

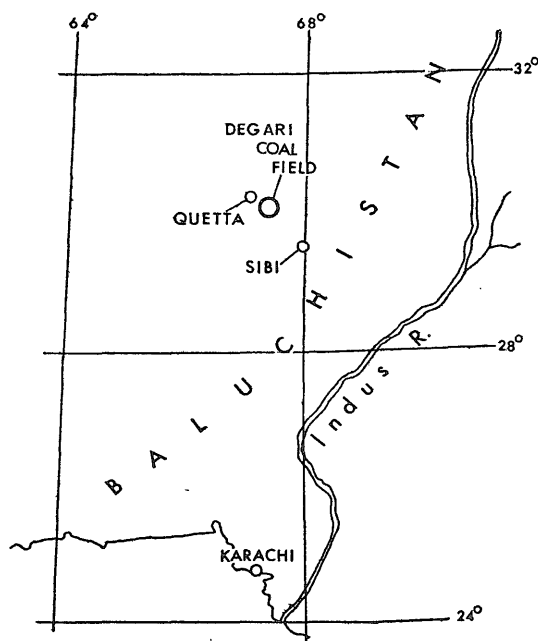
The Eocene Molluscan Fauna from the Degari Coal Field in Central Baluchistan, West Pakistan

By
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Introduction

This report deals with a part of the Eocene molluscan fauna, particularly of the coal-bearing facies of the Laki stage at the vicinity of the W.P.I.D.C. Degari Colliery in the Degari coal field, about 17 airmiles southeast of Quetta (30° 05'N 67° 13'E). The Eocene molluscan fauna from West Pakistan was clarified mainly by D' ARCHIAC and HAIME (1854), COX (1932) and EAMES (1951, 1952a-c), and now informations on its general feature have been further acquired.

A recent work by I. KAKIZAKI** and T. SHIMOYAMA** of Mitsui Mining Co., Ltd., who have been engaged in the geological survey of the vicinity of the Colliery under the general



Text-fig. 1 Location map of the Degari coal field.

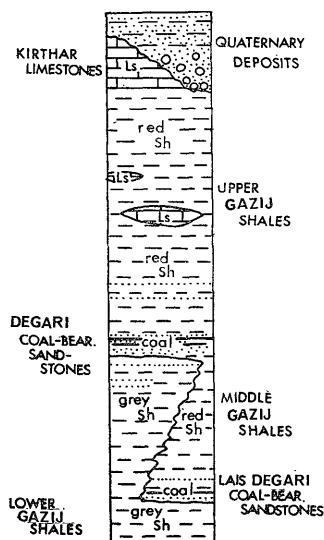
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managership of T. ASAKURA** of Sankoh Consulting Co., Ltd., found many molluscan fossils from the Eocene deposits of the area, which were presented to the writer for identification. They were all poorly preserved, but according to the writer's study, six new species and one problematical new species were found among the collection, the remaining of which includes many species hitherto recorded from other districts of West Pakistan. The faunal assemblage particularly of the coal-bearing facies were clarified. In the present report, the faunal occurrence in the Eocene deposits is briefly accounted and all the species including the new species are described.

Before going further, the writer manifests his sincere thanks to Mr. T. SHIMOYAMA whose geological informations were very useful to the writer, and also to the other staffs of the Mitsui Mining Co., Ltd., who helped the writer in many ways to study the fossils and prepare this manuscript.

Faunal occurrence

The rather steeply tilting thick Eocene deposits in the vicinity of the W. P. I. D. C. Degari Colliery exhibit the following stratigraphic sequence in descending order, according to KAKIZAKI and SHIMOYAMA's result of survey (personal communication): larger foraminifer-bearing limestone with more than few hundred metres thick; thick beds mainly composed of massive, red, non-fossiliferous claystone, partly intercalated with sandstone layers and some fossiliferous limestone lenses, which is about 1,000m thick in total; fossiliferous coal-bearing beds more than 100m in thickness; and beds of massive, grey, non-fossiliferous claystone. This sequence changes rapidly toward south and southeast, particularly in the lower part. That is, the coal-



Text-fig. 2 Outline of stratigraphic sequence in the Degari coal field (after T. KAKIZAKI and T. SHIMOYAMA).

** T. ASAKURA, I. KAKIZAKI and T. SHIMOYAMA were despatched to West Pakistan by the Japan Consulting Institute.

bearing part gradually dies out and lowest grey claystone horizontally pass to red claystone with the same nature as that upper than the coal-bearing part. Moreover, another coal-bearing bed appear below the red claystone, keeping grey claystone beneath it. Such a facies change as described above is schematically shown in text-fig. 2.

According to KAKIZAKI and SHIMOYAMA, each member in the vicinity of the Colliery is named in descending order as follows: Kirthar limestone, upper Gazij shales, Degari coal-bearing sandstone, middle Gazij shales, Lais Degari coal-bearing sandstone and lower Gazij shales. The first and the remainings of them seem to roughly correspond to the Spintangi limestone and Gazij shales denoted by the Government of Canada (1958) respectively.

The molluscan fossils described here were obtained from the certain limestone lens in the middle part of upper Gazij shales and also the upper part of Degari coal-bearing sandstone, those obtained from the last occupying a larger part. They are listed as follows.

Station 63-9-AB

<i>Faunus?</i> sp.	rare
<i>Turritella (Stiracolpus) harnaiensis</i> COX	common
<i>Cerithium baluchi</i> COX	rare
<i>Cerithiopsis punjabensis</i> EAMES	common
cfr. <i>Volutospina kohatica</i> EAMES	rare
<i>Sacella semibistriata</i> EAMES	rare
<i>Arca pakistanica</i> n. sp.	rare
<i>Isognomon pseudotomiyasui</i> n. sp.	common
<i>Pseudomiltha undata</i> COX	common
<i>Psammotaea</i> sp.	rare
<i>Corbula</i> sp.	common

Station 63-3S-AIL

<i>Faunus (Pseudobellardia) delphinus</i> (OPPENHEIM)	rare
<i>Vicarya eocenica</i> COX	rare
<i>Potamides (Exechestoma) pakistanicus</i> n. sp.	common

Station 63-3S-BIL

<i>Faunus?</i> sp.	rare
<i>Arca pakistanica</i> n. sp.	rare
<i>Barbatia</i> sp.	rare
<i>Anomia shimoyamai</i> n. sp.	rare
<i>Meretrix?</i> sp.	rare
<i>Pitar (Calpitarina) rakhiensis</i> EAMES	common

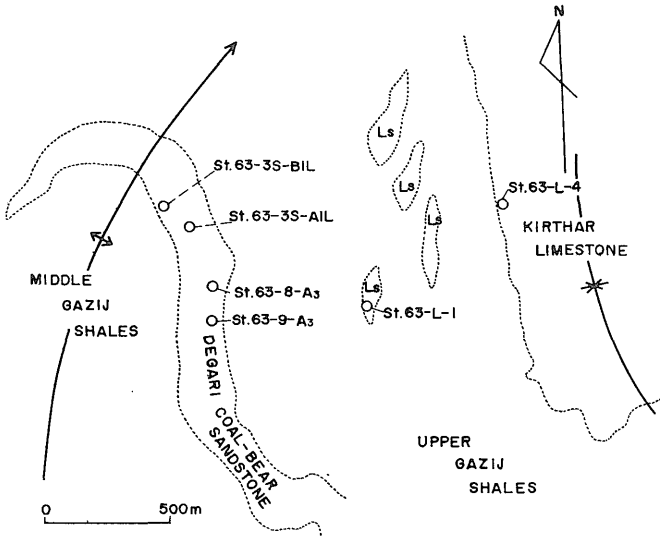
Station 63-8-A3

<i>Nerita</i> sp.	rare
" <i>Helix</i> " sp.	rare
<i>Chiraluta?</i> sp.	rare
<i>Macoma parabilella</i> n. sp.	very abundant

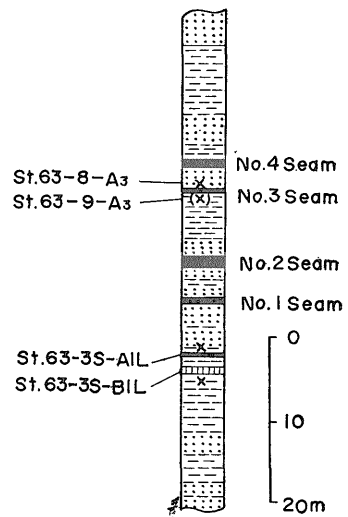
Station 63-L-1

<i>Chiraluta?</i> sp.	rare
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Chlamys cfr. *soriensis* EAMES rare
Ostrea (*Liostrea*) *mitsuiana* n. sp. rare
 Station 63-L-4
Tonna? sp. rare



Text-fig. 3 Geological map of the vicinity of the Degari coal field, showing the localities of fossils (after I. KAKIZAKI and T. SHIMOYAMA).



