CLIMATE OF KASHMIR DURING THE LAST 700,000 YEARS: THE BALTAL POLLEN PROFILE

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The Karewas, relict lake sediments dating back to c. 3.5Myr, were pollen analysed to infer palaeoclimatic changes in the valley of Kashmir, India. The results obtained from the upper portion of the Lower Karewa sediments exposed along the river Romushi at the Baltal locality are reported here. The 55m thick Baltal sediment profile revealed significant climatic changes during the mid-Pleistocene. The pollen profile was divided into nine pollen stages, five of which represent cold phases, each alternating with warm temperate/interstadial oscillations. Palaeomagnetic and fission track dating provide the basis of chronology of these sediments.

Key Words: Kashmir; Karewas; Pollen; Palaeoclimate

INTRODUCTION

The valley of Kashmir and its enclosing mountains seem to have endowed this basin not only with a distinct geographical character but also a marked cultural individuality through history. We have here a fertile plain embedded among high mountain ranges; the Himalayan Range on the NE and the Pir Panjals on the SW. The average height of the valley above the sea level is nowhere less than 5000ft. (1600m) and its peculiar position assure it a climate equally free from the heat of the Indian sub-continent and the rigours of cold typical of the higher regions in the north and east. The ancient legends described by Kalhana in his chronicle Rajatarangini1 and in the Nilmata Purana mention that the Kashmir valley was originally a lake. According to the tradition the lake was called Satisar, the sea of Sati (a goddess). This legend perhaps drew the attention of the first European travellers to certain physical features apparently supporting the belief that Kashmir was, wholly or to a large extent, occupied by a vast lake. But few seem to have recognised this so clearly as Drew2 and Godwin-Austen3 who identified the relict deposits in the form of the so-called udra or Karewa plateaus to be lacustrine in nature.

The NE of the basin was already shielded by the Miocene Himalayan orogeny. During early Pliocene, the SW flank started rising up and attained its present height of about 5000m. This, range known as Pir Panjal, impounded the drainage emanating from the Himalayan flank thus giving rise to the Karewa lake. The sediments so collected in the basin were uplifted and exposed by the subsequent river erosion. At a later stage a breach on the Pir Panjal flank near Baramula created the present river Jhelum (Fig. 1) which drained out the primaeval lake.
The plateau-like exposed lake sediments, or the Karewas, are now being used for studying palaeoclimatic changes in the valley through an interdisciplinary approach. The whole Karewa profile spans a thickness of about 1.2km and is dated to c. 3.5Myr by fission track and magnetic stratigraphic dating. The Lower Karewas exposed by the River Rembiara span a period of c. 3.5 to 1.8Myr and have mostly been pollen analysed. Below Baltal locality, on the section exposed by the Romushi river, we have analysed about 50 samples taken randomly, most of which proved poor or sterile in pollen. Similarly, the section above Baltal locality, which has Karewa and loess deposits, marked by a definite alkalinity, proved sterile.

Report on the pollen analysis results from the Baltal locality sediments on the Romushi river is given below.

Stratigraphy and Chronology

The Baltal section is exposed along the River Romushi (Fig. 1), 60km SW of Srinagar, the capital of Kashmir. The base of the Baltal sequence which falls in Zone 5 is stratigraphically about 330m above Zone 2 or the basal conglomerate of the Romushi valley section (Fig. 2). Approximately 15m below Zone 2, some volcanic ash falls have been fission track dated to c.2.3Myr. The Baltal locality section occupies the middle of Zone 5(Fig. 2). The 55m thick Baltal profile comprises mainly bluish, compact, fractured and laminated yellowish clays intercalated
Fig 2 Lithostratigraphy with magnetic polarity stratigraphy of the Romushi section. Our samples are from the Romushi Section IV. N$_8$/R$_7$ is the Brunhes/Matuyama boundary at 0.73Myr. The thickness of the Baltal sequence is marked.
with fine to medium grained, greenish, laminated sands followed by the ∼ 15m terrace gravel which is subsequently capped by the loessic silt (Baltal sediments are described in Table 1).

