SOME ASPECTS CONCERNING POLLEN-ANALYTICAL INVESTIGATIONS IN THE KASHMIR VALLEY

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ABSTRACT

Based on recent Pollen-analytical investigations of the Early and Late Quaternary deposits in the Kashmir Valley, the various aspects discussed include the background information regarding vegetation, the nature of the peat deposits, the present and past pollen rain, the parallelism in the course of vegetational development during the Late and Early Quaternary, the correlation of Post-glacial pollen diagrams, the past altitudinal shifts in the vegetational belts, and the role of the climate vs biotic factor upon vegetational development.

INTRODUCTION

THE Quaternary history of the Kashmir Valley has been investigated for well over one hundred years. The sub-fossil pollen was first studied by Wodehouse and De Terra in 1935 and later some attempts were made by Puri and others until the work on pollen analysis commenced at the Sahni Institute in the year 1957. The earlier palaeobotanical and palynological work was mostly qualitative. More often the interpretation of the data did not include any stratigraphical or proper ecological considerations indispensable in most Quaternary investigations (PURI, 1948, 1957). Besides utter disregard and misuse of known stratigraphy, the principles of pollen analysis also have been overlooked (NAIR, 1960).

The recent pollen analytic work concerns the Lower Karewas (VISHNU-MITTRE, SINGH & SAXENA, 1962) and the Postglacial deposits from the valley proper (SHARMA, 1964) and at high altitude (SINGH, 1963). The Lower Karewa megafossils have been reconsidered ecologically and stratigraphically by Vishnu-Mittre (1964). The demarcation of Plio-Pleistocene boundary and the history of oaks in the valley have been reviewed by Vishnu-Mittre (1963a, 1963b). The speciation of modern and subfossil pollen of *Quercus* and *Alnus* from the Lower Karewas has been also attempted (VISHNU-MITTRE & SINGH, 1963; SINGH, 1963; VISHNU-MITTRE & SHARMA, 1963). Besides the study of modern pollen rain and its correlation with the composition of forests has been carried out (SHARMA *l.c.*; SINGH *l.c.*). The results obtained hitherto have brought to light information of considerable value chiefly concerning the development of vegetation, the climatic alterations and the origin and progressive development of agriculture in the valley together with the factual information regarding the history of oaks and alders which are absent from the valley today. Although the information unearthed from lake and peat deposits requires to be substantiated from several more pollen analyses from the valley and in the adjoining regions, yet there are certain aspects of wider interest and applicability in these pollen analytical investigations which require discussion and consideration so as to serve as guiding factors for future pollen analyses in this region.

SOME ASPECTS OF BOTANICAL BACKGROUND

Relationships of the Flora — Besides the European, the Central Asian and the Tibetan elements in the Kashmir flora, some Alpine species occur as far as America. But a bulk of the flora is typically Himalayan distributed from Afganistan to Sikkim or even China and is mostly found between 2000 to 2,300 metres. The Himalayan forest zone has a preponderance of western species over those of the eastern. The Mediterranean element occurs largely on the upper Chenab in the arid belt. The tropical element is absent.

Several plants have been introduced by the Moghals and later by the Britishers and some of these such as *Sternbergia* and *Ixiolirion* have naturalized there. The Lombardy Poplar and Chinar were introduced by Moghals in 1612 and 1635 respectively.

Factors Controlling the Distribution of Vegetation in the Valley — In a mountainous region as obtained in the Himalayas besides climate, soils and the biota, physiography also constitutes an important factor. The well-marked physiographic features such as the aspect, the steep and gentle slopes, the leeward and windward sites, depressions and cliffs modify the effect of both the climatic and edaphic factors, besides controlling the biotic factor. Physiography may have overriding influence over that of the other factors as, for instance, the lofty Pir Panjal prevents moisture laden monsoons from the south from entering the Kashmir Valley and the high Himalayan Chain in the north has cut off the valley from the dry icy winds from Tibet.

Varying physiographic environment has confined plants of the same species to different situations resulting in different ecads. Blue pine, for instance, at lower levels occupies moister depressions and cooler aspects whereas its high level form is confined to warm aspects, dry spurs and lower slopes. Deodar has ± the same preference for physiography as pine. Silver fir, the associate of high level pine, occurs in cooler aspects, moist depressions and the upper slopes. Associated with *P. gerardiana* it usually occupies the western slopes. At higher elevations silver fir occurs in all aspects, even populating the tops of ridges sometimes but it is usually stunted. At high altitude Silver fir usually avoids depressions. Spruce normally occurs in cool and moist situations. The yew forms an undergrowth in sheltered and moist situations.

Climate — Very variable climate occurs from the valley proper to snow clad mountains. Temperature shows a fall of 1° after every 333 m. Depending upon montane physiography the precipitation patterns also vary despite the extremely low rainfall (VISHNU-MITTRE, 1963a). The main annual temperature is from 16° to 25° and the total rain fall is much under 1000 mm (about 600-700 mm.) though at certain stations it approaches the threshold of the lowest obtained in the south of the Pir Panjal.

Soils — Blue Pine prefers the well-drained to moderately dry and even moist, fresh and deep soils invariably avoiding wet and badly drained soils or very dry ones. It grows well on boulders, gravel, in beds of rivers and newly formed soils, on undecomposed fresh soils from mica schist and on limestone provided the soil is deep and rich. Deep, fairly porous, soils are preferred by *Cedrus* but moist, deep, rich soil is good for fir and spruce.

The requirement for soil, climate, etc. of the broad-leaved species some of which are absent must be the same as in other parts of the Western Himalayas (TROUP, 1921; CHAMPION, 1936). A moist, deep, rich soil containing undecomposed humus is formed under a mixed conifer forest.

Biotic factor — Until 1922 *Cedrus deodara* the only marketable conifer has been exploited for building purposes, furniture and sleepers for the railway and blue pine for resin tapping, for boxes and general carpentery. Matches and wood pulp have been manufactured from *Abies* and *Picea. Juglans regia* has supplied all the needs for gunstocks of the Indian Army. Oaks although absent in the valley are used for fuel as well as timber in other parts of the Himalayas.

Lopping is a regular practice in the valley. Injuries to the forest are also caused by browsing, by eating and trampling the seedlings and by barking and ringing the stems. Besides harming young seedlings light and heavy grazing has generally affected the spp. of *Artemisia, Indigofera, Desmodium*, wild roses, brambles and *Berberis*. In the absence of the shrubs animals usually feed on the seedlings of conifers. The high altitudes are often visited by the graziers — Gujars and Bakarwals — with their herds and flocks during the summer causing considerable damage to the forest. They often lop and fell the forest to their exclusion as the removal of leaves for sheep at Kainmal about 1000 m. above Gulmarg has resulted in wholesale destruction of birch forest.

Climbers such as *Rosa moschata, Hedera*, and *Clematis* also cause damage of the blue pine, but the loranthaceous parasite, *Arceuthobium minutissium*, does considerable harm. *Viburnum foetens* and *Parrotia jacquemontiana* prevent natural reproduction of pine by their dense growth. The fungal pests damage adult plants as well as seedlings.

The progressive increase in population resulting in increase in agriculture and domestic industries based on wood has caused considerable destruction of the indigenous vegetation. Besides the demand for fuel, frequent fires have further destroyed the forest. The lack of indigenous vegetation has been known as early as 1836 when Baton Hugil visited the valley.

Before 1891 there was practically no management of the Kashmir forests. It is only about 50 years ago that the ruthless destruction was stopped. To provide for fuel *Salix* and *Robinia* have been planted and several other indigenous and exotic trees of economic importance have been introduced. By 1947 ten thousand acres were brought under plantations of *Salix*. The bare hill slopes in the valley were forested until recent historical times.

Some Aspects of Modern Flora, Certain Anomalies and Plant Successions — The flora of the valley like that of the entire J & K State is in fact the north western extension of the Western Himalayan Flora, but for certain constituents which are either absent in the valley or are over- or under-represented. The lower limit of the forest is about 2,000 m. Between 2,000 and 5,000 m. the altitudinal disposition of the conifers is:

Pine — deodar — spruce — fir, as observed on the Pir Panjal.

Prunus, maple, horsechestnut, walnut, *Celtis* and a little of *Corylus* and some of *Populus* occur in these pine forests in the order of abundance. A contrast, however, is seen between the flora on the northern side of the Pir Panjal and on its southern side in the absence of the sub-tropical flora. The recent afforestation of dry temperate hill slopes of Shankaracharya Hill in the Valley (FIRDAUS, 1944; MEHTA, 1947) has revealed that sub-tropical taxa such as *Ailanthus glandulosa*, *Melia azedarach* and *Pinus roxburghii* together with certain other exotic ones find the climatic conditions obtained here quite suitable for their growth. These sub-tropical taxa do not normally grow in the valley.

