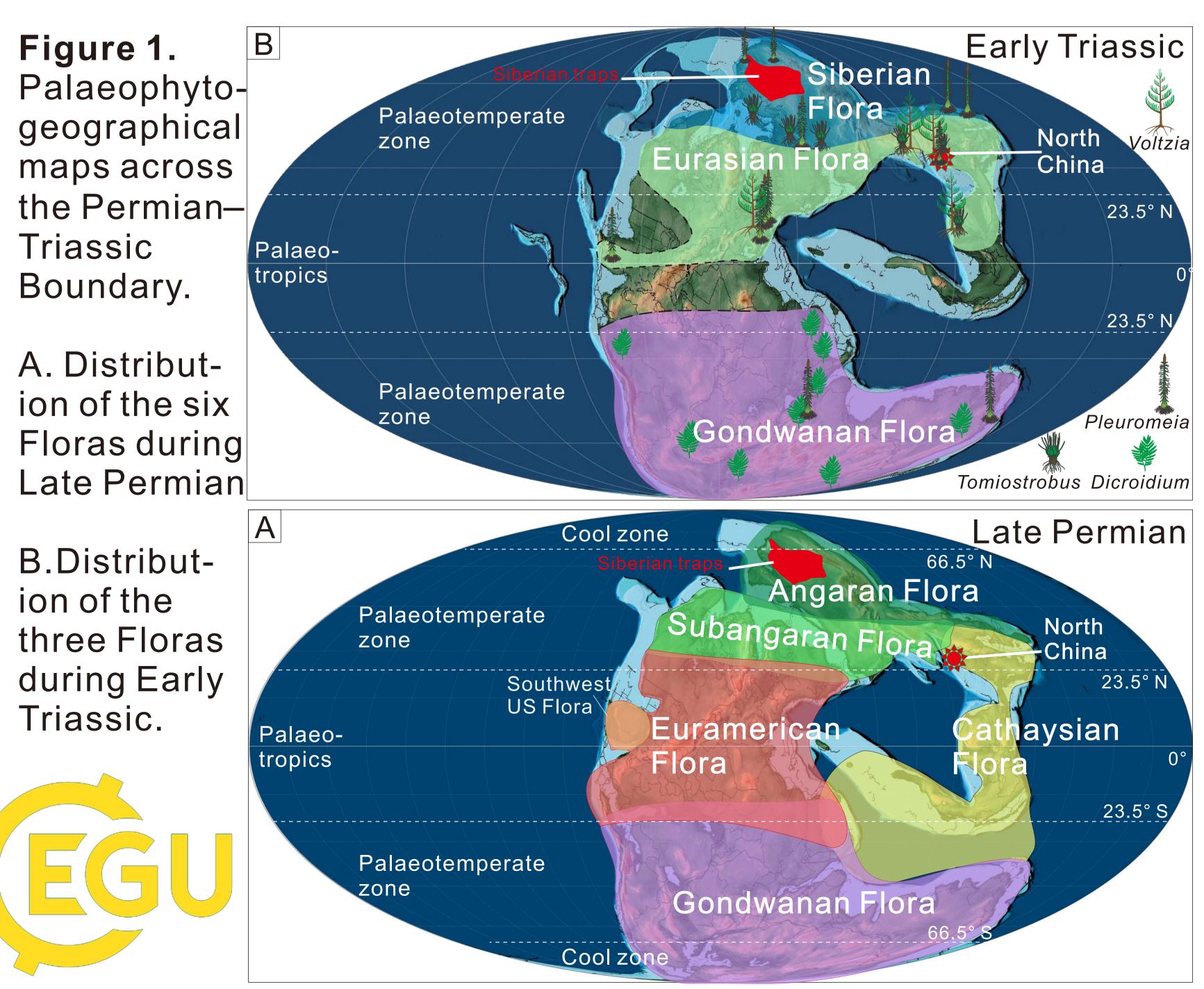


Stepwise Recovery of Vegetation from Permian–Triassic Mass Extinction in North China and Implications for Changes of Palaeoclimates