**Table 1**

*Stratigraphy of the Baltal profile*  
(Bottom upwards)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Depth Range (m)</th>
<th>Nature of sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0-8.3</td>
<td>Medium coarse sand with yellowish-reddish coloured laminations on cm scale. Pebby layer is present in the upper part.</td>
</tr>
<tr>
<td>2.</td>
<td>8.3-9.2</td>
<td>Fine sand without laminations. Brownish yellow coloured small pebbly layer present.</td>
</tr>
<tr>
<td>3.</td>
<td>9.2-22.2</td>
<td>Compact fractured, blue coloured mud, cm scale whitish laminations are rare.</td>
</tr>
<tr>
<td>4.</td>
<td>22.2-22.6</td>
<td>Fine laminated mud.</td>
</tr>
<tr>
<td>5.</td>
<td>22.6-23.3</td>
<td>Upper part reddish non-laminated; middle compact blue; and lower compact greyish mud.</td>
</tr>
<tr>
<td>6.</td>
<td>23.3-27.5</td>
<td>Structureless, compact greyish mud without laminations.</td>
</tr>
<tr>
<td>7.</td>
<td>27.5-32.5</td>
<td>Compact, fractured, bluish mud with 4 strips of yellowish-reddish clay of 4.5, 8 and 3.5 cm thickness respectively.</td>
</tr>
<tr>
<td>8.</td>
<td>32.5-33.2</td>
<td>Fine laminated greyish and bluish mud with reddish clay in the upper part.</td>
</tr>
<tr>
<td>9.</td>
<td>33.2-34.7</td>
<td>Bluish fractured and compact mud.</td>
</tr>
<tr>
<td>10.</td>
<td>34.7-37.9</td>
<td>Bluish, compact and badly fractured mud; fracture pattern in NE direction.</td>
</tr>
<tr>
<td>11.</td>
<td>37.9-45.1</td>
<td>Greyish, structureless, fractured and compact mud, laminations are rare.</td>
</tr>
<tr>
<td>12.</td>
<td>45.1-46.5</td>
<td>Upper portion bluish, fractured mud without laminations. Lower portion greyish mud.</td>
</tr>
<tr>
<td>13.</td>
<td>46.5-49.1</td>
<td>Yellowish highly fractured and compressed mud, fractures in NE direction or vertical to bedding. Laminations are rare.</td>
</tr>
<tr>
<td>14.</td>
<td>49.1-49.4</td>
<td>Fine laminated sand interbedded with yellowish strips of clay. Laminated blue and yellow strips.</td>
</tr>
<tr>
<td>15.</td>
<td>49.4-51.2</td>
<td>Yellowish compact and fractured mud. Sometimes sandy mud.</td>
</tr>
<tr>
<td>16.</td>
<td>51.2-52.0</td>
<td>Laminated yellowish, grey mud. Laminations of cm scale. Mud strips are greyish, brownish and yellowish.</td>
</tr>
<tr>
<td>17.</td>
<td>52.0-56.0</td>
<td>Upper portion is like the varvites; laminations are bluish and yellowish coloured. Lower portion yellowish coloured compact mud.</td>
</tr>
<tr>
<td>18.</td>
<td>56.0-61.1</td>
<td>Pebby layer (terrace gravel). No sediment layering. No imbrications. The pebbly layer of the upper part intrudes into loess, so contact is irregular.</td>
</tr>
<tr>
<td>19.</td>
<td>61.1-70.0</td>
<td>Loess deposit.</td>
</tr>
</tbody>
</table>

The Romushi section (Fig. 2) has been dated on the basis of magnetic stratigraphy and fission track dates of the volcanic ashes. Unfortunately, the volcanic
ashes are confined to Zone 1 (Fig. 2) and therefore one has to work out approximate sedimentation rate for different zones. The Baltal section can be confined to a time bracket of roughly 0.6Ma and 0.2Ma. (For a more detailed discussion of chronology of Baltal and other Romushi sections, see Agrawal et al., this volume). The age of the five cold peaks will be given at a later stage when detailed chronological framework is worked out.

TECHNIQUES

In the 55m thick Baltal profile a total of 80 samples was collected more or less equidistantly starting from above the basal sand. 9.5m onwards (Fig. 3). Out of 80 samples, 44 mud samples yielded pollen while sands proved palynologically barren. Basal 9.5m sediments were coarse sand, hence not sampled.

Pollen samples were macerated according to Erdtman’s standard maceration method. Identification of pollen grains was made with the help of modern

**Fig 3** Baltal pollen diagram with sample location (by the right side of the Litholog) and depth in metres. Horizontal axis shows pollen spectra while NAP/AP ratio is given on the right side. The column next to NAP/AP ratio shows climatic sequence. Black portions show cold periods while white show amelioration in climate.
reference pollen collections, photographs etc. A total of 250 pollen grains was counted per sample but in case of some poor samples the sum was less than 250. The pollen diagram was drawn for total land plants pollen in terms of relative pollen percentages. Fern spores and aquatics were not considered in pollen percentage calculation. NAP/AP ratio and stratigraphy are shown in the pollen diagram (Fig. 3). The whole pollen profile was divided into 5 cold and 4 cool-temperate pollen stages (independent of lithology) on the basis of broad-leaved/conifers ratio (B/C ratio).

RESULTS

The description of the result starts with stage I, the bottom-most stage in the pollen profile.

Stage I

Stage I was characterised by high values of conifers like Pinus wallichiana, Picea and Abies. There was a continuous competition noticed between P. wallichiana and Picea, as a rise in one genus caused a fall in the other and vice versa. Picea showed high frequency for this stage. Almost 75 per cent of the total taxa were represented by Picea alone. Amongst the broad-leaved elements Betula, Ulmus, Juglans, Quercus and Alnus had low values not exceeding 5 to 7 per cent of the total taxa. Shade loving ferns and aquatic plants such as Typha and Myriophyllum were also noticed, though comprising only 2 to 3 per cent of the total taxa. Non-arboreals such as Porceae, Cheno/Ams, Caryophyllaceae, Asteraceae and Artemisia had very poor and sporadic representation. Thus the stage was marked by a conifer forest. The broad-leaved/conifer ratio for this stage was about 0.01.

