LIBYA—A PROBABLE PART OF GONDWANALAND

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ABSTRACT

Palynological assemblages from subsurface samples ranging in age from Lower Carboniferous to Upper Triassic from Libya have been assessed. It has been observed that during Carboniferous, the miospores were more or less similar in Libya, Europe and also in Gondwanaland. Middle Permian to Middle Triassic spores and pollen grains from Libya, however, show more resemblance to Gondwana miofloras than that of Europe. This led the authors to postulate that Libya, most probably, was a part of Gondwanaland. Oceanographic researches on mid-oceanic ridges and plate tectonics also provide additional support to this view.

INTRODUCTION

The word Gondwana was first introduced by MEDLICOTT (1872) in his field report submitted to the Geological Survey of India, Calcutta. He coined this word as the rocks were first recognized by him in the kingdom of Gond—a pre-Aryan tribal people inhabiting in part of Madhya Pradesh, India. Later, FEISTMANTEL validated the name by publishing it in 1876. The four fold succession of sediments from India for which the name Gondwana System was originally proposed, was also subsequently reported from South Africa, Australia and South America. In the present state of our knowledge, Gondwanaland now comprises major parts of Africa, Antarctica, South America, Australia and India. In addition Ceylon, Falkland, Madagascar and Tasmania also come within its boundaries.

It is generally agreed that Gondwanaland did not exist in the present North African countries because the *Glossopteris* flora has not so far been recorded from any one of these areas. The huge alluvial deposits and scanty exposures also limited the search for megafossils which would have thrown light on this aspect.

PALYNOLOGICAL EVIDENCES

In recent years, an extensive oil exploration programme in Libya has resulted in a considerable accumulation of geological and palaeontological data of Devonian, Carboniferous, Permian and Triassic periods.

LELE, MILLEPIED AND JAIN (Ms.) have completed the study of Carboniferous subsurface palynology recovered from the bore hole no. A. I-49 (632 m.) from Libya. They have found *Punctatisporites*, *Libyapollis* (new genus), *Vallatisporites* and *Verrucosisporites* as dominant and *Tholisporites*, *Colatisporites*, *Cyclogranisporites*, *Retusotriletes*, *Apiculiretusispora*, *Spalaeotriletes*, *Leiotriletes*, *Anaplanisporites* and *Calamospora* as subdominant taxa.

The basic composition of the miofloral assemblage falls within the broad frame work of '*Vallatisporites*-suite' recognized by SULLIVAN (1968) in the Tournaisian (Kinderhookian) miofloras of the world. Regarding the Libyan miospore assemblage from Carboniferous they have remarked, "—it seems possible to visualize that the southern counterparts of the *Vallatisporites*-suite possessed some inherent peculiarities of their own which somewhat

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modified its overall texture. In the Libyan assemblage, the southern peculiarities are evidently intermingled with certain characteristic elements of the northern *Vallatisporites*-suite. In other places, for example in Australia, the southern peculiarities appear to overdominate in the Hunter valley mioflora (Playford and Helby, 1968) whereas the northern characteristics are more evident in the North-West Australian assemblage (Balme, 1960). Therefore, a fairly widespread data is needed for synthesizing the trends of development in the Lower Carboniferous floras of the southern part of the globe which could have once occupied the Gondwanaland."

Widespread Permo-Carboniferous glaciation in Gondwanaland is eloquent by the conspicuous presence of Buckeye tillite in Antarctica, Bacchus Marsh tillite in Australia, Itarar tillite in Brazil, Assises glaciaires et périglaciaires in Zaïre (Congo) and Talchir tillite in India. The impact of this long range and persistent glaciation in Gondwanaland was so profound that all the previous vegetation either died out or migrated to warmer regions. A few species might have transformed into new types by means of mutation on the onset of glaciation. The present position of Antartica may be cited here as an example. The titanic ice sheets of this continent coupled with severe cold and bizarre wind allowed no vegetation to grow on this vast virgin land.

