

# STUDIES OF POSTGLACIAL VEGETATIONAL HISTORY FROM THE KASHMIR VALLEY—1. HAIGAM LAKE

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## ABSTRACT

The Postglacial vegetational sequence revealed by the pollen diagrams constructed from the Haigam Lake, about 1,300 metres a.s.l., in the Kashmir Valley proper is divisible into eight vegetational stages.

The vegetational history begins with Ash-elm-alder-oak-wood phase and is followed by a conifer-mixed-wood phase. With the amelioration of climate a broad-leaved-conifer mixed forest is established.

Probably in response to the worsening of climate or under the dual influence of climate and the biotic factor the oak-mixed wood declines and the pine woods are re-established.

Evidences of the origin and the progressive development of agriculture during the Postglacial period are very convincingly brought out by the pollen diagrams. The earliest forest clearances took place in the conifer-mixed woods. The paper also discusses the correspondence between the progressive development of agricultural activity and the historical and archaeological evidences obtained in the valley.

The pollen diagrams also present an interesting record of the occurrence of oaks, alder and elm in the valley proper which are absent from the valley today.

## INTRODUCTION

THE Haigam lake is situated (TEXT-FIG. 1) in the N. W. of Srinagar (38.6 kilometres away) on Srinagar-Baramula main road near the village Hanspur. It is connected with the Wular lake by a channel. The area around the Haigam lake is mostly plain and here and there few terraces or outcrops of the Karewas break the monotony. The indigenous forests are 16-32 kilometres away. The region is intensely cultivated and completely devoid of any forest. The main crop produced is that of paddy. Besides stray planted trees of *Salix*, *Populus*, *Platanus*, *Morus*, *Robinia* and *Acer* around villages and the orchards of apple, pear, peach, plantations of *Salix* are the only representatives of arboreal vegetation.

The region is studded with small to large swamps and lakes. The swamps have mostly been reclaimed and now brought under cul-

tivation. Even some of the margins of the lakes are also reclaimed. The Haigam lake too once extended far beyond its present margins, a considerable marginal part of which has been reclaimed. This reclaimed area has been under cultivation for many years. The more swampy margins bear *Salix* plantation. The Haigam lake has been preserved as an excellent duck shooting centre. The shooting butts have been constructed in the centre of the lake by accumulating stems and twigs of *Typha* and *Salix*. A dyke cuts across the lake for the plying of the boats carrying the shooting parties. The water supply of the lake is maintained through a channel connectng it with the Wular lake. During one of our two visits to the lake a considerable part of the area was more or less dry while the sheet of water could be seen in the centre. The vegetation (TEXT-FIG. 2) comprises.

I—*Deep water association* (submerged plants)

*Potamogeton*, *Hydrilla*, *Myriophyllum spicatum* and *Chara*.

II—*Free floating association*

*Nymphaea alba*, *Nelumbo nucifera*, *Lemna*, *Euryala ferox*, *Trapa natans* and *Salvinia*.

*Trapa* and *Salvinia* were found restricted to the NW side of the lake with the *Trapa* community surrounded on all sides by *Salvinia*.

III—*Reed swamp and Marsh association*

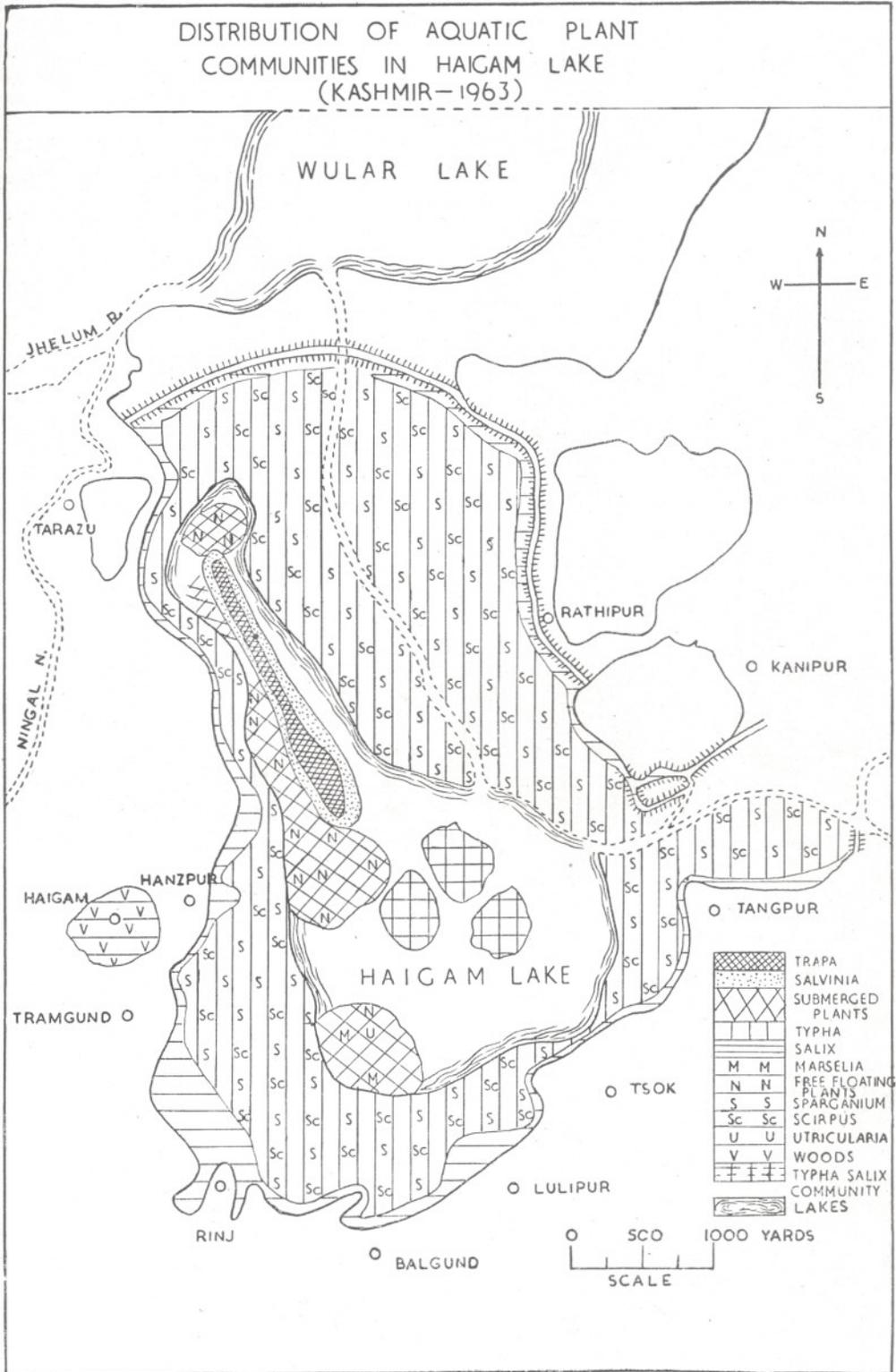
*Typha*, *Sparganium*, *Scirpus*, *Carex*, *Ranunculus aquatilis*, *Acorus*, *Callitriche*, *Hippuris*, *Juncus*, *Ceratophyllum*, *Marselia* and *Utricularia*. The last two genera are restricted to southern part of the lake.

*Typha* is the most dominant constituent almost covering the whole area. *Sparganium* and *Scirpus* are comparatively far less in frequency.

IV—*Bushland association*: There is nothing like the Bushland vegetation.

Some planted trees already referred to above and shrubs of *Rhus*, *Rosa*, *Crateagus*, *Astragalus*, *Ribes*, etc., are seen growing along the road.





TEXT-FIG. 2

### MATERIAL AND METHODS

(a) *Field work* — After making trial borings, the deepest bore hole was selected for final sampling. The samples were collected at an interval of 5 cm. with the help of peat auger constructed at Lucknow (Hiller's model) with 50 cm. chamber.

(b) *Preparation of the samples* — Each sample was first boiled with 10 per cent KOH and then sieved through a mesh to remove the coarse debris. The residue was washed thoroughly to remove alkali and then examined for seeds, fruits and other megascopic remains. The filtrate was chlorinated by using 5 cc. of glacial acetic acid, 3-4 cc. of conc. sodium chlorate solution and about 5 cc. of conc. hydrochloric acid. After chlorination, the material was centrifuged and acetolysed. The proportion of acetic anhydride and conc. sulphuric acid used was 7:3. The material was then boiled in 15-20 cc. of 40 per cent hydrofluoric acid for a couple of minutes. It was then washed and the slides prepared in concentrated glycerine.

(c) *Construction of Pollen diagrams* — For the construction of pollen diagrams minimum 150 arboreal pollen grains were counted from each sample except in two of them where not more than 88 could be counted. The percentages for arboreal and non-arboreal pollen are expressed in terms of AP sum.

The individual constituents are represented by curves. Besides a separate pollen curve for total pine pollen, the curves for *Pinus wallichiana* and *Pinus* type are also separately given.

For percentages below 1 per cent a plus sign is used.

### STRATIGRAPHY

The plan of the series of borings and the precise position of the bore holes are shown in Text-fig. 3. Owing to release of water into the lake, it was not possible to study stratigraphy as exhaustively as it was planned.

The lake basin is deeper than 6 metres (TEXT-FIGS. 4, 5) since the Hiller auger could not be penetrated beyond this depth owing to the extremely compressed nature of the deposit. It, however, touched sand or concretions in the other bore holes.

The dark organic mud filling the lake basin is overlain by very much decomposed

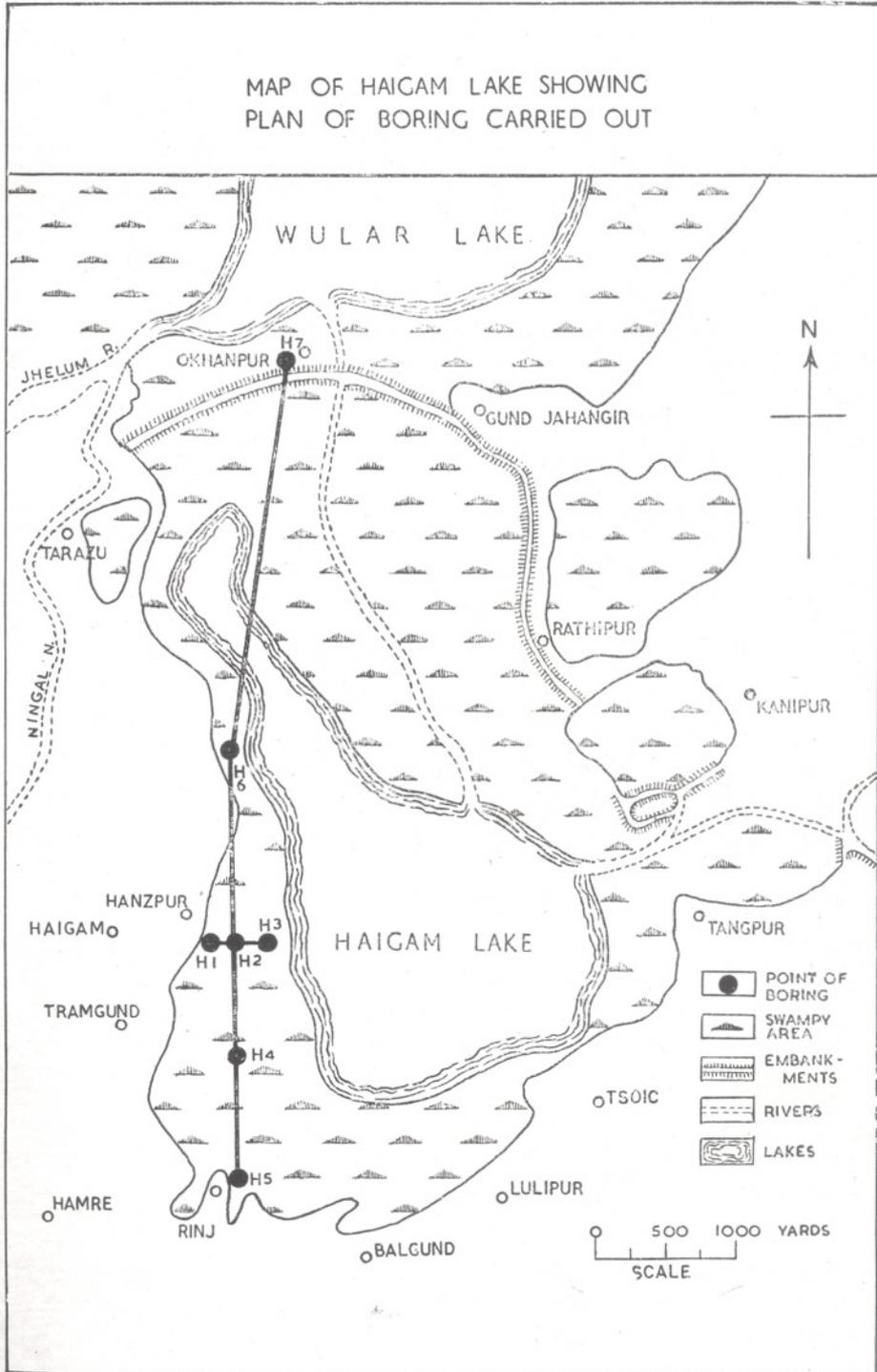
brown detritus turning dark on exposure. It is overlain by peaty clay which is deeper towards the interior of the lake but along the extreme marginal parts it is all clayey silt. Clay bands of varying thickness are met with in the detrital layer. Whereas towards the centre of the lake the clayey peat is overlain by silty clay, along the margins it is a continuous deposit until overlain by silt towards the extreme top at about 2 metres or below it. In the marginal bore holes charcoal fragments were encountered slightly below a depth of 1 metre. Layers of shells were met with together with clay bands and occasional shells were seen in the organic detritus also at various levels.

