
Permian phytogeography of China

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Based on the characteristics, developing history and geotectonic position of different floral localities, the Permian flora of China may be divided into 13 phytoprovinces which belong to five phytoareas of four phytorealm, respectively.

Key-words—Phytogeography, Permian flora, China.

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सारांश

चीन का परमियन युगीन पादपभौगोलिक अध्ययन

वांग जुन एवं शेन ग्वांगलॉंग

चीन का परमियन युगीन वनस्पतिजात विशेष लक्षणों, वैकासिक इतिहास एवं विभिन्न स्थानों की भूविवर्तनिक स्थिति के आधार पर चार परिमंडलों के पाँच पादप क्षेत्रों से सम्बद्ध 13 पादप-प्रदेशों में विभक्त किया जा सकता है।

THE palaeobotanical data documented up till now indicate that the Permian floral distribution in China was very widespread and China is the only country in the world, where four Late Palaeozoic floras, namely, the Euramerican, Cathaysian, Angaran and Gondwanan floras had developed. Several workers (Li *et al.*, 1979, 1981, 1992; Hsu, 1973, 1976, Hsu *et al.*, 1990; Zhang *et al.*, 1985; Zhang, 1989; Huang, 1977, 1993; Hu, 1985; Wu, 1993; Sun *et al.*, 1991; Sun, 1989; Shen *et al.*, 1989, 1990, 1992; Asama, 1976; Halle, 1935, 1937; Kimura, 1987; Kon'no, 1968) described the outline of the Permian phytoprovince of China in different ways, but no comprehensive synthesis has been prepared. Based on both the available material and principles of phytogeography, a primary framework concerning the Permian phytogeography of China for the future theoretical studies is compiled.

DIVISION AND CHARACTER OF PERMIAN PHYTOPROVINCE IN CHINA

On the basis of various features of individual floras, with regard to the particular developmental

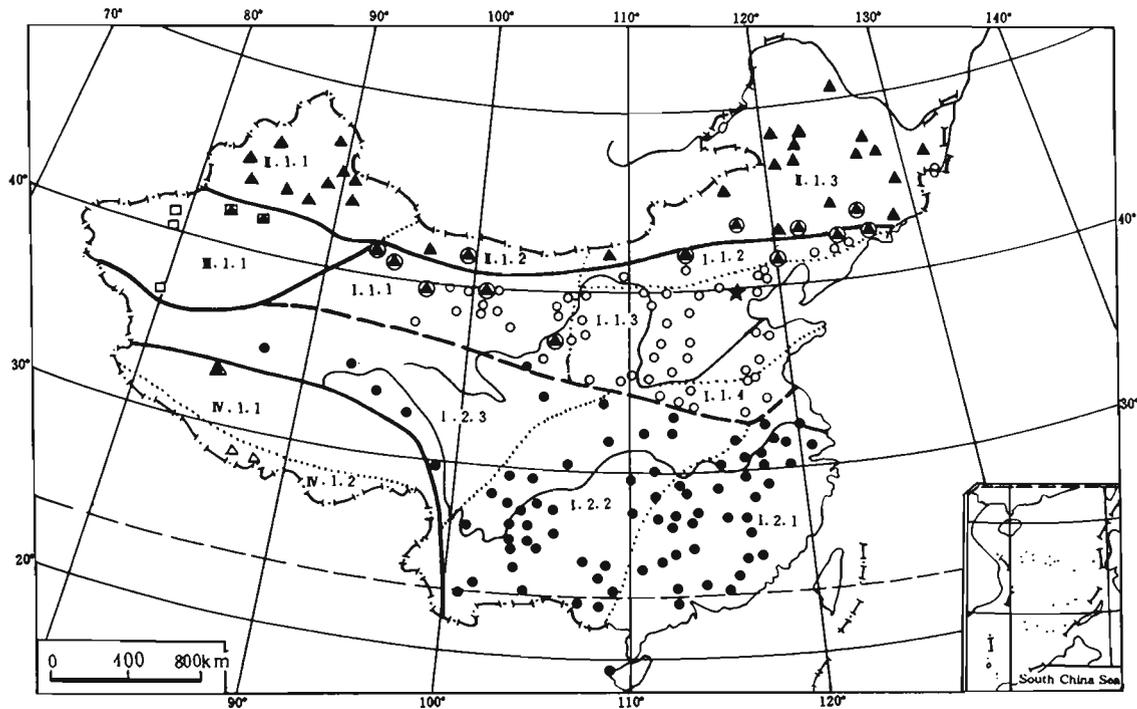
conditions of the palaeovegetation during different stages of the Permian, as well as the geotectonic position of floral localities, the Permian floral distribution of China may be divided into the following 4 phytorealm, 5 phytoareas and 13 phytoprovinces (Wang *et al.*, 1996; Text-figure 1; Table 1).

