ON THE PLIO-PLEISTOCENE BOUNDARY IN NORTH-WEST INDIA

VISHNU-MITTRE

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

The problem of the delimitation of the boundary in the N.W. India is discussed in the light of the recent developments in the concept of demarcating this critical horizon. The suggested position of this boundary is largely based upon the biological evidence with subsequent climatic indication. The boundary is not found to be synchronous with the glacial epoch, rather it precedes it. The paper suggests the placing of the boundary at the base of the Pinjor stage in the Upper Siwaliks and towards the bottom of stratigraphical zone 1 (after De Terra and Paterson) of the Lower Karewas.

INTRODUCTION

THE desirability of fixing a base for the Pleistocene series was considered by the Temperoray Commission of XVIII International Geological Congress held in London in 1948. In the same year the Geological Society of America at its 59th Annual Meeting discussed the problem of the delimitation of the Plio-Pleistocene Boundary (COLBERT, 1948). In the light of the conclusions arrived at in the above meetings and the recent advancement in the concept of fixing a base for the Pleistocene series, it was thought necessary to re-examine the desirability of defining the Plio-Pleistocene boundary in the N.W. India.

From the discussions held in London, one gathers as if the Commission was not concerned with whether the base of the Pleistocene series would also coincide with the initiation of the glacial period. Owing to the Pleistocene being a division of the Geological time, it was suggested that it should be defined on the stratigraphical and the faunal evidence.

More or less similar conclusions were arrived at in the symposium organized by the Geological Society of America, but here the glacial evidence, based upon climatic factors, was considered to be a workable definition of the beginning of the Pleistocene sequence for the unglaciated (peri-glacial) regions, and it was suggested that the reliance must also be placed on other criteria, particularly the faunal evidence. The inclusion of the preglacial sediments, which often depict a period of moisture and cooling, in the Pleistocene was considered to be a matter of definition of the Pleistocene period. Diastrophism was not considered as a consistent and world-wide criterion for dating the beginning of Pleistocene.

The criteria generally used to determine the Plio-Pleistocene boundary, comprising the geological (a stratigraphical break), climatic (indication of the refrigeration of climate) and biological (a change in the flora and fauna preferring cooler climate and decline of warmth loving flora and fauna) are largely inter-related; the floral or faunal change can be caused by a change in climate directly or indirectly by bringing about edaphic or physiographic changes. A stratigraphic break may also in the same way be attributed indirectly to the change in climate, though in regions affected by tectonic movements, it may be independent of that.

The Plio-Pleistocene strata are mostly transitional into those of the Pleistocene. The stratigraphic break in such cases may be locally recognizable of which hardly any regional significance can be made out. It is, therefore, that many workers have taken recourse to the other two factors, namely the biological and the climatic evidences in delimiting the Plio-Pleistocene boundary.

This thesis has been categorically supported by a number of workers (GIRMUNSKI, 1931; SCHULTZ, 1938; MOVIUS, 1944; SZAFER, 1954 and FLINT, 1957). Flint (1957) has recently once again advocated his view that the Plio-Pleistocene boundary be drawn on the basis of fossils with subsequent climatic indications. This boundary does not indicate a significant evolutionary change between the faunas and the floras above and below it but only an indication of climatic cooling. Regarding the status of the Plio-Pleistocene boundary, Flint (*loc. cit.*) writes, "to consider such a boundary as separating time unit of so major an order as periods, equivalent in rank to the Cretaceous period, is to emphasize its importance". He further believes that the Plio-Pleistocene boundary can only have "series value" rather than "system value". The reconciliation at least in Europe of two diverse views, one of Osborn (1915) suggesting correlation of faunas with the glacial and the interglacial stages established on physical evidence and the other of Hopwood (1936) suggesting correlation of faunal composition without regard to the climatic evidence regarding the subdivision of the Pleistocene series on a basis of land mammals is an encouraging and hopeful fact suggesting the decisive nature of the climate as a factor in delimiting the Plio-Pleistocene boundary.

