CLIMATO-DIATOMOLOGICAL RESULTS FROM BALTAL—LOWER KAREWA BEDS, KASHMIR, INDIA

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ABSTRACT

The climatic record of the Kashmir valley for the past 4 million years is preserved in the Karewa sediments, having an estimated thickness of ~1000 m, deposited under glacio-fluvial lacustrine conditions capped by a mantle of loess. These primaeval lake sediments were diatom-analysed to infer palaeoclimatic changes in the Kashmir valley. Here we report the reconstruction of the palaeoecological and palaeoenvironmental set-up of a portion of the Lower Karewa sediments exposed on the left bank of the Romushi at Baltal locality. Though there are a few reports of fossil diatoms from Kashmir areas in the past, studies on fossil diatoms of exposed sediments are not available and no serious attempt was made to determine the palaeoenvironment of the valley on the basis of fossil diatoms. The main aim of this study is to reconstruct the palaeoecology on the basis of fossil diatom flora as they have distinct ecological tolerances and are useful palaeoecological indicators.

INTRODUCTION

THE Karewa lake originated because of the rise of Pir-Panjals, probably in Pliocene times. Further rise of Pir-Panjals lifted up the Lower Karewa sediments and pushed the lake towards the Himalayan flank. At some stage, the Baramula fault breached the Pir-Panjals and the Jhelum drained out the lake. This is a simplified model as proposed by De Terra and Paterson[1]. A boat-shaped valley thus formed has a sediment profile of several hundred metres with beautiful exposures caused by tectonics and erosion[2]. These relict lake sediments of the Kashmir valley present a unique challenge for palaeoclimatological investigations. As there have been differences of opinion regarding the age of Karewas[3-10], palaeoclimatic and palaeoecological conditions prevailed in the valley during the past ages; these sediments thus have attracted geologists, palaeobotanists, palaeontologists and archaeologists for almost a century now. In trying to decipher the long-term climatic record of the Karewas, one has to contend with a variety of evidences. One cannot afford to take only a single parameter climatic change; its multifold manifestations have to be studied. Thus various techniques are being employed both to delineate climatic and environmental changes in the past. Of the biological remains which can be found and identified in the sediment, diatom frustules are usually the best preserved. Among the sediment components fossil diatoms give rise to a promising data set for interpreting past environments. They have been used to provide relative chronologies and evolutionary trends. As phytoplankton, they are restricted to the mixed layer. They are diverse and their physiology and ecology are far better understood than any other group of microfossils. Against this background we have used diatoms as a biological parameter to unravel the depositional environments of the Kashmir valley. Here we report our diatomological investigations from the Baltal locality of the Lower Karewa sediments.

STRATIGRAPHY

The site Baltal is a village (33° 49′ 20″ N; 74° 49′ 00″ E) near Romu, on the Romushi valley. The Romushi flows west to east, cutting through and exposing the thick pile of the Karewas along its course, till it meets the Jhelum. The main exposures are on the left bank of the river Romushi (figure 1). Baltal is a new locality and diatoms are being reported for the first time. The section exposed at Baltal consists of mud, clay and loess sand (table 1).

MATERIALS AND METHODS

In the 70 m thick Baltal profile, a total of 80 samples were collected with much precaution so as

