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VEGETATION AND CLIMATE OF THE DMANISI MAN PERIOD (EAST GEORGIA) FROM PALYNOLOGICAL DATA

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ABSTRACT. As a result of palynological studies of coprolites from the bone-beds of Dmanisi containing remnants of the most ancient man dated back to the Late Tertiary (1.8 mln years BP) a list of palynoflora ratcher rich in its taxonomic composition has been established. Ecological analysis of the components of the spore-pollen spectra is indicative of existence of diversified vegetation formations in Southern Georgia. At that period the vertical belts were clearly expressed there. The mountains were rather high: the avaiability of such elements as *Selagilella selaginoides*, *Lycopodium alpinum*, *Botrychium* bears witness to existence of the alpine and, probably, subnival vegetation belts. In the region under study the high-mountain forests consisted mainly of *Abies*, *Betula*, *Pinus* with some admixture of *Fagus*. The middle mountains were covered by broadleaved forests with *Fagus*, *Carpinus*, *Ulmus*. In the low-mountain belt *Castanea*, *Tilia* and *Quercus* were prevalent. All the mentioned formations could be spread on the offshoots of the Javakheti range and on the high steps of the Dmanisi plateau. At lower altitudes and adjoining plain, meadow-steppe or forest-steppe vegetation seemed to grow. The lowland climate radically differed from that of the adjoining mountains. The palynological data are in good agreement with the results of studies of the vertebrate fauna.

KEY WORDS: Coprolites, vertebrates, palynology, paleoecology, Dmanisi man

INTRODUCTION

In November 1987 the Palynological Laboratory of the Institute of Palaeobiology of the Georgian Academy of Sciences received some material (coprolites) taken from the bone-beds of Dmanisi (East Georgia). The results of the palynological analysis turned out to be unexpectedly interesting. However, we did not venture to make far-reaching conclusions based on the studies of single samples. That is why the palynological data have not been reflected fully enough in the literature unitil now. Nevertheless, some brief information appeared for the first time in the paper "The environment of ancient fossil people in the Caucasus" (Gabunia et al. 1988), and the conclusions of the palynological analysis were used by palaeontologists in the subsequent years (Vekua A. K. & Vekua Z. A. 1988, Vekua A. K. 1991).

After the sensational discoveries made in Dmanisi in September, 1991, and after the fact of the most ancient man of the territory of Georgia became known to scientists, the obtained palynological data seem to have become of pecial interest not only for reconstruction of palaeoecological situation characteristic of the period of the Dmanisi man, but they also clarify a lot of archaeological problems of the Stone Age in Georgia and, probably, in Euroasia as a whole.

MATERIAL AND METHODS

The fossil coprolites were first treated with KOH solution, further by flotation methods and acetalized by the Erdtman (1943) method. The pollen and spores were analyzed on preparations in glycerine solution using the M8iJ-15 light microscope. The investigated material is kept in a collection of the Palaeobotanical Department of the Institute of Palaeobiology of the Georgian Academy of Sciences, Tbilisi.

The percentage count of the pollen and spores was made for separate groups: 1) arboreal and shrubs, 2) herbaceous plants and 3) spore-bearing plants.

Material saturation with polen and spores is average, but they have been preserved very well. It should be noted that zoogenic formations among other sediments both of organic and inorganic origin are characterized by extremely good preservation of pollen and spores (Zaklinskaya 1954, Tikhomirov & Ukraintseva 1973, Straka 1975, Ukraintseva 1988a, 1988b, Dinesman et al. 1989, Kvavadze et al. 1992).

RESULTS

One gram weight of the analyzed material contains 370–309 pollen grains and spores. Among them arboreal plants account for 32–38%, herbaceous plants account for 8%, while spore-bearing plants account for 60–52 % (Tab. 1, Fig. 1 Pls 1, 2). Among the arboreal plants the pollen of *Alnus* (21–20%), *Fagus* (21–13%) and *Pinus* (27–21%) predominates. There is a considerable amount of the *Abies* pollen (7–8%). The *Cedrus* pollen was found in single grains. The proportion of broad-leaved trees is equal to 38–30%. They are represented by *Fagus* (21–13%), *Castanea* (12–11%), *Tilia* (6–3%), *Carpinus* (2–1%). There are single pollen grains of *Ulmus*, *Salix*, *Betula.* Among shrubs the pollen of *Rhododendron* (2–3%), *Corylus* (3–2%) and *Vaccinium* (2%) is predominant. The content of *Cornus* is insignificant.