In cases of marine and nonmarine strata where the Plio-Pleistocene boundary has been determined on the basis of cooling climate as in England, Netherland, Poland etc., it has been invariably seen that the boundary line precedes the truly glacial deposits which occur at a considerably later horizon (KING, 1956). It is probably, therefore, that many geologists, palaeogeographers and botanists feel convinced that the main difference in separating the Pliocene from the Pleistocene is of a climatic nature (SZAFER, 1954; FLINT, 1957). This has indirectly led to the abandonement of the four cold maxima of the glacial succession in the Alps and Southern Germany established by Penck & Brückner (1909). Despite the great value of the four fold Alpine nomenclature, it is suggested especially in regard to the local successions that the 'Glacial epoch' and the Pleistocene should not any longer be considered strictly equivalent (LAGAAIJ, 1952; KING, 1956).

Regarding the inference of climate from the fossils it must be stated that the concensus of opinion is that the plants and the marine invertebrates are the better indices of climate than the land mammals. But it is always profitable that the aspect of a whole fauna and of a related flora, as far as possible, should be considered together before any inferences are deduced regarding the climate and the biotypes. This can be done most effectively if the population shifts are determined both qualitatively and quantitatively.

THE PLIO-PLEISTOCENF BOUNDARY IN NORTH-WEST INDIA

Fixing the base of the Pleistocene in N.W. India has been discussed previously by numerous geologists, especially Pilgrim (1944), De Terra & Paterson (1939) and Wadia (1951) and from their consideration of the problem (discussed below) of demarcating the Plio-Pleistocene boundary two diverse schools of thought have emerged — one led by Pilgrim & Wadia and the other by De Terra & Paterson. Whereas both Pilgrim & Wadia are in agreement in the delimitation of this boundary in the Upper Siwaliks, they disagree with each other in the correlation of the northern slopes of the Pir Panjal with a sequence in the Upper Siwaliks. Pilgrim in regard to the latter agrees with De Terra & Paterson in attributing the First Interglacial age to the Lower Karewas. Wadia, however, believes that the boundary runs astride the Lower Karewas. De Terra & Paterson are radically opposed to Pilgrim & Wadia in placing the boundary in the Siwaliks. It may be pointed out that these eminent geologists base their opinions on both the stratigraphical and biological evidences, besides that Pilgrim has also taken into account diastrophism as a factor.

Since 1951 when Wadia restated his views on this problem, there has been considerable progress (outlined above) in our concept of fixing this boundary and the opinions abroad have been revised consequently. The recent pollen-analytical work in N.W. India has brought out some significant results which appear to have a great bearing on the Plio-Pleistocene boundary. In the light of these developments, it was thought necessary and advisable to evaluate the facts toward the revision and precise definition of this boundary in the N.W. India.

The Siwaliks — The best deposits which constitute critical areas for the Plio-Pleistocene in India occur in the Siwaliks. They have been divided into the Lower, the Middle and the Upper Siwaliks. The field geological work coupled with the palaeontological evidence (COTTER, 1933; WADIA, 1943 and PILGRIM, 1944) shows that the Middle Siwaliks pass gradually into the Upper Siwaliks and the few minor stratigraphical breaks noted are sporadic which disappear laterally. An unconformable overlap between the Upper Siwaliks and their overlying strata does not constitute the main unconformity but this, too, is not a hiatus of any regional importance since it tends to diminish in the Soan Valley (WADIA, 1943). The precise division of the Siwaliks into stages by means of the locally abundant mammalian fauna is possible. The Mid-Siwaliks and the Upper Siwaliks are generally grouped together into one unit because of the difficulty of separating them by a definite geological dividing line. According to one school the Upper Siwalik, except perhaps in the very topmost zone, is preglacial and lies astride the Plio-Pleistocene interval of Europe (PILGRIM, COTTER, WADIA, 1943). The other school led chiefly by De Terra (DE TERRA & PATERSON, 1939) believes that the entire Upper Siwalik belongs to the Pleistocene and recognizes an unconformity at the base of the Upper Siwalik separating the Dhok Pathan stage. This unconformity seen in the Tatrot conglomerate of the Attock area by De Terra, as the detailed geological work in the Soan Basin has shown, is of local occurrence and untraceable in the Soan Basin (WADIA, 1951). Thus De Terra's view of placing the Plio-Pleistocene boundary at the base of the Tatrot stage does not seem to be supported by stratigraphy.