Text-fig. 4 Columnar section of upper part of the Degari coal-bearing sandstone at Adits No. 2 and No. 3, showing stratigraphic situation of fossils (after I. KAKIZAKI and T. SHIMOYAMA). That of Adit No. 8 is also shown by (X).

Among the faunules, one of Station 63-9-A3 is comprised in poorly sorted dark grey mudstone situated just above the trace of coal seam No. 3. Many rather small type fossils, more or less broken and worn out, crowd in the mudstone. From the faunules, twelve species are discriminated, and among them *Turritella*, *Cerithiopsis*, *Isognomon*, *Pseudomiltha* and *Corbula* are commonly found. Another faunule Station 63-3S-BIL was found in muddy fine-grained or very fine-grained sandstone just below the No. 1-2L coal seam. It consists of six species, among which *Pitar* is commonly occurred. On the other hand, from grey mudstone just above the same coal seam, thiarid and potamidid faunule (Station 63-3S-AIL) consisting of four species are found at Adit No. 3 skip-incline cross-cut. From Adit No. 8, greenish coloured, ill-sorted sandy mudstone occurs peculiar faunule very predominant in a new species of *Macoma* in intermediate horizon between the coal seams No. 1 and No. 4. It consists of four species. All the faunules described above came from the coal-bearing sandstone.

The other faunules are only poorly represented. One limestone lens, partly very sandy, in the upper Gazij shales rarely yields megafossils. They are only represented by three species including a new species of *Ostrea*.

The Kirthar limestone is very abundant in larger foraminifers, but very poor in molluscan fossil. *Tonna?* sp. is comprised in the northeastern area of the Colliery.

Some notes on the molluscan fauna

In Sind and Baluchistan, the following standard division has been generally accepted for the lower Tertiary deposits: Ranikot (Paleocene), Laki (lower Eocene) and Kirthar (Middle-upper Eocene) in ascending order. Moreover, EAMES (1952a, c) discriminated the upper Eocene Tapti stage from the last stage. According to some previous works, the Laki stage is divided into the Dunghan limestone and Gazij shales, in ascending order, in the vicinity of Bolan Pass, southeast of Quetta, where the Ranikot is absent and the basal Laki directly covers the Cretaceous. According to NUTTALL (1925), the two divisions are respectively characterized as follows. The Dunghan limestone, unconformably covering the Cretaceous, consists of hard dark grey massive limestone which is usually conglomeratic, and is correlated with the Meting limestone in Sind. The Gazij shales, corresponding to the "lower Eocene" of BLANFORD (1883) and named by OLDHAM (1890), is mostly represented by olive to grey fissile shales, with limestone bands near the top and some thin sandstone beds in the lower third, and lignite is contained in the shales. Its lower part corresponds to the Laki limestone in Sind. The Gazij shales was considered to be partly Laki and partly lower Kirthar by KRISHNAN (1960). Based upon the foraminiferal sequence, the Laki is considered to represent the lower Eocene (Thanetian and Ypresian) and the lower and middle Kirthar to represent the middle Eocene (Lutetian) (NUTTALL, 1926).

The Eocene sequence seen in the vicinity of the Degari Colliery appears to be imperfectly represented, being unknown both in its upper and lower limits, and moreover no detailed stratigraphic record has been published so far around the Degari coal field. These make the correlation of the sequence with the standard division somewhat difficult. From the lithological viewpoint, however, the thick part predominant in claystone, associated with limestone in upper part and with coal seams in middle part, may belong to the Gazij shales, and the uppermost limestone may represent the lowest Kirthar. The Dunghan limestone is missing in the area.

So far as the molluscan fauna described in this report is concerned, the followings may be pointed out on the matter.

The four faunules of the Degari coal-bearing sandstones consist of marine subtidal or brackish water (probably polyhaline) species. Among them, that of Station 63-3S-BIL is exclusively shown by the latter forms, while those from the other stations includes both forms, though rather predominant in the marine form. The facts may suggest rather unstable condition of the coal-basin at the depositional time, when the area may have changed from lagoonal or estuarine to very shallow sea environments.

A part of the fauna of the coal-bearing facies of such character rather agrees with the fauna reported by COX (1932) from the Gazij shales at Harnai about 40 miles east of the Degari Colliery: the fauna includes the conspecific forms with the Degari faunas; *Vicarya eocenica*, *Faunus delphinus* and *Turritella harnaiensis*, the last of which is characteristic in the upper Laki, according to EAMES (1952c). Another determined species are mostly occupied by those hitherto reported from the Laki stage or Gazij shale and near it: *Cerithium baluchi* and *Pseudomiltha undata* are known from the Laki of Hindu Bagh (COX 1932); *Cerithiopsis punjabensis* and *Saccella semibi-*

striate were reported from the Gazij shale at Zinda Pir (EAMES, 1951; 1952b); and *Volutospina kohatica* was from the upper Laki at Rakhi Nala and Kohat. *Pitar rakhiensis* is found in the upper Laki and lower Kirthar at Rakhi Nala. These facts lead the writer to the conclusion from the paleontological viewpoint that the Degari coal-bearing sandstones are safely correlated with a part of the Gazij shales of Laki.

On the other hand, the marine faunules from the "upper Gazij shales" and "Kirthar limestone" are too poorly represented to discuss the correlation. That *Chlamys soriensis* occurs in the Kirthar (EAMES, 1951) and the new species of *Ostrea* is rather similar to *Ostrea pseudoflemingi* EAMES restricted to the Kirthar horizon (EAMES, 1951) may possibly suggest the attribution of a part of the "upper Gazij shales" at least to Kirthar horizon, but the final conclusion on this respect should be given after a careful study on more abundant materials from the part in question.

Description of species

The following new species are described in this article.

Gastropoda

Faunus n. ? sp.

Potamides (Exechestoma) pakistanicus n. sp.

Pelecypoda

Arca pakistanica n. sp.

Isognomon pseudotomiyasui n. sp.

Anomia shimoyamai n. sp.

Ostrea (Liostrea) mitsuiana n. sp.

Macoma parabillella n. sp.

CLASS GASTROPODA

Family Neritidae

Genus *Nerita* ADANSON, 1757

Nerita sp.

pl. 1, fig. 14

Remarks: Two small specimens of *Nerita* were obtained. In general outline, they seem to be similar to *Nerita noorpoorensis* D'ARCHIAC et HAIME (1854, p. 279, pl. 25, fig. 8) from Punjab, but the sure identification is impossible, owing to the strong deformation of their shells. The figured specimen exhibits the maximum diameter of 8.8 mm.

