

Fossil Diatoms from Baltal, Karewa Beds of Kashmir

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We report here the occurrence of fossil diatoms on the site of Baltal village near Romu on the Romushi River valley.

RESULTS

We have analysed in all 41 samples from Baltal area of which about 60% have shown a number of diatoms, both centric and pennate types. Besides these, we analysed 250 samples from other localities but they proved sterile in diatoms.

In Baltal the following 21 genera of diatoms were recorded:

Melosira, *Cyclotella*, *Stephanodiscus*, *Tetracyclus*, *Opephora*, *Fragilaria*, *Cocconeis*, *Achnanthes*, *Gyrosigma*, *Caloneis*, *Diploneis*, *Stauroneis*, *Navicula*, *Pinnularia*, *Amphora*, *Cymbella*, *Gomphonema*, *Epithemia*, *Hantzschia*, *Nitzschia* and *Surirella*. Thus the generic assemblage found is very rich since almost all the commonly found fresh water genera are represented here.

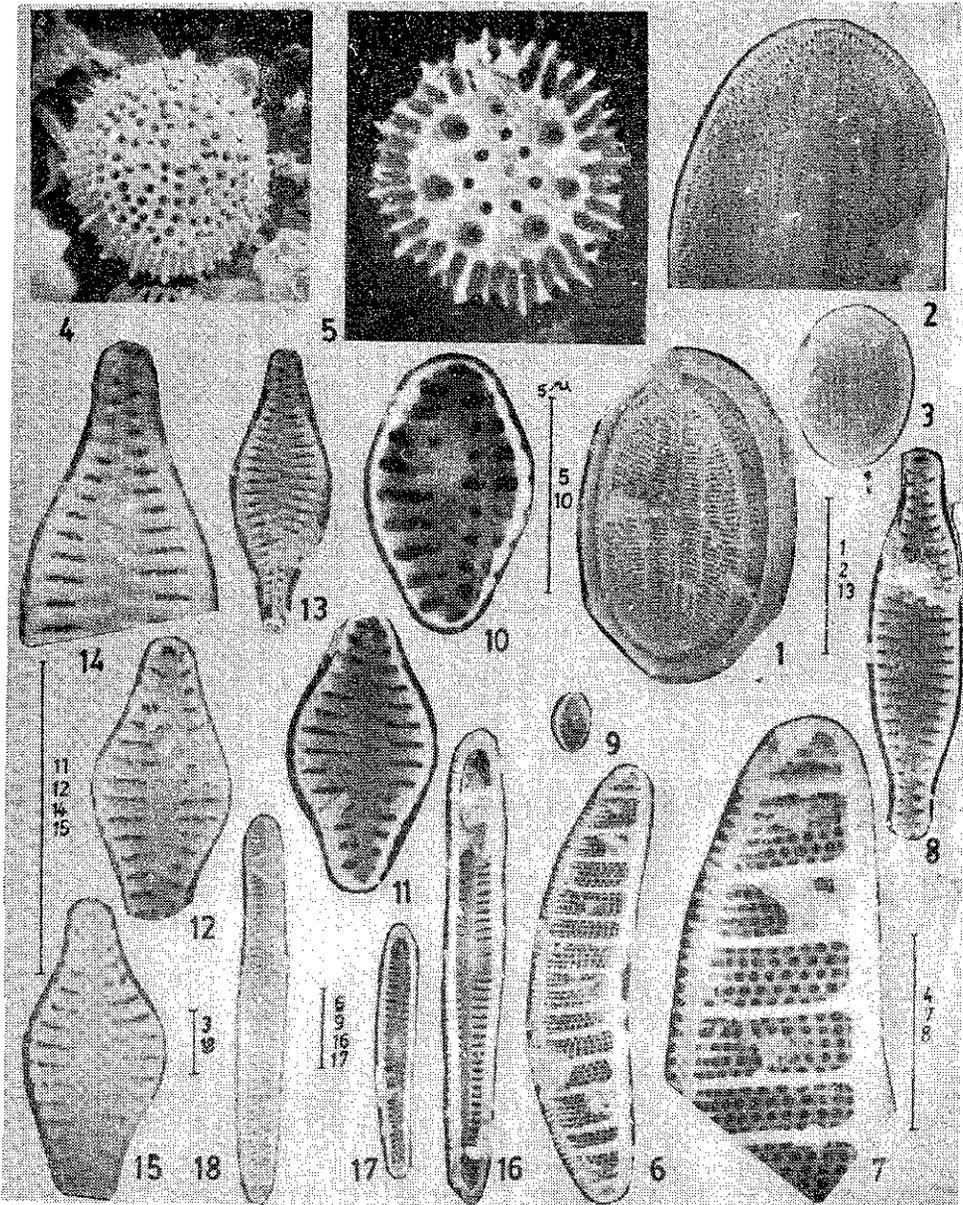
The representative species of most of the given genera are as follows: *Melosira granulata* (Ehr.) Ralfs; *Cyclotella comta* (Ehr.) Kütz.; *C. iris* Brun; *C. Kützingiana* Thw.; *C. -var. ambigua* var. nov.; *C. -var. planetophora* Fricke; *C. -var. radiosa* Fricke (*C. kützingiana* Thw and its varieties were thought to be *Liradiscus* or a new centric diatom); *Tetracyclus emarginatus* (Ehr.) W. Sm.; *Stephanodiscus astrea* (Ehr.) Grun.; *S. -var. minutula* (Kütz.) Grun.; *S. hantzschii* Grun.; *Opephora martyi* Heribaud; *Fragilaria