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GLOBAL PALEOBOTANY, AS EXEMPLIFIED BY SOME UPPER CARBONIFEROUS PTERIDOSPERMS

by

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ABSTRACT

A detailed study of the geographical and stratigraphical distribution of the genera *Paripteris* Gothan and *Linopteris* Presl reveals important chronological discrepancies in the levels of their first occurrence between widely separated geographical regions. The general implications for biostratigraphy, paleogeography, systematics and evolution are discussed.

RESUME

L'étude précise de la distribution géographique et temporelle des genres *Paripteris* Gothan et *Linopteris* Presl montre des décalages chronologiques importants entre les niveaux de première occurrence entre régions éloignées. Les implications générales aux plans biostratigraphique, paléogéographique, systématique et évolutif sont analysées.

KEY WORDS

Carboniferous, Pteridosperms, *Paripteris, Linopteris*, biostratigraphy, paleogeography, evolution, Europe, China.

MOTS CLES

Carbonifère, Ptéridospermophytes, *Paripteris, Linopteris*, biostratigraphie, paléogéographie, évolution, Europe, Chine.

1. INTRODUCTION

During the last two decades, a multidisciplinary approach has become increasingly important in the various domaines of the Earth Sciences, including paleobotany. Nowadays paleobotany must be, as far as possible, global, or better still, "total". By the latter we mean that whatever the line of research initially pursued in a paleobotanical study, as soon as one wants to deepen the question, one is obliged to look at it from all angles : Systematics, Biostratigraphy, Paleobiogeography and Evolution, each of these fields being intimately related with all the others, and with the constant and underlying frame of time.

On the basis of a precise chosen example from the wealth of paleobotanical data, we will here show the permanent interrelationships between the various subjects and try to draw some general and methodological conclusions.

2. MORPHOLOGICAL CHARACTERISTICS AND DISTRIBUTION OF

PARIPTERIS GIGANTEA (Sternberg)

A) Main morphological characteristics

Paripteris gigantea (Sternberg) is a particularly abundant pteridosperm in the Carboniferous of Eurasia. Initially described under the name *Osmunda gigantea*, this species was soon integrated into the genus *Neuropteris* after the creation of the latter taxon by Brongniart (1822).

Later on, the main characteristics of this species were progressively defined as follows (fig. 1) : last

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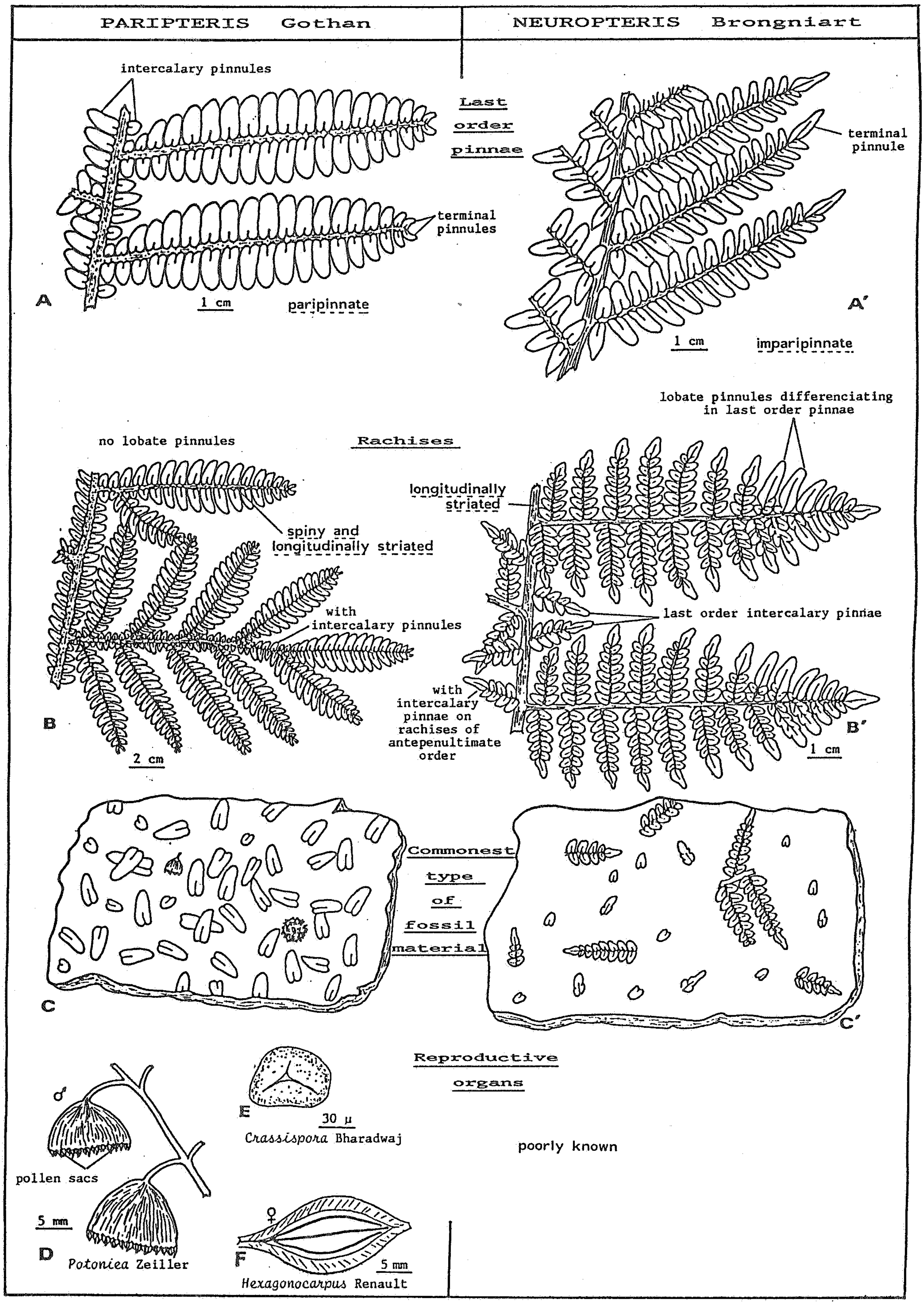

