PERMIAN TRUE MOSSES OF ANGARALAND

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ABSTRACT.—In this paper the author deals with true mosses, first determined by her from leaves and shoots in the Upper Paleozoic of Angaraland and Permian in general. 14 species, either new or recently described, have been studied by the author from the Lower and Upper Permian sediments of Kuznetzk, Tungus and Pechora basins of the USSR, using the morphological-anatomical method. They belong to 10 genera, 7 of which belong to subclass Bryales : *Intia* Neub., *Salairia* gen. nov., *Uskatia* gen. nov., *Polyssaievia* Neub., *Bajdaievia* gen. nov., *Bachtia* gen. nov., *Muscites* Brongn., and 3 to subclass Sphagnales, to the order Protosphagnales Ordo nov.,—*Junjagia* gen. nov., *Vorcutannularia* (Pog.) Neub. and *Protosphagnum* gen. nov.

Some features of the structure of Sphagnales, observed in the morphological and anatomic structure of leaves of Bryales, lead us to suppose that the initial group of these two was Bryales mosses.

The presence of quite different genera of true mosses, already in Lower Permian, proves their wide development in the Upper Paleozoic but the appearance of mosses themselves must be dated back to Devonian at least.

The comparative study of leaf structure of Permian and recent Sphagnales, the latter taken in one of the earliest stages of their development, shows that the structure of their cellular network is similar.

The composition of mosses in the Lower and Upper Permian of Angaraland is different, the fact having significance for stratigraphy

The origin of peat-bogs in the conditions of Angaraland, the climate and landscapes of that time are discussed from the point of view of the presence of mosses in Permian vegetation. The presence of mosses in the flora of the Tungus botanical-geographical region and their absence or rarity in flora of Euramerian region can be explained, to the author's mind, by the difference of paleogeographic conditions in each of these regions during the Upper Paleozoic.

OF the two classes of Bryophyta, only the liverworts (Hepaticae) have been positively dated, beginning with the Carboniferous, whereas the true mosses (Musci frondosi) were, until recently, well represented from the Tertiary only. In sediments of earlier date, moss remains of this class are extremely rare. These include the two specimens of Sphagnales recently described by Reissinger (1950) from the Lower Jurassic of Germany, and the other two long known finds from the Upper Carboniferous of Central France referred to the Bryales (Renault and Zeiller, 1888). These imprints found in France have been preserved so badly that their relationship with the mosses has never been convincing. The reason for the absence or extreme scarcity of mosses in the Pre-Tertiary has been under discussion until recently.

The investigators have made various conjectures as to the cause of this circumstance, such as late phylogenetic development of mosses, the fragility of their cellular membranes rapidly destroyed in the course of fossilisation, the acquisition of antirot properties in the course of evolution after the appearance of the group itself, etc. Owing to the discovery of true moss remains in the Permian sediments of Angaraland, all such conjectures have now become invalid.

The absence of moss remains, at any rate, from the Upper Carboniferous to the Lower Jurassic, has left a wide gap in the palaeontological documentation of these plants, not allowing investigators to have any idea of the Pre-Tertiary history of true mosses, their development and phylogeny. This group had no significance whatsoever for purposes of stratigraphy, and contributed nothing to our concepts on the paleogeography of that time, for it was absolutely lacking in the Upper Paleozoic flora of Angaraland and in the Permian flora in general.

The fossil moss remains first discovered by the author in the bores from the Permian sediments of the Kuznetzk basin (1941-1942) were being found by her during several subsequent years among other vegetable remains in different collections submitted for determination from the sediments of the Kuznetzk, Tungus and Pechora basins all dated to the same time.

The author's work resulted in a collection of mosses comprising 212 specimens from drill bores, mining pits and natural outcrops and has formed the basis of her monographic studies.

It should be pointed out that moss remains had been found in the basins in question even earlier, but because of the superficial examination, the vegetable remains actually belonging to mosses had not been correctly indentified, and were erroneously referred to other groups such as conifers, lycopods and equisetites.

In studying this abundant material of fossil true mosses, the author employed the morphological-anatomical method, obtaining preparations by means of one of the most up-to-date techniques of modern paleobotany, chiefly, one of the variants of the so-called Peel transfer method, by which the relief of the fossil or its organic remains—the phytoleima—are transferred from the rock to a cellulose film for microscopical study.

By this method more than 400 preparations with leaves and shoots of mosses were obtained, with no trace, however, of any reproductive organs. It appeared that moss remains in the form of phytoleima, usually well preserved, were detected on all the rock specimens from the three basins mentioned.

This shows that the cellular membranes of the mosses endure fossilization quite well and that optimum preservation of moss remains in fossil state, as in case of other plants, depends only on the presence of suitable conditions such as were present in the Upper Paleozoic of Angaraland, and will be dealt with further on.

A detailed study of this material will be found in a monograph on the Permian true mosses of Angaraland now in preparation for publication. The present paper contains the main results of this study.

1. COMPOSITION OF PERMIAN TRUE MOSSES AND DATA ON THE HISTORY OF THEIR DEVELOPMENT AND PHYLOGENY.

A detailed study of the cellular structure of leaves and their impressions from the Permian coal-bearing sediments of the Kuznetzk, Tungus and Pechora basins helped to identify 14 moss species, 13 of them being new, belonging to 10 genera, 9 of the latter being new as well. One of these 10 genera is represented by four species, another by two, while the rest are monotypic.