Hardly any megascopic remains were met with in either the organic detritus or clayey muds except rootlets and decomposed fragments of rhizomes. Broadly speaking two distinct horizons can be distinguished both in the central and the marginal profiles — a lower horizon of organic detritus and the top clay deposit in the central profiles and top organic detritus and lower clayey deposit in the marginal ones.

The frequent clay and silt bands seem to represent the facies of the flooding horizons. The various kinds of sediments met with reveal changes in water level from shallowing phases to open and deep water conditions resulting probably from frequent floods with a differential effect on the marginal areas. When the deep sheet of water was created towards the centre with considerable deposition of mineral matter, the shallow marginal areas continued to form organic debris until the silt deposition on extreme top, resulting from a flood or series of floods.

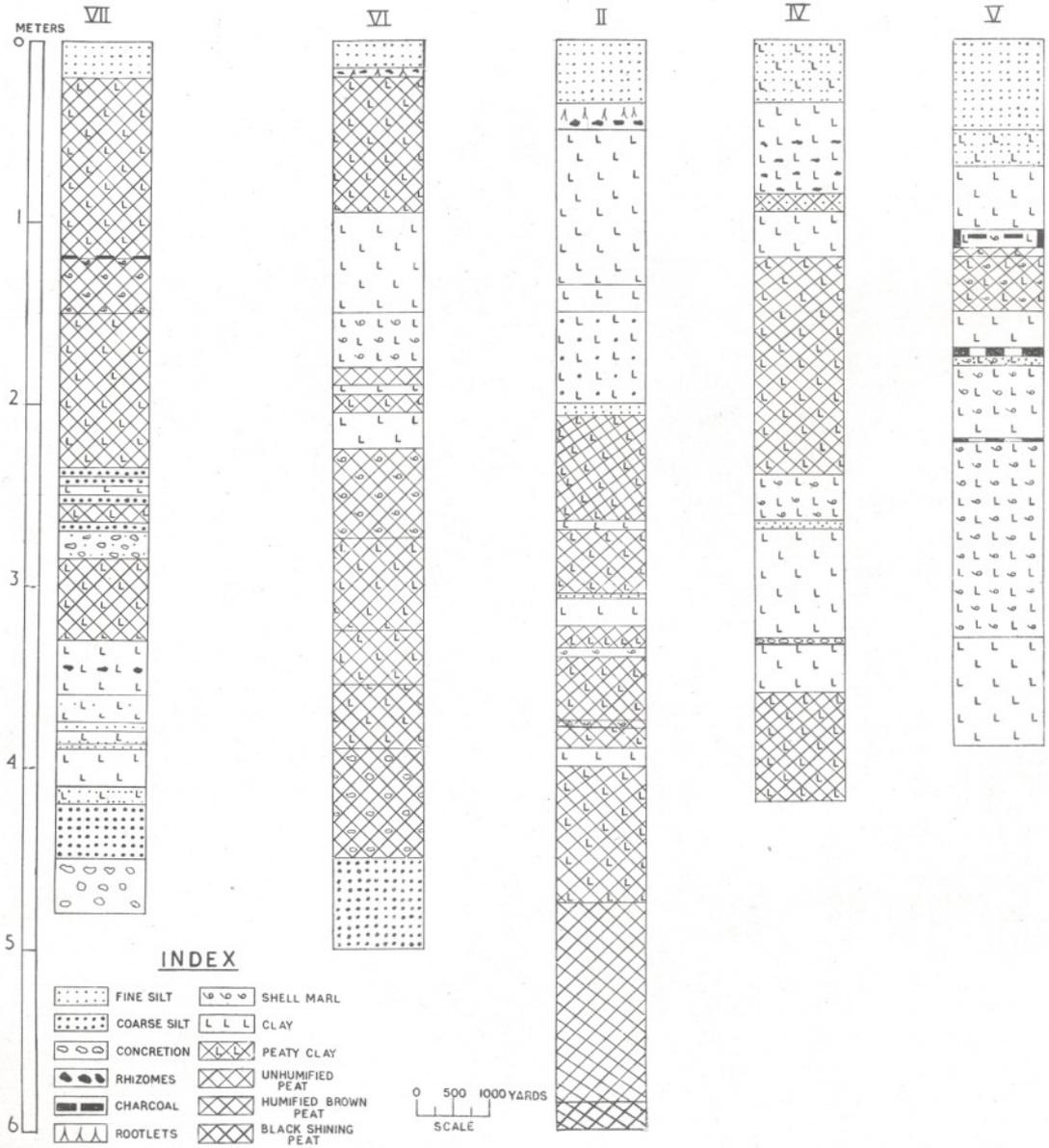
Below are given the details of the bore hole (II, cf. TEXT-FIGS 4, 5) selected for pollen analysis.

- 0-35 cm. Silt without any organic debris
- 35-50 cm. Large number of rootlets along with other vegetable debris. *Pediastrum* frequently met with.
- 50-135 cm. Greyish clay, few seeds of *Potamogeton*, Compositae, *Urtica*, *Chara* and a complete spikelet of rice. *Pediastrum* present in appreciable percentage.
- 135-150 cm. Greyish clay with fine silt without organic debris. Two nocules of *Chara*, *Pediastrum* present in low percentage.



TEXT-FIG. 3

DATA OF BORE HOLES AT HAIGAM LAKE



TEXT-FIG. 4 — Bore holes along Section H<sub>5</sub>-H<sub>7</sub> (cf. Text-fig. 3).

TEXT-FIG. 5 — Bore holes along Section H<sub>1</sub>-H<sub>3</sub> (cf. Text-fig. 3).



- 150-200 cm. Greyish clay with coarse silt. *Pediastrum* present in low frequencies.
- 200-207 cm. Fine silt. *Pediastrum* absent.
- 207-265 cm. Peaty clay. *Pediastrum* present in good percentage.
- 265-270 cm. A band of clay. A fruit of *Trapa natans*. *Pediastrum* abundant.
- 270-305 cm. Peaty clay. Single seed of *Scirpus*. Several *Pediastrum* colonies at 275 cm.
- 305-308 cm. A band of fine silt. *Pediastrum* in low values.
- 308-323 cm. Clay. *Pediastrum* present.
- 323-335 cm. Peaty clay. *Pediastrum* present.
- 335-340 cm. Shell marl. *Pediastrum* present.
- 340-390 cm. Peaty clay with a small band of shell marl at 375 cm. *Pediastrum* and *Botryococcus* present in low values.
- 390-400 cm. Clay. *Pediastrum* and *Botryococcus* present.
- 400-475 cm. Peaty clay. One seed each of *Potamogeton* and *Chara*. From 450 cm. downwards *Pediastrum* absent.
- 475-585 cm. Very much humified brown to blackish peat with soapy touch. Few seeds of *Potamogeton*, *Scirpus*, *Urtica* and *Chara*. At 480 cm. a large number of moss twigs probably belonging to *Bryum*. *Pediastrum* very rare.
- 585-600 cm. Very much humified black shining peat.

#### POLLEN ANALYSES

Pollen analysis of the following three moss cushions was carried out to see how far the pollen spectra reveal the composition of the forest around.

1. *Pahalgam* — The moss cushion was collected from a Karewa terrace bearing plantations of *Salix* along the right bank of the river Lidder on the left side of the main Srinagar-Pahalgam road, the left bank of the river bearing the "Blue Pine" forest. Between the forest and the left bank of the stream a strip of land about 50-100 metres broad is intensely cultivated.

The pine forest is almost pure with stray plants of *Acer*, *Juglans* and *Fraxinus*. A few trees of *Juglans regia* are also found in the cultivated strip, obviously they are

planted. The scarce shrubby vegetation in the forest consists of *Viburnum* and *Rosa*. The open slopes are populated by species of *Ferula*, *Cnicus*, *Verbascum*, with scattered shrubs of *Spiraea*, *Plectranthus*, *Urtica* etc. *Thymus serpyllum*, *Senfellarina prostrata*, *Taraxacum officinale*, *Plantago* etc. are fairly common.

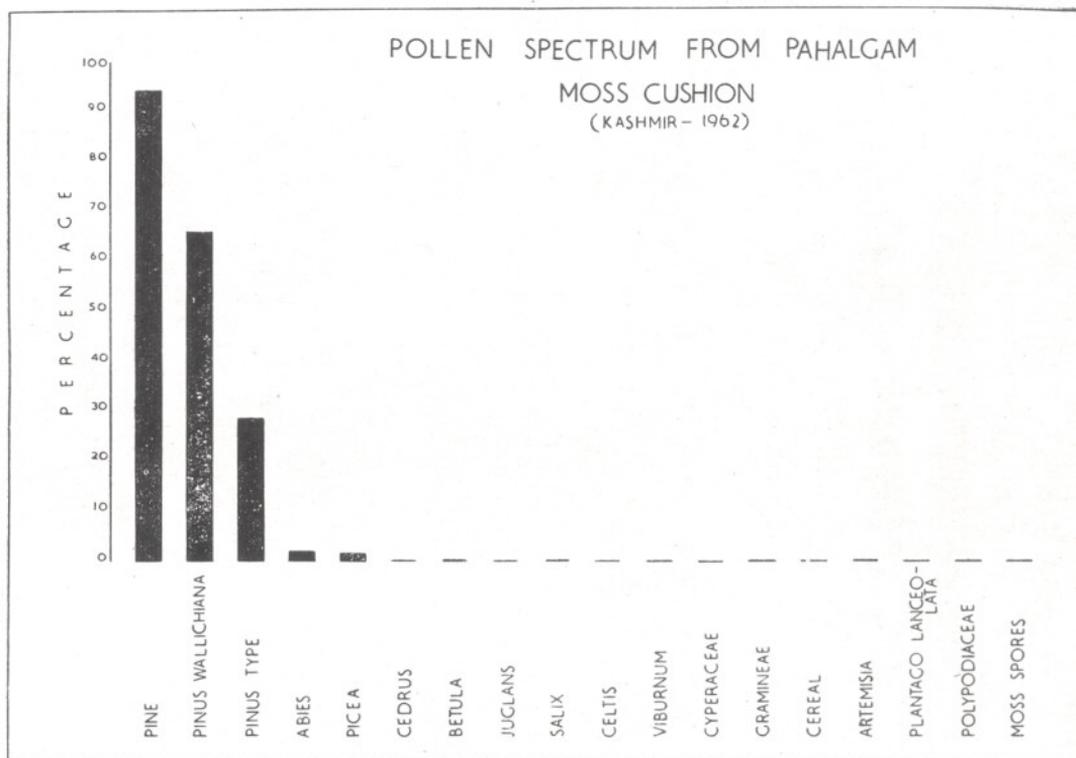
*Pollen spectrum* — The pollen spectrum (TEXT-FIG. 6) shows abundance of "Blue Pine" with *Abies* and *Picea* 2 per cent each and extremely low percentages of *Cedrus*, *Betula*, *Juglans*, *Salix*, *Celtis*. Stray grains of *Viburnum* are also present. Cyperaceae, Gramineae, Cereals, *Artemisia*, *Plantago lanceolata*, Polypodiaceae and Moss spores are present in very low frequencies.

The pollen spectrum brings out pine-forest with *Abies* and *Picea* either as stray constituents of the forest or their occurrence at comparatively higher altitude. The same may be said of *Cedrus*, birch and *Celtis*. *Salix* and *Juglans* are of local origin. The agricultural activity practised close to the site is also reflected in the spectrum. The pollen of several herbs and shrubs largely being insect-pollinated is either unrepresented or poorly present in the spectrum.

2. *Achhabal* — The moss cushion was collected from a tree stump from within the pine-cedar forest with pine about 80 per cent containing few plants of *Quercus dilatata* and some trees of *Rhus*. The plants of *Parrotiopsis jacquemontiana*, *Sambucus ebulus* and *Paeonia emodi* grow along the margins of the forest.

*Pollen spectrum* — The pollen spectrum (TEXT-FIG. 7) reveals the presence of about 79.2 per cent of "Blue Pine" and 18.2 per cent of *Cedrus deodara* and very low values of *Picea*, *Rhus*, *Celtis*, *Parrotiopsis*, *Sambucus*, *Strobilanthes*, Urticaceae, Gramineae, Chenopodiaceae and Polypodiaceae. The pollen spectrum more or less faithfully brings out the composition of the forest but for the presence of oaks, of which not a single grain was recovered though some plants of *Quercus* grow hardly a few metres away from the site of collection of the moss cushion. It is very likely that few plants of *Quercus*, a low pollen producer, do not produce sufficient quantity of pollen so as to affect the pollen rain.