Table 1. Percentage of pollen and spores of Upper Tertiary deposits of various genesis in East Georgia

Location	Dmanisi		Javakheti		Kvabebi	
Deposit genesis	coprolites		lacustrine		marine	
Number of samples	1	2	1	2	1	2
1	2	3	4	5	6	7
Taxons(%)						
AP	38	32	73	35	56	45
NAP	8	8	18	64	42	55
Spores	52	60	9	–	1	–
Abies sp.	8	7	–	2	–	–
Cedrus sp.	2	–	–	5	11	

Table 1. Continued

1	2	3	4	5	6	7
Picea orientalis L.	–	–	1	–	5	5
Pinus sp., *Juniperus* sp.	–	–	3	2	5	–
Junglans regia L.	–	–	2	4	–	–
Salix sp.	–	1	:	–	–	–
Alnus sp.	21	20	50	64	20	–
Betula sp.	2	1	–	–	3	11
Carpinus caucasica Grossh.	2	1	3	4	–	5
C. orientalis Mill.	–	–	1	–	–	11
Corylus sp.	1	3	1	4	3	5
Castanea sp.	11	12	7	4	2	5
Fagus orientalis Lipsky	21	13	–	4	3	–
Quercus sp.	–	–	–	–	1	–
Ulmus sp.	1	1	–	–	–	–
Platanum sp.	–	–	3	5	2	–
Tilia caucasica Rupr.	3	6	12	4	10	5
Cornus sp.	1	1	–	–	–	–
Vaccinium sp.	3	1	–	–	–	–
Rhododendron sp.	3	2	–	1	–	–
Gramineae gen. indet.	3	12	21	6	22	9
Cyperaceae gen. indet.	3	8	–	–	2	–
Carex sp.	:	:	:	–	2	–
Chenopodium sp.	3	8	–	–	:	–
Chenopodiaceae gen. indet.	–	–	3	50	28	13
Artemisia sp.	–	4	3	18	23	50
Compositae gen. indet.	9	8	–	8	2	13
Polygonaceae gen. indet.	9	24	–	–	:	–
Caryophyllaceae gen. indet.	3	–	–	–	2	–
Rosaceae gen. indet.	–	–	6	–	–	–
Geraniaceae gen. indet.	–	4	–	–	–	–
Convolvulaceae gen. indet.	–	–	10	–	–	–
Leguminosae gen. indet.	3	–	–	1	–	–
Plumbago sp.	6	:	–	–	–	–
Umbelliferae gen. indet.	–	–	–	–	2	–
Lebiatae gen. indet.	–	–	–	–	2	4
Plantago sp.	6	:	22	2	–	9
Urtica sp.	–	–	10	–	–	–
Ranunculaceae gen. indet.	–	12	–	–	–	–
Onagraceae gen. indet.	–	4	–	–	–	–
Sparganium sp.	–	–	3	–	–	–
Typha sp.	–	–	6	–	–	–
Herbs	17	12	21	–	20	–
Lycopodium clavatum L.	2	5	–	–	–	–
Lycopodium alpinum L.	13	11	–	–	–	–
Lycopodium selago L.	1	2	–	–	–	–
Lycopodium sp. 1	:	1	–	–	–	–
Lycopodium sp. 2	–	1	–	–	–	–
Selaginella fusca N. Mczedl.	–	1	–	–	–	–
Selaginella selaginoides (L.) Link	1	–	–	–	–	–
Botrychium sp.	3	2	–	–	–	–
Pteris sp.	:	:	–	–	–	–

Table 1. Continued

1	2	3	4	5	6	7
Pterypodium sp.	–	1	19	–	–	–
Polypodiaceae gen. indet.	61	66	69	–	99	–
Dryopteris sp.	6	4	–	–	–	–
Asplenium sp.	2	2	–	–	–	–
Athyrium sp.	2	2	–	–	–	–
Polystichum sp.	–	1	–	–	–	–
Blechnum sp.	–	2	–	–	–	–
Sphagnum sp.	–	2	–	–	–	–
Bryales gen. indet.	–	:	12	–	–	–
Unindentified trilete spores	12sp.	6sp.	–	–	1	–
Total number of calculated palynomorphs	370	309	187	154	152	40
Gram-weight	0.5g	0.5g	3g	3g	3g	1g
Number of taxons	45	50	26	18	27	15