These new data substantially fill in the gap in the palaeontological documentation of true mosses and with their aid we may attempt to outline the history of the development of this group at least from the Upper Carboniferous.

In the size of their leaves, the fossil mosses do not exceed the limits known for the recent mosses:

According to the nature of the cellular network of the leaf-blade and partly the form of the leaves, the mosses in question may be divided into two groups.

In the first group, with a sufficient variety of leaf cells, the cellular network of the leaves does not show any stable differentiation (dimorphism) of cells. Consequently, the structure of the leaf as a whole, as well as its cell structure, although bearing certain distinctions, allows us to refer the forms of this group to the modern subclass Bryales. To this subclass the following Lower Permian mosses are referred: (1) *Intia vermicularis* Neub., (2) *I. variabilis* Neub., (3) *I. falciformis* sp. nov., (4) *I. angustifolia* sp. now., (5) *Salairia longifolia* gen. et. sp. nov., and the Upper Permian mosses, (6) *Uskatia conferta* gen. et sp. nov., (7) *Polyssaievia spinulifolia* (Zal.) Neub., (8) *P. deflexa* sp. nov., (9) *Bajdaievia linearis* gen. et sp. nov., (10) *Bachtia ovata* gen. et sp. nov., and (11) *Muscites uniforme* sp. nov.

The second group of mosses is characterized by leaves, the cellular network of which distinctly reveals a sphagnum-type cellular dimorphism ; therefore, this group is placed in the subclass Sphagnales. Due to a number of peculiarities in leaf structure, however, this group is classified as a new order—Protosphagnales—ordo. nov. To this Order we refer two Lower Permian moss species : (12) *Junjagia glottophylla* gen. et sp. nov., (13) *Vorcutannularia plicata* Pog. in litt. emend. Neub., and one Upper Permian, (14) *Protosphagnum nervatum* gen. et sp. nov.

The first striking feature in the leaf structure of Paleozoic mosses of all the genera (except *Muscites uniforme* for which only a fragment of the leaf blade is known) is the presence of a distinct midrib separating the lateral nerves in some species including Sphagnales, the recent representatives of which have no midrib at all.

In Bryales the genera are so different in morphology and cellular structure of leaves, that there can be no doubt about the independence of each but now it is hard to note any evidence of genetic affinity between the Upper and Lower Permian representatives of this group. This may be also explained, of course, by the very limited composition of this group known as yet, considering the enormous period of time over which it extends. On the other hand, it may be supposed that such diversity of distinctive moss genera already in the first collections indicates their undoubtedly extensive development in the Upper Paleozoic of Angaraland, and the antiquity of their origin.

Among the Lower Permian mosses of this group, the genus *Intia* has lanceolate or oblong-oval leaves with dentate margin, the cellular network of the blade consisting of vermiculate cells arranged in oblique or vertical rows (Pl. 1, figs. 1-6). On the other hand, the ribbon-like leaves of *Salairia* are characterized by a network of large, uniform, polygonal cells (Pl. 3, fig. 13). Likewise widely diverse are the Upper Permian mosses. The linear-lanceolate or elongate-ovate smooth-margin leaves of *Uskatia* with a cellular network of polygonal, rhombic or rectangular cells increasing in size towards the base (Pl. 3, figs. 14-16) are distinctly different from the acuminate leaves with sac-like (concave) bases of *Polyssaievia*, the cellular network of which is characterized by rather complicated intertwining—"lateral nerves" (Pl. 2, figs. 7-10). The very small moss *Bajdaievia* is noted for its almost linear leaves, the cellular network consisting of small irregular-shaped cells. The blade of the ovate leaves of *Bachtia* is characterized by collenchymatic cells (Pl. 2, figs. 11, 12).

Most interesting in the subclass Bryales is the genus *Intia* represented by four species in the Lower Permian of the Pechora basin. In leaf shape and sometimes in cellular structure, but not in the structure of the marginal border, it resembles the representatives of the modern genera *Bryum* or *Mnium.* But apart from that, it reveals a number of features peculiar to Sphagnales and, along with other traits, of the fossil representatives of the latter. The following features are noted in the leaf structure of *Intia* :

(a) The cell groups resembling the primary triads of Sphagnum but without any signs of functional differentiation between the cells, occasionally appearing in the cellular network of the leaves of *Intia* among the vermiculate or oval-vermiculate cells arranged in rows so typical of the genus in question (Pl. 1, fig. 6) ;

(b) the origin of marginal serration,—the dents are formed not by independent cells but in the author's opinion, by the lower parts of the outer

