PALYNOLOGY OF THE SUBSURFACE SEDIMENTS OF MANHERA TIBBA STRUCTURE, JAISALMER, WESTERN RAJASTHAN, INDIA*

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ABSTRACT

Palynological studies on the sub-surface sediments namely the Shumar, Kirthar, Laki, Ranikot, Parh and Goru sediments from the Manhera Tibba Jaisalmer district, Rajasthan, have been carried out. The sporomorphs recorded in the sediments have been listed according to the successive rock units and the age and environment of the sediments have been discussed. The results are based on the data obtained from the study of 370 samples.

The study indicates that the Tertiary and the Mesozoic sediments were deposited mainly in shelf zone environment and there has been repeated transgression and regression of the sea. The data further tend to suggest a warm, humid climate and a luxuriant flora during the deposition of Goru sediment (Albian-Cenomanian), changed to a semi-humid to semi-arid climate during the deposition of Parh (Upper Cretaceous) is subsequently changed over to an arid climate with considerably poor vegetation during the deposition of Tertiary (Ranikot, Laki, Kirthar) sediments (Paleocene-Middle Eocene) had changed over to desert conditions during the deposition of Shumar formation.

INTRODUCTION

THE Manhera Tibba structure is located north west of Jaisalmer town. A number of wells have been drilled by Oil & Natural Gas Commission on this structure. Palynological studies on sub-surface samples from the wells namely Manhera Tibba well No. 3 & 4 have been carried out and the data obtained from the various rock formations are presented here. The various rock units encountered in the Manhera Tibba structure in general from top are, Shumar, Kirthar, Laki, Ranikot, Parh and Goru formations. Palaeontologically the Goru and Parh formations are dated as Aptian to Coniacian in age; the Ranikot, Laki, and Kirthar is Paleocene to Middle Eocene (Lutetian) in age, while the age of Shumar formation is unknown due to absence of reliable microfossils. Dasgupta *et al.* (1958) on field evidence consider the the Shumar sediments as sub-recent deposits. The subsurface stratigraphy of Manhera Tibba in general be summarized as in Table-1. The data and interpretations are based on the results obtained from 370 samples studied from the two wells.

1. Shumar Formation

This is a sand, limestone, shale unit differentiated into four members from top to bottom namely, α, β, γ, δ members. The α member is mainly buff to brown eolian sand at the top followed by an intercalation of clay with medium to fine grained sandstone. The β member is characterized by dirty white, yellowish limestone bands with buff sandstone. Reworked foraminifera are observed in α and β members. The γ member is medium to coarse grained gravel sandstone, and sticky veriegated clay at the base. The δ member is characterised by alternations of medium grained to gravelly sands with bands of variegated clays with glauconitic clay at the base. Reworked microfauna have been observed in γ and δ members.

Palynologically, the sediments are found practically devoid of sporomorphs except a few *Triletes*, *Tricolpites*, *Triporites*, *Tricolporites*. The frequency of the sporomorph is very poor. Based on the poor sporomorph data, it is not possible to establish the age and environment of deposition of the Shumar formation. However, the total absence of microplanktons in the sediments tends to suggest that these sediments might have been deposited under non-marine, environment.

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TABLE 1 — GENERAL SUB-SURFACE STRATIGRAPHY OF MANHERA TIBBA JAISALMER BASIN

GROUP	SYSTEM	SERIES	STAGE	FORMATION	MEMBER	LITHOLOGY
Quaternary		Recent			Dune sands α	Sand
		? Sub-Recent		Shumar	β	Limestone and Calcareous Sst.
					γ	Sandstone and variegated clay
					δ	Alternating variagated clay and coarse grained sandstone and glauconitic clay UNCONFORMITY
Tertiary	Eocene	Middle Eocene	Lutetian	Kirthar	Bakhri Tibba Habib Rahi	Clay Limestone (A4) Clay Limestone (B2)
		Lower Eocene	Yprecian	Laki	Ghazij	Shale Limestone (B4) Shale
	Paleocene			Ranikot	Dunghan	Limestone (C2) Marl Limestone (C4)
						Marl/Clay/Shale DISCONFORMITY Limestone (D4) Clay & Marl Sandstone (D6) Clay Sandstone UNCONFORMITY
Mesozoic	Cretaceous		Coniacian Turonian	Parh		Marl (Fd) Clay/Marl/Limestone (Fe). Clay (Ff) Clay & Marl (Fg) Limestone (Fh)
			Cenomanian Aptian	Goru		Marl (Ga) Shale (Gb) Clay (Gc) Shale (Gd) Calcareous Siltstone & Shale (Ge) Sandstone (Gf) Shale & Calcareous Siltstone (Gg) Sandy shale and argillaceous sandstone (Gh)

2. Kirthar Formation

The Kirthar formation underlies the Shumar with a distinct unconfoımity. In the Manhera Tibba structure, the top of this formation is represented by a marly clay bed succeeded by two principal members namely the Bakhri Tibba limestone and the Habib Rahi limestones. These two members are separated from one another by a clay bed. The clay bed at the top is devoid of sporomorphs.

The Bakhri Tibba limestone is whitish, grey, massive, locally bioclastic, foraminiferal limestone.

A few *Triletes* (psilate), *Monocolpites* (reticulate) *Tricolpites*, *Triporites* (reticulate) have been noticed in the Bakhri Tibba limestone. The frequency of the spores is very poor. As a whole the sediment is poorly fossiliferous. No *Hystrichosphaeridium* has been recorded in the sediment.

