' Syndicate may be formed to reorganize mixed-farming on sound lines indicated below for promoting both the industries, viz agriculture and dairying.

(vi) **Utilization of Culturable Waste Lands.**—In the Thar area, there are extensive stretches of land which cannot be cultivated due to the inadequate and poorly distributed rains and lack of irrigation. However, these pieces of land can be utilized by storing rain water in reservoirs and by providing wind mills for lift irrigation, as said above. One such flat area of about 1,53,600 acres extends from Kasbo to Churio Berano and from Ghartiani to Adhigam in the Nagar Parkar taluka. The Gordharo and Bhatiani streams are fed by rain water coming down the Karonjhar hills and run about 1½ miles long when all the rain water flowing through them goes to waste into the Runn of Cutch; if reservoirs are constructed and lift irrigation with the aid of small wind-mills is resorted to, the abovementioned area can be better utilized for agricultural purposes.

(C). **Industrial progress.**—Many industries of the Thar like, those of the other parts of Sind, are dying out because they cannot keep pace with the changing times, varying aesthetic tastes and needs of the market. The industrial progress should, therefore, be scientific and bear relation to the economic conditions and needs of the market. Bearing this in mind, the following industrial development has been outlined for the Thar:

(1) **Cattle breeding and dairying.**—This has to be wholly organized on the modern principles of animal genetics and scientific lines. There is a great scope and need for improving the Thari breed. For this purpose, breeding centres should be opened where certified prime bulls should be stationed for service. The pedigree records should be maintained at such stations. The well-bred dairy animals can then be exported, as there is a great demand for Sindhi cows, in as well as out of India.

Dairying is in a very crude and unscientific state as very unclean and inefficient equipment is used for curdling and churning milk. It therefore offers room for improvement and reorganization. At present every herdsman prepares butter and sells it to ghee merchants who clarify it further to manufacture ghee. Conse-

quently, not only there is loss of butter yield from milk and that of ghee from butter by handling small quantities and by using old country methods and tools, but the middleman exploits each herdsman separately.

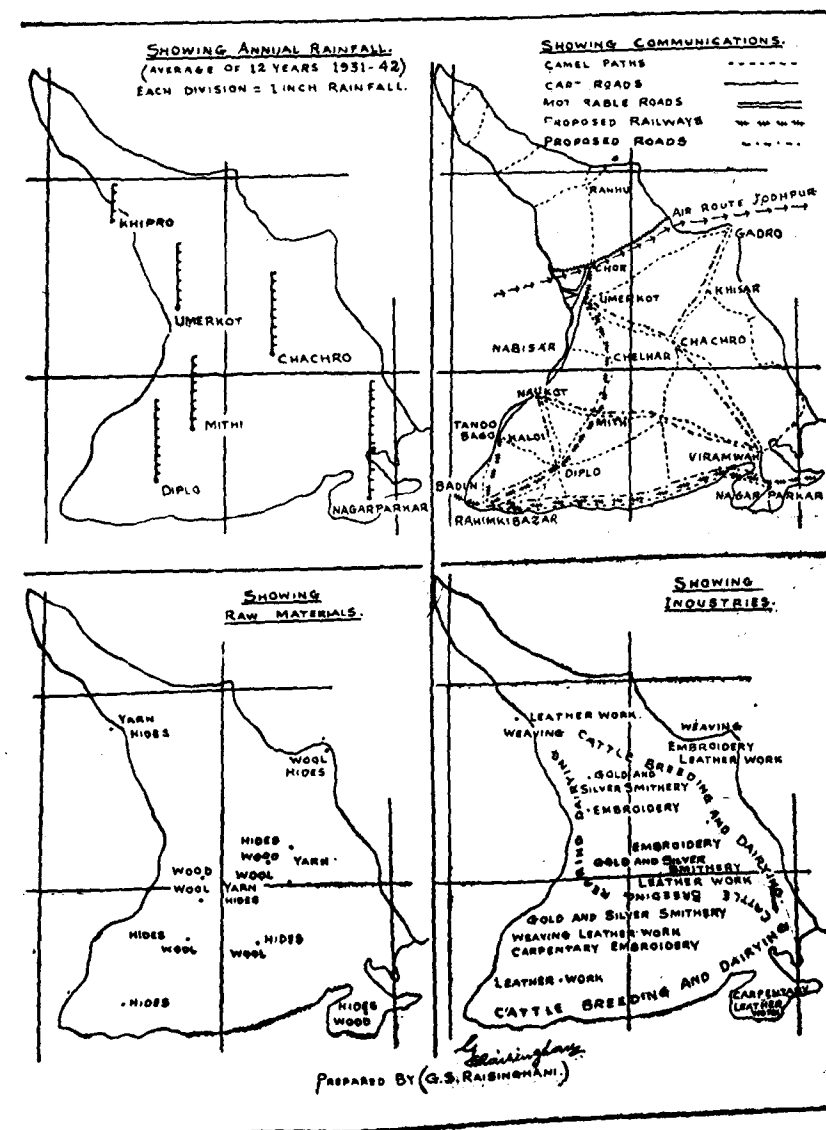
A few dairy centres should, therefore, be opened for pooling milk and manufacturing milk products like cream, khoya, butter, ghee by the modern efficient and scientific methods. There are very good prospects for the industrial manufacture of casein, tinned milk and milk powder. A Dairy Farmers' Co-operative Society may be formed for the manufacture and export of the dairy products to avoid exploitation by middlemen.

(2) **Embroidery.**—The aboriginal industry of embroidery is not flourishing on account of lack of contact between the producer and the consumer, because the places where embroidery is done such as Chachro, Mithi and Nagar Parkar are in the interior of the desert and there are neither good communications nor efficient means of transport. The merchants, therefore, do not take interest in dealing with this industrial product of the Thar on account of these difficulties of transport. Besides this, embroidery is a spare-time hobby rather than full-time occupation of women; hence the production and the supply are not well regulated, but all the same this industry has very much lagged behind the market requirements and the consumer's standard. In recent years, people have developed an aesthetic sense for articles for decoration, such as door curtains, pillow cases, table and tea-poy covers, bed sheets, etc. There is a large market for such articles in cities like Hyderabad and Karachi in Sind as well as outside Sind. The industry, if it has to flourish, has to be reorganized to conform to the needs and demands of the consumer through the market.

(3) **Weaving.**—This industry too needs to be reorganized to satisfy the aesthetic taste, quality and standard of the consumer and the market requirements. At present the cloth of coarse texture and old designs and shades of colour is produced, though it is durable. A new orientation and direction have to be given to this industry with regard to colour, texture, pattern and design of the cotton as well as woollen textiles to make them presentable to and acceptable by the gentry. More and better markets can be successfully found at Mirpurkhas, Hyderabad, Nawabshah and Karachi for these goods as the experiments at the Government Emporium and Industrial Exhibitions at Karachi have proved that

