CHAPTER VI

ICHNOFACIES

Inchnofacies is a sedimentological term meaning a certain appearance (facie = facies) imparted to sediment by lebensspuren (trace). As suggested by Frey (1975, p. 469), the term "ichnofacies" has to be used in harmony with the term "biocoenose" (community of organisms). Recognition of a biofacies should ultimately lead to the reconstruction of a paelobiocoenose and the ichnofacies to the reconstruction of an ichnocoenose (Frey, 1975). In ichnological investigation the main way to determine characteristic lebensspuren (Frey, 1975) is to investigate profiles (or other quantitative sampling arrangements) consisting of a considerable number of representative samples from different environments. Then by comparing the ichnocoenoses related to different substrate one can evaluate bioturbation features that are common to several or to all environments of the profile, and discuss which lebensspuren are restricted to one specific environment. It is also important to define the physical environment of an ichnocoenose i.e. a characteristic lebensspuren (trace) must be defined by its particular sedimentological characters, such as grain size, content of organic matter, aeration, and depositional sedimentary structures including indicators of currents, wave action, and rates of deposition, reworking or erosion.

From the standpoint of characteristic assemblages of trace fossils (lebensspuren) one of the most useful approach is that by Seilacher (1964, 1967), popularly known as the "concept of universal trace fossil facies". This scheme is based upon the observation that particular kinds of trace making animals tend to congregate under particular sets of environmental conditions. Especially important are such things as water currents or turbulences, suspended or deposited food material, substrate consistency, oxygenation, and salinity, all of which relate (ideally, at least) to water depth or distance from the shore (Frey, 1972).

Seilacher (1964, 1967) recognized and defined four ichnofacies as Skolithos, Cruziana, Zoophycos, and Nereites on the basis of worldwide observations on trace-fossil associations (or assemblages) in rocks of all ages. These trace fossil biofacies that have served as models in determining paleoenvironments of deposition, paleogeography, and structure of fossil communities are summarized in the following paragraphs (adopted from Frey 1975, with inclusion of two more ichnofacies as recommended by him).

(A) Ichnofacies - Scoyenia:

Characteristic lebensspuren

- vertebrate tracks, trails, and burrows, mainly of aquatic or semiaquatic species but also of terrestrial species coming to water. Abundant

- insect and other arthropod traces. Certain forms of Planolites, scattered snail and calm trails and shallow burrows. Local diversity and abundance generally less than in marine environments.

Benthonic Environment and bathymetry

- Non-marine clastic, especially continental "red beds", floodplain deposits, etc.

(B) Ichnofacies - Glossifungites

Characteristic lebenspuren

- Vertical cylindrical, U-shaped or sparsely ramified dwelling burrows; protrusive spreiten in some, developed mainly through growth of animals. Many species leave the burrows to feed (e.g. Crabs); other are mostly suspension feeders (e.g. polychaetes, pholads). Diversity low, although burrows of given types may be abundant.

Benthonic environment and bathymetry

- Marine littoral zone and sublittoral omission surfaces. Stable coherent substrates either in protected, low-energy settings (e.g. salt marshes; muddy quiet-water bars, flats and shoals), or in areas of slightly high energy where semi-consolidated substrates offer resistance to erosion.

(C) Ichnofacies - Skolithos

- Vertical cylindrical or U-shaped dwelling burrows; protrusive and retrusive spreiten, developed mostly in response to substrate aggradation or degradation (i.e. Diplocraterion; forms of Ophiomorpha consisting predominantly of vertical or steeply inclined burrow components). Animals mainly suspension feeders. Diversity low although given kinds of burrows may be abundant.

Benthonic environments and bathymetry

- Littoral and very shallow sublittoral zones; relatively high energy conditions. Well-sorted, shifting sediments, abrupt erosion or deposition (e.g. beaches, inlet bars and shoals, tidal deltas). Very often higher energy, increasing physical reworking and obliterates biogenic sedimentary structures, leaving preserved record of physical stratification and for this reason, the very shallow sublittoral (shoreface) is often left barren of traces.

(D) Ichnofacies Cruziana:

Characteristic lebensspuren

- Abundant crawling traces, both epi-and intrastratal. Inclined U-shaped burrows having mainly protrusive spreiten (Rhizocorallium); forms of Ophiomorpha and Thalassinoides consisting of irregularly inclined to horizontal burrow components; scattered vertical

- cylindrical burrows. Animals mostly carnivores and suspension feeders, although some are deposit feeders. Diversity and abundance generally high.

Benthonic environment and bathymetry

- Shallow sublittoral; below daily wave base (but not storm wave base) to slightly quiter offshore conditions. Moderate to relatively low energy; well sorted silts and sands to interbedded muddy and clean sands; appreciable but not necessarily rapid sedimentation. A very common type of depositional environment overlapping with that of the <u>Zoophycos</u> assemblage.

(E) <u>Ichnofacies</u> <u>Zoophycos</u>:

Characteristic lebensspuren

- Relatively simple to complex, efficiently executed grazing traces and shallow feeding structures. Spreiten typically gently inclined. Distributed in delicate sheets, ribbons, or spirals. Animals mostly deposit feeders. Diversity and abundance generally low.

Benthonic environment and bathymetry

- Sublittoral to bathyal; quiet water, offshore-type conditions. Impure silts and sands. Below storm wave to upper continental slope or equivalent in areas of relict sediments free of turbidity flows

- (where deposit feeding is scare). A broad gradational "zone" intermediate between, and in many places indistinguishable from the Cruziana and Nereites "zones" respectively.

(F) Ichnofacies Nereites:

Characteristic lebensspuren

- Complex grazing trails reflecting highly organized, efficient feeding behaviour (e.g. Paleodicton); numerous crawling-grazing traces and sinuous fecal casting (e.g. Halminthoida, Cosmorhaphe). Animals mostly deposit feeders and "scavengers". Local diversity and abundance generally low, but somewhat greater than Zoophycos assemblage. Net density of lebensspuren increased by virtue of very slow deposition.