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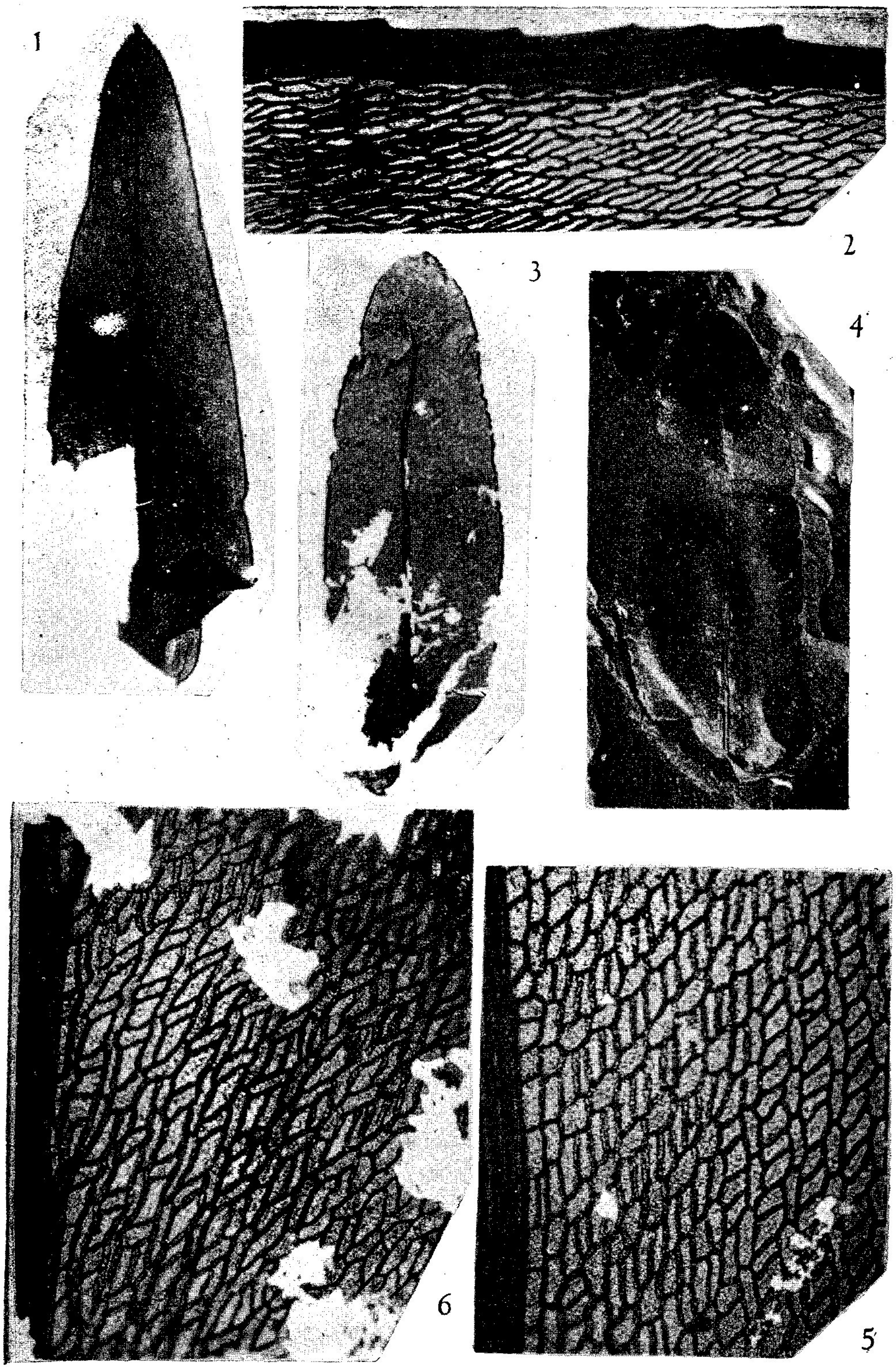
Explanation of Plate I

Figs. 1 and 2—*Intia vermicularis* Neub., Pechora basin. Upper Vorcutan suite. Lower Permian. Fig. 1—Holotype, ×10. Fig. 2—leaf margin with dentate border, ×150.

3-6—*Intia variabilis* Neub. Pechora basin. Lower Vorcutan suite. Lower Permian. Fig. 3—leaf transferred to a film. Fig. 4—impression of the same leaf, ×10. Holotype. Fig. 5—cellular network near midrib with vermiculate cells lying in oblique and vertical rows, ×150. Fig. 6—the same, with sphagnum-like cell arrangement, ×150.



