CHAPTER - VIII

8.0 PALEODEPOSITIONAL ENVIRONMENT

As could be ascertained earlier, the microfloral assemblages in Broach Depression recorded from the subsurface Paleogene sediments encountered in Gandhar, Pakhajan, Dahej, Palej and Matar areas are mainly represented by the plant groups pteridophytes, gymnosperms and angiosperms. The marine phytoplanktons on the other hand are represented by different types of dinoflagellate cysts and acritarchs.

In the following discussion, the distribution of montane plants, inland plants, fresh water plants, ferns, low salinity water plants, prohaline plants, tidal plants, fungal spores and marine floral assembalges from the subsurface sediments have been fully taken into consideration while interpreting the paleoenvironments. The different ecological groups as proposed by Watson(1928), Venkatachala (1950), Banserau (1957) and Mathur (1977) are followed by author and paleoenvironmental interpretation for Olpad Formation, Cambay Formation, Ankleshwar formation and Dadhar Formation are proposed. Finally the palynofossils are grouped under the following different ecological complexes based on their dissimilar habitats and adoptabilities.(Fig.6).

8.1. MONTANE PLANT COMPLEX

This group comprises monosaccates, disaccates and trisaccates etc. Such plants normally grows on higher altitudes under temperate conditions (Mathur et al.,1977).

In the samples processed by the author, these high altitude microfloral elements are rarely distributed and their use in paleoenvironmental or paleoeological interpretation is therefore very insignificant. Podocarpidites (podocarpaceae) is the only genera/species recorded in the studied samples.

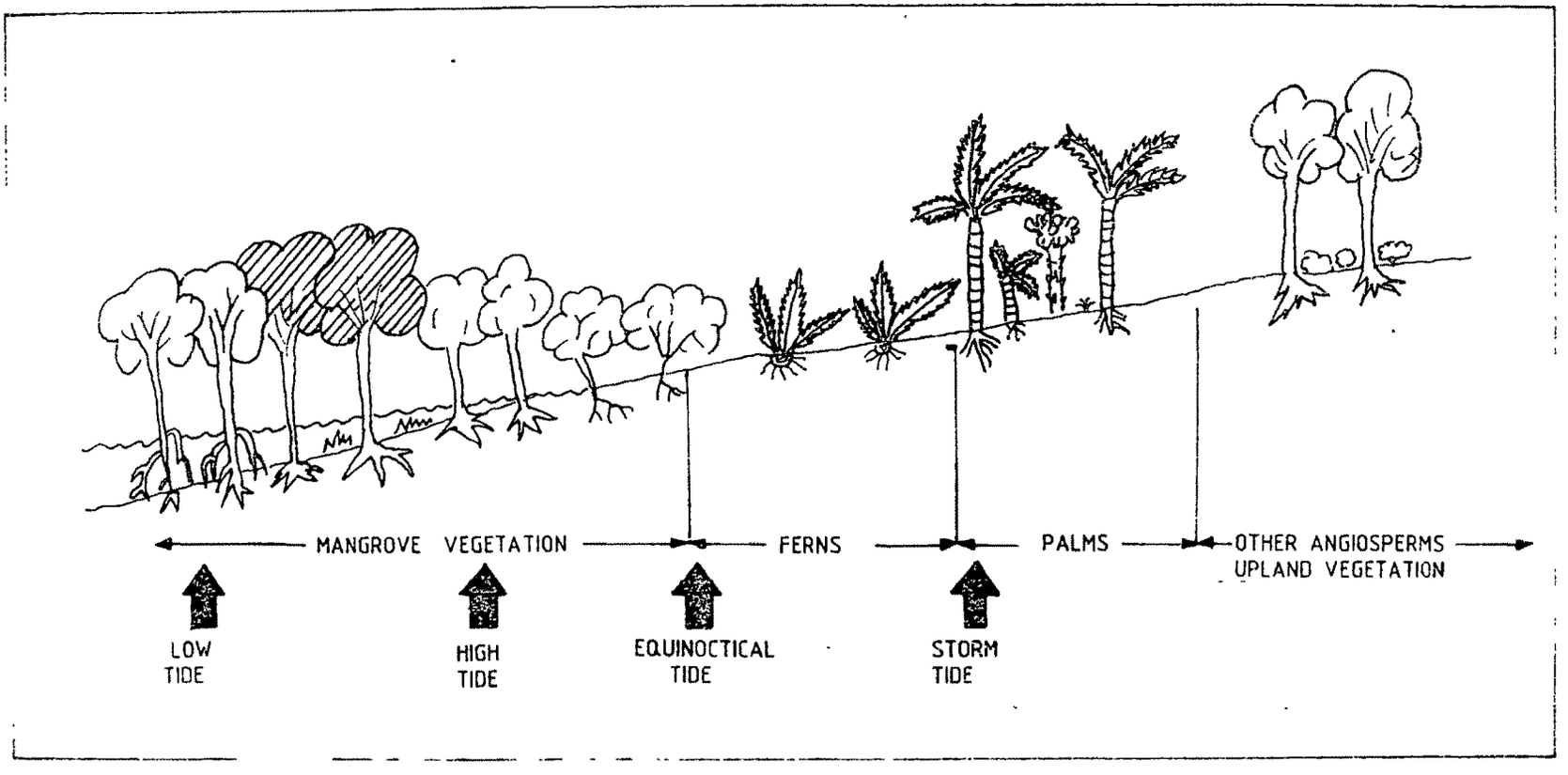

FIG. 6. ZONATION OF VEGETATIONAL GROUPS (AFTER DANSEREAU, 1957)

8.2 INLAND PLANT COMPLEX

This group consists of angiosperm pollen which grow on the solid ground beyond palm region. The following are the important plants recorded in the study area:

Polycolpites spp.((pedaliaceae)

Stephanocolpites spp.

Striacolporites sp.(fabaceae)

Anacolosidites sp.(Anacolosa)

Tricolporites spp.(Oleaceae)

Bombacacidites (Bombacaceae)

Cupanieidites (Sapindaceae)

Polygalacidites (Polygalaceae)

Meliapollis (Meliaceae)

Umbelliferoipollenites (Umbelliferae)

Margocolporites (Caesalpiniaceae)

Tricolporopollis (Eubhorbiaceae)

Araliaceoipollenites (Araliaceae)

Rhoipites (Anacordaceae)

Symplocoipollenites (Symplocaceae)

Meliapollis (Meliaceae)

Tricolporopollis (Euphorbiaceae)

Polybrevicolporites

8.3 FRESH WATER PLANT COMPLEX

The plants grouped under this complex normally grow in and around fresh water streaks, channels, ponds, swamps, and marshes. The following are the important genera beloning to different families recorded

in the author's study :

Dicolpopollis (Calamus)

Triorites (Trapa)

Pseudonothofagidites

Pediastrum (Algae)

8.4 FERN COMPLEX

The pteridophytic spores such as trilete and monolete fern spores are mainly grouped under this complex. These fern spores are water and shade loving plants generally growing where the water and shades are available They are also considered important constituents of marshes near the sea shore. The following genera are the common reprsentatives in the study area:

Polypodiisporites (Polypodiaceae)

Polypodiaceaesporites (Polypodiaceae)

Polypodiaceoisporites (Polypodiaceae)

Lycopodiumsporites (Lycopodiaceae)

Osmundacidites (Osmundaceae)

Lygodiumsporites (Lygodium)

Cyathidites (Cyatheaceae)

Cicatricosisporites (Parkeriaceae)

Magnastriatites (Ceratopteris)

Schizaeoisporites (Schizea)

8.5 PALM COMPLEX :

The palm plants which grows in dry sandy and coastal areas are grouped under this complex. The following are the important genera recorded here:

Palmaepollenites (Palmae)

Laliacidites (Liliaceae)

Couperipollis (Palmae)

Palmidites (Palmae)

8.6 XEROPHYTIC PLANT COMPLEX

The plants belonging to this group normally grow in a dry and sandy environment in the vicinity of sea. The following are the genera recorded in the studied samples :

Triorites (Proteaceae)

Proteacidites (Proteaceae)

Ephedripites (Ephedra)

8.7 LOWSALINITY WATER PLANT COMPLEX

The plant included under this group are low growing palms which can tolerate the marine influence. They are however less tolerant to salinity than even the mixed mangrove plants. This complex gradually merge with the flora of the upper relief. The following genera are encountered in the study area :

Proxapertites (Nipa)

Arecipites (Phoenix)

Spinizonocolpites (Palmae)

8.8 PROHALINE WATER PLANT COMPLEX

The plants grouped under this complex normally are salt tolerant fresh water habitates, growing in the zone where there is a mixing of marine water from sea and fresh water from the rivers.

Marginipollis (Barringtonia) is the only genera/species recorded.

8.9 TIDAL MANGROVE COMPLEX

The plants grouped under this complex indicate typical mangrove vegetation grows in tidally submerged coastal wood land swamps. The following genera are the representatives of the study area.

Zonocostites (Rhizophoraceae)

Floraschuetzia (Sonneratiaceae)

8.10 MARINE MICROPLANKTON COMPLEX

The marine microplankton group includes dinoflagellates and acritarchs which are common in shallow marine conditions. The following genera are the representatives in the study area:

Hystichosphaeridium

Polysphaeridium

Homotryblium

Hystrichokolpoma

Cordosphaeridum

cyclopsiella

Michrystridium

8.11 Paleoenvironmental Interpretation for different formations :

The distribution and interrelationship of the various ecological complexes described above can now be related to identify and interprete the distinctive characteristics of the depositional environments in individual formations.

8.11.1 OLPAD FORMATION

This formation unconformably overlies the Deccan Trap and has gradational and intertonguing relationship with overlying Older Cambay Shale. The Olpad Formation is encountered in wells Gandhar-A, Palej-A and Matar-A between 4320-4500 m, 1835 -2000 m and 1541-1800 m respectively. This formation mainly comprised of trap derivatives with minor sandstones, siltstones, shale and claystone. The earliest Paleogene sedimentation in Broach Depression is marked by the deposition of volcanic wacke-arenite complex in this formation.

As mentioned earlier, the Olpad Formation has poor representation of palynofossils. Marine phytoplanktons are totally absent here. The dominance of inland plants (38-59%) and Ferns (0-42%) have been noticed in the well Gandhar-A (Fig.41E). The other associated palms and low salinity water plants are poorly distributed and constitutes 5-18% and 0-11% in total population respectively.

In Matar area (Matar-A) the percentage of montane flora (8-14%), Ferns (14-40%) and palms (20-30%) are varying from one complex to other (Fig.4.8), while the palm and low salinity water plant elements are fairly distributed in the Olpad Foramtion. They are varying in abundance as 5-18% palm flora, and 0-11% low salinity water plant complex in the total population. The dominance of fresh water ferns and inland floral elements alongwith fairly distributed coastal and low salinity water floral elements indicate that the sedimentation in Gandhar area took place in coastal to brackish water conditions whereas in Matar area the sedimentation took place in a fluvial to brackish water environments (fig.4.8).

Such a conclusion is further supported from the earlier studies viz. Narendra et al., (unpublished ONGC Report, 1988) have opined that Olpad

Formation represents different stalked alluvial fans with the conglomerates in the proximal fan deposits and trap wacke, and claystone deposits representing the distal fan environments of deposition. Mohan et al., (unpublished ONGC Report, 1988) opined that not much of the vegetation or other forms of life are initially expected to exist in the basaltic country and whatever little vegetation or life existed may not have been preserved due to highly oxidising environment prevalent during deposition of the sediments. According to Pandey et al., (unpublished ONGC Report, 1993), the Olpad Formation was deposited under fresh water to slightly brackish water coastal environment with poorly sorted angular to subangular sediments that were transported under high energy conditions and deposited directly as fan deposits.

As a whole the microfloral ecoassemblage studies by the author suggests fluvial to slightly brackish water environment of deposition for the Olpad Formation.

8.11.2 Cambay Formation

Cambay Formation overlies unconformably the Olpad Formation. The formation is extensive in the subsurface tnroughout the Broach Depression and is not exposed in the outcrops. The foramtion has conformable relation with overlying Ankleshwar Formation in the South Cambay Basin. It has conformable, gradational and intertonguing contact in the underlying Olpad Formation. This formation is encountered in well Gandhar-A between 2 980-4060 m and from 3800-4000 m, 1875-1895 m and 1520-1580 m in wells Pakhajan-A, Palej-A and Matar-A respectively. The formation is composed of dark grey to black, moderately hard compact shale with thin sands which are colourless to dirty white, fine grained silts and brownish grey moderately hard and compact claystone.

In Gandhar area (Gandhar-A) the microfloral ecoassemblage constitutes

(0-73%) inland flora, (5-64%) ferns, (5-44%) palms, low salinity water plants (0-22%,) mangrove floral elements(0-2%,) marine floral elements(0-47%) fungal complex(0-12%,) fresh water flora(0-42%)and montane flora (0-9%)in the total population (Figs. 4.1B, 4.1C, 4.1D, 4.1E, 4.2B, 4.3, 4.4B, 4.5C, 4.8).

In Pakhajan area (Pakhajan-A)the percentage of the low salinity water plants (6-19%), mangrove flora (0-5%) and marine microplanktons (5-19%) is decreased compared to Gandhar area whereas palm flora (13-29%), ferns (6-27%) and inland flora are almost equally distributed. Fungal remains 0-4% and fresh water floral elements 0-13% are also fairly distributed.

In Matar area(Matar-A) the marine floral elements are totally absent. The mangrove flora (2-6%), low salinity water flora (18-22%) and palm floral elements (11-12%) are fairly distributed where as inland floral elements (34-52%) dominates the population. Ferns (6-11%) and fresh water floral elements are meagre.

It is thus interesting to note that in its overall composition the Cambay Formation floral contents show variation in microfloral ecoassemblages in the basinal (Gandhar area) and marginal towards Matar area. The percentage of low salinity water plants, mangrove plants and marine floral elements are varying from one complex to other.As variously postulated variations in percentage of these plant communities generally emerges when the 'PH' value of water is fluctuating. Such a change is often attributed to changes in shoreline complex and to the influx of fresh water in the basin of deposition. Frequent fluctuations in water levels alongwith bathymetric variations are the additional causes expected to bring similar changes.