leptostauron* (Ehr.) Hust., *F. -var. dubia* Grun.; *F. -var. amphiteras* Grun.; *F. -var. binodis* (Ehr.) Grun.; *F. -var. baltalensis* var. nov.; *F. -var. venter* (Ehr.) Grun.; *F. inflata* (Heid.) Hust.; *F. virescens* Ralfs; *Cocconeis placentula* Ehr var. *euglypta* (Ehr.) Cl.; *C. -var. lineata* (Ehr.) Cl. *Actinanthes* sp.; *Gyrosigma* sp.; *Caloneis schumanniana* (Grun.) Cl. var. *bicanstricta* Grun.; *Diploneis elliptica* (Kütz.) cl.; *D. -var. ladogensis?* Cl.; *D. subovalis* Cl. var. *ovata* var. nov.; *Stauroneis acuta* W. Sm. var. *tenuis* Gonzal. et Gandhi; *Navicula anglica* Ralfs; *Nperegina?* (Ehr.) Kütz.; *N. gastrum* Ehr.; *N. -var. signata* Rust.; *N. scutelloides* W. Sm.; *N. pelliculosa?* (Breb.) Hilse; *Pinnularia viridis* (Nitz.) Ehr.; *P. lacunarum* Hust.; *P. dairiana* A.S.; *Amphora* sp.; *Cymbella lata* Grun.; *C. cuspidata* Kütz.; *C. reinhardtii?* (Lyngb.) Kütz.; *Gomphonema olivaceum?* (Lyngb.) Kütz.; *G. intricatum* Kütz.; *G. -var. dichotoma* (Kütz.) Grun.; *Epithemia zebra* (Ehr.) Kütz.; *E. -var. saxonica* (Kütz.) Grun.; *E. -var. subcapitata* May.; *E. sorex* Kütz.; *Hantzschia amphioxys* (Ehr.) Grun. var. ?; *Nitzschia* 2-3 species; *Surirella robusta* Ehr. and 1-2 species.

Here a few diatoms are treated taxonomically with their illustrations and or SEM photomicrographs revealing their finer structures. The known stratigraphy is also given with other details and remarks. In this taxonomic treatment the diatoms are arranged alphabetically for the sake of convenience. Only the new records for India and new taxa are fully described here.

