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Assessment of Holocene climate from Kumaun Himalaya: palaeontological approach

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ABSTRACT

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The present contribution provides an account of palaeontological investigation of sedimentary profiles from temperate zone of Kumaun Himalaya. The study reveals knowledge of faunal and floral remains above 200 µm size, i.e. molluscan shells and legume fruits (uncovered in palynological analysis) and corresponding climate at the region since Middle Holocene. Around 4950 year B.P., the investigated area had no molluscan shell which indirectly reflects that the climate of the region was not sufficiently humid. Near the onset of Late Holocene, numerous planispiral gastropods came in to existence, indicating appearance of suitable humid conditions at the region. Subsequently, several conispiral gastropods also appeared with bivalves, reflecting further amelioration in climatic conditions. Thereafter, the later developed forms disappeared but earlier ones continued, which reflects restoration of earlier conditions. The upper part of sequence has shown abundant legume fruits with seeds, supporting anthropogenic activities with present day conditions at the region. The appearance and specific distribution of these bio-remains indicate that area enjoyed fluctuating humid condition during Late Holocene which broadly supports the climatic conclusion drawn from palynological and geochemical investigations.

Keywords: Palaeontology, Quaternary, Middle Holocene, Climatic interpretation, Himalaya, India.

INTRODUCTION

Quaternary sediments of the Himalayan region of India have been studied from over a century ago and past climate has been deciphered on the basis of reconstructed vegetation based on pollen analysis. Due to continued upheaval, this region remained tectonically highly disturbed and therefore emphasis is given to multidisciplinary analysis in order to obtain more authentic results. Kumaun (Lat. 28°44' to 30°49' N, Long. 78°45' to 81°05' E) has attracted attention of Quaternary researchers since last five decades and a large amount of palynodata has been gathered from subtropical zone (Vishnu-Mittre et al 1967, Gupta 1977, Chauhan & Sharma 1993). During last two decades, such attention extended to temperate zone as well (Gupta 2002, 2007, 2008). In addition, geochemical analysis (Gupta 2010a, 2011) and palaeontological analysis have also been attempted.

The present contribution deals with the palaeontological analysis (bio-remains above 200 µm in size) of two profiles from Saria Tal and corresponding climate. The bore-core profile represents the upper part of Late Holocene (i.e. since about 1720 years B.P.) whereas exposed-section represents Middle Holocene to middle part of Late Holocene (i.e. since about 4950 years B.P. to 1200 years B.P.). The composite data

generated from these two profiles represent the knowledge from complete sequence since Middle Holocene. A part of Late Holocene is represented in both the profiles and data generated from this contemporary part of two profiles are similar to each other which strengthens the reconstructed knowledge of past biota and corresponding climate. Pollen analytical and geochemical investigations of these profiles have already been published (Gupta 2002, 2007, 2010a). Data generated from palaeontological investigation broadly corroborate to those of earlier once.

It is necessary to point out that the bore-core profile shows normal order of superposition of the sediments whereas exposed-section profile shows reverse order. Saria Tal has concealed fold and these profiles belong to different arms of this fold thus showing reverse order (Gupta 2010b). Since different sediments (including bio-remains) remained intact with neighboring one, so got undisturbed during the course of rock movement and their chronological categorization represents the correct information of past even from reverse deposits. Presence of such concealed fold matches to geologic

