DIATOMS FROM THE PLEISTOCENE DEPOSITS OF KASHMIR (INDIA) — PART I. CENTRIC DIATOMS

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INTRODUCTION

ALTHOUGH the Pleistocene microfossil flora of Kashmir has been investigated by various workers ever since it was first discovered by Godwin Austen (1859), not much has been observed about the diatom flora. It is mostly the pollen that has been studied. The earliest record of the occurrence of some species of diatoms is by Cogner (De Terra & Paterson 1939; Puri, 1948). In a later paper Iyengar & Subrahmanyan (1943) have described and figured 15 species of diatoms, most of which have been compared to modern fresh water and marine genera and species.

Some pieces of clayey blocks from Laradura in Kashmir were obtained by the authors through the courtesy of a friend. Maceration of these blocks showed a rich diatom flora part of which is being described in the present paper.

MATERIAL AND METHODS

The material was in the form of two clayey blocks, one ash coloured and small grained, the other blackish in colour, peaty and with large amount of organic remains. But it is the ash-coloured clayey matter that yielded a larger number of diatoms. We are inclined to think that this material is a pure aquatic deposit, as it contained mainly diatoms. The other blackish material contains pollen, cuticles, and woods, etc., probably indicative of a peaty deposit.

The maceration was mainly done after treating the clay with Hydrofluoric acid for twelve to eighteen hours and then treating it with strong nitric acid for two to four days. The material was then washed and dehydrated after decanting and finally mounted in Canada Balsam. The centrifuge was used at various stages in the above process. This technique, however, was not very successful, because some of the diatoms were dissolved in Hydrofluoric acid.

Slight variation of this technique was the elimination of Hydrofluoric acid and addition of Nitric acid (concentrated) along with potassium chlorate crystals. Part of the material was treated with Sodium hydroxide (10 per cent solution in distilled water) and a part with Potassium hydroxide (10 per cent solution in distilled water) for about ten minutes. But Somehow sodium hydroxide gave better results.

In a different technique employed, the material was treated with concentrated Hydrochloric acid for six days and then repeatedly washed in distilled water, dehydrated and mounted in Euparol. Hydrochloric acid was sometimes replaced by Sulphuric acid with better results. This material was then centrifuged and was spread on a clear slide smeared with Myers albumen, and stained in the way recommended by Iyengar & Subrahmanyan (1944). Iron alum, haemotoxalin and fast green were the only stains that proved very helpful.

Of course, bleaching of diatoms with a mixture of equal quantities of hydrogen peroxide, 10 per cent solution with 30 per cent alcohol, preceded the staining process.

All the sketches have been made with the help of a camera lucida, often with the added help of an oil immerson lens.

DESCRIPTION

Order	...	Centrales
Sub-order	...	Discineae
Family	...	Coscinodiscaceae
Sub-family	...	Melosiroideae
Genus	...	Melosira

***Melosira* Agardh (1824)**
M. ambigua* var. *laradura

Pl. 1, Fig. 1; Text-figs. 1, 2

This type of diatom is the most commonly found type in the matrix. The frustules in girdle view are cylindrical, united in chains (Text-fig. 1; Fig. 1), the semicells in this

view measure 8·30 μ in height and roughly 7·6 μ in diameter. The space between the sulci is broader than long, and measures 3·32 μ in height. The sulcus between the semicells and also the space referred to above are quite clear and are apunctate (TEXT-FIG. 1; Fig. 1). In the girdle view, small punctae are distributed over the rest of the surface in sinuous oblique vertical rows, as indicated diagrammatically in (TEXT-FIG. 1). The number of punctae in each row would be about twenty to twenty-four. Valve view is circular (TEXT-FIG. 2), 8·3 μ in diameter and is covered by minute punctae disposed in no definite order.

Two types of a species of *Melosira*, somewhat similar to this, have been described by Kanaya T. (1959) from the Miocene deposits of Onnagava formation in North-east Japan.

DIMENSIONS

Diameter	8·3 μ
Height of one semicell	7·6 μ
Height of the space, between the sulci of two adjacent valves	3·32 μ

Melosiraambigua* (Grün) O. Mull. *M. ambigua* var. *desikacharya

Pl. 1, Fig. 2; Text-figs. 3, 4

Frustules cylindrical 9·28 μ long by 4·98 μ broad, placed end to end in chains (TEXT-FIG. 3; FIG. 2). Space between the sulci of two adjacent valves is broader than long as in the previous species. The cell wall is clearly punctate, punctae all over the surface except between the sulci. There is no sulcus between the semicells as in the previous species. Valve view circular (TEXT-FIG. 4), 9·98 μ in diameter and apunctate.