Glossopteris flora could not only withstand the cold climate but also flourished all over the Gondwanaland within a relatively short period. This flora, being fed by the glacial environment was very different from contemporary Angara and Eurasian floras. The occasional report on the presence of *Glossopteris* in the northern hemisphere or the presence of *Lepidodendron* in the southern have been repeatedly questioned and it seems that during the Permian Period there was no mixing and the flora of the two supercontinents were very different from each other (Asama, 1970; Meyen, 1970; Surange, 1971).

The barometer to measure whether a particular region was a part of Gondwanaland or not, will therefore, be the Permian flora. In all the Gondwana countries, Permo-Carboniferous miospore assemblages are dominated by monosaccates. In later stages, triletes and striate bissacates outnumber the monosaccates. Lower Permian microflora in Europe and America, on the other hand, is not much different from that of Upper Carboniferous because there was no drastic environmental change.

Recently, Kar, Kieser and Jain (1972) have proposed the following five palynological zones for Middle Permian to Upper Triassic horizons in Libya:

Zone 5—(Upper Triassic)—Nonstriate bisaccates dominant (72%), laevigate triletes (12%) and microplankton (7%) common. Striate bisaccates (3%) and zonate triletes (2%) rare.

Important genera: *Alisporites* (26%), *Vitreisporites* (22%), *Klausipollenites* (21%), *Punctatisporites* (10%) and *Veryhachium* (7%).

Zone 4—(Middle Triassic)—Monoletes dominant (44%), laevigate triletes (22%) subdominant, nonstriate bisaccates (14%) and apiculate triletes (13%) common. Striate bisaccates (2%) rare.

Important genera: *Saturnisporites* (44%), *Punctatisporites* (19%), *Verrucopunctasporites* (11%), *Lundbladispora* (5%), *Limitisporites* (5%) and *Klausipollenites* (4%).

Zone 3—(Lower Triassic)—Laevigate triletes dominant (39%), microplankton subdominant (34%), zonate triletes (9%), apiculate triletes (8%) and nonstriate bisaccates (6%) common.

Important genera: *Punctatisporites* (34%), *Veryhachium* (34%), *Calamospora* (5%), *Apiculatisporis* (4%) and *Cyclogranisporites* (3%).

Zone 2—(Upper Permian)—Microplankton dominant (52%), striate bisaccates

(39%) subdominant, laevigate triletes (7%) common, apiculate triletes (1%) and zonate triletes (1%) rare.

Important genera: *Verylachium* (52%), *Striatopiceites* (21%), *Strotersporites* (13%) and *Punctatisporites* (4%).

Zone 1—(Middle Permian)—Bisaccates (53%) dominant, striate bisaccates (28%) and nonstriate bisaccates (25%); monosaccates (36%) subdominant, laevigate triletes (9%) common.

Important genera: *Potonieisporites* (36%), *Limitisporites* (13%), *Striatites* (13%), *Punctatisporites* (7%), *Cuneatisporites* (6%), *Strotersporites* (6%) and *Striatopiceites* (5%).

It may be pointed out here that Zone 1 palynological assemblage from Libya does not closely resemble with that of Middle Permian assemblages described from Europe. On the contrary, it comes closer to the miospore assemblage described from Assise des schistes noirs de Walikale of Zaïre (Congo) by Bose and Kar (1966). In both the assemblages bisaccates, triletes and monosaccates are fairly common. But some important genera like *Potonieisporites* which is quite common in Libya is hardly represented in Walikale assemblage.

Zone 1 also broadly corresponds to Zone 3 proposed by Kar (1973) for Upper Karharbari palynological assemblage in North Karanpura sedimentary basin, Bihar, India. In this zone, monosaccates are dominant, striate bisaccates come next and the triletes are fairly common. Some of the important genera are also common in both the assemblages while others maintain their individualistic distributional pattern.

It is rather interesting to note that *Cannanoropollis* Potonié & Sah (1961), *Plicatipollenites* Lele (1964), *Parasaccites* Bharadwaj & Tiwari (1964) and *Divarisaccus* Venkatachala & Kar (1966)—the most common monosaccate genera associated with glacial tillites and varvites are conspicuous by their absence in Libya. *Potonieisporites* (Bharadwaj) Bharadwaj (1964) on the other hand, which is very common in Libya, is a quantitatively insignificant genus in South African, Australian, South American and Indian assemblages.