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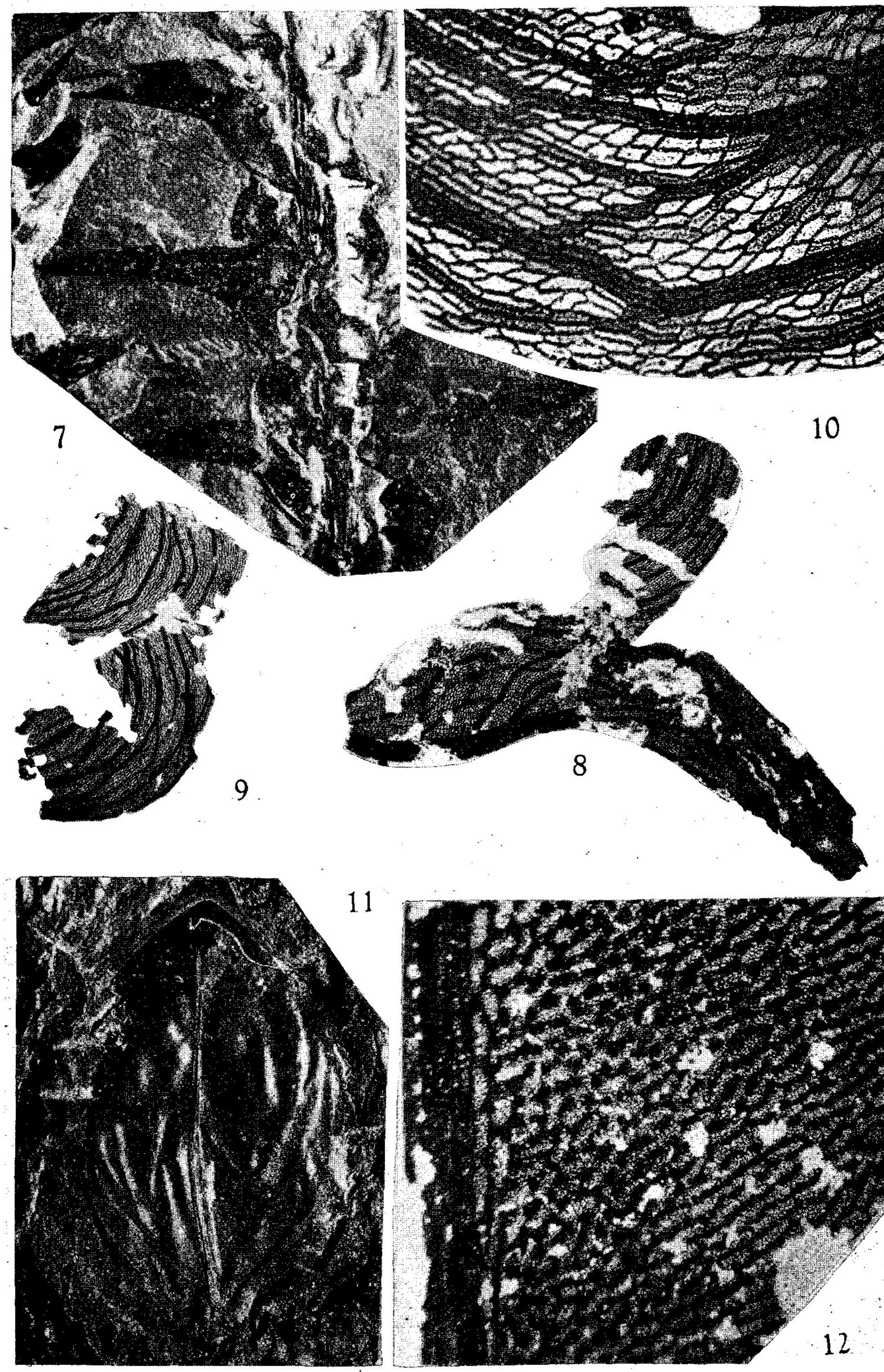

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walls of the marginal prosenchymatic cells of the leaf border, the upper parts probably being destroyed (Pl. 1, fig. 2);

(c) the presence of a colourless bordering of the leaf margin typical for the leaves of *Sphagnum* (see the figure cited above and Pl. 4, fig. 22).

The three genera of the subclass Sphagnales may also be easily distinguished by their form and by the details of the cellular structure of their leaves, but, at the same time, they are affined by the common sphagnoid structure of their cellular network.

As regards the external structure of their leaves, the two Lower Permian genera are noted for blade undulation, less typical for *Junjagia* and more for *Vorcutannularia* (Pl. 3, figs. 17, 18) in which the structure of the leaf margin is similar to that of the following fossil genus.

In the third genus—the Upper Permian *Protosphagnum*–the leaves are flat and oval. Such leaves together with the nature of their marginal dentation, the colourless border of the leaf margin and the distinct midrib, on the one hand, associate this genus with the Lower Permian bryal moss *Intia*, and on the other, resemble the leaves of twigs of *Sphagnum* of which, however, the midrib is not characteristic (Pl. 4, figs. 20-23).

Further, while in *Intia* the sphagnoid cell arrangement bereft of functional significance is found in the cellular structure of the blade only occasionally, the distinct and permanent sphagnoid dimorphism in the leaf structure in all the above-mentioned genera is a common and characteristic feature. This sphagnoid structure, however, having certain peculiarities in each of the three fossil genera, is quite primitive as compared to the structure of the recent *Sphagnum*, for the structure of the meshes of the assimilative network is usually confined to primary, elementary triads with two chlorophyll-carrying and one hyaline cell. Although the hyaline cells, as well as the meshes of the assimilative network, do not practically differ in size from the hyaline cells of modern *Sphagnum*, their structure in fossil forms is more simple. Their walls bear no thickenings or openings so typical of adult leaves in modern *Sphagnum*, but they have only one or two (occasionally several) thin partitions situated obliquely to the longitudinal axis of the hyaline cell and dividing it into 2-3 (sometimes several) daughter cells. Alongside of this, more complex T-shaped partitions (Pl. 4. fig. 23) may be observed in the Upper Permian *Protosphagnum.*

This structure of the cellular network, especially pronounced in the adult leaves of *Protosphagnum*, resembles the leaf structure in the young stage of the modern *Sphagnum* (e.g., see Campbell, 1940, fig. 89c).

In short, the obvious conclusion is that in ontogenesis the leaves of modern *Sphagnum*, so to say, repeat the phylogenetic development of the leaves of the group.

