
Tectonic implications of Permian floras in China

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On the basis of comprehensive palaeophytogeographical study, the Permian flora of China may be divided into 4 phytorealm, 5 phytoareas and 13 phytoprovinces. The tectonic implications of the Permian floras and phytoprovinces in China are preliminarily discussed.

Key-words—Palaeophytoprovinces, Tectonic implications, Permian flora, China.

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सारांश

परमियन युगीन वनस्पतिजातों का विवर्तनिक महत्व

शेन ग्वांगलॉंग, वांग योंगडॉंग, वांग जुन, लियु हुआकिंग एवं झांग श्वांगक्वान

पुरापादप भौगोलिक अध्ययन के आधार पर चीन का परमियन युगीन वनस्पतिजात चार परिमंडलों, पाँच पादपक्षेत्रों एवं 13 पादप प्रदेशों में विभक्त किया जा सकता है। इस शोध-पत्र में चीन में परमियन युगीन वनस्पतिजातों एवं पादप-प्रदेशों के विवर्तनिक महत्व की प्रारम्भिक विवेचना की गई है।

A striking feature of the Permian palaeophytogeography of China lies in the existence of four Late Palaeozoic floras, namely, the Euramerian, Cathaysian, Angarian and Gondwanan floras, which started to diversify at least from the middle stage of Carboniferous and reached their flourishing acme in Permian. The unique distribution of palaeophytoprovince is, obviously, the concrete reflection of both tectonic and palaeogeographic environments of China during the Permian Epoch. It has been recognized in terms of plate tectonics that the present day Chinese mainland is composed of a great number of palaeoblocks (or palaeomicrocontinents) and terrains of the geological past, which differ in their landsizes and developmental histories. To probe into the exact or the approximate locations and the processes of drifting and assembling these palaeoblocks and terrains during geological times, it is indispensable to depend on the palaeobotanical data properly, as well as the study of the geotectonics

in a deepgoing way. The present article deals with the tectonic constraint of Permian floras of China based on the systematic statistics and analyses of the documented palaeobotanical data of Permian floras in China uptil now.

DIVISION OF PERMIAN PHYTOGEOGRAPHICAL PROVINCES OF CHINA

According to a recent generalization of Wang Jun *et al.* (1996), the Permian floras of China may be divided into the following units :

- I. The Angarian Phytorealm**
 - I.1. The Peri-Angarian Phytoarea
 - I.1.A. The Junggar Phytoprovince
 - I.1.B. The Beishan Phytoprovince
 - I.1.C. The Hinggan Phytoprovince
- II. The Cathaysian Phytorealm**
 - II.1. The North China Cathaysian Phytoarea
 - II.1.A. The Qilian-Alxa Phytoprovince

- II.1.B. The Daqingshan-Tumen Phytoprovince
- II.1.C. The Shaanxi-Shanxi-W. Shandong Phytoprovince
- II.1.D. The W. Henan-N. Anhui Phytoprovince
- II.2. The South China Cathaysian Phytoarea
- II.2.A. The Jiangnan Phytoprovince
- II.2.B. The Yangtze Phytoprovince
- II.2.C. The N. Tibet-S. Qinghai Phytoprovince

III. The Euramerian Phytorealm

- III.1. The Central Asian Phytoarea
- III.1.A. The Tarim Phytoprovince

IV. The Gondwanan Phytorealm

- IV.1. The N.E. Gondwanan Phytoarea
- IV.1.A. The Himalayan Phytoprovince
- IV.1.B. The Gangdise Phytoprovince

Due to the limited space, it is impossible for us to account the detailed floral characteristics of each individual phytoprovince which will be discussed in our another paper (Wang *et al.*, 1996) in detail.

