



OLIGOCENE OSTRACODE BIOSTRATIGRAPHY OF KACHCHH AND BOMBAY OFFSHORE BASINS, INDIA

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ABSTRACT

Seventy-six ostracode taxa are recorded from the Oligocene of the Kachchh and Bombay Offshore basins, India. Of these, *Acanthocythereis muktaensis*, *Alocopocythere waiorensis*, *Asymmetricythere kachchhensis*, *Bairdoppilata maharashtraensis*, *Bairdoppilata mumbaiensis*, *Bythocypris mumbaiensis*, *Phlyctenophora ramaniaensis*, *Quadracythere alata* and *Uroleberis indica* are new. On their First Appearance Datum (FAD) and Last Appearance Datum (LAD), the Lower Oligocene strata in the Bombay Offshore Basin are divided into four ostracode interval zones. They are in ascending order: 1-*Uroleberis sohni* - *Pokornyella kutchensis* Interval Zone, 2-*P. kutchensis* - *Phlyctenophora ramaniaensis* n. sp. Interval Zone, 3-*Phlyctenophora ramaniaensis*-*Acanthocythereis muktaensis* Interval Zone and 4-*Acanthocythereis muktaensis*- *Hornibrookella ramaniaensis* Interval Zone. The Upper Oligocene in the holotype of the Waior river section, Kachchh is best developed and divided into four interval zones. They are: *Alocopocythere waiorensis* Range Zone, 2. *Alocopocythere waiorensis* - *Alocopocythere elongata* Interval Zone, 3. *Alocopocythere elongata*- *Haplocytheridea manifesta* / *Loxoconcha keralaensis* Interval Zone and 4. *Haplocytheridea manifesta*/*Loxoconcha keralaensis*-*Uroleberis sohni* Interval Zone. The Lower Oligocene ostracode zones of the Bombay Offshore Basin are fairly well correlated and traced laterally in the Kachchh Basin.

Keywords: Ostracode, biostratigraphy, Oligocene, Interval zone, Kachchh, Bombay Offshore

INTRODUCTION

The early Palaeogene (Palaeocene and Eocene) and Neogene (lower and middle Miocene) ostracodes of the West Coast basins of India are fairly well documented in the form of atlases (Bhandari, 1996, and Bhandari *et al.*, 2001) and their stratigraphic ranges are now well established (Bhandari, 2003). However, the stratigraphic ranges of the Oligocene ostracodes are yet to be established in the Indian sedimentary basins. To fill this lacuna in our knowledge, a detailed study on the Oligocene ostracodes of the Berwali river section and holotype of the Waior river section (Fig. 1a) Kachchh and the Lower Oligocene cored intervals of Bombay Offshore well B-EE-B and SW-E and cuttings of the Upper Oligocene, well B-EH-A (Fig. 1b) were studied at close intervals. In all, 63 ostracode taxa from the Oligocene of Kachchh and 54 taxa from Bombay Offshore are recorded (Table 1). The stratigraphic ranges and ostracode events of the Lower Oligocene of the Berwali river and the Upper Oligocene of the Waior river section and Bombay Offshore are plotted in Figs. 2-3 and Figs. 4-6 respectively. Ostracode bioevent correlation of Ramanian stage, Kachchh and Bombay Offshore is also given (Fig. 7). All the recorded ostracode taxa are revised and brought up to date. Only new taxa are described here in detail and they are illustrated in plates I and II.

The specimens described and illustrated in this paper are deposited in the collection of the Palaeontology Laboratory KDM Institute of Petroleum Exploration, Oil and Natural Gas Corporation Limited, Dehra Dun with catalogue numbers IPE/O4/9065-9089.

PREVIOUS WORK

The Oligocene ostracodes of Kachchh were described by Tewari and Tandon (1960), Tewari and Bhargava (1968). Guha (1967) recorded for the first time 19 ostracode taxa from the

Oligocene subgroups of the Cambay Basin. The ostracodes include: *Actinocythereis tumefaciens*, *Bairdoppilata poddari*, *Bradleya latebrosa*, *Cyprideis chaudhuryi*, *Cytheroptron* sp., *Cytherelloidea cambayensis*, *Costa cambayensis*, *Leguminocythereis lunejensis*, *Occultocythereis boldi* and *Occultocythereis* sp.

Subsequently, Guha (1974) recorded twenty ostracode taxa from the Ramanian and the Waiorian stages of Kachchh. They include: *Actinocythereis levinsoni*, *Aurila chaasraensis*, *Bairdia poddari*, *Bradleya latebrosa*, *Cytherella protuberans*, *Cytherelloidea barkhanensis*, *Cytherelloidea cutchensis*, *Cytherelloidea insolens*, *Cytherella (F.) trifurcata*, *Ehinocythereis fossularis*, *Hermanites purii*, *Krithe autochthona*, *Leguminocythereis lunejensis*, *Leguminocythereis mutata*, *Loxoconcha* sp., *Neomonoceratina oertli*, *Occultocythereis chaasraensis*, *Paracytheridea perspicua*, *Trachyleberis spinellosa* and *Quadracythere arcana*.

Khosla and Pant (1988) published a detailed work on the Oligocene ostracodes and recorded 37 taxa from the Ramanian and the Waiorian stages of Kachchh. They revised the ostracode taxa reported by Guha. The check list of ostracode taxa include: *Acanthocythereis decoris*, *Acanthocythereis gujaratensis*, *Actinocythereis khariensis*, *A. kutchensis*, *A. ramaniaensis*, *A. spinellosa*, *A. validiyai*, *Alocopocythere lunejensis*, *Archicythereis reticulata*, *Bairdoppilata rakhdiensis*, *Cytherelloidea parachaaraensis*, *Cytherelloidea mitra*, *Cletocythereis* sp. cf. *C. bradyi*, *Costa* sp. cf. *C. cambayensis*, *Dentokrithe autochthona*, *Haplocytheridea manifesta*, *Hornibrookella kutchensis*, *H. purii*, *H. ramaniaensis*, *Loxoconcha* sp. cf. *L. alata*, *Loxocorniculum bensoni*, *Miocyprideis kutchensis*, *Neomonoceratina bermottensis*, *N. khariensis*, *Neonesidea indica*, *Paracypris* sp. cf. *P. pandyai*, *Phlyctenophora* sp. cf. *P. meridionalis*, *Paracytheridea* sp. cf. *P. perspicua*,

Table 1: Distribution of Oligocene Ostracoda in Kachchh and Bombay Offshore Basins.

OSTRACODA	Lower Oligocene		Upper Oligocene	
	KACHCHH (Berwali River)	Bombay Offshore B-EE-B	KACHCHH Waior River Section	Bombay Offshore B-EE-B
<i>Acanthocythereis muktaensis</i> n. sp.	+	+		
<i>Acanthocythereis gujaratensis</i> Khosla and Pant	+		+	
<i>Acanthocythereis khariensis</i> Khosla and Pant		+		
<i>A. ramaniaensis</i> Khosla and Pant	+	+		
<i>Actinocythereis khariensis</i> Khosla and Pant			+	
<i>Actinocythereis kutchensis</i> Khosla and pant	+		+	+
<i>Actinocythereis gujaratensis</i> Tewari and Tandon				+
<i>A. spinellosa</i> Lyubimova and Guha			+	
<i>Actinocythereis vinjhanensis</i> (Tewari and Tandon)				+
<i>Actinocythereis</i> sp.			+	
<i>Asymmetrycythere kachchhensis</i> n. sp.		+		
<i>Alocopocythere elongata</i> Khosla and Pant			+	
<i>Alocopocythere waiorensis</i> n. sp.			+	
<i>Alocopocythere lujensis</i> (Guha)	+	+		
<i>Bairdoppilata rakhdiensis</i> Khosla and Pant	+	+		
<i>Bairdoppilata maharashtraensis</i> n.sp.	+	+		
<i>Bairdoppilata mumbaiensis</i> n. sp.	+	+		
<i>Bythocypris mumbaiensis</i> n. sp.	+	+		
<i>Caudites</i> sp.	+	+		
<i>Costabuntonia secedens</i> (Lyubimova and Guha)			+	
<i>Cletocythereis bradyi</i> Holden	+	+		
<i>Cushmanedia</i> sp.		+		+
<i>Cytherelloidea parachaasraensis</i> Khosla and Pant		+	+	
<i>Cytherelloidea chaasraensis</i> Guha		+	+	
<i>Cytherelloidea cutchensis</i> Lyubimova and Guha			+	
<i>Cytherelloidea insolens</i> Lyubimova and Guha	+	+	+	
<i>Cytherelloidea</i> sp.		+		
<i>Cytherelloidea costatruncata</i> Lyubimova and Mohan	+	+	+	
<i>Cytheretta</i> (F.) <i>trifurcata</i> Lyubimova and Guha			+	+
<i>Cytherella</i> sp. A	+	+	+	+
<i>Cytherella</i> sp. B			+	
<i>Dentokrithe autochthona</i> (Lyubimova and Guha)	+	+	+	+
<i>Gyrocythere siddiquii</i> Khosla		+	+	
<i>Haplocytheridea manifesta</i> (Lyubimova and Guha)			+	+
<i>Hornibrookella</i> sp.	+		+	
<i>Hornibrookella kutchensis</i> Khosla and Pant	+	+		
<i>H. ramaniaensis</i> Khosla and Pant	+	+		
<i>H. purii</i> (Tewari and Tandon)	+		+	
<i>Loxoconcha confines</i> (Lyubimova and Guha)			+	
<i>Loxoconcha keralaensis</i> Khosla and Nagori			+	
<i>Loxocorniculum bensoni</i> Khosla and Pant	+	+	+	
<i>Macrocyprina decora</i> (Brady)	+	+	+	
<i>Miocyprideis</i> sp.		+	+	
<i>Miocyprideis kutchensis</i> Khosla				+
<i>Neomonoceratina bermotiensis</i> Khosla and Pant	+	+		
<i>N. khariensis</i> Khosla and Pant	+	+	+	
<i>Neonesidea</i> sp. A	+	+		
<i>Neonesidea indica</i> (Tewari and Tandon)	+	+		
<i>Neonesidea</i> sp.B	+	+		
<i>Paranesidea nandanaensis</i> Khosla		+		
<i>Paracypris pandyai</i> Khosla	+		+	
<i>Paracypris</i> sp. A	+	+		+
<i>Pachycaudites</i> sp.		+		
<i>Paracypris</i> sp. B		+		
<i>Phlyctenophora meridionalis</i> (Lyubimova and Guha)			+	

<i>Phlyctenophora ramaniaensis</i> n. sp.	+	+		
<i>Phlyctenophora</i> sp.				+
<i>Pokornyella kutchensis</i> Khosla and Pant	+	+		+
<i>P. bhatiai</i> Khosla and Pant	+	+		+
<i>Propontocypris</i> sp.	+	+		+
<i>Pterygocythereis</i> sp.	+			
<i>Quadracythere</i> sp.				+
<i>Quadracythere alata</i> n. sp.		+		
<i>Ruggeria</i> sp.	+			
<i>Stigmatocythere (S.) chaasraensis</i> (Guha)				+
<i>Stigmatocythere (Bhatiacythere) khariensis</i> Khosla and Pant	+	+		+
<i>Stigmatocythere (Stigmatocythere) bermotiensis</i> Khosla and Pant	+	+		+
<i>S. (S.) reticulata</i> Khosla and Pant	+	+		+
<i>Tenedocythere</i> sp.		+		
<i>Triebelina</i> sp.	+	+		
<i>Trachyleberis khariensis</i> Khosla and Pant	+			
<i>Uroleberis sohni</i> Khosla and Pant	+	+		+
<i>Uroleberis indica</i> n. sp.	+	+		
<i>Xestoleberis subglobosa</i> Bosquet	+			+
<i>Xestoleberis</i> sp.		+		+
Indct. genus sp.	+	+		

Pokornyella bhatiai, *P. kutchensis*, *Stigmatocythere (Bhatiacythere) khariensis*, *Stigmatocythere (Stigmatocythere) bermotiensis*, *S.(S.) reticulata*, *Trachyleberis khariensis*, *Uroleberis sohni*, *Xestoleberis* cf. *X. mulleriana* and *Xestoleberis subglobosa*.

