

NAMURIAN FLORA FROM SOUTHWESTERN MARGIN OF TARIM BASIN

Yao Zhao-qi

(Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing 210008)

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Summary

No Namurian plants from the Tarim basin in southern Xinjiang have been described so far, though scarce records of the Carboniferous plants were occasionally cited in some geologic literature. Owing to the lack of descriptions and illustrations these records could hardly be used as a source for further investigation.

The fossil plants described in the present paper are of specific interest in paleobotanic researches, because they are the Namurian plants discovered for the first time from southern Xinjiang, and they would contribute to the definite demarcation of the boundary between the Angara and Euramerican floras in this area during the Namurian time.

The fossil plants described here include the following species:

Lepidostrophophyllum lanceolatum (Lindley et Hutton), *L.* ? sp., *Lepidophylloides* sp., *Mesocalamites cistiformis* (Stur), *Mesocalamites* sp., *Asterophyllites* sp., *Calamostachys* cf. *haasensis* Leggewie et Schonefeld, ? *Cardiopteridium spetsbergense* Nathorst, *Alloiopteris* cf. *angustissima* Sternberg, *Pecopteris* sp., *Neuropteris cardiopteroides* Bohlin, *N. gigantea* Sternberg, *Neuropteris* sp.

Together with indeterminable plant remains.

The plant remains were collected from the lower part of the Carboniferous section which is located in Bolu of Lop district, Xinjiang (Text-fig. 1, locality 15), about 30m in thickness, consisting mainly of grey sandstone intercalated with greenish grey silt shale and carbonaceous shale with thin coal seams. These strata are conformably overlain by greyish and purplish crystalline limestone intercalated with clastic sedimentary rocks. Abundant brachiopod fossils have been found from the limestones, including Middle and Late Carboniferous elements such as *Ambocoelia planconvexa* (Schmard), *Brachythyris* cf. *strangwaysi* (Verneuil), *Phricodothyris asiatica* (Chao), *Eneletes* cf. *obesa* Grabau, *E. lamarcki* Fischer de Waldheim, *Neospirifer* cf. *fasciger* (Keyserling), etc. The underlying strata of the plant-bearing rocks consist mainly of purple sandstone and conglomerate yielding typical Late Devonian plants such as *Leptophloeum rhombicum* Dawson, etc.

It is obvious that the geologic range of the described fossil flora is stratigraphically determined as within the interval of Early Carboniferous to Namurian.

AGE OF THE FLORA

The discovery of fossil plants from the southwestern margin of the Tarim basin was first reported in the "Regional Stratigraphy of Northwest China—The Xinjiang Uighur Autonomous Region" (1981). There some plant remains have been found in the lower part of the Middle Carboniferous Karawuyi Formation of the Achik section, including *Stigmara ficooides*, *Calamites cistii*,

Calamites sp. and *Macrostachya* sp., with some fusulinids also reported from the same formation, such as *Fusulinella* sp., *Profusulinella* sp. and *Eostaffella* sp. The authors of the book considered the Karawuyi Formation as belonging to the Middle Carboniferous, but at the same time they also mentioned: "Considering the regional tectonics, it is most probable that the formation may be Early Carboniferous in age".

Recently, based on detailed field work the Qinghai-Xizang (Tibet) Plateau Scientific Expedition divided the Carboniferous strata of the Achik section into two parts; namely, the Lower Carboniferous, which yields the fossil plants as described here, and the Upper Carboniferous, which contains abundant fossil brachiopods as listed above.

These fossil plants represent a more characteristic Namurian flora. Among the less abundant fossils a number of specimens belonging to the genus *Mesocalamites* are most prominent; this is exactly an important feature of the Euramerican Namurian floras.

Among the plant remains described above, *Lepidostrophophyllum lanceolatum* is a characteristic European Namurian species. This species has mainly been found in Namurian A and C, though it can be traced even in Westphalian D; in China, its comparable specimens have been found in the Early Carboniferous Chaishui Formation of Hunan. *Mesocalamites cisiformis* was found in West Europe mainly in Namurian A, but it can be seen in Namurian B and C, even in Westphalian A in West Germany and the Netherlands; in China, this species was reported from Namurian A and B of Gansu, with some comparable specimens also noticed from Namurian C of Ningxia. The calamitean cone *Calamostachys* cf. *haasensis* is conformable to *C. haasensis*, the latter being a synonym of *C. polystachya* described by Stockmans and Williere (1953) from Namurian B of Belgium.