Abstract

The Permian–Triassic was a major transition in the evolution of life in the earth history, when happened the greatest mass extinction during the Phanerozoic and an unusually prolonged or delayed recovery. Most studies have been carried in the marine facies while very few in the continental facies. On land, plants play a great role in the interaction of climate and terrestrial ecosystems. Here we present a regional case of stepwise recovery of vegetation in North China. Prior to the Permian-Triassic mass extinction, the voltzialean conifer forest community dominated in the Changhsingian. Consequently, the extinction event wiped out of the voltzialean conifer forest community, probably conciding with the extension of the red beds. The first post-crisis flora was an Induan herbaceous lycopsid community, succeeded by the Pleuromeia-Neocalamites shrub marsh community. A pteridosperm shrub woodland community dominated for a short time in the late Early Triassic along with the reappearance of insect herbivory. In the early Middle Triassic, gymnosperm forest communities gradually rose to predominate in both uplands and lowlands along with other diverse plant communities, indicating the beginning of the establishment of the Mesophytic Flora. In the late Middle Triassic-Late Triassic, it was occupied by the Danaeopsis-Symopteris flora and the opportunism elements gradually were replaced by the advanced taxa, which represents the complete establishment of the Mesophytic Flora.



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Geological setting

North China, with its Permian Cathaysian Flora, traversed low latitudes (~30°N), drifting north toward the north-eastern part of the Paleo-Tethys Ocean during the late Paleozoic and early Mesozoic. Sedimentary sequences suggest there was a large lake in North China during that time. The Permian to Late Triassic succession in North China is divided into the Sunjiagou, Liujiagou (Qishan), Heshanggou, Ermaying, Tongchuan and Yanchang formations.