STRATIGRAPHY

A. Kachchh Basin

The Oligocene beds, designated as the Maniyara Fort Formation, are extensively developed in an arcuate belt extending from Lakhpat (23°50'N: 68°47'E) in the north-northwest to Goyela (23°26'N: 68°49'25"E) in the south-southwest in the western part of the Kachchh mainland, Gujarat (Fig.1A). The generalized stratigraphy of the Oligocene beds

of Kachchh is summarized below (Table 2.)

MANIYARA FORT FORMATION

The formation is Named after Maniyara Fort (23°28'05"N: 68°37'00"E) by Biswas and Raju (1971). The type section is continuously exposed along Bermoti Nadi (stream) flowing between Maniyara Fort and the Bermoti village from a locality 1.6 km. NNE of Bermoti to a locality about 450 m SE of the village. Besides, the formation is well exposed in the Ramanian stream, Waior stream, Berwali Nadi, Bermoti stream and also in the area around Lakhpat. The formation is divided into four members. The lower three members viz. Basal member, the Lumpy clay member and the Coral Limestone member are Lower Oligocene, while the Bermoti Member is Upper Oligocene in

Table 2: Palaeogene stratigraphy of Kachchh mainland (after Biswas, 1992).

SERIES		STAGES	FORMATION	MEMBER	FORAMINIFERAL ZONE	
NEOGENE	MIOCENE	LOWER	Aidaian	Khari Nadi	-	<i>M.tani</i> poorly fossiliferous
			UPPER	Waiorian	Maniyara Fort	Bermoti
	~~~~~ Coral limestone	<i>N.fichteli</i> / <i>E.dielelata</i> <i>N.fichteli</i>				
	Lumpy clay					
	OLIGOCENE	LOWER	Ramanian	~~~~~ Fulra Limestone	Basal member	
MIDDLE		Babian	Harudi	-	~~~~~ <i>T.rohri</i> <i>O.beckmanni</i>	
	EOCENE					

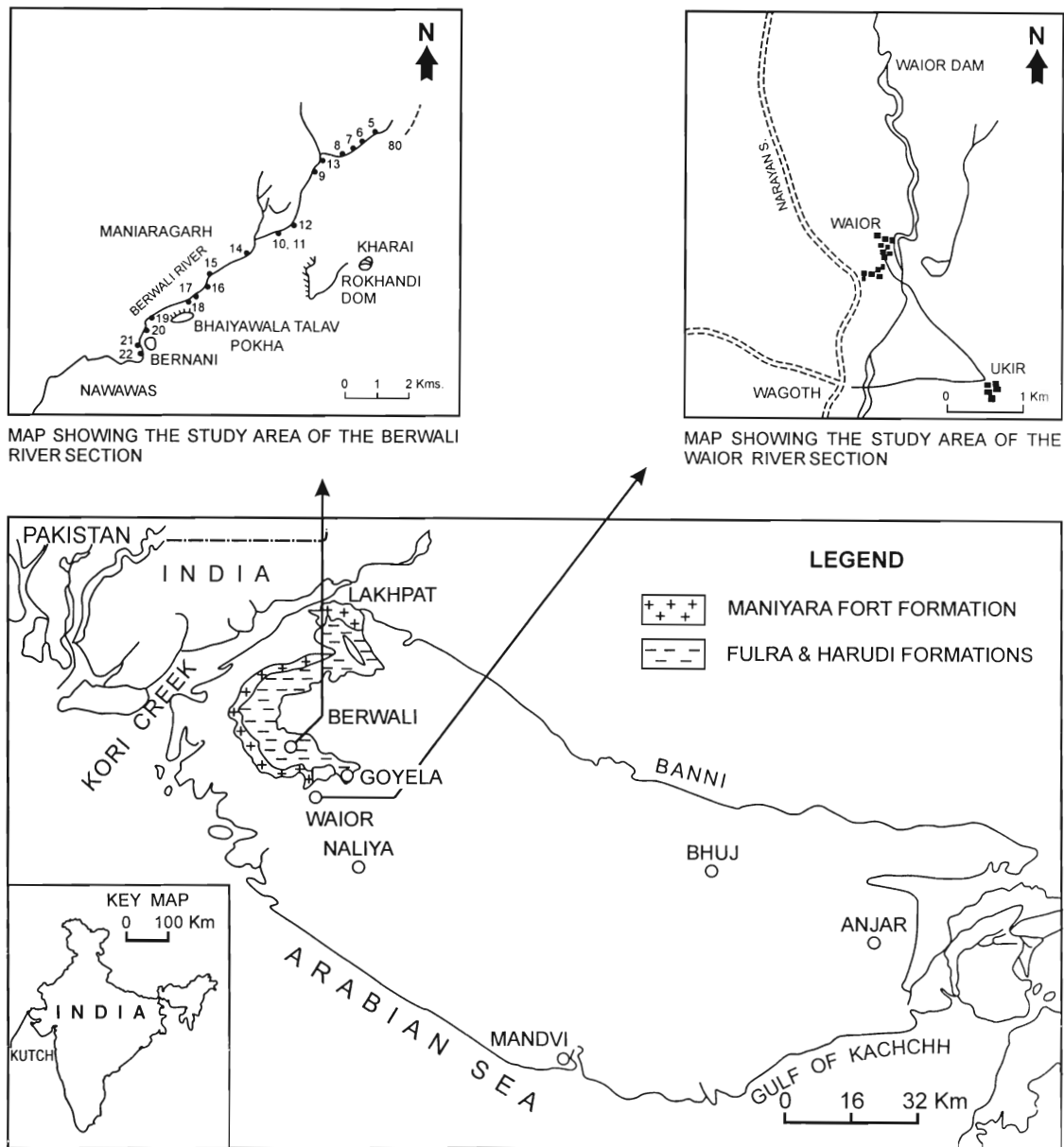


Fig. 1a. Location map of Kachchh.

(i) Berwali River Section.

(ii) Waior River Section.

age.

The lower contact between the Basal Member and the Fulra Limestone is represented by an erosional unconformity and a diastem between the Coral Limestone Member and the Bermoti Member.

In the present work, the stratigraphic section sampled by Shukla (1991) around the Berwali river near Barwani, Kachchh and the Waior river section sampled by the author near Waior village (Fig. 1a) have been used for ostracode study. The reconstructed stratigraphic section along with ostracode frequency and diversity is shown in Figs. 2-3. The details of hypostratotype sections of the Ramanian and Waiorian stages are given below:

#### A. Ramanian Stage (Lower Oligocene)

*Hypostratotype section:* Berwali river, near village Barnani,

Kachchh.

*Thickness in reference section:* About 21m, 27 samples collected include XA-134 – XA-179.

*Lithology:* Argillaceous limestone, yellow massive, dirty white and Nodular limestone, alternates with grey calcareous, greenish, brown colour shales.

*Microfauna:* Rich assemblage of foraminifera and ostracodes. Larger foraminiferal taxa include *Nummulites fichteli*, *N. clypeus*, *N. vascus*, *Operculina* sp. and smaller benthic foraminifera.

#### B. Waiorian Stage (Upper Oligocene)

*Holostratotype section:* The type section is discontinuously exposed at cliff sections along the banks of Waior-Cheropadi stream 0.3 km. NNW of Waior village (23°25'05"N: 68°91'37"E).

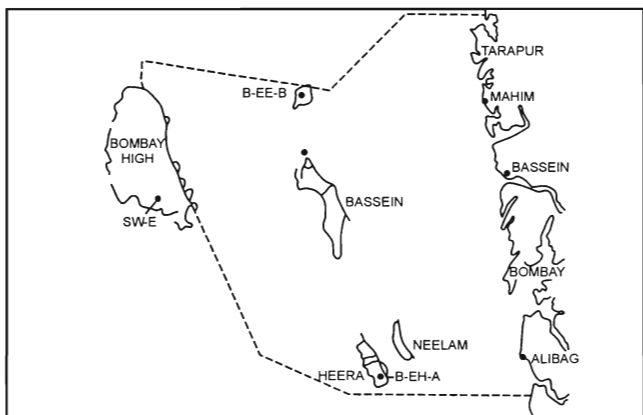


Fig. 1b. Location map of Bombay Offshore.

- (i) Location of well B-EE-B.
- (ii) Location of well SW-E.
- (iii) Location of well B-CH-A.

Thickness of reference section: 9 m.

**Lithology:** The lower part consists of rusty brown, friable glauconitic argillaceous sandstone with pseudoolites. The upper part is composed of thinly bedded, grey to yellowish hard foraminiferal limestone with interbeds of clay/marl. The upper most part consists of silty marly full of *Spiroclypeus*.

**Fauna:** The member is richly fossiliferous with echinoids, pelecypods, gastropods, corals, crabs and vertical burrows.

The important foraminifera recorded are *Nummulites*, *Planolinderina freudanthalii*, *Miogypsinoidea bermudezi*, *M. (M.) complanata-formosensis* and smaller benthic foraminifera and a rich ostracode assemblage.

**B. Bombay Offshore**

The Bombay Offshore Basin is a pericratonic rift basin (Biswas and Singh, 1988) (Fig. 1B), located on the continental shelf of western India and extends from Saurashtra coast in the north to Goa in the south. Westward it extends to the Arabian Sea; northeastward the basin is linked to the Gulf of Cambay. The Upper Palaeogene (Oligocene) stratigraphy of Panna-Bassein Block of Bombay Offshore is given in Table-3.

In Panna-Bassein Block, the Oligocene sediments are extensively developed. They are designated as the Mukta and Heera formations of Lower Oligocene age and overlain by Alibagh Formation of the Upper Oligocene age. These formations are rich in foraminifera and ostracodes. The

details of these formations are given below:

**MUKTA FORMATION**

The formation extends over the entire block of Panna-Bassein Block of Bombay Offshore. It is unconformably underlain by the Bassein Formation and overlain conformably by the Heera Formation. The formation consists of argillaceous limestone underlain by 15-20 m thick shale. The limestone is white to dirty white, hard, compact, argillaceous fossiliferous limestone. It is equivalent to *Nummulites fichteli* Range Zone and dated as Lower Oligocene.

**HEERA FORMATION**

The formation extends over the entire Panna-Bassein Block. It conformably overlies the Mukta Formation and is unconformably overlain by the Alibagh Formation. The Formation consists of an alternating limestone-shale and is dated as Lower Oligocene.

**ALIBAGH FORMATION**

It unconformably overlies the Heera Formation and is overlain by the Bombay Formation. It extends over Panna-Bassein Block. The formation comprises of splintery shales interspersed with thin limestone bands. The limestone is hard, compact and fossiliferous. The formation has been assigned Upper Oligocene age.

In the present work, Oligocene ostracodes are studied from the following wells of Bombay Offshore.

**WELL SECTIONS**

1. B-EE-B, Panna-Bassein Block, about 120 core pieces from nine continuous cores (CC#1, 2058-2075.8 m to CC#9, 2194-2203 m) are studied at close intervals.
2. SW-E, conventional core (CC#4, 1965.5-1973 m).
3. B-CH-A, cuttings of the Alibagh Formation (1200-1375 m).

**OSTRACODE BIOZONES**

Khosla and Pant (1981) have divided the Oligocene beds of Kachchh into two zones. The lower one is *Actinocythereis ramaniaensis* Range Zone of the Ramanian stage. It corresponds to *Nummulites fichteli - intermedius/ Lepidocyclina (Eulepidina)* Zone (Raju, 1974) and is dated as Lower Oligocene. The overlying ostracode zone is designated as *Actinocythereis kutchensis* Range Zone, which corresponds to *Miogypsina (Miogypsina) complanata - M. (M.) bermudezi* Zone (Raju, 1974) and dated as Upper Oligocene.

Biostratigraphic studies are carried out at close intervals on the continuous cores of the Mukta and the Heera formations