Figure 1. : Comparison of the main characteristics of the genera *Paripteris* Gothan and *Neuropteris* Brongniart.

order pinnae paripinnate, *i.e.* ending in a pair of pinnules smaller than the adjacent ones (fig. 1A) ; rachises of all orders longitudinally striated, with spiny protrusions and bearing entire pinnules never lobate (fig. 1A and B) ; probable abscission zone at the base of the pinnules with the consequence that the most common fossil type in this (and related) species is represented by beds of numerous dispersed pinnules (fig. 1C) ; male reproductive organs known as *Potoniea* Zeiller (fig. 1D) with pollen grains (Laveine, 1971) still with a pteridophytic habitus (fig. 1E) and probably known in the dispersed condition as *Crassispora kosankei* (Pot. & Kr.) ; seeds of medium size, of *Hexagonocarpus* Renault type (fig. 1F) or allied genera. Many of these very distinctive characteristics were used to justify the separation from the genus *Neuropteris* Brongniart and the ereation of the genus *Paripteris* by Gothan (1941), and even the separation at a higher level within the *Parispermae* by Laveine (1966, 1967).

For comparison, in typical *Neuropteris* the last order pinnae are imparipinnate (fig. 1A′), *i.e.* with a single terminal pinnule in the prolongation of the rachis, bigger than the adjacent pinnules ; the penultimate rachises are devoid of rachial pinnules (fig. 1A′, B′), but the antepenultimate rachises bear intercalary last order pinnae (fig. 1B′) ; all the rachises show a marked longitudinal striation but without any spiny protrusions ; there is a gradual differentiation from simple entire pinnules to last order pinnae (fig. 1B′) by a progressive lobation of the pinnules (Laveine *et al.*, 1977) ; when one considers a last order pinna, as the lateral pinnules are differentiated by lateral lobation of the terminal pinnule, there is always a strong adherence to the rachis of the last formed lateral pinnules, so that even though the fronds may be strongly disaggregated during fossilization (*e.g.* due to the turbulence of the depositional environment), at least some fragments of last order pinnae with a single terminal pinnule flanked by a few lateral pinnules can always be found (fig. 1C′). As to the reproductive organs, the most that can be said is that they are far from being well known, and this also is a clear difference when compared with the frequent occurrence of *Potoniea* Zeiller within the Parispermae.

B) Stratigraphical distribution

By the above mentioned characteristics *Paripteris gigantea* is easily identified. It is also a very common species, having been widely recorded during the last century from Western European Coalfields. Its stratigraphic range has been very precisely established. It appears exactly at the base of the Upper Namurian B (Havlena, 1969), that is, at the base of the R2 ammonoid zone which is characterized by *Reticuloceras gracile* Bisat and *Reticuloceras bilingue* (Salter).

Western European paleobotanists were thus satisfied with the biostratigraphical results obtained and pleased to have at their disposal, together with other guide species, an apparently nicely adjusted biostratigraphic scale.

Settled in such a comfortable certainty, one of us, in a study on a well-preserved flora with *Paripteris gigantea* from the Pyrénées area (Delvolvé & Laveine, 1985) which was associated with some goniatites that gave an early Namurian B age to these fossiliferous levels (Kullmann & Delvolvé, 1985), even questioned the generally accepted prevalence of the ammonoid scale over the plant scale, because of the very well-known stratigraphic range of *Paripteris gigantea*

Nevertheless, with the welcome opening of so vast a country as China, with good and extensive Carboniferous outcrops, a lot of information relevant to the question under debate here became progressively available out. In particular, *Paripteris gigantea* (Sternberg), still described by our Chinese colleagues as *Neuropteris gigantea* (Sternberg), was to be found in China as early as the Upper Visean (see *e.g.* Yang Shipu *et al.*, 1983 ; Zhao Xiu-hu & Wu Xiu-yuan, 1985).

