

Floras and the evolutionary dynamics across the Permian-Triassic boundary nearby the border of Guizhou and Yunnan, South China.

Thèse soutenue par : Yu Jianxin

Le 28 mai 2008

Abstract :

Permian-Triassic is an important stage for the “evolving earth” from Paleozoic to Mesozoic. Hence, geologists in the world have been working hard on the origin, scale, content and characteristics of this specific period of dramatic change in the living world. As the establishment of the Global Stratotype Section and Point (GSSP) of the Permian-Triassic boundary (PTB), the establishment of a terrestrial associate Stratotype Section and Point of the Permian-Triassic and the exact determination of its boundary is now on the agenda.

The western Guizhou and eastern Yunnan area of southwest China commands a unique and significant position globally in the study of Permian-Triassic boundary (PTB) events as it contains well and continuously exposed PTB sections of marine, non-marine and marginal-marine origin in the same area. By using a range of high-resolution stratigraphic methods including biostratigraphy, eventostratigraphy, chronostratigraphy and chemostratigraphy, not only are the non-marine PTB sections correlated with their marine counterparts in the study area with high-resolution, the non-marine PTB sections of the study area can also be aligned with the PTB Global Stratotype Section and Point (GSSP) at Meishan in eastern China.

Terrestrial facies Chahe and Zhejue sections and marine-terrestrial alternative facies Mide and Tucheng lied in western Guizhou and eastern Yunnan are selected as researching objects of this thesis. They are made up of Late Permian Xuanwei and Early Triassic Kayitou Formations. Very abundant fossil plants occurred in these sections. This dissertation is hence focused on the fossil plants to refine the definition of the terrestrial and marine-terrestrial alternative Permian-Triassic boundary in western Guizhou and eastern Yunnan and the extinction and recovery patterns of the paleofloras across Permian-Triassic boundary in associated with the characteristics of paleoclimate reflected by these sections.

Based on the changes of the composition, abundance and diversity of fossil plants across Permian-Triassic boundary, non-marine two macrofloral assemblages were established, in ascending order: **a.** *Gigantonoclea guizhouensis-Annularia pingloensis* Assemblage (Latest Permian Changhsingian, Upper Xuanwei Formation), standing for the late Cathaysian flora, is also the last Permian assemblage in western Guizhou and eastern Yunnan. This assemblage is very different from the coeval paleofloral assemblage of North China in compositions, reflecting two-typed paleofloras and climates. In western Guizhou and eastern Yunnan, the paleoflora kept with the features of the Lungtanic (Wuchiapingian) Cathaysian Flora, *i.e.* coal-forming plants. In North China, Euramerican plants had invaded into this region, showing the vegetation typical of a much dry climate. **b.** *Annalepis-gigantopterids* Permian relicts Assemblage (Early Triassic Induan, the top part of Xuanwei Formation and Kayitou Formation), filled up the blank between late

Upper Permian Changhsingian *Gigantonoclea guizhouensis*- *Ullmannia* cf. *bronnii* established by Li et al. (1995) and the late Lower Triassic Olenekian *Neuropteridium-Albertia-Voltzia* assemblage named by Zhou et Li (1979) in South China.

According to the vertical changes of the abundance, diversity and composition of the Xuanwei macroflora and microfloral assemblages compared with the palynomorph assemblages of Meishan section, combining with the isotopic age and eventostratigraphy, the PTB in the continental Chahe and Zhejue sections is considered to respectively lie within Bed 67 and Bed 48, which corresponds to Bed 27 at Meishan. This represents the most precise location of the PTB in a continental succession. In the marine and terrestrial transitional Mide (A), Mide (B) and Tucheng sections (respectively Bed 45/Bed 46, Bed 18/ Bed 19, Bed 16/ Bed 17), the first appearance of *Annalepis* is considered as marking the beginning of Triassic deposition in marine-terrestrial transition sections. Therefore, the appearance of the genus *Annalepis* occurred here earlier than in the Yangtze River area. During Early and Middle Triassic, it migrated to the north and widely spread to the middle and lower reaches of the Yangtze River, in relation to the marine regressions and transgressions. Its stratigraphic time span ran from Early Induan to Late Carnian.

The paleofloral assemblage of the Latest Permian Upper Xuanwei Formation contains abundant coal-forming plants fossil, such as *Lepidodendron*, *Paracalamites* and Gigantopterids and so on. Coal seams occurred in multiple horizons in four sections, extending to be quite close to the Permian-Triassic boundary. It is certain that the climate was humid and warm during the Latest Permian. Although the coal bed/seam disappeared in Early Triassic Induan Kayitou Formation, that analyzing compositions of this paleofloral assemblage shows the climate is similar to the Late Permian, leaved in humid condition in western Guizhou and eastern Yunnan. Coal-forming plant fossils (*Lepidodendron*, *Paracalamites*) persisted into the Earliest Triassic beds of the Kayitou Formation. They co-existed with *Annalepis*. In the Tucheng section, fragments of Gigantopterids occurred above the strata bearing fossil plant *Annalepis*. *Stigmaria* is frequently found in Late Permian strata containing, or not, coal and below coal seams in western Guizhou and eastern Yunnan. In Early Triassic Induan strata, fragmentary *Stigmaria*, associated with gigantopterids, *Annalepis* and single leaf-cushion of *Lepidodendron* occurred.