Table 3: Stratigraphy of Panna-Bassein Block (after Zutshi et al., 1993).

SERIES		STAGE	FORMATION
MIOCENE	LOWER	Vinjhianian	Bombay
		Aidaian	
OLIGOCENE	UPPER	Waiorian	Alibagh
	LOWER	Ramanian	Heera/Mukta
EOCENE	MIDDLE	Babian	Bassein

of well B-EE-B, Bombay Offshore, which enabled to divide the Ramanian stage into four Interval zones. The Alibagh Formation comprises a single biostratigraphic zone. The zones are briefly described below.

### RAMANIAN STAGE (LOWER OLIGOCENE)

1. *Uroleberis sohni* – *Pokornyyella kutchensis* Interval Zone  
*Holostratotype*: B-EE-B well, between 2192.3-2165m intervals.

*Thickness*: 27.3m.

*Definition*: This zone is defined as the interval from the first appearance datum (FAD) of *Uroleberis sohni* Khosla to FAD of *Pokornyyella kutchensis* Khosla.

*Assemblage*: This zone is poorly fossiliferous due to dolomatization. Characteristic ostracodes recorded are; *Uroleberis sohni* Khosla, *Stigmatocythere (Bhatiacythere) khariensis* Khosla and Pant and *Bairdoppilata* sp.

*Age*: Lower part of the Lower Oligocene.

*Remarks*: This zone is probably absent in the outcrop section of Kachchh.

2. *Pokornyyella kutchensis* – *Phlyctenophora ramaniaensis* n. sp. Interval Zone

*Holostratotype*: B-EE-B well, Bombay Offshore, sample 2165 – 2115m interval below depth.

*Thickness*: 50m.

*Definition*: This Zone is defined as the interval from the first appearance datum (FAD) of *Pokornyyella kutchensis* Khosla to FAD *Phlyctenophora ramaniaensis* n. sp.

*Assemblage*: This zone is characterized by *Uroleberis sohni* Khosla, *Pokornyyella bhatiai* Khosla and Pant, *P. kutchensis* Khosla and Pant, *Hornibrookella ramaniaensis* Khosla and Pant, *Uroleberis indica* n. sp., *Cletocythereis bradyi*, *Quadracythere alata* n. sp. and *Loxocorniculum bensoni* Khosla and Pant.

*Age*: Middle part of the Lower Oligocene.

*Lateral extent*: This zone has been recognized in the hypostratotype section of the Berwali river section Kachchh between sample no.138 and 140.

3. *Phlyctenophora ramaniaensis* n. sp. – *Acanthocythereis muktaensis* Interval Zone

*Holostratotype*: B-EE-B well, Bombay Offshore, sample 2115-2061.2m interval below depth.

*Thickness*: 53.8m.

*Definition*: This zone is defined as the interval from the FAD of *Phlyctenophora ramaniaensis* n.sp. to LAD of *Acanthocythereis muktaensis* n. sp.

*Assemblage*: This zone is highly fossiliferous. Important ostracodes recorded include: *Uroleberis sohni* Khosla, *Phlyctenophora ramaniaensis* n. sp. *P. bhatiai*, *Hornibrookella ramaniaensis* Khosla and Pant, *Bairdoppilata rahkhdiansis* Khosla and Pant, *Paranesidea nandanaensis* Khosla and Pant, *Uroleberis indica* n. sp., *Loxocorniculum bensoni* Khosla and Pant, *Acanthocythereis muktaensis* n. sp., *Stigmatocythere (S.) reticulata* Khosla and Pant, *Actinocythereis ramaniaensis* Khosla and Pant, *Macrocyprina decoris* and *Quadracythere alata* n. sp.

*Age*: Upper part of the Lower Oligocene.

*Lateral extent*: This zone is traced in the hypostratotype of the Berwali river section, Kachchh, between sample 140 and 152 m.

4. *Acanthocythereis muktaensis* – *Hornibrookella ramaniaensis* Interval Zone

*Holostratotype*: B-EE-B well, samples between 2061.2-2058m intervals below surface.

*Thickness*: 3.2m

*Definition*: This zone is defined as the interval from the LAD of *Acanthocythereis muktaensis* n. sp. to LAD of *Hornibrookella ramaniaensis* Khosla and Pant.

*Assemblage*: Most of the ostracode taxa of the underlying zone continue into this zone. Frequency and diversity of ostracodes near the top of this zone drops. The characteristic ostracodes recorded include: *Bairdoppilata* sp., *U. sohni* Khosla and Pant, *P. bhatiai* Khosla and Pant, *P. kutchensis* Khosla and Pant, *H. ramaniaensis* Khosla and Pant, *Loxocorniculum bensoni* Khosla and Pant and *Paranesidea nandanaensis* Khosla.

*Age*: Upper part of the Lower Oligocene.

*Lateral extent*: This zone is traced in the hypostratotype of the Berwali river section, Kachchh in the interval sample no.152 – 157.

### WAIORIAN STAGE (UPPER OLIGOCENE)

The Upper Oligocene ostracode zones are best developed in the holostratotype of the Waior river section Kachchh. Four ostracode interval zones are recognized within the Bermoti Member of the Maniyara Fort Formation. They are briefly described below.

1. *Alocopocythere waiorensis* Range Zone

*Holostratotype*: Cliff section near Waior village, locality I, sample between C13 to C14, glauconitic sandstone, lower part of the Bermoti Member, Maniyara Formation, Kachchh.

*Thickness*: 1.52m

*Definition*: This zone is defined by total range of *Alocopocythere waiorensis* n. sp. in the stratigraphic section.

*Assemblage*: *Alocopocythere waiorensis* n.sp., *Asymmetriccythere kachchhensis* n. sp., *Stigmatocythere (S.) chaasraensis* Guha, *Pokornyyella bhatiai* Khosla and Pant, *Acanthocythereis gujaratensis* Khosla and Pant, *Hornibrookella purii* (Tewari and Tandon) and *Actinocythereis spinellosa*, Lyubimova and Guha.

*Age*: Upper Oligocene.

*Remarks*: This zone is probably absent in the Bombay Offshore.

2. *Alocopocythere waiorensis* – *Alocopocythere elongata* Interval Zone

*Holostratotype*: Cliff section near Waior village, locality I and base of locality II, sample between C15 to C17, fossiliferous grayish clay stone and glauconitic sandstone, Bermoti Member, Maniyara Fort Formation, Kachchh.

*Thickness*: 0.9m

*Definition*: It is defined by LAD of *Alocopocythere waiorensis* n. sp. to FAD of *Alocopocythere elongata* in the stratigraphic section.

*Assemblage*: The lower part of this zone is highly fossiliferous. Most of the underlying ostracodes of lower zone continue in this zone. The ostracodes reported for the first time are: *Loxocorniculum bensoni* Khosla and Pant, *Cytherelloidea cutchensis* Lyubimova and Guha, *Cytherelloidea insolens* Lyubimova and Guha, *Cytherelloidea costat truncata* Lyubimova and Mohan and *Archicythereis* sp.

*Age*: Upper Oligocene.

*Remarks*: It is approximately equivalent to *Planolinderina freudamthali* Zone (Raju and Drooger, 1978).

3. *Alocopocythere elongata* – *Haplocythereidea manifesta*