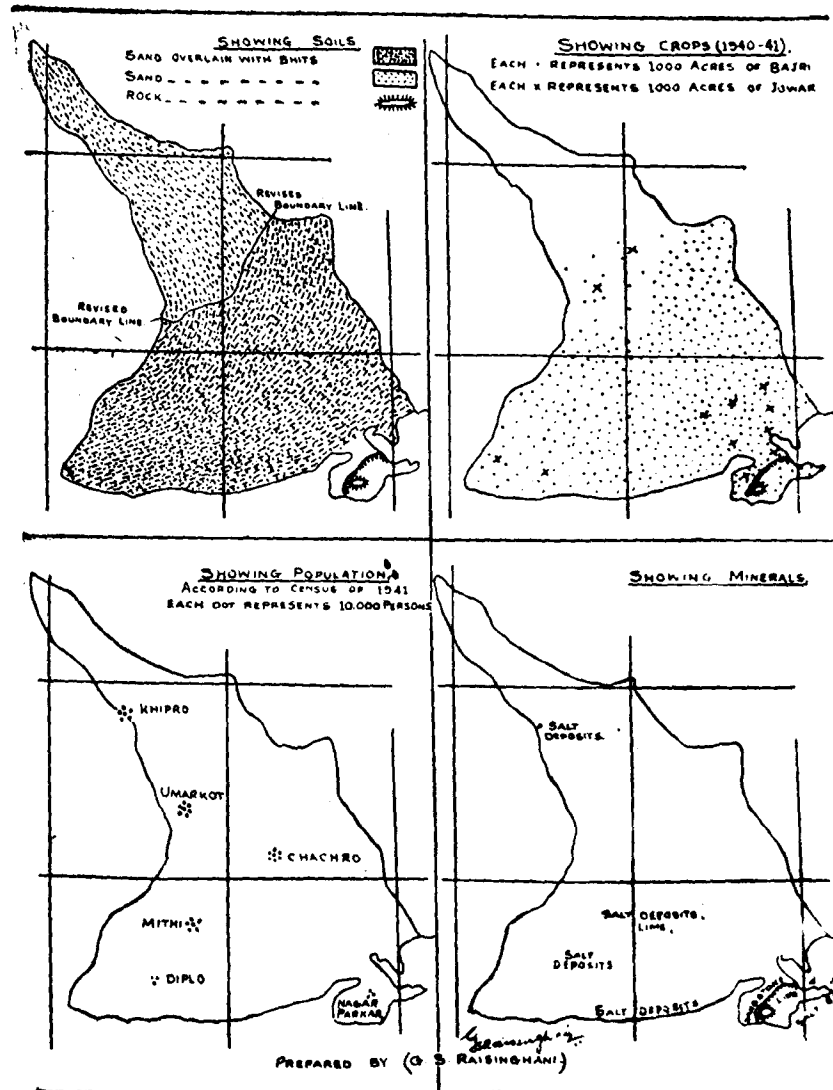
MAPS OF THE 'THAR' DESERT IN SIND.

SCALE 1 INCH = 32 MILES.



MAPS OF THE 'THAR' DESERT IN SIND.

SCALE 1 INCH = 32 MILES.



the public have got an appreciation and demand for these essential and artistic articles of wear and decoration, being home-made. There is a large export of wool from the Thar which should be utilized by establishing more local spinning and weaving work-shops. Last year and year before last, the woollen blankets and lohis made at Gadro were supplied to the flood sufferers of Bihar and to the Supply Department of the Government of India.

(4) **Leather works.**—In addition to other leather goods, rough and coarse shoes are made after a country design and only for rough wear. But if chappals, slippers, sandals and shoes are made of fine quality and up-to-date style, there will be a great demand for them particularly in the villages all over Sind, as shoe-makers are mostly confined to towns like Karachi, Hyderabad, Mirpurkhas Nawabshah, Sukkur, Shikarpur, Larkana and Jacobabad. The rest of rural Sind has to send for shoes and chappals from these towns. But the supply of shoes from the abovementioned towns is neither sufficient in quantity nor satisfactory in quality and durability, whereas genuine leather can be had easily and cheap in the Thar, where the shoe industry can compete with that of other places of Sind in quality, price and durability.

Deer and rabbit skins which are available in abundance can be sold readily at fancy prices in cities like Hyderabad, Karachi, Lahore and Bombay after curing and refining, as they can be made use of for decoration and furs.

Combs and grip handles are made from bones, which also can be improved in respect of design and quality.

(5) **Tanning and Dyeing of Hides:**—There is a great future for hide curing and tanning industry in the Thar, where there are large numbers of cattle which die due to periodic famine, fodder scarcity and animal diseases. The dyeing and glazing of hides is a very paying proposition, not yet developed in Sind. A gum resin called 'thumbhan' is one more marketable side-product from the 'vakhi' of the tanning industry of great commercial use and economic value. This will stop the present large export of hides from the Thar and add to the material wealth and economic welfare of the people.

(6) **Bone Factory:**—There is a large export of bones also from the Thar outside Sind. A local industry for manufacturing

bone-meal or toys and articles of stationery like pen holders, paper weights, etc., of bone can be established. It will be an economical and paying business concern.

(7) **Exploitation of Natural Vegetation:**—There is a large number of natural floras growing wild and spontaneously on the sand-hills and in the valleys. They are of well-known industrial and other economic uses and medicinal properties and should be exploited. There is one tree called *konbhut*, which yields gum of excellent quality. The *aoglan* tree exudes resin known as 'gugur' which is used as 'dhoop' in religious ceremonies by Hindus and Parsees and can be sold readily in the market. *Bauri* also yields gum. The *loheero* furnishes timber for building purposes of a very superior quality. There are grasses like *daman*, *sinn*, *limb*, *ghandhir*, *murt*, *bhurt*, *ghamo*, *kuri* and *cheeho*, which are excellent for the purposes of fodder, grazing and ensilage. The other flora like *phog*, *morari*, *ak*, *roheero*, *hangro*, *bhatar*, *kotak*, *malir mendi*, *beparivel*, *mundheri*, *ganvel*, *gulbinosho*, *gazban*, *trikundee*, *garoo*, *harkyo* and *satavari* are some of the well-known medicinal plants possessing the tried therapeutic properties, which all need to be exploited scientifically for their medicinal uses and therapeutic values.

In fact, the entire scheme of industrial development needs to be sponsored and liberally aided by Government with regard to the expert technical advice and guidance and finance. The Department of Industries should direct its attention to the industry relating to drugs and medicines, milk and its products, particularly tinned milk to supplement food production and tanning and dyeing of skins and hides for which there is a great scope in the Thar. There is an urgent need of improving the quality of wool by improving the breed of local sheep by crossing if possible, and the Agricultural Department can take the initiative in this direction.

(D) **Social and Economic Uplift:**—The above agricultural improvement and industrial development will naturally result in the social and economic progress of the people, since their income will increase and their social standard of living will consequently rise.

The Tharis are generally under-nourished as they eat only *bajri*, pulses and curds, since there are no fruits and vegetables available; nor can these be imported for lack of good communication and efficient means of transport. However during the monsoon

season, the people eat wild vegetables and fruits like *pipoon*, *golaro*, *phog*, *mareero*, *lunak*, mushrooms, etc. But by providing water storage reservoirs and lift irrigation with the aid of small sized wind-mills, a number of small pieces of land near villages like Mithi, Chachro, Nagar Parkar and Diplo can be taken under garden crops, which can be eaten fresh, or, de-hydrated and preserved.

To meet with the shortage of fruits and vegetables and to balance the diet of the people scientifically, fish will prove a useful and nutritive supplementary food. But again due to the lack of good communication and efficient means of transport, fresh fish can not be imported into the interior of the desert. A few tanks can therefore near Chachro, Mithi, Diplo and Nagar Parkar in which rain water may be collected to last for about 4 to 6 months, should be stocked with fish like *Labeo rohita*, *Catla catla* and *Cirrhina mrigala* species, which attain full size rapidly and will serve as a boon. Poultry farming should be encouraged with a view to supply chickens and eggs to meet with the scarcity of vegetables.

There is one more difficulty of paucity of potable water on account of which people have to use the saline sub-soil water for the purposes of drinking and cooking. There are, however, *katcha* water-tanks known as 'tarais' for collecting rain water during the monsoon near every village as Mithi, Chachro, Diplo, Nagar Parkar, Rahimki, Islamkot, Gadro and Satdera. This lasts for a period of about 3 to 4 months, depending upon the size of 'tarais' and the loss due to the withdrawals, evaporation and percolation. The water of these 'tarais' is used for drinking, cooking and washing. Having due regard for the health and hygiene of the public, there is an urgent and imperative need of improving the 'tarais' by constructing a number of large-sized cement-lined tanks with covers to ward off dust and dirt getting into them. Thus the rain water supply can last longer. There should also be separate tanks reserved for drinking and washing purposes and for animals. In addition to this, in each house, underground tanks may be constructed, particularly at Mithi, Chachro, Diplo and Nagar Parkar, in the court yards in which rain water may be collected for domestic uses by means of an aqueduct, from clean cement-lined house tops when it rains.

