
The Angara flora from north China

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The Angara flora flourished in northern China during the Late Paleozoic and evolved and developed parallel to the Cathaysia flora in China from Carboniferous to Early Permian. Since Late Permian the two floras were mixed in a limited area around the border of the two phytogeographic regions.

Key-words—The Angara flora, Parallel evolution, Carboniferous-Permian, Northern China.

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सारांश

उत्तरी चीन से अंगारा वनस्पतिजात

हाँग बेनहाँग

उत्तरी चीन में अनंतिम पुराजीवी कल्प में अंगारा वनस्पतिजात का उद्भव एवं विकास कार्बनीफेरस से प्रारम्भिक परमियन कल्प में कैथेसिया वनस्पतिजात के समानान्तर हुआ था। अनंतिम परमियन कल्प से ये दोनों वनस्पतिजात दो पादपभौगोलिक क्षेत्रों की सीमा के आस-पास सीमित क्षेत्र में परस्पर मिश्रित हो गये।

ANGARA flora constitutes the Carboniferous and Permian plants in northern China and has mainly been found in northern Xinjiang, Gansu Ningxia, Nei Mongol and north-east China. The southern limit of the distribution of the Angara flora in China is roughly a line from the Telasi River in eastern Xinjiang, eastward through Alxa, Yinshan, Onder Sum, Xar Moron River of Nei Mongol to Songhua Lake and Yanji of Jilin. Some Late Permian elements of the flora have also been found farther south.

The Angara flora in China ranges from Early Carboniferous to Late Permian as in Angaraland. The Early and Middle Carboniferous ones are mainly distributed in northern Xinjiang and generally occur widely in marine and continental sediments and paralic facies. The Late Carboniferous ones are widespread in the continental sediments in the region. The Early Permian plants are poor, but the

Late Permian ones are most flourishing and occur almost everywhere in the region.

The Angara flora in North China may be divided into Early Carboniferous, early Late Carboniferous, late Late Carboniferous, Early Permian and Late Permian assemblages.

1. *Early Carboniferous assemblage (Lepidodendropsis-Tomiodendron-Chacasso-pteris assemblage)*—This assemblage occurs mainly in the Heishantou, Nanminshui and Dishuiquan formations of northern Xinjiang, and the Lujuatun Formation of central Jilin. The assemblage mainly consists of *Sublepidodendron xinjiangense* Sun, *S. mirabile* (Nath.) Hirm, *Lepidodendropsis dilohodes* Sun, *L. triticea* Sun, *Lepidodendron* sp., *Prelepidodendron varium* Radcz., *Lepidodendron kirghizicum* Zal., *L. pseudo-kirghizicum* Radcz., *Caenodendron primaevum* Zal., *C. karagandaense* (Borsuk), *Belonophyl-*