The reason for this disparity in palynological assemblage is to be sought in the geographical distribution of different parts of the then Gondwanaland. South Africa, Eastern Antarctica, South America, Australia and India were juxtaposed and faced severe polar climate due to Permo-Carboniferous glaciation. The recurrence of tillites in most of the continents point out that glacial period was prolonged. Since all these continents were closely placed and were within the same climatic belt, the flora was uniform. Libya on the contrary, was situated on the northernmost part of Africa fringing the Tethys. It seems that the climate in Libya, during Permo-Carboniferous was not at all severe since it was away from the cold region and was nursed by the ice-free Tethys.

Zone 2 miospore assemblage from Libya also resembles the assemblage described from Lower Coal Measures (K_2) Katewaka-Mchuchuma coalfield, Tanganyika by Hart (1960), Upper Permian assemblage reported by Hemer (1965) from Saudi Arabia; Bharadwaj (1962, 1966), Bharadwaj and Salujha (1964), Kar (1968) from India and Balme and Hennelly (1955, 1956) and Segroves (1967, 1969) from Australia. The Upper Permian Iraqian assemblage described by Singh (1964) is distinguished by its abundance of monoletes mostly represented by *Punctatosporites* and *Thymospora*.

Upper Permian palynological assemblage from Europe though also dominated by striate bisaccates is distinguished from the Libyan one by good representation of the following species: *Lueckisporites virkkiae* Potonié & Klaus (1954), *Klausipollenites schaubergeri* Potonié & Klaus (1954), *Jugasporites delasaucei* Leschik (1956), *Falcisporites zapfei* Potonié & Klaus (1954), *Nuskoisporites dulhuntyi* Potonié & Klaus (1954) and *Strotersporites richteri* Klaus (1963).

The Lower Triassic microfossils from Libya (Zone 3) is dominated by triletes. This dominance of triletes has also been observed in Lower Triassic of Australia by HENNELLY (1958) and BALME (1963); in Tasmania by PLAYFORD (1965); in India by SRIVASTAVA AND PAWDE (1962), BHARADWAJ (1970) and KAR (1970). In Lower Triassic of West Pakistan though the assemblage is dominated by microplankton genera viz., *Veryhachium* and *Micrhystridium* but the triletes are also fairly common (BALME, 1970).

The Lower Triassic miospore assemblage from Europe resembles the Libyan one in the presence of some genera like *Cyclogranisporites*, *Apiculatisporis*, *Verrucosisporites*, *Kraeuselisporites*, *Densoisporites* and *Lueckisporites*. But the typical Lower Triassic species of Europe viz., *Triadispora staplini* Jansonius (1962), *T. falcata* Klaus (1964), *T. crassa* Klaus (1964), *Voltziceaesporites heteromorpha* Klaus (1964), *V. nephrosaccus* Klaus (1964), *Illinites kosankei* Klaus (1964), *I. melanocorpus* Klaus (1964), *Microcachryidites fastidioides* (Jansonius) Klaus (1964), *M. sittleri* Klaus (1964) and *Alisporites grauvogeli* Klaus (1964) are absent in Zone 3 of Libyan assemblage.

The striking difference between Upper Permian and Lower Triassic palynological assemblages throughout the Lower Gondwanas may perhaps be attributed to the change in environment or even due to nondeposition for certain time (GEE, 1932; BALME, 1969; KUMMEL & TEICHERT, 1966, 1970). In plant megafossils also the erstwhile abundance of *Glossopteris* in Upper Permian had gradually dwindled down in Lower Triassic and subsequently a new flora viz., *Dicroidium* emerged.

The change from Upper Permian to Lower Triassic palynological assemblages in Europe, on the other hand, is gradual and there is no striking difference between the two. In both the assemblages, disaccates are found in abundance and the delimitation of palynological boundaries are made by the presence or absence of some genera and species. This is attributed to the gradual change in flora and also the continuity of deposition from Upper Permian to Lower Triassic. The demarcation between the two horizons thus may not be very convincing. It may be mentioned here, that FREUDENTHAL (1964) reported an Upper Bunter (Lower Triassic) assemblage from Holland dominated by the striate bisaccates.