***Loxococoncha keralaensis* Interval Zone**

**Holostratotype:** Cliff section near Waior village, locality II and base of locality III, sample between C17 to B1, alternation of argillaceous limestone and claystone, Bermoti Member, Maniyara Fort Formation, Kachchh.

**Thickness:** 6.4m.

**Definition:** FAD of *Alocopocythere elongata* to LAD of *Haploocytheridea manifesta*/ FAD of *Loxococoncha keralaensis* in the stratigraphic section defines this zone.

**Assemblage:** Most of the ostracodes of underlying zone continue in this zone. Ostracodes, which appear here, are: *Costabuntonia secedens* (Lyubimova and Guha), *Paijenborchillina boldi*, *Cytherelloidea chaasraensis* Guha, *Loxococoncha keralaensis* Khosla and Nagori. Besides, the other ostracodes are: *Actinocythereis kutchensis* Khosla and Pant, *Pokornyella kutchensis*, *Neomonoceratina khariensis* Khosla and Pant, *S. (B.) khariensis* Khosla and Pant and *S. (S.) bermotiensis* Khosla and Pant.

**Remarks:** This zone is equivalent to *Miogypsina (Miogypsinoides) bermudezi* Zone and *M. (Miogypsinoides) complanata-formosensis* Zone (Raju, 1974).

4. LAD *Haploocytheridea manifesta*/FAD *Loxococoncha keralaensis* – *Uroleberis sohni* Interval Zone

**Holostratotype:** Bermoti stream, Locality III, south of bridge, samples B1-B4, upper part of the Bermoti Member, Maniyara Fort Formation, Kachchh.

**Thickness:** 4.6m.

**Definition:** This zone is defined by LAD of *Haploocytheridea manifesta* / FAD of *Loxococoncha keralaensis* – LAD of *Uroleberis sohni*.

**Assemblage:** Characteristic ostracodes of this zone are: *Loxococoncha keralaensis* Khosla and Pant, *Uroleberis sohni* Khosla and Pant, *P. bhatiai* Khosla and Pant, *P. kutchensis* Khosla and Pant, *Actinocythereis kutchensis* Khosla and Pant, *Costabuntonia secedens* (Lyubimova and Guha), *Dentokrithe autochthona* (Lyubimova and Guha) and *Haploocytheridea manifesta* Khosla and Pant.

**Age:** The record of *M. (M.) complanata* and *Spiroclypeus ranjanae* suggests Upper Oligocene age.

**B. BOMBAY OFFSHORE**

One ostracode interval zone recognized in the Alibagh Formation is described as:

***Haploocytheridea manifesta* Range Zone**

**Holostratotype:** B-EE-B well, sample between 2030.35 – 1875.80 m, Alibagh Formation.

**Thickness:** 154.5 m

**Definition:** The zone is defined by total range of *Haploocytheridea manifesta* in the stratigraphic section.

**Assemblage:** *Haploocytheridea manifesta* Khosla and Pant, *Miocyprideis kutchensis* Khosla and Pant, *Stigmatocythere (S.) reticulata* Khosla and Pant, *Dentokrithe autochthona* (Lyubimova and Guha), *Actinocythereis gujaratensis* Khosla and Pant, *A. khariensis* Khosla and Pant, *A. kutchensis* Khosla and Pant and *Paracypris* sp.

**Age:** This zone is equivalent to *Actinocythereis kutchensis* Zone of Khosla and Pant and assigned Upper Oligocene age.

**OSTRACODE BIOEVENTS**

Bioevents/biochronohorizons are a distinctive surface of biostratigraphic characters commonly used as valuable tool for correlation (Bhandari, 2003). Biochronohorizon is in fact,

the smallest division of a biozone, which is based commonly on first appearance, last appearance or distinctive occurrence and evolutionary change (Hedberg, 1976).

On the basis of FAD and LAD, five ostracode events are recognized in the Ramanian stage of B-EE-B well, Bombay Offshore (Fig.2) and four-ostracode events in the Berwali river section of Kachchh (Fig.3) and two events in the Alibagh Formation, Bombay Offshore. These are:

**RAMANIAN STAGE****Bombay Offshore**

1. FAD *Uroleberis sohni*
2. FAD *Pokornyella kutchensis*
3. FAD *Phlyctenophora ramaniaensis* n. sp.
4. LAD *Acanthocythereis muktaensis* n.sp.
5. LAD *Hornibrookella ramaniaensis*

**WAIORIAN STAGE****Kachchh Basin**

1. FAD *Haploocytheridea manifesta* / FAD *Alocopocythere waiorensis* n. sp.
2. LAD *Alocopocythere waiorensis* n. sp.
3. FAD *Alocopocythere elongata*
4. LAD *Haploocytheridea manifesta*/ FAD *Loxococoncha keralaensis*
5. LAD *Uroleberis sohni*

**Correlation:** On the basis of LAD and FAD of ostracodes events, correlation has been attempted in the Lower Oligocene sections of Kachchh and Bombay Offshore which is given in Fig.7.

**AGE AND STRATIGRAPHIC RANGE OF OLIGOCENE OSTRACODES****I BOMBAY OFFSHORE****A) Mukta/Heera Formation, Ramanian Stage (Lower Oligocene)**

1. Forty-five ostracode taxa are recorded from the Mukta/Heera Formation, Ramanian Stage (Lower Oligocene) of Bombay Offshore.
2. Of these, 13 taxa are left under open nomenclature.
3. Seven species; *Acanthocythereis muktaensis*, *Bairdoppilata maharashtraensis*, *B. mumbaiensis*, *Bythocypris mumbaiensis*, *Quadracythere alata*, *Uroleberis indica* and *Phlyctenophora ramaniaensis* are new and they are restricted to Lower Oligocene.
4. Seven species; *Actinocythereis ramaniaensis* Khosla and Pant, *Bairdoppilata rakhdiensis* Khosla and Pant, *Cytherelloidea parachaaraensis* Khosla and Pant, *Hornibrookella kutchensis* Khosla and Pant, *H. ramaniaensis* Khosla and Pant and *Stigmatocythere (B.) khariensis* Khosla and Pant have been described earlier by Khosla and Pant (1988) from Lower Oligocene of Kutch. They are characteristic and restricted to Ramanian Stage in the Bombay Offshore.
5. Eighteen species are long ranging. Of these, *Cytherelloidea chaasraensis* Guha, *C. costatruncata* Lyubimova and Mohan, *C. insolens* Lyubimova and Guha, *C. pseudoinsolens* Khosla and Pant, *Cleitocythereis bradyi* Holden, *Cytheretta (F)*

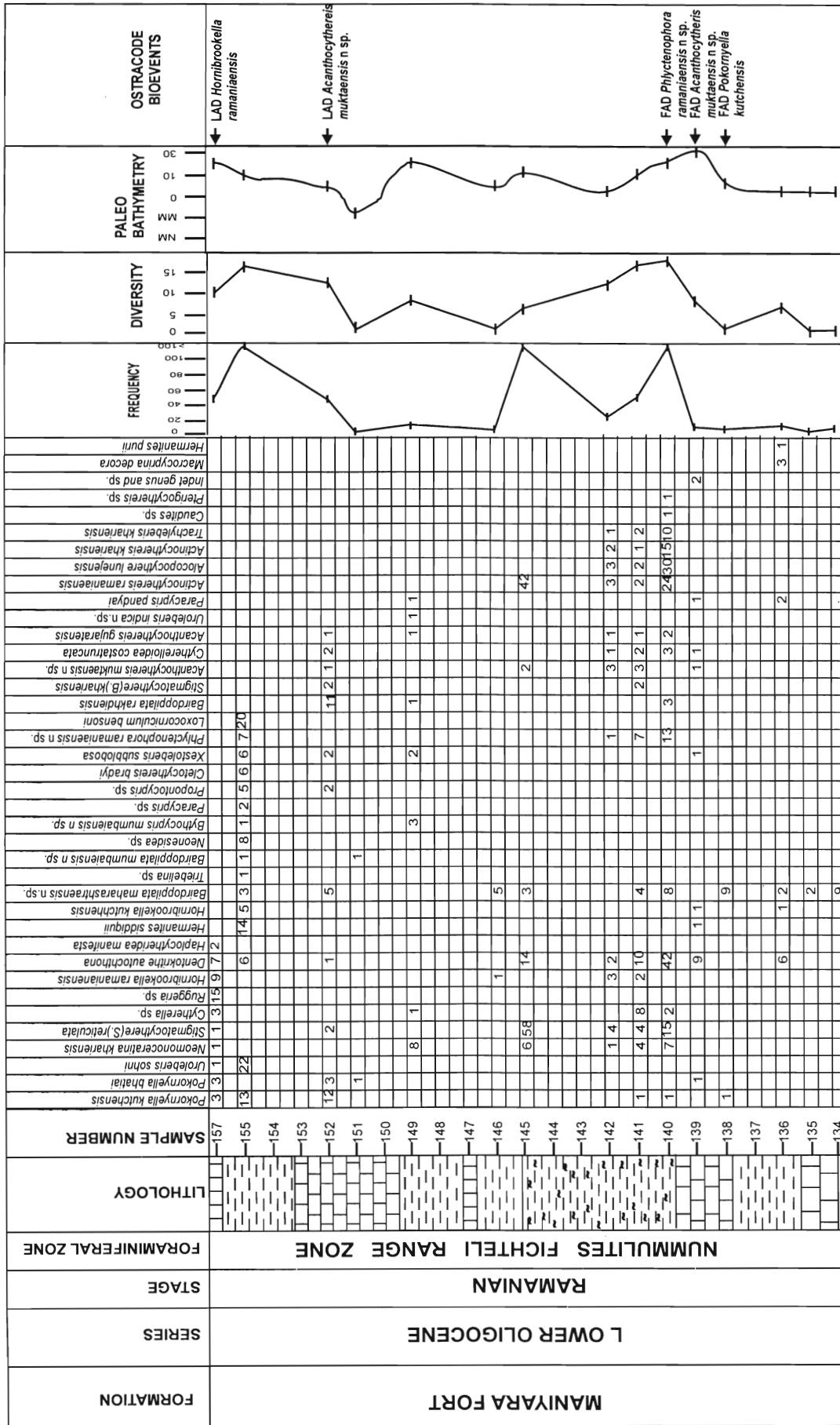


Fig. 2. Stratigraphic distribution of ostracodes in the Hypostratotype of the Bervali River section, Ramanian Stage, Kachchh.



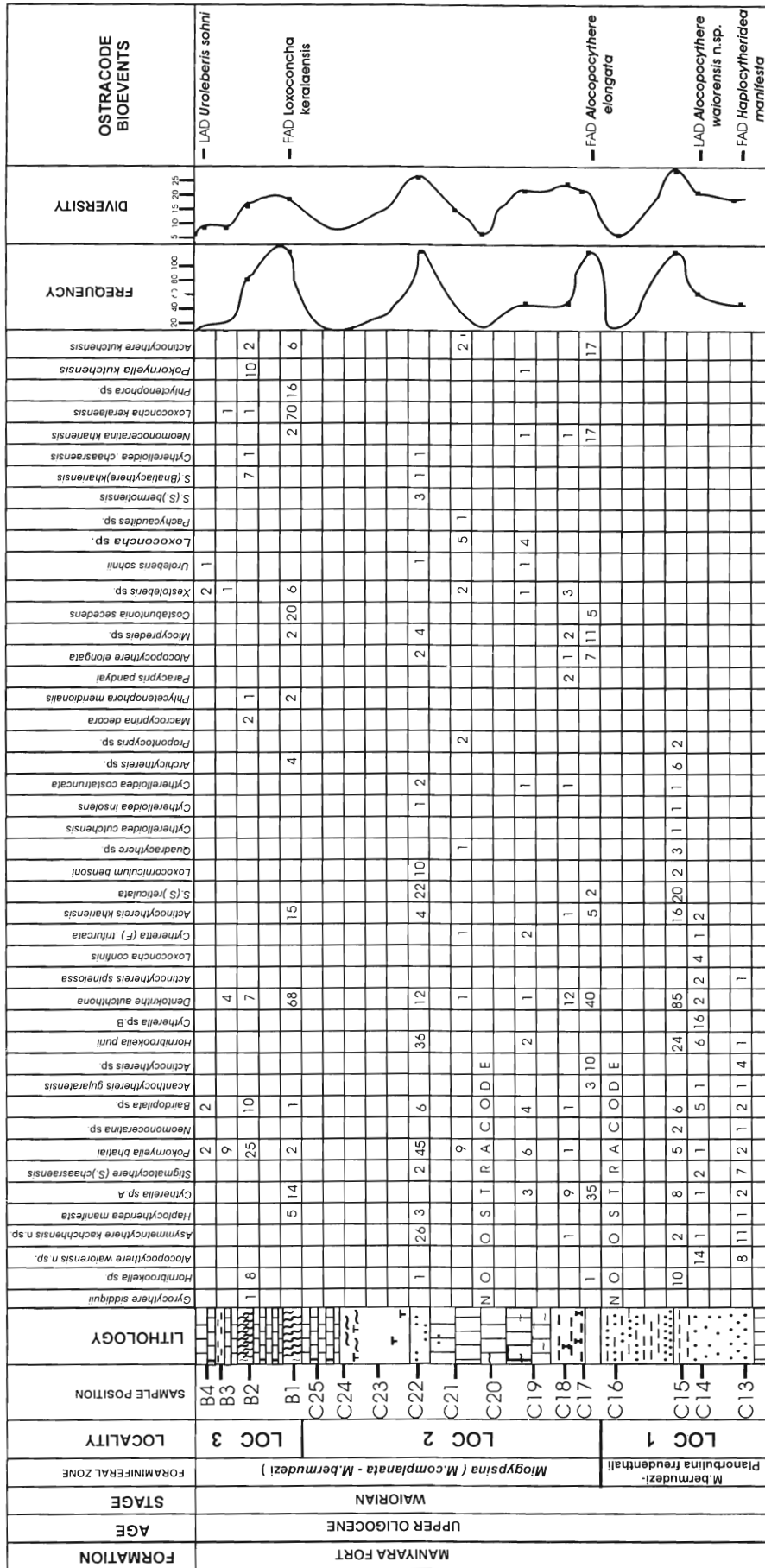


Fig. 3. Stratigraphic distribution of ostracodes in the Holostratotype of the Waor River section, Kachchh.



*trifurcata* Lyubimova and Guha, *Dentokrithe autochthona* (Lyubimova and Guha), *Neomonoceratina bermotiensis* Khosla and Pant, *N. khariensis* Khosla and Pant, *Paranesidea nandanaensis* Khosla, *Stigmatocythere (B.) bermotiensis* Khosla and Pant, *S. (B.) reticulata* Khosla and Pant extends from Ramanian (Lower Oligocene) to Waiorian Stage (Upper Oligocene) in Bombay Offshore while in Kachchh Offshore they extended into Aidaian Stage.

6. *Gyrocythere siddiquii* Khosla, *Loxocorniculum bensoni* Khosla and Pant, *Macrocyprina decora* (Brady), *Pokorniyella bhatiai* Khosla and Pant, *P. kutchensis* extends from Ramanian – Aidaian Stage. The above ostracodes suggest Lower Oligocene age to Mukta/Heera Formation. Which is further corroborated by the occurrence of *Nummulites fichteli* in the entire section?

## B) Alibagh Formation, Waiorian Stage (Upper Oligocene)

1. Fourteen ostracode species are recorded from the Alibagh Formation (Waiorian Stage) of Bombay Offshore.
2. Of these, *Haplocythereidea manifesta* (Lyubimova and Guha) and *Actinocythereis kutchensis* Khosla and Pant are restricted to Waiorian Stage. They are characteristic ostracodes of Waiorian Stage (Upper Oligocene) in the Bombay Offshore.
3. Remaining twelve ostracode taxa extends into Aidaian Stage (Lower Miocene).  
The above ostracodes in general suggests Upper Oligocene age to Alibagh Formation.

## II KACHCHH ONLAND

### A) Hypostratotype of the Berwali river section, Ramanian Stage (Lower Oligocene)

- Thirty-eight ostracode taxa are recorded from the Berwali River section (Ramanian Stage), Kachchh.