Following the description of the geology of Kashmir by De Terra & Paterson, Pilgrim (1944) considers two horizons of the Boulder Conglomerate overlying the Pinjor stage — the Upper and the Lower. The Upper, containing the faceted boulders and some coarse flakes and merging into a ground moraine of the second glaciation, is probably equivalent to the second glacial stage and most of the Lower Conglomerate beds are equivalent to the first Interglacial. The basal beds of the Lower Conglomerate, according to Pilgrim (1944), might represent the first glaciation which may still be unrecognized.

The first undoubted earliest glacial evidence in the Upper Siwaliks comes from Bain, in the Marwat Hills, Shekh Budin range of Waziristan (MORRIS, 1938). The Boulder bed about 70 ft. thick is underlain by strata with *Elephas planifrons*, *Equus siwalensis* and *Cautlevi* and *Bos* or *Bubalus* sp. and overlain by beds containing *Elephas planifrons*, *Elephas hysudricus*, *Equus cautlevi* and *Bos* or *Bubalus*.

The three type mammals on the basis of which the Plio-Pleistocene boundary is now-a-days drawn include, *Elephas*, *Equus* and *Bos*. *Elephus planifrons* is the most primitive elephant and is believed to be the guide fossil for the Early Pleistocene deposits. Thus it seems more reasonable as the faunal evidence suggests to draw the Plio-Pleistocene boundary at the base of the bed underlying the Bain Boulder bed. Based on faunal similarities, the Pinjor stage will be equivalent to the bed underlying the Bain Boulder Bed. Since the Pinjor stage is succeeded by glaciation, it is included in the Preglacial phase of the Pleistocene. Thus we find that the Plio-Pleistocene boundary in the Sub-Himalayan plains precedes the actual glaciation. It may be pointed out here that De Terra & Paterson have repeatedly stressed the early Pleistocene nature of the Pinjor fauna (DE TERRA & PATERSON, 1939, p. 266). The Tatrots are believed to be transitional between Pliocene and Pleistocene (KRISHNAN, 1960, p. 560). The faunal remains from the Upper Conglomerate including *Equus namadicus*, *Bubalus palaeindicus* and *Boselaphus* cf. *namadicus* are of very advanced type and probably belong to early Middle Pleistocene. Animal remains from the Conglomerate bed at Bhaun near Rawalpindi, collected by De Terra & Paterson including Camel, *Bos*, *Hippopotamus*, etc., are again of the advanced type.

Ice-Age Deposits of Kashmir — The other area which possesses the critical evidence of the transitional Plio-Pleistocene passage comprises the Karewa series constituting the well-bedded lacustarine sediments contemporaries of the Upper Siwaliks of the Punjab. The Karewa series are divided into two stages — the Lower and the Upper Karewas separated by a well-defined hiatus. The Lower Karewas comprising over 4700 ft. thick soft, dark grey, tough clays, shales and sandstones, with seams of lignite and well-bedded conglomerates rest on folded Triassic and other pre-Tertiary rocks. De Terra & Paterson (1939) have described some sections such as near Sedau at the outlet of the Vishav River, near the Malshahibagh, the Rimbiara Valley and at Malapur where the Lower Karewa clays overlie a series of brown to pink gravels and sands. Though unstriated and unfaceted these gravels are believed by De Terra and Paterson to represent the outwash deposits of the First Glaciation.