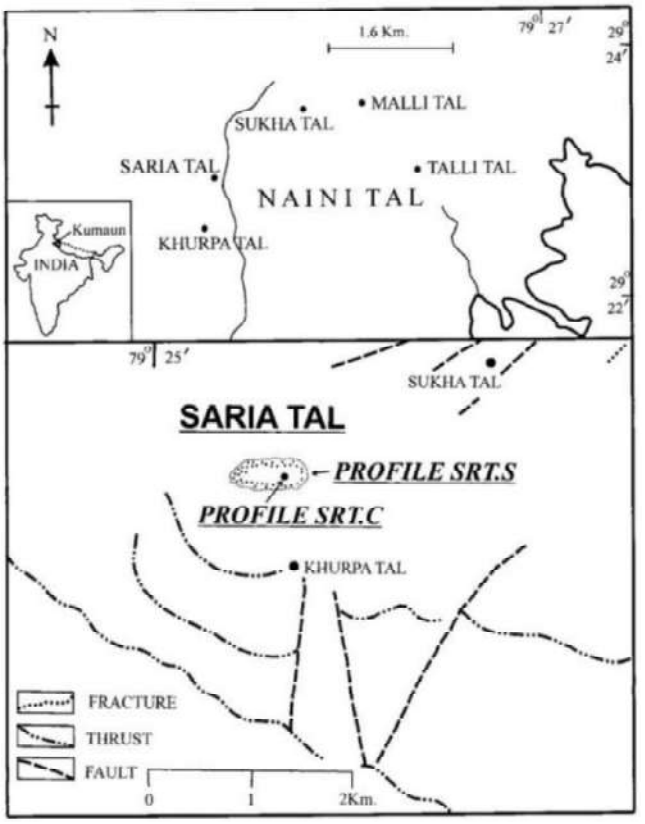

Figure 1. Map showing location of Saria Tal, Kumaun Himalaya; and tectonic disturbances around it (after Pal & Merh 1975, Valdiya 1988).

Figure 2. Showing part of lake surface (depression) of Saria Tal, Kumaun Himalaya.

Figure 3. A view showing part of section exposed at Saria Tal, Kumaun Himalaya.

conditions of the area. The geological knowledge on Kumaun has been published frequently (Middlemiss 1890, Gansser 1964, Tiwari & Mehdi 1964, Pande 1974, Fuchs & Sinha 1974, Hukku et al. 1974, Pal & Merh 1974, 1975, Raina & Dungrakoti 1975, Valdiya 1980, 1988, 2001, Valdiya et al. 1984, Thakur 1993, Singhvi et al. 1994, etc.) showing tremendous natural disturbances at the region. Saria Tal is an extinct lake, situated in Nainital District, at an elevation of 1735 m above sea level (Figure 1). Geologically, it lies in Krol Nappe between Infra-Krol and Tal formations (Table 1).

MATERIAL AND METHODS

The investigated profiles were collected from Saria Tal, Kumaun Himalaya, from two different places (Figures 2, 3) during March 1998. One of them was bore-cored near middle of lake (depression) with the help of Hiller's Peat Auger and could reach 85 cm deep from surface. The other profile was scraped from section exposed at the lake boundary and covered 2 m thickness. Seventeen samples were collected from the bore-core and 40 samples from the exposure, all at an interval of 5 cm each. Further deep sampling remained not feasible in core owing to hard substratum beneath and in section due to emergence of water.

About 10 gm of each sample of both the profiles were used for the investigation. The molluscan shells

Table 1. Tectonostratigraphic succession of Lesser Himalaya zone. Asterisk (*) indicates situation of investigated site (Thakur 1993).

Belt	Formations
	Subathu Formation
	Tal Formation
	*Krol Formation
Krol Belt	Infra-Krol Formation
	Blaini Formation
	Nagthat Formation
	Chandpur Formation

Table 2. Lithological succession of profile SRT.C (bore-core) and SRT.S (exposed section)

Profile	Depth (in cm)	Lithology
SRT.C	00–25	Silty-sandy clay with pebbles
	25–60	Silty-sandy clay with granules, pebbles and gravels
	60–80	Silty-sandy clay with granules
	80–85	Silty-sandy clay
SRT.S	00–55	Silty-sandy clay with granules and fine-medium pebbles
	55–80	Silty-sandy clay with granules and fine pebbles
	80–110	Silty-sandy clay with granules and rare fine pebbles
	110–140	Silty-sandy clay with rare granules
	140–190	Silty-sandy clay with granules and rare fine pebbles
	190–200	Silty-sandy clay with granules and fine-medium pebbles

Table 3. Radiocarbon dates of profile SRT.C (bore-core) and SRT.S (exposed-section)

Profile	Serial No.	Depth (in cm)	Reg. No.	^{14}C Dates (in years B.P.)
SRT.C	1	30–35	BS–1554	180±120
	2	80–85	BS–1455	1720±130
SRT.S	1	20–25	BS–1481	4140±90
	2	55–60	BS–1553	2850±170
	3	190–195	BS–1453	1250±100

