THE TERTIARY FLORA OF INDIA AND PROBABLE DISPOSITION OF CONTINENTS

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ABSTRACT

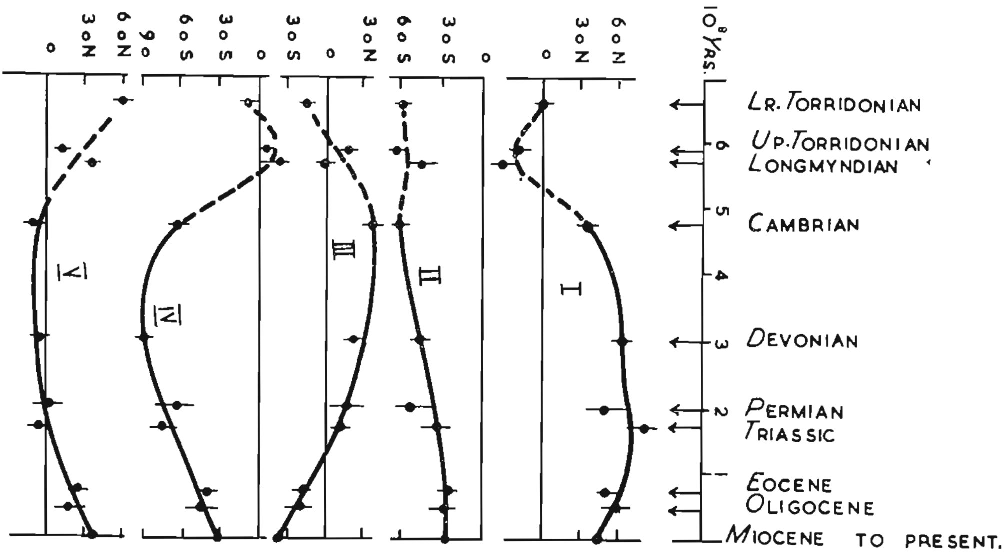
Rock magnetism of the Deccan Traps of India consistently indicates the position of this land, during the early Eocene period, at about 30° south of the equator There is also evidence to show that the movement from that to the present position has been gradual. An analysis of the Tertiary fossil woods of India, so far recorded, shows a general agreement with both these conclusions arrived at through palaeomagnetic investigation, and thus supports strongly continental drift in preference to polar wandering. Much more additional data are, however, necessary on palaeomagnetism and fossil plants before continental drift is accepted as an established theory.

IT is only comparatively recent times that some attention has been paid to the Tertiary plant remains of India. This was to some extent due to lack of knowledge of the tropical flowering plants and their internal structure. From nineteen thirty onwards considerable work has been done on the Tertiary fossils, and we have now a fairly large amount of data which enable us to draw some broadly based hypotheses. These hypotheses, however, need constant testing and revision, as additional evidence comes to light. In this paper only the fossil secondary woods (xyla) of the perennial dicotyledons will be considered.

An analysis of the information available brings out some interesting points. For instance, a large section of the present vegetation can be traced back to Pleistocene, Pliocene and Miocene periods. But when it comes to the Early Eocene and Late Cretaceous, very few remains of the existing vegetation are met with. In fact, there is a complete lack of affinity between the vegetation of the Miocene and the Eocene. How this happened, has remained a puzzle. One might argue that the study of the Eocene perennial flora was exclusively confined to the Deccan Traps and it was, therefore, possible that the volcanic eruptions had wiped out the entire flora, and a new flora, which was established during the Miocene, is still in existence. But a systematic analysis shows that it is not so. The very composition of the Eocene and the Miocene flora of India is different; the former indicates affinity with the flora south of equator while the latter with that of north of equator. For, it is commonly known that the vegetation of a land is determined by its climate. The climate of a particular land mass is governed by its position in relation to sea, mountain, wind and other environmental conditions and also to a great extent by the latitude. The question, therefore, arises whether India was situated, throughout the Tertiary period on the same latitude as it is today.

Blackett's recent work (1956) on rock magnetism has opened the door to a hitherto unknown store of information. Many aspects of this problem have been taken up by other investigators. For instance, Irving (1958) dealing with polar wandering and continental drift has drawn two curves, one (FIG. 1) shows the variations in latitude in five continents namely, North China, South Africa, South-east Australia, South Brazil and eastern U.S.A., predicted from the European curve of polar wandering. The other (FIG. 2) gives the variations of magnetic latitude in Britain, eastern U.S.A. and western U.S.A. A comparison of these curves clearly shows that there is a stronger support for continental drift than for polar wandering. Again, Opdyke & Runcorn (1959, 1960) investigated the direction of the trade winds of ancient geological times as preserved in eolian sandstone to see whether it would agree with the results obtained by rock magnetism. Both the results showed agreement.