The Middle Triassic miospore assemblage from Libya (Zone 4) is unique by its dominance of zonate monoletes represented by *Saturnisporites*. This assemblage is closely comparable to that of Middle Triassic assemblage described from Tiers Formation (Middle Triassic) of Tasmania by PLAYFORD (1965). In both the assemblages, zonate monoletes predominate.

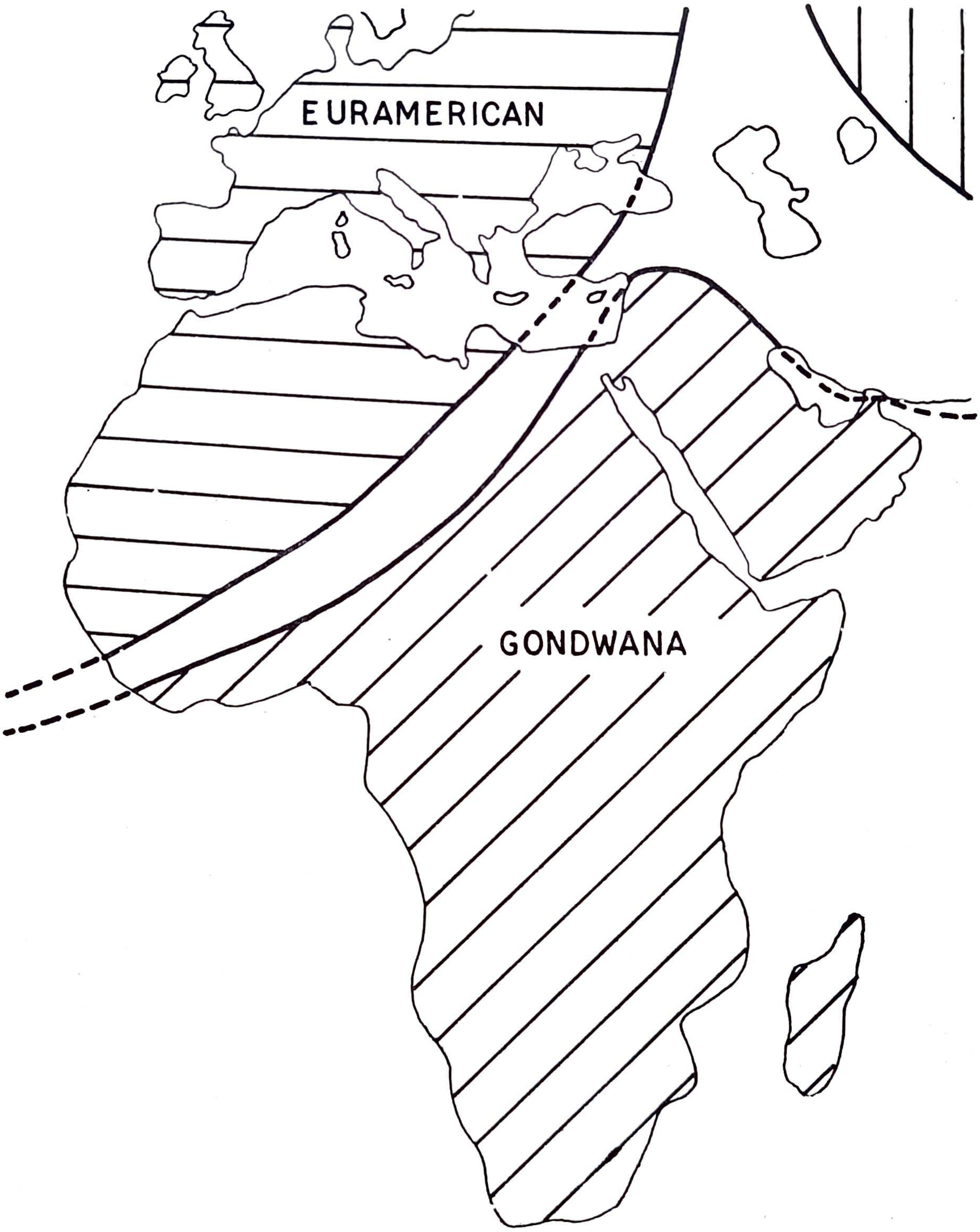
Zone 5 from Libya closely resembles the assemblages described by BHARADWAJ AND SRIVASTAVA (1969) from India; HERBST (1965) and JAIN (1968) from Argentina; DE JERSEY (1970), BALME (1964) and PLAYFORD (1965) from Australia and Tasmania by the dominance of nonstriate bisaccates.

