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The Palaeozoic stratigraphy of China

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INTRODUCTION

The Palaeozoic strata are well developed in China. They consist of diverse sedimentary rocks containing abundant biota and mineral resources. The recorded study of the Palaeozoic stratigraphy began in 1882 and lasted for more than one hundred years.

In this talk we are going to introduce something about Palaeozoic stratigraphy such as the distribution of the strata, the types of the sedimentation, the classification of chronostratigraphy of China, the boundary problems and the biogeographical provinces.

I. THE CAMBRIAN SYSTEM

The Cambrian is well developed and widely distributed in China, with various types of sedimentation and a variety of biotas, and is rich in mineral deposits of phosphate, iron, mercury, rare elements, gypsum and salts, pyrite and coal, etc. It occurs especialy extensively in the southern part of the Northeast, North, Central and Southwest China, with the exception of the Altay, Junggar, North Tibet and Taiwan.

(I) Cambrian Sedimentary and Faunal types

The sedimentary types of the Cambrian in China comprise stable platform type on the one hand, and active geosynclinal type on the other even acompa-

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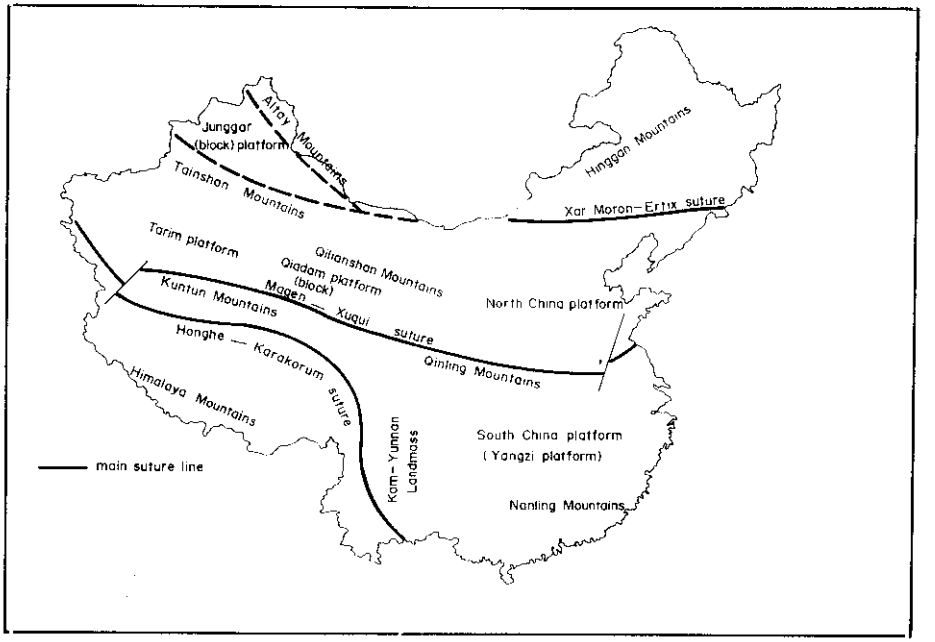

nied by strong volcanic activities in some districts. In respect of sedimentary environments, there are littoral shallow sea, deeper shallower sea, embayment, semiseparated sea, lagoon, island arc sea, etc. As to the nonmarine strata, it is hard to recognize their ages, owing to the lack of evident keys and proofs. Based on the present materials, the Cambrian can be temporarily divided into three sedimentary types.

1. *The North China type.* It represents a sedimentary environment of littoral sea, belonging to stable sedimentary type. Its deposits are mainly of lightly coloured sandy shale, limestone, dolomite, oolitic limestone and wormkalk, with mudcracks and ripple-marks. Thickness is comparatively small. Under semi-closed sea basin or lagoon environments, there are deposited abundant dolomite, gypsum and salts. As oxygen is comparatively sufficient in shallow sea water, so biota is rich, and there appear various benthonic biotas, such as fairly big vagrant Trilobites, Archaeocyathus, Brachiopoda, Hyolithids and Algae.

