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Vol. XIV

October—December, 1939

No. 4

The Journal of The Madras Geographical Association

PUBLISHED QUARTERLY.

EDITOR

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



THE MADRAS GEOGRAPHICAL ASSOCIATION,

Gopalapuram,

Cathedral P.O.,

Madras.

The Journal of The Madras Geographical Association

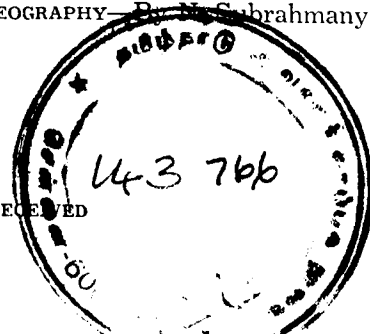
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CONTENTS

	PAGE
THE PHYSICAL ASPECTS AND THE GEOLOGY OF THE NEIGHBOURHOOD OF MADRAS—By P. G. Dowie ..	319
MILK SUPPLY IN THE CITY OF MADRAS—By K. C. Ramakrishnan	402
CINCHONA CULTIVATION IN INDIA—By K. N. Pasupathi ..	410
MUSLIM CONTRIBUTIONS TO GEOGRAPHY—By Nafis Ahmad ..	415
PHYSIOGRAPHIC DIVISIONS OF INDIA—By M. B. Pithawalla ..	423
THE DIRECT STUDY OF GEOGRAPHY—By M. Subrahmanyam ..	435
SELECT CONTENTS ..	439
NEWS AND NOTES ..	440
REVIEWS ..	443
BOOKS AND JOURNALS RECEIVED ..	445



The Physical Aspects and the Geology of The Neighbourhood of Madras

By

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INTRODUCTION.

This article is an attempt to give a brief Survey of the Geology of the Neighbourhood of Madras to Geographers, Geologists and others. The limits for such a description have been arbitrarily taken as the district limits of the Chingleput district. The first part deals with the physical aspects, as they are very essential in bringing out their close relationship with the Geological features.

It has been too frequently suggested, even by persons occupying responsible positions, that the neighbourhood of Madras has very little to offer in the form of Geological interest: the author's aim in writing these few pages will be more than achieved, if he has succeeded in showing to such persons the vast field of Geological interest, which goes almost unheeded near the very place of one's residence. It is also hoped, that this article will be of some help, in arranging excursions to places of Geological interest, to students of Geology and Geography.

ACKNOWLEDGEMENTS

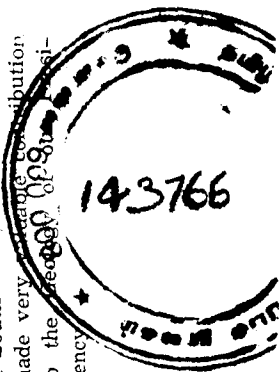
The author's indebtedness to the host of workers, who had so very keenly and enthusiastically endeavoured to study the area and to record their observations, especially, to the pioneers in the field of Indian Geology in the Presidency, R. Bruce Foote, William



SIR THOMAS HOLLAND, K.C.I.E., who was attached to the Geological Survey of India for only 21 years (1890-1910), during which period he was Director for eight years, had a unique official career in that he had revolutionised the methods of Petrographical Study by his descriptions of the Charnockite Series near Madras, and the Elaeolite and Corundum Syenites of Coimbatore of the Madras Presidency.



WILLIAM KING, Esq., B.A., D.Sc., F.G.S., who was for some time Director of the Geological Survey of India (1887-1894) was an officer of the department for about 37 years. He was for 20 years Superintendent in charge of South India, and as such had made very valuable contribution to the Geological Survey of India.



—By kind permission of the Director, Geological Survey of India.



ROBERT BRUCE FOOTE, Esq., F.G.S., who had been attached to the Geological Survey of India for over 33 years (1858-1891), surveyed in collaboration with Dr. King almost the whole of the Madras Presidency and the south-western portion of the Bombay Presidency—a joint record unsurpassed by that of any two other members of the Geological Survey. His work covered an extensive field of not only the various branches of Geology, but also prehistoric archaeology. On retirement, he settled down at Yercaud, and died in India.

PHYSICAL ASPECTS & GEOLOGY OF MADRAS 321

King and Sir Thomas Holland, whose work forms a sure foundation for all later workers, will be apparent in almost every page. The author wishes to thank all those, who have gladly and readily lent photographs to illustrate the article as the Director, Geological Survey of India; Mr. B. M. Thirunaranan of the University Department of Geography; and Mr. S. Narayanaswamy. His sincere thanks are also due to Mr. V. Kalyanasundaram, of the Department of Geology, Presidency College, Madras for kindly typing the article for the printer from a not very legible manuscript.

BOUNDARIES AND ADMINISTRATIVE DIVISIONS.

District Boundaries.

The district of Chingleput including the Madras city, is bounded on the north by the Nellore district, on the west by the Chittoor and the North Arcot districts, on the south by the South Arcot district and on the east by the Bay of Bengal. The northernmost limit touches latitude of $13^{\circ} 42' 23''$ N. near Sulerpet and the southern limit $12^{\circ} 13' 49''$ N. on the banks of the Ongur river or the Athangarai Ar—a distance of about 102 miles north to south; the eastern and the western limits are at longitude $89^{\circ} 20' 40''$ E. at Kattupalli about eight miles south of the village Pulicat, and $79^{\circ} 33' 38''$ E. at about 10 miles W. N. W. of Conjeevaram town respectively. Hence, the extreme length is about 100 miles N—S and the breadth at the widest place is about 47 miles E—W.

Administrative Divisions.

Leaving aside the Madras city, which is the capital of the Presidency, and which is 9 miles in extreme length and $4\frac{1}{2}$ miles in extreme breadth, the district is divided into seven taluks for purposes of political and revenue administration: the Saidapet taluk immediately surrounds the Madras city stretching as far as the Ennore backwaters in the north, Tambaram in the south and Timmanur on the west. To the west of it lies the Tiruvallur taluk; to the north of both of them the Ponneri taluk; immediately south of the Saidapet taluk is the Chingleput taluk while to the south west of the former lies the Sriperumbudur taluk; west of Chingleput taluk is situated the Conjeevaram taluk and Madurantakam taluk forms the southernmost of all. These administrative divisions have no basis or connection with either the physical or physiographic features or on the geologic structure of the area, except that in certain taluks the rivers form a natural as well as political boundary for some distance as (1) the north-eastern boundary of Madurantakam taluk follows the lower course of the Palar;



(2) the southern boundary of the same taluk is fixed by the Ongur or the Athangarai river; (3) a portion of the eastern limit of Conjeevaram is the Palar river; (4) and the southern frontier of the Ponneri taluk for some distance follows the Arani or Narayana-varam river.

MORPHOLOGY AND RELIEF.¹

Scenery.

The general aspect, as characteristic of a coastal belt is flatness with a gentle slope towards the east or seaward, dreary near the sea and undulating and rarely hilly elsewhere. The general level ranges from below the sea level near some of the break-waters gradually up to 300 feet above the mean sea level in the western parts of the Conjeevaram and Tiruvallur taluks. There is not much in the way of scenery in the Saidapet, the Tiruvallur and the Ponneri taluks, except where in the extreme north and north-west of the Ponneri and the Tiruvallur taluks, the Kambakkam—Nagalapuram ranges, the Satyavedu hills and the Allikkuli hills contribute a little mountain scenery. The character of the first two hill ranges consisting of quartzites of Cuddapah age has been described as "bluff ridge and beetling Crag" with ridges here and there steeply starting up into sharp tapering peaks. The tops are generally bare, and the more gently sloping surfaces are clothed with coarse grass and jungle. The climate of the Kambakkam Drug is not in the least disagreeable, and was once thought to be suitable for European settlement. There is plenty of vegetation and excellent, cool, crystal clear water including a beautiful bathing pool. The best time of the year to visit it is immediately after the N. E. monsoon i.e., in January; it is a place excellently suited for excursions—geological and geographical. The place appears to have been once occupied by the Poligars,² whose chief built the fort, the ruins of which may

1. The following One Inch Survey of India sheets comprise the District under review:—57 0/11, 0/12, 0/14, 0/15, 0/16, P/9, P/10, P/11, P/13, P/14, P/15, P/16; 66C/2 & 6, C/3, C/4, C/7, C/8; 66D/1 & 5, D/2, D/3 & 4.

2. Poligars, who were mostly Naiks, were the hereditary chiefs, who had jurisdiction over the various southern kingdoms under the suzerainty of the Rajah of Vijayanagar during the latter's time; they were, however, later recognised by the English ever since their first settlement as responsible for maintaining the peace of the country; in return they were allowed to levy petty duties on various food stuffs. (Vide: An interesting account of them by Dr. E. Asirvatham, Madras Tercentenary Commemoration Volume, pp. 167-172).

be seen at the present day. The fort fell later, into the hands of the Nawab of the Carnatic, who built his summer palace there in order to enjoy the fine air and the beautiful scenery. Though no fruit cultivation is to be seen there now, the place appears to have grown once the best oranges of the Carnatic; the climate decidedly is suited for the cultivation of oranges and plenty of limes are cultivated at present in comparatively poorer areas, as around the Allikkuli village.³ As the elevation of the Satyavedu and the Allikkuli hills is much lower consisting of huge boulder conglomerates of Upper Jurassic age laid on the gently sloping shore of the Cuddapah quartzites or the Peninsular gneiss there is practically no scenery to be observed in them; here and there, vertical conglomeratic precipices and apparent stacks may be seen taking all kinds of fantastic shapes; the area is covered only with scrub-jungle. The Conjeevaram taluk is also marked by little to relieve the dreary monotony which characterises it; there is an entire absence of scrub jungle or forests except sporadic presence of tamarind and palmyra trees, while near the Palar river they are replaced by the coconut palms. But parts of the Chingleput and the Madurantakam taluks decidedly offer rather pleasing undulating plains, varied by ridged or conical ellipsoidal hills rarely exceeding in height 600 feet; the higher hill ranges are covered with thick scrub jungle and the smaller ones are usually rocky and barren of vegetation. Parts of the Madurantakam taluk appear to be well suited for mango and coconut groves, the last in the S. E. part of the taluk.

As one would expect in the case of coastal continental slope receiving the terrigenous debris for many geological periods, the regions bordering the sea are flat, tame, dreary and uninteresting, consisting of marshes, lagoons, small bays and backwaters. Besides, these are the result of the blocking up of the drainage at the mouths of rivers by the continued action of the epigene agencies, as the rivers bringing sediments, mostly during the monsoon times, the prevailing sea currents and wave actions heaping up sand bars, and the wind action in distributing the sand to form dunes over wide areas. As one proceeds inland from the coast, one first comes across a rather high sandy ridge of blown sand forming the shore for one, two or even three miles, then a shallow extremely saltish or brackish water lake or lagoon; and that passed *terra-firma* begins, which is also flat and uninteresting. During the rainy season the area is almost impassable being intersected by rivers and drainage streams.

3. Vide: Col. Monteith—A Visit to Cumbaucom Drug. Mad. Jour. Lit. and Sc., July 1836, pp. 134-138.

swollen, muddy, miry and dangerous to be crossed. Marshes are to be seen near the mouths of rivers, while further on, on either side are the lagoons and backwaters. The coast line which is approximately 96 miles in length, is straight and sandy, the sand forming a belt of varying breadth up to three miles. The general trend of the sand bars, and the shapes of the submarine five and ten fathom contours indicate that the prevailing current and wave action are as equally responsible for their formation, as the other epigene agents, as river and wind action.

The principal of these lagoons, which are of all sizes, is the Pulicat lake, and is situated in the Ponneri taluk between the Chingleput and Nellore districts. It has an extreme length of about 37 miles and a breadth varying from 3 to 11 miles. The river Arni or the Narayanavaram embouches near Pulicat, forming first a series of swamps, next a mostly dry sandy lagoon partly filled with sea water, and then a sand bar rising to a height of about 10 feet above the sea level. This shoal is said to be fairly dangerous to ships from the north, and a wide berth must be given especially during night time.

From the mouth of the Narayanavaram river to that of the Korttalaiyar near Ennore, there is a very big long partly dry lagoon communicating with the sea only near Ennore. Only this narrow eastern portion is occupied by bitter sea-water, and the remaining area is either dry or marshy or miry, and is used as salt pans for the manufacture of common salt. It is likely that during the monsoon times these lagoons may become brackish, when the rivers and channels draining into them will be full. The Ennore backwater extends as far as Edayanpalaiyam, three miles W.N.W. of Tiruvotiyur, but it must have extended still further southwards to north of Madras in the recent geologic past.

South of Madras also the same phenomenon may be noticed in a narrow elongated lagoon extending from three miles north of Covelong to about three or four miles south of the Seven Pagodas or Mahabalipuram. The sea enters only to a small distance both at Covelong and near Edaiyur four miles S.S.W. of Mahabalipuram. The rest of the area is occupied either by swamps or by dry areas converted into salt pans. There is no doubt, that this lagoon must have extended a few miles northward, and also southward connecting with similar lagoons south of the Palar river near Cheyur, through the small lagoon situated immediately south of the mouth of the Palar, but must have been separated by the Palar alluvium after its change to its present course. Further south, one finds

again rather extensive lagoons in Yedyanthittu Kaliveli and the Kaliveli tank; a good portion of the former is dry and partly converted into salt pans, while the latter though dry appears to be a slightly brackish water lake during the rainy season. The piece of land called Yedakainadu⁴ or left hand land south of the lagoon near Cheyur, bounded on the east by the sea and the Kaliveli tank in the south appears to have been separated from the main land by an irruption of the sea. The land itself consists purely of alluvium, and it must have been converted to dry land due to accumulation of coastal debris both in historic and in geologically recent times. This explains its rather fertile sandy soil excellently suited for the cultivation of cocoanuts, which are the best produced in the district.

*The Buckingham Canal.*⁵

The above mentioned natural features have been taken advantage of in the construction of the Buckingham canal running all along the coast of the district, and still further north as far as Pedda Ganjam in the Guntur district, and as far as the Kaliveli tank or the Markkanam tank in the South Arcot district by cutting through the various high grounds between the lagoons or backwaters.⁶ The canal was dug piece-meal from time to time, and the first eleven miles from St. Mary's or Hutton's bridge in the City northward called the Cochrane's Canal was dug in or earlier than 1806. By 1837 it was extended to the northern extremity of the Pulicat lake and this portion was called the Kantapilli channel. It was continued further northward in the next twenty years, so that by 1857 it was cut as far as Dugarazpatnam in the Nellore district, and it was called the East Coast canal. By 1877, as a relief work during the famine of 1876-77, it was extended as far as Krishnapatnam, a distance of about 114 miles from Madras. The next year saw its extension to its present limit namely as far as Pedda Ganjam, a length of about 196 miles from Madras, and it was called the Northern Canal. In the City, the canal runs for a small distance along an old river, the Elambore river, just west of the General Hospital and

4. "It is called Yedakeinadu or left hand land, and tradition points to its having been separated from the remainder of the taluk by an irruption of the sea."—C. S. Crole—The Manual of the Chingleput district, 1879, p. 128.

5. *Vide*, for an interesting account V. K. Sourirajan. Jour. Mad. Geo. Assocn., Vol. III, 1928-'29, pp. 108-120.

6. From Pedda Ganjam the canal becomes a fresh water one called the Commamur canal, traversing further inland and joining with the Kistna river at Bezwada.

George Town, as could be easily made out by its width and volume of water in this portion.

The section south of Madras, called the South Canal, was excavated between 1852 and 1857 from the Adyar to the mouth of the Palar, an approximate length of 41 miles; this was extended in 1882 to the Markkanam backwaters.

The connection between the South Canal and the East Coast Canal or the Northern Canal in the City was made only in 1876—77, as a famine relief work. Just south of the General Hospital forming the northern arm of the Cooum, the Canal utilises a portion of an artificial channel excavated in order to change the course of the Elambore river further westward to provide for more space for the strengthening of the fortifications of the Fort St. George, during 1754-1779.⁷

The Canal was once very useful, and even now to some extent, in facilitating easy and cheap transport of food stuffs and heavy goods which can be transported leisurely. But with the advent of quicker and fairly cheap means of transport as the railway and the motor lorries, it is not so much used at present. Yet, it forms the chief means of transport for fire-wood (*Casuarina equisetifolia* lamellibranch shells for burning into chunam, rice and paddy, avaram bark (*Cassia auriculata*), building stones and to a small extent timber.

The following observations may be noteworthy in a study of the coastal features near Madras:—

1. Lagoons and marine or salt-water lakes seem to be present almost continuously along the coast; their general shape is elongated parallel to the coast line.

2. The breadth of the lagoons appreciably decreases and they altogether disappear near the mouths of rivers; this is manifestly due to the sediments brought by the rivers. Hence, the geological history of coastal towns, as Madras, depends largely in the unravelling of the stages in the filling up of the lagoons.

3. The drying up of the lagoons has given rise to salt deposits, and a good portion of the area has, hence, been converted into salt pans for the manufacture of common salt; the sandy

7. Vide, F. L. Conradi's map of 1755 of old Madras reproduced in Vol. III. Jour. Mad. Geog. Assocn., as Map VII of Prof. C. S. Srinivasachari's article, 1928-29.

coastal belt is far from being a fertile area, suitable for the growth of only *Casuarina* (providing fire-wood for the city of Madras), *Palmyra*, *Cashewnut*, *Pandanus*, and other thorny bushes and coarse grass. The land is, hence, very cheap resulting in plenty of space being available for a growing town as Madras.⁸

4. The big bulge in the coastal alluvium between Pulicat village and Ennore, and a relatively smaller one at the mouth of the Palar are remarkable. The former makes us conclude, that some bigger river than the Korttalaiyar must have embouched near and north of Ennore—the old Palar or Vridhakshiranadi.

5. The interesting growth of sediments at the mouths of rivers (a) at the mouth of the Narayanavaram river a sand bar running in the direction of the prevalent currents; (b) the peculiar shape of the five fathoms submarine contour off Ennore and the less pronounced ten fathom contour forming what appears to be a submarine bar; (c) a small bulge, which is more marked in the five fathom contour at the mouth of the Adyar and a slightly bigger one at the mouth of the Cooum as shown by the ten fathom contour; this is, probably, due to carrying off and deposition of the finer materials of the city's refuse; (d) an indented bulge in the five, and in the ten fathom contours off the mouth of the Palar; the bulge is not exactly situated opposite its mouth.

6. The presence of two reefs, which are dangerous, close to the shore between Covelong and the Seven Pagodas,—the one on which the carved temples stand, and the other three miles north of the Seven Pagodas—at a distance of about 25 miles south of Madras. This is very remarkable in a straight sandy coast as that of the East coast of the Peninsular India, extending for about 1,200 miles from the mouth of the Ganges to Cape Comorin; the only other places, where the rock outcrops near the coast, are between Ganjam and Vizagapatam where four such ledges are recognised^{8a}. Near the former place the East India Company's ship *Rockingham* was totally wrecked in 1776.

8. Cf. Bombay and Calcutta—L. W. Lyde: "The Continent of Asia", 1933, p. 471. "The one merit of the city itself is that, as the poor land was not valuable, there was little demand on it, and so—for an eastern city—Madras is widely spread and openly spaced."

For this reason Madras is often described as a City of distances.

8a. S. W. Cushing, The East Coast of India, Bull. Amer. Geog. Soc., Vol. XLV, 1913, p. 90.

7. The accumulation of sand just south of the Madras harbour forming a wide beautiful beach for Madras city, probably entirely due to and later than the building of the Madras Harbour, as the result of interference caused by the harbour wall to the prevalent currents.⁹

HILLS AND MOUNTAINS OF THE DISTRICT

The various hills and ranges of the district may be considered according to their situation in the various taluks; and as already mentioned one can see some really beautiful mountain scenery only in the Kambakkam--Nagalapuram range, situated in the northernmost part of the district, immediately after the N.E. monsoon. Elsewhere, the hills and ranges are not high enough either to give rise to good scenery or an appreciable change in the climate. The hillocks consisting of very ancient crystalline gneisses of the Peninsula to be seen in the Saidapet, Chingleput, Sriperumbudur, Conjeevaram and Madurantakam taluks frequently occur in groups; that these oval or round usually barren hillocks are the stocks of very ancient folded chains may be inferred from their rather regular arrangement in roughly N.E. to S.W. direction.

9. G. G. Armstrong—Mad. Tercen. Comm. Vol., p. 211.
F. E. Penny: On the Coromandel coast, p. 23.
Hodgson: "T. Parry, Free Merchant", p. 14.
C. S. Srinivasachari: Jour. Mad. Geog. Assocn., Vol. III, p. 105.
G. Kuriyan: Mad. Tercen. Comm. Volume, 1939, p. 313.

No map of the area before the building of the Harbour in 1881 shows the wide expanse of the sand south of it.

The more interesting mountains of the district are given in the tabular statement below:—

Name of Mountain or Hill.	Height of the highest point in ft.	Position of Highest point.		
		Latitude.	Longitude.	
<i>Ponneri Taluk.</i>				
Kambakkam Durgam.	2539	13° 34' 27"	79° 51' 40"	The Kambakkam--Nagalapuram--Ramagiri range is a continuous one with a trend of N.N.W.-S.S.E. in the northern portion and gradually swerving N.N.E.-S.S.W. in the southern part. The Kambakkam Durgam can be reached from the village Varadayyakalaiyam. In both the places there are Forest Rest Houses.
Nagalapuram peak.	2891	13° 26' 23"	79° 46' 40"	Both the peaks are situated in the Nagalapuram hills, the Ramagiri malai being the southern. There are several less high peaks some of which are accessible from Nagalapuram.
Ramagiri malai.	2839	13° 25' 40"	79° 45' 20"	
Ambakkam peak.	708	13° 22' 10"	79° 52' 43"	Accessible from the south-east from the village Pudukuppam.
Satyavedu peak.	930	13° 28' 7"	79° 53' 43"	This is in the western part of the ranges and is nearer to and also accessible from Tripurantakapuram. Both the Ambakkam and the Satyavedu peaks are situated in the Satyavedu ranges.

Name of Mountain or Hill.	Height of the highest point in ft.	Position of Highest point.		
		Latitude.	Longitude.	
<i>Tiruvallur Taluk.</i>				
Allikkuli eastern Peak.	1020	13° 17' 47"	79° 48' 10"	The Allikkuli range forms the southern continuation of the Satyavedu ranges separated from the Satyavedu ranges by the Arani river.
Allikkuli N.W. Peak.	1052	13° 19' 7"	79° 45' 40"	
Allikkuli S.W. Peak.	1254	13° 17' 0"	79° 43' 57"	
<i>Sriperumbudur Taluk.</i>				
Malaipattu hill.	458	12° 54' 53"	80° 0' 50"	These hills are to be found on the eastern portion of the taluk and are interesting in that they form the eastern limits of the Jurassic formation.
Erumaiyur hill.	378	12° 57' 13"	80° 4' 33"	
<i>Conjeeveram Taluk.</i>				
Kunnavakkam hill.	339	12° 50' 50"	79° 54' 5"	This is the only hill to be found in the Taluk being situated in the eastern border of the Taluk; this forms the S.W. limit of the Jurassic formations.
<i>Saidapet Taluk.</i>				
St. Thomas Mount.	250	13° 0' 13"	80° 11' 40"	All the hills from St. Thomas Mount to the Vandalur hill, are arranged in a rough N.E.-S.W. direction.
Pallavaram hill.	499	12° 58' 10"	80° 9' 45"	
Tirunirmalai hill.	198	12° 57' 47"	80° 6' 57"	
Another hill N.E. of Tirunirmalai at a distance of about ½ mile.	265	12° 58' 0"	80° 7' 28"	
Mullu malai.	321	12° 56' 53"	80° 6' 47"	These hills are to be seen N. and N.E. of Tambaram village.
Pachai malai.	360	12° 56' 37"	80° 7' 38"	
Tambaram hill.	440	12° 56' 8"	80° 6' 27"	
Vandalur hill—	563	12° 53' 47"	80° 5' 48"	

Name of Mountain or Hill.	Height of the highest point in ft.	Position of Highest point.		
		Latitude.	Longitude.	
northern peak. Nanmangalam hill.	230	12° 55' 30"	80° 10' 38"	These are to be seen further east of the group St. Thomas Mt.-Vandalur mentioned above.
Sittalapakkam hill.	266	12° 53' 3"	80° 11' 43"	
Ottiyambakkam.	150	12° 51' 33"	80° 11' 22"	
<i>Chingleput Taluk.</i>				
Vandalur—southern peak.	113	12° 53' 23"	80° 5' 23"	East of Vandalur hill.
Nedugunram hill.	349	12° 52' 50"	80° 6' 30"	
Guduvancheri hill.	431	12° 49' 50"	80° 3' 43"	The Guduvancheri-Karaikalani range includes also the hillocks between them.
Karaikalani hill.	364	12° 48' 40"	80° 3' 14"	
Appur hill.	500	12° 48' 10"	79° 59' 10"	This may be called Appur---Venkatapuram group with the hillocks between these including the Venpakkam hill.
Venkatapuram hill.	457	12° 45' 47"	79° 58' 25"	
Venpakkam hill.	352	12° 46' 13"	79° 57' 10"	
Tirukkachchiyur hill.	301	12° 46' 27"	79° 59' 37"	These form the Tirukkachchiyur-Settipunyam-Kandalur range.
Settipunyam hill.	836	12° 44' 53"	79° 59' 0"	
Kandalur hill.	405	12° 43' 23"	79° 58' 47"	
Hanumantaputter hill.	782	12° 40' 40"	79° 58' 3"	S.W. of Chingleput town.
Tirumani hill.	769	12° 39' 3"	79° 58' 47"	S. of Chingleput town.
Alappakkam hill.	415	12° 40' 15"	80° 0' 10"	These form the Tirumani-Alappakkam-Vallam---Kunnavakkam---Angur range.
Vallam hill.	686	12° 41' 30"	80° 1' 22"	
Kunnavakkam hill.	702	12° 42' 23"	80° 1' 7"	
Angur south peak.	615	12° 42' 53"	80° 2' 44"	
Angur north peak.	590	12° 43' 20"	80° 3' 0"	

Name of Mountain or Hill.	Height of the highest point in ft.	Position of Highest point.		
		Latitude.	Longitude.	
Alagusamudram hill.	341	12° 38' 23"	80° 1' 13"	These form the Alagusamudram--Nemmali--Porundavakkam---Santhakuppam-Ramamalai-Agaram-Kalway range.
Nemmali hill.	567	12° 40' 3"	80° 1' 44"	
Porundavakkam hill.	515	12° 40' 33"	80° 2' 33"	
Santhakuppam hill.	386	12° 42' 50"	80° 4' 10"	
Rama malai.	501	12° 44' 13"	80° 5' 10"	
Agaram hill.	291	12° 45' 23"	80° 6' 7"	These form the Kumili-Ammanampakkam-Nallambakkam---Unamanjeri group.
Kalway hill.	301	12° 46' 23"	80° 6' 50"	
Kumili hill.	548	12° 48' 0"	80° 6' 50"	
Ammanampakkam hill.	420	12° 49' 0"	80° 7' 20"	
Nallambakkam hill.	367	12° 50' 33"	80° 7' 13"	
Unamanjeri hill.	226	12° 51' 10"	80° 7' 53"	These form the Tirukkalikunram-Talambedu-Oragadam-Edakunram-Mailai-Vembedu group.
Tirukkalikunram.	470	12° 36' 37"	80° 3' 38"	
Talambedu hill.	706	12° 36' 53"	80° 2' 13"	
Oragadam hill.	431	12° 38' 0"	80° 3' 57"	
Edakunram hill.	253	12° 41' 18"	80° 6' 10"	
Mailai or Kattur hill.	295	12° 42' 35"	80° 7' 15"	
Vembedu malai.	246	12° 44' 40"	80° 8' 10"	<i>Madurantakam Taluk.</i>
Karunguli hill.	420	12° 32' 10"	79° 53' 27"	
Sattamai hill.	314	12° 33' 38"	79° 54' 13"	
Perumberkandigal --Acharapak-kam range.	659	12° 23' 0"	79° 47' 23"	
Avirmedu hill.	490	12° 27' 13"	79° 54' 45"	

Name of Mountain or Hill.	Height of the highest point in ft.	Position of Highest point.		
		Latitude.	Longitude.	
Muppantal--Tonnadumalai.	451	12° 23' 40"	79° 54' 10"	These form the Muppantal-Tonnadu-Mangill Kuchi -- thatharmalai group including the hillocks near Peruvali, Porur, Melvasali and Kakkakrantangal.
Kuchi-thatharmalai.	320	12° 21' 30"	79° 53' 18"	
Mangill malai.	401	12° 22' 30"	79° 52' 55"	
Edamich hill.	652	12° 41' 30"	79° 51' 53"	This includes several detached hills, the highest of which is near the village Edamich; it includes the hillocks near Kunnavakkam, Baleswaram, Mambudur, Palaveri and Arunkunnam.
Sittalapakkam hills.	450	12° 43' 47"	79° 51' 6"	Sittalapakkam hills include those situated west of Edamich extending to the banks of the Palar.
Oratti hill.	528	12° 22' 37"	79° 40' 42"	
Malaivaiyavur hill.	340	12° 35' 43"	79° 53' 35"	

To bring out the orogenic direction of the region, I propose arranging the hills to be found in the Saidapet, Sriperumbudur, Chingleput, Conjeevaram and Madurantakam taluks in the following manner proceeding from the west to the east :—

Kunnavakkam hill.	Malai pattu hill.	Erumaiyur hill.	St. Thomas Mount.	Nanmangalam hill.	Sittalapakkam hill.	Vembedu malai.
Sittalapakkam hill (including hills N.E. of it).	Edamich hill.	Appur hill.	Pallavaram hill.	Unamanjeri hill.	Kalway hill.	Mailai (or Kattur hill).
	Oratti hill.	Venpakkam hill.	Mullumalai. Pachaimalai.	Kumili hill.	Agaram hill.	Edakunram.
		Venkatapuram hill.	Tambaram hill.	Angur hill.	Ramamalai.	Tirukkalki-kunram.
		Malaivaiyavur hill.	Vandalur hill.	Vallam hill.	Santhakuppam hill.	Muppantal malai.
			Guduvancheri hill.	Alappakkam hill.	Nemmali hill.	Mangill malai.
			Settipunyam hill.	Tirumani hill.	Alagusamudram hill.	Kuchi malai.
			Kandalur hill.	Acharapakkam hill.	Avirmedi hill.	Thathar malai.
			Hanumanthaputter hill.			
			Sattamai hill.			
			Karunguli hill.			

RIVERS OF THE DISTRICT

The rivers of the region are all non-perennial ones very capricious in their nature, as they depend upon the N. E. monsoon and occasional cyclonic downpours, the latter especially occurring during the early part of May or October. Of the rainfall about 2/3 or about 30 inches fall during the N. E. monsoon in the months of September, October, November and December and the remaining 1/3 is received either during the S.W. monsoon or during cyclones, to which the coastal region for about 100 miles north and south of Madras is peculiarly liable. The average rainfall of the district is about 45 inches, though very occasionally more than twice that amount has been recorded locally, and even upto 20.75 inches within an interval of 24 hours; on the other hand in some years as low a rainfall as about 20 inches have also been recorded. This clearly indicates the extreme undependable and capricious nature of the rivers for irrigation purposes, frequently causing disastrous floods and at other times deplorable famines.