Stage II

Conifers such as P. wallichiana and Picea had fallen in this stage and broad-leaved elements showed increasing trend. The B/C ratio rose upto 0.1. Non-arboreals were almost negligible.

Stage III

In this stage P. wallichiana and Picea percentages were 30 and 60 respectively of the total taxa. Broad-leaved elements also reappeared but in poor frequency. B/C ratio again went down to its minimum value of 0.01. Non-arboreals had a little rise in this stage.

Stage IV

This stage was marked by low values of P. wallichiana and Picea and hence B/C ratio rose upto 0.1. Non-arboreals also showed little rise.

Stage V

This stage reached a B/C ratio of 0.01, P. wallichiana had very high values (almost 70 per cent) while Picea showed a fall. Abies was only 5 to 10 per cent. Broad-leaved were negligible and non-arboreals showed an increasing trend.
Stage VI

This stage was marked by an increase in B/C ratio from 0.01 to 0.13. Non-arboreals showed low values at the bottom of the stage but showed an increase towards the top of the stage.

Stage VII

This stage showed very high values of non-arboreals such as Caryophyllaceae and Cheno/Ams at the bottom of the stage which decreased towards the top. Conifers were represented in moderate values. *Picea* showed decreasing trend from this stage while *Pinus* acquired high values at the cost of *Picea*. Broad-leaved were very negligible. B/C ratio fell to 0.01 in this stage.

Stage VIII

In this stage non-arboreals gained high values once again. Broad leaved also reappeared but in low values and due to their reappearance the B/C ratio gradually rose to nearly 0.1. Conifers such as *Pinus wallichiana* and *Picea* have low values while *Abies* fell to almost a zero value.

Stage IX

In this stage conifers, *Pinus wallichiana* and *Picea*, regained high values (70 per cent and 25 per cent respectively of the total taxa). Broad-leaved and non-arbooreal almost disappeared from the scene and hence B/C ratio again fell to 0.01.

Discussion

The bottom of the profile was characterised by a high frequency of *Picea* and *P. wallichiana*. At present the frequency of *Picea* in the forest vegetation is very low in the Kashmir valley, especially in the Baltal region. Usually *Picea* grows at elevations of 2100 to 3300m; but it has also been found growing higher upto 3000m in warmer conditions whereas it descends down to the lower reaches if the climate is cooler. The present day elevation of Baltal is c.2000m. Thus it indicates comparatively cooler conditions during the deposition of the bottom of the profile in the Baltal region as *Picea* was growing profusely at lower elevations compared to the usual height at which it grows today.

At the top of the profile, *Picea* had a decreasing trend. *Picea* might have descended down in the valley due to deteriorating conditions and its frequency might have decreased. *Pinus wallichiana* behaved in a contrasting manner because perhaps *Pinus wallichiana* can withstand severe climatic conditions than *Picea*. Still it had also a sharp decline at times and non-arboreals seemed to replace *Pinus*, characteristic of cold and arid climatic conditions indicating more deterioration in climatic conditions. At the top of the profile even non-arboreals almost disappeared and only conifers represented the whole vegetation assemblages (in poor absolute value) perhaps due to the vertical mobility of the winged pollen grains of conifers which can ascend up on the mountains from the valley below. Thus one can
summarise the vegetation changes emerging out of the present pollen study of the Baltal pollen profile as follows (bottom upwards):

1. High frequency of *Picea*.
2. Fall in the value of *Picea* and rise in value of *Pinus*.
3. Fall in value of arboreal taxa and rise in value of non-arboreal taxa showing steppic conditions.
4. Fall in value of non-arboreals also indicating desertic conditions.

**CONCLUSION**

On the basis of vegetation assemblages and B/C ratio, the Stages I, III, V, VII and IX have been attributed to cold climate and Stages II, IV, VI and VIII to cool temperate/interstadial ameliorated climatic conditions. The higher values of steppic elements, characteristic of halophytes towards the middle of the profile indicate cold and dry climatic condition. The absence of non-arboreals at the top probably indicates cold desertic conditions.
The oxygen isotope stages based on sea cores matches well with our results. There are several cold oscillations represented after 0.7 Myr to about 0.2 Myr \(^{10}\) (Fig. 4). At this stage a greater precision than saying that roughly between 0.6 Myr and 0.2 Myr, five cold stages each alternating with ameliorated climatic phases is not possible. To build up an absolute correlation of the pollen result with the deep sea core isotopic stages one needs to have a high resolution absolute chronosтратigraphy. At the moment it is under process.

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