Palynology of the Circum-Mediterranean Triassic: Phytogeographical and Palaeoclimatological Implications[1])

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With 3 figures and 2 plates

Zusammenfassung

Zufolge einer vorläufigen Auswertung palynologischer Information über ladinische und besonders karnische Schichtfolgen, scheint es deutliche Anzeichen zu geben, daß qualitative und quantitative Unterschiede in der Zusammensetzung palynologischer Assoziationen gut angewandt werden könnten beim Testen der Konzepte von triassischer Phytogeografie und Paläoklimatologie.

Untenstehende Implikationen werden betont:

(1) Es gibt genügend palynologischen Beweis, daß das Mittelmeergebiet auch einen Bereich enthält, der von gemischten, nördlichen (laurasischen) und südlichen (gondwanischen) Floratypen charakterisiert ist.

(2) Das Konzept einer wesentlich ariden Natur einer breiten äquatorialen Zone wähwährend der Trias wird durch palynologische Forschung unterstützt.

(3) Palynologische Daten wiedersprechen nicht dem Konzept, daß es eine ausgesprochene Abnahme von Niederschlag in westliche Richtung des Mittelmeergebiets gab.

(4) In Europa kann die Anwesenheit von hygrophytischen Palynofloren und Kohlen in einer ariden klimatischen Zone erklärt werden durch die Wasserzufuhr von extensiven Flußsystemen.

Abstract

Following a tentative evaluation of palynological information from Ladinian and, more particularly, Karnian successions, there seems to be every indication that qualitative and quantitative compositional differences of palynological assemblages could well be applied in testing concepts of Triassic phytogeography and palaeoclimatology.

The following implications are emphasized:

(1) There is sufficient palynological evidence that the Mediterranean region includes a domain of mixed northern (Laurasian) and southern (Gondwana) types of floras.

(2) The concept of an essentially arid nature of a wide equatorial climatic belt during Triassic times finds palynological support.

(3) Palynological evidence does not contradict a concept of pronounced decrease in precipitation towards the western part of the Mediterranean region.

(4) In Europe, occurrences of hygrophytic palynofloras and coals within an arid climatic zone can be explained by the water-supply of extensive river-systems.

Résumé

Suivant un essai d'évaluation des indications palynologiques recueillies dans les séries du Ladinien et plus particulièrement du Karnien, il semble qu'il y ait certaines indications pour que des différences qualitatives et quantitatives dans les assemblages palynologiques

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puissent très bien être mises en pratique pour tester des conceptions phytogéographiques et paléoclimatiques relatives au Trias.

Les conclusions suivantes sont soulignées:

(1) Il y a suffisamment de témoignage palynologique indiquant que la région méditerranéenne renferme un domaine avec un mélange de types de flores septentrionales (laurasiennes) et méridionales (gondwaniennes).

(2) L'idée d'une nature essentiellement aride formée d'une large ceinture climatique équatoriale pendant les temps triasiques trouve un soutien palynologique.

(3) Le témoignage palynologique ne conteste pas la conception d'une diminution manifeste des précipitations vers la partie occidentale de la région méditerranéenne.

(4) En Europe, la présence de palynoflores hygrophitiques et de charbons dans une zone climatique aride peut s'expliquer par l'adduction d'eau de systèmes fluviaux de grande extension.

Краткое содержание

Предварительная оценка палинологических данных на ладинских и, особенно, карнисских свитах дает указания на то, что, как количественные, так и качественные различия состава ассоциаций спор можно с успехом применять для решения задач фитогеографии и палеоклимата.

При этом подчеркивается, что:

1) имеется достаточно палинологических данных, что среднеземноморская область вмещала регионы, характеризующиеся смешанной, северной (лауразийской) и южной (гондванской) типами флоры;

2) гипотеза о широкой аридной по своей природе экваториальной зоне во времяна триаса подтверждается данными палинологических исследований;

3) палинологические данные не противоречат теории, по которой имелось явное уменьшение осадков в западном направлении средиземноморья;

4) присутствие в Европе гидрофильной палинофлоры и углей при наличие аридного климата можно объяснить приносом воды могучими системами рек.

Introduction

Palynology deals, to a large extent, with the study of spores and pollen of land plants; that is to say, with reproductive organs of pteridophytes (such as ferns and lycopodiophytes) and spermatophytes (gymnosperms and angiosperms). Although produced by land-dwelling organisms, spores and pollen can be dispersed by wind and water-action over considerable distances, and may be deposited not only in continental but also in marine sedimentary environments.