According to the most widespread modern conception, the origin of Sphagnales is associated with the leafy liverworts (Jungermaniales akroginae). However, the Permian true mosses with their distinctive morphological and anatomical structure of the leaves reveal no significant traces of close affinity with the Carbon-Permian liverworts.

As for the noted similarity in morphological leaf structure between some Permian representatives of Bryales and Sphagnales, does it not indicate that the original group of these two was Bryales, the cellular network structure of which had already revealed certain sphagnoid features in their cell arrangement and in the nature of their leaf border or at least its margin ?

The noted peculiarities of some bryal mosses could at first have developed as a necessary adaptation to moist environment. These features proving useful were stabilized and perfected in the course of the historical

Explanation of Plate 2

Figs. 7-10—*Polyssaievia spinulifolia* (Zal.) Neub. Kuznetzk basin. Yerunakov suite. Upper Permian. Fig. 7—impression of a shoot, ×10. Neotype. Fig. 8—leaf blade and Fig. 9—leaf bases transferred to a film, ×30. Fig. 10—part of cellular network from leaf base, ×150.

11-12—*Bachtia ovata* gen. et sp. nov., Tungus basin. Peliatkin suite. Upper Permian. Fig. 11—leaf impression, ×10. Holotype. Fig. 12—part of cellular network of leaf, ×150.

evolution of the group. As a result, already in the Upper Permian there appeared a branch well adapted to its permanently moist conditions of habitat. So far, this group is represented by a genus—*Protosphagnum*. With further perfection in organisation under the same conditions, the midrib proved superfluous and was lost in the course of evolution already towards the Lower Jurassic, while the water-carrying hyaline cells with their complex structure typical of modern *Sphagnum* underwent further development.

Available data seem to indicate that representatives of Bryales and Sphagnales existed simultaneously in the Upper Paleozoic section of Angaraland—in the Lower Kungur stage of Lower Permian. And if the branch of development of true mosses : *Intia* — *Protosphagnum* — Reissinger's Lower Jurassic *Sphagnum* (1950, pl. xi, fig. 12)—modern *Sphagnum*, may be followed with considerable confidence, the origin and relationship to this branch of the somewhat peculiar Sphagnales : *Junjagia* and *Vorcutannularia*—is less clear. This is possibly another, more ancient and extinct branch of Sphagnales that had been separated from Bryales still earlier, being expressed evolutionally, as far as we can judge, in the branch *Junjagia*—*Vorcutannularia*—Reissinger's Lower Jurassic moss (Reissinger, 1950, pl. xi, fig. 15), but so far it is unknown after the Lower Jurassic.

Certainly, many intermediate links are still lacking to feel absolutely assured of the generalisations stated, yet the author is convinced that they cannot fail to impress after acquaintance with the results of the present work, which in its full text contains a considerable amount of the required comparable facts.

Whatever value may be attached to the concepts and conjectures drawn from the investigated material on the genetic relationship of true mosses and their development and phylogenetic connections, one thing is perfectly clear : the sphagnoid structure of the cellular network of the leaf adapted to life in conditions of excessive moisture (which it is difficult to regard as purely the result of convergence) had taken shape, though naturally in a primitive form, already in the Lower Permian, and at any rate since then there is sufficient representation of both subclasses of Musci-Bryales and Sphagnales.

To add to this, the organisation of these groups as mosses by then had been already so perfect that the appearance of the class Musci proper should have been postponed until at least the Devonian, so that their presence in Carboniferous sediments should not be unexpected. Thus, our data corroborate the authenticity of the findings of the representatives of this group in the Upper Carboniferous of Central France hitherto regarded as non-convincing.

2. THE SIGNIFICANCE OF MOSSES IN THE STRATIGRAPHY OF PERMIAN SEDIMENTS IN ANGARALAND.

As in other regions of Angaraland the fossil flora plays a prominent part in the division of strata and comparative stratigraphy of continental coal-bearing sediments in the Kuznetzk, Tungus and Pechora basins. Until now, discoveries (and their stratigraphic use) were made of all the main higher plant groups of the Upper Paleozoic, the only unknown ones being the remains of Bryophyta and particularly Musci.