DIMENSIONS

Diameter	4·98 μ
Height of one semicell	9·28 μ
Height of the space between the sulci of two adjacent valves	3·32 μ

Melosira ambigua* var. *krishna

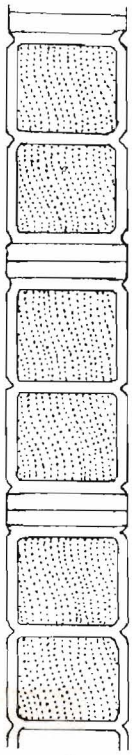
Pl. 1, Fig. 3; Text-figs. 5, 6

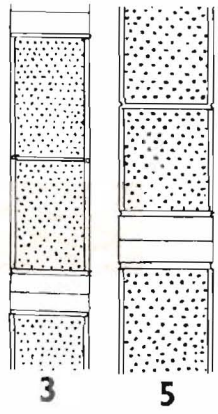
Frustules cylindrical (TXET-FIG. 5, FIG 3) in chains, cells longer than broad, each semicell is 9·96 μ in height by 6·64 μ in breadth, alternating with the small space between the sulci of adjacent walls, which is 3·32 μ in height. Valve view punctate, punctae arranged in transverse rows all over the frustules. Sulcus present in between the semicells. Valve view circular and apunctate (TEXT-FIG. 6).

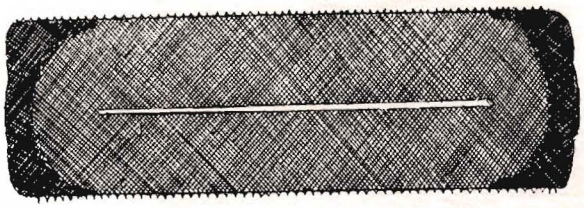
DIMENSIONS

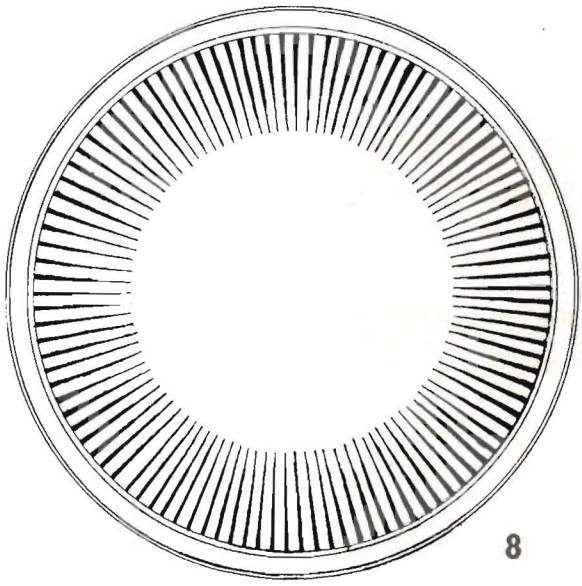
Diameter	6·64 μ
Height of one semicell	9·96 μ
Height of the space between the sulci of two adjacent valves	3·32 μ

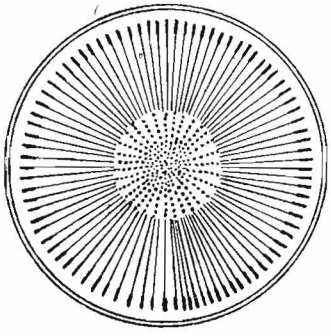
The three varieties described above seem to resemble *M. ambigua* and to some extent *M. granulata* (HUSTEDT, 1930, pp. 89) except in the absence of a neck, but a careful examination shows that they differ from both of these in not possessing pointed projections on the septa differentiating the two semicells. The arrangement and the number of punctae are different in each of the species described above. In *M. ambigua* var. *laradura*, the punctae are in oblique vertical rows, while in the other two varieties they are in transverse rows. In *M. ambigua* var. *laradura* the semicells are of almost the same height and width while in the variety *desikacharya* they are about two times longer than broad and in var. *krishna* they are slightly longer than broad. The sulcus is present in between the semicells in var. *krishna* but in var. *desikacharya*, on the other hand, there is no sulcus between the semicells. All the above three varieties show rather certain close resemblances that lead one to think that they may be more or less related, or that they are different stages of the same species. But the fact that in the collection there are no intergrading specimens between these varieties and what is more important, the presence of the small structural differences stated above, suggest that these are definitely different types and could be kept apart as new varieties. Even these minute differences are of sufficient significance in dealing with fossil material. Normally perhaps these differences could be regarded in living plants as of not great importance. But in the study of plant fossils including microfossils size and minute variations are of some significance. It is from this point of view that these 3 types described above have been placed as 3 new varieties of a species with which they show general resemblances.