At Malapur and other sites the unstratified subangular gravels and breccias up to about 100 ft. in thickness are seen underlying the Lower Karewa deposits. The breccias, composed of angular debris embedded in sandy loam, are, according to De Terra & Paterson, reminiscent of the "loam breccias" or solifluxion soils now-a-days formed in the cold climate of higher Tibet.

Though the information regarding the lower limit of the Lower Karewas is very scanty and an extensive stratigraphical work is desired, the presence of angular debris composed of sandy loam gravels and breccias underlying the lower Karewas and suggestive of their being the outwash deposits of the First Glaciation led De Terra and Paterson to assign the Lower Karewas to the First Interglacial. Pilgrim (1944) also regards the Lower Karewas as belonging to the First Interglacial. Wadia (1943, 1951, 1957) has recently expressed the view that the underlying Lower Karewas are of pre-glacial age and contemporaries of the older stages (Tatrot and Pinjor) of the Upper Siwalik on the opposite side of the Pir Panjal. According to Wadia the base of the Lower Karewas is probably Pliocene, touching as low a horizon as the Dhok Pathan stage of the Middle Siwaliks (WADIA, 1957, p. 383).

The floral evidence is plenty in the Lower Karewas but the same is not true for the faunal evidence since it has come forth only from a single bed. Whatever may be the climatic inferences from the plant and animal remains, it is very necessary first to know their exact position in regard to stratigraphy. Based on stratigraphical correlations in the Lower Karewas exposed along the North-eastern slope of the Pir Panjal, De Terra & Paterson (p. 109) divide the entire Lower Karewas into 5 zones running serially from bottom to top. It is only the zone 4 towards the top of the Lower Karewa deposits that has yielded the leaf impressions which have been described by Stewart (DE TERRA & PATERSON, p. 118) and Puri (1948). This plant record indicating 'subtropical' climate belongs to the top region of the Lower Karewas. From the sediments in the basal zones (Zone 3) scanty and impoverished pollen-analytical information has recently come forth (NAIR, 1960) and the pollen spectra so constructed reveal the occurrence of open Pine forests. The other constituents of these spectra *Alnus*, *Betula*, and *Picea*, etc., are the temperate or subtemperate genera except *Pinus roxburghii* (earlier known as *P. longifolia*) which is a subtropical element. A re-examination of the pollen slides made by Nair (*loc.cit.*) showed that all the pollens of *Pinus* belong to *Pinus wallichiana* — a temperate sp. and there are hardly any pollen grains of *P. roxburghii*. Thus the floral evidence establishes, howsoever scanty the information is, that the lower beds of the L. Karewas indicate cold temperate or subarctic climate, middle and top ones the subtropical and the topmost ones are succeeded by the glacial climate. The L. Karewas would, therefore, seem to present a climatic alternation of an Interglacial — a sequence of cold-warm-cold.

The faunal evidence from the lowermost beds (zone 1) of the Lower Karewa comprises the remains of mammals from Sombur and Badgom and the remains of fish belonging to *Schizothorax* or *Oreinnus*. The shells, of which some (*Bithynia*, *Gyraulus* and *Planorbis*) are found even today in Kashmir in association with the Palaeoarctic forms, have been recorded from the grey clay (zone 1) and from the shaly sands of the lignitic beds (zone 3). The diatoms from Handawor and the Shaliganga valley (zone 3) suggest a mild temperate climate. The mammalian fauna include remains of *Elephas*, *Rhinoceros*, deer, birds, *Cervus*, etc. The remains of *Elephas* are believed to belong to *Elephas hysudricus*. The section from the Marwat formation extends the range of *Elephas hysudricus* into the First Interglacial since the sediments containing this overlie the Bain Boulder bed. Thus the overall information from the faunal evidence suggests temperate climate when the sediments of the Lower Karewas were laid down. It is needless to point out here that Pilgrim (1944), an authority on Indian mammals, casts doubt on the identification of the remanis of *Elephas* from the Lower Karewas with *E. hysudricus* and looks upon this species much closer to the modern Indian elephant and considers it later than Villafranchian.

