SOME LOWER MESOPHYTIC MICROSPORES OF EUROPE WITH REMARKS ON THEIR RELATION TO THE GONDWANA-MICROFLORA

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ABSTRACT.—Microspore associations of the Alpine salt rocks are described and compared with spores reported from Gondwana sediments in India and Australia. In Middle-Europe they commonly occur in large quantities and in a good state of preservation in Upper Permian and Lower Triassic salts, clays and shales. The striking similarities of European spore types with those found in Gondwana formations lead to the conclusion that the immigration of the majority of "Glossopteris"-elements reached as far as Middle-Europe. This invasion through the Tethys-region apparently began during the Late Permian. The absence of megafossils in association with Gondwana-microspores suggests that the spore producing plants have been growing far away from places favourable for the preservation of large remains of plants.

INTRODUCTION

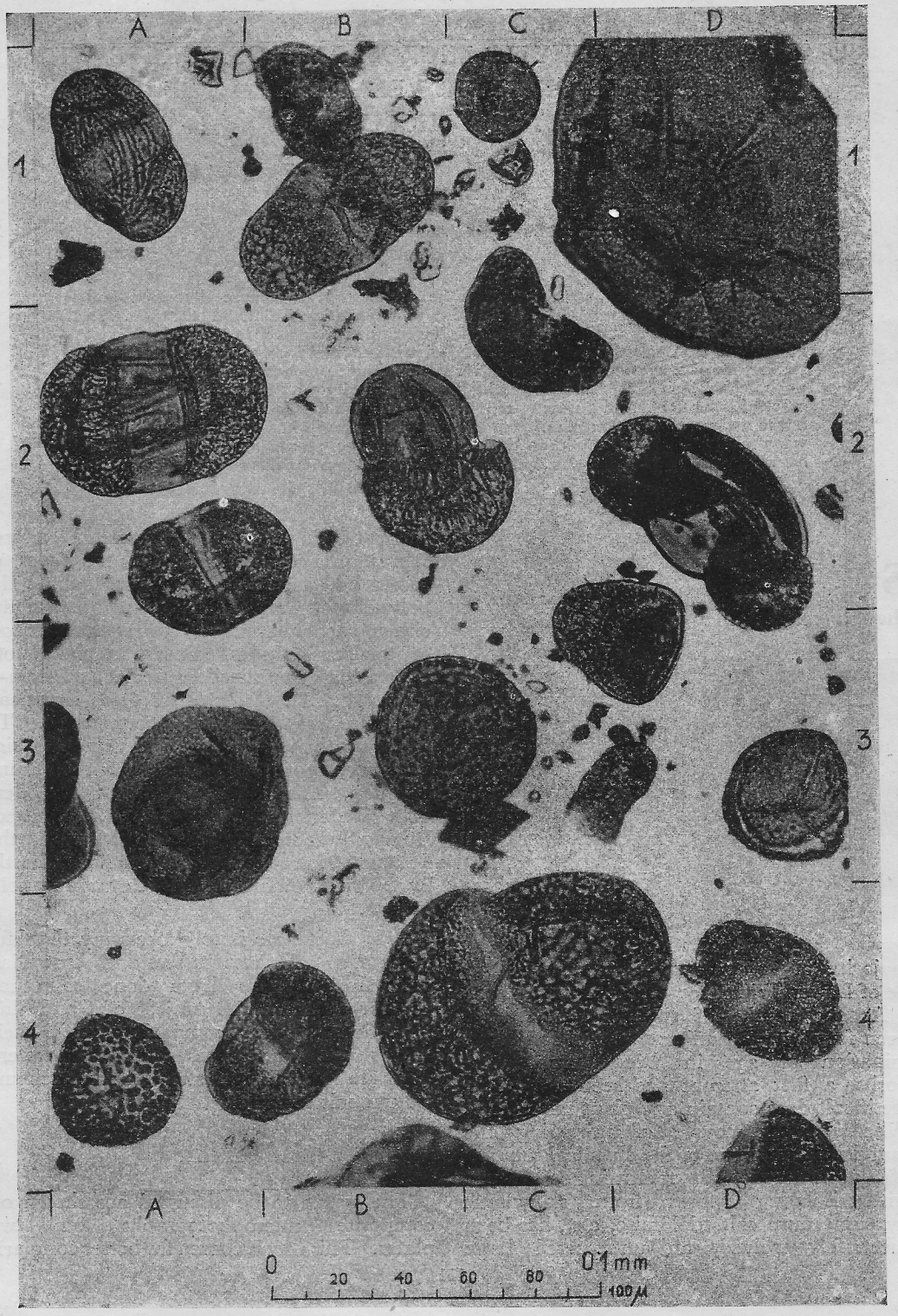
SALT deposits occur in several places within the Austrian Alps. Since more than a century they have been the subject of numerous stratigraphical investigations. Embedded in mesozoic sediments which contain megafaunas of great stratigraphic value, the bulk of the saltrocks has never rendered any fossils at all. Therefore the problem of the age of the salt deposits was still open to discussion. By the majority of investigators it is supposed to be of Lower Triassic or Upper Permian age.