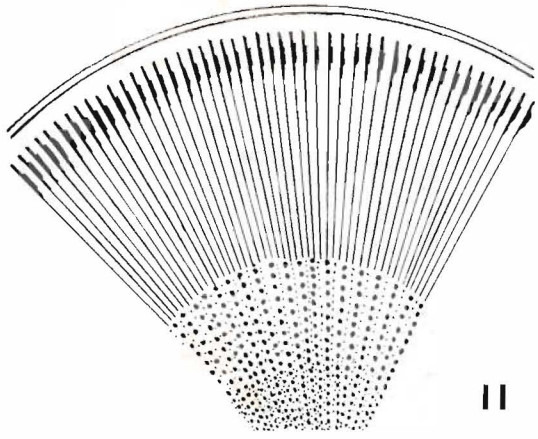












TEXT-FIGS. 1-11

***Melosira arenaria* Agardh (1824)**

Pl. 1, Fig. 4; Text-figs. 7, 8

Frustules discoid, broader than long, 38·18 μ broad by 14·94 μ in height. In girdle view the entire surface is marked by series of fine lines which cross each other (TEXT-FIG. 7), small echinulate markings are seen on the upper and lower margins.

The shaded corners in the figure represent the thickness of the curved valves. No neck is visible, a clear median streak is seen in the girdle view, vertical walls very thick. Valve view (TEXT-FIG. 8; FIG. 4) circular with marginal radiating striae, which are broader towards the periphery and narrower towards the centre, diameter 38·18 μ, central area clear.

This diatom is one of the rarer types in the collection. It has not also been found in regular chains as is generally found in Melosiroideae. Only two or three specimens of two-celled filament were found. The others were generally solitary. In fact the reference of this type, to the genus *Melosira* was a little doubtful. But Smith (1950. pp. 462) has pointed out that in non-sulcate Melosiras the girdle view is ornamented. Since our specimens show abundant very fine criss-cross striae in the girdle view and a few specimens of the filamentous condition have been found, we have referred this type to the genus *Melosira*. This fine sculpturing of the girdle has also been used as a diagnostic character by Fritsch (1927). This type resembles *Melosira arenaria* a Kette (HUSTEDT, 1930, FIG. 60), but is smaller in size; the fine streak in the middle of the girdle in our specimen is also found in Hustedt's figure (FIG. 60). The exact nature of this streak is not clear. A fossil specimen of this species from Italian rocks has been figured by Coupin (FIG. 25 s, t, PL. 285). Evidently this species is very variable in size as the measurement recorded ranges from 15 to 100 μ in diameter.

DIMENSIONS

Diameter	38·8 μ
Height of frustule	14·94 μ

SUB-FAMILY COSCINODISCOIDEAE
GENUS CYCLOTELLA KÜTZING F.T. (1834)

***Cyclotella comta* (Ehr.) Kütz (1834)**

Pl. 1, Fig. 5; Text-figs. 9-11

Frustules solitary, discoid, girdle view (TEXT-FIG. 9) narrowly rectangular, ornamented in two rows of striae on both sides of the girdle with a median convexity on either side, walls thick, 27·22 μ in diameter and 3·32 μ in height. Valve view (TEXT-FIG. 10) circular, ornamented with marginal striae, and radiating rows of punctae in the centre. The striae (PL. 1, FIG. 5; TEXT-FIG. 11) become broader or double themselves towards the margin. The wall is two-layered. The striae are numerous and 8·30 μ in length. This is the most common type met with in the collection. This species bears a very close resemblance in size, shape and sculpturing to *Cyclotella comta* (Ehr.) Kütz. var. *radiosa* (Grün.) reported by Frenguelli (1927, FIG. 12, PL. 1), from the Pleistocene deposits of the place Udai Refuf of Kharga in Egypt.

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TEXT-FIGS. 1-11 — 1-2, *Melosira ambigua* var. *laradura*. Filamentous girdle and valve views respectively. Girdle view shows the larger semicells, and space between the sulcus of one valve and that of the next. Girdle surface is punctate with punctae arranged in sinuous oblique rows. 3-4, *Melosira ambigua* var. *desikacharya*. Girdle and valve views respectively. Girdle view shows semicells, and a space between the sulcus of one valve and that of the next. Entire surface punctate, punctae without any regular arrangement. Valve surface completely apunctate. 5-6 *Melosira ambigua* var. *krishna*. Girdle view and valve view respectively. Girdle view shows the semicells and a space between the sulcus of one valve and that of the next. Entire girdle surface punctate, punctae not arranged in any definite order. Valve surface apunctate. 7-8, *Melosira arenaria* Agardh a Kette. Girdle and valve views respectively. Girdle view shows very fine criss-cross lines, and a median streak, corner thickenings are due to doubled margins. Margin shows echinulate structures. Valve view shows the clear outer wall, the peripheral striae and central clear area. Striae are radially arranged and much broader towards the periphery. 9-11, *Cyclotella comta* (Ehr.) Kütz. Girdle and valve views and a sector of the valve view respectively. Girdle view shows bullate surfaces. The marginal ornamentations really belongs to the valve surface but are seen in the girdle view due to the curvature of the valve margin. Valve view shows the outer zone of radiating striae, and central area with punctae in radial rows. Fig. 11 is a magnified view of the margin which shows the marginal striae and central punctae. The striae are thickened at their terminations. The punctate area shows minute indistinct punctae and larger distinct punctae, both arranged in radial rows.