The Palar.

The Palar is the principal river in the district. It rises to the south-west of Chintamani town in the Kolar district, and after flowing through the North Arcot district, and receiving in its course the Poiney, from the north about 6 miles of Arcot town, enters the district some ten miles west of Conjeevaram. About twelve miles east of the latter place and three miles E.S.E. of Walajabad, it is joined by the Cheyyar at Tirumakkudal, and reaches the sea after a further course of about 30 miles at a place about 4 miles south of Sadras and about forty miles south of Madras. The valley of the river has been cut from its source to as far as Vishar, about 6 miles west of Conjeevaram, in the highly folded Archæan gneisses of the Peninsula, and east of Vishar as far as Walajabad in the Older Alluvium (the Conjeevaram Gravels of R. Bruce Foote) most probably resting on still older jurassic beds. From Walajabad upto about six or seven miles from the coast the valley is again cut in gneissic and granitic rocks, while east of Nerumbur till its mouth it runs through the coastal alluvium mostly consisting of sands and grits with some intercalated clay beds. Hence, the whole course of the river from below Arcot to its mouth is covered by the recent river alluvium of clays, sands, gravels and pebbles, made up of materials eroded by the river in its course through the gneissic rocks above Arcot.

The amount of water in the Palar year by year is by no means constant; frequently, it is not in floods for several years consecutively; but in rare years it continues to be in flood for six months in a year at one stretch.¹⁰ As the gradient of the river after its debouchure to the coastal slope to the sea is rather steep, the current also is very rapid during the floods, thus making it both difficult and dangerous to be crossed. Such floods are caused by sudden and torrential downpours of rain during the N.E. monsoon or during cyclones, and the successive breaching of tanks supplied by it higher up in its course.^{10a}

The Korttalaiyar.

The Korttalaiyar starts as the Kaveripak-nadi in the surplus weir or Kalingula of the Kaveripak tank about eight miles north-east of Arcot, and before it enters the district receives two torrential tributaries the Mahindravadi or Kallar and the Tappur. It enters the district at about a mile east of Manuru railway station between the 32nd and the 33rd mile on the Madras-Arkonam broad gauge, and flows through the Tiruvallur and the Ponneri taluks. At about 2 miles E.N.E. of Takkolam, it is crossed by an anicut, the Kesavaram Anicut, about 18 feet in height above the river bed, which diverts a portion of its waters to the Place's or the Old Bungaru channel. Then it makes an abrupt turn to N.N.E. from a roughly easterly direction and runs on to Krishnapuram, where it is joined by the Nagari river, which has already become fairly important on account of the inflow into it of the waters of the Trittany or the Nandi river. Near Pagalmedu, it is again, crossed by an anicut called the Damarappakkam anicut from the village of that name about 25 feet in height from the river bed, which diverts some of its waters to the Cholavaram tank, and to Velliyur for the irrigation facilities of the villages near about. Besides irrigating the surrounding areas, the Cholavaram tank also supplies the Red Hills lake situated south-east of it through a channel connected to the northern side of the latter, which is tapped off from its southern side by another

10. Cf. "It was expected that the channels from the Palar Anicut would ultimately irrigate an area of 78,668 acres, but it irrigates at present not more than 19,204 acres. From the financial point of view also this system has so far proved a miserable failure."—Hon. Mr. Yakub Hasan in his address to the landowners of the Palar river basin on 22 April, 1938.

10a. B. M. Thirunaranan: *The Rivers of the Palar Basin*, Jour. Mad. Geog. Assn., Vol. XIII, June 1938, pp. 147-160.

channel to supply the Kilpauk water works, which supply the water facilities of the town of Madras. Near the mouth of the Korttalaiyar at Simapuram, this process is again repeated by a small dam across the river in order to irrigate the villages Minjur, Vallur, etc., and it falls into the Ennore backwaters about seven miles north of Madras,¹¹ thoroughly spent up after rendering such good service.

The Cheyyar.

The Cheyyar is the impetuous tributary of the Palar, and it rises in the Javadi hills, and enters the district seven miles east of the town Cheyyar in the N. Arcot district at about 1½ miles west of Perunagar. It is very useful for irrigation purposes in that it fills many tanks in its course by channels leading from it; it joins the Palar about three miles east of Walajabad, at Tirumakkudal.

The Arani.

The Arani (or the Araniyanadi, the Wilderness river) begins as the Narayanavaram river from the quartzitic ranges of that name; it enters the district at Koppedu and runs through the Tiruvallur and the Ponneri taluks, and joins the sea near Pulicat. Its utility is in that it fills in its course several tanks, the important of which are the Nagelapuram tank, the tank near Vadamadurai, the tank near Arani and the one near Perumbedu.

The Cooum.

The Cooum (or the Madras river, or the Triplicane river) starts in the Conjeeveram taluk at the surplus weir of the tank of that name west of Kilacheri, and is joined by the Place's Canal,

11. Recently, in order to store up a permanent supply of water for the city of Madras even in exceptionally dry years when both the monsoons more or less fail locally, it has been proposed to construct a dam of about 50' high between the Rangapuram and the Pundi hillocks, which are about 90' in height above the surrounding region. This scheme will convert an area of about 11.85 square miles into a reservoir submerging several villages completely as Pundi, Rangapuram, Arumbakkam, Kattanur, and parts of Thirupper; Ramanjeri, Pandur, Kamankaranai, Melagaram, Kolandalur, Thiruvananbudur and Kannammapettai. The capacity is estimated to be about 4,400 million cubic feet and the reservoir will be roughly four miles N.E. to S.W. with a maximum breadth of about 5 miles, and hence will not only extend as far as the junction of the Nagari and the Korttalaiyar rivers, but will also stretch for about three miles into the present valley of the Nagari as far as Ramanjeri.

(or the Old Bungaru Channel) and runs through the Tiruvallur, the Sriperumbudur, and the Saidapet taluks and the very heart of the City of Madras dividing it roughly into two halves, the northern and the southern; it joins the sea at Madras, after forming a small 'Island', near the Madras University buildings. Considering its length and size, it is a very important river for irrigation. It irrigates a large number of villages all along its course in the three taluks mentioned above, the more important being Sattarai, Kadambattur, Pinjivakkam, Ariyattur, Kuppam, etc., in the Tiruvallur taluk; Vayalanallur, Nemam, Kuttambakkam, Padur, etc., in the Sriperumbudur taluk and Ayanambakkam and other villages in the Saidapet taluk. A small anicut has been thrown across it at about a mile N.E. of Korattur and its water diverted through the New Bungaru channel to the large Chembarambakam tank, which irrigates a large fertile patch of land including Poonamalle, and Mangadu. At Sittukkadu about $5\frac{1}{2}$ miles N.E. of Poonamalle, it appreciably decreases in width; this is remarkable in that the place appears to mark, in the course of the river, the transition from the river alluvium to that of the coastal estuarine, the latter chiefly consisting of clays.

The Adyar.

The Adyar (or the Saidapet river) has its origin as a small stream in the hill south of Guduvancheri, and is joined by two similar streams, one draining the low ground between Orattur and Arambakkam and the other the region between Vellarai, Sriperumbudur and Irungattukottai including the surplus water of the Sriperumbudur and the Chembarambakkam tanks. But it does not attain any respectable size till it reaches the coastal alluvium half a mile west of the village Anakaputtur. As the level of the water in the stream is usually very low, it is not of much value for irrigation purposes; but, its water is used largely for washing clothes by the dhobies of Madras, at or near the town Saidapet. At its mouth, it widens greatly forming a fresh water lagoon surrounding the Quibble Island, and giving rise to a beautiful scenery ideally suitable for excursions and picnics near Madras.

The Kiliyar.

The Kiliyar Ar originates as the Sukanadi in the high ground and hills near the town of Wandiwash, and is joined by a similar stream a mile north-east of the village Padiri called the Salavemadu, which drains the region south and west of the village

Salavedu. Then it flows into the Madurantakam tank and continues eastward over the kalingula, and joins the Palar a mile east of the village Isur, and about eleven miles from the mouth of the Palar.

The Ongur.

The Ongur river, which forms for some distance the southern boundary of the district, begins as the Nedungal Ar draining the area north-west of the village Nedungal, and is supplemented by the inflow into it of two similar streams, one draining the northern and the other the southern portions of the village Olakkur about a mile north of the village Ongur. Near its mouth its bed becomes very narrowed, and the river here goes by the name of the Athangarai Ar; it embouches into the back-water of Yedyanthittukaliveli east of Chunampet Village.

The Kandigayeru.

North of the Satyavedu hills, there is a torrential stream called the Kandigayeru (or the Yellappanayudupet), which rises in the Nagalapuram ranges as the Sodamakona. It irrigates a few flourishing villages along its valley, as Birakuppam, Pravalavaraneswarapuram, Pandur, Arudur, Varadayyalaiyam and Kalattur. It falls into the Kalangi river about $1\frac{1}{2}$ miles south of the town of Sulurpet, a fairly important town in the Madras-Gudur broad gauge section.

GEOLOGY OF THE REGION.¹²

The following sequence of geological formations is to be met with in the area under review, and they will be considered in order from the oldest to the youngest:—

12. It is assumed that the reader is familiar with the beautiful popular account regarding "The Geographical Evolution of Madras and its Environs" by the late Prof. H. Narayana Rao published in Vol. I of the Jour. Mad. Geog. Assn., 1926-'27, pp. 59-68.

<i>Geological formations.</i>	<i>Age.</i>	
Aeolian formations	Recent	Aryan Era.
Alluvial formations, fluvial, estuarine and marine.		
Detrital or Recemented Laterite	Upper Tertiary (?) & Pleistocene.	
Conjeeveram Gravel and Older Alluvium.		
Compact Laterite occurring over the Jurassic beds.	Cretaceous and Tertiary	
Upper Gondwana formations belonging to the Sriperumbudur and the Satyavedu stages.	Middle and Upper Jurassic.	Purana Era.
Cuddapah formations belonging to the Nagari stage.		
Gneisses and the associated Igneous rocks.	Vedic Era.	

GNEISSIC AND OTHER IGNEOUS ROCKS.

The gneissic rocks of the area with the exception of the Charnockites, which have been described rather in detail below, have not been carefully studied and classified. Beyond the fact that they consist of biotite or hornblende gneisses, mostly granitic in composition with an appreciable proportion of felspar nothing more can be inferred at present. The alteration and weathering of these rocks have, no doubt, given rise to the Conjeeveram gravels and the pure porcellanous Sriperumbudur shales of the area. These gneisses have been folded roughly in the N. N. E., to S. S. W., direction not only before the intrusion of the Charnockites series, but also to a less extent immediately after the intrusion of the Charnockites. As a result of these foldings the Charnockites appear to have formed the core of these mountain chains, and the general trend of the folding may hence be inferred by the present arrangement of the hillocks, which represent the root or stock of the original mountain chains.

Subsequently during the submergence and the deposition of the Cuddapahs, and again during the elevation of the deposits, the

area appears to have been again tectonically affected: the various porphyritic dolerite dykes containing porphyritic crystals of hornblende and felspar to be seen in the Nagari and Tiruttani region, probably, are to be associated with the first phenomenon: and the



Dolerite Dyke across the Nagari Valley below Nagari village.

—Photo by Mr. S. Narayanaswamy.

Cuddapah rocks are nowhere penetrated by these. Two sets of dykes can be recognised one set running roughly N-S with a variation of about 5° east or west, and the other set N. E. to S. W., though both sets appear to be of the same age. As these project out

of the surface for quite a good height forming bold ridges and crests, they form characteristic topographic features of the country. They have been described as forming "one of the most remarkable displays of trappean injection known in any country."¹³

After the deposition of the Jurassic formation and its elevation, there appears to have been no remarkable structural changes in the region.

*The Charnockites.*¹⁴

The various members of the Charnockite series form a closely related group of gneissic rocks, which are found widely distributed in the various parts of South India, and which are distinguishable both in the field and in the laboratory, on account of these possessing some common remarkable, unmistakeable and individualistic characteristics. These common features are so expressive, that the different types in the series itself may be mistaken one for the other, e.g., the acid member for the basic one.

The leading features in hand specimens of the various members are the medium grained texture, the bluish gray to dark green colour, the subconchoidal fracture, and the absolutely fresh condition of the common unaltered specimens. *Quartz* when present is invariably blue in colour; the *felspars* present a similar blue or blue-gray colour, and they may be mistaken for quartz but for their cleavage, lustre and fracture. These two minerals, (which are usually white in colour in acid members of normal igneous rocks) and the black minerals as *pyroxenes*, *amphiboles* and *iron ores*, which are equally abundant, make the acid as well as the basic members look similar in hand specimens.

Microscopic characters are equally distinctive. The constant structure is the granulitic or even grained character of the constituents, and the constant mineral is *rhombic pyroxene*, which is generally pleochroic approaching *hypersthene*, or in some cases *amblystegite* in composition.

13. R. B. Foote, North Arcot District Manual, 1895, p. 14.

14. Sir T. H. Holland: Mem. G.S.I., Vol. XXVIII, pt. 2. The series was so named by Sir Thomas Holland after Job Charnock, the founder of Calcutta, who died in 1693 and whose tombstone, discovered about the time the series was being studied, was found to be made out of this rock brought from St. Thomas Mount, near Madras.

Nearly all the varieties exhibit a linear arrangement of minerals, but the absence of crushing shows that this arrangement of crystals with their longer axes perpendicular to the direction of pressure must have taken place before the complete consolidation of the magma. Those varieties, which show a clearly defined gneissose structure, invariably contain pink garnets.

The Charnockite group of rocks occur in four sharply marked off divisions:—

(1) The Acid division or Charnockite, which is a *hypersthene granite* having a constant specific gravity of 2.67 and silica percentage of about 75. It is typically seen in the central portion of the triangular hill rising to about 250 feet above the mean sea level, south-west of the powder magazine at St. Thomas Mount, a military station eight miles south of Madras. It is cut by coarse quartz-felspar or charnockite pegmatite *contemporaneous* veins. The black minerals, as ferro-magnesian silicates and the iron ores, which are found in mere traces, exhibit a linear arrangement parallel to the general foliation of the country N. N. E. to S. S. W. This rude foliation appears to have taken place before the complete consolidation of the magma. The main mass of St. Thomas Mount is made up of *norite* with plenty of acid veins.

The Charnockite also occurs associated with *Norite* and *Leptynite*, the latter occurring in the junction of the two, near Pallavaram, eleven miles south of Madras; east of the railway station the leptynite forms small rocky ridges and the lower portion or gully is occupied by *norite*; west of the railway station a rather rare charnockite containing biotite and garnet is found; and the small hill near the village of Pammal two miles west of Pallavaram is composed principally of *hornblende-augite norite* with numerous acid veins much coarser in texture than the *norite*; a *pyroxenite* dyke 3 feet to 5 feet in thickness is also found to cut the *norite* branching in a rather ramifying manner. A similar dyke 9 inches in thickness is seen to run N.N.E. to S.S.W. in a hill north-east of Pallavaram railway station. Still further south, about 35 miles from Madras the charnockite forms the crystalline rocks of Mahabalipuram or the Seven Pagodas out of which the various caves and temples are carved. Here, the rock chiefly consists of blue quartz and micro-perthitic felspar, and the latter has been decomposed to fairly great depths when compared to the freshness of the rocks making up the other outcrops. This is, probably, due to the fact that being near the coast the region might have been submerged below the sea during the Jurassic times, when the marine coastal beds on the Coromandel coast were deposited.

(2) The Intermediate division is by far the most abundant, and is characterized by an apparently composite structure, all the minerals of the series being frequently found in the same hand-specimen with a tendency for the coloured minerals to gather into groups. The average specific gravity is 2.77 and the silica percentage is about 64. Acid contemporaneous veins and basic fine grained *schlieren* or *segregation* products are also common. Sheva-roy Hills form the typical exposure. A good number of outcrops of crystalline rocks in the Chingleput and the South Arcot districts, as those in Tindivanam, in Nemmali, in Perumbakkam, in Kunam etc., consist of the intermediate variety.

(3) The Basic division or Charnockite Norite is composed of *hypersthene*, *augite*, *plagioclase* and *iron ores*, often with *hornblende*. The type areas are the flanks of the hill mentioned under (1). Specific gravity averages 3.03, and silica percentage about 50 to 52. The main hill of St. Thomas Mount consists of this variety, which is intruded a great deal by acid veins. This is the variety more frequently used for monumental purposes, tombstones and other ornamental structures in and around Madras; it takes an excellent black polish, which is intensified by coating the polished surface with a very thin film of oil.

(4) The Ultrabasic sub-group chiefly consists of *pyroxenites*, which are composed of *hypersthene*, *augite*, *hornblende* and sometimes with *olivine*, *green spinel* and *magnetite*. Specific gravity is 3.37 and the silica percentage varies between 47 to 50. Amphibolisation of the pyroxenes is common. These frequently occur as dykes in the other charnockite members running parallel to the general foliation and rarely across in a ramifying manner. A pyroxenite dyke 3 feet to 5 feet in thickness may be seen cutting the norite in a ramifying manner in the small hill near Pammal, a village two miles west of Pallavaram. A similar dyke about 9 inches in thickness may also be seen running N. N. E. to S. S. W. in a hill north-east of Pallavaram railway station.

Garnetiferous Leptynite.

Near the margin of Charnockite, where it comes into contact with norite, there occurs a friable cream coloured rock with plenty of pink garnets, which take the place of the usual hypersthene in charnockites. Both in the field and in the laboratory examinations, the rock exhibits signs of dynamo- or pressure-meta-morphism; the weaker minerals have been crushed and are surrounded by granulated selvages: quartz shows very strongly marked undulose extinction, but preserves the bluish gray colour.

The chief minerals found in the Charnockite series are blue, gray or greenish quartz with acicular inclusions of rutile,¹⁵ microcline and microperthite in acid types, labradorite, andesine in basic types, pale green feebly pleochroic hornblende, biotite, graphite, zircon, apatite, and iron ores as magnetite, titanoferrite, pyrite and pyrrhotite. The iron ores are usually found in large quantities and sphene is characteristically absent.

THE CUDDAPAH FORMATION

The quartzites, which go to make up the Nagari peak, near the village of that name, though the peak itself is outside the limits of the district, is worth mentioning; the peak, or the 'Nagari Nose' as it is called, is so high (2814 feet) that it can be seen from great distances. It was a very valuable land-mark to the English sea-men in the early days of the East India Company, the peak being visible even when the ship was 50 miles away.¹⁶ The quartzites belong to the lower division viz., the Nagari stage of the Cheyair series,¹⁷ which is a division of the Cuddapah group of rocks and forms the southernmost outlier of the Cuddapahs.¹⁸ A little further north, the rocks are also seen near Narayanavaram and near Kalahasti.

15. The colour appears to be due to acicular inclusions of rutile. Vide: N. Jayaraman—Pro. Ind. Acad. Science, Vol. IX, No. 3, March, 1939.

16. L. W. Lyde—The Continent of Asia, 1933, p. 470.

17. W. King—On the Kadapah & Karnul formations in the Madras Presidency—G. S. I., Vol. VIII, p. 126. The Kadapah formation according to W. King is divisible into the following divisions:—

Kistna group		{ Sreeshalum quartzites
2,000 feet.	..	{ Kolumnullah slates
		{ Irlaconda quartzites
Nallamullay group		{ Cumbum slates.
3,400 feet.	..	{ Byrenconda quartzites.
Cheyair group		{ Poolumpett slates
10,500 feet.	..	{ Naggery quartzites
Paupugnee group		{ Vainpully slates
4,500 feet.	..	{ Goolcherod quartzites.

18. Some detached gigantic blocks of quartzite are also to be seen apparently below the Jurassic beds of the Allikkuli region in the western portion; these represent the southern-most extension of the Cuddappahs at the present day; but the occurrence of quartzitic boulders in the Allikkuli and the Satyavedu areas indicate an extension of the quartzite beds to these places during the Jurassic times.

while the main outcrop begins at Tripetty and the extreme south end of the Vellakonda ranges and runs on to the type area, Cuddapah, and to a great distance further north to the banks of the Krishna river. The southern and eastern approaches of the ranges are remarkably magnificent and highly picturesque, forming grand scarped white cliffs resembling ramparts. The rocks are mostly quartzites, sandstones, grits and conglomerates with occasional thin bands of slates or slaty shales; the conglomerates consist of pebbles of gneiss, quartz and banded jaspers. The prevalent colours are pale gray, gray and drab, becoming on weathering, buff, or pale brown.

East of the outcrops mentioned above, another important outlier of the Nagari quartzites is to be seen, in the form of an elongated crescent facing westward, the northern part of which forms the Kambakkam Drug and the southern portion the Nagalapuram ranges. As already pointed, these ranges form the highest mountains to be met with in the district itself, the Nagalapuram peak being 2,891 feet. As the Kambakkam durgam itself is 2539 feet, the climate in most months of the year is very pleasant, and the region is probably the nearest rather thickly forested area to Madras. The quartzites rest uncomfortably over the gneiss and frequently also the eastern margin of these is much crushed by lateral thrusts proceeding from the east, so that the dip is not constant. Three sub-stages may be recognised in the area: the bottom-most consists of thick and massive quartzites, sandstones and conglomerates, more cleaved and jointed than the overlying ones. The thickness may be about 400—500 feet. (2) This is overlaid by about 700 feet of banded sandstones and flags, which are in turn followed by (3) which is made up of a thick bed of quartzites including coarse sandstones and conglomerates, which are more ripple marked,¹⁹ but not so coarsely conglomeratic as the lowermost band. The middle band occasionally contains talcose flags, which are occasionally strongly seamed with white quartz. The peak of Nagari Nose consists of the lower most band, and in Ramagiri Malai only the middle division is to be seen; in the other outcrops more or less all the three sub-stages may be recognised.

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19. This reveals that the eastern coast of the Peninsula was determined as early as the Cuddapah times as compared to the west coast which is agreed to have been fixed in the late Cretaceous or in early Tertiary times. Vide also Prof. H. Narayana Rao, Jour. Mad. Geog. Assocn., Vol. I, 1926-'27, p. 62.

THE JURASSIC FORMATIONS

General Distribution.

All the outcrops of the Jurassic beds belonging to the Sriperumbudur and the Satyavedu stages north of the Palar river are found distributed within an area of about 1,000 square miles. The boundary of this extensive patch starting from about four miles west of Conjeevaram at Vishar extends northward along the western base of Allikkuli and the Satyavedu hills; following the foot of the latter hills in the north, it runs eastward along the lateritic outcrops to be found north of the Arani river and following the eastern boundary of these it continues southward to the Red Hills: from there it turns south-westwards and stretches across the Poona-mallee alluvium to Palanjur on the north bank of the Chembarambakam tank, and from there roughly southward to the Appur hills; then it continues westwards to Conjeevaram and a little beyond to Vishar. Besides this wide basin, several detached much smaller outcrops may be recognised south of the Palar: a very small but interesting one is found near Mamandur and Umaiyapuram and about 25 similar patches, all of them situated in the Arcot taluk south-west of Conjeevaram town; three more fairly extensive areas occur further south in the district itself. The northernmost of these is seen between Uttaramerur and Nelvay, the middle one around Padiri and the southernmost around Velangadu west of the Acharapakkam hills. Further, the Jurassic beds appear to extend eastward below the coastal alluvium as revealed by a boring in Ennore,²⁰ and we do not know to what distance into the Bay of Bengal. These detached occurrences in rather widely separated areas clearly show a much greater extension of the beds in the geologic past, these outcrops being either the denuded remains or the inliers covered up by later deposits consisting chiefly of laterites, of this extensive formation, probably deposited in one unbroken stretch along the continental slope of the east coast of the Peninsula. As one could infer from their occurrence in the Allikkuli and the Satyavedu ranges, the depth must be decidedly appreciable; even in the shaly zone at Kilacheri a boring penetrating to a depth of 430 feet did not reach the basement gneiss.²¹

20. Mem. G.S.I., Vol. XXXII, pt. 1, 1901, p. 51.

21. *Ibid.*, p. 78.

Five groups.

From their superficial distribution, the outcrops may be considered in five groups:—(1) the Satyavedu region; (2) the Allikuli region; (3) the Palayanuru region;²² (4) the Sriperumbudur region and (5) the outcrops south of the Palar. The exact relationship of the formations of these five regions could not be made out definitely, due to lack of section showing them in contact; the first area is almost wholly conglomeratic; the second conglomeratic with shaly beds below them; the third, sandy and shaly; the fourth mostly shaly and the last mostly sandy.

Stratigraphic Divisions and Age.

Stratigraphically, the Jurassic beds may be roughly divided into two divisions (1) the lower stage mainly consisting of shale the Sriperumbudur stage and (2) the upper stage made up of conglomerates and sandstones—the Satyavedu stage.²³

Age of the Sriperumbudur Stage.²⁴

The peculiar and characteristic plant fossils (*Pecopteris reversa*, *Taxites planus*, *Gingko crassipes*) occurring in this stage are also to be found in the Raghavapuram stage; and among the ammonites the same form occurs in both the localities. Taken as a whole the plants represent a *mixed flora* containing types belonging to the Rajmahal and the Jabalpur series, but the peculiar forms of the Rajmahal series (e.g. *Macrotaeniopteris*, *Cycadites*, and large *Pterophyllum*) are absent. Hence it is assigned a slightly higher position than the Rajmahal series. The other outcrops which appear to belong to the same age are the Athgarh stage near Cuttack, the

Vemavaram stage in the Guntur district, and the Utatur stage in the Trichinopoly district.

Age of the Satyavedu Stage.²⁵

No definite age can be assigned to the stage as the fossils are too poorly preserved and indeterminate except a *Dictyozamites* but as it lies over the Sriperumbudur stage it must be younger than the latter; hence it is generally considered Upper Jurassic.

22. This corresponds to the Pyanoor division of R. B. Foote, for the Pyanoor village of the Indian Atlas sheet 78 appears to be none other than the Palayanuru village of the One Inch Survey of India sheet.

23. R. Bruce Foote, who recognised the two divisions called them *groups* (Mem. G.S.I., Vol. X, 1873, p. 64; Rec. G.S.I., Vol. III, 1870; pp. 14 & 15). These were afterwards modified into *series* by Sir Thomas Holland and G. H. Tipper (Mem. G.S.I., Vol. XLIII, pt. I, 1913, p. 107; Vol. LI, 1928; p. 155). They were, however, still later designated *stages* by C. S. Fox in 1931 (Mem. G.S.I., Vol. LVIII, 1931, p. 210 & 214).

24. O. Feistmantel, Palaeontologia Indica Series, II, Vol. I, pt. 4; 1879; p. 2.

C. S. Fox, The Gondwana system and related formations, Memoirs of the Geological Survey of India, Vol. LVIII, 1931, p. 214.

25. O. Feistmantel, *ibid.*, p. 3.
C. S. Fox, *ibid.*, p. 214.

Fossils.

The following fossils have been got from the Sriperumbudur stage, chiefly from the N. E. portion of the basin. As the plants are more numerous and more important in fixing the age they are mentioned first :³²—

FERNLIKE FORMS—(FILICES AND PTERIDOSPERMÆ)

Thinnfeldia sp.
Thinnfeldia sp. (*Dichopteris*).
Alethopteris whitbyensis.
Alethopteris indica.
Pecopteris reversa.
Angiopteridium spatulatum
Angiopteridium McClellandi.

CYCADS—(CYCADEACEÆ)

Anomozamites lindleyanus.
Pterophyllum footeanum.
Pterophyllum sp.
Otozamites abbreviatus.
Otozamites rarineris.
Otozamites bunburyanus
Ptilophyllum acutifolium.
Ptilophyllum catchense
Ptilophyllum catchense, var., *minimum*.
Dictyozamites indicus.

CONIFERS—(CONIFERÆ).

Palissya conferta.
Araucarites catchensis.
Araucarites macropterus.
Pachyphyllum peregrinum.
Brachyphyllum sp.
Echinostrobus rajmahalensis.
Echinostrobus rhombicus.

32. O. Feistmantel—Pal. Indica Series II, Vol. I, pt. 4, 1879, p. 3.
 C. S. Fox—The Gondwana system and related formations, Mem. G.S.I., Vol. LVIII, 1931, p. 214.
 F. Stoliczka—Rec. G. S. I., Vol. I, pt. 3, 1868, p. 59.

Various Outcrops in the Madras Presidency.				
Indian Age.	West Godavari and Kistna Dts.		European Age.	
	Guntur Dt.	Chingleput Dt.	Trichinopoly Dt.	
Jabalpur stage.	Tripetty ²⁶ stage.	Pavalur ²⁷ stage.	Satyavedu stage.	Sandstone stage.
	Raghavapuram ²⁸ stage.	Vemavaram ²⁹ stage.	Sriperumbudur stage.	Utatur ³⁰ stage.
Kota Stage.		Budavada ²⁷ stage.		
Rajmahal Stage.	Golapalle ³¹ stage.			
			Portlandian Kimmeridgian	Upper Oolite
			Lusitanian Oxfordian Callovian Bathonian Bajocian.	Middle Oolite
			Aalian Toarcian Charmouthian Sinemurian Hettangian	Lower Oolite
				Upper Jurassic
				Middle Jurassic
				Lower Jurassic.

26. Tripetty or Chinna Tripetty is situated about 24 miles N.E. of Ellore.
 27. Pavalur and Budavada are about 12 miles N.W. of Chinna Ganjam.
 28. Raghavapuram is about 29 miles N.E. of Ellore.
 29. Vemavaram is located about 2½ miles S.W. of Chinna Ganjam.
 30. Utatur is situated about 20 miles N.N.E. of Trichinopoly town.
 31. Golapalle is 12 miles west of Ellore.

Taxites planus.

Gingko sp.

Gingko crassipes.

Of the animal remains a few small indistinctly preserved Ammonites belonging to the Dentate group have been got, one of these is the same as that found in the Raghavapuram and Budavada stages; in addition the following also were present:—

Lamellibranchia:—*Leda*, *Yoldia*, *Tellina*, *Psammobia*, *Lima*, *Pecten*.

Brachiopoda:—*Rhynchonella*.

All the Lamellibranchia are remarkably thin shelled forms, the allied ones of which are to be found at present in the sandy bottom of the sea at depths varying from 8-10 fathoms. Several exhibit a resemblance to specimens from the cretaceous rocks of Trichinopoly, but none appear to be superficially identical.

The plant fossils occurring in the Satyavedu stage are too ill preserved and indeterminate except a Dictyozamites.³³

DESCRIPTION OF THE AREAS

(1) The Satyavedu Region.

The region, though now limited to the Satyavedu hills must have been once continuous with the Allikkuli hills across the valley of the Naranavaram or Arani river. Practically the whole hill consists of very coarse conglomerates, the pebbles varying in size from one's fist to about two feet cemented together by a hard dark purplish, chocolate brown ferruginous calcareous or siliceous cement. The whole area is so covered up by the weathered conglomerates that it is impossible to know the real sequence of beds except very locally. Thus, the weathering of the Satyavedu and the Allikkuli hills has given rise to the pebbly and gravelly laterite covering the greater part of the lower and eastern coastal alluvial plain as far as the Red hills. A fairly good section is to be seen north of Surutapalli³⁴ in the narrow valleys of the S. E. portion of the hills, where three great conglomeratic beds crop out with inter-

33. O. Feistmantel—Pal. Indica, Series II, Vol. I, pt. 4, 1877; p. 3.

34. Surutapalli appears to be the same village as Sirguppilly of Ind. Atlas Sheet 78 and R. B. Foote's description. Sirguppilly finds no place in the One Inch Sheet.

vening less compact conglomerates. The northern part of the hill is made up of a similar very coarse conglomerate exposed in steep cliffs up to 150 feet along the valleys with intercalated beds of sandstones. The sandstone is quarried at various places for building stones or for making into shallow water-tubs, which are used by the villagers in the feeding of their cattle. Such quarries may be seen at Surutapalli, near Satyavedu and along the road from Satyavedu to Kannavaram. The sandstones which assume various colours as deep red, purplish red, reddish yellow etc. are soft possessing little or no lamination and contain frequently pebbles of quartzite.