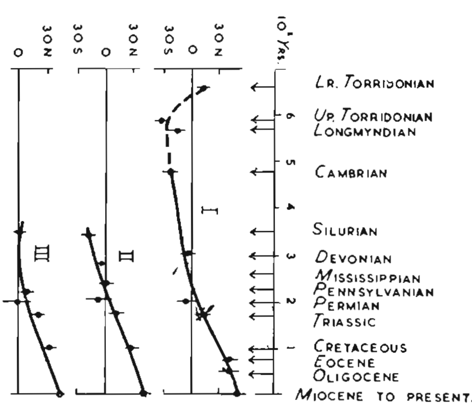
In 1961, Blackett made a " comparative study of ancient climate with the ancient latitudes deduced from rock magnetic measurements ". In this masterly analysis he dealt with many aspects of the problem, such as distribution in latitude of ancient salt deposits, late Paleozoic glaciation and



THE VARIATIONS IN LATITUDE IN FIVE CONTINENTS PREDICATED FROM THE EUROPEAN CURVE OF POLAR WANDERING.

(I) NORTH CHINA (II) SOUTH AFRICA, (III) S.E. AUSTRALIA, (IV) SOUTH BRAZIL (V) EASTERN U.S.A.

TEXT-FIG. 1.



THE VARIATIONS OF GEOMAGNETIC LATITUDE IN BRITAIN (I), EASTERN U.S.A. (II), AND WESTERN U.S.A. (III). (AFTER IRVING, 1958)

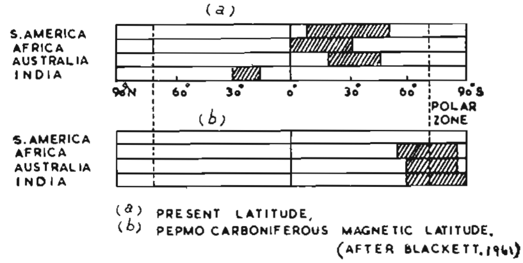
TEXT-FIG. 2.

Permocarboniferous coal measures. He systematically analysed all the available data. In spite of some discrepancies, the final conclusion he drew was that " the magnetic data as a whole give support to the hypothesis of continental drift ". He, however, pointed out that a great deal of research would be necessary before continental drift is accepted as a proved theory.

As far as India is concerned, Irving (1954) appears to be the first person to determine the magnetism of the rocks of the Deccan Traps. Although the number of specimens examined was small, yet his results showed consistently the same trend. This led other workers to investigate this particular geological formation. Clegg *et al.* (1956) worked on about 450 basaltic lava of the Deccan Traps, collected from 2 sites 500 miles apart, and came to the conclusion that India has drifted north from a position about 34° south of the equator when the rocks were formed 70 million years ago and has rotated anti-clockwise through 25°. They also found out that the " movement of India, relative to America and Europe, has taken place during the past 70 m.y." This work was extended by Clegg *et al.* (1957) to 4 other localities. The results were in broad agreement with those obtained earlier. They also noticed here that the pole position for lower flows from 3 localities " lie further from present geographical pole than to those from the upper rocks ". From this they were led to postulate that there was a possibility of a northward movement of India during the time when the Deccan Trap was being laid down. In 1958, Deutsch *et al.* determined remanent magnetism of another lot of over 400 specimens from the Deccan Traps and came to the conclusion that " India drifted northwards over 50° of latitude and rotated 25° anticlockwise within the last 70 m.y." These results were again confirmed by the same workers (DEUTSCH *et al.*, 1959) by examination of specimens from 2 new localities.

Having thus obtained a consistent results throughout the Deccan Traps Clegg *et al.* (1958) wanted to know the rock magnetism of older formation, and they selected Rajmahal Traps (Jurassic) of north eastern India. The conclusion they arrived at was that the combined results for Rajmahal and Deccan Traps conform best with the postulate that " there was a continuous northwards drift of Indian land mass extending from the Jurassic to the Eocene ". Furthermore, recently Althavale *et al.* (1963) examined over 560 specimens collected from five localities, one Jurassic and 4 Pre-Cambrian, and came to the conclusion that " with the new results together with similar data by other workers for Australia, North America and Europe it can be shown that, as far as the scanty data go, the rate of drift and orientation for the four continents has been of the roughly same throughout the period since 750 m.y."

Besides Geophysists, geologists are now supporting the continental drift. Dealing with the Himalaya mountains, Wadia (1964) has recently said " One of the most clearly established facts of geological science tells us of a sea, which girdled India along its north face through vast aeons of time — a true mediterranean sea, which divided the northern continent of Eurasia (known as Angaraland) from a southern continent of more or less uncertain borders, but which united within its compass the present disjoined peninsulas of Africa, Arabia, India and Australia (known to geologists as Gondwanaland) ". Then again (p. 850) he says, " This vast tract of northern India was under the waters of the mediterranean sea — known to geologists as the *Tethys* — continuously from the end of the Carboniferous period of earth-history to the end of the Eocene "