Benthnic environment and bathymetry

- Bathyal to abyssal; mostly very quiet waters, interrupted by turbidity flows; Pelegic muds, typically bounded above and below by turbidite deposits. In terms of the area occupied on the modern sea floor, this is the most important of the five marine "zones" in terms of representation in rock records, it is probably second in importance to the Cruziana "zone".

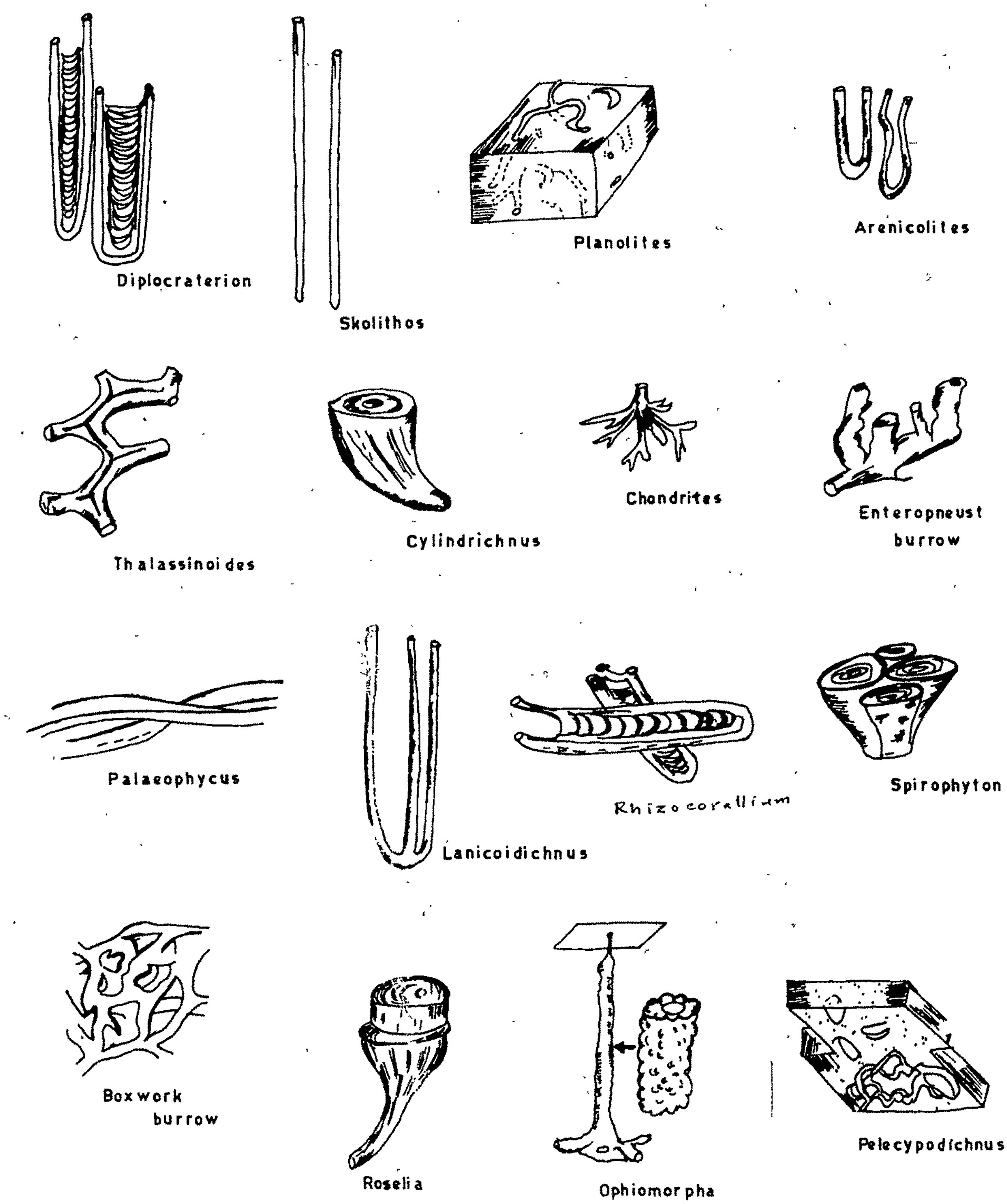
The author has broadly adopted Seilacher's (1964, 1967) concepts of ichnofacies while analysing his trace fossil assemblages of the eastern Kutch. A typological approach based purely upon the characteristics of individual genera was followed by him to differentiate these assemblages in terms of their probable ichnofacies. Details of these studies are given below and illustrated in Figures 17, 18, 19, 20 and 21.

DISTRIBUTION OF ICHNOFACIES IN STRATIGRAPHIC UNITS

Washatwa Formation:

(a) Kharol Member :- The *Skolithos-Cruziana* ichnofacies appears to be intimately associated with this lithological unit. The member, however, is represented by a reddish brown sandy facies in the north-east part (around Hamirpur) where *Scoyenia* ichnofacies appears with some other non-marine trace fossil forms. Density and diversity of trace fossils in both these ichnofacies is comparatively very low. The trace fossils of the Kharol Member as a whole show a broad range of form and behaviorial habits including dwelling, crawling and feeding traces by worms and crustaceons (e.g. *Paleophycos*, *Chondrites*, *Zoophycos*, *Rhizocorallium*, *Planolites* and *Thalassinoides*). The resting traces of bivalves are represented by the trace fossil *Pelecypodichnus*. On the whole the Kharol deposition indicates shallow water

FIG. 17. Graphic representation of the trace fossil association that define the Skolithos-Cruziana ichnofacies in Washtawa Formation



environment with nonmarine and marine conditions fluctuating between the north-east to south-west parts of the depositional basin.