The herbaceous group is represented by the pollen of *Chenopodiaceae*, *Compositae*, *Gramineae*, *Carex*, *Artemisia*, *Leguminosae*, *Caryophyllaceae*, *Polygonaceae*, *Plumbaginaceae*, *Ranunculus*, *Onagraceae*, *Geraniaceae*. One can see pollen grains of *Plantago*, which, as it is known, belongs to synantropic vegetation and grows on trampled out sites (Iversen 1941, Behre 1981, 1986, Berglund 1985).

The composition of spore-bearing plants is distinquished by an unusual abundance and diversification. Monolete spores of ferns deprived of perisporium are predominant (up to 66–61%), but there are also a lot of spores with preserved perisporium. These are *Asplenium*, *Athyrium*, *Blechnum*, *Dryopteris*, *Polystichum*. Considerable place in the spectrum are taken by lycopods: *Lycopodiun alpinum*, *L. clavatum*, *L. selago*, *Lycopodium* sp. There are also spores of *Botrychium*. As for *Selaginella selaginoides*, *S. fusca*, *Sphagnum*, they are found as single spores. There are also trilete spores of ferns which cannot be defined.

It should be noted that one and the some colour of sporomorphs allows us to claim that redeposited forms are absent.

The prevence of such hydrophillous elements of the flora as spore-bearing plants, *Abies*, *Fagus*, *Castanea* and some others in the spore-pollen spectra made us compare the pollen spectra of the coprolites with those of the even-aged deposits of mineral origin.

It can be seen that the former differ not only by better preservation of sporomorphs, but also by considerable taxonomic abundance of the palynocomplex (Tab. 1). The same conclusion was drawn as a result of our investigations of Holocene deposits of various types (including coprolites).

The comparison of the spore-pollen spectra of the coprolites from Dmanisi with those of lacustrine and marine deposits of the adjacent territories (Tab. 1, Fig. 1)[1] shows

[1] The data on palynological studies of the deposits from Kvabebi and Javakheti is partially published (Vekua & Kvavadze 1981, Vekua et al. 1985).

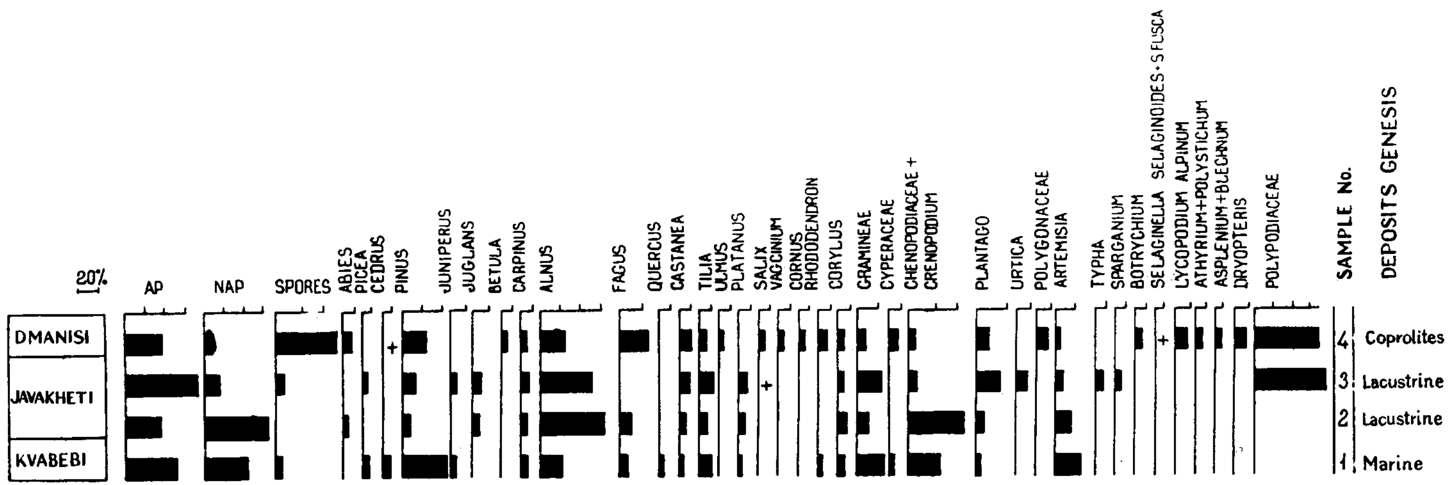

Fig. 1. Spore-polen spectra of the Upper Tertiary deposits of Dmanisi, Javakheti and Kvabebi