The intermediate clay bed between the Bakhri Tibba and Habib Rahi limestone is also poorly fossiliferous. The few sporomorphs recorded in the sediments are *Monolites*, *Polypodiaceaesporites* sp., *Cyathidites* sp., *Triletes*, *Inaperturopollenites*, *Monocolpites* (psilate & reticulate), *Palmaepollenites* sp., *Tricolpites* (reticulate). The distribution of these spores is very irregular and frequency very poor. No microplanktons have been recorded in the sediment.

The Habib Rahi limestone is characterized by whitish, cream to buff, massive foraminiferal limestone.

Monolites, *Triletes*, *Inaperturopollenites* (reticulate), *Monocolpites*, *Palmaepollenites* sp., *Retipilanopites* (cf. Potamogetonaceae pollen), cf. Malvaceae pollen, cf. Rubiaceae pollen, *Hystrichosphaeridium* sp., have been recorded in the sediment. The frequency and destribution is poor.

In general the Kirthar formation is poorly fossiliferous and the frequency and distribution of the sporomorphs recorded is poor. The sporomorphs therefore do not help to distinguish the various members of Kirthar formation from one another.

The *Hystrichosphaeridium* recorded in the Habib Rahi limestone is suggestive of a shallow marine environment.

3. Laki Formation

The Laki sediments underlying the Kirthar formation are represented by two principal members, namely the Ghazij shale at the top and Dunghan limestone below. The Ghazij member is principally an argillaceous unit differentiable into an upper and lower shale bed which are separated by a limestone bed, B4 limestone. The Ghazij shales are mainly composed of bluish grey, soft, plastic, pyritic clay with thin bands of foraminiferal limestone and marly limestone. The foraminiferal limestone associated with clay constitute the limestone bed (B4 limestone) which separates the upper and lower shale beds of the Ghazij member.

The sporomorphs recorded in general in Ghazij shales are *Triletes* (psilate & reticulate), *Monocolpites* (psilate and reticulate), *Tricolpites* (psilate and reticulate), *Tetracolpites*, *Polycolpites* sp., (7 to 9 colpi), *Triporites* (reticulate), *Proteacidites* sp., *Tricolporites*, *Hystrichosphaeridium* sp., marine cyst, and the algae, *Pediastrum* and *Botryococcus*. Although various spore types have been recorded in the sediment, their frequency and distribution are very poor. The sediment in general is poorly fossiliferous.

The presence of *Hystrichosphaeridium* in the sediment is suggestive of a shallow marine environment of deposition. The sediments at various intervals, are devoid of the microplanktons and wherever present, their frequency is poor. Besides at intervals, the marine cysts are also observed. It tends to suggest that the Ghazij shales had deposited under unstable sea level conditions.

The presence of *Pediastrum* in the sediment is suggestive of a fresh water influx. But its presence in Ghazij is not very much characteristic in the sense that the *Pediastrum* is not always recorded in all the Ghazij sections studied in the various wells. Therefore, the fesh water influx might have been only a limited and localized feature.

The lower member of Laki formation namely the Dunghan limestone is mainly composed of white, cream, dull-white, soft, friable bioclastic limestone.

The sporomorphs recorded in the Dunghan limestone are *Microthyriacites*, *Triletes* (psilate), *Inaperturopollenites* (psilate and reticulate), *Monocolpites*, *Tricolpites* (psilate & reticulate), *Tetracolpites*, *Pentacolpites*, *Triporites*, *Tricolporites* *Hystrichosphaeridium* sp., and marine cyst. The frequency and presence of various spore types is poor. A few Hystrichosphaerids recorded are suggestive of a shallow marine environment.

TABLE 2

FORMATION	MEMBER	SPOROMORPH GENERA	FREQUENCY/ DISTRIBUTION
1	2	3	4
Shumar		Devoid of Palynomorph; except solitary *Triletes, Tricolpites Triporites, Tricolporites*	Very rare
	UNCONFORMITY		
Kirthar	Bakhri Tibba limestone	*Triletes* (Erdtman ex Couper) Dettmann, 1963, *Monocolpites* Erdtman 1947, *Tricolpites* Erdtman 1947, *Triporites* Van-der Hammen 1953	Rare
	Clay	*Monolites* (Erdtman) Potonié 1956, *Polypodiaceaesporites* Thiergart, 1940, *Cyathidites* Couper 1953, *Triletes* (Erdtman ex Couper) Dettmann, *Inaperturopollenites* Thomson & pflug 1953, *Monocolpites* Erdtman, 1947, *Palmaepollenites* Potonié 1951, *Tricolpites* Erdtman 1947.	Rare
	Habib Rahi Limestone	*Monolites* (Erdtman) Potonié, *Triletes*, (Erdtman ex Couper) Dettmann, *Inaperturopollenites*, Thomson & Pflug, *Monocolpites* Erdtman, *Palmaepollenites* Potonié, *Retipilonapites*, Ramanujam, 1966 (cf. Potamogetonaceae pollen), cf. Malvaceae pollen, cf. Rubiaceae pollen, *Hystrichosphaeridium* sp.	Rare
Laki	Ghazij shales	Triletes (Erdtman ex Couper) Dettmann, *Monocolpites* Erdtman, *Tricolpites* Erdtman, *Tetracolpites* Erdtman 1947, *Polycolpites* Couper 1953, *Triporites* Van der Hammen, *Proteacidities* Cookson 1950, *Tricolporites* Erdtman 1947, *Hystrichosphaeridium*, Marine cyst, *Pediastrum* and *Botryococcus*.	Rare
	Dunghan Limestone	Triletes (Erdtman ex Couper) Dettmann, *Microthyriacites* Cookson 1947, *Inaperturopollenites* Thomson & Pflug, *Monocolpites* Erdtman, *Tricolpites* Erdtman, *Tetracolpites* Erdtman, *Pentacolpites* *Triporites* Van-der Hammen, *Tricolporites*, Erdtman, *Hystri chosphaeridium*, marine cyst.	Rare
Ranikot		*Microthyriacites* Cookson, *Monolites* Erdtman, *Polypodiaceaesporites* Thiergart, 1940, *Triletes* (Erdtman ex-Couper) Dettmann, *Schizaeoisporites* Potonié 1951, *Cyathidites* Couper, *Lycopodiacidites* (Couper) Potonié 1956, *Schizosporis* Potonié 1951, cf. *Pinus* pollen, *Inaperturopollenites* Thomson & Pflug, cf. Potamogetoniaceae pollen, *Monocolpites* Erdtman, *Palmaepollenites* Potonié 1951, Nymphaeaceae pollen, *Tricolpites*, Erdtman, cf. Fagaceae pollen, *Palaeocesalpiniaceaepites* Biswas, 1962, *Myrtaceidites* (Cookson & Pike) Potonié 1960., *Todisporites* Couper 1958, *Tetracolpites* Erdtman, *Hexacolpites*, Erdtman 1947, *Polycolpites* Couper 1953, *Triporites* Van der Hammen, *Proteacidites* Cookson 1950, cf. Tiliaceae pollen, *Tricolporites* Erdtman, *Illexpollenites* Thiergart 1937, *Hystrichosphaeridium*, marine cyst.	Rare
	UNCONFORMITY		
Parh		*Triletes* (Erdtman ex Couper) Dettmann, *Ceratosporites* Cookson & Dettmann 1958, *Lycopodiacidites* (Couper) Potonié' 1956, *Cicatricosisporites* Potonié' & Gelletich 1933, *Schizosporis* Potonié', *Classopollis-classoides*	Rare