Occurrence: Station 63-8-A3 (Adit No. 8)

Family Thiaridae

Genus *Faunus* MONTFORT, 1810

Faunus n. ? sp.

pl. 1, figs. 11, 38

Remarks: Two ill-preserved specimens are available to the writer. They are characterized by peculiar shape with high flat whorls, separated by very obsolete shallow sutures and orna-

mented only with axially nearly straight growth lines. In the respect of axially very elongated form, the similar form of *Faunus* can not be found elsewhere, and it is probable that they represent the new species of the genus. The preserved whorls attain about 17mm height in both the specimens.

Occurrence : Station 63-8-A3 (Adit No. 8)

Faunus? sp.

pl. 1, fig. 10

Remarks: Two fragments, both representing a part of spire respectively, were examined. Whorls are wider than high, very slightly convex and ornamented with very feeble spiral striae and axial growth lines. The growth lines are steeply oblique, slightly concave forwards at the upper portion and slightly convex at the lower portion of whorls. Such features are shown in *Turritella subathooensis* D'ARCHIAC et HAIME (1854, p. 297, pl. 28, figs. 1, la, 2), but it seems to have more inflated and lower whorls. Also the present species is similar to *Melanopsis Lamarcki* DESHAYES (1864, p. 472; 1866, pl. 31, figs. 25, 26), but the sure identification is impossible on account of poor preservation of shell. The preserved whorls shown in the figure of plate 1 measure about 13mm in height.

Occurrence : Station 63-9-A3 (Adit No. 9) and 63-3S-BIL (Adit No. 3)

Subgenus *Pseudobellardia* COX, 1931

Faunus (Pseudobellardia) delphinus (OPPENHEIM)

pl. 1, fig. 9

ref. 1931. *Pirena (Pseudobellardia) delphinus* (OPPENHEIM)-COX, *Trans. Roy. Soc. Edin.*, vol. 57, pt. 1 (no. 2), p. 47, pl. 1, figs. 2a, b.

Remarks : The single specimen at hand with height of 15.2mm is identified to the present species. The characteristics of shell—elongated subconical shape and flattened whorls with weak spiral cords and remarkable growth lines—seen in the specimen almost agrees with that of the species. However, the tubercles of dorsal penultimate whorl, pointed out by COX (1931) as another characteristics of the species, are not developed, and thus the specimen exhibits a somewhat similar shape to the “form without Kiel” of *Faunus (Pseudobellardia) auticulatus* (Schlotheim) illustrated by WENZ (1939, p. 697, fig. 2003b).

Occurrence : Station 63-3S-AIL (Adit No. 3)

Family Turritellidae

Genus *Turritella* LAMARCK, 1799

Subgenus *Stiracolpus* FINLAY, 1927

Turritella (Stiracolpus) harnaiensis COX

pl. 1, figs. 1, 2

1931. *Turritella harnaiensis* n. sp.—COX, *Trans. Roy. Soc. Edin.*, vol. 57, pt. 1 (no. 2), p. 48, pl. 1, figs. 4, 5.

Remarks : Three ill-preserved turritellid specimens were obtained. One is represented only by a fragment (pl. 1, fig. 2), but another is preserved as four spiral whorls and body whorl, measuring height of preserved whorls of 13.1 mm (pl. 1, fig. 1). They are very similar to *Turritella harnaiensis* COX lately attributed to *Stiracolpus* in subgeneric rank by EAMES (1952b, p. 24). The ornaments of spiral whorls in both the specimens consist of subequally arranged three strong spiral cords which intercalate weak cords in penultimate whorl. The body whorl is spirally sculptured with four strong and three weak cords alternatively arranged. One of the specific characteristics for *T. harnaiensis* is represented by faintly beaded cords. This character seems to be developed also in the writer's specimens, but the beads are very faint and obscure.

Occurrence : Station 63-9-A3 (Adit No. 3)

Family Potamididae

Genus *Vicarya* D' ARCHIAC et HAIME, 1954

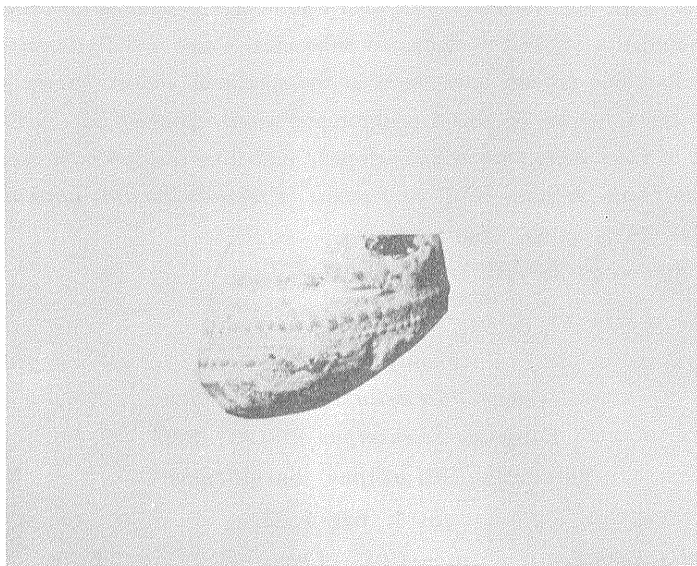
Vicarya eocenica COX

text-fig. 5 ; pl. 1, figs. 3, 4

1931. *Vicarya eocenica* n. sp. — COX, (*Trans. Roy. Soc. Edin.*, vol. 57, pt. 1 (no. 2), p. 44, pl. 1, figs. 7a, b, 8

Remarks : Two ill-preserved specimens, both being broken in apical and apertural parts, were examined. In spite of the poor-preservation, the specimens are safely identified to *Vicarya eocenica*, which is the ancestral form of the genus, very familiar to the Indo-Pacific Miocene faunas. The enlarged photograph of characteristic spiral ornaments of body whorl is shown in the text-figure. The width of body whorl in the specimens is measured to 11.5 mm and 12.0 mm respectively, showing smaller size than the holotype of this species.

Occurrence : Station 63-3S-AIL (Adit No. 3)



Text-fig. 5 Enlarged photograph of *Vicarya eocenica* Cox, $\times 3$.

Genus *Potamides* BRONGNIART, 1810

Subgenus *Exechestoma* COSSMANN, 1899

***Potamides (Exechestoma) pakistanicus* n. sp.**

pl. 1, figs. 5, 5a, 6-8

Description: Shell small in size, turreted with apical angle of 30-35. Whorls about 10, separated by deep, narrow suture. Spiral whorl convex, shouldered, with spiral and axial ornaments: spiral ornaments consisting of 8 or 9 spines regularly arranged on three subequal cords; in penultimate whorl one narrower cord developed between middle and lower cords and also between the lower cord and lower suture: axial ornamentation represented by numerous arched growth lines and predominant rises, the latter connecting the spiral spines on each cord vertically and almost disappearing at anterior and posterior parts of upper and lower spiral cords respectively. On body whorl, the strong spiral cords number 5, intercalating 4 narrower and weaker cords, and spines are predominant only on the uppermost cord, resulting in not so remarkable axial rises. The detailed feature of aperture is unknown. Dimensions of holotype: height, 25mm; diameter of body whorl, 12.0mm.

Remarks: Six specimens were examined, of which four are figured here. They are more or less broken in apical and apertural parts. The present new species is most similar to *Potamides (Exechestoma) armoricensis* (VASSEUR) illustrated in Cossmann and Pissaro (1900-'02, p. 156, pl. 17, fig. 7) in outline, but the former has lower shell. It also resembles *Cerithium Bonnardi* DESHAYES (1824b, p. 416, pl. 49, figs. 1-4), which is characterized by less prominent and narrower axial rises and more numbered spiral cords. The subgenotype of *Exechestoma*, *Potamides (Exechestoma) angulosus* (LAMARCK) (COSSMANN and PISSARO, 1907-'13, pl. 28, fig. 151-20) is clearly distinguished from the new species in having more turreted spire with more angulated whorls.