The valley flora is generally described to be dry temperate in contrast to the moist temperate flora on the other side of the Pir Panjal. Chiefly owing to dry climate spruce is very poorly present (about 3-5 per cent) but occasionally 10-15 per cent as at Surakhneri near Hejan. An unusual thing noted is the kinship between spruce and pine rather than with *Abies*. Like kail, (blue pine *P. wallichiana*) spruce also acts as a coloniser as the shingle islands in the beds of rivers are often seen populated with mixed thickets of kail and spruce.

Typical associates of fir in Kashmir are kail or kail and deodar (in Lolab) and there are no oaks, laurels, *Rhododendron*, *Pieris*, *Cornus* and *Ilex* unlike the fir forests elsewhere in the Western Himalayas. Similarly *Euonymous*, *Carpinus* or *Alnus* are either absent or extremely poor. The only broad-leaved species are maples, birch, hazel, horsechestnuts, etc. Fir forests are mostly poor perhaps due to their segregation in the wet depressions or their occurrence in the uppermost limit of the tree growth. *Strobilanthes*, hill-bamboos, brambles, *Daphne* and *Sarcococca* usually found in the fir forests in the rest of the Himalayas are absent. *Ivy*, *Skimmia laureola* and *Viburnum foetens* are however present. Though usually of high altitude, the fir forests may descend as low as 2160 m. as near Gratnar in Lolab.

The distribution of deodar is also restricted as in the Lolab valley. It is largely absent on the northern slopes of Pir Panjal, although temperature and moisture conditions are quite suitable. Because of restricted growth and rare occurrence of spruce both kail and fir dominate the valley and are usually associated with each other. The purity of kail, fir and deodar forests is noteworthy. A curious feature noted is the peculiar association of all the conifers, which normally are disposed altitudinally, at Alpathri not very far from Baba Rishi.

Changes in the Forest — The opening out due to clearance or fire of fir forest with sprinkling of blue pine results in complete replacement of fir by blue pine. The intermediate stage is represented by species of *Rubus*, *Rosa* etc. After 60-100 years pine forest is again replaced by fir forest. This change is more or less irrespective of the altitude. The freshly exposed soil due to avelanches, for instance, within the fir zone is usually colonized by maple and *Prunus*, which also act as nurseries to pine and fir. In the broad-leaved forest of the valley *Parrotia* has the same status as oak on the other side of Pir Panjal or in other parts of Himalayas.

Stages of vegetational succession in the colonization of abandoned fields in the high level fir zone during a span of about 20 years are as follows:

I Annuals — (*Rumex*, *Xanthium*, *Sambucus*, *Chenopods* and *Grasses*).

II Broadleaved Phase — *Viburnum* followed by trees distributed by birds, *Prunus*, *Corylus*, horsechestnut, *Acer*.

III Conifer Phase — immigration of blue pine.

IV Replacement by fir but invariably the following three stages are witnessed Herbs — (no shrubs) — conifer (pine) — fir.

Damaged conifer forest due to occasional land slides and avelanches is replaced by maple perhaps due to easy dispersal of its fruits.

Tremendous regeneration of pine on the ill-drained Karewas at Yus shows the following stages:

Herbs —

Few shrubs — (*Berberis, Rosa, Viburnum, Parrotia*).

Pine — (depending upon seed source).

The succession in the riverine fresh water deposits in the Pir Panjal is as follows:

Myricaria — Aralia — Pine.

Towards the North of the valley local variations are noted depending upon the direction and the nature of the aspect. On situations facing South and with dry aspects the succession is:

Herbs—

Shrubs — (*Plectranthus, Berberis, Ephedra, Daphne* — a mixture of xerophytic and mesophytic spp. and *Prunus armanis*).

Pine —

The situation facing N & NE show the following succession:

Herbs —

Shrubs — (*Parrotia, Berberis, Rosa, Clematis*).

Pine —

Cedrus — (invading within its own zone of distribution).

In the fir zone the wide openings made after 30 years of clearances are colonized by the xerophytic spp. such as *Rubus* and *Rosa* followed by pine.

Introductions and Ethnobotanical Data — The absence of *Alnus*, oaks and the low level elm (only seen protected in shrines) and the presence of introduced lofty poplars, *Salix*, and the huge chinars has already been mentioned.

As many as 7 spp. of *Populus* grow in the valley of which *nigra* cf. *italica, alba, deltoides, euphratica* (*deltoides* × *nigra*: common), and *tremula* are planted mostly from cuttings or from suckers. The woodland poplar *P. ciliata* is very sporadic and limited in the Kashmir state but in Batote and Doda on the other side of the Pir Panjal it is the first coloniser on landslips, freshly exposed soil and on burnt areas in the blue-pine deodar zone.

There are several species of *Salix* of which except the high level one, *S. wallichiana*, all the other bushy willows (*S. oxycarpa, lindelliana, hastata, elegans, daphnoides, viminalis*) are introduced. The high level willow occurs in the fir forests mostly at the transition from fir to birch.

Indigenous oaks have now been discovered from the valley (VISHNU-MITTRE, 1963a) and chir pine is doing well on the Shankaracharya Hill (FIRDAUS, 1944). Together with these some exotic conifers like *P. holepensis, P. canariensis* and *Cupressus arizonica* and the tropical and subtropical spp. such as *Ailanthus glandulosa, Robinia, Morus alba, Melia azedarach* grow on the Shankaracharya Hill. The successful establishment of some tropical and subtropical spp. reveals that the present climate of the valley is quite suitable for these species. It is equally suitable for oaks too (VISHNU-MITTRE, 1963a), the extinction of which from the valley is obviously due to a factor other than climate. The plantations of *Salix* and *Robinia* have been carried out especially to provide for fuel. Oaks providing the best fuel have been wiped out from the valley. The necessary information concerning conifers and walnut has already been given elsewhere.

Duthie (1892) records the use of *Artemisia maritima* as fodder for mules and donkeys in Gilgit and *A. parviflora* and *A. sacrorum* for sheep and goats. Since time immemorial *Artemisia* in the valley has been used as medicine for round worms. Including *Artemisia* several other tall herbs and shrubs have been exploited to supply charcoal for use in portable heating pots called Kangris.

PEAT DEPOSITS IN THE KASHMIR VALLEY

The occurrence of peat and its use as fuel in the valley has been known for a long time. A survey of the nature and kind of peat in the valley shows that the superficial deposits of peat are no where more than three to four feet in thickness. In some of the lakes and swamps peat is still forming in the Kashmir Valley. In Hokar Sar, the chief source of this kind of fuel, about 3-4 ft. of peat overlies a thick deposit of a shelly greyish clay filling the lake. The peat here is formed by spp. of *Myriophyllum, Nymphaea, Alisma, Marsilea, Phragmites communis, Juncus, Polygonum, Typha* and *Sparganium*. In other lakes like Anchar, Manasbal and Haigam it is largely the fine silty detritus (organic mud) which is met with. This black deposit overlies a brown detritus mud. Hardly any seeds occur in it. Besides considerable rootlets of Cyperaceae only 2 or three fragments of mosses other than *Sphagnum* were recovered in the entire profile of 6 metres. The bottom detritus is variously overlain by either silt or clay with or without shells.

Extensive but superficial deposits of peat occur at high altitude at Drang, Pejan Pathri and Toshmaidan whereas the depressions are filled with organic detritus. In some a horizon of moss peat with *Bryum alpinum*, *Aulacomnium palustre* and a species of *Webera* is met with (SINGH, 1963). Typical moss peat formed by Sphagna is wanting since sphagna are of extremely rare occurrence in the western Himalayas (RAO, 1964). Consequently it is not possible to recognize the Grenzhorizont and the various recurrence surfaces, important features in the peat deposits of Europe. Intercalated sandy and silty layers, however, suggest flooding episodes.

The top alternating layers of organic detritus with those of shelly layers in Anchar and Dal, for instance, seem to reveal the historical practice followed even today of constructing floating mats by the weeds collected from below the lake, on which are grown vegetables to form floating fields. Some of them bear *Salix* plantations. This temporarily reclaims part or shores of lakes to provide space for habitation and cultivation. No evidence of their abandonment is known except during floods.