So once more the question arose, and in a more crucial manner, on the possibility of the existence of an important chronological discrepancy between the "appearances" of that species in widely separated geographical regions, assuming that the identification and the given stratigraphic age were right.

Of course, if it was still possible to contest this information, the best way forward was to carry out mutual investigations in both areas with the hope of clearing up the question. So, in 1985, some common research on Carboniferous biostratigraphy began within the framework of a Franco-Chinese cooperation established by the CNRS and the Chinese Academy of Sciences.

In 1987, we took the opportunity of a trip in Gansu, North China, to make sure that *Paripteris gigantea* (Sternberg) could be recognized in the Chounioukou Formation, which is of Late Visean age. During the same year, *Paripteris gigantea* was recorded from strata of probable Late Visean to Early Namurian age in the vicinity of Guangzhou (Guangdong, South China). In 1988, similar observations were made again in Ningxia, North China, and once more in the Guangzhou area. In addition, some other discoveries with comparable stratigraphic conclusions were published by Wu Xiu-yuan *et al.* (1986).

On the balance of all these converging data one must accept the following evidence : *Paripteris gigantea* is found in China as early as the Upper Visean and is only recorded from the Upper Namurian B in the Western European Coalfields, that is, if we take into account the results of radiochronology, with a shift in time of at least five million years (fig. 2).

Those geologists and paleobotanists who concentrate mainly on biostratigraphy will certainly regret that there might be such an important chronological difference in the levels of first occurrence of a given taxon in more or less distant sedimentary basins. They may consider that it is to the discredit of the biostratigraphic method and would maybe try to minimize the importance of such discrepan-