Though the general dip is 10°—18° eastward or south-eastward, it is very varying; north-east of Surutapalli it is 10°—12° S.S.E.; about 3½ miles north-east of Tripurantakapuram, the coarse conglomerates, resting on horizontal quartzite beds of the Cuddapah system, show a dip of 5° N.W.; near Satyavedu it is 5°—10° N; and on the western portion 5°—10° W.S.W.

No fossils are usually found either in the sandstones or in the conglomerates; but in the quarries along the road from Satyavedu to Kannavaram and in those about 2 miles S. W. of Satyavedu in the yellow sandstone associated with the reddish brown or purple variety, fragmentary plant remains have been reported.

(2) The Allikkuli Region.

This area comprises the Allikkuli hills and the outcrops occurring north of the Nagari and the Korttalaiyar rivers, where both the Satyavedu and the Sriperumbudur stages are represented. The compact conglomerates which, as already pointed out, must have been once continuous with the Satyavedu area, is underlaid by friable sandstone conglomerate; the junction between the conglomerate and the sandstone is impossible to be made out on account of the conglomeratic debris; but it is very probable that the transition occurs in the valley north-west of Hadsanpuram; for, two miles due north of this place are to be seen the westernmost and lowest conglomerate beds which present as one proceeds eastward several escarpments.

The last and probably the thickest of the conglomerate beds is very remarkable in that it forms a deep ravine opening eastward formed by a non-perennial rivulet. The head of the valley is circular and amphitheatre-like with a diameter of about 250 yards; the depth of the ravine with vertical sides may be about 125 feet; the amphitheatre is by no means open and empty, but contains

here and there huge blocks of conglomerate with vertical or steep sides. On the southern side of the amphitheatre is to be seen a large and spacious cave which in ground plan is a shallow crescent,



Sandstone bed intercalated between conglomerate beds in a quarry near Allikkuli.



Eastern portion of the Allikkuli Cave.—Note the roof of the cave sloping in the direction of dip.



Weathering of the Upper Jurassic or the Satyavedu conglomerate in the Allikkuli region.



Caves adjacent to the main Allikkuli Cave.

—By Mr. B. M. Thirunaranan.

the chord of the arc measuring about 230 feet, the greatest breadth being about 65 feet. The height of the arch-like entrance, the margin of which is not definite but rounded and steeply sloping

with vertical side of the cliff higher up, may be about 30—40 feet; but the height of the roof of the cave is varying so much so at the farthest end it decreases to 4 or 5 feet: similarly the floor is not a perfect horizontal plane but gently sloping towards the entrance. The cave is cut entirely in the coarse boulder conglomerate, so that the roof, the sides and the floor consist of very coarse quartzite boulders or pebbles. There is no kind of deposit or encrustation except decomposing bats' dung on the floor and innumerable wasps' nests on the roof. The floor is abundantly strewn with loose large pebbles disintegrated from the conglomerate bed and from the roof trickles down, at several places, small quantities of deliciously cool clear and sweet water, which is collected in small earthen pots by the goat-herds and villagers, who frequent the place evidently for drinking. The floor is gently wet and cool; the air is soothing and pleasantly moist and the inner portion of the cave, as the inner walls and floor, is overgrown by ferns: in short, to take rest there on a hot summer day is marvellously pleasant and exhilarating. As a place suited for excursions and picnics, few places near Madras could be compared with it. Besides, the place is reached not with much difficulty from Gunipalaiyam, a village situated on the eastern side of the ranges along a foot-path in the mostly dry rivulet mentioned earlier. The distance is slightly over three miles.

Just away from the entrance of the cave at the head of the valley, the small rivulet forms a small waterfall, falling down the straight precipice. When one climbs up to the top of the precipice through narrow passages overgrown with thick and luxuriant vegetation, it will be seen that two small rivulets converge to the waterfall, draining two or three shallow valleys. There is not the least doubt that in the rainy season the amount of water in the waterfall and in the rivulet must be fairly abundant, and hence, must scour a good portion of the cave floor.

The formation of the cave is a problem. Foote felt that the river was too small a factor to carve this piece of magnificent geologic architecture and he thought that during the formation of laterite (which was according to him marine in origin) in the coastal plain, the sea must have entered the land and not only eroded the valley but also scooped the cave by marine and surf action.

The following facts appear to the author of the paper as relevant in explaining the origin of the cave:—

1. There is absolutely no evidence of any marine fossils in any part of the valley; nor is there any evidence of an existence of a beach in front of the cave or elsewhere in the valley.

2. Conglomerate is a rock which offers very little resistance to weathering agencies; it can be disintegrated merely by solution or weathering of the cement between the pebbles and boulders. So, it is extremely unlikely that the whole formation would have withstood marine action, had the sea extended so far inland. It was already pointed out that the amphitheatre was not open and empty, but strewn with huge cliffs of conglomerate here and there. These could not have withstood marine action.³⁵

3. It has been pointed out that huge blocks or precipices of boulder conglomerate 70 or 80 feet high with vertical sides may be seen both in the Satyavedu and the Allikkuli hills; if the formation of all these could be explained as due to weathering and river action it appears also possible that the amphitheatre could have been formed in the same manner by the same agency. Indeed, one could see in the vertical sides of the precipices at the head of the valley near the water-fall several narrow vertical crevices extending from the top to the very bottom, widening at intervals and leading into dark huge caverns. Roots of some trees situated at the top of the cliffs have sunk in their roots along these crevices to the very bottom of the valley; hence, it is likely that plants also to a subordinate extent, might have helped in the widening of cracks and crevices.

It was also stated above that just beyond the mouth of the cave there was a small water-fall formed by two rivulets joining together at the top of the precipice and that during the north-east monsoon the volume of water must be so appreciable as to scour a portion of the floor of the cave. Hence, it appears very likely that the stream must be considered as responsible for carving not only the whole valley, but also must have helped in the formation of the cave; the gentle slope of the cave-floor to that of the valley further favours this view. Besides, we do not know at present definitely the climatic change in this region during the Pleistocene

35. For this reason the author is indebted to Prof. C. K. Krishnaswami Pillai who also favoured the solution and erosive origin of underground and river water in his presidential remarks, when the author expressed his views at a meeting of the Mad. Geog. Association.

and late Tertiary times. Those workers, who have bestowed some attention on the Pleistocene period of South India, undoubtedly feel that at least two moist or humid periods may be recognised, when the climate must have been much more moist than at present. Thus, it appears that the rivulet must be considered a decidedly potent factor in the formation of the valley and the cave.³⁶

4. Those who have visited the cave even in the summer, would have noticed the moist environment of not only the cave from the roof of which, there was a continuous dripping of deliciously cool clear, and sweet water, but also of the shallow valleys above the precipice; even the narrow passage leading to the top of the cliffs was thickly overgrown with luxuriant vegetation with broad leaves. This clearly indicates that underground water is rather plentiful. The percolating water in the quartzite boulder conglomerate must necessarily do so through the cementing material and in so doing would easily loosen the large round smooth pebbles; this partly explains the occurrence of pebbles all over the area in such abundance. The villagers also testify to the fact that sometimes pebbles fall down from the roof of the cave and innumerable impressions of such fallen pebbles singly or in masses, may be seen in the roof; the floor also is quite completely covered over with pebbles and boulders.

As the percolating water will find it easier to work along the dip slope of the bedding planes, it will be observed that the roof of the cave also over large portions follows the dip of the beds; the dip is roughly eastward and though the bedding planes are not well marked, on account of the coarseness of the boulders, yet they could be easily recognised. Higher up on the escarpment side of the hill in two or three such hollows, cool clear water stagnates in which plenty of algae, of which the easily recognisable is *Chara*, is to be noticed.

5. It was described above, that the margin of the arch-like entrance of the cave is not definite, but that the roof of the cave steeply slopes to the vertical side of the cliff. In the case of marine and surf action there will be no appreciable erosion above the reach of the waves in storms or in high tides and hence this parti-

36. Vide F. J. Richards, L. A. Cammiade and M. C. Burkitt—*Geol. Mag.*, Vol. LXIX, pp. 195-205, 1932.

V. D. Krishnaswami, *Jour. Mad. Geog. Assocn.*, Vol. XIII, pp. 58-90, 1938.

cular feature observed cannot be explained. The steep inward slope appears to be due to the dissolving and weathering action of rain on the sides exposed during the monsoon times; it was pointed out that the cave faces northward and that the trend of the valley is roughly E. to W. This is not the only cave to be seen in the area though this is by far the largest; several small narrow caves much less in breadth could be seen, one in the valley itself further down at approximately the same level and two or three in the lower conglomerate beds above the water-fall.

6. The last factor, viz. the occurrence of caves at all heights clearly indicates a non-marine cause, as in the latter case all will be situated at the same level, namely, within the zone of marine or wave action.

As the result of the enormous quantity of conglomerate debris the real sequence of beds is very difficult to be made out. In the cliffs opposite the cave two lenticular inaccessible patches of sandstone may be seen intercalated with the coarse conglomerate; about two miles north of the Forest Rest House at Allikkuli village, a quarry has been opened out for the quarrying of sandstone which is fine grained and compact with purple or brown wavy bands and resembling in every respect the Satyavedu sandstone. There are practically no good sections revealing the relationship of the conglomerate and sandstone bed with the Sriperumbudur shales and that of the latter with the gneisses or the Cuddapahs. (1) In the off-flow channel bund of the Allikkuli village tank are exposed beds of soft clayey grit mottled white and brown underlaid by moderately coarse bed of uncompacted quartzite shingle conglomerate. (2) On the west side of the Allikkuli hills one and half miles north-east of Kaliyambakkam in a rain-gully about 25 feet in depth are exposed large conglomerates of quartzite and granite boulders with a clayey matrix similar to those underlying the Sriperumbudur beds. (3) Immediately east of Surikapuram also west of the ranges a micaceous schist is seen in contact with the Sriperumbudur stage, the former dipping at very high angles towards north-west, and intruded by trap dykes. (4) What appear to be huge blocks of the gray and white Cuddapahs partly disintegrated before the deposition of the Jurassic beds are to be seen between Illaturu and Kosalnagaram;³⁷ the quartzite blocks are seen to dip north at

37. Naikenpollam of R. B. Foote's description and Nakinpollum of Indian Atlas sheet 78 coincide with Kosalanagaram of the One Inch sheet. Evidently the name of the village has been changed.

gentle but varying angles and a good number have been tilted at high angles in various directions. (5) Sriperumbudur shales inter-layered with sandstones may be seen in a ridge about a mile north-west of Kosalnagaram; the shales have yielded a good number of fragmentary plant fossils. (6) In the southern extremity of the ranges close to and south of Sriharipuram³⁸ the gneiss is seen in a deep rain gully very near to the shale outcrop, though not in positive contact with it. (7) The stage which is arenaceous including granitic pebbles is also exposed in three or four places between the Allikkuli ranges and the Nagari river below the laterite, chiefly along the valleys of nullahs, (a) near Sriharipuram (b) along the large nullah which feeds the Kanjinadi tank (c) along the off-flow channel of the tank at Mallareddikhandrika (d) in a well section west of Ramanieri, where some pieces of silicified wood were found (e) and in a well a mile N.N.W. of Tomur where a few unrecognisable vegetable impressions were got. (8) The white or gray shales which appear to overlie the gritty or coarse conglomerate just described are displayed along the several nullahs south-east of the Allikkuli ranges draining into the Korttalaivar river (a) along the Kallaur or Allikkuli channel (b) along the Attirambakkam nullah and (c) along the Odappai and Meyyur nullahs. These shales are poorly fossiliferous and yielded only a small shell resembling *Lucina*, a fragment of an *ammonite* and indeterminably obscure plant remains.

Doubtful outliers of the Sriperumbudur stage consisting of whitish shales or buff coloured friable sandstone with small ferruginous concretions occur south of the Korttalaivar in several places (1) two miles south of Kallikuppam. (2) N. W. of Mittanemeli, (3) south of Puliyur. (4) at Tirumallaivayal and along the railway cutting near Avadi railway station.

The general dip of the coarse conglomerate in the main portion of the Allikkuli ranges is towards E. or S. E. at varying angles between 5° - 39° and of the sandstones and shales at Kanjipadi 15° - 20° E.S.E. However, east of Kosalnagaram it is 25° - 30° N.N.W. and N.W. of it 30° E.N.E.

38. Sriharipuram of the One Inch sheet coincides with Waterpollam of Sheet 78, and of R. B. Foote's description; evidently a more dignified name has been given to the same village as it became larger.

(3) *The Palayanuru Region.*

The southern central portion may be called the Palayanuru region, and this includes the various outcrops of the Sriperumbudur and the Satyavedu stages in and around the village Palayanuru found distributed within the angle formed by the junction of the Nagari and the Korttalaiyar rivers. The rocks are chiefly friable sandstones, sandy shales, pebbles and boulder beds belonging to the Sriperumbudur and the Satyavedu stages. As the rocks are covered up by later shingly lateritic conglomerate in several places, the outcrop skirts along the alluvium of the Nagari and the Korttalaiyar valleys. Hence, hardly a good section is available and the nature and distribution of the deposits may be made out only with the help of well-sections. West and south-west of Palayanuru, the belt widens considerably. The general dip is as usual roughly easterly at varying small angles 6°—16°, but local variations are very common.

The best section is to be seen at a low cliff of about 15 feet high near Krishnapuram³⁹ on the south bank of the Nagari river at its confluence with the Korttalaiyar; the same section on a smaller scale may be seen on the northern bank of the river also; the beds consist of a lower layer of boulder bed, followed by friable gritty sandstone with intercalated sandy clay, and is overlaid by quartzite and lateritic shingle. The friable sandstones in the northern exposure have yielded some plant remains. On account of the boulder bed containing large gneissic boulders, it has been possible to recognise it either occurring alone or associated with sandstone at various places as: (1) in the off-flow channel, north of the great tank at Palayanuru, (2) at the north end of the Uriyur tank consisting of shales and sandstones, (3) in the form of large gneissic boulders associated with gray or drab sandstone on the western edge of the rather elevated ground at Kanjampattu, (4) in the projecting granitic or gneissic boulders in the lateritic formations of the high ground south of the railway line near Harichchandrapuram,⁴⁰ close to the Tiruvelangadu railway station; north of the station also the boulder bed is exposed but not so pro-

39. This coincides with Kistnahporam of the Indian Atlas Sheet 78, and appears to correspond to Chittapuram of R. B. Foote's description.

40. The original name of this village appears to have been Catramatoor which is to be found in the Indian Atlas Sheet 78 and also in R. B. Foote's description.

nounced, (5) further westward at Mosur⁴¹ village numerous large rounded blocks of gneiss occur which appear from their position to have been once included in the friable sandstones, (6) in the elevated portion between Mosur and Harichchandrapuram great boulders of gneiss appear on the surface "through the lateritic gravel, some of such size as to suggest the idea of their being surf-worn pinnacles of the underlying granitic rocks". The boulders are chiefly of granite gneiss so large in size as to measure one foot to easily more than five feet in diameter so that many of them have been used by the Prehistoric people to form their "Kurumbar rings"; where the boulders are of quartzite the size is smaller attaining up to one foot in diameter.

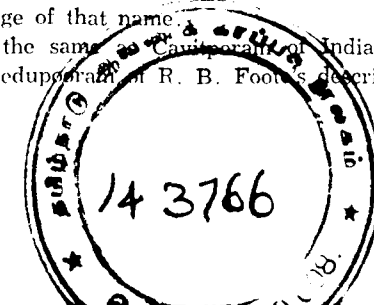
But the great extension of the conglomerate mixed with sandstone may be inferred from several well-sections as (1) in those to be seen about a mile south of Krishnapuram (2) in those of the high ground north of the village Kaverirajapuram,⁴² (3) in those near Palayanuru, (4) in a well between Palayanuru tank and the temple at Tiruvelangadu village and in other wells slightly westward of it, (5) in those to be found north of Palayanuru and in another north of Toidavaru, all exposing friable or micaceous sandstone; in the former locality it yielded a few brittle fragmentary plant remains and two distorted bivalves, (6) those at Attipattu from which some large boulders have been dug out; (7) in a well S.E. of Mosur exposing a pebbly conglomerate bed of about 12 feet in thickness and (8) in an old ruined well situated about 2½ miles north of Takkolam revealing friable sandstone including quartzite pebbles of about 7-9 feet in thickness.

(4) *The Sriperumbudur Region.*

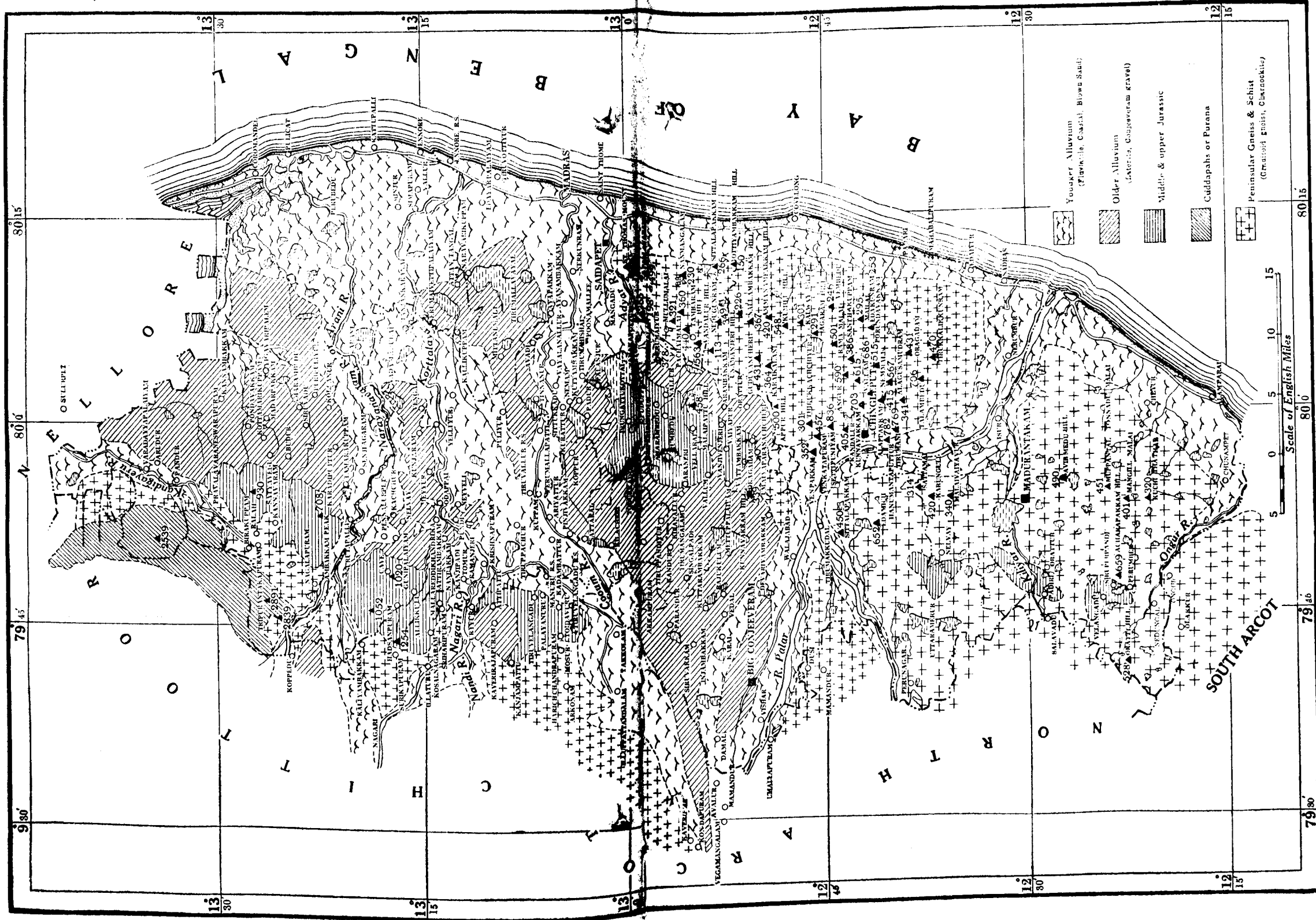
This area includes the Sriperumbudur or Kota stage occurring immediately around the town Sriperumbudur. Two sub-stages seem to be present the exact relationship of which is not known due to lack of sections showing them in contact: the one stage includes the plant shale beds with some underlying gritty sandstones mainly seen in the northern part of the area: and the other stage is seen in the southern portion consisting of grey clays reddish or purplish gritty sandstones and buff coloured arenaceous

41. Mosur is also a railway station on the Madras-Arakonam line situated half a mile west of the village of that name.

42. This appears to be the same as Cavitpooram of Indian Atlas Sheet 78, and Cavitpooram or Kaveduppooram of R. B. Foote's description.



A GEOLOGICAL MAP OF THE NEIGHBOURHOOD OF MADRAS



shales very unlike the shales and grits occurring in the northern stage.

The Northern Part.

The best section in the northern part of the area occurs on the flanks of a small hillock, six miles due south of Sriperumbudur town, and half a mile S.W. of Vallakottai village, where a few gritty sandstones and gritty shales occur overlaid by pure white compact porcellanous plant shales followed by lateritic conglomerates with palaeolithic implements. The same beds may also be seen on the banks of the Kambakkal channel running into the Sriperumbudur tank, about half a mile west of the travellers' bungalow at Sriperumbudur. The compact shales contain a good number of fragmentary and beautifully preserved plant fossils, but these are rather difficult to be obtained on account of the too compact nature of the shales. The shales are also seen at various places of which the more prominent occurrences are:—(1) in the bed of the big tank at Sriperumbudur when dry, (2) in the northern end of the same tank near the off-flow channel where it appears to be tilted to a vertical position; (3) in wells south-west of the tank from where several fossils were obtained in the unusually compact shales; (4) in a small shallow gully close to Todukkadu; (5) at Araneri three and a half miles south-west of the traveller's bungalow at Sriperumbudur; and (6) in the south end of the tank at Vallum in a rain gully. In the last two areas the shale beds definitely rest on grits; and near the last outcrop lies a silicified tree trunk one foot in diameter and about a yard long. Thus the whole of the northern half of the Sriperumbudur area appears to be occupied by plant shale beds and the high ground east of Araneri and north of Vallum the outcrop is free from lateritic capping affording good exposures. Further west at Tirumangalam, Kiranallur, Kandur and Tiruppaniyur⁴³ only the grits are exposed below the lateritic conglomerate as the shales seem to be denuded away.

Further east all along the nullah at Amarambedu from near Sriperumbudur to half a mile west of the Chembarabakam tank,

43. The village Punnoor of Indian Atlas Sheet 78, described by R. B. Foote is not to be seen in the One Inch Sheet but Tiruppaniyur appears to coincide with it; evidently the village has changed its name since R. B. Foote's description.

in the tank bottom at Nallur⁴⁴ one and a quarter miles E.S.E. of Amarambedu and in Puduppper in the north-eastern end of the Sriperumbudur area, a clayey shale is seen overlying the porcellanous variety described before separated by a band of large ferruginous rudely lenticular concretions, many of which measure 2 to 3 feet in length and 1 to 2 feet in width; these are very rich in fossils. The clayey shale itself is practically barren of any fossils. An abundant collection of marine fossils, in addition to plants and silicified wood, have been got in the concretions exposed in Vellarai, Nallur and Amarambedu.

The Southern Part

This part differs from the northern one in being occupied by a series of grits, sandstones and sandy clays, the exact relationship of which to the Sriperumbudur shales is not possible to know due to lack of sections in the intervening regions between the areas occupied by the former and the outcrops of the latter described above. But the likelihood is that the former is younger. Topographically also the southern half is separated from the northern Sriperumbudur basin by a rather high ground about half a mile north of the road leading to Walajabad.

The only good section can be seen at about a mile north-west of Umaiyaparanachcheri in the north side of the southernmost promontory of the Oragadam lateritic high ground close to the village of Vattambakkam. The thickness of the beds may be more than 30 feet made up of a variety of beds chiefly brownish reddish or whitish sandstones alternating with sandy, white or pale buff shales; the white and pale buff arenaceous shales occurring at about ten feet from the bottom is very fossiliferous: but the fossils are too difficult to be preserved owing to the very friable nature of the rock. The dip is 5°—10° east or east-south-east. No doubt the same series of beds continue northward as far as Vaiyapur and then westward to Mettupalaiyam occupying the whole of the high ground. In the bund of the tank south of Vaiyapur a yellow sandy shale outcrops, which is also fossiliferous. Further southeast a pale brick red sandstone underlain by large gneissic boulder conglomerate is exposed in the bed of a nullah at Orattur. The beds are interesting in that the dip is westerly. South-east of and close to

44. Nallur is not marked in the Indian Atlas Sheet 78, but appears closely to approximate the position of village Bootundalum. It is, however, marked in the One Inch Sheet.

Vanjivanjeri⁴⁵ in an area of about an acre, occur large angular weathered blocks of a very coarse compact conglomerate of quartzite pebbles associated with yellow sandy clays described above at Vaiyapur. Nothing definite can be said about this conglomerate except that they resemble most in mineral character the Satyavedu conglomerate.

Outliers of the Sriperumbudur stage in the Region.

Outliers of the Sriperumbudur stage are to be seen at various places north-east, north, north-west and west of the principal outcrops described above. The first is displayed south of Sattarai tank, about 12 miles north-west of Sriperumbudur, below the laterite in a series of headlands rising out of the alluvium of the Old Palar valley. Several plant fossils have been got from the ferruginous concretionary sandy shales associated with the grey shales exposed on the south end of the tank; the beds dip at 4° or 5° in a more or less easterly direction. Further south a friable sandstone bed appears to overlie the shale beds and this is exposed at the northern end of the tank at Kilacheri where the general dip is 8° or 9° east, but in the west of the section the dip is about 2° west. Whether this is due to a small anticline or mere undulation is not definitely known. (2) An extensive series of sandstones, grits and shale beds about 100—150 feet in total thickness is exhibited at Palanjur⁴⁶ in an artificially made section for the channel (Bangaru channel), which leads the Cooum waters to the large Chembarambakkam tank; a few *Estheria*-like forms and a cast of a bivalve were found there. (3) A series of sandstones and shales occur at Koppur about ten miles north-north-east of Sriperumbudur along the bank of a large nullah north of Koppur. The beds dip at 3°—5° north or north-east. Though only fragmentary badly preserved plant remains were reported by Foote, more plant and animal fossils are likely to be available there. (4) These shale beds appear to continue further north beyond the narrow alluvium of the Cooum and are exposed in a small rain gully falling from the south into a

45. Vanjivanjeri is not to be found either in the Indian Atlas Sheet 78 or in R. B. Foote's description; but Foote mentions a Vanjeri which is also not to be seen in Sheet 78. From the similarity in name together with the occurrence of the village in the area under review, I have taken Vanjivanjeri as the same as Vanjeri.

46. Palanjur of the One Inch Sheet appears to coincide with the position of Panjur described by R. B. Foote; the village finds no place in the Indian Atlas Sheet 78.

small tank east of Perumallapatti four miles W. S. W. of the Tinanur railway station, 18 miles from Madras in the Madras—Arkonam section. (5) West of Sriperumbudur very friable and highly micaceous or gritty sandstones were met with in Kuttarambakkam on the sides of a small village tank and near Rajukulam along a rain gully joining the feeder channel of the large Tenneri tank. Though the sandstones were not fossiliferous the associated ferruginous concretionary sandstones have yielded ill-preserved plant remains and a cast of a gastropod. A very similar friable sandy bed was also met with in a well-section about a mile east of Vishar below 8 or 10 feet of gravel (Conjeeveram gravel of Bruce Foote); this probably represents the westernmost extension of the Sriperumbudur stage.

(5) *The outcrops south of the Palar.*

In addition to the four major outcrops north of the Palar described above, outcrops of the Jurassic rocks are to be found in the form of a large number of small patches south of the Palar. Of these a fairly important one is to be seen around the Mamandur tank west of the village of that name referred to as the Mamandur group by Oldham⁴⁷, while a little S. W. of this three more patches may be made out; in all about 25 very small patches have been identified in the Arcot taluk. Oldham reported several plant fossils (*Ptilophyllum*, *Pecopteris*, *Sphenopteris*) from the little yellow sandstone to be seen in a small tank west of Dusi village when the water is low and also from the materials taken out of it in deepening. These fossils, which are all land plants, mostly occur in thin bedded sandstone, but some have also been got from the coarser variety. The best section is to be recognised four miles west of Dusi along the supply channel from the Palar near Umaiyapuram to the Mamandur tank.

Three more fairly extensive outcrops of the Jurassic beds are shown in the Geological map south of the Palar. The beds mostly consist of buff, friable sandstone containing plenty of vague carbonaceous or vegetable markings; though in lithological characteristics they resemble the Jurassic formations occurring north of the Palar, no definite fossils seem to have been reported. It is likely that a careful search will reveal at least some fossils. The first one occurs east of the Uttaramerur and west of Nelvay with an approximate width of three miles east to west; the extreme length of the patch which is triangular with concave sides may be about five

47. North Arcot District Manual, Vol. I, pp. 18 and 19 (1895).

miles. The next one is to be seen around Padiri and west of Oratur; it is rather an elongated oval, the longer axis running N.E. to S.W. about six miles in length with the same breadth as in the last case; the southernmost outcrop of the district is to be recognised around Velangadu north-west of Perumberkandigal and west of the Acharapakkam hills; it is also more or less crescent shaped, but the concave side faces south-west; the yellow friable fine sandstone may be made out clearly in many well sections in and around the village Siruperpandi.

THE LATERITIC FORMATIONS.

Laterite⁴⁸ is a reddish to brownish clay-like residual rock⁴⁹ containing a good percentage of iron in the form of hydrated oxide or limonite; it is remarkable for its tendency to form concretionary, conglomeratic or gravelly masses abounding in vesicular, vermicular and scoriaceous cavities. When freshly quarried, it can be easily cut with a spade or axe but on exposure to weathering agencies most varieties harden due to dehydration and the vesicular

48. The term was first applied by F. Buchanan on account of the great usefulness of the rock as a building material in several parts of South India (Latin: *Later*, *Lateris*—a brick). "The most proper English name would be *La'eterite*, from *Lateritis*, the appellation that may be given to it in science"—F. Buchanan, "A Journey from Madras through the countries of Mysore, Canara and Malabar", 1807, p. 440.