The recent pollen-analytical studies of the Lower Karewas (VISHNU-MITTRE, SINGH & SAXENA, 1962) have brought out a prominent oak phase in the lowermost strata (zone 1). By the gradual immigration of the pines (especially *Pinus wallichiana*) the oak phase is replaced by the subarctic open pine woods. This change to a boreal climate suggested by a sharp decline of the mesophytic woods to a dominance by conifers (especially *P. wallichiana*) is certainly suggestive of the prevalence of climatic conditions equivalent to glacial climate. With the destruction of the mesophytic woods towards the top of zone 1, the treeless wastes are created and the ground cover is also destroyed to a very great extent. The conditions devoid of vegetation continue during zone 2. It is not until towards the beginning of zone 3 that the bare area is first colonized by the herbaceous elements chiefly by Gramineae, and Cyperaceae and later by Chenopodiaceae and *Artemisia*. Gradually immigrating Pine woods soon replace the herbaceous vegetation. This cool oscillation brings about a change lasting for a considerable long period. Some plants of a mesothermic character, though in very small proportions, still continue to survive. Their evidence is perhaps due to the secondary pollen derived from the older strata.

A cool oscillation of so permanent a character cannot be anything less than of glacial nature. Cool oscillations within an Interglacial are generally of a temporary nature registering a temporary increase of trees of cool climate and checking the growth of the thermophilous elements which restore themselves as soon as the cool oscillation is over.

This pollen-analytical evidence casts doubt on the so far considered First Interglacial age of the entire Lower Karewas. This tends to show that the basal deposits of the L. Karewas (zones 1 & 2) could not belong to the First interglacial, they might be attributed to the Glacial, Preglacial or Pliocene. Of these it is the zone 1 which is characterized by the oak woods which are annihilated towards the top of it setting in a transitional phase in the vegetational succession which lasts throughout the zone 2 until towards the beginning of the subarctic phase in zone 3. The catastrophe resulting in the destruction of the oak woods and reaching its climax in the glacial climate of the subarctic phase could not have been other than the worsening of climate. It is probably this indication of change in climate that is suggestive of the beginning of the Glacial epoch in the Lower Karewas. Based on this conclusion the oak-phase in zone 1 should belong either to the Preglacial or Pliocene and the entire zone 2 together with the topmost part of zone 1 and the lowermost part of zone 3 — representing the Lower Transition Zone in the vegetational sequence should be referred to the Glacial Phase. The absence of the typical tertiary elements in zone 1 suggests its reference to Preglacial rather than to the Pliocene.

Correlation of the glacial cycle in the Lower Karewas with that in the Upper Siwaliks as discussed above is set out in Table 1. It is interesting to find that in both the beginning of the Pleistocene is not coeval with the beginning of the glacial epoch. It is hoped that future pollen analyses will bring out further information regarding the beginning of the Pleistocene and the Glacial epoch in N.W. India.

CORRELATION AND COMPARISON WITH EUROPE AND ASIA

Several workers have recently pointed out the hazards of large-scale correlations. The comments are, therefore, only restricted to correlations which have been referred to by Pilgrim (1944). Pilgrim has rightly correlated the Pinjor stage with the Calabrian and Val d'Arno, the Italian deposits, which are now included in the Pleistocene and the boundary of the Plio-Pleistocene is now drawn at their base. The same may be said of the Villafranchian stages of Perrier & Seneze in France. In East Anglia the Plio-Pleistocene boundary is now believed to run at the base of the Red Crags, thus making the Red Crags equivalent to the Pinjor stage and not to the Coralline Crag as Pilgrim believes.