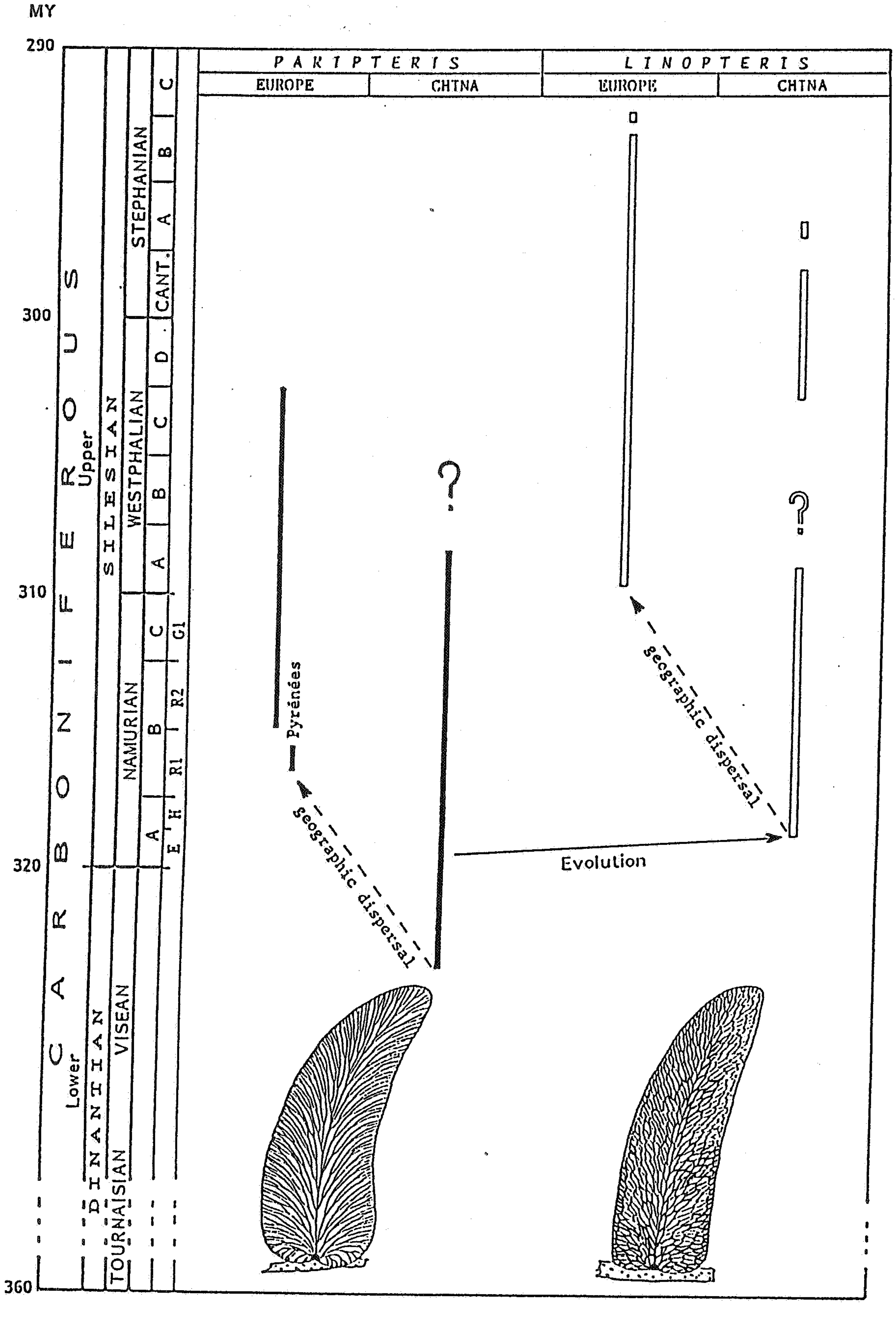

Figure 2. : Comparison of the stratigraphical distribution of the genera *Paripteris* Gothan and *Linopteris* Presl in Western Europe and China.

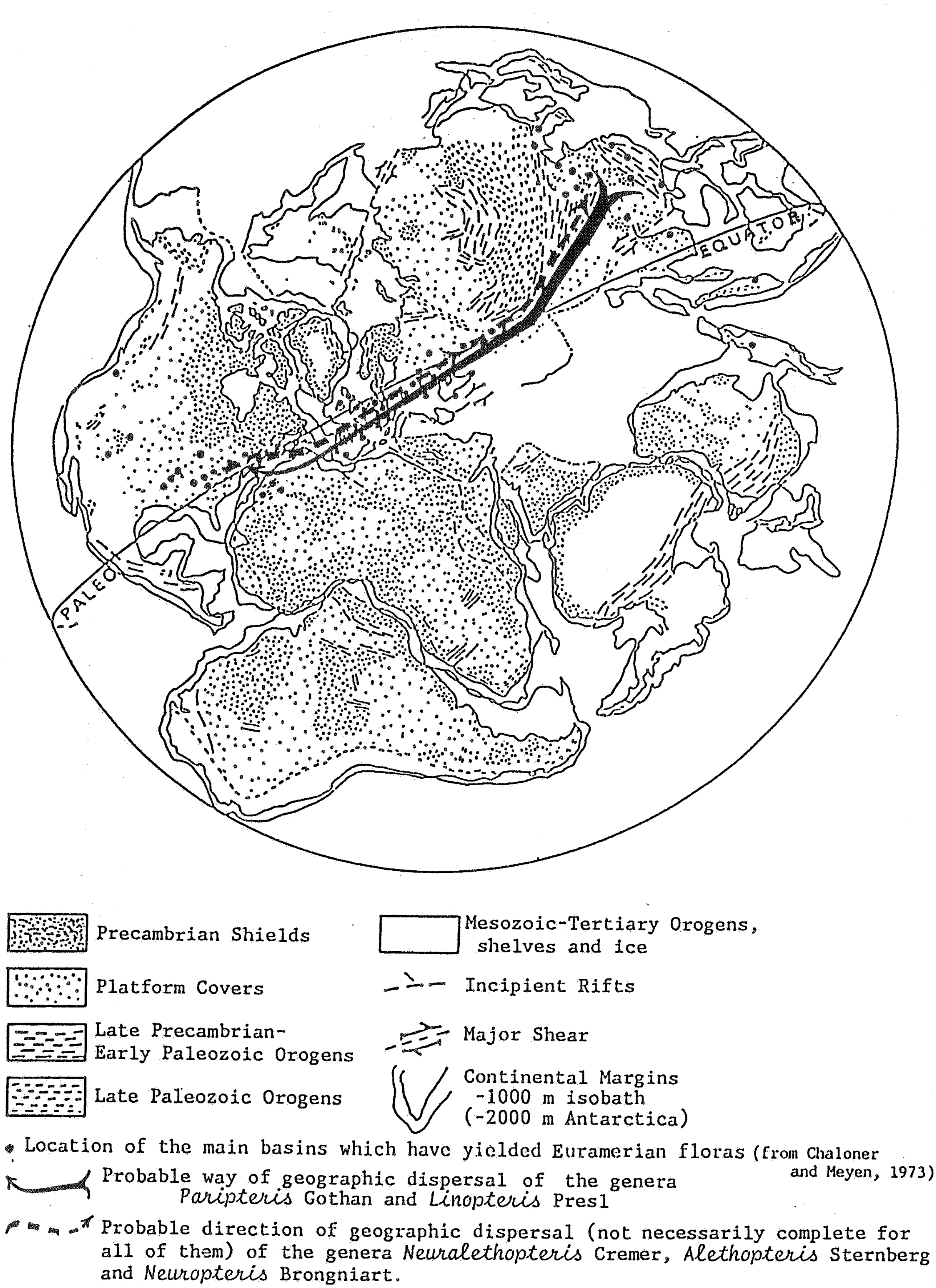

Figure 3. : Probable routes of migration resulting in the extension of geographical ranges (on a Pangea reconstruction for the Devonian - Mid-Carboniferous by Rickard & Belbin, 1980) for several genera of Carboniferous pteridosperms. The position of the paleoequator is not the one given by Rickard & Belbin ; it has been slightly moved on paleobotanical grounds.

