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PRELIMINARY NOTE ON PRESENCE OF EARLY CARBONIFEROUS FLORULE FROM JILIN

Zhang Shan-zhen*, Sun Ge* and Zhao Yan-hua**

Summary

The purpose of the present paper is to record the discovery of Early Carboniferous plants of Angara floral aspects from Jilin province, with special reference to its geological and phytogeographical bearings. The material was gathered by the geologists of the Regional Geological Survey, Bureau of Geology and Mineral Gesources, Jilin from the Lower Carboniferous Lujuantun Formation in Panshi District, Jilin Province (about 43°14′N Lat. and 125°31′E Long.) (Text fig. 1) during geological mapping. The Lujuantun Formation, a set of dark gray to black, slightly metamorphic siltstone series some 500 m in thickness, is overlain by the Upper Carboniferous Mopanshan Formation. Here published is the stratigraphical sequence of a section of the Lujuantun Formation in descending order for reference.

Overlying Mopanshan Formation (C_2m)

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Lujuantun Formation

20. Blackish gray siltstone intercalated with lenses of limestone yielding *Dibunophyllum bipartitum* (M'Coy), *Orionastraea* sp. indet., *Lonsdaleia manchuriensis* (Minato et Kato), *Lithostrotion asiatica* v. *minor* (Minato), *Gangamophyllum retiformis* Lin et Fan, *Palaeosmilia* sp., and *Arachnolasma* sp. 204.9 m

19. Dark gray limestone, yielding crinoid stems. 19.9 m

18. Yellowish green sandstone, yielding fragments of plant-fossils. 9.5 m

17. Dark gray limestone, yielding fragments of fossil corals. 9.3 m

16. Yellowish green sandstone. 4.6 m

15. Dark gray limestone, yielding fossil brachiopods. 6.6 m

14. Dark gray siltstone and carbonaceous siltstone, yielding plenty of the fossils plants *Mesocalamites jilinensis* sp. nov., *Angaridium panshiense* sp. nov., ?*Aneimites* sp. *Neuropteris* sp. aff. *N. pseudogigantea* Pot. *N.* sp., and *Carpolithus* sp. 13.2 m

13. Greyish black siltstone, yielding *Productus* sp., *Striatifera*? sp., *Athyris* sp., *Punctospirifer subtexta* (White), *Echinoconchus* sp., *E. elegans* (M'Coy); *Aviculopecten* sp., *Nuculosis*? sp., and *Crenipecten*? sp. 14.3 m

12. Dark grey limestone, with cherty nodules, yielding *Dibunophyllum turbinatum* M'Coy, *Aspidophyllum* sp., *Lonsdaleia manchuriensis* (Minato et Kato). *Arachnolasma* sp., *Gangamophyllum retiformis* Lin et Fan, *G. boreale* Gorsky, *G. divisum* Sayut., *Gigantoproductus* sp., *G.* cf. *giganteiformis* (Liss.), *G.* cf. *latissimmina* sp.; *Ozawainella* sp., *Tetrotaxis* sp., and *Climacammina* sp. 2.6m

11. Greyish black siltstone, yielding *Punctospirifer* cf. *subtexta* (White), *Echinoconchus* sp., and *E. elegans* (M'Coy). 36.8 m

10. Dark grey limestone, yielding *Punctospirifer* sp. 3.2 m

9. Greyish black siltstone. 9.3 m

8. Yellowish green sandstone, yielding *Punctospirifer* sp., and *Echinoconchus elegans* (M'Coy). 21.5 m

* Nanjing Institute of Geology and Palaeontology, Academia Sinica;

** Regional Geological Survey, Bureau of Geology and Mineral Resources, Jilin Province.

7. Yellowish green siltstone, yielding *Productus concinnus* Sow., *Spiriferllina* sp., *S.* cf. *cristata*, *Punctospirifer* sp., and *Productus* sp. 29.6 m

6. Greyish green siltstone, yielding fragments of bryozoans. 13.6 m

5. Greyish green siltstone, yielding *Productus concinnus* Sow., *P. jichangensis* Lee et Gu, *P. dugnensis* Sar., *P.* sp., *Athyris* sp., *Dictyoclostus* sp., and *Composita*? sp. 7.3 m

4. Yellowish green siltstone with limestone lenses yielding crinoid stems. 1.7 m

3. Greyish black siltstone, yielding *Neuropteris* sp. indet. 0.5 m

2. Yellowish green sandstone, yielding *Rhombotrypella* sp. 0.4 m

1. Greyish feldspathic-silicarenite. 2.7 m

Still lower part unexposed due to the covering of Quaternary deposits.