Occurrence: Station 63-3S-AIL (Adit No. 3) (type locality)

Family Cerithiidae

Genus *Cerithium* BRUGUIERE, 1792

***Cerithium baluchi* COX**

1931. *Cerithium baluchi* n. sp.—COX, *Trans. Roy. Soc. Edin.*, vol. 57, pt. 1 (no. 2), p. 42, pl. 1, fig. 6.

Remarks: The single specimen, attaining about 7mm in height, is identified to this species from the feature of ornamentation and shape of shell.

Occurrence: Station 63-9-A3 (Adit No. 9)

Family Cerithiopsidae

Genus *Cerithiopsis* FORBES et HANLEY, 1851

***Cerithiopsis punjabensis* EAMES**

1952. *Cerithiopsis punjabensis* n. sp.—EAMES, *Phil. Trans. Roy. Soc.*, ser. B, vol. 236, p. 45, pl. 2, fig. 64.

Remarks: Very ill-preserved small three specimens were obtained. They almost agree with the present species in the shape and characters of ornaments.

Occurrence : Station 63-9-A3 (Adit No. 9)

Family Tonnidae

Genus *Tonna* BRUNNICH, 1772

Tonna? sp.

pl. 2, fig. 5

Remarks : Single very ill-preserved inner mould specimen is available to the writer. It represents only a part of body whorl, which is large and globular, ornamented with regularly arranged subequal spiral ribs attaining more than 28 in number. From the feature of uppermost part of the body whorl, penultimate whorl and spire is possibly very low and very small. In this respect the specimen probably belongs to certain species of *Tonna*. The diameter of body whorl measures about 35mm.

Occurrence : Station 63-L-4

Family Volutidae

Genus *Volutospina* BULLEN-NEWTON, 1906

Cfr. *Volutospina kohatica* EAMES

pl. 2, figs. 7, 7a, 8

1952. *Volutospina kohatica* n. sp.—EAMES, *Phil. Trans. Roy. Soc.*, ser. B, vol. 236, p. 111, pl. 4, figs. 96a, b.

Remarks : Only two poorly preserved specimens were obtained. They are much deformed, pressed particularly from posterior side, and as the result, spire whorls fairly sink into the inner part of the well-defined shoulder of body whorl, and also its body whorl is deformed to obliquely globular form. Taking these results of deformation into a consideration, they seem to resemble the figures of *Volutospina kohatica* shown by EAMES. Particularly their ornaments consisting of axial ribs well developed on the spire whorls and of spiral many faint threads almost agree with those of the species. Spines are invisible on the whorls. One specimen attains a width of body whorl of 24.5mm.

Occurrence : Station 63-9-A3 (Adit No. 9)

Genus *Chiraluta* OLSSON, 1931

Chiraluta? sp.

pl. 2, figs. 6, 6a

Remarks : Two deformed inner moulds of body whorl were obtained. They are somewhat similar to *Prestrombus rockei* COX (1931, p. 52, pl. 2, figs. 6a, b) in outline, but seem to be less low and have less wide and large aperture. In such respects, they are akin to the genus *Chiraluta* known from the upper Oligocene of Peru. But there is some doubt as to their sure identification. The internal surface of the body whorl is ornamented nearly only by axial many weak striae except the apertural area where shallow and narrow inner crenulations seem to be developed.

Occurrence : Station 63-L-1 and 63-8-A3 (Adit No. 8)

Family Helicidae

Genus *Helix* LINNÉ, 1758

"*Helix*" sp.

pl. 1, figs. 12, 13

Remarks : Two deformed specimens were obtained, both being more or less broken in apertural part. The shell is naticoid and small, with four whorls separated by deep suture and with umbilicus which is open and deeply funicular. These characters are found in some species of *Macularia* ALBERS, 1850, shown in SACCO (1895, p. 63, 64, pl. 5), but the present form differs from them in having lower spire. Compared with "*Helix*" sp. reported by GARDNER (1945, p. 267, pl. 18, figs. 1-3) the Degari specimens have smaller shell with more inflated spiral whorls. The width of deformed body whorl is measured to 11.8mm in one specimen and to 5mm in the other.

Occurrence : Station 63-8-A3 (Adit No. 8)

CLASS PELECYPODA

Family Nuculanidae

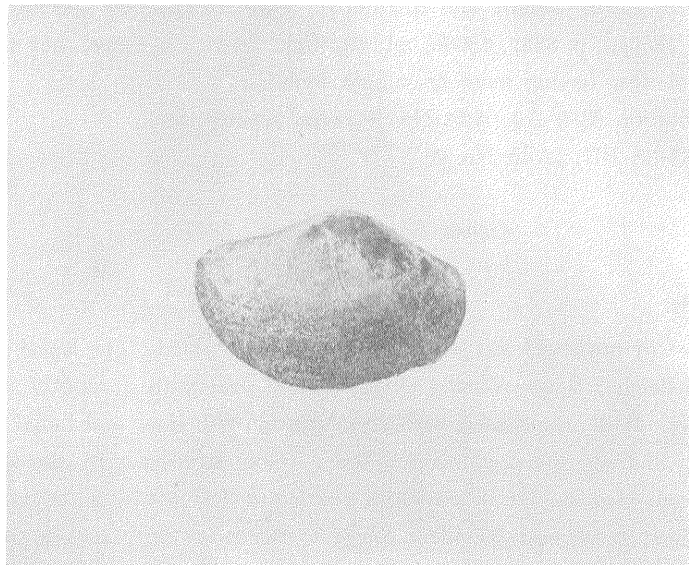
Genus *Saccella* WOODRING, 1925

Saccella semibistriata EAMES

text-fig. 6 ; pl. 1, figs. 15, 15a

1951. *Nuculana* (*Saccella*) *semibistriata* n. sp.—EAMES, *Phil. Trans. Roy. Soc.* ser. B, vol. 235, p. 325, pl. 9, fig. 12.

Remarks : Two imperfect specimens are at hand. They are very small, measuring 6.0mm length and 4.0mm height in the figured specimen. The specimen, inner mould of right valve, is somewhat broken in its posterior end. Its outline is closely similar to *Nuculana* (*Saccella*) *semibistriata* EAMES reported from the Green and Nodular Shales of Rakhi Nala. The species



Text-fig. 6 Enlarged photograph of *Saccella semibistriata* (EAMES), $\times 6$.

is characterized by the sculpture of shell, which was described by the original author as follows: "Ornament consisting of a very distinctive arrangement of concentric, incised lines. These are closely spaced on the posterior and ventral portions of the shell, but alternate ones die out anteriorly and dorsally —". In the writer's specimen the concentric sculpture is coarser dorsally and finer ventrally, but the peculiar feature cited above is doubtful, probably owing to the ill-preservation of shell.

Occurrence : Station 63-9-A3 (Adit No. 9)

Family Archidae

Genus *Arca* LINNÉ, 1750

Arca pakistanica n. sp.

pl. 1, figs. 34, 35, 35a

Description : Shell small transversely subquadrangular, moderately inflated, slightly sinuated in central-posterior portion of shell. Umbo prosogyrate, prominent, pointed, Antero-dorsal margin much shorter than the postero-dorsal; the former gradually passing to narrowly rounded anterior end, the latter making an obtuse angle with obliquely subtruncated posterior end; ventral margin broadly rounded, obliquely ascending and gradually passing to the anterior end, but abruptly turned to the posterior. Behind umbo a striking ridge obliquely running to postero-ventral corner. Surface of shell sculptured by numerous concentric growth lines and radial ribs, making very fine network: radial ribs about 30 in number, of them about 5-6 arranged at the posterior and anterior parts of shell respectively, separated by wider valleys than those between the remaining ribs which occupy a larger part of shell. Hinge line straight. The state of teeth and other markings of internal surface are unknown. Dimensions of holotype: length, 11.1 mm; height, 7.4 mm.