TABLE 2 — *Continued*

FOMATION	MEMBER	SPOROMORPH GENERR	FREGUENEY DISTOIBUTION
1	2	3	4
		(Pflug) Pocock and Jansonius 1961, *Inaperturopcllenites* Thomson & Pflug, *Gnetaceaepollenites* (Thiergart 1938) Jansonius 1962, *Monocolpites* Erdtman, *Tricolpites* Erdtman, *Triporites* Van der Hammen. *Tricolporites* Erdtman, *Hystrichosphaeridium, Micrhystridium* (Deflandre) Staplin 1961, *Pterospermopsis*, Marine cyst, Microforaminifera. *Triletes* (Erdtman ex Couper) Dettmann, *Foveotriletes* (Van der Hammen) Potonié 1956, *Chomotriletes* (Naumova) ex Nauvmova 1953., *Lycopodiacidites* (Couper) Potonié 1956, *Cyathidites* Couper 1953, *Schizaeoisporites* Potonié 1951, *Sphagnumsporites* Raatz 1937, *Cingutriletes* (Pierce) Dettmann 1963, *Dictyophyllidites* Cookson Dettmann, *Cicatricosisporites australinsis* (Cookson) Potonié 1956, *Cicatricosisporites* Potonié & Gelletich 1933, *Dictyosporites* Cookson & Dettmann, *Polycingulatisporites* Kedves, *Crybellosporites* Dettmann 1963, *Biretisporites* (Delcourt & Sprumont) Dettmann & Hughes 1963.	
Upper Goru		*Equisetosporites* (Daugherty) Singh 1964, *Classopollis classoides* (Pflug) Pocock & Jansonius 1961, *Classopollis itunensis* Pocock 1962, *Araucariacites* Cookson, *Cycadopites* (Woodhouse) Wilson & Webster 1946. *Laricoidites* Potonié Thomson and Thiegart, *Clavatipollenites* Couper 1958, *Monocolpites* Erdtman, *Tricolpites* Erdtman, *Triporites* Van der Hammen, *Inaperturopollenites* Thomson & Pflug, *Hystrichosphaeridium tubiferum* (Ehrenberg) Deflandre, *Hystrichosphaeridium* spp., *Palaeoperidinium* Deflandre, *Palaeohystrichosphora brevispinosa* Pocock 1962, *Pterospermopsis* sp., *Odontochitina* Deflandre, Gonyaulacysta sp. *Baltisphaeridium* Eisenack, *Microforaminifera*.	Fairly rich
Lower Goru		*Triletes, Chomotriletes, Ceratosporites* Cookson & Dettmann 1958, *Cyathidites asper* Bolkhovitina, *Cyathidites* spp. Couper 1953, *Crybelosporites* Dettmann 1963, *Cicatricosisporites dorogensis* Potonié and Gelletich, *Cicatricosisporites-australinsis* (Cookson) Potonié 1956, *Cicatricosisporites* spp., Potonié & Gelletich, *Densoisporites* (Weyland & Krieger) Dettmann 1963, Lycopodiacidites (Couper) Potonié 1956, *Polypodiaceaesporites* Thiergart 1940. *Reticulatisporites castellatus* Pocock 1962, *Schizosporis* Cookson & Dettmann *Dictyosporites* Cookson & Dettmann, *Murospora* Somers 1952. *Aequitriradites* (Delcourt and Sprumont) Cookson & Dettmann, *Rouseisporites* Pocock 1962, *Classopollis* (Pflug) Pocock & Jansonius, *Laricoidites* Potonié, Thomson & Thiergart, *Coptospora* Dettmann 1963 *Callialasporites monalasporus* Dev. 1961 *Callialasporites segmentatus* (Balme) Srivastava 1963, *Callialasporites trilobatus* (Balme) Dev 1961, *Arauchriacites* Cookson, *Cycadopites* (Woodhouse) Wilson & Webster, *Spheripollenites* (Couper) Jansonius 1962, *Clavatipollenites couperii* Pocock 1962, *Clavatipollenites* Couper 1958, *Eucommiidites* (Erdtman) Hughes, *Inaperturopollenites* Thomson & Pflug, *Hystrichosphaeridium, Baltisphaeridium* Eisenack, *Psudoceratium, Palaeoperidinium* Deflandre, *Gonyulacysta, Odontochitina* Deflandre, Microforaminifera.	Fairly rich

Laki sediments in general is poorly fossiliferous and the distribution and frequency of the sporomorphs recorded are inconsistent and poor.