(b) Nara/Chitrod Member:- The Nara Shale and the Chitrod Sandstone as mentioned earlier are the lateral equivalents of each other (Chapter V). The clastic units of this facies, especially at the Chitrod section are dominated by Skolithos/Glossifungites and Cruziana ichnofacies. Profusely developed vertical and U-shaped dwelling burrows characterize traces of the Skolithos/Glossifungites ichnofacies. Diversity of individual trace fossil genera is rather low but the density is very high. There are many forms like Thalassinoides (Spogliomorpha), Diplocraterion, Arenicolites, Chondrites which are also common to the Cruziana facies. On the whole the Skolithos/Glossifungites ichnofacies dominates and represents a zone densely populated by the suspension feeding dwelling animals. The associated sediments very often indicate curdly developed small-scale trough cross-stratification which indicate a high energy environment representing very shallow subtidal or intertidal deposits. This interpretation is in accord with that made by Fursich (1975) who concluded that the higher energy environments favoured deep burrowing and suspension feeding organisms.

Stratigraphic, lithologic, ichnofacies, & behaviorial distribution of trace fossils in WASHATWA Formation.

Formation	Member	TRACE FOSSILS	1	2	3	4	5	6	7	8	9	10	11
WASHATWA FORMATION	NARA / CHITROD MEMBER	Ophiomorpha		+				10	+				SHALLOW SUBTIDAL AND INTERTIDAL
		Thalassinoides		+	+			5	+				
		Palaeophycos	UMS	+	+			5	+				
		Planolites	UBS	+	+			4			+		
		Skolithos		+	+			5	+				
		Diplocraterion	LSS	+	+			10	+				
		Arenicolites		+	+			10	+				
		Lanicodichnus		+	+			10	+				
		Rosselia	LSS	+	+			10	+				
		Cylindrichnus	MSH	+				4	+				
		Spirophyton		+				4	+				
		Box work burrows	UMS	+				6	+				
		Enteropneust burrows	UBS	+				3	+				
	KHAROL MEMBER	Thalassinoides	TXS	+	+			3	+				SHALLOW MARINE \ LAGOONAL
		Chondrites	PTS	+	+			3				+	
		Zoophycos	MSH			+		1				+	
		Palaeophycos		+	+			3			+		
		Pelecypodichnus	LSS	+	+			3		+			
		Rhizocorallium		+	+			1	+				

1- LITHOFACIES - LSS, MSH, PTS, TXS, UBS, UMS (Legend in fig : 14.)
2- SKOLITHOS - GLOSSIFUNGITES, 3- CRUZIANA, 4- ZOOPHYCOS,
5- NEREITES, 6- ABUNDANCE (1= low, 10 = high) 7- DWELLING,
8- CRAWLING 9- GRAZING 10- DEPOSIT FEEDING,
11- ENVIRONMENT

Table. 10.

The Skolithos/Glossifungite ichnofacies with common elements of Cruziana, may therefore be regarded as one typical of an unstable substrate subjected to high rates of sedimentation and erosion, formed in shallow subtidal and inter-tidal environments.

Table 10, represents ichnofacies distribution in the Washatwa Formation and figure 17 shows the typical trace fossil associations in the particular ichnofacies.

THE LOWER KANTHKOT FORMATION

(a) Patasar Shale Member:- This member shows a significant change from the high energy environments prevailing during Nara Chitrod deposition. The bottom beds of the Patasar Member although have varieties of Arenicolites and other unidentified bioturbation forms their density has considerably been reduced. Table 11 and figure 18 provide a graphic display of Patasar ichnofacies that indicates trace fossil changes from shallow fine grained sandstone-siltstones to laminated shale beds, indicating gradual decrease in the water turbulence. In such conditions as claimed by Chamberlain (1978) the sediments feeding becomes more prevalent and accordingly, burrows become more horizontal and develop branches, lobes and backfill structures for

Stratigraphic, lithologic, ichnofacies & behaviorial distribution of trace fossils in KANTHKOT Formation

		TRACE FOSSILS	1	2	3	4	5	6	7	8	9	10	11
LOWER KANTHKOT FORMATION	FORTSANDSTONE MEMBER	Scolicia	UBS UMS PTS LSS		+		+	8			+	+	BEACH, BAR, BANK, LAGOON AND CHANNEL ENVIRONMENT
		Mantle burrow			+		+	8			+	+	
		Chondrites		+	+		+	4				+	
		Teichichnus		+	+			6				+	
		Rhizocorallium		+	+			4	+				
		Thalassinodes	UBS UNS	+	+			6	+				
		Box work burrows		+				4	+				
		Skolithos		+	+			4	+				
		Palaeophycos		+	+			4	+				
		Planolites		+	+			3	+		+		
		Ophiomorpha	TXS	+				10	+				
		Diplocraterion		+	+			2	+				
		Arenicolites		+	+			2	+				
	PATASARSHALE MEM	Muensteria	MSH		+			4			+		SHALLOW SHALF CONDITIONS
		Palaeophycos		+	+			3			+		
		Gyrochorte			+			6			+		
		Chondrites			+			3				+	
		Arenicolites		+	+			4	+				