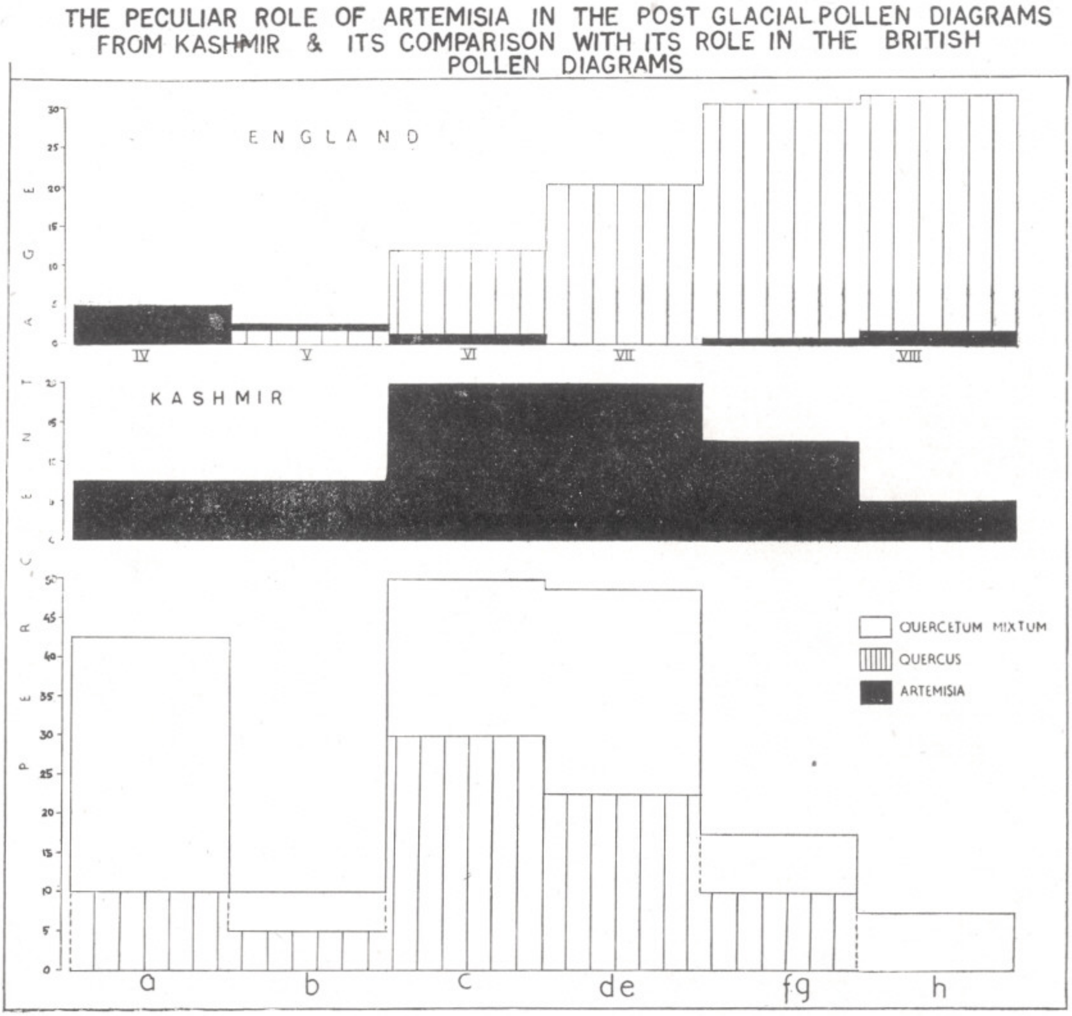
THE APPLICATION OF POLLEN ANALYSIS TO THE KASHMIR VALLEY

The Postglacial pollen diagrams bring out more or less similar broad pattern of vegetational development (conifers — oak woods — conifers) as obtained in the European diagrams. *Tilia* and *Fagus*, two important genera in the European diagrams, are absent in the Kashmir pollen diagrams. These genera do not occur in India as well as in Kashmir and perhaps never occurred here in the Quaternary period. Another outstanding difference is the suppressed values of *Corylus* which never rise beyond 15 per cent. In the European diagrams values attained by *Corylus* are up to 200 per cent or even more. *Corylus* at present forms a few stands in the valley in Pahlgam only. The close relation between the pollen curves for elm and *Corylus* during the early part of the Postglacial as witnessed in the British pollen diagrams is also not seen in the Kashmir diagrams. In the Haigam pollen diagram its maximum development is seen during the periods of maximum warmth but in the high altitude diagram it attains high values after the climatic optimum.

The sudden decline of oak, alder, elm, *Juglans* and *Corylus* towards the top of the diagrams may be due to climate. Most of these are absent from the valley proper, but oaks and alders are absent throughout the valley. Stray occurrence of indigenous oaks in the valley may be due to later introduction by man or through dispersal by birds (VISHNU-MITTRE, 1963a). The mystery of the occurrence of 7 per cent alder pollen in Shupian moss cushion alone remains unsolved. Birch is mostly dependent upon its local occurrences. It is highly developed during the climatic optimum and later in the Toshmaidan pollen diagram but its suppressed values and ultimate decline in the corresponding periods in the Haigam pollen diagram from the valley proper goes very well with its absence from the valley.

Pine shows a preponderance towards both the base and the top of the diagrams, *Abies*, also shows more or less the same trend though comparatively far reduced than pine. Local factors as discussed earlier perhaps explain better the higher values of fir in the top of the pollen diagrams from middle and high altitudes. Low values at the base of the Toshmaidan diagrams suggest past altitudinal shifts in the fir forests. Both Spruce and *Cedrus* have comparatively higher values at the base of the diagrams. As already pointed out, *Cedrus* is absent or extremely poor on the Pir Panjal and is restricted elsewhere in the valley. *Picea* in the Kashmir Valley forests is extremely poor.

An outstanding feature hitherto observed in the Kashmir Postglacial diagrams is the strange behaviour of the curve for *Artemisia*. The genus mostly includes plants distributed in the open and in drier habitat. Its maximum values in the Kashmir pollen diagrams coincide with the maximum development of the mixed-oak woods the decline of which is faithfully followed by *Artemisia* too (Fig. 1). This seems anomalous since after decline of the mixed-oak woods, it could spread considerably in the open. The grazing of sheep and goats as Duthie (1892) has observed may be held responsible for decline of *Artemisia*. A moister and humid climate as indicated by the oak woods would be most unsuitable for the shade intolerant dry habit plants of *Artemisia*. The presence



TEXT-FIG. 1 — Comparative distribution of *Artemisia*, *Quercus* and *QM* during the Postglacial in Kashmir and England.

of high Pir Panjal and its effect on the climate of the valley preclude the possibility of the occurrence of a moist period any time during the Postglacial. The abundant occurrence of *Artemisia* in the xerophytic *Pinus gerardiana* — *Quercus ilex* wood in Paddar in inner Chenab Valley and in the inner dry Kishenganga Valley probably also indicates that the mixed-oak woods during the Postglacial perhaps included *Quercus ilex*. The evidence of gradual desiccation of lakes in Kashmir seems to contradict above which rather indicates a moist period in the mid-Postglacial. Continued ecological and pollen-analytical work in the Kashmir Valley may help solve this anomaly. In the pollen diagram from the Lower Karewas the role of *Artemisia* is just as one would normally expect. Obviously then the oak-woods during the Lower Karewas had different climatic requirements than the Postglacial mixed-oak woods.

POLLEN SPECTRA AS AN INDEX OF FOREST COMPOSITION

Studies of pollen content of moss cushions and surface samples from undisturbed peat and lake deposits from various sites within the valley and at varying altitude have nevertheless demonstrated a close correlation between the pollen spectra and the respective wind-pollinated forest communities with the only difference that pollen of pine is found to be over-represented both in the samples collected from within the forest as well as in the open. There are, however, other differences too, for instance, few oaks present in the Achabal forest reserve remain unrepresented in the pollen spectrum of the moss cushion picked up from close to them, and the presence of 7 per cent *Alnus* pollen in the pollen spectrum from Shupian, whereas the genus *Alnus* is altogether absent from the valley. The middle altitude pollen spectra from within the fir-pine or pine-fir forests also show abundance of pine pollen over that of fir or spruce and the position is the same at high altitude. Figure 2 shows modern pollen rain as deduced from various pollen spectra from low and high altitude within the valley proper.