1. The Cathaysian Phytorealm

- 1.1. The North China Phytoarea
 - 1.1.1. The Qilian-Alashan (Alxa) Phytoprovince
 - 1.1.2. The Daqingshan-Tumen Phytoprovince
 - 1.1.3. The Shaanxi-Shanxi-W. Shandong Phytoprovince
 - 1.1.4. The W. Henan-N. Anhui Phytoprovince
- 1.2. The South China Phytoarea
 - 1.2.1. The Jiangnan Phytoprovince
 - 1.2.2. The Yangtze Phytoprovince
 - 1.2.3. The N. Tibet-S. Qinghai Phytoprovince

2. The Angarian Phytorealm

- 2.1. The Peri-Angarian Phytoarea
 - 2.1.1. The Junggar Phytoprovince
 - 2.1.2. The Beishan Phytoprovince



Text-figure 1—Showing the Permian floral distribution of China. 1. Occurrence of Angaran flora, 2. Occurrence of Euramerican flora, 3. Occurrence of Cathaysian flora (in the S. China Phytorealm), 4. Occurrence of Cathaysian flora (in N. China Phytorealm), 5. Occurrence of Gondwanan flora, 6. Occurrence of mixed flora of Angara and Cathaysia, 7. Occurrence of mixed flora of Euramerica and Angara, 8. Occurrence of mixed flora of Gondwana and Cathaysia, 9. Approximate position boundary between phytorealm, 10. Approximate position of boundary between phytorealm, 11. Approximate position of boundary between phytorealm.

2.1.3. The Hinggan Phytoprovince

3. The Euramerican Phytorealm

3.1. The Central Asian Phytorealm

3.1.1. The Tarim Phytoprovince

4. The Gondwanan Phytorealm

4.1. The N.E. Gondwanan Phytorealm

4.1.1. The Gangdise Phytoprovince

4.1.2. The Himalayan Phytoprovince

The main characteristics of each phytounit may be briefly described as follows :

1. *The Cathaysian Phytorealm*—It covers the largest part of China proper. The main features of this phytorealm are : (i) at the lowermost Permian it was characterized by such oriental-type lepidophytes as *Lepidodendron posthumii*, *L. oculus-feils*, *L. szeianum* and *Cathaysiodendron nanpiaoense* and the endemic genus *Tingia*, with certain species of the

Sphenopsida and Filicopsida (particularly *Pecopteris*) which are very abundant during the Stephanian stage in the Euramerican Phytorealm; (ii) at the middle stage of the Early Permian, a number of endemic species such as *Emplectopteris*, *Emplectopteridium* and *Lobatannularia* started to develop, but the typical gigantopterids including *Gigantonoclea* and *Cathaysiopteris* were far from common; (iii) from the late stage of the Early Permian to the early stage of Late Permian, along with the decline of the "Oriental lepidophytes", gigantopterids and *Lobatannularia* rapidly developed to dominate, and also certain endemic elements including *Fasciapteris*, *Otofolium* and *Yuania* appeared, then spread rapidly one after another; (iv) at the late stage of the Late Permian, gigantopterids were limited to the Yangtze block and N. Tibet-S. Qinghai region. Moreover, some western European Zechstein xerophytes have been found recently in the Uppermost Permian of N. China

Table 1—Showing distribution of Permian Phytoprovinces in China and their geotectonic position

Phytorealm	Phytoarea	Phytoprovince	Geographical area	Geotectonic unit
I	I.1	I.1.1	North Xinjiang (southward to the Tianshan Mt.)	Tianshan-Hinggan Hercynian Fold Belt
		I.1.2	Beishan area in Gansu and a small part of western Inner Mongolia	
		I.1.3	Da Hinggan Range, Xiao Hinggan Range and Northeast China Plain	
I	I.1	I.1.1	Westward to the Altun Mt., eastward to the Ordos Basin, northward to Beishan area southward to the Qaidam Basin(?)	Alxa Block, Hexi Corridor border Fold Belt, Qilian Caledonian Fold Belt
		I.1.2	The Yinshan Mt., Daqingshan Mt. the hinterland of Yanshan and west Liaoning	The North China Block
		I.1.3	The Ordos Basin, Shanxi Prov., West Shandong and Hebei Prov.	
		I.1.4	West Henan and North Anhui	
I	I.2	I.2.1	Fujian, Zhejiang, Jiangxi, Guangdong, Hunan, Guangxi and a part of Jiangsu and Anhui	The South China Block and Jiangnan Block
		I.2.2	Hubei, Sichuan, Guizhou and East Yunnan	The Yangtze Block
		I.2.3	Middle-North Tibet and South Qinghai	The Qiangtang Block and the Songpan-Garze Block
I	I.1	I.1.1	South Xinjiang (Tarim Basin)	The Tarim Block
IV	IV.1	IV.1.2	Himalaya Mt.	Himalayan Block
		IV.1.1	Gangdise Mt.	Gangdise Block