The section described above are worked out from the north limb of the Bingjiaoshan syncline. In the south limb of the syncline, fossils have been collected from intercalations of limestone lenses in grey siltstone, which may be correlated with bed 12 in the south limb, including *Yuanophyllum* sp., *Dibunophyllum turbinatum* M'Coy, *Gangamophyllum boreale* Gorsky, *Lithostrotion asiaticum* Yab. et Hag., and *Gigantoproductus* sp. In addition, another section has been studied in the Shaoguobei mountains where the Lujuantun Formation is directly overlain by the Mopanshan Formation disconformably.

The Lujuantun Formation is composed of a set of fossiliferous beds with plenty of brachipods, pelecypods and plant fossils in the sandstones, corals and brachiopods in the limestones. The rock sequence is fairly well exposed and the plant-bearing beds are intercalated in the late Early Carboniferous invertebrate-bearing beds; this enables the study of its geological age and also provides us with a palaeozoological evidence. It should be noticed that though the small florule described here is rather meagre as yet, it is recorded for the first time with relevant description and discussion on the florule elements, and it is of considerable interest in palaeophytogeography.

SYSTEMATIC DESCRIPTION

Mesocalamites jilinensis sp. nov.

(Pl. I, figs. 1—4)

Pith-cast 1—1.8 cm in breadth, and internode 1.5—2 cm in length; ribs less than 1 mm in breadth, running straightly through the node or alternately arranged, with pointed ends; infranodal scar elliptical, 1 mm long and 0.5 mm broad; nodal line not straight.

Fragments of pith-cast belonging to this species are found in the collection. Judged from the alternation and non-alternation of the ribs in the node, the present form is ascribed to the genus *Mesocalamites*, and may be compared with the species described from the Namurian of Europe, which has been thoroughly studied by Dr. Josten (1983) recently. *Mesocalamites cistiformis* Stur recalls the present material in its narrow (only 1 mm broad) ribs, pointed ends, small and elliptical infra nodal scars, but differs in the straight nodal line. *Mesocalamites ramifer* Stur is also characterized by its partially straight and partially geniculate nodal line, but with broader ribs which normally attain a breadth of 1—2 mm (Josten, 1983, p. 29), In addition to these differences, both European species of Namurian also may be distinguished from the present one by their longer internodes.

In Siberia, the genus also has been recorded from the Evseev to Mazurov Horizons of late Early Carboniferous to early Late Carboniferous of the Kuznetsk basin, the Ostrog Horizon of Early Carboniferous of the Gorlovsk basin, the Conglomerate Suite to the Poberezhn Suite of Early Carboniferous to Late Carboniferous of the Minusinsk basin and from the Tusham Horizon of early Late Carboniferous of the Tunguska basin (Golerova, 1978, p. 58, fig. 4; pl. 3, fig. 8; pl. 5, fig. 7). The Angara species which has been proposed by Radczenko as *Mesocalamites mrassiensis* Radcz. may be distinguished from the present form by its broader ribs marked with double lines, straight nodal line and longer internodes.

From Kuznetsk basin, another calamitean species instituted by Radczenko as *Paracalamites mras-*

siensis Radcz. (cf. Radczenko, 1957, pl. 1, figs. 1—2) is interesting, with narrow ribs and short internodes. In these respects, it may be compared with the present species, but as an element of the genus *Paracalamites*, its ribs are however alternating in the node.

Angaridium panshiense sp. nov.

(Pl. I, figs. 5—11, 12b)

Frond in simple (?) pinnae, elliptical—oblanceolate, generally attaining a length of more than 7 cm, and a breadth of 2.5—3 cm, with the broadest part above the middle of pinna, tapering gradually toward the base; rachis rather stout, about 2—3 mm broad; pinnules alternate or sub-alternate, arising at an angle of 30°—45° from the rachis, crowded or overlapping, oblong-rhombic, about 1.8 cm long and 0.4 cm broad, contracted strongly and assuming a short petiole at the base, cleft deeply into narrow segments; venation pinnate, with each segment receiving a lateral branch.