As the results of spore research have been found more and more useful for determination of age in Prequaternary deposits, a first attempt has been started to see if salt does contain any plant microfossil. When in the course of preparing the samples the problem of the chemical solution of the different salt rocks in connection with isolating spores from anhydrous gypsum, pure salt, dolomite, etc., has been successfully solved, an unexpected large amount of very good preserved microspores was discovered. But the types of spores had a somewhat strange look to the palynologist accustomed to investigate either carboniferous or younger mesozoic or tertiary samples. Except a short note and rather generalized figures of Zechstein—spores by H. Lück 1913, no European literature was available for comparison. To check up their stratigraphical value and significance, spore assemblages of the Alpine Permian, Triassic as also from the German Zechstein had to be investigated. During these studies, basic suggestions for the determination of spores were obtained mostly by the study of Indian and Australian publications.

This short note is to express my thankful feelings to all those Indian and Australian palynologists, who have done so much pioneer work on the subject of Gondwana microflora. The comparison of their results with our spores contributed essentially to establish a stratigraphic scheme for our salt deposits.

PLATES

The spores to be discussed are shown on composite microphotographs on two plates. This way is chosen for better compari-



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son of the whole spore association, instead of presenting somewhat difficult nomenclatorial discussions. Until spore-naming will have reached a state of internationally adopted uniformity, this way of presentation seems to give a more accurate picture of spores of certain strata.

MICROSPORES OF UPPER PERMIAN TO LOWER TRIASSIC IN THE ALPS

Generally speaking, the majority of microspores shows differentiations of the outer exine layers. These could be termed "air bladders". But some must not be actually inflated sacs, some show marginal fringes, which do look with their reticulum like wings. Some grains have a circular monosaccus. The majority has two wings. But many variations do occur in this group, ranging from two up to three, four or five bladders, which can also be connected to a closed monosaccus.

The size variations are considerable, even within one form species. Among this association a few spores with triradiate scar can be observed. But they are merely accessorial components.

Spores with air bladder-like differentiations. When well preserved, almost all types of this group show a more or less dark-brownish central body. It is easily detachable from the grain, which can happen either during fossilisation or afterwards on account of the chemical treatment during the preparation of the samples. With a very strong Schulze-mixture they can eventually be dissolved. Once detached, these more or less globular or bean-like bodies can be found among the other spores. Thus isolated from the grain, these bodies can be then erroneously considered as microspore species. But careful observation always reveals characteristic features either on the surface or in some of the coats. For instance most of the detached bean-like bodies in my samples bear a minute slit (see Plate 22, top row, C 1) which indicates their derivation. It depends upon the kind of spore from which the body derives : they may have one slit or one slit with secondary folds on the grain, which are located in more or less right angles to the slit ; other bodies have one main slit and a number of more or less parallel stripes. Some bodies are almost circular and then show a pronounced triradiate slit. (See plate 23, top row, D 1.)