Hystrichosphaeridium suggests deposition of sediments in general under a shallow marine environment. The poor frequency, inconsistent distribution of sporomorphs and the presence of marine cysts in the Ghazij shale tend to suggest that the Ghazij shales might have deposited under an unstable sea level condition.

The occasional presence of *Pediastrum*, in Laki sediments in general suggests more or less a limited and localized fresh-water influx.

4. Ranikot Formation

In the Manhera Tibba structure, the, Ranikot formation underlies the Dunghan member of the Laki formation with a disconformity as suggested by the presence of Glauconitic pyritic shales. The upper part of the formation is glauconitic, pyritic marly clay succeeded by argillaceous fossiliferous limestone (D4 limestone) and grey, plastic sticky, and slightly calcareous clay. The lower part of the formation is mainly medium to coarse grained grey, moderately sorted sandstone (D6 sandstone) with calcareous clay at the base.

The sporomorphs recorded are *Microthyriacites* sp., *Monolites* sp., *Polypodiaceaesporites* sp., *Triletes*, sp. .*Schizaeoisporites* sp., *Cyathidites* sp,. *Lycopodiacidites* sp., *Schizosporis* sp., cf. *Pinus pollen, Inaperturopollenites* sp., cf. Potamogetonaceae pollen *Monocolpites* (reticulate), *Palmaepollenites* sp., cf. Nymphaeaceae pollen, *Tricolpites* (reticulate), *Tricolporites* sp., cf. Fagaceae pollen, *Palaeocaesalpiniaceaepites* sp., *Myrtaceidites* sp., *Todisporites* sp., *Tetracolpites, Hexacolpites, Polycolpites* (8-10 colpi), *Triporites, Proteacidites* sp., cf. Tiliaceae pollen, *Tricolporites, Illexpollenites, Hystrichosphaeridium*, sp., and marine cysts.

The spore assemblage recorded in Ranikot sediments is relatively better than that recorded in Laki formation. But, the frequency and distribution of the various types are inconsistent. As such, it is not possible to delineate the sporomorph assemblage characteristic of Ranikot formation.

The sporomorphs recorded in this formation suggest that the Ranikot sediments had deposited under two environments namely fresh water and shallow marine environments. This is evidenced from the distribution of Nymphaeaceae pollen and *Hystrichosphaeridium* in the sediments. It is interesting to note that the *Hystrichosphaeridium* spp, have been recorded in the D4 limestone, the clay overlying and underlying the D4, and at the base of the D6 sediment, while they are absent in the major part of Ranikot sand designated as D6, which contain Nymphaeaceae pollen. This suggests, that the basal D6,D4 and the clay overlying & underlying D4 of Ranikot formation had deposited under shallow marine environment, while the upper part of D6 sand had deposited under fresh water environment. The Palynological data of Bakhri Tibba well No. 2 drilled in the area fruther supports the above observation. (Lukose and Srivastava, 1970 & 1971).

In general the Tertiary sequence represented by Kirthar, Laki and Ranikot formations are poorly fossiliferous. The distribution and frequency of the few sporomorphs recorded in these sediments are poor and inconsistent. Therefore, it is not possible to delineate a sporomorph assemblage caracteristic of each of the formation.

The palynological data obtained from these sediments suggest that the various rock formations had mainly deposited under a shallow marine environment except the D6 sand of Ranikot sediment, which had deposited under fresh water as well as marine environment. Further, the poor sporomorph frequency, inconsistent sporomorph distribution in the sediments in general, and presence of marine cysts in the Ranikot sediment tend to indicate, that the sediments have deposited under an unstable sea level condition.

Practically a complete absence of saccate coniferous pollen has been observed in the various Tertiary rock formations and it suggests that the topography near and around the basin of deposition had been low.

5. Parh Formation

Parh sediments unconformably underlie the Ranikot formation. In Manhera Tibba, the Parh formation is mainly constituted by greenish grey micaceous clay, whitish, bluish grey marl and marly clay and argillaceous limestone.

The sporomorphs recorded from this, sediment are *Triletes, Ceratosporites* sp., *Lycopodiacidites* sp., *Cicatricosisporites* sp., *Schizosporis* sp., *Classopollis classoides, In-*

aperturopollenites sp., *Araucariacites* spp., *Gnetaceapollenites* sp., *Monocolpites, Tricolpites, Triporites, Tricolporites, Hystrichosphaeridium, Micrhystridium* sp., *Pterospermopsis* sp., marine cyst and microforaminifera.

The frequency and distribution of the various spore types are poor. In general the sediment is poorly fossiliferous. The *Classopollis* sp., and microplanktons dominate among the sporomorph assemblage recorded from this formation. The various other spore types of the assemblage listed above are generally represented by solitary grains. Venkatachala (1966) indicated an Upper Triassic-Cretaceous range for sporegenus *Classopollis* with the exception of *Classopollis obidosensis* and *C. major* which have a Cretaceous-Paleocene range. *Classopollis classoides recorded* in Parh formation is so far not reported in sediments younger to Cretaceous. The presence of *Classopollis* and various types of angiosperm pollen along with the absence of important Lower Cretaceous sporomorphs suggests an Upper Cretaceous age for the Parh formation. The microplanktons recorded in the sediments are suggestive of a shallow marine environment.