As shown earlier the first marine conditions in the entire Broach Depression as supported by the presence of marine phytoplanktons prevailed during the Early Eocene time. There are in all six short lived transgrassive

(T_1 to T_6) and seven regressive (R_1 to R_7) phases, that can be confirmed during deposition of Cambay Formation in Gandhar area. Such a inference is supported by the variation in percentage of mangrove and Marine floral elements in the stratigraphic interval (2980-4060 m). The analysis of different plant complexes further suggest that the fluctuating environment ranged from shallow marine to near shore during the deposition of Cambay Formation in Gandhar and Pakhajan areas. In Matar area, the marine floral elements are replaced by mangrove and low salinity water plants with the dominance of inland floral elements. This suggest near shore conditions of deposition with more fresh water influx.

All the above evidences indicate that the overall depositional conditions in the studied area probably changing laterally from shallow marine (basinal part) to near shore (marginal part) during deposition of Cambay Formation (figs. 5, 5.1 and 5.7).

8.11.3 Ankleshwar Formation

The Ankleshwar Foramtion is conformably overlain by Dadhar Foramtion and unconformably underlain by Cambay Shale. It is encountered in wells Gandhar-A beteen 2573-2934 m and from 3445-3835 m, 1697-1835 m, 1396-1508 m. in wells Pakhajan-A, Palej-A and Matar-A respectively. The lower part of the Ankleshwar Formation is represented by an alternating sequence of shale, sandstone and claystone, while the upper part of the formation consists of claystone shale, sub grey wacke sand, carbonaceous shale and arenaceous limestone. It consists of 4 members from bottom to top viz. Hazad Member, Kanwa Shale Member, Ardol Member and Telwa Shale Member.

8.11.3a Hazad Member

This is the basal member of the Ankleshwar Foramtion and is encountered

in well Gandhar-A, 2777-2904 m and from 3615-3670 m, 2866-3086 m, 1789-1835 m, and 1471-1500 m in wells Pakhajan-A, Dahej-A, Palej-A and Matar-A respectively. It consists of alternating bands of sandstone and shales.

In Gandhar area (Gandhar-A) the dominance of palms (13-39%), Low salinity water plants (13-27%) and marine floral elements (5-27%) alongwith fairly represented montane plants (0-4%), inland flora (7-23%), fresh water plants (5-10%) and fungal remains (0-8%) indicate littoral, shallow marine and near shore conditions of deposition (Fig. 4.2B).

In Pakhajan area (Pakhajan-A) the percentage of marine phytoplankton (0-6%) as replaced by mangrove (0-20%) and low salinity water plants (0-33%) alongwith 0-8% monatane plants, inland flora (7-35%), fresh water plants (0-5%) and ferns (15-50%) is suggestive of littoral, near shore and brackish water conditions of deposition (Fig.4.5C).

In Palej area (Plaj -A) the high altitude monatane flora and inter tidal mangrove floral elements are totally absent. The dominance of inland flora (12-50%), palms (12-43%) and low salinity water plants (0-33%) alongwith fairly distributed marine phytoplanktons indicate shallow marine conditions of deposition.

In Matar area (Matar-A) the upland floral elements, fresh water plants and marine floral elements are totally absent. The other microfloral ecoassemblage constitutes 0-13% inland flora, 17-20% ferns, 0-10% fungal remains, 17-30% palms, 18-20% low salinity water plants and 10-17% mangrove floral elements of the total population. The absence of marine floral elements and moderately distributed palms, low salinity water plants and mangrove floral indicates near shore conditions of deposition.

In general, the Hazad sands in Gandhar area indicate their deposition

in fluctuating envrionment as inferred from the replacement of rthe low salinity water plants by marine microplankton at certain intervals. Such type of conditions generally are acquired when sea is regressed and shifting in shore takes places. (The microplanktons in this usual oceanic habitat require sea water upto 200 m level to flurish, while low salinity water plants grow on land which contains saline water (30% PH) and influx of fresh water). During fluctuating conditions, the colony of microplankton is shifted towards the sea and available place is occupied by the low salinity water plant in the same way as of the marine pulse encroaching the land. Some quantity of marine microplankton are thus mixed with the low salinity water plant complexes. Such changes are often incurred while there is a change in paleostrand line and bathymetry. In Gandhar area the Hazad sands therefore were deposited in a nearshore to shallow marine environments, whereas in Pakhajan area brackish water to littoral conditions prevailed. In Dahej and Palej area the deposition took place under shallow marine conditions. However, in Matar area the sands were deposited in nearshore environments.

8.11.3b Kanwa Shale Member

The Kanwa Shale Member is underlain by Hazad Member and overlain by Ardol Member of Ankleshwar Foramtion. It is encountered in well Gandhar-A between interval 2740-2777 m and from 3615-3670 m, 2850-2866 m, 1765-1789 m and 1445-1471 m in wells Gandhar-A, Pakhajan-A, Dahej-A, Palej-A and Matar-A respectively. It is composed of dark grey, silty and occasionally calcareous shale. This member has moderate representation of palynofossils.

In Gandhar area the dominance is of marine phytoplanktons (13-33%), palms (10-34%) alongwith (7-11%) inland flora, (5-8%) fresh water plants,(16-17%) ferns,(0-10%) fungal remains,(10-13%)low salinity water plants and(5-8%)mangrove

flora this suggests shallow marine conditions of deposition.

In Pakhajan area, the Kanwa shale Member has the percentage of mangrove (0-20%), low salinity water plants (10-20%) and palm floral elements (12-41%) varying from one complex to another (figs. 4.5B). The other microfloral assemblage 7-31% inland flora, 0-5% fresh water plant complex, 20-35% fern flora and 0-12% fungal remains.

In Dahej area the percentage of ferns (7-8%), palm flora (6-25%) and mangrove flora (6-8%) are slightly decreased as compared to Pakhajan and Gandhar area in this member. The other microfloral assemblages constitute 24-25% inland flora, 0-5% fresh water plant complex, 20-35% ferns 0-12% fungal remains, 12-41% palm complex and 18-19% low salinity water plants in the total population. The dominance of marine phytoplanktons alongwith moderately distributed intertidal mangrove flora suggest that the sedimentation took place in shallow marine conditions during deposition of Kanwa Shale Member in Dahej area (fig.4.6b).

In Palej area, the microfloral ecoassemblage constitutes 0-21% inland plant complex, 0-11% fresh water plant complex, 21-28% fernflora, 0-5% fungal complex, 16-44% palm flora, 0-17% low salinity water plants and 11-16% marine flora in the total population. Montane plants and mangrove floral elements are absent. The moderate occurence of marine floral elements alongwith palms and low salinity water plants indicate that the Kanwa Shale was deposited in a shallow marine to nearshore conditions in Palej area.

In Matar area, the montane plants, fresh water plant complex, fungal remains, mangrove flora and marine floral elements are totally absent. The other microfloral ecoassemblage constitutes 0-20% inland flora, 0-40% fern flora 0-20% palms and 10-20% low salinity water plants in the total population.

In general, the paleoenvironmental conditions in Gandhar and Dahej are are characterized by shallow marine, while in Pakhajan area these vary from nearshore to littoral environments. In Palej area nearshore to shallow marine can be inferred while in Matar area brackish water to near shore conditions prevailed during deposition of Kanwa Shale Member. Such environments may have developed due to transgressive sea or subsidence of basin suggested that in the north-eastern part of the basin, the transgressive activity was relatively less effective. Such an inference is supported by the absence of marine floral elements in Matar area (Fig. 7).

8.11.3c Ardol Member

This member occurs in the interval of 2606 -2740 m, 3515-3615 m, 2515-2850 m, 1706-1765 m and 1409-1445 m in the wells Gandhar-A, Pakhajan-A, Dahej-A, Palej-A and Matar-A respectively. The Ardol Member is essentially composed of sandstone and shale.

In Gandhar area (Well Gandhar-A) the Ardol Member has almost equal percentage of low salinity water plants (10-20%) and marine floral elements (5-21%) but the palm floral elements (13-39%) are relatively more. The other microfloral ecoassemblages constitute 4-5% montane plants, 11-23% inland flora, 4-20% fresh water plants, 6-15% fern flora and 4-21% fungal remains in the total population. The dominance of coastal and inland habitat flora alongwith mixed percentage of low salinity water plants and marine floral elements suggest shallow marine and neashore environment during deposition of Ardol sand sin Gandhar area.

In Pakhajan area (Pakhajan-A) the inland flora (7-41%), ferns (20-37%) and palms (7-41%) dominate the total population. Fresh water plants are meagre (0-5%). Marine phytoplanktons are fairly distributed and shows 0-7% while mangrove (0-20%) and low salinity water plants (0-27%) are moderately distributed. The fungal remains present throughout, represent 0-12% of the total assemblage. The montane plants are absent. The dominance of mangrove, low salinity water plants and palms alongwith fairly distributed marine phytoplanktons (fig. 4.5b) indicate that the Ardol sands were deposited in a nearshore to littoral environments in the Pakhajan area.

In Dahej area (well Dahej-A) the inland floral elements (5-55%) dominate the total population. The fresh water plant complex (6-26%), ferns (7-28%) palms (0-28%) and low salinity water plants (0-24%) are almost equally distributed while mangrove (0-15%) and marine phytoplanktons (0-18%) are moderately distributed in this area. The fungal remains represents 0-17% in the total population (fig. 4.6B). The equal distribution of mangrove and marine phytoplanktons in the Dahej area suggest that the Ardol sands were deposited in the littoral to shallow marine conditions in Dahej area.

In Pakhajan area (well Palej-A), the percentage of marine phytoplankton (0-8%) mangrove flora (0-8%), ferns (0-8%) and montane plants (0-6%) are reduced compared to Gandhar and Pakhajan area. The other microfloral ecoassemblages constitute 16-25% inland plants, 25-30% ferns, 8-24% palms and 8-23% low salinity water plants in the total population. The dominance of inland plants, ferns and low salinity water plants indicate that the Ardol sands were deposited under near shore conditions in Palej area (fig. 4.7).

In Matar area (well Matar-A), the marine phytoplanktons and mangrove

floral elements are totally absent. The dominance of inland flora (7-22%), ferns (43-56%) and palms (11-29%) have been noticed in Matar area. The other associated microfloral ecoassemblage such as fungal complex (0-7%) and low salinity water plant complex (11-14%) are fairly distributed. The absence of marine phytoplanktons and mangrove floral elements and presence of fairly distributed low salinity water plants indicate brackish water conditions of deposition during formation of Ardol sands in Matar area (fig. 4.8).

As a whole, the microfloral ecoassemblage indicate that the Ardol Member was deposited in a shallow marine to near shore conditions in Gandhar area, nearshore conditions in Pakhajan area, shallow marine to near shore conditions in Dahej area, near shore and brackish water conditions in Palej and Matar area respectively.

8.11.3d Telwa Shale Member :

The Telwa Member is overlain by Dadhar Formation and underlain by Ardol Member. It is encountered in well Gandhar-A between 2573-2606 m and from 3445-3515 m, 2485-2515 m, 1697-1706 m and 1396-1409 m in well Gandhar-A, Pakhajan-A, Dahej-A, Palej-A and Matar-A respectively. It is composed of grey to greenish grey laminated fissile shale.

In Gandhar area (well Gandhar-A) the microfloral assemablage mainly constitutes 15-31% inland plants, 11-27% fresh water flora, 27-31% ferns, 0-11% fungal remains, 11-17% palms, 0-9% low salinity water plants, 0-5% mangrove flora and 0-10% marine flora in the total population. The fair occurrence of marine phytoplanktons alongwith palms, low salinity water plants and mangrove floral elements (fig. 4.1A) indicate nearshore to littoral (fig.4.2A) conditions of deposition.

In Pakhajan area (well Pakhajan-A) the low salinity water plants (0-18%), mangrove floral elements (4-11%) and marine floral elements (0-10%) are moderately distributed in this member. The fresh water plants (0-15%) and fungal remains are poorly represented. The montane plants are totally absent. The above microfloral ecoassemblage indicate that the Telwa shale Member was deposited in a near shore to littoral environments in Pakhajan area.

In Dahej area (Dahej-A) the microfloral ecoassemblage constitute 14-20% inland plants, 10-13% fresh water plants, 8-35% ferns, 7-12% fungal remains, 7-32% palms, 7-8% low salinity water plants, 7-8% mangrove flora and 4-8% marine microplanktons in the total population. The moderate occurrence of marine and palm floral elements alongwith low salinity water plants indicate littoral to shallow marine conditions during deposition of Telwa shale in Dahej area.

In Palej area (well Palej-A) the microfloral ecoassemblages constitute 0-21% inland plant complex, 0-40% fern flora, 0-4% fungal remains, 0-21% palms, 0-9% low salinity water plants and 0-5% marine phytoplanktons. The montane mangrove and fresh water plants are absent. The moderate occurrence of palm flora alongwith fair representation low salinity water plants and marine floral elements indicate nearshore conditions during deposition of Telwa shale in Palej areas.

In Matar area (well Matar-A) the dominance of low salinity water plants (0-25%), palms (0-25%) along with inland floral elements (0-25%) suggest brackish water conditions of deposition.

In general, the paleoenvironmental conditions in Gandhar and Pakhajan areas varies from near shore to littoral. In Dahej area littoral to shallow marine environment prevailed: whereas in Palej and Matar areas

Nearshore and brackish water conditions prevailed during the deposition of Telwa Shale Member.

8.11.3e Dadhar Formation :

This formation according to (Sudhakar and Basu, 1973), is unconformably underlain by Ankleshwar Formation and Tarkeshwar Formation respectively. Later on Pandey et al (1993) opined that the relationship with the underlying Ankleshwar Formation is generally conformable. In well Gandhar-A this formation is encountered between (2212-2573 m) and from (3210-3445 m), (2200-2485 m) (1645-1697 m) and (1331-1396 m) respectively in wells Pakhajan-A, Dahej-A Palej-A and Matar-A. It mainly comprises of alternations of coarse to medium grained friable sandstones and moderately hard dark grey shales.