Remarks : One left valve (holotype) and one right valve specimens were examined, the latter measuring about 10 mm of length and 6.2 mm of height. The new species is similar to *Arca ornata* DESHAYES (1860a, p. 886; 1860b, pl. 70, figs. 18-20) in shape, but the former has far less numbered radial ribs, having more prominent umbo.

Occurrence: Station 63-9-A3 (Adit No. 9) (type locality) and 63-3S-BIL (Adit No. 3)

Genus *Barbatia* GRAY, 1847

Barbatia sp.

pl. 1, figs. 33, 33a

Remarks : Two ill-preserved left inner moulds were obtained. The small shell with 9.6 mm length and 4.7 mm height, is transversely elongated and oval with anteriorly situated umbo as shown in the figures. It is ornamented with concentric growth lines and radial ribs. The latter numbers about 40, of them the posterior 5-6 being rather striking. In the shape of shell the present species is somewhat similar to *Barbatia textiliosa* (DESHAYES) (COSSMANN and PISSARRO, 1904-'06, pl. 36, fig. 110-18) and *Barbatia Sacyi* COSSMANN (1921, p. 142, pl. 8, figs. 72-75), but these species are ornamented with many finer ribs. Also, the present species is somewhat similar to *Arca articulata* DESHAYES (1860a, p. 882; 1860b, pl. 70, figs. 7-9) but the latter has

more higher shell. In shape, the species is also very akin to *Barbatia (Plagiarca) lucidoides* KOROBKOV, 1961 from Kiev (KOROBKOV, 1962, p. 40, pl. 4, figs. 6, 6a, 7, 7a, 8; pl. 5, fig. 1), but *lucidoides* is characterized by coarser growth lines and finer radial ribs.

Occurrence : Station 63-3S-BIL (Adit No. 3)

Family Isognomonidae

Genus *Isognomon* SOLANDER, 1786

Isognomon pseudotomiyasui n. sp.

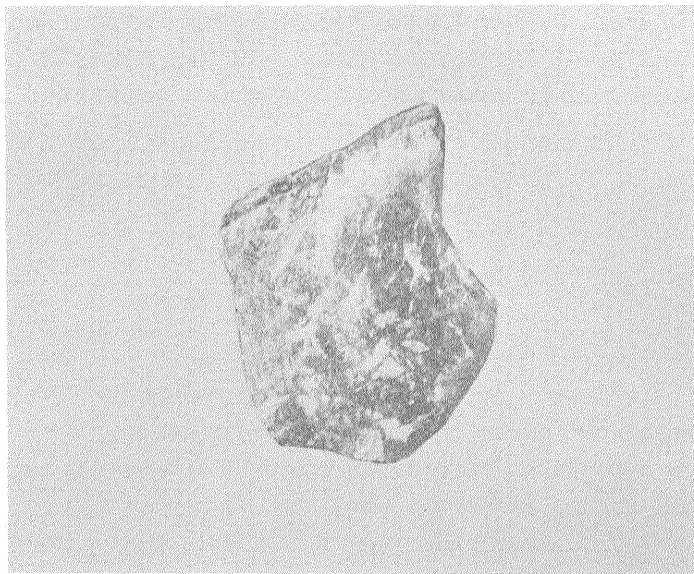
text-figs. 7, 8; pl. 2, figs. 3, 4

Description : Shell small to moderate in size, subquadrately mytiliform, nearly flat, with anteriorly produced pointed umbo. Anterior margin arched, concave, gradually passing to convex, rounded ventral margin : the posterior broadly convex, rather abruptly turned to the margin of hinge plate providing rather shallow wide grooves, about 7-9 in number and anteriorly somewhat deeper. Hinge margin nearly parallel to the ventral and jointed with the anterior margin in angle of 75-80. Surface of shell ornamented with numerous concentric growth lines. Dimensions of holotype : height, 40.5 mm; width, 26.8 mm.

Remarks : The new species slightly varies in shape. It seems to be closely similar to *Pedalion tomiyasui* NAGAO (1928, p. 103(7), pl. 20(3), figs. 4-8) which is known from the Ypresian-Lutetian Futagojima formation in northwestern Japan, but is distinguishable from the latter in having larger apical angle and less deeper ligamental grooves. *Isognomon pseudotomiyasui* differs from *Perna Bazini* DESHAYES (1864, p. 57; 1860b, pl. 76, figs. 1, 2) in having more concave anterior margin and more rounded outline, and also from *Perna lesperonensis* TOURN (COSSMANN, 1922, pl. 159, pl. 9, figs. 41, 42) in having higher shell. From *Perna Lamarckii* DESHAYES (1824a, p. 284, pl. 40, figs. 7, 8), it is easily distinguished in having lower shell with



Text-fig. 7 *Isognomon pseudotomiyasui* n. sp., $\times 1.5$, inner mould of holotype specimen (GSJ. 5340).



Text-fig. 8 *Isognomon pseudotomiyasui* n. sp., $\times 1.5$, inner mould, showing crenelation of hinge margin (GSJ. 5339).

larger apical angle.

Occurrence : Station 63-9-A3 (Adit No. 9) (Type locality)

Family Anomiidae

Genus *Anomia* LINNÉ, 1758

Anomia shimoyamai n. sp.

pl. 1, fig. 32

Description : Test thin. Shell obliquely trigono-suborbicular, very slightly higher than wide, much inflated. Antero dorsal margin obliquely long, nearly straight, passing to narrowly rounded anterior end; posterior margin broadly arched, convex, connected to broadly rounded ventral margin which is anteriorly faintly sinuated. Umbo small, pointed, situated about at the central portion of dorsal margin. Surface of shell ornamented with concentric, slightly rugated growth sculpture consisting of numerous feeble threads which is rather strongly developed periodically and thus being lamellae-like. Internal structure of shell is obscure on account of ill-preservation. Dimensions of holotype : length, 22.9 mm; height, 23.30 mm.

Remarks : The partly broken single specimen was obtained. The new species is somewhat similar to Rupelian *Anomia girondica* MATHERON (COSSMANN, 1922, p. 216, text-fig. 14; pl. 15, figs. 21, 22), but the latter has more lower shell, not ornamented by peculiar concentric sculpture. *Anomia Casanovei* DESHAYES (1864, p. 133; 1860b, pl. 85, figs. 5-9) differs from the new species in having higher shell with horizontally developed dorsal margin. The new species is easily distinguishable in having no radial ornaments from the anomiid species known from the Pakistan Eocene by COX (1938) and EAMES (1951).

Occurrence : Station 63-3S-BIL (Adit No. 3) (type locality)

Family Pectinidae

Genus *Chlamys* BOLTEN, 1798

Chlamys cfr. *soriensis* EAMES

pl. 1, fig. 36

1951. *Chlamys soriensis* n. sp.—EAMES, *Phil. Trans. Roy. Soc.*, ser. B, vol. 235, p. 344, pl. 9, fig. 23.

Remarks: The single inner mould with 18.6mm height was found from white limestone. It is very poorly preserved particularly in its apical part and surface sculpture. In having orbicular form ornamented with regularly arranged narrow radial ribs about 30 in number, it is doubtfully identified to the present species.