Several specimens in our collection were identified as *Cardiopteridium spetsbergense* with great conservation, but it is worth of being considered in determining the age of the flora, as this species is mainly characteristic of Early Carboniferous and also has been found from Namurian A of Gansu. The specimen identified as *Alloiopteris* cf. *angustissima* is similar to that from Yuerhchung, Gansu, described by Bohlin (1971) as *Corynepteris* cf. *sternbergi*; it also resembles the specimens from the Westphalian of West Europe. More interesting is the fragment described here as *Pecopteris* sp., which is somewhat similar in some aspects to *P. aspera*, the latter being characteristic of the Namurian, especially Namurian A of West Europe. *Neuropteris gigantea* has a relatively wide range from Viséan to Westphalian, though it can be more frequently found in the Westphalian of West Europe. The original specimens of *Neuropteris cardiopteroides* were probably found from the Middle Carboniferous deposits; some similar specimens were later (1975) described by Bohlin from Chapchal and Olonbuluk of Qinghai, and the plant-bearing deposits most probably belong to Namurian B in age. In recent years this species has been found from the basal part of the Middle Carboniferous of Longshoushan, Gansu, Namurian B of Ningxia and Namurian A of Gansu. Among the fossil materials at our disposal, the rather fragmentary specimen of *Neuropteris* sp. in some aspects resembles that of *N. antecedens*, the latter mainly being found from Culm and Namurian A of West Europe.

To sum up, the flora should belong to Namurian, and most probably to Namurian A in age. Thus, the age of the plant-bearing strata not only might be suggested based on regional tectonic features, but also can be proved by fossil plants as Early Carboniferous.

The Carboniferous flora of Xinjiang was mainly reported from the northern side of the Tianshan mountains, with its southernmost locality situated at the eastern extension of Mt. Narat, Hejing district (Text-fig. 1, locality 7), where the possible Namurian flora was found. On the southern side Tianshan only *Neuropteris* cf. *heterophylla* Brongn. and *Pecopteris* sp. have been described by Zhang (1985) from the southern slope of Mt. Tomort, Wensu district. Zhang regarded the

plant-bearing strata as Westphalian in age, for *Pecopteris* sp. is comparable in form with *P. plumosa* (Artis). In fact, *Neuropteris heterophylla* was found from Namurian A and B of England; *Pecopteris plumosa* was reported from Namurian A—C of Belgium, while in West Germany and France it was found from Namurian B and Westphalian, though this species was confined within the Westphalian of England. In our opinion, it is most probable that the age of the florule from Wensu is within the from Namurian to Westphalian.

PALAEOPHYTOGEOGRAPHIC SIGNIFICANCE

The discovery of Namurian flora from the southwestern margin of the Tarim basin is of essential significance in botanic and stratigraphic sense, especially in palaeophytogeographic consideration.

The fossil plants described here represent a typical Euramerican Namurian flora. Their representative elements such as the calamitean cone *Calamostachys* and the true fern *Alloiopteris* are characteristic of the Euramerican flora, but they are lacking in the Namurian Angara flora. On the other hand, the index fossil plants of the Angara flora have never been found here such as *Angarodendron*, *Chacassopteris* and *Angaropteridium*. Among the materials described in the present paper almost all genera and most species have their identical or equivalent elements in the Euramerican Namurian flora. Therefore, it is quite doubtless that the plants flourishing here during the Namurian period belonged to the realm of Euramerican floral province.

Based on materials accumulated till 1979, Li and Yao (1979) worked out a map showing the boundaries between three major floral provinces in East Asia during the Carboniferous and Permian time, but the western extension of the boundary between the Angara and Euramerican floral provinces in Xinjiang was uncertain and presumptive through the southern margin of the Tarim basin, though in the text the authors pointed out: "The Tianshan-Khingian Geosyncline, which covers a vast area extending from the northern border of the Tarim paraplatform (existing from Late Silurian to late Early Permian), might be regarded as a natural boundary between the Angara and Cathaysia floral provinces". Since no fossil plants were reported from the southern side of the Tianshan mountains till 1979, it was difficult to ascertain what floral province should the Tarim basin belong to.