TECTONIC IMPLICATIONS

To test with palaeobotanical data, the palaeoblocks and terrains constituting the present-day China mainland during the Permian Epoch may be grouped under four types as follows:

1. *The Angarian affinities type*—These blocks including the Junggar Block, the Beishan Block, the Song Liao Block and the Jiamuse Block, etc. were distributed around the peripheral area of the Siberian Plate and lay within the Hercynian Fold Belt of North China. In the late stage of the Hercynian orogenic movement period, owing to the eastward convergence with the Siberian Plate, they became a portion of the Angaraland one by one and were located within the middle-high latitude zone of the northern Hemisphere in the Permian Epoch. These blocks were not far away from the Angaraland certainly, just within the biotical distance. Thus, some plant elements with the sub-Angaran aspect, such as *Paracalamites*, "*Callipteris*", *Pursongia*, *Iniopteris*, *Comia*, *Zamiopteris* and *Noeggerathiopsis*, etc. invaded southward and gradually developed an independent phytogeographic unit, the Peri-Angarian Phytoarea with some endemic forms. According to the differences of the Permian plant as-

semblages in these blocks, three phytoprovinces, the Junggar, the Beishan and the Hinggan Phytoprovinces, can be recognized.

2. *The Gondwana affinities type*—It is generally believed that the Gondwanaland had broken up several times on its north, especially on its North-eastern sector during the Late Palaeozoic Era and formed a number of marginal blocks, some of them have been generally named as the Cimmeride microcontinents. Both the Himalayan Block and the Gangdise Block lying in the South of Tibet, China certainly came into being through the dispersion of the north margin of Gondwanaland, because the typical tillites-tilloides deposits and cold water fauna, such as *Eurydesma* and *Stepanoviella*, etc. have been found from these blocks in recent years.

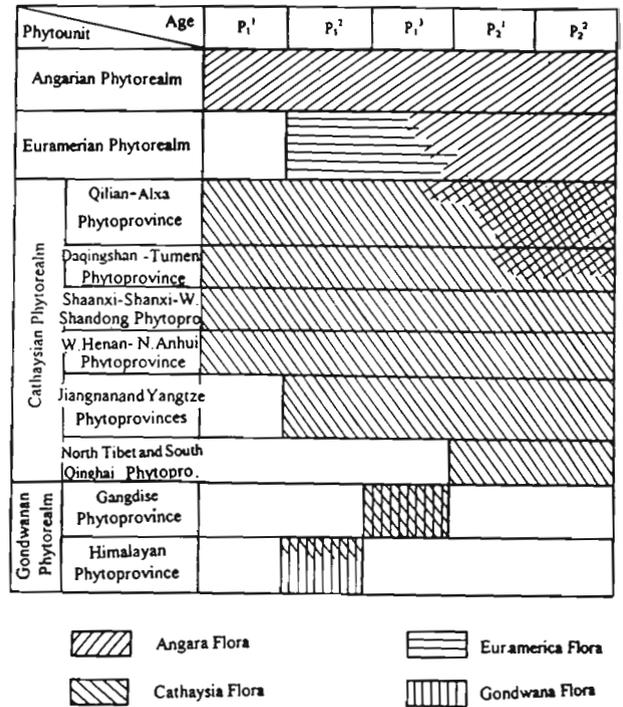
The occurrence of such typical plants of the Gondwanan flora as *Glossopteris communis*, *G. indica* and *Trizygia speciosa*, etc. in the Qubu Formation in Dingri and Dingjie counties of south Tibet is enough to provide that the Himalayan Block should be one part of the Gondwanaland. Although, there are no typical representative elements of the Gondwanan flora found from the Lower Permian Xiangangjiang flora of the Gangdise Block, lying to the north of the Himalayan Block, the obvious inter-arrangement of ribs and furrows on the stem of Sphenopsida and the existence of a large number of *Noeggerathiopsis* indicate that the Xiangangjiang flora is more or less related to the Gondwanan flora. On the other hand, some forms with the Cathaysian floral aspect have also been found in the Xiangangjiang flora. How to explain the existence of the mixed Gondwana-Cathaysian flora on the Gongdise Block? We hold that the Gongdise and Himalayan blocks, originally, were a part of the N.E. sector of the Gondwanaland and located within the middle-high latitude zone of the Southern Hemisphere. They had broken up from the Gondwanaland one by one and rapidly drifted northward in the Permian Epoch. While they drifted near to or across the low latitude zone, owing to the effect of the monsoon (air current), some Cathaysian plant elements dispersed onto the Gangdise Block and naturally made them possess certain Cathaysian floral aspects. The occurrence of the genus *Austroannularia*, which is very similar to

Lobatannularia of the Cathaysian flora, on the Himalayan Block and its neighbouring Kashmir of India can also be well explained in terms of this viewpoint.