Occurrence: Station 63-L-4

Family Ostreidae

Genus *Ostrea* LINNÉ, 1758

Subgenus *Liostrea* DOUVILLÉ, 1904

Ostrea (Liostrea) mitsuiana n. sp.

pl. 2, figs. 1, 1a-c, 2, 2a, b

Description: Test very thick. Shell medium in size, longitudinally suboval, nearly equilateral with ophistogyrate exogyroid small pointed umbo. Right valve strongly inflated, left valve less inflated. Dorsal margin slightly oblique, arched; both anterior and posterior margin broadly convex, except their upper portions which are concave, giving a tendency of slight bialation of shell; posterior part of ventral margin more or less sinuated. Sculpture of surface composed of both concentric and radial markings: the former is represented by striking growth lamellae; the lamellae regularly imbricated with 2-3mm width interspace, together with very feebly marked many growth lines: the radial markings are represented by weak, somewhat wrinkled numerous striae and also by several faint ribs, the latter being more or less striking in the anterior half of shell. Ligamental area subquadrate, rather large and high. Beneath the ligamental area crenulations are visible on the anterior inner margin of shell. Adductor scar rather large near the central part of shell. Dimensions of holotype: length, 34.8mm; height, 46.0mm; inflation (single valve), 25.6mm.

Remarks: Two specimens including one right and one left valve were obtained. The above description is based mainly upon the holotype of right valve. The paratype left valve specimen has smaller and more subtrigonal hinge part, and also the characteristics of surface sculpture is obscure on account of ill-preservation. Nevertheless, from its general characters, including shape, thickness of test, sculpture of obliterated shell surface, the writer considers that both valves belong to single species.

The new species is most similar to the specific group of *Flemingostrea*, VREDENBURG, 1916, which is generally considered now to be consubgeneric with *Liostrea* DOUVILLÉ, 1904 (JEWORSKI, 1926; COX, 1931; EAMES, 1951). Compared with *Ostrea flemingi* D'ARCHIAC et HAIME (1854, p. 275, pl. 23, figs. 14, 15), it has more inflated and subquadrate thicker shell with longer dorsal margin and much larger hinge plate. Another similar species, *Ostrea (Liostrea) pseudoflemingi* EAMES (1951, p. 260, pl. 12, figs. 58, 59, 60a, b, 61, 62a-d) found only from

the Kirthar horizon is characterized by lower shell with more bialate form and smaller hinge plate and is sculptured by more closely arranged growth lamellae. *Ostrea (Liostrea) cf. rouaulti* MALLADA (COX, 1931, p. 63, pl. 3, figs. 5-8) lately designated to *Ostrea (Liostrea) sp.* by EAMES (1951, p. 362) has also similar form with the new species, but the former is characterized in having finer growth lamellae and smaller hinge part. *Ostrea (Flemingostrea) morgani* VREDENBURG (1916, p. 197, pl. 17, 18) differs from the new species in having more trigonal form with somewhat irregular growth lamellae, *Ostrea (Flemingostrea) halhora* VREDENBURG (1916, p. 199, pl. 19, pl. 20, figs. 8a-c) is somewhat similar to *O. mitsuiana* n. sp., but it has lower shell with stronger sinuation of surface.

Occurrence : Station L-1 (type locality)

Family Lucinidae

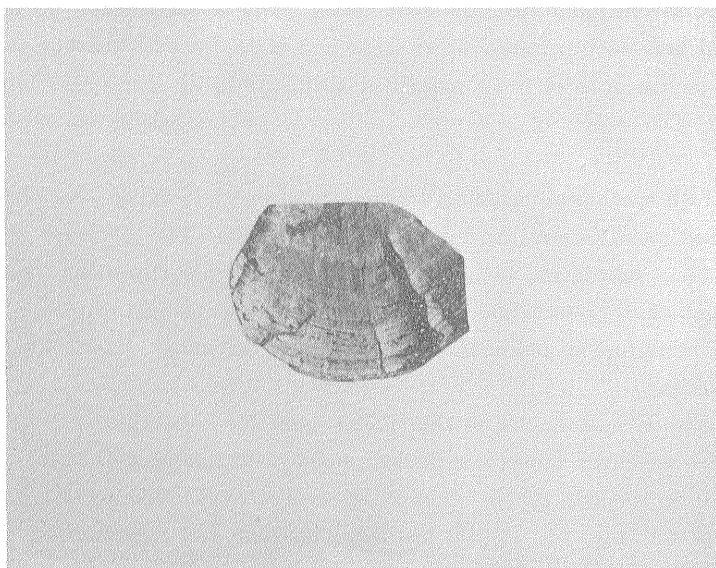
Genus *Pseudomiltha* FISCHER, 1887

Pseudomiltha undata (COX)

text-fig. 9, pl. 1, fig. 37

1931. *Lucina (Pseudomiltha) undata* n. sp.—COX, *Trans. Roy. Soc. Edin.*, vol. 57, pt. 1 (no. 2) p. 77, pl. 4, figs. 6a-c.

Remarks : Several specimens from one locality are available to the writer. They are more or less broken. Among them, the figured specimen of conjoined valves, 30 mm length and 23.5 mm height, is rather well-preserved, though it is somewhat deformed and more or less worn out. Its suboval form with umbo probably situated about at anterior one-third of shell quite agrees with that of *Lucina undata* COX from the Laki of Hindu Bagh. The Hindu Bagh specimen is characterized by its peculiar shell ornamentation of "delicate pattern of closely spaced zigzagging striae" (COX, 1931). This "*Acilana*" (KHOMENKO, 1937) type sculpture, shown in pl. 4, fig. 6c of COX's paper, is hardly visible in the Degari specimens; instead, they provide



Text-fig 9 A part of surface sculpture of *Pseudomiltha undata* (Cox), $\times 1.1$, left valve of holotype (GSJ. 5289).

many radial fine threads which are slightly wrinkled and rather distinct ventrally, but feebler dorsally, and thus the upper half of shells is sculptured with concentric growth lines and rarely visible very weak wrinkled threads tending to form very indistinct "Acilana" type sculpture. According to the writer's study, a variability of the "Acilana" type sculpture is recognized in *Portlandia* ("Acilana") *tokunagai* YOKOYAMA, 1925 and its related form widely distributed in the Miocene deposits of northern Japan, Sakhalin and Kamchatka: in some specimens that belong to the species, typical "Acilana" type sculpture characterizing the species almost dies away and its trace is weakly marked on a part of shell surface as wrinkled striae like as the present specimens of *Pseudomiltha*. Thus, the writer has the opinion that the specimens from Adit No. 3-1 represent certain form of *P. undata*.

Occurrence : Station 63-9-A3 (Adit No. 9)

Family Veneridae

Genus *Pitar* ROMER, 1857

Subgenus *Calpitarina* JUKES-BROWNE, 1908

***Pitar* (*Calpitarina*) *rakhiensis* EAMES**

pl. 1, figs. 16-18

1951. *Pitar* (*Calpitarina*) *rakhiensis* n. sp.—EAMES, *Phil. Trans. Roy. Soc.*, ser. B, vol. 235, p. 421, pl. 16, figs. 112a, b, 113a-c, 114.

Remarks: Several specimens of the present species, attaining about 10-15mm length and 8-11mm height, were obtained. Though they are smaller in size, and more or less deformed or partly broken, the ovate-subtrigonal forms with high and prominent umbo quite agree with that of *Pitar* (*Calpitarina*) *rakhiensis* EAMES. The shells are ornamented with concentric fine riblets.

Occurrence : Station 63-3S-BIL (Adit No. 3)

Genus *Meretrix* LAMARCK, 1799

***Meretrix*? sp.**

pl. 1, fig. 31

Remarks : The single right inner mould was obtained. It attains 15.0mm length and 12.0 mm height, being moderately inflated. The shell shows a subequilateral and subtrigonal form with prominent umbo slightly prosogyrate. Although its internal structure can not be seen, the above-mentioned feature probably suggests that belongs to certain species of *Meretrix*. It is akin to *Meretrix* (*Tivelina*) *gaasensis* COSSMANN (1921, p. 61, pl. 3, figs. 80-82), but has lower shell with more narrowly rounded antero-ventral corner. Compared with *Meretrix* cf. *villanovoe* (HEBERT et RENEVIER) reported by COX (1932, pl. 80, pl. 4, fig. 5), the Degari specimen has more trigonal and higher shell.