In Gandhar area (Well Gandhar-A) the microfloral ecoassemblages comprises (0-16%) montane plants, (5-55%) inland plants, (0-27%) fresh water plants, (9-67%) ferns, (0-16%) fungal remains, (0-33%) palms, (0-25%) low salinity water plants, (0-15%) mangrove flora and (0-25%) marine phytoplanktons of the total population. The dominance of inland flora and ferns along with moderate occurrence of low salinity water plants, mangrove flora and marine microplanktons indicate that brackish water to shallow marine conditions prevailed during deposition of sediments of Dadhar Formation in Gandhar area (Fig. 4.1A).

In Pakhajan area the inland plants (9-40%) ferns (22-63%) and palms (0-30%) are dominated in the total microfloral ecoassemblage. The other microfloral ecoassemblages constitutes (0-26%) marine microplanktons, (0-12%) mangrove plants, 0-16% low salinity water plants, (0-16%) fungal remains, (0-15%) fresh water plants and (0-7%) montane plants of the total population. The dominance of inland flora and ferns alongwith moderate occurrence of marin phytoplanktons suggest that the sediments of Dadhar Formation

were deposited in a littoral to shallow marine conditions in Pakhajan area (fig. 4.5B).

The ferns (12-58%) and palm floral continue to dominate in Dahej area (well Dahej-A). The other microfloral ecoassemblage constitute 0-22% marine phytoplankton, 0-14% mangrove flora, 0-15% low salinity water plants, 0-20% fungal remains 2-15% , fresh water plants, 0-24% inland plants, and 0-7% montane plants of the total population. The dominance of ferns alongwith moderately distributed marine phytoplanktons, mangrove flora and low salinity water plants suggest that the sediments of Dadhar Formation were deposited under shallow marine to near shore environments in Dahej area (well Dahej-A, fig. 4.6A).

The fresh water plants (33-60%) dominate the total population of Dadhar Formation in Palej area compared to Gandhar and Pakhajan areas. The other microfloral ecoassemblages such as montane plants (0-6%), inland plants (-519%), ferns (0-8%), fungal remains (0-6%) and palm flora (12-19%) are slightly decreased in this area compared to Gandhar, Pakhajan and Dahej area. The low salinity water plants are absent in this area. The dominance of fresh water plants along with fairly distributed marine flora, mangrove flora and palm flora suggest the nearshore conditions of deposition in Palej area.

In Matar area (well Matar-A) the marine phytoplankton, mangrove flora and montone plants are totally absent, while inland flora (20 - 50%) and ferns (29-44%) dominate the floral population. The other associated microfloral ecoassemblages constitutes 0-20% low salinity water plants, 14-29% palms, 0-13% fungal remains and 0-14% fresh water plants of the total population. The absence of marine phytoplanktons and dominance of inland flora and ferns indicate brackish water to coastal conditions prevailing during deposition of Dadhar Formation. (fig. 4.8).

The microfloral ecoassemblage evidences suggest that the Dadhar Forma- was deposited under near shore to shallow marine conditions in Gandhar area, littoral to shallow marine in Pakhajan area, shallow marine to near shore conditiosn in Dahej area, near shore conditions in Palej area and brackish water to coastal conditions in Matar area.

The analysis of different plant complexes also indicate that the main vegetation which contributed the flora grew in the proximity of shore line in tropical climate, some vegetation grew further inland in fresh water swamps and low land areas on flat topograhy.