TEXT-FIG. 3

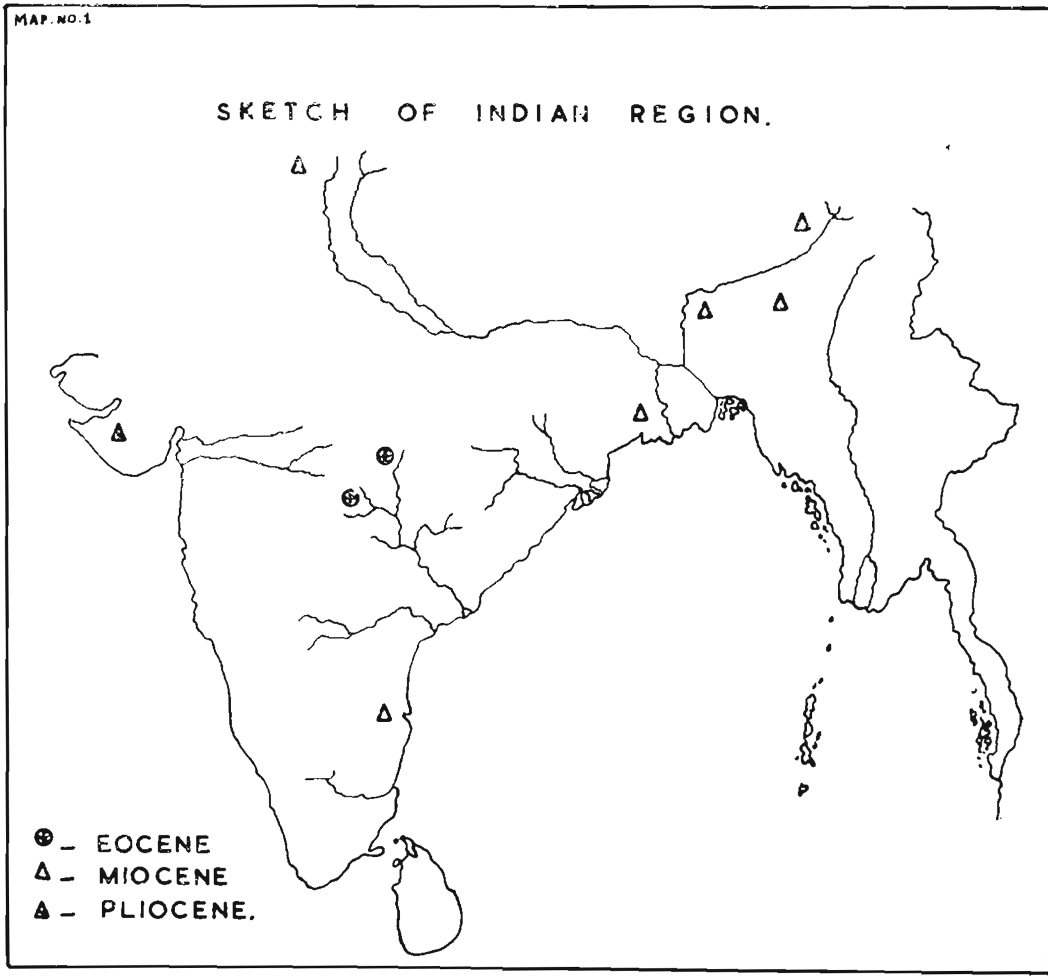
(FIG. 3). These data along with those of the Tertiary fossil flora are discussed in this paper and a probable explanation for the lack of affinity between the Miocene and the Eocene (including upper Cretaceous) flora of India is put forward.

MATERIAL AND METHODS OF STUDY

Material — About 60 fossil wood specimens have up to now been reported from the Tertiary formation of India. Of these, more than 45 belong to the Miocene to Pliocene age and the rest to the Upper Cretaceous or Eocene age. The first lot was collected from the Miocene of Assam, Bengal, Cuddalore Sandstone (Pliocene to Miocene), Middle Siwalik or Upper Miocene of the Punjab and the Pliocene of Kutch, on the north west coast of India. All of the second lot come from the Intertrappean beds (uppermost Cretaceous to Eocene) of Deccan (Map No. 1).

Methods of Study — The flowering plants, the most dominant group of the present time, have been subjected to intensive study. All their organs and parts thereof have received considerable attention. This has enabled us to know as to the isolated parts which could be most reliably used for classifying the mega-fossils of the Angiosperms. Though flowers are the main organs that are now used for the systematic study of living Angiosperms, yet in their fossil state the same techniques give rise to insuperable difficulties (CHOWDHURY, 1959). Amongst the other fossil parts, only the fruits, seeds and secondary wood have been found to be most suitable for minute anatomical study for comparison with the living and finally for accurate identification.

Researches on perennial Angiosperms have shown that there is no synchronized evolution in all their organs and tissues (BAILEY, 1951). Later work has also brought



out the fact that even the cells of the tissues of wood do not indicate any simultaneous evolution (CHOWDHURY, 1954). Furthermore, the anatomy of woods exhibits considerable variation depending on the family, genera and species to which it belongs (CHOWDHURY, 1948). Pioneer botanists were not aware of these fundamental facts of secondary xylem and have created many genera of which all are not tenable in the light of our present knowledge. This has created considerable confusion in literature, and many workers unknowingly make use of doubtful genus created long ago. In addition to these, the mega-fossils dealt with here are not all well preserved and do not show the necessary anatomical details that are used for their placement under the existing perennial vegetation of the earth. A fossil or a group of fossils must match in all anatomical details with a known group of specimens before it is placed under it. This principle is no doubt generally accepted by all but in practice not always adhered to. To avoid confusion in this comparative study, extra care was, therefore, necessary in the selection of specimens so far reported. I have considered only those specimens which appeared to me to be correct and left out the doubtful ones.