SYSTEMATIC

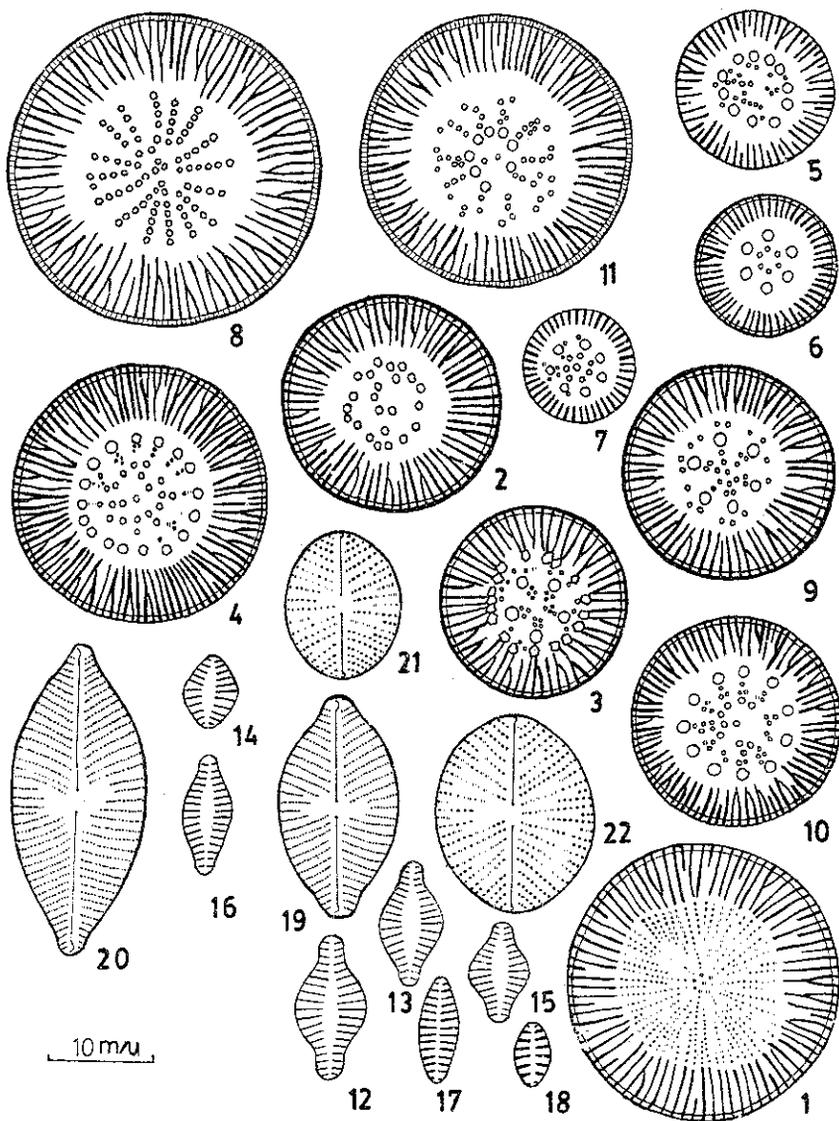
Cocconeis placentula Ehr. var. *euglypta* (Ehr.) Fig 9 19(1) Cl (Hustedt, F. 1930, *Bacil.*, p 190, Fig. 261.) Valves 24-284 μ long and 14-15 μ broad. Striae about 20-22 in 10 μ , dash like.

Fresh water fossil. Reported from Oligocene to the recent period. In the SEM photomicrograph the border zone is apparent from the striate one. The striae are punctate but intersected by longitudinal spaces on raphe valve.



EXPLANATION OF FIGURE 9 19

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|---|--|
| 1. <i>Cocconeis placenutula</i> Ehr var <i>euglypta</i> (Ehr) Cl | 9-12. <i>F.</i> —var <i>venter</i> (Ehr) Grun |
| 2-3. <i>C.</i> —var <i>lineata</i> (Ehr) Cl | 13-15. <i>F. inflata</i> Heid Hust |
| 4. <i>Cyclotella comta</i> ? (Ehr) Kütz | 16. <i>Gomphonema intricatum</i> Kütz |
| 5. <i>C. kützingiana</i> Ihw. var <i>planetophora</i> Fricks | 17-18. <i>G.</i> —var <i>dichotoma</i> (Kütz) Grun |
| 6-7. <i>Epithemia zebra</i> (Ehr) Kütz | |
| 8. <i>Fragilaria construens</i> (Ehr) Grun var <i>batalensis</i> var. nov | |



EXPLANATION OF FIGURE 9.20

1. *Cyclotella comta* (Ehr) Kütz
 2. *Cyclotella Kützingiana* Thw
 3-4. *C.*-var. *ambigua* var nov
 5-7. *C.*-var. *radiosa* Fricke
 12-13. *Fragilaria construens* (Ehr) Grun