This zone is also comparable to the Upper Triassic assemblages of Europe worked out by PAUTSCH (1958), KLAUS (1960, 1964), TAUGOURDEAU-LANTZ AND JEKHOWSKY (1959), MÄDLER (1964), CLARKE (1965), ANTONESCU (1970) and others by the dominance of nonstriate bisaccates. Some of the characteristic European Upper Triassic genera like *Camerosporites*, *Enzonalasporites*, *Ovalipollis*, *Zebrasporites* and *Aratisporites* are, however, not found in Libya zone.

From the above palynological data, it is obvious that the microfossils obtained from Libya show closer resemblance to the assemblages of Gondwanaland from Middle Permian to Middle Triassic than Europe. The Upper Triassic assemblage of Libya also corresponds more closely to Gondwanaland than that of Europe though all these assemblages are dominated by nonstriate bisaccates. It is known that in Jurassic, the flora of both the supercontinents were rather homogenous except some endemic vegetation here and there. So, it is quite likely, that during Upper Triassic, the flora was evolving towards this homogeneity.

It is rather surprising that Libya being so closely placed near European continent does not show much palynological similarity to it during Permian and Triassic periods. This anomaly may be better explained if we postulate that Libya was also an integral part of the Gondwanaland. The floral pattern obviously indicates that Libya was inhabited by more or less same kind of vegetation as we find in the different Gondwana countries. It may be mentioned here that during Upper Permian and Upper Triassic, Libya witnessed marine transgressions changing slightly its floral elements. The other Gondwana countries mostly exhibited continental deposition during this period but still the resemblance between them is very striking which leads to postulate some kind of land connection.

Plumstead (1973) produced a map showing Saudi Arabia, Ethiopia, Sudan and a part of Nigeria as Gondwana on subsurface borehole data. She has, however, excluded some parts of Egypt, Libya, Algeria, Morocco and West Africa from it (Text-Fig. 1). However,