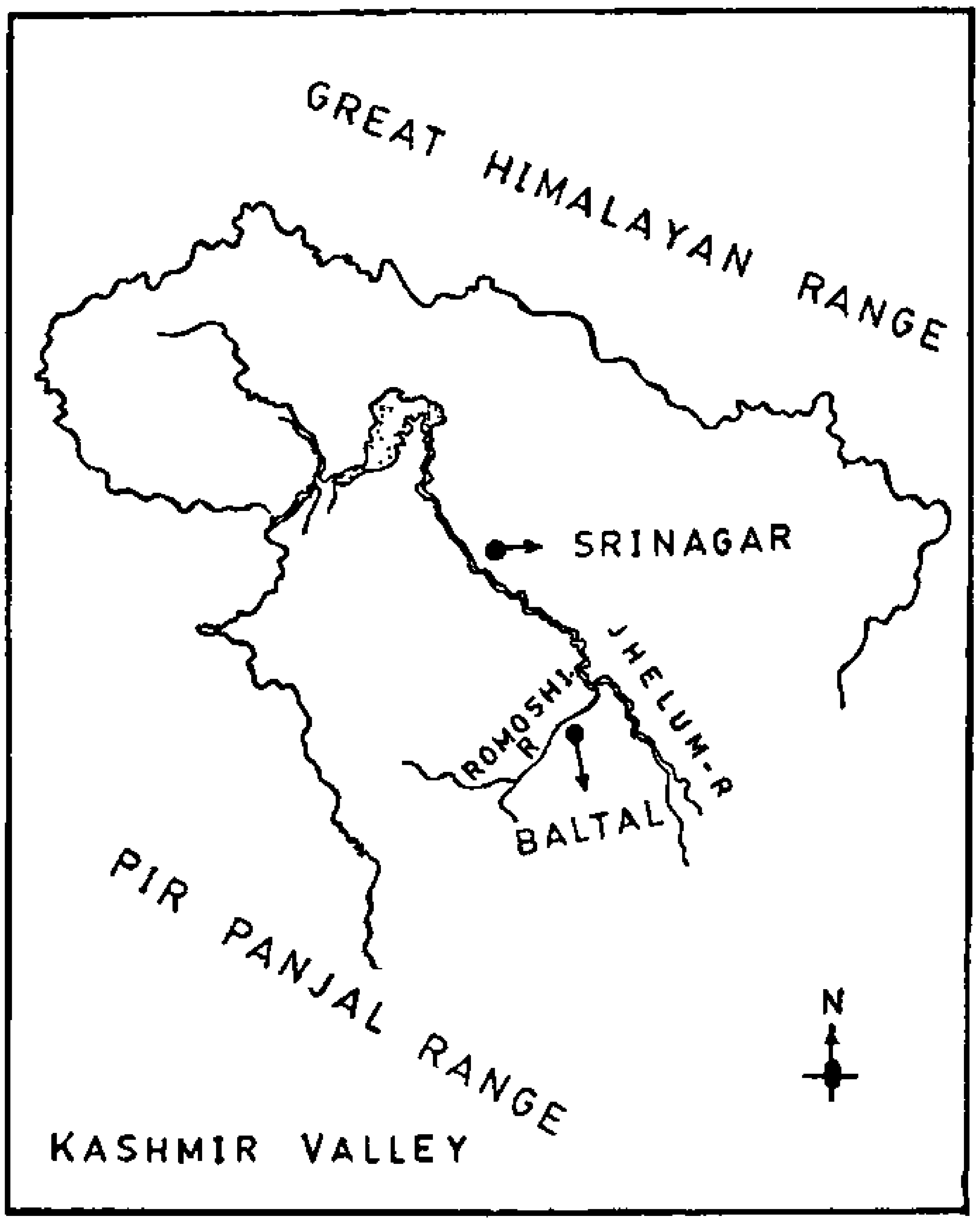


Figure 1. Map showing location of Baltal in Kashmir valley.

Table 1 *Sediment stratigraphy of the Baltal sediments (Bottom upwards)*

Length (m)	Sediment description
0–8.3	Medium coarse sand
8.3–9.5	Fine sand without laminations
9.5–22.5	Compact fractured blue to brown-coloured mud
22.5–22.93	Fine laminated mud
22.93–23.63	Upper reddish non-laminated, middle compact, lower compact greyish mud
23.63–27.83	Structureless and compact greyish mud
27.83–32.83	Compact fractured bluish mud with reddish clay
32.83–33.53	Fine laminated, greyish bluish mud
33.53–35.03	Bluish fractured and compact mud
35.03–38.23	Bluish compact mud
38.23–45.43	Greyish compact, structureless mud
45.43–46.83	Upper bluish and lower greyish mud
46.83–49.43	Yellow compressed mud
49.43–49.68	Fine laminated sand
49.68–51.51	Yellowish compact fractured mud, some time sandy mud
51.51–52.31	Laminated yellow mud
52.31–56.31	Upper portion bluish and yellowish-coloured, lower portion yellowish-coloured compact mud
56.31–61.41	Large medium size pebbles, small pebbles rare, no sediment layering, no imbrication
61.41–61.84	Loess
61.84–61 96	Palaeosol
61.96–71.31	Palaeosol and loess

