

# POLLEN AND SPORES FROM THE KAREWAS (QUATERNARY) OF KASHMIR\*

P. K. K. NAIR

National Botanic Gardens, Lucknow

## INTRODUCTION

THE Quaternary formation of Kashmir, known locally as the Karewas, covers the whole Kashmir valley, and extends up the Pir Panjal Range to an altitude of about 3660 m. The Karewas are known to be comprised of the Lower Karewas covering the first Glacial and Interglacial, and the Upper Karewas covering the second and third Glacials and Interglacials, and fourth Glacial periods (DeTerra and Patterson, 1939).

Although the records of megafossils comprising leaf impressions, flowers, cones, fruits, seeds, and pieces of bark, are considerable (Puri, 1948), our knowledge of microfossils is comparatively limited. Wodehouse (1935) reported the grains of *Pinus*, *Cedrus*, *Picea*, *Abies*, *Betula*, *Carpinus*, *Corylus*, *Alnus*, *Juglans*, *Fraxinus*, *Plantago*, *Myriophyllum*, *Artemisia*, *Cupressaceae*, *Gramineae*, *Chenopodiaceae*, *Compositae*, *Ephedra*, *Salix*, *Maoutia*, *Maclura*, *Ulmus*, and *Persicaria*, of which the last five have not been observed by Nair (1960) in his analysis of the pollen from the Karewa formations. In the above publications, the descriptions of the fossil sporomorphs are not provided to substantiate the identifications made, although the fossils have been compared with their present-day equivalents. But it should be considered important to provide a detailed account of the

fossil pollen and spore flora in order to facilitate future work on the Pleistocene palynology of Kashmir. The present paper contains detailed descriptions of the fossil sporomorphs (identified to the level of families or genera), reported earlier by the author (Nair, 1960). Along with the above, an account of the present-day vegetation represented by the pollen and spore microfossils is given.

The sedimentary samples from which the microflora has been recovered are deposited in the Birbal Sahni Institute of Palaeobotany bearing the numbers 30903, 30906, 30907, 30911, 30912, 30913, 30917, 30925, 30930, 30931, 30938, 30941, 30946, and 30949. The fossil pollen grains and spores have been recovered by the method suggested by Erdtman (1954). The sporomorphs described here are arranged in the order Bryophyta, Pteridophyta, Gymnospermae, Dicotyledons and Monocotyledons, and within each of the above groups, the taxa identified to the family and generic level, are arranged in alphabetical order. The numbers given within brackets against the name of the sporomorph denote the number of fossil grains recovered. Along with the descriptions of fossil grains are given an account of the present-day distribution of the plant species in Kashmir and neighbouring places, with the pollen of which the fossil pollen have been compared.

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\*This paper is a supplement to "Palynological investigations of the Quaternary (Karewa) of Kashmir (Nair, P. K. K., *J. sci. indust. Res.* 19c(6) : 145-54. 1960)



## BRYOPHYTA

## RICCIACEAE

*Riccia* (2) Fig. 1.

Spores trilete, spheroidal (equatorial diameter  $87\mu$ ). Wall thickness about  $8.6\mu$  (perine  $5.6\mu$ ; exine  $3\mu$ ), surface reticulate; lumina large.

Ricciaceae is represented by several species of *Riccia* and one of *Ricciocarpus*. Of these, *R. cruciata*, *R. fluitans*, *R. rosti*, *R. himalayaensis*, *R. melanospora*, and *Ricciocarpus natans* occur in the Western Himalayas including Kashmir.

## GYMNOSPERMAE

## PINACEAE

*Abies* (362): Fig. 2

Grains 2-saccate. Entire grain size  $112 \times 182\mu$  (corpus  $94 \times 144\mu$ ; saccus  $54 \times 67\mu$ ). Exine surface reticulate; meshes of sacchi larger than those of the corpus; marginal crest little developed.

*Abies pindrow* (entire grain  $116 \times 147 \times 105\mu$ ) occurs in Kashmir.

*Cedrus* (425): Figs. 3-4

Pollen grains 2-saccate. Entire grain size  $99 \times 126\mu$  (corpus  $81 \times 99\mu$ ; saccus  $99 \times 126\mu$ ). Exine surface reticulate (meshes of sacchi large and elongated along the height of the sacchi).