At a first glance, the present species seems to bear a certain resemblance to *Rhacopteris busseana* Stur (Hirmer, 1940, p. 56, pls. 12, 13) of the Westphalian C of the Ruhr basin, Lower Silesia and Canada in their general appearance, i.e. pinnatifid disposition, narrow and elongate pinnules with their strongly contracted bases and linear segments, but the former is distinguished by its small size of the pinnules which are only one half as large as that of the latter and its segments which are less confluent in their bases. In this connection, it should be pointed out that in the Euramerian flora other species of the genus *Rhacopteris*, e.g. *Rhacopteris asplenites* (Gutb.) Gothan, *Rhacopteris elegans* (Ettingsh.) Schimper are all characterized by their large size and more prominently confluent segments, in which they are quite different from the present form, and that their resemblance is thus only superficial

The present species is allied to the *Angaridium* of Siberia. Among this genus, *Angaridium potaninii* (Schmalh.) Zal. (Neuburg, 1948, p. 170, pl. 39, fig. 8; pl. 40, figs. 1—5) is the closest in the fine segments, but its segments are deeply cut, sometimes, e.g. as figured by Neuburg (1948) in her pl. 40, fig. 1, probably even up to the base or to the midrib of the pinnules, rendering the specimen a bipinnate-like appearance. Others are, however, less cleft, such as *Angaridium ignotum* Neuburg (1948, p. 177, pl. 40, fig. 7), *A. mongolicum* (Zal.) Zal. et Tchirk. (Neuburg, 1948, pl. 40, fig. 6; textfig. 20), *A. submongolicum* Neuburg (1948, p. 172, pl. 40, figs. 3, 4; pl. 41, figs. 1—6; textfigs. 7—11). Furthermore, their pinnules are broader and distant. In these respects there seems to be no question of specific identify between them.

More or less comparable forms have been described by Bohlin from Yüerhhung, Kansu as *A. kansuense* Bohlin (1971, p. 797, pl. 19, figs. 7a-c, 246) and *A. laceratum* Bohlin (1971, p. 97, pl. 20, figs. 1, 247), but the pinnules of both species are all shorter and cleft into segments less pronounced and only low-cut as compared with the present material.

?*Aneimites* sp.

(Pl. I, fig. 13)

Only one fragment has been tentatively determined under this designation, representing part of an ultimate pinna lanceolate in shape, 1.2 cm in breadth and at least 6.5 cm in length, with the distal part remaining unknown, owing to unsatisfactory preservation. Pinnules are alternate, just touching, arising at a narrow angle, deltoid-obovate, constracted below but attached to a rather broad portion of the base, decurrent, broadly rounded at the apex. Several veins entering into each pinnule, repeatedly bifurcating into dense, straight and radiating branches.

The present specimen is still too fragmentary to display the exact nature of the frond. It may be compared with some ultimate pinnae and their pinnules of *Sphenopteridium;* however, before the frond architecture is clearly known, any comparison is a matter of speculation. It also can be more or less compared with *Aneimites lopatinii* (Schmalh.) Zal. as figured by Gorelova (1978, pl. 11, figs. 2—4) from the Late Carboniferous Alkaevsky assemblage of the Angara flora, but its pinnules are narrower than those of the latter.

The present material is obscured by its unsatisfactory preservation; however, may it be compared with either of the above mentioned genera. Therefore, it is tentatively ascribed with a query under the genus *Aneimites*, following the course of Zalessky and Gorelova.

Neuropteris sp. aff. *N. pseudogigantea* Pot.

(Pl. II, figs. 4—14)

Here ascribed to the genus *Neuropteris* are a number of detached pinnules, oblong to lanceolate in shape, more or less symmetric bilaterally to slightly falcate, with strongly constracted base and pinnate venation, represented by some specimens in the present collection. It is highly possible that they belong to the group paripinnates, because of their association with circular pinnules with contracted base and radiate venation, which remind us those of the intercalations, i.e. intercalated pinnules, on the pinna rachis of the group.

The pinnules are ovate-oblong in shape, slightly falcate, generally 2—4 cm long and 0.8—1.6 cm broad, each with a blunt apex and contracted, oblique base. The midrib is very slender, breaking up at about two-thirds of the distance to the apex. The secondary veins arise almost parallel to the midrib at first, very fine and dense, arching strongly and bifurcating repeatedly, reaching the margin with about 35 veins per cm and cutting the latter at wide angles. In regard to the general appearance of the pinnules and the pattern of venation, the present material recalls fairly well *N. pseudogigantea* Potonie of the Westphalian of Europe and China, and *N. sibirica* Zalessky of the Late Carboniferous* of Siberia. As compared with the former, the midrib of the present material seems to be slender and shorter. In the Angara species of *Neuropteris*, *N. sibirica* Zal. may be the closest one allied to the present material, but its pinnules are narrower at the apex and its venation is less dense.