(E). **Communications and Transport.**—The problem of transport is the most serious handicap in the Thar and lack of good communication is the real bar to the development of the tract and

progress of its people. In the absence of good and efficient means of transport the settlements are very sparse; the movement of men and materials is slow and inconvenient. The people are steeped in ignorance and superstition. The famine relief measures, rural reconstruction propaganda, anti-locust drive or any other uplift movement is neither effective nor speedy on account of this. For the development of the Thar, good communication and quick and comfortable transport are indispensable.

With this end in view a practical suggestion may be made for laying a very light railway line to commence from Badin and to link up Tando Bago, Rahimkibazar, Diplo, Mithi, Chelhar Umarkot and then join the main Jodhpur Railway at Chhor. This step will go forward to greatly solve the present difficulty in the Thar. A number of roads too has been proposed as shown in the map, showing communications in the Thar. The sand-hills might have to be cut up and screen walls erected to avoid accumulation of wind-borne sand on the line, considering the relief and the direction of the wind. But all the same, it is worthwhile doing it.

Conclusion.—The Thar is not a desert in the real sense of the word, since it is neither entirely barren nor rainless. Normally, when the monsoon rains come, it is a fertile tract, rich in natural greenery, grasslands, agriculture and livestock. In the scheme of national planning of Sind, therefore, it is absolutely necessary to explore this forgotten land of the Thar, which has a substantial contribution to make towards the post-war reconstruction of Sind. The writers feel that the provision of good communication and transport will remedy many of the shortcomings of the Thar and its people. An endeavour to develop the Thar tract on the lines indicated above should now be made to produce the expected results in time.

The author is grateful to Professor M. B. Pithawalla, D.Sc., F.G.S., University Teacher in Geography, for his guidance in the research work, and to the University of Bombay for giving him a research grant to conduct it.

BIBLIOGRAPHY

- Khemchandani, H. T. . . (1943) Private communication dated the 9th June, 1943.
- Malkani, N. R. . . "Sind ja Hunr".
"Gothani chahar".
"Anar Dana".
- Pithawalla, M. B. . . (1936) A Geographical Analysis of the Lower Indus Basin (Sind), Parts I, II and III.
(1938) Problem of Communications in Sind.
- Rao Ramchandra, Y. . . (1941) A List of some of the More Common Plants of the Desert Areas.
- Thawani, T. D. . . (1942) Private communication dated the 19th October, 1942.
Desert Farming Scheme of the Department of Agriculture, Sind.
Annual Reports of the Department of Agriculture, Sind.
Season and Crop Reports of the Department of Agriculture, Sind.
Methods of Locust Control, Imperial Council of Agricultural Research, New Delhi.
Census Reports of the Bombay Presidency, 1901, 1911, 1921, 1931 and of the Province of Sind, 1941.
Sind Official and Sind Government Gazettes, 1931 to 1943.

APPENDIX I.

Natural Vegetation of the Thar.

A list of some of the common plants along with their industrial, other economic and medicinal uses.

Local name in Sindhi (Transliteration).	Natural Order.	Botanical Name.	Industrial or other Economic uses.	Medicinal properties.
1. Janhollo	.. Acanthaceae.	Tustica simplex.	For grazing.	..
2. Bhangro	.. "	Blehharis sindica.	..	For leprosy, spleen, eyes.
3. Sringhoo	.. "	..	..	..
4. Booh	.. Amarantaceae.	Aerua tomentosa.	Fodder for ass; its flowers used for stuffing pillows, cushions.	..
5. Takaro	.. Verbenaceae.	Cleorodendron phlomoides.	Its branches are hollow, used as pipe reeds, pens.	..
6. Ak	.. Asclepiadaceae.	Calotropis gigantea.	Its fibre is used for making ropes.	For inflammations, pains, syphilis, gonorrhoea, wounds and blood poisons.
7. Akri	.. "	" procera.	..	..
8. Khup	.. "	Leptadenia spartium.	For rope making; For camel's grazing.	..
9. Jogero	.. "	Orobanchae.	Used as vegetable.	..
10. Pipoon	.. "	..	..	..
11. Loheero or Robeero	.. Bignoniaceae.	Tecomella undulata.	Yields timber for buildings of superior quality.	..
12. Llyar	.. Boraginaceae.	Cordia rothii.	Its fruit is edible.	Diuretic, for spleen, stone jaundice, cough, dyspepsia leucoderma.
13. Gugarni or Goglan	.. Burseraceae.	Commiphora pubescens.	Exudes resin known as 'dhoop'.	..
14. Buguro	.. "	..	Used as fodder and as vegetable.	..
14a. Mogar	.. "	..	Fodder for camel, cow and goat.	..
15. Bauri	.. Acacia.	..	Yields gum of superior quality; serves as fodder.	..
16. Krir	.. Capparidaceae.	Capparis decidua.	Serves as fuel, its fruits are edible, wood used for making rafters.	Reduces spleen, stops bleeding, diarrhoea, Bark for cough, jaundice.
17. Dhanar Khathoori (Soneli)	.. "	Cleome brachycarpa.	..	Tonic for brain, heart, for bronchitis, diuretic encourages menses, cures spleen and liver troubles.
18. Thumo	.. "	Dipterigium glaucum.	Good fodder grass.	..
19. Lani	.. "	Suaeda frutescens.	Camel eats it fondly.	..
20. Bhatri or Dhantar	.. "	Launea chondri- loides or nudicaulis.	..	Its water extract used as eye drop to cure cataract redness and itch.
21. Phaer	.. "	Pluchea lanceolata.	..	..
22. Phulwal	.. "	Pulicaria angustifolia.	..	..

Local name in Sindh (Transliteration).	Natural Order.	Botanical Name.	Industrial or other Economic uses.	Medicinal properties.
23. Trikundee or Pat kandee	..	<i>Tribulus alatus.</i>	Camel, goat and cow eat it.	Diuretic.
24. Khumbhyoon	..	..	Used as vegetable.	..
25. Golaro	..	..	Fruits are edible.	..
26. Pat-kwar or Kranjh	Convolvulaceae microphyllus.	<i>Convolvulus or pleuricaulis.</i>	..	..
27. Oen	Convolvulaceae.	<i>Cressa cretica.</i>	..	Administered to poisoned person.
28. Khela	..	..	..	..
29. Lathio	Cruciferae.	<i>Farsalia jacquemantii</i>	Good fodder grass.	..
30. Trooh	Cucurbitaceae.	<i>Citrullus colocynthis.</i>	..	Relieves inflammation, reduces spleen, cures bronchitis.
31. Bhachti Matarwal	"	<i>Cucumis callosa</i>	Twigs used as tooth sticks, goat eats it.	..
32. Akhro or	"	<i>Melothria</i>	..	..
33. Pesooro Kutawal	..	<i>maderaspatana.</i>	Fodder for camel, goat and sheep.	..
34. Sataro	Malvaceae.	<i>Hibiscus punctatus.</i>	Eaten as vegetable.	..
35. Checho or Kul	Cyperaceae.	<i>Cyperus arcuatus</i>	For thatching huts.	..
36. Dutheli	Euphorbiaceae.	<i>Euphorbia hypericifolia.</i>	..	For curing sexual leblity.