49. Clay also is a residual product of decomposition of rocks, the composition being $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$; but the distinction between clay and laterite is the small amount of combined silica in proportion to Al_2O_3 to be found in the latter. Cf. "Now clays are to be regarded as the end products resulting from one mode of superficial decomposition of rocks; and laterites as the end products of another totally distinct mode of decomposition. When a rock breaks down into clay hydrated aluminium silicate is to be regarded as the pure end product, all oxides being removed in solution. When a rock is converted into *laterite* on the other hand, the reverse holds; aluminium and the other silicates are decomposed and the silica is removed in solution, presumably in the colloidal form, whilst the oxides of iron, aluminium, titanium and manganese, which were relatively soluble under clay-forming conditions are relatively insoluble under laterite-forming conditions. The oxides of calcium, magnesium, sodium and potassium are separately soluble under both sets of conditions . . . Pure clay then is hydrated aluminium silicate, while pure *laterite* is a mixture of one or more, or all of the oxides of iron, aluminium, titanium and manganese more or less hydrated, which I refer to in this paper as the lateritic constituents".—L. L. Fermor, *What is Laterite?*, Geol. Mag., Vol. VIII, 1911, p. 459. Vide also J. W. Evans—The meaning of the term "*Laterite*", Geol. Mag., Vol. VII, 1910, pp. 189 and 190.

and vermicular appearance becomes pronounced as the result of removal of softer clayey material in the pores and tubes. In course of time, it also gets coated, probably by capillary and segregative forces, with a dark brown or black smooth coating of iron oxide, which forms a protective layer against further atmospheric action. On account of its scabrous appearance, it is called in Tamil, *Chorikal* (சொறிகல்) or itch-stone. There is every gradation between this relatively hard compact variety to loose pisolitic gravel, which often passes into red coarse or fine sandy-clay or sandy loam.

The origin of laterite has long been a subject at issue, and it is not the aim of the present paper to enter into a discussion regarding the same. But what appears to the author as the most probable and what is accepted by most geologists at the present day is that laterite is formed as the result of decomposition of almost any kind of rock (unless it is one containing no trace of Fe. or Al. e.g., pure Limestone) *in situ* as the result of segregative and capillary action of percolating or underground water under certain conditions which are⁵⁰:—

50. C. S. Fox: "*Bauxite*", Crosby Lockwood & Son, 1927, p. 27. Also Mem. G.S.I., Vol. XLIX, pt. 1, pp. 6—10, 1923. Cf. At least in some localities laterites will have to be considered as not a direct weathered product but due to metasomatic or mechanical replacement.

The conditions for such a replacement according to M. Maclaren are as follows:—

1. Lateritic deposits are restricted geographically, because they require for their formation:—

- (a) Tropical heat and rain with concomitant abundant vegetation.
- (b) Alternating wet and dry seasons.

2. Their restriction in altitude is only apparent. Their present lines of alteration merely mark ancient or existing basin floors or plains.

3. They are derived from mineralized solutions brought to the surface by capillarity, and are essentially replacements (either mechanical or metasomatic) of soil or of rock decomposed *in situ* or of both.

4. In the humid regions of India the tendency of change in laterites is towards hydration and not towards dehydration." Geol. Mag., Vol. III, 1906, p. 546.

L. L. Fermor also corroborates with the conclusion of M. Maclaren in the formation of those lateritic deposits to be found over the Dharwar formation.

L. L. Fermor distinguishes between the following types of Laterites: (1) *Typical laterite* containing 90-100% of lateritic constituents; (2) *Quartzose laterite* with 50-90% of lateritic materials, but rich in quartz; (3) *Lithomargic laterite*, rich in Kaolin or litho-marge with 50-90% of lateritic constituents; (4) *Detrital laterite* when mixed with extraneous materials, but

(i) A tropical or subtropical climate subject to dry and wet seasons or monsoons alternately.

(ii) An elevated level or gently sloping land surface imperfectly drained and subject to not appreciable denudations.

(iii) The more rich the exposed rock is in alumina, iron oxide or TiO_2 or MnO_2 , the thicker the depth of laterite.

(iv) The infiltrating water to remain for fairly long periods so that the interspaces of the weathered rock are filled with it, but to drain away or dry up in the hot season.

The areas occupied by laterite are usually very barren and stony except for, here and there, a few large trees; but in the Allikkuli and Satyavedu areas, it is covered by scrub jungle. Shingly to pellety lateritic areas are characteristically barren and highly slippery due to the smooth rounded nature of the pellets.

Age.

Most of the laterite found near Madras are secondary or detrital in origin with the possible exception⁵¹ of those to be found over the various Jurassic formations consisting of a fairly compact nature (however, *vide infra*). As the present climate of the east coast is not moist enough to give rise to laterite, the age of the massive and compact laterite must be at least Pleistocene, when the climate must have been moister; or earlier than the Pleistocene. Anyhow, it cannot be older than the lower Cretaceous,⁵² while

containing 40-100% of lateritic constituents. Poorer varieties may be described as lateritic litho-marge, lateritic sand and lateritic soil.

51. Speaking of the laterites of the Madras Presidency, Mysore, Coorg, and Travancore, C. S. Fox states: "It is not necessarily all detrital laterite, but possibly the lateritised soil and debris which was left in isolated patches in situations suitable for lateritisation during the process of denudation of the whole country". Mem. G.S.I., Vol. XLIX, pt. 1, 1923, p. 187.

52. A somewhat similar view has been expressed by C. S. Fox, who states "that there is no laterite in India which is older than the beds of Upper Cretaceous age although there are laterites of all subsequent epochs and laterites in process of formation to-day."—C. S. Fox: "Bauxite", 1927, p. 27, Crosby Lockwood & Sons.

He also states elsewhere that "in India there is no record of lateritisation earlier than the beginning of the Eocene times," (Mem. G.S.I. Vol. XLIX, pt. 1, 1923, p. 44) because the formation of the Arabian Sea and hence also the monsoonic conditions in most of the Deccan area dates only from the breaking up of the Gondwana land at the close of the Cretaceous period. But it appears probable that the monsoonic conditions might have begun

possibly some of the detrital laterite covering a wide region may date from that period, it appears to belong mostly to the Pleistocene.

The lateritic formations rest unconformably in most places where they are detrital on denuded older formations as the Sriperumbudur shales, or the gneisses. In the Allikkuli and the Satyavedu areas there appears to be a gradual transition between the Jurassic conglomerates and the overlying laterite conglomerates, so that the latter appear to be a mere disintegration product of the former. It is interesting to note that in most cases they rest upon the upper Gondwana outcrops unconformably, and in many cases they also overlap on to the gneisses.

No fossils have been found in the laterites, except some secondary ones as silicified wood, washed up from older formations. But a large and interesting collection of Palaeolithic implements have been got from them at various depths in the detrital laterite. Though the area covered may measure several hundred square miles, the thickness of the formation is very meagre ranging from a few inches to a few feet.

Superficially the lateritic exposures fall into three divisions viz.: (1) those consisting of solid or recemented compact laterite (2) coarse conglomeratic laterite and (3) shingly to pellety laterite. No definite stratigraphic relationship has yet been made out between the three divisions, except that the first appears to be the basement plateau of the early Pleistocene times gently sloping towards the sea, consisting at various places and at various levels of coarse conglomeratic laterite containing angular fragments and of the shingly to pellety laterite, the former probably being the result of rapid sub-aerial weathering and the latter probably as detrital material deposited along gullies and river valleys, and hence both are younger than the first variety. This compact lateritic plateau must have been formed when the East Coast of India had a very moist climate probably like the present climate of the West Coast, conducive to the formation of laterite; and the present general height of the plateau is more than 100 feet above the mean sea level.⁵³ This plateau has been denuded and partly or totally removed in many places and on this denuded part resting either

earlier in the East Coast, as what is now the Bay of Bengal must date at least from the close of the Jurassic period.

53. It is 125 feet in the Red hills and near Manjankaranai about 111 feet.

on the compact laterite or still older formation occur the conglomeratic laterite or the pellety laterite.

Compact Laterite.

The typical exposures of solid or compact laterite of recemented pellets are to be seen at the Red Hills, which consist of hillocks rising to about 125 feet above the mean sea level and 80 feet above the surrounding country, bordering the Red Hills or the Fulal lake and the Cholavaram tank. Naravarikuppam⁵⁴ situated on the north-eastern banks of the Red Hills lake is an interesting site, in that it not only offers a good exposure of lateritic formation but also shows a large number of prehistoric stone circles or dolmens. The somewhat detrital nature of the laterite is revealed by the frequent occurrences of rounded quartzitic pebbles in it. The Red Hills typical laterite plateau extends as far north as Erumaivettipalaiyam on the southern banks of the Korttalaiyar. An interesting outlier is to be seen north of the river at Manjankaranai in a hillock rising about 60 feet above the surrounding plain. The summit consists of typical laterite passing down to angular fragments of laterite lighter in colour, which is underlaid by mottled coarse angular grit rather white in colour due to the cementing material being chiefly calcium and strontium carbonates with a little amount of alumina. The conglomerate becomes very coarse as one proceeds westward so that the boulders measure frequently one foot to two feet in size, near the Allikkuli and the Satyavedu hills. The same type of laterite may also be seen in the high ground S. W. of the Red Hills especially north and north-west of Avadi; further south near Sriperumbudur and Irumbedu;⁵⁵ around Oragadam about eight miles south of Sriperumbudur; at Tirumangalam; at Kandur; in the high ground south-west of Ariyavakkam; a small patch south of and opposite to Tiruvallur railway station. It also covers extensively the south end of the tank at Karadiputtur; at Budur; south of Satyavedu; at Siruvadu; at Amarambedu; at Madarpakkam; at Pondavakkam; further north-east at Kannambakkam; further south-south-east of Ama-

54. Narraincoopum of Indian Atlas Sheet 78 and R. B. Foote's description was situated on the northern banks of the original Red Hills lake; the village appears to have been shifted eastward near the north main road as the result of increasing the water capacity of the lake to supply Madras City in 1872, and also to prevent them from polluting the lower supply channel.

55. This is spelt Yerrember in the Indian Atlas Sheet 78.

rambedu it is also recognised extensively at Kollanur;⁵⁶ at Peripuliyur⁵⁷ and as far north as Yigavaripalem; further eastward it becomes gritty or clayey being mixed with sands and lateritic pellets.

Coarse Conglomerate.

Those patches of laterite occurring north and north-west of Tiruppachur and south of the Korttalaiyar is coarsely conglomeratic; the same feature is more pronounced near and along the foot of the Allikkuli and the Satyavedu Hills. R. B. Foote considered a well section near the village Sedulappakkam⁵⁸ as the best exposure showing extra-ordinarily coarse conglomerate.

Shingly Conglomeratic Laterite.

Lateritic formations bordering the Nagari river valley in the north and south sides are shingly in character with very little laterite cement between the pellets. Plenty of stone implements occur in the shingle beds south of Harichchandrapuram⁵⁹ near the Tiruvelangadu railway station and east of Takkolam in the Korttalaiyar valley. South of the Narayanavaram, coarse laterite shingle occurs at Pennalurupet, Gunipalaiyam and further west extending into the valley of the Allikkuli Hills. Further eastward, it is seen discontinuously at Kachchur all along the northern slopes of the high ground as far as Vadamadurai, where it is well displayed in the north-west side of the great tank and reappears in the elevated region west of Vengal, north of Sembedu, north of Meyyur and extending further west to the small scarps at Kunjaram.⁶⁰ North of the Narayanavaram or Arni river a more or less similar, but less coarse shingly laterite is exposed at Tamarakuppam⁶¹ and near Senjiagaram rising abruptly to about 30 feet

56. This appears to coincide with Colanur of R. B. Foote's description; it is not however marked in the Indian Atlas Sheet 78.

57. The place Peripuliyur of One Inch Sheet coincides with Pullore of the Indian Atlas Sheet 78 and R. B. Foote's description.

58. This village appears to correspond in position to Callapanidoopettah of the Indian Atlas Sheet 78, and Callapanaidoopettah described by R. B. Foote; the village is not marked in One Inch Sheet.

59. This, as elsewhere pointed out, coincides with Catramatoor of Indian Atlas Sheet 78 described by R. B. Foote.

60. This is not shown in the I.A.S. 78, but its position can be located at about a mile due east of Nelvay (Nelvay of the One Inch Sheet).

61. This place corresponds to Junglepilly of R. B. Foote's description; evidently the name of the village has been changed.

above the alluvium. The lateritic area in the Palayanuru region is very thickly strewn with extremely coarse quartzite shingle, evidently weathered from the lower layers.

These lateritic formations have drawn a great deal of attention as the result of the abundant and varied occurrence of palaeolithic artifacts of the prehistoric man of the neighbourhood of Madras; the more important workers were R. B. Foote, whose pioneer work has not probably been excelled by any other worker in the field, F. J. Richards, L. A. Cammiade and M. C. Burkitt⁶² and in more recent times T. T. Paterson and V. D. Krishnaswami. Messrs. F. J. Richards, L. A. Cammiade and M. C. Burkitt have been able to recognise the following facts from the succession of beds in a flat topped hillock rising some 60 feet above the alluvial plain and 111 feet above the sea-level near the village Manjankaranai.

- | | |
|--|--------------|
| (5) Grey soil | .. 1 foot. |
| (4) Midden refuse of Pottery & Neoliths | .. 1 foot. |
| (3) Compact laterite gravel rounded and pelleted | .. 6-8 feet. |
| (2) Angular fragments of laterite, light in colour | .. 3 feet. |
| (1) Solid laterite. ⁶³ | |

(1) Palaeoliths *in situ* were found between (2) and (3) in the abrupt junction between the two stages.

(2) Stage (3) appears as a sort of rubble filling up pockets in the underlying laterite, being washed down and filling cavities in gullies in (1) which is the original lateritic plateau situated well over 100 feet contour, formed probably from the Tertiary to early Pleistocene times.

(3) The climate which was conducive to the formation of (1) must have been more moist than the present; hence the area must have been thickly forested not suitable for a dense population of the Palaeolithic men.

(4) Stage (2) represents a change of the climate to a drier one with less vegetation, and hence suited for the lower palaeolithic culture.

(5) Stage (3) shows a return to moist conditions with a heavy rainfall which destroyed the larger part of the lateritic plateau and deposited the debris in gullies and pockets; hence they also contain palaeoliths; the moist condition was responsible for the removal of colloidal silica in the implements found in (3).

62. Geological Magazine, Vol. LXIX, May 1932 with notes on the petrography by S. W. Wooldridge and conclusions by P. Lake.

63. What is stated as solid laterite cannot be called laterite as it consists of angular gritty quartz pieces in a cement consisting chiefly of Calcium Carbonate; that is probably the reason why R. B. Foote referred it doubtfully to the Cuddalore sandstone.

(6) The typology of the Neoliths in (4) reveals a new culture quite different from that belonging to the lower stages.

Mr. V. D. Krishnaswami after a careful study of the area came to the following conclusions:—

(a) that the lateritic peneplain extending from the Allikkuli and the Satyavedu Hills to almost the coast approximately at a height of 100 feet above the Old Palar may be clearly made out.

(b) that tentatively in this peneplain T_0 , three more river terraces T_1 , T_2 and T_3 at levels approximately 60', 20' and 8' respectively above the Old Palar or Vridhakshiranadi may be recognised.

(c) that the terraces T_0 and T_2 correspond to clear pluvial periods, while T_1 and T_3 appear to be drier, though nothing definite can be said regarding them.

(d) that palaeolithic implements have been discovered not only in the terraces, but also, in the weathered laterite, detrital laterite, and the boulder conglomerates, thus revealing that man had already appeared on the scene, before the deposition of the boulder conglomerate.

To depositional peneplain may be seen typically at Vadamadurai in a section revealed in a recently dug up tank where the terrace can be recognised further west at Pundi, Sitanjeri and Kunjaram. T_1 or 60 feet terrace is seen near Attantangal on the banks of the channel connecting the Cholavaram tank with the Red Hills lake; in the sandy loam covering this terrace many implements were found. T_2 or 20 feet terrace is displayed near the village Attirambakkam covering a large area and extending as far as the Nambakkam tank. The tools found therein are rich in variety and form; the terrace is seen imperfectly on the right bank of the Kortalaiyar round about Pundi. T_3 or 8 feet terrace is displayed only at Erumaivettipalaiyam. The author recognised definitely in all five cultures corresponding to the three stages shown in section at Vadamadurai, the T_1 and the T_2 terraces; the sixth industry characteristic of T_3 , according to him, is yet to be made out clearly.

Decidedly, more thorough investigation is absolutely necessary before placing these inferences on a firm and convincing basis, firstly, in fixing definitely the course of the Old Palar or the Vridhakshiranadi, and secondly in tracing the various terraces along its sides taking account of the spot-heights and river profiles, the geologic or lithologic and the cultural features.

CONJEEVERAM GRAVEL.

The rather raised ground northwest, north and north-east of Conjeeveram town is occupied by a peculiar quartzite gravel deposit characterised by the absence of ferruginous matter as compared to the overlying lateritic formation. The area is bounded on the north by the Old Palar and on the south by the Palar alluvia,

which meet each other further westward at about three miles south-east of Kaveripak at Vegamangalam, which hence represents the western-most extension of the gravel formation.

Good sections may be made out (1) along the banks of the Tenneri tank off-flow channel north of Devariambakkam (2) in a ruined well near Injambakkam, (3) in the off-flow channel of the tank at Karai, where it rests conformably on white friable grits; (4) in Vedal, where it is conformably overlaid by lateritic gravel; (5) in a well section at Damal, where $3\frac{1}{2}$ feet of greyish red, gritty, coarse lateritic sand rests on false bedded gritty friable felspar gravel exposed to about 10 feet in depth; the same may be seen along the banks of the channel leading to Damal tank from Avalur; (6) in the channel leading to the Parandur tank; (7) in the valley running eastward from Siruvakkam to the Tenneri tank; (8) In a well three fourths of a mile east of Vishar, the Conjeeveram gravel 8 or 10 feet in thickness rests on what appear to be Jurassic beds of friable shaly sandstone.

As R. B. Foote had reported a number of stone-implements in the shape of axes and spear heads in the gravel beds between Akkampuram and Singalpadi, the age of the formation might be considered the same as that of the lateritic deposits to be found further east of the area.

ALLUVIAL DEPOSITS

These fall under three heads viz., marine, estuarine and fluvial; the distinction between the regions occupied by the first two cannot be made out, as one gradually merges into the other, while only to some extent fluvial or river alluvium can be definitely marked off from the areas occupied by the other two in the coastal regions. Hence, their rough relative positions only will be attempted to be fixed.

The area under consideration has been subjected to one major or principal uplift at the close of the Jurassic period; the presence of the Jurassic outcrops at various widely separated places below and surrounded partly or wholly by the lateritic formations, suggests that very likely the original limit of land due to this upheaval must roughly coincide with at least the present extension of the basal or compact lateritic formations. The region east of the laterite, forming the estuarine and coastal alluvia, must have been the result of the accumulation of the terrigenous debris in the depressions in the coastal parts and in the continental slope, ever since the upper Jurassic times.

The accompanying geological map of the area suggests, that the present Palar river course is mostly in the gneissic region; and as the recent fluvial alluvium overlies the laterite or the Older Alluvium in places, the age of the present course of the river is decidedly post-lateritic. Remembering that the peninsular gneisses and the associated igneous rocks are very hard materials offering great resistance to erosion and weathering forces, as compared to the sedimentary formations to be seen a little further north, it appears rather strange that the Palar should behave in this manner. Thus, there appears to be every reason to believe, that it might have had a different and a more northern course through the less hard sedimentary formations in the near historic and probably also geologic past. There are also definite historical evidences to show, that the Palar had a more northern course running north of Conjeeveram town at the close of the eleventh or the beginning of the twelfth century.⁶⁴

64. (1) Jayamkondar's *Kalingaththu Parani*. Edited by A. Gopalayan. In verses 354-356, Jayamkondar, who was a poet of the time of Rajendra Cholan (1070-1119 A.D.) enumerates the rivers crossed by the troops in their march towards the north for the war against the Kalingadesa; the war might have taken place between 1095-1115 A.D.

“பாலாறு குறைக்கலை லொன் அறகரி
பாறாறு படர்ந்த தெரு தெருக்கி யெனு
நாலாறு மகன் லொரு பெண்ணை யெனு
நதியாறு கடந்தா நடந்தா லேன”

Vide also, the foot notes for the verse by the Editor, who had cited a change in the course of the Palar near Gudiyattam; this appears rather irrelevant as further eastward, there appears to be a definite geological evidence to show that the Palar flowed north of and near to Conjeeveram.

(2) Vide, B. M. Thirunaranan: The Rivers of the Palar Basin, Jour. Mad. Geog. Asso., Vol. XIII, No. 2, p. 155.

(3) One Gundu Gopal Row, a deputy of the Hindu King of Vijayanagar, was said to have excavated a channel which diverted the Palar from its old course, the Vridhakshiranadi to its present course by the village of Orikai.—C. S. Crole, The Chingleput District Manual, 1879, p. 118.

Vide also, A. F. Cox & H. A. Stuart: The North Arcot District Manual, Vol. I, p. 7 (1895), where the said Gundu Gopal Row is described as probably a servant of the Raja of Conjeeveram.

(4) “At Kondapuram, near Kaveripak, an inscription on the walls of a temple describing its position as being south of the Palar, whereas it is situated to the north of the river, which shows that the course of the river was changed after the temple was built.”—Hon. Yakub Hasan in his address

However, there appears to be no definite historical evidence to show what the exact course of the Vridhakshiranadi was, before its diversion to its present course. The accompanying geological map shows that Conjeeveram is situated on a rather high ground consisting of the older Conjeeveram gravel and that there is north of this a shallow valley consisting of the younger or the recent alluvium; as this valley starts from about ten miles east of Arcot, and joins with the present Palar valley a little further east near Walaajbad, it appears possible that before the diversion to its present course (probably by Gundu Gopal Row), the Palar might have flowed along the valley north of Conjeeveram.

Again, the geological map reveals another arm of the river alluvium starting from a little west of the one just described above, but running N. E. ward widening in that direction. This marks clearly the course of an old river, which must have been larger than the Palar as shown by the width as well as the coarseness of the alluvium which consists of coarse sand and gravel. R. B. Foote has recorded a tradition of the people that the Vridhakshiranadi flowed near the village Palur, which is now situated in the alluvium of the Old Palar. He has also pointed out, that where the river alluvium starts some eleven miles east of Arcot are situated gneissic protuberances in the river bed opposite the villages Vegamangalam and Mamandur, where the bed narrows considerably, and the raising of the river bed during some great flood above these must have diverted it a little southward where the "fall of the land surface was more rapid." Probably, the course of the river before such a diversion would have followed the Old Bungaru Channel or the Place's Canal, and then turned eastward and flowed along the present Cooum river to its mouth a few miles west of Poonamallee. It is very difficult to fix the date and period, when it flowed along the Cooum valley; it is likely, as inferred from the references already cited, that this might have been the course of the old Palar earlier than the end of the eleventh century.⁶⁵ This

to the owners of land fed by the Palar at Pudupadi on April 22, 1939. This is evidently taken from the North Arcot District Manual.

Vide, A. F. Cox & H. A. Stuart, North Arcot District Manual, 1895, Vol. I, p. 7.

65. Vide also, B. M. Thirunaranan's article on the site and situation of Madras in the Madras Tercentenary Commemoration Volume, p. 332 foot-notes: "The Cooum is known as the old Palar at Tiruverkadu, a village two miles north of Poonamallee and close to the river. (p. 227, *Swasthala Manjari* in Tamil edited by V. T. Subramania Pillai, Madras, 1931)."

inference, as pointed out by R. B. Foote, is supported by geological evidence in that a wide branch of the coarse Old Palar alluvium may be traced diverging from the still more important valley of the river (vide infra) just west of Tiruvallur R. S., and continuing along the course of the Cooum till it reaches the estuarine alluvium a little west of Poonamallee at the villages, Sittukkadu and Tirumahishai and along the New Bungaru Channel westward.

A very important and very wide branch of fluvial alluvium running north-eastward from the Place's or Old Bungaru Channel between Tiruvallur R. S. and the lateritic hillock at Pundi, is also indicated by the geological map; this alluvium finally merges with those of the Korttalaiyar and the Arani rivers; as shown by the width and coarseness of the alluvium consisting of gravel and coarse angular sand particles, this river must have been larger and the current more powerful than the present Palar. The bulge in the coast line between the mouths of the Korttalaiyar and the Arani, makes us conclude that the old Palar must have embouched into the Bay of Bengal slightly north of the Ennore backwaters. The general climate, which must have been prevalent on the east coast when the Palar flowed in this direction, must have been much moister than at present: as plenty of palaeolithic stone implements of Abbévilian to late Acheulean age have been collected *in situ* from the terraces of this river, we conclude, that the river must have formed a very important physical feature, and probably also a cultural centre, during the Middle and Upper Pleistocene times, when the primitive man dwelt in this part of India.

The probable cause for the successive changes in the course of the Palar is difficult to be made out definitely; R. B. Foote has pointed out that if the course is a natural one, it must be due to silting up of the Old Palar river valley, and its diversion by itself during some great flood. In addition, we shall have to remember, that the drainage of the area has been to a very large extent interfered with by human agency, chiefly for purposes of irrigation either by damming up the river, or by diverting its freshes through channels to tanks or lakes; thus, one of these attempts either deliberately or accidentally, might have resulted in the change in the direction of flow of the river. An instance cited above in the reference, stating that one Gundu Gopal Row diverted the river from flowing north of Conjeeveram to its present course might be taken as an evidence to show human interference with drainage.

But it appears to the present writer, that the following facts, showing a gentle submergence and tilting of the region towards south-east, might have helped the above causes to a less or greater extent:—

1. It has been remarked by those geologists, and archaeologists, who have visited the Shore Temple of the Seven Pagodas, that the region appears

to have been submerged even during historic times. Thus, an old road in the area has been discovered by archaeologists at a level of five or six feet below the present level. "Lord Napier, then Governor of Madras, visited the spot about a week after the snake deity was dug up, and had excavations made to a depth of 7 or 8 feet, which exposed a great number of figures and animals and showed that the old road must have passed in front of the rock at a depth of five or six feet below the present level . . .".⁶⁶

2. R. D. Oldham seems to agree with Capt. T. J. Newbold, when he stated that the "St. Thomé, a short distance south of Madras is said to have been formerly situated twelve leagues inland and forty miles further south, the town of Mahabalipuram is said to have been overwhelmed by the sea".⁶⁷ "I was informed by Lord Elphinstone and Mr. W. Elliot, that whenever a storm took place from the seaward, Roman and occasionally Chinese coins were cast upon the beach. One of the former, according to Mr. Norton, is of the reign of Valentinianus. General Fraser informs me that south of these ruins, at Ariacoopang and Cuddalore, pieces of brick, tiles and pottery are taken up from the bed of the sea at considerable distance from the shore, beyond the recoil of the tidal wave. Still further south near the embouchure of the Cauvery, the Brahmans point out the submerged site of another ancient city.⁶⁸ At Madras, from all I can collect from the oldest inhabitants and survey, the sea has certainly encroached latterly on the ground it formerly occupied while St. Thome⁶⁹ an ancient Portuguese settlement, a little south of Madras, is traditionally said to have stood twelve leagues inland.⁷⁰ It would appear that, there is not much of definite evidence to show a submergence of a coastal strip to the extent of twelve leagues; but it is quite likely, that a submergence of a few feet might have been exaggerated by the people.

3. As already pointed out, a strip of land, in the S.E. portion of Madurantakam taluk, bounded on the east by the sea and the Kaliveli tank on the south, called Yedakeinadu or left-hand-land, appears to have been by tradition, once separated from the mainland by an irruption of the sea.⁷¹ The present continuity of land may be explained as due to filling up of the

66. Quoted from Dr. Hunter's work on the Seven Pagodas, C. S. Crole: The Chingleput District Manual, 1879, p. 98.

67. R. D. Oldham, Manual of the Geology of India, p. 12.

68. This is evidently the famous Kaverippumpattanam of Tamil literature mentioned in *Chilappadikaram*.

69. St. Thome was definitely a Portuguese monastic settlement about 1522 A.D., under the name of San Thomé de Meliapor; traditionally, however, it is associated with the Apostle Thomas, and hence, must date back to the first century. The place probably meant here is the adjacent place of Mylapore which appears to be older than San Thomé being possibly the Malliarpha mentioned by Ptolemy.

70. Capt. T. J. Newbold: Summary of the Geology of Southern India. Jour. Roy. Asia. Soc., Vol. VIII, p. 250, 1846.

71. C. S. Crole, The Chingleput District Manual, 1879, p. 128.

shallow lagoon-like depression, which must have separated that strip of land.

4. The thickness of recent coastal alluvium above the gneissic rocks in the coastal belt shows that as one proceeds from Madras southward, the depth increases; it is almost about 58 feet in Madras, but a boring put in Pondicherry did not reach the basement gneiss even after a depth of 550 feet.⁷²

It must be remembered, that the unusual thickness of coastal alluvium in Pondicherry is due to its situation in the Pondicherry-Cuddalore bay, which was bigger than the Madras-Poonamallee bay; making due allowance for this, it appears to the author, there is a considerable depth which could be only explained as due to a sinking continental shelf.

5. R. B. Foote also appears to imply a slight lowering of land on the S.E. of the region under consideration; for he does not explain, why the fall of the land is more rapid in an eastern direction than in the old bed.⁷³

Again he has noted that "a few yards to the west of the small channel above Kalingula, a part of the grit bed about 40 feet long and 1½ to 2 feet thick has been pushed up into a vertical position and protrudes above the surface like a small dyke.⁷⁴ Evidently, this must have taken place due to and during the tilting of the area. R. B. Foote also suggests the probable occurrence of a fault in the Allikkuli area as inferred "from the peculiar nature of the case," i.e., the shale bed occupying the western part, and the conglomerate the middle part without any visible transition, due to the accumulation of the conglomerate debris.⁷⁵

6. Mr. V. D. Krishnaswami, who has been carefully studying the lateritic deposits in the Red Hills area near Madras, has also come to the same conclusion, viz., that the land has been tilted towards the S.E. He appears to have recognised a fault, which he is trying to date by the help of the Pleistocene terraces. This was the result of a discussion, which the author had with him after these pages had been written, and when they were about to go to the press.

It is interesting to note, that the course of the Korttalaiyar east of the Allikkuli hills follows close to the lateritic formation and the Sriperumbudur shales to be seen on the northern side of the

72. R. D. Oldham, Manual of the Geology of India, p. 404, *vide also*, *op. cit.* p. 10 "near Pondicherry, beds of peat at various levels below the surface of the ground show that there has been subsidence".

Though we have no data to depend upon, it is likely that the coastal alluvium will decrease in thickness as one proceeds south till Mahabalipuram where charnockites are exposed; then very likely, it will increase steadily up to Pondicherry; anyway it does not affect the argument.

73. R. B. Foote, Mem. G.S.I., Vol. X, part I, 1873: p. 21.

74. *Op. cit.*, p. 102.