- 14-16. *F* var. *venter* (Ehr) Grun.
 17-18. *F* *pinnata* Ehr
 19. *Navicula gastrum* Ehr.
 20. *N.*-var. *signeta* Hust
 21-22. *N. scutelloides* W. Sm

Note Scale bar on the plates indicates 10 microns or as indicated

Cocconeis placenula var. *lineata* Cl. Fig. 9 19(2-3) (Hustedt, F. 1930, *Bacil.*, p. 190, Fig. 262) valves 30-40 μ long and 21.3-23 μ broad. Striae 20-30 in 10 μ , clearly punctate, intersected by broad irregular hyaline bands on the rapheless valve

Fresh water fossil. Reported from the Pleistocene and older strata upto recent period. The SEM photomicrograph clearly represents the features of striae intersected by broad irregular longitudinal zones, punctae towards the margins are more scattered

Cyclotella comta (Ehr.) Kütz Fig. 9 19(4); Fig. 9 20(1). (Hustedt, F. 1930, p. 103, Fig. 69; 1927-1959, *Die Kieselalgen*, Teil. I, p. 354, Fig. 183 a-d; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 224, Figs. 1-4, 18, 23-25; Rao, A. R. & Awasthi, P. 1962 Pleistocene deposits, p. 85, Pl. 1, Fig. 5, text Figs. 9-11; p. 86, Pl. 1, Fig. 7, text Figs. 14-17) (= *compta* var. *affinis* Grun.)

Valves 15-25 μ in diameter, discoid. Striae 13-14 in 10 μ central field clearly punctate, punctae arranged in radial rows, punctae very coarse. Some striae seem to dichotomise in their course to the periphery

Fresh-water fossil. Reported from the Miocene to Pleistocene deposits, also recent. The SEM photomicrograph clearly shows the pores in the central zone radially arranged, at the very centre 5-7 pores are a little large and some striae represent dichotomies although the diatom is not complete.

Remarks: Hustedt, in this *Die Kieselalgen*, reduced *C. compta* var. *affinis* Grun. to the type proper

Rao & Awasthi have created *C. iyengaria* a new taxon, (loc. cit., p. 88 text Figs. 18-19), but it is no other than *C. compta*. The photomicrograph is poor and the illustrations are very diagrammatic. The reference made by Rao and Awasthi of their new entity to *C. glomerata* Bachmann, has nothing to do here. In the girdle view, the point of bulge stressed by them is not relevant. In fact, when these diatoms formed in chains—some individuals have such bulges and the others have corresponding depressions.

Cyclotella kützingiana Thw. Fig. 9 20(2). (Hustedt, F. 1930, *Basil.*, p. 98, Fig. 62; Schmidt, A. S. 1874-1959), *Atlas Diat.*, Pl. 222, Figs. 1-7, 13-14)

Valves 18,24 μ in diameter. Middle field with few or more alveoli irregularly disposed. Striae about 12 in 10 μ , coarse, some dichotomise in their course towards margin

Fresh-water fossil. Reported from the Pleistocene, older to recent strata.

Cyclotella kützingiana Thw. var. *ambigua* var. nov. Fig. 9 20(3-4) Valves 17-27 μ in diameter, discoid. Middle field with small and large alveoli, large alveoli in a ring surrounded or followed by smaller pores arranged in groups or not. Striae about 11-13 in 10 μ , coarse, some of which dichotomise. Fresh water fossil. A new record for the science.

These diatoms show ambiguous arrangement of small and large alveoli, but the large alveoli are found arranged into a ring consisting of few to many alveoli associated by smaller ones in groups or otherwise. Under the change of focus of the microscope the pores appear polygonal in outline as in *Coscinodiscus*. This diatom has superficial resemblance to *Cyclotella (compta) pantanelli* Castr. (Schmidt, 1874-1959, *Atlas Diat.*, Pl. 233, figs. 1-5 and particularly figs. 1, 4) However, the arrangement of larger pores here is different. The middle field structure in *C. compta* (Ehr.) Kütz is very different. It consists of uniformly small pores arranged in radial rows. *Cyclotella kützingiana* Thw. var. *planetophora* Fricke, Fig. 9 19(5); Fig. 2(5-7) (Hustedt, F. 1930, *Bacil.*, p. 99, fig. 63; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 222, figs. 9-12)