DIMENSIONS

Diameter	27·22 μ
Height of frustule	4·98 μ
Length of striae	8·30 μ

Cyclotella comta* (Ehr.) Kütz var. *affinis

Pl. 1, Fig. 7; Text-figs. 14-17

Frustules solitary, very common in matrix, valve view circular 18·26 μ in diameter (PL. 1, FIG. 7; TEXT-FIG. 14). In one focus a clear thick wall, a central granular area, and a peripheral zone of striae, can be seen. The central granular area is large and circular, punctate, the smaller punctae showing a radiating arrangement. A few larger punctae are also seen in the area with no definite arrangement. In the peripheral striate zone the striae are thin, long and dichotomise (PL. 1, FIG. 7; TEXT-FIG. 15) towards the periphery of the frustule. The peripheral striae (ps) resolve themselves into two kinds, shorter undivided peripheral striae (ps) and longer divided striae. At a slightly different focus the same valve presents a slightly different appearance, the larger central punctae, and a ring of rectangular areas (a) come into focus (TEXT FIG. 16). The latter are evidently the spaces where the striae dichotomise. The exact nature of these areas is not clear. The girdle view (TEXT-FIG 17) is elongated and 4·98 μ in height, bullate on both the surfaces, clear overlaping of epi and hypo valves, unornamented.

This species of diatom can be compared with *Cyclotella comta* (Ehrenb) Kütz var. *affinis* Grün (ENGLER & PRANTL, 1900, p. 66, FIG. 85), Coupin (1910, p. 289, FIG. 13. PL. 289) and Fritsch (1948, p. 567) in all respects except the size of the punctae. Still we think that this species belongs to *Cyclotella comta*.

DIMENSIONS

Diameter	18·26 μ
Height of frustule	4·98 μ
Length of striae	4·98-5·2 μ

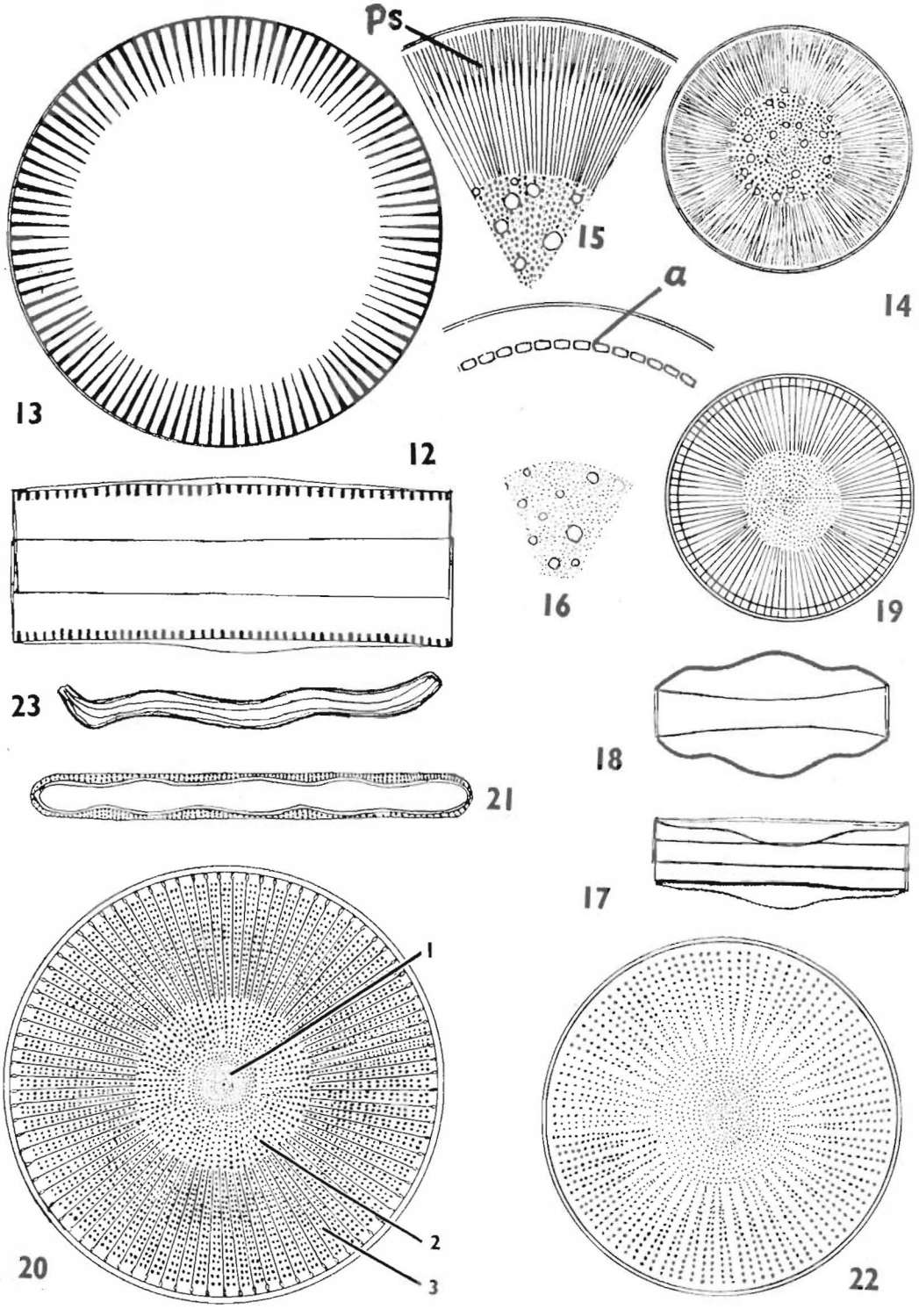
***Cyclotella meneghiniana* Kütz (1834)**