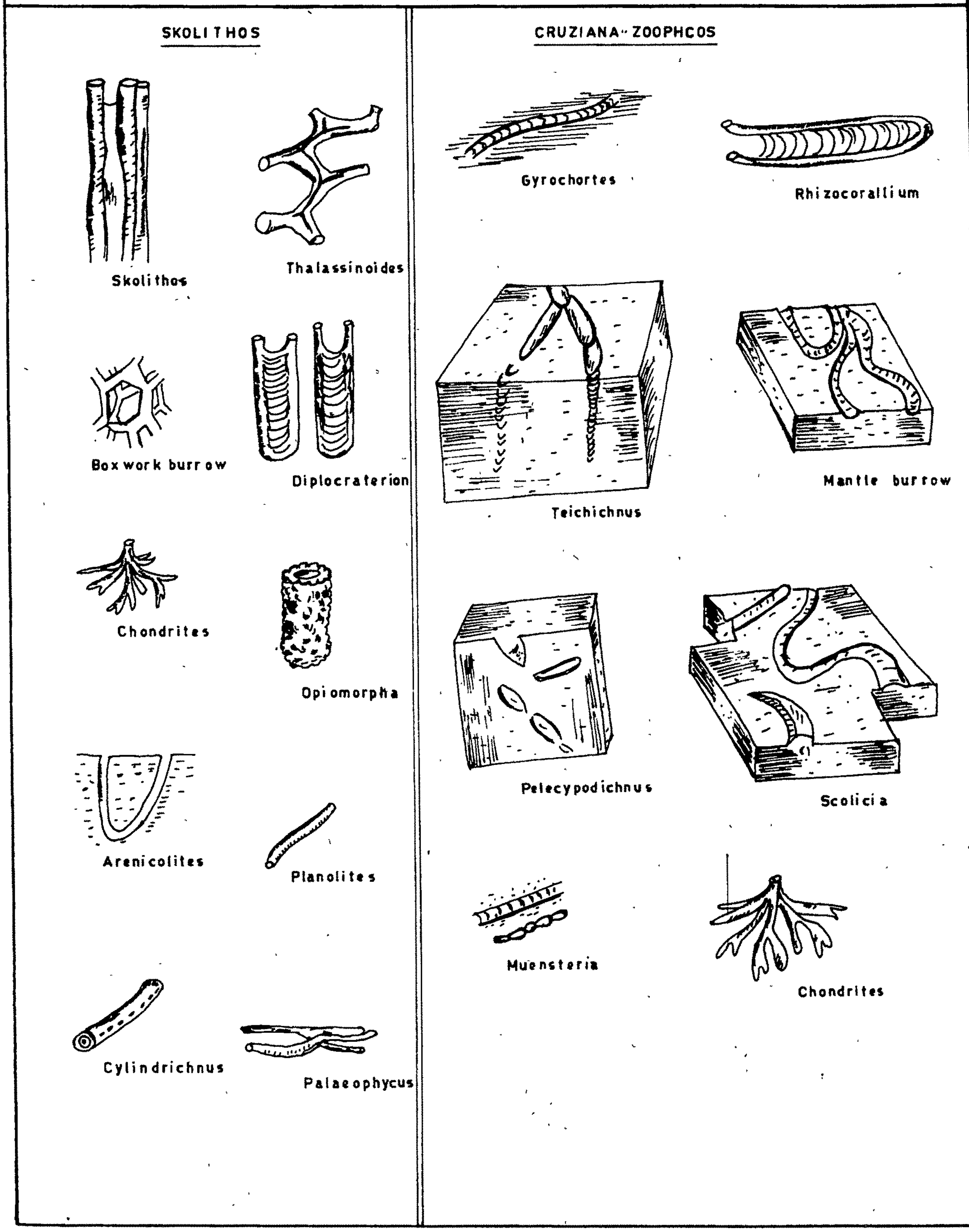
Table. 11.

better exploitation of the sediments. The crawling, grazing and resting traces of the Patasar Shale Member that have succeeded the lowermost suspension feeding group of organisms have exactly represented these features. The Patasar Shale thus appears to be deposited in shallow shelf conditions.

(b) Fort Sandstone Member:- Figure 18 and Table 11 represents the graphic distribution of ichnofacies in the Fort Sandstone Member. These ichnofacies display the presence of Skolithos and Cruziana ichnofacies with a few Nereitic elements in it. The traces are dominated especially by the dwelling organisms and a few grazing deposit feeding forms.

The depositional conditions of the Patasar Shale appears to be changed with the advent of the Fort Sandstone deposition. This change is well documented by the trace fossils in the lower parts of the Fort Sandstone Member (Fig. 18). It contains concentration of Arenicolites, Diplocraterion, Skolithos and Ophiomorpha traces. The dense population of Ophiomorpha in this unit is rather significant. The Ophiomorpha burrows with several of their vertical branches that terminate progressively higher up in the younger bedding planes indicate positions of erosional bedding surfaces. Similar Ophiomorpha burrow making the former position of a beach surface. Similar predictions could be made for the

FIG. 18. Graphic representation of the trace-fossil association that define the Skolithos, Cruziana & Zoophycos ichnofaces in Lower Kanthkot Formation



lowermost sedimentary deposits of the Fort Sandstone Member.

Overlying these beach deposits, the sediments in the moddle portion of the Forst Sandstone are almost barren of trace fossils. However, prominent planner and cross-bedding structures are displayed in these. Cross-bedding becomes less prominent once again at the upper sections of the Fort Sandstone stratas and horizontal and oblique branching burrows attributed to _Thalassinoides_, _Rhizocorallium_, _Trichichnus_, _Chondrites_, _Palaeophycos_ become more common.

On the bases of the stratigraphic sequence, sedimentary structures and trace fossil contents the Fort Sandstone Member could be interpreted as a tidal bar deposit that was transgressed over by a beach-barrier system that during its later stage of deposition was succeeded by the near shore sand and gradual continental deposition. It is possible that the _Skolithos_ - _Cruziana_ assemblage of the Fort Sandstone Member represents beach, bar, bank, lagoon (?) and channel environments with their particular inherent environmental factors and ichno fossil assemblage.

THE UPPER KANTHKOT FORMATION

(a) _Adhoi_ _Member_: The ichnofacies of the Adhoi Member are the most diverse as compared to any other stratigraphic units in the Wagad group. All the four ichnofacies

Stratigraphic, lithologic, ichnofacies & behaviorial distribution of trace fossils in UPPER KANTHKOT Formation.