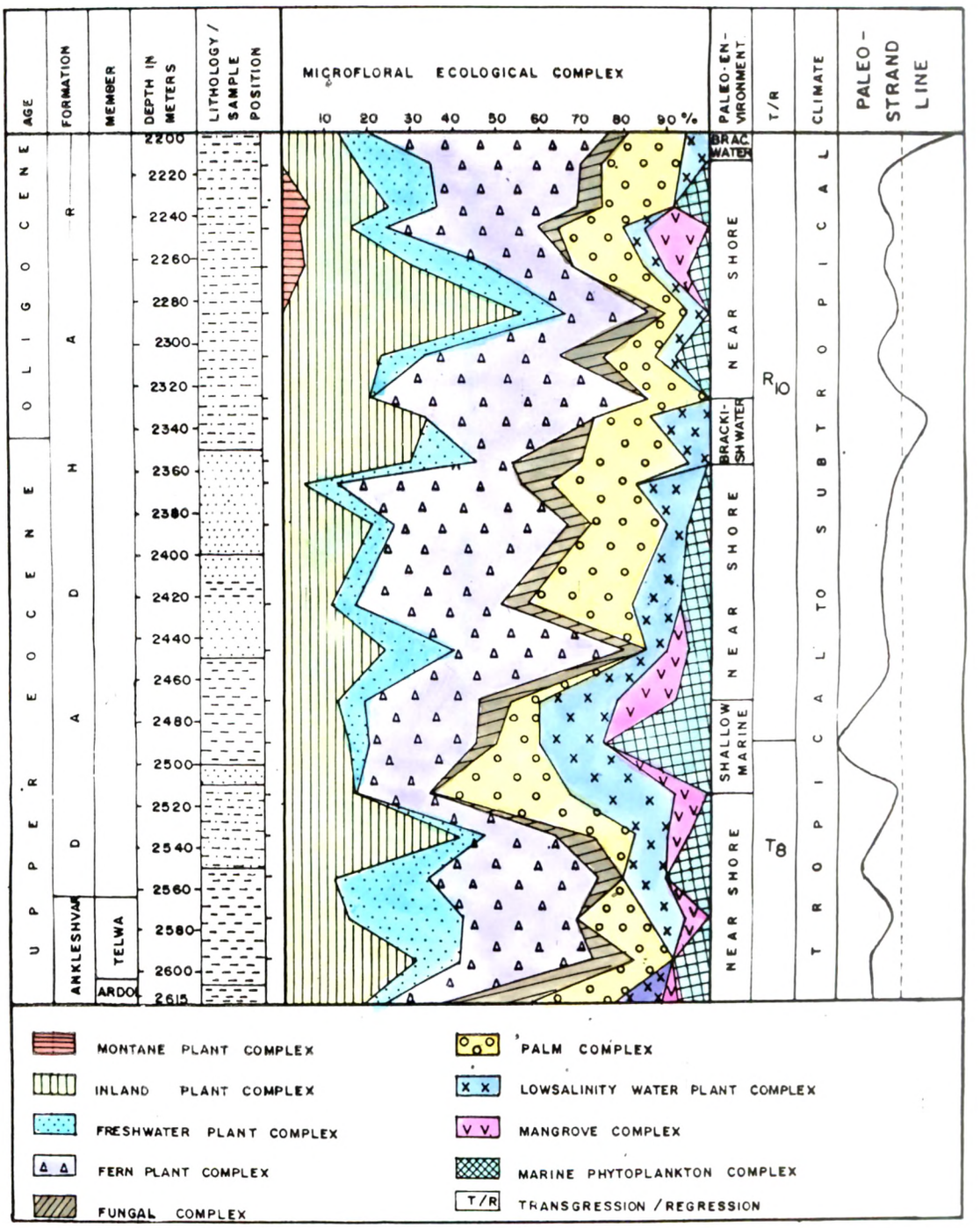

FIG 4·1A. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL GANDHAR-A

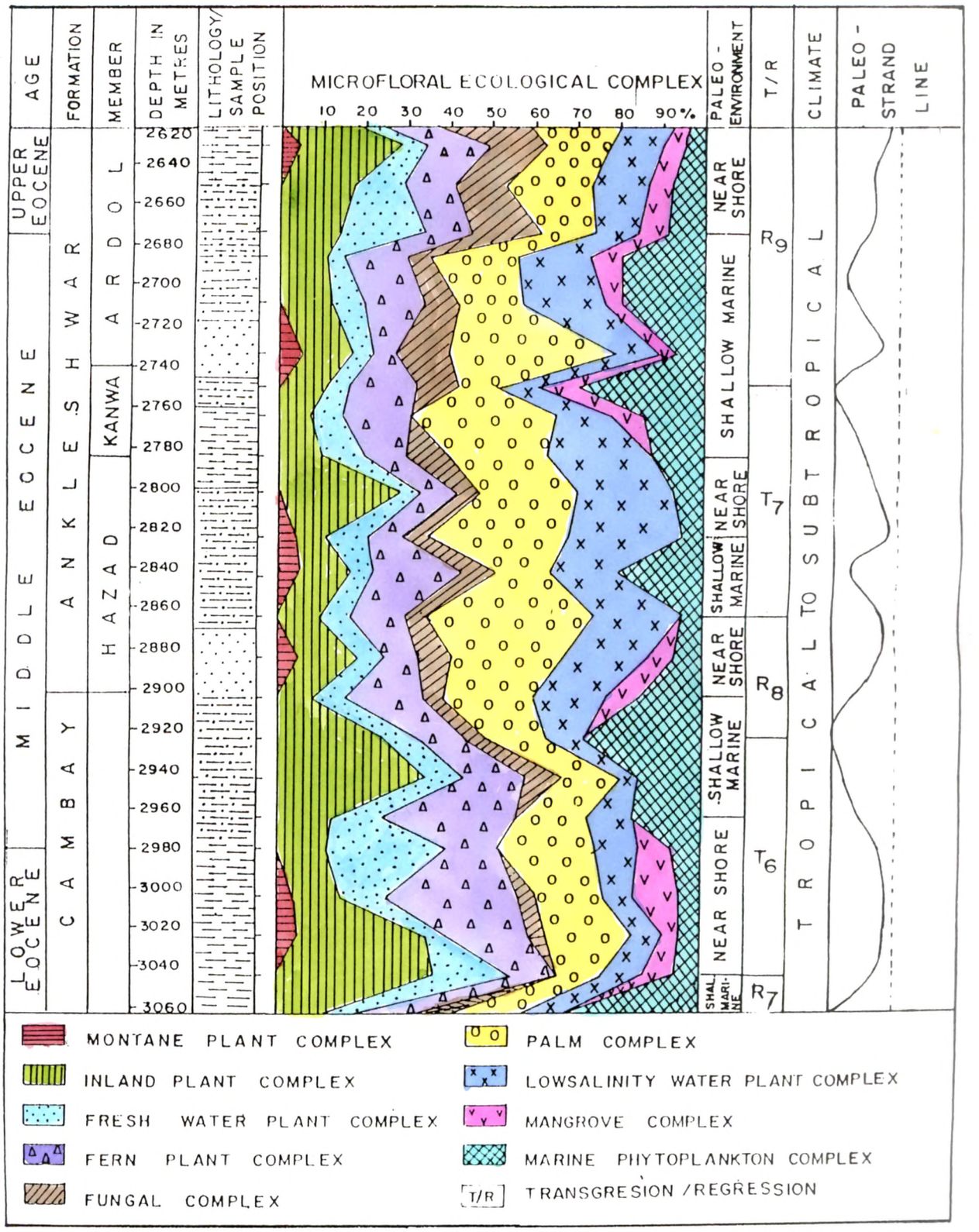

FIG-4·IB. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL GANDHAR-A

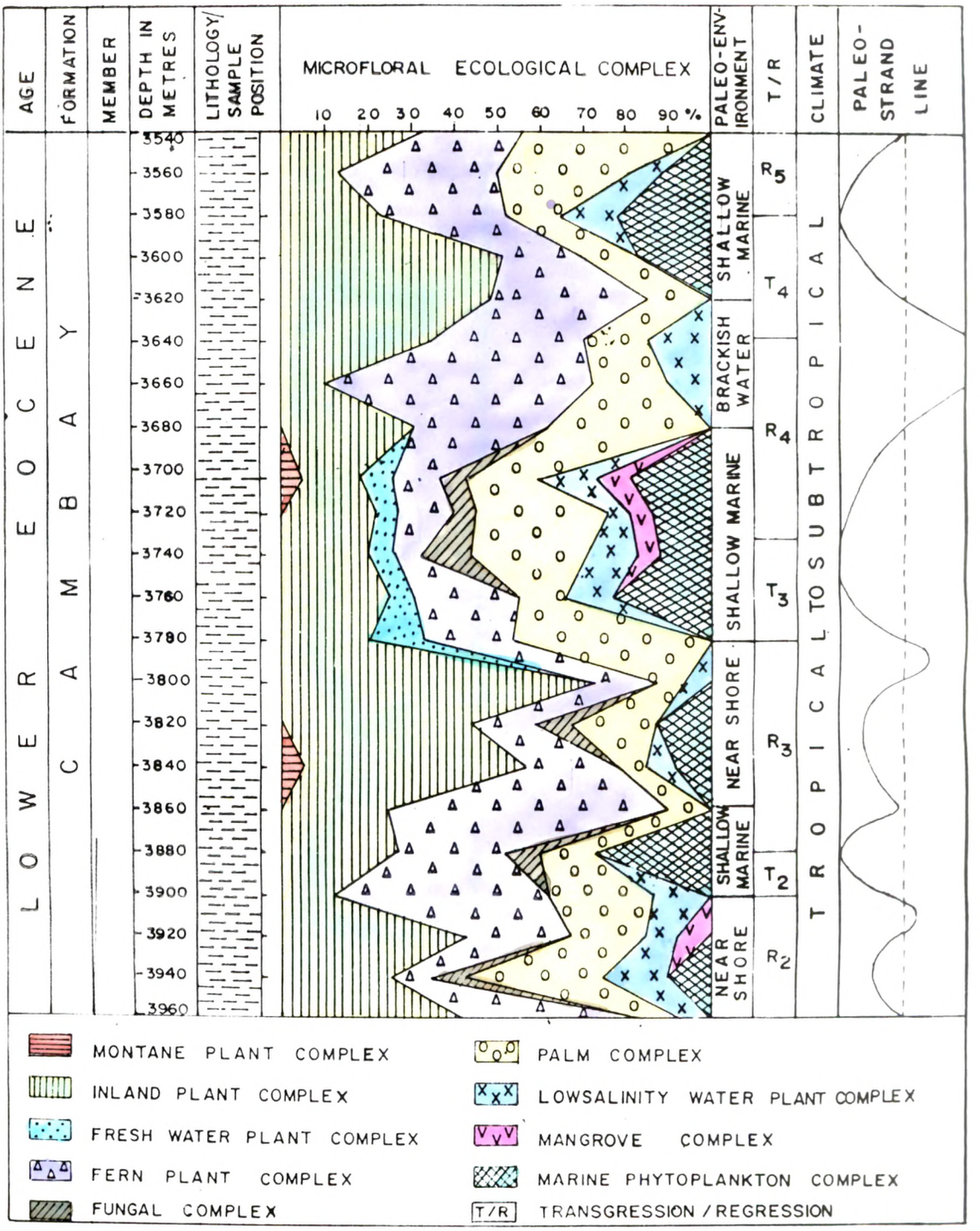

FIG-4·IC PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL GANDHAR-A

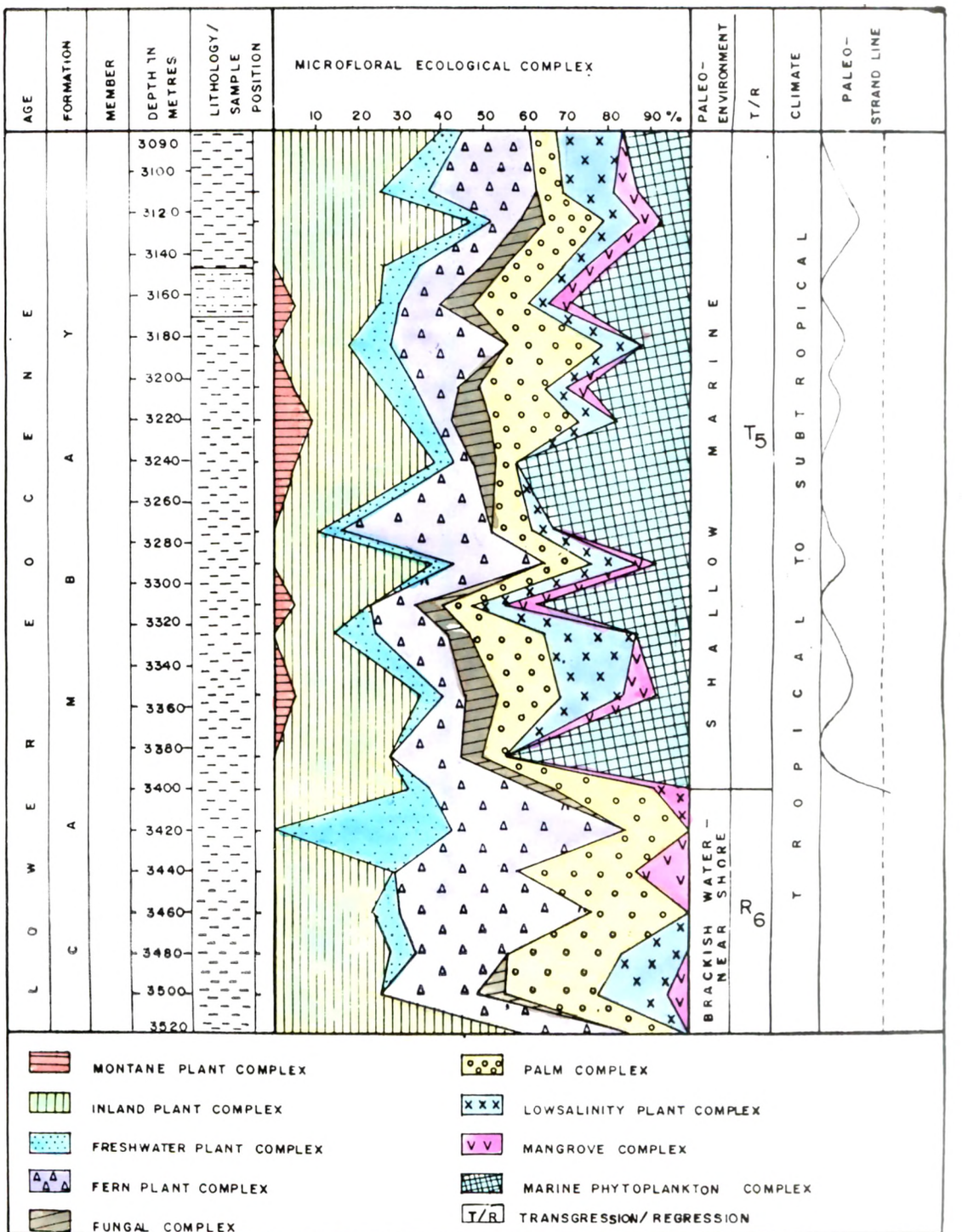

FIG-4 ID. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL GANDHAR-A

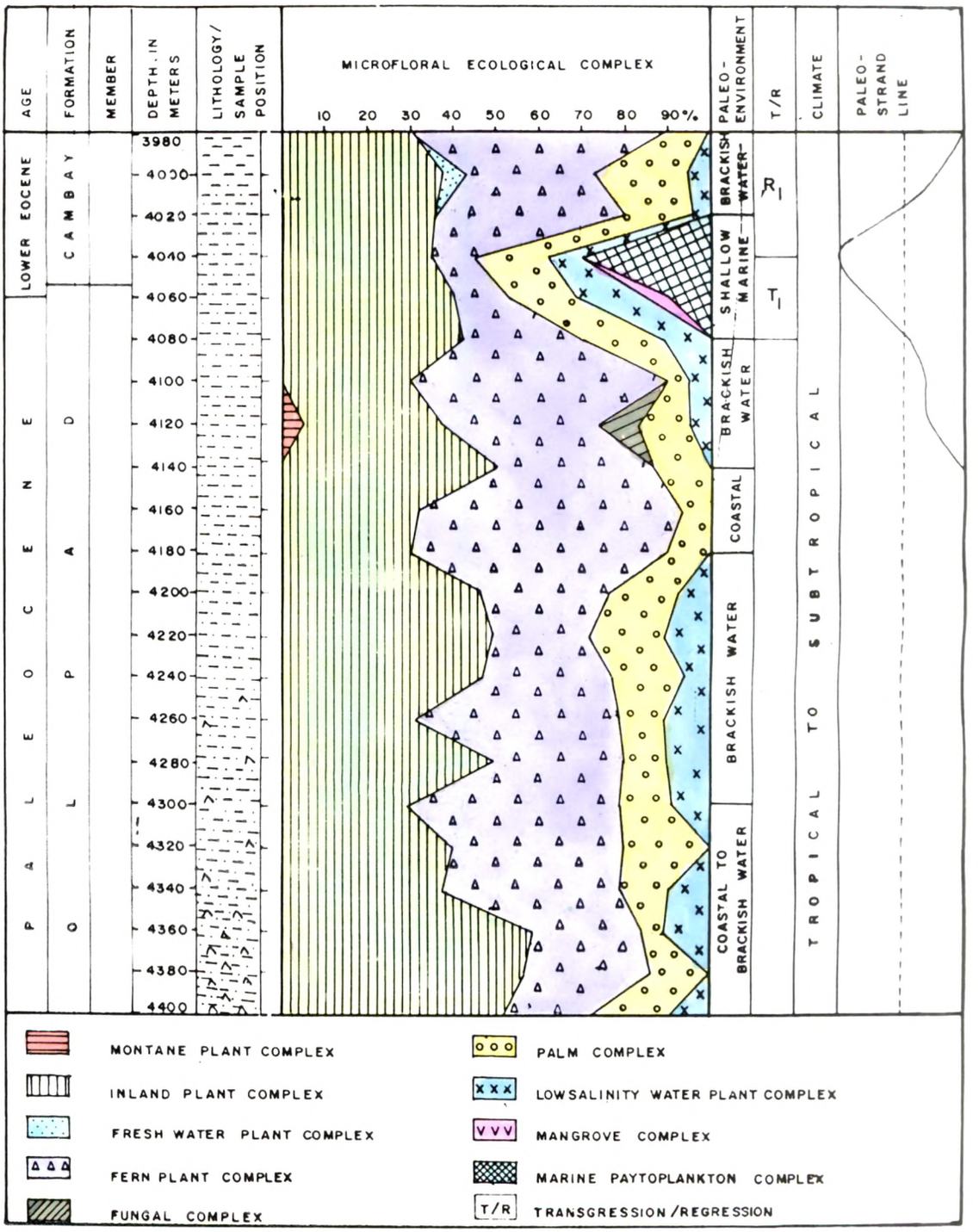

FIG-4 E. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECOASSEMBLAGES IN WELL GANDHAR-A

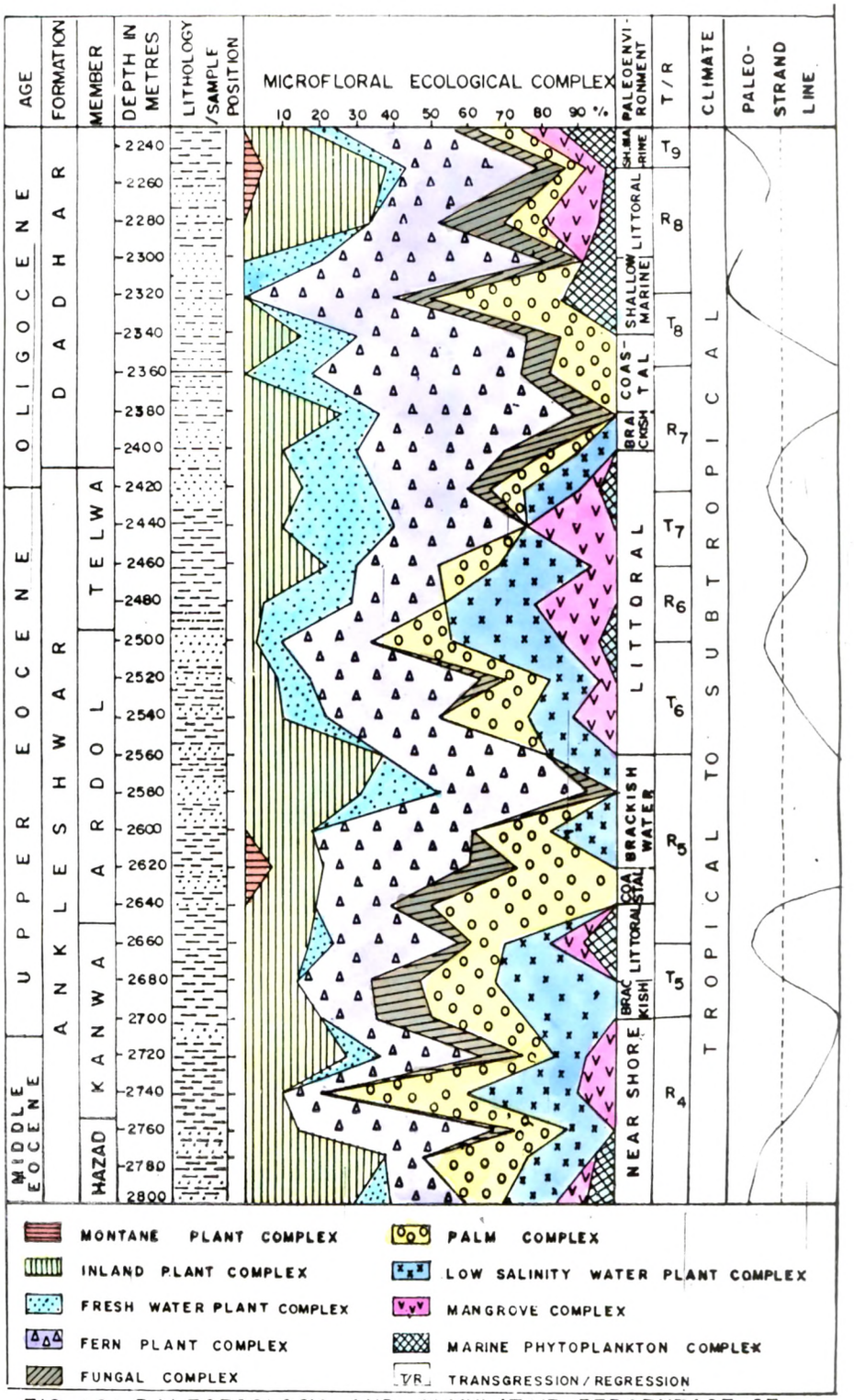

FIG-4·2A PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL GANDHAR-B

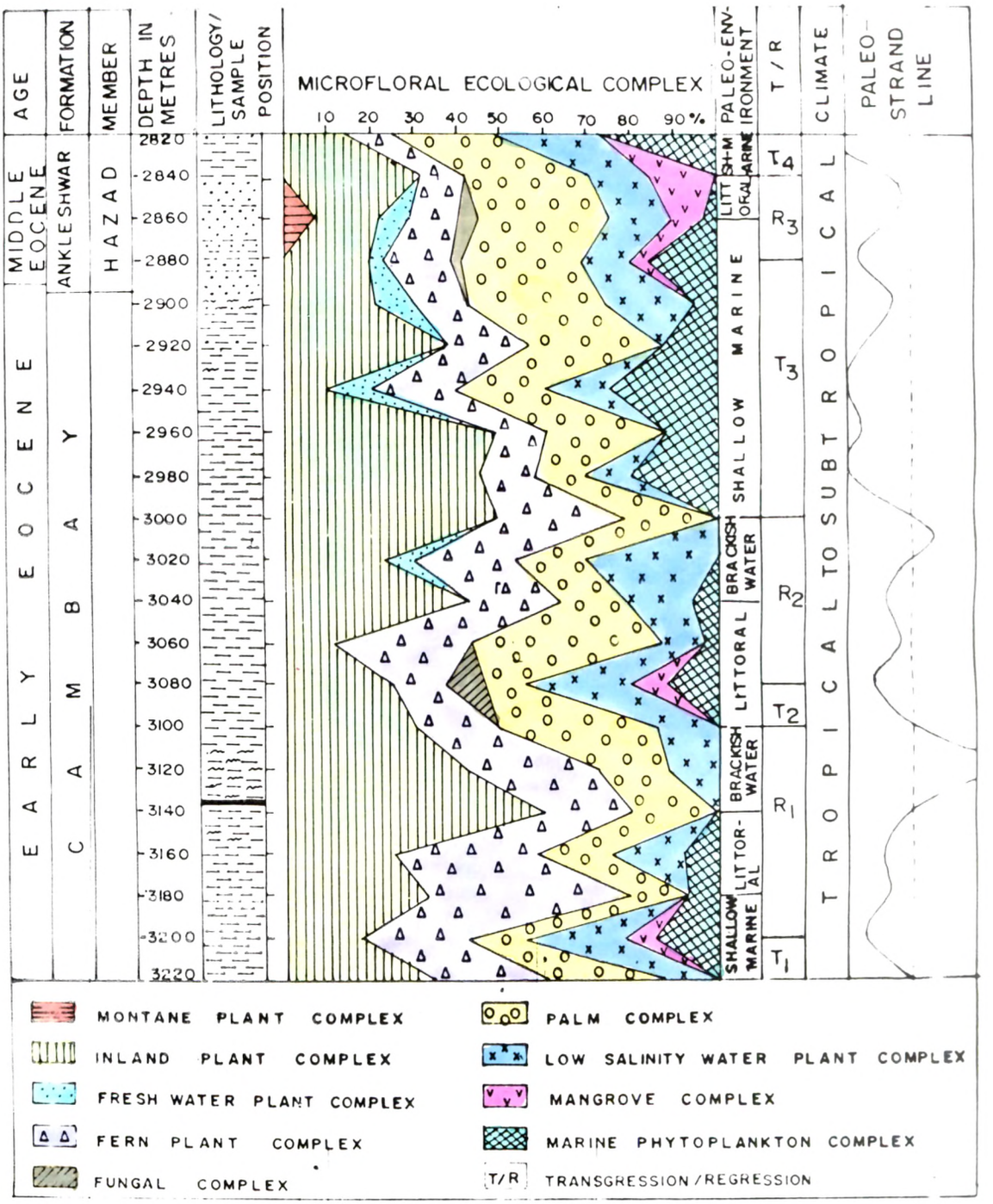

FIG. 4.2B. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO ASSEMBLAGES IN WELL GANDHAR-B