6. Goru Formation

Underlying the Parh sediments, is the Goru sediments mainly composed of grey green marl, grey green shale with argillaceous fine grained sandstone and glauconitic shale at the bottom. On the basis of lithology this sediment is broadly recognizable into eight beds designated as Ga to Gh (Goru a to h). These beds from top are (a) marl, (b) shale, (c) silty clay stone with siltstone, (d) shale, (e) calcareous siltstone and shale, (f) argillaceous siltstone and sand (g) sandy shale and calcareous siltstone and (h) sandy shales and argillaceous sandstone at the base.

The sporomorphs recorded in this sediment are recognizable into two distinct assemblages. That is, the upper beds from Ga to Gd with an assemblage having angiosperm pollen and the lower beds from Ge to Gk with an assemblage devoid of angiosperm pollen but having the spore genus *Callialasporites*.

The sporomorphs recorded in Ga to Gd are *Triletes, Foveotriletes,* sp., *Chomotriletes* sp., *Lycopodiacidites* sp., *Cyathidites* sp., *Schizaeoisporites* sp., *Sphagnumsporites* sp., *Cingutriletes* sp., *Dictyophyllidites Cicatricosisporites australinsis, Cicatricosisporites* sp., *Dictyosporites* sp., *Polycingulatisporites* sp., *Crybelosporites* sp., *Biretisporites* sp., *Equisetosporites* sp., *Classopollis classoides, Classopollis itunensis. Araucariacites* spp., *Cycadopites* sp., *Laricoidites* sp., *Clavatipollenites* sp., *Monocolpites, Tricolpites Triporites, Inaperturopollenites, Hystrichosphaeridium tubiferum, Hystrichosphaeridium* spp., cf. *Palaeoperidinium* sp., *Palaeohystrichophora brevispinosa, Pterospernmopsis* sp., *Odontochitina* sp., *Gonyaulacysta* sp., *Baltisphaeridium* sp., *Microforaminifera.*

The sporepollen assemblage recorded in the lower Ge to Gh beds consists of *Triletes, Chomotriletes* sp., *Ceratosporites* sp., *Cyathidites, C. asper. Crybelosporites* sp., *Cicatricosisporites dorogensis, C, australinsis, Cicatricosisporites* sp., *Densoisporites* sp., *Lycopodiacidites* sp., *Polypodiaceaesporites* sp., *Reticulatisporites castellatus, Schizosporis, Dictyosporites* sp., *Murospora* sp., *Aequitriradites* sp., *Rouseisporites* sp., *Classopollis* sp., *Laricoidites* sp., *Coptospora* sp., *Callialosporites monalasporus, C. segmentatus, C. trilobatus, Callialasporites* sp., *Araucariacites,* sp., *Cycadopites* sp., *Spheripollenites* sp., *Clavatipollenites couperii, Clavatipollenites* sp., *Inaperturopollenites.* sp., *Eucommiidites* sp., *Hystrichosphaeridium* sp., *Baltisphaeridium* sp., *Pseudoceratium* sp., *Palaeoperidinium* sp., *Gonyulacysta* sp., *Odontochitina* sp., marine cyst, microforaminifera.

The known range of *Callialasporites* is Jurassic to Lower Cretaceous, with the* top limit to Albian. Undisputed, and well recognizable angiosperm pollen occur from Cenomanian and extend allthrough in the Tertiary. In the Goru sediments the assemblage with angiosperm pollen is recorded in the upper beds namely Ga to Gd member. In the lower members, namely, Ge to Gh, the sporomorph assemblage is devoid of angiosperm pollen (with the exemption of *Clavatipollenites,* a doubtful angiosperm pollen) but have *Callialasporites* spp. Since the known upper limit of the genus *Callialasporites* is Albian and this genus disappers at top of Ge bed (i.e. the Calcareous siltstone and shale bed) together with the appearance

*Sah & Kar (1970) reported the occurrance of *Callialasporites* in Laki sediments in Kutch. However, they did not discuss the importance of its occurance in Laki sediments or the age of Laki sediments. I consider, its occurance in the Laki sediments is due to redeposition of older (Mesozoic) sediments.

of angiosperm pollen at the base of Gd bed (shale) in Goru sediment, a floral break/change may be demarcated between the beds Gd & Ge. As the known top limit of *Callialasporites* is Albian and the genus disappears at the top of Ge member supported with the appearance of angiosperm pollen from the base of Gd member in Goru sediments, the floral break between Gd and Ge may correspond to Albian/Cenomanian boundary. Based on this, it is possible to divide the Goru sediments into Lower Goru and Upper Goru, suggesting Albian and Cenomanian age respectively with the calcareous siltstone and shale member (Ge) as the top limit of the Lower Goru and the shale member (Gd) as the base of the Upper Goru. Micropalaeontological evidence suggests an ? Aptian-Cenomanian age for the Goru sediments.

The various types of microplanktons recorded in the sediment suggests that the Goru sediments are deposited under marine to shallow marine environment.