From a recent appraisal of the problem of the Plio-Pleistocene boundary one would agree with Flint (1957, p. 398) in drawing the Plio-Pleistocene boundary at the base of Czorsztyn in Poland including Mizerna 1, I/II, since the pollen-analytical evidence here is suggestive of cooler climate. The Pinjor stage is, therefore, correlatable with the Czorsztyn of Poland and the Praetiglian of Netherland.

CONCLUSION

A reconsideration of the Plio-Pleistocene boundary in N.W. India from both stratigraphical and biological viewpoints suggests that the boundary should be drawn at the base of the Pinjor beds in the Upper Siwaliks

TABLE 1 — THE SUGGESTED CORRELATION OF THE GLACIAL CYCLE IN THE LOWER KAREWAS WITH THAT OF THE UPPER SIWALIKS OF NORTH-WEST INDIA

FLUVIAL DEPOSITS OF THE PUNJAB-HAZARA SUB-HIMALAYAS

				STAGES	FAUNA
UPPER SIWALIKS	PLEISTOCENE	GLACIAL SERIES	II Gl.		
			I INTERGLACIAL	BOULDER CONGLOMERATE STAGE	*Elephas namadicus*, *Equus*, *Camelus*, *Buffelus*
			I Gl.		
		PREGLACIAL		PINJOR STAGE	*Elephas planifrons*, *E. hysudricus*, *Equus*, *Bos*, *Boselaphus*, *Hemibos*
	PLIOCENE			TATROT STAGE	*Elephas Clifti*, *Leptobos*, *Equus*, *Hippophus*, *Sus*

THE EARLIEST PLEISTOCENE GLACIAL DEPOSIT IN N.W. INDIA

Above	*Elephas planifrons*, *E. hysudricus*, *Bos*
	BAIN BOULDER BED
Below	*Elephas planifrons*, *Equus*, *Bos*, *Bubalos*

GLACIAL CYCLE IN THE LOWER KAREWAS

		Vegetation	Climate	Other organic evidence
	II Gl.		COOL	
LOWER KAREWAS	5		TEMPERATE	Fossil leaves & fruits of Rose, Cinnamon, Oak, Maple, Walnut, *Trapa* etc.
	4	*Juglans*-Elm woods; Spruce-oak-woods	TEMPERATE	
	3	Upper Transition zone; Blue Pine woods	Subarctic	
	2	Lower Transition zone	COOL	
	1	Oak woods	TEMPERATE	*Elephas* cf. *hysudricus*, *Schizothorax*, *Oriennus*
		Thick Gravel FANS		

and at the base of zone 1 of the Lower Karewas. This boundary indicating the beginning of the Pleistocene period is not synchronous with the beginning of the Glacial epoch. The evidences of the First Glaciation appear to be on top of the Pinjor stage (the lowermost strata of the Boulder Conglomerate) and towards the top of zone 1 in the Lower Karewas. The sediments in zone 1 between the suggested Plio-Pleistocene boundary and the commencement of the glacial epoch (Pinjor stage in the Siwaliks and zone 1 on the Lower Karewas) should be referred to the Preglacial.

The suggestion put forward above does not reconcile with the placing of the Plio-Pleistocene boundary at the base of the Tatrot stage in the Siwaliks and at the base of the Lower Karewas by De Terra & Paterson (*loc. cit.*). On the other hand it confirms the views of Pilgrim (*loc. cit.*), Cotter (*loc. cit.*) and Wadia (*loc. cit.*) that it lies astride the Upper Siwaliks and the Lower Karewas. In its precise delimitation, the suggestion supports views of Krishnan (1960, p. 560) that the Plio-Pleistocene boundary should be drawn at the base of the Pinjor stage in the Upper Siwaliks while in the Lower Karewas it suggests the shifting of the boundary proposed by Wadia (1951, 1957) at a horizon corresponding with the base of zone 4 to the bottom of zone 1 amongst the stratigraphical subdivisions of the Lower Karewas by De Terra and Paterson (*loc. cit.*).