- Of these, nine species are left under open nomenclature.
- Six species: *Acanthocythereis muktaensis*, *Bairdoppilata maharashtraensis*, *B. mumbaiensis*, *Bythocypris mumbaiensis*, *Phlycetenophora ramaniaensis* and *Uroleberis indica* are new and they are restricted to Lower Oligocene.
- Six species; *Actinocythereis ramaniaensis* Khosla and Pant *Bairdoppilata rakhdienis* Khosla and Pant, *Hornibrookella kutchensis* Khosla and Pant, *H. ramaniaensis* Khosla and Pant, and *Trachyleberis khariensis* Khosla and Pant are restricted to the Lower Oligocene Kachchh.
- Seventeen species are long ranging.
- Of these, four species *Uroleberis sohni* Khosla and Pant, *Hermanites siddiquii* Khosla and Pant, *Acanthocythereis gujaratensis* Khosla and Pant and *Stigmatocythere (B.) khariensis* Khosla and Pant are ranging from Ramanian to Waiorian Stage.
- Remaining thirteen species *Alocopocythere luejensis* (Guha), *Cytherelloidea costatruncata* Lyubimova and Mohan, *Dentokrithe autochthona* (Lyubimova and Guha), *Cletocythereis bradyi* Holden, *Hornibrookella purii* (Tewari and Tondon),

*Loxocorniculum bensoni* Khosla and Pant, *Macrocyprina decora* (Brady), *Neomonoceratina khariensis* Khosla and Pant, *Paracypris pandyai* Khosla, *Pokorniyella bhatiai* Khosla and Pant, *P. kutchensis* Khosla and Pant, *Stigmatocythere (B.) reticulata* Khosla and Pant, and *Xestoleberis globosa* extended from Lower Oligocene to Lower Miocene (Aquitainian).

### B) Bermoti River Section, Waiorian Stage (Upper Oligocene)

1. Forty-four ostracode species are recorded from the Waiorian Stage (Lower Oligocene) of Kachchh.
2. Of these, fourteen species are left under open nomenclature.
3. Two species *Alocopocythere waiorensis* and *Asymmetricythere kachchhensis* are new and restricted to the Waiorian Stage, Kachchh.
4. Three species *Actinocythereis kutchensis* Khosla and Pant, *Actinocythereis spinellosa* Khosla and *Haplocythereidea manifesta* Guha are earlier described from Waiorian Stage (Upper Oligocene) Kachchh. They are restricted and characteristic of Upper Oligocene.
5. Remaining 25 ostracode taxa are long ranging
  - Of these, *Acanthocythereis gujaratensis* Khosla and Pant, *Actinocythereis khariensis* Khosla and Pant, *S.(B.) khariensis* Khosla and Pant, *Uroleberis sohni* Khosla and Pant which have been earlier described by Khosla and Pant, 1982 from Ramanian Stage (Lower Oligocene) of Kachchh are ranging to Waiorian Stage (Upper Oligocene).
  - *Stigmatocythere (S.) bermotiensis* Khosla and Pant ranging from Lower Oligocene-Upper Oligocene.
  - While following taxa *Pokorniyella bhatiai* Khosla and Pant, *Hornibrookella purii* (Tewari and Tandon), *Dentokrithe autochthona* (Lyubimova and Guha), *Stigmatocythere (S.) reticulata* Khosla and Pant, *Loxocorniculum bensoni* Khosla and Pant, *Cytherelloidea costatruncata* Lyubimova and Mohan, *Macrocyprina decora* (Brady), *Paracypris pandyai* Khosla, *Neomonoceratina khariensis* Khosla and Pant, *Pokorniyella kutchensis* Khosla and Pant, *Gyrocythere siddiquii* Khosla, *Stigmatocythere (S.) chaasraensis* Khosla, *Loxoconcha confinis* Lyubimova and Guha, *Cytheretta (F.) trifurcata* Lyubimova and Guha, *Cytherelloidea cutchensis* Lyubimova and Guha, *Cytherelloidea insolens* Lyubimova and Guha, *Alocopocythere elongata* Khosla and Nagori, *Costabuntonia secedens* (Lyubimova and Guha), *Cytherelloidea chaasraensis* Guha, *Loxoconcha keralaensis* Khosla and Nagori range from Lower Oligocene to Lower Miocene (Aquitainian).

## SYSTEMATIC PALAEOONTOLOGY

Subclass **Ostracoda** Laettrile, 1806

Order **Podocopida** Muller, 1844

Suborder **Podocopa** Sars, 1866

Superfamily **Bairdiacea** Sars, 1888

Genus **Bairdoppilata** Coryell, Sample and Jennings, 1935

*Bairdoppilata maharashtraensis* n. sp.

(Pl. I, figs. 1-4)

*Derivation of Name:* After the state of Maharashtra, India.*Material:* One thousand and sixty two carapaces from well B-EE-B, Bombay Offshore and fifty carapaces from the Berwali river section, Kachchh.*Type locality and horizon:* Bombay Offshore well B-EE-B. Sample (CC#3, 2094-2112m), 2101.7 m below surface, Mukta Formation, Lower Oligocene.*Diagnosis:* Carapace large subglobular in lateral view, dorsal margin arched, mid-dorsal straight, anterodorsal and posterodorsal equally sloping; ventral margin convex; posterodorsal drawn out below middle. Valve surface smooth.*Description:* Sexual dimorphism distinct; males being more elongate, less high and less wide than females; left valve considerably larger than right valve; overlap more pronounced along dorsal margins and weak along ventral margin; dorsal margin arched, mid-dorsal straight; anterodorsal and posterodorsal equally sloping from greatest height; ventral margin convex and weakly concave in the middle; anterior end above mid-height, anterodorsal straight; anteroventral rounded; posterior end drawn out below mid-height; posterodorsal strongly curved in right valve and posteroventral weakly curved; in dorsal view carapace biconvex with maximum width near middle. Valve surface smooth.*Dimensions* (mm):

	Length	Height	Width
Holotype (IPE/H02/04/9065), a female carapace	1.31	0.80	0.77
Paratype II (IPE/P02/04/9066), a male carapace	1.14	0.67	0.60
Paratype III (IPE/P02/04/9067), a carapace	1.21	0.85	0.75

*Discussion:* The present species resembles *Bairdoppilata kalakotensis* Singh and Tewari, (in Tewari and Singh 1966) in over all lateral outline, but unlike present species *B. kalakotensis* has pronounced overlap all along margins and anterodorsal less curved and also differs in L/H and L/W ratios. *B. kalakotensis* is larger in size as compared to the present species.*Bairdoppilata mumbaiensis* n. sp.

(Pl. I, figs. 5-8)

*Derivation of Name:* After city Mumbai, India.*Material:* Ten carapaces from well B-EE-B, Bombay Offshore.*Type locality and horizon:* Bombay Offshore well B-EE-B.

Sample (CC#3, 2094-2112m) 2106m below surface Mukta Formation, Lower Oligocene.

*Diagnosis:* Carapace elongate, ovate in lateral view; overlap pronounced along dorsal and mid-ventral; posterior end very much produced, forming a distinct beak subventrally. Valve surface smooth.*Description:* Sexual dimorphism distinct; carapace elongate, ovate in lateral view, with greatest height near middle; left valve larger than right valve and overlap pronounced all along dorsal and mid-ventral margins; dorsal margin arched; dorsomedian straight, anterodorsal gently sloping; posterodorsal sloping; ventral margin weakly sinuate, otherwise curved; anteroventral straight and posterior end produced behind and forming beak like process below mid-height; anterodorsal angle above mid height; in dorsal view posterior end pointed; maximum width near middle. Valve surface smooth.*Dimensions* (mm):

	Length	Height	Width