Close attention should be paid to these parts of spores, as in several publications one can find pictures and drawings, in which such forms are considered as separate microspore types. It is to be admitted that

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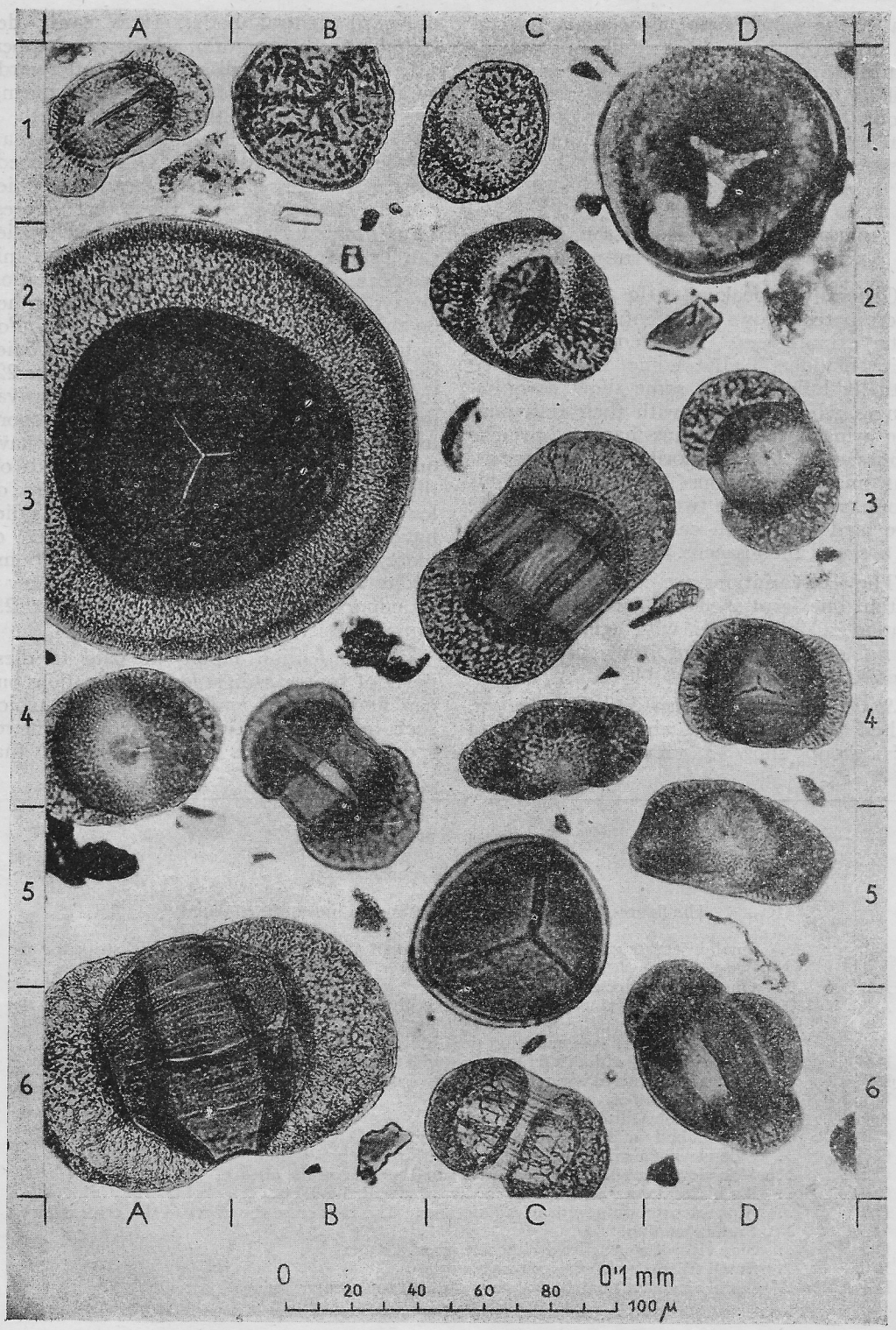
EXPLANATION OF PLATE 22

Magnification of spores 500 ×

The figures (f.i. A 3) refer to the marginal index of the plates.

A 1	..	Small bisaccate grain with one proximal main slit and a number of parallel stripes on the body.
A 2	..	One-slitted bisaccate grains.
A 3	..	Monosaccate grain. Central body with a small triradiate scar. Surface of the grain rough.
A 4	..	Trilete spore with **verrucae** on the distal surface.
B 1	..	Bisaccate grain with distal furrow parallel to the roots of the wings.
B 2	..	Part of a one-slitted bisaccate grain with a partially disconnected central body.
B 3	..	Trilete microspore with **verrucae**.
B 4	..	Bisaccate one-slitted grain.
C 1	..	Central body of a one-slitted bisaccate grain.
C 1, 2	..	Side view of a small bisaccate grain with rudimentary slit.
C 2, 3	..	Side view of a bisaccate grain with small meshes on the airsacs.
C 4	..	Big bisaccate grain with wide meshes on the air bladders.
D 1	..	Monosaccate grain with triradiate scar. The rays cross the edges of the central body. Surface smooth.
D 2	..	Side view of a one-slitted bisaccate grain.
D 3	..	Small trilete spore, surface rough.
D 4	..	Distal view of a small bisaccate grain with rudimentary wings.