rather interesting reguliarities. In the whole vegetation the spore-bearing plants reach threir maximum values (up to 52–60%) in the coprolite spectra; in the lacustrine and marine deposits their content does not exceed 9% and 1%, respectively. The coprolite spectra from the Holocene deposits of Ardon gorge in North Ossetia at an altitude of 1650 m a.s.l. are also characterized by extraordinary abundance of microfossils of spore-bearing plants (Kvavadze et al. 1982). Herbaceous plants are mostly observed in the lacustrine deposits of Javakheti (up to 64%), their quantity is less in the marine deposits of Kvavebi (up to 42–55%), while in the coprolites their quantity does not exceed 8%. The amount of arboreal pollen in the lacustrine spectra reaches its maximum (up to 35–73%). In the pollen spectra of Kvavebi it does not exceed 45–56%, while in the coprolites it is equal to 33–38%.

It should be pointed out that among arboreal plants in all types of deposits the pollen of *Alnus* and *Picea* is predominated: up to 64% and 44%, respectively. In the marine deposits there is a lot of pollen of *Cedrus* (up to 11%) and *Picea* (up to 5%). There are no pollen grains of *Abies* there, while in coprolites they reach 7–8%. In the lacustrine deposits the content of the *Abies* pollen is equal to 2%, that of *Picea* – to 1%, while the *Cedrus* pollen was not found at all.

As for broad-leaved plants, in all deposits there is a lot of pollen of *Fagus*, *Castanea*, *Tilia*, *Carpinus*. The pollen grains of *Juglans* are only found in lacustrine deposits, those of *Quercus* in marine deposits, while those of *Ulmus* are registreted only in the coprolite spectra. *Platanus* is characteristic of spore-pollen spectra of lacustrine and marine formations. *Corylus* is found in equal quantities in all genetic types of deposits; the pollen of *Rhododendron*, *Juniperus*, *Vaccinium*, *Cornus* is registreted less often. Herbaceous plants are represented by *Gramineae*, *Compositae*, *Plantago* in all the deposits and almost in equal quantities. The pollen of *Chenopodiaceae* and *Artemisia* is mostly found in lacustrine and marine deposits.

Summing up the aforementioned, we can conclude that the taxonomic composition of the coprolite pollen spectra is much richer (45–80 taxons) than the spectra of the marine (Kvabebi) and lacustrine (Javakheti) deposits, which include 27 and 26 taxons respectively.

DISCUSSION

Ecological analysis of the components of the spore-polen spectrum under study is indicative of existence of rather diversified vegetation formations in Southern Georgia. It should be especially emphasized that at the end of the Tertiary period the vertical belts there were clearly expressed. The mountais were rather high: the availability of such elements as *Selaginella selaginoides*, *Lycopodium alpinum*, *Botrychium* point to the existence of high-alpine and, probably, subnival vegetation belts in the Minor Caucasus. High-mountains forests consisted of *Abies*, *Betula*, *Pinus* with admixture of *Fagus*. In the undergrowth there was *Vaccinium*.

For the considered high-mountain phytocenoses with predominance of elements of the middle latitudes, *Cedrus* is alien, that is why its pollen grains should be considered as transported from the southern mountains of Asia Minor. Some researches (see Kvavadze 1991) repeatedly pointed to the ability of the *Cedrus* pollen to spread by winds for distances of several hundred kilometers.

The middle montain belt were covered with broad-leaved forests consisting of *Fagus*, *Carpinus* and *Ulmus*. In the low-mountain belt *Castanea* and *Tilia* were prevalent. There was also some admixture of *Quercus* there (Klopotovskaya 1989). *Corylux*, *Salix* and *Rhododendron* could grow both in the low- and high-mountain belts. Floodplain forests consisting of *Alnus* were rather widely spread. In the undergrowth of the forests in the mountains and on river banks along with *Corylus* and *Cornus* the fern and moss cover was intensively developed.

