GEOCHRONOLOGY OF THE PAI AEOCLIMATIC EVENTS OF THE LATE CENOZOIC PERIOD IN THE KASHMIR VALLEY

by

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C O N T E N T S

S Y N O P S I S

The present study was carried out to provide a chronology to the palaeoclimatic and palaeoenvironmental events of the late Cenozoic period in the Kashmir valley using radioactive and magnetic polarity dating methods.

The Kashmir valley (Lat. 33° 30' to 34° 30' N., Long. 74° to 75° 30' E.) has a continuous and easily accessible record of the late Cenozoic lake sediments of about 3000m thickness. This relict lake bed which was drained out due to tectonic uplift provides suitably exposed sections with well preserved signatures of the various glacial and interglacial events, marking palaeoclimatic fluctuations. The lake sediments rest on the Palaeozoic and Triassic basal rocks.

The deposits of the basin can be divided into three members: Loess, Upper Karewa and Lower Karewa. As the drained out lake bed presents plateau like surfaces, they have been termed Karewa in the local dialect. This term has now been accepted in the geological literature. The Lower Karewa deposits comprise tilted and folded beds of boulder conglomerate, lignite with an alternation of clay, silt and sand layers. Their total thickness is estimated to be about 2500m. The Upper Karewa formation, on the other hand, consists of horizontal beds of gravel, calcareous clays, marl-bands etc.

and has a total thickness of about 100m. Various glacial moraines and out-washes intrude into the Karewa formations and provide stratigraphic markers. According to de Terra and Paterson, the lake finally drained out during the II inter-glacial, thus exposing the lake beds on the Himalayan north-east side also. The Pir Panjals were continuously rising and the lake beds on that side were already exposed when the Karewa lake shrank and shifted towards the Himalayan side. It appears that the last(?) glacial period is marked by loessic deposition which is thicker on the Pir Panjal side, as it was exposed earlier, and thinner on the Himalayan side.

This continuous record of the Late Cenozoic palaeoenviron-mental events has been a subject of great interest to geologists for over 100 years. The classical methods of geomorphology, palaeontology, and palynology have been applied to these deposits but not yet in a comprehensive and systematic manner. So far no physical methods were available to the earlier workers and therefore many controversies remained unresolved. For example, the beginning of the Karewa lake has been variously dated from Miocene to Pleistocene times.

The Kashmir basin attracted our attention as it provided a unique sediment profile of ~3000m thickness in a continental

situation. So far the long palaeoclimatic records were provided only by the sea-cores and the lake profiles (for example, lake Biwa or lake Van) have been so far bored only upto a maximum depth of 200m or so. But since in the case of Kashmir we could go back to perhaps 5 m.y. and sample 3000m 'deep' sediment without recourse to boring, I took up the problem of dating the Karewa lake sediments by using radioactive and palaeomagnetic techniques.

The results of these studies are presented in six chapters, the first being introductory and the last summarising the conclusions.

In CHAPTER TWO, I have provided an outline of the geomorphological features and their stratigraphic correlations in the valley. I have described the physiography and geological formations including the present day ecology. I have also tried to define the problem of Plio-Pleistocene boundary. The drainage pattern and glacial manifestations have been described in detail as they provide geomorphological markers for dating the events. The role played by tectonics has also been explained.

In short, the available evidence on geomorphology, palynology, and palaeontology has been summarised to provide a backdrop for the problems to be tackled. Though the available palaeontological and palynological evidence is not yet adequate, it does

provide broad chronological pegs on which a time-frame can be hung. It must be emphasized that it is a continuous and unique record so it is an ideal location for magnetic stratigraphy.

I have also shown that the loess represented the last depositional episode in the valley and probably marks the last glacial aridity. In the body of the loess there are several palaeosols which should represent the relatively wetter and warmer episodes in an otherwise arid and cold phase.

CHAPTER THREE deals with radioactivity dating in which I include radiocarbon and uranium/thorium methods. I have described the theory and technique of both the methods and their limitations in the context of the samples collected by me. I have also described the methane reactor that was developed by me for preparing radiocarbon samples.

The upper part of the "Loess" deposit has been dated with the ^{14}C method; both organic and inorganic fractions were extracted and their radioactivity determined to check on the validity of the "dates". It is gratifying to note that in general there was a good concordance between the ^{14}C dates based on organic and inorganic fractions.

Since the Karewas cannot be dated with the ^{14}C method, I have attempted to obtain approximate "ages" using the Ionium method. There are many marl beds and calcareous layers in the Upper Karewa deposits which I thought could be dated with the Ionium dating, following Kaufman and Broecker's attempt at the lakes Lahontan and Bonneville. Although we examined several samples, we have not been successful largely because of the high clay content of these samples (~50%). Further experiments to obtain purer carbonate samples are being made.

The top palaeosol, on the Himalayan margin of the lake, gives c.18,000 ± 1000 B.P. date and probably represents the last deglaciation in the valley. These sites are generally located at about c.1600m altitude. This result is in accord with the evidence from ^{14}C dated pollen profile from a bog at c.3120m altitude that the deglaciation was in progress there at c.15,000 B.P. Thus I find that the last deglaciation in the Central Asian context had started around c.18,000 ± 1000 B.P., which is now in keeping with the latest global evidence as reported by the Climatic Committee report of the Australian Academy of Sciences. The lower palaeosols are older than 30,000 B.P. About 10 sites have been sampled for palaeosol-dating.