3. *Shupian* — The moss cushion was collected from within the plantations of *Salix* and *Juglans* on the left side of the river Rimbiara near the Shupian village at



TEXT-FIG. 6

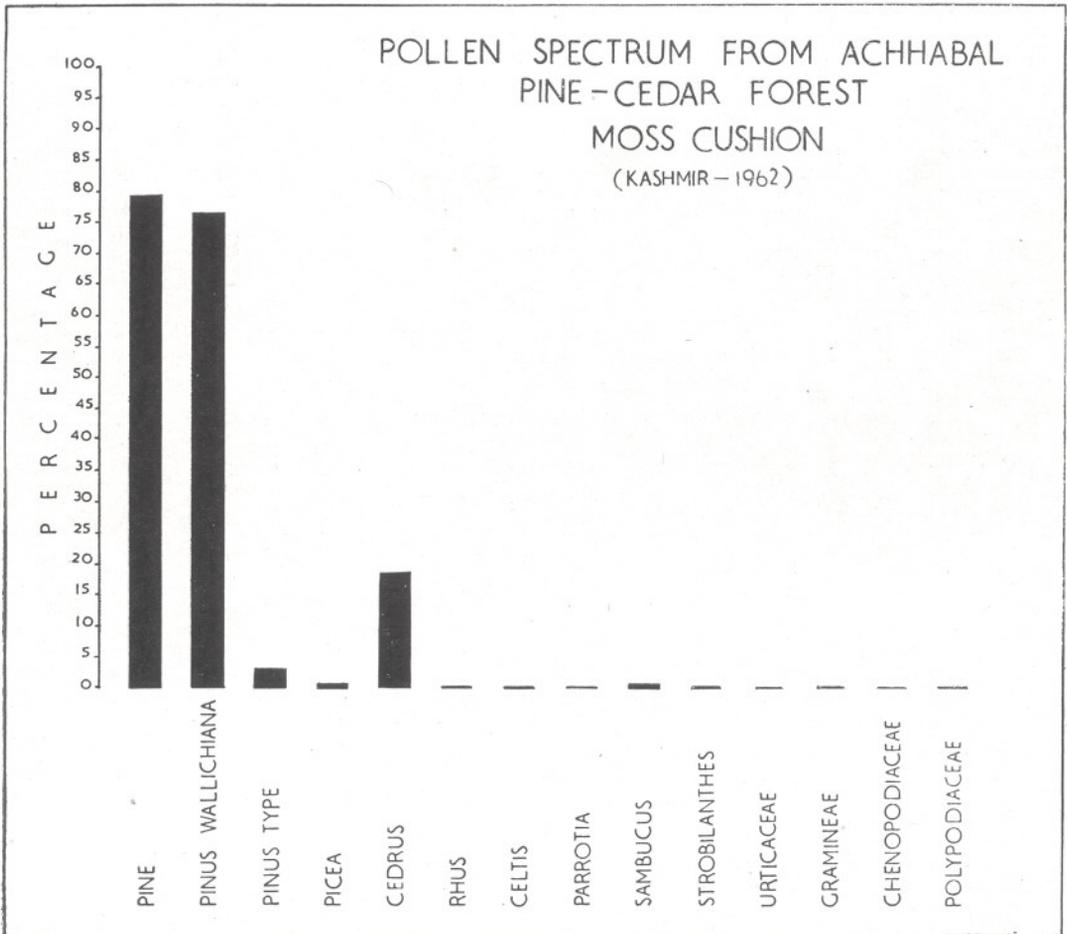
the foot of northern side of Pir Panjal. The region is under intense cultivation and there are orchards of mulberry and apples also. At high altitude the surrounding hills are clothed with pine forest with about 80 per cent pine and stray trees of spruce, fir and deodar.

*Pollen spectrum* — Pollen spectrum (TEXT-FIG. 8) depicts 70.8 per cent of "Blue Pine", 9 per cent *Salix*, 7 per cent *Juglans*, 7 per cent *Alnus*, 2 per cent *Picea* and a low percentage of *Abies*, *Cedrus*, *Ephedra*, *Betula*, *Ulmus*, *Morus* and *Celtis*. Besides a very low percentage of *Viburnum*, Gramineae, Cereals, *Artemisia*, Compositae, *Plantago lanceolata*, *Rumex*, Chenopodiaceae, Ranunculaceae, Rosaceae, Polypodiaceae and moss spores is present.

In contrast to the open conditions in the vicinity, pollen spectrum reveals a pine forest. The pollen rain is dominated by pine pollen from forest at high altitude. The cereal pollen along with that of *Plantago lanceolata* and *Rumex* brings out the farming.

*Alnus*, of which about 7 per cent pollen is recorded, is known to be absent from the valley of Kashmir at present. The occurrence of *Alnus* in the moss cushion is quite mysterious and may either indicate some unrecorded alder plants in this region or may be attributed to long distance transport probably from the southern slopes of Pir Panjal where recognizable belts of alder are present.

From the above correlation of pollen spectra with the composition of the respective plant communities it becomes clear that the wind-pollinated plant species are usually faithfully represented in the pollen spectra although differences may occur owing to differential rate of pollen production in some of them. On the whole the pollen spectra may be relied upon for the composition of the forest but there can be certain anomalies such as the absence of oak pollen in Achhabal pollen spectrum and the presence of *Alnus* in Shupian. Whereas *Alnus* is known to be absent from the valley,



TEXT-FIG. 7

oaks in Achhabal form very small percentage of the forest. These are some of the limitations of pollen analysis which have important bearing upon the interpretation of pollen profiles.

#### Description of Pollen Diagrams

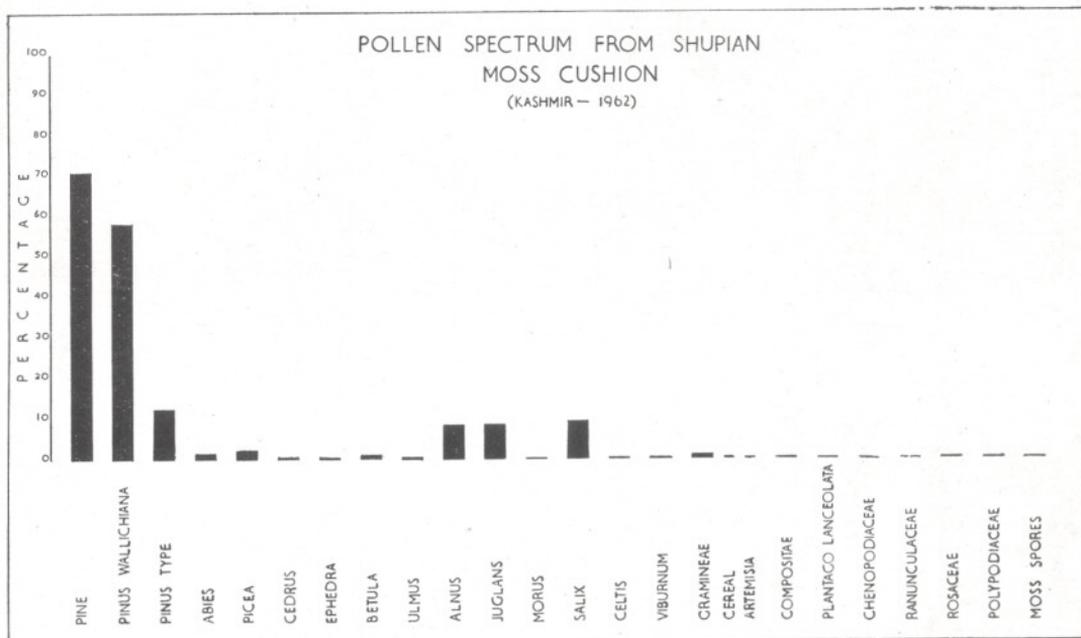
(Text-figs. 9, 10, 11, 12)

Pollen diagrams reveal a succession between the broad-leaved forest and the conifers. Eight major stages of vegetational development recognized from the shifts in arboreal plant communities are described below:

Stage "a". *Ash-elm-alder-oak-wood phase*  
— The pollen diagram begins with oak-elm-

alder-ash-wood phase with the other constituents comprising, walnut, *Acer*, *Rhus*, *Carpinus*, *Corylus*, *Aesculus*. The shrubby vegetation is represented by a single pollen of *Skimmia laureola*. The ground flora is very poor and consists of Gramineae, a very low percentage each of *Artemisia* and Compositae, Caryophyllaceae, Polygonaceae and Polypodiaceae.

With the increasing values of elm and ash, elm-ash-alder-walnut wood phase is developed until towards the top of stage "a" *Fraxinus* dominates thus forming ash-elm-alder-oak wood. Oaks, *Acer*, *Juglans*, *Carpinus* and *Corylus* are considerably reduced to low values. *Aesculus* is unrepresented and birch attains comparatively



TEXT-FIG. 8

high values towards the top of this phase.

The conifer constituent comprises a very low percentage of *Abies* and *Taxus* and a single pollen grain each of *Cedrus* and *Picea*. Pine commences a gradual invasion into this broad-leaved forest until towards the top of this stage attains 40 per cent frequencies and those of *Taxus* rise to 10 per cent.

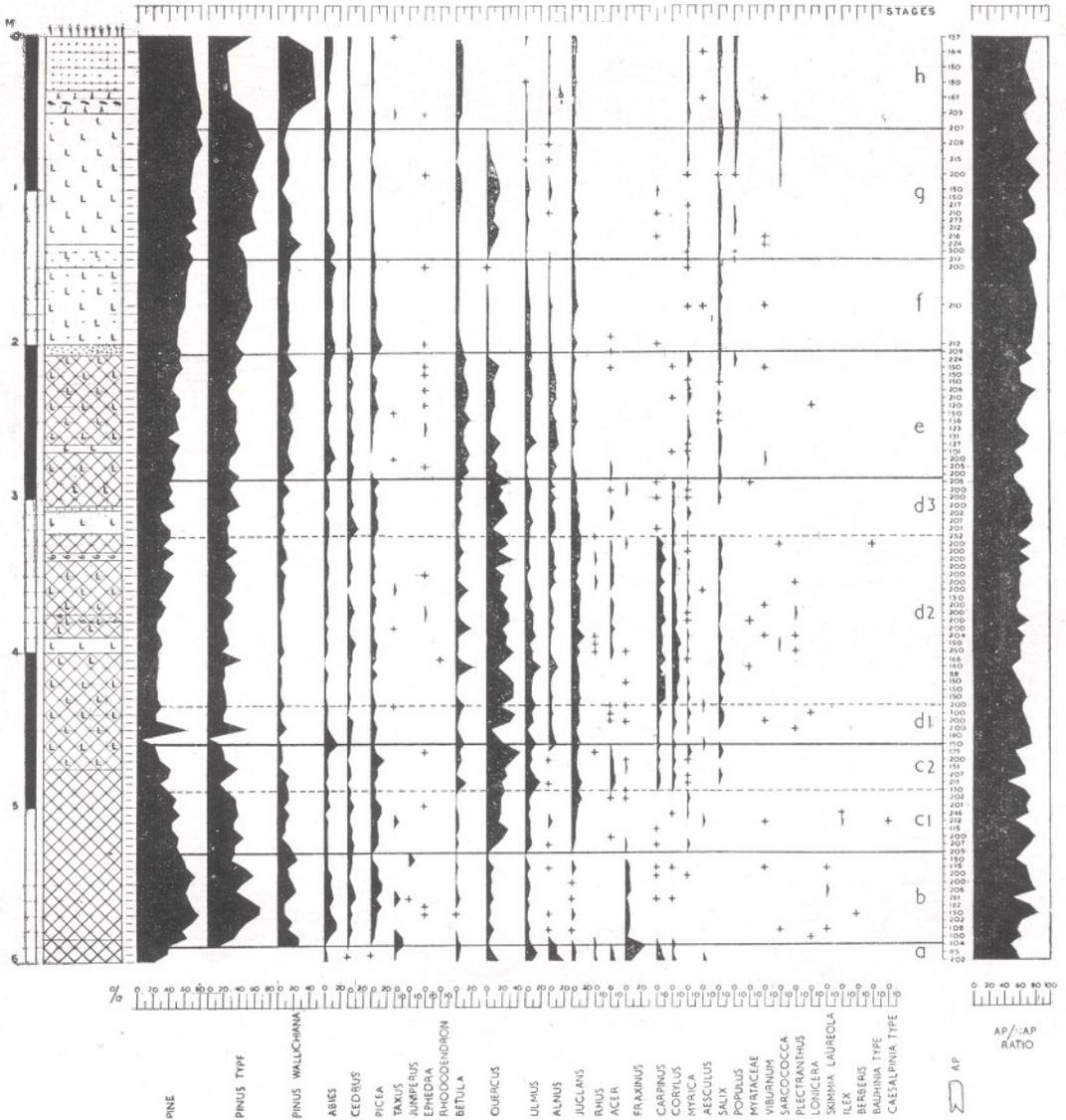
The ash-elm-alder-oak wood is accompanied by very high values of *Artemisia* and *Chenopodiaceae* which after a rise to 20 per cent show a gradual decline. Caryophyllaceae and Gramineae show a rising trend towards the top of this phase. Some stray pollen of *Rosaceae* and a small percentage of *Plantago* pollen are also seen during this phase. Cyperaceae has extremely low values at the base of this stage but reaches a maximum of 40 per cent towards the top of this phase. *Acanthaceae*, *Polygonum* and *Polemonium* are sporadically present. *Poly-podiaceae* present in fairly high values throughout the stage reaches its maximum towards the close of this stage.