All the mentioned formations could be spread on the offshoots of the Javakheti range and on the high steps of the Dmanisi plateau. At the some time at lower altitudes and on the plain adjacent to the plateau there grew meadow and steppe as well as forest and steppe vegetation of the savanna type with prevalence of *Gramineae*, *Chenopodiaceae*, *Carex*, *Compositae*, *Artemisia*, etc. Composition of the herbaceous species suggests that the climate of the lowlands differed radically from that of the adjoining mountains. Considerable amount of *Chenopodiaceae*, *Artemisia* and *Gramineae* is indicative of arid climate of the lowlands. A similar conclusion was made on the basis of the data on coprolites by G. S. Avakov. From the bone-beds in Dmanisi he indentified the seeds of *Celtis glabrata* as well as numerous herbaceous plants of the *Boraginaceae* family which are peculiar to dry habitats. *Lycopsis orientalis* L., *Buglossiodes arvensis* (L.) Johnst, *Nonea flavescens* (C. A. Mey) Fisch et Mey were indentified up to the species level. The seeds of *Anchusa* sp. are encountered relatively more rarely. It is worth noting that many of the above mentioned plants are ruderal.

As for the adjoining mountain ranges, proceeding from the qualitative peculiarities of the spore-pollen spectra, one can claim that there was mild and rather humid climate there. The same conclusion was drawn by N. B. Klopotovskaya and D. O. Lortkipanidze who performed palynological analysis of the mineral formations of Dmanisi (Dzaparidze et al. 1989). Probably, this fact was caused not only by the meridional position of rather high Javakheti range intercepting humid air masses from the West, but also by intensive volcanic activity accompanied by a mass outburst of water vapour.

The results of the palynological and palaeocarpological analyses agree with the data on the fauna of vertebrates among which the inhabitants of open areas predominate (horse, *Etruscan rhinoceros*, southern elephant, hyena, marmot, hamster, gigantic ostrich.*)*. At the same time in the Dmanisi bone-beds the fragments of bones of the animals living only in forest sites were found (bear, deer, leopard, lynx, roe deer, wolf).

It should be pointed out that the palaeobotanical material has registered the existence of man in Dmanisi. This fact was established due to presence of remnants of weeds that accompany man. The amount of synanthropic vegetation is also rather considerable in the Late Tertiary lacustrine deposits in Javakheti (Fig. 1), which speaks in favour of man's existence on that territory as well.

Thus, as a result of palynological studies of fossil coprolites most interesting information was obtained concerning natural conditions of the Dmanisi man period. Besides, the foregoing material shows that the coprolite spectra are to a great extent averaged and they reflect the vegetation of rather a large region. At first sight this fact seems to be not only suprizing, but even puzzling. Food and drinking water are known to play an important part in information of a spore-pollen spectrum of animals on excrements. As for the coprolites from the Dmanisi bone-beds, they belong to predatory animals, namely, according to our assumption, to hyenas. Like many beasts of prey, hyenas are very strong, fierce and can run at a speed of 65 km/h. They are fed on carrion, though they attack animals thenselves. In search of food they can make far sorties in the radius of about 80 km (Novikov 1971). Thus, due to its high speed the hyena could visit a lot of landscape belts during a day. And if we take into account the fact that the ridge of Javakheti range is at a distance of 30–35 km only from Dmanisi, then it becomes clear in what way the coprolite spectra could reflect the pollen and spores from high mountains. Most probably, the animals made its sorties just along the Mashavera river gorge which was covered with flood-plane forests and was less dangerous for the animal. The headwater of the Mashavera is in the said ridge part of Javakheti range. Taxonomic abundance of the pollen spectrum can also be explained by that the hyena could have eaten a hebrivorous animal which come down from the mountain regions to the river valley. Probably, some other explanations can also be found. Nevertheless, proceeding from the factual material, we cannot deny that in the Upper Villafrank on the territory of South Georgia there were not only mountain forests characterized by rich taxonomic composition, including dark conifers-broad-leaved and broad-leaved formations, but also subalpine and alpine meadows.

In conclusion it should be emphasized that the comparison between the list of the palynoflora from Dmanisi which was obtained by us and the Late Tertiary leave floras of East Georgia (Uznadze 1965, Dolidze 1981, Shatilova & Ramishvili 1990) has shown that there is certain agreement between them.