		TRACE FOSSILS	1	2	3	4	5	6	7	8	9	10	11
UPPER KANTHKOT FORMATION	ADHOI MEMBER	Scolicia	LSS		+		+	5		+			ESTAURINE, SHALLOW MARINE, OFFSHORE BAR, NEAR SHORE, TIDAL FLAT.
		Bolonia			+		+	5			+		
		Mantle burrow			+		+	5			+		
		Gyrophyllites			+		+	2	+				
		Helminothopsis			+		+	4			+		
		Paleodicton					+	1			+		
		Taenidium			+	+	+	6			+		
		Chondrites			+	+	+	4				+	
		Scalarituba			+	+		2			+		
		Teichichnus			+			2				+	
		Zoophycos	MSH			+		1				+	
		Rhizocorallium			+	+		2	+				
		Muensteria			+			8			+		
		Gyrochorte			+			8			+		
		Palaeophycos			+			3		+			
		Planolites			+			4			+		
		Palaeophycos			+			7			+		
		Walcottia			+		+	6		+			
		Crossopodia			+		+	6		+			
		Cylindrichnus		+	+			5	+				
		Spongeliomorpha		+	+			5	+				

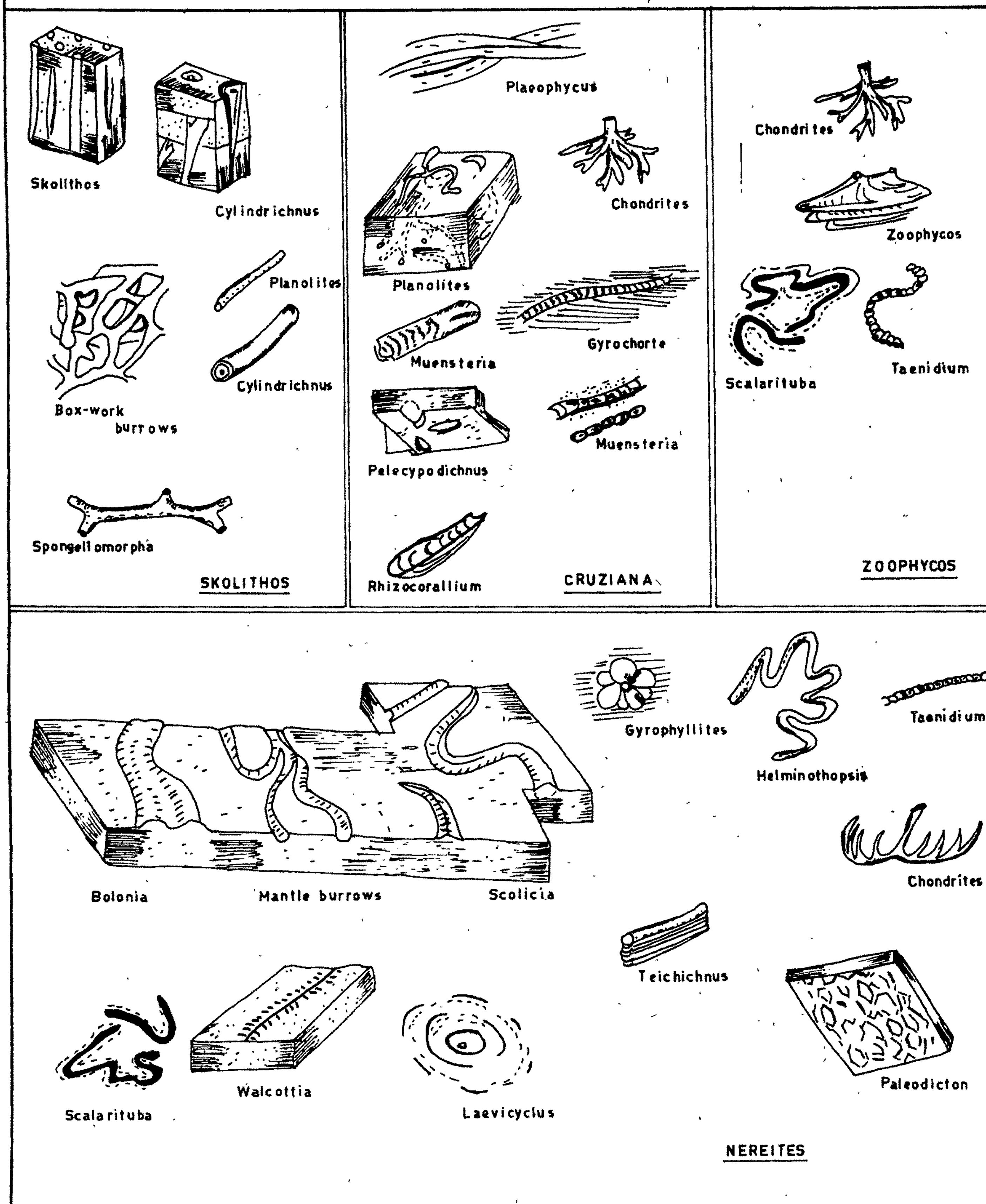
Table. 12.

viz. Skolithos, Cruziana, Zoophycos and Nereites are documented in this lithofacies representing almost equal distribution of the dwelling, crawling, grazing and deposit feeding types of organisms (Table 12).

The occurrence of shallow burrows Spongeliomorpha and Cylindrichnus ichnofacies during the initial depositional phase (Fig. 19) suggest that this association was best developed in moderately low-energy conditions and the sedimentation rates were comparatively slow as indicated by the extensive associated mottling.