From the northern side of the Tianshan mountains, in the Junggar basin and its adjacent area of Xinjiang, the Early and Middle Carboniferous floras have been reported in Altay, Jeminay, Fuyun, Yumin, Toli, Qinghe, Mori, Qitai, Yiwu, Hami, Toksun and the eastern extension of Mt. Narat in Hejing district. Their most distinctive and widespread forms are *Caenodendron primaevum* Zal., *C. karagandense* (Borsuk), *Chacassopteris concinna* Radc., *Angaropteridium cardiopteroides* (Schmalh.), *A. lingulatum* Neub., *Cardioneura sibirica* Zal., *C. microphylla* Ract., *Angaridium potaninii* (Schmalh.) and *Noeggerathiopsis theodori* Tschir. et Zal., etc., which are all characteristic forms of the Carboniferous Angara flora.

To date, only a few Carboniferous plants have been discovered from Southern Xinjiang. Zhang (1985) first reported two Carboniferous plants of the Euramerican type from Wensu district and ascertained that the area on the southern side of Tianshan was situated in the realms of the Euramerican floral province. The discovery of the Euramerican type Namurian flora from the southwestern margin of the Tarim basin provides further evidence for this conclusion. No Carboniferous flora of the Euramerican type has been found from the eastern margin of the Tarim basin, but a few early Middle Carboniferous plants obviously of the Euramerica type have been reported from Anxi, Gansu, which is situated not far from the Tarim basin.

Based on the materials mentioned above, this paper presents a phytogeographic map showing the more precise boundary line between the Angara and Euramerican floral provinces during the Namurian time (Text-fig. 1).

DESCRIPTIONS

Lepidostrobophyllum lanceolatum (Lindley et Hutton)

(Pl. I, fig. 1)

This species is represented by two detached sporophylls as shown in Pl. I, fig. 1. Both sporophylls are not well-preserved, with the lower sporangia-bearing part not well-exposed. In the smaller sporophyll shown in fig. 1, the upper part is lanceolate in form, about 36mm long, with the broadest part about 9mm broad near the middle and 6mm broad at the base; the apex is more or less acuminate, while the single central vein is well marked, about 1mm broad at the base, tapering gradually to the apex. In the rather big sporophyll the upper part is slightly ovate-lanceolate in form, with the lower sporangia-bearing part only partly preserved; the lamina is 46mm long and about 9mm broad with the broadest part rather below the middle; the apex is acute, while the central vein is well marked, about 1mm broad at the base, tapering gradually upwards.

Our specimens agree almost in all aspects with the Namurian specimen of Belgium described by Stockmans and Williere (1953, pl. VII, fig. 8; pl. XXXII, figs. 12, 13) as *L. lanceolatum* (L. et H.). In one of our specimens, the broadest part of the lamina is rather below the middle so that the blade is somewhat ovate lanceolate rather than lanceolate. This sporophyll resembles the large and broader rather than the smaller and narrower one of the syntypes refigured by Crookall (1966, Pl. XCIX, fig. 5).

Lepidostrobophyllum? sp.

(Pl. II, figs. 13, 14)

The counterparts of a single specimen are shown in figs. 13 and 14. In the specimen the preserved sporangia-bearing part is about 5mm in breadth; the depression area is about 3mm × 2mm, and structure is unknown. Here the specimen is temporarily described under this generic name because of its likeness to the sporangia-bearing part of the sporophyll *Lepidostrobophyllum*.

Lepidophylloides sp.

(Pl. I, fig. 8)

Leaf linear; exposed part more than 5cm long and 4.5mm broad, with a central vein of 1.5mm in breadth, expressed in the form of three parallel fine ridges; areas between the ridges and margins occupied by two shallow grooves. Since no nodes have been found in the interval of the leaf exposed length, the possibility of articularian affinities can be ruled out.

Mesocalamites cistiformis (Stur)

(Pl. I, figs. 2, 2a, 3, 3a)

The species is only represented by 2 specimens in our collection. In the specimen shown in Pl. I, fig. 2, there are two incomplete internodes, measuring 20—45mm long and 17mm broad; the ribs are straight, about 1mm across and those alternating between the nodes form acute angles (Pl. I, fig.

2a), all bearing fine longitudinal striations; the furrows are straight and bounded by two distinct lines as shown in fig. 2a, while the tubercles are small, obscure and oval, about $1\text{mm} \times 0.6\text{mm}$, only at the upper ends of the ribs. In the specimen figured in Pl. I, fig. 3, there are three incomplete internodes, with the middle one measuring 40mm long and 12mm broad, while the tubercles are rounded-oval, about 0.6mm across.