Pl. 1, Fig. 6; Text-figs. 12, 13

Frustules solitary, discoid, girdle view (TEXT-FIG. 12) rectangular, slightly bullate, epi and hypo valve clear, ornamented, 33·20 μ in diameter, 12·4 μ in height. Valve

→

TEXT-FIGS. 12-22 — 12, 13, *Cyclotella meneghiniana* Kütz. Girdle and valve views respectively. Valve view shows the marginal zone of radiating striae much thickened at the periphery, and a very broad central clear area. 14-17, *Cyclotella comta* (Ehr.) Kütz var. *affinis* valve view, sector of the valve view, sector of the valve view at a slightly different focus, and girdle views respectively. Fig. 14. Valve view shows the central punctate area with two types of punctae, larger scattered ones and smaller punctae in radiating rows. Fig. 15 shows the outer wall, larger circular punctae of equal size, the smaller punctae, striae which dichotomise in the outer region, between the dichotomy and punctate area the striae are single. Fig. 16 represents the same valve view at a different focus under oil immersion lens. The larger punctae and the wall come into focus. The central region with smaller punctae become hazy. The striae are also out of focus. The ring of squarish areas seen are perhaps the regions of the dichotomy of the striae which come into focus. Fig. 17 represents a diagrammatic girdle view as the diatom would not rest on the girdle surface for a long. The girdle view is bullate and unornamented. 18, 19, *Cyclotella iyengaria*. Valve and girdle views respectively. Valve view shows the peripheral zone of radiating striae of uniform thickness all along their length occupying almost two-thirds of the valve. Central area punctate, punctae very small and showing a faint radial arrangement. 20, 21, *Stephanodiscus astraea* (Kütz) Grün. Valve and girdle views respectively. Valve view shows a clear outer circular margin and ornamented by three ill-defined concentric zones of punctae: (a) central squarish area of very small-sized punctae; (b) middle circular area of punctae larger than the central ones in radiating rows; (c) outermost zone of punctae occupying nearly two-thirds of the valve in radiating often divided rows, ending in a dilated punctae, probably the bases of spines. There are clear striae-like areas in between these dividing rows. Girdle view unornamented, showing wavy margins. Ornamentations are seen due to curvature of the valve margins. This species has been referred tentatively to *Stephanodiscus* in view of the above characters which are particular to this genus, and partly because the type cannot be accommodated in any other genus. The dilated marginal elliptic punctae-like structures are regarded by us as the bases of short deciduous spines. But at the same time we would like to point out that the girdle view does not indicate the presence of any clear spines. 22, 23, *Stephanodiscus astraea* var. *bizonata*. Valve and girdle views respectively. Valve view shows uniform punctae in two concentric zones, a central area shows irregularly arranged punctae and a peripheral area shows punctae in dividing radiating rows. Girdle view is sinuous and without any ornamentations with the ends raised up in the same direction.



TEXT-FIGS. 12-22

view (PL. 1, FIG. 6; TEXT-FIG. 13) circular, 33·20 μ in diameter, a clear broad unornamented central area present, striae marginal, broader towards the periphery and narrower towards the centre, 4·98 μ in length.

This species resembles closely to *Cyclotella meneghiniana* Kütz. We feel that this comes definitely under the species *C. meneghiniana*.

DIMENSIONS

Diameter	33·20 μ
Height of frustule	12·4 μ
Length of frustule	4·96 μ

***Cyclotella iyengaria* sp. nov.**

Pl. 1, Fig. 8; Text-figs. 18, 19

Frustules solitary, discoid, valve view (PL. 1, FIG. 8; TEXT-FIG. 19) circular, 18·26 μ in diameter, striated, striae unbranched, radially arranged, central area punctate, punctae small, uniform and show radial arrangement in some parts. Girdle view (TEXT-FIG. 18) is approximately rectangular and unornamented, but bullate on both the surfaces. It has not been possible to compare this species with any living types. The valve view agrees with those of many centric diatoms figured by Hustedt (1930) and Gonzalves & Gandhi (1952, p. 124, FIG. 9, PL. 1). But the girdle view is different not only in form but also in ornamentation.