Consequently, in contrast to virtually all other biostratigraphically significant groups of fossils, spores and pollen have the potential of providing biostratigraphical correlations between sequences deposited under widely differing environmental conditions.

During the last decade, this potential has been investigated and applied with respect to the Triassic of Europe by a research-team of the Laboratory of Palaeobotany and Palynology of the State University of Utrecht. As a result of these investigations, palynology is now providing a new and invaluable tool for recognizing the ammonoid-based standard stages of Triassic chronostratigraphical subdivision in those areas where ammonoids never had a chance to penetrate (Schuurman, 1977, 1979; Visscher and Krystyn, 1978; other papers in press or in preparation).

In this way, palynology is notably contributing to the solution of the classic problem of the correlation of the Alpine and the Germanic facies-development of the European Triassic. Such interregional correlations are possible because of the presence of similarities in the composition of palynological assemblages from widely separated areas. Triassic palynological assemblages may even include a number of more or less cosmopolitan elements, enabling intercontinental correlation.

Apart from stratigraphically important similarities, however, Triassic assemblages frequently show significant differences in both qualitative and quantitative composition. Since extant plant communities are well-known for their environmental dependence, there is every indication that in the fossil record differences in the composition of coeval palynological assemblages may well reflect differences in environment. Through an analysis of compositional differences, palynology may thus have important implications with regard to the discrimination of palaeoenvironments as well as to general phytogeography and palaeoclimatology of the Triassic period.

In this respect notably the palynological information from the circum-Mediterranean Triassic proved to be of fundamental importance. This is by no means surprising: the present Mediterranean region formed the centre of the Triassic world and can not be neglected in any study of the Triassic on the more world-wide scale.

In the present contribution, therefore, two general working-hypotheses in the field of Triassic phytogeography and palaeoclimatology will be tested on the basis of palynological assemblages corresponding to the *Camerosporites secatus* phase (VISSCHER and KRYSTYN, 1978) which palynologically characterizes the Ladinian and Karnian stages.

Testing a Phytogeographical Model

Drafts of world maps for the Triassic show the existence of a single chevron-shaped continent (Fig. 1). The two arms of the chevron constitute the eastern parts of Laurasia and Gondwanaland, respectively. These landmasses are positioned approximately on either side of the palaeo-equator; they are separated by the Tethys. The shorelines are converging towards the west, coalescence taking place in the western part of the present Mediterranean region.

From this palaeogeographical model, the following phytogeographical working-hypothesis may be deduced:

— *During Triassic times the Mediterranean region could well include a domain characterized by mixed Laurasian/Gondwana types of floras.*

According to the phytogeographical interpretation of plant megafossils, floral diversification during Triassic times is thought to be considerably less pronounced than during the Permian. In effect, only two principal types of floras have been distinguished, viz. the Laurasian and the Gondwana floras (VAKHRAMEEV et al., 1978). It should be realized, however, that in reality these floras represent a Laurasian and a *southern* Gondwana flora, geographically separated by a wide belt (northern Gondwanaland) from which there is virtually no record of Triassic plant megafossils.