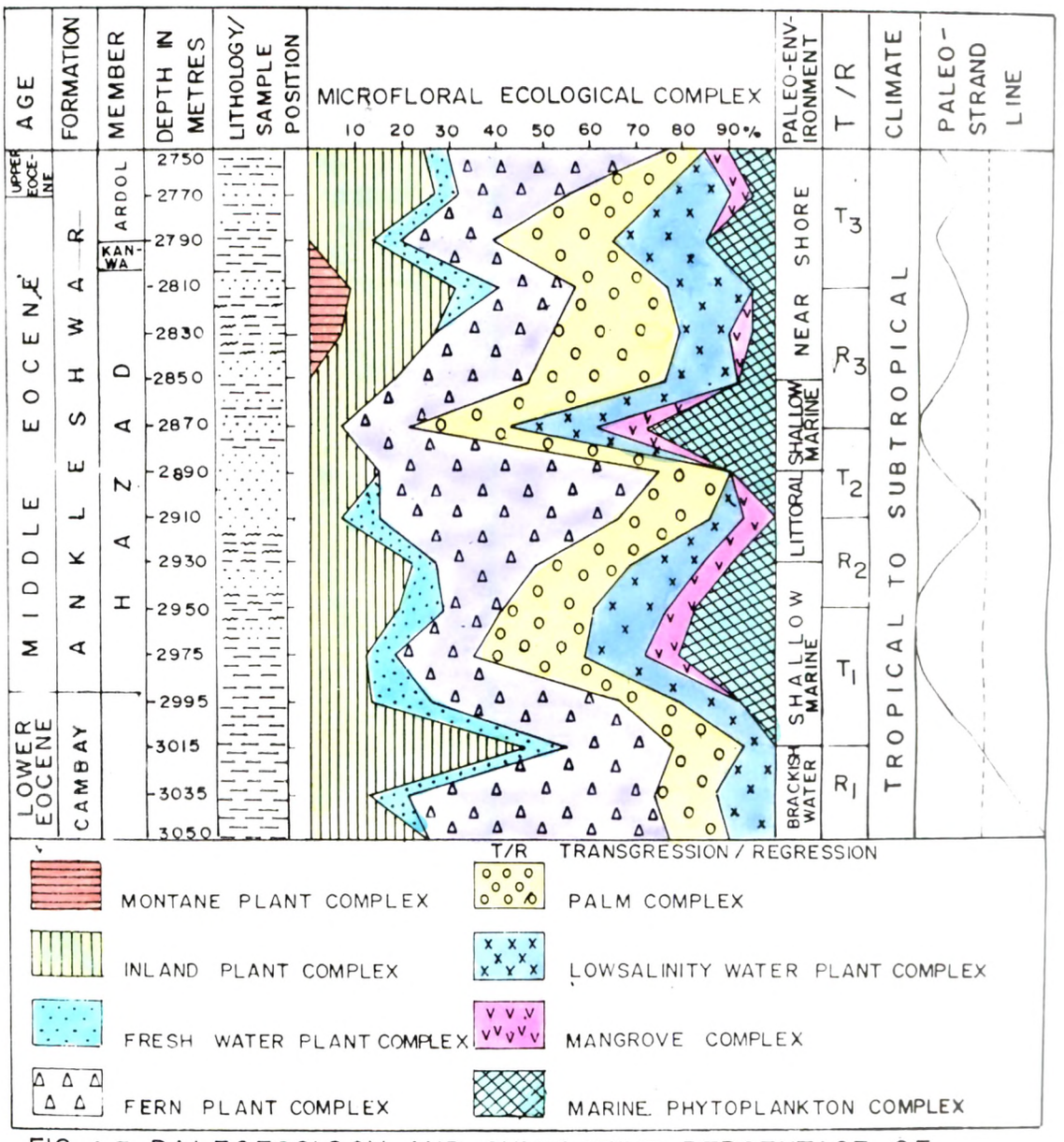

FIG-4·3. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL GANDHAR-C

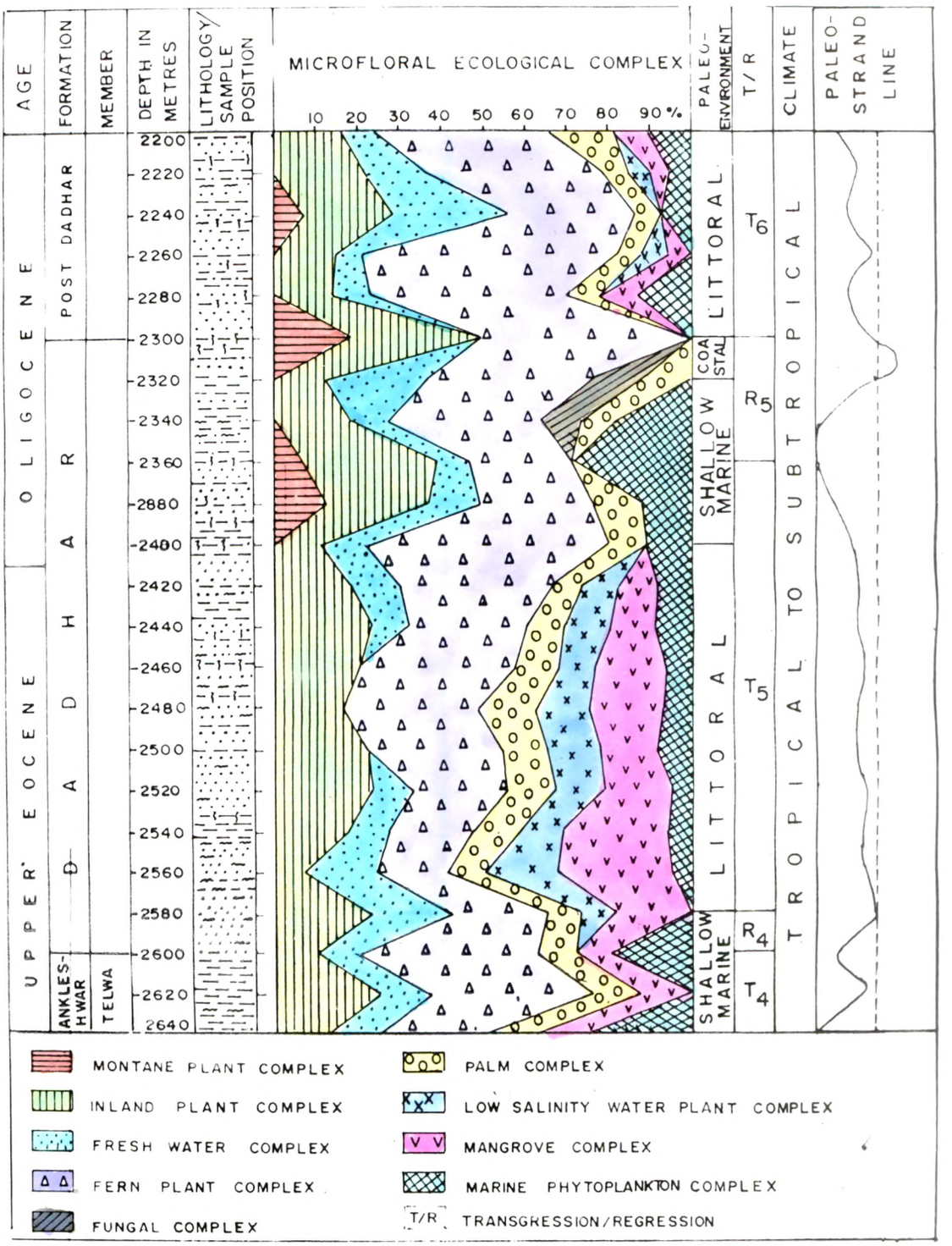

FIG-4·4A. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL GANDHAR-D

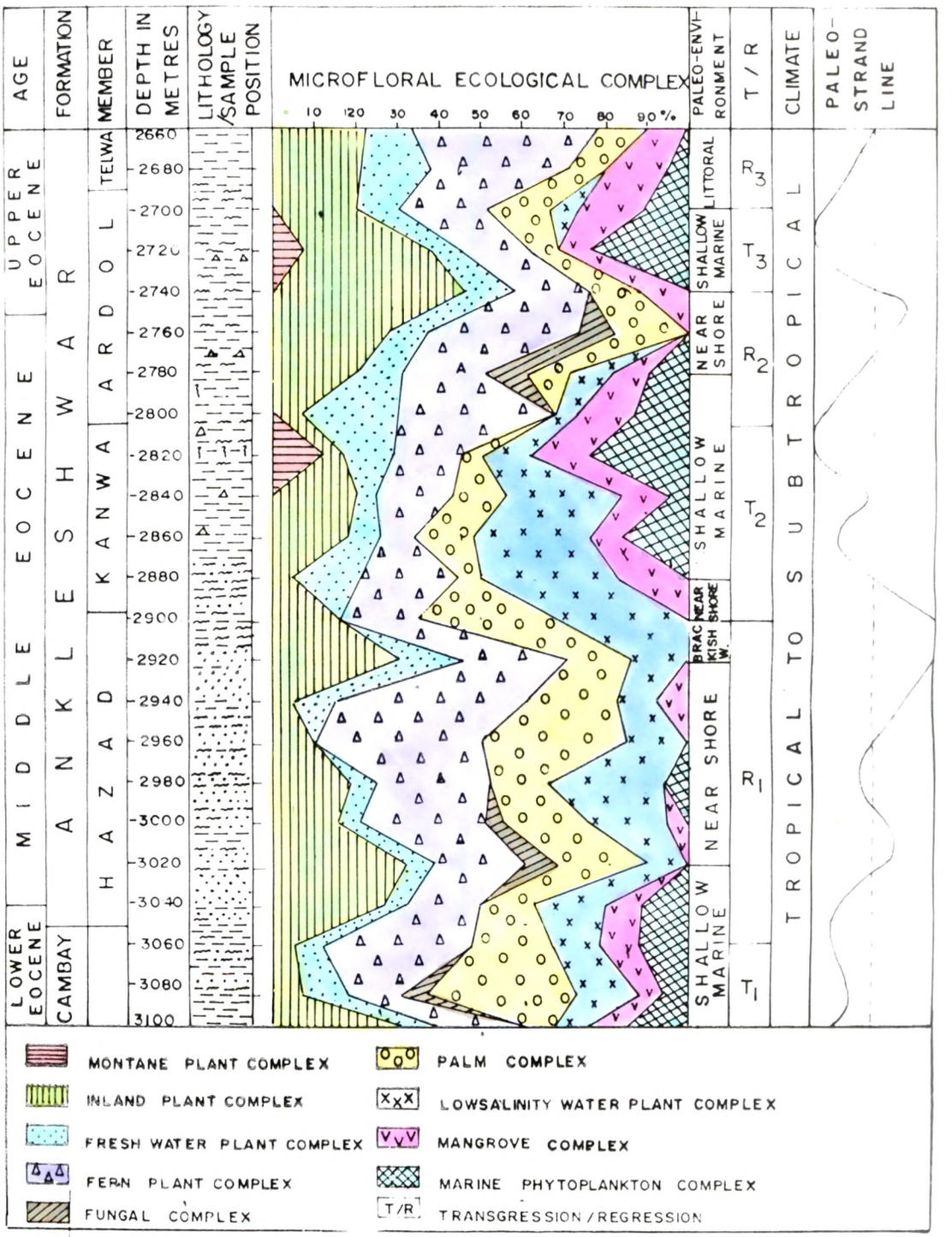

FIG-4·4B. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN GANDHAR-D

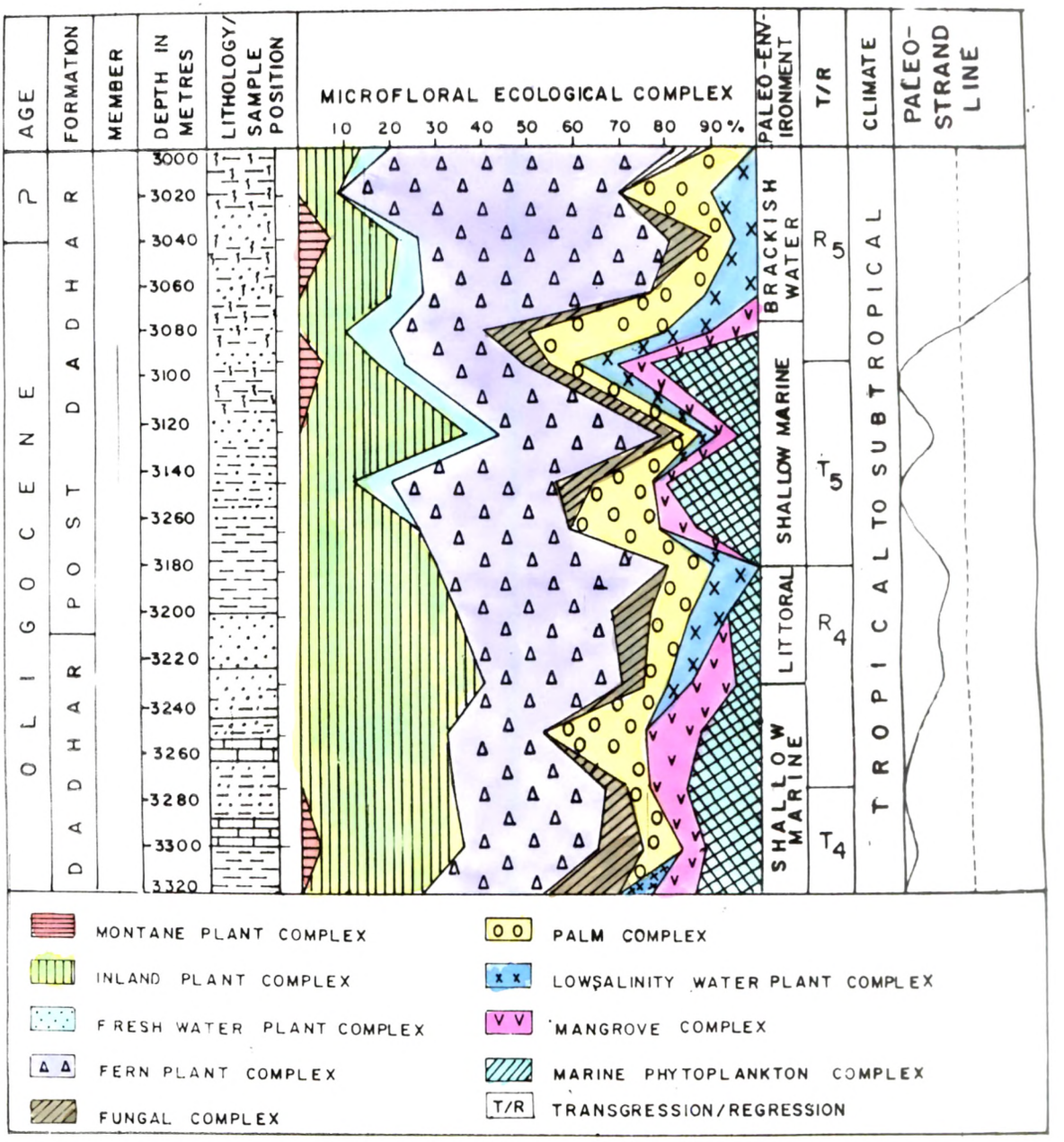

FIG - 4.5A PALEOLCOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL PAKHAJAN-A