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PLATES

All microphotographs were made under oil immersiom with the Apochromat × 100 N.A.1.32 objective, 4:1 projektive and Carl Zeiss Jena Matic equipment to the Amplival microscope. The magnification of all reproduced micrographs is × 1000.

Plate 1

1, 2. *Polypodiaceae*

3–5. *Lycopodium alpinum* type

6, 7. *Pteridium*

8. *Sphagnum*

10, 11. *Pinus*

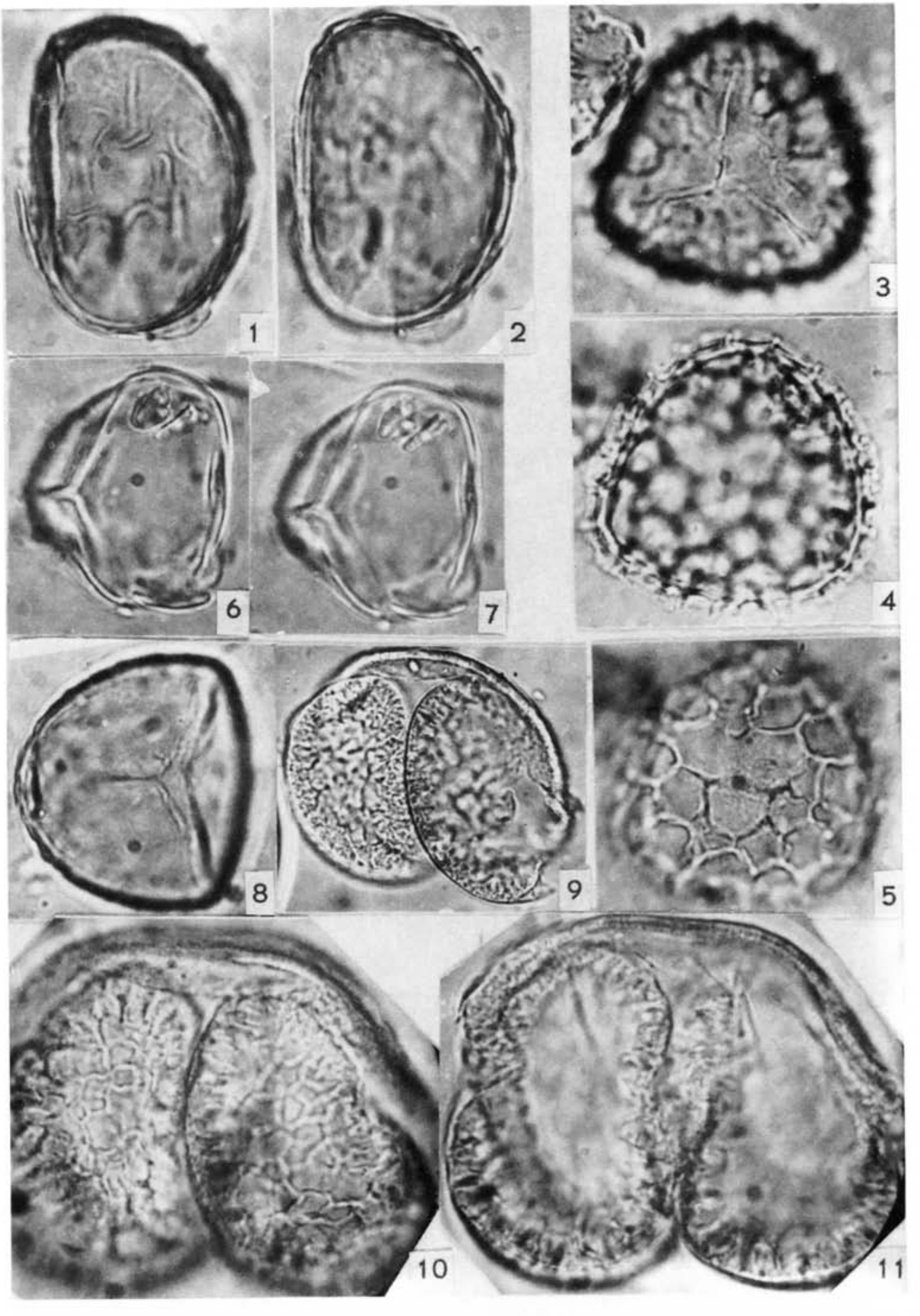
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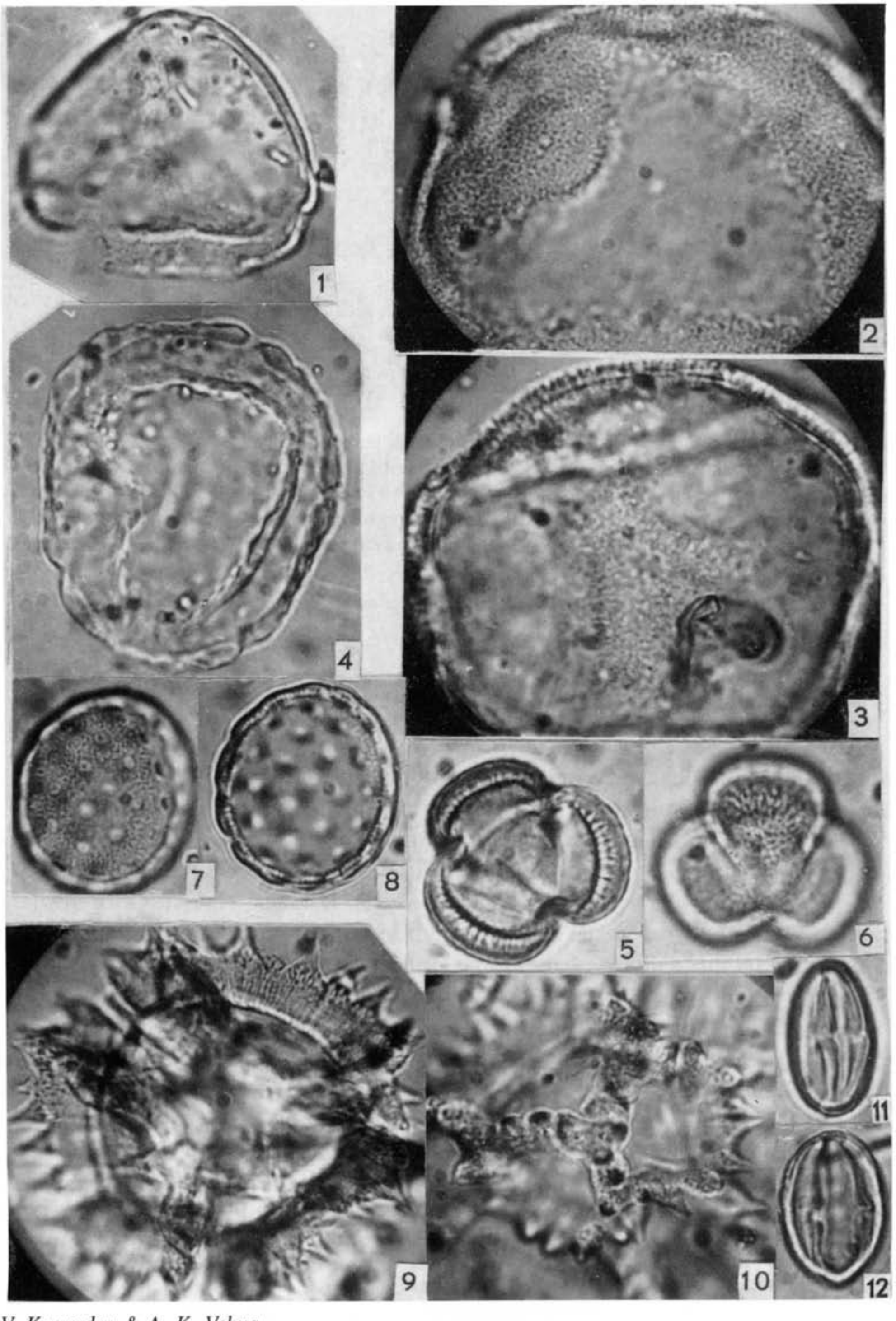
Plate 2

1.	*Corylus*
2, 3.	*Fagus*
4.	*Ulmus*
5, 6.	*Artemisia*
7, 8.	*Chenopodiaceae*
9, 10.	*Cichorium*
11, 12.	*Castanea*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