REGRESSION AND TRANSGRESSION

The present study indicates that the lower part of Ranikot formation i.e. the D6 sandstone and the Shumar formation that unconformably overly the Kirthar sediments, have been deposited under fresh water environment. Similarly, the Goru, Parh, Upper part of Ranikot, Laki and Kirthar formations have deposited under shallow marine environment. See chart 2. These fresh water facies between the marine facies suggest regressions of sea in the basin, one at the close of the Mesozoic i.e. after the deposition of Parh sediments and another at the close of the Lower Tertiary sediments namely the Kirthar formation. It may also be observed that after these two regressions, the basin had been inactive in deposition for a considerably long period, and is evidenced from the two unconformities, one between the Parh and Ranikot sediments and another between Kirthar and Shumar sediments. On Palaeontological evidence, the Parh sediments have been considered as Turonian to Coniacian in age. The Ranikot (Paleocene) sediments resting unconformably over the Parh (Turonian-Coniacian) sediments, indicate a break in sedimentation after the regression of sea at the close of Mesozoic deposition in this basin and this break corresponds to Santonian to Maastrichtian periods. Similarly, the Shumar (? Sub-recent) sediments, rest unconformably over the Middle Eocene Kirthar (Lutetian) sediments. It indicates once again that the basin had been inactive in sedimentation for considerably long period after the regression of sea at the close of the deposition of Kirthar sediments.

After the regression, and period of unconformity at the close of Upper Mesozoic (Parh) sediments the basin sank under fresh water and deposited the D6 sand of the Ranikot formation under the fresh water environment. Thereafter, the sea transgressed into the basin and the deposition of the upper part of Ranikot, Laki and, Kirthar sediments have taken place in marine environment, under unstable sea level condition. This has been evidenced from the presence of *Hystrichosphaeridium* and marine cysts in these sediments. The *Hystrichosphaeridium* in general suggests a shallow marine environment and the presence of marine cysts indicate an adverse environment-unstable sea level condition.

During the deposition of Kirthar sediments again the sea regressed and the basin remained inactive in sedimentaion for a long period as has been evidenced from the unconformity between the Kirthar and the overlying Shumar formation. After this period of unconformity the Shumar sediments had deposited under non-marine environment. Palynologically, there is no positive evidence to indicate as to under what exact environment the Shumar sediments had deposited. However, the, negative evidence i.e. a complete absence of any microplanktons, supported by the absence of micropalaeontological fossils other than a few reworked fauna in the Shumar sediments tends to suggest that the Shumars had deposited under non-marine environment.

PALAEOCLIMATE AND TOPOGRAPAY

The Goru, Parh, Ranikot, Laki and Kirthar sediments representing the Albian to Middle Eocene (Lutetian) period are devoid of disacate coniferous pollen grains. It tends to suggest, that the topography near and around the basin of deposition would have been low.

The palynological data obtained from the various rock units shows a rich sporomorph assemblage with a good percentage of pteridophytic spores in the Goru (Albian-

Cenomanian) sediment, and a successive reduction in the total terrestial floral elements as well as equally reduced percentage of pteridophytic elements in the overlying Parh (Upper Cretaceous), Ranikot, Laki, Kirthar (Paleocene-Middle Eocene) sediments and almost complete absence of sporomorphs in the Shumar (? Sub-recent) formation.

The chart No. 1 shows the percentage of terrestrial and non-terrestrial elements calculated from the total sporomorph count obtained from the Goru to Shumar sediments. Out of a total 41% terrestrial sporomorphs 15% are pteridophytic elements in the Goru sediments. It suggest the existence of a luxuriant flora and a warm humid climate during the deposition of Goru sediments. The total percentage of terrertrial sporomorph is considerably reduced in the Parh sediments i.e. almost 1/6 to that of the Goru sediments and the percentage of pteridophytic spores are also relatively reduced in the Parh sediments. The considerable reduction in the total terrestrial sporomorph percentage and the reduction in the percentage of pteridophytic elements in the Parh sediments suggest a poor flora and a semi-humid to semi-arid climate during the deposition of Parh sediments.

While the total terrestrial sporomorph percentage remained unchanged, the percentage of pteridophytic spores has been considerably reduced (to 0·5%) in the Ranikot sediments. The total, terrestrial sporomorph percentage has been successively reduced in the Laki and Kirthar sediments. Equally, the pteridophytic elements are also reduced. It tends to suggest poor vegetation and a successive increase in degree of aridity during the deposition of Laki and Kirthar sediments.

The absence of sporomorph and the nature of Shumar sediments in general, suggests an almost complete absence of vegetation and probably the existence of a desertic condition during the deposition of Shumar sediments.

Thus, it is interesting to note that the warm and humid climate and the luxuriant flora during the deposition of Goru (Albian-Cenomanian) sediments changed to a semi-humid to semi-arid climate with considerably reduced flora during the deposition of Parh (Upper Cretaceous) sedimentss subsequently changed over to an arid climate and poor vegetation during the deposition of Ranikot, Laki and Kirthar (Paleocene Middle Eocene) sediments had possibly changed over to desertic conditions during the deposition of Shumar sediments.

SUMMARY

Palynological studies on the subsurface sediments namely the Shumar, Kirthar, Laki, Ranikot Parh and Goru sediments from Manhera Tibba, Jaisalmer district, has been carried out. The topmost formation namely the Shumar is practically devoid of sporomorphs. As such, it is not possible to indicate the age and environment of the sediment. But from the total absence of any microplankton in the sediment suggests that the sediments might been deposited under non-marine influence.

The Kirthar formation unconformably underlie the Shumar formation. Bakhri Tibba and Habib Rahi limestones principally constitute the Kirthar formation. Underlying the Kirthar sediments is the Laki formation constituted by Ghazij shales and Dunghan limestone. Ranikot formation underlies the Laki formation. The sporomorphs recorded in the above Tertiary, sequence, in general are poor, and do not help to distinguish the various rock units. However, the data suggest that the various rock units have been deposited under shallow marine environment except the basal Ranikot (i.e. the D6 sand) which had deposited under fresh water environment. Limited and more or less localised fresh water influx is also evidenced in the Ghazij shales.