75. North Arcot District Manual, 1895, Vol. I, p. 16.

river; and it is still more surprising, that it should run between two lateritic hillocks, between Pundi and Rangapuram lateritic hillocks. It appears to the present writer, that in this portion of its course very probably the Korttalaiyar is actually running in the valley of a tributary of the Vridhakshiranadi, and its course (that of the Korttalaiyar) closely following the lateritic high ground must be explained as due to deepening of the valley as the result of greater amount of torrential water brought by the various impetuous streams viz., the Attirambakkam, the Odapai and the Meyyur nullahs from the north resulting in greater erosion, and the consequent diversion of the Nagari, and probably, a little subsequently also the Korttalaiyar along the course of the tributary valley, which hence, became the main valley.⁷⁶

R. Bruce Foote has also suggested that the Nagari river undoubtedly would have run N.E. ward and joined the main Narayanavaram or Arani river in the recent past, instead of taking a S. E. course a little east of Nagari village, and joining the Korttalaiyar. The place of such a diversion appears to be at a place about 3 miles east-south-east of the Nagari village, where the gneissic rocks together with dolerite dykes are exposed in the river bed in the form of a neck. The increase in the width and extension of the alluvium along the present course of the Nagari river below this place, and the wide patch of alluvium in the dry subsequent valley running N. E. ward occupied by a small stream, a tributary of the Arani for some distance in the lower portion, confirm this inference. It is probable, that a smaller tributary of the Nandi or Tiruttani river might have occupied the lower portion of the present Nagari valley, and this stream by head erosion might have made possible the diversion of the Old Nagari river flowing N. E. ward to S. E. ward; ⁷⁷ the gradual small tilt of the land referred to earlier might have made the diversion easier.

76. Cf. R. B. Foote's statement "It is uncertain whether this passage (i.e., the one between the lateritic hillocks near Pundi) was forced by the water of the united Corteliar and the Naggery river or whether it had already been made by the Old Palar. There is no distinct evidence on the subject, but the probability is the passage was forced by the Old Palar river after it had silted up its valley in the narrower part lying between Trivellore and Nemaly (Neyveli) to a height sufficient for its water to flow into what undoubtedly was an old valley formed by denudation during the period of elevation which raised the implement bearing laterite to its present position."

77. "And in the case of the Nagari river, from the fact that the cutting through the gneiss by which the river escapes from its old alluvial valley

The deposits of the Korttalaiyar consist of reddish loam or loamy sand, sometimes intermixed with a good proportion of clay. A good deposition is to be seen between Illuppattandalam and Takkolam. The relative position of the two alluvia viz., the Old Palar and the Korttalaiyar may be seen east of the railway line between Arkonam and Conjeeveram.

The alluvium of the Palar is fairly coarse to fine grained sand, but consists locally of gravel or clay; all these materials are mostly derived from the gneissic and other rocks of the North Arcot district. Fluvial clay deposits are to be seen near Chingleput and further east near its mouth forming some swampy areas.

The Old Palar or Vridhakshiranadi alluvium is coarse sandy, or gritty, or gravelly with a paler reddish colour, as compared to that of the Korttalaiyar; several lateritic outcrops, much of which have now been removed for road material, may be seen surrounded by it near Tiruvallur R. S., and the coarse sandy nature continues till its junction with finer marine sand west of Poonamallee. In the N. E. valley of the Old Palar, one can recognise the same characteristic angular particles of gritty sand, but it occasionally becomes mixed with clay washed down from the adjoining higher lateritic formations.

The fluvial deposits of the Narayanavaram river consists of pure sand associated with quartzite boulders, pebbles, gravel and ferruginous material derived from the older lateritic and the Jurassic formations.

In the region of Madras there was an extensive, but shallow bay extending from the coast to a little west of Poonamallee during the Pleistocene and earlier times; this bay was converted into an estuarine one when the Old Palar or Vridhakshiranadi was diverted from the northern course to flow along the present Cooum valley, probably, during the late Pleistocene times. The limits of the bay is to be traced by the presence of black sticky clay in practically the whole of the basin at various depths from 0 to 50 feet or slightly more, according to distance from the original shore and depth of the sea, except in or near the bed of the Old Palar where it con-

presents every appearance of being of artificial origin, and must in that case have been the work of a people boasting some considerable civilization."—R. B. Foote in the North Arcot District Manual p. 22. Vide also, *Ibid.*, p. 7.

sists of coarse sand, and along the shores of the original bay, where it consists of fine-sand.⁷⁸

Thus, we may more or less trace the boundary of the bay from the mouth of the Adyar westward along the alluvium of the same river to Anakaputtur, then along the north-eastern part of the village Kunnattur turning N. W. ward to a little west of Poonamalle to Tirumahishai and Sittukkadu then continuing eastward along the bed of the Cooum to Ayapakkam; it finally turns N. E. ward closely following the south-eastern extension of the lateritic plateau, which extends approximately to the eighth mile on the northern trunk road. Between Anakaputtur and Kunnatur one finds black sticky clay indicating the original presence of the Pammal tank. From the coast as far as Poonamallee the deposit consists of pure fine drab sand; further westward, this fine sand becomes mixed with estuarine clay, while near Tirumahishai and Sittukkadu the fine marine sand is associated with coarse gritty sand

78. Some recorded well-sections in Madras:—

1. B. Babington: *Tran. Geol. Soc. of London* Vol. V. Series I, Jan. 1819, pp. 337—338.
2. T. G. Taylor, *Mad. Jour. Lit. & Sci.*, Vol. XIV, 1847, pp. 183—186.
3. Vredenburg: *Mem. G.S.I.*, Vol. XXXII pt. I, 1901.
4. Capt. Newbold, *Jour. Roy. Asia. Soc.*, Vol. VIII, p. 249. Experimental borings of the earth at the Land Custom House, Madras. 1832. (The Land Custom House appears to coincide with the Madras Museum compound).
5. *Vide also* R. B. Foote, *Mem. G.S.I.*, Vol. X, pt. I, 1873.
6. W. King *Rec. G.S.I.*, Vol. XIII, pt. 2, pp. 115, 136—138.
7. B. M. Thirunaranan, *Madras Tercentenary Commemoration Volume*, p. 331 foot notes.

In all these wells black sticky clay was met with at various levels containing estuarine fossils and the gneiss struck at about 58' or 60'. In a well section sunk recently in the Spur tank, Egmore, the following sequence was observed by the author:

- 0—6'—Brownish gray clay.
- 6'—12'—Coarse loose sand stained with iron oxide.
- 12'—20'—Grayish black to black sticky clay with oyster shells.
- 20'—34'—Loose sandy clay with iron stains here and there.
- 34'—40'—Loose fine sand with greenish yellow clay mixed intimately.

The well was deepened a little later, when at approximately 45' some calcareous rocks with good fossils of *Ostrea* sp. *Pecten* sp. and ramified coral (?) like calcareous structures were found. At approximately 40' or a little below that level small smooth sub-angular gravelly pebbles of Charnockites and gneiss together with sub-angular smooth brownish chert pieces were found.

of the Old Palar. The junction may be traced along the New Bungaru Channel to Perumalappatti where they meet the Sriperumbudur shales. Eastward, the village Ayapakkam stands on coarse sand of the Old Palar at a height of about 10 feet above the general level of the estuarine plain.

During the last stages in the filling up of the bay, chiefly by the alluvium brought by the Old Palar and to a certain extent also by the Adyar, several marshy tanks or lakes must have been formed, some of which might have been freshwater, some others brackish or bitter; evidently, due to drying up of these latter tanks minerals like Selenite, fibrous gypsum etc. have been reported in various places when digging wells. (e.g. Northern part of Madras City, Poonamalle).⁷⁹ The brackish water got from some localities in the city is another evidence towards the drying up of some back waters or inland lakes. The various tanks which may be recognised at present, or which have been filled up partly or wholly as: the Spur tank, the Pammal tank, the Ambattur tank, the Long tank or the Mambalam tank, the Nungambakkam tank, the Vyasarpadi tank, the Perambur tank, etc., are the relicts representing the very last stage in the filling up of the extensive estuarine lake. The mouth of the bay must have been to a large extent closed by long sand bars and dunes similar to those to be found north and south of Madras along the coast; one sand dune as already pointed out is to be seen prominently north of the New University Examination Hall, west of the Beach Road in Madras.⁸⁰ That these extensive marshy conditions must have persisted during late historic times there can be no doubt, and most of them were drained and filled up only when the City of Madras began to grow in population in the last three centuries, thus bringing about a considerable change in its topography.

79. Ten years' correspondence on the Resources of India with reference to Mr. Greenough's Geological Map of India, pp. 40, 43, 49 & 51.

80. Mr. B. M. Thirunaranan by the help of old maps has recognised several sand dunes in the city, *Mad. Tercentenary Commemoration Volume*, p. 330.

A Panoramic view of part of Fort St. George, depicting the Fort as it looked in 1718, by Jan Van Ryne, a Dutch engraver, reproduced in Prof. C. S. Srinivasachari's article on the Maps of Old Madras, published in the *Jour. Mad. Geog. Assocn.*, Vol. III, 1928—29 as Map IV (b) reveals a few mounds, which appear to be sand dunes. One of the mounds with a building on its top Col. Love suggested might represent St. Thomas Mt.; this the author of this paper thinks extremely improbable, as it appears too near the Fort.

There appears to be no definite evidence at all of any local elevation of the region during the Recent, and probably also, during the Pleistocene times, while as already stated, there seems to be some evidence to indicate a gradual and very slow submergence of the whole area under consideration and the amount of submergence appears to be greater in S. E. portion of the district.

North of Madras City, the coastal alluvium narrows till the eastern limits of the lateritic formation of the Red Hills, but widens further northward joining with the fluvial alluvium of the Kortalaiyar, the Old Palar, and the Arani rivers. North of the Arani, it again narrows, so that south of the Pulicat lake, it is approximately six miles, and S. W. of the same lake it dwindles greatly in breadth, being only about two miles. Here also, there appears to be no definite evidence of upheaval, and the probability is that the land has submerged to some extent, though the amount may not be so great as in the S.E. part of the area under consideration.

SUB-AERIAL SAND DEPOSITS

Sand deposits in the form of sand dunes or hillocks occur all along the coast. South of Madras, there is a continuous stretch of such hillocks from about 2½ miles south of Covelong up to 2 or 3 miles south of Mahabalipuram. Still further south, they are seen in the form of elongated detached dunes parallel to the coast starting from near Kanattur about 1½ miles south of the mouth of the Palar, and extending to Kaliveli tank and beyond. The height varies usually from 25 to 30 feet, while frequently they may be 40 to 50 feet and occasionally, 60 feet or even slightly more.⁸¹ At Covelong, they appear to cover old ruined buildings and at Mahabalipuram they may be seen advancing towards the monolithic temples; near the former place, an inland dune may be seen west of the backwater. Small dunes of about 8' or 10' high also occur near Madras in the Elliot Beach, and one within the City just north of the University Examination Hall, and west of the Beach Road, forming the fishermen colony. Speaking generally the size of the dunes appears to decrease as one proceeds from the south to the north of the district so that north of Madras, though wide stretches of sand may be seen, high dunes are rare. At Ennore some small ones occur making an inroad on small temples and ruined buildings.

81. E.g. East of Yadayanthittu Kaliveli, where sand dunes of more than 65 feet are to be seen.

But the highest ones reaching between 40'—50' appear at Sinthamanipuram. North of this place, till the Pulicat light-house, the dunes are not important; but three miles north of Coromandel, at the village Thoppalampalaiyam they become of some importance and attain heights upto 30 feet. At Pungulam about eleven miles north-west of Pulicat, it forms a hillock, which is interesting in that the sand is reddish in colour probably due to the action of the S. W. monsoon carrying red lateritic dust north-eastward, and not due to the N. E. monsoon for the Pulicat lake is situated north-east of it.

Except at places where rivers and backwaters join the sea, the whole coast is a vast stretch of sands, forming probably one of the magnificent beaches in the world. Frequently, the mouths of rivers also get blocked by sandbars formed across the mouths, chiefly due to the action of the breakers. This may be seen beautifully at the mouth of the Cooum in Madras, and the bar has to be broken annually during the north-east monsoon to permit a free flow of water, and to prevent a flooding of the low level regions of the city. Here the deposition of sand appears to be the result of the building of the Madras Harbour which impedes the coastal currents, thus making a beautiful and fine beach for Madras.⁸²

The prevention of the sand dunes from migrating and covering the surrounding cultivated fields and inhabited regions is an interesting problem. This has been fairly successfully tackled by the growth of various hardy rather xerophytic plants, which bind the sand either by the roots, or by the roots and runners as: *Launea pinnatifida*, *Anacardium occidentale*, *Pandanus*, *Spinifex squarrosus*, *Ipomea biloba*, *Cyperus anenarius*, *Hydrophyllax maritima*, *Borassus flabellifer* and *Casuarina-equisetifolia*, which thrive well in such an ecological environment. The last tree is so important economically in that it forms the chief fuel for the people of Madras, that large and thriving plantations may be seen over wide regions all along the coast.

SOILS

Though soils bear a very close relationship to the underlying geological formations, they appear to have been moved about to such a great extent, mostly as the result of rather sudden and

82. Vide, references given elsewhere in the paper.

torrential rainfalls during the N. E. monsoon and frequent cyclones, that they have been sorted out to some extent, presenting the appearance of sedimentary formations in exhibiting a rough stratification. These, no doubt, link the truly sedimentary deposits with the truly sub-aerial deposits to be found so widely distributed superficially in the area.

Generally speaking the soil of the district is poor and sandy with a general tinge of red or yellow colour. The *purely sandy soil* is mostly confined to the coastal alluvium, and this improves with age, and hence, with distance from the shore, where it becomes red ferruginous and loamy by intermixture with clay; the Poona-mallee and the immediately surrounding parts are probably the best example for this; and the coastal alluvium here enters inland in the form of a small bay extending as far as Sittukkadu and Tirumahishai, bounded on the south and south-east by the gneissic area, and on the other sides either by the older or younger river alluvium. The same is true of a good portion of the soil of the Saida-pet Taluk, which possesses a fairly good soil except in places, where it becomes alkaline (e.g., along the southern branch of the Adyar river), or saline (e.g., near the coastal lagoons). Nearer the coast, the coastal alluvium is so sandy as to be practically useless for the growth of any vegetation except *Launea pinnatifida*, *Amma-cardium occidentale*, *Pandanus*, *Spinifex squarrosus*, *Ipomea biloba*, *Cyperus anenarius*, *Hydrophyllax maritima*, *Borassus flabellifer*, *Cocos nucifera* and *Casuarina equisetifolia*; all these plants not only help to bind the sand, but also increase the humic content of the poor soil, thus functioning as the first colonisers of the plant kingdom; in addition, the last plant enriches the soil in nitrogenous material, as the result of the activity of nitrifying bacteria in its root-nodules. Frequently, the coastal sandy area becomes excellently suited for the cultivation of cocoanut topes; though cocoanut trees are to be seen right along the coastal belt, special mention must be made of the S. E. portion of the Madurantakam taluk, separated from the mainland by a depression, called Yedakainadu or left-hand land, where the best cocoanuts of the area grow; they find an easy and ready market in the district itself. A little further inland the region is so saline, that even these plants find it difficult to grow; such areas, frequently including salt swamps, have to a large extent been utilised for the manufacture of common salt. In addition to common salt a large number of minerals which are the result of desiccation of inland coastal lagoons have been reported as fibrous gypsum, selenite, carbonate of soda, fuller's

earth, and lime.⁸³ Here the soil is so poor and the general appearance so desolate that the belt has been compared to the region around the Dead Sea. The soils covering the *Older Alluvium* are either quartzitic gravelly and mixed with Soda, lime and relatively free from ferruginous matter, or lateritic, which may be gravelly, gritty or sandy. These soils are generally speaking much inferior to the loamy soils to be described below. The first type is to be seen largely in the Conjeeveram taluk, covering the high ground in the north, north-east and north-west of the town in the form of an elongated patch east to west, weathered from the Conjeeveram gravel and the latter in the Tiruvallur taluk. Though the Tiruvallur taluk receives the greatest amount of rainfall in the district, being about 60" on the average, yet on account of the poor nature of the soil, it is no better off than regions, which receive half its rainfall, but contain rich black soil; but the taluk contains a good portion of the wooded areas of the district; this is probably more due to the rainfall, than to soil richness. A good portion of the district is covered by *recent alluvium* consisting of dusty loamy soil to gritty or rarely gravelly soil deposited by the rivers Palar and its tributaries along their course; a still wider band may be traced along the Old Palar river or Vridhakshiranadi starting from about ten miles east of Arcot following the Place's canal, to between Tiruvallur and Neyveli, till it reaches the Korttalaiyar and the Arani or the Narayanavaram alluvia, and following their course to almost their present embouchures; one band is also recognised north of Conjeeveram starting about two miles east of the first place and joining with the Palar alluvium near Walajabad; and they are also seen along the courses of the Korttalaiyar, the Arani, the Cheyar, and to a less extent in the valleys of smaller streams; it is quite likely the mouth of the Old Palar would have been situated further inland, and also slightly north of the present embouchure of the Korttalaiyar with an extensive lagoon or break-water. The *Old Palar alluvial soil* is mostly gravelly and gritty, while the *Palar soil* is either gritty or finer sand of reddish colour, frequently passing into loam or greyish black or black clay; the last formation is confined mostly to its banks near its mouth east of Chingleput.

The wide gneissic area about 16 miles wide and 26 miles in length occupying practically the whole of the S.E. of the district.

83. Ten years correspondence on the Resources of India with reference to Mr. Greenough's Map of India, pp. 38-51.

between the coastal alluvium of the coast and Poonamallee, the Old River alluvium on the west, and the Palar alluvium on the south, is mostly stony and rocky, except in the depressions, which are made up of smaller angular or subangular pebbles, grits, sands and clays washed down from the round, protruding, detached, rocky masses barren of vegetation, or covered with a thin scrub jungle. Hence, in these depressions the thickness of the soil cover is by no means uniform, and where the depression is extensive as well as fairly deep, there has been relatively greater chance for the underground water as well as surface run-off to stagnate, thus forming relatively fertile areas; the capacity to hold water in such depressions, has been increased frequently, by bunding up the lower sides, thus forming lakes or big tanks (eg. the Chingleput lake); sometimes, as the result of diversion of streams, or cutting channels to bigger rivers, the water capacity is still more augmented (e.g. the Madurantakam tank). Hence, the red loamy soil of this region is fairly fertile, and is superior to the soils of the other regions of the district. Tanks and lakes, most of them artificial, are very abundant in the district, and they form excellent places for the accumulation of fine silt and clay not only of the surrounding area, but also of distant parts, as they are frequently connected to rivers or to flood canals of rivers; thus, in tank beds one finds black or gray clay rich in humus.

ECONOMIC ASPECTS

Underground water resources.

The following observations may be helpful in giving some idea of the underground water resources of the region. In the Madras-Poonamallee bay,⁸⁴ water is likely to be met with at very shallow depths from about 10 feet up to about 58 feet, at which approximate depth gneissic rock is likely to be struck. The water may or may not be fresh, as the region appears to have been occupied by a salt water lake (probably in many respects similar to the Pulicat lake), which appears to have been evaporated to dryness in places. On account of the shallowness of the sources of water, and the great porosity of the sandy soil of the upper levels, the water is likely to get easily impure and infected by surface infiltration.

84. Vide W. King Rec. G.S.I., Vol. XIII, pt. 2, pp. 115, 136-138, and other references given elsewhere in the paper regarding well-sections in Madras.

tion.⁸⁵ The available amount also may not be large, considering the irregular nature of the distribution of the porous strata, and the quality and the degree of purity cannot be uniform over long periods. Besides, in good many places the water is likely to be brackish. The rate of flow, to fill a large depleted well with a diameter of 20 feet, was found to be approximately 3 feet in 24 hours.

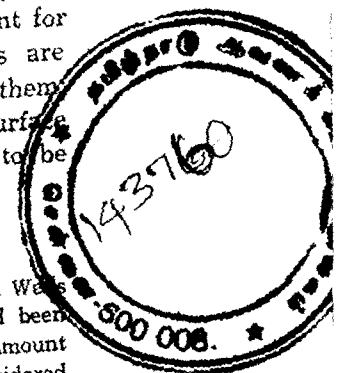
The coastal alluvial regions, on account of their sandy nature, frequently contain excellent water stored up. These may form important sources of good water, provided the demand is not great and, for the reasons pointed out above, it is tapped with caution. The sandy areas north of Madras including the Seven Wells, and the ancient fort Alamparai (Alumparva) in the southernmost boundary of the district are historic examples.

In the regions south of Madras occupied by the gneisses and gneissic granites, there is not much hope of finding important sources of water, except to some extent in the surface altered portion of the rock. However, in low-level areas in the form of small basins between the hillocks, where thicker accumulation of such weathered material is possible, there is a good chance of finding larger and more permanent supply of water.⁸⁶ A careful geological study of the region will be necessary before such basins can be made out. Anyhow, the available amount of water may not be sufficient to supply towns, and may be doubtfully sufficient for large cantonments.⁸⁷ The river or drainage channel beds are likely to afford a good supply of water, if wells are sunk in them, but they ought to be protected from the percolation of surface impurities. A fairly good supply of fresh water is likely to be

85. Cf. "Fears were also entertained about the quality of the Seven Wells water and a report made by Mr. Meyer and Dr. Wyndow, who had been appointed to analyse the water of the Wells said that the smallest amount of impurity found was double that which the authorities at home considered possible and that the natural and only sound inference from the conditions of the soil was that it would be necessary for Government to look for water beyond this polluted area (the area of the Wells)"—V. D. Krishnaswami, Mad. Tercentenary Commemoration Volume, p. 288.

86. It is also likely, as these areas are usually converted into tanks by damming up that portion where the basin is open, there will be a good accumulation of under-ground water, so as to say, to form under-ground tanks to be utilised in the dry season, when the tank above becomes dry.

87. General Report of G.S.I., for 1936, pp. 46 & 47.



392 JOURNAL OF THE MADRAS GEOGRAPHICAL ASSN.

got from sinking wells in the prominent faults or fissures and joints in rocks. Here again, a good and careful geological study must be conducted before the faults may be recognised.

The regions occupied by river alluvia in the map form excellent places for getting a large and good supply of water, especially the valleys of the Old Palar, the Korttalaiyar and the Arani rivers. As the coarse to fine sandy or gritty beds are underlaid by conglomerates of slightly older age, the latter also form important reservoirs of underground water, because the bed underlying them appear to be a shaly one of Sriperumbudur age, which is impervious. The lower beds underlying the shales do not appear to possess any important water bearing stratum; for a boring at Ennore sunk in 1883 to penetrate into these rocks struck only a poorly water-bearing stratum at about 213 feet below the surface.⁸⁸

The areas occupied by the Satyavedu sandstone stage, as the Satyavedu region, the Allikkuli region, the Palayanuru region and the isolated outliers of Jurassic age south of the Palar, as those to be found near Uttaramerur, around Padiri and around Velangadu are also areas, where a fairly good supply of fresh water is available at very shallow depths of 15 to 20 feet; but a greater depth will undoubtedly be necessary to ensure a perennial supply.

Economic Minerals.

The economic resources of the region under review are not very great. Building stones form the most important economic material of the area; and they consist of the biotite or hornblende gneisses, the Charnockites, the laterites and the Satyavedu sandstone. The hornblende gneiss is quarried in the gneissic regions at various places, as near Walajabad etc. The Charnockites are extensively quarried near Pallavaram not only as building stone, but also as road and railroad metal; they are used as curry-stones, pounding-stones or mortars, road rollers etc; the basic Charnockites form very good ornamental stones in building, as they take an excellent and beautiful black polish looking like black marble but infinitely more durable and the polish more enduring; hence, they are used as tomb and ornamental stones. Compact laterite of the Red Hills region and the areas further westward and those between the Korttalaiyar and the Arani rivers form also good

building stones; they have been used in these places for temples, tank-bunds, tank-weirs, railway stations, Choultries etc. Gravelly or friable laterite is widely used as a road-metal either alone or mixed with the gneissic or Charnockite pieces; in the latter case, it forms a good cementing material. Satyavedu sandstone also is widely excavated; on account of its easy workability it forms a good building and ornamental stone; the reddish or yellowish red colour with an imperfect stratification gives it a rather pleasing appearance; it is cut out near Satyavedu, Nagalapuram, Conjeeveram etc.

Near the coast, as the result of desiccation of backwaters some surface salt deposits are economically important; salt also occurs in the form of bitter brine, which is made use of in the manufacture of common salt; extensive salt pans may be seen in several places as near Ennore, Pulicat, Covelong etc. Thin beds of gypsum, and rarely Selenite have been recorded with shale beds in the digging of wells in the coastal regions.

Sriperumbudur shale beds form a very important pure deposit of clay near Madras, suitable for the manufacture of good porcelain ware; but plenty of clear, fresh water, which is difficult to obtain in the area, will be required for its exploitation

Sandy clay is very widely used for brick manufacture near Madras as in Chetpet, Nerkunram etc.; and fine sand is also available in good quantities for mixing with chunam and cement. Plenty of lamellibranch shells are obtained in the Pulicat lake and along the coastal parts south of Madras pits are dug to obtain them.

88. Mem. G.S.I., Vol. XXXII, pt. I, 1901, p. 51.

APPENDIX

LIST OF PLACE NAMES WITH THEIR LOCATION IN THE
ONE INCH SURVEY OF INDIA MAPS.

NOTE:—Latitudes are all north; longitudes are east of Greenwich.

The spelling, as far as possible, strictly conforms to that of the One Inch Maps of the Survey of India; the names given in brackets refer to those used either in the Indian Atlas Sheet 78, or in the description of R. B. Foote (or other earlier workers) or in both as equivalents.

Acharapakkam hill	.. 12° 23' 0"	79° 47' 23"
Agaram hill	.. 12° 45' 23"	80° 6' 7"
Akkampuram (Ackeramperam, Ackerum- perum)	.. 12° 58' 27"	79° 46' 0"
Alagusamudram hill.	.. 12° 38' 23"	80° 1' 13"
Alamparai (Alumparva, Alamparva)	.. 12° 16' 0"	80° 0' 47"
Alappakkam hill	.. 12° 40' 15"	80° 0' 10"
Allikkuli peak	.. 13° 17' 0"	79° 43' 57"
Allikkuli village (Alicoer, Alicoor)	.. 13° 15' 54"	79° 47' 6"
Amarambedu (Amanumbaid, Amerumbode).	12° 57' 54"	80° 1' 0"
Amarambedu (Amerumbardoo, Amerambode)	.. 13° 23' 53"	80° 0' 40"
Ambakkam peak	.. 13° 22' 10"	79° 52' 43"
Ammanampakkam hill	.. 12° 49' 0"	80° 7' 20"
Anakaputtur (Anacotore, Anakaputur)	.. 12° 58' 47"	80° 7' 43"
Angur hill	.. 12° 42' 53"	80° 2' 44"
Appur hill	.. 12° 48' 10"	79° 59' 10"
Arambakkam	.. 12° 52' 0"	80° 0' 40"
Araneri	.. 12° 55' 23"	79° 55' 0"
Arani village	.. 13° 19' 53"	80° 5' 13"
Arcot	.. 12° 54' 0"	79° 19' 40"
Ariyattur	.. 13° 5' 53"	79° 53' 10"
Ariyavakkam (Arryapaucum)	.. 12° 58' 57"	79° 50' 30"
Arkonam (Arconum, Aricoonum)	.. 13° 4' 40"	79° 40' 10"
Arudur	.. 13° 34' 37"	79° 56' 40"
Arumbakkam	.. 13° 12' 0"	79° 51' 25"
Arunkunnam	.. 12° 43' 50"	79° 52' 0"
Attan tangal	.. 13° 12' 14"	80° 10' 5"
Attipattu (Oxapet, Attiput)	.. 13° 10' 10"	79° 46' 33"
Attirambakkam (Attrampakkam)	.. 13° 13' 50"	79° 53' 20"
Avadi (Avady, Aoady)	.. 13° 7' 0"	80° 6' 10"
Avalur (Outtoor, Onatoor)	.. 12° 53' 30"	79° 32' 40"
Avirmedu hill	.. 12° 27' 13"	79° 54' 45"
Ayanabakkam	.. 13° 4' 40"	80° 9' 7"
Ayyapakkam (Ayappallicum, Ayapakkam)	.. 13° 5' 40"	80° 8' 0"

Baleswaram	.. 12° 39' 47"	79° 50' 53"
Birakuppam	.. 13° 27' 20"	79° 50' 50"
Bezwada	.. 16° 31' 26"	80° 36' 15"
Budavada	.. 15° 51' 0"	80° 12' 0"
Budur (Boodoor)	.. 13° 25' 0"	79° 57' 40"
Chetpet	.. 13° 4' 10"	80° 14' 0"
Cheyur	.. 12° 21' 0"	80° 0' 23"
Cheyyar	.. 12° 39' 24"	79° 32' 40"
Chinna Tripetty	.. 16° 59' 0"	81° 20' 0"
Chingleput	.. 12° 41' 33"	79° 58' 33"
Chintamani	.. 13° 24' 14"	78° 3' 24"
Chunampet	.. 12° 15' 13"	79° 54' 40"
Conjeeveram (Conjeveram)	.. 12° 50' 0"	79° 42' 0"
Coromandel	.. 13° 27' 13"	80° 18' 20"
Covelong	.. 12° 47' 7"	80° 15' 0"
Damal (Damul)	.. 12° 53' 10"	79° 35' 40"
Damarappakkam	.. 13° 12' 50"	80° 1' 40"
Devariyambakkam (Devaroyempakkam)	.. 12° 49' 0"	79° 52' 27"
Dugarazpatnam	.. 13° 58' 30"	80° 10' 0"
Dusi (Doshee)	.. 12° 46' 30"	79° 40' 47"
Edaiyur	.. 12° 34' 10"	80° 10' 53"
Edakunram	.. 12° 41' 18"	80° 6' 10"
Edamich hill	.. 12° 41' 30"	79° 51' 53"
Edayarpalaiyam	.. 13° 10' 47"	80° 16' 27"
Ennore	.. 13° 14' 50"	80° 19' 40"
Erumaivettipalayam (Yermootapolliam)	.. 13° 14' 20"	80° 7' 23"
Erumaiyur hill	.. 12° 57' 13"	80° 4' 33"
Ganjam	.. 19° 23' 30"	85° 3' 0"
Golapalle	.. 16° 43' 0"	80° 58' 0"
Gudiyattam	.. 12° 50' 20"	78° 52' 20"
Guduvancheri hill	.. 12° 49' 50"	80° 3' 43"
Guduvancheri village	.. 12° 50' 47"	80° 3' 47"
Gunipalaiyam (Goempollium, Goempolliam)	13° 17' 0"	79° 51' 14"
Hadsanpuram (Hodson's Pettah)	.. 13° 17' 0"	79° 46' 25"
Hanumantaputter hill	.. 12° 40' 40"	79° 58' 3"
Harichchandrapuram (Catramatoor)	.. 13° 5' 9"	79° 44' 37"
Ilatturu (Ilatoor)	.. 13° 14' 50"	79° 41' 27"
Iluppattandalam (Illeputundlum, Illepu- tandalum)	.. 13° 1' 0"	79° 40' 0"
Injambakkam (Ingepaucum, Ingepaukum)	.. 12° 53' 40"	79° 41' 40"
Irumbedu (Yerremboor)	.. 12° 57' 0"	80° 0' 17"
Irungattukottai	.. 12° 59' 37"	79° 59' 30"
Isur	.. 12° 32' 23"	79° 59' 37"