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- lum acirculum* Zal., *Chacassopteris concinna* Radcz., *Cardiopteridium parvulum* (Schm.), *Sphenophyllum tenerrimum* Ett., *S. pachycaule* Deber, *Archaeocalamites scrobiculatum parvulum* (Schm.), *Sphenopteris divaricata* (Goepf.), *Angaridium panshiensis* Zhang et Sun, etc. The plant-bearing beds are intercalated by those yielding Visean-Tournaisian fauna. In addition, in the neighbouring Mongolia at the same latitude, the assemblage contains *Tomiodendron? mongolicum* Durante, *T. kemeroviense* (Chachl.), *Angarophloios obscurus* Durante, *Andiantites* sp., *Angaropteridium* sp., etc. (Durante, 1976).
2. *Early Late Carboniferous assemblage (Angaropteridium-Cardioneura-Mesocalamites assemblage)*—This assemblage occurs in the strata represented by Karajira, Batmaineis han, Julidene formations, and the lower part of Bulage Group. The assemblage consists of mainly : *Angaropteridium cardiopterides* (Schm.), *A. ligulatum* Neub., *Belonophyllum accriculum* Zal., *Cardioneura* sp., *Koretrophyllites junggarensis* Sun, *Angaridium potaninii* (Schm.), *A. panshiensis* Zhang et Sun, *Chacassopteris concinna* Radcz., *Calamites (Mesocalamites) cistiformis* Stur, *C. (M.) schiitzeiformis* Kidston, *Mesocalamites jilinensis* Zhang et Sun, *Neopteris dichotoma* Neub., *Cyclopteris* sp., *Cardiocarpus* sp., etc. The strata yielding the above assemblages often underlie the Shiqiantan Formation associates with marine beds yielding ammonites goniatitid *Neodimorphceras* sp., *Diabaloceras* sp., and fusulinids *Pseudostafella-Profusulinella-Eostafella* assemblage. The marine fauna shows early Late Carboniferous age; the plant assemblage may be correlated roughly with those
 3. *Late Late Carboniferous assemblage (Angaridium-Neuropteris-Zamiopteris assemblage)*—The assemblage occurs in the Harjiawn, Karagang and Konqiping formations. The assemblage consists of *Angaropteridium cardiopteridea* (Schm.), *A. ?mongolicum* Durante, *A. neuburgae* Durabte, *Angaridium potaninii* (Schm.), *A. mongolicum* Zal., *A. submongolicum* Neub., *Cardioneura sibirica* Zal., *C. microphylla* Zal., *Neuropteris orientalis* Radcz., *N. murassiensis* Radcz., *N. cf. dichotoma* Neub., *N. cf. piambaensis* Rasskz., *N. cf. izylensis* (Tchirk.), *N. tomiensis* (Zal.), *N. topkiensis* (Zal.), *Zamiopteris* cf. *glossopteroides* Schm., *Z. cf. tailuganensis* (Chachl. et Poll.), *Chacassopteris concinna* Radcz., *Noeggerathiopsis subangusta* Zal., *N. tomiensis* Radcz., *N. theodori* Tsch. et Zal., *N. tschirkovae* Zal., etc.
 4. *Early Permian assemblage (Crassinervia-Nephropsis-Zamiopteris assemblage)*—The assemblage occurs in the Lower Jijicaozi Group, Ulang Group, Aggikbulak Formation in western China and the Daheshen, Tumenling, Tatouhe formations in the eastern. The assemblage comprises *Crassinervia lanceolata* (Chachl. et Pall.), *Z. tailuganensis* Gorel., *Z. cf. glossopteroides* Schm., *Sphenopteris* cf. *kumpanii* Neub., *S. incrassata* Neub., *Annularia longissima* Neub., *Neuropteris daheshenensis* Huang, *Cordainthus volkmann* (Ett.), *C. curtus* Sze and *Pecopteris*, *Paracalamites*, *Stenophyllum*, *Cordaianthus*, *Noeggerathiopsis*, etc.
 5. *Late Permian assemblage*—It occurs in the Tomorlong, Quanzijie, and Wutonggou formations in the western part and the Linxi, Sanjiaoshan and Hongshan formations in the eastern

A. Xinjiang region

North of Tianshan

Angaropteridium cardiopteroides,
Angaridium potaninii, *A. mongolicum*,
A. submongolicum, *Cardioneura sibirica*,
Neuropteris microphylla, *Neuropteris* sp.,
Noeggerathiopsis subangusta, *N. derzavintii*

South of Tianshan

Sphenophyllum cf.
verticillatum
Neuropteridium sp.,
Neuropteris sp.

B. Monolia and Nei Mongol China

Southern Mongolia

Neuropteris paimbaensis,
Angaropteridium cardiopteroides,
Angaridium mongolicum, *A. potaninii*
Caenodendron(?) sp.,
Paragondwanidium sibiricum,
Tomiodendron prokopleviensis
Angaropteridium obrutschewii,
Ursodendron chacassicum,
U. meleschtenkovii

Nei Mongol, China

Sphenopteris neimongolensis
S. cf. *obtusiloba*,
Neuropteris otozamioides,
N. gigantea, *N. kaipingiana*
Pecopteris aspera, *P. plumosa*,
P. miltonii, *Tingia? tarilobata*
Linopteris cf. *densissima*,
L. neuropteroides,
Lepidodendron ninghsiaense,
L. tripunctatum

C. Da Xingan Ling Mts.

North of Xar Moron River

Angaropteridium? neuburgae
A.? *mongolicum*
A. cardiopteroides
Angaridium potaninii
A. submongolicum
Neuropteris murassiensis
N. cf. *dichotoma*
N. orientalis
N. tomiensis
Pecopteris sp.
Nephropsis sp.
Noeggerathiopsis sp.,