Plant megafossils (“megaplants”) in the study area indicate a major loss in abundance and diversity across the PTB, and coal beds and/or seams are no more deposited in the non-marine Lower Triassic although they are very common in the non-marine Upper Permian. The megaplants, however, did not disappear consistently across the whole area, with some elements of the Late Permian Cathaysian *Gigantopteris* flora surviving the PTB “mass” extinction and locally even extending up to the Lower Triassic. Palynomorphs exhibit a similar temporal pattern characterized by a protracted stepwise decrease from fern-dominated spores in the Late Permian to pteridosperm and gymnosperm-dominated pollen in the Early Triassic, which was however punctuated by an accelerated loss in both abundance and diversity across the PTB itself. Contemporaneous with the PTB crisis in the study area was the peculiar prevalence and dominance of some fungi and/or algae species.

The temporal patterns of megaplants and palynomorphs across the PTB in the study area are consistent with the regional trends of plant changes in South China, which also show a long-term decrease in species diversity from the Late Permian Wuchiapingian through the Changhsingian to the earliest Triassic, with about 28% and 75% losses of species occurring respectively in the end-Wuchiapingian and end-Changhsingian. Such a “drawn out” extinction process spanning the entire Late

Permian and across the PTB therefore does not support a globally synchronous end-Permian catastrophic event such as meteor impacts; rather it is more consistent with a protracted global climate change that may have been initiated by Pangea formation, and then exacerbated by the Siberian Trap (and also possibly the Emeishan Basalt) volcanism at the end-Permian.

The Induan plant assemblage is dominated by the herbaceous lycopsids *Annalepis*, which differ from the Late Permian arboraceous lycophytes *Lepidodendron*, *Sigillaria*. This assemblage also includes some elements of Peltaspermales and a few relics of Late Permian Cathaysian flora in western Guizhou and eastern Yunnan. They steadily appeared in about 2-4 plant-bearing biostromes. Based on plant preservation, the plant-taphocoenoses is nearly an allochthonous burial.

The *Annalepis*-dominated flora of western Guizhou and eastern Yunnan is similar to Induan Liujiagou Formation flora of North China, which is also lycopsid but *Pleuromeia*-dominated. In Gondwana, the herbaceous lycopsids (*Cylostrobus*, *Skulliostrobus*), which had been only a small part of the Permian land flora, expanded with the advent of the Triassic and became dominant during the Early Triassic, but then declined and virtually disappeared by the end of the Period. The Early Triassic paleoflora in South China is correlated to that of the Gondwana. Therefore the *Annalepis*-dominated flora can be similarly considered to represent the first stage of the Triassic land-plant recovery starting from South China.

The analysis of the Permian-Triassic plant fossils in western Guizhou and eastern Yunnan indicates that the recovery depends on the new group including the crisis progenitors in the surviving time rather than the Paleozoic surviving flora, such as Gigantopterids. Specifically, *Annalepis* are mainly responsible for the recovery.

Based on analyzing paleoflora, paleoclimatology and paleoethanatoecoenosis of the Early Triassic Induan Kayitou Formation, it is possible that this area of western Guizhou and eastern Yunnan was one of the main refugia for the plants in Early Triassic at a global scale. A few relics of gigantopterids, *Lepidodendron*, *Lobatannularia*, *Paracalamites* and *Compsopteris* and so on in the Kayitou Formation paleoflora could be sheltered in the refugium, and where pioneers of newly evolved opportunistic species (e.g. herbaceous lycopsids *Annalepis*) might again foothold. According to Lazarus taxa, the large allochthonous and fragments burial plant taphocoenosis at the bottom and upper part of the Kayitou Formation is a good example for continental plants. This existence of a refuge may have promoted the recovery of vegetation, not only by sheltering many Palaeozoic relicts such as *gigantopterids*, *Pecopteris* and *Paracalamites*, but also by producing the Mesozoic pioneers *Annalepis* *Peltaspermum* and others in this region.

Both biotic (including gigantopterids migration and evolution) and nonbiotic features of nonmarine rocks near the Permian-Triassic boundary in China indicate that tropical and humid conditions persisted in South China throughout the Permian and Early Triassic Induan, but in North China, by early Late Permian, climatic conditions alternated between wet and dry, and by late Late Permian most of the Northern Hemisphere was experiencing extreme arid conditions. This different climate results in forming the different Paleofloras. Therefore, climate played an important role in the evolution and recovery of the plants across the Permian-Triassic boundary.

In a word, there are well-developed sections from terrestrial facies and marine-terrestrial transitional facies to marine continuous deposit, which contain abundant fossil plants. Macrofloras in this study show an obvious change in abundance and diversity across Permian-Triassic boundary. But the paleoclimate remained first

basically similar in this period. Consequently this area likely formed a refuge during the P / T transition Earliest Triassic, where land plants started to the “post crisis recovery”.

Keywords: western Guizhou and eastern Yunnan, non-marine Permian-Triassic, paleoflora (macro- and microflora), biostratigraphy, paleoclimatology, extinction and recovery