2. *The Jiangnan type.* It was formed in a sedimentary of deep shallow sea, environment off-shore or embayment deposit, generally of silicous, carbonaceous and carbonate strata, dark coloured and rich in pyrites. In the comparatively deep and calm sea water, oxygen is insufficient, so it shows reducting or weak reducting environments, containing comparatevely more organic matter

and hydrosulphate. Fossils are mainly of Agnostida or other planktonic trilobites, sponge spicules, hyolithids, etc.

3. *The Southeastern type.* This is the sedimentary type in active region, often associated with flysch, flysch-like and volcanic rocks. Such a type is composed of rhythmic sandy shale, marl, limestone and various kind of volcanics, etc. With huge thickness, but fossils are generally rare, including occasionally small chitinous in articulate brachiopods, sponge spicules, etc.

Faunal types:

During Early Cambrian there existed over the world two biogeographical realms. One was the East or Pacific realm, characterized by yielding Redlichiid fauna and another the West or Atlantic realm, characterized by yielding Olenellid fauna. During the early Cambrian China belonged to the East realm.

From Middle to Late Cambrian there may be recognized two faunal types. The North China and the Jiangnan types. The North China type is mainly composed of benthonic vagrant trilobites; besides, it contains also Brachiopoda, Grastropoda, Hyolithids, Algae, etc. The Hiangnan type is mainly composed of planktonic trilobites, small Brachiopoda and sponge spicules.

(II) Classification of Cambrian Chronostratigraphy of China

A unified national chronostratigraphical scale is based on the North China type stratigraphic sequence, because its boundaries are clearly defined and its biota is rich, with quick trilobite evolution, serving therefore as a standard. The stratotype section for the Lower Cambrian was chosen in Eastern Yunnan, and for Middle and Upper Cambrian, it was chosen in Western Shandong and Eastern Hubei. Stages are established mainly on the basis on strato-type sections. For accurately defining their ages and reliable correlations among different districts, fossil zones or fossil assemblages are relied on. Isotopic dating and paleomagnetic data are also needed.

The Cambrian System is divided into 3 series, 10 stages as follows: Lower Cambrian: Meishucun stage, Quingzhusi stage, Canglangpu stage, Longwangmiao stage; Middle Cambrian: Maozhuang stage, Hsuzhung stage, Zhangxia stage; Upper Cambrian: Gushan stage, Changshan stage and Fengshan stage.

(III) Regional stratigraphical characteristics

Basing on sedimentary type, faunal type, geological history and geographical factors, the Cambrian system in China may be divided into 10 stratigraphical regions as follows: 1. Tianshan-Hingan Region, 2. Tarim Region, 3. North

China Regions, 4. Qilian Region, 5. Kunlun-Qinling Region, 6. Western Yunnan-North Xizang Region, 7. Himalayas Region, 8. Yangzi Region, 9. Jiangnan Region and 10. Southeastern Region.

(IV) Stratigraphical boundaries

1. The lower boundary of the Cambrian, transitional formation between the Sinian and Cambrian of China is very developed. There are fine continuous sections with typical and widespread tillites, phosphates rocks, various kinds of faunas and floras. Jinling of Yunnan, Omei of Sichuan, Yichany of Bubei are some of the best representative sections so far discovered.

In all the Cambrian Sections, below the most ancient trilobites there are rich shelly assemblages without trilobites. In biostratigraphy the appearance of the most ancient shelly fauna is taken to mark the beginning of Cambrian. In China, such fossils begin at the base of Meishucun stage, and the lowest fossil assemblage is called *Anabarites - Circotheca* assemblage.

2. Boundaries between Lower and Middle Cambrian and between Middle and Upper Cambrian.

The boundary between Lower and Middle Cambrian is drawn between the *Redlichia murakamii - Hoffetella* zone and *Shantungaspis* zone (on the top of the Maoxhuangian).

The boundary between the Middle and Upper Cambrian is put at the base of Gushanian, and drawn between the *Damesella* zone and the *Blackwelderia* zone.

