Sudden warming epochs

Ghosh and Bhattacharya[1] attempt to reconstruct the pattern of climate changes between 42 and 28 ka from climatically sensitive higher central Himalaya. In view of the fact that very little information exists on climate change from higher Himalayas bordering Tibet, this paper would have been a welcome contribution towards generating a new database. I feel that the authors have overlooked many vital ground truths and ventured into hasty and untenable conclusions. Such unsubstantiated data, when published, creates confusion rather than bringing out the scientific truth. Goting is a small part of a major multi-institutional project funded by the Department of Science and Technology, Government of India (Project No. ESS/CA/A3-17/95) that is aimed to generate authentic database on Quaternary seismicity and climate change. The present study is based on the varve samples handed over to S. K. Bhattacharya (Physical Research Laboratory) on his request for isotopic studies.

It appears that the authors have not considered lake sedimentology, especially the pattern of sedimentation in proglacial lakes. Climatic studies based on sedimentary archive require due consideration (appreciation) towards the geological processes in order to give the logical interpretation to laboratory data. Many inferences drawn are based on illusionary observations and are factually incorrect as detailed below.

(1) Our study on the past extent of valley glaciation has shown that Goting basin once supported a proglacial lake that was fed by glacial meltwater. We also demonstrated that the lake owed its genesis to the existence of Trans-Himadri Fault (South Tibetan Detachment System) in the form of Khal Kurans Ridge that arrested the end or push moraines of the retreating valley glacier (observed at the base of Khal Kurans). Following the retreat of the valley glacier it was dominantly the glacial meltwater body that was responsible for the deposition of varve and rhythmites when the glacier stood impinging on the lake at the confluence of rivers Raimkana and Dhauliganga (see figure 1 for the location) where it has deposited lateral moraines. Presently the snout of the valley glacier is located above 5000 m at the base of mount Kameth. In a concise manner these observations were published in *Current Science*[2]. To the best of my knowledge, neither of the authors ever visited this high altitude site nor have they read our old paper critically. Otherwise, they would not have invoked an alternate hypothesis for the formation of proglacial lake at Goting by landslide for which there are no field evidences.

(2) When we used the word proglacial, it has significance in terms of the climatic condition prevailed during the existence of the Goting lake. The nomenclature not only draws strength from the geomorphological situation of the basin but more importantly on the sedimentological evidences such as the presence of varve and rhythmite, ice rafted debris and dropstones, all indicating the prevalence of proglacial environment during the existence of the lake. A detailed description of the processes and climate has been presented in Juyal *et al.*[3].

(3) The authors have suggested that the region is influenced by the monsoon precipitation. On the contrary, the basin lies in the rain shadow zone due to the presence of Nanda Devi massif in the south.

(4) Our thin section studies of the varved sediments revealed presence of detrital calcite along with other minerals (Figure 1). Fine clays have been derived through glacial grinding of the Tethyan sedimentaries and brought down into the lake by subglacial processes. It has been proposed by the authors that the thin section study (picture not given in the paper) indicates presence of micritic carbonate grains of ~100 micron. This observation is at variance with our study. Figure 1 clearly shows presence of detrital calcite embedded in calcareous matrix.

(5) It has been increasingly realized that the stratigraphic inconsistency in ^{14}C ages could be due to the hardwater effect.

Figure 1. Presence of detrital calcite embedded in calcareous matrix.

This looks plausible considering the catchment lithology that is dominated by the Tethyan carbonate and our data indicate that majority of the organic carbon is aquatic in nature. In such a situation, the inconsistency in organic carbon age and preferential overestimation is always found[4–6]. Hence, unless the terrestrial organic carbon is dated from such lakes, ^{14}C ages should not be used for any meaningful climatic interpretation. We have attempted luminescence dating of the lake sediments from Goting and found that ^{14}C ages are not only overestimated, at times >50%, but have also suffered from variable magnitude of hardwater effect[2]. The authors have omitted those ^{14}C numbers that fall outside the linear regression line without providing logical justification. Strangely, the authors have even attempted power spectrum analysis based on a very feeble chronology. Probably they will enlighten me how the precise periodicities of '~275, ~300, ~465, ~530, ~740 (figure 3*c*) with strongest power in 740 ± 20 yrs,' (page 64, para 4) can be obtained when the errors involved in ^{14}C ages range from 1550 to 4130 years? (table 2, page 63).

(6) The relevance of meteorological data from Mukteshwar (located in Lesser Himalaya) to interpret past climatic change in higher Himalaya bordering Tibet is not understood. The climatic picture would be far from reality even if they have tried to correct Mukteswar data by using the dry adiabatic lapse rate of 0.65°C/100 m. We still remember sampling the Goting profile when both the banks of river Dhauliganga were frozen and dry gusty Tibetan winds were battering the barren landscape while the lesser Himalaya enjoyed misty sunshine. We also did a futile exercise by using 100 years of meteorological data from Joshimath at the southern fringe of higher Himalaya (a more proximal site than Mukteshwar) and the results were very frustrating when we realized that Goting basin neither receives monsoonal rains nor does it attain temperatures comparable with Joshimath.