*Cedrus deodara* (grain size  $53 \times 70 \times 80\mu$ ) occurs in Kashmir and other parts of Western Himalayas.

*Larix* (60) Figs. 5-6.

Pollen grains inaperturate (faintly 1-colpate), spheroidal (diameter varying:  $74-164\mu$ ). Exine thin (thickness about  $1\mu$ ), surface smooth.

*Larix griffithiana* (grain size  $99\mu$ ) occurs in places outside the Kashmir valley.

*Pinus* (1049): Figs. 7-9.

Pollen grains 2-saccate (rarely 4-saccate), and have varying sizes (Fig. 7: entire grain  $58 \times 80\mu$ , corpus  $56-64\mu$ ; saccus  $51 \times 16\mu$ ; Fig. 8: entire size; Fig. 9:  $88 \times 112\mu$ , entire size  $48 \times 51\mu$ , corpus  $40 \times 48\mu$ , saccus breadth  $40\mu$ ). Exine of corpus provided with marginal crests, surface reticulate; meshes larger on sacchi than on corpus. Some grains are very small (Fig. 9). *Pinus gerardiana*, and *P. wallichiana* (grain size  $82\mu$ ) occur in Kashmir, while *P. roxburghii*, is absent in Kashmir but found to occur on the Southern slopes of the Pir Panjal Range (Sher Singh, 1929). Abnormal grains with varying numbers (1-4) of sacchi are known for the living species (Puri, 1945; Vishnu Mittre, 1957).

*Picea* (122): Fig. 10.

Grains 2-saccate. Entire grain size  $99 \times 144\mu$  (corpus size  $63 \times 99\mu$ ; saccus  $54 \times 90\mu$ ). Exine surface reticulate; meshes on corpus small and gradually passing into those of the sacchi.

*Picea smithiana* (entire grain size  $109 \times 147 \times 90\mu$ ) is the only species occurring in the Western Himalayas. Pure spruce forests are unknown in Kashmir, and in mixtures, it hardly exceeds 3.5% or even less (Sher Singh, 1929).

## DICOTYLEDONES

## ANACARDIACEAE

*Rhus* (1): Fig. 11

Grains 3-zonocolporate, subprolate ( $25 \times 22\mu$ ). Endocolpium alongate ( $2.8 \times 11.2\mu$ ), spindle-shaped. Exine about  $1.4\mu$  thick, surface striate-reticulate.