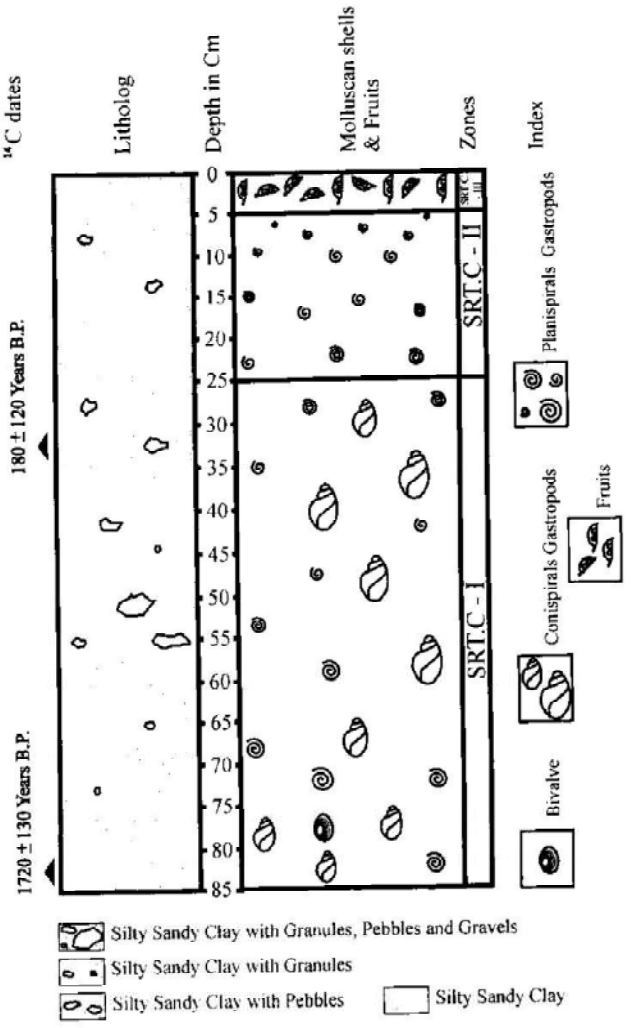

Figure 4. Diagrammatic representation showing distribution of macrofossils in Profile SRT.C (bore-core) from Saria Tal, Kumaun Himalaya.

and fruits were obtained by simple picking as well as sieving method. Data generated from these profiles are mentioned separately. Profile from bore-core is named 'SRT.C (bore-core)' and from exposed-section 'SRT.S (exposed-section)' after site abbreviation. Both profiles largely consist of silty-sandy clay with or without intrusion of granules, pebbles/gravels. Their lithological succession (from top to bottom) is shown in Table 2. Two samples of profile SRT.C and three of SRT.S have been radiocarbon dated in the Radiocarbon Laboratory of the Birbal Sahni Institute of Palaeosciences, Lucknow. The determined dates with relevant information are shown in Table 3.

OBSERVATIONS

Profile SRT.C (bore-core) as well as SRT.S (exposed-section) have yielded considerable amount of molluscan shells and legume fruits (Gupta 2006, 2009), which are qualitatively poor but quantitatively rich and have shown specific distribution. On the basis of such specificity each of these profiles has been divided into zones.

Profile SRT.C (bore-core)

Profile SRT.C (bore-core) is divided into 3 zones (Figure 4), numbered as I, II and III prefixed with site abbreviation SRT.C, from bottom to top, in chronological order.

Zone SRT.C–I: Two radiocarbon dates are available from this zone, one each from lower and upper part. One of them, i.e. 1720±130 years B.P., is from 80–85 cm depth and other, i.e. 180±120 years B.P. is from 30–35 cm. This zone consists of a large number of gastropod shells, both planispiral and conispiral, with poor bivalves. The conispirals show smaller forms in the beginning, followed by larger once and again smaller at the top of the zone. The occurrence of different types of molluscs indicates that the investigated area had suitable humid conditions during this tenure.