(7) Our sampling interval was ~5 cm in which number of varves (light and dark bands) was averaged and the same samples were analysed for isotopic studies. In such crude sampling interval, how could the isotopic signature of light

(summer) and dark (winter) bands (page 63, para 2) be resolved? More confusing is the oxygen isotopic estimation of Goting lake water that, according to them, is close to snow and river water and deviates significantly from the glacial meltwater. I am at loss to understand this interpretation. The river water at Goting is nothing but the glacial melt only. It would have been better and closer to reality if the estimates were based on the meltwater samples provided to them from Goting basin. It has been suggested that $\delta^{13}C$ of Goting carbonate mimic the marine carbonate and negative excursions are attributed to soil CO_2. First, barring a few there are no major excursions that can be attributed to soil CO_2 and the dominant fluctuations are between –2‰ and 1‰ (figure 3*b*). Even if I presume the interpretation is correct, this does not go with the field observation considering the terrain that is devoid of vegetation and no soil profiles were found. Hence, it can be inferred that condition during the existence of the lake would have been much severe in terms of soil development.

(8) The authors have used the location map of Goting basin (figure 1, page 60) from our earlier publication without any reference to it. Figure 2 (page 61) is still more shocking as it is neither from Goting nor does it show varves. The figure shows soft sediment deformations at Garbyang en route to Kailash–Mansarover that has been published to our surprise without our knowledge and consent.

1. Ghosh, P. and Bhattacharya, S. K., *Curr. Sci.*, 2003, **85**, 60–67.
2. Pant, R. K., Juyal, N., Rautela, P., Yadav, M. G. and Sangode, S. J., *Curr. Sci.*, 1998, **75**, 850–855.
3. Juyal, N., Pant, R. K., Basavaiah, N., Yadava, M. G., Saini, N. K. and Singhvi, A. K. *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 2003 (in press).
4. Krishnaswami, S. and Lal, D., In *Lakes: Chemistry, Geology and Physics* (ed. Abraham Lerman), Springer-Verlag, New York, 1978, pp. 153–177.
5. Geyh, M. A., Schotterer, U. and Grosjean, M., In Proceedings of the 16th International ^{14}C Conference, Radiocarbon, 1998, pp. 921–931.
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Response:

Our paper (G.B.)[1] is based on an earlier study by Pant *et al.* (R.K.P.)[2] discussing the geological aspects of sediments from the Goting palaeo-lake and their chronology. Here we address the relevant issues raised by the present comments.

(1) According to R.K.P., formation of the Goting lake is related to the Trans-Himadri Fault leading to creation of the Khal Kurans Ridge acting as a geomorphic barrier for the glacial moraines to accumulate and make the pro-glacial lake. A redistribution of moraines required to establish the blockage was possibly caused by earth movement (probably due to re-activation of the fault) or landslide. However, our data and interpretation do not depend on how the lake was formed.

(2) Goting basin is located close to Mukteswar which receives substantial amount of monsoon rain. In the absence of meteorological data from any station in the Goting basin we used IMD data from Mukteswar. It is not reasonable to claim that Goting basin does not experience monsoon just because it lies in the rain shadow zone without support from meteorological data.

(3) Our study is based on the premise that major part of the carbonate is micritic. We do not agree that all calcite grains are detrital. Pant's comment itself mentions that bigger calcite grains are embedded in 'calcareous matrix' which are nothing but fine-grained carbonates.

(4) The chronology used in our paper is based on that given by R.K.P. We have discussed and used the age data with necessary correction. The new luminescence dating data mentioned is still not published. It is obvious that any change in the chronology will affect the interpretation.

(5) To explain the genesis of light and dark bands we examined, their composition and observed large oxygen isotopic depletion in the light band (summer band) relative to the dark band. This is caused by seasonal change in water composition. We also found that the river water resembles the snow rather than glacial melt water (depleted) in isotope ratio. This observation was used for interpretation. It is obvious that the glacial melt water is different in composition (probably due to its origin at higher altitude) from the river water. It is not correct to assume that 'the river water at Goting is nothing but the glacial melt only'.

(6) Figure 2 in G.B. demonstrates the nature of the varves and the banding. The visual nature of this sample is exactly the same as other Goting samples. Figure 1 is a modified version of the detailed map published in R.K.P. to show the geographical features more clearly.

1. Ghosh, P. and Bhattacharya, S. K., *Curr. Sci.*, 2003, **85**, 60–67.
2. Pant, R. K., Juyal, N., Rautela, P., Yadav, M. G. and Sangode, S. J., *Curr. Sci.*, 1998, **75**, 850–855.

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Reply:

(1) The response by Ghosh and Bhattacharya[1] is self-contradictory. At the first place, G.B. appear to be emphatic on attributing tectonics for the genesis of the lake and towards the end they reject the very question as they think it is irrelevant for the interpretation of their data. I am at loss to understand why the question of the genesis should at all be raked. It will be better to leave it to the specialists to debate and decide on whether it could be regarded as a 'proven fact' or not.

(2) I have already indicated in my rejoinder that the radiocarbon ages from the lake deposits in a carbonate terrain suffer from hard water effect hence are unreliable. Goting basin lies in the Tethyan Himalaya. Therefore, climatic inferences drawn based on radiocarbon chronology are bound to be misleading. Juyal *et al.* (ref. 3 in our previous correspondence) have proposed a new chronology based on the luminescence technique that has helped us assign ages to the initiation of the lake and time of its breaching in addition to defining the climatic and seismic events in a chronological order. G.B. is silent on their time series data that was questioned in the rejoinder. Does that mean that they have deliberately avoided answering it realizing the unreliability of radiocarbon dates?