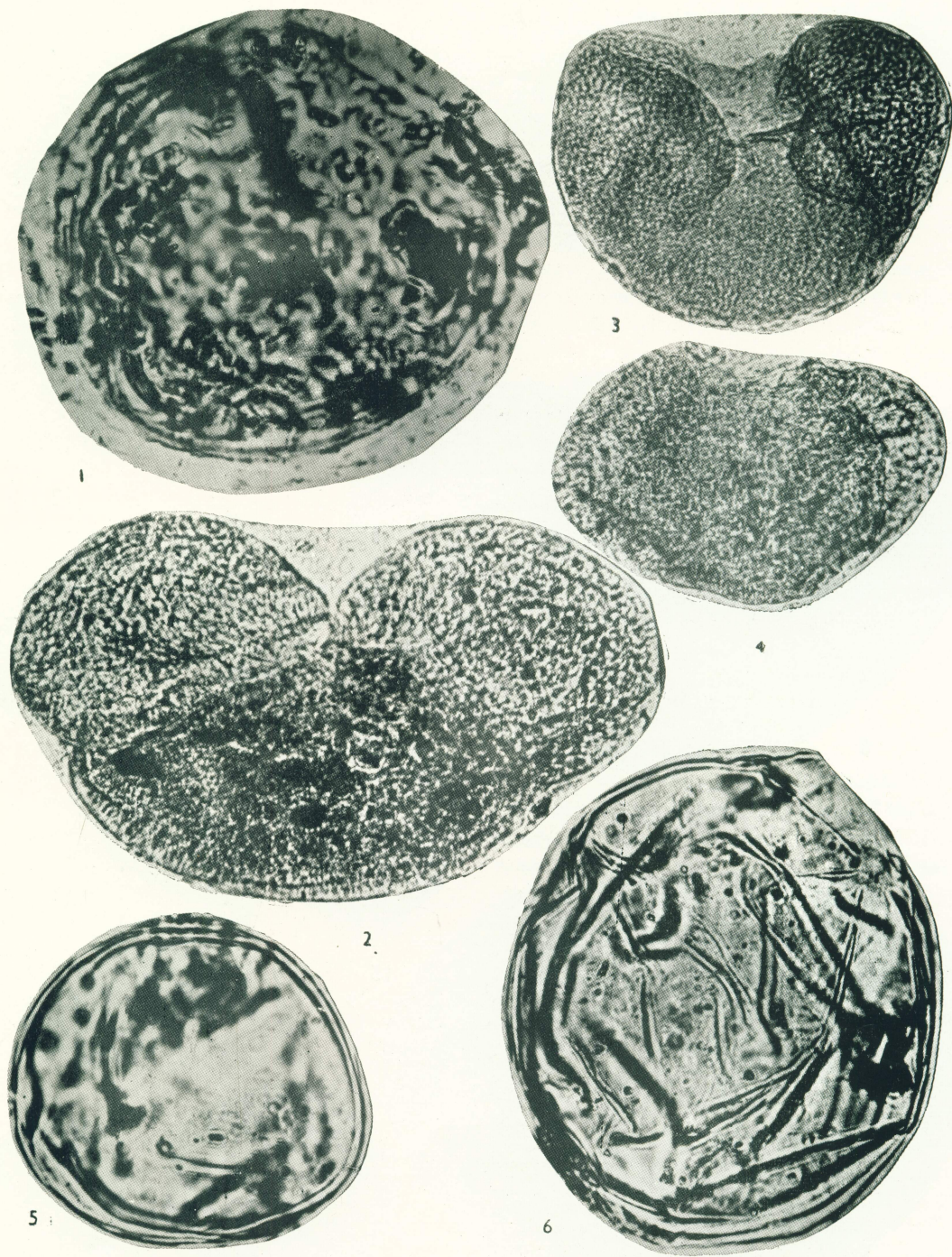
*Rhus continus* occurs in the Western Himalayas.

## EXPLANATION OF PLATE 6

1. *Riccia* (Proximal view).2. *Abies* (lateral view).3. *Cedrus* (lateral view).4. *Cedrus* (surface view).5-6. *Larix* (surface view).