Occurrence : Station 63-3S-BIL (Adit No. 3)

Family Asaphidae

Genus *Psammotaea* LAMARCK, 1813

***Psammotaea* sp.**

text-fig. 10



Text-fig. 10 *Psammotaea* sp., $\times 1.3$, left (?) inner mould (GSJ. 5320).

Remarks : A single ill-preserved specimen probably of left inner mould, attaining about 12mm length, was obtained. Its apical part is broken. The transversely elongated and subequilateral, obliquely trigono-oval shell with faint internal radial threads suggest its generic attribution to *Psammotaea*. It somewhat resembles *Psammobia* sp. BOETTGER, 1880, p. 34, pl. 1, figs. 6-9a, b) in a general outline, but the latter has somewhat trapezoidal form with more inflated beak. Also, the present species is similar to *Psammotaea* sp. (COX, 1940, p. 368, pl. 7, fig. 4), which has larger shell with larger apical angle.

Occurrence : Station 63-9-A3 (Adit No. 9)

Family Tellinidae

Genus *Macoma* LEACH, 1819

***Macoma parabilella* n. sp.**

pl. 1, figs. 21-24, 24a, 25-30

Description : Test thin. Shell of moderate size, transversely oval, slightly inequilateral, rather inflated in anterior part. Umbo low, small, pointed, situated at central to slightly posterior portion of shell. Postero-dorsal margin oblique, gradually passing to the posterior end which is postero-dorsally produced at the upper portion of shell; the antero-dorsal arched, convex, anteriorly continued to semi-circular anterior margin; the ventral broadly rounded; posterior end of shell very faintly curved to the right. Surface of shell ornamented with distinct concentric growth lines. Escutcheon sharply defined, rather long, lanceolated. Hinge provides small two cardinal teeth. Pallial sinus only poorly preserved; it seems to be widely oval-subrhombic. Dimensions of holotype : length, 29.0mm; height, 19.6mm.

Remarks : Very abundant tellinacean fossils were obtained from the type locality. They are somewhat variable in shape and proportion of height to length. The results of measurements of paratype specimens figured in this paper are shown below.

Specimens (the number of figure in pl. 1)	length (mm)	height (mm)
21	26.0	18.0
22	25.2	17.8
23	25.3—	20.0
24	23.5	15.2
25	25.0	17.5
27	16.9	11.8
28	20.6	14.8
29	23.7	17.0
30	22.0	15.4

However, it is noteworthy that the fairly large apical angle and the postero-dorsally produced posterior end are found throughout nearly the whole specimens. In this respect, the present new species clearly differs from several species of *Macoma* reported from West Pakistan by EAMES (1951). It is very similar to *Abra parabilis* ZHIZHCENKO (MERKLIN, 1950, p. 78, pl. 6, figs. 1-4) in outline, but the former belongs to *Macoma*, having higher and larger shell. *Tellina biornata* BOETTGER (1875, p. 30, pl. 5, figs. 40a, b) somewhat resembles this new species, but it has smaller apical angle and posteriorly situated umbo. *Arcopagia Boussaci* COSSMANN (1921, p. 41, pl. 2, figs. 38, 39) is more similar to the new species in shape, but the former has higher shell.

Occurrence: Station 63-8-A3 (Adit No. 8) (type locality)

Family Corbulidae

Genus *Corbula* BRUGUIÈRE, 1797

Corbula sp.

pl. 1, figs. 16, 17

Remarks: One right valve and two left valves are examined. They exhibit very small shells only a little more than 4 mm of length, and are characterized by transversely oval-subquadrate form with rather small and non-prominent umbo. From the umbo runs a distinct carina towards postero-ventral corner. One specimen (pl. 1, fig. 16) measures length of 4.5 mm and height of 3.0 mm and another (pl. 1, fig. 17) measures length of 4.2 mm and height of 2.6 mm. *Corbula pseudorakhiensis* EAMES (1951, p. 439, pl. 14, figs. 89a-c) from the Gazij Shales is one of very similar forms to the present species, but the former is characterized by more short valves with more prominent beak.

Occurrence: Station 63-9-A3 (Adit No. 9)

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西パキスタン, デガリ炭田の始新世化石貝類群について

水野篤行

要 旨

西パキスタン, デガリ炭田付近には, 次の層序をもつ始新統が発達している, 上位から, キルタール石灰岩層・上部ガジー頁岩層・デガリ夾炭砂岩層・中部ガジー頁岩層・ライスデガリ夾炭砂岩層・下部ガジー頁岩層 (三井鉱山 K. K. 柿崎・下山両氏の資料による)。このうち, キルタール石灰岩層, 上部ガジー頁岩層の中部, デガリ夾炭砂岩層に含まれる貝類化石を検討する機会を得た。

前 2 者のものは種類が少ないが, 後 1 者には浅海棲ないし高鹹汽水棲の巻貝・二枚貝化石が多数含まれている。そのおもなものは, *Turritella harnaiensis* COX, *Cerithium baluchi* COX, *Cerithium punjabensis* EAMES, *Vicarya eocenica* COX, *potamides pakistanius* n. sp., *Saccella semibistriata* EAMES, *Arca pakistanica* n. sp., *Ostrea mitsuiana* n. sp., *Anomia shimoyamai* n. sp., *Isognomon pseudotomiyasui* n. sp., *Pitar rakiensis* EAMES., *Pseudomiltha undata* COX, *macona parabilella* n. sp. である。化石群を従来西パキスタンで知られている始新統の化石層序と比較すると, デガリ夾炭砂岩層のものは始新世初期のラキ階のものに一致する。また, 上部ガジー頁岩層のものはキルター階 (中部～上部始新統) を示す可能性が強い。検討した化石 (新種 6 種を含む) をすべて記載した。

PLATES
AND
EXPLANATIONS

(with 2 Plates)