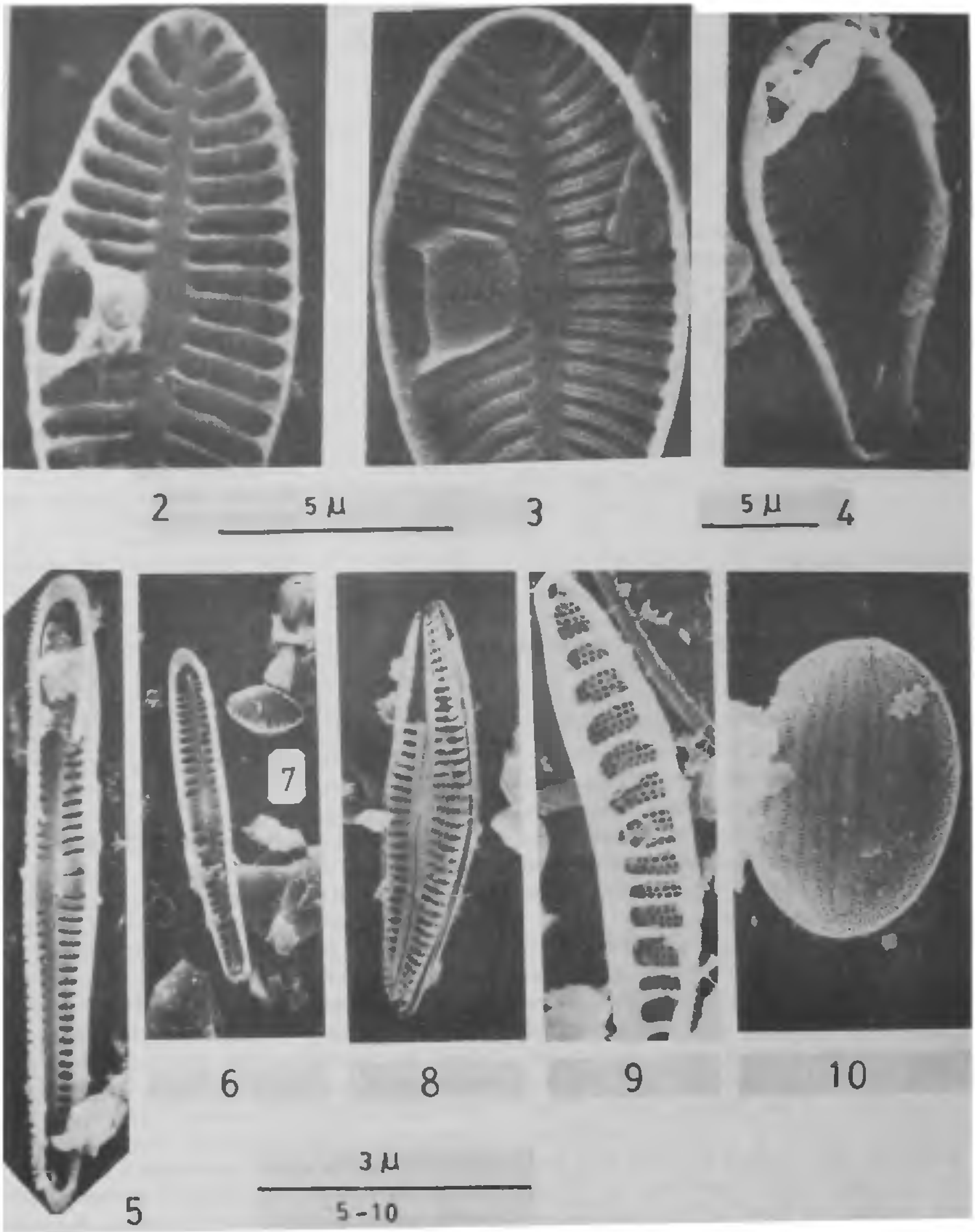
to avoid contamination. All the samples were thoroughly examined in the field and their colour and other details were recorded. The samples were transferred to clean glass specimen tubes, labelled and sealed. These samples were brought to the laboratory for further processing.

The samples were first treated with hot concentrated HCl to remove carbonates. To remove the organic material from the samples, they were treated with hot concentrated nitric acid and a pinch of potassium dichromate. The acid residue was removed by washing the samples repeatedly with distilled water. A portion of the cleaned samples was transferred into 18 mm^2–No. 1, glass coverslips for light microscopy. The coverslips were then dried and mounted on glass slides employing a Hyrax mounting medium. At least 10 slides per sample were examined in their entirety and the diatoms were identified under 1500 × oil immersion using a Ernst Leitz Wetzler microscope. Duplicate slides were prepared and deposited in the diatom herbarium of the Department of Botany, Gujarat University collections.