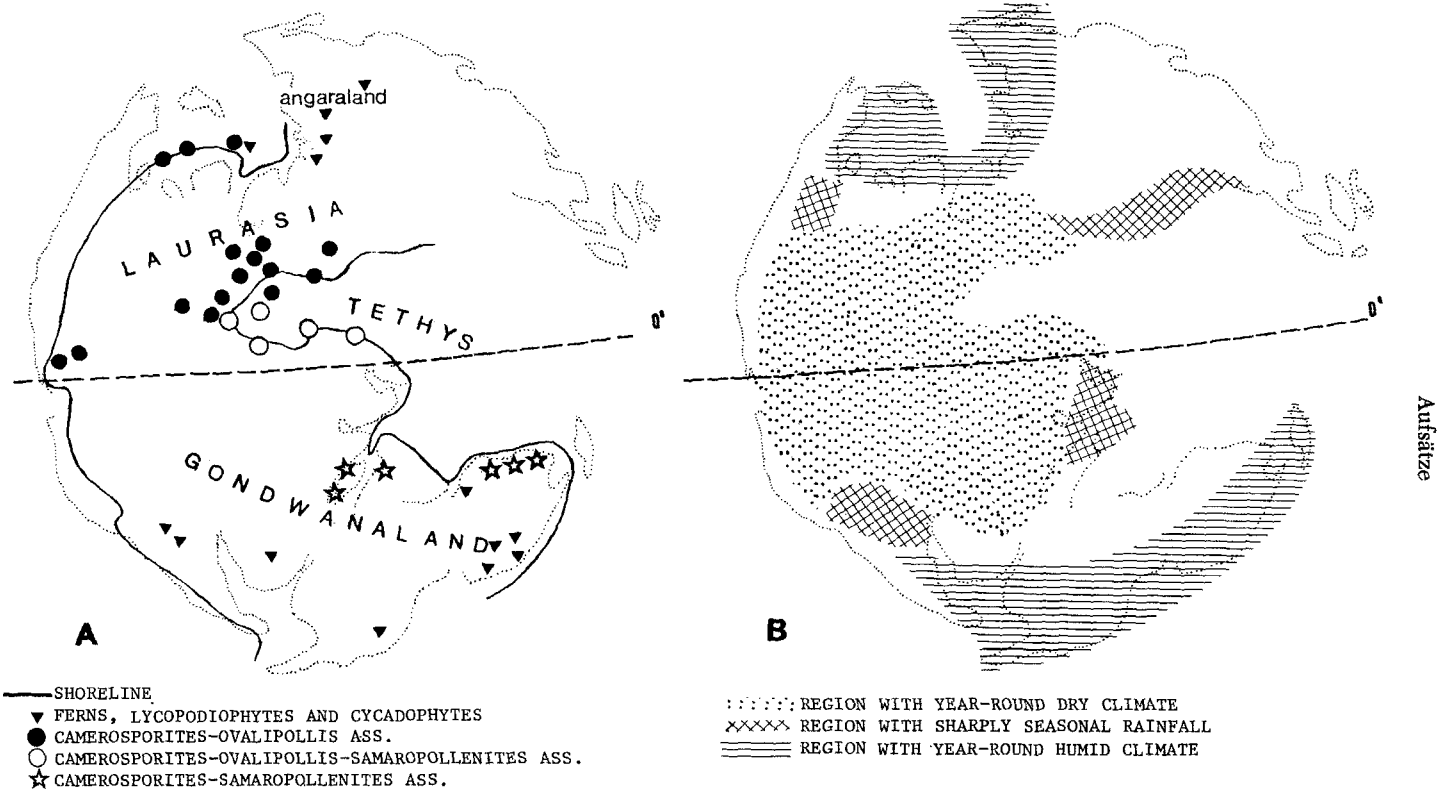

Fig. 1. Karnian world geography after Seyfert and Sirkin (1979). a — distribution of palynological assemblages characteristic for separate phytogeographical domains. b — principal climatic zones after Robinson (1973).

A generalized palynological picture of floral diversification during Ladinian-Karnian times may provide a more complete picture (Fig. 1 a). Based on an analysis of compositional similarities and differences, one may recognize — in generalized terms — three principal palynofloral domains:

(1) A northern domain in Laurasia (Angaraland), palynologically characterized by a qualitative and quantitative abundance of pteridophytic spores and/or the cycadophytic (gymnospermous) pollen type *Cycadopites*.

(2) A very wide equatorial domain in both Laurasia and Gondwanaland, palynologically characterized by *Camerosporites secatus* and a number of other gymnospermous formgenera, such as *Duplicisporites, Paracirculina, Enzonalasporites, Vallasporites,* representing conifers.

Within this belt a threefold palynofloral subdivision may be made:

(2 a) Northern palynofloras, in which *Camerosporites secatus* occurs together with *Ovalipollis pseudoalatus*.

(2 b) Southern palynofloras, in which *Camerosporites secatus* occurs together with *Samaropollenites speciosus*.

(2 c) Mixed palynofloras, in which *Camerosporites* occurs with both *Ovalipollis* and *Samaropollenites*.

(3) A southern domain in Gondwanaland, palynologically characterized (similar to the situation in Angaraland) by pteridophytic spores and/or *Cycadopites*.

Thus, in the Mediterranean region the northern palynoflora with *Camerosporites secatus* and *Ovalipollis pseudoalatus* frequently includes southern elements. *Samaropollenites speciosus* may form an important constituent in assemblages from Libya, Sicily and Spain. A number of additional spores and pollengrains first-described from Gondwanaland and so far unknown from northern and central Europe may be regularly present in Ladinian and/or Karnian assemblages from Alpine-Mediterranean Europe.