3. The Upper boundary of the Cambrian. It lies at base of the Tremadocian of North Europe. The highest trilobite zone of the Upper Cambrian in North China type is the *Calvinella Mictosaukia* zone; in the Jiangnan type it is the *Hedinaspis Charchagia - Lotagnostus* assemblage, while the base of Ordovician is *Onychopyge borealis - Leiostegium (Alloleiostegium) punctatum* trilobites assemblage or *Hesterolenus* zone; in conodont facies, it is the appearance of *Drepanodus simplex* that marks the beginning of Ordovician.

II. THE ORDOVICIAN SYSTEM

The distribution of Ordovician sedimentation types and sedimentary regions is similar to that of the Cambrian, thus reflecting the general geotectonic regime prevailing in the Early Palaeozoic. Hence, as in the Cambrian, the Chinese Ordovician may be divided into three main types (stable, mobile, and transitional) and ten stratigraphic regions with some minor changes.

(I) Ordovician sedimentation types

1. *Stable or platformal and paraplatformal type sedimentation (North China type).* It is found in the Tarim (2), North China (3), Yangzi (8) and Himalayan (7) regions. The platformal type consists chiefly of carbonate rocks with homogenous lithofacies of moderate thickness and with monotonous faunal make-up, which resembles the North American realm. the paraplatformal deposits consist mainly of carbonate rocks intercalated with thin, well-bedded clastic rocks of irregular thickness, but with marked facies changes.

2. *Mobile or basin type sedimentation (South-east China type).* It is found in the Tianshan-Hingan (1), Qilian (4), and South-east (9) regions. The Kunlun-Qinling region (5), which in the Cambrian Belongs to the transitional type, and the North Xizang-West Yunnan region. The basin Ordovician deposites are mainly composed of very thick carbonaceous, siliceous, detrital rocks (flysh type), of graptolite facies. No volcanic rocks are present. This typical south-east type is similar to the Australian type. The basin deposites are characterized by volcanic rocks intercalated with very thick, regionally metamorphosed detrital and carbonate rocks of unequal thickness, with marked facies changes. All of these features reflect deposition in unstable environments, as found typically in the Hingan subregion, and the Qilian, Kundun and Qinling regions.

3. *The transitional type (the Jiangnan type).* It includes only the marginal facies of platforms (e.g. North Xizang and west Yunnan (6) or paraplatforms and of miobasins (e.g. South-east region (9).

(II) Classification of Ordovician Chronostratigraphy of China

A two-fold division into the Lower and Upper Ordovician is now generally accepted for the Ordovician of China on the basis of two different stages of organic evolution. The graptolites include (1) Diplograptids-sinograptids stage and (2) the Dicellograptids stage. Chinese cephalopods may be differentiated: (1) the Ellesmerocerida, Endocerida, and Actinocerida stage, and (2) the Oncocerida, Tarphycerida, and Discocerida stage. Palaeogeographic provincialism was distinct in pre-Llandeilian time, whereas the post-Llanvirnian was characterized by cosmopolitan associations.

The Lower Ordovician includes the Yichangian (Tremadocian). Honghuayuantun, Dawarian (Arenigian) and Guniutanian (Llanvirnian), while the Upper-Ordovician includex the Miaopoan (Llandeilian and Caradocian pars), Baotaan (Caradocian pars), Linxiangian (Upper Caradocian and Lower Ashgillian) and Wafengian (Upper Ashgillian).

(III) Boundary problems

In the region where the Ordovician sequence is well-developed, such as in Yangzi region, the upper limit of the Ordovician is concerned with the age of «Dalmanitina beds» (the Guanyingiao Formation). Where these beds contain the *Hirnantia* fauna (Trilobite), and *Diplograptus bohemicus* zone they are treated as latest Ordovician.