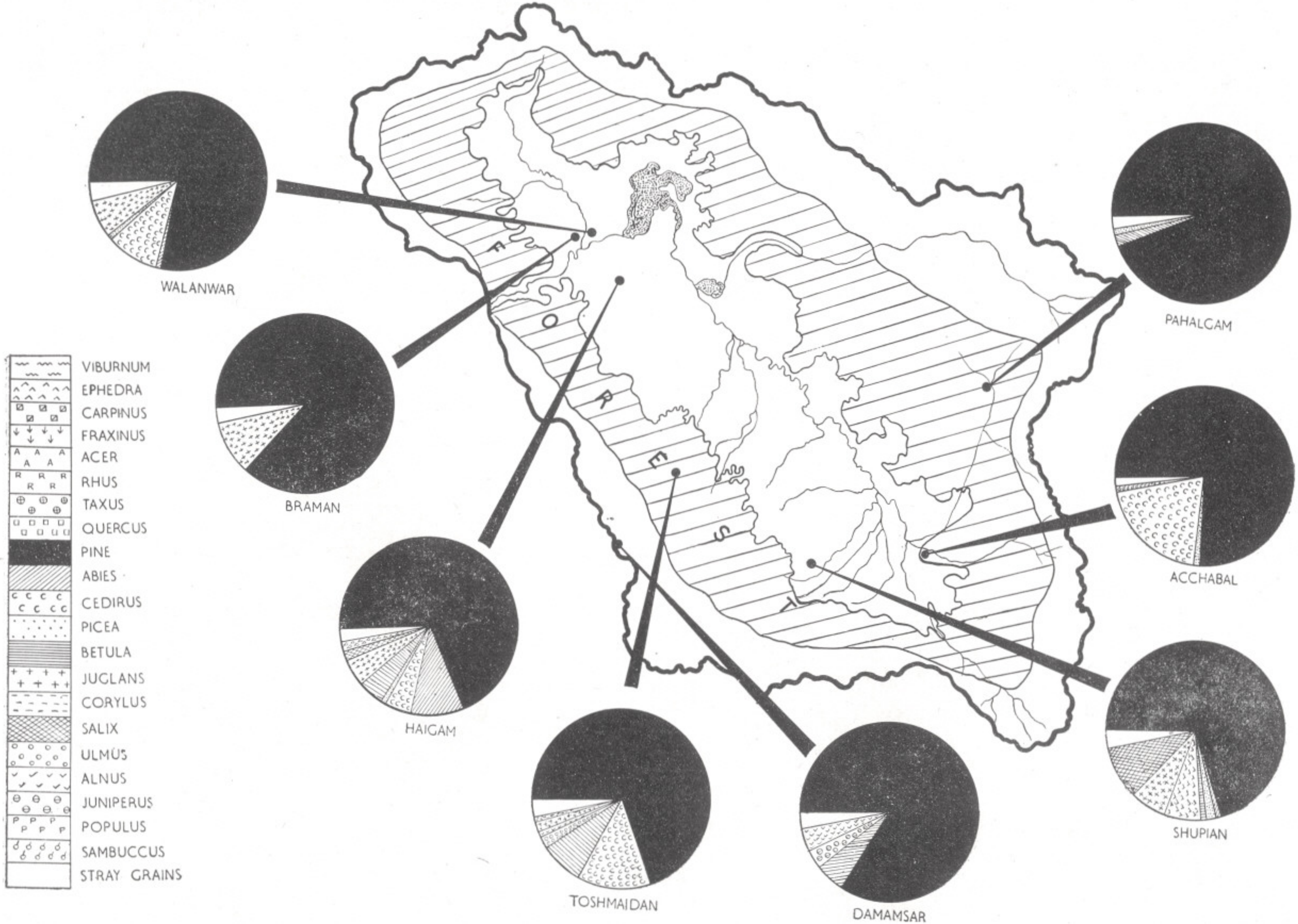
Contribution to pollen rain by insect pollinated spp. is either nil or the least and that is why *Parrotiopa jacquemontiana* a gregarious plant making dense undergrowth together with several members of Leguminosae and Rosaceae etc. remains unrepresented. This limitation from which pollen spectra always suffer can be of serious nature in providing an incomplete picture of the past vegetation as is illustrated by investigation of the Lower Karewas. The lignitic deposits at Nichahom, for instance, show abundance of pine pollen, but amidst the megafossils not a single needle or cone-scale of pine is met with, instead there are numerous leaves of oaks (*Q. dilatata*), *Salix* and of several legumes. Likewise the bed at Botapathri, with hundreds of mummifield fruits of *Trapa*, is devoid of any pollen of *Trapa*. Furthermore the Lithozone 4 has yielded several megafossils including conifers, but natural orders such as Rosaceae, Leguminosae, Lauraceae, Euphorbiaceae and Rhamnaceae are completely unrepresented in the pollen analyses.

A more precise overall comparison between the microfossil and megafossil data from the Lower Karewas may, perhaps, illustrate better the incomplete information of former vegetation inferred from either of them. The hitherto-known entire assemblage of megafossils from the Lower Karewas is distributed over forty Natural Orders, 75 genera and 130 plant species (VISHNU-MITTRE, 1964). The identification of some of the genera and species is questionable (VISHNU-MITTRE, *l.c.*) but in the overall comparisons a very small proportion of questionable identifications would not matter very much. Amongst this assemblage the following natural orders, 35 genera and 63 spp. (the later two cited by their numbers in parenthesis against the natural orders) are completely unrepresented in the pollen record:

Berberidaceae (1:3)
Pittosporaceae (1:1)
Rhamnaceae (2:4)
Rutaceae (2:2)
Sabiaceae (1:1)
Cornaceae (2:3)
Myrsinaceae (1:3)
Lauraceae (4:7)
Euphorbiaceae (1:1)
Araceae (1:1)
Leguminosae (2:9)
Rosaceae (5:14)
Hamamelidaceae (1:1)
Lythraceae (1:1)
Araliaceae (1:1)
Rubiaceae (1:1)
Oleaceae (4:4)
Buxaceae (1:2)
Urticaceae (1:1)
Ceratophyllaceae (1:1)
Selaginellaceae (1:1)

In addition to that fourteen natural orders partly represented in the pollen record are listed below together with the number of genera and species mentioned against them. The word 'general' signifies the identification of N:O but not of any specific genus or species.

N:O	GENERA & SPP. FROM POLLEN	GENERA & SPP. FROM MEGA-FOSSILS	GENERA & SPP. MISSING IN POLLEN RECORD
Ranunculaceae	General	(2: 2)	2: 2
Aceraceae	(1: 1)	(1: 7)	0: 6
Anacardiaceae	(1: 1)	(2: 4)	1: 3
Compositae	General and (1: 1)	(2: 2)	1: 1
Ulmaceae	(1: 1)	(1: 5)	0: 4
Betulaceae	(3: 3)	(3: 9)	0: 6
Fagaceae	(1: 1)	(2: 5)	1: 4
Salicaceae	(1: 1)	(2: 9)	1: 8
Cyperaceae	General	(2: 2)	2: 2
Typhaceae	(1: 1)	(2: 2)	1: 1
Hydrocaryaceae	(1: 1)	(1: 2)	0: 2
Nyphaeaceae	(1: 1)	(3: 3)	2: 2
Coniferales	(4: 4)	(6: 6)	2: 2
Filicales	General	(2: 2)	2: 2



TEXT-FIG. 2—Modern pollen rain in the Kashmir Valley. The dominance of pine in the spectra is very striking both in the open as well as in the forest zone. *Alnus* is absent in the valley but its pollen in the pollen spectra from Shupian and Damamsar is noteworthy.

From the above it appears that amongst the known megafossils, about 50 per cent natural orders are completely absent in the pollen record, and 35 per cent are partly represented and only 15 per cent are present and as many as 65 per cent genera and 82 per cent species are completely wanting in the pollen record.

The pollen record, however, brings out some families and genera mentioned below, of which no record has been obtained in the megafossils. These are:

Coniferales	*Larix, Cedrus,*
Plantaginaceae	*Plantago*
Lemnaceae	*Lemna*
Balsaminaceae	*Impatiens*
Caryophyllaceae	
Liliaceae	
Umbelliferae	
Polygonaceae	*Polygonum*
Compositae	*Artemisia*

A remarkable difference is observed in the reconstruction of vegetation during Lithozone 4 independently from the macroscopic and pollen records. Whereas the megafossils show the occurrence of pine-oak woods or oak-pine woods, the pollen analyses from a single site belonging to this Lithozone (Botapathri) bring out the occurrence of spruce-oak or oak-spruce woods which later changed over to *Juglans*-elm-spruce-fir-oak woods. Pine was present extremely lowly. The aquatic vegetation in the pollen diagram shows progressive succession between Nymphaeaceae and *Typha* whereas megafossils show abundance of *Trapa* together with *Ceratophyllum, Myriophyllum* and *Nelumbo* in the Karewa lake, along the shores of which the reed swamps were formed by *Typha, Sparganium* and spp. of *Cyperus, Scirpus* and *Acorus*.

In the same way the precise composition of the forest as deduced from the pollen diagram is far too inadequate as compared to the one constructed from megafossils. The chief difference lies in the absence of considerable information concerning several constituents of the arboreal vegetation especially those making the shrub layer, although the ground flora is comparatively better represented in the pollen analyses.