It may be concluded that the hypothesis of mixed floras in the Mediterranean region finds ample palynological support. The concept of the existence of only two distinctive floras, on the other hand, has to be modified when the Triassic palynological record is taken into consideration.

Testing a Palaeoclimatological Model

In addition to phytogeographical considerations, Triassic world geography may be the basis for a palaeoclimatological working-hypothesis for the circum-Mediterranean region:

— *During Triassic times the Mediterranean region could well represent a domain showing a pronounced decrease in precipitation towards the west.*

A theoretical model of Late Triassic climate based on the overall configuration of land and sea has been worked out by ROBINSON (1973); the principal climatic zones deduced are indicated on the map of Fig. 1 b.

It appears that climatic theory is strongly in favour of the presence of a wide arid belt on either side of the palaeo-equator. Unlike the recent situation, the major Late Triassic winds are thought to have blown consistently over land; they will therefore be dry, causing an arid climate in the equatorial latitudes.

Only along the shores of the wider (eastern) part of the Tethys, monsoonal activity is likely to have caused seasonal rainfall regimes. It is unlikely that the latter regimes have still influenced the climate of the western Mediterranean region.

According to climatic theory, in the high latitudes, both in the north and in the south, a year-round humid climate is to be expected.

In the present-day phytogeography, the general distribution pattern of the world's main floras coincides with the climatic belts. With respect to the Late Triassic, it seems that in general terms the palynofloral record is not in serious conflict with Robinson's climatic zones: high-latitude hygrophytic floras, characterized by pteridophytes and cycadophytes are separated by a xerophytic equatorial flora, characterized by conifers.

However, when comparing the two maps of Fig. 1, for various parts of the world a number of discrepancies may be detected. Partly these may result from insufficient data or from oversimplification. It is outside the scope of the present paper to discuss all these discrepancies. For the Mediterranean area, in a broad sense, it will however be attempted to develop a somewhat more detailed picture.

In her considerations on Late Triassic climate, Robinson attempted to test the theoretical model with the help of occurrences of presumed climate-sensitive rocks, notably evaporites and coals. Indeed, the occurrences of Late Triassic evaporites well correlate with the concept of an arid equatorial belt. Seemingly, also the areas of coal-deposition are in agreement with the high-latitude humid belts. However, in her correlations Robinson has omitted occurrences of coal in both Alpine and outer-Alpine Europe as well as in the eastern U. S. A.

In Fig. 2, therefore, major occurrences of evaporites and coals have been plotted on a palaeogeographical map for the Karnian of Europe and adjacent parts of Asia, Africa and North America. The map is a generalized version of one of the maps composed by W. A. Brugman for internal use in the Triassic project of the Laboratory of Palaeobotany and Palynology, Utrecht.

In Europe, Karnian coals may regularly occur stratigraphically and geographically close to evaporites. Such close occurrences contradict the frequently quoted dogma that coals represent objective indications for a humind climate. Yet it can be reasonably assumed that the Karnian coals, in contrast to the evaporites, represent a humid *environment.*

As a consequence, one may suspect, that Karnian palynological assemblages from Europe should at least show two different compositions: the composition of assemblages from evaporites may reflect a xerophytic flora, whereas the assemblages from coal-bearing strata may be indicative of a hygrophytic flora.

This picture is now confirmed by the relatively extensive palynological record from the European Karnian. Despite the similarities, enabling a stratigraphical correlation, Karnian assemblages have become well-known for their considerable compositional differences, both qualitatively and quantitatively.

In order to facilitate practical quantitative analyses on a routine basis, 15 categories of readily recognizable morphological groups of spores and pollengrains have been distinguished (categories A—O; see Fig. 3). The composition of the individual groups will be outlined elsewhere; it is here sufficient to examplify the various groups by means of illustrations of a selection of characteristic representatives (Plates I and II).