REFERENCES

COLBERT, E. H. (1948). Pleistocenes of the Great Plains — 1. Summary and Conclusions. Symposium 59th Annual Meeting of Geol. Soc. America. *Bull. Geol. Soc. America.* **59**: 627-630.

COTTER, G. SE P. (1933). Geology of Attock District, Punjab. *Mem. Geol. Surv. Ind.* **55**: 63-161.

FLINT, R. F. (1957). Glacial and Pleistocene Geology. New York and London.

GIRMUNSKI, A. M. (1931). Versuch einer Verglei chenden Zusammenstellung westeur opaischen, amerikanischen, und russischen schemen fur de Gilderung den Quatäzeit. *Zeitsch. f. Gletscherk.* **5** (19).

HOPWOOD, A. T. (1936). Fossil elephants and Man. *Proc. Geol. Assoc.* **73**: 185-188.

KING, W. B. R. (1956). The Pleistocene epoch in England. *Geol. Soc. London Quat. J.* **111**: 187-208.

KRISHNAN, M. S. (1960). Geology of India and Burma. *Madras.*

LAGAAIJ, R. (1953). The Pliocene Bryozoa of the Low Countries and their bearing on the marine stratigraphy of the North Sea Region. *Med. Geol. Sticht., Series-V.*

MOVIUS, H. L. (1944). Early man and Pleistocene stratigraphy in Southern and Eastern Asia. *Harvard Univ. Peabody Mus.* Papers 5, **19** (3): 113.

MORRIS, T. O. (1938). The Bain Boulder bed, a glacial episode in the Siwalik series of the Marwat Kundi Range and Sheik Budin, North West Frontier Province, India. *Quart. Journ. Geol. Soc. London.* **94**. 385-421.

NAIR, P. K. K. (1960). Palynological investigations of the Quaternary (Karewa) of Kashmir. *Journ. Sci. Indust. Res.* **19C** (6): 145-154.

OSBORN, H. F. (1915). Review of the Pleistocene of Europe, Asia and Northern Africa. *New York Acad. Sci. Annals.* **26**: 215-315.

PENCK, A. & BRUCKNER, E. (1909). Die Alpen im Eiszeitalter. *Leipzig, Tauchnitz.*

PILGRIM, G. E. (1944). Lower limit of the Pleistocene in Europe and India. *Geol. Mag.* **81**: 28-38.

PURI, G. S. (1948). The flora of the Karewa series of Kashmir and its phytogeographical affinities with chapters on the methods of identification. *Indian Forester.* **74** (3).

DE TERRA, H. & PATERSON, T. T. (1939). Studies in Ice Age in India. *Carnegie Inst. Washington. Pub.* **493**: 1-354.

SHULTZ, J R. (1938). A late Cenozoic vertebrate fauna from the Caso mountains, Inyo County, California. *Carnegie Inst. Washington. Pub.* **487**: 75-109.

SZAFER, W. (1954). Pliocenska Flora okolic Czorsztyna jej stosunek do Plejstocenu. *Inst. Geol. Prace.*: 1-238.

VISHNU-MITTRE, SINGH GURDIP & SAXENA, K. M. S. (1962). Pollen-analytical investigations of the Lower Karewas. *Palaeobot.* **11** (1, 2): 92-95.

WADIA, D. N. (1943). The Pliocene-Pleistocene Boundary in North Western India. *Proc. Nat. Inst. Sci. India.* **9** (1): 37-42.

Idem (1951). The transitional passage of Pliocene into the Pleistocene in the North Western Himalayas. *Rep. 8th Session International Geol. Cong. U.K.* 1948, Pt. XI: 43-48.

Idem (1957). Geology of India. *London & New York.*