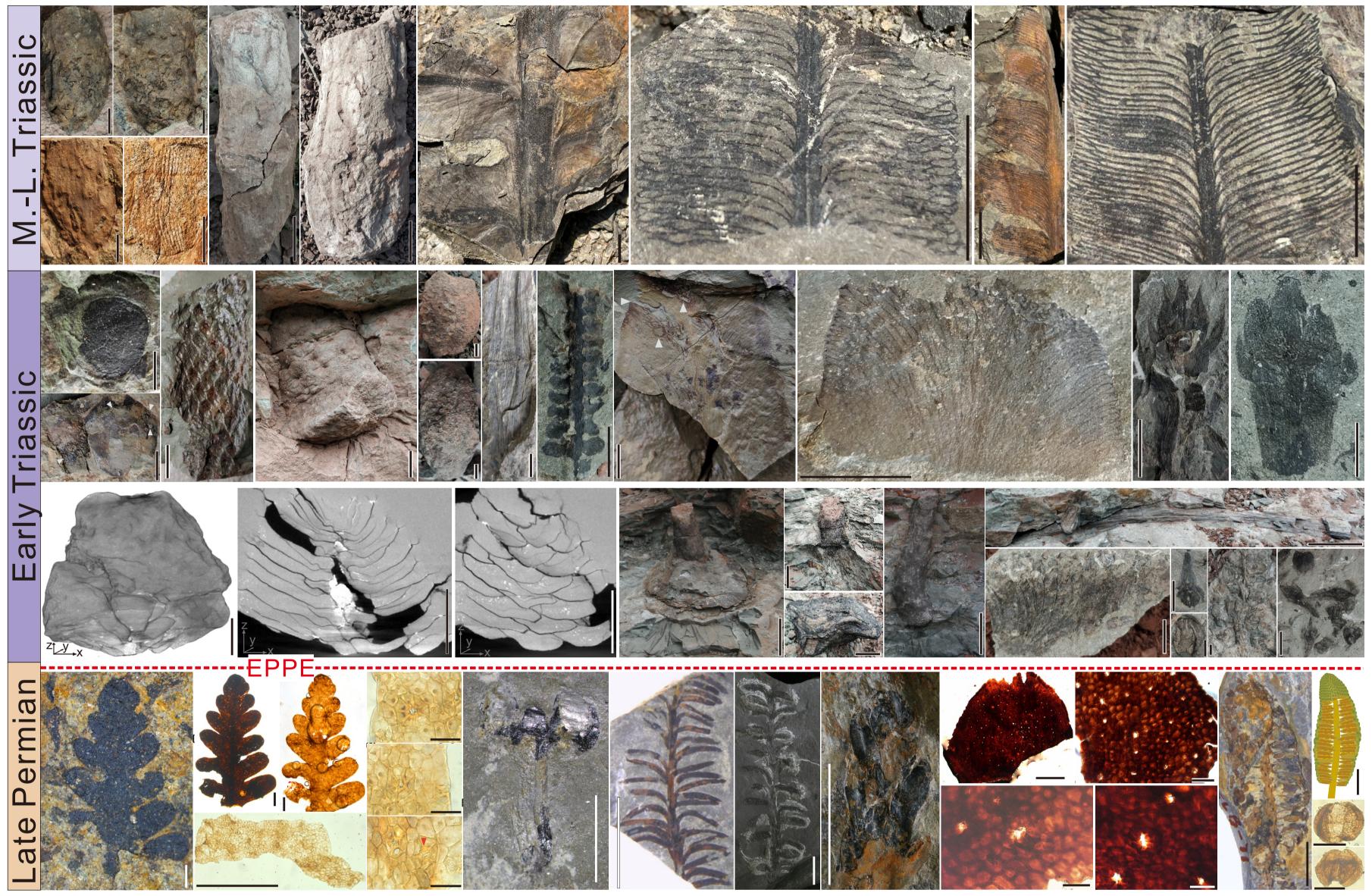


Figure 2. Fossil plants of Late Permian to Late Triassic in North China.

Materials and Methods

This study is mainly based upon over 1800 plant megafossil specimens collected from nine locations ranging through all the target formations and megafossil data (see in Shu et al., 2022) from previous studies in North China. These include compression, impression, and permineralized fossils. The fossils represent shoots, leaves, cones, or fertile parts and some trunks/fossil woods, most of which were identifiable. All fossils studied are stored in the paleontological collection of the State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan, China). Plant megafossil specimens were photographed using a Canon EOS 7D digital camera, and some in situ pollen, bract-scale complexes, small shoots specimens were examined and photographed using a LEICA-DM-750P microscope equipped with an automatic camera image stacking system. In addition, one well-preserved strobilus of *Pleuromeia* from the Liujiagou Formation were scanned using a nanoVoxel 4000 micro-computed tomography scanner (Sanying Precision Instruments, Tianjing, China) and the raw projections were converted into image stacks using VoxelStudio Recon (Sanying Precision Instruments). The isometric voxel size (spatial resolution) for the *Pleuromeia* is 31.60 µm.

Results

New plant assemblages from Late Permian to Early Triassic in North China:

3. Pleuromeia–Anomopteris–Tongchuanophyllum assemblage

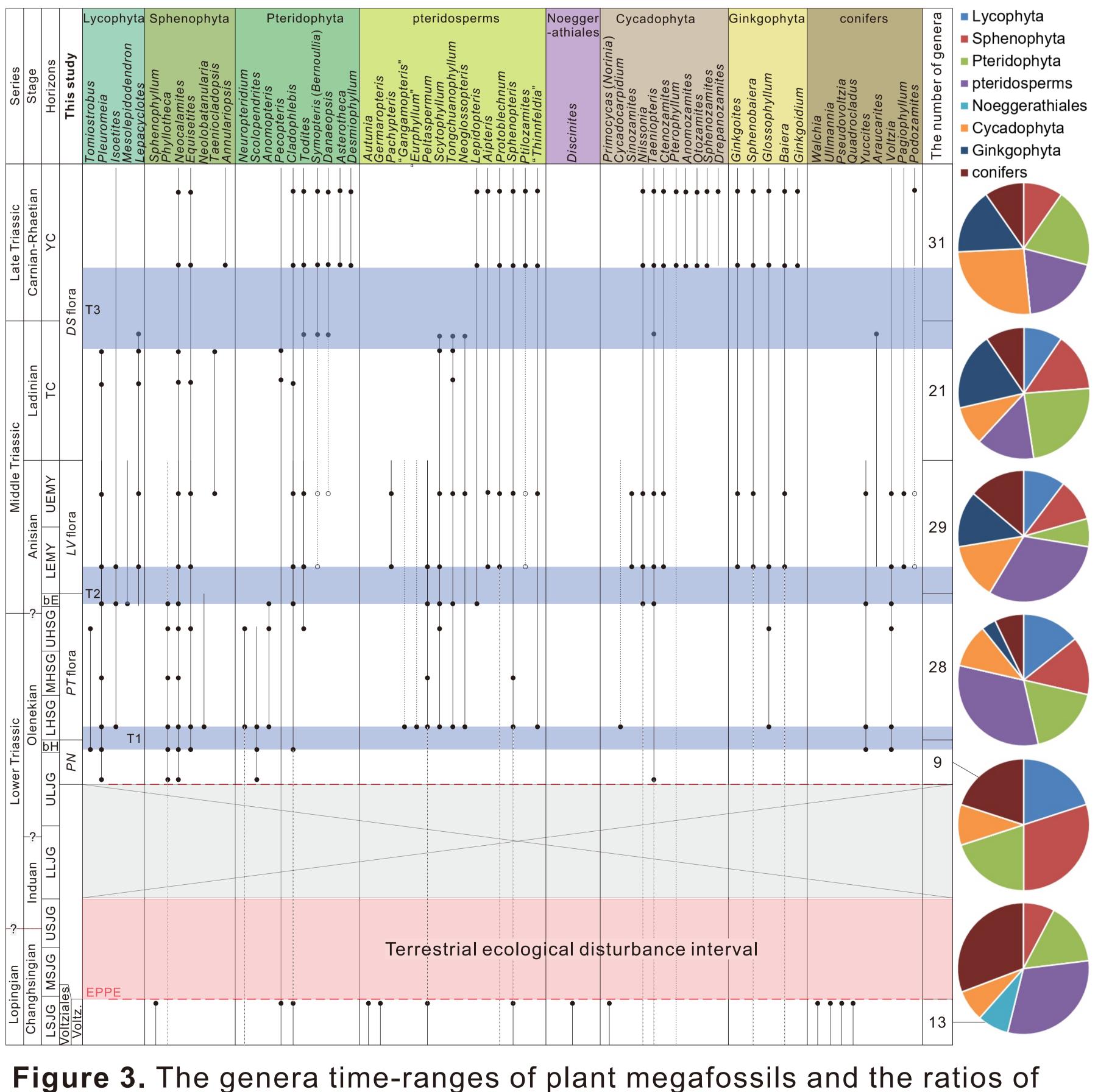
- 2. Pleuromeia-Neocalamites-Scolopendrites assemblage
- 1.*Ullmannia*–*Pseudovoltzia*–*Germaropteris* assemblage

Five floras from Late Permian to Late Triassic in North China:

- 5. Danaeopsis–Symopteris flora (DS flora)
- 4. Lepacyclotes–Voltzia flora (LV flora)
- 3. *Pleuromeia–Tongchuanophyllum* flora (*PT* flora)
- 2. *Pleuromeia*–*Neocalamites* flora (*PN* flora)
- . The Voltziales Flora

Conclusion

Five floras were established from Late Permian to Late Triassic in North China. After the mass extinction, the stepwise recovery of vegetation came along with the establishment of Mesophytic Flora, reappearance of coal and changes of the humid-dry palaeoclimates.



different plant classes from Late Permian to Late Triassic in North China.