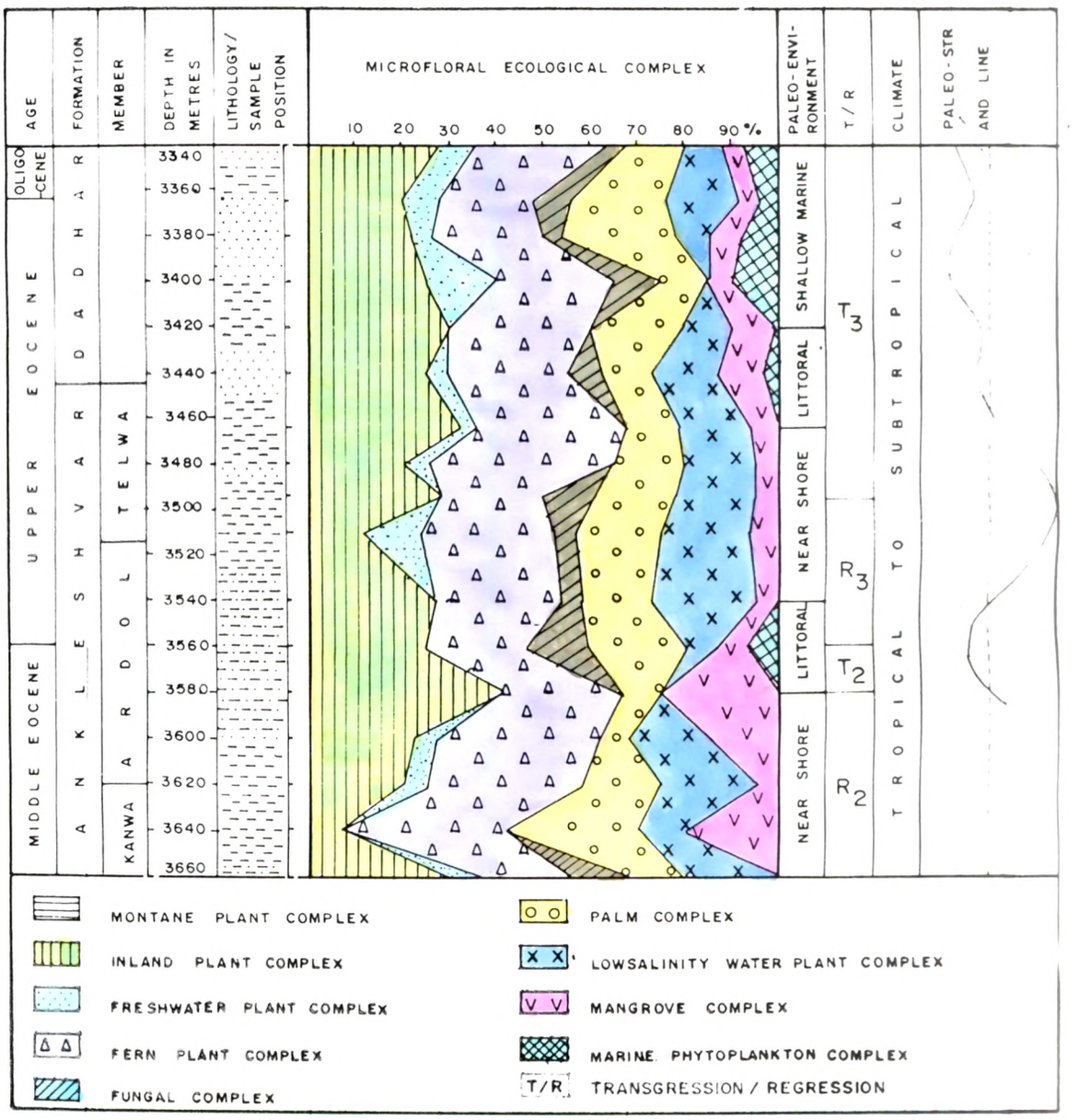

FIG 45B. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL PAKHAJAN-A

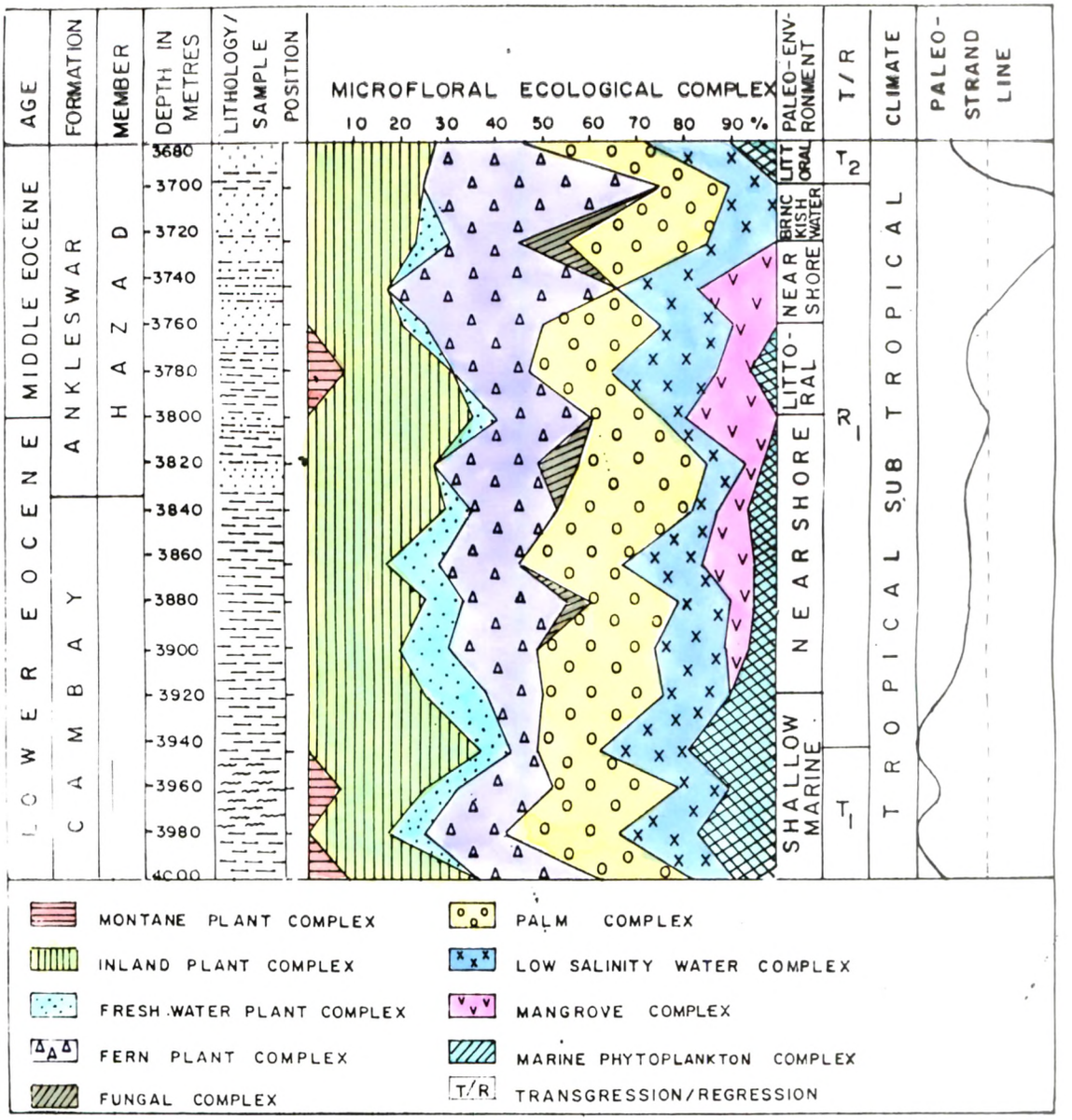

FIG - 4·5C. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL PAKHAJAN - A

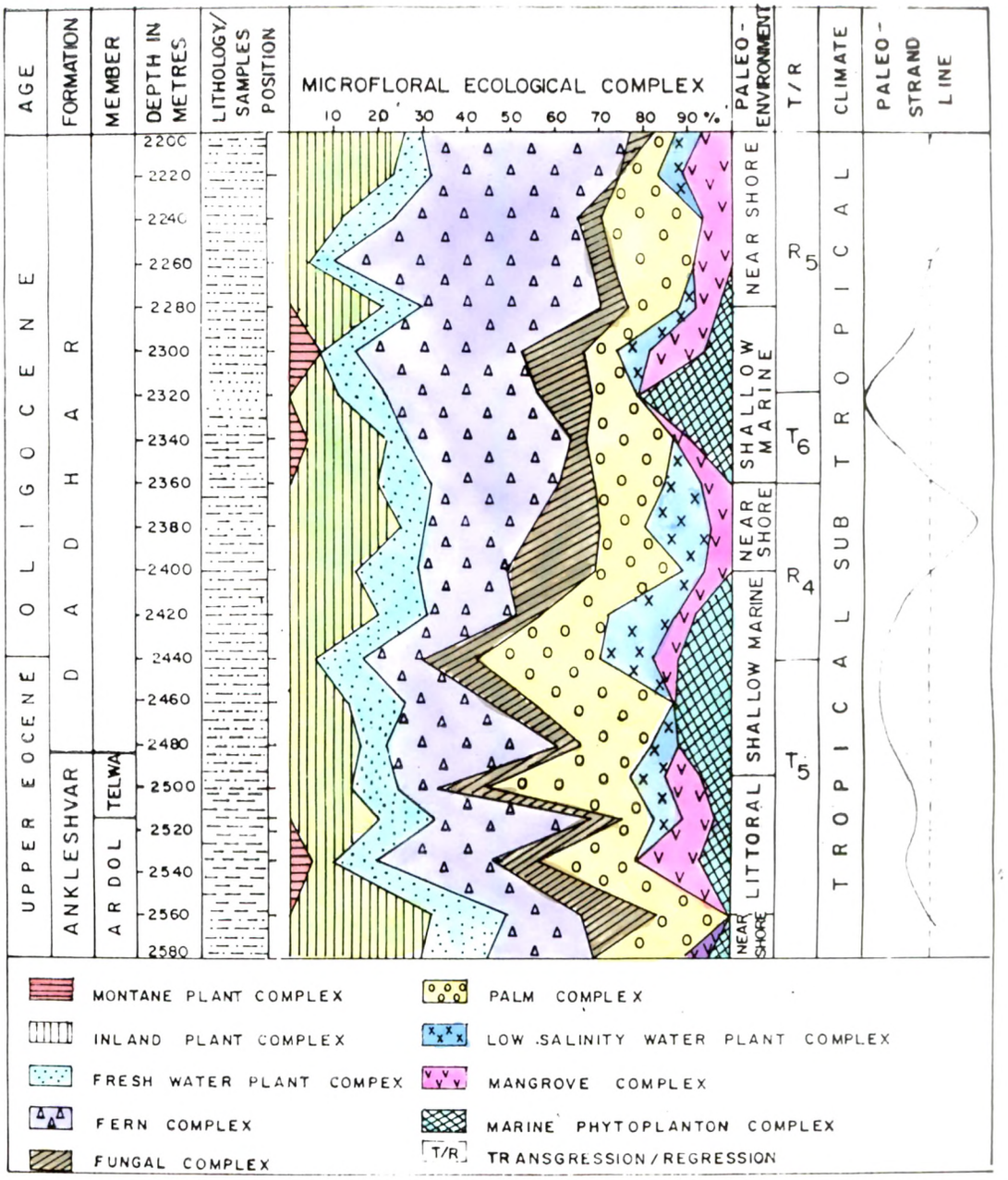

FIG-4·6A. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL DAHEJ-A

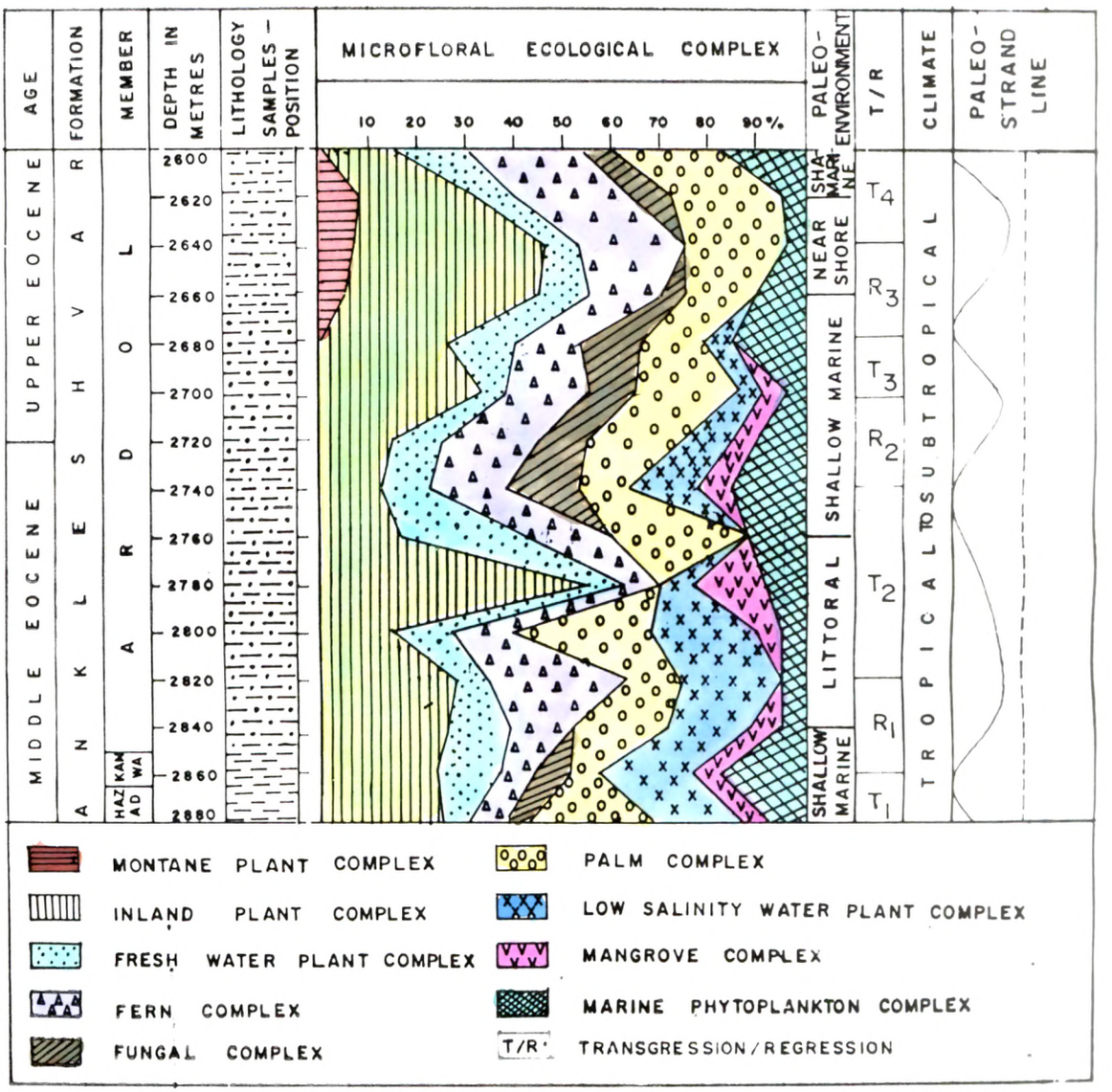

FIG. 4·68-PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL DAHEJ-A