Valves 0.5-24 μ in diameter, discoid. Middle field with large and small pores or alveoli either irregularly or more or less regularly arranged in circles, sometimes 6-7 large alveoli distinctly arranged in a ring with or without another ring of small alveoli in the same number. Striae 9-13 in 10 μ very coarse and a few or more dichotomise towards the periphery, towards the margin very thin and short striate markings present

Fresh water fossil. A new record for India

The SEM photomicrograph represents the middle zone having 6-7 large alveoli arranged in a ring inside which another ring of small pores. The striae show dichotomies towards margin. Other illustrations show many large alveoli interspersed with smaller ones in regular or irregular arrangement. *Cyclotella kützingiana* Thw. var. *radiosa* Fricke Fig. 9.20(8-11) (Hustedt, F 1930, *Bacil*, p 99, Fig. 64; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 222, Fig. 8)

Valves 18-35 μ in diameter, discoid, margin striate. Middle field with large radial rows of alveoli or the ring of large alveoli are associated with smaller ones showing radial arrangement. Striae about 9-12 in 10 μ , coarse, few or more of them dichotomise in their course towards periphery. Fresh water fossil. Stratigraphically is not known but reported from fossil beds. It is a new record for India

In these diatoms pores in the middle field under different focus of the microscope show rounded to polygonal shape and where the density of pores occur the structure looks like in *Coscinodiscus*, evidently surrounded by striae.

Epithemia zebra (Ehr.) Kütz. Fig. 9.19(6-7). (Hustedt, F 1930, *Bacil*, p. 384-385, fig. 729; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 252, fig. 1)

Valves 67-80 μ long and 9-11.5 μ broad, acute. Ribs 2-3 in 10 μ , rows of alveoli 11-12 in 10 μ , rows of alveoli between two ribs 3-6

Fresh water, fossil. Reported from the Pleistocene to recent period

The SEM photomicrography represents clearly the rows of alveoli as stated, the poles are not constricted but smoothly rounded.

Fragilaria construens (Ehr.) Grun. Fig. 9.20(12-13) (Hustedt, F. 1930, *Basil*, p. 140, Fig. 135; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 296, Figs. 25-29, 39-42) Valves 9-15 μ long and 5.5-6 μ broad, rhomboid lanceolate with rostrate rounded ends. Pseudoraphe narrow lanceolate. Striae about 14-15 in 10 μ .

Fresh water fossil. Reported from the Pleistocene and older deposits. It is a very variable species. The apices are sometimes slightly capitate.

Fragilaria construens (Ehr.) Grun. var. *baltalensis* var. nov. Fig. 9.19(8)

Valves 18-22 μ long and 4.5 μ broad, linear-lanceolate, ends constricted, produced and capitate. Pseudoraphe wide about 1/3 the width of the valves, linear lanceolate. Striae about 14-16 in 10 μ , slightly radial towards ends, lineolate. Fresh water fossil. It makes a new record for the science. This entity resembles or compares *F. construens* (Ehr.) Grun. such as the striae and pseudoraphe. The striae are finely lineate and well indicated in channel like depressions. It differs from *F. bicapitata* A. Mayer (Hustedt, *loc. cit.* p. 143, Fig. 148) in having broader, narrowly lanceolate pseudoraphe and narrower capitate ends. *Fragilaria construens* (Ehr.) Grun. var. *venter* (Ehr.) Grun. Fig. 9.19(9-12); Fig. 9.20(14-16). (Hustedt, F 1930, *Basil* 141, f. 138; 1927-1962, *Die Kieselalgen*, Teil II, p. 156, Fig. 670 h-m; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 296, Figs. 30-33, 47)

Valves 7-12 μ long and 3.7-5 μ broad, rhomboid or broadly lanceolate, ends more or less constricted, more less produced broadly rounded. Pseudoraphe fairly wide, lanceolate. Striae about 13-15 in 10 μ , thick, slightly radial throughout lineolate. Fresh water, fossil. Reported from Oligocene, Pleistocene to recent period

The SEM photomicrographs clearly show the lineolations of the striae, fairly broad lanceolate pseudoraphe. It is a new record for India.