The Cruziana ichnofacies of the Adhoi Member is very significant and includes most of the trace fossils occuring in the Wagad Group of rocks. The stratigraphic sequences mainly are thin to medium bedded sandstones with interbedded shales with irregular wavy shale partings, clearly indicating shallow marine to intertidal, including tidal channel deposits and inter-distributary flats (Briggs, McBride, Miola, 1976, in Chamberlain, 1978, p. 33). The presence of Palecypodichnus and a number of gastropod-like trails provide strong evidence of an estuarine or nearshore molluscan fauna. The Cruziana ichnofacies of the Adhoi Member, therefore, appears to range from estuarine, offshore bar, through nearshore environments.

FIG.19. Graphic reprasentation of trace fossil association that define the Skolithos, Cruziana, Zoophycos & Nereites ichnofacies in upper Kanthkot Formation.



The *Zoophycos* ichnofacies of Adhoi Member is documented by both simple and complex grazing traces displaying low density. It is most common in siltstone and clayey fine-grained sandstones.

In the *Zoophycos* ichnofacies in the Manfara section along with the ichnogenera *Zoophycos* other eurybenthic and cosmomopolitan forms such as *Chondrites*, *Scalarituba*, *Taenidium* also occur. These forms are considered to represent quite and probably deeper water conditions (Chamberlain, 1978).

The main characteristics of the *Nereites* ichnofacies in the Adhoi Member is the predominance of grazing patterns that are made within the sediments. The trace fossils typically are complex horizontal deposit feeding patterns and occur mainly as hyporeliefs at the base of the sandstone/shale sequence, as epirelief and full reliefs. The high density and low abundance of specialized forms in this lithofacies is typical of a stable but low resource environment (Valentine 1971). The apparent high number of trace fossils, however, may be because of the long time which few individuals successfully reworked the sediments.

THE GAMDAU FORMATION

The Gamdau Formation is represented by *Skolithos*, and the *Scoyenia* ichnofacies. *Skolithos* characterises the lower part while rest of the portion represents *Scoyenia*. The overall occurrence of trace fossils is very low and is documented by only a few forms (Table 13, Figure 20).

The earlier shallow marine conditions appear to have been entirely replaced by the fluviatile conditions during the major part of the Gamdau deposition is very well indicated by its trace fossil contents.

ICHNOFACIES AND THEIR INTERPRETATION

Figure 21, illustrates and summarises the ichnofacies, environmental zones, and common trace fossil occurrence in the Wagad region of the eastern Kutch. The existence of *Scoyenia*, *Skolithos*, *Glossifungites*, *Cruziana*, *Zoophycos* and *Nereites* ichnofacies in its sediments provide excellent guides to the bathymetric conditions of the basin.

Skolithos:- Skolithos ichnofacies occur at several horizons through the Washatwa, the Kanthkot and the Gamdau Formations. The main characteristics of the Kharol, Nara/Chitrod and the Fort Sandstone Members of these formations is that the Skolithos ichnofacies is always dominated by the

Stratigraphic, lithologic, ichnofacies & behaviorial distribution of trace fossils in GAMDAU Formation

	TRACE FOSSILS	LITHOFACIES	ICHNOFACIES	FEEDING TYPE	ABUNDANCE [1 = low 10 = high]	ENVIRON-MENT
GAMDU FORMATION	Scoyenia	PTS TXS Red beds	Scoyenia	Dwelling	5	SHALLOW MARINE REPLACED BY FLUVIATILE
	Chondrites		"	Deposit Feeding	5	
	Crustacean burrow		"	Dwelling	7	
	Veertebrate track		"	Grazing	1	
	Endichinal burrow		"	Deposit Feeding	2	
	Skolithos	UBS	Skolithos	Dwelling	3	
	Planolites		"	"	3	
	Thalassinoides		"	"	3	
	Ophiomorpha		"	"	2	

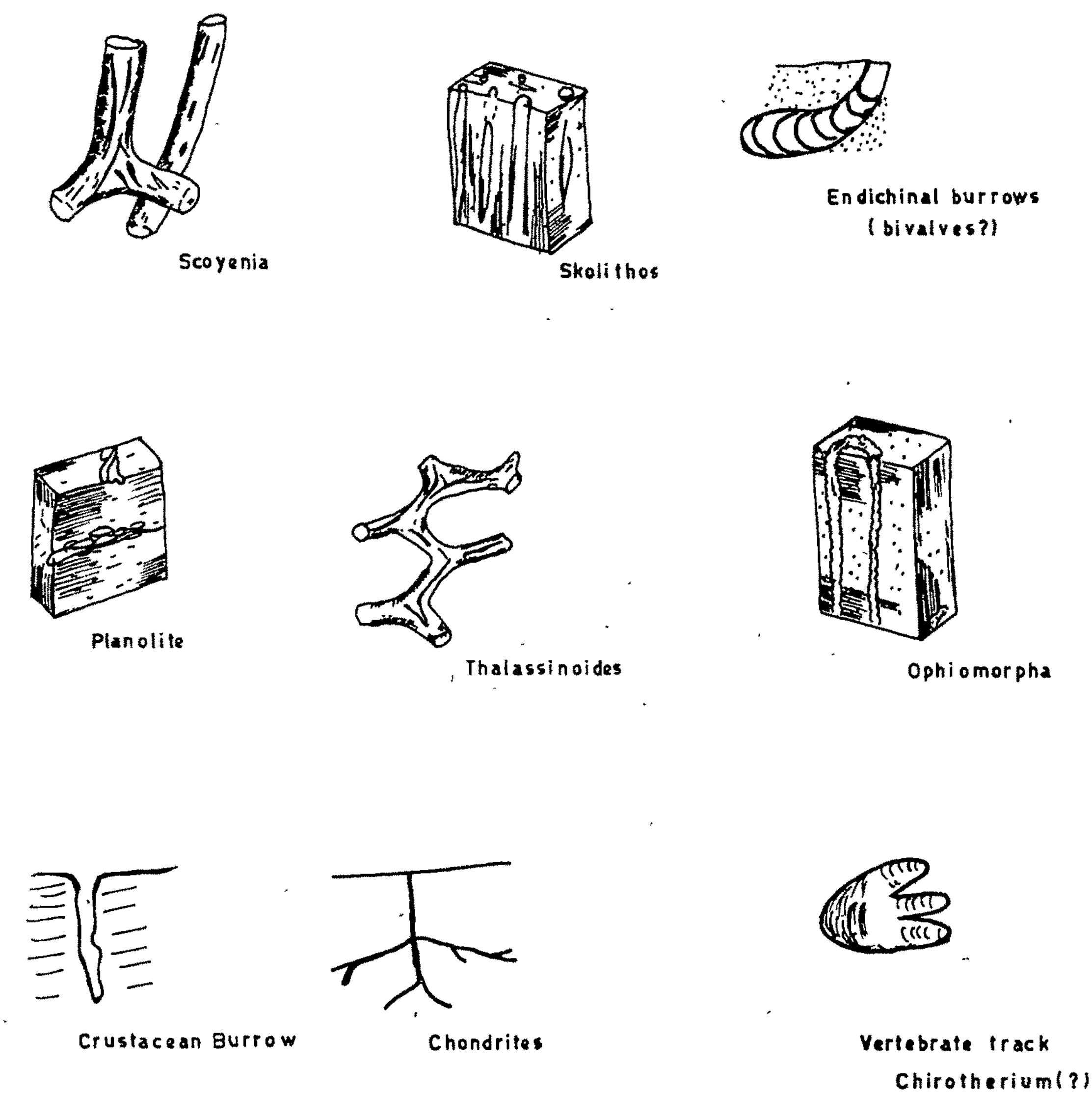
Table. 13.