Zone SRT.C–II: This zone is characteristically devoid of the shells of conispiral gastropods and bivalves. However, there are plenty of shells of the planispiral gastropods which extend till top of the zone, but their size is often small at the upper part. The disappearance of conispiral gastropods and bivalves indicates deterioration of climatic conditions.

Zone SRT.C–III: Characteristically, this zone is marked by predominance of legume fruits having two seeds each. The existence of fruit producing plants reflects further change in climate, as compared to the earlier zone.

Profile SRT.S (exposed-section)

This profile is also divided into three zones (Figure 5), numbered as I, II and III prefixed with site abbreviation SRT.S, from top to bottom, in chronological order.

Zone SRT.S–I: Two radiocarbon dates are available from this zone, i.e. 4140±90 years B.P. from 20–25 cm and 2850±170 years B.P. from 55–60 cm depth. Characteristically, this zone is completely devoid of macro bio-remains. The absence of molluscan shells indirectly reflects that the climatic conditions of the investigated area were not suitable for the molluscs during this tenure.

Zone SRT.S–II: This zone characteristically consists of a large number of molluscan shells belonging to planispiral gastropods which initially represents smaller forms, then the larger forms. The appearance of such molluscan shells indicates the change in climate towards suitable humid conditions.

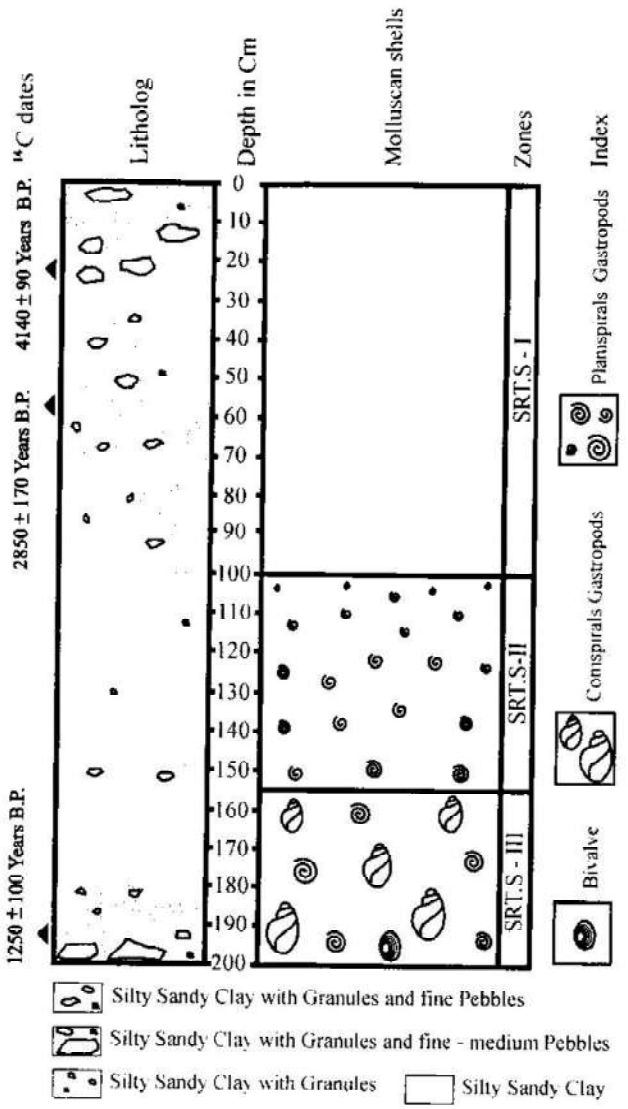

Figure 5. Diagrammatic representation showing distribution of macrofossils in Profile SRT.S (exposed-section) from Saria Tal, Kumaun Himalaya.

Zone SRT.S–III: This zone is dated 1250±100 years B.P. at 190–195 cm depth. It consists of a large number of conispiral and planispiral gastropod shells with poor occurrence of bivalves. Conispirals show smaller forms in the beginning, followed by larger forms. The appearance of conispiral gastropods and bivalves indicates further amelioration of climatic conditions.