A single specimen discovered in the present collection (pl. 1, figs. 12, 13) shows a detached pinnule more or less circular in shape, with a cordate base and radiating venation. The pinnule is rather interesting, because it reminds us of the intercalated pinnules of Paripinnates. Were it derived from the Eurameria flora one would recognize it without the least hesitation. Within the Angara flora, there is *Angaropteridium* proposed by Zalessky, the pinnules of which may be rounded, as in *Angaropteridium cardiopterioides* (Schmalh) Zal., and provided with a cordate base and radiating dichotomous venation. They are more or less comparable with the present specimen, but the leaf of *Angaropteridium* is considered to be deciduous (cf. Gorelova, 1978, p. 66). Leaves of deciduous plants are often present in large quantities, but in the present collection only a single pinnule has been found in close association with scores of ordinary pinnules of *Neuropteris*. It seems more probable that the present rounded pinnule represents an intercalated pinnule of paripinnates rather than that of the *Angaropteridium*.

CONCLUSION

The present florule is now still rather meagre, mainly consisting of fern-like foliages, with a few articulates. The plant fossils have been identified as follows:

Mesocalamites jilinensis sp. nov.
Angaridium panshiense sp. nov.
?*Aneimites* sp.
Neuropteris sp. aff. *N. pseudogigantea* Pot.
Neuropteris sp. 1
N? sp.
Carpolithus sp.

This florule affords evidences of considerable weight in three folds. Firstly, it reveals an Angara floral aspect although the Angara flora has been known from the north border of China sporadically, palaeobotanical study on this flora remains unsatisfactory known in literature, especially about the Carboniferous flora, which is virtually undescribed. Secondly, the present flora is derived from the north of Panshi County nearby the boundary between the Cathaysian-land and the Angaraland. The discovery of an Angara floral assemblage may throw light on the palaeophytogeographical and

* i.e. Middle and Late Carboniferous as originally called.

plate tectonic study. And lastly, inasmuch as it reveals an Early Carboniferous age. it has stratigraphical importance. The following is a conclusive discussion on these problems.

1. Angara affinity of the florule

From the plant fossil list and descriptions given above, it is clear that *Angaridium panshiense* is most interesting among the assemblage, although it is a new species, its resemblance to the typespecies *A. potaninii* is striking; the genus is hitherto confined to the Angaraland. *Neuropteris,* one of the genera with a wide geographical distribution, is common to the Euramerican and Cathaysian floras and is not unfamiliar in the Angara flora. One of the distinguishing features of the neuropterids of Angara flora lies in the lack of group imparipinnates. Both direct and indirect evidences have pointed to the paripinnate nature of the neuropterids hitherto discovered from the Angaraland. In the present collection,scores of specimens of *Neuropteris* have been found, all preserved as isolated, detached pinnules with no pinna rachis attached. Associated with them is a small, prbiculate pinnule with radiate venation which recalls the intercalated pinnules of some of the paripinnate *Neuropteris* or *Paripteris* as proposed by Gothan. As a rule, the pinnules of the group *Paripteris* are apt to be detached from their rachis and preserved as isolated ones, because of their very strong contraction at the base, reducing the attachment to a rather narrow zone. In addition to the normal pinnules, there are orbiculate, radiately veined pinnules intercalated on the pinna rachis. In these respects, *Neuropteris* found from Panshi in the present collection, seems to be in favour of its assignation to the group Paripinnates and is in consistence with the Angara flora in floral nature. The pith-cast of articulates is here described as a new species of *Mesocalamites, M. jilinensis.* This genus is another Eurameria genus and also has been recorded from China. Generally, articulates of the Angara flora are different from those of the Euramerican and Cathaysian floras. Recently, remains of the genus *Mesocalamites* has, however, been recorded by Radczenko in the Kuznetsk basin and described as *Mesocalamites mrassiensis.* Since then, the species has been discovered from various basins of Siberia. (Gorelova, 1978, p. 58), and therefore, the presence of a new species, *Mesocalamites jilinensis,* in the collection is by no means unexpected. Furthermore, its gloss morphology is different from that of the Euramerican elements. The specimen here described as *?Aneimites* sp. is insufficient in both preservation and quantity, and it has been recorded only for reference, but its superficial resemblance to *Aneimites lopatinii* (Schmalh.) Zal. is of some interest. For this reason, the fragment is tentatively ascribed to the genus with a query.