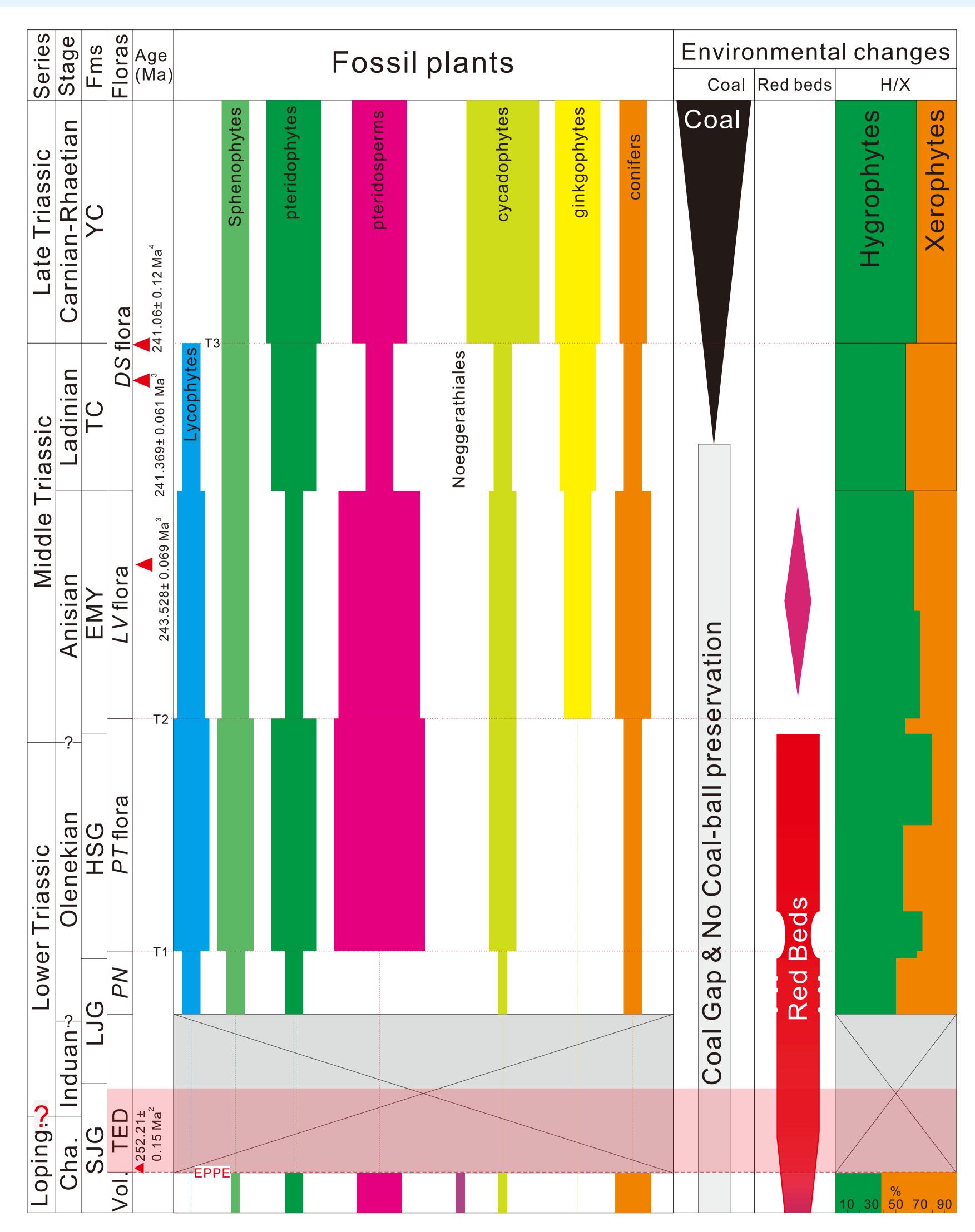


Figure 4. The distribution of plant diversity and correlations with the reappearance of the coal, red beds and changes of the humid/dry palaeoclimates.

Acknowledgements & Ref.

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