cies, as did more or less one of us (J.-P. L.) on the Pyrénées flora. That would not, in our opinion, be the right and best position. We shall, later on, more largely comment on the biostratigraphic consequences, which depend on the scale involved, and we shall see that some shade is always necessary on such points. But let us say briefly here that, *within the limits of a basin*, experience shows that settlement of a given species is practically instantaneous when compared with the duration of geological time, therefore the biostratigraphic method is, in that case, by far the "less bad" for datation and correlation of strata.

C) Geographical distribution

At a larger scope and on other viewpoints, the important chronological difference recorded between the first occurrence of *Paripteris gigantea* in different regions may be considered to represent in itself a justification of the value of paleobotanical data for paleogeographical purposes. It implies that such a species as *Paripteris gigantea* with seeds of rather large size, was able to extend through its known geographical range only by means of land connections between the corresponding regions. So paleobotany can afford very substantial arguments for the paleogeographic reconstructions in Late Paleozoic times.

For instance, if we consider the two main blocks constituting Eastern China, *i.e.* the North China Block (Sino-Korean Craton) and the South China Block (Yangtze Craton), many controversial views on the age of their accretion have been published over the last years. Many structuralists and paleomagnetists (for instance Lin Jin-lu *et al.*, 1985 ; Klimetz, 1985 ; Sengor, 1985) are in favour of a Triassic-Early Jurassic accretion for these blocks. But the close similarity between the Lower Carboniferous plant assemblages recorded (which, of course, are not restricted to the one species *Paripteris gigantea*) in North and South China shows that these blocks were already in contact at least since the Early Carboniferous, and such conclusions are in accordance with the view of Zhang *et al.* (1984) and the opinion of Mattauer *et al.* (1985), who profess that the corresponding accretion occurred during the Devonian.

This also means that there was a continental connection with Europe and that *Paripteris gigantea*, after its differentiation in East Asia during the Late Visean, extended westwards step by step (fig. 3), maybe through Kazakhstan, Northern Afghanistan, Asia Minor, Southern Europe, Western Europe and North Africa to finally reach North America where it is rather poorly represented. This example illustrates the importance, not only for paleogeography but also for the reliability and refinement of inter-regional stratigraphic correlations, that must be given to the careful examination of the possible migration routes followed by various species to cover their maximal geographic ranges for evaluating say the "duration of the journey", or, in more technical terms, estimating the chronologic difference induced by prochoresis (geographic extension).

However the consequences are not restricted to the fields of paleogeography and biostratigraphy. As was said in the introduction, everything is related and these facts also affect evolutionary interpretations, and may be of great help in highlighting areas in need of research and in defining goals;

D) Evolutionary implications

For the sake of coherence we shall mainly base the discussion on *Paripteris gigantea*(Sternberg), but a short introductory comment on some major trends in foliar morphology within the group of the Pteridospermophyta must be given.

In this group it has been well known for a long time that, among several major fairly well-defined subgroups, every genus with an open fasciculate venation has a closely related genus with reticulate venation. It is well known that to *Alethopteris* Sternberg is related *Lonchopteris* Brongniart and that to *Neuropteris* Brongniart is related *Reticulopteris* Gothan. In each case the genus with reticulate venation occurs later than the genus with open venation.

Paripteris Gothan does not make an exception to that "rule" and also has a reticulate correspondent, *Linopteris* Presl, which possesses the same overall general characteristics : identical paripinnate pinnae, identical frond architecture, identical male reproductive organs of *Potoniea* type, same kind of pollen grains, and so on ...., the difference lying in the clearly reticulate venation. In Western Europe, the first indisputable representatives of *Linopteris* are found in the Lower Westphalian A.

The passage from open venation to reticulate venation has been studied by paleobotanists. Some intermediates have been found within the genus *Alethopteris*, the venation of which became more and more flexuous and indicates how the genus *Lonchopteris* could have become differentiated from the genus *Alethopteris*. In the same manner, *Neuropteris semireticulata* Josten represents a clear gradual link between *Neuropteris* and *Reticulopteris*. However, as there was no such gradual transition between *Paripteris* and *Linopteris* in Western Europe, it was more or less supposed that the passage occurred more abruptly, by an evolutionary "jump" and nothing more has been said on this point.