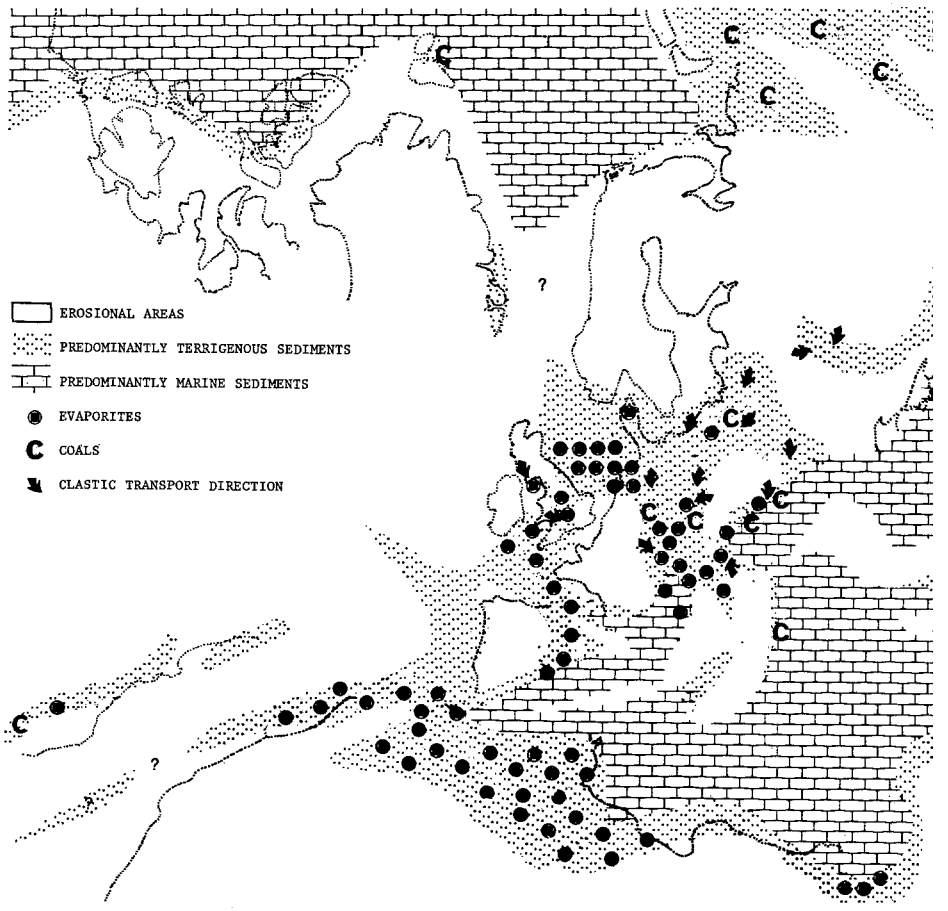

Fig. 2. Generalized Karnian palaeogeography of Europe and adjacent parts of Asia, Africa and North America, showing distribution of environment-sensitive rocks.

Based on the analysis of assemblages from evaporites and coals, respectively, high percentages of the elements A—G may broadly reflect hygrophytic plant communities, whereas high percentages of the elements K—O are thought to reflect xerophytic communities. The status of the groups H, I and J is either indifferent or unknown. It should be noted that the essentially hygrophytic elements A—G principally include various types of spores of pteridophytes as well as the pollen of cycadophytes (part of group G). Although less diversified, these groups include a number of palynological taxa characteristic of assemblages from northern Laurasia (Angaraland) and/or southern Gondwanaland. The groups K—O include a large number of pollen types of undoubted or presumed coniferalean affinity.

Using these groups, for many Karnian assemblages relative-frequency histograms have been composed. A selection of these figures have been reproduced on the map of Fig. 3.

In most cases a xerophytic or hygrophytic nature of the assemblages may be easily deduced. When using literature information, a transtation of assemblages in terms of xerophytic or hygrophytic may sometimes become much more subjective. Occasionally the quantitative information is sufficient to become expressed in histograms; frequently, however, the nature of assemblages can only be approximated by estimating the spore/pollen ratio.

In order to test the palaeoclimatological working-hypothesis of a pronounced decrease in precipitation towards the west, it is necessary to consider the most easterly and the most westerly palynological records from the circum-Mediterranean Karnian.

The most easterly assemblages originate from the Black Sea area (western Caucasus, locality 11). Unfortunately the information from this area published by YAROSHENKO (1978) could not be expressed in relative-frequency histograms. Yet, from the published qualitative/quantitative data, the nature of the Karnian assemblages may be estimated as being moderately hygrophytic. Lithologically, the source-strata of the assemblages do not show any indication of either extremely dry or extremely humid environmental conditions.

The western assemblages (Spain, localities 5, 6), on the other hand, show the most xerophytic nature so far recognized in Europe (extremely low percentages of pteridophytic spores). They originate from evaporite-bearing successions.

Geographically, the Caucasian record approximates an area in which Robinson suspected a climatic regime with sharply seasonal (monsoonal) rainfall. The Spanish records are from the extreme western end of the Tethys realm, that is to say, from an area in which no monsoonal activity can be expected.