A new specific name *Cyclotella iyengaria* is given to this specimen.

DIMENSIONS

Diameter	18·26 μ
Height of frustule	6·64 μ
Length of the striae	4·98 μ

Cyclotella iyengaria listed here differs widely in size and the pattern of sculpturing from *C. glomerata* described and figured by Hustedt (1930, p. 105). In *C. iyengaria* the central portion is punctate and the radial striae extend inwardly up to the outer margin of the punctate area. This does not agree with the figures of *C. glomerata* given by Hustedt. In his figures the punctae are limited in number, and between them and the striae zone there is a clear area. These are not present in *C. iyengaria*. In view of this sculptural difference we propose to separate *C. iyengaria* from *C. glomerata*.

***Stephanodiscus astraea* (Ehr.) Grün.**

Pl. 1, Fig. 9; Text-figs. 20, 21

Frustules discoid, solitary, valve view (PL. 1, FIG. 9; TEXT-FIG. 20) circular, 34·86 μ in diameter, completely punctate, punctae in three indistinctly defined zones: (1) a central squarish zone of very small punctae, not very clear; (2) circular area of large radiating punctae; (3) puntae in radiating rows, which dichotomise in the middle and are separated by very narrow areas, looking like striae and ending with dilated punctae towards the margin, probably the bases of spines, girdle view (TEXT-FIG. 21) linear, narrow and unornamented.

This species can be compared in all respects except the size with two types of the variety *spinulosa* (Grün.); of *Stephanodiscus astraea* Kütz (Grün.) figured and described by Frenguelli (1927, p. 9, FIGS. 14, 15; PL. 1), from the Pleistocene deposits of the place Udai Refuf of Kharga locality in Egypt. The two types which he has described measure 86 μ and 76 μ. Our specimens are intermediate in size between these two.

A species very much similar to ours has also been described from the Pleistocene deposits of different zones of Argentina, locality Pampa, by Frenguelli G. (1945, p. 214, FIGS. 33, 34; PL. 13) as *Stephanodiscus astraea* var. *minilula* (Kütz) Grün.

DIMENSIONS

Diameter	34·86 μ
Height of frustule	3·32 μ

Stephanodiscus astraea* var. *bizonata

Pl. 1, Fig. 10; Text-figs. 22, 23

Frustules solitary, discoid, valve view (PL. 1, FIG. 10; TEXT-FIG. 22) circular, 29·88 μ in diameter, punctate, punctae all over, uniform, grouped into a circular area in the centre and arranged in radiating rows towards the outer two-thirds of the valve. Girdle view (TEXT-FIG. 23) linear, narrow and sinuous, 3·32 μ in height. This specimen could not be compared more definitely but can no doubt be accommodated in the extremely variable genus *Stephanodiscus*. A Cretaceous species *Coscinodiscus meculosus* recorded by Long Fuge, Smith & Dingley (1946) from the Moreno Shales of California, U.S.A., resembles our specimen but is roughly twice as big and bears scattered colourless spaces on the inner side of the valve view.

TABLE 1

Deterra & Paterson				Iyengar, M. O. P. & Subrahmanyan, R.				Rao & Awasthi			
Names of genera	Habitat	Locality	Age	Names of genera	Habitat	Locality	Age	Names of genera	Habitat	Locality	Age
Cyclotella comta (Ehr.) and varieties	F.W.	Handwar	Lower Karewa beds. Very soft dark grey shale much lime-lake beds (alkaline water lake)	—	—	—	—	—	—	—	—
—	—	—	—	*Cyclotella meneghiniana* (Kützin) (Kütz)	F.W. B.W.	Gulmarg way about 9000 ft. altitude	Karewa beds	*Cyclotella meneghiniana*	F.W.	Laradura	Karewa beds
—	—	—	—	—	—	—	—	*Cyclotella comta*	—	Laradura	Karewa beds
—	—	—	—	—	—	—	—	*Cyclotella comta* var. *affinis*	—	Laradura	Karewa beds
—	—	—	—	—	—	—	—	*Cyclotella iyengaria* sp. nov.	—	Laradura	Karewa beds Kashmir
Cyclotella kützingii	F.W. B.W.	Naushahra sample	Upper siwalik period. Jatrot stage, early pleistocene light coloured lime rock	—	—	—	—	—	—	—	—
—	—	—	—	*Melosira distans* (Kütz)	F.W.	Gulmarg 9000 feet altitude	Karewa beds	—	—	—	—
—	—	—	—	—	—	—	—	*Melosira ambigua* var. *laradura*	—	Laradura	Karewa beds Kashmir
—	—	—	—					*Melosira ambigua var. desikacharya*	—	Laradura	Karewa beds Kashmir
—	—	—	—	—	—	—	—	*Melosira ambigua* var. *krishna*	—	Laradura	Karewa beds Kashmir
—	—	—	—	—	—	—	—	*Melosira arenaria*	—	Laradura	Karewa beds Kashmir
—	—	—	—	—	—	—	—	*Stephanodiscus astraea* var. *bizonata*		Marine Laradura	Karewa beds Kashmir
—	—	—	—	—	—	—	—	*Stephanodiscus astraea*	—	Laradura	Karewa beds Kashmir

DIMENSIONS

Diameter	29·88 μ
Height of frustule	3·32 μ

This specimen resembles closely *Stephanodiscus astraea*. But there are certain significant differences also. *S. astraea* var. *bizonata* shows two zones of punctae and absence of a striae-like area in between the rows of punctae in the outer zone. In *S. astraea* on the other hand, the punctae zone is threefold and there are definite striate areas between the punctate rows. In view of this we propose to put our specimen under a new varietal name *bizonata*.