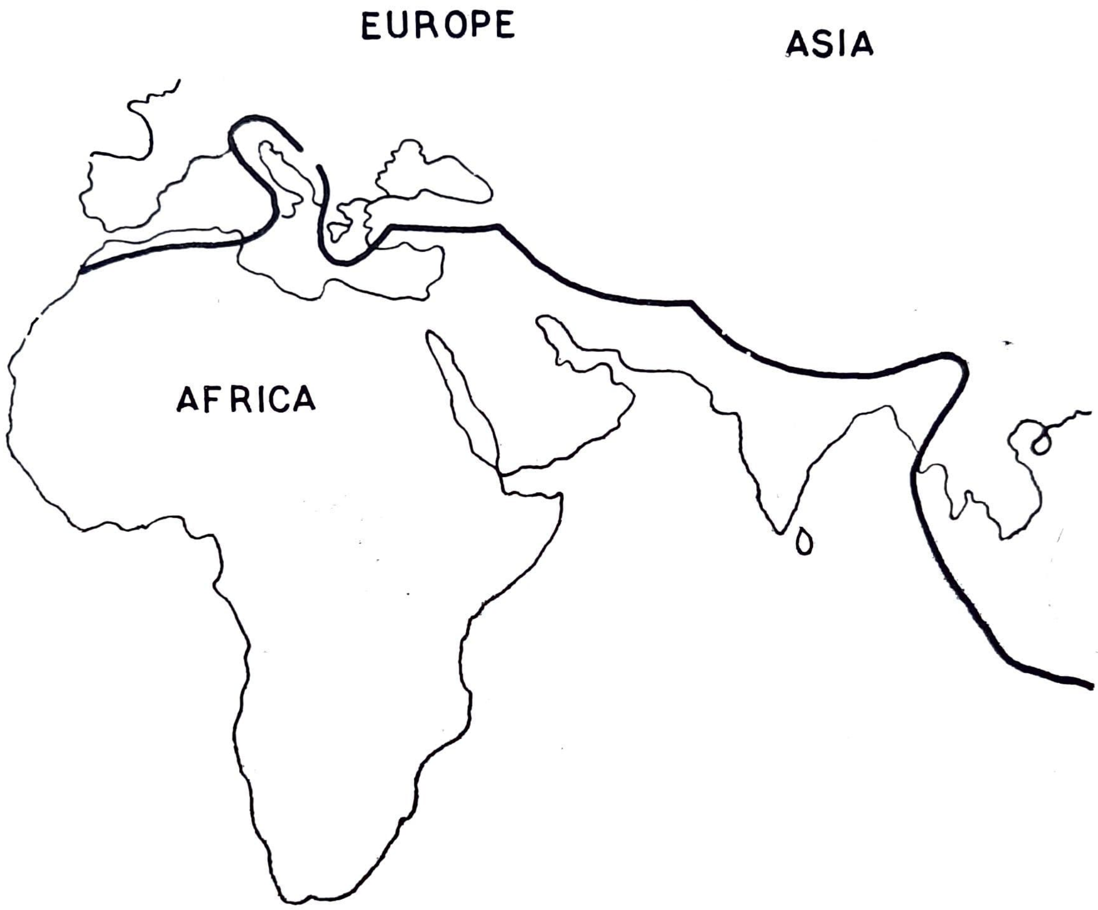


Text-Fig. 1—Showing the extension of Gondwanas in Africa based on surface and subsurface data (after Plumstead, 1973).

from the present data, it seems plausible that Libya was also a part of Gondwanaland and the ancient sea might have extended along its northern territory.

MID-OCEANIC RIDGES

This supposition also gets support from the recent oceanographic researches. The mid-oceanic ridges which are responsible for pushing apart the continents due to rising up of convection currents from the mantle has been shown by WILSON (1963). The ridges pass through the northern border of Algeria and Morocco and then it travels towards the Mediterranean leaving Libya unscathed. From the map and discussion put forward by PLUMSTEAD (1973), it is obvious that Saudi Arabia was also a part of Gondwanaland. This explains that the minor ridges which subsequently formed the Red Sea appears to be a recent phenomenon (Text-Fig. 2).