The aquatic vegetation is represented by *Myriophyllum* and *Typha* the latter increasing towards the top of this stage when *Potamogeton* was also present in the lake.

*Stage "b". Conifer-mixed-wood phase* — The gradual invasion of pine into the ash-elm-alder-wood phase and gradual but considerable rise in the values of *Abies*, *Picea* and *Cedrus* and overall decline in all the broad-leaved constituents establishes during stage "b", a conifer-mixed-wood phase. *Cedrus* forms a low consistent curve but *Taxus* shows sporadically high values towards the base and the middle of this stage and *Juniperus* towards the top only. Stray pollen of *Ephedra* is met with in the middle of this stage. Oak, elm and ash maintain consistently low values except sudden decline towards the top. Birch and *Juglans* are consistently low and sporadic. There are stray grains of *Alnus*, *Carpinus* and *Corylus*, *Rhus* and *Acer* are lowly represented towards the base of the stage but absent thereafter. Stray grains of *Skimmia laureola*, *Lonicera*, *Sarcococca*, *Viburnum* and *Berberis* are the only evidence of shrubby vegetation.

Cyperaceae shows ascending values and Gramineae declines towards the top. *Chenopodiaceae* and *Artemisia* increase at the base and *Compositae* shows sporadically high values. *Plantago*, *Cruciferae*, *Umbelliferae*, *Caryophyllaceae*, *Rosaceae*, *Ranunculaceae*,

POLLEN DIAGRAM FROM HAIGAM LAKE (KASHMIR-1962)  
ARBOREAL POLLEN  
(PERCENTAGES CALCULATED IN TERMS OF AP)



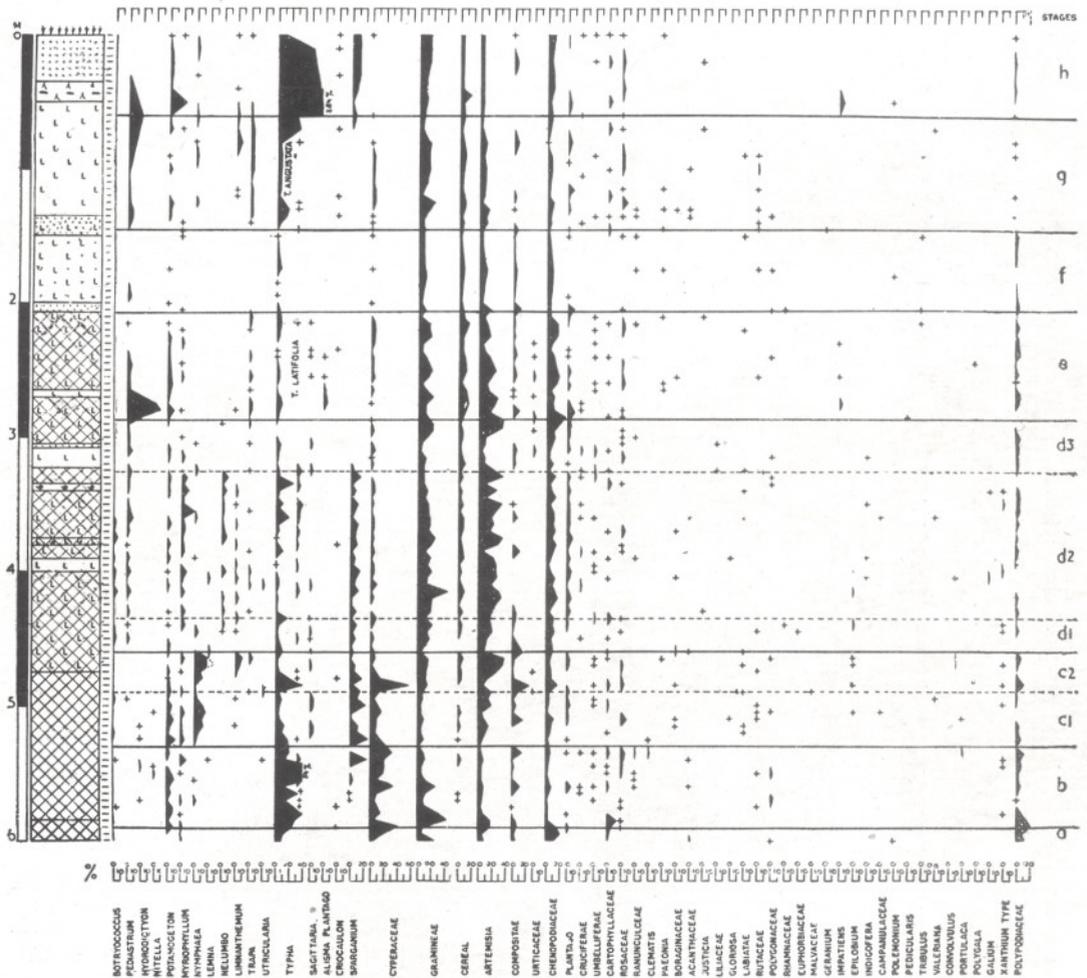
TEXT-FIG. 9

Acanthaceae, Polygonaceae and *Portulaca* etc. constitute the other bulk of the ground flora. Stray cereal pollen is seen during the middle of this stage and a small sporadic curve towards the top. Declining Polyodiaceae in the beginning of this stage

becomes sporadic but later forms a low continuous curve.

*Botryococcus*, *Pediastrum*, *Hydrodictyon* and *Nitella* are sporadic. The other members of the sub-merged vegetation were *Potamogeton* and *Myriophyllum*. *Nymphaea*

POLLEN DIAGRAM FROM HAIGAM LAKE (KASHMIR-1962)  
NON-ARBOREAL POLLEN  
(PERCENTAGES CALCULATED IN TERMS OF AP)



TEXT-FIG. 10

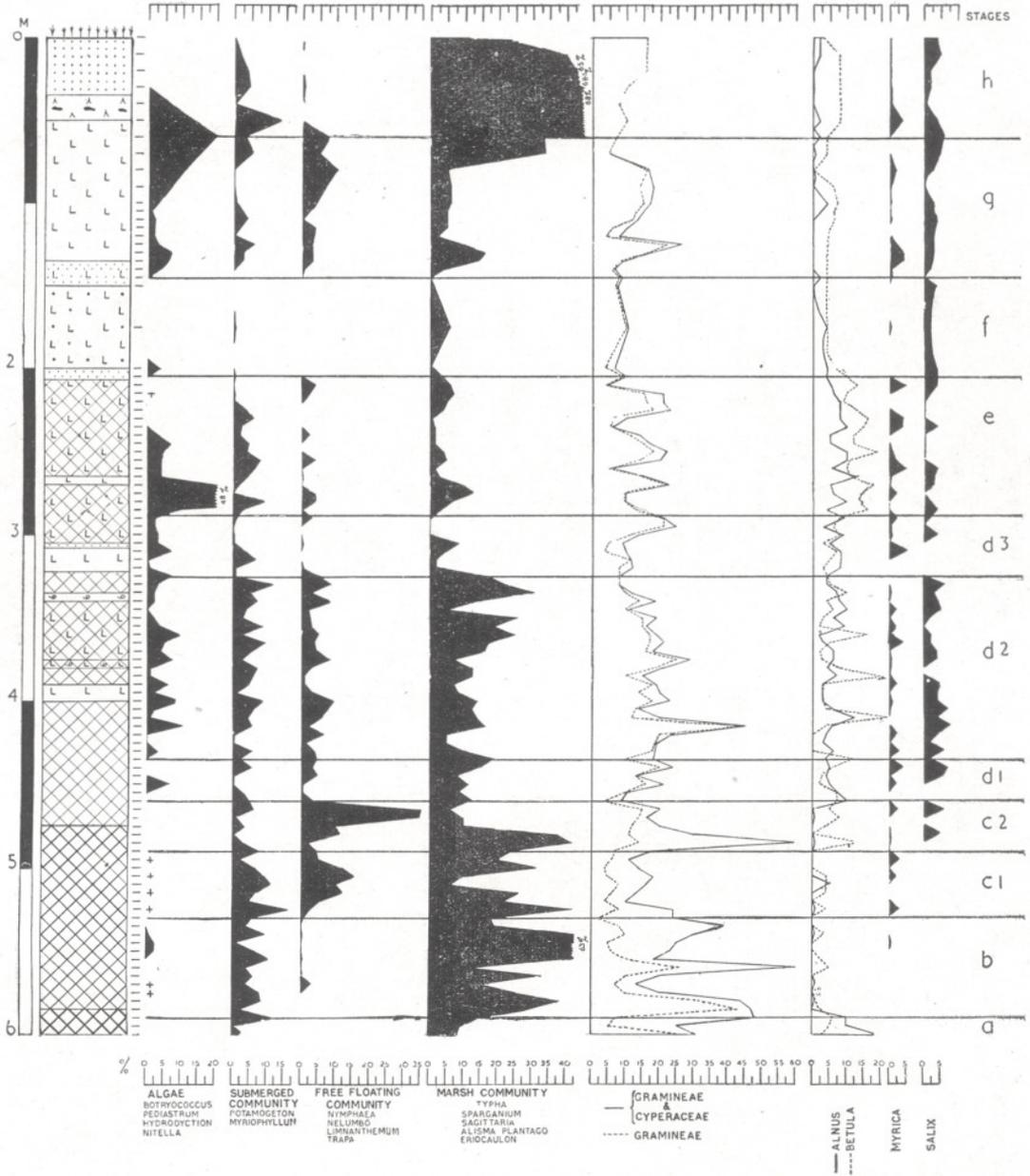
has sporadic values in the middle of this stage. *Lemna* and *Utricularia* appear towards the top. *Typha* and some of the sedges probably formed the reed swamp community along the shores of this lake. *Sparganium* appears in the middle of the stage and attains sporadically high values towards the top.

Stage "c". *Oak-mixed-conifer-wood phase* — This stage is divided into two sub-stages 'c 1' and 'c 2': 'c 1' is characterized by oak-elm-walnut-spruce-pine phase and 'c 2' not only by the ascending values of the above

phase but also by the beginning of continuous curves for *Acer*, *Corylus* and *Carpinus*.

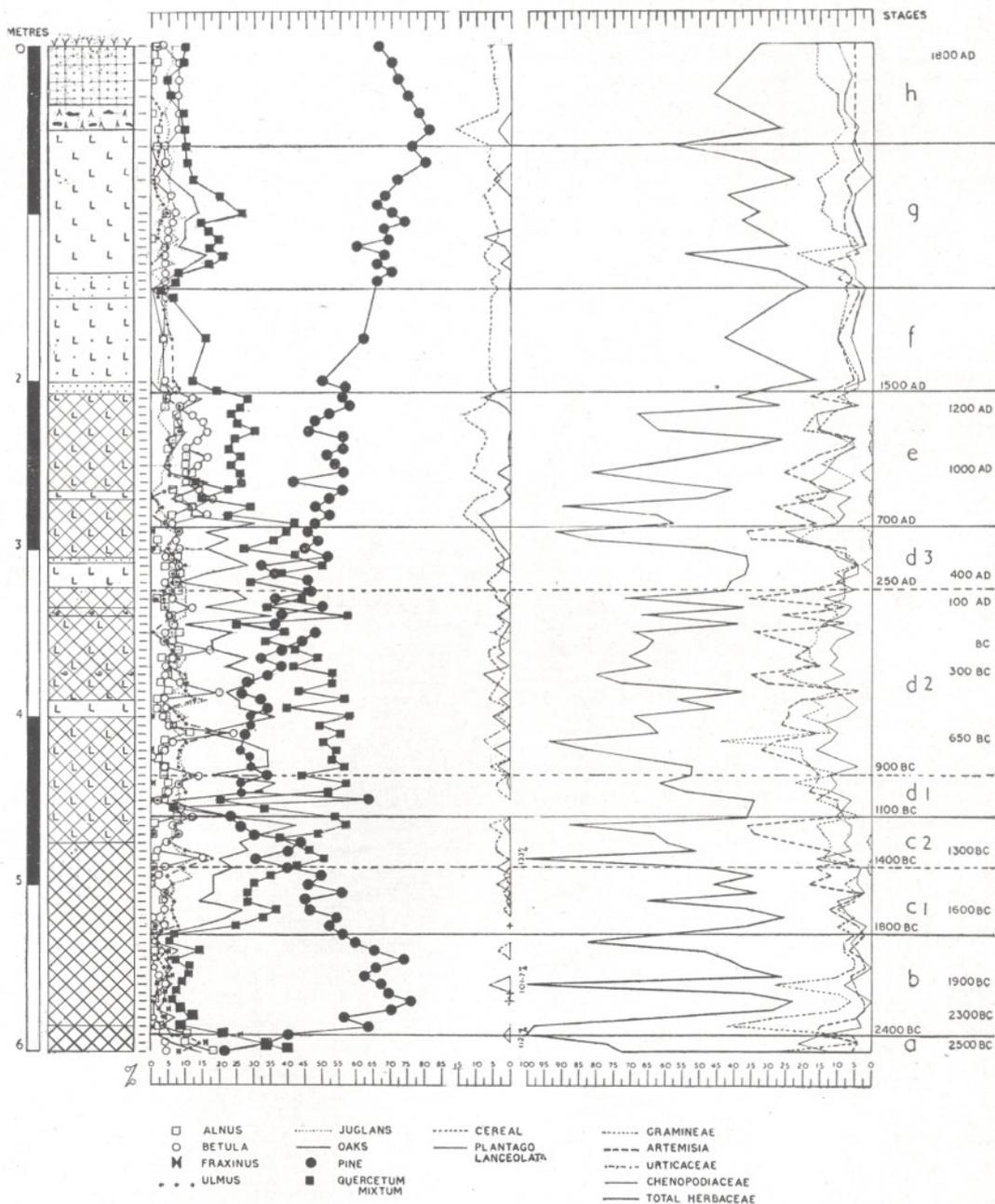
Sub-stage "c 1". *Oak-elm-walnut-spruce-pine phase* — This phase is comprised by consistently high values of pine and elm. A continuous curve for walnut begins at the commencement of this sub-stage. Birch is very lowly present. The other broad-leaved constituents are sporadically present. Whereas pine shows a decreasing trend, *Picea* maintains fairly high values, *Abies* is comparatively reduced and *Cedrus* maintains a low but continuous curve. *Taxus*