DISCUSSION

The diatom flora of the Pleistocene deposits of Kashmir has been recorded, so far as we are aware by Cogner from Handwar, and Iyengar and Subrahmanyan (1943) from the Karewa deposits, and also by Puri (1948).

The present paper describes some diatoms that have been discoverd at a different locality Laradura. Cogner reported only two species of centric diatoms, *Cyclotella comta* and *C. kützingii*. Iyengar & Subrahmanyan (1943) have reported on the other hand *Cyclotella meneghiniana* and *Melosira distans*. Our list includes 4 species of *Cyclotella*, four species of *Melosira* and one hitherto unreported genus *Stephanodiscus*. These facts are indicated in Table 1.

It is not advisable at this stage to comment in general about the diatom flora found in these Laradura clays. We are studying the Pennate diatoms also and then the entire collection may throw some light on the nature of diatoms in these beds.

As already stated the blocks macerated were of two kinds, one was grey, soft and fine grained, and this, showed mostly diatoms. The other block was dark brown in colour, soft, slightly porous and was rich in organic matter. It is likely that the former represented the fine silt of the centre of a lake bed while the latter represents perhaps the marginal deposits rich in organic debris like cuticles, woods, pollens, etc.

ACKNOWLEDGEMENTS

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REFERENCES

AGARDH, C. A. (1824). *Systema Algarum* **1**: 312. *London.*

COUPIN, H. (1910). Album Genrall der Cryptogames. *Tomo Permier* **1**: Paris; E. Orlhac Editeur Librairie Generale L'enseignment 4. rue Dante.

FRENGUELLI, G. (1927). Diatomee dei Travertini del Uadi Refuf; Presso Loasi di Kharga nell Al to Egitto. Estratto; dal Bollellno della Societa *Geologica Italiana* **XLVI**: Fasc 1. Roma Industria Tipographica. Romana via Germanico. 146.

FRENGUELLI, J. (1945). El. Platerse Y. Sus diatomeas Por J. Frenguelli. Universidad. Nacional de la plata. Entracto de la Revista del museo de la Plata (Nuerva Serie) Succion Geologia Tomo II. 287-311 Y seccion Paleontologia Tomo III, 77-221 *La Plata Republica Argentina.*

FRITSCH & WEST, G. A. (1927). Treatise on British Fresh Water, Algae. *Cambridge.*

GODWIN AUSTEN, H. H. (1859). On the Cacustrine of Karewa deposits of Kashmir. *Geol. Surv. London Quart. Jour.* **15**: 223-229.

GONZALVES, E. A. & GANDHI, H. P. (1952). A systematic account of the diatoms of Bombay and Salsette Part I. Centrales and Pennales. *J. Indian bot. Soc.* **31**: 117-151.

HUSTEDT, F. (1930). Bacillariophyta (Diatomeae), Die Süsswasser, Flora Mitteleuropas. Aeft 10, *Jena.*

IYENGAR, M. O. P. & SUBRAHMANYAN, R. (1943). Fossil diatoms from the Karewa beds of Kashmir. *Proc. Nat. Acad. Sci. India,* **13** Pt. 4: 225-236.

KANAYA, T. (1959). Miocene diatom assemblages from Qnnagawa formation and their distribution in the co-relative formations in North-east Japan. *Science Reports of Tohoku University, Sendae, Japan, Second series (Geology)* **30**: 1-30.

KUTZING, F. T. (1949). Species Algarum Lipsiae. 19.

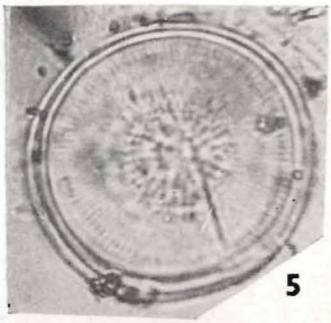
LONG, J. A., FUGE, D. P. & SMITH, J. (1946). Diatoms of the Moreno Shale. *Jour. Paleont.* **20**: No. 2.

PURI, G. S. (1948). The Flora of the karewa series of Kashmir and its phytogeographical affinities with chapters on the methods used in identification. *Indian Forester.* **74**: No. 3.

RABENHORST, L. (1894). Flora Europaea Algarum Lipsiae.