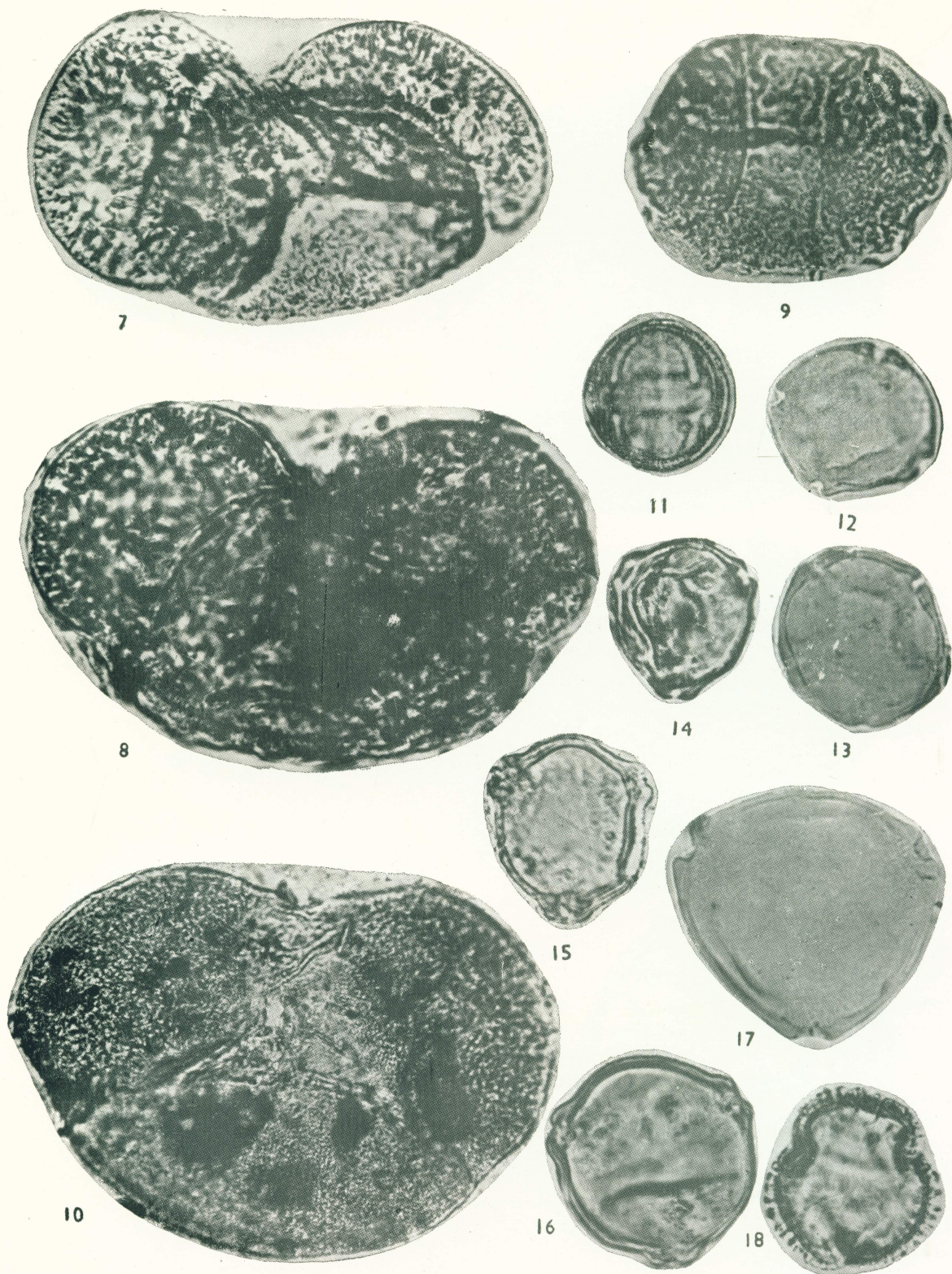
Magnification X 1000, except for Figs. 2-4. (X 500).





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BETULACEAE

*Alnus* (1303): Fig. 12-13.

Pollen grains 4-(5)-zonoporate. Equatorial diameter  $26-32\mu$ . Pores aspidote (aspis diameter  $7.8\mu$ ; mesaspidar diameter  $10.2\mu$ ). Exine  $1.4\mu$  thick. Arci connecting the pores characteristic. Exine surface faintly granulose.

*A. nepalensis* and *A. nitida* occur in the Western Himalayas. *Alnus* is absent from the present-day flora of the Kashmir valley, although they are abundant in neighbouring areas, beyond south of the Pir Panjal Ranges.

*Betula* (3): Figs. 14-15.

Grains, 3-4-zonoporate, amb circular (equatorial diameter  $27-32\mu$ ). Pores circular (diameter  $2.8\mu$ ), aspidote (aspidar diameter about  $9\mu$ ; mesaspidar diameter,  $27\mu$ ).

*B. utilis* (pollen diameter;  $E=32\mu$ ), and *B. alnoides* ( $E=28\mu$ ), occurs in the Western Himalayas. The fossil possibly belongs to *B. utilis*.

*Carpinus* (6): Fig. 16.

Grains 3-zonoporate. Equatorial diameter  $28\mu$ . Pores aspidote. Measpidar diameter  $13.5\mu$ . Exine  $1.4\mu$  thick, surface smooth.

*Carpinus viminea* occurs in the Western Himalayas.

*Corylus* (6): Fig. 17.

Pollen grains 3-zonoporate. Equatorial diameter  $45\mu$ . Aspis not well developed as in other genera of Betulaceae.

*C. colurna* (pollen diameter  $E=37\mu$ ); occurs in the Western Himalayas.

CAPRIFOLIACEAE

*Viburnum* (12): Figs 18 and 19.