A reconstruction of shrubby vegetation based on megafossils in the Lithozone 4 (VISHNU-MITTRE, *l.c.*) reads as follows:

" The shrubby undergrowth formed a distinct and recognizable storey. It largely consisted of *Prunus jacquemontii, Rosa macrophylla* and a small-leaved *Rosa webbiana* cf. *R. beggariana* together with species of *Rubus, Spiraea, Berberis, Indigofera* and *Desmodium*. In this rich shrubby vegetation *Viburnum* and *Salix elegans* were also present. Some spp. of *Rosa, Hedera nepalensis* and *Clematis montana*, rare and insignificant members of this vegetation, clothed the branches and the boles of the trees".

A pollen sequence belonging to this zone tells of the occurrence of *Viburnum* only and of none other shrubs.

Going back to Nichahom, the famous site for lignite in the valley, the pollen diagram reveals a predominant pine phase — a mixed pine wood phase to be more precise — but there is no trace of any conifer in the megafossils. Should the pine phase be looked upon as a true representative of former vegetation or some other explanation be sought is a matter of personal choice. The role of pine pollen has earned considerable notoriety and is perhaps far more difficult to interpret than the pollen of other genera. But surprisingly in the general trend of the vegetational sequence in the pollen diagram from the Lower Karewas it seems to fit in very well.

PARALLELISM IN EARLY AND LATE QUATERNARY VEGETATIONAL SEQUENCES

Howsoever meagre the information from both the Early (Lower Karewas) and the Late (Postglacial) Quaternary of the Kashmir Valley is, it nevertheless reveals a general parallelism in the vegetational development. A broadly-based three-fold vegetational sequence comprising a conifer phase, a broad-leaved phase and a conifer phase in their successive order is very markedly seen in the Postglacial diagrams both from the base and the high altitude of the valley. The broad-leaved phase is not strictly purely broad-leaved but more precisely it is broad-leaved-mixed-conifer phase. The Postglacial diagram from Haigam, however, brings out a broad-leaved phase preceding the conifer phase. The significance of this is not very clear although it is quite apparent that the climate which supported this broad-leaved phase must have been different from the one that controlled the succeeding conifer phase. The typical Late Glacial phase as known in the European diagrams has not been discovered as yet. The bottom sediments in the Kashmir lakes which have not been penetrated as yet seem to be promising in this connection. Local factors affecting differences in the composition of plant communities in each of the broadly based vegetational phase have been already mentioned early.

A close correspondence between the broadly-based vegetational phases in the two Postglacial diagrams is further witnessed in the recognition of eight vegetational stages referred to by the small alphabetical letters 'a' to 'h'. The vegetational stages may not be synchronous with each other because of altitudinal difference in the sites and due to local factors and they may not all be climatically controlled, though some of them may be. A careful assessment and consideration of data reveals six major parallel stages as shown in Table 1 below. The table also shows the Blytt and Sernander's scheme and pollen zonation scheme of Postglacial climate and vegetation as used in Europe merely to indicate that the number of climatic and vegetational phase in Europe and Kashmir is the same despite vast differences in latitude and vegetation. The correlation shown in the table is supplemented with Fig. 3 to illustrate commonness in the vegetational phases in the low and high altitude pollen diagrams. The differences are of local origin. For correlation purposes the local effects have not been considered. These are separately mentioned below in the description of six major parallel stages. The correspondence of the Postglacial stages from Kashmir with the West European pollen zonation schema as shown in the figure does not suggest complete identity with that. It is only for convenience of understanding the Postglacial climatic and vegetational sequences that the European scheme is mentioned.

For the purpose of detailed comparative description of the major vegetational stages with climatic inference, those in the Haigam profile will be considered as standard.

1. The Preceding Warm Period (The Pre-Boreal Period — or the Vorwarm-Zeit).

This is represented by stage 'a' in the Haigam pollen profile and is chiefly based on the determination of the AP/NAP ratio and the dominance of the thermophilous elements. In the absence of a typical Late Glacial period, it would be most inadvisable to refer it to the Allerod stage. It is the oak-alder-elm-ash wood stage with about 35 per cent pine and other conifers such as fir and yew. No comparable stage in the Toshmaidan Profile is seen.

2. The Early Warm Period (The Boreal Period) is represented by stage 'b' in Haigam profile and by stages ' a, b, c ' in the Toshmaidan pollen diagram. In both pine is dominant (about 75 per cent). Fir and spruce have higher percentage in Haigam profile whereas *Cedrus* and oak have higher values in the Toshmaidan profile. *Ephedra* and *Alnus* are absent in Haigam and ash, elm and walnut are absent from the Toshmaidan profile.

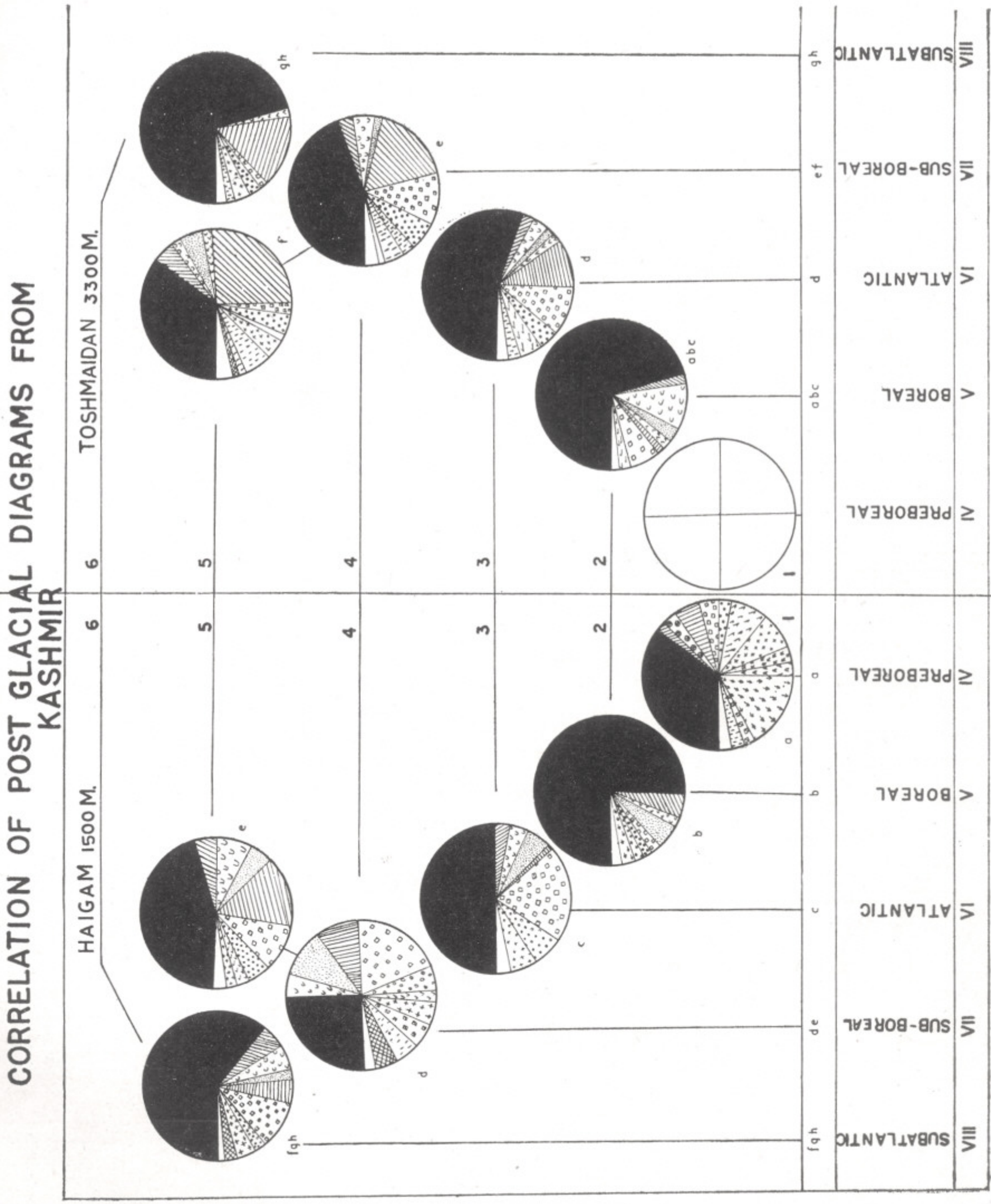
3. The Middle Warm Period (The Atlantic Period) — It is represented by stage 'c' in Haigam and stage ' d ' in Toshmaidan.