RESULT AND DISCUSSION

Kumaun Himalaya is tectonically highly disturbed and such disturbances continued in the Quaternary Period. In Holocene, the prominent activities occurred from 10000–8000 years B.P. and from 3000–1000 years B.P. (Kotlia et al. 1998). There are natural disturbances all around Saria Tal and this lake itself possesses concealed fold. Presently investigated profiles represent both limbs of this fold, thus showing reverse order of superposition. Profile SRT.C (bore-core) belongs to initial limb so having normal order, while profile SRT.S (exposed-section) to upturned limb thus the reverse order.

Profile SRT.C (bore-core) having younger sediments, yielded bio-remains above 200 μm in size throughout the sequence and its zones have been marked to demarcate change in the distribution of fauna (molluscs) and flora (fruits). Its older zone SRT.C–I (around 1720 years B.P.) consists shells of different types of molluscs, i.e. planispiral gastropods, conispiral gastropods and bivalves, which indicates that humid conditions existed at the region during this tenure. Next zone, SRT.C–II (around 124 years B.P.) is devoid of shells of conispiral gastropods and bivalves but planispiral gastropods continued, reflecting relative deterioration of humid conditions. The younger zone SRT.C–III shows copious legume fruits, indicating change in climate to present day conditions.

Profile SRT.S (exposed-section), containing older sediments, shows much variation in the distribution of molluscan shells. Its oldest zone, SRT.S–I (around 4950

years B.P.), is completely devoid of any molluscan shell, indicating that the climatic conditions of the region were not suitable for molluscs. Its subsequent zone SRT.S–II (around 2270 years B.P.) shows plenty of shells of the planispiral gastropods, which indicates change in climate to suitable humid conditions, thus animals of this form came into existence and flourished. In next zone, SRT.S–III (around 1725 years B.P.), shells of conispiral gastropods and bivalves also appeared and found with planispiral gastropods, reflecting that climatic conditions became further more suitable so other forms also appeared at the region.

Comparison of different zones of the investigated two profiles from Saria Tal (Figure 6) shows that the older zone of profile SRT.C (bore-core), i.e. SRT.C–I approaches to the youngest zone of profile SRT-S (exposed-section), i.e. SRT.S–III because both these consist shells of planispiral gastropods, conispiral gastropods and bivalves. These zones are also comparable in age and cover the part of sequence represented in both the profiles (i.e. 1720 years B.P.–1160 years B.P.). It is interesting to note that the zone in question is well represented in profile SRT.C (bore-core) but lacks its younger part (i.e. 1160 years B.P.–124 years B.P.) in profile SRT.S (exposed-section). Besides, the younger two zones of profile SRT.C (bore-core), i.e. SRT.C–II and SRT.C–III are not represented in profile SRT.S (exposed-section) possibly due to erosion. Likewise, the older two zones of profile SRT.S (exposed-section), i.e. SRT.S–I and SRT.S–II remain unrepresented in profile SRT.C (bore-core) due to failure in recovery of deeper sediments.