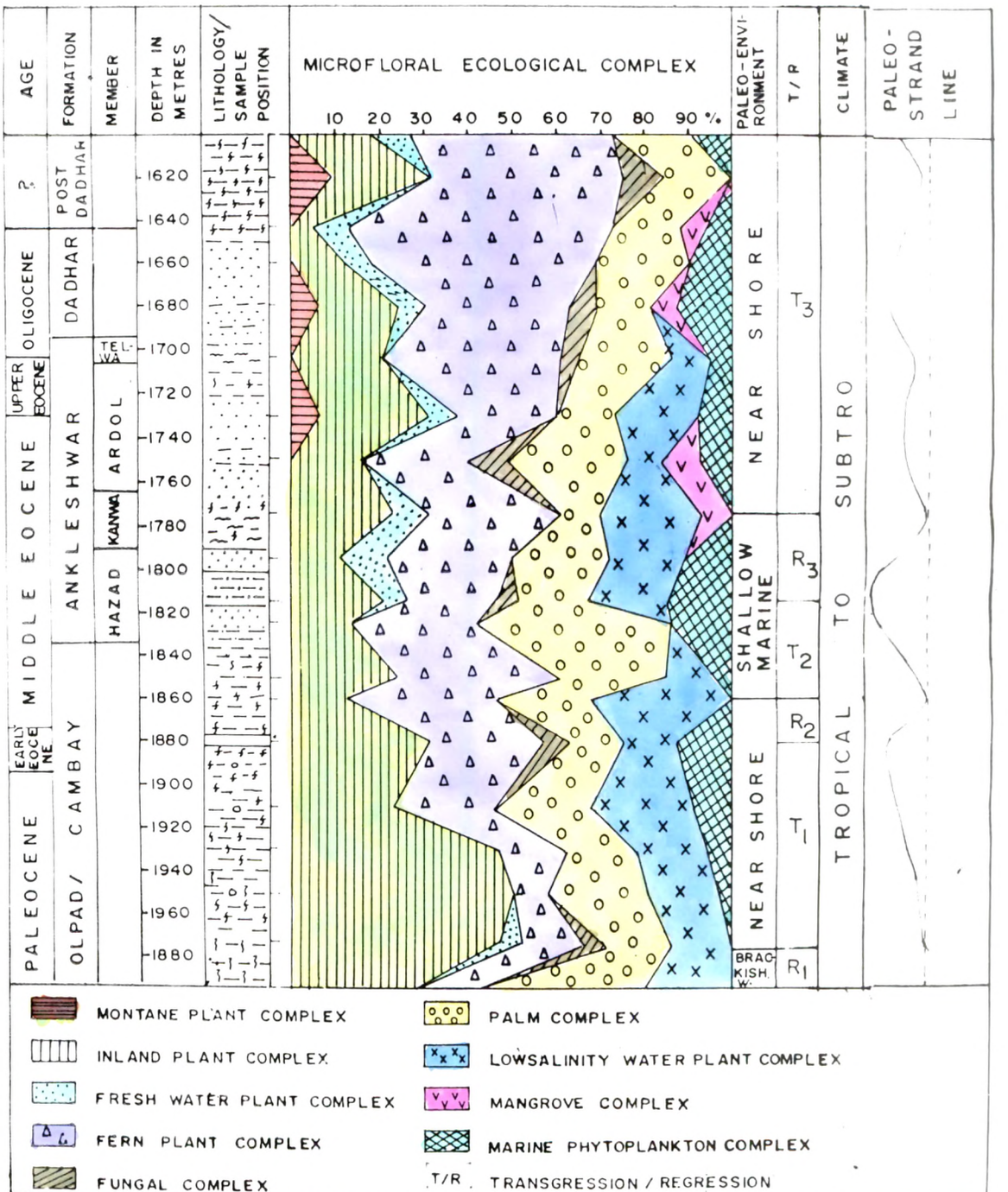

FIG -4.7. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL PALEJ-A

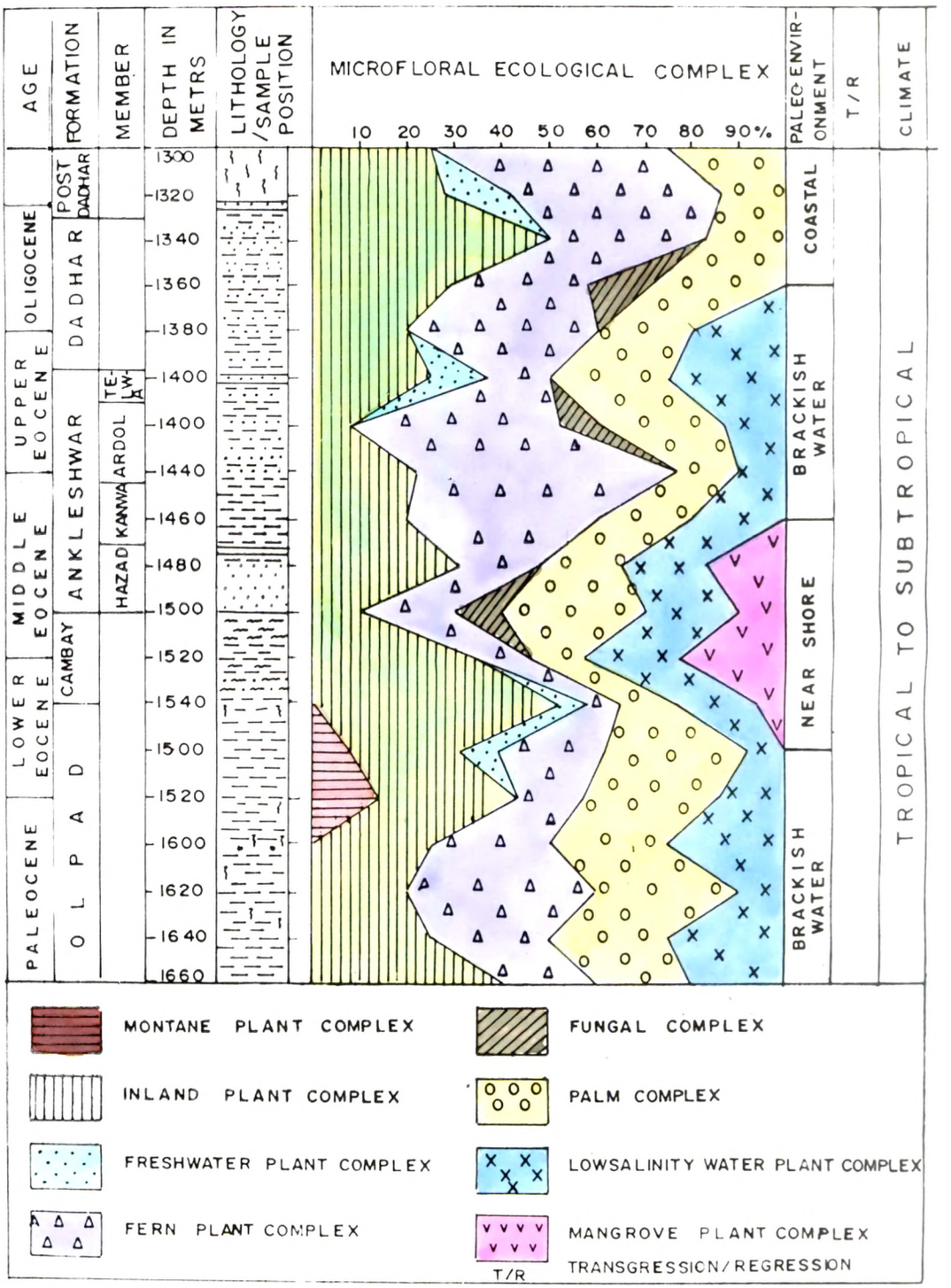

FIG-4.8. PALEOECOLOGY AND CUMULATIVE PERCENTAGE OF MICROFLORAL ECO-ASSEMBLAGES IN WELL MATAR-A

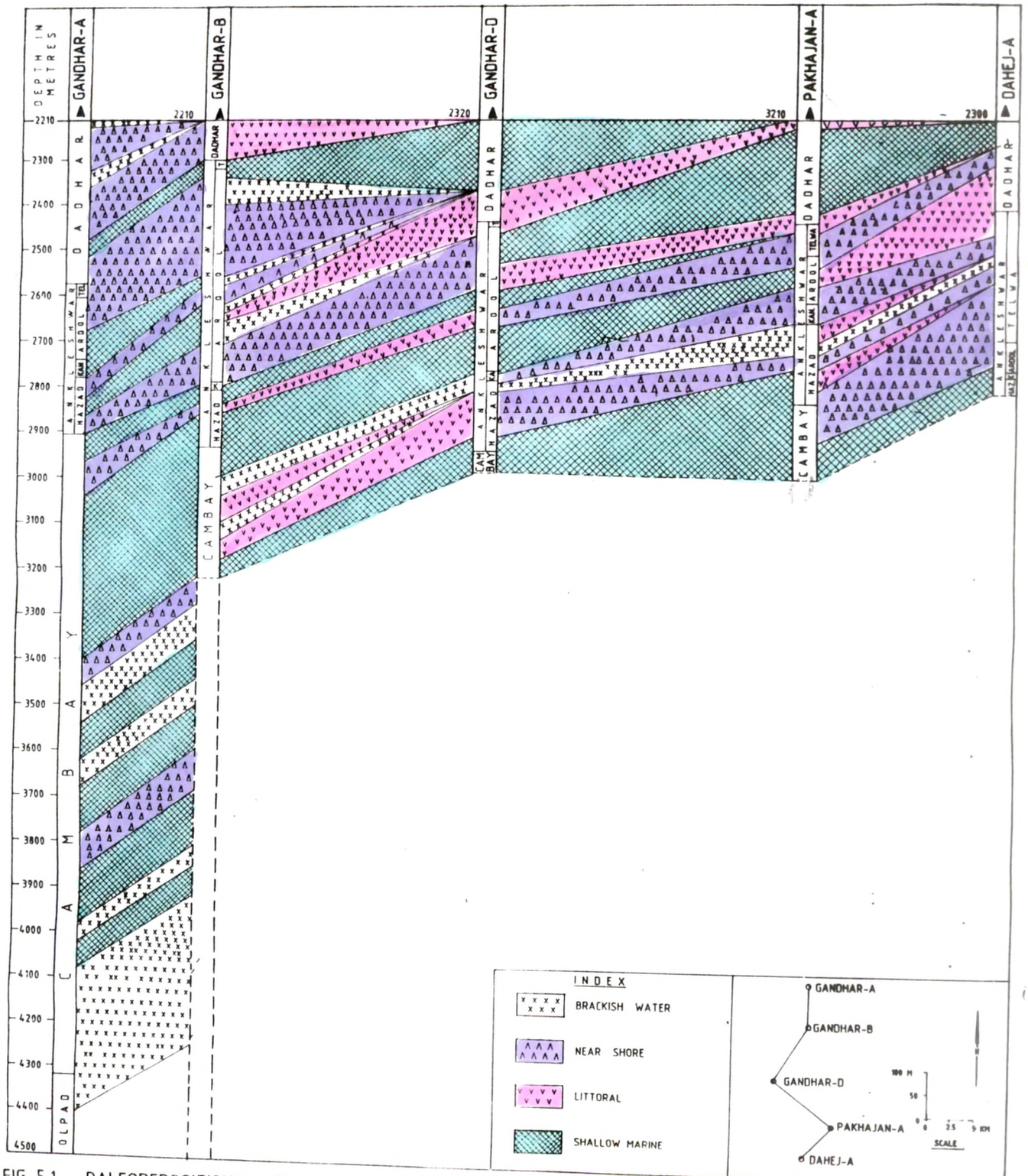

FIG. 5.1 PALEODEPOSITIONAL ENVIRONMENT OF PALEOGENE SEQUENCE IN GANDHAR - PAKHAJAN - DAHEJ AREA BROACH DEPRESSION, SOUTH CAMBAY BASIN