According to the proposal of the second All-China Stratigraphic Conference (1979) a two fold division of the Ordovician System is now generally accepted, and the boundary between the two divisions is drawn between the Miaopoun and Guniutanian, i.e. between the *Glyptograptus teretiusculus* zone and the *Pterograptus elegans* or *Didymograptus murchisoni* zone.

III. THE SILURIAN SYSTEM

The uplift that had caused the withdrawal of the CaradocianAshgillian seas persisted into the Silurian in the same areas, so a large part of North China, Southern Norht-east China, etc. became land. The Silurian rocks as a result are spread much less extensively than Cambrian and Ordovician rocks, although the Silurian seas still covered quite a large part of China.

(I) Silurian sedimentation types and biofacies

Three sedimentation types (the stable or platformal, mobile or basinal, and transitional) are recognized.

Stratigraphic regions are as follows: A-Stable (Yangzi-type) which includes the Tarim (3), Yangzi (8), and Himalaya (7) regions; B-Mobile or basinal (South-east type) which includes the Hingan (1), Tianshan-Nei Mongol (2), Qilian (4), Kunlun-Qinling (5), North Tibet-west Yunnan (6), and South-east (10) regions; and C-the transitional type which includes typically the Jiangnan region.

The biofacies associations include:

1. Entirely graptolitic facies, mainly graptolitic shale in the south-east region;
2. Mixed graptolitic and shelly facies occurring in eight regions:
platformal type (Yangzi, Tarim and Himalaya regions);
basin type (Tian shan-Nei Mongol, Qilian, Kunlun-Qinlin,
North Tibet-West Yunnan and Kiangnan regions).
3. Entirely shelly facies of mainly clastic deposits as found in the Hingan region.

Within the mobile sedimentation type the Llandovery series generally consists of graptolitic facies with an *Oktavites spiralis* zone at top, whereas the Wenlockian to Pridolian series are mostly shelly or mixed facies. Within the stable or platformal sedimentation type, the lower Llandoverian series is graptolitic and the upper Llandoverian to Pridolian series are shelly.

(II) Classification of Silurian chronostratigraphy of China

In China the Silurian system can be divided into four series and seven stages, such as:

Pridol. Series	Yulongsian stage
Ludlow. Series	Miaogaoan stage
Wenlock. Series	Guandian stage
	«Xuishanian» stage
Llandovery Series	Baisha'an stage
	Shinialanian stage
	Longmaxian stage

Typical sections for the Llandovery and Wenlock series are located in the border areas of Sichuan, Yunnan, Guizhou and Hubei Provinces, and for the Ludlow and Pridoli series in Qujing, eastern Yunnan Province.

(III) Boundary problem

Lower limit

The boundary between the Ordovician and Silurian is clearly defined in seven of the ten stratigraphic regions, where the two systems are mostly conformable.

In either the mobile or stable regions the Lower part of the Llandovery series is characterized mostly by the graptolitic facies. As the base of the *Glyptograptus persculptus* zone is well-marked at many places, it has been taken as the lower limit of the Silurian. Below it is the *Diplograptus bohemicus* zone or *Hirnantia-Dalmanitian* beds.

Llandovery-Wenlock boundary

The boundary between the Llandovery and Wenlock is marked by the top of the *Oktavites spiralis* zone which is present in the mobile regions or the top of the *Spathognathodes celloni* zone which is present in the platform regions. In the entirely graptolitic facies, the boundary is defined as beeing between the *Cyrtograptus centifugus* or *insectus*, and the *Oktavites spiralis* zone or *Stomatograptus grandis* zone or *Monograptus crenulatus* zone.

Wenlock-Ludlow boundary

The boundary between the Wenlock and Ludlow is marked by the top of the *Ozarkodina sagitta bohemicus* zone. In the graptolitic facies as in the Southern and West Yunnan, the base of *Pristiograptus nilssoni* zone is taken as the boundary between the Wenlock and Ludlow series.

Ludlow-Pridoli boundary

The boundary between Ludlow and Pridoli series is drawn at the base of graptolite *Pristiograptus ultimus* zone or the base of conodont *Ozarkodina remscheidensis eostenhornensis* zone.