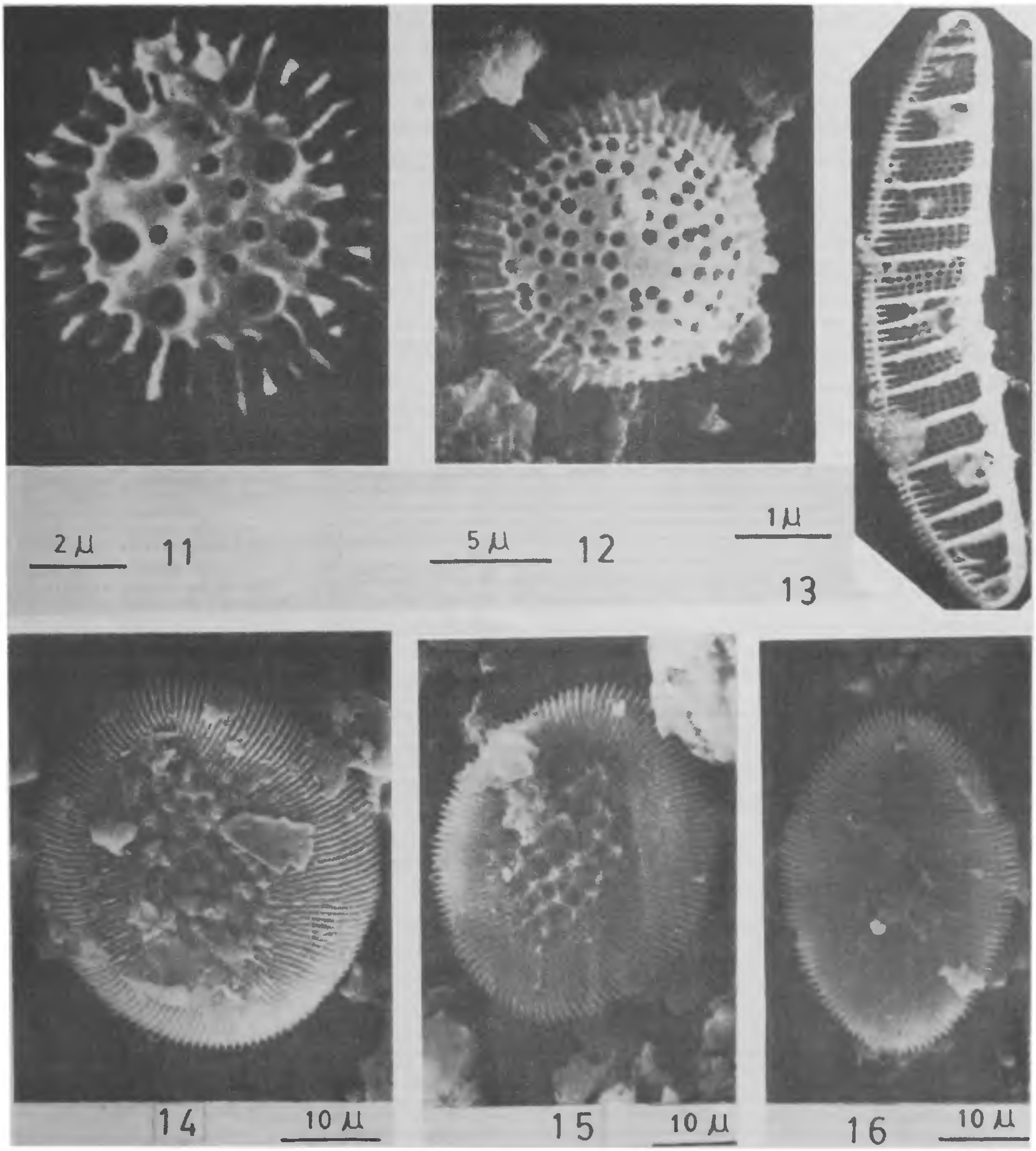
RESULTS AND DISCUSSION

Baltal is a new locality and diatoms are being reported for the first time. From Baltal 80 samples were collected of which 30% yielded diatoms. The diatom flora that characterized these sediments was diverse with several species of diatoms belonging to both centric and pennate types (figures 2–16). In this study we observed a total of 101 diatom species belonging to 20 genera. It is rich in genera and almost all commonly occurring freshwater genera are represented. 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 iris* and its varieties which are predominated in Baltal sediments and the second dominant entity found was *Fragilaria construens* and its varieties followed by *F. pinnata*, *F. virescens* and *Melosira granulata*, etc.