37. Thuhar	..	<i>Euphorbia nerrifolia.</i>	It is an excellent live hedge, when burnt, goat eats it.	..
38. Kundheer	..	..	Its root is used as potato as vegetable.	..
39. Asoti	..	..	Camel is fed for vigour.	Cures gonorrhoea, syphilia.
40. Kuadhal	..	..	..	..
41. Hazardoni	Ficoidae.	<i>Mollugo cerviana.</i>	..	..
42. Kotak	"	<i>Mollugo hirta</i>	..	..
43. Lunak	"	<i>Trianthema hyaspica.</i>	Used as green vegetable.	..
44. Lular	"	<i>Trianthema pentandra.</i>	Used as green vegetable and fodder for cattle.	..
45. Dinik	Gramineae.	<i>Andropogon annulatus.</i>	An excellent grass for grazing and silage.	..
46. Kuri	"	..	Good grazing grass.	..
47. Limb	"	<i>Aristida funiculata.</i>	Good for grazing and silage.	..
48. Bhurt	Gramineae.	<i>Cenchrus biflorus.</i>	Yields edible grain; is excellent for grazing and silage.	..
49. Daman	..	<i>Chloris virgata.</i>	Excellent for grazing and silage.	..
50. Mandhani	..	<i>Eleusine aegyptica.</i>	A very good grazing grass.	..
51. Drubbh or Kabab	..	<i>Cynodon dactylon.</i>	Poor grazing grass.	..

Local name in Sindhi (Transliteration).	Natural Order.	Botanical Name.	Industrial or other Economic uses.	Medicinal properties.
52. Savri	..	Echinochloa colona.	Yields edible grains, good grazing grass.	
53. Ghetio	..	..	Very good grazing grass.	
54. Ghamo	..	Panicum antidotale.	Excellent grazing grass.	
55. Kurya	..	..	Good grazing grass.	
56. Ghandhir	..	Eleusine flagellifera.	Fairly good for grazing.	
57. Murt	..	Panicum turgidum	An excellent grazing grass for fodder and silage.	
58. Ghetio	..	Sporobolus arabicus.	Good for grazing and silage.	
59. Chiryun jo Khet	..	..	Good for grazing.	
60. Malir mendi	..	..		In decoction and extract are cooling.
61. Buhur	.. Leguminosae.	Acacia arabica.	Goat's favourite fodder.	Fodds used for virility.
62. Kandero	..	Alhagi camelorum.		Purative.
63. Ghorawal or	..	Cassia obovata or 'articulata.	Yields a valuable dye.	For diarrhoea, asthma, chest and throat troubles.
64. Sen	..	Crotalaria burhia.	Graded by cattle, used for making ropes and thatching.	

65. Guar	..	Cyamopsis psoraloides.	Strength giving fodder, used as vegetable.	
66. Makhiya	.. Leguminosae.	Indigofera anabaptista.		
67. Makhi	..	Bragrostis tennifolia.	Yields edible grain.	
68. Visooni	..	..	Camel and goat eat it.	
69. Bepari	..	Indigefera cordifolia.	Camel is fodder.	
70. Vekkar	..	Abutilon muticum.	Ropes are made out of it.	
71. Gidarwal	.. Malvaceae.	Azadirachta indica.		Its leaves are used for painful inflammations, flowers for blood heat and impurities.
72. Kan kodi	..	Phoenix dactylifera.	Its fruits are edible.	Increases virility, cures bladder troubles.
73. Neem	.. Meliaceae.	Polygala abyssinica.	Eaten by cattle.	
74. Khaji	.. Palmaeae.	..		For fevers and flatulence.
75. Haran chapri	.. Polygalaceae.	Zizyphus jujuba.		Induces vomiting, roots for curing rheumatism.
76. Gun vel	..	Populus euphratica.		Cooling and refreshing.
77. Wan vel	..	..		Anthelmintic, cures diarrhoea.
78. Gulbinosho	..	..		
79. Ber	.. Pharnaceae.	..		
80. Bahan (rare)	.. Saliaceae.	..		
81. Jar	.. Salvadoraceae.	Salvadora pleioides.	Fruits are edible.	
82. Morari	.. Solanaceae.	Lycium europoem.	Goat and camel eat it.	

Local name in Sindhi (Transliteration).	Natural Order.	Botanical Name.	Industrial or other Economic uses.	Medicinal properties.
83. Bai-jo-batio	..	Sterculiaceae.	Melhania denhami.	It yields inferior pulse pulse which poor people eat.
84. Lai	..	Tamaricaceae.	Tamarix dioica.	Provides fuel wood.
85. Garoo	..	..	..	Specific for fevers. For debility.
86. Mundheri	..	Tiliaceae.	Corchorus antichorus.	
87. Pan	..	Typhaceae.	Typha elephantina.	Mats and ropes are made out of its fibre.
88. Kunbhut	..	..	Acacia ?	Yields fuel wood, gum.
89. Kandi	..	Prosopis spicigera.	..	Yields fuel wood, inferior wood for building and edible fruits.
90. Harkyo	..	..	..	Specific for rabies.
91. Harkyo	..	..	..	

A Study of the Rainfall Regime at Vellore

By

K. RAMAMURTHY,

Vellore (12°55' N. & 79°91' E.) is the headquarters of North Arcot, a district in the Province of Madras, and is situated on the right banks of the Palar river after it enters the plain from the ghats. (See Map on Page 211.) It is near the northern end of the Javadi Hills and close upon it on its eastern side are low hills. It owes its origin and growth to its position at the junction of two natural routes, one the Palar valley route running east to west, and the other, the foot-hill route running north to south. These natural routes are none the less important climatically as they serve as the gateway for the seasonal winds also.

In any study of rainfall it has been the custom in most books to use the ordinary arithmetic average as the basis of study. The mean is easy and simple, but it is overweighted by sporadic phenomena. It slurs over small occurrences and does not disengage the incidental from the accidental. The arithmetic mean being thus vitiated, the mode and the median are better for purposes of rainfall study, but the median is the best of them all, being the most informative.¹ Rainfall analysis by later writers² is therefore made dependent on the Median.

The Calendar month has been traditionally used as the unit interval of time for climatic and weather studies. It is too long a period to locate clearly the climatic changes in the course of the year. It may also be said that all the Calendar months are not of the same length. Hence in this paper the Calendar month has

1. Dr. H. A. Mathews: A New View of some Familiar Indian Rainfalls, Scot. Geog. Mag. Vol. 58 (1936) pp. 84-97.

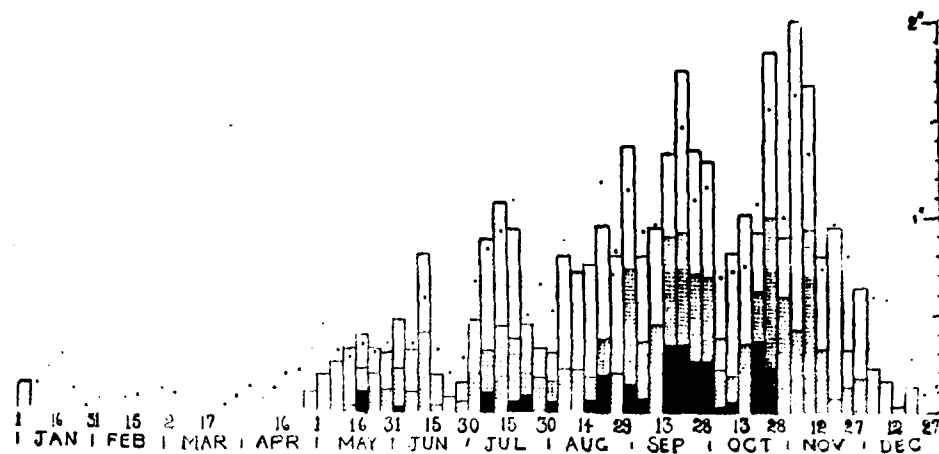
P. R. Crowe: An Analysis of Rainfall Probability—A Graphical Method and its application to European Data, Scottish Geographical Magazine Vol. 49 (1934) pp. 73-91.