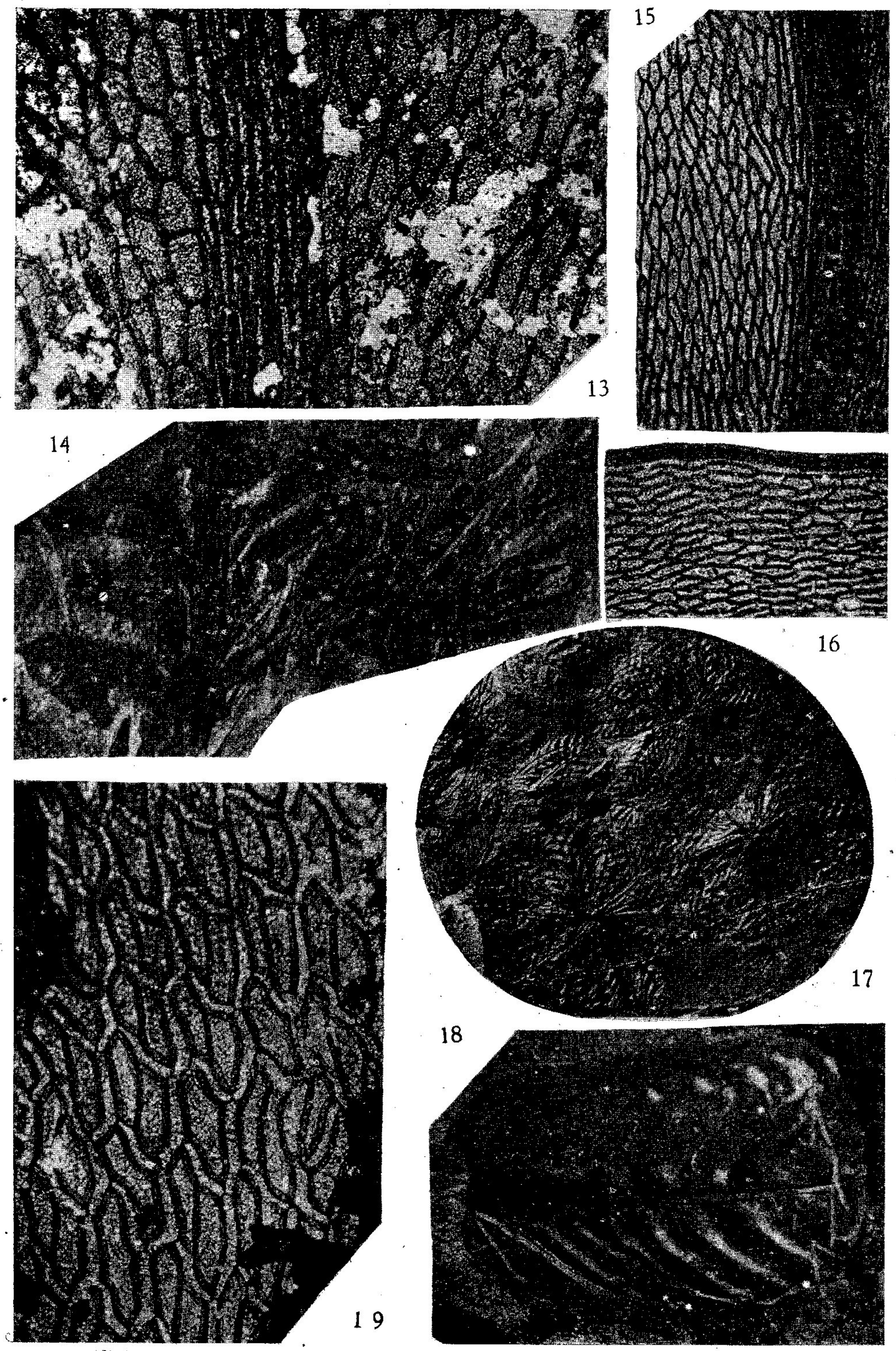
And yet, the vegetative parts of mosses, at any rate, are preserved very well and after respective treatment permit investigation of the cellular structure of leaves which

EXPLANATION OF Plate 3

Fig. 13—*Salairia longifolia* gen. et sp. nov., Kuznetzk basin. Upper Balakhon suite. Lower Permian. Cellular network of leaf blade, × 150.

14-16—*Uskatia conferta* gen. et sp. nov. Kuznetzk basin. Ilyin suite. Upper Permian. Fig. 14—shoot impression, × 10. Part of holotype. Fig. 15—part of cellular network of leaf, × 150. Fig. 16—the same with marginal border, × 150.

17-19—*Vorcutannularia plicata* Pog. in litt., emend. Neub., Pechora basin. Lower Vorcutan suite. Lower Permian. Fig. 17—impression of leaf rosettes, nat. size. Holotype Fig. 18—leaf impression, × 5. Fig. 19—part of cellular network of leaf, × 150.



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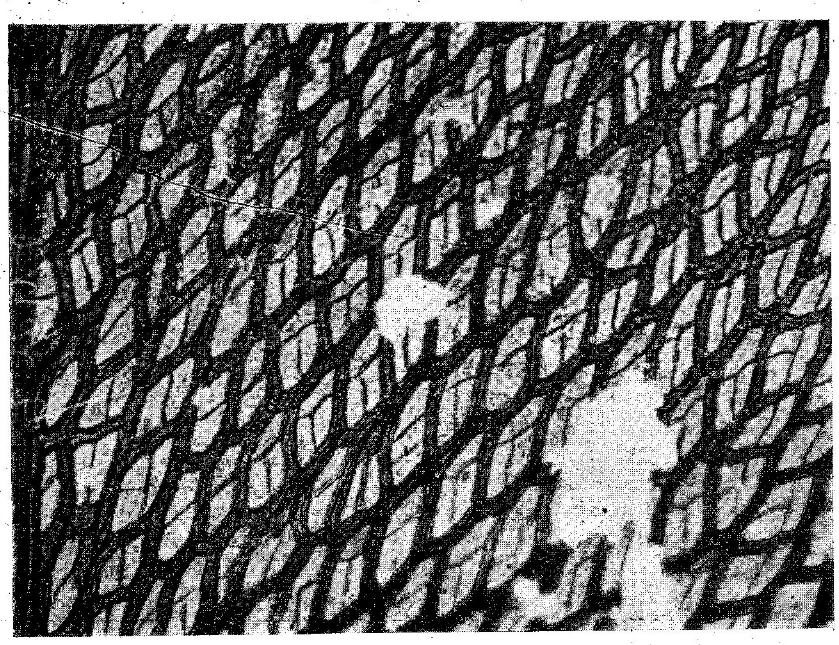