The results are recorded in the form of diatom



Figures 2–10. Scanning electron micrographs of diatoms. **2–3.** *Achnanthes lanceolata* Brabisson and its varieties (× 10,000); **4.** *Gomphonema grovei* M. Schmidt (× 5,000); **5.** *G. intricatum* Kutzing (× 2,000); **6.** *G. intricatum.* var. *dichotoma* (Kutz.) Grunow (× 2,000); **7.** *Fragilaria construens.* var. *venter* (Ehr.) Grunow (× 2,000); **8.** *Amphora ovalis* Kutzing (× 2,000); **9** and **13.** *Epithemia zebra* (Ehr.) Kutzing (× 2,000); **10.** *Cocconeis placentula.* var. *lineata* (Ehr.) Cleve (× 2,000).



Figures 11–16. 11. *Cyclotella kutzingiana.* var. *planetophora* Fricks (× 10,000); **12.** *Cyclotella comta*? (Ehr.) Kutzing (× 5,000); **14–16.** *Cyclotella iris* Brun. var. *ovalis*. var. nov? Mohan (× 2,000).

diagram drawn on the basis of total diatom percentages (figure 17). A total of 101 diatom species are recorded from Baltal sediments. This diagram is divided into 5 zones on the basis of its presence in the samples. Diatom zones were built up from the base of the diagram.

The diatoms which first appeared in large numbers in zones 1 and 2 decreased considerably in