Pine around 50 per cent in both. Oaks far more abundant (up to 20 per cent) in

TABLE 1

(*Tentative correlation of Vegetational stages in the Haigam and Toshmaidan pollen diagrams and their probable correspondence with the pollen zonation and Blytt and Sernander's Schemes used in Europe.*)

Pollen zones in Europe	Blytt and Sernander's Schemes	The climatic periods	Vegetational Stages: Haigam 1700 m	Vegetational Stages: Toshmaidan 3300 m
IX			h	h
VIII	Sub-Atlantic	THE POST WARM PERIOD	f, g	g
VII	Sub-Boreal	THE LATE WARM PERIOD	d, e	e, f
VI	Atlantic	THE MIDDLE WARM PERIOD	c	d
V	Boreal	THE EARLY WARM PERIOD	b	a, b, c
IV	Pre-Boreal	THE PRECEDING WARM PERIOD	a	


CORRELATION OF POST GLACIAL DIAGRAMS FROM KASHMIR
HAIGAM 1500 M.
TOSHMAIDAN 3300 M.
SUBATLANTIC VIII
SUB-BOREAL VII
ATLANTIC VI
BOREAL V
PREBOREAL IV
PREBOREAL IV
BOREAL V
ATLANTIC VI
SUB-BOREAL VII
SUBATLANTIC VIII

Text-fig. 3

Haigam than in Toshmaidan. Birch highly developed in Toshmaidan but walnut is absent. Hazel, alder and *Ephedra* absent from Haigam pollen profile.

4. The Late Warm Period (The Sub-Boreal) is represented by stages 'd, e' in Haigam and by 'e, f' in Toshmaidan.

Pine in Haigam is about 50 per cent less than its percentage in Toshmaidan. Oaks, spruce and *Salix* are far more abundant in Haigam than in Toshmaidan which shows increase in birch.

5. The Post Warm Period (The Sub-Atlantic Period) is represented by stages 'f, g' & h' in Haigam and stages 'g & h' in Toshmaidan.

Pine around 30 to 45 per cent but around 60 per cent in stage 'h' in both the diagrams. Most of the broad-leaved constituents reduced though maintaining comparatively higher values in Haigam than in Toshmaidan with the exception of birch which has higher values in Toshmaidan. *Salix*, *Viburnum*, *Corylus* and *Ephedra* absent in Haigam.

Stage 'h' registers sporadic occurrences, if any, of most of the broad-leaved constituents but for birch which continues to have much higher values in Toshmaidan than in Haigam. It is advanced stage of the Post Warm Period. The presence and absence of certain genera is obviously due to local effect owing to differences in vegetational belts in varying altitudes.

The above six major vegetational phases show trends in the Postglacial climatic alterations in the Kashmir Valley. They may ultimately prove valuable in constructing a pollen zonation schema for the valley when several more diagrams will have been constructed.

Assessment of data at hand also helps to understand the altitudinal shifts of vegetation belts during the Postglacial period. Figs. 4 a & b illustrate how the vegetation belts have been changing during the Postglacial periods of climatic optimum as compared to their present distribution.

In view of the disputed age of the Lower Karewas (Pliocene and I Interglacial, or I Interglacial), and the controversy regarding the stratigraphical position of the Lower Karewas, the parallelism in vegetational development between the Lower Karewas and the Postglacial becomes of added interest especially when seen in the light of Von Post's three-fold climatic sequence that has characterized most Postglacial and Interglacial vegetational sequences. Judging from that (Fig. 5) the upper half of the Lower Karewa pollen diagram faithfully reveals the periods of increasing warmth and climatic optimum. The period of decreasing warmth is missing because the sediments belonging to the topmost lithozone 5 have not been examined as yet.

This parallelism in the vegetational development between the Postglacial and the upper half of the Lower Karewas is helpful in dating the Lower Karewas. Obviously then it is in the Lower half of the Lower Karewa pollen diagram, one ought to look for the evidences of the first Glaciation, the Preglacial and the commencement of Pleistocene, since the vegetational sequence in the upper half dates it to an Interglacial. The predominant oak-alder wood phase, its decline and annihilation, followed by a stage devoid of vegetation, the gradual colonization by Gramineae and other herbs and the ultimate invasion of pine until a pine phase is established are some of the interesting stages of vegetational evolution in the lower half of the Lower Karewa diagram. These stages seem to suggest the Preglacial, the Glacial and the commencement of the I Interglacial as has been interpreted by Vishnu-Mittre (1963b) and shown in Fig. 5. This strictly pollen-analytical approach towards the recognition of the Interglacial within the Lower Karewas is not in conformity with the definition of an Interglacial period — a period recognized by a stratigraphical deposit between two glacial deposits. The overlying glacial deposit in the Lower Karewas is undisputedly present but the underlying deposit has been variously interpreted. The silty clayey sediments above the decline of the

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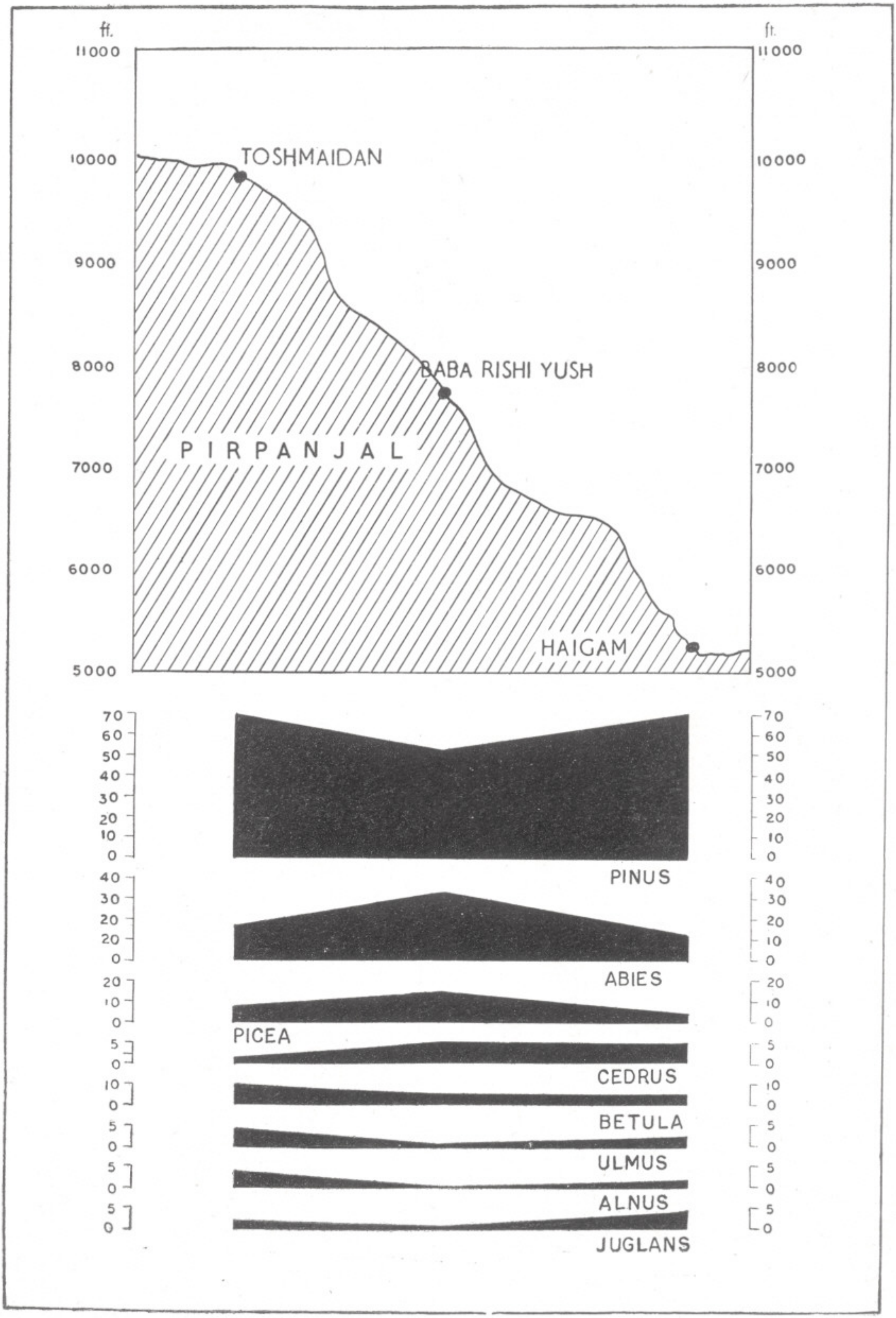
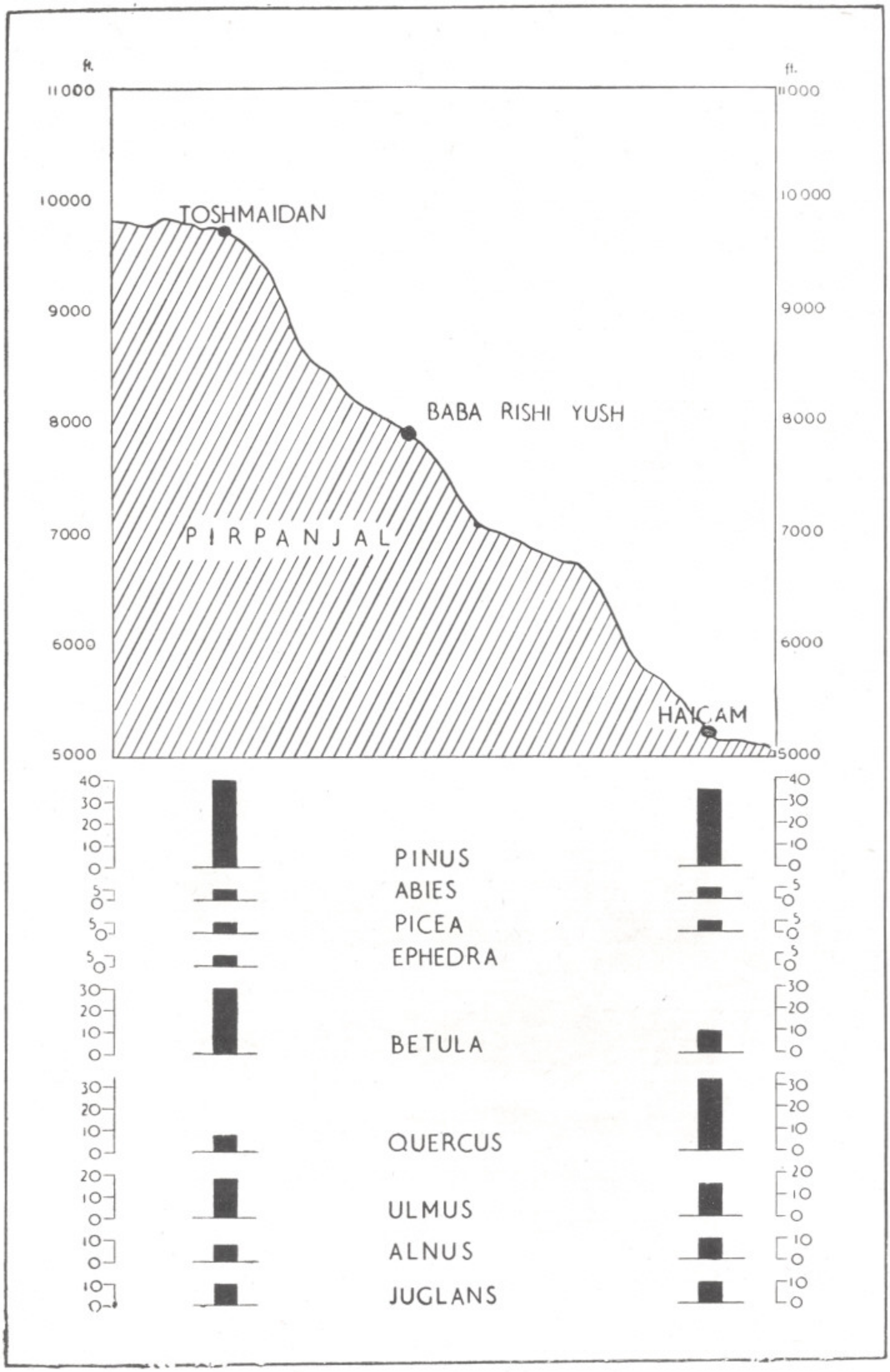
TEXT-FIG. 4a — Altitudinal shifts in the vegetational belts. The diagram shows the composition of modern vegetation belts based on modern pollen spectra at Haigam, Baba Rishi Yus and Toshmaidan along the Pir Panjal an approximate profile of which is shown on top of the diagram with the position of the sites and their altitude.