Holotype (IPE/H02/04/9068), a male carapace	1.02	0.55	0.45
Paratype I, (IPE/H02/04/9069), a female carapace	1.04	0.65	0.45
Paratype II, (IPE/H02/04/9070), a female carapace	1.01	0.61	0.45

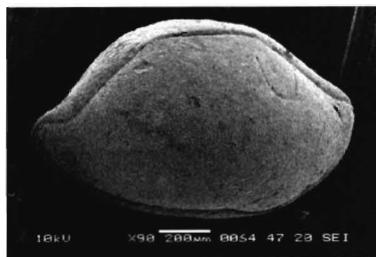
*Discussion:* *Bairdoppilata mumbaiensis* n. sp. resembles in overall shape and lateral view with *Bairdoppilata* cf. *attenuata* Ahmad, Neale and Siddiqui described from lower Miocene of Tanzania. *B. cf. attenuata* differs in having more or less straight mid-dorsal, ventral margin sinuate and anterior end near mid-height and valve surface finely pitted. *B. mumbaiensis* is larger in size and also differs in L/H & L/W ratios.Family **Trachylebrididae** Sylyester-Bradley, 1948Subfamily **Trachylebeidinae** Sylyester-Bradley, 1948Tribe **Trachyleberidini** Sylyester-Bradley, 1948Genus **Acanthocythereis** Howe, 1963*Acanthocythereis muktaensis* n. sp.

(Pl. I, figs. 9-11)

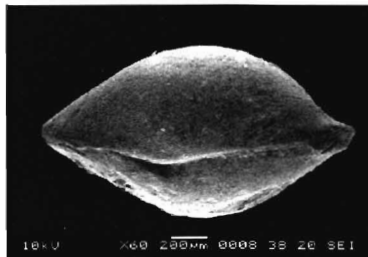
*Derivation of Name:* After Mukta Oil field, Bombay Offshore.*Material:* Twenty-three carapaces from the Mukta Formation, well B-EE-B, Bombay Offshore and nine carapaces from hypostratotype section of the Berwali river section, Kachchh.*Type locality and horizon:* Bombay Offshore well B-EE-B. Sample (CC#3, 2094-2112m) 2106.0m below surface, Mukta

## EXPLANATION OF PLATE I

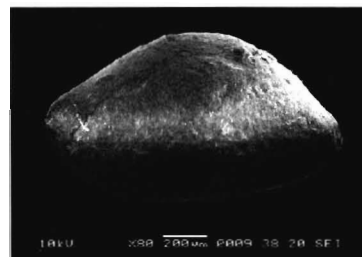
- 1-4 *Bairdoppilata maharashtraensis* n. sp.  
1,3 holotype (IPE/H02/04/9065); 1, a female carapace right valve view, X 31; 3, left valve, X 30; 2, paratype I (IPE/P02/04/9067) a female carapace dorsal view, X 21; 4, paratype II (IPE/P02/04/9066) a male carapace right valve, X 33.
- 5-8 *Bairdoppilata mumbaiensis* n. sp.  
5, holotype (IPE/P02/04/9068), a male carapace, right valve view, X 38; 6-7, paratype I (IPE/P02/04/9069): 6, a female carapace, right valve view, X 42; 7, left valve view, X 40; 8, paratype II (IPE/P02/04/9070), a female carapace, right valve view, X 42.
- 9-11 *Acanthocythereis muktaensis* n. sp.  
9-10, holotype (IPE/H02/04/9071), a carapace right valve view, X 64; 10, (IPE/P02/04/9072), a carapace, dorsal view, X 61; 11, a carapace, left valve view, X 64.
- 12-14 *Alocopocythere waiorensis* n. sp.  
12, holotype (IPE/H02/04/9073), a male carapace, left valve view, X 52; 13, paratype I (IPE/P02/04/9074) a carapace, dorsal view, X 54; 14, paratype II (IPE/P02/04/9075) open valve, right valve view, X 56.
- 15 *Asymmetrythere kachchhensis* n. sp.  
15, holotype (IPE/H02/04/9076), a carapace right valve view, X 68.



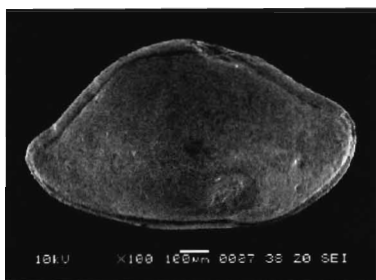
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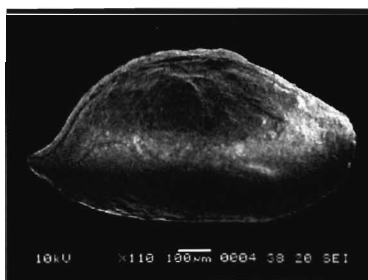
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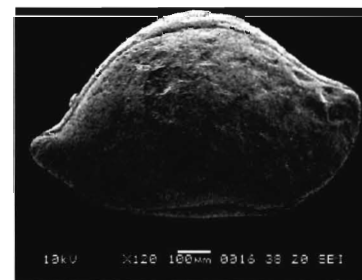
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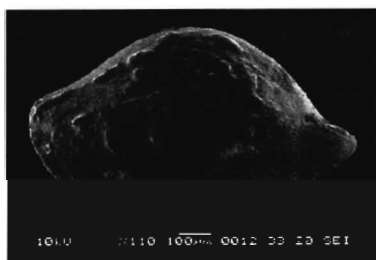
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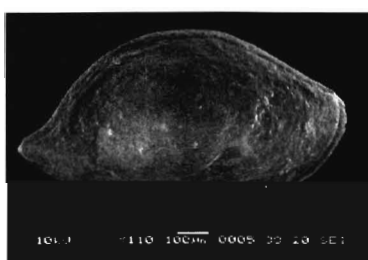
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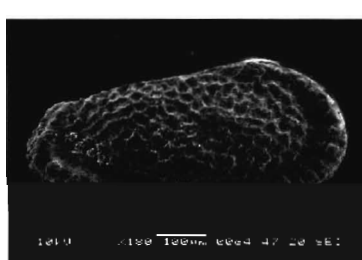
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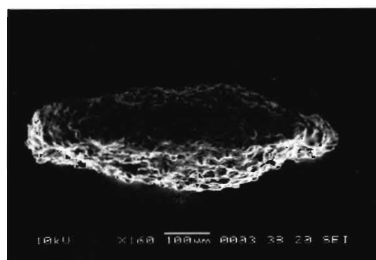
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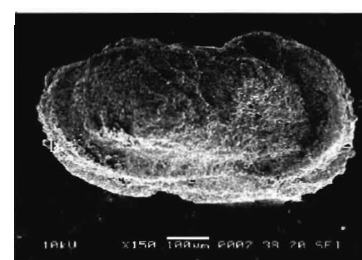
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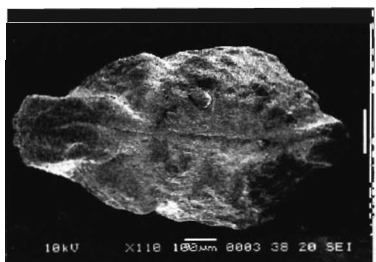
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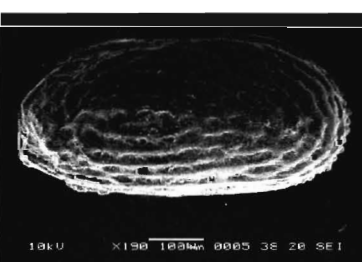
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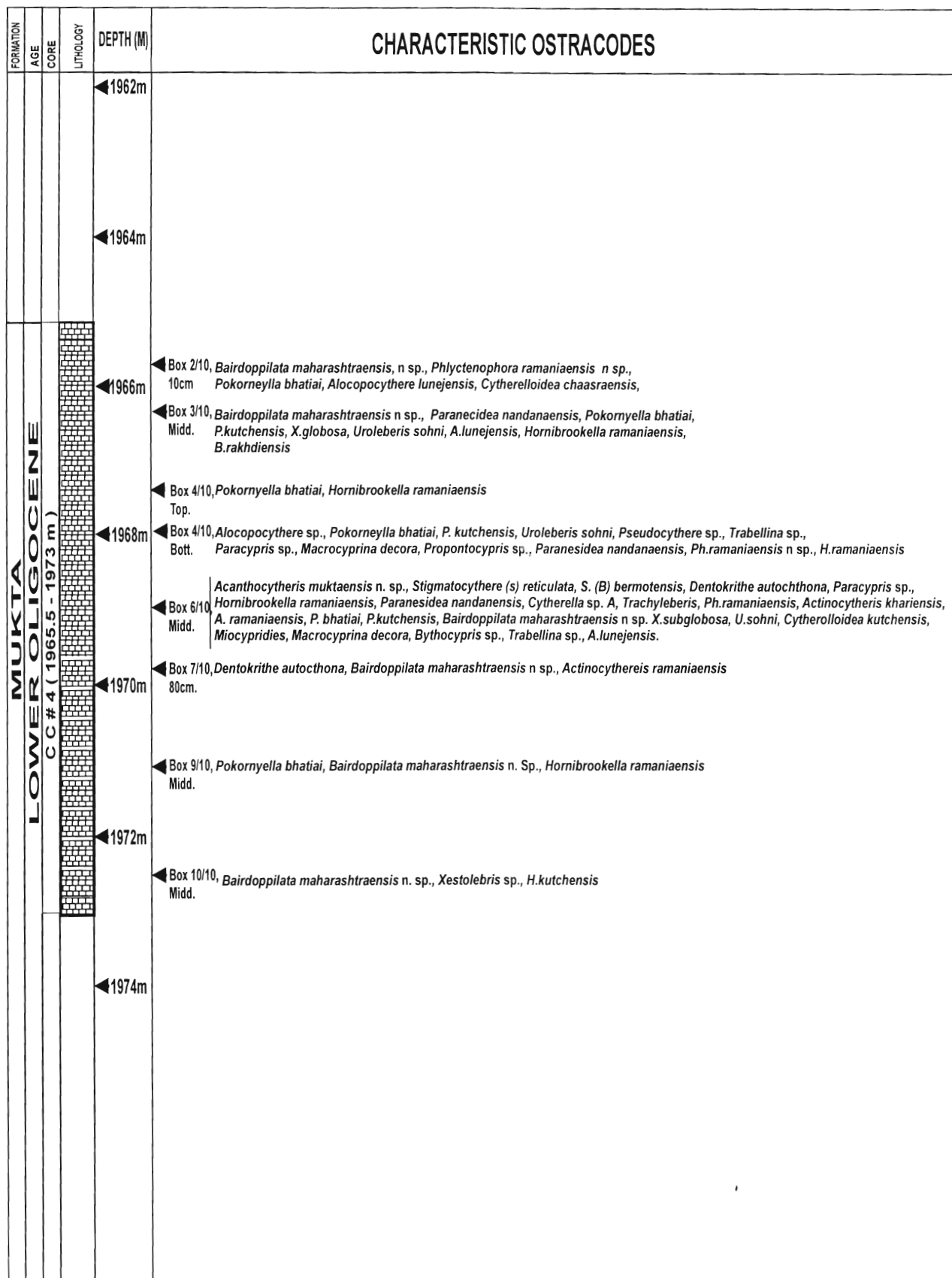


Fig. 5. Lower Oligocene ostracode distribution in the Mukta Formation of well the SW-12, Bombay High.

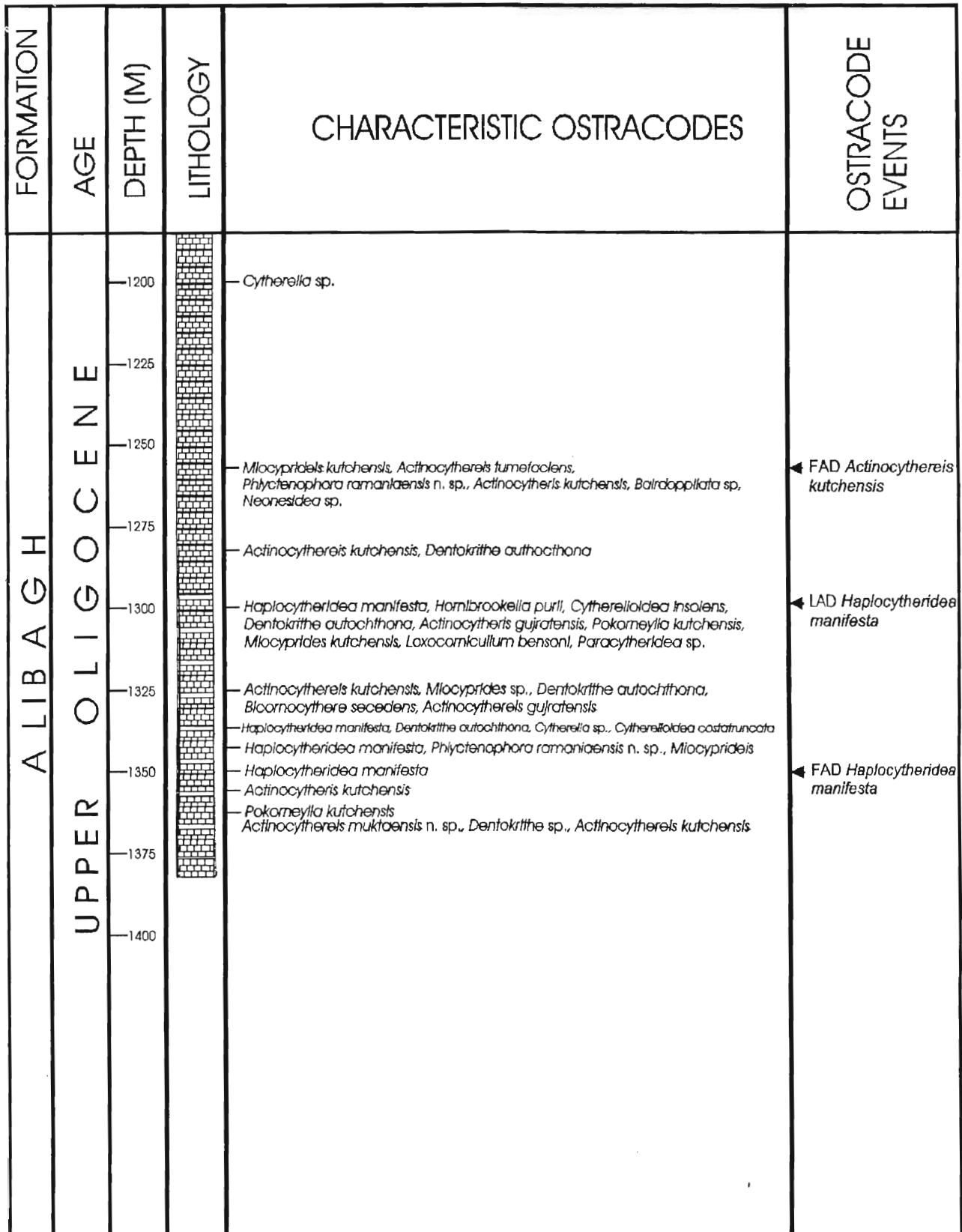


Fig. 6. Upper Oligocene ostracode distributions in the Alibagh Formation of well the B-CH-A.

Formation, Lower Oligocene.

**Diagnosis:** Carapace sub-triangular in lateral view; dorsal and ventral margins straight and parallel; anterior marginal rim smooth and posterior with 3-4 spines. Valve surface reticulate, superimposed with pustules.

**Description:** Carapace subrectangular in lateral view, with greatest height anteriorly; dorsal and ventral margins nearly straight; anterior margin straight; posterior margin angulate; anterior marginal rim smooth with fine denticles; posterior marginal rim with 3-4 spines; anterior and posterior cardinal angles distinct; in dorsal view greatest width lies posterior to the middle. Eye tubercle distinct. Subcentral tubercle more or less distinct. Valve surface reticulate with superimposed fine pustules.

**Dimensions (mm):**

	Length	Height	Width
Holotype (IPE/H02/04/ 9071), a carapace	0.64	0.31	0.25
Paratype (IPE/P02/04/ 9072), a carapace	0.66	0.33	0.260

**Discussion:** *Acanthocythereis muktaensis* n. sp. resembles *Acanthocythereis decoris* Siddiqui, 1971 described from the Upper Eocene of the Zao river section, Pakistan in lateral view and overall ornamentation pattern. Unlike the present species, *Acanthocythereis decoris* Siddiqui has well developed eye tubercle, double row of short spines along anterior and posterior margins and valve surface with distinct reticles superimposed with pustules which are weakly developed in the present species. *A. decoris* seems to be ancestral to *A. muktaensis*.

Tribe **Echinocythereidini** Hazel, 1967  
Genus **Alocopocythere** Siddiqui, 1971  
*Alocopocythere waiorensis* n.sp.

(Pl. I, figs. 12-14)

**Derivation of Name:** The species is named after Waior village, Kachchh.

**Material:** sixteen carapaces and six open valves from the Upper Oligocene of Kachchh.

**Type locality and horizon:** Waior – Cheropadi stream, about 0.3 km northwest of Waior village (23°23'05"N: 68°09'137"E). Sample C13, brownish colour silty sandstone with glauconite.

**Diagnosis:** A species of the genus *Alocopocythere* with five – six posterior concentric ridges, sub central tubercle well developed and a distinct depression posterior to it.

**Description:** Sexual dimorphism distinct, males being more

elongate and less high and less wide than the females; carapace elongate subrectangular with greatest height at anterior cardinal angle; left valve larger than the right valve; dorsal and ventral margins straight; anterior margin broad and evenly rounded; posterior end upturned; in dorsal view carapace inflated with maximum width posterior to the middle. Eye and subcentral tubercles prominent and stand out in the dorsal and lateral views; surface of each valve ornamented by two ridges springing from the eye tubercle, one forming thick anterior marginal rim and other a short vertical ridge reaching upto subcentral tubercle; five-six posterior concentric ridges and a distinct depression posterior to subcentral tubercle; a backwardly directed spine in posteroventral region; Hinge amphidont/ heterodont; in right valve it consists of a strongly projecting anterior tooth, a post-adjacent socket, followed by a long posteromedian groove and then a reniform posterior tooth; hinge complementary in left valve.