P. R. Crowe: Rainfall Regime of the Western Plains, Geographical Review, Vol. 26 (1936) pp. 463-484.

L. S. Mahalingam: An Analysis of Indian Rainfall using the Median as a Statistic, Ind. Met. Dept. Scientific Notes, Vol. 7, pp. 243-254.

been altogether discarded and a unit interval of five-days has been substituted instead. The year has thus been divided into 73 five-day intervals.

RAINFALL REGIME AT VELLORE.



The portion below the lower limit is shaded black. The portion between the lower limit and the median is shown as dotted area. The mean for each five-day is shown as a dot.

From the "Daily Rainfall of India" published every year by the Indian Meteorological Department, the amounts of rain which fell in each of the five-day intervals have been calculated for 35 years for Vellore, the station under study. A word of explanation is necessary in the construction of the rainfall chart given here from the above data. Along the abscissa (or the Horizontal line), 73 equipaced intervals are taken, each to represent a five-day interval. As an illustration the first five-day interval January 1st to 5th may be taken. It is the first division on the horizontal line. The 35 records for this five-day period for the 35 years are plotted, each by means of a dot above this interval, at a height representing the amount of rainfall in each year. Draw a horizontal line at the highest and the lowest of the 35 dots to complete the rectangle of frequency for this interval. This rectangle encloses all the dots standing at their several heights. Mark a horizontal line across the median, or the middle-most dot; i.e., the eighteenth dot counting from the top or bottom. Thus there are as many dots above the median as below it. Next, to cut off the extremes in this rectangle of frequency to get the picture of the normal rainfall, we have to insert a line Lu below the upper end and a line Ll above the lower end. The position of these limit-lines has been determined differently by different writers.

A STUDY OF THE RAINFALL REGIME AT VELLORE 199

Crowe³ suggests that from the upper end and the lower end a quarter of the dots should be cut off—the Quartile Qu and Ql—and limit-lines inserted there. In case where extreme values are important, the eighth, the Octiles (Ou and Ol) may be cut off instead. The Hexiles (Hu and Hi) may be similarly drawn. Williamson and Clark⁴ take two records above and two below the median and define by them deviation from mean probability.

Dr. Savur⁵ works out a formula for n years for locating the limits. Here Lu and Ll have definite statistical meaning. It is obvious that the median will vary with the sample of the years chosen for study. The limits Lu and Ll of the interval within which the median may range, allowing an error of 5%, are given by the relation u is the integral part of $\frac{1}{2} (n - 1 - 1.6449 \sqrt{n})$ and l is $n + 1 - u$.

In a sample of 35 years, putting $n = 35$ in the above formula, we find $u = 12$ and $l = 24$. That is, the 12th and the 24th of the dots from the top give respectively the upper limit Lu and the lower limit Ll of the interval. The interval from Lu to Ll is called the 5% confidence interval for the median, because if we take any other sample of years for study, the median of that sample will lie outside this interval only in 5% of the cases. In this particular case of 35 years, where u and l are the 12th and the 24th dots counting from the top, a third of the years have rainfall below Ll, a third between Lu and Ll, and the remaining third above Lu.

If a sixth of the dots from either end are cut off, the upper and the lower hexiles are obtained. In this case the 6th and the 30th dots from the top are these upper and lower hexiles. In fact in the sample of 35 years chosen, Hu, Lu, M, Ll and Hi (the 6th, 12th, 18th, 24th and 30th dot from the top) are all hexiles marking every group a sixth of the whole series.

In the diagram given here, only Lu, M and Ll are shown. The average of the 35 years has also been indicated for purposes of comparison by means of dots.

3. Ibid.

4. Williamson and Clark: The Variability of the Annual Rainfall of India, Quart. Four. Royal Met. Soc. Vol. 57 (1931).

5. Dr. S. R. Savur: The Median as a Statistic, Current Science (Bangalore) Vol. 5 (1936-37), pp. 419-421.

Dr. S. R. Savur: The use of the Median in Tests of significance, proceedings of the Indian Academy of Sciences (Bangalore) Vol. 5 (1937) pp. 564-576.

Now let us compare the five-day average rainfall in relation to the median. A study of the diagram, or better still of the table, will show that the average exceeds the upper limit in 56 of the 73 five-day intervals. That is, in about three-fourths of the five-day intervals, the rainfall records have been less than the average in more than two thirds of the years. This in itself is sufficient argument for replacing mean by the median in a rainfall study.

From a close study of the rainfall dispersion chart for Vellore, with respect to the occurrence of rainfall at this station, we can divide the year into 2 parts, one in which rain has fallen in more than half the number of years, and the other in which rain has fallen in less than half the number of years. The former, which we may call as the rainy period of the year, extends from the 11th May to 1st December, and the other, which we may designate as the dry period of the year, from the 2nd December to the 10th May. In this dry period 2nd December to the 10th May, if we exclude the two end portions 2nd to 21st December and April 26th to May 10th, the rain has occurred in the five-day intervals in less than a third of the years (with the exception of January 1-5). This we may call as a very dry period. Again even in this very dry period, there is an inner period of marked dryness from the 16th January to the 10th April, when rain has not fallen in any five-day interval in more than a sixth of the years.

The spurt in the first five-day of January as shown both in the upper hexile and the upper limit cannot be disregarded as an accidental phenomenon. Rain has occurred in 13 years out of 35, in this five-day interval, whereas in the intervals preceding and succeeding, the rain years are much less.⁶ This spurt is also seen in the average for this five-day interval. Why there is this spurt after the final ceasing of the rains towards the close of the year is difficult to explain.

Towards the end of the dry period, the hot weather showers become more and more frequent and hence a steady increase in the number of rainy years and intensity of rainfall is to be observed in the five-day intervals and we pass on to the wet

6. Rain has occurred in
 Dec. 27-31 in 9 years.
 Dec. 22-26 in 5 years.
 Jan. 6-10 in 8 years.
 Jan. 11-20 in 8 years.
 Jan. 16-20 in 5 years.

A STUDY OF THE RAINFALL REGIME AT VELLORE 201

period of the year on May 11th. The hot weather showers are highly frequent from the 16th May to 14th June after which a minimum sets in before the break of the southwest monsoon. The actual minimum occurs in the interval June 20th to 24th, when rain has not fallen in more than a third of the years and even these show only poor records.

The southwest monsoon rains may be said to extend from the 25th June to the 2nd October. This period may be divided into two parts, one from the 25th June to the 12th September, and the other from the 13th September to the 2nd October. In the early part, the rainfall is significant⁷ in 7 out of the 16 five-day intervals and there is a maximum in August 29th to September 2nd. Beyond this nothing definite can be said about the rainfall of this period of the maximum activity of the southwest monsoon.

The second part from the 13th September to 2nd October is probably the rainiest period of the year. The lower limits of the confidence intervals being well above zero, the rain is well assured throughout this period of 20 days, which is marked by abrupt changes on either side. This is the period of calms when the southwest monsoon has weakened and the thunderstorms are most active.⁸ The change at the end of this period is nearly significant, the upper limit of October 3rd to 7th being only just above September 28th to October 2nd.

In the remainder of the wet period of the year (from October 3rd to December 2nd) the median rainfall tends to a maximum in October 23rd to 27th (over 1"—only one such instance in the year!). The period October 3rd to 17th of only moderate rainfall may be described as the period of transition from the preceding season of the southwest monsoon to the succeeding season of the retreating monsoon. In the latter season, though the medians are high and excessive falls are frequent up to the 16th November, the rainfall is significant only in the first ten days. Hence the rains of this season are much less reliable than in the period September 13th to October 2nd. In November 2nd to 6th, both the upper limit and the upper hexile are highest in the whole year indicating the maximum probability of excessive falls of the year in this period.