Fragilaria inflata (Heid.) Hust. Fig. 9.19(13-15) (Hustedt, F 1927-1962, *Die Kieselalgen*, Teil II, p. 155, Fig. 669 f, g, l)

Valves 20-30 μ long and 5.5-7 μ broad, broadly lanceolate with constricted, narrowly produced rounded ends. Pseudoraphe fairly broad, lanceolate following the outline. Striae about 14 in 10 μ , slightly radial, lineate between the ridges, ridges reach the middle axis making the pseudoraphe very narrow. Fresh water fossil. Stratigraphy not known. It is a new record for India.

The SEM photomicrographs represent striae between the ridges the ridges reach the mid axis reducing the pseudoraphe to an extremely narrow region. The striae leave out a broad lanceolate pseudoraphe. The striae are lineate but lineations suffer destruction due to fossilization.

Fragilaria pinnata Ehr. Fig. 9 20 (17-18) (Hustedt, F. 1930, *Basil.*, p. 142, Fig. 141; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 297, Figs. 47-53; Pl. 298, Figs. 47-74) Valves 5-10 μ long and 3.5-4 μ broad, lanceolate with rounded ends. Pseudoraphe narrow, more or less linear. Striae about 11-12 in 10 μ , slightly coarse and radial, lineations fine.

Fresh water fossil. Reported from the Pleistocene and older strata as well as recent.

Gomphonema intricatum Kütz. Fig. 9.19(16). (Hustedt, F. 1930, *Basil.*, 375; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 235, Figs. 15-17; Pl. 236, Figs. 1-8) Valves 50-80 μ long and 5-7 μ broad. Striae 8-10 in 10 μ punctate.

Fresh water fossil. Reported from the Miocene to recent period. In the SEM photomicrograph raphe ends in the central nodule appear hook like curved and other part prolonged. This feature finds illustration in the *Atlas Diat. I*.

Gomphonema intricatum Kütz. var. *dichotoma* (Kütz.) Grun. Fig. 9 19(17-18). (Hustedt, F. 1930, *Basil.*, 375; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 234, Figs. 51-55; Pl. 235, Figs. 30-33.) Valves 32-58 μ long and 5-6.5 μ broad, clavate-linear, linear throughout with rounded ends. Raphe thick, with the character as in the type. Axial area linear; central area larger almost unilaterally extended to one side opposite to the stigma. Striae 11-12 in 10 μ , slightly radial throughout, fine but clearly punctate. Middle striae distinctly separated and one opposite to it is very small or absent.

Fresh water fossil. Reported from the Miocene to the recent period.

The character of this entity is that it is all throughout narrow and has 11-13 striae in 10 μ . It is a new record for India.

Navicula gastrum Ehr. (Hustedt, F. 1930, *Basil.*, p. 305, Fig. 537; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 398, Figs. 1-2)

Valves 20-25 μ long and 13 μ broad, broadly linear lanceolate, ends abruptly constricted with broadly rostrate rounded. Raphe thin and straight, central pores distinct and terminal fissures shortly curved. Axial area quite narrow, linear; central area large, transversely expanded. Striae 9-10 in 10 μ , radial throughout, slightly curved, indistinctly punctate, middle striae short and long.

Fresh water fossil. Reported from the Pleistocene and older strata; also recent.

The present specimens represented smaller dimensions, broader valves with very evident rostrate ends. But such variations exist in this entity.

Navicula gastrum Ehr. var. *signata* Hust. Fig. 9 20(20) (Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 403, Figs. 27-28) Valves 29-32 μ long and 13-14 μ broad, broadly lanceolate, ends constricted and rostrate rounded. Raphe thin and straight with central pores distinct and terminal fissures shortly curved. Axial area narrowly linear; central area fairly wide with a stigma on one side. Striae 11-12 in 10 μ , radial throughout and slightly curved, punctate, middle striae more or less short and long.

Fresh water fossil. Stratigraphic status is not known. It is a new record for India.