SUCCESSION OF AQUATIC PLANT COMMUNITIES  
IN HAIGAM LAKE (KASHMIR-1962)



TEXT-FIG. 11 — Pollen diagram showing the succession of aquatic plant communities.

POLLEN DIAGRAM FROM HAIGAM LAKE (KASHMIR-1962)



TEXT-FIG. 12 — A composite pollen diagram from Haigam showing the changes in arboreal vegetation, cerealia, culture pollen and total herbs. The dates estimated of various events are also given on the left side of the diagram.

is present during the middle of the sub-stage.

Cyperaceae is comparatively reduced than in the previous stage Gramineae has low values. *Artemisia* shows ascending values. Compositae is sporadically high and Chenopodiaceae and *Plantago* form a continuous curve from the middle to the top of the sub-stage. Umbelliferae, Caryophyllaceae, Rosaceae, Ranunculaceae, Boraginaceae, Rutaceae, Polygonaceae, Rhamnaceae, Euphorbiaceae, *Epilobium*, Campanulaceae, *Valeriana*, *Portulaca*, *Xanthium*, type etc. are very sporadically present. The cereal pollen grains tend to form a low and continuous curve. Polypodiaceae declines further towards the top of this sub-stage.

The lake vegetation consists of low and sporadic values of *Botryococcus*, *Pediastrum* and *Nitella* and comparatively high values of *Potamogeton* over that of *Myriophyllum*. *Nymphaea* has very high values while *Limnanthemum* is very rare. *Trapa* appears for the first time towards the close of this sub-stage. *Utricularia* is sporadic. The reed swamp community consists of *Typha*, *Sparganium*, *Sagittaria* and the sedges. *Typha* has fairly high values at the base but gradually declines to low values towards the top. *Sparganium* maintains high values both towards the base and the top with a decline in the middle.

Sub-stage "c 2". Oak-elm-walnut-birch-acer-conifer-wood phase — More or less the same pattern of arboreal vegetation is seen as in 'c 1' but for the values of oaks which continue to rise until they decline suddenly towards the top. Birch has fluctuatingly high values. Elm and *Juglans* are comparatively very high. *Alnus*, *Rhus*, and *Fraxinus* are very sporadic. A continuous curve for *Alnus* appears towards the top of this sub-stage. *Acer* forms a continuous curve and maintains high values. The continuous but low curves for *Carpinus* and *Corylus* begin during this sub-stage. Pollen of *Aesculus* appears towards the top and *Salix* appears for the first time with sporadically low values. Pine declines but *Picea* shows a sudden rise towards the upper part of the sub-stage. *Cedrus* and *Abies* maintain low values although *Abies* rises towards the close of this sub-stage.

Shrubby constituents are altogether absent.

Cyperaceae shows fairly high values at the base but declines towards the top.

Values of Gramineae and *Artemisia* increase very much. There is an increase in the values of cereals with a corresponding increase in Chenopodiaceae. Compositae shows high fluctuating values towards the base and top but is reduced in the middle. Sporadic and stray pollen is found of Urticaceae, *Plantago*, Umbelliferae, Caryophyllaceae, Rosaceae, *Paeonia emodi*, Boraginaceae, Acanthaceae, Labiatae, Rutaceae, Polygonaceae, *Epilobium* etc. Polypodiaceae  $\pm$  forms a continuous curve with sporadically high values.

Amongst the aquatics *Potamogeton* shows a descending trend and *Myriophyllum*, *Lemna*, *Limnanthemum*, *Trapa* and *Utricularia* are sporadically present. Reed vegetation is represented by *Typha* and *Sparganium* which have high values in the lower part of this sub-stage but, thereafter, decline, *Sagittaria* is sporadically present in the latter part.

Sub-stage 'd 1'. Oak-elm-walnut-alder-wood phase — Pine is further reduced very much and so are *Picea* and *Abies*. *Cedrus* shows comparatively high values until it is reduced towards the top. *Acer* is reduced to stray grains. *Salix* increases slightly and maintains a low curve.

*Viburnum*, *Plectranthus* and *Lonicera* are represented by stray grains.

Cyperaceae is very much reduced. Gramineae shows higher and ascending values. A continuous curve for the cereals starts from the middle of this sub-stage. *Artemisia* is reduced at the base but later rises. Compositae has higher values at the base but reduced towards the top. Chenopodiaceae maintains consistently high values. *Plantago* is very much reduced. Stray pollen grains of Cruciferae, Caryophyllaceae, Rosaceae, Boraginaceae, Acanthaceae, Euphorbiaceae and *Xanthium* type are also present. Polypodiaceae are further reduced.

Aquatic vegetation is poor. *Botryococcus* and *Pediastrum* have extremely low values. The curves for *Potamogeton*, *Myriophyllum*, *Lemna*, *Limnanthemum* and *Nelumbo* are sporadic. *Trapa* is absent. *Typha* and *Sparganium* are very much reduced. *Typha* has comparatively high values at the base and top of the stage and decline in the middle and *Sparganium* shows low ascending trend. *Sagittaria* is sporadic.

Sub-stage "d 2". Oak-elm-walnut-alder-Corylus-Carpinus-wood phase — This is the continuation of the previous phase but for

high values of *Carpinus* and *Corylus* and the commencement of a  $\pm$  continuous curve for *Acer* from the middle of this phase. The continuous curve for *Salix* shows a declining trend. *Rhus* is present in sporadic values especially towards the upper part of the sub-stage while stray pollen of *Fraxinus* is seen towards the lower part. Conifers are further reduced. Pine, *Picea* and *Cedrus* show slightly higher values during the middle of this phase. Stray pollen of *Taxus*, *Ephedra* and *Juniperus* is also met with.

The shrubby vegetation is represented by stray pollen of *Viburnum*, *Sarcococca* and *Plectranthus*.

The curve for Cyperaceae maintains low values. Gramineae shows high value towards the base but gradually declines towards the top. The continuous curve for cereals shows low and fluctuating values. Very high values of *Artemisia* are maintained although the other Compositae are sporadic. Chenopodiaceae has consistently high value and curve for *Plantago* is low and continuous. Cruciferae, Umbelliferae, Caryophyllaceae, Rosaceae, Ranunculaceae, Boraginaceae, *Justicia*, Labiatae, Polygonaceae, *Epilobium*, *Indigofera*, Campanulaceae, *Valeriana*, *Convolvulus*, *Galium* and *Xanthium* are sporadically present. Polypodiaceae is sporadically present throughout the sub-stage.

*Pediastrum* is restricted to the middle while *Botryococcus* is present throughout though in low values. *Myriophyllum* and *Nelumbo* attain high values towards the upper half of the sub-stage. *Potamogeton*, *Nymphaea*, *Lemna*, *Limnanthemum* and *Trapa* are sporadically represented. Reed vegetation is very lowly represented. *Typha* only attains high values towards the top but *Sparganium* continues to maintain moderately high values.

Sub-stage "d 3"—The vegetation is very much as in the previous sub-stage with the only difference that *Carpinus* and *Corylus* are very much reduced. *Carpinus* is reduced to stray pollen. Oaks, elm and birch decline. *Picea* and *Cedrus* show comparatively higher values. The gradual ascending trend in pine continues. *Salix* is  $\pm$  sporadic and discontinuous.

Cyperaceae is further reduced, Gramineae declines to low values in the middle and then attains high values towards the top. The curves for Chenopodiaceae, *Artemisia* and *Plantago* show  $\pm$  the same trend as that

for Gramineae. The cereal pollen curve is  $\pm$  the same in the previous sub-stage. The other members of the ground vegetation are sporadically present. Polypodiaceae increases gradually maintaining fair values in the middle but disappearing towards the close of the sub-stage.

*Botryococcus* is absent. *Pediastrum* is present throughout except a break in the beginning but towards the close of the sub-stage it rises consistently. *Limnanthemum*, *Myriophyllum*, *Trapa* and *Nymphaea* are sporadic. *Potamogeton* maintains sporadically high values. *Typha* is very much reduced. *Sagittaria* is sporadically present. *Sparganium* disappears after some time.

Stage "e". Oak-birch-alder-elm-pine-wood phase—This stage is characterised by an overall reduction in the curve for oak, consistently high values of birch and elm and comparatively higher values of alder except towards the base of this stage. A comparative rise in the curves for pine and *Abies* is also noticed. The values of *Cedrus* are consistent whereas *Picea* shows only high values towards the upper part of the stage. *Juglans* is reduced except in the middle. *Carpinus* is absent and there are stray grains of *Corylus*. *Salix* maintains a discontinuous and low curve. Pollen of *Populus* first appears towards the top of this stage.

Cyperaceae is further reduced except slightly increased values towards the top. Gramineae, *Artemisia* and Chenopodiaceae maintain consistently high and fluctuating values. Cereals show consistently high values for the first time during this stage. Compositae and *Plantago* maintain low curves. The other members of the ground vegetation are sporadically present. Polypodiaceae forms  $\pm$  a continuous curve with some breaks.

A tremendous rise is seen in *Pediastrum*. *Potamogeton* slightly increases. *Trapa* is  $\pm$  present throughout in sporadically high values. *Typha* is further reduced. *Sparganium* is absent. Stray pollen of *Sagittaria*, *Eriocaulon* and *Alisma plantago* is also present.

Stage "f". The conifer-mixed-woods phase—This stage is characterized by a sudden decline of oaks to sporadic values towards the top, a gradual decline in birch, alder, elm and *Juglans*. *Salix* maintains a continuous curve. The ascending trend in the conifers becomes more apparent although *Pinus wallichiana* and *Abies* maintain con-

sistent values. *Cedrus* and *Picea* show gradually declining trend. Stray pollen is present of *Acer*, *Carpinus*, *Corylus* and *Viburnum*.

Cyperaceae is represented by stray grains. Gramineae, cereals, Compositae and Chenopodiaceae have continuously consistent low values with a rise in the middle. *Plantago* becomes sporadic towards the top. Ranunculaceae, *Paeonia*, Labiatae, Rutaceae, Polygonaceae, *Polemonium* and *Tribulus* are represented by stray pollen only. Polypodiaceae is very much reduced in the middle of this stage while it increases in the beginning and towards the top.

Algae are largely absent. *Pediastrum*, *Potamogeton* and *Myriophyllum* are represented by sporadic grains. *Typha* is reduced to stray pollen.

Stage "g". *The conifer-mixed-oak-wood phase* — This is  $\pm$  the continuation of the previous stage except the high values obtained by the oaks again. Birch, elm and walnut register increase in the middle. Alder is sporadic. The curve for *Populus* is sporadic towards the base but it  $\pm$  becomes continuous towards the upper half. Pine shows ascending trend and high values. *Cedrus* and *Picea* maintain consistently low values. Except high values towards the base *Abies* is consistently low.

The shrubby vegetation consists of *Viburnum* and *Sarcococca*.