COMPOSITION OF THE MODERN FOREST AT DIFFERENT ALTITUDES IN THE NORTHERN FACE OF THE PIR PANJAL IN THE KASHMIR VALLEY



COMPOSITION OF THE FOREST DURING THE PERIOD OF CLIMATIC OPTIMUM ON THE NORTHERN FACE OF PIRPANJAL IN THE KASHMIR VALLEY



TEXT-FIG. 4b

oak-alder-woods are hardly suggestive of glacial origin, but there are, however, horizons of conglomerate and cross-bedded sands. A possibility, however, suggests that these sediments being unsuitable for preservation of pollen are in fact responsible for the poor content of pollen in them and consequently the pollen spectra constructed from them are unrepresentative of the former vegetation. Surprisingly enough all the ten spectra from these various sediments bring out more or less identical results.

In the absence of any stratigraphical evidence of glaciation within Lower Karewas, how far the evidence from the pollen sequence should be allowed to suggest that may be a matter of opinion.

Another similar phase registering decline of pine towards the top of the Lower Karewa diagram occurs almost at the transition between the pine-wood phase and spruce-oak woods phase. This may well suggest a climatic oscillation or the maximum worsening of climate which ultimately resulted in the establishment of spruce-oak woods.

There may be difference of opinion on the interpretation sought through parallelism in the vegetational development in the pollen diagrams from the Early and Late Quaternary deposits of the Kashmir Valley but that this parallelism in the vegetational development has proved very helpful in interpreting the sequence from the Lower Karewas as demonstrated above can hardly have two opinions.

CLIMATE *VS* BIOTIC FACTOR

The parallelism in vegetational development in the Lower Karewas and the Postglacial as described above reflects parallelism in the major climatic alternations which seem broadly synchoronous so far as the three-fold division of climate during an Interglacial or Postglacial is concerned. There may be vast differences in precise inferences. For instance, the oak-alder phase at the bottom of the Lower Karewa diagram and the spruce-oak woods phase towards the top of it obviously indicate different climates though essentially wet to moist in both. Likewise the mixed-oak woods phase in the middle of the Postglacial pollen diagrams indicates different climate than that of oak-ash woods phase at the extreme bottom of the Haigam diagram.

Amongst the other factors besides climate that might have affected the course of vegetational development in the Kashmir Valley may be included edaphic and physiographic (both of which are indirectly related to climate) and diastrophic. If there is any evidence of considerable diastrophism it is after the Lower Karewas had been laid. The qualitative and quantitative differences in pollen content from clay, lignite or even sandstone belonging to the same Lithozone or climatic phase may be due to edaphic factor. An allowance has, however, to be made to the differential suitability of the kind of sediment for the preservation of pollen.

During the Postglacial besides the factors mentioned above there is yet another factor — the biotic, the effect of which progressively increases from the Neolithic period onwards masking or obliterating the combined effect of the other factors. It begins to operate right at the base of the Haigam diagram. The culture pollen (*Plantago lanceolata*) appears at the change-over of stage 'a' to stage 'b' and thereafter it is on progressive increase. The decline of the mixed oak woods more particularly oaks and alders towards the top of the diagram ultimately resulting in their complete extermination from the valley is perhaps more due to biotic than the climatic factor. A gradual decline of *Artemisia* may also be explained that way. A great scarcity of fuel in the valley and use of *Artemisia* by goats and sheep and as fuel are sufficient indications to suggest that the progressive effect of biotic factor on indigenous vegetation is largely responsible for the shortage of fuel so much so that measures have now been adopted to plant *Salix, Robinia,* etc. the quick growing plants to meet this scarcity. The purity of the forests, absence of deodar