Plate 9

- Figs. 1, 2. *Turritella (Striracolpus) harnaiensis* COX $\times 3$, St. 63-9-A3 : Fig. 1, dorsal view (GSJ, 5313); Fig. 2, fragment of spire (GSJ. 5310).
- Figs. 3, 4. *Vicarya eocenica* COX Dorsal views, St. 63-3S-A1L : Figs. 3, $\times 1.1$ (GSJ. 5295); Fig. 4, $\times 1.3$ (GSJ. 5296).
- Figs. 5, 5a, 6-8 *Potamides (Exechestoma) pakistanicus* n. sp. Figs. 5, 5a, dorsal and apertural views, $\times 1.2$ (GSJ. 5303, holotype); Figs. 6-8, paratype; Fig. 6, $\times 1$ (GSJ. 5304); Fig. 7, $\times 1.2$ (GSJ. 5303); Fig. 8, $\times 1.1$ (GSJ. 5306). All the specimen came from St. 63-3S-A1L.
- Fig. 9. *Faunus (Pseudobellardia) delphinus* (OPPENHEIM) $\times 1.2$, dorsal view, St. 63-3S-A1L (GSJ. 5301).
- Fig. 10. *Faunus?* sp. $\times 1.3$, fragment of spire, inner mould, St. 63-3S-B1L (GSJ. 5299).
- Figs. 11, 38. *Faunus* n.? sp. $\times 1.1$, dorsal views, St. 63-3S-A1L : Fig. 11, (GSJ. 5297); Fig. 38, (GSJ. 5298).
- Figs. 12, 13. "*Helix*" sp. Obliquely apical views of deformed specimens, St. 63-8-A3: Fig. 12, $\times 1.1$ (GSJ. 5311); Fig. 13, $\times 1.2$ (GSJ. 5212).
- Fig. 14. *Nerita* sp. $\times 1.1$, St. 63-8-A3, obliquely apical view of inner mould (GSJ. 5315).
- Figs. 15, 15a. *Saccella* cfr. *semibistriata* (EAMES) $\times 3.3$, St. 63-9-A3, inner mould of right valve (GSJ. 5294); Fig. 15a, dorsal view.
- Figs. 16, 17. *Corbicula* sp. $\times 2.4$, St. 63-9-A3, Fig. 16, inner mould of left valve (GSJ. 5318); Fig. 17, inner mould of right valve (GSJ. 5219).
- Figs. 18-20. *Pitar (Calpitaria) rakhienis* EAMES Fig. 18, $\times 1.1$ (GSJ. 5288) : Fig. 19, $\times 1.1$ (GSJ. 5285); the both inner mould of right valve : Fig. 20, $\times 1.0$, deformed inner mould of right valve (GSJ. 5286). All the specimens came from St. 63-3S-B1L.
- Figs. 21-24, *Macoma parabilella* n. sp. Figs. 21 (GSJ. 5375), 22 (GSJ. 5329), 25 (GSJ. 5334), 27 24a, 25-30. (GSJ. 5332), $\times 1.0$, right valve : Figs. 23 (GSJ. 5333), 30 (GSJ. 5337), $\times 1.0$, left valve : Figs. 24, 24a (GSJ. 5338), 28 (GSJ. 5336), 29 (GSJ. 5331), $\times 0.9$, left valve : Fig. 26, $\times 0.8$, right valve (GSJ. 5330, holotype). All the specimens came from St. 63-8-A3.
- Fig. 31. *Meretrix?* sp. $\times 1.1$, St. 63-3S-A1L, inner mould of right valve (GSJ. 5287).
- Figs. 32, 32a. *Anomia shimoyamai* n. sp. $\times 1.5$, St. 63-3S-B1L, Fig. 32a, dorsal view (GSJ. 5322 holotype).
- Figs. 33, 33a. *Barbatia* sp. $\times 3$, St. 63-3S-B1L, inner mould of left valve; Fig. 33a, dorsal view (GSJ. 5292).
- Figs. 34, 35, *Arca pakistanica* n. sp. Figs. 34, $\times 2.5$, St. 63-3S-B1L, inner mould of right valve 35a. (GSJ. 5290); Figs. 35, 35a, $\times 3.2$, St. 63-9-A3 left valve (GSJ. 5293).
- Fig. 36. *Chlamys* cfr. *soriensis* EAMES $\times 1.5$, L-1, inner mould (GSJ. 5321).
- Fig. 37. *Pseudomiltha undata* (COX) $\times 1.5$, St. 63-9-A3, very worn out right valve (GSJ. 5289).

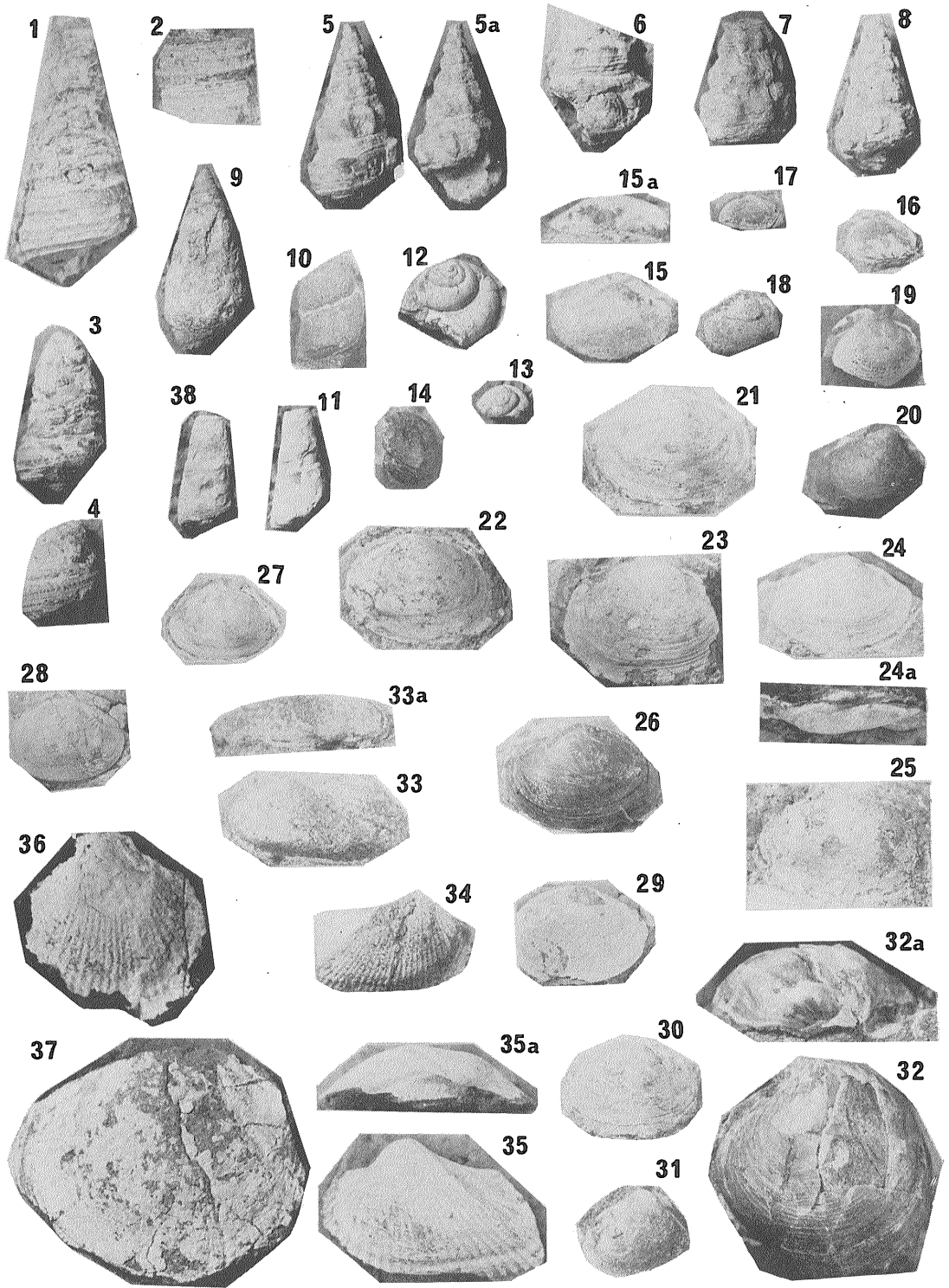


Plate 10

Figs. 1, 1a-c. *Ostrea (Liostrea) mitsuiana* n. sp.

2, 2a, b: $\times 1.1$, L-1; Figs. 1, 1a-c, right valve (GSJ. 5324 holotype); Fig. 1b, posterior view; Fig. 1c, dorsal view; Figs. 2, 2a, b, left valve (GSJ. 5323); Fig. 2b, anterior view.

Figs. 3, 4. *Isognomon Pseudotomiyasui* n. sp.

St. 63-9-A3: Fig. 3, $\times 1.3$, internal view of very worn left valve (GSJ. 5326, holotype); Fig. 4, $\times 1.2$, inner mould of broken left valve (GSJ. 5328).

Fig. 5. *Tonna?* sp.

$\times 1.1$, St. 63-L-4, inner mould of body whorl, dorsal view (GSJ. 5317).

Figs. 6, 6a. *Chiraluia?* sp.

$\times 1$; St. 63-L-1, inner mould of body whorl: Fig. 6, dorsal view; Fig. 6a, apical view (GSJ. 5284).

Figs. 7, 7a,b. cfr. *Volutospina kohatica* EAMES

8. $\times 1$, St. 63-9-A3, Figs. 7, 7a, very worn out shell, much deformed (GSJ. 5282); Fig. 7b, model of outer cast of a part of the shell; Fig. 8. model of outer cast of another shell, obliquely apical view (GSJ. 5281).