7. Rainfall is said to be significant when the 5% interval does not include zero (when L1 is above zero), i.e. Rain has occurred in more than 2/3 of the years.

8. Frequency of Thunderstorms in India, Ind. Met. Dept. Scientific Notes, Vol. I (1931) p. 55.

SUMMARY OF THE

(H_u = Upper hexile, L_u = Upper limit, M = Median, L_l

	Dates	H _u	L _u	M	L _l	H _l	Mean
JANUARY	1-5	.81	.13	0	0	0	.56
	6-10	.25	0	0	0	0	.13
	11-15	.10	0	0	0	0	.21
	16-20	0	0	0	0	0	.28
	21-25	0	0	0	0	0	.10
	26-30	0	0	0	0	0	.01
FEBRUARY	31-4	0	0	0	0	0	.05
	5-9	0	0	0	0	0	0
	10-14	0	0	0	0	0	.06
	15-19	0	0	0	0	0	.07
	20-24	0	0	0	0	0	.01
	25-1	0	0	0	0	0	.1
MARCH	2-6	0	0	0	0	0	.08
	7-11	0	0	0	0	0	0
	12-16	0	0	0	0	0	.11
	17-21	0	0	0	0	0	.05
	22-26	0	0	0	0	0	.03
	27-31	0	0	0	0	0	.07
APRIL	1-5	0	0	0	0	0	.12
	6-10	0	0	0	0	0	.06
	11-15	.23	0	0	0	0	.11
	16-20	.14	0	0	0	0	.19
	21-25	.53	0	0	0	0	.21
	26-30	.60	.10	0	0	0	.33
MAY	1-5	.77	.19	0	0	0	.45
	6-10	.73	.28	0	0	0	.32
	11-15	.65	.33	.03	0	0	.28
	16-20	.95	.46	.22	.10	0	.38
	21-25	.61	.33	.20	0	0	.32
	26-30	1.02	.31	.11	0	0	.39
JUNE	31-4	1.23	.48	.22	.02	0	.61
	5-9	1.05	.32	.10	0	0	.35
	10-14	1.23	.85	.41	0	0	.58
	15-19	.63	.19	.03	0	0	.32
	20-24	.37	.07	0	0	0	.20
	25-29	.58	.15	.05	0	0	.27
	30-4	1.60	.47	.20	0	0	.67

RAINFALL AT VELLORE

(L_u = Upper limit, H_l = Lower hexile).

	Dates	H _u	L _u	M	L _l	H _l	Mean
JULY	5-9	1.77	.91	.32	.10	0	.86
	10-14	1.93	1.10	.44	0	0	.95
	15-19	2.67	.96	.38	.05	0	1.11
	20-24	.97	.45	.20	.08	0	.50
	25-29	.91	.33	.17	0	0	.66
	30-3	.77	.30	.15	.05	0	.52
AUGUST	4-8	1.95	.85	.22	0	0	.90
	9-13	2.63	.72	.21	0	0	1.03
	14-18	3.01	.77	.18	.06	0	.98
	19-23	2.98	.98	.38	.19	.05	1.21
	24-28	1.76	.82	.20	0	0	.84
	29-2	2.53	1.40	.74	.14	0	1.17
SEPTEMBER	3-7	2.19	.81	.36	.07	0	.95
	8-12	2.30	.97	.44	0	0	.98
	13-17	2.62	1.36	.92	.34	0	1.36
	18-22	3.41	1.78	.94	.34	0	1.49
	23-27	2.19	1.38	.71	.28	.05	1.12
	28-2	2.24	1.32	.70	.28	0	1.18
OCTOBER	3-7	2.19	.81	.36	.03	0	.69
	8-12	2.07	.83	.18	.05	0	.73
	13-17	2.62	1.36	.92	0	0	.78
	18-12	2.26	.94	.62	.35	.06	1.09
	23-27	3.44	1.88	1.02	.22	0	1.59
	28-1	2.27	.91	.60	0	0	1.62
NOVEMBER	2-6	4.43	2.04	.42	0	0	1.66
	7-11	2.80	1.71	.96	0	0	1.36
	12-16	1.58	.82	.32	0	0	.75
	17-21	1.45	.97	.07	0	0	.98
	22-26	2.39	.32	.13	0	0	.81
	27-1	2.27	.65	.17	0	0	.91
DECEMBER	2-6	1.34	.22	0	0	0	.60
	7-11	.78	.16	0	0	0	.59
	12-16	.27	.03	0	0	0	.18
	17-21	.64	.13	0	0	0	.27
	22-26	0	0	0	0	0	.09
	27-31	.20	0	0	0	0	.13

Some Aspects of the Physical Geography of the North Arcot District

By

V. KALYANASUNDARAM,

The landscape of a region is a function of 3 factors, the structure, the process and the stage. Structure as a factor in determining the landscape may be viewed comprehensively as including not only the geological structure, but the character of the rocks also. The result of the action of the same processes in the same stage of the cycle, though broadly similar will be different in different structures. The chief elements apart from geological structure which determine the features of landscape are firstly the nature of the rocks—the sedimentary or igneous nature and secondly the actual kind of the rock itself. Taking the igneous or sedimentary rocks as a group there are varietal differences between the various species—granites and basalts in the case of the former, and sandstones, limestones and shales in the latter, which differences leave their impress on the resulting lineaments of the landscape. A generalised knowledge of the geological features of the region is a necessary pre-requisite to a proper understanding of the cycle of erosion and to get a proper picture of the landscape.

Taking the district of North Arcot, the first impression that one gets is that physically it consists of the following units:—

- (i) the plateau of Mysore along the N.W. border which slopes steeply down to the Palar valley in the north and less steeply to the Ponnaiyar valley in the south-west;
- (ii) the Javadis and other related mountains which strike in a roughly NNE to SSW direction and which are separated from the plateau by
- (iii) the broad valley of the Palar which eventually opens out into the coastal plain of the Carnatic on the east.

Only a small portion of the Mysore plateau lies within the district and everywhere it presents a steep face—an escarpment towards the plains, rising steeply, in some places as much as 1000'

THE PHYSICAL GEOGRAPHY OF THE N. ARCOT DT. 205

over the level of the surrounding plains to about 2000' the general elevation of the plateau. The steepness of this physical obstacle for movement is modified at a number of places by the dissection of the plateau edge into a number of spurs and valleys trending in a N.W. to S.E. direction by several streams which, rising on the plateau drain down its edge into the Palar valley.⁽¹⁾ The dissection has gone on so far in some places as to cut off partially isolated ridges and hills which nevertheless indicate their former connection with the plateau surface by their flat topped summit planes and their approximation to the general elevation to the plateau. The dissection of the plateau edge is still in its youthful stage and the renewed vigour of the streams, evidently due to rejuvenation has not succeeded in effacing completely the initial surface while the boldness of the relief and the number of gorges etc., are evident indications of youth. Above the escarpment the plateau has a roughly undulating aspect and presents features of an elevated peneplane.

• The plateau is made up mostly of medium to coarse grained thin banded hornblende-biotite gneiss or granitoid gneiss of pinkish colour, types of which are well seen on the eastern edge of the plateau, in the plains as well as in the hills west of Ambur, at Satghur, Sainigunta and other places.⁽²⁾ Similar coarse grained gneisses occur in the country north of the Palar on the borders of the Chittoor Dt. To the south of the Palar again there are bands of granitoid or syenitoid gneisses some of them remarkable for their coarseness of texture which is blotchy and markedly porphyritic, (e.g.) the rock forming the base of the Pallikonda hill

(1) The valleys of the Malattar, Kaundinya nadi and Good-ar are examples of this feature. The valleys of the latter two rivers afford an easy access from the plain to the plateau. The valley of the Good-ar being broader and less steep than that of the Kaundinya nadi is followed by a metalled road which after passing Sainigunta cuts across by a low saddle the water parting between the Good-ar and the Kaundinya nadi to get into the upper stretches of the latter and then on to Palmaner. Another route follows the valley of the Bata Vanka a right side tributary of the Malattar and ascends to Nayakkaneri on the plateau. This formerly used to be one of the most frequented routes but has now been given up in favour of other routes which follow a lesser gradient.