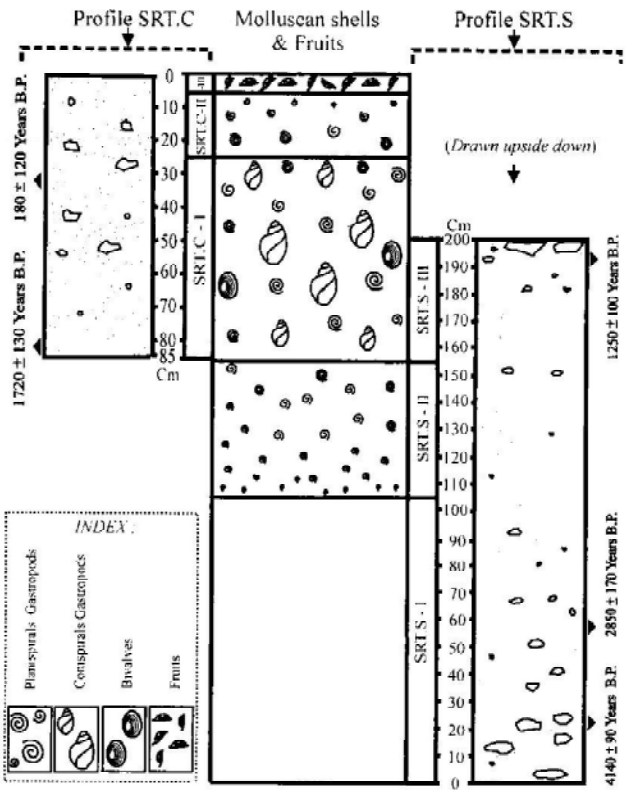

Figure 6. Complete macrofossils sequence from Saria Tal, Kumaun Himalaya, reconstructed from chronological merging of data of profiles SRT.C (bore-core) and SRT.S (exposed-section).

The chronological merging of palaeontological data generated from both the investigated profiles reveals the knowledge of complete sequence since Middle Holocene (Figure 6). In the beginning of sequence, around 4950 years B.P. (represented by oldest zone of profile SRT.S (exposed-section, i.e. SRT.S–I) the investigated area had no molluscs, indirectly reflecting that the climate existed at the investigated site was not congenial for them (i.e. not suitably humid). Near commencement of Late Holocene, around 2270 years B.P. (represented by middle zone of profile SRT.S 'exposed-section', i.e. SRT.S–II) plenty of planispiral gastropods came in to existence–indicating change in climate to suitable humid conditions. Subsequently, around 1725 years B.P. (represented by upper zone of profile SRT.S 'exposed-section', i.e. SRT.S–III, and by lower zone of profile SRT.C 'bore-core', i.e. SRT.C–I) numerous animals of another form of gastropods, i.e. conispiral gastropods along with bivalves came into existence – reflecting further amelioration in climatic conditions. Thereafter, around 124 years B.P. (represented by middle zone of profile SRT.C 'bore-core', i.e. SRT.C–II) conispiral gastropods and bivalves disappeared but planispiral gastropods continued – indicating restoration of preceding conditions. Near the end of Late Holocene, represented by upper zone of profile SRT.C–III, molluscs vanished while plants (legumes) occupied the area which produced copious fruits with seeds, reflecting further deterioration in climatic conditions. Such appearance and

disappearance of aforementioned molluscan shells/ fruits indicate fluctuation of humid conditions at the region during Late Holocene.

Presently generated data is broadly comparable to the data reported from palynological and geochemical analyses of same profiles. Pollen analysis (Gupta 2002, 2007) has revealed that in Middle Holocene this area had predominance of non-arboreals with poor presence of arboreals. The latter, particularly *Quercus*, showed increasing upwards trend which resulted mixed oak forest at Late Holocene with warm and humid climate. Such forest continued onwards but showed phases of depression and expansion – reflecting fluctuations in humid conditions during Late Holocene. Geochemical analysis (Gupta 2010a) exhibited that in the beginning of sequence the investigated area had low organic matter and moisture with sufficient carbonate contents. Near onset of Late Holocene the organic matter and moisture showed increasing trend while carbonate contents considerable decline – indicating amelioration of humid conditions. During Late Holocene organic matter and moisture showed abrupt enhancement but with fluctuations – indicating fluctuating humid conditions at the region. Palaeonotological investigation has shown that in middle Holocene, there was no mollusc, indicating that climatic conditions of the region were not sufficiently humid. Near onset of Late Holocene, planispiral gastropods came in to existence – supporting appearance of sufficient humid conditions at the region. Subsequently, conispiral gastropods and bivalves also appeared, but thereafter these later developed forms disappeared whereas the earlier one (i.e. planispiral gastropods) survived, and then became diminished. Soon after, legume plants occupied the area, favoring anthropogenic activities at the region. The specific distribution of faunal and floral remains supports fluctuating humid conditions at the region during Late Holocene. Molluscs are soft bodied invertebrate creatures which secrete a hard external shell. These shells are found preserved in the geologic deposits due to their resistant nature (Preston 1915 and Woods 1985, etc.). Since molluscs feed on plant materials, their presence also favors to the presence of sufficient vegetation (i.e. mixed oak forest) at the region during this tenure. Thus, palaeonotological investigation has strengthened the knowledge of past climate generated from palynological and geochemical analyses.

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