In CHAPTER FOUR, I discuss the problems and results of the magnetic measurements made on the Karewa profile. We have taken the Hirpur section as the typical representative formation of the Lower Karewa and for the Upper Karewa, Saki Paparian and Olchibagh have been chosen. The results have been verified by sampling few other sites. As the Upper Karewa deposit has a thickness of only about 100m, I could do an intensive sampling by covering all the clay bands present. Thus about 80 samples were measured for the Upper Karewa. The Lower Karewa samples presented formidable problems of extensive field-work and accessibility of the exposed sections because of their sheer steepness. I have satisfactorily covered only about a 10km long section in the Rimbiara valley, near Hirpur. As it was essential to cover the whole Lower Karewa section to detect all the magnetic epochs, I decided upon an extensive sampling and collected about 80 samples at broad intervals. Thus my palaeomagnetic stratigraphy is based upon 150-160 magnetic samples.

In this Chapter, I have also dealt with the principles and technique besides giving the sampling procedure adopted by me. The measurements were made with the help of an astatic magnetometer mounted with Helmholtz coils to neutralize the earth's ambient magnetic field; this instrument which was made available for my work was housed at a field station far away from the city for higher sensitivity measurements.

The magnetic measurement results have been stratigraphically correlated to the different exposed sections available in the valley. All the Upper Karewa samples show normal polarity. Near the top of the Hirpur section (Lower Karewa) I have some samples depicting a reversed polarity covering a 10m thick segment of the section. The lower sections exhibit normal polarity. Keeping in view the geological stratigraphy, radioactive dates and the climatic events, I find that the magnetic measurements provide a consistent chronological framework. Our results thus show that the Karewa lake sediments probably cover the Brunhes (< 0.72 m.y.), Matuyama (0.72-2.47 m.y.) and Gauss (2.47-3.41 m.y.) magnetic epochs.

CHAPTER FIVE makes use of the chronology determined in the present work using the radioactive and palaeomagnetic techniques, to locate various palaeoclimatic and palaeoenvironmental events in the valley in a time-sequence.

CHAPTER SIX summarizes the results of the present work which clearly points to the availability of a complete palaeoclimatic sequence covering the late Cenozoic. It would be important to check by sampling several sites in the Lower Karewas to determine the oldest available sequence.

Three conclusions could be drawn from the present work:

(1) The top-most palaeosol in the loessic deposit represents the last deglaciation which started at 1600m at 34° N. Lat. at about c.1800 ± 1000 B.P.

(2) The Upper Karewa represents Brunhes Epoch (<0.72 m.y.).

(3) There is good indication that the top-most section of the Lower Karewa represents the Matuyama Epoch (0.72-2.47 m.y.) and the section below probably indicates the Gauss (2.47-3.41 m.y.) magnetic normal Epoch.

These investigations have made available a chronologic sedimentary sequence covering the late Cenozoic in the Kashmir valley which can now be more extensively studied using conventional techniques to delineate palaeoclimatic changes in this period.

It should be emphasized that this work provides the first dates on the Karewas based on physical dating methods.

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I hereby state that the work described in this thesis has not been submitted to this or any other University for Ph.D. or any other degree.

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a) Statement regarding the discovery and important new facts

Absolute chronologies have been provided to the palaeo-climatic and palaeoenvironmental events of the Late Cenozoic period in the Kashmir valley. For the first time, I have used physical dating methods for providing chronologies to exposed 'Karewas' (the relict lake beds) in the Kashmir valley. So far only classical methods were used to date the Karewas.

The radioactive dating methods were used for dating the palaeosols within the topmost loessic deposit and the Upper Karewas. The magnetic polarity dating was employed for the Upper and the Lower Karewa deposits.

The top-most palaeosol within the loessic deposits dates to c.18,000 ± 1000 years before present, thus dating the last deglaciation in Kashmir. The Upper Karewa is ascribable to the Brunhes Epoch (< 0.72 m.y.). The topmost sediment below the gravel bed in the Hirpur section probably belongs to the Matuyama Epoch (0.72-2.47 m.y.) and the section below this probably the Gauss (2.47-3.41 m.y.) magnetic normal epoch.

b) Statement regarding contribution of the author

The large number of samples of soils (palaeosols) for radiocarbon dating and samples of clay for palaeomagnetic studies were collected at several sites in the Kashmir valley and were measured by the author. Assistance was provided in the field work by Dr. D.P. Agrawal, Mr. R.V. Krishnamurthy, Mr. V. Nautiyal and Dr. R.K. Pant.

The preparation of counting gas for radiocarbon dating and the extractions of uranium and thorium were done by the author with occasional help from Mr. R.V. Krishnamurthy, Dr. S. Krishnaswami, Dr. R.K. Pant and Dr. B.L.K. Somayajulu.

The low background, gas proportional counters were used for radiocarbon dating. The procedure of preparing contamination free counting gas in a closed reaction vessel was developed by the author.

The palaeomagnetic measurements were carried out using an astatic magnetometer housed at Tata Institute of Fundamental Research (Khandala) and at the National Geophysical Research Institute (Hyderabad) in collaboration with Dr. S.D. Likhite and Mr. S. Rao.

The planning of sampling procedures and sampling regions, was done in consultation and collaboration with my guide Dr. D. Lal and Dr. D.P. Agrawal

The interpretation of experimental results have been carried out by the author in consultation with my guide Dr. D. Lal, Dr. D.P. Agrawal and Dr. C.R.K. Murthy.

In all these phases of investigations the author carried out a significant share of work.

A list of publications of the author together with a copy each of the papers supporting the thesis are attached at the end of the thesis.

(Sheela Kusumgar)

I certify that the above statements are correct

D. Lal
(Guiding Teacher)

LIST OF FIGURES

LIST OF TABLES

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