coexisting with a few Cathaysian species. In addition, what is worthy of mention is that in the northern margin of N. China Phytoarea there were a few mixed floras of both Cathaysian and Angarian, which shows the migrating and expanding process between the two different palaeofloras.

Li *et al.* (1979) divided the Cathaysian Province into two subprovince: the North China and South China subprovinces. Recently, Du and Mei (1994) divided it into four independent units, namely the N. China subprovince, S. China subprovince, Qilian-Tarim subprovince and Yu Huai subprovince. With respect to this recent data, the present authors divide the Cathaysian Province into two phytoareas and

subdivide them into seven phytoprovinces, about which brief characteristic descriptions are presented as follows:

1.1: *The N. China Phytoarea included four phytoprovinces*

1.1.1: *The Qilian-Alashan (Alxa) Phytoprovince*—The floral aspect was closely similar to that of the Shaanxi-Shanxi-W. Shandong Phytoprovince excepting for the poor development of gigantopterids until the early stage of the Late Permian. During the Late Permian more species with a Subangaran aspect existed here to form the distinct Subangaran-Cathaysian mixed flora.

1.1.2: *The Daqingshan-Tumen Phytoprovince*—With its general plant aspect consistent with that of the N. China Phytoarea, this phytoprovince was characterized by relatively more diversified. *Emplectopteris*, several species of which were endemic, and invasion by a few endemic plants of the subangarian during the Late Permian.

1.1.3: *The Shaanxi-Shanxi-W. Shandong Phytoprovince*—It was the typical example of the N. China Phytoarea, despite the appearance of a few Zechstein and Angarian plants in the uppermost Permian.

1.1.4: *The W. Henan-N. Anhui Phytoprovince*—It holds a strong relationship to both, the N. China and the South China Phytoareas, where gigantopterids were developed relatively well; a few species of which were endemic.

1.2: *The South China Phytoarea includes three Phytoprovinces*

1.2.1: *The Jiangnan Phytoprovince*—This phytoprovince appeared in the middle stage of Early Permian and flourished from the late stage of the Early Permian to the early stage of the Late Permian. The flora of this region was typical of the Gigantopteris flora dominated by gigantopterids.

1.2.2: *The Yangtze Phytoprovince*—The floral aspect of this phytoprovince was closely similar to that of Jiangnan with the strong prevalence of gigantopterids. It reached its greatest development in the Late Permian and in local cases persisted into the lowermost of the lower Triassic.

1.2.3: *The N. Tibet-S. Qinghai Phytoprovince*—Apart from a few endemic species, the floral aspect closely resembles that of the Yangtze Phytoprovince. What was significant is that the *Gigantonoclea guizhouensis-Selaginellites tibeticus* assemblage might be regarded as the latest assemblage of the Cathaysian flora, representing probably the latest phase of the last Permian flora in the world (Li *et al.*, 1981).

2: *The Peri-Angaran Phytoarea*—*Angaropteridium*, *Angarites* and *Noeggerathiopsis* have always been reported in the Junggar-Hinggan region, Northwest and Northeast China occurring since Carboniferous, which indicates a strong Angaran floral aspect. Furthermore, upon entering into the Permian time, the appearance of many subangarian genera, namely *Paracalamites*, *Koretrophyllites*, "*Callipteris*",

Zamiopteris, *Purssongia*, *Comia*, *Iniopteris*, *Lepeophyllum*, *Sylvia*, *Nephropsis* and *Crassinervis* together with the disappearance of 'some Euramerican genera that had been common from the Late Carboniferous to Early Permian, and the lack of typical Cathaysian genera definitely indicates that the region belongs to the Angarian phytorealm. According to the components of individual floras, the phytoarea can be divided into three phytoprovinces including the Junggar Phytoprovince, the Beishan Phytoprovince and the Hinggan Phytoprovince. In Beishan region, the flora most strongly developed in the Late Permian, dominated by subangaran elements, with certain Cathaysian members intermingled, with none endemic, due to which it showed similarity to that of the southwesterly adjacent Qilian-Alashan Phytoprovince; in Hinggan Phytoprovince, the flora was characterized by abundant endemic species, with a few species of *Lobatannularia* scattered along the southern boundary at the late stage of the Late Permian.