Grains 3-zonocolpate, prolate spheroidal ( $35 \times 32\mu$ ). Exine  $1.4\mu$  thick, pilate (retipilate).

Several species of *Viburnum* occur in the Western Himalayas including Kashmir.

CHENOPODIACEAE

(250) Fig. 20.

Grains pantoporate, spheroidal (diameter  $28-33\mu$ ). Pore diameter  $2\mu$ . Exine  $1.4\mu$  thick, faintly granulose.

There are many genera and species belonging to Chenopodiaceae in the present-day flora of Kashmir of which *Chenopodium* is the best represented.

COMPOSITAE

*Artemisia* (193): Fig. 21.

Grains 3-zonocolpate. Equatorial diameter  $25\mu$ , Exine  $2.8\mu$  thick, tegillate, surface faintly granulose.

Several species of *Artemisia* occurs in Kashmir and other parts of Western Himalayas.

Other Compositae (25): Figs. 22-23.

Grains 3-aperturate (Fig. 22), lophate and (seem to belong to some members of the tribe Cichoreae: *Launea*, *Sonchus*, *Taraxacum* etc.). There are also other types which are 3-zonocolpate and spinose (Fig. 23).

FAGACEAE

*Quercus* (181): Figs. 24-25.

Grains 3-zonocolpate (colpate with a very faint endocolpium), prolate spheroidal

EXPLANATION OF PLATE 7

- |                                   |                                   |                                  |
|-----------------------------------|-----------------------------------|----------------------------------|
| 7-8. <i>Pinus</i> (lateral view). | 11. <i>Rhus</i> (equatorial view) | 16. <i>Carpinus</i> (polar view) |
| 9. <i>Pinus</i> (surface view)    | 12-13. <i>Alnus</i> (polar view)  | 17. <i>Corylus</i> (polar view)  |
| 10. <i>Picea</i> (lateral view)   | 14-15. <i>Betula</i> (polar view) | 18. <i>Viburnum</i> (polar view) |

Magnification X 1000, except for fig. 10 (X 500).



( $28 \times 26\mu$ ). Exine  $1\mu$ ). thick, surface faintly granulose.

Several species of *Quercus* occur in the Western Himalayas. But, it is significant that *Quercus* is absent from the Kashmir valley.

#### JUGLANDACEAE

*Juglans* (280) : Fig. 26.

Grains pantoporate (pores confined to one face), spheroidal (diameter  $45-55\mu$ ). Pores circular or slightly elliptical ( $2.1 \times 1.4\mu$ ); inter-polar distance various ( $12.5-15.6\mu$ ). Exine  $2\mu$  thick, surface granulose (faint L0).

*Juglans regia* is found in the temperate regions of Himalayas including Kashmir.

#### LENTIBULARIACEAE

*Utricularia* (1) : Fig. 27

Grains stephanocolpate (colpi 13), spheroidal (diameter  $35\mu$ ). Exine thin, surface smooth.

*U. flexuosa* is found occurring in Kashmir lakes.

#### NYMPHAEACEAE

*Nelumbo* (60) : Fig. 28.

Grains 3-zonocolpate, (colpi indistinct), spheroidal (diameter  $77\mu$ ). Exine about  $5.6\mu$  thick, surface punctate-retipilate.

*Nelumbo nucifera* occurs in the lakes of Kashmir.

#### ONAGRACEAE

*Jussieuia* (1) : Fig. 29.

Grains 3-zonocolporate, amb circular (equatorial diameter  $84\mu$ ). Colpi small, aspidote;

endocolpium (syn. ora) circular and the ectocolpium (syn. colpus) lies within the limits of the endocolpium.

#### PLANTAGINACEAE

*Plantago* (1582) : Figs. 30-31.

Grains pantoporate, spheroidal (diameter  $25-39\mu$ ). Exine  $1.4\mu$  thick, surface granulose.

The fossil grains compare closely with those of *P. lanceolata*. There are a few more species of *Plantago* occurring in the Western Himalayas.

#### POLYGONACEAE

*Polygonum*

(i) *P. sp.* (10) : Fig. 32.

Grains 3-zonocolporate, prolate ( $21 \times 14\mu$ ). Polar ends nearly straight. Exine  $1.4\mu$  thick, surface smooth.