The low curve for Cyperaceae during the middle of this stage becomes sporadic towards the base and the top. Gramineae, *Artemisia* and Chenopodiaceae and cerealia show slight increase. *Plantago* which was  $\pm$  absent in the previous stage has sporadic but high values. The trend in the curves for Rosaceae and Caryophyllaceae is also more or less alike. Cruciferae, Umbelliferae, Ranunculaceae, *Paeonia*, Boraginaceae, *Justicia*, Labiatae, Rutaceae, Polygonaceae, *Tribulus*, *Valeriana* and *Convolvulus* are sporadically present. Polypodiaceae is very sporadic.

*Pediastrum* regains its continuous curve with low values at the base and high values towards the top. *Trapa* has a  $\pm$  continuous curve during this stage and attains the maximum values. *Limnanthemum* has a continuous curve towards the top. *Typha* has high values toward the top and the base. The curve for *Sparganium* begins towards the top of the stage.

Stage "h". *Pine-fir-birch-walnut-wood phase* — This is largely characterized by the complete absence of oaks, negligible values of alder and elm, reduced values of *Juglans* but high values of birch. The values of *Populus* and *Salix* are comparatively high to begin with then decline and later show a slight rise towards the top of this stage. Similar increase is seen in *Juglans*. Birch starts with low values but increases towards the top. *Picea* is low and declining. *Cedrus* and *Abies* slightly increase towards the top. *P. wallichiana* decreases to extremely low values (10 per cent) and *Pinus* type increases.

On the whole the *Pinus* curve shows a declining trend. A slight decline in birch is seen towards the extreme top.

Cyperaceae is represented by stray pollen. Gramineae shows an ascending trend. The cereal pollen curve has higher values in the lower half but consistently low values at the top. *Artemisia* is consistently low throughout the stage. Chenopodiaceae shows an increasing trend. Compositae is sporadic. Consistently low values of Rosaceae are seen in the middle. Caryophyllaceae and *Plantago* are sporadic. Towards the base of this stage *Impatiens* shows high values, but thereafter, it is absent. Polypodiaceae is reduced to sporadic values towards the base and top but a low consistent curve is seen in the middle.

*Pediastrum* has high values at the base and with a gradual decline disappears in the middle of the stage. *Potamogeton* after high values at the base maintains low and consistent curve. *Typha* attains maximum values at the base of the stage and *Sparganium* has extremely low values. Towards the extreme top of the diagram *Typha* shows a sudden decline to low values.

#### DATING THE POLLEN DIAGRAMS

In the absence of any pollen zonation schema and the C14 dates, certain features in the Haigam pollen profile may be considered from chronological view-point. First amongst these is the Cereal Pollen Curve. The stray cereal pollen at the base of the diagram suggests that the diagram is not very much older than the "Neolithic" period. The stray, sporadic and discontinuous nature of the Cereal pollen curve from the top of stage "b" to the middle of stage "d" reveals the early attempts of the "Neolithic" folk towards settlement based

on their nomadic way of life. A continuous curve from the middle of stage "d-1" to the close of stage "d-3" reveals  $\pm$  a continuity of the settlement. Slight but significant rise in the middle of stage "d-2" probably represents a period of prosperity. During stage "e" Cereal pollen curve attains maximum values thus indicating a period of maximum prosperity in the valley. Thereafter, the pollen curve maintains low and consistent values with a slight increase during stage "f" and the lower part of stage "h".

Luckily the old literature available (cf. RAY, 1957) describes the history of the valley as far back as the 6th or 7th century A.D. or even slightly earlier. In view of the authenticity of some of the records, accounts of travellers and the archaeological discoveries supporting the written records, it may not be unsafe to rely upon the written record for any purpose. The old literature describes that the period between the 7th and 9th centuries is the period of maximum prosperity in the valley. During this period several industries came into existence. There existed trade contacts of Kashmir with China, Central Asia and Tibet. Attempts were made to guard against the floods by constructing dykes and embankments. A little later in the 9th century (855 to 883 A.D.) the marshes south of the Wular lake were reclaimed by an engineer named Surya, the Irrigation Minister, in the court of King Avanti Verman. This period of history regarded as the period of maximum prosperity seems to correspond with the stage "e" in the Haigam pollen diagram showing maximum farming. The decline of oaks and walnut during stage "e" may also be attributed to agricultural activity. This correspondence between the pollen diagram and the historical records helps to date the beginning of stage "e" to 700 A.D.

The historical records describe the earliest flooding phase in 580 A.D. and then another in 970 A.D. At the close of the 11th century (1099 A.D.) the valley is reported to have suffered from a very severe flood, plague and famine which must have affected the economy of the valley to a great extent. After the last flood during the close of 11th century to 1338 A.D. is recorded a period of quick succession of rulers, anarchy, wars and also invasions towards the later part of the fourteenth century. The correspondence of the close of vegetational stage "e"

with a flooding phase followed by a decline in agricultural activity perhaps suggests that the close of stage "e" and the beginning of stage "f" may be dated to 1100 A.D. A flooding horizon in the middle of stage "d3" slightly earlier than that would then correspond to 580 A.D.

From recent excavation at Burzahom the previously known "Megalithic" site in the valley, the "Neolithic" phase has recently been discovered. Mr. T. N. Khazanchi, Superintendent, Archaeological Survey who conducted the excavations has been able to recognize two phases of the "Neolithic" period — phase 1 characterized by dwelling pits and phase 2 characterized by mud walls and timber which is coniferous and appears to be of pine. The "Neolithic" phase is unconformably followed by the "Megalithic" phase comprising two horizons the lower characterised by monuments and the upper, the "Post-Megalithic", characterized by the historic red ware and constituting the early historic period. The Radio Carbon assay of the "Neolithic" phase 2 has dated it to roughly about 4000 years from now (1860 B.C.). The beginning of agriculture in stage "b" might correspond to the "Neolithic" phase 1 whereas the farming indicated towards the top of stage "b" and in stage "c1" may correspond with the "Neolithic" phase 2 which is dated to 1860 B.C.

Between the beginning of stage "e" dated to 700 A.D. and stage c1 dated to 1860 B.C. about 240 cm. of the organic sediments were laid in about 2500 years at the rate of about 10 cm. of detritus in 100 years. This, therefore, provides us with a dating mechanism from the "Neolithic phase" II to 700 A.D. and the dates determined are shown in Text-fig. 12. The rate of deposition of the organic mud dates the close of stage "e" to 1500 A.D. rather than 9th century A.D. as described earlier and this also receives support in the evidence of poplar which first appears towards the close of stage "e" but is found continuously in stage "g". Since pollen is not seen before stage "e", it could not be ascribed to indigenous *Populus ciliata* which is of very limited and sporadic occurrence in the Kashmir valley. Whereas the fact that this woodland poplar behaves as a first coloniser on landslips, freshly-exposed soils and burnt areas in the Blue Pine-Deodar zone and its first occurrence in the pollen

diagram corresponds with the sudden decline of most of the broad-leaved forest cannot be overlooked, the introduction of poplar by the Mughal Emperor Jahangir in the 15th and the 16th century can hardly be forgotten.

The introduction of poplar into the valley may have been slightly earlier than that during the period of Sultan Zain-ul-Abidin who ruled between 1420 A.D. and 1470 A.D. The evidence of *Populus* pollen, therefore, dates the close of stage "e" and the beginning of stage "f" to about 1450 A.D. or 1500 A.D. This is in accord with the dating based on the rate of deposition of sediments. Thus the stage "e" corresponds with both the Hindu Period and the Period of Sultans from 700 A.D. to 1500 A.D. a span of about 800 years.

Human memory is a witness to the fact that about 40-80 years ago pine forests clothed the slopes of Karewas and they have since disappeared from the lower slopes of the valley owing to ruthless clearances by man. The senior members of Forest Department of Jammu and Kashmir State have witnessed the clearances of pine from the lower slopes. From this evidence the decline of "Blue Pine" in the extreme top of stage "h" from 40 per cent to 10 per cent indicate probably the close of 19th century to the beginning of the 20th century.

Amongst the other evidences as indirect as those discussed above pollen of *Morus*, Chinar, Saffron and Cotton may also be mentioned although their pollen grains have not been encountered in the Haigam lake pollen profile. Chinar was first introduced by the Moghals and it is believed that the silk industry in the valley was given birth to by King Zain-ul-Abidin (1420-1470 A.D.) when the plants of mulberry must have been introduced. Similarly cotton in the valley was introduced in the recent historical past.

Quite a large number of fruit trees belonging to Rosaceae such as apples, pear, plum, peach, apricot etc. have made the valley well-known since 7th century A.D. but apple was probably not known at that time as Huen Tsang does not mention in his travels. It is also on record that during the period of Moghals or Sultanate several fruit orchards were established. Although it is not possible to separate the pollen of several of the fruit trees from the wild members of this family but comparatively

high values attained by rosaceous pollen during stage "e" dated to 7th to 15th century A.D. and later during stages "g" and "h" corresponding to the 17th-18th centuries may probably provide additional evidences for dating. But the stray pollen of Rosaceae towards the extreme top perhaps cautions us, unless otherwise explained, about the non-reliability of Rosaceae curve for dating this diagram.

## VEGETATIONAL HISTORY

### 1. Vegetational development and climatic alterations

The pollen diagram begins with the broad-leaved deciduous forest comprising genera such as *Betula*, *Quercus*, *Ulmus*, *Alnus*, *Juglans*, *Acer*, *Rhus*, *Corylus*, *Carpinus*, *Fraxinus* etc. which are all thermophilous in nature. The gradual succession of the oak-elm-alder-ash wood phase into elm-ash-alder-walnut woods and later into the ash-elm-alder-oak woods towards the top of the stage "a" suggests progressively drying up of climate.

The gradual invasion of pine and yew and other conifers into this community takes place towards the top of stage "a". The immigration and increase of conifers and decline of ash-elm-alder-oak woods results in the formation of the conifer-mixed-wood, in stage "b". This change over from the broad-leaved forest (stage 'a') to a forest dominated by conifers (stage 'b') must have been in response to the worsening of climate. This is further evidenced by the absence or sporadic values of most thermophilous species (*Alnus*, *Juglans*, *Corylus*, *Carpinus*, *Rhus*, *Acer*, *Aesculus*, *Pediastrum*, *Botryococcus*, *Utricularia*, *Nymphaea*, *Nelumbo* and *Trapa*). *Potamogeton* a genus of usually cooler climate thrives very well in this stage forming a continuous curve. Ferns, however, are present in fairly good percentage.

Towards the close or the upper half of stage "b" the conifers show a gradual decline but for *Cedrus deodara* and *Picea* which begin to rise towards the top of the stage. The decline in conifers is followed by gradual re-establishment of the broad-leaved forest. The increase in the broad-leaved constituents after decline of conifers is due to warming up of climate. Thus the upper half of the stage "b" represents the begin-

ning of the period of increasing warmth. The progressively warming climate during stage "c" tends to establish oak-mixed-conifer woods. Of all the conifers spruce alone maintains high values. Alder and elm are the other important broad-leaved constituents of the forest. Birch attains higher values towards upper half of stage "c". Further warming up of climate is seen during sub-stage "c 2" with the formation of oak-elm-walnut-birch woods with *Acer* and *Salix* as the other important constituents. Both *Corylus* and *Carpinus* which were hitherto found in traces now become recognizable constituents of this community.

*Potamogeton* a plant of comparatively cooler climate shows a gradual decline and finally becomes sporadic. Some of the thermophilous species such as *Nymphaea* and *Nelumbo* show fairly high values. *Trapa* appears to the top of this sub-stage. *Sagittaria* and *Alisma plantago* are present in low frequencies.

In the succeeding stage (sub-stage 'd1') alder becomes an important constituent of the forest while *Acer* is almost reduced to sporadic pollen. The oak-elm-walnut-alder-birch community so formed suffers a sharp decline during the middle of this phase. Amongst the conifers fir shows high values towards the base only, spruce is gradually reduced and alder still maintains the same values as before except towards the top of this stage where it declines to extremely low values.

*Botryococcus* and *Pediastrum* which were absent in the preceding stage reappear in fair percentages. *Potamogeton* further declines and becomes sporadic towards the close of this stage. *Myriophyllum*, *Nymphaea*, *Nelumbo* etc. which are missing in the beginning start rising towards the close of this stage.

The optimal conditions of climate are attained during stage "d2" when the oak-elm-walnut-alder community becomes well-established with both *Corylus* and *Carpinus* reaching fairly high values. The conifers are further reduced. The reappearance of continuous curve for *Acer* from the middle of this stage is fairly significant. Along with the broad-leaved constituents there is corresponding increase in all the aquatics except *Nymphaea*. *Botryococcus*, *Myriophyllum* and *Nelumbo* show their maximum rise during this stage. *Potamogeton* though

present throughout in low percentages never forms a continuous curve.

In the succeeding sub-stage "d 3", *Picea*, *Cedrus*, *Abies* show rising trend while Blue Pine starts rising during the middle of sub-stage "d 2". There are not many notable changes but for the slight decline of elm and walnut and reduction of *Carpinus* to extremely low values (stray pollen). Values of *Corylus* curve are further reduced. There is remarkable change in the aquatic plant constituents. *Botryococcus* is altogether absent. *Pediastrum* forms  $\pm$  a continuous curve. The other aquatics which thrived very well in the preceding stage are sporadically present.