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yield important systematic data, as is the case with modern mosses. Besides, a single slab of rock may yield such quantities of moss remains that even their fragments offer a complete idea of the structure of leaves or shoots (frequently belonging to several species), which may be confidently used for comparative investigation of remains from different parts of the section and of different localities. In this respect mosses have certain advantages over other plants. All this leads us to hope that mosses together with other plants will prove of great use for the stratigraphy of continental sediments of the Angarian type. But possibly they will also have independent significance both owing to good preservation which enables more detailed study, and because Permian mosses, as their contemporary descendants, formed stable associations reflected in their fossils, which is so important for comparative stratigraphy.

The material investigated shows that, judging by the three chief Angaraland basins containing Permian sediments, the composition of mosses in the Upper and Lower Permian is entirely different not only in their species composition but even generically, although representatives of both Bryales and Sphagnales occur in both strata.

Remains of Lower Permian mosses have been obtained from the Kuznetzk and Pechora basins. As to the former, only one species of the genus *Salairia* has been determined, namely, for the Upper Balakhon suite. In the Pechora basin, almost the entire Vorcutan series is characterized by *Vorcutannularia* and *Intia* (four species), sometimes found in direct combination. In this series *Junjagia glottophylla* has been found in the lowest moss-containing strata.

On the contrary, the Upper Permian sediments—the Kolchugin series of the Kuznetzk basin—are much better characterized by mosses, including genera and even species of broad regional significance, such as *Polyssaievia spinulifolia*, *Bachtia ovata* and *Protosphagum nervatum*. This complex together with several other species is typical for the middle part of the Kolchugin series in the Kuznetzk basin but is also repeated in the Upper Permian Peliatkin suite of the Tungus basin, owing to which the respective strata of the latter suite may be correlated with the middle parts of the Kolchugin series of Kuznetzk basin. Another species of the genus *Polyssaievia*—*P. deflexa*—appears in the Upper Permian Pechora series of the Pechora basin.

Thus, according to available, though still quantitively insufficient data on fossil mosses, we may already say that with the accumulation and detailed study of new material this group will undoubtedly acquire increasing stratigraphical significance, at any rate for the Permian continental coal-bearing sediments of Angaraland.

3. The significance of mosses in the problems of palaeogeography

The true mosses investigated so far show that the presence of representatives of this group in the Angarian Permian is by no means accidental for the vegetation of the mentioned period. Such generic diversity, both quantitative and qualitative, in a collection rather small for the section under consideration proves that true mosses were extensively developed in time and space and were a substantial, but yet insufficiently studied element of the vegetative cover of at least a part of Lower Permian (Kungur stage) and Upper Permian. By the general organisation of their sterile organs Permian mosses, essentially, have no difference whatsoever compared to the modern ones; on the contrary they are very similar to them. They include analogues even of such a specialized group as Sphagnales. This similarity enables us to surmise that Permian mosses required, and existed in, similar climatic and ecological conditions.

Explanation of Plate 4

Figs. 20-23—*Protosphagnum nervatum* gen. et sp. nov. Kuznetsk basin. Yerunakov suite. Upper Permian. Fig. 20—leaf transferred to a film, ×10, holotype. Fig. 21—cellular network of leaf with midrib, ×150. Fig. 22—leaf border with dentate margin, ×300. Fig. 23—cellular network of leaf in median part, ×150.

All material of the investigated group of Paleozoic mosses and their holotypes are kept in the Institute of Geology, Academy of Sciences of the U. S. S. R., Moscow.

In modern conditions the mosses have been adapted to the most varied ecological environments, and yet they mostly inhabit the temperate and cool zones with sufficient or even excessive moisture (*Sphagnum*). Similar conditions are likewise quite assumable for the Permian mosses, all the more so because the presence of annual rings in the Upper Paleozoic Cordaites of Angaraland, testifies seasonal changes of climate, and the occurrence of leaves, except usual normal leaves, also of bud scale-type makes us suppose that the Cordaites of the Tungus botanical region grew in a temperate climate. Therefore, mosses do not contradict but confirm our assumption of a temperate and sufficiently moist climate.

The significance of recent mosses in the process of bogging up of water bodies, watersheds and forests and their role in peat formation are well known. This role is not only confined to the mosses themselves as being peat-forming material. By participating in the bogging up of dry land and water bodies they create conditions for the accumulation of vegetable matter at the expense of other plants as well. Therefore, the presence of true mosses in the Permian flora of Angaraland enabled the formation on this continent of swamps as well as both lowland and upland (convex *Sphagnum*) peat bogs.

No doubt, besides this type of swamps the accumulation of mother of coal in Permian time could have taken place also under other conditions not less varied than at the present time.