Upper limit

The upper boundary of the Silurian is fairly distinct in five of the ten stratigraphic regions, where the SilurianDevonian sequence is complete.

It is marked by the top of the *Ozarkodina remscheidensis eosteinhornensis* zone, or the bottom of the *Caudicriodus woschmidti woschmidti* zone, and or by the top of the *Pristiograptus transgrediens* zone.

IV. THE DEVONIAN SYSTEM

The Caledonian or Qilianian movement, an important event at the close of the early Palaeozoic, brought about the folding of the Qilian basin into mountain ranges, thus joining the Sino-Korean and the Tarim paraplatforms into an extensive continent, a vast expanse of land under denudation, which accentuated the distinctness of the northern basin from the Tethys to the south. In south China, east of the Kam-Yunnan landmass, the same movement caused the formation of the South-east Caledonian foldbelt and the emergence of the main Yangzi massif from below scalevel. Hence, the Devonian marine domain in South China is limited to Yunnan, Quizhon, Guanqui, and west Guangdong Provinces and both the Lower and Middle Devonian successions are transgressive from south-west to north-east. West of the KamYunnan landmass was the subsiding trough of the eastern Tethys, interrupted by a series of medium-sized massifs.

(I) Devonian sedimentation types

On the basis of litho-facies and biotic features, the Devonian of China can be subdivided into the following 3 categories and 6 types.

Category 1. Marine facies of Geosynclinal Region (Mobile type):

1. **The Hingan type** developed in the geosynclinal region consists mainly of marine volcanic lava and tuff with some carbonate and is of great thickness. There are local unconformities and deposition gaps. The biota is mainly composed of benthos rich in endemic taxa. Such a type reflects a shallow and unstable environment with large depressing amplitude, and is represented by Junggar-Hingan region.
2. **The Baoxing type** also developed in the geosynclinal region comprises chiefly of carbonate, associated with clastics and volcanics of considerable thickness and subjected to regional metamorphism. The Devonian here overlies conformably the Silurian and all sequences in the series are conformable. The biota consists largely of many kinds of corals with graptolites and tentaculites. The Baoxing type reflects an off-shore, deeper and unstable environment and is represented by such areas as west Sichuan, Lijiang and Mijiang of West Yunnan.

Category 2. Marine facies of platformal region (stable type)

3. **The Xiangzhou type** occuring in platformal region is composed of bioclastic limestone, dolomite and marlite often intercalate with clastics. The basal part of the section generally is composed of thick-bedded clastics, and usually unconformable with the pre-Devonian. The Devonian biota consists mainly of benthos with numerous endemic taxa. This type represents a near-shore, shallow water environment rich in oxygen and strong hydrodynamic activites. It is represented by such areas as north Guangxi, Central Hunan, southeastern Gueizhou, Longmenshan and Qinling.
4. **The Nandan type** occuring also in platformal areas, is composed mostly biogenetic limestone, dolomite, siliceous rock and black carbonaceous mudstone, only with clastics in the basal part which overlies disconformably the pre-Devonian. The biota is characterized by the occurence of ammonoids, tentaculites, and pelagic trilobites mostly of cosmopolitan character. This type represents and off-shore, rather deep water and stable environment and occurs typically on South-eastern Yunnan and southwestern Guangxi.

Category 3. Continental-Littoral facies

5. **Qilianshan type** occuring in intercontinental basin is composed of red coarse clastics intercalated with volcanics. There are local unconformities within formation. The biota mainly consists of plants and Placodermi of cosmopolitan elements. The typical representative is at Ningxia, north slope of Qilianshan.

6. **The Qujing type** containing mainly continental red beds intercalated with marls and light-coloured sandstone; fairly thickness. The Lower Devonian contains a rich vertebrate fauna of typically oriental aspect, such as: new families and genera of Galeaspidida, Polybranchiaspidida, and Antiarchi. The middle to upper series yields from the lower to upper horizons *Bothriolepis* and new endemic genera of antiarchi. Such a type occurs in Qujing of Yunnan.