Vegetational changes observed in stage "d 3" indicate a gradual trend in climate towards deterioration which reaches climax in stages "e" and "f". In fact the climatic optimum is represented by the entire stage "d", though more precisely by stage "d2", the stages "d1" and "d3" being of transitional character between the periods of increasing warmth and climatic optimum and the periods of climatic optimum and the onset of cool phase respectively. This period of maximum warmth was accompanied by dryness of climate as high frequencies of *Artemisia* pollen would indicate. The flooding phases noted in stratigraphy may probably be attributed to the melting of ice at high altitude.

The trend in the worsening of climate as already noted in sub-stage "d 3" becomes much more apparent during stage "e" with the sudden rising trend in the curves for Blue Pine and fir and a sharp declining trend in oaks and walnut and increase in birch, elm and alder. The full impact of the cool phase is noted at the beginning of stage "f" when oaks and alders show a sudden decline to extremely low values and birch declines abruptly. Elm and walnut record gradual decline. Pine, *Picea* and *Abies* attain high values. There is corresponding decrease in the aquatic thermophilous species but on the other hand *Potamogeton* once more shows maximum rise in stage "e" after prolonged suppressed values in preceding stages. In the subsequent stages it is represented by sporadically high values.

This onset of the cool phase brings about a lasting change in the oak woods although in stage "g" oaks fluctuate again to fairly high values adversely affecting conifers

which show corresponding decline. There is slight rise in the constituents of the broad-leaved forest also. The oaks again decline to extremely low values towards the top of this stage but they are absent thereafter. The topmost phase of vegetation in stage "h" opens with pine-birch-woods with little of elm, *Salix* and poplar. *Picea* and *Cedrus* are found in extremely low values while pine dominates. Towards the extreme top of the diagram Blue Pine shows a sudden decline and so does birch also but the values of fir, *Salix* and poplar increase. The top of the pollen diagram thus brings us to the present-day vegetation of the valley proper where both pine, alder and birch are absent except the former along the higher slopes. Elm is protected in the shrines. Together with stray trees of elm, planted walnut, plantations of *Salix*, *Robinia* and poplar, fruit orchards and planted trees of *Platanus orientalis* and some other introduced trees constitute the only members of the arboreal vegetation.

## 2. History of Plant Economy

The inference of anthropogenous influence upon vegetation is largely based on the cereal pollen curve and on *Plantago lanceolata*. From the fluctuation in cereal pollen curve (TEXT-FIGS. 10, 12) the following recognizable phases are distinguished:

1. The commencement of agriculture.
2. Period of low but continuous economy.
3. Period of increased economy and
4. The decline in agriculture.

The commencement of agriculture began when the conifer (blue pine) woods predominated in the valley and comparatively cooler climate prevailed. Consequently the Blue Pine was affected very much, which receded as a result of clearances and recovered after the abandonment of the site. Later forest clearances during the early part of climatic optimum when vegetation largely consisted of oak-woods affected the broad-leaved forest. Oaks suffered most though elm also showed a slight decline whereas birch and Blue Pine acted as colonisers of the abandoned fields. Other stages are as usual. In the specially constructed subsidiary diagram (TEXT-FIG. 13) the various stages in the 'Landnam' phases are indicated to facilitate their understanding.

The various phases of agricultural activity are described below.

(a) *The commencement of Agriculture*—The earliest agricultural activity appears somewhere in the middle of stage "b" when the conifer-mixed-woods existed in the lower slopes of valley. This is indicated by only two cereal pollen. At this level there is a sharp decline in the curves for blue pine, fir, *Cedrus*, birch, elm and oak, Gramineae, *Artemisia* and Compositae which regain their values soon after it. A sporadic activity of this kind continuous until a continuous curve is formed by the cereal pollen in stage "c1".

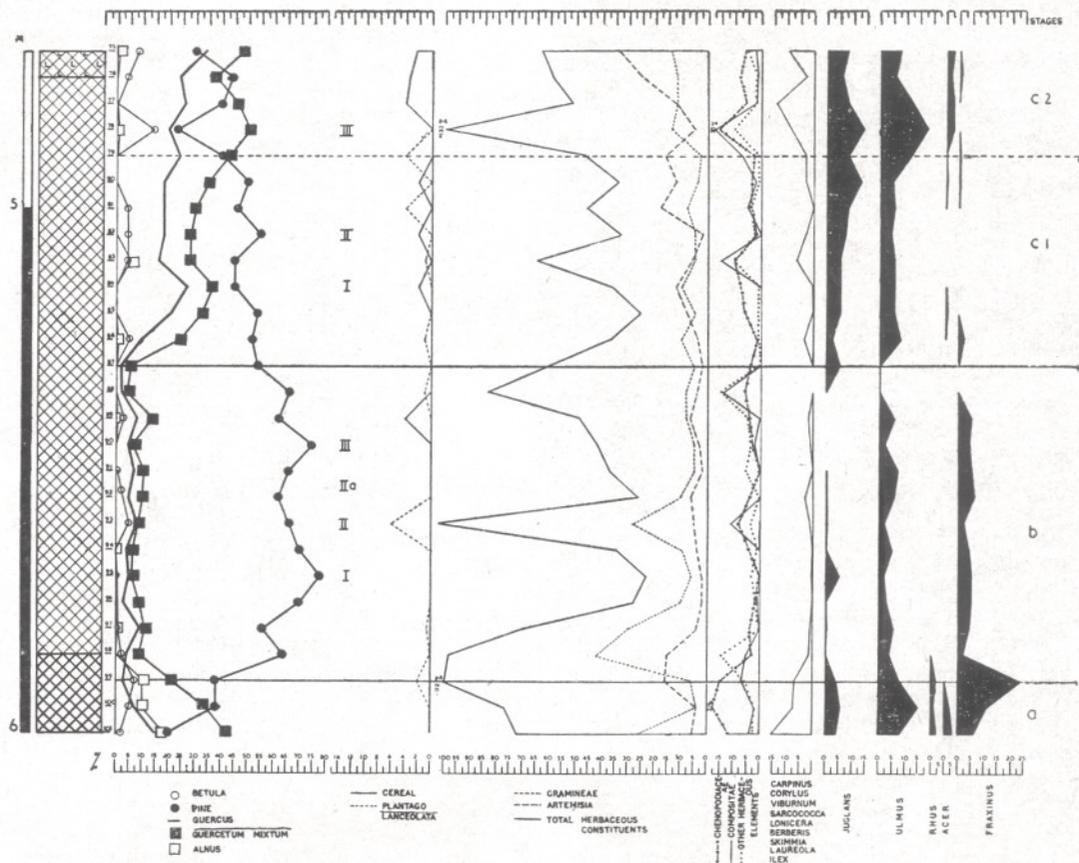
Although no cereal pollen is seen prior to the middle of stage "b", pollen of *Plantago lanceolata* first appears towards the top of stage "a" with an increase in its frequencies at the transition between stages "a" and "b". In the Post-glacial diagrams *P. lanceolata* is usually believed to be suggestive of the commencement of changing intensity of a farmer culture in the "Neolithic" and later Ages. If the same role may be attributed to it in Haigam profile, then the beginning of agricultural activity may be shifted down to the close of stage "a" and the beginning of stage "b".

Towards the top of stage "b" about 8 per cent cereal pollen appears again. This too more or less corresponds with the decline of conifers which takes place slightly earlier. Oak, elm and birch in fact rise where maximum agricultural activity is seen and correspondingly a slight rise is observed in Gramineae, *Artemisia* and Chenopodiaceae but Compositae alone shows a rise after it.

The cereal pollen curve again becomes sporadic or discontinuous during the stage "c1". Here *Artemisia* and cereal pollen grains behave more or less faithfully while the curves for Gramineae, Compositae and Chenopodiaceae show a rise. During this stage the oak woods had begun to establish themselves followed by decline in conifers. It is indeed difficult to interpret this change in arboreal vegetation whether due to climate or man or both.

(b) *The period of low but continuous economy*—Though still discontinuous the curve for cereal pollen increases in frequency during the stage "c2" with Gramineae, Compositae and Chenopodiaceae behaving more or less faithfully. The curve for *Artemisia* shows considerable increase after the decline of cereal curve. Corresponding with the rising fluctuations of cereal curve decline is noted in the curves for birch, elm

THE BASAL PART OF THE HAIGAM POLLEN PROFILE SHOWING VARIOUS STAGES IN THE LANDNAM PHASES



TEXT-FIG. 13 — The Landnam phase during stage 'b' shows various stages in the decline and recovery of pine and that in the stage 'c' shows decline and rise of mixed oak woods.

and walnut. The gradual decline in *Acer* corresponds well with the gradual rise of cereal curve. At this level a further decline of blue pine is noted. The oaks continue to maintain higher fluctuations.

From stage "d1" to the top of stage "d3" the cereal pollen curve is continuous and maintains low but occasionally fluctuating values with the maximum fluctuation reaching 10 per cent. During this period the broad-leaved forests dominated by oaks had been already established. With the rise in agricultural activity during stage "d1" decline is noted in most of the broad-leaved constituents (oaks showing it several times more rises than the others) but during the later rises in agricultural activity,

oaks show increased values when the other members of the broad-leaved forest decline.

This period is further distinguished from the previous one because it is characterised by a continuous cereal pollen curve as contrasted from its sporadic and discontinuous nature in the earlier phase. It probably suggests a change-over from the nomadic life to settled economy.

*Plantago lanceolata* maintains a continuous curve from the middle of "d1" to the close of "d2" but attains higher values towards the close of "d3". Similarly *Artemisia* and *Chenopodiaceae* show high values more especially in stage "d2". *Compositae* is sporadically present. Other herbaceous

elements probably associated with agriculture are sporadically present.

(c) *The period of increased economy* — During stage "e" the cereal pollen curve attains maximum values which are maintained throughout the stage. The high values of cereal pollen (14 per cent) in the lower half of this stage correspond with decline in the curves for Gramineae and Chenopodiaceae whereas *Artemisia* registers increase. At the same level Compositae, Urticaceae and plantain are sporadically present though they show increased values before the rise of the cereal curve. Oak, elm, walnut, *Cedrus* and pine record a decline whereas slight increase in the values of *Betula* and *Abies* is noted.

With a sharp decline the cereal curve again rises in the middle of the stage accompanied by corresponding rise in Gramineae and *Artemisia*. Chenopodiaceae declines. A slight increase is also noted in *Plantago* though present in low values. Compositae and Urticaceae are sporadically present. Amongst the aboreals oak and elm register a further decline while *Alnus* and *Juglans* slightly increase. *Betula* which normally attains maximum values throughout this stage also shows increased values at the same level. *Picea* shows a slight increase whereas other conifers decline.

After another decline the cereal pollen curve attains high values towards the top of the stage. This third rise is accompanied by decline in *Artemisia*, a corresponding increase in Gramineae and Chenopodiaceae and appearance of *Plantago*. Oaks rise considerably up to 16 per cent at the same level and elm, alder, birch and walnut show a corresponding decline. An increase in *Cedrus* and blue pine is also noted.

The cereal pollen curve declines towards the close of stage "e" and is followed by a corresponding increase in the values of *Artemisia*, Compositae and Chenopodiaceae whereas there is decline in Gramineae. The oaks are reduced to negligible values. A slight rise is noted in elm but birch falls after this level. Alder and walnut show a slight rise. Thereafter, alder is reduced to traces whereas walnut also registers a gradual decline. Birch which enjoyed maximum percentage (up to 18 per cent) in the preceding stage is extremely affected and is hardly up to 4 per cent. *Picea*, *Abies* and blue pine show a corresponding increase while *Cedrus* is suppressed.

(d) *The decline in Agriculture* — The period of decline sets in towards the close of stage "e" and it continues in the succeeding stages except minor rising trends in the middle of stage "f" and comparatively higher values up to 8 per cent in "g" and "h" with two rising fluctuations in "g" and a rise at the base of "h" thereafter, the curve for cereal maintains low and continuous values.

The rising trends in the cereal pollen curve are accompanied by corresponding rise in some culture pollen. For instance the rise during the middle of stage "f" is accompanied by a rise in Gramineae, *Artemisia* and Compositae. A similar behaviour is observed in stage "g" and  $\pm$  the same in "h" also. Gramineae and Chenopodiaceae increase after the general decline towards the upper half of stage "h". There is an overall decrease to extremely low values of the members of the broad-leaved forest except oaks attaining high values during stage "g" and birch in stage "h". Their low fluctuations show  $\pm$  the same trend as interpreted in the earlier phases.

In view of the extremely reduced cereal pollen curve towards the top of the diagram neither the herbaceous elements nor the members of the broad-leaved forest show any response, only the conifer forest seems to have colonized the area. Extensive grazing and clearance of the broad-leaved constituents for fuel and industrial use have probably prevented their recurrence.