SMITH (1950). The fesh water Algae of United States. *London*

WODEHOUSE, R. P. & DE TERRA (1934). The Pleistocene pollen of Kashmir. *Rec. Geol. Surv. India* **68**: 121-176.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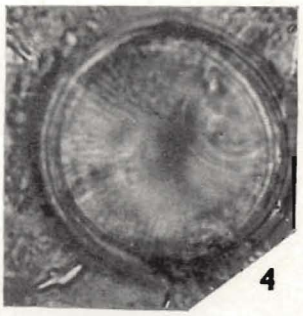
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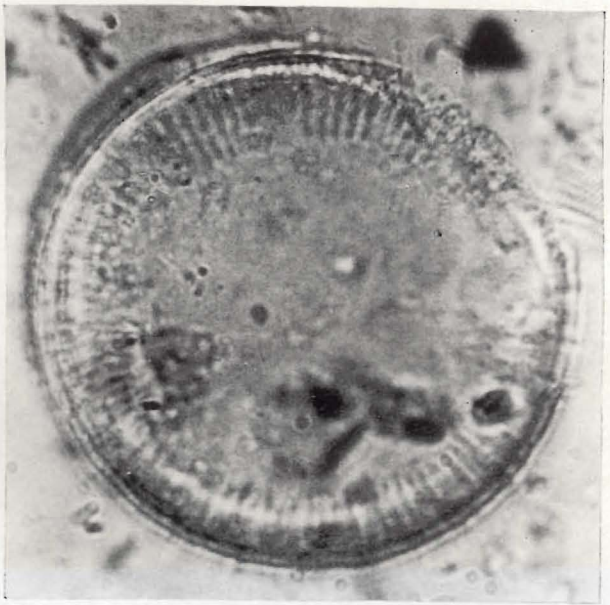
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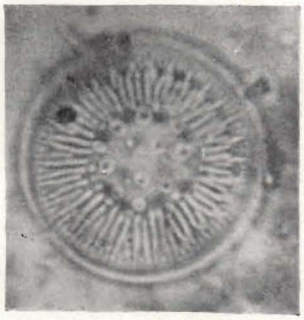
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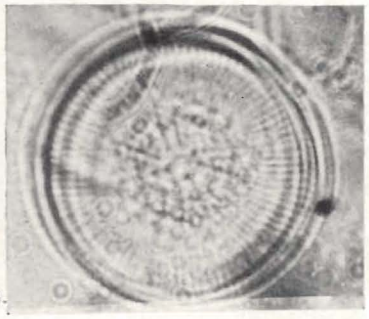
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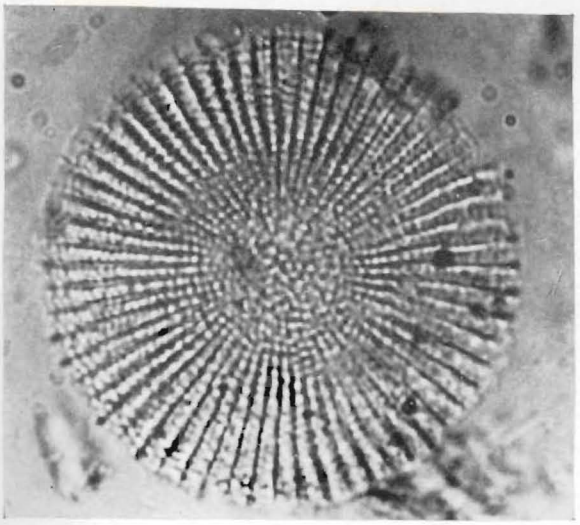
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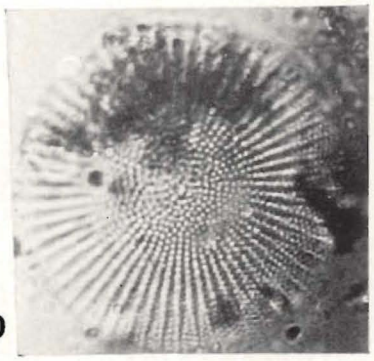
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EXPLANATION OF PLATE 1

1. *Melosira ambigua* var. *laradura*. Girdle view. × 1140.
2. *Melosira ambigua* var. *desikacharya*. Girdle view. × 960.
3. *Melosira ambigua* var. *krishna*. Girdle view. × 432.
4. *Melosira arenaria*. Agardh, a Kette. Valve view. × 630.
5. *Cyclotella comta* (Ehr.) Kütz valve view. × 1480
6. *Cyclotella meneghiniana* Kütz valve view. × 1675.
7. *Cyclotella comta* (Ehr.) Kütz var. *affinis* valve view. × 1400.
8. *Cyclotella iyengaria* 1. Valve view. × 1540.
9. *Stephanodiscus astraea* (Ehr.) Grün Valve view. × 2760.
10. *Stephanodiscus astraea* var. *bizonata*. Valve view. × 2760.