The palynological information from the Caucasus and Spain is in agreement with the palaeoclimatological model for the western Tethys. However, at present palynology does not independently confirms the model. The records from the intermediate region is too much influenced by the effects of sharp local differences in environmental conditions which are not merely controlled by climate.

It is here considered that the many hygrophytic assemblages recorded from Europe (compare Fig. 3) have to be primarily related to the influence of the extensive river-systems characteristic of the European Karnian. It has been the water-supply of rivers rather than rainfall that has created local conditions for hygrophytic plant communities within an arid climatic belt. Or, introducing a recent analogy, the fluviatile/deltaic coal-bearing facies of, for example, the Germanic "Schilfsandstein" and the Alpine "Lunzer Schichten" reflect "Nile-valleys and Nile-deltas in a Karnian Sahara".

General Conclusions

It cannot be overemphasized that the present contribution should be regarded as of a preliminary nature. It may however show patterns that even in their present incomplete and inaccurate form appear to foreshadow the value of palynological research in solving the problems of Triassic phytogeography and climate.

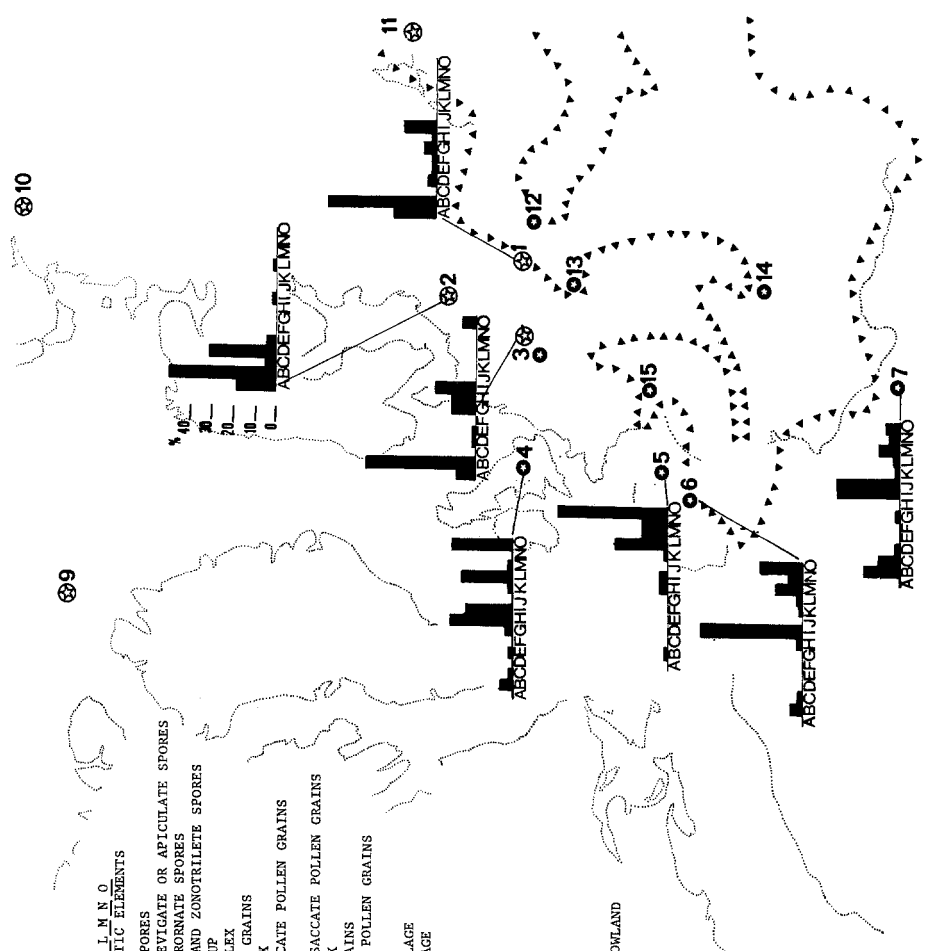

Fig. 3. Geographical distribution of a selection of hygrophytic and xerophytic palynological assemblages from the Karnian.

When palynological information accumulates, we believe that these patterns will steadily increase in consistency.

In the meanwhile, the most logical conclusion would appear to be that of a more relative attitude with regard to some current generalizations in Triassic phytogeography and palaeoclimatology. In particular, (1) the concept of only two distinctive floras, (2) the concept that present-day climatic zonation is the key to the past, and (3) the concept that coal exclusively implies a humid climate, have to be reconsidered.