#### CONCLUSION AND DISCUSSION

The shifts in plant populations in the Haigam pollen profile have been found to be between the broad-leaved forest and the conifers exhibiting a broad three-fold climatic pattern of the Post-glacial climate as has already been shown by Singh (1963) in the Toshmaidan pollen profile. The typical Late-glacial phase preceding the period of increasing warmth has not been observed rather in its place there are indications of a broad-leaved forest of which the real significance cannot be understood presently until the samples below it have been pollen-analysed.

The opening out of the earlier broad-leaved forest followed by the invasion and the establishment of the conifers might have been caused by biotic factor (fire, man) or might have been induced by a cool oscillation

corresponding to the latest Post-glacial Ice advance in the Kashmir Valley recorded by De Terra & Hutchinson (1936). Pollen of *Plantago lanceolata* at the transition between the earlier broad-leaved forest and the conifer forest, between stages "a" and "b" in Haigam profile, may perhaps at the same time hold human hand responsible for the shifts in the plant populations which are interpreted to indicate a change in climate. It may seem too much to attribute an exclusive influence to either of these two factors for such a change which might in fact have resulted from the combined effect of both.

*Phytogeographical implications* — This investigation confirms the findings of Singh (1963) that the oaks had existed in the valley during the Post-glacial period. Perhaps they could have continued to exist in the valley but for the human hand and not probably due to climate since the present climate of the valley is not unamiable to the growth of indigenous oaks there (VISHNU-MITRE, 1963). At least two of the indigenous species of the oaks *Quercus dilatata* and *Q. semecarpifolia* not only occur but regenerate well in the valley proper as reported by Vishnu-Mitre (*l.c.*).

During the Post-glacial period *Alnus*, absent today from the valley, was an important constituent of the broad-leaved forest as already reported from Toshmaidan (SINGH, 1963). Like oaks in the valley *Alnus* also seems to have met a similar fate. The occurrence of stray pollen of *Alnus* towards the top of the Haigam pollen profile and the occurrence of as much as 7 per cent pollen of *Alnus* in a surface sample from Shupian may either be due to long distance transport or may indicate a few stands of stray trees of *Alnus* in the Kashmir Valley unrecorded so far. Like the recent discovery of indigenous oaks in the valley soon after their discovery in the Post-glacial it is hoped that alder may be discovered here in the near future.

*Carpinus*, another genus absent from the Kashmir Valley, has been found right from the beginning of pollen diagram until towards the close of stage "g". It has been a very important constituent of the shrubby vegetation during the Post-glacial climatic optimum. Its decline eventually resulting in its extermination from the valley may have resulted from the dual effect of climate and man.

Elm in the valley proper today is either protected in shrines or an extremely small percentage of it occurs in the *Cedrus deodara-Pinus wallichiana* community. It has been a very important constituent of Post-glacial vegetation in the Kashmir Valley. It was also present in fairly high values in earlier broad-leaved forest phase and then during the Post-glacial climatic optimum. Its curve seems to gradually decline through the later phases until it becomes sporadic towards the top of the pollen diagram. The decline of elm during the clearance phases is noteworthy suggesting that the human influence might have contributed towards its decline.

*Corylus* has been an important constituent of the broad-leaved forest during the Post-glacial climatic optimum, but today only an isolated stand is found above Pahalgam.

Birch today occurs only at high altitude in the Kashmir Valley whereas in the Post-glacial period it seems to have occurred in the valley proper in fairly high values after the fall of the broad-leaved forest, thereafter, it has declined. Its occurrence in fair amount in the top of the Haigam diagram perhaps suggests its recent extermination from the valley proper, obviously due to human influence. The names of certain sites such as Burzahom ('Burz' means birch in Kashmiri language) suggest the occurrence of birch woods in the valley proper even in the recent historical past. The destruction of birch may be attributed to the removal of its leaves to feed sheep and goats and the removal of its bark to provide the famous "Bhojpatra" for writing manuscripts. It may here be pointed out that merely by the removal of leaves for sheep a whole-sale destruction of birch forest at Kainmal about 1000 m. above Gulmarg has taken place in recent human memory.

*Juglans* today is mostly planted in the valley proper. It also occurs as a less frequent constituent of the forest at high altitude. During the period of climatic optimum walnut was comparatively very widely spread. The wood of walnut is usually used for the manufacture of rifle parts. Kashmir has always met the entire demand of the Indian army for rifle parts.

The overall decline of several broad-leaved constituents to the extermination of some of these is a feature of considerable interest in the flora history of the Kashmir Valley. Their decline might have been

initiated by the onset of the cooler phase at the beginning of stage "e" but human hand seems to have done a far greater damage than climate as is apparent from the historical and ethnobotanical records. The deforestation in the valley is traceable to about 2000 B.C. (conservative estimate) when the Aryans entered the valley and introduced a far advanced civilization than previously existed here. According to Stebbing (1904) the Aryans who were agricultural and pastoral people burnt down huge stretches of dense forests for cultivation and pastures. The deforestation continued later in a larger measure during the invasion by the central Asian people. Kashmir has been well known since Mohanjo-Daro times for timber supply and later during 326 B.C. when Alexander the Great (on the authority of Hyadespes of the old Greek writers) is known to have got timber from Kashmir. Besides the state of Kashmir has been a great supplier of timber to the outside world for the manufacture of boats. The increasing population in the valley with their increasing demand for fuel and for industrial use such as wood work etc. levied heavy taxes on the already diminishing broad-leaved forest in the valley. Together with that the nomadic tribes with their herds of cattle, sheep and goats brought from various parts of Punjab and Hazara further brought about a decline of the broad-leaved forests. In course of time the fast vanishing broad-leaved constituents of the forest created a scarcity of fuel and wood in the state. The measures to do good the loss have been adopted recently by introducing plantations of *Salix* and *Robinia* to provide fuel to the inhabitants of the valley.

How much loss to these forests has been there by the stripping off the bark of blue pine and deodar by wild black bear and the destruction of seeds and seedlings of blue pine, walnut and *Corylus* by monkeys and the destruction of young cones of deodar and blue pine by flying squirrels and by certain insects and the parasitic fungi and parasitic angiosperms such as *Arceuthobium minutissimum* and *Viscum album* is not possible to say. Nevertheless from the above it appears that the biotic factor and fire have been very strongly operative in the destruction of the forest wealth of the Kashmir Valley.

The present study has failed to bring out any evidence of the occurrence of *Parrotiops*

*sis jacquemontiana* in the valley. Perhaps, insect-pollinated this is very gregarious both in the conifer as well as the broad-leaved forest and spreads widely after clearances. It has the same status as oaks in the broad-leaved forest in the other parts of the Himalayas. Similarly there is no evidence of *Platanus orientalis* although introduced about a couple of centuries ago.

Of the two kinds of sub-fossil pine pollen, one is of *P. wallichiana* and the other is not so different that it may be referred to any other species of *Pinus*. Of the two pines distributed in the valley today (*P. roxburghii* was planted recently) *P. wallichiana* is very widely spread but *P. gerardiana* is restricted to the drier valleys formed by the river Chenab and Kishenganga. It is very likely that it may be an ecospecies of *P. wallichiana*.

Spruce occurs very sparsely (usually below 5 per cent but rarely up to 10-15 per cent) in certain sites in the Kashmir Valley today and pure forests are altogether absent. During Post-glacial it has been present in higher frequencies up to 20 per cent as a member of the conifer forest. Its decline after stage "g" in Haigam pollen diagram might have been due to progressively drying up of the climate or to other factors. Spruce flourishes profusely on the southern side of Pir Panjal with a monsoon climate the absence of which in the Kashmir valley explains its overall reduction during the later part of the Post-glacial period.

*Cedrus* today is  $\pm$  absent on the Pir Panjal side but in other parts of the valley it is found in the *Cedrus* — *Parrotiopsis* forest and in the mixed conifer forest both in the dry and moist regions. It is of limited occurrence in the valley unlike blue pine and fir. In the past *Cedrus deodara* was comparatively far more widespread than it is today. Both historical and archaeological evidences show that *Cedrus* has been exploited by man since the Mohanjo-Daro civilization where timber of Deodar has been found. Further it has been the only marketable conifer until 1922 whereas blue pine and fir became marketable after 1922. It, therefore, appears that *Cedrus* too has suffered at the human hand.

#### Prehistoric Plant Husbandry

The commencement of agriculture took place when the vegetation around consisted of conifers dominated by blue pine.

Obviously the first clearances took place in the conifer forest. Pine being a dominant constituent suffered the most. During the 'Neolithic' period the climate must have been very much cooler than today as is evidenced by the 'Pit dwelling' habit of the 'Neolithic' folk discovered at Burzahom. It is interesting to note here that the 'Neolithic' forest clearances in Europe were confined to the broad-leaved forest. Later forest clearances, however, affected the mixed-oak woods. The recognition of landnam phases has brought out the usual stages in the shifts of plant population from decline to recovery of the forest corresponding with the clearance of the forest, settlement and abandoning of the site.

Besides the fluctuations in cereal pollen curve and the *Plantago lanceolata* no other evidences have provided any clues towards the history of the agriculture with the exception of charcoal layers discovered at depths of 220 cm. and 175 cm. and a sub-fossil spikelet of rice at 100 cm. The 'Neolithic' man practised farming as has become clear from the discovery of Pounders and crop cutting instruments at Burzahom.

The progressive decline of agricultural activity after stage "e" may be attributed to fairly widespread flooding of the valley floor specially its north western parts from where the pollen diagram has been constructed. During stage "e" between 700 A.D. to 1500 A.D. the several times higher frequencies of cereal pollen suggesting far more intense agricultural activity than today finds support from historical records. According to Ray (1957) the population of Kashmir in the past was far greater than today and the number of the villages during the period of Sultans was far larger than today and during the Hindu period it was still larger. During these periods the prosperity in the valley was much greater as is also evidenced by the accounts of Hiuen Tsang (7th century A.D.) and the Venetian traveller Marco Polo (13th century A.D.; YULE, 1875). Excavation at Handwara belonging to the Buddhist period (4th century A.D.) and Awantipur (9th century A.D.) from where a large number of Jars and other potteries, "Kangri", incense burner, lamps and earthen wares are recovered are suggestive of well-established prosperity. Besides sites of the early settlements pertaining to the Hindu period are wide-spread in the valley.

Whereas the historical records mention the cultivation of rice, barley, pulses and fruits, the pollen analyses fail to provide us with any such information. It is hoped that the future pollen analytical investigation will evolve useful methods with the help of highly developed optical equipment to throw light on the kinds of crops cultivated.

There is practically not much information on the pastoral activity from the pollen diagrams from the valley floor. The entire grazing today is carried out at higher altitude which the Gujjars, the Bakarwals and the Herdsmen accompanied by herds of cattle, flocks of sheep and goat ascend during summer. In the Tosh-Maidan pollen diagram, suppressed values of Gramineae and the high values of *Artemisia* were interpreted by Singh (1963) indicating pastoral culture. *Artemisia* being a non-palatable herb was probably spared by the cattle which accounts for the high pollen frequencies as has been brought out in the Tosh-Maidan profile. Surprisingly enough in both the pollen diagrams such high frequencies of *Artemisia* correspond with the high frequencies of the broad-leaved forest. *Artemisia* is generally believed to indicate open conditions but the contemporary presence of the broad-leaved forest indicates just the contrary. In the absence of any pastoral activity in the valley floor the attribution of high frequencies of *Artemisia* to the pastoral activities may be ruled out. Thus the occurrence of high values of *Artemisia* together with high values of the broad-leaved forest becomes an ecological anomaly.

*Artemisia brevifolia* is well developed in the dry temperate parts of the valley. Together with *A. maritima* it is highly developed in the open *Parrotiopsis* forest. An extensive and luxuriant growth of *A. maritima* var. *brevifolia* is found in the mixed forests comprising *Pinus gerardiana*, *Cedrus deodara*, *Pinus wallichiana*, *Abies pindrow* and the broad-leaved constituents such as *Celtis australis*, *Fraxinus*, *Quercus ilex*, *Acer pictum* etc. The high altitude *Artemisia roxburghiana* occurs in the *Abies-Betula* association forming the lowest strips of the alpine forest and still higher up *Artemisia vulgaris* is found in the alpine scrub. Various species of *Artemisia* are also found in the arid zone comprising barren stretches of the cold desert of Ladakh, Baltistan and Dardistan.

From the above account it appears that *Artemisia* indicates not only the open condition but also the aridity of climate. Based on this it would appear that the broad-leaved forest during which *Artemisia* had also been very highly represented flourished during drier climate. But it is quite surprising that with the opening out of the broad-leaved forest *Artemisia* also declines to extremely low values. It is not clear whether this change in the frequencies of *Artemisia* is due to a change in climate or any other factor.

Taking into consideration a large demand for fuel in the valley proper it may be conjectured that together with the fate of the broad-leaved constituents *Artemisia* has also been adversely affected by man. Duthie (1893) reports the use of *Artemisia maritima* as fodder for mules and donkeys in Gilgit and that *A. parviflora* and *A. sacrorum* are eaten by sheep and goats in Kashmir. Duthie's observations seem to explain better the decline of *Artemisia* in the valley after the forest clearances.

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