With reference to the latter question, the data recorded from Eastern China have to be taken into account. *Linopteris* is also present in China, and it also follows the "rule", *i.e.* it appears later than *Paripteris*. But once more the chronologic information is of fundamental importance to the argument. When does the genus *Linopteris* appear in China ? In strata of Early Namurian age, that means earlier than the level of the first occurrence of *Paripteris* in Western Europe. In other words, it would have been devoid of sense to use sophisticated techniques and methods on western specimens to study lineages leading from *Paripteris* to *Linopteris*, as the transition occurred in Eastern Asia. It is clear that one can hope to find out the details of the transition between these two genera only in Eastern Asia and not in Western countries where they are later immigrants.

Apart from the evolutionary aspect, it must be noted that we can make the same observations for *Linopteris* as for *Paripteris* and reach the same conclusions about biostratigraphy and paleography. Here too we can draw the same scheme : an appearance in the Far East and a westward gradual geographic dispersal (fig. 3), probably along the same route, and also with an important chronological discrepancy between the first occurrences at the two ends of the geographical distribution.

3. METHODOLOGICAL IMPLICATIONS

A) Biostratigraphic implications

When considering such chronological discrepancies, the first idea that comes to mind, after verifying that the identification is correct, is to question the datation of the corresponding strata. In newsletter n° 6 (1988, p. 18) the Mid-Carboniferous boundary working group (Subcommission on Carboniferous Stratigraphy of the IUGS) discussed the shortcomings of the section studied during the 1987 field excursion in Gansu province. This is not the place to comment on the shortcomings of the candidacy of the section to be chosen as the international reference section but to take into account the fact (point 3 of the report) that specimens of *Linopteris* Presl can be found in strata "between the marine Arnsbergian, *G. bilineatus bollandensis* faunas and in the lowest *D. noduliferus*" (and, point 2 : "the association of *D. noduliferus* and *Neognathodus symmetricus* indicates on horizon higher than the ***base*** of the Chokerian stage"). So, whatever these restrictions may be, these levels are of Namurian A age, and it is difficult to understand what is meant exactly by the last part of point 3 : "Plant specialists on the excursion agreed that ***early Namurian plants*** were present, but were accompanied by genera such as *Linopteris*, which in Western Europe, do not occur below the Late Namurian - Early Westphalian interval" !!

Does this mean that the accompanying Early Namurian plants should not be here considered as Early Namurian plants (and, in that case, what are the consequences for the other areas where they are accepted as Early Namurian indices ?), and the same question must be asked for the conodont assemblages bounding these plant levels ? Or does it mean that the plant specialists present at the meeting do not accept the age given by the faunal assemblages or, alternatively, that they have some difficulty in recognizing that *Linopteris* appears earlier in China and can therefore no longer play the part of a key index taxon in inter-regional stratigraphic correlations (and, of course, we must remember that what can be true for one taxon may be true for all taxa !) ?

Let us now add a few comments on the latter points, viz., the paleontologically determined age. More or less important chronological discrepancies may occur in any group and the main question here lies in the weight that may be given to the different fossil index groups. Which is the most reliable : ammonoids, conodonts, or plants ? The answer is evident : it depends on the speed of geographic dispersal, whatever the speed may only correspond to the usual biological mechanisms of dispersal or may be increased by morphological features facilitating *post mortem* transportation. The answer can only arise from the demonstrated efficiency given by field evidence. The field evidence here tends to show that plants may not be the most accurate elements for long-distance stratigraphic correlations, and even inside the plant community, the speed of dispersal is surely not the same for all species. It thus seems highly probable that the dispersal should be quicker for plants with light dissemination elements (for instance small isospores) than for others with relatively large seeds.

A supplementary fact supports the idea that the effective chronological discrepancy in the first occurrence of *Linopteris* and *Paripteris* between the Far East and Western Countries is related to the time necessary to occupy the whole area and not related to an eventual wrong datation of the corresponding strata. In the case of a wrong datation the trend for all taxa in the chronological and geographical discrepancy should always appear in the same direction. This is not the case. On the other hand, if the geographic dispersal of plants was so easy and independent (for most of them) of terrestrial connections, there should be no chronological differences in their first occurrences anywhere. But this is not the case either.

Assuming that *Paripteris* and *Linopteris* probably first appeared in the Far East in Visean and Namurian times respectively, and reached Western Countries during the Namurian and Westphalian, the genera *Neuropteris* Brongniart, *Neuralethopteris* Cremer, *Alethopteris* Sternberg, *Lonchopteris* Brongniart for instance seem to be of western origin. Let us consider *Neuropteris* : we have not yet seen, among the collections or in the field, any representative of this genus in China, except for *Neuropteris ovata* Hoffmann and probably related species (or synonyms !), in strata of at most Late Westphalian age. When one realizes that it is a very common genus with many representatives in Western Countries in the Upper Namurian and Lower Westphalian, and with some early species in the Visean, it seems highly probable that the centre of origin of the genus is situated in Western Countries. Furthermore, if some supplementary information is found to ascertain the generic identification, the genus *Neuropteris* probably appeared (or differentiated) in North America during the Early Carboniferous (Gensel, 1988) and then gradually extended eastwards during Middle Carboniferous times.