South of Xar Moron River

Mesocalamites cf. *cistiformis*,
Lepidodendron aff. *worthenii*,
L. cf. *tripunctatum*, *Rhodea shimenensis*,
Sphenophyllum emarginatum, *S.* cf. *laterale*
S. oblongifolia, *Alethopteris shidafenensis*
Callipteridium tachingshanense
Annularia pseudostellata
Tingia carbonica, *T. partita*,
Pecopteris cyathea, *P. candolleana*,
P. arborescens, *Sphenopteris neimongolensis*
Neuropteris ovata, *N. kaipingiana*,
N. gigantea, *N. microphylla*,

D. Chanbaishants area

North

Mesocalamites jilinensis,
Angaridium panshiense,
A. cf. *mongolicum*,
Neuropteris orientalis,
N. murassiensis,
N. dichotoma
N. sp.,
Aneimites sp.,
Carpolithus sp.,
Crassinervia kuznetskiana,
Zamiopteris cf. *glossopteroides*,
Noeggerathiopsis subangusta,
N. cf. *latifolia*,

South

Lepidodendron ninghsiaense,
Neuropteris gigantea,
N. pseudogigantea,
N. kaipingiana,
Linopteris brongniartii,
L. neuropteroides,
N. ovata,
N. plicata,
Sphenophyllum oblongifolium,
Sphenopteris neuropteroides,
Pecopteris candolleana,
Tingia carbonica,
Mariopteris cf. *busquetii*,

2. Early Permian

A. Tiansh region:

South of Tianshan

Noeggerathopsis cf.
derzavinii
Noeggerathopsis sp.,
Paracalamites cf. *stenocostatus*,

North of Tianshan

Sphenophyllum minor, *S. neofimoriatum*,
Pecopteris orientalis,
Emplectopteris triangularis, *Alethopteris* sp.,
Annularia stellata, *A. cf. mucronata*,
Lobatannularia ensifolia, *Cordaites schenkii*,
Tingia carbonica, *Shizoneura manchuriensis*,

B. Monolia and Nei Mongol, China

Southern Mongolia

Noeggerathopsis derzavinii,
N. singularis,
N. latifolius,
N. theodorii,
Phyllopteris heeri
Neuropteris cf. *rhomboides*,
Crassinervia cf. *kuznetskiana*

Nei Mongol, China

Asterophyllites cf. *equisetiformis*
Annularia gracilescens,
Lepidodendron carinum,
L. tachingshanense, *Tingia namaguchii*,
Pecopteris liuiana,
Rhacopteris bertrandii,
Cordaianthus volkmannii,

C. Da Xingan Ling Mts.

North of Xar Moron River

Stenophyllum cf. *nuinerutum*
Pecopteris cf.
comptula

Sphenopteris cf.
kumpanii
Phyllothea sp.
Conites sp.

South of Xar Moron He River

Sphenophyllum thonii, *S. oblongifolium*, *S. speciosum*,
S. sino-coreanum, *Annularia stellata*, *A. orientalis*,
Lobatannularia ensifolia, *L. multifolia*,
Sphenopteris tenios, *S. grabaui*, *Fasciapteris sinensis*,
Pecopteris wongii, *P. chibliensis*, *Emplectopteris minima*,
Gigantonoclea umita, *G. cf. acuminatiloba*, *G. teayingensis*
Zeileropteris yujiaensis, *Taeniopteris halle*, *T. integra*,
T. taiyuanensis,