(2) The references to the geology of the region are scattered in numerous publications of the Geological Survey of India, mostly in the records. The following are the more important references:—Records. G. S. I. Vols. 12, 57, 58, 59, 60, 61, 62, 63, 65.

S.E. of Gudiyattam, Vaniyambadi trigonometrical station hill and the Yelagiri near Jalarpet.

In contrast to this the gneisses further south are different from the massive type firstly in their containing a greater amount of hornblende, (a mineral which brings about foliation) and secondly, as a natural consequence of the former, in their possession of a well developed foliation. The gneisses seem to occur over almost the whole of the plain and in some of the hills too. In addition to these gneisses, which are mostly well foliated, there occurs in the region south of the Palar a number of exposures of the Charnockite series. While they are seldom met with on the plateau surface they attain a prominence by their wide distribution in the region south of the Palar. The westernmost exposure of the series occurs as thin bands west of Jalarpet; they are extensively developed to the east in the Javadi hills, where they form most of the prominent ridges and again in the hills east of Vellore. As far as our present knowledge goes they are found to become less prominent to the east where they die out near Arcot, the easternmost exposure being a band of decayed charnockites near Arkonam. To the south they have been traced as far as Tiruvannamalai where they form the main mass of the hill—a fact to which the latter owes its form and high elevation.

The charnockites are found as sills intruded along the foliation planes of the older gneisses and forming high hills and ridges (e.g.) Kailasgarh, about 4 miles S.W. of Vellore. To the west they alternate with gneisses and granites, as in the Javadi hills, striking approximately in a NNE to SSW direction. The strike of foliation of these gneisses is roughly NNE to SSW which is clearly seen by their influence on the course of the rivers of the region—as in the upper course of the Cheyyar and again in its course from a little beyond Chengam, in the course of the Agaram-ar, in the upper course of the Pambar etc. The upper courses of the Cheyyar and the Agaram-ar lie in the same longitudinal valley a remarkably straight one trending N.N.E. to S.S.W. in the Javadis and with only a low saddle separating their sources. This remarkable parallelism which is often repeated in the case of the other streams as well, cannot be accidental but may be taken as an instance of structural control over drainage courses. The rivers seem to have worked along the plane of contact between the charnockites and the gneisses a direction of weakness. It is possible to make out on the Javadis and the other hills of the

THE PHYSICAL GEOGRAPHY OF THE N. ARCOT DT. 207

with two well defined lines of weakness—N. 5°-10° E. to S. 5°-10° W. (roughly NNE to SSW) and another perpendicular to this—directions which have been taken advantage of by streams. On the plateau there are again 2 directions NNW to SSE and another perpendicular to this of which the former appears to be the more well developed and obviously a more easy direction as the Palar and the Ponnaiyar have a greater part of their course along this direction and here and there turn abruptly—almost perpendicularly to have a short course in the other direction before resuming their normal NNW to SSE course. This feature in the dissection of the plateau edge has given rise to a number of NNW to SSE ridges while the hills of the plains have a general NNE to SSW trend.

The Palar is the major river of the district and drains the whole of the district except the extreme south-west. Rising on the surface of the plateau within sight of the Nandi hills, it has a sluggish course for nearly a third of its entire length before descending the edge of the plateau through a narrow gorge between Thumasi and Thimmampeta—a feature which has been referred to as an evidence of a recent rejuvenation. Opposite Jalarpet the river, instead of flowing southwards into the Ponnaiyar valley, swings round and takes an almost perpendicular turn to flow through the Vaniyambadi valley which progressively narrows towards Ambur, east of which it gradually opens out again. There is little doubt that there has been a recent reversal in the course of the Palar resulting in the diversion of the originally south flowing tributary of the Ponnaiyar into an independent SW to NE course to the sea—the present Palar.⁽³⁾ It follows the strike of the plateau edge—ENE to WSW—as far as Gudiyattam where it again swings round to a W to E direction which is maintained up to Arcot. This part of the river's course is, as has been referred to previously, a convenient boundary between the charnockitic and the non-charnockitic regions. So well marked is this boundary between these two provinces that one is tempted to refer the W to E course as having been excavated along the contact between two distinct rock types. But perhaps a more rational explanation will be to associate the W to E trend of the river with the intrusions of dykes which are so abundantly

(3) Journal of the Madras Geographical Association Vol. 13.
The Rivers of the Palar Basin—B. M. Thirunaranan.

developed here. Dykes of syenite pegmatites, dolerites etc., are found in large numbers, the most abundant being those of the dolerites. The general direction of the majority of the dykes is W-E changing to WSW to ENE⁽⁴⁾ and the evident parallelism between the course of the Palar east of Gudiyattam and the trend of these dykes is very significant.

The valley of the Palar between Jalarpet and Ambur appears to be a line of fault.⁽⁵⁾ Mylonitised and crushed zones are found both in the bed of the river and in the areas closeby and there are several parallel zones showing crushing. There are other indications pointing to faulting in this region. The plateau edge descends down steeply, almost precipitously to the level of the Palar valley while across the valley lies the Javadis and other hills which are characterised, as in the case of the Yelagiri and some parts of the Javadis by an almost level or gently undulating summit plane. The other and probably more striking feature is the remarkably straight trend of the two relief features—the plateau scarp trending in a NE to SW direction and the Javadis in a NNE to SSW direction converging towards the Palar valley in the neighbourhood of Ambur. These two features strongly suggest a contiguity of these two elements in the relief of the district, a feature which has been lost by faulting. One particular character of these two relief features serves to add weight to this conclusion. These two relief features lacking a definite axis of elevation (in the sense in which it is applied to fold mountains) cannot be regarded as independant units.⁽⁶⁾ If special elevation due to folding is ruled out we are irresistably led to favour contiguity. Earlier observers on the field were inclined to believe in the role of marine denudation and according to them the plain of the Carnatic from the coast to the foot of the ghats represented a plain of marine denudation with the plateau scarp and the steep face of other hills representing a sea cliff while the intervening probably less resistant materials were denuded away.⁽⁷⁾ Apart from the vague resemblance of the ghat face to a sea cliff there is nothing else to warrant this conclusion. Recent studies in

(4) Records Geological Survey of India, Vol. 65. P. 112.

Vol. 63 P. 125.

(5) Records Geological Survey of India, Vol. 58. P. 59.

(6) Oldham, *Geology of India*, P. 5.

(7) Cushing: 'East coast of India' Bulletin of the American Geographical Society Vol. 45, pp. 81-92.

India and elsewhere have shown that vertical movements due to faulting have to be reckoned with as a potent factor in mountain building.⁽⁸⁾ In the light of these observations and the remarks made earlier we may assume the plateau to have had a greater extension in the past and that the plateau was cut up into several units by faulting. The faulting must evidently have taken place in geologically speaking recent times, for the dissection of the plateau edge initiated by the fracture is still in its youthful stage with numerous falls and gorges below the falls.⁽⁹⁾ The most probable period of faulting must be post cretaceous—a period subsequent to the break up of the Gondwanaland as the structural disturbance of such a magnitude must have set in train a series of supplementary shocks following the main one and the faulting hinted at above may also be referred to the same group and to the same period.