The science of earth has received attention of geologists, geodesists, physicists and paleontologists. Wegener, who was not a specialist in any of these subjects, has made some important contribution to it. For the last forty years or so two principal hypotheses namely, polar wandering and continental drift have been talked about and debated upon. The present distribution of land masses, their geology, climate, fauna and flora in comparison with those of the past have often formed part of this discussion. Quite recently rock magnetism (BLACKETT, 1956) has been brought in as a new tool to help to solve this problem. Some points from these researches will be discussed at appropriate places in this paper, in relation to the Indian continent.

RESULTS

(a) PALAEOBOTANICAL DATA

The relation between anatomy and taxonomy has been repeatedly pointed out by anatomists or by taxonomists and anatomists jointly. As far as the anatomy of the secondary xylem is concerned, the present position was summarized by me some years ago (CHOWDHURY, 1959) and it still holds good. I quote it below:

" Wood anatomists have found that plants grouped together by taxonomists sometimes show similar anatomical structure and sometimes do not. Some orders and many families exhibit constant anatomical similarities while there are others which show heterogeneous structure. At generic level the secondary xylem is usually homogeneous. But at specific level the secondary xylem is only occasionally helpful in recognizing a single species. Below this rank, anatomy has not been found to be of much use for classification and identification. Here it must be pointed out that the anatomical characters which are used for separating different orders, families, and genera are not the same. Certain characters or combination of characters may be useful in setting apart the genera in one family but those very characters may not serve the same purpose in another family. In short, without disturbing the taxonomic classification, the wood anatomists have now worked out a system by which they can classify woods of various families and genera and even identify isolated wood specimens from unknown sources. But, in spite of all these achievements it must be pointed out here that anatomists' method of classification is an artificial one and has no phylogenetic basis ".

Based on these principles, the Tertiary fossil woods of India have been grouped in Table 1 and 2, showing the genera which appeared to me to be correct and those which need re-investigation. Table 1 includes the specimens from the uppermost Cretaceous and early Eocene of the Deccan Traps and, therefore, deserve special precaution. Because during their botanical investigation it was not known that the land, on which they grew, was situated thousands of kilometre south of the equator and had entirely different climate and vegetation. Apparent resemblance of these fossil woods with those from existing Indian vegetation does not preclude their more close affinity to the trees which are now growing outside the Indian continent. There is also a possibility that the trees which produced these fossil woods might no longer be in existence.

Taking into consideration the genera which have been suggested for re-investigation, *Bridelioxylon* Mädel (*Euphorbioxylon* Felix) and *Paraphyllanthoxylon* Mädel (*Glochidioxylon* Prakash) belong to Euphorbiaceae, a family well known for homo-

TABLE 1 — UPPERMOST CRETACEOUS AND EARLY EOCENE WOODS OF INDIA, 1964

APPEAR TO BE CORRECT		APPEAR TO NEED RE-INVESTIGATION	
1. *Ailanthoxylon* Prakash,	1958	1. *Bridelioxylon* Mädel	1962
		Euphorbioxylon Felix	1957
2. *Simarouboxylon* Shallom,	1960	2. *Paraphyllanthoxylon* Madel	1962
		Glochidioxylon Prakash	1958
3. *Aeschynomene* Prakash,	1962	3. *Barringtonioxylon* Shallom	1960
4. *Mallotoxylon* Lakhanpal & Dayal,	1962	4. *Elaeocarpoxylon* Prakash & Dayal,	1963
		5. *Leeoxylon* Prakash & Dayal,	1963
		6. *Grewioxylon* Prakash & Dayal	1963
		7. *Boswellioxylon*, Dayal	1964

TABLE 2 — MIOCENE AND PLIOCENE WOODS OF INDIA, 1964

Appear to be correct		Appear to need re-investigation	
1. *Glutoxylon* Chowdhury,	1934, 1936	1 *Caesalpinoxylon* Schenk,	1954
2. *Dipterocarpoxylon* Holden*	1936	2. *Shoreoxylon* Den Berger,	1955
3. *Cynometroxylon* Chowdhury & Ghosh,	1946	3. *Sapindoxylon* Kräusel,	1956
4. *Kayeoxylon* Chowdhury & Tandan,	1949	4. *Dipterocarpoxylon*** Kräusel,	1956
5. *Acacioxylon* Schenk,	1954	5. *Anisopteroxylon* Ghosh & Kazmi,	1958
6. *Terminalioxylon* Schönfeld,	1955	6. *Hopeoxylon* Navale,	1962
7. *Sonneratioxylon* Hofmann,	1956	7. *Castanoxylon* Navale,	1962
8. *Ebenoxylon* Felix,*	1958		
9. *Tamarindoxylon* Ramanujam,	1959		
10. *Pahudioxylon* Chowdhury, Ghosh & Kazmi.	1960		
11. *Phyllanthinium* Ogura,	1960		
12. *Bridelioxylon* (Ramanujam) Mädel,	1962		
13. *Anogeissusoxylon* Navale,	1962		
14. *Ailanthoxylon* Prakash,	1963		
15. *Terminalia tomentosa* W & A,	1964		

*These names include all the genera in the family.
**Kräusel used this in generic sense.