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forms with many parallel stripes and bean-like shape could erroneously be considered as pollen grains of Ephedra. The same applies to the round bodies with the triradiate scar; they could be easily considered as ordinary trilete microspores. But always some characteristic features could be established which might give indication as to the relation between this body and the spore. The remaining grain with air bladders does not show much damage after the release of the body. Only the central part appears thinner and better visible under the microscope.

Monosaccate grains.—Three different types of this kind frequently can be met with in our samples. The grain shown on plate 23, AB, 2, 3, has a triradiate scar and a central body which is surrounded by a circular bladder with radially stretched meshes. Typical for this grain is the outline, marked by a dark marginal rim of about 5—10 μ. These grains are the most outstanding components of the Upper Permian and Lower Triassic. It is not yet found in the Lower Permian of the Alps and only one single grain has been encountered in German Muschelkalk. A body of that grain is shown on plate 23 top row, D 1.

Another, a little smaller type (see plate 22, top row, D 1) of monosaccate grain has a smaller central body and the rays of the triradiate scar cross the edge of the central body and reach into the bladder area. The reticulum consists of small regular meshes. The surface is smooth. The spore does not occur in large quantities, but can be found almost in every sample, especially in Lower Triassic.

The same may be said about the occurrence of another grain with a central body and a very faint triradiate scar with extremely short rays. (Plate 22, A 3) The reticulum appears to be extraordinarily small and the surface of the grain is rough. The two last mentioned types frequently show secondary folds.

Grains with two or more bladder-like differentiations: Grains with two airsacs and a proximal slit which connects the roots of the wings belong to the most frequent types of our samples. We might point out, that this slit is proximal (dorsal) and situated at right angles to the distal (ventral) furrow of the conifer pollen grains. In my opinion there is but a remote relation of the mother plant of this pollen grain to a conifer. Apparently this type of grains has already been found, figured and described by Virkki, 1945, plate 1, figs. 4 and 5. Our grains are shown on plate 22, A2, D2, B4, plate 23, A1, B4, C3. It appears first in the Lower Permian in the alpine region and can be met with in large quantities in the Upper Permian and Lower Triassic. Geologically speaking, from this time on, the one-slitted grain develops a lot of variations: f. i. numerous parallel stripes to the main slit (plate 22, A1, plate 23 AB6, C6) variations of the

EXPLANATION OF PLATE 23

Magnification of spores 500 ×

A 1	..	One-slitted bisaccate grain.
A 2, 3	..	Monosaccate grain with triradiate scar.
A 4	..	Bisaccate grain with a very short slit.
A 6	..	Bisaccate grain with one main slit and a number of parallel stripes.
B 1	..	Trilete spore with a marginal rim and undulated surface.
B 4	..	Dorsal view of a one-slitted winged grain.
C 1	..	Small bisaccate grain without central body.
C 2	..	Bisaccate grain with central body.
C 3	..	Bisaccate grain with longitudinal furrows and a short slit on the central body.
C 4	..	Side view of a bisaccate grain with but a minute proximal slit.
C 5	..	Trilete spore with a faint ornamentation on the surface.
C 6	..	Bisaccate grain with wide meshes on the airsacs and many parallel stripes on the body.
D 1	..	Central body of a grain like A 2, 3.
D 3	..	Bisaccate grain with one proximal slit.
D 4	..	Bisaccate grain like D 5 but with a triradiate scar (occurs very seldom).
D 5	..	Bisaccarate grain with a very faint reticulum and a short slit on the proximal side.
D 6	..	Trisaccate variation of a one-slitted grain.

airsac reticulum (Plate 23, C3, C6) and the number of wings (Plate 23, D6) and size (Plate 23 AB 6). By Potonie & Klaus 1954 such types have been named *Lueckisporites*. The one-slitted grain has received the species name "*virkkiae*".