Kachchur (Cutchoor)	.. 13° 17' 27"	79° 53' 37"
Kadumbattur	.. 13° 5' 50"	79° 51' 50"
Kalahasti	.. 13° 45' 0"	79° 42' 0"
Kalattur	.. 13° 48' 42"	79° 57' 7"
Kaliyambakkam (Cullumbaucum)	.. 13° 19' 40"	79° 43' 28"
Kallikuppam (Callicoopum)	.. 13° 12' 23"	80° 5' 15"
Kalway hill	.. 12° 46' 23"	80° 6' 50"
Kambakkam Durgam	.. 13° 34' 27"	79° 51' 40"
Kanattur	.. 12° 28' 0"	80° 7' 33"
Kandalur hill	.. 12° 43' 23"	79° 58' 47"
Kandur (Candoor, Kandoor)	.. 12° 56' 54"	79° 50' 7"
Kanjampattu (Kinjamut, Kinjamuttoo)	.. 13° 9' 20"	79° 42' 20"
Kanjipadi (Conjibuddy)	.. 13° 12' 43"	79° 47' 13"
Kannammapettai	.. 13° 11' 50"	79° 53' 10"
Kannambakkam (Cunnumpacum, Cunnumbaucum)	.. 13° 29' 33"	80° 2' 0"
Kannankaranai	.. 13° 9' 27"	79° 51' 20"
Kannavaram (Carnaveram)	.. 13° 26' 5"	79° 52' 33"
Karadiputtur (Caradecootoor, Caradepootoor)	.. 13° 21' 47"	79° 58' 3"
Karai (Corree)	.. 12° 52' 53"	79° 43' 30"
Karaikalani hill	.. 12° 48' 40"	80° 3' 14"
Karunguli hill	.. 12° 32' 10"	79° 53' 27"
Kaveripauk (Cavrepauk)	.. 12° 54' 27"	79° 27' 50"
Kaverirajapuram (Cavitporam, Cavitpooram, Kavedupooram)	.. 13° 10' 0"	79° 45' 0"
Kattanur	.. 13° 11' 43"	79° 50' 53"
Kattupalli	.. 13° 18' 17"	80° 19' 53"
Kattur hill	.. 12° 42' 35"	80° 7' 5"
Kilacheri (Reesary, Keesary)	.. 13° 1' 30"	79° 51' 6"
Kiranallur (Keremulloor, Kiranullur)	.. 12° 55' 30"	79° 49' 54"
Kokkarantanal	.. 12° 20' 3"	79° 55' 30"
Kolandalur	.. 13° 10' 0"	79° 52' 30"
Kollanur (Colanur)	.. 13° 22' 20"	80° 1' 5"
Kondapuram	.. 12° 54' 7"	79° 28' 0"
Koppedu	.. 13° 24' 27"	79° 42' 13"
Koppur (Coopore, Coopoor)	.. 13° 4' 23"	79° 58' 0"
Korattur	.. 13° 4' 27"	80° 1' 8"
Kosalnagaram (Naikenpolliam, Nakinpollium)	.. 13° 14' 40"	79° 43' 40"
Krishnapatnam	.. 14° 17' 5"	80° 7' 30"
Krishnapuram (Kistnahporam, Chittapuram)	.. 13° 10' 30"	79° 50' 0"
Kuchimalai	.. 12° 21' 30"	79° 53' 18"
Kumili hill	.. 12° 48' 0"	80° 6' 50"
Kunjaram (Cunjalum)	.. 13° 15' 33"	79° 53' 7"
Kunnattur	.. 12° 59' 10"	80° 5' 43"
Kunnavakkam hill (in Chingleput taluq)	.. 12° 42' 23"	80° 1' 7"
Kunnavakkam hill (in Conjeevaram taluq)	.. 12° 50' 50"	79° 54' 5"
Kunnavakkam village	.. 12° 40' 0"	79° 49' 20"

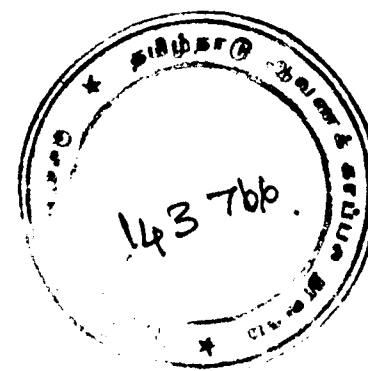
Kuppam	.. 13° 6' 20"	79° 54' 30"
Kuttambakkam	.. 13° 3' 33"	80° 1' 40"
Kuttarambakkam (Cotrumbaucum)	.. 12° 53' 52"	79° 45' 34"
Madarpakkam (Maderapaucum)	.. 13° 26' 47"	80° 0' 20"
Madurantakam town	.. 12° 30' 33"	79° 53' 20"
Mahabalipuram	.. 12° 37' 0"	80° 11' 40"
Mailai hill	.. 12° 42' 35"	80° 7' 5"
Malaipattu hill	.. 12° 54' 53"	80° 0' 50"
Mallareddikhandrika (Mullyreddypolliam, Mallareddypolliam)	.. 13° 14' 20"	79° 46' 40"
Mamandur (Maundoor)	.. 12° 52' 43"	79° 30' 30"
Mamandur (Maumdoor)	.. 12° 45' 10"	79° 40' 40"
Mambudur	.. 12° 40' 10"	79° 51' 6"
Mangadu	.. 13° 0' 20"	80° 6' 0"
Mangillmalai	.. 12° 22' 30"	79° 52' 55"
Manjankaranai	.. 13° 16' 15"	80° 7' 0"
Manuru	.. 13° 5' 33"	79° 48' 13"
Markkanam	.. 12° 11' 30"	79° 56' 42"
Melagaram	.. 13° 10' 10"	79° 51' 36"
Melaivaiyavur	.. 12° 35' 43"	79° 53' 35"
Melvasalai	.. 12° 22' 20"	79° 55' 44"
Mettupalaiyam (Motopullum, Molopullum, Mettapaluyam)	.. 12° 52' 0"	79° 55' 0"
Meyyur (Myoor)	.. 13° 14' 27"	79° 56' 40"
Minjur	.. 13° 16' 40"	80° 15' 33"
Mittanemali (Mittanemalei, Metnavilly)	.. 13° 9' 17"	80° 4' 13"
Mosur (Moshoor)	.. 13° 5' 0"	79° 43' 13"
Mullumalai	.. 12° 56' 53"	80° 6' 47"
Muppantalmalai	.. 12° 23' 40"	79° 54' 10"
Nagalapuram peak	.. 13° 26' 23"	79° 46' 40"
Nagalapuram village	.. 13° 23' 10"	79° 47' 47"
Nagari peak	.. 13° 22' 47"	79° 35' 47"
Nagari village	.. 13° 19' 20"	79° 35' 15"
Nallambakkam	.. 12° 50' 33"	80° 7' 13"
Nallur (Bootundalum)	.. 12° 57' 23"	80° 2' 0"
Nambakkam	.. 13° 14' 10"	79° 51' 23"
Nanmangalam hill	.. 12° 55' 30"	80° 10' 38"
Naravarikuppam (Naraincoopum)	.. 13° 11' 17"	80° 11' 15"
Narayanavanam village	.. 13° 25' 30"	79° 35' 27"
Nedugunram hill	.. 12° 52' 50"	80° 6' 30"
Nedungal	.. 12° 20' 47"	79° 44' 55"
Nelvay	.. 12° 36' 53"	79° 49' 27"
Nelvay (Nelway)	.. 13° 15' 27"	79° 52' 12"
Nemam	.. 13° 4' 0"	80° 1' 13"
Nemmali hill	.. 12° 40' 3"	80° 1' 44"
Nemmali village	.. 13° 0' 10"	79° 55' 23"
Nerkunram	.. 13° 4' 0"	80° 11' 10"
Nerumbur	.. 12° 31' 10"	80° 4' 7"
Neyveli (Nemaly)	.. 13° 12' 30"	79° 54' 0"

Odappai (Odapei, Odipee)	.. 13° 13' 47"	79° 54' 0"
Olakkur	.. 12° 18' 43"	79° 43' 5"
Ongur	.. 12° 19' 33"	79° 46' 47"
Oragadam hill	.. 12° 38' 0"	80° 3' 57"
Oragadam village (Woodagurm, Oragidam)	.. 12° 50' 30"	79° 56' 54"
Oratti hill	.. 12° 22' 37"	79° 40' 42"
Orattur	.. 12° 28' 43"	79° 47' 53"
Orattur (Ooratoor)	.. 12° 50' 57"	80° 1' 3"
Ottiyambakkam hill	.. 12° 51' 33"	80° 11' 22"
Pachaimalai	.. 12° 56' 37"	80° 7' 38"
Padiri	.. 12° 29' 10"	79° 46' 15"
Padur	.. 13° 3' 0"	80° 0' 36"
Pagalmedu	.. 13° 14' 7"	80° 1' 27"
Palanjur (Panjur)	.. 13° 1' 10"	80° 2' 27"
Palaveri	.. 12° 44' 13"	79° 52' 55"
Palayanuru (Pyanoor)	.. 13° 7' 20"	79° 47' 17"
Pallavaram hill	.. 12° 58' 10"	80° 9' 45"
Palur	.. 12° 57' 43"	79° 40' 15"
Pammal	.. 12° 58' 30"	80° 8' 10"
Pandur	.. 13° 32' 53"	79° 55' 30"
Pandur	.. 13° 9' 25"	79° 51' 0"
Parandur (Parundoor)	.. 12° 56' 33"	79° 44' 20"
Pavulur	.. 15° 51' 0"	80° 14' 0"
Pedda Ganjam	.. 15° 38' 30"	80° 13' 47"
Pennalurupet (Benaloor)	.. 13° 18' 24"	79° 51' 20"
Peripuliyur (Pulloor)	.. 13° 23' 20"	80° 2' 10"
Perumallapatti (Perumalpett, Permaul-naigput)	.. 13° 6' 33"	79° 59' 37"
Perumbedu	.. 13° 21' 27"	13° 14' 40"
Perumberkandigal hill (Perumber hill)	.. 12° 23' 0"	79° 47' 23"
Perumberkandigal village (Perumber village)	.. 12° 22' 40"	79° 46' 47"
Perunagar	.. 12° 38' 50"	79° 39' 37"
Peruvali	.. 12° 25' 47"	79° 54' 55"
Pinjivakkam	.. 13° 4' 37"	79° 51' 50"
Pondavakkam (Paundawaucum, Paundavaucum)	.. 13° 28' 20"	79° 59' 47"
Poonamallee (Poondamallee)	.. 13° 2' 40"	80° 6' 47"
Porundavakkam hill	.. 12° 40' 33"	80° 2' 33"
Porur	.. 12° 21' 0"	79° 54' 40"
Pravalavaraneswarapuram	.. 13° 30' 0"	79° 53' 5"
Pudukuppam	.. 13° 21' 10"	79° 54' 43"
Pudupper (Poothoopare, Puduperu)	.. 12° 58' 54"	80° 3' 0"
Pulicat village	.. 13° 24' 53"	80° 19' 3"
Puliyur (Pilyur, Pilwoor)	.. 13° 9' 17"	80° 1' 0"
Pundi	.. 13° 12' 40"	79° 52' 45"
Pungulum	.. 13° 29' 10"	80° 11' 7"
Raghavapuram	.. 12° 52' 23"	79° 46' 17"
Rajukulum (Rajah's Choultry)	.. 17° 2' 0"	81° 23' 0"

Ramagirimalai	.. 13° 25' 40"	79° 45' 20"
Ramamalai	.. 12° 44' 13"	80° 5' 10"
Ramanjeri	.. 13° 12' 0"	79° 47' 40"
Rangapuram	.. 13° 13' 7"	79° 52' 7"
Sadras	.. 12° 31' 27"	80° 9' 47"
Saidapet	.. 13° 1' 20"	80° 13' 23"
Saint Thomas Mount	.. 13° 0' 13"	80° 11' 40"
Saint Thomé	.. 13° 2' 0"	80° 16' 40"
Salavadu	.. 12° 28' 40"	79° 43' 53"
Santhakuppam hill	.. 12° 42' 50"	80° 4' 10"
Sattamai hill	.. 12° 33' 38"	79° 54' 13"
Sattarai (Suttry, Settorei)	.. 13° 3' 10"	79° 51' 0"
Satyavedu village (Sattavedu, Sattavade)	.. 13° 26' 7"	79° 57' 30"
Satyavedu peak	.. 13° 28' 7"	79° 53' 43"
Sedulapakkam (Callapanidoopettah, Callapanaidoopettah)	.. 13° 26' 53"	79° 58' 40"
Sembedu (Chumbode)	.. 13° 14' 13"	79° 59' 40"
Senjiagaram (Chingcagrin, Sinjeagaram)	.. 13° 19' 40"	79° 56' 23"
Settipuniyam hill	.. 12° 44' 53"	79° 59' 0"
Seven Pagodas	.. 12° 37' 0"	80° 11' 40"
Simapuram	.. 13° 15' 36"	80° 15' 13"
Singalpadi (Singilpadi)	.. 12° 55' 10"	79° 47' 40"
Sinthamanipuram	.. 13° 21' 20"	80° 20' 16"
Siruperpandi	.. 12° 23' 17"	79° 45' 40"
Siruvadu (Seerwaydoo, Seervedu)	.. 13° 23' 43"	79° 59' 45"
Siruvakkam (Surebaucum)	.. 12° 54' 47"	79° 42' 53"
Sitenjeri	.. 13° 16' 43"	79° 53' 30"
Sittalapakkam hill (in Saidapet taluq)	.. 12° 53' 3"	80° 11' 43"
Sittalapakkam hill (in Madurantakam taluq)	.. 12° 43' 47"	79° 51' 6"
Sittukkadu (Chittagauda)	.. 13° 5' 20"	80° 3' 0"
Sriharipuiam (Woterpolliam)	.. 13° 13' 53"	79° 46' 3"
Sriperumbudur town (Sripermatoor, Street-permatoor)	.. 12° 58' 0"	79° 57' 0"
Sulurpet	.. 13° 41' 50"	80° 1' 7"
Surikapuram (Suroperam)	.. 13° 17' 23"	79° 42' 43"
Surutapalli (Sirgulpilly)	.. 13° 20' 0"	79° 52' 33"
Takkolam village (Tukkool, Tukkolum, Tukkolum)	.. 13° 1' 0"	79° 44' 0"
Talambedu hill	.. 12° 36' 53"	80° 2' 13"
Tamarakuppam (Junglepilly)	.. 13° 20' 50"	79° 55' 33"
Tambaram hill	.. 12° 56' 8"	80° 6' 27"
Tambaram village	.. 12° 55' 27"	80° 6' 17"
Thatharmalai	.. 12° 21' 30"	79° 53' 18"
Thirupper	.. 13° 12' 36"	79° 50' 15"
Thiruvallambudur	.. 13° 11' 23"	79° 52' 4"
Thomas Mount	.. 13° 0' 13"	80° 11' 40"
Thoppalanpalaiyam	.. 13° 29' 17"	80° 17' 33"

Tinnanur (Tinnanore, Tinanoor), Railway Station	.. 13° 7' 20"	80° 1' 47"
Tinnanur village	.. 13° 6' 45"	80° 1' 40"
Tirukkachchiyur hill	.. 12° 46' 27"	79° 59' 37"
Tirukkalkil-kunram hill	.. 12° 36' 37"	80° 3' 38"
Tirukkalkikkunram village	.. 12° 36' 20"	80° 3' 30"
Tirumanishai (Trimalchy)	.. 13° 3' 0"	80° 3' 33"
Tirumakkudal	.. 12° 45' 23"	79° 51' 40"
Tirumallivayal (Tirumullavayal, Trimulla- voil)	.. 13° 8' 7"	80° 8' 0"
Tirumangalam (Tremungalum, Tirumun- galum)	.. 12° 55' 54"	79° 53' 23"
Tirumani hill	.. 12° 39' 3"	79° 58' 47"
Tirunirmalai	.. 12° 57' 47"	80° 6' 57"
Tiruppachur (Tripassore)	.. 13° 8' 17"	79° 52' 40"
Tiruppandiyur (Punnoor)	.. 12° 57' 33"	79° 52' 47"
Tirutani (Tirutany)	.. 13° 10' 30"	79° 37' 0"
Tiruvallur (Trivellore) Railway Station	.. 13° 7' 0"	79° 54' 50"
Tiruvallur town	.. 13° 8' 37"	79° 54' 27"
Tiruvelangadu Railway station (Chinnama- pett station, Chinamapett Station)	.. 13° 5' 20"	79° 46' 0"
Tiruvelangadu village (Trevalangall, Tre- valankadu, Trevatangul)	.. 13° 7' 47"	79° 46' 40"
Tiruverkadu	.. 13° 4' 13"	80° 7' 0"
Tiruvotiyur	.. 13° 9' 33"	80° 18' 7"
Todukkadu (Todocaud, Todukadu)	.. 12° 59' 37"	79° 56' 6"
Toidavuru (Tydoor, Tyloor)	.. 13° 5' 27"	79° 46' 27"
Tomur (Toombul, Tumbol)	.. 13° 12' 15"	79° 48' 15"
Tonnadumalai	.. 12° 23' 40"	79° 54' 10"
Tripetto (Chinnatripetto)	.. 16° 59' 0"	81° 20' 0"
Tripurantakapuram (Tipporandaporum)	.. 13° 27' 33"	79° 51' 43"
Umaiyparanachcheri (Omeallicherry)	.. 12° 50' 0"	79° 58' 33"
Umaiypuram (Umaiverum, Umayapu- ram)	.. 12° 49' 13"	79° 35' 30"
Unamanjeri hill	.. 12° 51' 10"	80° 7' 53"
Uriyur (Waroor, Warroor)	.. 13° 2' 47"	79° 46' 27"
Utatur	.. 11° 4' 0"	78° 55' 0"
Uttaramerur	.. 12° 36' 50"	79° 45' 40"
Vadamadurai (Waramderry, Vadamadiri)	.. 13° 17' 5"	80° 2' 30"
Vaiyapur (Vippoor, Vippur)	.. 12° 52' 23"	79° 58' 0"
Vallakottai (Valleycottah, Vellakotta)	.. 12° 53' 0"	79° 56' 10"
Vallam hill	.. 12° 41' 30"	80° 1' 22"
Vallum (Vellum)	.. 12° 53' 40"	79° 56' 6"
Vallur	.. 13° 15' 20"	80° 17' 0"
Vandalur hill	.. 12° 53' 47"	80° 5' 48"
Vanjivanjeri (Vanjeri)	.. 12° 52' 31"	79° 50' 49"
Varadayyapalaiyam	.. 13° 35' 53"	79° 56' 0"
Vattambakkam (Vautumbaucum)	.. 12° 50' 28"	79° 58' 23"
Vayalanallur	.. 13° 5' 7"	80° 4' 24"

Vedal (Vidaloor)	.. 12° 52' 47"	79° 45' 0"
Vegamangalam, (Mavamanglum, Mara- mungalum, Mavamunglum)	.. 12° 52' 40"	79° 29' 30"
Velangadu	.. 12° 24' 35"	79° 46' 7"
Vellarai (Vallerry, Vellare)	.. 12° 55' 20"	79° 59' 20"
Velliyur	.. 13° 13' 0"	80° 0' 40"
Vemavaram	.. 15° 41' 0"	80° 13' 0"
Vembedu malai	.. 12° 44' 40"	80° 8' 10"
Vengal (Vungul, Vingul)	.. 13° 15' 0"	80° 0' 50"
Venkatapuram hill	.. 12° 45' 47"	79° 58' 25"
Venpakkam hill	.. 12° 46' 13"	79° 57' 10"
Vishar (Visier, Vizier)	.. 12° 49' 49"	79° 37' 26"
Vizagpatam	.. 17° 41' 20"	80° 18' 0"
Walajabad (Wallajabad, Wallajahbad)	.. 12° 47' 23"	79° 49' 27"
Wandiwash	.. 12° 30' 10"	79° 36' 25"
Yigavaripalem (Ingawarpollum, Ingawar- polliam)	.. 13° 27' 7"	80° 3' 30"



Milk Supply in the City of Madras

By

K. C. RAMAKRISHNAN, M.A.

The problem of milk supply in a city like Madras is an interesting study in economic geography. The location of milk industry catering to a city, to a tropical city in particular, is governed more by considerations of demand than of the physical fitness of the area for production. The demand for milk in the Madras city is growing with the growth in its population, particularly of middle class families settling down in the suburban and other extensions. The coffee-habit is growing faster among all classes of population, though the working class cannot afford to take it with milk, while among the rest half the milk is generally consumed with coffee. The majority of the population are vegetarian by faith or by virtue of economic necessity, and therefore appreciate milk and milk products. Low as the average consumption is, there is a large and unsatisfied demand for milk.

It is difficult to get a correct idea of the quantity of production and import of milk in the city or even of the number of milch cattle actually yielding milk at any one time. The first official investigation made about 20 years ago¹ revealed that there were then 1,473 cows and 2,944 she-buffaloes in the 686 'registered' cattle yards of the city. The number of milch-cattle kept by others, one or more each for domestic use, was not taken into account, as there was, and even now there is, no need to register them. In 1932, the registered cattle yards had increased to 1776 with 3,639 cows and 4,068 she-buffaloes. According to the quinquennial cattle census of 1935, of "cattle over 3 years of age kept for milk or breeding in the city," there were 3,536 cows and 2389 she-buffaloes. As per the latest available report of the Corporation of Madras, for the year ending 31st March 1939, there were 1403 'approved' cattle yards with 3,850 cows and 5,000 she-buffaloes and 258 'unapproved' yards with 434 cows and 714 she-buffaloes. This does not include the animals kept by individual households for the supply of milk for home use.

1. A Survey of the Madras Dairy Trade by A. Carruth.

The Madras and Southern Mahratta Railway is said to have conveyed in the year ending 31st March 1939 from Guntur and Nellore districts to Tiruvottiyur (in the northern outskirts of the city of Madras where all the milch cattle are sold) about 5,000 cows and 7,000 she-buffaloes. It is not known how many of these milch cattle are taken to districts in the south and west by road or by mail, and how many stay on in the city. Nor is it known beyond doubt how many cows and buffaloes, when they get dry, are sent back to the district from which they came, for a temporary sojourn until next lactation, or permanently. It was estimated at 500 per year a few years back, but as a result of the intervention of the Agricultural Marketing Officer in Madras, the Railway has since February 1937 reduced the freight for sending back dry cows from Madras to 50 per cent of the rate for the journey to the city or Tiruvottiyur. This is said to have induced a thousand more dry animals to be sent back last year. But even then the number sent to the slaughter house in the year ending 31st March 1939 is said to have exceeded 2,000 cows and 3,000 she-buffaloes, so that nearly 40 per cent of the number of milch cattle arriving in the city every year find their end after one or two lactations. This is indeed a terrible drain and it accounts for the small number of milking animals kept at any one time in the city. We are not sure how many of these are actually yielding milk. Perhaps we may not be very wide of the truth if we put down 3,000 cows and 4,000 she-buffaloes as actually in milk every day.

The cows are almost all of the Ongole breed; there is just a sprinkling of cross-bred cows; the buffaloes, with the exception of a few hundreds of Delhi or Murree breed, also come from Guntur district. These animals are undoubtedly the best milkers in this Province and it will not be an over-estimate if we take the average yield of each animal per day at 2½ Madras measures or 10 lbs. (1 gallon). The 8,000 animals may therefore account for a daily output of 20,000 Madras measures.

There is a considerable quantity of milk arriving by railway trains from villages within 25 miles of the city, from Trivellore side (N.W.), Ponneri (N.) and Tambaram (S.). It has been variously estimated from 2,000 to 4,000 Madras measures. We may take it at an average of 3,000 measures. Let us note that 20 years back when the first official survey was made this rail-borne import of milk was negligible. The issue of cheap season tickets by the M. & S. M. and S. I. Railways has facilitated this traffic. All the milk is brought by producers or their agents by passenger trains

and not consigned as parcels carried by the railways. Most of this milk is said to reach coffee and other hotels, and in a few cases some dairies in the city. Practically nothing is supplied to domestic consumers direct, though some city milkmen are found to purchase this milk at the railway stations.

The Madras Co-operative Milk Supply Union, organised in 1926, and recently equipped with pasteurisation plant, cold storage, bottling machine, etc., supplies in its motor vans about 2,000 measures per day, out of which three-fourths come from societies affiliated to the Union and located in villages in the Chingleput district, and one-fourth is from cows and buffaloes maintained within the premises of the Union itself at Iynavaram (near Perambur) or its neighbourhood. We have thus altogether about 25,000 measures or 100,000 lbs. of milk per day supplied and consumed in the city with a population of about 700,000—which means an average consumption of about 2·3 oz. per head per day! No account is taken here of the milk products—to a small extent curds and to a much larger extent butter and ghee—arriving in the city from far and near. If account were taken of these and rendered in terms of milk, the rate of consumption might be double, i.e., 5 oz. per day, which is still poorer than in northern cities of which estimates are available.²

The ideal prescribed for a balanced diet by the authorities of the Nutrition Research Institute at Coonoor ranges from 15 to 30 oz. per day—varying with the age and work and other conditions of persons concerned.³ This is an impossible ideal in our country.

2. Dr. N. C. Wright's Report on Dairy Industry in India, 1937.

Municipality.	Consumption (in oz.) per head per day of		
	Milk.	Ghee.	other milk products.
Madras ..	1·4	0·18	0·10
Lucknow ..	1·4	0·35	0·27
Lahore ..	2·0	0·40	0·01
Agra ..	2·6	0·42	0·47
Surat ..	6·1	0·75	0·35
Amritsar ..	7·3	1·25	2·61

3. Health Bulletin, No. 23, by Dr. Aykroyd.

For even in England the actual consumption per capita is about 10 oz. only per day. But people there consume a lot of meat and fish and eggs, which like milk are first class 'protective foods'. In a poor country like ours 8 oz. may be deemed a workable ideal. The well-to-do citizens of Madras do consume at least 8 oz. per head of milk, not including the intake of ghee. The middle class, a very composite class, may be taking anything from 4 to 8 oz. including the milk that goes to the making of ghee. Milk is indeed the most variable item in the diets of the members of this class. The working classes consume very little of milk (1·25 oz. on an average per day) as was revealed by an intensive study of their Family Budgets collected in the city in 1935.⁴

The price of milk in Madras, though its quality is poor, is greater than that of milk of richer quality sold in London, which gets its supply of milk from great distances—50 miles and upwards—where the cows live in a more natural environment in the countryside. Not only England, but several other European countries—notably Denmark, Holland, and Switzerland, not to speak of Ireland—have splendid pasture grounds and all of them supplement their natural supply of grass with special leguminous fodder crops and root crops, which are carefully stored and supplied during winter when animals are stall-fed, and with oil cakes, mostly imported. Our city cows get no doubt a richer ration in the stalls in their milking period in the shape of oil-cakes and pulse husks than what they could get in the villages at the hands of poorer farmers; but it is often an ill-balanced diet. They get little or no succulent grass or fodder in any part of the year and most of them are tied to the cattle shed all through the year, except when they are trotted out in the morning and evening for milking at customers' doors. Perhaps a few cows in the spacious compounds of the rich are more fortunate; but not all the rich keep cows in spacious compounds. Many of these are kept in congested residential quarters in George Town, in the little cattle yards and verandahs of pucca houses fouling the air all round.

The vast majority of the cows and buffaloes suffer in the stuffy hells called cattle sheds in the city, with little more than elbow space in most of them. The 'model cattle yards', built by the Corporation of Madras, accommodate about 500 animals; but they are not models that we would advocate. Cows and buffaloes which

4. Family Budgets of Industrial Workers in Madras City by N. K. Adyanthaya, p. 31.

have been bred in the rural areas of Guntur and Nellore, where the soil is rich in lime and the climate is drier, cannot thrive well in the humid climate and congested condition of the city. Due to the lack of fresh air, fresh water and grounds to roam about, many of them become poor yielders in the course of a few years and with the unsystematic breeding practised by the generality of milkmen in the city, it is often deemed wiser to dispose of the deteriorated animals to the butchers at a low price. This is no doubt in direct violation of the Hindu veneration for cows but it is the inexorable economic pressure, the cost of maintaining a dry cow without sufficient recompense in the next lactation in many cases that drives the milkman to turn a deaf ear to sentimental appeals.

The keeping of cows is a speculative proposition in the city of Madras. The cost of maintenance of a cow in milk, including the purchase of oil-cakes, bran and pulse husk, and the labour charges works out on an average to 9 annas per day. Interest on capital cost, rent of stalls, and taxes might amount to 3 annas per day per animal. If the yield of milk per cow is $2\frac{1}{2}$ measures per day, it fetches Re. 1 per day, which leaves a net income of 4 annas per day. Cow-dung is given away in lieu of conjee or rice water. Taking 8 months as the average period of lactation, the income from milk is Rs. 60 per cow per lactation. A good milking animal would cost at least Rs. 100 per head. But when it turns dry, it is worth only Rs. 30. The lean calf, if one survives, after lactation is not worth much. There is, therefore, a heavy depreciation which is not made up for by the net income. A cow does not often pay its way; the buffalo is a little better. No wonder, the Madras dairy trade has been condemned as a bankrupt trade and there is some justification for all the sleight-of-hand tricks at adulteration by the milkmen. Buffalo-milk is toned down by the addition of water and sold as cow's milk; milk is warmed and the cream is skimmed off and the rest is sold as whole milk.

Milk is a comparatively bulky commodity, highly perishable and inconvenient to carry long distances except in vehicles of the perfectly smooth-running type on first class roads. Milk is demanded early in the morning and as fresh as possible. In view of the extraordinary facility in diluting and adulterating milk, the well-to-do housewife insists on the milking of the animal in her presence at her house. It is not given to the poor to indulge in this luxury on account of the very limited individual demand of each family, which has to buy what is offered at a lower price. We witness, therefore, the unnatural and cruel spectacle of the city cow being taken from house to house and forced to yield its milk

morning and evening often in instalments at more than one house. Still, how many of these consumers could be sure of the purity or the quality of milk? The sleight-of-hand tricks practised by the experienced milkman in diluting the milk even while the cow is milked at the house of the consumer can only be detected by the very wary observer. Even when milk is not so diluted, it is not rich in quality for two reasons. If the cow is milked in more than one house, the first served always gets poorer quality of milk with low butter fat contents, so low indeed that children cannot thrive on such milk, while the last served gets the milk too rich in fat. Even if a consumer gets the entire supply of milk of a cow, the milk of city-bred cows is inferior in quality because of the total absence of succulent fodder and inadequate stall feeding. There is at present practically no pasture ground in the city, though here and there cattle are turned to graze on what are really standing grounds. Madras is said to have had plenty of pasture grounds a hundred years back, when the population was far smaller and the number of animals very limited. Even 40 years back it was common for most of the gentry in Madras to keep a cow or more each in their spacious compounds and send them out for grazing in charge of servants. But on account of the building activities in the city, especially in the post-war period, there is practically no pasture or exercising ground for cattle within the city proper—barring the play grounds like those on the Island on which we find a number of cattle are turned. Even cut-grass which is brought in head loads for some period after the rains is bought more for horses than for cows or buffaloes, which have to be satisfied with dry straw. Naturally cattle accustomed to rich green fodder-grasses and cholam stalk in their original homes, deteriorate for want of succulent fodder in the city.

If the dairy industry should be placed on a profitable basis, the animals maintained in a natural environment with more space to move about, and insanitary practices inevitable in the keeping of a large number of cattle within the city done away with, it is necessary to remove all the cattle outside the city. There must be a search for vast open spaces round about the city, within a radius of 20 miles, where on cultivable land fodder crops could be raised so intensively as to replace economically the dry rain-fed paddy and millets raised at present. Lands growing more valuable crops like wet paddy, plantains, sugarcane, betel and vegetables should not be disturbed; but these crops cover only a small area comparatively. The wastes that cannot be reclaimed for cultivation by the plough may yet serve as pasture ground or at least

exercising ground for cattle. What is needed is an intensive survey by an expert committee of the soil, climate, irrigation and other facilities in the neighbourhood of the city for the raising of forage crops and the maintenance of milch cattle of the finest breeds. City conditions offer little scope for better breeding and rearing of cattle, without which the cost of milk cannot be brought down.