Acknowledgements

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PLATE I

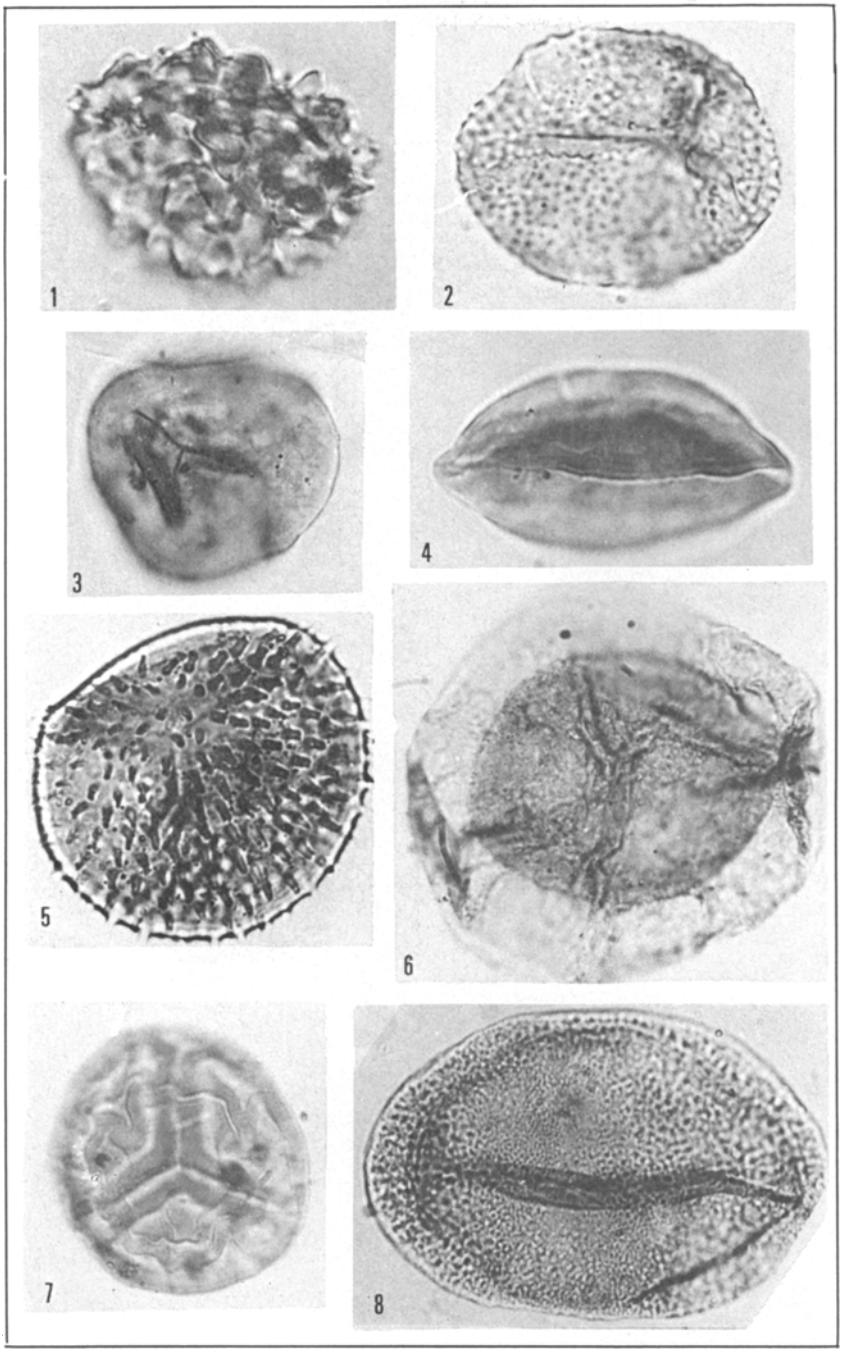

Plate I. Aspect of a hygrophytic Karnian palynoflora (magnification approx. 1050 x). 1 — *Thymospora ipsviciencis* (group A). 2 — *Punctatosporites walkomii* (group A). 3 — *Leschikisporites aduncus* (group A). 4 — *Cycadopites* sp. (group C). 5 — *Carnisporites spiniger* (group B). 6 — *Aratrisporites* sp. (group E). 7 — *Camerozonosporites rudis* (group D). 8 — *Ovalipollis pseudoalatus* (group H).