3. Late Permian

Angaran floristic region

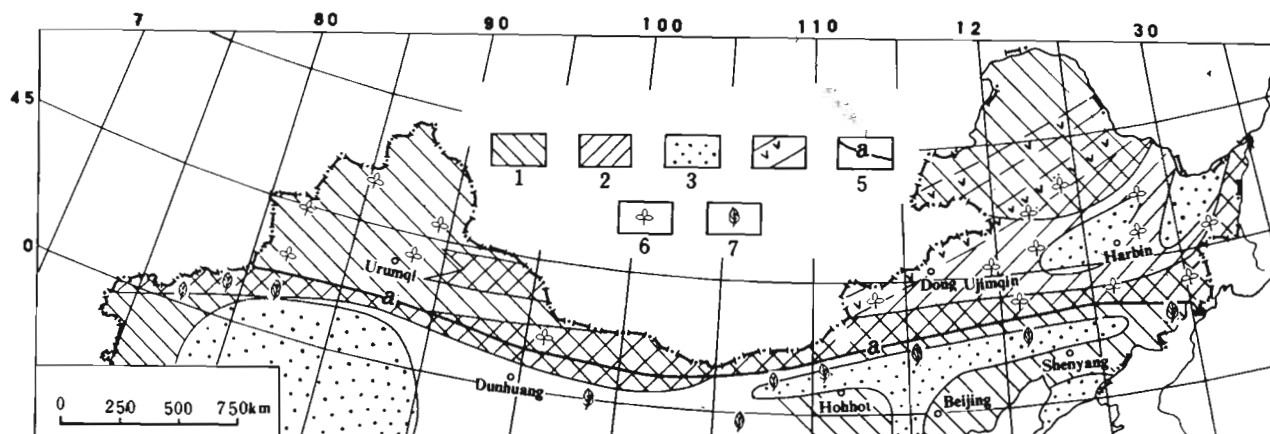
Comia, *Iniopteris*, *Purssongia*,
Zamiopteris, *Crassinervia*, *Sylvia*,
Compsopteris, *Eichwaldia*, *Neph-*
ropsts, *Lepeophyllum*, *Callipter-*
eris, *Glottophyllum*, *Rhipido-*
opsis, *Pecopteris*, *Lobatannularia heianensis**, *L. multi-*
*folia**, *Pecopteris condollea-*
*na**, *P. yabei**, *Sphenopteris*
*taeyuanensis**, *Pterophyllum*
*eratum**, *Taeniopteris* cf. *integra*

Cathaysian floristic region

Asterophyllum longifolius
Taeniopteris multipteris
Supaia wongii,
Schizoneura manchuriensis,
Cordaites principalis,
Pecopteris, *Prinoeyca*,
Neuropteridium, *Calamites*, *Callipteris zeilleri***

*Cathaysian plant element

** Angaran plant element



Text-figure 1

and mainly comprises *Callipteris zeilleri* Zal., *C. angustata* Zal., *C. altaeca* Zal., *C. heilongjiangensis* Huang, *C. adzvensis* Zal., *C. cf. confluens* Neub., *Supaia shenshuensis* Huang, *S. tieliensis* Huang, *Xinganphyllum aequale* Huang, *X. inaequale* Huang, *Tychopteris densinervis* Hu, *Cras-sinervia keylmeyeraensis* Hu, *Comia dentata* Radcz., *C. major* Schw., *C. yichunensis* Huang, *C. xinjiangensis* Gu, *C. tenuensis* Huang, *C. microphylla* Huang, *Iniopteris sibirica* Zal., *Compsopteris tchirkovae* Zal., *C. cf. adzvensis* Zal., *Sylvia xinjiangensis* Gu, *S. dabanensis* Huang and *Lepeophyllum*, *Zamiopteris*, *Sphenopteris*, *Rhipidopsis*, *Pecopteris*, *Nilssonia*, *Pterophyllum*, *Petscheria*, *Lobatannularia*, etc. (Table 1).

RELATION BETWEEN ANGARAN AND CATHAYSIAN FLORAS

It seems that the Angaran and Cathaysian floras had almost developed independently and parallel from Early Carboniferous to Late Permian in North China. The composition of these two floras in various stages are as follows :

PHYTOGEOGRAPHY OF ANGARAN AND CATHAYSIAN FLORAS IN NORTH CHINA

According to the palaeobotanical data from China, the main reason of restricted situation of the two floras is the result of natural barrier of the Tianshan-Xiingan geosyncline (Li & Yao, 1983) which was represented by a wide sea in Carboniferous to Early Permian. However, Dou and Sun (1985) suggested

that the sea was closed and the Eurasia formed as a united land since in the Late Permian Beishan area of western Nei Mongol plateau some elements of Cathaysian flora have been found, which indicate that the Cathaysian flora had mixed up with those of the Angaran flora. Zhu and Shen (1977) are also of the same opinion. Wang and Wang (1987) studied the Permian plants of Shanxi and pointed out that Angara elements did not mix with the Cathaysian flora before Late Permian. This obviously indicates that the collision of the Angaran land with the Cathaysian land took place somewhere in the end of Permian. The inversion of Tianshan-Hinggan geosyncline and disappearance of sea consequently formed the Eurasia as a united land where the exchange of the Angara flora with the Cathaysian could be possible.

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