It may be too drastic a step to take—to clear at one stroke the city of all milch cattle. But this may be done by stages; the most congested quarters may first be cleared; cattle in private compounds of more than a fixed area may be taken away last. With the increasing demand for house-sites it will only be a natural adjustment. Such removal of cattle has been found necessary in all big cities in the West. They are contemplating it in Bombay⁵ and in Calcutta where the evils of city-bred cattle and cruelties inflicted by milkmen on them are, if anything, worse than in Madras.

There are, however, new and difficult problems which the shifting of the source of milk supply away from the City is bound to create. Consumers in the City want fresh, unspoilt, unadulterated milk at an early hour in the morning so as to have their morning coffee between 6 and 7. Absolute freshness is impossible as milk will have to travel 10 to 20 miles. Milking at the untimely hour—between 3 and 4 a.m.—is relished neither by the cow nor the milkman in the village, especially if milking is only a sideline to agriculture. Even if milking is done at a very early hour, milk will have to travel over rough roads, at least until the main trunk road is reached. This is sure to tell on the quality of milk. And in the evening when it is much warmer, milk gets spoiled sooner by transport. Milk does not get spoiled for 24 hours in cooler climates, but in South India it rarely keeps well for more than 6 hours. With the best of intentions, therefore, milk may get spoiled in the local conditions of production and transport. Freedom from adulteration and contamination can be guaranteed only when there is a reliable agency to look after the milk from the stage of milking the animal in the village to that of delivery at a central depot for mere bottling or canning before distribution or for pasteurisation in addition, as is done by the Madras Milk Supply Union at Iyavaram.

5. The Government of Bombay contemplate the removal of cattle sheds from the city to places like Palghar or Trombay having plenty of grazing grounds and the formation of a public limited company with a capital of Rs. 20 lakhs with exclusive rights to sell milk of quality at 100 distributing centres; or the municipal corporation will be asked to take up the question.

Pasteurisation and cold storage before delivery are done with a view to ensure clean and disease-free milk and to keep the milk in a safe condition for at least 12 hours in our warm climate and thus avoid too early milking of cows in the villages. The danger, however, will still be there, if from the beginning of milking in the village and after taking delivery of milk from cold storage scrupulous care is not exercised in the handling and conveying of milk. Pasteurisation will have to be done in perhaps half a dozen centres at different approaches to the City and not in one central place. This may be worthwhile doing only when practically all the supplies come from outside the City and not partly from within. Bulk handling is essential for reduction of costs. If milk can be transported within six hours after it is milked, it may not be necessary to resort to pasteurisation at all, especially as milk in our country is seldom used without boiling, though we are told we are thereby losing some vitamins. Even then a number of depots will be necessary to collect milk coming from different directions into the City. It is impossible for individual producers to meet consumers in the City. The best organisation for collection and distribution would be a co-operative organisation like the Madras Milk Supply Union. Municipalisation of milk supply is an alternative that has often been canvassed; but the record of municipal control of adulteration, not to speak of other municipal enterprises, is not even as good as that of co-operative control and trade. The Geographical Conference is not the best place to discuss the pros and cons of co-operative v. municipal milk-supply. But it is necessary to understand the implications of the suggestion to transfer the source of milk-supply from the City to the rural parts round about.

Cinchona Cultivation in India

By

K. N. PASUPATHI, B.A., L.T.

Few people perhaps are aware that quinine, the well-known, popular and cheap remedy for Malaria in all its forms, is made in India; and fewer still perhaps know that the Madras Government manufacture it. There are two factories both of them, government concerns—manufacturing quinine and allied drugs. One of them is situated in Mungpoo on the Darjeeling Himalayan Railway in Bengal, and the other, at Naduvatam, in the Nilgiris, on the Ootacamund-Mysore Road. The latter is owned and managed by the Madras Government and run on a semi-commercial basis in that the department, known as the Cinchona department, is self-supporting. The department makes only a small profit, its main object being to make cheap quinine available to the suffering masses through hospitals and post-offices.

Quinine is obtained from the bark of a plant which really grows into a tree, twenty feet high and more, called Cinchona and named after its discoverer, Conde del Chinchon, the wife of a Viceroy of Peru, in South America. She was cured of an intermittent fever while in Peru in 1638, thanks to the administration by the natives of the powdered bark of cinchona. How the native Peruvians acquired the knowledge of the virtues of this bark is not exactly known. In 1640 the Jesuits in Spain had the bark sent to them by their brethren in Peru. And for nearly two centuries, the drug was administered in the form of a decoction of powdered cinchona bark, the alkaloids in it not having been "isolated" till the nineteenth century.

The plant was brought to Europe by the Countess of Chincon, when the surprisingly successful, curative effects of the bark were noticed. Its uses were soon recognised. A regular and scientific cultivation of the plant was carried out in the course of the 19th century in different parts of the world, the most successful of them being in Java. The Indian plantations, those in the Nilgiris and in the Himalayas, were considered, about 70 years ago, to be the most promising and likely to become the world supplier. But, for reasons not yet thoroughly investigated, India now holds a rather backward place in the world as a Cinchona-supplier.

The Java plantations which are owned and managed chiefly by the Dutch are now the leading world suppliers; and this pre-eminent position of Java is mainly attributable to the systematic and scientific cultivation of the plant combined with the hard work of the Dutch planters.

There are three varieties of Cinchona bark: (1) Ledgerina or Ledger; (2) Succirubra and (3) Hybrid, which is obtained by hybridising Ledger and Succirubra. The Ledgerina, largely found in Sikkim, has a high percentage of quinine content, though it is a very delicate plant and its successful cultivation is therefore rather difficult. A good sample of this variety has a quinine content of 7 or 8 per cent, and 12 to 13 per cent of total alkaloids. This plant flourishes well at an altitude of 3,000 feet, such as in the Wynaad.

The second species, Succirubra, grows at a higher elevation, above 7,000 feet. It is a weak, straggling tree attaining to a height of about twenty feet, largely grown in the Nilgiris, Ceylon and Sikkim. It is the most important plant cultivated in the Nilgiris. It is more robust than the Ledger, and needs less care. But it yields only about three per cent of quinine, and seven or eight per cent of total alkaloids.

The hybrid, on the contrary, is a happy blending of the two species above-named. It combines the sturdiness or robustness of Succirubra with the richness of Ledgerina. This is a very popular variety now. But, for cleanness in extraction work, the chemical extraction of quinine, alkaloids etc., there is nothing to equal Ledger bark.

All the three varieties are cultivated in the Madras Government plantations. These are found in three different places: (1) at Naduvatum, the biggest area, about 1,000 acres being under cultivation; (2) at Doddabetta, about 200 acres; and (3) in the Anamalai Hills, about 600 acres.

Cinchona grows best above an altitude of 3,000 feet, and that explains why all plantations are in the hills. It requires a cool climate, in which the contrasts between summer and winter, between day and night, are not very great. At Ooty, about 7,500 feet above the sea, the minimum lowest temperature in the shade is about 50 degrees F., the maximum being 70 degrees F. At Naduvatam, 2,000 feet lower down, the minimum is 54 degrees F. and the maximum 66 degrees F. In the Nilgiris, all species make their vigorous growth during the time when sunshine and shower alternate. They

grow for two months after the rains cease. The rainfall at Ootacamund is 44 inches; at Naduvattam, 105 inches. It is about 165 inches in the Sikkim plantations. But the plants are impatient of stagnant moisture. They require an open, gravelly subsoil, a sloping exposure and a rich loam to dry, clay soil.

Each cinchona plant is provided with a shading tree and the one selected for this purpose, at Naduvattam, is the Silver Oak. The plant has to be protected too against heavy winds. Seeds are planted first, and the small seedlings have to be transplanted three or four times and carefully nurtured until they attain the age of two or three years. When mature, the tree is scraped for bark—that is, after seven or eight years. It is this pretty long period of waiting for returns that highly discourages most Indian planters who often prefer growing tea or coffee which yield in two or three years. This is one of the reasons why private enterprise in Cinchona cultivation is so poor. Want of a proper knowledge of cultivation and lack of capital are of course other reasons. The government has recently investigated the possibilities of increasing Cinchona cultivation in India by encouraging private enterprise and it is to be hoped that this encouragement will be soon forthcoming.

Cinchona bark contains principally the Cinchona alkaloids which are estimated to be about 200 in number; tannin, useful for tanning purposes; and colouring matter, called Cinchona red. In quinine extraction all others are rejected except Cinchona alkaloids which are known as quinine, Cinchonidine, Cinchonine, Quinidine and amorphous alkaloids comprising the rest. The most essential and powerful remedial agent in Cinchona bark is termed quinine.

The Madras Government puts on the market Quinine Sulphate, the pink powder and tablets sold in Post offices—and other salts of Quinine such as Quinine Hydrochloride, Quinine Bi-hydrochloride, Quinine Bi-sulphate, etc., as well as Febrifuge and Totaquina, made from residues and used as a cheaper substitute for Quinine. Totaquina, though made from residues, is made strictly to the standards laid down by the Health Department of the League of Nations. This contains too more quinine than Febrifuge and is moderate in price. It is a standard preparation recognised by the medical authorities.

The curative properties of Quinine and allied drugs have been tested and found almost infallible. To a malarial ridden country like India, the problem of quinine supply is of very great importance. It is the best drug for treatment: the more quinine, the

lower the malarial death-rate. In all countries, generally, the supply is found to be insufficient, and the cry is for more quinine at lower price. We know that to-day, the Netherlands Indies produce about 90% of the world's supply in the mountain districts of Java.

Almost every human disease which shows a tendency to recur in regular fits or paroxysms is alleviated by the use of quinine. Hence its value is great not only for treating malaria but also for neuralgia, whooping cough, etc. It is also reputed to be a powerful, though unpalatable, tonic, when administered in small doses. As an antiseptic for treating wounds and in the treatment of pneumonia, it has been found efficacious too.

To make consumption easier, Quinine is supplied in the form of tablets. The Madras Government's factory at Naduvattam turns out about 22,000 lbs. of quinine every year. Here the production is limited owing to the inadequate supply of Cinchona bark, in spite of the purchase of bark from Bengal. Purchase from Java seems to have been now discontinued.

The need for increasing the production of quinine is acute. It can be done by increasing the area of cultivation of Cinchona as well as by increasing the productivity of the areas under cultivation. The Imperial Council of Agricultural Research in India recently investigated the question of increasing the area under Cinchona cultivation. As for increasing the productivity of the areas and the quality of bark in respect of its alkaloid contents, planned, experimental work is necessary.

The following figures taken from the Report of the Botanical Survey of India for 1937-38 explain the position of quinine production and supply in India:—

“India's stock of bark opened with a balance of about 494,600 lbs., of which Java bark was about 170,100 lbs. The bark treated at the Mungpoo factory of the Bengal Government was about 120,050 lbs., yielding about 4,400 lbs. of quinine and 2,000 lbs. of Cinchona febrifuge. The sale of Quinine Sulphate tablets rose from 340 lbs. to 2,400 lbs., the bulk of the supply going to the Punjab. The total revenue realised from the sale of Cinchona products was about Rs. 4,48,100. The year opened with a total stock of about 1,30,940 lbs. of quinine and ended with 1,12,560 lbs.”

The two Indian factories, that of Madras and the other of Bengal, supply quinine to hospitals, jails and post-offices in India. Still, imports of the drug have to be made to meet the increased

demand. A successful industry, by private enterprise, would be the best solution to the problem.

In Java, both the climate and soil are peculiarly favourable to the cultivation of Cinchona with a high percentage of quinine. So Java will always hold its own against India. In the world to-day, there are about twenty quinine factories, about a dozen of them being in France, England, Germany and Holland put together; 4 or 5 in America; 2 in India; and 1 in Java.

Now, India has been given a liberal supply of this invaluable drug-quinine, at a remarkably low price: the post office sells a packet of 20 tablets for five annas. The working of the Indian plantations has given employment to numbers of poor people. If enterprising Indian planters who own sufficient capital and command the necessary knowledge of the subject come forward to invest it in Cinchona cultivation in India, there is bound to be a prosperous future not only for themselves, but also for the millions of poor people in India to whom the quinine tablets, cheap as they are, are still not within easy reach. The Government of India must do all it can to encourage private enterprise in Cinchona.

Muslim Contributions to Geography

BY

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Greek and Roman contributions to Geography reach their high water mark with Ptolemy, and it would not be too much to say, that with him the story of ancient discovery comes to an end. Books in Greek and Latin ceased to have more information and gradually the Dark Age of Geography set in, with a negation of the Spirit of inquiry which generally characterises the early centuries of the Christian era. The pagan Greeks and their intellectual attainments failed to find favour with Christian Savants and later under the shadow of the proselytizing zeal of the Great Constantine things worldly ceased to charm the human mind. In short, early Christian teachings deliberately avoided pre-Christian Geographical theory. In the words of St. Ambrose "to consider the nature and position of the earth does not help us in our hope of the life to come."

The introduction of new extravagances began to replace the so-called pagan views, the end of the world was freely anticipated in 1000 A.D. and the spherical shape of the earth and the existence of antipodes were subjects of ridicule. Monk Cosmos carried these ideas to their logical conclusion by entirely refuting the pre-Christian view about cosmography (astronomical geography) in his work "Christian Topography". His earth was flat, rectangular, and oblong, twice as long from East to West as from North to South, and was surrounded by oceans. In addition a high mountain rose in the north behind which the tiny sun played hide and seek to bring forth day and night and then, beyond the unknown of the vast oceans lay Paradise! These conceptions about the earth remained the fundamental teachings of what we can call the 'School of Violent denial.' It is in fact against such a background that are to be judged the merits of the Geographical works of the early Muslims who rekindled the spirit of Classical Greece, nay carried it a step further in enriching geographical thought.

The Arabs were indeed the heirs of that Hellenistic Culture, for which a way was first opened by the conquests of Alexander

and which became so widely diffused throughout the eastern provinces of the later Roman Empire. Nearly all the deeper wisdom of the Greek thought became handy to the Arab-speaking world because works of noted authors were translated. And thus the heritage of Classical Greece helped to enrich a new civilization. Arnold very aptly remarks "Western Europe is apt to view the Muhammadan world as something entirely remote from itself; such a judgment leaves out of consideration that both the Christian West and the Muhammadan East are in many respects heirs of the same vivifying cultural influences and that Islam in the ultimate analysis of its civilization reveals itself as the aftermath of Hellenism in the East." The translation of Ptolemy in fact laid the foundation of that Geographical Science which the Muslims carried so far. Above all, geography formed part of that broader learning which was often cultivated for its own sake and displays so much balance, sanity and accuracy based on observation of actual facts.

The rise of the Prophet Muhammad is one of the most stupendous events in history. He appeared at a time when the Persian and the Byzantine Empires were exhausted by a prolonged conflict. The Arabs became the upholders of a creed which united them. In addition, attracted by the love of riches and spoils awaiting them, they raised the structure of an Empire the equal of which had not been seen. On the one hand it touched the borders of China and on the other it was washed by the waves of the Atlantic, a distance of some 7,000 miles. Further, Islam seems to have given the Arabs a psychological impulse to diffuse their culture. The behest of the prophet "Go unto China to acquire knowledge," explains the strong urge to visit far-flung areas. An extensive commercial activity and the vastness of the Muslim world offered unlimited scope for the increase of knowledge.

Two things must be borne in mind in connection with the scope and the influence of Muslim Geographical thought. Firstly, their contribution was not only immense but reveals a distinct advance over Classical achievements generally. Secondly, it influenced Europe perhaps only indirectly and in a limited sense, because of the prejudices and ignorance of contemporary Europe, which was accentuated due to the long-drawn conflict between the Cross and the Crescent.

Taking the Muslim contributions to Geography as a whole it is convenient study to resort to a fourfold division. (1) Descriptive Geography, (2) Advancement of Geographical conceptions

and geographical interpretations, (3) Astronomical and Mathematical geography, (4) Cartography.

Descriptive Geography can be taken to include a detailed knowledge of various places and countries of the world, along with the descriptions of the ways and lives of their peoples. In addition to Roman knowledge of lands and seas the Arabs were better acquainted with four other regions, hitherto only vaguely known.

Strabo and Ptolemy's knowledge about the regions round the Caspian Sea and the N. E. of the black Sea was very scanty. Pliny regarded the Scythians as cannibals, while Ptolemy's Sea of Azov extended upto the site of present Moscow. The sea of Aral was not mentioned at all. The lake of Khovarsm (Aral) is represented on a map of Khalif Al Mamun's days for the first time. Many expeditions were sent in this direction from Baghdad. In 1921 Ibn Fozlan visited South-Eastern Russia and leaves the first reliable account of the area. After this numerous Arab traders followed in this direction, went from S. Russia to Poland and extended their trading activities to Scandinavian countries. The evidence is borne out by the fact that in Sweden alone more than 30,000 Arab coins have been collected.

In those early times, the frequency of typhoons and the danger of the pirates were positive menace to sea ventures in Far Eastern Waters. The Roman trade with South-Eastern China was directed through the Burma-Yunnan route and their knowledge about Malaya and East Indies was inaccurate. Ptolemy had supposed that South-Eastern Asia extended westwards in the South, to join with Africa, thereby making the Indian Ocean a landlocked body. Undoubtedly, Arab and Persian maritime activity had been extended to Chinese waters before the advent of Islam. But with the rising tide of the new religion the Prophet wished his message to be taken to China. Arabs thus reached Canton, built a mosque and founded settlements with Chinese goodwill. The first accounts about these regions are those of Sulaiman the merchant and Abu Zeyad also known as Hasan of Siraf, in the second half of the 9th Century. Later on, Ibn Battuta's remarkable travels gave much information in this direction.

The Greeks and the Romans had frequented the East African coast and the former had also founded coastal settlements. But their activity was largely confined to the littoral portions. Muslims not only claim many maritime adventures in these seas but also seriously undertook inland penetration upto the coast of modern

Natal. The adventures of Sindbad the sailor are very largely concerned with exploits off the African Coast. No doubt much of fact is mixed with fiction in the narration of such events, but a great deal of knowledge about these lands was forthcoming.

Roman "Africa" largely meant Mediterranean Coastal regions plus the bordering desert fringes and Egypt. Soon after the conquest of Egypt the Arabs penetrated into the Sahara, explored Sudan and established friendly relations with Habash (Abbyssinia).

In fact such vast expansions in the knowledge about descriptive geography, were possible—among other factors—on account of extensive commercial activity, political and spiritual dominance of the Muslims and the remarkable achievements of intrepid travellers like Ibn Fozlan, Alberuni, Ibn Haukal, Masoudi and Ibn Battuta and seamen of the calibre of Sindbad. The annual congregations at Mecca provided vast opportunities for the exchange of views, story-telling and narration of events, when thousands of Muslims from different climes and far-off lands met their co-religionists.

The Arabs did not only increase the geographical knowledge of new lands in Asia and Africa, but what is more creditable they contributed to methods of geographical interpretations, which can be regarded as the earliest beginnings of a "regional conception" in Geography which preceded modern sociological and human studies by so many centuries. Thus many of their works in Geography reveal a study of cause and effect to explain man's reactions to his environment, and herein certainly lies their superiority over their Greek and Roman masters. In fact the Arabs made a serious departure from old traditions by pulling geographical studies out of the dominating astronomical and mathematical tangle. Even that great master, Ptolemy, can be described to be "more of an astronomer than a geographer." He used his net of longitude and latitude to devise a mathematical division of the world, upon which were based his geographical regions, without any attention being paid to physical and political boundaries. As Arab geographical studies developed, this method was found increasingly unsatisfactory and gradually the new approach of a "Regional Study" based upon the study of geographical surroundings and their influence on human activity, began to be increasingly adopted.

Valuable Muslim contributions in this connection grew out of the rich intellectual pursuits of the period of the Abbasid dynasty (Bannu Abbas). An account of the works of some leading geo-

graphical writers of this age is of enormous interest. Ibn Khurdadbeh is one of the pioneers of Arab Geography. He was a chief post-master who compiled his book 'on Routes and Kingdoms' in 850. This work though steeped in the tradition of the 'Ptolemaic School' is useful in giving a summary of the trade routes of the then Arab world. Unfortunately the descriptions are coloured with fabulous story-telling. His works provide us with descriptions of such distant lands as China, Japan and Korea. Yakouti wrote about 900 A.D., his Gazetteer-like compilation, "The book of Countries," giving details and names of numerous places and their distances, but what is more important he relates a series of facts based on physical aspects, explaining the human geography of many areas. Because of his industry and accuracy Yakouti is sometimes regarded as the father of Arab Geography.

The next great figure is that of Ibn Haukal who travelled far and wide for over 30 years (953-88 A.D.). He wrote a comprehensive account of his journeys and furnishes a geographical, political and economic account of the vast domains of the Islamic Khalifate. Ibn Haukal's geographical conceptions were based in his own words, on "Geography being a science which interests princes and peoples of all classes." Istakhari the merchant traveller and a contemporary of Ibn Haukal compiled his "Book of Climates." Masoudi remains an outstanding Muslim Geographer and like several Arab Savants his writings are based on sound personal observations. He tramped all over the known world from Spain in the West to Turkistan in the East, while Sofala, Zanzibar, Sind, China and Madagascar all are mentioned by him. Sir Percy Sykes regards Masoudi's encyclopaedic works to be of a very high order. His book 'Meadows of Gold and Mines of precious stones,' is an application of geographic principles to history. Masoudi's map of the world was compiled in 956 A.D. Bu Ali Sina of Bokhara, the Aviceenna of Europeans, though noted for his philosophic learnings, was also a keen student of Geography. According to Howarth, he can perhaps be credited with ideas as to the elevation of mountains by folding and their sculpturing by erosion and also the long period necessary to such processes which appear almost to anticipate modern physiographic studies.

Idris (1099-1154 A.D.) is familiar to Europeans because he was a native of Spain and spent his later fruitful years at the court of King Roger II of Sicily. He was a product of the great Cordova University, early acquired a 'wander lust', travelled through Africa and Asia Minor, visited the shores of France and England and

ultimately settled down in Sicily. He made a celestial sphere and a map of the world in silver for King Roger and later wrote a description of the world based on the reports of observers sent out by Roger. Among Arab Geographers his knowledge about Europe is fuller and his navigation Charts reach a high level: Yakouti (1179-1223 A.D.) of Merv wrote his 'dictionary' providing descriptions of vast and varied areas with remarkable accuracy and Abul Fida (1273-1331 A.D.) was the author of a useful 'Geography.'

An account of the development of geographical learning remains spiceless and incomplete without a mention of the wonderful travels and writings of Ibn Battutā (1304-78 A.D.) who was born at Tangier on the North African coast. His momentous travels lasted for over 30 years till a young man of 20 grew into an old man of 50. His three great journeys extended to over 75,000 miles and took him to East Africa, India, Malaya, Archipelago, Syria, Arabia, Asia Minor, Caspian and Black Sea areas and Spain. Finally he returned to Fez in Morocco and dictated accounts of his wanderings, which are certainly the most remarkable ever compiled. They contain a mine of Geographical information. It is a pity that contemporary Europe failed to benefit from his wisdom due to its ignorance.

But it is with Ibn Khaldur, that great master, that scientific geographic interpretations reach their high water mark. Undoubtedly he was the greatest historical thinker of Islam and his 'Universal History,' has few equals in intellectual compilations. Ibn Khaldur (1332-1486) worked at Tunis. It is to his Introduction to 'Universal History' that geographers are greatly indebted. He was one of the early pioneers of Social Science and his attempts at correlation of environment with human activity, contained in the Introduction, entitle him to be called the forerunner of later geographical thought in the 19th Century. His geographical accounts are placed in the beginning of his work for the proper understanding of sociology and history. In the words of Hozayen, "He attempts to trace the effects of both climatic conditions and local environment upon the physical and mental qualities of different peoples. He treats the whole subject in a modern scientific manner. Ibn Khaldur also inaugurated an elementary classification of different modes of life by distinguishing between what he calls *Badyia* (land of nomadic life) and *Hadar* (place of settled life). To this study he adds many remarks on the type of habitat in the Badyia, and the geographical factors which affect the rise and development of the "City." It is in such remarks, scattered in

his Introduction, and in most cases suffused by his sociological studies, that lies the interest of his work as a proto-type of modern human and social geography.

It is regrettable that such scientific traditions were discarded by Muslims in the midst of the general decay which engulfed their culture and learning. And it was no less unfortunate that through deep-rooted prejudices the Baleric and Germanic Schools of Mathematical and Cartographical development in Mediaeval Europe, failed to be influenced by Islamic descriptive and social geography. Thus followed many centuries of retrograde geographical conceptions.

In the sphere of Astronomical and Mathematical Geography the Muslim contributions show a distinct improvement over Greek and Roman sources. Arabs being the children of the desert were naturally much interested in astronomical observations and their contributions in mathematics are bright. The spherical shape of the earth and its rotation and revolution were common accepted facts at the Universities of Cordova, Seville and Baghdad. The use of the Compass was perhaps wide in maritime activities, the Sundial was further improved and the representation of latitudes and longitudes was a common features of maps. The Tower of observation at Seville still stands as a monument to the urge for accuracy in the study of natural phenomena.

Muslim Cartography failed to attain high standards because of the Arabs' love for decoration. In many works the picturesque is preferred to the accurate. In general representation of the world on a map, the older Greek and Babylonian conception of the engirdling ocean returns because of the increased Arab maritime activity taking them to wider oceans. The Ptolemaic conception of a landlocked Indian Ocean disappeared and a vague idea of the vastness of the Pacific and the Atlantic Oceans tempted them to revert to the recognition of a surrounding expanse of water.

Certainly in many respects, in pure Cartography, Mediaeval Europe was in advance of the Arabs, but elsewhere the latter were undisputed masters.

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Geography Magazine 1932.

Physiographic Divisions of India

By

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Last year, in the Discussion Paper read by me on "The Need of Uniformity in the Physiographic Divisions of India", before the Lahore Session of the Indian Science Congress, I proposed a tentative scheme, which, for some reasons, was not accepted by the Members present. As the discussion was actually held under the joint auspices of the Sections of Geography, Geology, Physics (for meteorologists), Botany and Zoology, it was intended that with the help and co-operation of all the Scientists concerned, some kind of agreement would be arrived at. But the criticism, passed at the meeting, appeared to me to be one-sided, and, for want of sufficient time, was brought suddenly to a close.

Subsequently, therefore, I distributed printed copies of my Paper among some competent Indian and foreign geographers and I have now obtained their opinions. They have, without an exception, welcomed the principle of dividing the country *physiographically* as suggested by me and accepted the fundamentals of such a division, viz., geological structure (including economic resources) and history of erosion (including climate), due regard having been paid to the prominent topographical features. They have agreed upon rejecting all mixed, political and other artificial criteria for it. Unscientific notions about the so-called "natural" regions of India have been discarded and the idea of limiting the geographer, in a precise and specific manner, to geomorphological considerations in the first place, while producing the chief divisions, has found favour. Over such scientific and logical divisions of the country, all matters relating to climate, natural vegetation and even human settlement must drape themselves completely and to the satisfaction of all other advocates of allied sciences.

Geomorphological Data.

The disagreement which prevailed among my critics, was really in regard to the matter of details, the manner of approach

and the lack of geomorphological data to work upon. But I contend that in the numerous Records and Memoirs of the Geological Survey of India, there is really enough and precious material regarding land-forms, types of topography etc., for us geographers to sift from. In fact, I found the material in connection with my studies of the Indus Basin very reliable and useful. It is neither necessary nor possible for us, at this stage, to explore the whole of India from end to end, but it is enough for our purpose to know the history of erosion and subaerial denudation and to describe as fully as possible, the land-forms.

Aerial Reconnaissances

What would indeed be very valuable and creditable to us, Indian geographers, in this connection of regional surveys in India, is aerial reconnaissances. It would really be worth our while to 'resurvey' our land from the air and to check the data secured from geological surveys in the past. With a camera and 1 inch topographical survey maps, now obtainable in our country, it is possible to visualise much excellent local material, to supplement our literary and cartographical knowledge. Amateur pilots, who are friendly, should be our best friends now to help us to collect more and more geomorphological data.

Thus it is possible to supplement the work done by the Survey. Such an experience and personal knowledge of local geographers, who live within certain regions, would be most welcome to us in solving certain difficulties involving local problems while fixing the actual boundaries, minor divisions and sub-sections. Thus a large step forward can be taken by preparing at least a Map of India, showing the physiographic regions, at any rate.

In the light of the above facts and considerations, I have now prepared a revised edition of my Paper and the Map, especially with regard to (1) the more important Provinces, and sections. (2) their nomenclature and (3) the mode of numbering them. As before, minor geographical peculiarities have been subordinated to the main features. At the same time, I have made corrections of certain errors, that had crept in, and additions of facts, in further support of my scheme.

Alterations made in the Scheme

Extra-Peninsular Mountains.—In the Western Highland Province, the Kirthar-Suleiman ranges are considered as one and continuous.

The Kashmir Valley is renamed the Dun Section, as it is a typical Himalayan Dun, as a result of thrustfaulting.

Instead of taking a frontier (i.e. political) section by itself, I have included the Potwar region in it, as it is related to it, and given the whole the name of the Potwar Section.

The Eastern Highlands: In dividing this region, some details had been mixed up. e.g. Shillong plateau, made up of crystalline complex, a horst so to say, between the Himalayas proper and the folded Tertiary rocks of Assam and Burma. It has, really speaking, a veneer of undifferentiated Tertiaries covering parts of Assam and merging into the Burmese Yomas. The Irrawadi Basin is a most convenient physiographic region in these parts with all their precious mineral oil wells. And lastly, the Shan Plateau again is another block of Archaean rocks, separated by plains, valleys and lakes. (A separate map of Burma with its own divisions would be better still).

Indo-Gangetic Plain.—In the Upper Indus Valley, the two Sections required are: the Doab Section of higher (Bhangar) ground cut up by the Punjab rivers and the Punjab proper of low lands (Khadar) upto the junction (Panchnal) of the Indus with the Five Rivers, from where the Lower Indus Basin should be really marked.

In the Upper Ganges Valley, the Doab Section is re-named Jamna-Ganges Doab and in the Lower Ganges Valley, the Sections are marked as the Brahmaputra Valley, the Old Ganges Delta and the New Ganges Delta.

The Peninsular Area.—This area is somewhat overhauled. The two coastal strips are not treated as separate Provinces, but as the shore-facies (Sections) of their respective structural Provinces. viz., the Konkan Coast belonging to the Deccan Trap Province and the Malabar and Coromandel Coast lands belonging to the Southern Plateau. Kathiawar, consisting of threefold region, with the important Rann of Cutch and the Northern Plain of Gujarat, is separated and called the Western Peneplains.

Several Sub-Sections have been pointed out in the Provinces of North-Eastern Foreland (as a complex group of denuded rocks) and the Southern Plateau (mainly consisting of Crystalline Complex), to satisfy the needs of botanists, meteorologists and others.