PLATE II

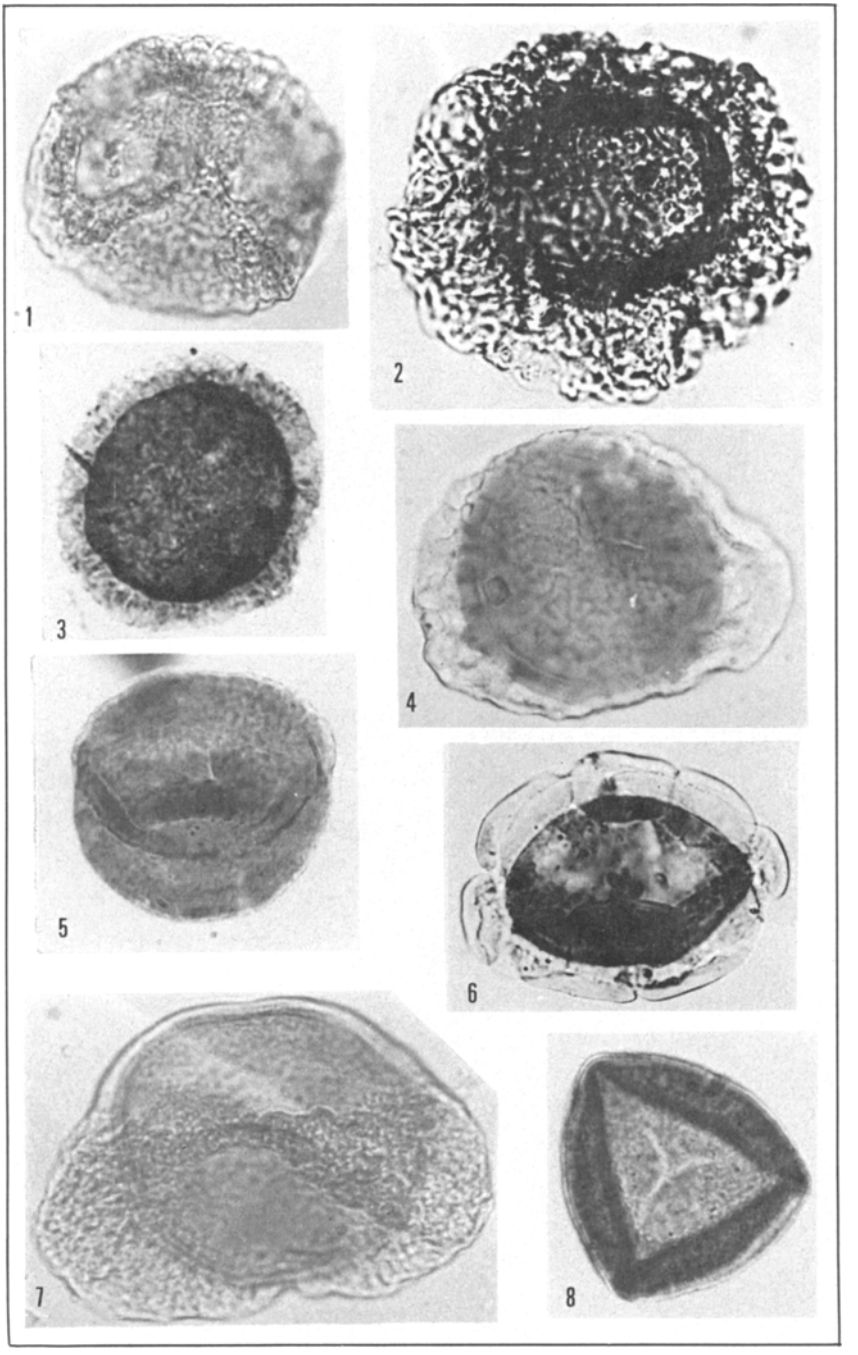

Plate II. Aspect of a xerophytic Karnian palynoflora (magnification approx. 1050 x). 1 — *Vallasporites ignacii* (group M). 2 — *Patinasporites densus* (group N). 3 — *Enzonalasporites vigens* (group M). 4 — *Triadispora plicata* (group L). 5 — *Partitisporites* sp. (group O). 6 — *Camerosporites secatus* (group O). 7 — *Samaropollenites speciosus* (group I). 8 — *Duplicisporites granulatus* (group O).