(II) Classification of Devonian chronostratigraphy of China

In South China the Devonian is well exposed, extensively developed and marked by a variety of sedimentary associations and rich biotas. Thus it could be selected as the standard section of China.

The Lower Devonian includes Lianhuashansan, Nagaolingian, Yijiangian, and Tangdngian or Sipainian; the Middle Devonian includes Nabiaonian or Yintangian and Dongganglngian, and the Upper Devonian includes Shetiangiaonian and Xikuangshanian.

(III) Regional stratigraphical characteristics

On the basis of the sedimentary types, the history of stratigraphic development and palaeontological characteristics, the Devonian System of China can be subdivided into the following 10 regions: 1. The Junggar-Hingan region; 2. The south Tianshan region; 3. The Qilianshan region; 4. The Longmenshan-Qinling region; 5. The South China region; 6. The south-eastern China region; 7. The Ganzi-Lijiang region; 8. North Xizang region; 9. The Qomolongma region and 10. Qinzhou region.

(IV) Boundary problems

1. Lower/Middle Devonian boundary. The boundary between the Lower and Middle Devonian is fixed between the *Nowakia sulcata* zone and *N. holynensis* zone or near the bottom of *Polygnathus costatus costatus* zone.

2. Middle/Upper Devonian boundary. The boundary between the Middle and Upper Devonian is drawn near the base of *Polygnathus asymmetricus* zone or in most cases above the *Strongocephalus or Nowakia otomeri* zone.

3. The upper limit of the Devonian for the ammonoid-bearing sequence in south Guizhou, South China region is put at the top of the *Wocklumeria* zone. While in some place of south China. The upper limit of the Devonian is drawn between the *Siphonodella praesulcata* and *S. sulcata* zones.

V. THE CARBONIFEROUS SYSTEM

The Carboniferous system of China is remarkably well developed and coal-bearing, reflecting the luxuriant growth of vegetation and the consequent formation of the coal measures. It includes a number of sedimentary associations of different facies, normal neritic carbonates, paralic coal-bearing clastics, occasionally with lavas and pyroclastics and/or flysch and continental deposits. It is marked by a new surge of life, as well as rich mineral deposits, such as iron , manganese, aluminium, phosphate, fire-clay, and gypsum.

(I) Carboniferous sedimentation types

On the basis of lithofacies, biotic features and sedimentary development, the Carboniferous of China can be subdivided into the following four main types.

1. The normal neritic type developed in the various regions are mainly composed of bioclastic limestone, usually 1000-2000 m in thickness, with comparatively complete sequences. Many biota flourished and may be divided into two types according to the benthonic characteristics of early Lower Carboniferous: the *Syringothyris-Siphonophyllia* subtype is represented by Bolohulu of Xinjiang, Panshi of Jilin and south slope of Qilianshan, the *Eochoristites-Pseudouralinia* is represented by South China.

2. The littoral coal-bearing type covers a broad territory. It's characterized by coal series of alternation of marine and continental deposits, with less thickness and simple cyclical textures. The fauna and flora are numerous and cosmopolitan. The coal series of the Lower Carboniferous restrictly distributed in north of Northeast China and Qilian-Helan Mountains.

3. The volcanic type developed in the geosynclinal regions consists mainly of marine clastics with volcanic lava and tuff and show great changes in lithofacies and thickness. There are local unconformities and depositional gap. Its fauna is mainly composed of brachiopods and corals accompanied with some ammonites. This type occurs typically in East and West Junggar, North Tianshan, north of Northeast China, Kunlun Mts. and Qomolongma area.

4. Flysch type developed in the transitional regions consists mainly of clastics with coal-bearing and carbonatite, locally intercalated volcanic rocks. With great thickness and complex cyclical textures. This type was restrictly distributed in Xiao Tanggula Shan of South Qinghai.