Thus to the minor divisions and Sections, previously made, I have added some 29 Sub-Sections, leaving room for more to be

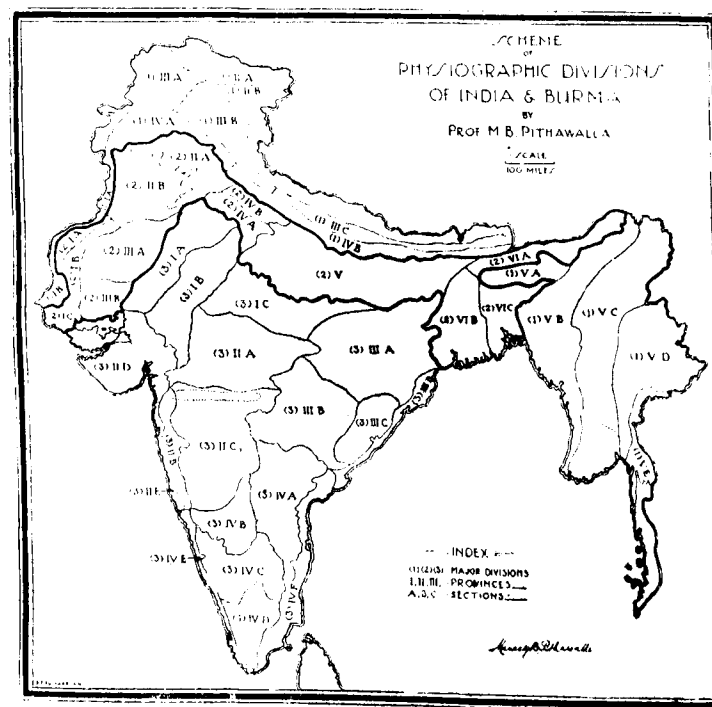
formed by local geographers and the scheme is made comprehensive, so as to give ample opportunities to them to consider the claims and requirements of all departments. Once these divisions are settled and the Map is completed, our next step will be to try and fix the boundary lines actually on the surface.

Revised List of Physiographic Divisions of India

(1) EXTRA-PENINSULAR MOUNTAINS.

Province I. Western Highlands.

Section A. *Kirthar-Suleiman Mountains*.—Barren mountains nearly 6,000 feet high and consisting of folded Tertiary rocks. The



monsoons do not reach here, and there is little soil left on top. Subaerial denudations considerable, forming small plateaus. Inland drainage. Coal seams found within the re-entrant angle between the two ranges.

Section B. *Kohistan Section*.—Lower ranges with slightly more rainfall including winter showers received from western depressions. Subaerial denudation is greater with the resulting broad anticlinal valleys in which a little soil is available for grass to grow. Many hot springs due to fractures in the folds of rocks. Typical dryland topography of limestone country. Some chances of mineral oil deposits.

Province II. Greater Himalayas

Section A. *Northern Himalayan Section*.—Snow-covered mountains with very high peaks, e.g., Mt. Everest, K2, Kinchin-jangha, Nanga Parvat, Nanda Devi. Highly fossiliferous sedimentary rocks from the Paleozoic to the Eocene age. Complex geology. Older rocks are exposed due to action of glaciers etc. The leeward side merges into the Tibetan plateau. Stages of flora and fauna. Sub-Section (a) Tibetan borders.

Section B. *Southern Himalayan Section*.—Wetter parts of the mountains receiving the full force of both the monsoons. Forested areas. Sources of most of the Himalayan rivers. Newer and highly contorted rocks outcrop in some places.

Province III. Middle Himalayas

Section A. *North-West Dry Lands*. Hot and dry region, very cold winters. Marine rocks are exposed.

Section B. *Dun Section*.—Lying between high ranges of mountains, 15,000 to 20,000 feet high. Kashmir a most beautiful Dun or valley, strewn over with lakes and glacial materials. Cut by the Jhelum river. Mountain passes on all sides. Forests on the windward side with rainfall about 25 to 30 inches. Very good mineral resources including coal. Other Duns are Dehra Dun etc. Sub-Sections (a) Indus valley, (b) Jhelum valley.

Section C. *Himalayas Proper*.—Snowline 16,000 feet. Highly folded rocks with thrust faults. Crystalline, metamorphic and Purana rocks with granite intrusions. Unlimited resources.

Province IV. Sub-Himalayan Region.

Section A. *Potwar Section*.—Largely occupied by the Rawalpindi country, cut by the Scan valley. A crumpled geosyncline.

Sub-Section (a) The Salt Range, rich in minerals including rock-salt and oil.

Section B. *Siwalik Section*.—Outer Himalayas, intervening between the Middle Himalayas and the Indo-Gangetic Plains. Low flat hills, 300 to 500 feet high. Tertiary fluvial deposits. Area

Section C. *The New Ganges Delta*.—Eastern parts of the delta, full of marshes, enclosing swampy islands. Rather unhealthy parts, which are under water during floods. Mangrove swamps, called Sunderbans, holding up silt and sand. Sub-Sections of (a) the Damodar valley and (b) the Meghna valley are possible.

(3) THE PENINSULAR AREA.

Province I. Rajputana Uplands.

(Parts of the oldest but the most highly denuded mountain system).

Section A. *North-western Section*.—Sandy waste. A rolling plateau. Poorly watered. Includes Marwar, harbouring migratory people.

Section B. *Mewar Plain*.—Morphologically varied plain, irregular and gneissic in character. Outcrops of Dharwar rocks with rich mineral deposits, e.g., mica, marble, beryl, steatite. Heart of Rajputana. Relic of the ancient gigantic mountains, down which even glaciers flowed in Permo-Carboniferous times. Now a great synclinalorium of tectonic origin. Sub-Section (a) The Aravalli Hills.

Section C. *South-eastern Section*.—Pathar and Uparmal. A triple plateau of concentric scarps of Vindhyan sandstones. Rich diamond deposits.

Province II. Deccan Trap Region.

(Mainly consisting of the Deccan trap rocks, differentially denuded and decomposed in parts)

Section A. *Central India Tableland*.—Basaltic lava rocks, forming part of the Narbada valley in the south and the Vindhya mountain. Flat hill-top topography. Sub-Section (a) the Vindhya.

Section B. *Western Ghats*.—Highest parts of the denuded tableland. Maximum height 5,000 feet. Full of Deccan lavas and bearing the brunt of the S.W. monsoon. Good rainfall with forests on the windward side. Little disturbed by earthquakes. Flat-topped hills and intervening tableland, cut by river valleys. Sub-Section (a) Forest area. (b) Narbada valley.

Section C. *Bombay Deccan*.—Leeward side of the Ghats mainly. Less rain and thinly populated. Regur or black cotton soil is the lava product. Laterite caps here and there, prominent

in the Tapti valley, through which the monsoon penetrates. Sub-Sections: (a) Laterite caps (b) Tapti valley.

Section D. *Western Peneplains*.—Show surfaces of ancient and recent peneplains with complex structural geology. Rings of Archaean, Deccan Trap, folded Jurassic, Cretaceous and Tertiary rocks, ending in vast shore facies of post-Tertiary age in Cutch and Kathiawar. Effects of marine denudation prominent. Hilly parts yet unstable. Sub-Sections: (a) Cutch—Outcrops of older rocks surrounded by vast alluvial tracts. A shallow swamp in the monsoon season and a sandy desert in the dry season. Has suffered upheaval and subsidence due to seismic movements in the past. Probably formed part of the deltas of the Old Indus and the Hakra of Sind. (b) Kathiawar. A similar block separated from the N.W. plateau by a peneplain of the old Aravallis. Has a coastal plain of Tertiary origin and with some good ports. (c) Gujarat, largely consisting of the shore facies of the Western Ghats. Good cotton soil.

Section E. *Konkan Coast*.—A Pacific type of coast land. Sandy soil suitable for rice cultivation. Nearly 100 inches of rainfall. A plain of marine denudation with rocky spurs here and there with raised beaches or submerged swampy areas.

Province III. North-Eastern Foreland

(Complex groups of denuded rocks ending in a block of old Archaean rocks at the eastern end.)

Section A. *The Mahanadi Basin*.—Archaean gneisses and schists of Bundelkhand, Cuddapah—Vindhya rocks of Bhagelkhand and Gondwana rocks, coal and iron deposits of Bihar. Effects of the double monsoon. Rainfall 40 to 60 inches. Ends in an alluvial fan of the delta and the lake Chilka, the largest in India. Luxuriant vegetation. Sub-Section (a) The delta.

Section B. *The Godavari Basin*.—Gondwana system of rocks with coal and iron deposits. Less rainfall here (30 to 40 inches). A rift valley with sand-banks cultivated. The Nagpur forest plateau with better soil and scattered villages of primitive people, suitable for a sub-section (a).

Section C. *The Eastern Ghats*.—Not worth the name, as the rocks of Archaean origin are highly and unevenly denuded. Rainfall 60 to 80 inches due to the double monsoon. A rolling land of

the Inselberg type with isolated hill ranges, ending in an extensive deltaic plain again.

Sub-Section (a) Forest Belt.

Section D. *Golconda Coast Shore facies of the Eastern Ghats*, including the deltas of the Mohanadi, the Godavari and the Krishna rivers.

Province IV. Southern Plateau.

(Ancient Archaean mass of rocks.

A rolling plateau, an Inselberg with reddish soils, essentially dusty in the dry season.)

Section A. *Cuddapah Section*.—Rocks of the Cuddapah and Vindhya ages, a crescent of thin rocky soil, forming Sub-Sections. (a) Krishna basin and (b) Penner valley. Horizontal flat hills.

Section B. *Bellary Section*.—Leeward side of the Ghats. A scrubland. Rain shadow area with scanty rain. Good cotton soil. Lower levels of a gently sloping plain.

Section C. *Nilgiri Hills*.—Dharwar rocks with rich mineral deposits Mica, gold, manganese ores. Forested owing to good rains. Mountain slopes for tea plantations. There are also terraces and water-falls. The Ghats are cut up by the big Palghat gap, the valley of a lost Gondwana river.

Section D. *Tamil Section*.—Archaean rocks of considerable denudation. Gneisses and schists. Double monsoon and good cultivation in the valleys of the rivers. Sub-Sections: (a) Palghat gap, (b) Tambraparni valley, (c) Palar valley, (d) Cauveri valley.

Section E. *Malabar Coastland*.—Shore facies of the Southern Plateau with belts of sandhills, lake lagoons, foot-hills and hill-slopes. Alluvial plains, cut by short and rapid rivers. Heavy rainfall of the S.W. monsoon. Coconut trees grow. Rice land. Few natural harbours.

Section F. *Coromondal Coastland*.—(Carnatic.) Broad, flat plain rising from 1000 feet and reaching the east coast. Parallel belts from the Ghats to the delta of the Cauvery, and other river deltas. Marine denudation is abundant with resulting platforms.

Summary

Thus the whole of India is first divided into 3 Major Divisions, which are again divided into 15 Provinces, subdivided into 44 Sections and 29 Sub-Sections as under :—

Major Divisions, marked (1), (2), (3)	Provinces, marked I, II, III	Sections, marked A, B, C.	Sub-Sections, marked (a), (b), (c).
(1)	5	14	8
(2)	6	12	4
(3)	4	18	17
Total. 3	15	44	29

Conclusion

The problem of dividing India suitably and with a view to serve all purposes, economic and others, is getting increasingly urgent. It is the business of Indian geographers to guide the country in this manner. Without their collaboration and co-ordination of researches, there will be a great loss. Various proposals have been made for dividing the country suitably, but the method of physiographic division is the most suitable for all.

For instance, there is the redistribution of the political boundaries of India demanded by the people according to languages. Commenting on certain dynamic problems of India, Dr. A. Geddes said last year. "In view of the burning interest in peninsular India in the question of 'linguistic provinces,' it may be well to mention certain *related* problems. The relation of language, of religion, and of other criteria of culture, not only to each other but to economic distribution can undoubtedly be clarified by conscientious use of *geographic method*. In Southern India at this time when few regard the internal political boundaries as either economic, just or final, I was struck by the rarity of any discussion of possible economic provinces. The concept of the region and even the word is rarely met with. I have little doubt that, as the mapping of important distributions proceeds without slavish adhesion to existing political boundaries, geography can do much to guide the reformation of her internal political frontiers." No doubt the Madras Geographical Association has made a good beginning with local and regional problems. Had we but succeeded in making a satisfactory division of India to serve such purposes, we, Indian geographers, would have got greater credit than what foreigners have been able to give us. In our efforts to do so, we are really helped by nature. When we know, for instance, how well the Province of Western Peneplains, proposed by me, includes all Gujarati-speaking people and the Deccan Trap Province all the Marathi-speaking

people, the hope of making a division of our country physiographically to meet all our requirements could be fulfilled at last.

Even for the purposes of a Federated India, the scheme proposed by Sir Sikander Hyat Khan, of dividing India into certain zones, can be helped and improved upon by us geographers, and the difficulty of bringing, into the Federation, all the British India provinces and the Native States, not as two distinct components but as integrated parts of a completed whole, can be solved on the regional basis. "It will encourage collaboration between contiguous units, i.e., both British Indian provinces and Indian States whose geographical proximity, common language and affinity of economic and other interests form natural ties to bind them together." So also in the matter of communications, sharing of economic resources, racial and cultural relationships, etc. such physiographic divisions would be ideal and the services, rendered by Indian geographers to India in this connection, will be valuable. If Sir Sikander Hyat Khan's scheme of the seven zones is substituted by that of the 15 physiographic provinces proposed by me, it would serve the purpose well and an excellent *uniformity* could be attained from the points of view of representation and administration. It would, indeed, conduce to the solidarity of the whole country and the stability of the Central Government for all times. Let me hope that this dynamic problem will receive a *satisfactory* solution during the year 1940.

The Direct Study of Geography

Hints and Suggestions with special reference to Saidapet.

By

N. SUBRAHMANYAM

Under the above caption goes an important section of the new L.T. Syllabus in Geography, which reads as follows:—"The observation and expression of the facts of Local Geography: the possibilities and uses of different environments. (This should be done through a practical study either of the student's home region or of the home region of the Training College)."

As the home regions of the students under training will necessarily be different, it is proposed to offer some hints and comments regarding some of the main topics relating to Saidapet in a suggestive rather than a comprehensive way. It is expected that the students will be able to apply and follow them up for their own *respective* places also, when they return to them. Probably it is unnecessary to state that it is not a full regional survey that is intended, as that term is applied for what is a good deal more than Geography. But in so far as the geographical part of it (which is its core) is concerned, its aims and methods may be adopted especially by way of personal investigation, recording the data, mapping the distributions and expressing the data diagrammatically.

The start may be made by getting a *bird's-eye view* of the *whole locality* from what may be called, an "outlook tower"—an eminence in the neighbourhood such as the top of St. Thomas Mount, and fixing the features and landmarks with the help of the *one-inch topographical map* of the Survey of India. With the same map or better still with one on a bigger scale, preliminary rambles may be made to different parts of the town, noting facts and features not to be found in the map owing to changes having taken place since the map was prepared at first, either by removal or by addition and growth. For example, on the latest one-inch map the present Teachers' College is still shown as Agricultural College, in spite of the fact that it is over 30 years since the latter was removed to Coimbatore. Conversely, Todhunternagar, Y. M. C. A. College of Physical Education, the Golf Links, the Richards Park, Panagal Buildings, Water storage tank, etc., do not

find a place in it. It is a good exercise for groups of students to go round the different parts of the locality and note such changes in an outline map.

Surveying the college compound, contouring levels near the Adyar bank or Little Mount, and sketching the different areas visited and noting the features observed and the routes are other important items of practical work, connected with map-making.

The times and exact directions of *sunrise and sunset* and *midday altitudes* of the sun should be noted periodically in the course of the year, expressed diagrammatically and correlated with the seasons. The method of finding and drawing the meridian line should be learnt and applied. Simple methods of finding the mid-day altitude of the sun will be learnt incidentally.

The surface levels and features and the courses of the Adyar and the Cooum, especially the curves and the bed of the latter, should be observed and noted in rambles and visits, gathering evidences of erosion and deposition. Specimens of rocks and soils in the neighbourhood should be collected, examined and classified. Peeps at bed-rock may be obtained in railway cuttings and in diggings made for underground drainage, wells or foundations for buildings. The changing water-table in the wells of the different parts of the locality should be noted in the different seasons. Visits to the countryside and to the rivers in flood are particularly useful in illuminating much that is otherwise purely theoretical in the study of physical geography.

Weather recording offers a specially rich field for observational work. Wind direction, maximum and minimum temperature and rainfall are some of the chief items to be observed, recorded and expressed in appropriate diagrams such as the wind-rose and the climograph. The results of observational work may be compared with published normals and actual figures available in the meteorological reports.

Preparation of *land utilisation maps* affords scope for another valuable kind of direct study of environment. Important public buildings, groups of residential areas, cultivable lands, open spaces, parks, etc., may be noted in special outline maps and studied side by side with the topographical map as already suggested. The straggling nature of the municipality of Saidapet, extending from Chengamedu on the right bank of the Cooum through Puliur, Kodambakkam, Saligramam, West Mambalam, Mettupalaiyam, and Saidapet proper to Guindy and Little Mount beyond the Adyar river, with large stretches of cultivated and barren land and brick pits intervening, the water-works, the bazaar, the temples, mosques

and churches, and the groupings of the people in communities, occupational or otherwise should all find their places in the map. The difficulties of natural drainage (said to be due to the bunding up of the Adyar bank for the construction of the Marmalong bridge), the methods of disposal of sullage water and their relation to public health are worthy of note.

On the economic side, there are important items to observe and collect data about. In the adjoining cultivable lands, agriculture is precarious owing to poor fertility of the soil and want of irrigation facilities; but, market gardening, especially of vegetables and flowers, is more important, owing to the proximity of the town. The brick industry is a flourishing one; the location of the kilns, the soil and other conditions, transport and market are to be studied. The weaving industry of Thopet is another local industry to be investigated. The locality, the community engaged in it, the kinds of stuff woven, the market and the present condition of the industry should be inquired into. Dhobying is another well-known occupation in Saidapet, the bed of the Adyar being a dhobykhana of Madras. The easy transport and the fresh water in the river above the tidal limit as well as the presence of the washer class in connection with the bleaching work of the weaving industry should be noted as favouring causes. Jutka-making and jutka-repairing were well-known in Saidapet; but this industry seems to have fallen on evil days with the growth of the motor transport and the running of the electric train.

Regarding the population: besides noting its distribution in the several wards, it will be interesting to find out the extent to which Saidapet is suburban in character, that is, what proportion of its inhabitants are working for their livelihood in Madras and not at Saidapet. The relative popularity of the train and the bus is an interesting piece of investigation to make.

Taking the road transport: the southern trunk road—or the Mount Road as it is called here, as leading to St. Thomas Mount—with its width, tarring, etc., and the colleges, and open spaces on either side of it—is what gives the best impression of Saidapet to the casual passer-by. But the other roads, especially those linking Saidapet with West Mambalam, Saligramam and Chengamedu should be visited, and the causes for their bad condition should be investigated: e.g., the effect of brick carts, bad finances of the municipality or the unremunerative nature of some of these roads, having to link up distant residential areas. The traffic in the trunk road should be observed and noted at different times in the day

and in the different seasons, as to the kinds of goods taken and as to how far it is local and how far 'through'. Some of the commonest in evidence are brick, straw, hay, grain, curds and vegetables in head loads, fish in Ford cars from Sadras, hides and skins, tanning materials. Note the extra hard cementing of the sides of the road for heavy laden carts to pass. Note also the diversion of the slow traffic on race days through Alandur road, when the congested motor traffic has to pass through the bottle-neck of the Marmalong bridge. The seasonal fruits, flowers and vegetables in the market and in the field should also receive attention.

One of the most interesting topics is the study of the formation and growth of the different types of settlements in the locality itself: for example, Guindy and Fanepet as roadside settlements; Little Mount as a Christian settlement round the place of martyrdom of a Saint; the weaving ward of Thopet with its broad open streets for pitching the looms; the old type of settlement round a temple as in Perumal Koil St., Karaneeswarar Koil St., and southern part of West Mambalam; the bungalow type near the Guindy Railway Overbridge. The location of particular trades and occupations in particular places is to be noted; as the dhoby near the river, the potter just on the outskirts, the jutka-repairer near the main road and the binder near the college.

Further, as Saidapet is a suburb of Madras, lying on the trunk road and the electric railway (four stations on which serve the municipality) possibilities of planning new extensions on the lines of Theagarayanagar may be examined and explored, taking into account the lie and structure of the land and facilities of water-supply, drainage, open space, etc.

Geography has as much to do with man's play and leisure as with his work: and sports competitions and physical demonstrations in the colleges, the races at Guindy, the festivities in the Little Mount and of the Karaneeswara temple that draw large crowds from the city and its environs are noteworthy—the times and seasons when they take place, the incidental increase of trade and transport in particular directions at the time of the festivities, and how far they disturb the normal even life of the residents and their other reactions.

Possibilities of improvement are not outside the scope of local study. It is unnecessary to repeat that personal observation, collection of data, mapping and diagrammatic expression, and interpretation should all go hand in hand in such a study. Most of this can be co-operative work.

Select Contents

- The Geographical Journal*: October 1939.
The Irrawaddy Plateau—By F. Kingdon Ward.
- The Geographical Journal*: November 1939.
Peaks of the Assam Himalaya—By H. W. Tilman.
- The Geographical Magazine*: October 1939.
Poland in Danzig—By Prof. Bernard Massey.
Art and Life in Bali—By Dr. F. C. E. Knight.
- The Scottish Geographical Magazine*: September 1939.
Some Aspects of Conservation in the United States—By Gordon Bowen.
Diffused Light and Sunlight in relation to Relief and Settlement in High Latitudes—By Alice Garnett.
- Geography*: September 1939.
Recent Economic and Social Developments in Sa'udi Arabia—By A. McKie Frood.
Notes on the Construction of Simple Meteorological Instruments—By J. H. G. Lebon.
The Cinema and Geography in Senior Schools—By J. W. L. Symes.
- The Journal of the Manchester Geographical Society*: Vol. XLIX, 1938-39.
Through India, Iraq and Sudan—By Sir William Himbury.
Forbidden Bhutan—By John Davie.
Kenya Colony—By W. F. Machin.
- Geographical Review*: October 1939.
A New Coefficient of Humidity and Its Application to the United States—By Phil. E. Church and Edna M. Gueffroy.
- Journal of the Andhra Historical Society*: Vol. XII, Part II.
The Soras and Their Country—By G. V. Sitapati.
- Indian Information*: October 1, 1939.
Facts and Figures re: Irrigation and Power Development from Water in India.
- Indian Information*: December 1, 1939.
India's River Problems: What Research can do.

News and Notes

Three meetings of the Association were held in the last quarter of the year (October-December); and in these the series of talks to teachers of geography, carried on in the previous quarter, were continued and completed. On 14-10-'39 Mr. B. Clutterbuck spoke on 'the Use of Diagrams in Teaching Geography'. On 28-10-39 Mr. George Kuriyan delivered a lecture, illustrated with slides, on 'the Far Eastern Problem.' On 25-11-39 Miss J. M. Gerrard completed the series with a talk to teachers on 'the Lesson Plan.'

An excursion by bus was organised to Vellore on 16th and 17th December 1939 and conducted by the Secretary, visiting en route the Victory Memorial Blind School at Poonamallee, the shale-beds at Sriperumbudur and Conjeeveram. On the afternoon of the first day the historic fort at Vellore was visited and the Vellore hill (1,670 feet) climbed. The following day the party climbed Kailasgarh (2,741 feet), 5 miles from Vellore, and returned to Madras the same night.

The Tenth Geographical Conference of the Association will be held at Ambasamudram in the Tinnevely District in May 1940, when papers on various aspects of the Geography of the District will be read and discussed. Further details regarding the Conference will be announced in due course.

Mr. P. G. Dowie of the Geological Department, Presidency College had contributed a paper to the Ninth Geographical Conference at Madras on 'The Physical Aspects and Geology of the Neighbourhood of Madras,' which has been included in this issue. In this paper he has brought together a good deal of material found scattered in the Memoirs of the Geological Survey of India and presented them in an interesting and exhaustive manner from his intimate personal knowledge of the region.

Prof. M. B. Pithawalla of Karachi has revised in this issue in some details his plan for a division of India into Physiographic Re-

gions presented to the Lahore session of the Indian Science Congress and published in the previous issue of the journal.

We welcome with pleasure Mr. Nafis Ahmed, M.Sc., Lecturer in Geography, Muslim University, Aligarh, as a contributor to our journal. His paper on 'Muslim Contributions to Geography' published in this issue, will be found interesting. It is understood that Mr. Ahmed has been appointed Professor of Geography in the Islamiah College, Calcutta, and that he will be leaving Aligarh shortly.

The 27th Session of the Indian Science Congress will be held in the Medical College, Madras from the 2nd to 8th January 1940 under the presidency of Prof. B. Sahni, F.R.S. The Geography and Geodesy Section of the Congress will be presided over by Dr. Shibaprasad Chatterjee of Calcutta University, whose address will deal with 'the Place of Geography in National Planning.'

The main item of business in the special meeting of the General Committee of the Congress is the re-grouping of the Sections; and among the proposals is one to transfer Geodesy to Mathematics section, to be called the section of Mathematics, Astronomy, Statistics and Geodesy, and another to amalgamate Geography and Geology sections into one as it was before the Jubilee Session at Calcutta in 1938.

The British Association met in Dundee on August 30, 1939; and in section E (Geography) about one third of the papers had been read when on September 1st the Session was interrupted upon receipt of the news of the German invasion of Poland.

"The Presidential Address to Section E, delivered on September 1, by Mr. A. Steevens, contained a lucid examination of the most conspicuous geographical concept whose enunciation is associated with British Geographical thought, the concept connected with the phrase *Natural Geographical Region*, especially in so far as it is exemplified in North America, Russia and Europe. It appears to Mr. Steevens that the unity of the natural geographical region is dependent in large measure upon organisation, in the shape particularly of communications, In Western Europe

the increased efficiency of communication and recently the peculiarly intimate cohesion organised by the radio, have so far expanded the area throughout which a perfect neighbourliness may be found that it is possible nowadays to define the European nation-state as 'a community occupying a natural geographical region as its immediate environment, because it is a natural growth limited by its Geographical circumstances.'

With the break-up of the session, progress with plans for a British National Atlas proposed by Prof. E. G. R. Taylor at the Cambridge Session last year, had now to be delayed indefinitely.

Few of the social functions and none of the longer excursions had taken place when the session abruptly closed."

—*Scottish Geographical Magazine*, Sept. 1939.

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The invasion of Finland, the latest instance of unprovoked aggression by a mighty power on a small state and the heroic resistance of the latter against odds should ultimately lead through untold suffering to a new world order in which freedom and safety can be vouchsafed for all peoples of the world, big or small, in Europe or elsewhere, whether through the League or through a new federal union.

* * * *

Reviews

Geology and Allied Sciences: Part one—German and English. By Walther Huebner. (Veritas Press, New York). 1939. Price \$7.50.

This volume is a thesaurus and a co-ordination of English and German terms in Geology and allied sciences. Owing to the lack of a comprehensive and up-to-date thesaurus of geological terms in any modern language there has been a great gap in international geological literature which has been filled in a large measure by this monumental volume, the fruit of 15 years of research work. This thesaurus, with its more than 25,000 entries in each language presents a practically complete collection and co-ordination of German and English specific and general terms. While adhering strictly to the terms in actual use, the author has taken care to point out where terms have been incorrectly or wrongly used; and in some cases obvious mistakes have been corrected.

Regarding the wide-spread confusion about the meaning and position of the stratigraphical levels from the *Cambrian* to the *Silurian*, century-old discrepancies have been attempted to be eliminated by giving at the end of the book (p. 404) a table showing the various levels in their historical development and their proper co-ordination as indicated in the last column of this table.

The volume is complete not only by reason of the number of terms, but also by its comprehensiveness, including terms not only of Geology proper, but also of a number of allied sciences such as biology, geography, meteorology, physics etc., in proportion to their relationship to Geology.

A very useful feature of this book is the grouping of related terms under one key word, thereby facilitating a general survey of related geological terms. We have no doubt that this comprehensive volume will be welcomed as much by the geographer as by the geologist.

Poland and its Frontier. By S. P. Chatterjee. 1939. (Bulletin No. 1 of the Calcutta Geographical Society).

This is a monograph based on 'Europe Centrale' by E. de Martonne and 'Poland' by R. H. Kinzig—presenting briefly the funda-

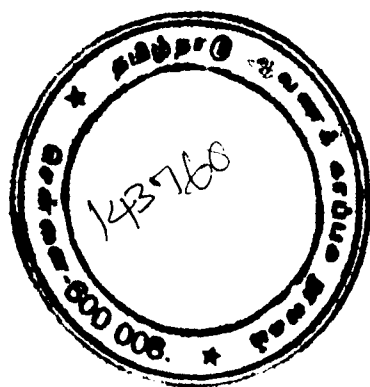
mentals of the geography of Poland. The correlation of the regional background and the human activities of the country have been well brought out in a general way and illustrated by fine sketch-maps and a full-size map of Poland.

Our Presidency and Country (Tamil). By A. N. Schwartz. (Christian Literature Society for India: Madras). 1939. Price As. 8.

This class-book of Geography for standard 5 of elementary schools is written by an experienced teacher of Geography in strict accordance with the recent syllabus for elementary schools issued by the Madras Educational Department. It, therefore, suffers from the inherent defects of that syllabus in being ambitious, exhaustive and too logical; but the author has succeeded in making the treatment interesting and inspiring. The suggestive and stimulating questions and exercises at the end of each chapter and the numerous sketch-maps, pictures and diagrams enhance the value of the book, whose big bold type and neat get-up render it particularly attractive to children.

The Atlas Geography of South Arcot District. (Tamil). By K. Narayanaswami Ayyar. (K. N. Publishing House: Villupuram). 1939. Price annas 5.

This text-book of Geography for pupils in standard 4 of elementary schools in the South Arcot District has also been prepared in accordance with the latest syllabus of the Madras Educational Department; and so suffers from the defects of that syllabus in being logical, analytical and too factual in treatment. But big bold type, diagrams, sketch-maps and illustrations and simple language are some of its merits.



Books and Journals Received

- Poland and its Frontier*. By S. P. Chatterjee.
Our Presidency and Country. (Tamil). By A. N. Schwartz.
The Atlas Geography of the South Arcot District. By K. Narayanaswami Ayyar.
Report of the Department of Industries & Commerce, Madras (for the year ending 31st March 1939).
Journal of the Andhra Historical Research Society: October 1938.
The Geographical Journal: September, October and November, 1939.
The Journal of Indian History: August 1939.
The Indian Journal of Economics: July 1939.
The Indian Educator: September, October and November 1939.
The South Indian Teacher: September, October and November, 1939.
Southern India Commerce: August, September, October and November 1939.
Indian Information: October 1 & 15, November 1, 15 & 25, and December 1, 1939.
Brahma Vidya: (Adyar Library Bulletin): October and December 1939.
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The International Review of the Hungarian Geographical Society: Vol. LXVII 1939. (Nos. 1, 2 and 3).
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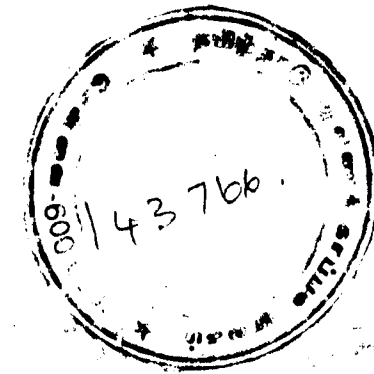
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