***Mesocalamites* sp.**

(Pl. I, figs. 4—6)

In the specimen shown in Pl. I, fig. 4, there are only two incomplete internodes; the lower one is about 60mm long and 17mm broad, while another node line appears to be placed just near the margin of breakage; the ribs are about 2mm across and those alternating between the nodes form acute angles (Pl. I, fig. 4). The furrows are bounded by two distinct lines as shown in figs. 4 and 6.

Morphologically the present species is close to *Mesocalamites cistiformis* (Stur), in which the ribs may attain 2mm across and the furrows are bounded by two distinct lines. But it can not be identified with certainty, for the length of the internode and the tubercles are unknown.

The present species is also comparable with the Namurian specimen shown by Stockmans and Williere (1952) in their Pl. LVII, fig. 13 as *Calamites* sp., in which the ribs are about 2mm broad and the furrows are also bounded by two lines. Stockmans and Williere use the broad sense for the genus *Calamites*, which includes the genus *Mesocalamites*. Furthermore, their figure shows no node line, whereas the node of the present specimen can be seen clearly; thus the present specimen can be ascribed to the genus *Mesocalamites* with certainty.

***Asterophyllites?* sp.**

(Pl. I, fig. 7)

The preserved portion of the calamitean slender shoot is about 35mm long and 3mm broad. Three nodes can be seen, with internodes of 11mm long. Six longitudinal ribs pass through the nodes, while six small circular tubercles can be observed on the upper node, obviously indicating leaf traces. The leaves are not preserved.

The generic name *Asterophyllites* is used for certain group of calamitean foliages; it can hardly be used for the leafless calamitean stems. Considering that the stem quite resembles those of *Asterophyllites* and the leafless condition may result from the taphonomic process, the present author places the specimen to the genus *Asterophyllites* temporarily with hesitation. Perhaps it will be more appropriate to name the specimen just as a calamitean stem.

***Calamostachys* cf. *haasensis* Leggewie et Schonefeld**

(Pl. I, figs. 8, 8a, 8b)

Cone cylindrical, 4cm long and averagely about 4mm broad, shortly stalked; axis about 1mm broad, with longitudinal striations, containing about 16 internodes which are about 2mm long. Sterile bracts narrow, extending over about 2 internodes, springing from the axis nearly at right angles and then bending upwards. Fertile whorl consisting of about 6 sporangiophores.

In size and general structure the specimen described here most closely resembles certain specimen of *Calamostachys haasensis* Leg. et Schon. (= *C. polystachya* in Stockmans and Williere, 1953) from Namurian B of Belgium and Namurian C of Germany. The present specimen can not be identified with certainty at the specific level, as there is only a detached cone and the range of its morphologi-

cal variety is unknown for the time being.

Our specimen also bears certain resemblance to *Calamostachys sahnii* Stockmans et Williere from Namurian B of Belgium and Namurian C of Germany, but in the latter, the cone seems to be much larger than in our specimen.

?*Cardiopteridium spetsbergense* Nathorst

(Pl. II, figs. 3—5)

There are only 3 detached pinnules in our collection, which may represent the species. The pinnule shown in fig. 3 is cordate in form, about 15mm in length and 12mm in maximum breadth, contracted at the base and forming a very short petiole, with an obtuse apex; its veins radiate from the short petiole, repeatedly bifurcating and reaching the margin at a more acute angle, without distinct midrib. The specimen shown in fig. 4 represents only a fragment of a pinnule in which the base is cordate, contracted in a short petiole, and the veins spring out radiately from the petiole, without midrib. The pinnule in fig. 5 is more specific in elongate form, about 30mm long and 7mm broad, with slightly concave upper margin and a little convex lower margin, thus becoming somewhat irregular in appearance; its apex is obtuse, and its base is contracted, forming a short petiole, from which the veins spring out, without midvein.

Among these isolated pinnules the specimen in fig. 3 closely resembles the intercalated pinnule of *Neuropteris gigantea* described by Wu and Zhao (1987) from Namurian B of Ningxia, but differs from the latter in having an indistinct short petiole.

The pinnule with more or less distinct petiole is a character of the species of *Cardiopteridium*, but the petiole of the present specimens is somewhat different in character from that of *Cardiopteridium*, though the shape and size of their pinnules are quite conformable to each other. For this reason, the specimens are ascribed to the present species with reservation.