The fossil grains compare well with those of *P. plebejum*, which is presently found in Kashmir.

(ii) *P. sp.* (12) : Fig. 33.

Grains pantocolpate, spheroidal (diameter  $49\mu$ ). Exine  $3.8\mu$  thick, reticulate.

The fossil grains are comparable to those of *P. amphibium*, which occurs in the area at the present-day.

(iii) *P. sp.* (7) : Fig. 34.

3-zonocolporate, subprolate ( $39 \times 34\mu$ ). Endocolpium (syn-ora) alongate ( $5.6 \times 7.7\mu$ ). Exine  $2.8\mu$  thick, surface foveolate.

There are several species of *Polygonum* in Kashmir and other parts of Western Himalayas.

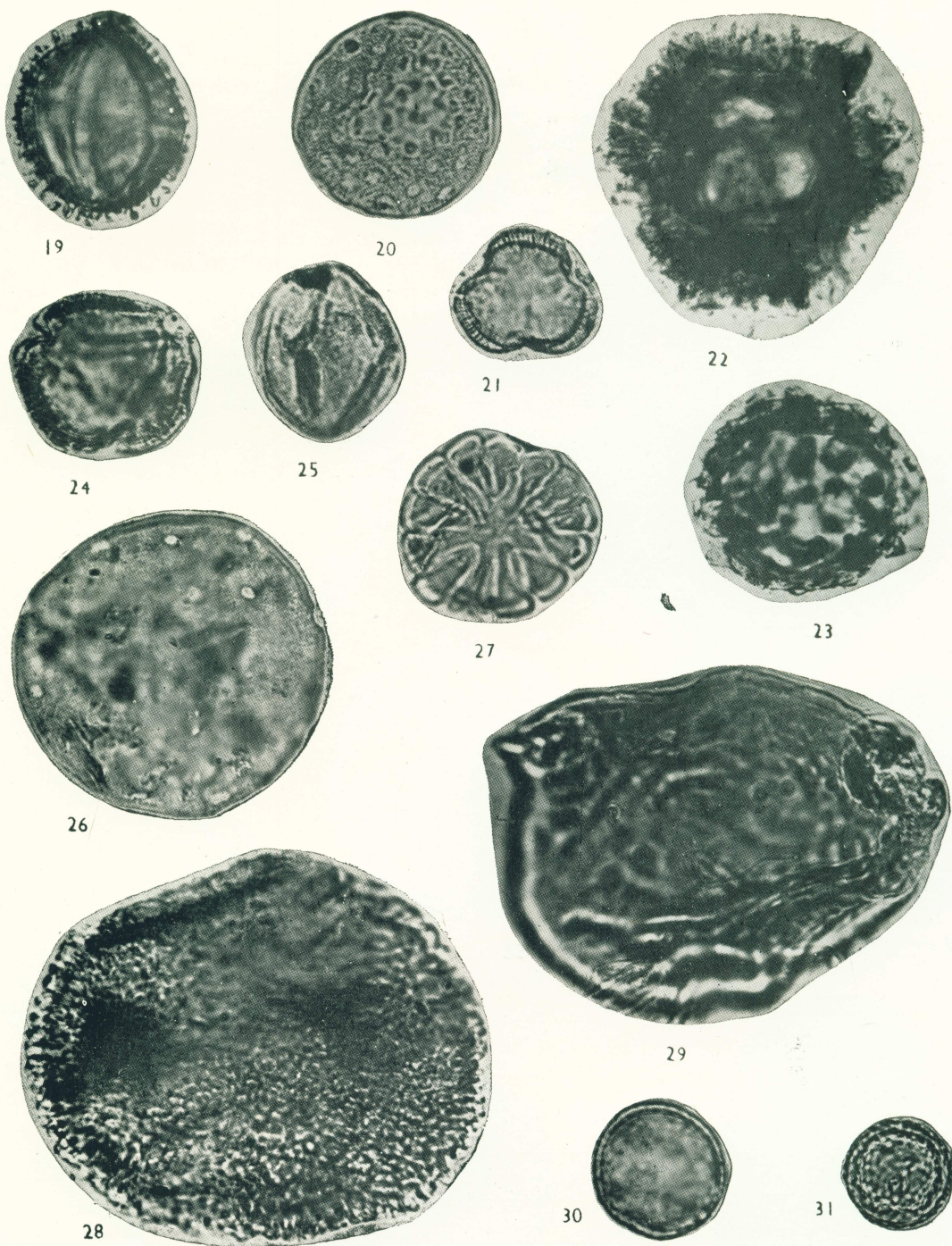
### EXPLANATION OF PLATE 8

Magnification X 1000

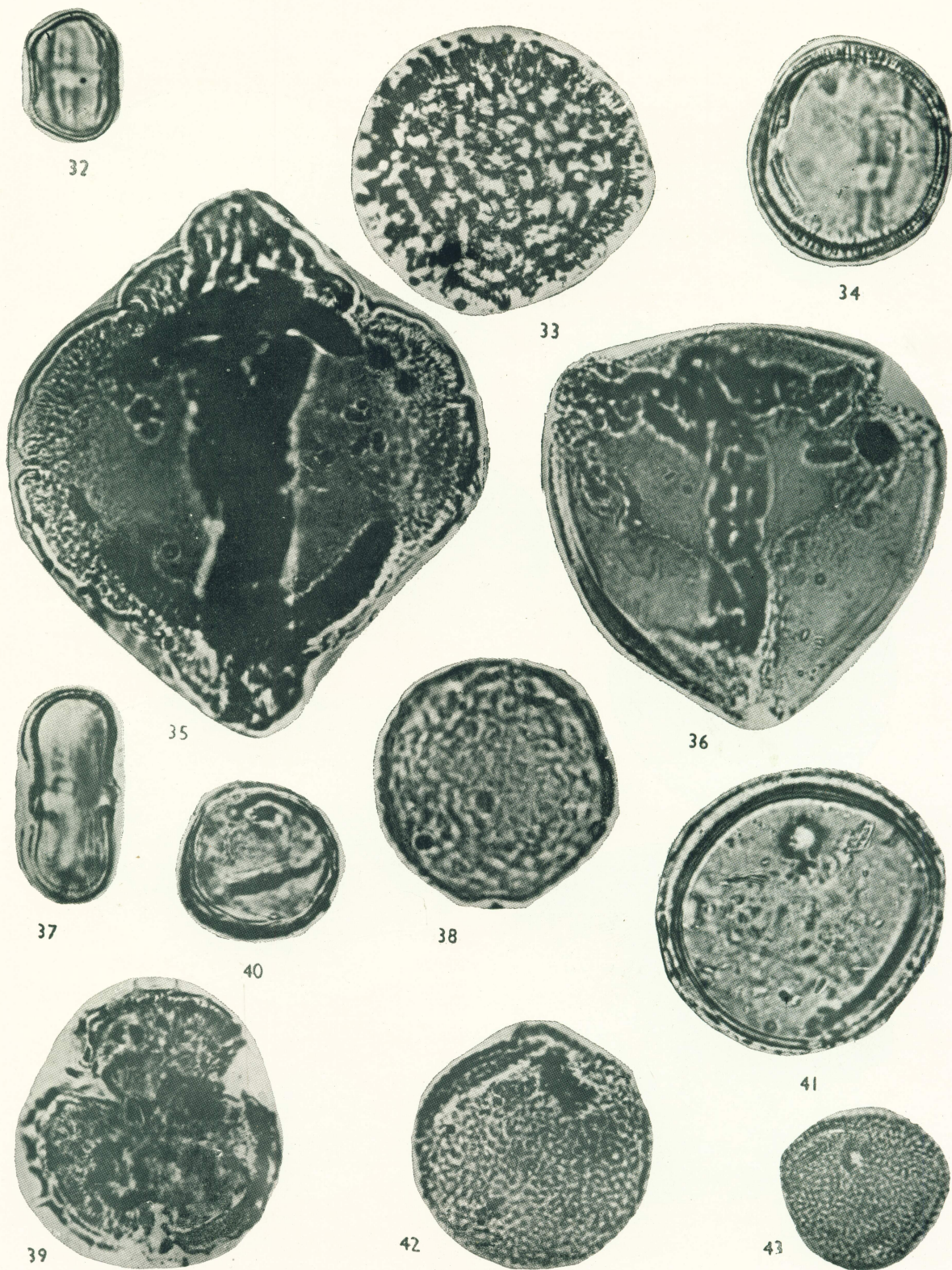
19. *Viburnum* (equatorial view)
20. *Chenopodium* (surface view)
21. *Artemisia* (polar view)
22. Compositae (equatorial view)
23. Compositae (Cichoriace)
24. *Quercus* (polar view)