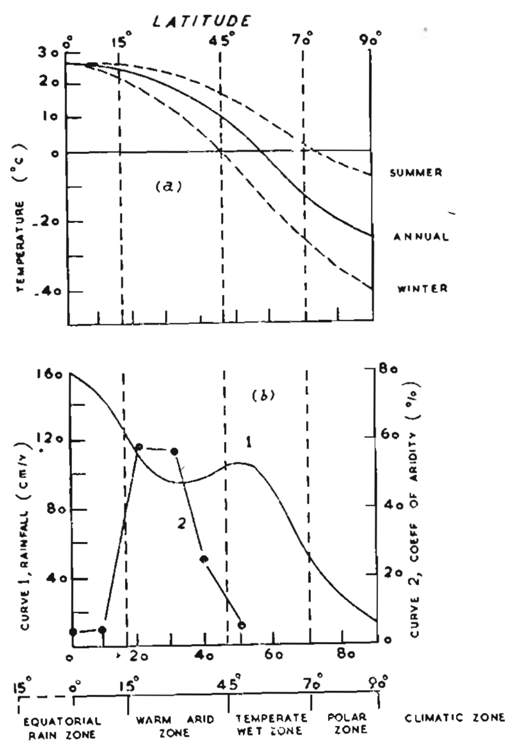
geneous wood structure among its many genera. Recent changes in the generic names of these fossil specimens confirm this fact. Now, *Barringtonioxylon* Shallom is a genus of the family Myrtaceae. Its various genera may sometimes be easy to separate but not always, due to overlapping anatomical structure. One should, therefore, be hesitant to use the name of *Barringtonia* without further intensive study of this family. The genus *Elaeocarpoxylon* Prakash & Dayal belongs to Elaeocarpaceae. All the genera in this family do not have homogeneous structure. Even in the genus *Elaeocarpus* there is heterogeneous wood structure; some being heavy and hard and others, light and soft. This particular fossil wood appears to belong to the later group which again resembles some of the woods of the genus *Echinocarpus*. In this state of our knowledge, I feel hesitant to make use of the name *Elaecarpoxylon* for the present study. *Leeoxylon* Prakash & Dayal is a large shrub with very soft wood, having characteristic anatomy of the shrubs. Our knowledge of the soft wooded shrubs is very limited. It is, therefore not advisable to accept this name till further investigation has been carried out in many more shrubs. Finally, *Boswellioxylon* Dayal needs re-examination. Radial intercellular canals are no doubt often helpful in tracing the identity of isolated pieces of modern wood, but it is also known that this particular anatomical structure is found in many genera belonging to more than one family. Furthermore, the gross and minute anatomical structures of some of the genera with radial canals are so similar that anatomist can identify with confidence an isolated piece of wood only when he knows the locality from which it came. In this particular instance, the locality, where it grew 70 million years ago, is said to be south of the equator. It will, therefore, be risky for the present investigation to accept *Boswellioxylon* Dayal based on the details given by the author. This much should suffice to show why these seven fossil woods need re-examination.

In Table 2, *Dipterocarpoxylon* (Holden, 1916) and *Ebenoxylon* Felix (Ghosh & Kazmi, 1958) signify not any particular genus but all the genera that have been placed by taxonomists under the family Dipterocarpaceae and Ebenaceae. Among those which need re-investigation the names *Caesalpinoxylon* Schenk (Ramanujam, 1954), *Sapindoxylon* Kräusel (Navale, 1956) and *Castanoxylon* Navale (1962) are untenable because of the heterogeneous structure found in the woods of these families. *Dipterocarpoxylon* Kräusel (Ramanujam, 1955), *Shoreoxylon* Den Berger (Ramanujam, 1955; Navale, 1962), *Anisopteroxylon* Ghosh & Kazmi (1958), *Hopeoxylon* Navale (1962) are doubtful because these genera exhibit characters which overlap. In fact, the family Dipterocarpaceae needs further intensive research from the point of view of taxonomy and anatomy. It will not, therefore, be judicious at this stage to split up the family into doubtful genera based on their secondary xyla.

DISCUSSION

(a) Latitude and Climate

Since climatic variation is to a great extent governed by the latitude, an analysis of the present-day latitude in relation to climate may throw some light on the present problem. Figure 4 gives the temperature at different latitudes from the equator. It also gives an idea of the temperature in summer and winter. In Fig. 5 the annual rainfall and the aridity of various latitudes are given. The rainfall is maximum at equator with a shallow minimum about 30° north and south of equator and a fall at



CLIMATIC ZONING AND LATITUDE. (P.M.S.BLACKETT 1961)