***Alloiopteris cf. angustissima* Sternberg**

(Pl. II, fig. 6; Text-fig. 2)

Species only represented by a fragment of an ultimate pinna preserved with only 11 pinnules. Vascular bundle in the rachis narrow, slightly flexuose. Pinnules alternate, very small, about 1.5mm long and 1.3 mm broad, attached to the rachis at an angle of 70°—80°, with anadromous margin somewhat contracted and catadromous margin slightly decurrent at the base; thus the pinnule subsequently divided into 3—4 lobes; a single vein entering the pinnule branching dichotomously 2—3 times, and supplying each point of the lobe with a veinlet.

The specimen in our collections is close to that described by Bohlin (1971) from Yuerhhung, Gansu as *Corynepteris cf. sternbergi* (Ettingsh.), especially to his specimen in fig. 96. According to Danze (1956), *Corynepteris sternbergi* (Ettingsh.) should be regarded as the synonym of *C. angustissima* Sternb. It seems appropriate to identify our specimen as *Alloiopteris cf. angustissima* Sternb. as the exact fertile part of the fossil plant in our disposal still remains unknown up to the present time.

***Pecopteris* sp.**

(Pl. II, fig. 8)

Specimen figured here representing the terminal part of an incomplete ultimate pinna, with a breadth of 3mm. Pinnules very small, about 1—1.5mm long and 1mm broad, attached to the rachis with whole base; apex obtuse; midvein distinct, slightly flexuose; lateral veins arising from the midvein

at an acute angle, usually bifurcating once.

This species is characterized by the very small size of the pinnules. Judging from the somewhat flexuose midvein and fewer bifurcating lateral veins, the present specimen is closest to *Pecopteris aspera* Brongn., but it is impossible to make a specific determination due to the fragmentation of the specimen.

Neuropteris cardiopteroides Bohlin

(Pl. II, figs. 1, 1a, 2)

Species represented by several isolated pinnules in the collection. Pinnule shown in fig. 2 well-preserved, somewhat falcate in shape, 33mm long and 7mm broad, with a maximum breadth at the base; margin entire, with upper margin more or less straight and lower margin obviously arched; base slightly oblique, somewhat cordate; apex acute to acuminate. No distinct midvein observably; veins radiating from the point of attachment, running straight or in a slight curve to the margin and meeting it at acute angles of about 20°—30° in the middle and distal parts, and about 60° in the basal part of the pinnule.

The characteristic features of the pinnules figured here almost fully agree with the diagnosis given by Bohlin (1971), and the present specimens are also identical with those from Gansu and Ningxia described by Liu and Shen (1983) as *Neuropteris cardiopteroides* Bohlin.

Neuropteris gigantea Sternberg

(Pl. I, fig. 9)

Only some detached pinnules in the collection. Pinnule shown in Pl. I, fig. 9 slightly falcate in shape, about 17mm in length, and about 6mm in maximum breadth; anadromous margin relatively straight and catadromous margin somewhat arched; apex more or less obtuse and base contracted in cordate form. Nervation consisting of an indistinct midvein, dissolving at about one-third of the distance to the apex, giving off finely arched lateral veins, which meet the margins at an angle of 30° in the middle and distal parts, and about 45° in the basal part of the pinnule.

The specimens of this species at our disposal are somewhat different from the European ones in the indistinct midvein and in the lateral veins meeting the margins of the pinnule more obliquely. Wu and Zhao (1987) regarded such a difference as not substantial. The writer agrees to this opinion and uses the specific name *N. gigantea* for the material described here.

Neuropteris sp.

(Pl. II, fig. 7)

Species only represented by a pinnule fragment, with shape and length unknown. Pinnule about 2mm in half breadth; midvein indistinct; lateral veins arising from midvein, branching twice dichotomously and meeting the margin at an angle of about 90°. The specimen described here most probably belongs to the genus *Neuropteris*, and is closest to the fragment of *N. antecedens* Stur.

图 版 说 明

标本保存于中国科学院南京地质古生物研究所。产地层位均为新疆洛浦县布鲁乡阿克克山, 卡拉乌依组下部。野外号均为 88K152。

图 版 I

1. *Lepidostrobophyllum lanceolatum* (Lindley et Hutton)

×1, 登记号: PB14866。