(II) Regional stratigraphical characteristics

On the basis of the distribution of the various sedimentary associations and fossil content, nine stratigraphic regions may be differentiated as follows: 1.

The Tianshan-Hingan region; 2. The Tarim region; 3. The Qilian-Helan region; 4. The North China region; 5. The Kunlun-Qaidam region; 6. Qinling-Dabei region; 7. The North Tibet-West Sichuan region; 8. The South China region; 9. The Qomolangma-West Yunnan region.

(III) Classification of Carboniferous chronostratigraphy of China

The second All-China Stratigraphy Conference in 1929 adopted two divisions of the Carboniferous, instead of the former three, on the grounds that there is a sharp contrast between the Lower series and the former Middle and Upper series in terms of organic evolution, lithology, sedimentatonal environment, and palaeogeography.

The Lower and Upper Carboniferous are respectively called Fengningian (equivalent to the Dinantian of Western Europe and the Mississipian of the USA), and the Hutainian (equivalent to the Moscovian and Uralian combined).

The subdivisions of the Carboniferous of China are as follows:

Upper series (Hutianian)
Mapingian stage (Uralian of the Russian subdivision)
Weiningian stage (Moscovian and Bashkirian of the Russian subdivision) or
Dalaan stage
Huashibanian stage
Lower series (Fengningian)
Dewnian stage (Serpukhovian)
Datangian stage (Visean of Western Europe)
Yanguanian stage (Tournaisian of Western Europe)

(IV) Biogeographic provinces

Consideration of the foregoing biostratigraphic data suggests the existence of three biogeographic provinces in Carboniferous times in China, namely, South China, the Northern basin, and Southwest China.

South China Province: The south China Provinces is characterized by benthonic life of Indo-Pacific origin with strong regional features. During the Early Fengningnian both corals (*Pseudouralinia*) and brachiopods (*Eochoristites* and *Martiniella*) are typically chinese forms, which spread widely over south China, but they are absent from the Northern basin region. In late Fengningian both corals (*Kueichouphyllum, Heterocaninia, Yuanophyllum*) and brachiopods (*Kansuella, Gondolina*) still reflect their strongly regional features and are distributed all over south China. The south China faunas contain a few elements

of West European and North American faunas only at the high of the transgression.

Northern basin province: The Northern basin province has a profusion of ammonoids and brachiopods, but corals are not numerous, there, the early Lower Carbonifeous faunas are closely akin to those of North America and Siberia, while in the western part of the region the faunas are mixed with some Central Asian and West European elements. The main brachiopods are *Syringothyris* and *Rotaia*, and the corals are represented by *Sugiyamaella* and *Siphonophyllia*. In the Late Carboniferous, as a result of regression occurring in the Northern basin, the marine connection with the North America province was severed. With the onset of the Late Carboniferous transgression both the Northern and Southern regions were further submerged, so the faunal characters are closely related to those of the Urals, the Russian Platform and the Palaeotethys.

Southwest China province: The Southwest China province is characterized by mixed fauna, i.e. both corals and brachiopods found in South China and the Northern basin are known to have flourished side by side here. In the Qomolangina area and Central Tibet there are colossal Carboniferous detrital deposits which bear faunas with Gondwana affinities, it is interesting to note that Gondwana-type faunas appeared in the Late Carboniferous.

VI. THE PERMIAN SYSTEM

In China the Early Permian is similar to the Late Carboniferous in Such features as the extent of marine transgression, and the basic tectonic frame and palaeogeographical outline. The North China and Tarim platforms stood as prominent tectonic units that separated the Northern basins and the Northern biogeographical province from the Palaeotethys, with its typical faunas, to the south. South of the Yarlung Zangbo River in Himalaya region the *Glossopteris* flora and the cold-water fauna (*Stepanoviella*) appeared, which indicate the link with the Gondwanan forms.

By the end of the Early Permian, crustal movements brought about the folding and uplifting of the Northern basins. In Late Permian times the Qinling-Rulan mountains marked the boundary of the Land in the north and the seas in the south, a situation which persisted until the Triassic.