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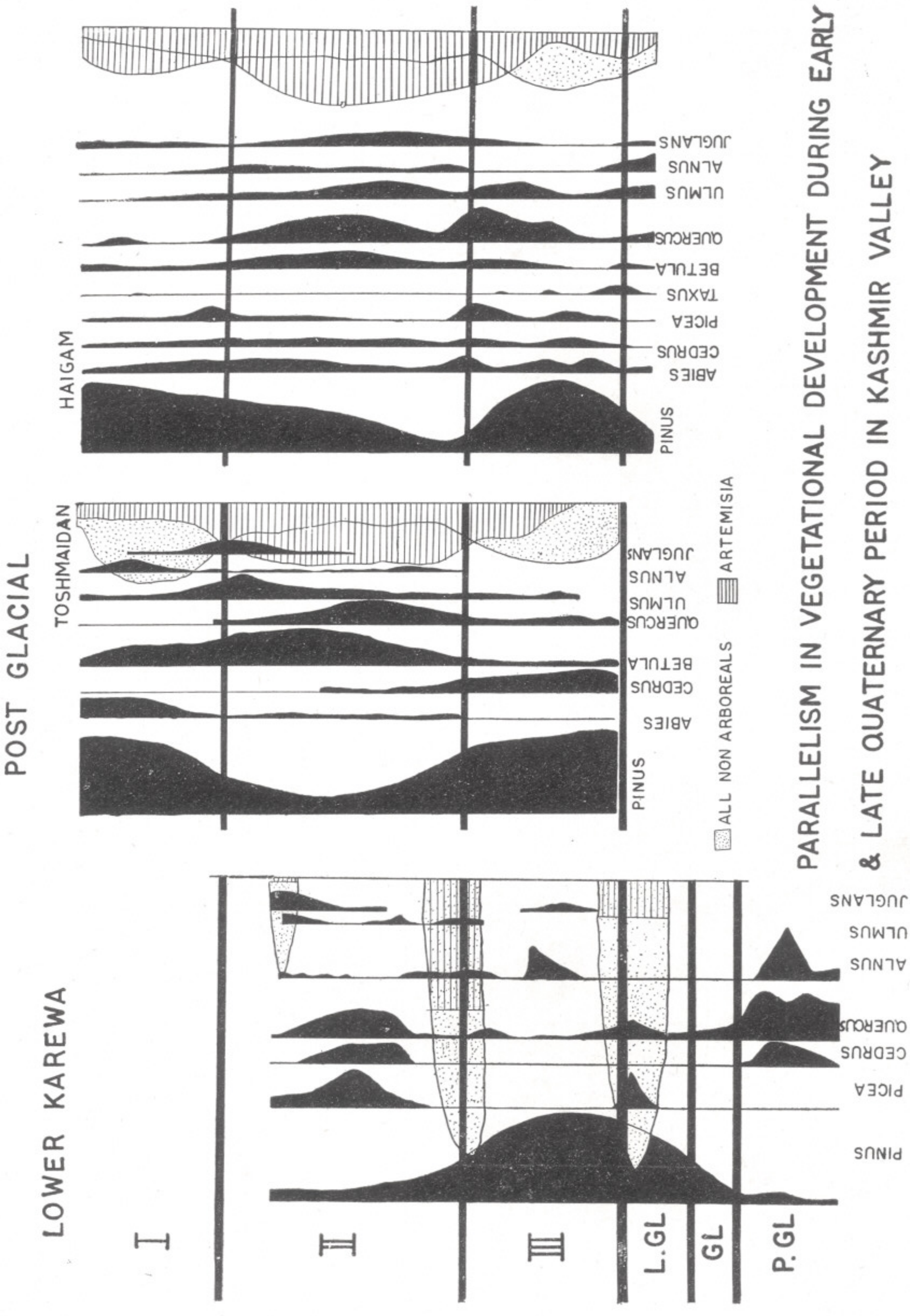
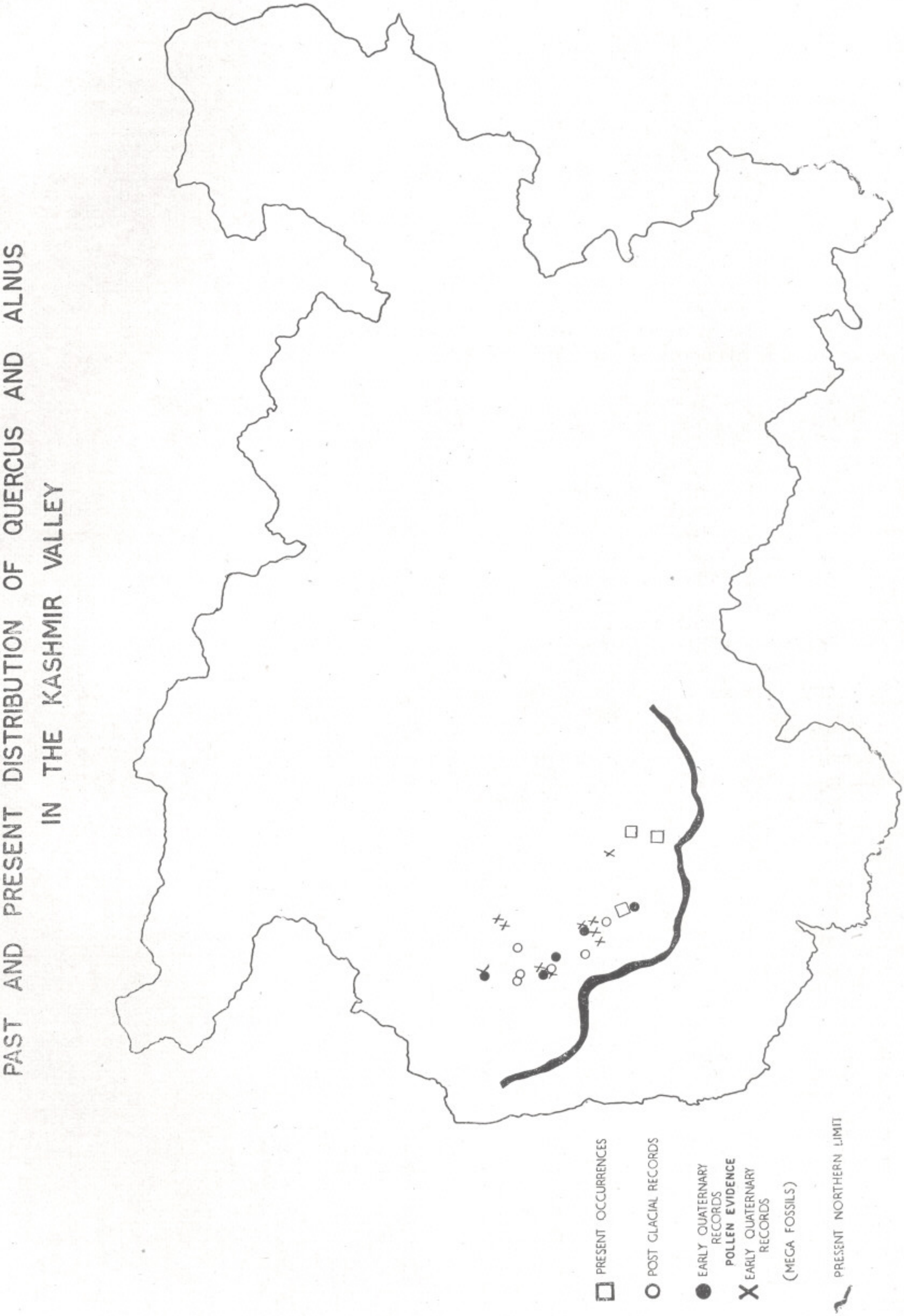
TEXT-FIG. 4b — Additional shifts in the vegetational belts. The diagram shows vegetational belts during Postglacial climatic optimum at two sites Haigam and Toshmaidan. The broad-leaved constituents dominated over that of the conifers during the period of maximum warmth and they were far more abundant at low altitude than at high altitude.



TEXT-FIG. 5 — Parallelism in the vegetational development during the Early and Late Quaternary in Kashmir.



TEXT-FIG. 6 — Past and present distribution of oaks and alders in the Kashmir Valley.

on the Pir Panjal and the absence of pine, walnut and elm in the valley proper can safely be attributed to the effect of grazing and domestic and commercial exploitation of the forest constituents.

Although some changes in Postglacial pollen diagrams may be attributed to the effect of biotic factor, it seems difficult to imagine the overriding influence of this factor. Perhaps in the dual effect of climate and biotic factor on Postglacial vegetation, the role of man was proportionatey greater than that of climate, so far as the Kashmir Valley is concerned. But it seems hard to reconcile with one of the views that the recognition of Postglacial climatic alterations is illusory and that the vegetational changes are all induced by the biotic factor and more especially by man.

Leaving aside the controversial aspect concerning the climate vs the biotic factor, an important aspect can hardly be overlooked that the earliest forest clearances were within the dominant pine woods rather than in the mixed-oak woods as in the European diagrams and the climate during the Early Neolithic was extremely cold and consequently the Neolithic folk resorted to dwelling in pits and their plant economy largely comprised weeds, such as *Lithospermum arvense*, spp. of *Trifolium, Lotus, Ipomoea* and *Medicago falcata* and *denticulate* some of which are used today as fodder plants.

For a long time the mysterious absence of oaks and alders from the valley has been attributed to the uplift of Pir Panjal resulting in drier climate in the valley since its lofty peaks have prevented the monsoons from entering the valley. The Postglacial pollen analyses have established their past occurrence and gradual extermination from the valley by the dual effect of man and climate. Oaks existed in Yus maidan and in the vicinity of Baba Rishi in the recent past. And they have been extensively present in the valley during the Late and Early Quaternary both before and after the uplift of Pir Panjal and extended considerably northward than today as shown in Fig. 6.

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