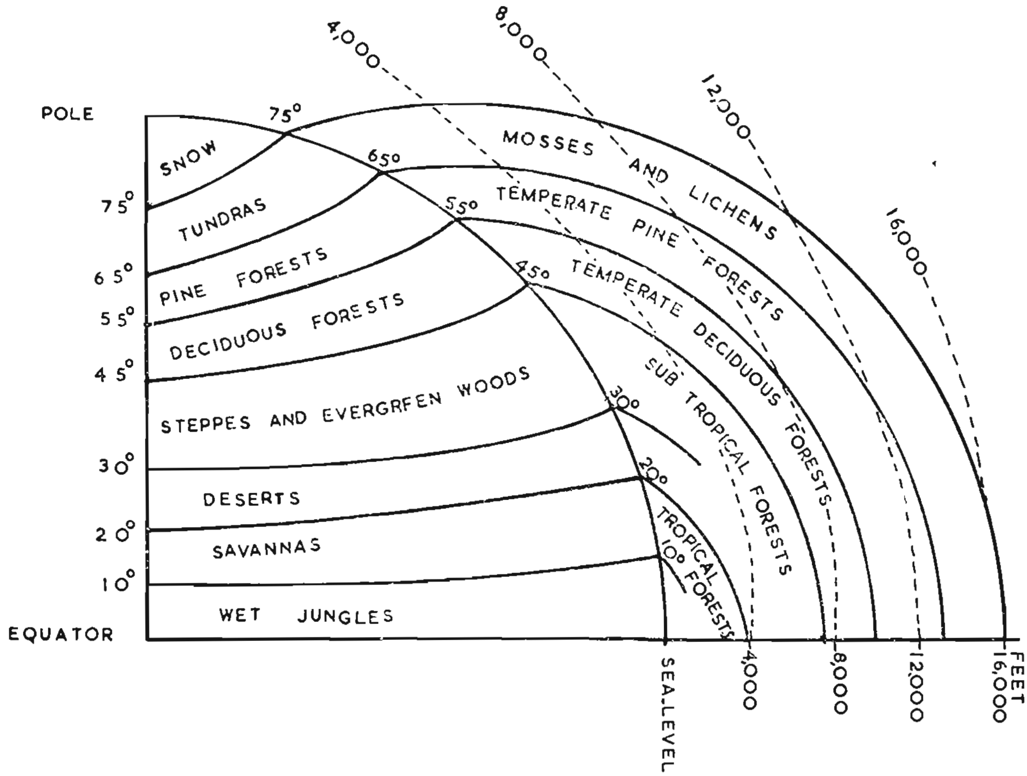
Text-figs. 4-5

the poles (Blackett, 1961). The warm aridity is between 15° and 30°.

This broad relation between the latitude and the climate does not, however, take into consideration the altitude, which also plays an important part in determining climate. Furthermore, for this investigation, it will be necessary to split up the main climatic zones into smaller ones. Only then can we expect to find some relation, if any, between the climate and the vegetation. Figure 6 shows a diagrammatic representation of vegetation-zone in relation to latitude and altitude (Good, 1947). These climatic zones are not only applicable to the present time but also to the past geological age. The ancient climate of different regions of the earth might have been different from what it is today but this difference could not have been very great, for it is the latitude which mainly determines the climate.

(b) Latitude, Fauna and Flora

Fauna — The reef forming corals have for many years been thought to be a suitable material for studying climatic conditions. These are fairly abundant in a clear, shallow sea, the temperature of which does not fall below 21°C. They are also known to be confined to about 30° north and south of the equator. Considerable research has been done by Hill (1948, 1951, 1957, 1959 in Blackett, 1961) Ma (1957) and Craig (1961 in Nairn, 1961) to bring out the relation between the position of continents and the distribution of reef corals. There are, however, other workers (Termier & Termier, 1960) who point out the danger of taking the distribution of ancient coral sites as giving any reliable indicator of temperature. Here again Blackett (1961) made an intensive study of all the available data and drew some conclusions. According to him " the present coral and rock data is inedquate alone to make certain an asymetric ancient climate. If, however, the recorded coral distribution is assumed not to have been grossly distorted by the rock distribution, then the ancient latitudes, as calculated from the coral data from America and Euro-Africa, do agree roughly with the magnetic latitudes. If the coral data has been grossly distorted by the rock distribution, then this agreement would have to be considered as a fortuitous result of the latitude distribution of rocks of different



DIAGRAMMATIC REPRESENTATION OF THE VEGETATION ZONES OF LATITUDE AND ALTITUDE. (AFTER GOOD, 1947)

TEXT-FIG. 6

ages. As this seems unlikely, the agreement between the magnetic and coral data suggests that the latter has not been grossly distorted ". These findings are of considerable value to the present investigation because reef corals and tropical perennial plants exist under more or less similar climatic conditions.

Here it may be pointed out that before the paleomagnetic results were known, Hora (1953) based on fossil fishes held the opinion that " south America still formed a part of the Gondwanaland during the Upper Cretaceous ".

Flora — First of all it may be pointed out that till recently it was believed that the Indian land mass was situated throughout the entire Tertiary period on the latitude it is today. As a result, proper precautions were not always taken by botanists to look to the vegetation of the neighbouring continents and lands as possible ancestors of the fossil and the existing vegetation. Research on paleomagnetism now shows that the early and middle Tertiary fossil plants of India are likely to have some affinity with the past and the present vegetation of Africa, Arabia, South America, Australia and Antartica (KING, 1958).