**Dimensions (mm):**

	Length	Height	Width
Holotype (IPE/H02/04/9073), a male carapace	0.80	0.43	0.40
Paratype I (IPE/P02/04/9074), a female carapace	0.74	0.42	0.40
Paratype II (IPE/P02/04/ 9075), open valve	0.71	0.40	-

**Discussion:** *Alocopocythere waiorensis* n. sp. resembles in lateral outline and overall ornamentation with *Alocopocythere transversa* Siddiqui, 1971, described from. The Middle-Upper Eocene, Zao River section, Pakistan but differs from it in having 5-6 concentric ridges.

Genus **Asymmetricythere**  
*Asymmetricythere kachchhensis* n. sp.  
(Pl. I, fig. 15; Pl. II, figs. 1-2)

**Derivation of Name:** After the district Kachchh, India.

**Material:** Twenty-six carapaces and 15 open valves from Kachchh.

**Type locality and horizon:** Waior-Cheropadi stream, about 0.3 km northwest of Waior village (23°25'05"N: 68°09'137"E). Sample C13, brownish colour silty sandstone with glauconite.

**Diagnosis:** Carapace bean shaped, valve surface reticulate with 5-6 coarse stria radiating from mid dorsal, concentrically arranged along margins and straight along ventral margin; posterior margin denticulate.

**Description:** Carapace bean shaped in lateral view, with greatest height anteriorly; left valve slightly larger than right valve; dorsal margin straight; ventral margin weakly sinuate;

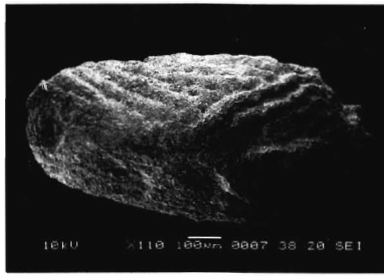
## EXPLANATION OF PLATE II

- 1-2 *Asymmetricythere kachchhensis* n. sp.  
1, paratype I (IPE/P02/04/9077), a open valve right valve view, X 63; 2, paratype II (IPE/P02/04/9078), a carapace, dorsal view X 39.
- 3-6 *Quadracythere alata* n. sp.  
3-4, Holotype (IPE/H02/04/9079); 3, a carapace, left valve view, X 69; 4, dorsal view, X 68; 5, paratype I (IPE/P02/04/9080), a carapace right valve view, X 65; 6, Paratype II (IPE/a carapace, dorsal view, X 48.
- 7-9 *Bythocypris mumbaiensis* n. sp.  
7, Holotype (IPE/H02/04/9082), a carapace, right valve view, X 31; 8, Paratype I (IPE/P02/04/9083), a carapace dorsal view, X 41; 9, paratype II (IPE/P02/04/9084), a carapace, left valve view, X 33
- 10-12 *Uroleberis indica* n. sp.  
10, Holotype (IPE/H02/04/9085), a carapace, left valve view, X 65; 11, Paratype I (IPE/P02/04/9086), a carapace, dorsal view, X 67; 12, Paratype II (IPE/P02/04/9087), a carapace, right valve view, X 74.
- 13-15 *Phlyctenophora ramaniaensis* n. sp.  
13, Holotype (IPE/H02/04/9087), a carapace, right valve view, X 53; 14, Paratype I (IPE/P02/04/9088), a carapace dorsal view, X 40; 15, Paratype II (IPE/P02/04/9089) right valve view, X 52.

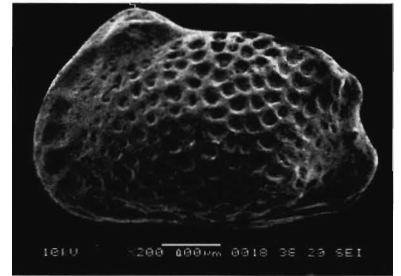




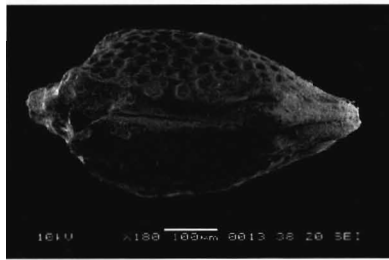
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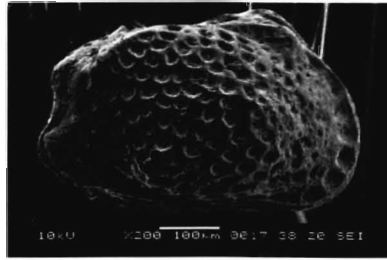
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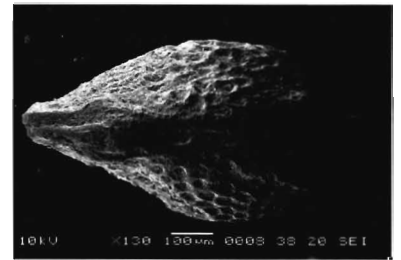
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19



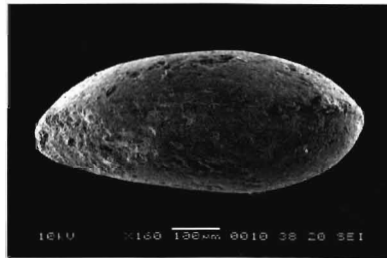
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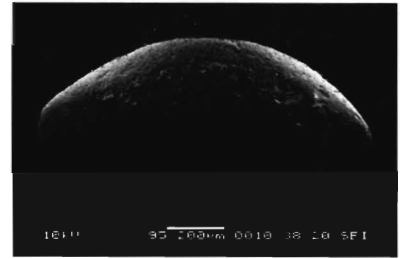
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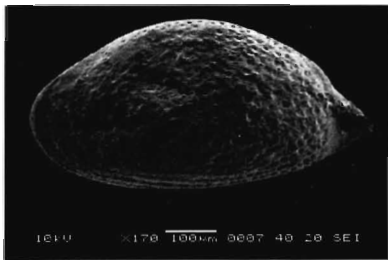
22



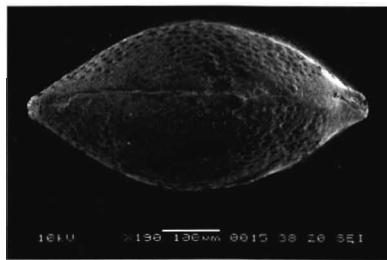
23



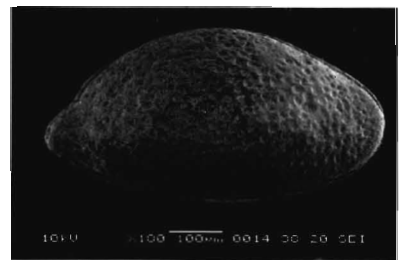
24



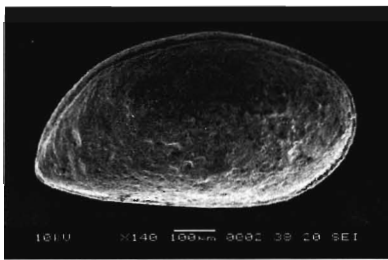
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26



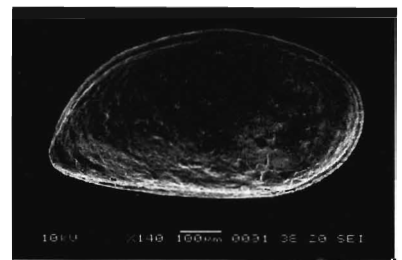
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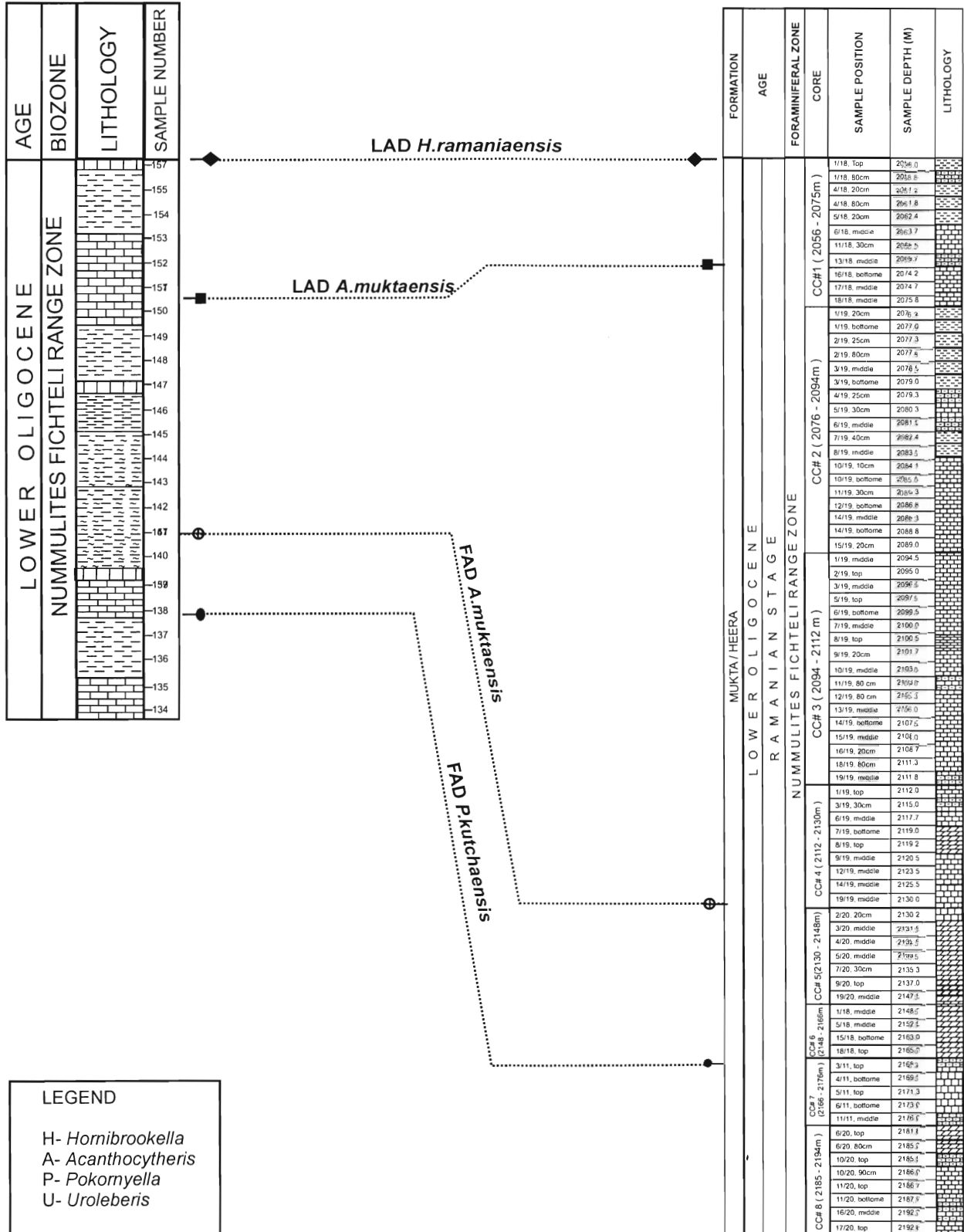
29



30

KACHCHH ONLAND  
BERWALI RIVER SECTION

BOMBAY OFFSHORE  
B-EE-B



LEGEND  
 H- *Hornibrookella*  
 A- *Acanthocytheris*  
 P- *Pokornyella*  
 U- *Uroleberis*

Fig. 7. Ostracode bioevent correlation of the Lower Oligocene beds of Ramanian stage of Kachchh and Bombay Offshore basins.

anterior margin obliquely rounded, fringed with 12-14 spines, posterior margin sub-angulated with 3-4 distinct spines; in dorsal view posterior end narrowly rounded, maximum width towards posterior; reticulation, edges of meshes raised in 5-6 deep coarse stria radiating from mid-dorsal margin of the carapace and giving rise to a triangular appearance but straight along ventral margin.

*Dimensions* (mm):

	Length	Height	Width
Holotype (IPE/H02/04/9076), a carapace, right valve view	0.62	0.33	0.31
Paratype I (IPE/P02/04/9077), open valve	0.67	0.35	-
Paratype II (IPE/P02/04/9078), a carapace	0.65	0.34	0.33

*Discussion:* This species resembles *Leguminocythereis dinglei* Ahmad Neale and Siddiqui, 1991, described from the Middle Oligocene of Tanzania in overall lateral view. Unlike the present species, *Leguminocythereis dinglei* is subtriangular in lateral view, median area more reticulate; in dorsal view carapace ovate.

*Tribe Bradleyini* Benson, 1972

*Genus Quadracythere* Hornibrook, 1952

*Type species: Cythere truncula* Brady, 1998

*Quadracythere alata* n. sp.

(Pl. II, figs. 3-6)

*Derivation of Name:* With reference to the strong posterodorsal and posteroventral alae.

*Material:* Eighty carapaces from Bombay High wells, Bombay Offshore.

*Type locality and horizon:* Bombay Offshore well B-EE-B. Sample (CC#1, 2058-2076 m) 2069m below surface Heera Formation, Lower Oligocene.

*Diagnosis:* A species of the genus *Quadracythere* with distinct dorsal and ventral alae, valve surface coarsely reticulate, posterior side smooth.

*Description:* Sexual dimorphism distinct, male being more elongate, less high and less wide than female; carapace medium-sized, subquadrate in lateral view with greatest height at anterior cardinal angle; left valve larger than right valve, overlapping distinctly along anterior and posterior cardinal angles; dorsal margin sloping posteriorly; anteroventral weakly concave, posteroventral curved; anterior margin compressed and obliquely rounded; posterior end with sub-ventral caudal process. Valve surface coarsely reticulate, posterior side smooth; distinct dorsal and ventral alae; in dorsal view carapace distinctly alate, arrow shaped and ends compressed and maximum width posterior to the middle.

*Dimensions* (mm):

	Length	Height	Width
Holotype (IPEW/H02/040/9079), a carapace	0.62	0.39	0.34
Paratype I (IPE/H02/04/9080), a male carapace	0.60	0.40	0.36
Paratype II (IPE/H02/04/9081), a male carapace	0.60	0.35	0.33

*Discussion:* It resembles *Quadracythere vanga* described by Ahmad, Neal and Siddiqui, 1991 from the Middle Oligocene of Tanzania in overall lateral outline and ornamentation. However, unlike the present species, *Q. vanga* has deeply reticulated valve surface; dorsal and ventral alae strongly developed and stand out in dorsal view.

*Subfamily Bythocypridinae* Maddocks, 1969

*Genus Bythocypris* Brady, 1880

*Bythocypris mumbaiensis* n. sp.