The Parh sediments unconformably underlie the Ranikot sequence. The sporomorph recorded in Parh sediments is suggestive of Upper Cretaceous age. The microplanktons recorded in the sediment are indicative of a shallow marine environment.

The Goru formation underlies the Parh formation. Based on the sporomorph assemblage recorded from this sediment, the Goru sediments be distinguishable into Upper and Lower Goru formation. The Upper Goru has angiosperm pollen and the Lower Goru devoid of angiosperm pollen, has the spore genus *Callialasporites*. Undisputed and well recognizable angiosperm pollen occurs from Cenomanian and extends throughout the entire Tertiary. The known range of *Callialasporites* is Jurassic to Lower Cretaceous extending the top limit, to Albian. Based on the floral break/change

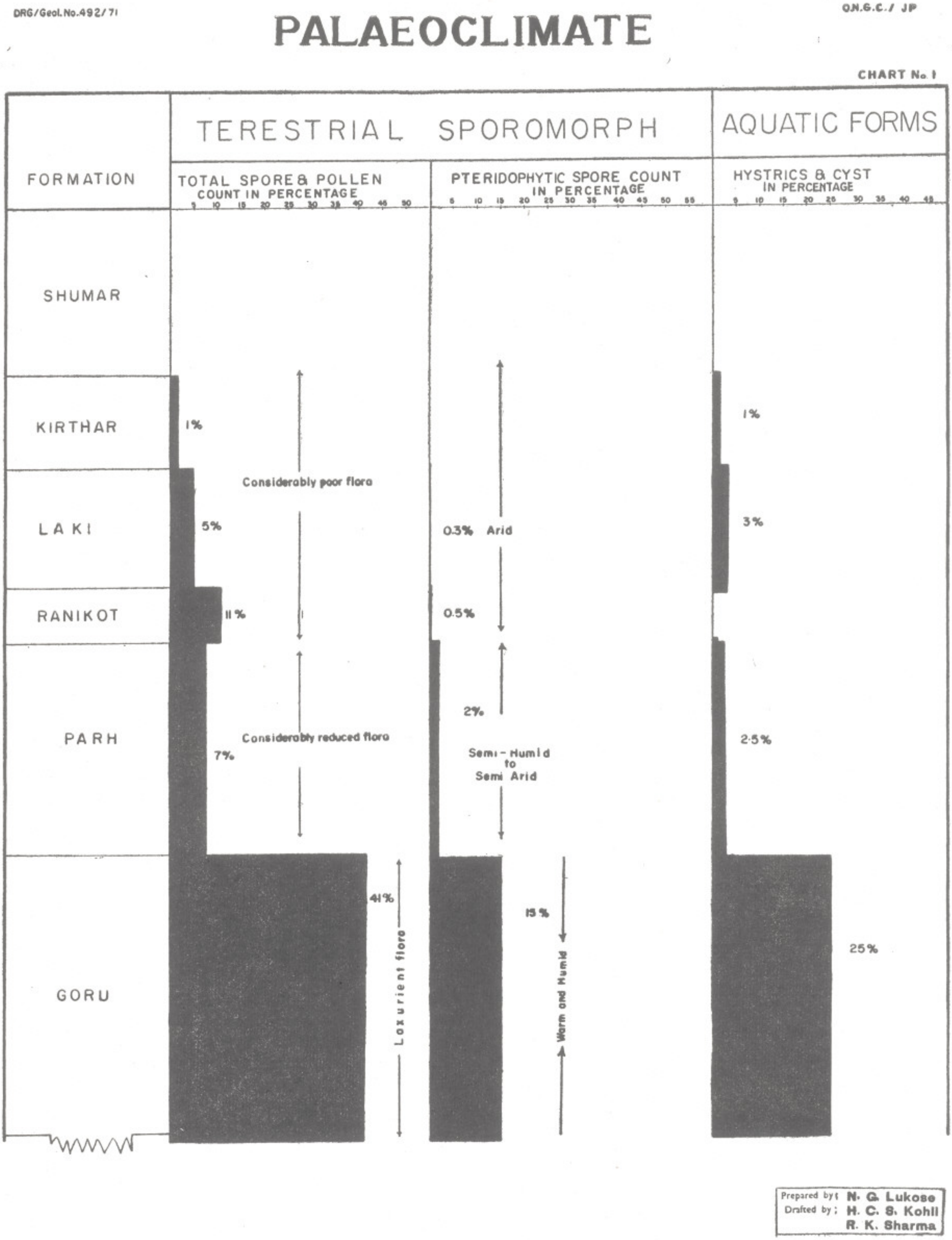

DRG/Geol.No.492/71
O.N.G.C./ JP
PALAEOCLIMATE
CHART No. 1
FORMATION
TERESTRIAL SPOROMORPH
AQUATIC FORMS
TOTAL SPORE & POLLEN COUNT IN PERCENTAGE
PTERIDOPHYTIC SPORE COUNT IN PERCENTAGE
HYSTRICS & CYST IN PERCENTAGE
SHUMAR
KIRTHAR
LAKI
RANIKOT
PARH
GORU
1%
5%
11%
7%
41%
Considerably poor flora
Considerably reduced flora
Luxurient flora
0.3% Arid
0.5%
2%
Semi-Humid to Semi Arid
15%
Warm and Humid
1%
3%
2.5%
25%
Prepared by: N. G. Lukose
Drafted by: H. C. S. Kohli
R. K. Sharma