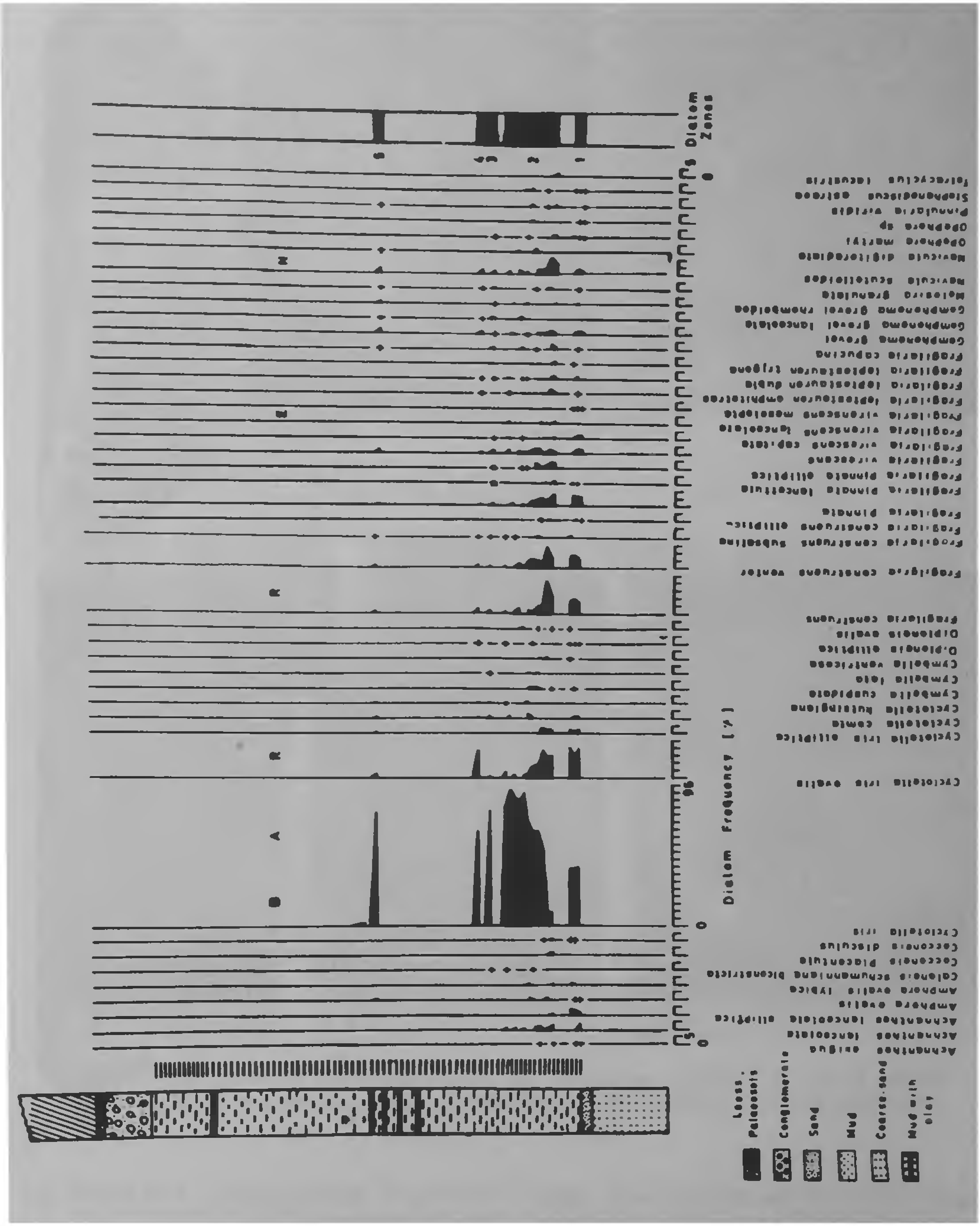


Figure 17. Diagram of diatoms, Baltal, Kashmir.

the sediment of zones 3, 4 and 5. *C. iris* and its varieties display high values in all 5 zones. In zones 1 and 2 as there were enough specimens on the slides to give a total count of 200–300 frustules, whereas in the 3rd, 4th and 5th zone samples only 100–150 frustules could be found. The composition of the flora in these zones was almost the same. In Baltal sediments many more broken frustules were eroded and were thus difficult to identify. Zone 1 is dominated by *C. iris* and its varieties followed by *F. construens* and its varieties and *F. pinnata.*

Zone-2 could be divided into two parts because of differences in the diatom species. In the lower part *C. iris* and its varieties display highest values, whereas *F. construens* and its varieties, *F. pinnata* and *Navicula scutalloides* display moderate values. There was considerable decrease in the diatom flora in the upper part except *C. iris* which continues to display highest values.

Zones 3, 4 and 5 are dominated only by *C. iris.* There was absolute decrease in the diatom flora in these three zones with an exception of *C. iris, Achnanthes lanceolata* and its varieties. *Amphora ovalis* and its varieties appeared in zones 1 and 2, and disappeared in zones 3, 4 and 5.

Like Ara[11], Baltal diatoms too have a very wide temporal range which stretches from Oligocene to the Holocene, and the diatom assemblage is dominated by the Pleistocene forms, though there were quite a few long surviving types we can assign it to the Pleistocene period. Roy[10] indicated generic assemblages of diatoms based on his 1000 samples collected from 32 sites. On the basis of these he ascribed the Mio-Pliocene age of the Karewas and made bio-zones I and II of the lower Karewas. We have not found any such zonations separating centric diatoms from the pennate types as reported by Roy[10]. Such a feature is hardly to be expected. The early evolution of centric diatoms may be true but not at all in the present freshwater situation, since the Karewa sediments do not reach early Miocene nor they are marine in origin. Conger[12] examined the samples of sedimentary rocks originating from Handwor and Shaliganga valley listed many diatoms. These diatoms were stated to be of the Pleistocene, freshwater fossil. Iyengar and Subrahmanyan[13] reported an illustrated account of fossil diatoms from Karewa beds (around Gulmarg at about 9000′ elevation). The assemblage of diatoms indicates their non-marine (freshwater) origin. Geologically these beds were considered to be of Pleistocene period.