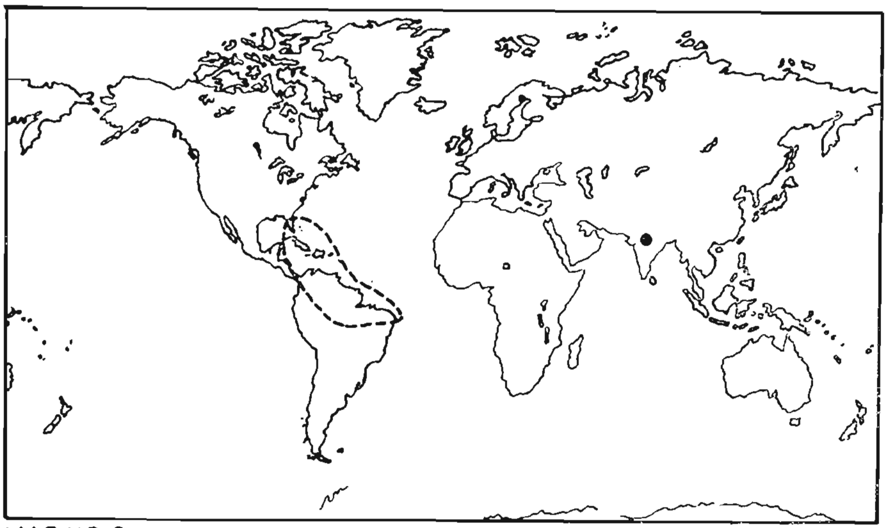
Symington (1941) has pointed out that two plant communities may be distinct floristically and still be ranked equal fundamentally. This is because out of the entire population, only a few are true representatives and the rest have wide distribution and are not of importance for the classification of the vegetation as a whole. This principle applies to the four genera recorded from the Deccan Traps. Only *Simarouboxylon* Shallom (1960) is of importance, because the genus *Simarouba* (RECORD, 1924; RECORD & HESS, 1949) is now found mainly in South America, specially in Brazil, Jamaica and Nicaragua extending into Cuba and Florida. It is totally absent in other continents. Importance of its presence in Indian upper most Cretaceous and early Tertiary will be discussed later in this paper. The genera *Ailanthus* (PRAKASH, 1958), *Aeschynomene* (PRAKASH, 1962) and *Mallotus* (LAKHANPAL & DAYAL, 1962) have extensive distribution. *Ailanthus* is now cultivated in Europe, America and many parts of Asia, but is said to be indigenous in China, New Guinea and Australia (BRANDIS, 1902; GAMBLE, 1922; WILLIS, 1960; ANONYMOUS, 1964). *Aeschynomene* and *Mallotus* grow almost in all the continents of the world but nowhere in abundance (JACKSON, 1946), The original home of all these three is unknown. In view of this, it will be unwise to take their presence in the Deccan Intertrappean beds as a proof of continuous vegetation in India from the Eocene to the present day.

Out of 15 genera (TABLE 2) recorded from the Miocene of India, 4, namely *Gluta* (CHOWDHURY, 1936, 1952), different genera belonging to Dipterocarpaceae (CHOWDHURY, 1938; GHOSH & GHOSH, 1958, 1959; RAMANUJAM, 1955; EYDE, 1962, NAVALE, 1962); *Cynometra* (CHOWDHURY & GHOSH, 1946), *Kayea* (CHOWDHURY & TANDAN, 1949); *Pahudia* (CHOWDHURY, GHOSH & KAZMI, 1960; GHOSH & KAZMI, 1961) are without doubt confined to the tropical evergreen rain forest, where precipitation is over 3,000 mm. per year. In India they are now confined to only eastern and south-eastern territories touching Burma and extreme south of the West Coast. The point to note here is that the fossil remains of these plants have been recorded at a great distance from their present home. The remaining genera (CHOWDHURY & TANDAN, 1964, EYDE, 1962; GHOSH, 1958; GHOSH & KAZMI, 1958a & 1958b, HOLDEN, 1916; LAKHANPAL & AWASTHI 1963; NAVALE, 1955, 1956, 1962c & 1963; RAMANUJAM, 1954, 1955, 1956a & 1956b,1 960, 1961; SCHWITZER 1958) belong to the tropical deciduous forest. Most of the fossil remains of this group have been found in the localities where they are now growing — at least not far from the standing ,trees.

It is clear from the above data that there is not a single genus common to the Deccan Traps and the Miocene formations. There is more than this. Disappearance of the genus *Simarouba* after the eruption of the Deccan Traps is of considerable significance. It is suggested that during the early Eocene, South America and India were near one another, having more or less similar climate and vegetation. While India was drifting northwards, with the volcanic eruption going on, South America drifted in another direction. These two continents were never again near one another to give a chance to *Simarouba* to re-establish itself in India. This is why there is no *Simarouba* in India now (MAP NO. 2). This hypothesis is supported by recent researches on geology and paleomagnetism. Furthermore, some botanists have already pointed out affinity of plant remains from the Deccan Traps with the present vegetation of tropical South America (SAHNI & SURANGE, 1953; MAHABALE, 1956; PRAKASH, 1960).