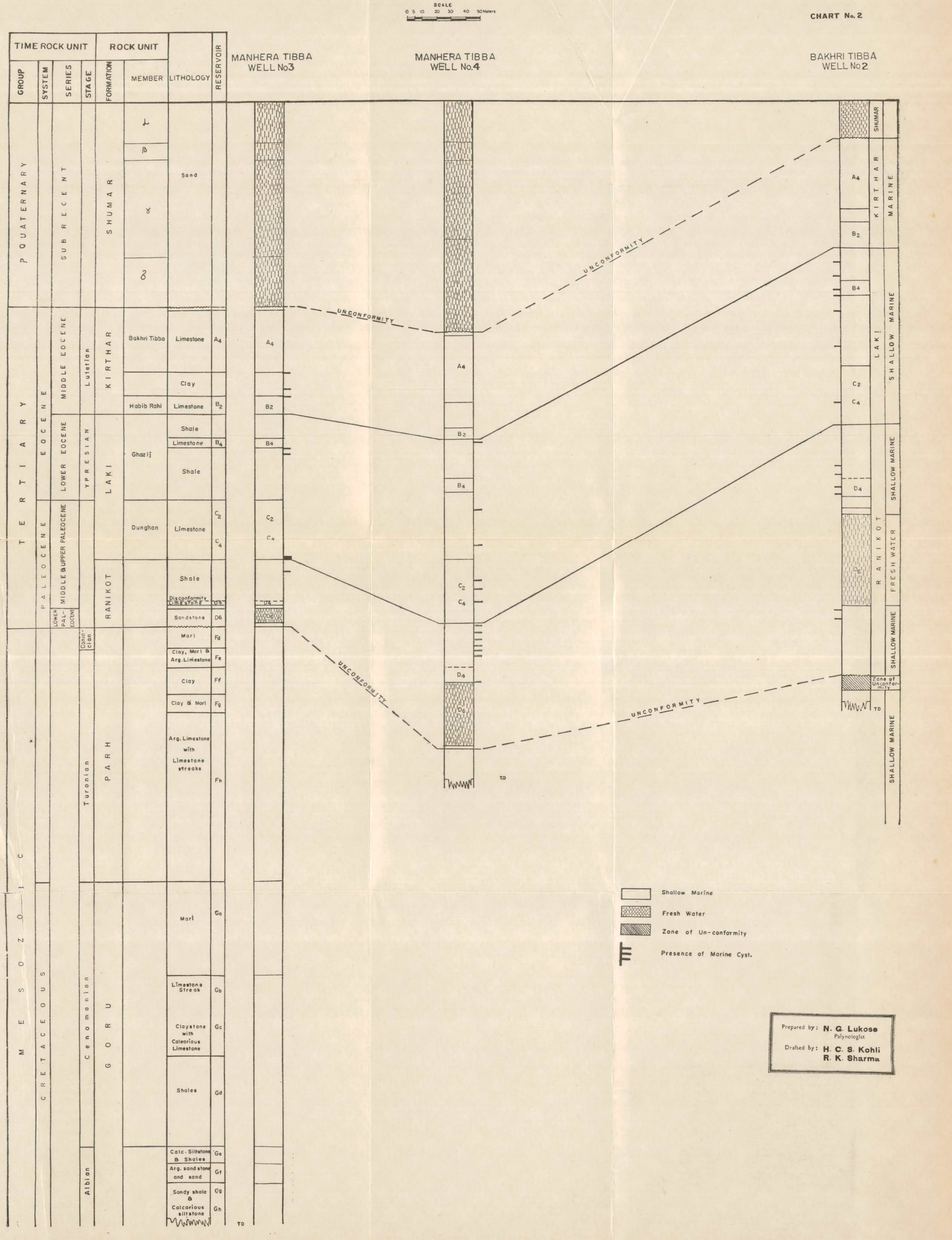
Chart 1

DRG/Geol.No. 494/71

ENVIRONMENT OF DEPOSITION

ONGC/JP

CHART No. 2



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and two corresponding sporomorph assemblages noted in Goru sediment, Cenomanian age is suggested for Upper Goru and Albian age for Lower Goru sediments. The various microplanktons recorded in the Goru sediments are suggestive of shallow marine to marine environment.

It has been observed that the major part of D6 sandstone (i.e. the basal Ranikot formation) had deposited under fresh water environment. This fresh water facies suggests, regression of the sea in the basin; one at the close of Upper Cretaceous (Parh) sediments and another at the close of Lower Tertiary (Kirthar) sediments. After these two regressions, the basin had been inactive in deposition for a considerably long period, which is evidenced from the unconformity between Parh Ranikot and Kirthar Shumar formations. After the regression and the period of unconformity at the close of the Upper Mesozoic (Parh) sediments, the basin sank under fresh water and the basal Ranikot D6 sandstone (Paleocene) had deposited under fresh water environment. Thereafter, the sea transgressed into the basin and depositited the upper part of Ranikot, Laki and Kirthar sediments, under shallow marine environment. This is evidenced from the presence of microplanktons in these sediments. At the close of the deposition of Kirthar sediments once again the sea regressed and the basin remained inactive in deposition for a considerably long period and followed by the deposition of Shumar sediments under a non-marine environment.

The Cretaceous, the Tertiary and the Shumar (Sub-Recent) sediments have been found practically devoid of bisaccate coniferous pollen grains. It tends to suggest a low topography near and around the basin during the deposition of Goru, Parh, Ranikot, Laki, Kirthar and Shumar sediments.

The data further suggest a luxuriant flora and a warm humid climate during the deposition of Goru (Albian-Cenomanian) sediments, a semi-humid to semi-arid climate and considerably reduced flora during the deposition of Parh (Upper Cretaceous), and an arid climate with poor vegetation during the deposition of Ranikot, Laki and Kirthar sediments, (Paleocene-Middle Eocene-Lutetian). The climate changed over to desertic conditions during the deposition of the ? Sub-Recent Shumar formation.

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