Lundquist[14] listed 52 fossil diatoms from the Kashmir region representing freshwater ecology. Rao and Awasthi[15] reported 10 centric Plejstocene diatoms from Laredura locality belong to genera *Melosira, Cyclotella* and *Stephanodiscus* indicating a non-marine ecology. Our report concurs to a very large measure with Conger[12], Lundquist[14], Gandhi *et al*[16], Okuno[17, 18] and many others. A complete analysis of species content of genera with their known stratigraphic status shows that the Pleistocene diatoms predominate in Baltal sediments. Moreover, on checking the individual diatom species a large majority of them indicate their Pleistocene or Plio-Pleistocene period and hence Pliocene-Pleistocene

Table 2 *Baltal diatom flora belonging to freshwater lacustrine conditions*

Diatoms	Known bio-stratigraphic status
Achnanthes exigua Grunow	Uk.
Amphora ovalis. var. *pediculus* Kutzing	Ple.
Cocconeis placentula Ehrenberg	Ple., O-R
C. placentula. var. *euglypta* (Ehr.) Cleve	Ple.
Cyclotella comta (Ehr.) Kutzing	Ple.
C. iris Brun	Aurillac fossil
C. kutzingiana Thwaites	Ple.
C. kutzingiana. var. *radiosa* Fricke	Uk.
C. ocellata Pant	Uk.
Cymbella aspera (Ehr.) Cleve	Ple., M.
C. cistula (Hemp.) Grunow	Ple., O, M, R.
C. ehrenbergii Kutzing	Ple.
C. minuta Hilse ex Rath	Uk.
C. ventricosa Kutzing	u, T., O-R
Caloneis schumaniana. var. *bioconstricta* Grunow	Ple.
Epithemia hyndmanni W. Smith	Ple.
E. sorex (Ehr.) Kutzing	Ple.
E. turgida (Ehr.) Kutzing	Ple.
E. zebra (Ehr.) Kutzing	Ple.
Fragilaria capusina Desmezieres	Uk.
F. construens (Ehr.) Grunow	Ple., O-R.
F. construens. var. *venter* (Ehr.) Grunow	Ple., O, M.
F. pinnata Ehrenberg	Ple., O, R.
F. pinnata. var. *lancettula* (Schum.) Hustedt	Uk.
Gomphonema intricatum Kutzing	Ple.
Gyrosigma attenatum (Kutz.) Rabh.	Ple.
Hantzschia amphioxys (Ehr.) Grunow	Ple.
Melosira granulata (Ehr.) Ralfs	Ple., O, M, R.
Navicula placentula. var. *rostrata* Mayer	Ple.
N. pseudoscutiformis Hustedt	Ple., M.
Opephora martyi Heribaud	Ple.
Stephanodiscus astraea (Ehr.) Grunow	Ple.

O, Oligocene; M, Miocene; P, Pliocene; Ple, Pleistocene; R, Recent; u, T, Upper tertiary; Uk, Unknown.

Table 3 *Baltal diatom flora belonging to cold climatic conditions*

Diatoms	Known bio-stratigraphic status
Cyclotella iris Brun	From Aurillac fossil
Cymbella aspera (Ehr.) Cleve	Ple., M.
C. ehrenbergii Kutzing	Ple.
C. lata Grunow	Ple.
Navicula renharti Grunow	Uk.
Navicula scutelloides W. Smith	Ple.
Opephora martyi Heribaud	Ple.
Pinnularia viridis (Kutz.) Ehrenberg	Ple., M.
Tetracyclus japonica Reichelt? Petit	Ple., M.
T. lacustris Ralfs	Uk.

M, Miocene; P, Pliocene; Ple, Pleistocene; Uk, Unknown.

stratigraphy of the Karewas at the most liberal estimate.

From the point of view of environmental markers, the following species (table 2) are specially indicative of lacustrine conditions. The lacustrine ecology is indicated by one or more species of *Melosira, Cyclotella, Stephanodiscus, Amphora, Achnanthes, Cymbella, Epithemia, Fragilaria, Gomphonema, Cocconeis, Navicula*, etc.

From the point of view of temperature markers, the following species (table 3) are specially indicative of cooler climatic condition. These diatoms belong to cold latitudes and thus the climate prevailing in the past in Baltal locality should be considered as cooler.

On the basis of diatomological investigations, it can be stated that the Karewa sediments under this investigation belong to freshwater lacustrine origin of cooler climate as indicated by genera such as *Stephanodiscus*, long forms of *Cymbella, Pinnularia, Opephora, Tetracyclus* and others. Since the sediments are dominated by the Pleistocene diatoms, we can assign it to the Pleistocene period. The data are also confirmed by magnetic stratigraphy as the sediments belong to Brunhes chronology (younger than 0.7 m.y.).

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