I think it should not be called *Pityosporites*, as this genus was created by Seward 1914 for *Abietineae*-like pollen grains. But abietineous grains never show longitudinal slits on the proximal side. I am strongly in favour of the opinion, that *Lueckisporites* might have some relation to *Pteridosperms*. According to the investigations of Virkki it seems very reasonable to consider relations with *Glossopteris*. If that is the case, *Glossopteris* itself or close relatives might have been growing in Europe during the Permian and Triassic. The last remainder of a slitted pollengrain with wings does occur in Upper Triassic beds.

Besides this frequent occurrence of the mentioned type, we find other winged grains, where the slit is not so pronounced and only to be observed in very good preserved individuals (Plate 22, D4, C2, Plate 23, C1, A4.) Under this category falls a very small grain with two rudimentary air bladders. A detached central body very seldom occurs. The grain is confined to Upper Permian and Lower Triassic.

Another type with similar features has air bladders which do extend a little more ; the meshes of the wings are very small and are not regular ; (Plate 22, CD23, Plate 23, C2, C4, D5) the central body of this type is very easily detachable from the grain (see Plate 23, C2.) The stratigraphical range is from Upper Permian to Muschelkalk ; sometimes it can be found also in Upper Triassic rocks.

Occasionally very large grains with oval outline, large meshes on the airsacs and a very minute longitudinal slit do occur in our samples. Obviously they are of stratigraphical value for the uppermost Permian (Plate 22, C4).

It remains to be mentioned only one type with air bladders (Plate 22, B 1) and that really appears to be of conifer origin. It occurs sparingly in our samples from Permian to Middle Triassic. *Pityosporites* in that case would be suitable name. It has some resemblance to a grain of carboniferous age, which has been photographed and described by Florin 1938—1945 as *Pityosporites Jeffreyi*. No central body or proximal slit can be observed on that winged grain.

Spores without air bladders.—Each sample does contain a few individuals of trilete microspores mostly with a small equatorial rim. They have some resemblance to a *Lycospore* of the Carboniferous. The surface can be smooth or shows a lot of variations from small granules, and spines up to prominent warts as can be seen on the photographs. (Plate 22, D3, BC3, A4 ; Plate 23, B1, C5.) The rays of the triradiate scar are with only few exceptions rather straight and reach up to the edge of the rim. Their stratigraphical value is not yet quite clear. I found them in Upper Permian and also in Lower Triassic, but not yet in Muschelkalk.

GEOLOGICAL RELATIONS

When comparing the described assemblages with photographs of spores of Indian and Australian Gondwana deposits it seems that the winged grains with proximal slit are the most typical features of both Permian floras. Similar to our monosaccate spores with triradiate scar are those figured by Dulhunty 1945 and other Australian and Indian authors. Obviously in the Gondwana flora are some different spores which I have not found yet in Europe. But they appear to be of minor stratigraphical value and might be of the same rank as our small trilete spores.

When investigating German Zechstein spores, almost the same assemblages as in the Alps have been encountered. Only the very big grain with two airsacs and wide meshes, which is shown on Plate 22, bottom row, C4, has never been so far met with in the Zechstein sediments. Also the wingless small trilete spores are apparently missing there. The quantities of the different spore species, of course, vary within large limits.

Almost the same applies to the spore community of the Permian in the Southern Alps.

In spite of the great difficulty to get acquainted with the numerous Russian publications, it seems that in the Permian of Eastern Europe also winged spores with longitudinal furrows do occur.

SUMMARY AND CONCLUSIONS

From a comparison of European Upper Permian and Lower Triassic microfloras with the descriptions and photographs of spores from the Indian and Australian Gondwana formations it could be concluded, that a considerable amount of mother plants in both areas seem to be the same or at least closely related. This applies in the first line to spores with longitudinal slits. It might therefore be possible that parts of the so called Gondwana flora were not restricted to the southern hemisphere but might even have extended into Europe as far as the Alps and the German Zechstein area.

ACKNOWLEDGMENTS

I am gratefully indebted to Dr. M. R. Sahni, Palaeontologist of the Geological Survey of India, who made accessible to me a number of important Indian papers on Gondwana flora.

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Manuscript received 26th July 1957