presence of U-shaped burrows of the polychate worm tubes. As established by Seilacher (1964) the Skolithos ichnofacies always represents littoral and very shallow littoral zone [illegible] inhabited mainly by suspension feeders. These high energy environments include beach, bar or tidal deltas and because of its constant reworking of sediments the trace fossils are generally more sparce is further reflected in the low diversity and higher density of individual trace fossil genera. The coarsening upward sequences of the Washatwa and the Kanthkot Formations very well document these features repeatedly because of their prograding nature.

Cruziana:- Ecologic and sedimentologic conditions make the trace fossil associations in the Cruziana ichnofacies the most diverse of all the ichnofacies in behaviorial and preservational types. Because food was well distributed in the overlying water column and in the substrate, scavengers, carnivorous, suspension feeders, and deposit feeders are all common in this ichnofacies (Chamberlain, 1978). Thus, this ichnofacies is dominated by feeding and dwelling structures as well as by the resting and crawling traces.

In the eastern Kutch, the Cruziana ichnofacies has been well documented in both the Washatwa and the Kanthkot Formations. The boxwork burrows and the Enteropneust burrows occurring in the Chitrod section indicate hard ground omission

FIG. 20. Graphic representation of trace fossil assoçistions in the <u>Scoyenia</u> & <u>Skolithos</u> ichnofacies in Gamadu Formation



surfaces belonging to the *Glossifungite* ichnofacies that is closely allied to the *Skolithos*.

ZOOPHYCOS:

The *Zoophycos* ichnofacies has been interpreted by Seilacher (1964) more specifically as ranging below the wave base to the begining of turbidite sedimentation i.e. typically between the outer shelf and the outer slope deposits. Recently this ichnofacies has been considered as one of the most controversial (Osgood and Szmne 1972) because the genus *Zoophycos* is found to be eurybathyic and occurs in DSDP cores from abyssal depths (Chamberlain 1975, Ekdale 1974), deep water flysch of Europe (Seilacher 1964, 1967a) and elsewhere interbedded in shallow eperic marine deposits (Osgood & Szmne 1972). As claimed by Frey and Howard (1970) the *Zoophycos* genera rarely shows an inequivocal significance to its facies. Varieties of both *Skolithos* and *Zoophycos* have been reported from the *Cruziana* ichnofacies (Frey & Howard 1972). *Zoophycos* genera and *Zoophycos* ichnofacies in particular are, therefore, different from place to place, and the bathymetric adoptation seems to range from near shoal to abyssal conditions.

The *Zoophycos* genera located in the Patasar Shale Member and in the Adhoi Member include other eurybathyic and cosmopolitian forms such as Chondrites, Palaeophycos, Thalassinoides, Scalerituba, Taenidium etc., and represent quite and probably deeper water conditions.

NEREITES:

The main characteristic of the Nereites ichnofacies is the predominance of grazing patterns that were made within the sediment. Mining and crawling patterns also are present and like the crawling traces complex feeding patterns that represent a highly organized and efficient processing of sediment for nutrients is also present (Seilacher, 1964, 1967a, 1974, 1977).

This ichnofacies is prominently developed in the Manfara, Mae and Nara sections. The ichnofacies display high diversity but low abundance of specialized forms (Fig. 21). This is thought to be typical of a stable but low-resource environment (Valentine 1971). The apparent high number of trace fossils are thought to be because of the long time in which few individuals were successfully able to reworked the sediments.

The Nereites ichnofacies has been interpreted as bathyal to abyssal (Seilacher 1964, 1967a, 1967b, 1974,1977; Frey 1971; Crimes 1975; Chamberlain 1971) but according to Chamberlain (1978) it may be closely duplicated in quiet shallow water deposits.