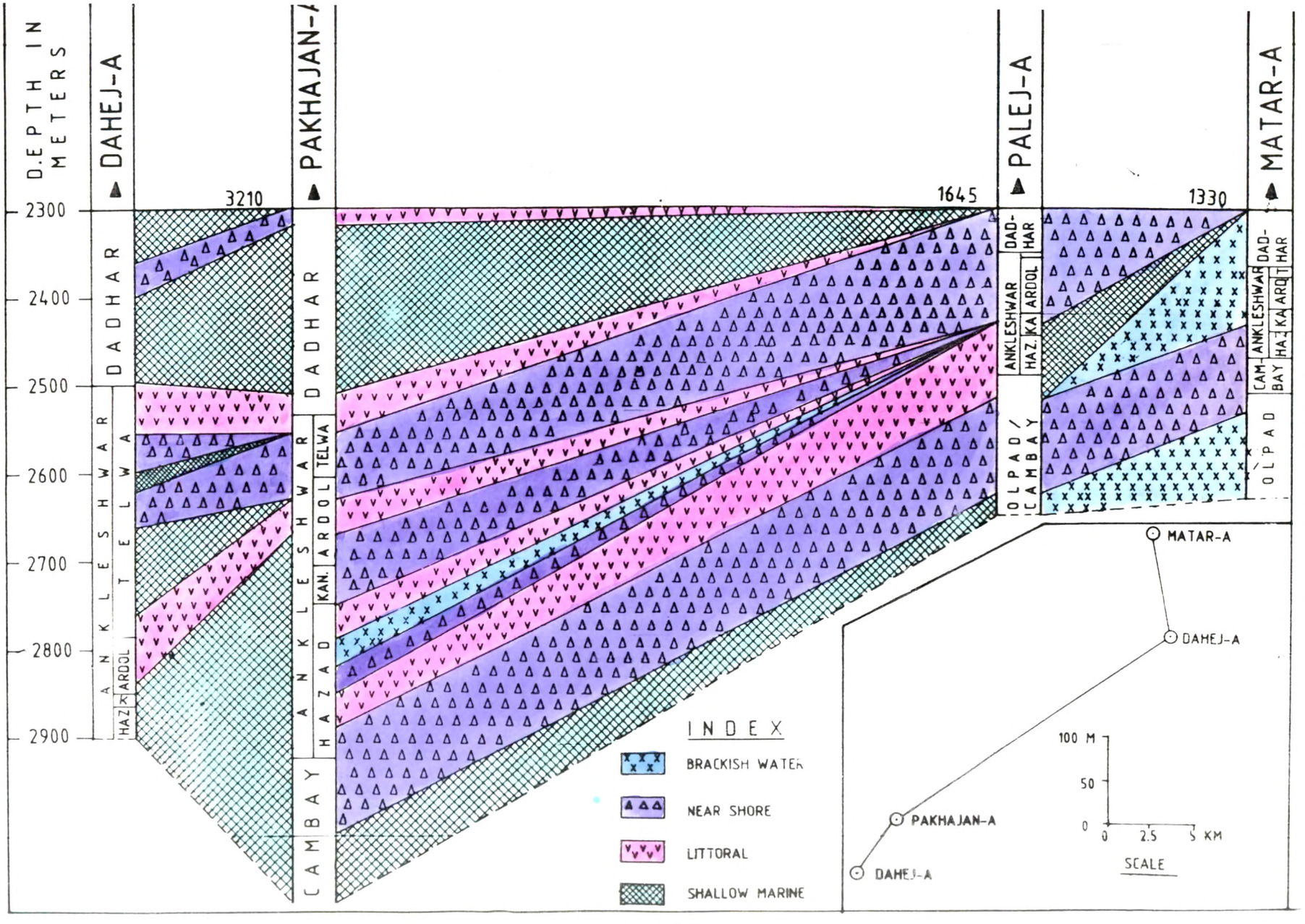

FIG. 5.2 PALEODEPOSITIONAL ENVIRONMENT OF PALEOGENE SEQUENCE IN DAHEJ - PAKHAJAN - PALEJ - MATAR AREA, BROACH DEPRESSION SOUTH CAMBAY BASIN

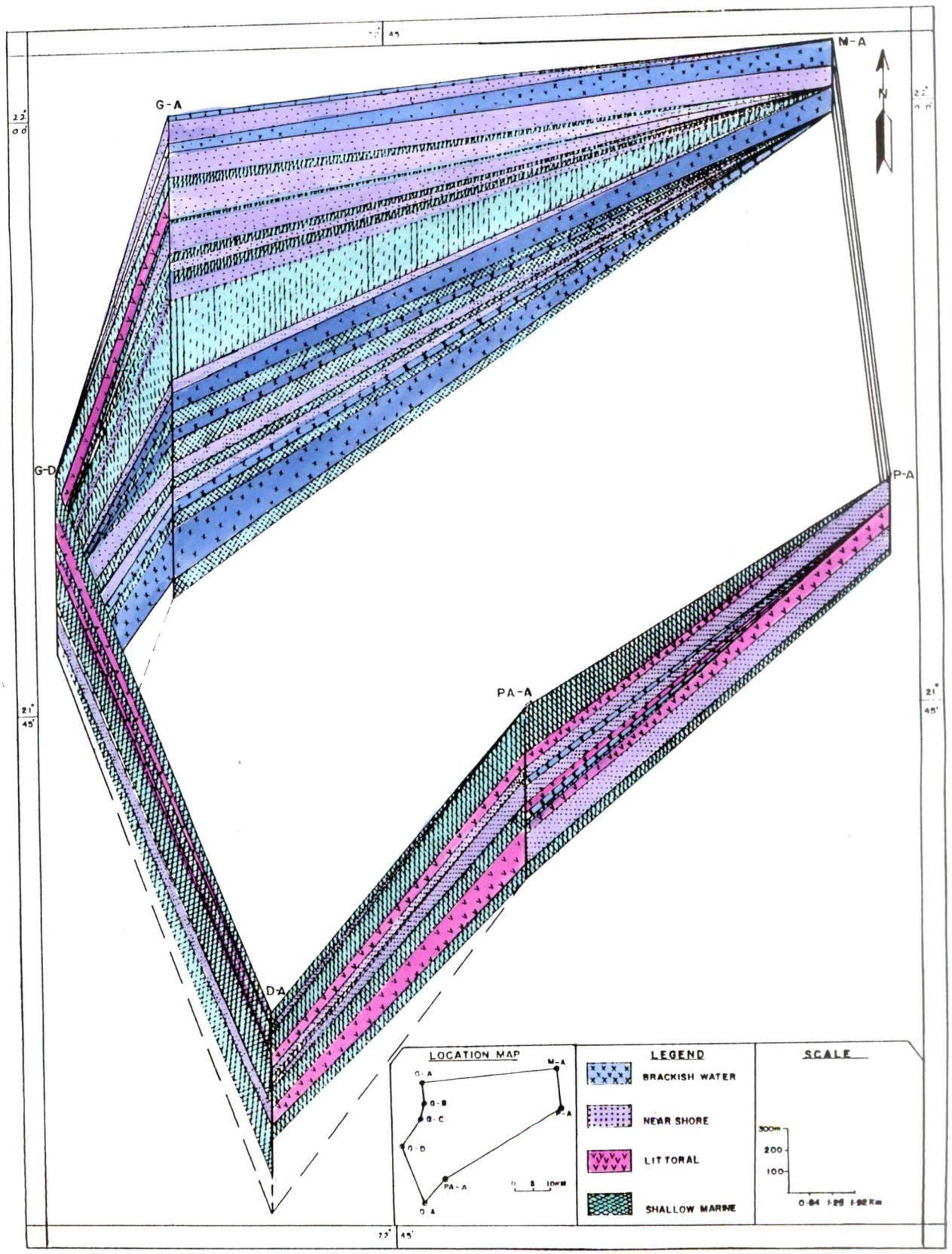

FIG-7 PANEL DIAGRAM SHOWING LATERAL VARIATION IN FLORAL ECOLOGICAL COMPLEX IN THE BROCH DEPRESSION, SOUTH CAMBAY BASIN DURING THE DEPOSITION OF PALEOGENE SEDIMENTS

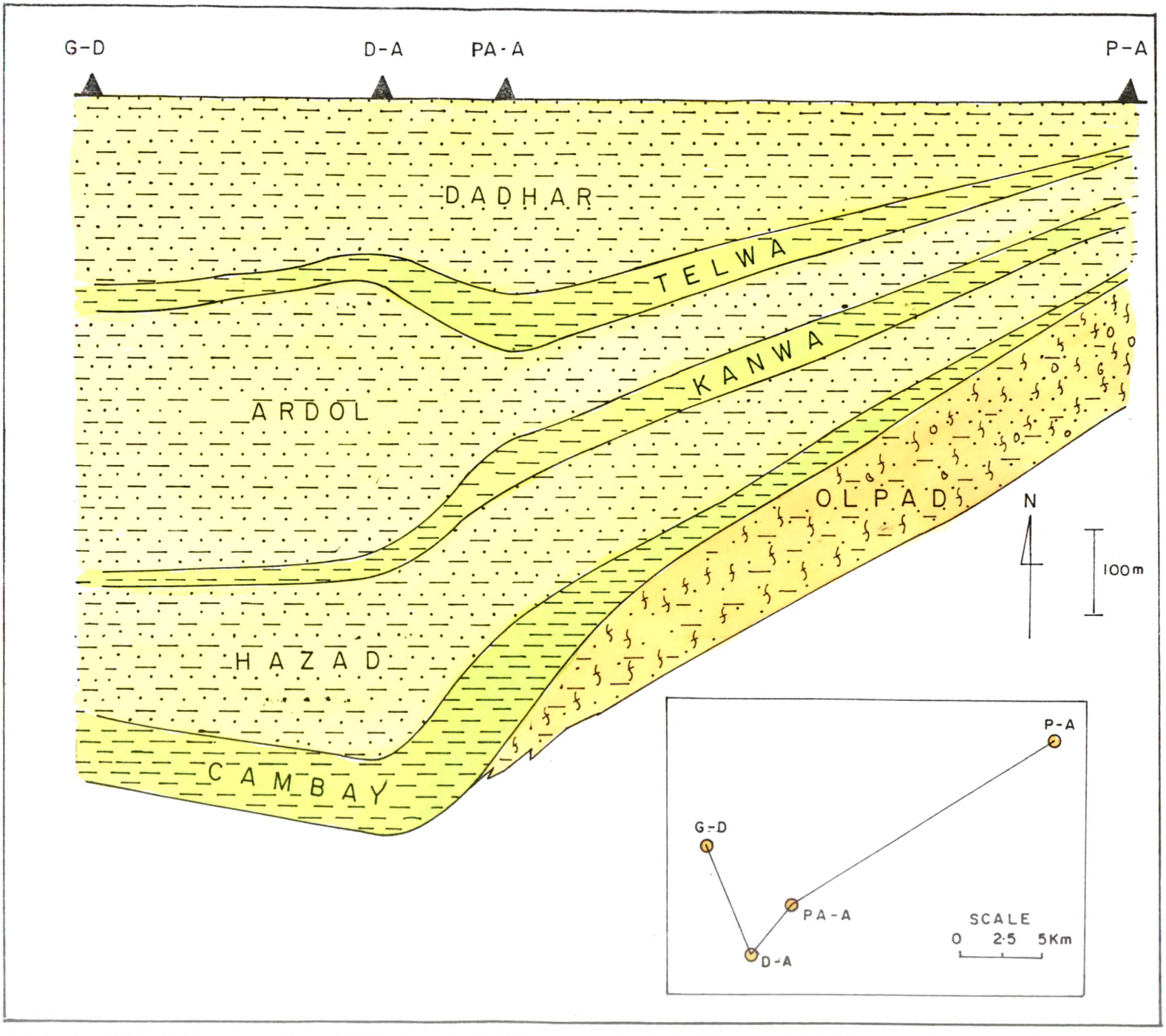

FIG-8 VERTICAL AND LATERAL VARIATION IN PALEOGENE SEDIMENTS IN BROACH DEPRESSION