For instance, the analysis of concrete data referring to the burial of mosses leads to the following considerations. Most of the rocks containing moss remains are extremely fine, grey or dark-grey argillite that has apparently originated from lake silt. The shoots and leaves of moss could have fallen into the silt after tearing from floating moss blankets or nearby shores and descending to the silty bed bogged up the reservoirs. In either case the mosses were buried in almost the same places where they had grown. This mode of burial, unpreceded by transfer of vegetable material, is the only possible explanation of the extraordinary preservation of the majority of studied mosses from the Permian of Angaraland.

The occasionally witnessed pyritisation of the rocks containing these remains in its turn testifies to the existence of swampy, stagnant conditions.

All this shows that as soon as we include this new plant group, called the true mosses, into the composition of the Permian vegetative cover, our concepts of the conditions of formation of Permian coals in Angaraland, their initial matter, the landscapes of that period and even the very term "peat bog", as applied to the respective formations of Angaraland, may become considerably more definite and concrete.

It seems that on this continent the formation of peat-coal proceeded in Permian times not only at the expense of Cordaites and other associated plants, as was generally believed until now, but also at the expense of bryal and sphagnum mosses, with their direct and specific participation. Besides, at different times during the period in question the landscape was likewise characterized by cordaite "forest-taiga" bogged up in places with the participation of those very mosses. As already mentioned, substantial diversity was introduced into the landscape by other types of swamps in which the formation of peat was dominated by mosses which likewise imparted a specific aspect both to the vegetable covering and the respective areas of terrestrial surface.

As regards the causes of the conspicuous appearance of mosses in the flora of the Tungussian botanical-geographical region and their absence or rarity in Euramerian they are apparently connected with paleogeographical and, chiefly, climatic differences. Thus, the development of true mosses in the Upper Paleozoic of Angaraland under continental conditions in a temperate climate is absolutely logical. This and the frequently occurring favourable conditions of burial explain the widespread distribution of the remains of these plants in the Paleozoic sediments of Angaraland. No less logical, perhaps, is the almost total absence of mosses in the Upper Paleozoic sediments of Euramerian region. If we assume that mosses under tropical or subtropical conditions of this area had, as now, chiefly inhabited mountain region, there is very little chance that the remains of these fragile plants could have undergone a transfer, reached unharmed the sites of their burial and could have been noticed there among other plant remains. Therefore, it is probably no accident that in the whole history of investigation in Euramerian flora, only the two mentioned specimens of true mosses have been found in the Upper Carboniferous. It would be still more difficult to expect remains of representatives of this group to be found in most of the Permian of the region mentioned, as well as in the Western part of Angaraland (Zapadnoe Priuralie of today) where vegetation developed in conditions of progressive aridity.

Up to the present, there are no indications of remains of true mosses in the sediments of Lower Gondwana, although the paleogeographical conditions in the Upper Paleozoic of Gondwanaland seem to have been suitable for the development of the given group too.

Taken together, all that has been said stresses the importance of the discovery of the plant group in question in the Upper Paleozoic of Angaraland for elucidating a number of general and specific points of geology and biology which the author has attempted to put forward.

REFERENCES

ABRAMOVA, A. L., K. T. LADYJENSKAYA and L. I. SAVITCH-LUBITSKAYA 1954, Vol. III. Flora of spore plants of the USSR, Vol. III. Edition of the Academy of Sciences of the USSR.

CAMPBELL, D. H., 1940, The Evolution of the Land Plants (Embryophyta). London.

GOTHAN, W., 1953, Die Folge der Pflanzengruppen im Laufe der geologischen Erdperioden. *Wiss. Ann.* 1953, 2, No. 3, S. 154-179.

GOTHAN, W., und WEYLAND, H., 1954, Lehrbuch der Paläobotanik, Akademie, Berlin.

NEUBURG, M. F., 1956, Paleozoic Mosses of Angaraland. Resumenes de los Trabajos Presentatados. *XX Congreso Geologico International.* Mexico, 1956, p. 120-121.

NEUBURG, M. F. 1956, Discovery of true mosses in Permian sediments of the USSR. Doklady Academii Nauk SSSR. V. 107 No. 2, pp 321-324.

POTONIE', H., 1921, Lehrbuch der Paläobotanik. Zweite Auflage. 1921. Berlin.

REISSINGER, A., 1950, Die "Pollenanalyse' ausgedehnt auf alle Sedimentgesteine der geologischen Vergangenheit. Zweiter Teil. *Palaeontographica,* Ed. 90, Abt. B, Lief. 4-6, S. 99-126, t. XI-XIX.

RENAULT, B., et R. ZEILLER, 1888, Flore fossile du terrain houiller de Commentry. *Bull. Soc. Industr. Min.*, text et atlas, p. 34-36, pl. XLI, figs. 2-4, Saint-Etienne.

WALTON, J., 1925, Carboniferous Bryophyta. I. Hepaticae. *Ann. of Botany,* Vol. 39, p. 563-572, pl. XIII. London.

———, 1928, Carboniferous Bryophyta. II. Hepaticae and Musci. *Ann. of Botany,* Vol. 42, No. 167, p. 707-716, pl. XII. London.

WEYLAND, H., 1925, Beitrage zur Kenntnis fossiler Moose, II. Zur Frage der Erhaltung fossiler Moose. *Senkenbergiana,* Bd. 7, S. 8-16.