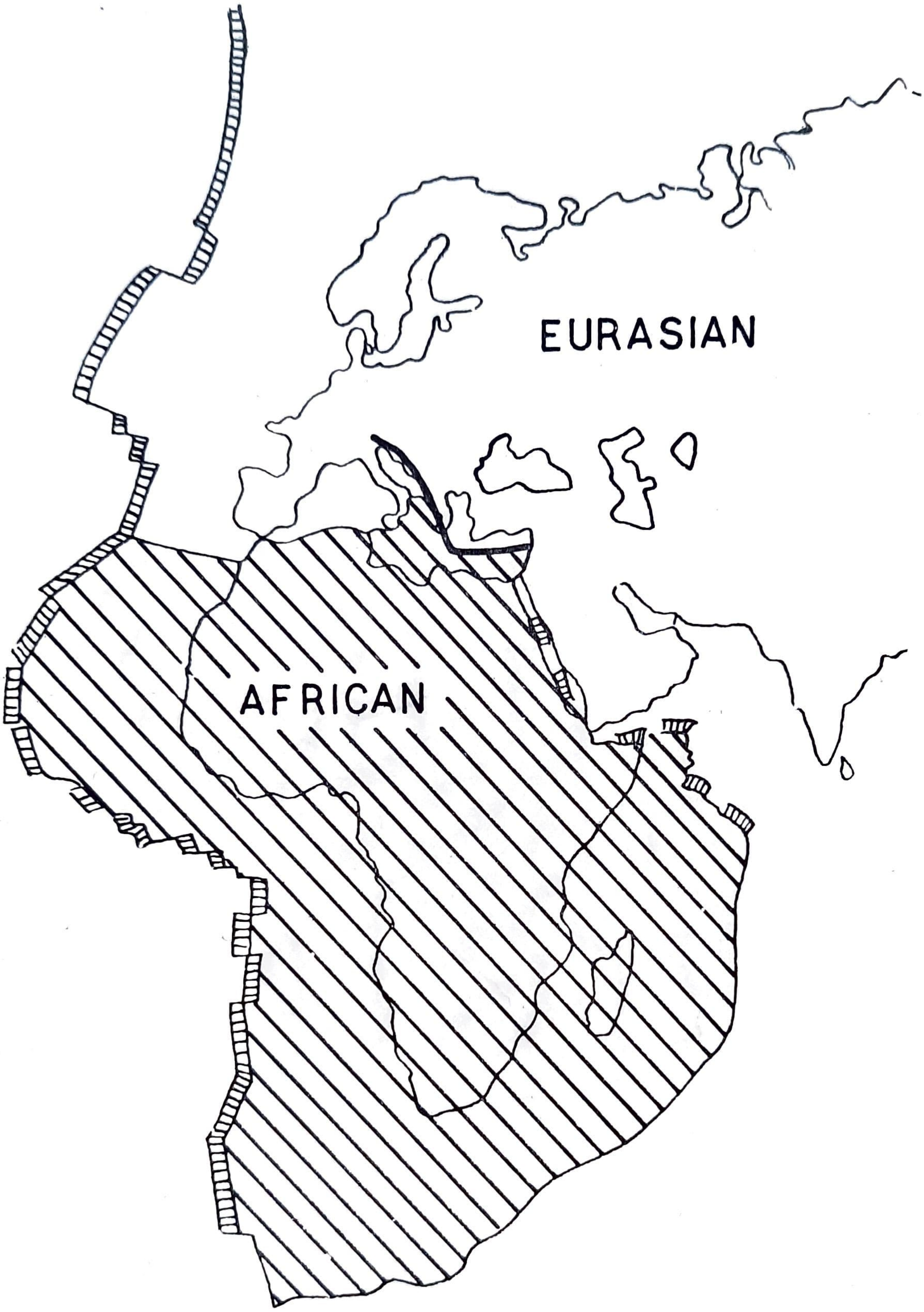


Text-Fig. 2—Showing the mid-oceanic ridges around the African continent (after Wilson, 1963).

PLATE TECTONICS

Modern researches on plate tectonics have also revealed that the earth comprises six major plates and a few minor ones. These plates are rigid but adjust their positions accordingly. BULLARD (1969) has shown in a map (reproduced in Text-Fig. 3) the position of the African plate in relation to other plates. It is interesting to note that South and North Africa including Algeria, Morocco, Libya and Egypt are made up of one massive, solid plate and there is no breakage to form rift valleys except in Red Sea and adjacent regions. If the configuration of the African plate has been correctly drawn, then there should be no wonder if Libya exhibits floral assemblage similar to Gondwanaland during Permian to Middle Triassic times.

N.B.—Para under "Mid-Oceanic Ridges" along with Text-fig. 2 have been wrongly included and should not be read—Authors.



Text-Fig. 3—Showing the extension of the African major plate (after Bullard, 1969).

CONCLUSION

1. From the above discussion it becomes apparent that palynological assemblages recovered from Libya during Permian-Middle Triassic resemble more with Gondwana countries than its European counterparts.

2. Oceanographic ridges also reveal that Libya was not cut off from the main African land during this period.

3. Plate tectonics also support that Libya was always a part of the major African plate.

4. During Permian and Triassic, there were marine transgressions in Libya. Moreover, since Libya was situated at the border of Tethys, it seems that it did not face a very cold climate as in other continental parts of Gondwanaland. Absence of *Cannanoropollis* Potonié & Sah (1961), *Plicatipollenites* Lele (1964) and *Divarisaccus* Venkatachala & Kar (1966) and other spore-pollen genera which are found in association with the tillites in other parts also strengthen this supposition.

5. Thus, in conclusion, it seems that most evidences favour the inclusion of Libya into the orbit of Gondwanaland.

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