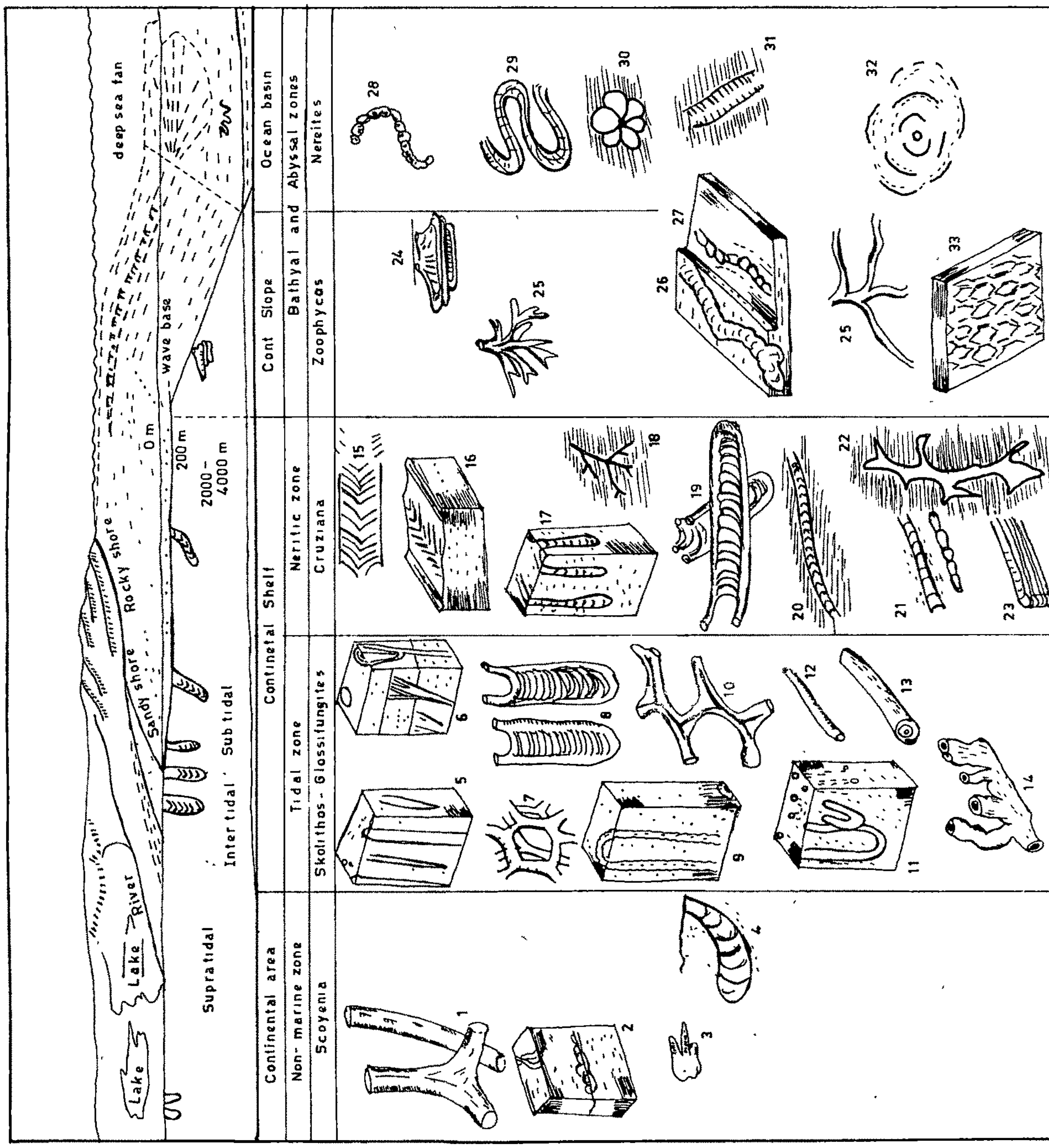
Of the ten species of trace fossils present in the Nereites ichnofacies of the Ahoi Member all are probably deposit feeding forms; three are crawling patterns, six are grazing forms and one is the mining traces.

The Nereitic assemblage (Fig. 21) that defined this ichnofacies in Adhoi is widespread and persistant throughout the whole sequence in Manfara and Mae sections. It is similar to the modern deep-sea trace fossil assemblages (Chamberlain 1975; Ekdale 1974, 1977) in the presence of cosmopolitian and relatively simple, generalized traces like Palaeophycos, Chondrites, Teichichnus, Taenidium and Scolicia.

In conclusion the Callovian-Oxfordian sediments of the eastern Kutch show marked fluctuations of depth from shoal to shallow marine with corresponding changes in their trace fossil assemblages in most of the units. The bathymetric interpretation of the Zoophycos and Nereites ichnofacies in the Adhoi Member, however remains as elusive as elsewhere.

On the whole the presence of the particular inchofacies seems to fit the general and classifical model for each ichnofacies, but not without engendering some questions.

FIG. 21. Diagram illustrating ichnofacies, environmental zones and common trace fossils of Wagad Group in eastern Kutch, (Modified after Seilacher 1967, Crimes 1975, and Chamberlain 1978).



1 SCOYENIA
2 PLANOLITES
3 VERTEBRATE TRACK
4 SPIREITEN BURROW

5 SKOLITHOS
6 CYLINDRICHNUS
7 BOXWORK BURROW
8 DIPLOCRATERION
9 OPHIOMRPHA
10 THALASSINOIDES
11 ARENICOLITES
12 PLANOLITES
13 CYLINDRICHNUS
14 ENTEROPNEUST BURROW

15 SCOLICIA
16 WALCOTTIA
17 TEICHICHNUS
18 CHONDRITES
19 RHIZOCORALLIUM
20 GYROCHORTE
21 MUENSTERIA
22 THALASSINOIDES
23 TEICHICHNUS

24 ZOOPHYCUS
25 CHONDRITES
26 LAMINITES
27 SCALARITUBA
28 TAENIDIUM
29 HELMINTHOPSIS
30 GYROPHYLLITES
31 SCOLICIA
32 LAEVICYCLUS
33 PALEODICTON