Apart from *Neuropteris ovata* and related forms as mentioned above, the only Namuro-Westphalian species from China which may be related to the group of the Neurodontospermae (*sensu* Laveine, 1966, 1967) is *Lopinopteris intercalata* Szc (Gu and Zhi, 1974). Indeed this species resemble such western species as *Neuropteris obliqua* Brongniart.

This point could be correlated with the existence, for instance, in Kazakhstan of *Neuropteris heterophylla* Brongniart and *Neuropteris obliqua* Brongniart (Oschurkova, 1978).

The same can be said about the genera *Alethopteris, Lonchopteris* and *Neuralethopteris*, the centres of origin of which have yet to be precisely located, but which are very probably of western origin and have extended eastwards. Despite the fact that *Neuralethopteris schlehani* Stur has been described several times in the chinese paleobotanical literature (we have examined all the corresponding specimens and there is no *Neuralethopteris schlehani*), the genera *Neuralethopteris* and *Lonchopteris* do not seem to have extended beyond the Caucasus (Anisimova, 1979). This could be due to the fact that they disappeared rather early (for unknown reasons) before having reached the Far East. As to the genus *Alethopteris*, it is necessary to examine it very carefully at the species level to correctly analyse its general geographic dispersal and, to answer this question, more data are needed.

It is now evident that such facts contribute much to biostratigraphy.

We can postulate that the dispersal of a species ***in a basin*** was practically instantaneous and thus that the level of first occurrence can be used as an indicator of an isochronous level ***within the basin***, but it now seems evident that this cannot be done on a global scale without detailed analysis. In this last case, in order to get the best biostratigraphic results possible, it is better to keep in mind the possibility of heterochrony and to find it out as precisely as possible, instead of trying to ignore it.

But to delimit as precisely as possible on a global scale the possible heterochrony related to the geographic dispersal of any species, we reach the conclusion, which may seem paradoxical to non-concerned people, that very precise work must be done in each sedimentary basin in order to be sure, with the multiplicity of records, that the stratigraphic ranges of the various species are almost certainly correct. And only then will it be possible to compare the level of first occurrences from one basin to another in order to define the exact rate of geographic dispersal.

Indeed this presupposes correct identification of species (and the undertaking of related systematic and evolutionary studies) and also the support of all geological information in a step-by-step comparison from one basin to its immediate neighbour. In order to avoid circular reasoning inside paleontological arguments, as far as possible it will be necessary, in all cases, to take into account all the available key-beds such as volcanic ash-falls or any other kinds of datum levels (but not linked with paleontology) common to two or more adjacent basins, in order to precisely define the possible differences in time of the first occurrences of the different species and to find out the direction of their geographic dispersal. Under these conditions, it will be feasible to use as accurately as possible plant fossils with a fairly good stratigraphical precision.

Nevertheless, it is clear that a lot of time and work is necessary to meet all these goals, but it must be said that no one can ignore the potential pitfalls of any biostratigraphic correlation and that the dream of defining type sections and boundary stratotypes for world-wide correlation must, of course, be stimulated and carried on as precisely as possible, but in keeping with a certain amount of wisdom and philosophy.

B) Paleogeographic implications

The definition, as accurate as possible, of the route and duration of geographic dispersal is not only important for biostratigraphy, but also for paleogeographic purposes.

As has already been mentioned, the chronologic discrepancies in the geographical distribution are in themselves a justification of the importance of plant distribution for paleogeographical studies. Thus, when more precise information is obtained with the increase of accurate biostratigraphic records, one can hope to be able to elucidate the reasons for the sudden interruption in the geographic dispersal of a species in two presently close basins, and to estimate the kinds of barriers (ocean, ecological environment) that may be the cause of these variations or interruptions in the geographic dispersal.