Besides, those who have worked or are still working on the wood remains of the Deccan Traps, have come across difficulties in matching them with the wood from the existing Indian forest. I have not personally made careful investigation of the fossil woods from the Deccan Intertrappean beds but a large number of specimens have been sent to me for opinion because of my many years' interest in the woods of living trees of India. The impression I have gathered is that the woods from Deccan Traps are entirely different from those that are now found in the Indian forest and that the trees from which woods of Deccan Traps come were probably grown south of equator. All these years there was no support for my impression but now rock magnetism shows that my impression was not altogether wrong.

Secondly, the Miocene flora belonging to the evergreen rain forest seems also to have some significance. They had much wider distribution in India than they have now. For example, *Dipterocarpoxylon* Holden has been reported from Kutch on the north West Coast of India and *Anisopteroxylon* Ghosh & Kazmi (*Dipterocarpoxylon*) from the Punjab foot hills and West Bengal. These localities are thousands of kilometer away from where these trees now grow. A somewhat similar occurrence seems to have taken place also in East Africa, where Bancroft (1933) discovered some fossil woods of the Dipterocarpaceae. Paleomagnetic results (IRVING, 1957) indicate that in the past India and Africa were near one another. It is suggested that both these continents, while moving northwards, collected some members of



MAP. NO. 2

GENUS *SIMAROUBA.*

---- = PRESENT DISTRIBUTION.

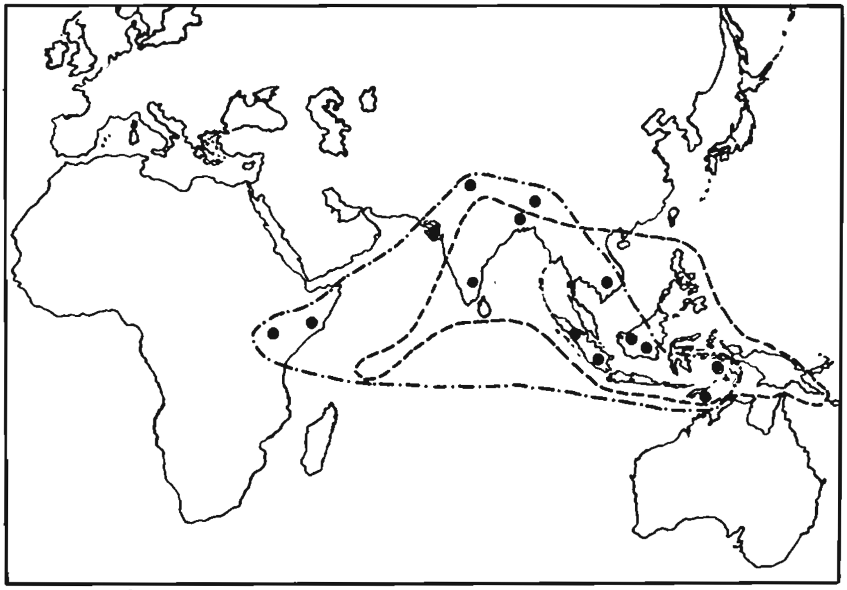
● = FOSSIL DISTRIBUTION.

Dipterocarpaceae at the time they were more or less in a line with the present position of Malaya, the original home of this family. Both North India and East Africa now have only fossils and no living Dipterocarps. Here I may point out that I agree with Bancroft (1933, 1935) about the two genera of Dipterocarpaceae which still grow in Africa. They are anatomically different from the rest of the Dipterocarpaceae and should be placed under a sub-family (MAP No. 3).

The present distribution of *Cynometra* and *Pahudia* complex supports to a great extent the hypothesis put forward for the Dipterocarps. While Dipterocarps are now confined to only Indo-Malayan region, various species of *Cynometra* and *Pahudia* occur in Africa, South America and also in the Malayan region. Due to lack of data on the past distribution of these genera, it is not possible at this stage to reconstruct their movement during the past geological age. As regards *Gluta* (and *Melanorrhoea*), whose original home appears to have been the Malayan region, was possibly established in India about the same time as the other genera of tropical evergreen forest. Its past and present distribution shows a great similarity to the Dipterocarps. In the Miocene period it was growing in West Bengal and Assam but now confines itself to extreme south West Coast and south Burma. The present and past distribution of *Kayea* shows a general agreement with that of *Gluta*.

Some conclusions can now be drawn. The data on the fossil woods and the rock magnetism of India are not yet adequate to draw a clear picture of continental drift. Researches on palaeomagnetism have consistently brought out the fact that India in early Tertiary was situated about 30° south of the equator from where it had drifted about 3500 km. to come its present position. A systematic analysis of the fossil woods of the Deccan Traps and later geological formations supports this hypothesis.

A study of the woods of Miocene and early Eocene period, clearly shows that there is little similarity between them. It is possible that the Indian continent had been situated south of equator during the Eocene. The land mass moved northwards while the volcanic eruption was going on. During this movement the Eocene flora was destroyed and the Miocene flora was established. The new flora moved further north



MAP. NO. 3

DIPTEROCARPACEAE.

---- = PRESENT DISTRIBUTION.

-.-.- = FOSSIL DISTRIBUTION.

and now contains many genera of the Malayan region. Some of the Malayan genera have been wiped out in the north India due to unsuitable climatic conditions prevalent there. They, however, have found shelter in the south and eastern India where the climate is somewhat similar to that of the Malayan region.

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