(I) Permian sedimentation types

Being distributed over all China, the Permian consists of the Platformal, geosynclinal and transitional sedimentary types. According to depositional and palaeontological characters, they may be divided into seven types:

1. The Wujiaping (Yangzi type) -platformal type- consisting of shallow marine carbonate.

2. The Ganzhong type (Jiangnan type) - platformal shallow marine and coal-bearing littoral lagoonal facies deposit.

3. The Cuipingshan type (Southeastern type) - shallow marine and coal-bearing littoral lagoonal facies and continental deposit.

4. The North China type - continental coal-bearing clastics and red deposits.

5. The Kunlun type - geosynclinal facies, consisting of cyclical deposits of clastics and carbonatites.

6. The Hingan type - geosynclinal facies comprising pyroclastics with medico-acidic lava and carbonatites.

7. The Qomolangma type - platformal facies, normally shallow marine and intercalated with glacial deposits.

(II) Regional stratigraphical characteristics

Permian rocks are widely distributed in China and are characterized by a considerable range of deposits and a profusion of biotas, both marine and continental. On the basis of these factors, the Permian System in China may be divided into the following 10 stratigraphic regions: 1. The Tianshan-Hingan region; 2. The Tarim region; 3. The North China region; 4. The Kunlun-Bayan Har region; 5. The Xizang-West Yunnan region; 6. The Qinling-Yangzi region; 7. The Jiangnan region; 8. The south-east region; 9. The Himalayan region; 10. The Taiwan region.

(III) Classification of Permian chronostratigraphy of China

The Permian system of China is traditionally divided into 4 stages, belonging to two series:

Lower series (Yungsinian series)
- Qixian stage
- Maokonan stage

Upper series (Lopingian series)
- Wujiapingian stage
- Changxingian stage

(IV) Biogeographic provinces

On the basis of fossil distribution, the Permian in China apparently contains 3 biogeographic provinces:

1. *Northern (Boreal) province:* containing chiefly cold water fauna of Arctic province and a few warm water elements characterized by genera such as *Monodixodina, Lytuolasma, Spiriferella, Yakovlevia, Waagenophyllum;* the continental deposit are characterized by the Angara flora.

2. *Southern (warm water) or Tethys province:* It has copious deposits of warm-water benthos, such as fusulinids, corals, and brachiopods, which are closely allied to those of the Tethyan province. Among the chief representatives are fusulinids (*Misellina, Neoschwagerina, Neomisellina, Polydiexodina* and Palaeofusulina), compound corals (*Polythecalis, Ipciphyllum, Iranophyllum, Wentzelella and Waagenophyllum*) and brachiopods (*Monticulifera, Gryptospinifer, Oldhamina*). Representative plants include such genera as *Gigantonoclea, Gigantopteris, Lobatanularia* and *Sphenophyllum,* all typical of the Cathaysian flora.

3. *Himalaya Province:* consisting of cold water elements such as *Costiferina, Taeniothaerus, Verbeckiella, Trachypsammia, Lytuolasma,* and *Endamplexus,* associated with the Gondwana flora.

(IV) Boundary problems

1. *The Permian-Carboniferous boundary*

In China the lower boundary of the Permian System is drawn at the base of the *Pseudofusulina moelleri* or *Propapanoceras* zone of the Longyin Formation, e.g. between the Asselian and Sakmarian age.

2. *Lower-Upper Permian boundary*

The boundary between the Lower and Upper Permian is drawn at the top of the Fusulinids *Neomisellina-Condonofusiella* zone.

3. *Permian-Triassic boundary*

In most areas of South China, as the Permian and Triassic Systems form a continuos sequence, a biostratigraphic boundary between them is stressed and that is placed between the extinciton of *Palaeofusulina, Rotodiscoceras, Pseudotirolites, Pleuronodoceras* and the widespread appearance of *Otoceras, Ophiceras, Claraia wangi* or at the top of conodont *Neogondolella subcarinata changxingensis - N. deflecta* zone.