C) Systematic and evolutionary implications

It is clear that the biostratigraphic results and the benefits to other disciplines that may be expected from these results are of no value if the taxa are not well defined. For instance, many biostratigraphers are not yet well aware of the striking morphological differences which exist between *Paripteris* Gothan and *Neuropteris* Brongniart. This may not be too important when they are able to go to the specific level, because it is generally well known that *Neuropteris gigantea* (Sternberg) is in fact *Paripteris gigantea* (Sternberg). But in some cases, when it seems impossible to reach the specific level, it is important to be sure of the generic one : it is important to avoid confusion between *Neuropteris* sp. or *Paripteris* sp. Some paleobotanists do not accept the use of *Paripteris* because they consider, when they have at their disposal only a few isolated pinnules, that it is impossible to decide if it is *Paripteris*, so they only use the designation *Neuropteris* sp. (for example Darrah, 1969). We can add that this is not a good argument because, in that case, it must be said that the amount of systematic information given by a neuropteroid morphology of a few isolated pinnules is too poor, and not restricted to the genera *Paripteris* and *Neuropteris*, but may also be found within other genera such as *Cardiopteridium* Nathorst, *Neurocardiopteris* Lutz, *Cardioneura* Zalessky or *Neuralethopteris* Cremer for instance. Then it seems once more necessary to claim that, if the recorded details are too poor, it is devoid of sense to try to give a generic identification which is only approximative or may be wrong. The main result of such a misleading procedure is that it worsens the information, both for stratigraphic and paleogeographic use.

On the contrary, if the work on these points is correctly led, it may furnish interesting information, even at a strict systematic level.

For instance Taylor and Taylor (1987) mainly on the basis of similarity of the pollen grains, have included the male reproductive organ of *Potoniea* Zeiller within the Lyginopteridales. In so far as *Potoniea* is, on the ground of a fairly constant association, almost certainly the male reproductive organ of *Paripteris* and *Linopteris*, this implies that these two genera must also belong to the Lyginopteridales and not to the Medullosales where they are generally classified, together with for instance *Neuropteris* and *Alethopteris*

Despite what is generally said, the relationship between the stem structure *Medullosa* Cotta and *Neuropteris* type foliage is up to now not fully demonstrated. On the reverse, it seems more or less clearly established that *Linopteris* (and consequently *Paripteris*) is related to the stem structure *Sutcliffia* Scott which itself bears a very close similarity which *Medullosa* except, as was suggested by Stidd *et al*, 1975, for the distal part of the rachises (of *Myeloxylon* type) where the vascular bundles can show a pattern which may recall the lyginopterid pattern.

Therefore we are confronted with the following alternative : is the morphology of pollen grains of heavier weight compared with the general anatomy ? It is very questionable that the morphology of the pollen grains of *Potoniea* must take the prevalence. This type of pollen grains which seems to represent a primitive type is not restricted to that genus and, in a cladistic manner of reasoning, it could be interpreted as a plesiomorphic character of little value for the evalutation of systematic proximity. At this level of uncertainty it may be of interest to remind that the genera *Paripteris* and *Linopteris* are probably of Far East origin and that the genus *Lyginopteris* is, up to now, unknown in China (with the restriction that Sze, in 1953, described a new species, *Sphenopteris parabauemleri*, considered to be of lyginopterid affinity, but in fact it is unclear whether this species could not be *Pecopteris pennaeformis* Brongniart, the discovery of fructified specimens would be decisive on that point). As the genus *Lyginopteris* probably originated in Western Countries, and the genera *Paripteris* and *Linopteris* in Far East, it implies that there is no close relationship between the latter two genera and the Lyginopteridales. *Paripteris* and *Linopteris* seem to stand apart as a special group, whatever the name given to the group : Potonieinae, Parispermae, Parispermales or Sutcliffiales, the apparent similarities with other groups being plesiomorphic characters probably inherited from the early diversification of the Pteridosperms.

4. CONCLUSION

As this short attempt tries once more to demonstrate, paleobotanical studies must now be carried in all main directions of the paleontological field. Of course, depending on the kind of material at hand, on the scarcity or abundance of specimens, some aspects may be privileged, but it must be said that it is only on a global scale that the results can take all their significance. On the reverse, global conclusions are possible and valuable only if the detailed studies have been made as precisely as possible.

This is rather stimulating because it demonstrates the strong unity of paleontology, with the proof that all kinds of research are necessary and useful, at the only condition that the work be done as objectively as possible. No paleobotanist, no biostratigrapher should allow himself to indicate the existence of a taxon outside its up to date recognized stratigraphical or geographical range without furnishing the proofs on the correctness of the identification or about the stratigraphic level involved. If not, how will it be possible, in a given area, to draw out precisely the stratigraphical range of the various species if a correct systematic research is not carried at the same time ? How will it be possible to reach correct evolutionary conclusions on ill defined species and biostratigraphy ? How will it be possible to correctly study the paleoecological and paleogeographical aspects on doubtful taxa or doubtful age ? How will it be possible to precise from place to place, step by step, the modalities of geographic dispersal if precise biostratigraphical works have not been done in the various basins and if we are not sure of the position of the levels of first occurrences and, consequently if we are unable to precisely find out the centres of differentiation of the various species and so far, how could paleobotany bring interesting data to the other fields of Earth Sciences ?

It seems evident that, for any junior paleobotanist who accepts to carry on research with an open mind, a lot of wonderful discoveries are still to be made in connection with all the other Earth Sciences.

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