Navicula scutelloides W. Sm. Fig. 9.20(21-22). (Hustedt, F. 1930, *Basil.*, p. 311, Fig. 557; Schmidt, A. S. 1874-1959, *Atlas Diat.*, Pl. 404, Figs. 22-25)

Valves 13-19 μ long and 12-15 μ broad, broadly elliptical without any constriction. Raphe thin and straight with central pores distinct and terminal fissures shortly curved. Axial area narrow, linear; central area small elliptical rounded, sometime slightly unilateral. Striae 11-13 in 10 μ , very coarsely punctate, radial throughout but more so towards poles, few or more intervening striae are short.

Fresh water fossil. Reported from the Pleistocene and older strata. It is a new record for India.

Here, out of several diatoms listed in the beginning only 18 are treated taxonomically. Out of these, 7 are new records for India, two are considered to be new varieties for the science. The diatoms, *Cocconeis placentula* Ehr. var. *euglypta* (Ehr.) Cl.; *C.*—var. *lineata* (Ehr.) Cl.; *Cyclotella comta*

(Ehr.) Kütz.; *Epithemia zebra* (Ehr.) Kütz.; *fragillaria construens* (Ehr.) Grun.; *Gomphonema intricatum* Kütz., are previously reported as fossils from the Karewa Beds of Kashmir by Conger (1939), Iyengar and Subrahmanyam (1942)—Chiefly *Cocconsis placentula* var. *euglypta* (Ehr.) Cl., *Fragilaria construens* (Ehr.) Grun. and Roy & Awasthi (1962)—*Cyclotella comta* (Ehr.) Kütz. The specimens, *Cyclotella comta* var. *laffinis* Grun. and *Cyclotella iyengaria* mentioned by Rao & Awasthi (1962) are discussed and reevaluated. The diatoms, *Cyclotella kützingiana* Thw., *Fragilaria pinnata* Ehr., *F.*—var. *lancetula* (Schum.) Hust., and *Navicula gastrum* Ehr., recorded as non-fossil by earlier workers are found here in fossil state.

GENERAL REMARKS

All the diatoms listed and detailed above are essentially of fresh water origin. Further, no genera here show abundance in species hence the species assemblage is rather poor. Of the noted species the number of specimens found to be variable but not in high frequency excepting *Cyclotella comta* (Ehr.) Kütz., *Stephanodiscus astrea* (Ehr.) Grun. and *Cyclotella kützingiana* Thw. and its varieties (somewhere thought to be *Liradiscus*)

In all the samples *Stephanodiscus astrea* (Ehr.) Grun. predominated, and the second dominant entity found was *Cyclotella kützingiana* Thw. and its varieties

Baltal is a new locality and the diatoms are being recorded for the first time. Our findings show that the assemblage is a mixture of both centric and pennate types. It is very rich in genera shown earlier but not in species content. Rao & Awasthi (1962) reported from Ladakh such an assemblage although in their paper they dealt with only the centric diatoms belonging to genera *Cyclotella*, *Melosira* and *Stephanodiscus*. Roy's (1974) proposal of bio-zones seems to be arbitrary so also the concept of very rich, moderately rich and poor assemblages. It may be appreciated that a large number of genera of diatoms and or their species in any sample make a rich assemblage and not the number of specimens of one or more species, because the specific species may be gregarious or producing blooms.

So far all the diatoms reported or discovered in India have a very wide temporal range which stretches from the Oligocene to the Holocene. However, considering the assemblage of diatom species the strata from which the samples are derived, for our knowledge or understanding, belong to very late Pliocene or early Pleistocene period as similar assemblages are reported from other countries. This is our tentative observation. As our critical systematic analysis is in progress—at a later date we hope to provide a much clearer picture of the stratigraphy and the past climatology and also the palaeoecology.

We have not found any kind of zonations separating centric diatoms from the pennate types as reported by Roy (1974). Such a feature is hardly to be expected. The early evolution of centric diatoms may be true but not at all in the present fresh water situation, since the Karewa sediments do not reach early Miocene nor they are marine in origin. Moreover, the genera like *Melosira*, *Cyclotella*, *Stephanodiscus* etc. do not have an evolutionary status or series.

It can be stated here for certain and without hesitation that the Karewa sediments under this investigation belong to fresh water lacustrine origin of cooler climate as indicated by genera such as *Stephanodiscus*, *Tetracyclus*, *Opephora*, larger forms of *Cymbella*, *Pinnularia* and others.

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