3. *The Cathaysian Islands or the Cathaysian composite land type*—It was composed of a lot of microcontinents and a certain number of terrains, such as the North China Block, South China Block, Yangtze Block, Qaidam Block, Qiangtang Block and Alxa Block, etc. These blocks and terrains were separately or close to each other and situated across the palaeoequator and low-latitude zones of the Southern and Northern Hemispheres. The Permian floras on these blocks and terrains are characterized by typical elements of the Cathaysian phytorealm such as *Emplectopteris*, *Emplectopterium*, *Tingia*, *Lobatannularia*, *Yuania*, *Fascipteris*, *Otofolium* and a certain number of oriental-type lepidophytes including *Lepidodendron oculus-felis*, *L. posthumii*, *L. szeianum*, *Cathay-siodendron nansiaoense* and *C. incertum*, etc.

During most of the Permian Epoch, these blocks and terrains were quite near, because of the roughly identical palaeoecological and palaeogeographical environment, the components of these floras in these blocks were similar. During Late Permian, both the Alxa Block and the North China Block rapidly drifted northward accompanied anti-clockwise rotation, gradually approached to and successively jointed with the Angarian palaeocontinent from the west to the east. So a possibility of the interchange of both the Cathaysian flora and Angarian flora developed along the northern margin of North China Block as well as on the Alxa Block.

During the course of drifting, the palaeoecological condition of these blocks and terrains was obviously changing with the appearance of the latitude-gradient, which was resulted from the difference in both the drifting speed and the drifting direction, and some endemic plant elements were arisen. According to this, two secondary and some third phytogeographical units can be recognized from the Cathaysian phytorealm (see above). From the palaeobotanical data, it can be seen that the facing direction of the North China Block at the Permian Epoch was obviously different from that of the



Text-figure 1—Permian phytogeography of China.

present-day. It roughly spreaded NW-SE-ward and was closed to or jointed with the South China (Yangtze) Block in the west Henan and N. Anhui. Thus a path was formed through which the southern and the northern Cathaysian floras can interchange and an independent phytogeographical unit, the W. Henan-N. Anhui phytoprovince, gradually established. Owing to the similarity of the general features of the phytoprovince to that of the North China Cathaysian flora, we class it under the North China Cathaysian Phytorealm.

4. *The Kazakhstan affinity type*—The Tarim Block is the unique example of this type, which was originally one of the Cathaysian Islands in the Early Palaeozoic Era. It first and rapidly drifted away northward in the Late Palaeozoic Era and jointed itself together with the Kazakhstan Block and was located within the middle-low latitude zone of the Northern Hemisphere during Carboniferous. In the Early Permian, the flora on this block was very similar to that of the central Asian area with the dramatical Euramerican floral aspect and belonged to the Euramerican Phytorealm. At the end of Early Permian, the

continuing northward drifting of the Tarim Block led to the eventual disappearance of the Tianshan Sea Trugh, which separated the Tarim and Junggar Blocks, and resulted in the southward invasion of the Subangarian flora of the Junggar Block onto the Tarim Block. So the formerly Early Permian Euramerican flora was entirely replaced by the later coming Subangarian flora. As a result, the Late Permian flora of the Tarim Block became a member of the Peri-Angarian Phytoarea.

From the developmental and changing process of the Permian phytogeography of China (Text-figure 1), it is clear that the palaeobotanical data are also an effective tool to the deepgoing study of theoretical geology and related academical fields.

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