25. *Quercus* (equatorial view)
26. *Juglans* (surface view)
27. *Utricularia* (polar view)
28. *Nelumbo* (equatorial view)
29. *Jussieuia* (polar view)
- 30-31. *Plantago* (surface view)











## TRAPACEAE

*Trapa* (127) : Figs 35-36.

Grains 3-zonocolpate, oblate spheroidal ( $75 \times 82\mu$ ); Equatorial and polar diameters are sometimes similar ( $75\mu$ ). Three meridional crests are conspicuous.

*T. natans* occurs in the Kashmir lakes. Fossil fruits of *Trapa* are also known from the Karewas.

## UMBELLIFERAE (4) : Fig. 37.

3-zonocolporate, perprolate ( $34 \times 16.8\mu$ ). Endocolpium lalongate ( $2.8 \times 4.2\mu$ ). Exine  $1.4\mu$  thick, surface granulose.

The family is stenopalynous. There are several genera and species of Umbelliferae in Kashmir and other parts of the Western Himalayas.

## URTICACEAE

*Ulmus* (27) : Fig. 38.

Grains 5-zonoporate, spheroidal (diameter  $26-28\mu$ ). Pores circular (diameter  $26-28\mu$ ). Exine  $1.4\mu$  thick, surface with irregularly shaped luminoid areas.

*U. wallichiana* is the common species occurring in Kashmir.

## VALERIANACEAE

*Valeriana* (3) : Fig. 39.

Grains 3-zonocolpate, amb circular (diameter  $48\mu$ , inclusive of spines). Exine surface spinose; spines with a bulbous base.

There are several species of *Valeriana* occurring in the present-day flora of Kashmir.

## MONOCOTYLEDONES

GRAMINEAE (82) : Figs. 40-41.

Grains 1-porate. Size various (diameter  $24-49\mu$ ). Pores provided with annulus.

Gramineae is a stenopalynous family. Several genera and species occur in Kashmir valley and the Western Himalayas. Wodehouse (1935) compared the grass pollen from Karewas to those of *Poa annua*.

## TYPHACEAE

*Typha* (1008) : Fig. 42-43.

Grains 1-porate, spheroidal (diameter various,  $25-39\mu$ ). Pore ill-defined. Exine  $1.4\mu$  thick, surface reticulate.

*Typha laxmanni* and *T. angustata* occur in the present-day aquatic flora of Kashmir.

## FLORAL SUCCESSION

As evident from Text-fig. 1, there was a dominance of herbaceous vegetation composed of *Typha* and Chenopodiaceae during the early stages of the lower Karewas. Arboreal vegetation composed of *Pinus*, and *Cedrus* are found dominating in the succeeding stages up to the middle of the First Interglacial. After this, there is a significant dominance of *Alnus* followed by its sudden fall, but with a corresponding increase of *Pinus* among trees, and *Plantago* among herbs. A detailed account of the floral succession is given elsewhere (Nair, 1960).

## EXPLANATION OF PLATE 9

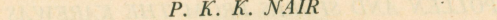
Magnification  $\times 1000$ .

- |   |                                    |
|---|------------------------------------|
| 32. <i>Polygonum plebejum</i> (equatorial view) | 37. Umbelliferae (equatorial view) |
| 33. <i>Polygonum sp.</i> (equatorial view)      | 38. <i>Ulmus</i> (polar view)      |
| 34. <i>Polygonum sp.</i> (polar view)           | 39. <i>Valeriana</i> (polar view)  |
| 35. <i>Trapa</i> (equatorial view)              | 40-41. Gramineae (lateral view)    |
| 36. <i>Trapa</i> (polar view)                   | 42-43. <i>Typha</i> (lateral view) |



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