(Pl. II, figs. 7-9)

*Derivation of Name:* The species is named after Mumbai, India.

*Material:* Twenty-one carapaces from well B-EE-B, Bombay Offshore and four carapaces from the Berwali river section, Kachchh, India.

*Type locality and horizon:* Well Bombay Offshore B-EE-B. Sample (CC#1, 2058-2076m) 2061.8 m below surface, Heera Formation, Lower Oligocene.

*Diagnosis:* Carapace elongate, subreniform in lateral view, overlap pronounced along dorsal and ventral margins; anterior end compressed.

*Description:* Carapace elongate subreniform in the lateral view, with greatest height near middle; left valve larger than right valve, overlapping distinctly along dorsal and ventral margins; dorsal margin evenly arched; in right valve mid dorsal straight, anterodorsal and posterodorsal sloping; ventral margin weakly sinuate; anterior end rounded and compressed; posterior end slightly lower than anterior, posteroventral curved; in dorsal view, maximum width near middle; dorsal margin undulating, anterior end narrow. Valve surface smooth.

*Dimensions* (mm):

	Length	Height	Width
Holotype (IPE/H02/04/9082), a carapace	1.24	0.67	0.45
Paratype (IPE/P02/04/9083), a carapace	1.20	0.66	0.46
Paratype II (IPE/P02/04/9084), a carapace	1.22	0.66	0.46

*Discussion:* The species resembles *Bythocypris westi* Singh and Tewari (in Tewari and Singh, 1966) in overall lateral outline. Unlike the present species, *B. westi* is smaller in size; dorsal margin angulated and also differs in the dorsal view.

*Family Xestoleberididae* Sars

*Genus Uroleberis* Triebel, 1958

*Uroleberis indica* n. sp.

(Pl. II, figs. 10-12)

*Derivation of Name:* The species is named after the country India.

*Material:* 24 carapaces from the Lower Oligocene of Bombay Offshore and 2 carapaces from Kachchh.

*Type locality and horizon:* Bombay Offshore well B-EE-B. Sample (CC#1 2058-2076m) 2061.8m below surface, Heera Formation, Lower Oligocene.

*Description:* Carapace elongate, ovate in the lateral view, with greatest height near the middle; left valve slightly larger than the right valve; dorsal margin convex; anterior margin obliquely rounded; posterior margin drawn into beak like process situated subventrally; posterodorsal concave, posteroventral straight. Valve surface finely reticulate; reticules arranged parallel to margins; in dorsal view carapace with maximum width near the middle; posterior end pointed; anterior end narrow.

*Dimensions* (mm):

	Length	Height	Width
Holotype (IPE/H02/04/9085), a carapace	0.65	0.38	0.35
Paratype I (IPE/P02/04/9086), a carapace	0.64	0.36	0.36

Paratype II (IPE/PO2/9087), 0.57 0.35 0.32  
a carapace

*Discussion:* The present species resembles *Uroleberis procera* Deltel, 1962, described from the Aquitanian of France in overall shape and lateral outline. Unlike the present species, *Uroleberis procera* has maximum height posterior to the middle and dorsal margin arched, posterodorsal margin straight and ventral margin straight.

Superfamily **Cypridacea** Baird, 1845

Family **Candonidae** Kaufman, 1900

Subfamily **Paracypridinae** Sars, 1923

Genus **Phlyctenophora** Brady, 1880

*Phlyctenophora ramaniaensis* n. sp.

(Pl. II, figs. 13-15)

*Derivation of Name:* After Ramanian stage, Lower Oligocene.

*Material:* Thirty-nine carapaces from well B-EE-B, Bombay Offshore and eighteen carapaces from the Berwali river section, Kachchh.

*Type locality and horizon:* Bombay Offshore well B-EE-B. Sample (CC#3, 2094-2112m) 2100m below surface, Mukta Formation, Lower Oligocene.

*Diagnosis:* Carapace subtriangular, ovate in lateral view with greatest height anterior to the middle; dorsal margin arched; ventral straight.

*Description:* Carapace subtriangular in lateral view, with greatest height near middle; left valve slightly larger than the right valve; dorsal margin weakly arched; ventral margin nearly straight; anterior end higher and broadly rounded; posterior margin sloping and making an angle with ventral margin; in dorsal view carapace convex in females with maximum width near the middle, while in males anterior to the middle. Valve surface smooth.

*Dimensions* (mm):

	Length	Height	Width
Holotype (IPE/H02/04/9087), a carapace	0.75	0.45	0.30
Paratype I (IPE/P02/04/9088), a carapace	0.75	0.47	0.36
Paratype II (IPE/P02/04/9089), a carapace	0.75	0.46	0.37

*Discussion:* The present species differs from other known species of *Phlyctenophora* in being more ovate in shape and length/height ratios.

## CONCLUSIONS

- Oligocene ostracodes of the hypostratotype section of the Ramanian stage (Lower Oligocene) and holostratotype section of the Waiorian stage (Upper Oligocene) of Kachchh are studied and correlated with equivalent sediments in the subsurface of the Bombay Offshore Basin.
- In all, 76 ostracode taxa are recorded from the Oligocene of Kachchh and Bombay Offshore. Of these, 63 ostracode taxa are from Kachchh and 54 taxa from the Bombay Offshore Basin.
- The Mukta/Heera Formation (Ramanian stage) in the Bombay Offshore is divided into four ostracode zones and five-ostracode events equivalent to *Nummulites fichteli* Zone (Lower Oligocene). The ostracode events recorded, in ascending order, are 1-FAD of *Uroleberis sohni*, 2-FAD *Pokorniyella kutchensis*, 3-FAD

*Phlyctenophora ramaniaensis* n.sp., 4-LAD *Acanthocythereis muktaensis* n.sp, and 5-LAD *Hornibrookella ramaniaensis*.

- These events are correlatable with hypostratotype of the Berwali river section, Ramanian stage of Kachchh.
- The Waiorian stage in the holostratotype section of Kachchh is divided into five ostracode events. In ascending order they are: 1.FAD *Haplocythereidea manifesta/ Alocopocythere waiorensis* n.sp. 2. LAD *Alocopocythere waiorensis* n.sp 3.FAD *Alocopocythere elongata*, 4.LAD *Haplocythereidea manifesta/FAD Loxoconcha keralaensis*, 5. LAD *Uroleberis sohni*.
- One ostracode range zone and two ostracode events are recognized in the Waiorian stage (Upper Oligocene) of Bombay Offshore.

## ACKNOWLEDGEMENTS

The author is thankful to Dr. D.M. Kale ED and Head, KDMIPE, ONGC, Dehradun, for extending all facilities and Dr. D. Ray (demised lately), who had allowed to under take field sampling. He is indebted to Dr. D.S.N. Raju, (former DGM, ONGC) for extending help during field work and acquainting me with holo- and hypostratotype sections of Kachchh for sampling, and to Prof. Q.A Siddiqui (Canada) for reviewing the manuscript and offering his valuable comments. Thanks are due to Pallav Baruah, Joyshree Baruah, Sujay Sinha for sorting of ostracodes, Yashpal for SEM photography and Bharat Singh for computer assistance. The views expressed in this paper are those of the author only and not necessarily of the organization.

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Manuscript Accepted January 2007