From what has been stated above, the writers are of the opinion that the florule derived from the Lujuantun Formation of Panshi County, Jilin bears an Angara affinity.

2. Age of the florule

A marked change in the floral composition in Siberia that can be observed in the Angara flora is the change which took place at the end of Early Carboniferous, where the lepidophyte flora was replaced in time by cordaite flora. Generally the Lower Carboniferous flora is characterized by its lepidophyte composition, and the upper ones by the cordaite flora (cf. Neuburg, 1961, p. 443). In the present collection there are neither lepidophyte nor cordaite remains. Therefore no clues to the geological age of the flora have been revealed from the dominant elements which are either lepidophytes or cordaites. The present florule is mainly composed of fern-like foliages and of either new forms or indefinitely determined elements. What is described here as *Angaridium panshiense* sp. nov. is closely allied to *A. potaninii,* the type-species of the genus, known from the lower part of Upper Carboniferous in Siberia. *Mesocalamites jilinensis* sp. nov. recalls *M. mrassiensis,* a species of late Early Carboniferous to early Late Carboniferous in age. The detached pinnules of neuropterids are ascribed under the designation of *Neuropteris* sp. aff. *N. pseudogigantea* Pot., and can be compared with *N. izylensis, N. orientalis, N. tomiensis* and *N. dichotoma.* They have been described from the Upper Carboniferous of Angaraland, possibly derived from beds as lower as the lowest Upper Carboniferous. Judged from the geological range of the allied

forms, the age of the present florule may be not older than late Early Carboniferous, nor younger than Late Carboniferous.

From the stratigraphical point of view it is interesting to note that the plant-bearing horizon (Bed 14) is underlain and overlain by marine beds yielding a rich fauna of Late Visean. From the marine beds underlying the plant bed are obtained *Yuanophyllum* sp., *Gangamophyllum retiformis* Lin et Fan, *Lonsdaleia manchuriensis* (Minato et Kato), *Dibunophyllum turbinatum* M'Coy, *Gigantoproductus* sp., *Productus concinnus* Sow., and *Striatifera*? sp. while from the beds above the plant bed are obtained *Gangamophyllum retiformis* Lin et Fan, *Orionastraea* sp., *Lithostrotion asiatica* v. *minor* (Min.), *Dibunophyllum bipartitum* (M'Coy), *Lonsdaleia manchuriensis* (Min. et Kat.) and *Arachnalasma* sp. Judged from the faunal assemblages and stratigraphical sequence, the present florule must be fo Late Visean in age.

3. Significance of the study on the present florule

1) Bearing to the palaeophytogographic provinces and plate-tectonics

The discovery of an early Carboniferous florule from the Lujuantun Fm. has proved for the first time the existence of the Angara flora in Early Carboniferous in Northeast China, which throws new light on the study of palaeophytogeographic provinces at that time.

It was held that the differentiation of palaeophytogeographic provinces commenced from the Upper Carboniferous (Gu et Zhi, 1974, p. 178). In his study of the Westphalian florule from South Tian-shan, one of the present writers, Zhang pointed out that the florule is represented by *Neuropteris* cf. *heterophylla* and *Pecopteris* sp. allied to *P. plumosa* Art., which showed no essential difference from the Westphalian Euramerican flora, while in North Xinjiang, there is the Angara flora represented by *Chacassopteris consinna* Radcz., etc., in early Early Carboniferous, which belongs to a quite different province, and that the distribution of florae must be related with tectonic movement (Zhang, 1985, p. 147). The discovery of the present Angara florule is of considerable interest, inasmuch as it was derived from the Panshi district and nearby an eastward zone of the so-called Jilin Geosyncline, which has been detected (Zhang et He, 1985) as the suture of Siberia plate and Tarim-Sino-Korean plate, or the boundary between Angara floral province and Cathaysian province.

2) Bearings on the stratigraphic development and geological history

From the study of the present florule, it is evident that there are late Early Carboniferous terrestrial deposits in Northeast China, which sheds light on studies of the Carboniferous stratigraphy along the northern border of China and the Late Palaeozoic geological history of NE China.

What has been revealed from the faunal composition, such as corals, is an environment of rather shallow and warm sea beach. In early Carboniferous, the present fossil locality might be in a subtropic region, and separated from the Cathaysian flora, which was comparatively in the south of the present florule, by the shallow sea, which was not very wide at that time.