If we were to assume that the hill masses like the Shevaroy, Palnis and Javadis originally formed part of the plateau of Mysore, one feature has to be explained. It will be apparent that the Yelagiri, the Javadis and the Shevaroy (outside the districts) are much higher in elevation than the plateau—the Javadis reach an elevation of about 3800' in the south. If they had been contiguous with the Mysore plateau and got separated from it by the faulting of the intervening bit how does it happen that the block which was so separated comes to lie at a higher elevation than the main block? The answer is probably to be found in the petrology of the area. The Javadis are charnockitic in character. The charnockitic region now contains the highest peaks in the peninsula of India and in Ceylon. A consideration of the Orographic map of India shows that the charnockitic region is on the whole more

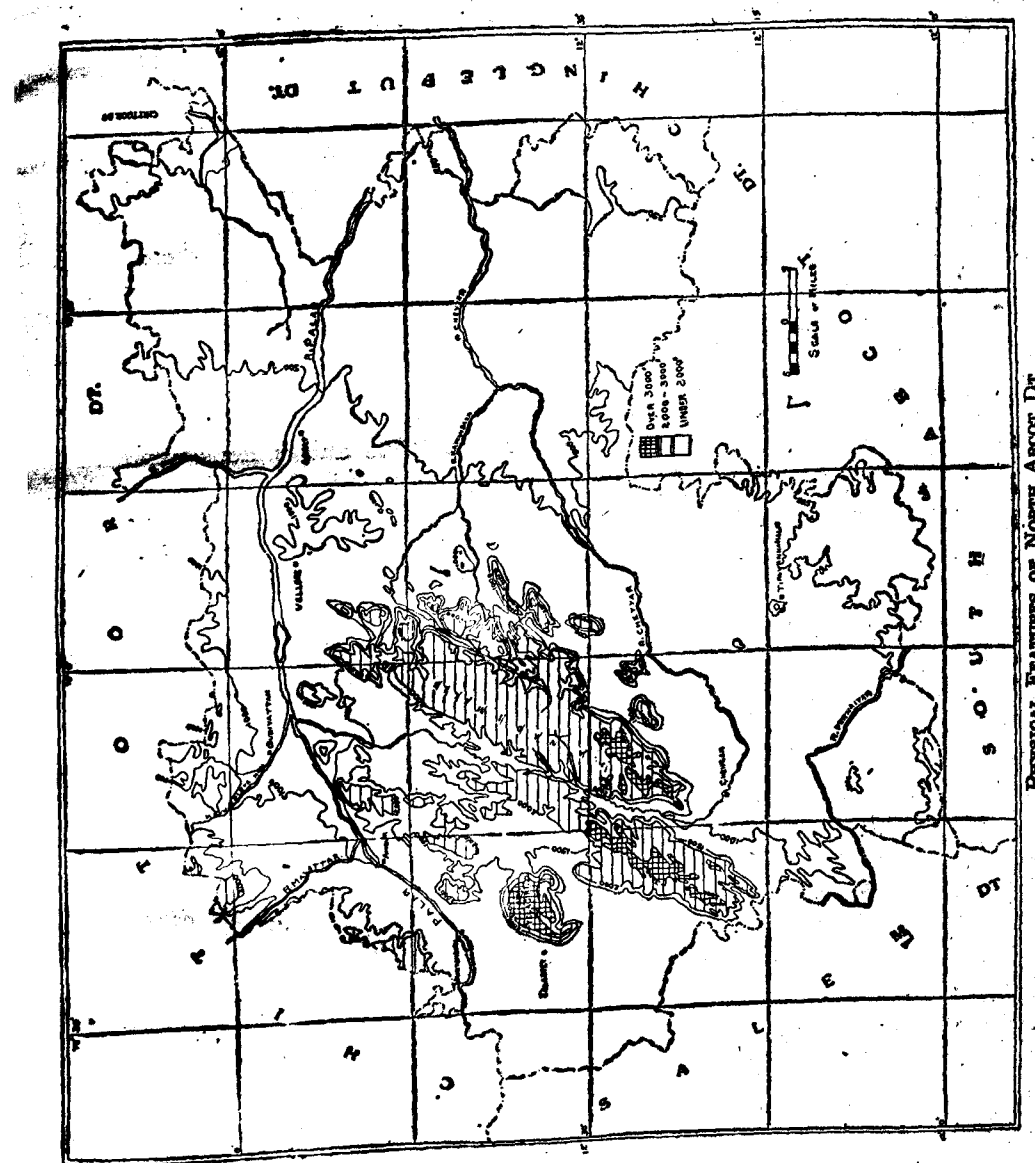
(8) Wadia: General Presidential address, Proceedings of 29th Session of the Indian Science Congress, Part II pp. 14-19 "Several systems of longitudinal fractures intersect the one million mile gneissic terrain...." The more well-known of these are:—(1) the tectonic basins in which the Gondwanas were deposited; (2) the fracture along the Makran coast; (3) the straight and steep forms of the Malabar coast and lastly the close parallelism between the strike of the plateau scarp and the strike of foliation of the Vizagapatam tract.

(9) The Palar has cut a gorge between Thumasi and Thimmampeta into the plateau edge. Similarly the other rivers of the plateau have incised deep gorges into the plateau edge. Above and below the gorges the river exhibit signs of maturity while the gorges in the plateau scarp indicate youthfulness due to recent local rejuvenation.

elevated than the non-charnockitic region although composed of rocks that must once have been at a great depth below the surface. This probably implies that there must have been a rise of several thousand feet of the rocks of the charnockitic region relative to the rocks of the non-charnockitic region.

There are two ways in which this uplift could have occurred. One would be by a general slight tilt of the peninsula producing a relative uplift of the eastern edge and the southern end (including Ceylon)—the charnockitic province of L. L. Fermor; the other is by relative vertical uplift along the junction between the charnockitic and the non-charnockitic region. As the boundary line or zone between the two regions has in no place been made the subject of exact survey or study, it is impossible at present to indicate whether either or a combination of the above hypotheses is adequate to explain the phenomenon. But on the analogy of the relationship of the two regions (provinces) in the Vizag area we may not be far from the truth when we say that the latter of the two processes has been the cause of the elevation (that relative uplift along a zone of faulting seems more likely to explain the phenomenon than a mere general tilt of the peninsula.⁽¹⁰⁾

Count F. de Montessus de Ballore's memoir on the "the Seismic phenomena in Br. India⁽¹¹⁾ and their connection with its geology" appears to throw some light on this problem. In this paper the author indicates a greater tendency to seismic phenomena in the S.E. and southern end of his region VI (which region will include the whole of the Peninsula except the northwestern part of Bundelkhand and the northeastern corner) than elsewhere. This coincides roughly with the charnockitic province. Such a high frequency of seismic phenomenon along this region may not be merely due to the fairly modern formation of the coastline, for while there are numerous epicentres near the East coast there are very few near the west coast which is undoubtedly more recent in origin. This peculiar distribution is most probably suggestive of the fact that charnockitic terrain is less stable than the non-charnockitic terrain; and consequently afford support to the view that the elevation of the charnockitic region of India relative to the non-charnockitic region is due not



(10) Mem. Geol. Sur. of India, Vol. LXX P. 142.

(11) Mem. Geol. Sur. of India, Vol. XXXV 1904.

to tilt but to vertical uplift. The fairly uniform distribution of epicentres and earthquakes within the charnockitic region suggests that the unstability of this region is not merely marginal but general.

The foregoing pages have given us a fair measure of the dependance of the morphology of a region on the structure. The main relief features of the district—the plateau and the Javadis appear to have been contiguous with one another in the past but got separated by faulting during a (geologically) recent period. Further the Javadis which are charnockitic in character appear, in common with the related features further south, to have suffered an uplift as a result of which they acquired a greater relative elevation than the contiguous parts further north. It is not possible in the present state of our knowledge to hazard any statement with regard to the date of this uplift. This and various other details of the landscape will have to wait until the geology of the region is more fully worked out.