3: *The Central Asian Phytoarea*—During the middle stage of the Early Permian, the flora was dominated by Euramerican species, of which *Autunia* was dominant, none of the typical Cathaysian or Angaran species were developed, and overall aspect of the plant assemblage was consistent simultaneously with that of the Central Asian phytoprovince, so that the Tarim Phytoprovince can be distinguished. Such a phase was maintained through the late stage of the Early Permian, while *Paracalamites* and *Noeggerathiopsis* first appeared till the late Early Permian, then along with the closing of the Tianshan Trough, some subangaran elements such as *Iniopteris*, *Comia*, *Zamiopteris* and "*Callipteris*" migrated into and replaced the previous Euramerican ones, transforming the former Euramerican Phytoarea into the Peri-Angarian Phytoarea.

4: *The N.E. Gondwana Phytoarea*—It refers to the Qubu flora in the middle-late stage of Early Permian and the Xiagang Jiang flora in the latest stage of the Early Permian. The Qubu flora, which was distinguished by the *Glossopteris communis-Austroannularia qubensis* Assemblage, bears a striking resemblance with the coeval Kashmir flora. Some palaeobotanists referred it as a Gondwanan-Cathaysian mixed flora because its representative

Table 2

Phytounit		Age		Early Permian (P ₁)			Late Permian (P ₂)	
		P ₁	P ₂	P ₁	P ₁	P ₁	P ₂	P ₂
I	I.1	I.1.1	Unnamed Assemblage				"Callipteris" zeilleri-Comia detata Assemblage	
		I.1.2	(Marine deposits)				"C." ad-In. s Assemblage	
		I.1.3	No. s-Ne. o Assemblage	Zamiopteris lanceolata-Neogg. derzavinii Assemblage		"C." a-Co. sh Assemblage	Co. y-Lob. h Assemblage	
I	I.1	I.1.1	Neuropteris pseudovata Lepidodendron-posthumii Assemblage	Emlpectopteris triangularis-Emlpectopteridium alatum	Al. n-Lob. s Assemblage	Y. s-Cl. o Assemblage	In. s-Lob. l Assemblage	
		I.1.2		Assemblage	Emlpectopteris triangularis-Tingia sp. -Cathaysiotes whitei Assemblage	Gigantonoclea hallei-Fasci-pteris spp. -Lobat. heia-nensis Assemblage	Ullmannia bronnii-Yua-nia magnifolia Assemblage	
		I.1.3						
	I.2	I.2.1		Emlpectopteris triangularis-Taeniopteris multinervis Assemblage	Gigantopteris nicotianae-folia -Tingia carbonica Assemblage	Gigantopteris dictyophyl-loides -Lob. multifo-lia Assemblage	Gigantonoclea guizhouensis-Ullmannia bronii Assemblage	
		I.2.3	(Marine deposits)				Gs. d-R. c Assemblage	Ga. g-Sel. Assemblage
I	I.1	I.1.1		Aut. c-Cl. k Assemblage	Noeg. -P. syg. Assemblage	"Ca." zeilleri-Comia kulga-nensis Assemblage		
IV	IV.1	IV.1.1		Noeg. -Pl. Assemblage				
IV	IV.1	IV.1.2		Cl. c-Aust. q. Assemblage	(Marine deposits)			

species *Austroannularia qubuensis* is strongly similar to *Lobatannularia*, however, it lacks the typical Cathaysian genus *Gigantonoclea* which suggests a closer relationship to the Indian Gondwana flora. The Xiang Jiang flora also showed some relation to that of the Cathaysian Phytorealm by the presence of *Pecopteris arcuata* and *Plagiozamites? oblongifolius*. Overall, based on the available data, it is reasonable to identify the relevant area as two independent phytounits in the N.E. Gondwana Phytoarea, namely the Himalayan and Gangdise phytoprovinces respectively.

Because of the limited space, it is impossible to analyse the provincial characters in greater details. The main characters are summarized in Table 2.

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